ExTemp Series

Intrinsically Safe Infrared Temperature Sensor

Guide to Certification and Installation

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CALEX
ELECTRONICS LIMITED

Issue C – May 2015 – *last edited 11/05/2015*

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About Calex

Calex Electronics Ltd is an independent, privately-owned company focused on the design, manufacture and sale of innovative infrared temperature sensors and industrial instrumentation. Our sensors are designed and manufactured in our factory in Leighton Buzzard, UK, and we sell our equipment worldwide via our network of distributors.

Since 1973 we have been at the cutting edge of innovation in non-contact temperature measurement, and in recent years we have launched some of our most successful products. These include the PyroMini, the world's first infrared temperature sensor with integrated touch screen display and data logging, and the PyroCouple, which is low-cost, simple, and extremely popular thanks to its choice of analogue outputs and exceptional performance. As well as these general-purpose sensors for non-hazardous applications, we now have a sensor that satisfies ATEX and IECEx requirements: the ExTemp.

The ExTemp was developed to satisfy a growing demand for an intrinsically safe infrared temperature sensor that could be used in all hazardous areas for surface equipment including Zone 0 and Zone 20. This removes the requirement for bulky flameproof enclosures while still providing the highly accurate and repeatable readings that customers have come to expect from affordable Calex products.

The development of the ExTemp was assisted by a world-renowned authority on intrinsic safety, Chris Towle, who has also written this application guide recommending how the ExTemp should be installed and maintained in all non-mining gas and dust Zones.

We hope you find this guide helpful.

As this document is continuously being reviewed, please check for the current version on our website at www.calex.co.uk.

If you have any questions or comments, please email mail@calex.co.uk as we would very much like to hear from you.

About the author

This document was compiled by Chris Towle who has many years of working with hazardous area instrumentation. He was initiated into the mysteries of intrinsic safety in the mid 1950's [the BS 1259 era] when trying in vain to get a Kent Instruments chart recorder certified.

The years from 1959 to 1971 were dominated by the design and application of shunt-diode safety barriers with the consequent need to learn about earthing and stray currents. With 1971 came redundancy, the formation of Measurement Technology Ltd [MTL] and the position of Technology Director. The change led to increased exposure to many industrial sites in many countries, while providing consultation and/or training. During this period he wrote many articles and gave lectures in the UK and many other parts of the world. Over the years from 1996 he progressively withdrew from direct involvement in the day to day activities of the company and now operates as an independent consultant and irritant.

His involvement in standards began in 1961 on the intrinsic safety committee of BSI and followed shortly after by joining the main and code of practice committees. From 1970 he became involved in both IEC and Cenelec intrinsic safety committees and was secretary of both for a fifteen year period. He is still actively involved in all three organisations.

His contribution to the art has been recognised by awards from BSI, IEC, Baseefa, Hazardex, ISA, and the Institution of Measurement and Control which recently made him an Honorary Fellow.

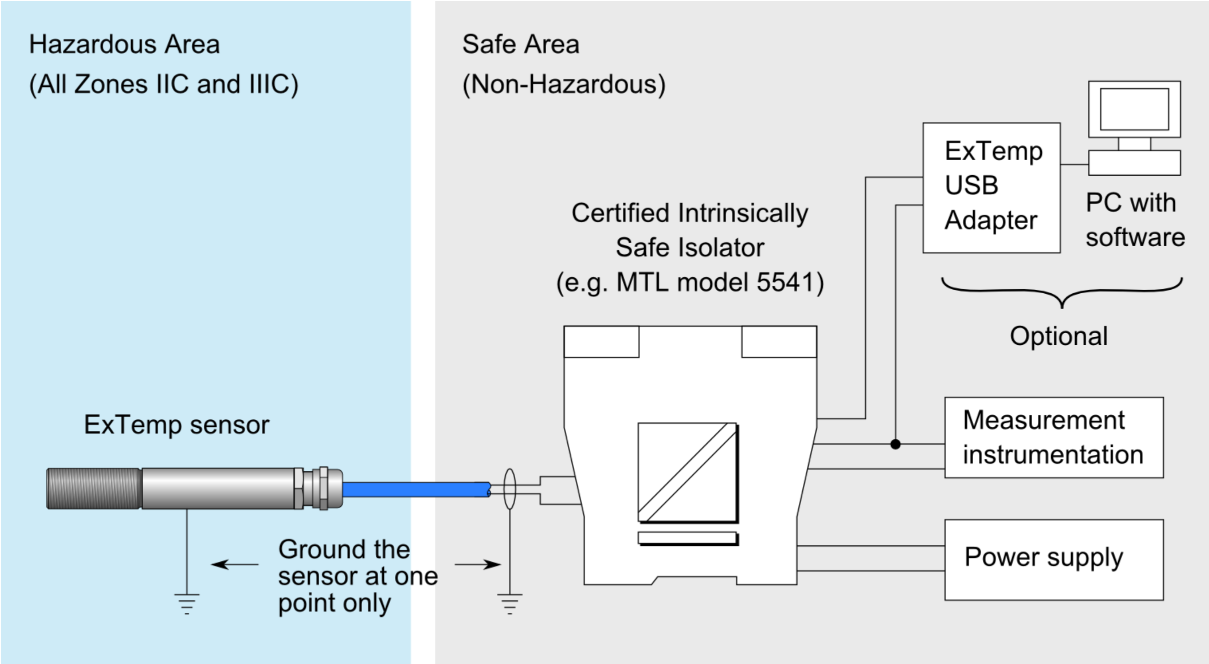

Figure 1: Basic intrinsically safe system for ExTemp sensor.

1 Foreword

This document discusses those aspects of the installation and use of the ExTemp infrared temperature sensor which are relevant when the sensor is used in an intrinsically safe [IS] circuit. An inevitable effect of this comprehensive analysis is to create the impression that installation and design of the system is complex. In practice connecting the sensor by a screened two core cable to an IS isolator [provided that the cable is not too long, less than 275 m] creates an ia IIC system with a T4 sensor which can be used in almost all gases and locations. The preparation of safety documentation can be simplified by cross reference to this document.

The sensor converts the radiated infrared using two thermistors and the differential resistance is converted into a 4-20 mA signal using the usual two wire transmitter techniques. Figure 1 illustrates the basic IS system.

The range and emissivity settings of the sensor are set by using a protocol similar to that of HART and consequently when it is required that these functions are changeable from the safe area the IS interface must be capable of passing the necessary signal. Frequently these functions are fixed and then less complex interfaces may be used.

This document uses Measurement Technology Ltd devices to illustrate the possible interfaces. There are a number of alternative suppliers who offer identical or similar devices but the document would be extremely complex if it attempted to cover all the possible variations. Where alternative suppliers are preferred the text and diagrams from this document can be readily adapted and the result is equally acceptable.

2 Analysis of marking and certification requirements

2.1 Introduction

This section analyses the marking on the ExTemp sensor and supplements this with some information from the certificates. Inevitably the label can only summarise the certification requirements. The latest version of the IEC Ex certificate or ATEX certificate or Document of Conformity should be consulted for information used in system design. These documents are available on the website www.calex.co.uk. The label contains a significant amount of redundant information. This is because the marking must meet the requirements of the standards to obtain a certificate. The standards are created by individuals all of whom have specific interests to promote and all who believe implicitly in the power of labels to prevent explosions. Fortunately the major part of the technical information is common to both ATEX and IEC Ex certificates and is not required to be repeated. The conspicuous difference is between the ATEX Categories and the IEC Ex Equipment Protection Levels and consequently both must be marked.

2.2 Label content

The need to identify the manufacturer is satisfied by the marking of the company name, address, and telephone number. Possibly the most useful reference is the website address. The traceability of the sensor is ensured by the' ExTemp Series' marking and the Model type and year of manufacture recorded at the bottom of the label. The ‘Made in England’ is an archaic requirement of previous legislation not an ATEX requirement.

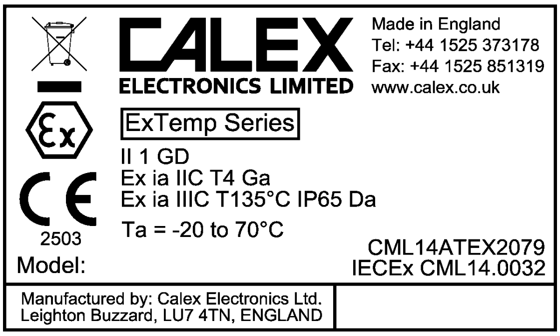

Figure 2:ATEX/IECEx marking on the ExTemp.

The cancelled dustbin is an indication that at the end of its life the sensor should be disposed of in a controlled manner [as with most electronic equipment] not just dust-binned.

The hexagonal Ex symbol indicates compliance with the ATEX Directive.

2503

This mark is a statement by the manufacturer that the equipment complies with all the relevant Directives of the European Community. The Document of Conformity supports this mark and lists the Directives with which the equipment complies. The number beneath the mark is the registered number of the certification body responsible for the quality control of the manufacture of the equipment. In this case the number is that of the body issuing the certificate [CML Ex] but the use of different authorities is permissible.

II 1 GD

The II indicates that the equipment is suitable for use in surface industries. The 1 is the ATEX category which specifies the level of risk of creating an explosion. Basically category 1 is safe with two countable faults in the same way as ia apparatus and is usually considered as being suitable for use in Zone 0 and 20 locations. The GD confirms that the sensor is suitable for use in both gas and dust atmospheres.

Note: The symbol II covers both dust and gas atmospheres in ATEX terms but IEC Ex uses II for gas and III for dust.

Ex ia

This indicates the highest level of IS protection [safe with two countable faults], usually considered suitable for all hazardous areas including Zone 0.

Level of protection	Zone	Countable faults
Ia	0	2
Ib	1	1
ic	2	0

IIC

This indicates that the sensor is suitable for use in all flammable gases experienced in surface industries from a spark ignition viewpoint. Flammable gases used in surface industries are grouped in three groups [IIC, IIB and IIA] in accordance with the amount of energy required to cause spark ignition of the ideal mixture of the gas and air. The most sensitive group is IIC and hydrogen is in this group and is the representative gas used for IIC testing. The IEC standard IEC 60079-20-1 contains both gas and temperature classification data for most industrial gases.

Gas group	Typical gas	Ignition Energy
IIA	Methane	160 µJ
IIB	Ethylene	80 µJ
IIC	Hydrogen	20 µJ

Table 1: Gas groups

T4

This indicates that the sensor is adequately safe when used with gases with an ignition temperature not less than 135 °C. This excludes a few gases which have T5 and T6 classification typified by carbon disulphide and some gases used in the semiconductor industry, but the majority of industrial gases are covered. Ignition temperature [the temperature at which a gas/air mixture spontaneously ignites] and ignition energy are not correlated and the gas group and ignition temperature of a given gas should both be ascertained before choosing equipment. Frequently IIC ia T4 equipment is chosen since this satisfies almost all needs and is a defence against possible changes in requirements.

T1	T2	T3	T4	T5	T6
450°C	300°C	200°C	135°C	100°C	80°C

Table 2: Temperature classifications

Ga

This states the Equipment Protection Level [EPL], which is the IEC Ex equivalent of ATEX Categories and indicates that the sensor is suitable for use in surface industry gases in all Zones. It replicates some of the information contained in the IIC ia T4 statement.

Ex ia IIIC

This indicates that the apparatus is intrinsically safe with two countable faults and is adequately safe from a spark ignition risk perspective for use in all types of dust atmospheres including electrically conductive dust and Zone 22 locations.

T135°C

This is the marking required by the IS standard for equipment with an input power of 650 mW at 70 °C and means that the sensor could theoretically be immersed in dust which has a smouldering or cloud ignition temperature not less than 200 ºC, which is the majority of flammable dusts. It is intended to produce an IEC standard IEC 60079-20-2 to include data on flammable dusts but at the present time it is necessary to use other references for information on dusts.

IP 65

This is an indication of the level of protection provided by the enclosure against the environment, known as 'ingress protection'. The 6 indicates that the enclosure is dust-tight and the 5 that it is proof against water jets. This level of ingress protection is considered to be more than adequate for most industrial locations.

This IP rating is considered necessary for some aspects of both the gas and dust certification and should be maintained throughout the life of the sensor. For example the gland tightness should form part of any inspection procedure.

Ta = -20 to 70 °C

This is the temperature range which has been considered in the certification. The acceptable temperature range is applicable to the service temperature rather than the ambient temperature of the atmosphere. For example the temperature of the ExTemp sensor is largely determined by the temperature of the base on which it is mounted, which might be affected by radiation from the monitored target.

CML 14ATEX2079

This is the number of the ATEX certificate. CML is the accepted mark of Certification Management Limited, who are an approved body for the issue of both ATEX and IEC Ex

IECEx CML 14.0032

This is the number of the IECEx certificate. The content is the same as the ATEX certificate with a variation on the sequence of the data.

2.3 Information from certificates

This section lists information from the certificates which is necessary for the creation of IS systems. Fortunately the information is identical in both certificates and hence does not need to be repeated.

Ui = 28 V	This is the maximum voltage which is permitted to be applied to the sensor cable.
Ii = 93 mA	This is the maximum current which is permitted to be applied to the sensor cable.
Pi = 0.651 W	This is the maximum power which is permitted to be applied to the sensor cable.

These three parameters match the output parameters of a number of commercially available IS interfaces, but are slightly restrictive. It can be argued that these parameters can be relaxed in ic circuits but this would need to be covered by a risk analysis since no formal authorisation of this relaxation exists at the present time.

Ci = 8 nF	This is the effective capacitance which is considered to exist at the end of the 25 m sensor cable. It is predominantly the cable capacitance with a small contribution from r.f. decoupling capacitors.
Li = 0	The input inductance is considered to be negligible. This is justified since the inductance permitted by 93 mA in IIC is 4.2 mH and the actual input inductance is a few micro-Henries.

3 Intrinsically safe interfaces

3.1 Pragmatic solution

The commonly used solution is to use an isolator capable of passing a HART type signal such as the MTL 5541. If the use of barriers is preferred then consideration should be given to using an active barrier such as the MTL 7706.

3.2 Introduction

The input parameters of the ExTemp sensor [28V, 93mA, 651mW] make it almost inevitable that the only acceptable IS interfaces for this application must have output characteristics which match these parameters. Interestingly the 28V 93mA parameters were derived some years ago [early 1960] and the parameters would be 28V 120mA if the current standards were used. The original values continue to be used because of the large number of hazardous area equipment already certified with these input parameters.

Figure 3: Example of a smart isolator with built-in power supply.

Figure 4: Example of a smart barrier.

3.3 IS interface barrier or isolator?

Satisfactory results can be achieved using barriers or isolators and the choice is often decided by which solution has been adopted for existing IS systems on the plant. The arguments for the two choices can be summarised as follows:

1) Barriers cost less, but arguably are more expensive to install.

2) Barriers need a defined safety earth point with substantial well-defined inter-connections. In practice the bonding of the cable screen of the hazardous area cable of an isolator system requires similar consideration from an operational and safety viewpoint. The earthing and bonding of electrical equipment in hazardous areas always requires considerable thought. Section 6 contains further advice on earthing for this particular application.

3) Isolators make available a larger voltage in both the hazardous and safe area thus avoiding problems caused by cable resistance. Active barriers can be used to solve this problem. Both these solutions require a separate 24 V supply. In the particular case of the ExTemp sensor the use of a passive barrier is not practical unless a well regulated 26 V power supply is available or the safe area equipment requires less than 5 V. Section 5 on the requirements of the intermediate cable contains further details

4) Isolators provide isolation between the safe and hazardous area 4-20 mA signals and also the 24 V power supply which allows greater flexibility in the application of the signal.

5) Passive barriers are simpler and are considered to be more reliable when analysed using the SIL techniques commonly used for system reliability analysis. However applying this technique to the ExTemp sensor system raises some difficult questions.

Whichever IS interface is chosen then if it is required to be able to reset the emissivity and range of the sensor from the safe area the interface must be capable of transmitting the HART type signal. Arguably even if this facility is not thought to be necessary initially it might be considered wise to use an interface capable of passing the signal just in case.

4 Junction box requirements

4.1 Introduction

The sensor has a permanently connected cable which is chosen to be suitable for use in high temperatures [70 °C] and adverse environments and can be supplied 25m long. In some installations this cable has to be extended by using a junction box and a suitable two core screened cable. Junction boxes are regarded as 'simple apparatus' in an intrinsically safe circuit, and are not required to be certified. However there is a need for operational reliability and the avoidance of faults to earth and this can be readily met by the use of enclosures and terminals certified for other purposes.

4.2 Acceptable solution

A straight forward reasonably economic solution is to use an Exe certified stainless steel enclosure together with Exe certified terminals and glands. This ensures that the junction box is reasonably robust and provides adequate protection against most environments. A common mistake is to choose a small box which does not leave adequate space for positioning the cables and making off the conductors so that the connections are not under stress. The box requires four terminals, two for the conductors and two to allow termination of the screens without connecting them together. Two glands compatible with the cables used are necessary and the box size is marginally determined by this. The box should have an external connection point enabling it to be bonded to the local structure so as to reduce the risk of electrostatic charge. In some highly humid circumstances, where the box is subject to large temperature variations it is desirable to fit a drain plug, but in the majority of installations because the dissipation in the box is small a drain plug is not essential.

The box is a convenient point to do circuit testing should this prove necessary, and care should be taken to locate it so that access is easy,

4.3 Intrinsic safety requirements

The junction box is considered to be 'simple apparatus' and provided that Exe terminals are used meets the necessary segregation requirements. The junction box can be added to an IS circuit without modifying the safety argument. Simple apparatus has the category ia and is suitable for use in IIC gases. The service temperature of the box is usually determined by that of the terminals used and frequently is -40 °C to +70 °C. The low power of IS circuits ensures that only a small temperature rise can occur within the box and a T6 [85 °C] temperature classification is justified.

The box should carry marking which positively identifies it as being part of an intrinsically safe circuit. 'Calex ExTemp Intrinsically Safe Circuit' or something similar would suffice.

5 Intermediate cable

5.1 Pragmatic solution

In almost all systems using an IS isolator with the ExTemp sensor, the additional intermediate cable is less than 375 m long. In this case a screened twisted two core cable with insulation suitable for the cable's environment is all that is required. The resultant system is suitable for use with all gas classifications [the T4 temperature classification of the ExTemp sensor has to be taken into account] and all dust atmospheres. The following diatribe examines the subject in detail but in most cases the choice of cable is as simple as this paragraph suggests.

5.2 Detailed analysis

Frequently there is a need to extend the permanently connected cable [maximum length 25 m] by using additional cable between a junction box and the IS interface. The cable should not be made too long since it is difficult to protect long IS cables from misuse. Usually hazardous areas are limited in extent and the IS interface should be mounted in the safe area as close as is practicable to the hazardous area. Some interfaces such as the MTL 5541 are 'certified' for mounting in Zone 2 and this can provide a solution to some difficult problems including keeping this intermediate cable short. Where there is a need to use an intermediate cable, this cable must meet both the functional and intrinsically safe requirements.

5.3 IS requirements

The IS system standard [IEC 60079-25] requires that all IS cables should have insulation which can withstand a test voltage of 500 Va.c. or 750 Vd.c. It is important to note that this is a test voltage not a working voltage and most cables satisfy this requirement. There is also a requirement that cable strands should not be less than 0.1mm in diameter. This requirement is intended to prevent hot-wire ignition. In this particular circuit the short-circuit current is limited to 93 mA and hence there is no risk of this type of ignition. However the standard does not allow any exceptions.

There is also a requirement to identify IS cables. Where colour is used for identification the recommended colour is light blue. This is not compulsory, but is effective and desirable.

The permitted capacitance of the cable [75 nF] is the determining factor for the permitted length of most cables. The system standard suggests that 200 pf/m and 1 µH/m are acceptable maxima for the parameters of a cable of this type. Using these values the maximum permitted length of the intermediate cable is 375 m. In practice the majority of instrumentation cables have a capacitance of less than 100 pF and consequently if a longer cable is necessary then it is worthwhile to measure the parameters of a sample length [IEC 60079-26 suggests a method] and recalculate the acceptable length. Alternatively if the system is to be used with IIB classified gases or in a flammable dust atmosphere then the permitted output capacitance of the interface is 650 nF and the cable capacitance problem disappears.

As in all high voltage [30 V] and low current [100 mA] IS circuits the inductive parameters are only relevant when the hazardous area equipment has significant inductance. The input inductance of the ExTemp sensor is considered by the certifying authority to be negligible and consequently the permitted inductance of the cable is the 4.3 mH of the output inductance of the isolator. Using the 1 µH/m figure specified in the system standard a cable length of 4.3 km is derived and this in excess of most probable installations.

5.4 Functional requirements

For operational reasons the cable should be a two core screened cable with a slow twist, thus reducing the probability of problems being caused by high or low frequency interference. The choice of insulation is usually determined by the anticipated working temperature and other environmental factors of the cable. The choice of insulation does affect cable capacitance.

There is limited voltage available in the circuit and at 20 mA this particular interface has only 16.5 V available for the cable and sensor. The sensor requires 12 V to operate and consequently there is 4.5 V available for the cable and any other field equipment such as an indicator. In practice a high value of the current [24 mA] is often used as an

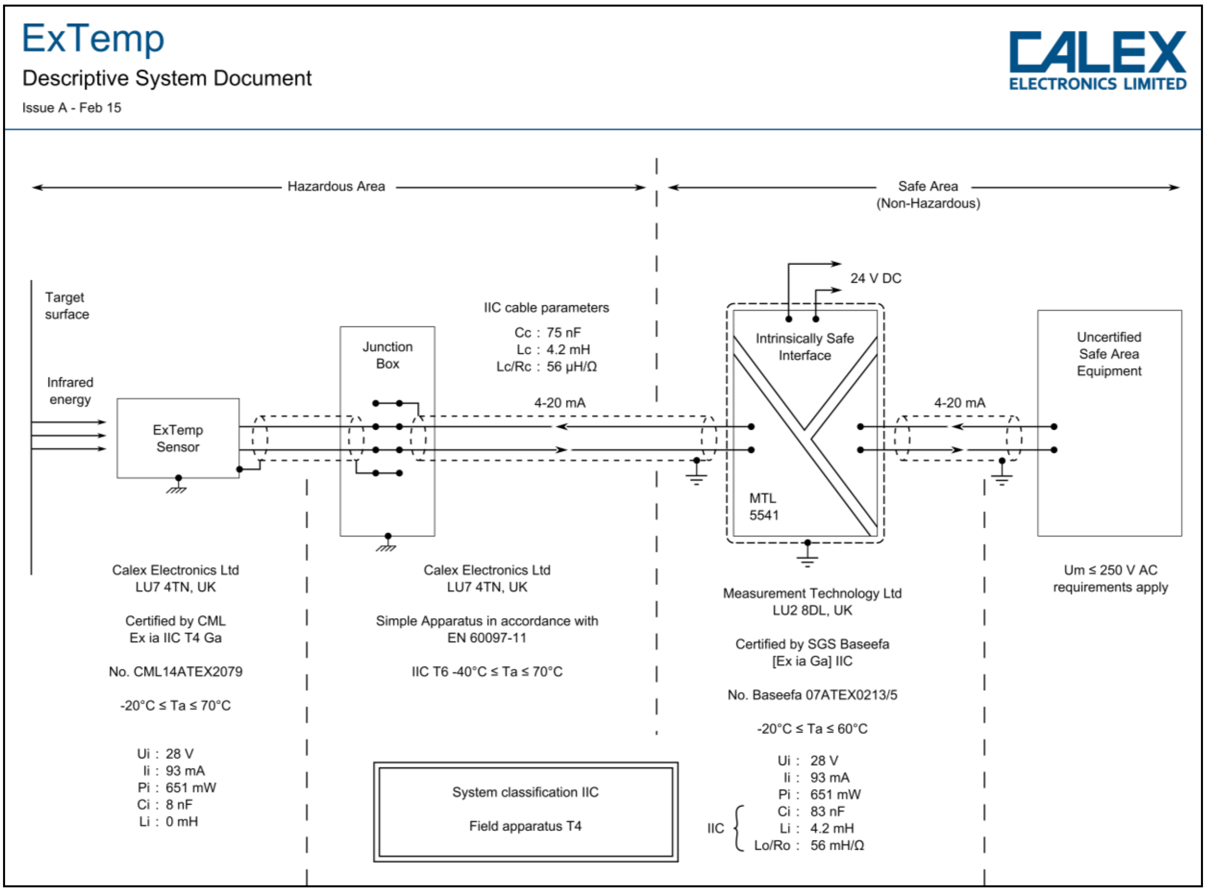

Figure 5: Descriptive System Document for ExTemp sensors

indication of the malfunction of the sensor and if this facility is required this current must be considered when calculating the acceptable cable resistance. If the 20 mA and 4.5 V figures are used the acceptable cable resistance is 225 Ω. The thinnest cable normally used is 22 AWG [0.32 mm^2] which has a loop resistance of 120 Ω/km which gives a possible cable length of 1.8 km, which is usually adequate. If a thicker cable is used, for example 18 AWG [0.81 mm^2], which has a loop resistance of 52 Ω/km then there is greater flexibility. For example this enables equipment such as 4-20 mA indicators [requires 2 V] or alarm systems to be introduced into the hazardous area wiring without difficulty.

5.5 Cable requirements for use with shunt-diode safety barriers

Where a passive barrier such as the MTL 7787 is used with a well regulated 26 V supply the maximum cable resistance which is acceptable is 45 Ω. The barrier has the same output characteristics as the MTL 5541 and hence the arguments on cable parameters are equally applicable, and the capacitance limitation to 375 m in IIC is also applicable. The available resistance corresponds to 375 m if 22 AWG cable is used but the system lacks flexibility.

An alternative is to use an active barrier such as the MTL 7706 which has the same output parameters as the isolator and provides 4 V for the cable voltage drop. This is slightly less than the isolator but the same discussion is applicable. Usually this is the recommended solution if barriers are preferred.

6 System design

6.1 Introduction

Intrinsic safety is essentially a system concept and consequently it is usual to create a Descriptive System Document [DSD] which contains all the information to justify a level of acceptable safety. In practice, it is also necessary to create another loop diagram, which translates the generalisations into specific information which covers the requirements of a particular installation. For example translating the cable parameters into a specific cable and specifying the location of the equipment. Figure 5 illustrates the DSD for the ExTemp sensor connected to an MTL 5541 isolator. This example can be used directly in the preparation of safety documentation if a MTL 5541 is used and slightly modified if some other IS interface is used.

The DSD of Figure 5 is directly applicable to systems where the risk is from IIC gases. The DSD could have included the data for flammable dusts but this would make the DSD more complex and introduce possible confusion. In general it is safer to create a diagram to cover a specific requirement.

This section explains how the information on the DSD is derived. A fuller explanation of the requirements of the additional cable and the earthing and bonding requirements are included in this document as separate sections.

6.2 Analysis

Certification information

It is necessary that sufficient information is available for the certification state to be confirmed and access to the certification is available. This is achieved by including the name of the manufacturer and the certificate number. The example used utilises the ATEX certification. Both the sensor and interface are IEC Ex certified and these alternative numbers can be used if they are the preferred solution. IEC Ex certificates have the advantage that the latest version of the certificate is available on the IEC Ex website.

Simple apparatus

Where a 'simple apparatus' such as the junction box is included in the system, then some justification for making that claim should be included in the safety documentation. See Section 4 on the design of the junction box which can be used to justify this claim.

Apparatus group, and gas group

Both pieces of certified apparatus are certified ia IIC and the simple apparatus is always considered to be ia IIC. Provided that the interconnecting cable satisfies the cable requirements listed on the DSD then the system is ia IIC.

Voltage current and power parameters

It is necessary that the output parameters of the interface should not be greater than the input parameters of the sensor. In this particular case all three parameters are equal and hence acceptable. The parameters are listed so that the comparison can be readily made and the acceptability confirmed. The comparison is simple in this particular system and the majority of systems using a single piece of hazardous area apparatus. However if there are more than two pieces of certified apparatus in a system then a more detailed analysis is necessary and details of this analysis should be included in the safety documentation.

Cable parameters

Section 5 of this document discusses the requirements of the additional cable in this system. The IS limitations on the cable inductance and inductance are explained in detail in that section. The critical limitation is cable capacitance [75 nF], which restricts the cable length in IIC gases.

Temperature classification

Temperature classification is applicable to each piece of hazardous area apparatus and not to the system as a whole.

Ambient/service temperature

The specific service temperature restriction is applicable to each individual piece of apparatus including the IS interface.

Uncertified safe area equipment

The IS interface is certified so as to be considered adequately safe with a fault voltage of 250 Va.c. applied directly to its safe area terminals. The limitation is intended to prevent a fault coming directly from a high voltage high power source breaking down the isolation of the interface and creating a hazard in the hazardous area. Almost all industrial apparatus used in instrumentation systems is considered to satisfy this requirement and a detailed analysis is not normally considered necessary.

6.3 Local indication of measured temperature

If indication of the measured temperature within the hazardous areas is required then this can be achieved by monitoring the 4-20 mA signal with a suitably certified indicator. The indicator should be certified as having input parameters equivalent to 'simple apparatus' and then it can be added to the system without a significant modification of the safety documentation. A minor adjustment of the acceptable cable parameters to allow for the input capacitance and inductance of the indicator may be necessary. Operationally the voltage drop of the indicator [typically 2 V] must be taken into account, which necessitates the use of an isolator or an active barrier.

There are a number of suppliers of suitable indicators, for example BEKA Associates [www.beka.co.uk]

6.4 Conclusion

The DSD of Figure 5 contains all the information necessary to deduce that the system is adequately safe for ia IIC applications and is an adequate tool for reference purposes in both initial and subsequent inspections.

7 Earthing and bonding

7.1 Introduction

The usual requirement is that intrinsically safe circuits should be fully floating or connected to earth at one point only. The single point earth is intended to prevent unspecified currents circulating within the IS circuit due to potential differences within the plant structure. [These differences are predominantly caused by leakage or fault currents from high power electrical equipment]. In the majority of hazardous plants the structure, pipe work, cable trays and armoured cables are all bonded together to form an almost equipotential plane. Some plants reinforce this plane by having several earth mats

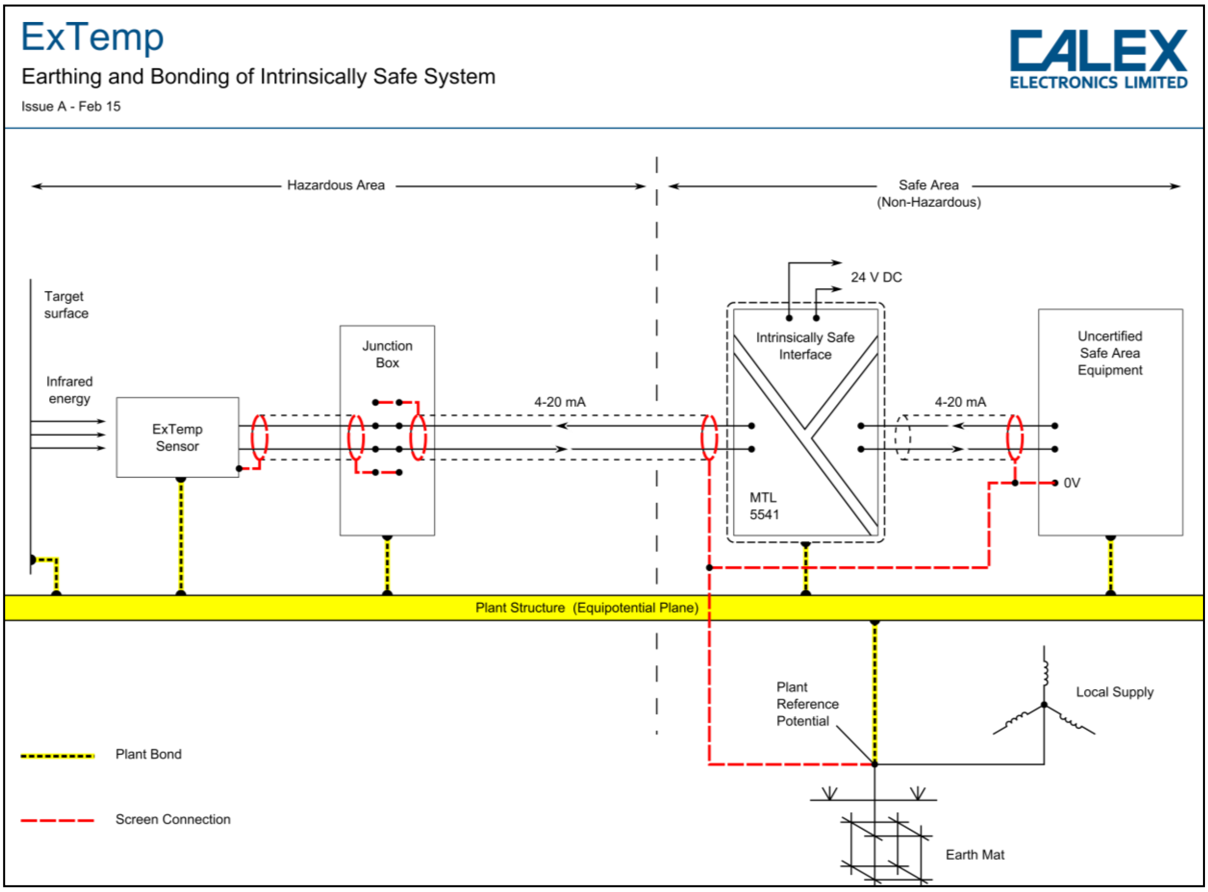

Figure 6: Earthing and bonding of IS system

interconnected by a substantial copper cable. The principal advantage of this technique is that it provides junction boxes which are clearly defined points to which bonding connections can be made.

The complete earthing and bonding required within a plant is usually considered as a whole and includes the requirements for high voltage electrical equipment, lightning protection and the control equipment. The IS requirements are only a small part of what should be an overall system.

7.2 Enclosure bonding

Metallic enclosures containing electrical equipment are usually bonded to the structure so as to reduce the risk of electrocution and to provide a fault current return path so as to cause protection devices to operate swiftly. IS equipment does not create an electrocution risk but the outer enclosure is usually bonded to the structure so as to reduce the possibility of a build-up of static and also to minimise the effect of radio interference [RF] Usually the method of mounting provides an adequate conducting path but if there is any doubt a bonding conductor should be used. Ideally the bonding conductor should be short, straight and mechanically secure.

The enclosure of the ExTemp sensor forms part of the RF protection of the sensor and must be bonded. Where the mounting does not provide an adequate conducting path then the sensor should be bonded by using a ring tag under the mounting nut and a bonding conductor

7.3 Screen earthing

The purpose of the screen is to reduce the effect of RF on the circuit by enclosing it in a Faraday cage at a uniform stable potential. Ideally screens are connected to the electrically quietest point on the plant which is usually the point where the star point of the supply meets the earth mat, which is sometimes referred to as the plant reference potential. In common with other IS circuits screens should be earthed at one point only. However from an RF perspective they are usually earthed at more than one point by the RF decoupling capacitors at the terminals of the IS apparatus. These capacitors are considered when the apparatus is certified but for IS system purposes are not considered to earth the circuit since their impedance at the relevant frequencies is high. They do however affect the output or input capacitance of the IS apparatus.

The screen of the permanently connected cable of the ExTemp sensor is connected to the enclosure since this provided the best RF rejection and consequently it is bonded when the sensor is bonded. It is recommended that the screen of the extension cable is earthed as is shown to the plant reference potential. The two screens are isolated from one another in the interconnecting junction box.

7.4 Conclusion

Earthing and bonding is always a controversial subject. Fundamentally it requires 10 V to create an incendive spark and hence if everything is bonded together with a low impedance path which can carry the maximum fault current without overheating then the system is adequately safe. It follows that many versions of bonding are safe and functional. The proposed system meets the requirements and is practical and should be used. However if you prefer a different system use it.

Final thought; if a bonding system would work on an aeroplane it is probably right.

8 APPENDIX A: Certification and standards

8.1 Introduction

This appendix is intended to provide guidance on the certification used in the design and application of the equipment discussed in this document. Inevitably, this area is one of constant but usually slow change and hence the date on which it is written should be taken into account when considering any action based on this document.

All standards are created by individuals who have a specific interest in the subject. The time involved and the costs incurred by participants are considerable. This restricts the people involved to those with an enforcement or commercial interest which they tend to promote. Inevitably, the major representation on international committees is from certification bodies; manufacturers have adequate representation but end-users are not adequately represented. The resultant standards are reasonable and produce adequately safe equipment, which is surprising and a testament to the integrity of the individuals involved.

8.2 Standards organisations

IEC

International standards for electrical equipment are created by the International Electrotechnical Committee [IEC]. Those covering hazardous areas are created by specific committee TC31 and its numerous sub-committees and form part of the IEC 60079- series. The process of creating and modifying standards is inevitably slow because of the lengthy but essential consultation process. An interval of five years between editions of the standards is quite common, Almost all national standards making organisations are members of the IEC and it is a truly international organisation.

The format of the IEC standard number is IEC 60079-xx: 1066. The xx being the part number of the specific section.

CENELEC

The European Committee for Electrotechnical Standardisation [CENELEC] are the European standards making body for electrical equipment. Currently IEC and CENELEC hazardous area standards are voted on simultaneously and bear the same number. The CENELEC committee on intrinsic safety exists but has not found it necessary to meet for several years. The standards are identical in technical content but the CENELEC standard contains further information to make it more useable with the ATEX directive. The apparatus standards are 'harmonised' as being an acceptable interpretation of the ATEX directive. It is important to recognise that the directive is a European Union [EU] document not a CENELEC standard and hence introduces some minor differences.

The CENELEC standard number [European Norm] is the same as the corresponding IEC standard and has the form EN 60079-xx: 1067.

BSI

The British Standards Institution [BSI] is the United Kingdom's participating member of both the IEC and CENELEC. BSI publish an English language version of the CENELEC standard. The form of the standard number is BS EN 60079-xx: 1068.

8.3 IEC Ex

The IEC has an affiliated organisation which issues certificates of compliance with the IEC 60079 series of standards; there are a number of other related activities. These certificates are based on detailed test reports created by approved testing organisations and are granted to manufacturers with approved quality control systems. The organisation is based in Australia, it has strong secretariat responsible to a committee structure controlled by the approved testing authorities. A major advantage of IEC Ex certificates is that the latest version is available on the web and hence can be consulted at any time. IEC Ex certificates can only be issued by notified bodies. Anyone can use the IEC standards as a basis for 'certification' but this does not create an IEC Ex certificate.

The intended ideal is for IEC Ex certificates to be accepted universally. Some progress has been made in this direction, for example in Australia and Singapore, and there has been considerable support from the relevant United Nations organisation. Numerous countries issue certificates based on the IEC test report but sometimes the acceptance is questioned in excruciating detail and other barriers to issuing the certificates erected. It can still be an irritating, expensive business. It is disappointing that the IEC Ex certificates are not acceptable in Europe and the US [there are some chinks in the US barrier]. In countries where the end-user decides what is acceptable then the IEC Ex certificates are usually favoured. The usual practice of European manufacturers is to obtain an IEC Ex certificate and test report and use these to obtain an ATEX certificate. The only consolation is that the current situation is a considerable improvement on the late 20th century when everybody used different standards and their own specifically defended single certification body.

It is difficult to be too definitive about where IEC Ex certificates are accepted because there does not appear to be an authorised list. Australia, New Zealand and Singapore are known to accept IEC Ex certificates. Brazil, China, Russia, Korea and India are known to issue local certificates based on the IEC test reports.

8.4 ATEX

Introduction

There are two **AT**mosphères **EX**plosives directives [ATEX] in use at the present time. The directive that covers the marketing and manufacture of equipment for use in hazardous atmospheres is 94/9/EC, generally referred to as the 'Apparatus Directive'. The other directive, 1999/92/EC, is intended to ensure at least the minimum level of protection for the workers in industries using hazardous materials. It is generally known as the 'User Directive'.

User Directive 1999/92/EC

This 'worker protection' directive can be summarised as requiring a detailed, well-documented risk analysis of the installation. Defining the acceptable risk is very difficult task. The usual approach is to use equipment with appropriate Documents of Conformity [DoC] installed and maintained as required by the EN codes of practice [EN 60079-14, and -17] so as to achieve an acceptable solution. Theoretically a risk analysis can be used to circumvent the use of certified apparatus, but this would require a very detailed comprehensive knowledge of all the relevant factors, which is not usually available. Consequently, this option is not often used, but can sometimes be used to justify the continued use of old equipment or installations.

All European legislation has to be enacted in each country. Within the United Kingdom this directive became law as part of the 'Dangerous Substances and Explosive Atmospheres Regulations' [DSEAR]. These regulations also include the requirements of the 'Chemical Agents' directive. This arrangement can be slightly confusing, but is a convenient arrangement, since the requirements overlap.

Compliance with these regulations is the responsibility of the end-user. Some notified bodies do offer to carry out investigations and inspections. These reports can be used to support the safety documentation, but the responsibility still rests with the end-user.

Apparatus Directives 94/9/EC and 2014/34/EU

The directive which covers the design and marketing of equipment for use in hazardous areas is currently the 94/9/EC directive. It will be replaced on April 20th 2016 by the recently created directive 2014/34/EU. Fortunately, as far as the supply and use of apparatus is concerned, the continued use and supply of equipment that is already certified will be permitted. New equipment, or equipment being significantly modified, will be certified to the new directive from that date. It will be necessary to issue revised DoCs for existing equipment from the changeover date. The new directive does slightly tighten the requirements for Notified Bodies and it will be interesting to see if there is a flood of new certificates on the day after the Notified Bodies have their ratification renewed

The ATEX certificate is used as evidence of compliance with the requirement of minimising the risk of an explosion and authorities the use of the distinctive hexagon Ex mark. Usually ATEX certificates are based on the CENELEC standards [EN 60079-x series] but theoretically can be issued based on the 'essential safety requirements' of the directive. There are requirements for the manufacturer to have adequate quality control systems, so as to ensure that the product produced complies with the certification. The directive only requires Category 1 and 2 equipment [usually interpreted as equipment for use in Zone 0 and 1] to be certified by a Notified Body. Category 3 [Zone 2] equipment can be 'certified' by the manufacturer but this is not always acceptable to the end-user and consequently most Notified Bodies do issue 'certificates' for Category 3 equipment. There is no shortage of Notified Bodies, for example, the UK has eight, which contrasts with one prior to ATEX.

The ATEX certificate is evidence of compliance with minimising the explosion risk, but the legal requirement, and the CE marking, requires compliance with all relevant directives. This is recorded on the DoC which lists the relevant directives and the method of compliance. The directives that are usually quoted for instrumentation are the ATEX directive, the Low Voltage directive and the Electromagnetic Compatibility directive. Other directives, such as the Machinery directive, are applicable to some equipment. The DoC is the responsibility of the organisation placing the equipment on the market.

ATEX Countries of use

There are a large number of countries where it is a legal requirement to comply with the ATEX directive. The 28 states of the European Union [EU] [no longer the European Community] together with the three states that are members of the European Free Trade Area [EFTA] [Iceland, Liechtenstein and Norway] form the core of the common market. There are a variety of customs agreements with Monaco, San Marino, Andorra and Turkey. Switzerland has 'an enhanced Mutual Recognition Agreement' with the EU. In addition, a number of territories with ex-colonial attachments are also involved. These are French Guyana, Guadeloupe, Azores, Madeira, Canary Islands, Reunion, Saint-Barthelemy and Saint-Martin. The combination of these countries forms a large market.

There are some marginally surprising exceptions to this combination and in these territories ATEX is not a legal requirement. These include the Cayman Islands, Falkland Islands, Antarctic Territories, Bermuda, Faroe Islands, Greenland and Gibraltar. All of these have European connections but are not included.

In these and some other countries, end-users specify ATEX certified equipment as a guarantee of quality. This is common practice in the Middle East, some Asiatic countries and for some marine applications. Possibly the trend is to specify IEC Ex equipment in preference to ATEX but the additional commitments of the DoC still influence some end-users. Offering both forms of certification is the option adopted by most European manufacturers.

8.5 Relevant standards

This section lists the Explosive Atmosphere standards which are relevant to instrumentation with some additions for completeness. There are other standards which are partially relevant but a comprehensive list would be very long. The IEC standard is quoted in this document. The EN version has the same number as the IEC version and has identical technical requirements but with annexes which satisfy the ATEX apparatus requirements. The English language version of the CENELEC EN standard is published by BSI as a BS EN and is usually used by UK manufacturers for both IEC Ex and ATEX certification.

It is important to recognise that the standards are not primers on the subject and some expertise in the subject is assumed. Similarly the requirements are additional to those required to ensure adequate safety and performance of non-hazardous equipment.

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

This contains the requirements which are common to two or more methods of protection. For example requirements for the avoidance of electrostatic risk and impact test requirements are included. The individual apparatus standards state which sections are applicable to the specific method of protection, for example IEC 60079-11 the intrinsic safety [IS] apparatus standard excludes several sections of 60079-0.

IEC 60079-1 Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures ''d''

Implications of 'da','db' & 'dc' are being worked out.

IEC 60079-2 Explosive atmospheres – Part 2: Equipment protection by pressurized enclosure ''p''

This is quite a complex document covering different levels of protection for different circumstances.

IEC 60079-7 Explosive atmospheres – Part 7: Equipment protection by increased safety ''e''

Contains 'ec' requirements which will replace 'nA'

IEC 60079-10-1 Explosive atmospheres – Part 10-1 Classification of areas – Explosive gas atmospheres

This contains guidance on this difficult subject with some examples. Some other organisations such as the Institute of Petroleum produce documents which give useful guidance on particular situations

IEC 60079-10-2 Explosive atmospheres – Part 10-2 Classification of areas – Combustible dust atmospheres

This is a dust equivalent of the above.

This space has been allocated but there is no supporting document. Information is available from different sources on the web. R. K. Eckhoff's book 'Dust Explosions in the Process Industries' [ISBN 0 7506 32704] contains a useful list and is a good general reference on the subject.

IEC 60079-11 Explosive atmospheres – Part 11 Equipment protection by intrinsic safety 'I'

This contains reference curves and tables as well as apparatus requirements. It also contains the initial concept 'ic' requirements, which replaces 'nL'.

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

This standard attempts to be comprehensive so that users do not have to consult other standards. It is intended to supplement the usual good engineering practice and not replace it. There is strong interaction with IEC 60079-25, the IS system standard.

IEC 60079 – 15 Explosive atmospheres – Part 15: Equipment protection by type of protection 'n' electrical apparatus.

Base document.

'nL' has become 'ic' and 'nA' is migrating to 'ec', hence reference has to be made to the last appropriate edition of the standard for information on 'nL' or 'nA' equipment.

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

Contains information on 'live maintenance' of IS circuits and other Zone 2 circuits. In addition it has an interesting Annex C on 'fitness-for-purpose assessment' which permits a large degree of freedom in the use of non-certified equipment.

IEC 60079-18 Explosive atmospheres – Part 18: Equipment protection by encapsulation ''m''

There are three levels of protection available. Surprisingly this isn't often used for instrumentation. Encapsulation of IS apparatus uses slightly different rules.

IEC 60079-19 Explosive atmospheres – Part 19: Equipment repair overhaul and reclamation

The majority of instrumentation is difficult if not impossible to repair, but this standard gives guidance on competence and methods if this is to be attempted.

IEC 60079-20-1 Explosive atmospheres – Part 20–1 Material characteristics for gas and vapour classification – Test methods and data

Contains a comprehensive list but inevitably does not include every explosive gas.

IEC 60079-20-2 Explosive atmospheres – Part 20-2 Characteristics of combustible dusts

This space has been allocated but there is no supporting document. Information is available from different sources on the web. R. K. Eckhoff's book 'Dust Explosions in the Process Industries' [ISBN 0 7506 32704] contains a useful list and is a good general reference on the subject.

IEC 60079-25 Explosive atmospheres – Part 25 Intrinsically safe electrical systems

This contains guidance on the safe combination of IS apparatus. Interacts with and supplements IEC 60079-14.

IEC 60079-26 Explosive atmospheres – Part 26 Equipment with equipment protection level [EPL] ''Ga''

Contains requirements for equipment used in Zone 0 or on the interface between Zone 0 and 1 not covered by 'ia','ma', 'da' and the pressurised standard. It requires detailed installation and maintenance instructions.

IEC 60079-31 Explosive atmospheres – Part 31 Equipment dust ignition protection by enclosure ''t''

Lists the extensive requirements from IEC 60079-0 which are applicable.

IEC 60529 Degrees of protection provided by enclosures (IP code)

Base document.

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