Application Guide

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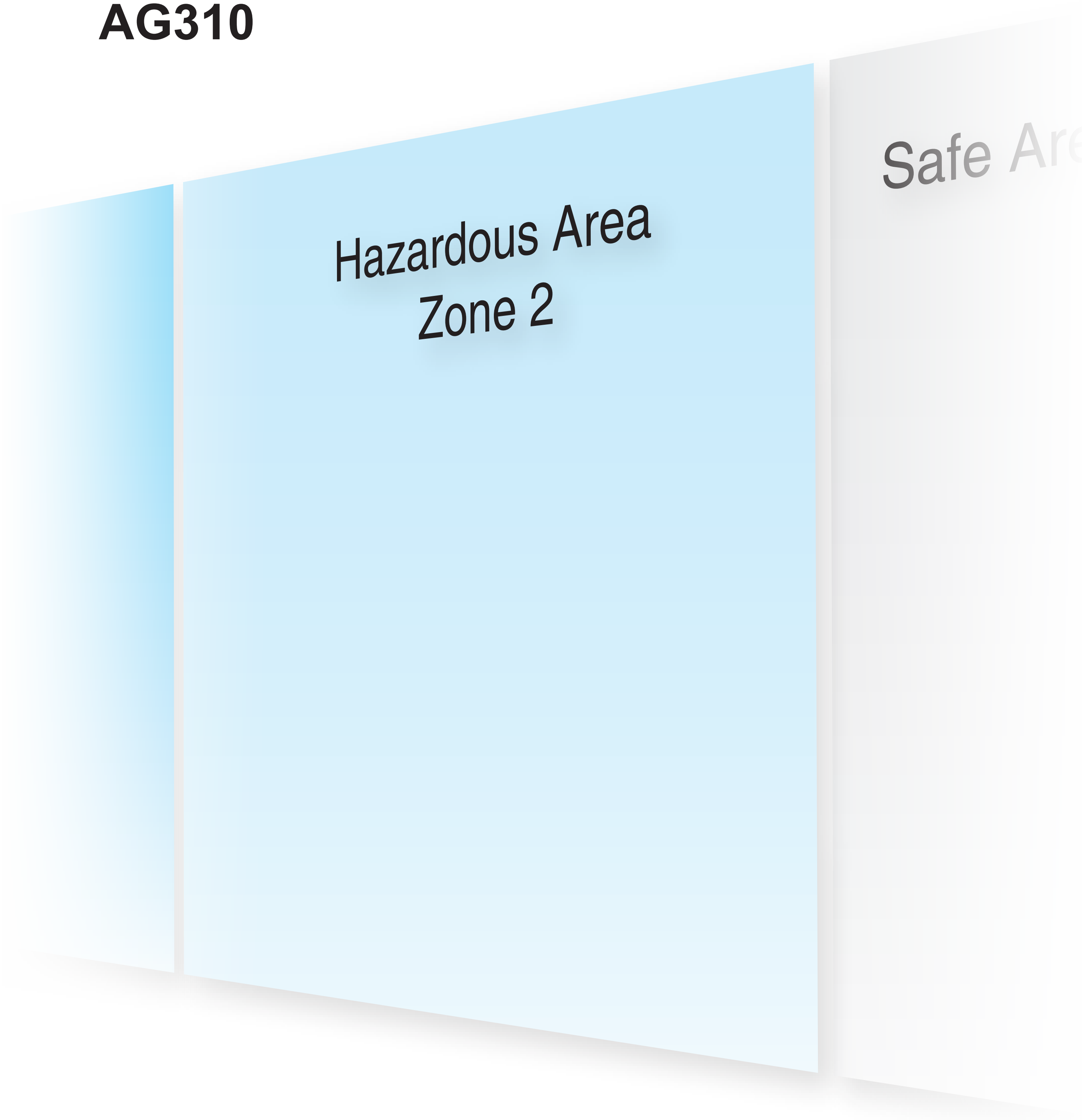

Installation of
[extra low voltage dc]
Ex nA instrumentation

BEKA associates

About BEKA

BEKA associates is an independent privately owned company specialising in the design, manufacture and sale of process display instrumentation, predominantly for use in potentially flammable areas although general purpose instrumentation is also manufactured. All design and manufacture is conducted within the UK and our products are purchased by end users, major instrument companies and contractors worldwide.

Since the installation of the first BEKA intrinsically safe loop powered indicator in 1984, BEKA associates have been at the forefront of indicator development culminating in the launch of the fourth generation 'E' models in 2011. These new instruments are based on the accumulated experience gained from thousands of installations coupled with the latest electronic, production and certification technology, resulting in larger digits, improved visibility and more standard features than the previous generation. In addition to Ex i intrinsically safe models, the new generation includes ATEX and IECEx certified Ex nA indicators for installation in Zone 2 without the need for Zener barriers or galvanic isolators.

Unlike intrinsic safety there is no published installation Code of Practice specifically for low power Ex nA apparatus such as instrumentation. We have therefore commissioned internationally respected independent consultant Chris Towle to write this application guide recommending how BEKA Ex nA indicators should be installed and maintained in Zone 2. Although written around loop powered indicators, the recommendations contained in this document apply to the installation of all Ex nA certified instrumentation.

We hope that you find the guide helpful.

This document is under constant review. If you are reading a printed version, please check the current edition which may be downloaded from http://www.beka.co.uk/application_guides.html

Comments and suggested additions for future editions are always welcome. Please contact chrisb@beka.co.uk

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 was 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.

Chris Towle BSc, CEng, MIMech.E, MIET, FInstMC.

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1. FOREWORD

This document discusses the requirements of extra low voltage d.c. 'nA' apparatus and its possible applications. The interaction with other methods of protection is also explored. The BEKA 4-20mA indicators BA304NE (4 digit) and BA324NE (5 digit) are used to illustrate the construction and marking requirements. Their application in various ways is used to illustrate the more usual applications of 'nA' instruments in hazardous areas. The basic principles of 4-20mA loop powered indicators are illustrated in Figure 1.

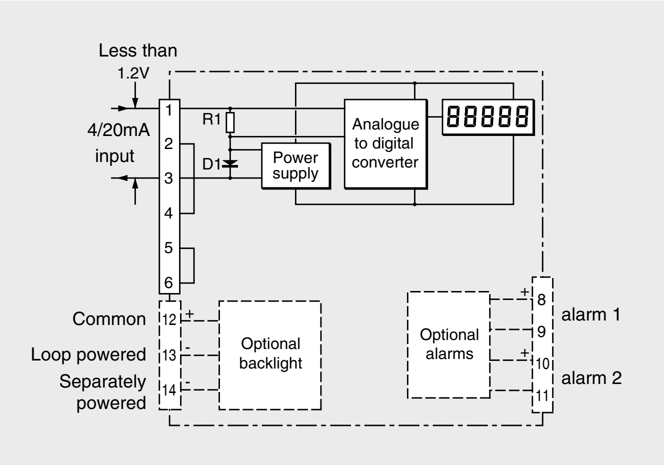


Figure 1 Indicator block diagram

The operation of the indicator can be simply explained as follows: the 4-20mA input current flows through the resistor R1 and forward biased diode D1. The voltage developed across D1 is multiplied by a switch mode power supply and used to power the instrument. The voltage developed across R1 provides the input signal to the analogue to digital converter which drives the display.

The backlight and alarm functions are factory fitted options.

2. INTRODUCTION

The type of explosion protection predominately used in Zone 2 is Type 'n'. The requirement of Type 'n' apparatus is that in normal operation it is not capable of igniting a surrounding explosive atmosphere. The relevant standard [IEC 60079-15 which compliments the General Requirements IEC 60079-0] is intended to ensure that a malfunction capable of causing ignition is not likely to occur. Type 'n' apparatus is not considered as capable of causing ignition by electrical sparks and consequently is not gas classification sensitive but apparatus is still required to be temperature classified. However since this is done in normal operation a T4 temperature classification is usually readily achieved. The basic principle of being safe in 'normal operation' is what differentiates operation in Zone 2 from the more onerous requirements of operation in Zones 0 and 1.

For completeness the IEC 60079-15 definitions are as follows:

Type of protection 'n'
Type of protection applied to electrical equipment such that, in normal operation and in certain specified regular expected frequently expected occurrences, it is not capable of igniting a surrounding explosive gas atmosphere.

Non-sparking device 'nA,
Device constructed to minimize the risk of arcs or sparks capable of creating an ignition hazard during conditions of normal operation.

It is important to recognise that this document discusses the design and application of extra-low d.c. voltage instrumentation [usually 24V] utilising low power [less than 10W]. The majority of Type n equipment utilises higher voltages and power, and the techniques described in this document are not applicable to this type of equipment

This document brings together some current thinking on the use of instrumentation in Zone 2 in particular the use of indicators with instrumentation using different types of protection.

The current Type 'n' standard IEC 60079-15 : 2010 contains only three methods of protection, 'nA' [non-sparking], 'nC' [enclosed-break] and nR [restricted breathing]. However the methods of protection intrinsic safety 'ic', encapsulation 'mc' and pressurization 'pz' all cover equipment which is intended for use in Zone 2 locations. In addition any apparatus which is suitable for use in Zones 0 or 1 can be used in Zone 2 if required. It is also possible to use an 'nA' indicator mounted in Zone 2 to monitor flameproof [Exd], increased safety [Exe] or pressurised [Exp] equipment which is mounted in Zone 1. The possible combinations are almost infinite and this document concentrates on combinations which are known to have occurred in practical situations. The use of 'ic' systems is covered adequately elsewhere and hence this document concentrates on Zone 2 installations which utilise one or more of the other methods of protection.

Intrinsically safe apparatus is not normally used in 'nA' systems and can only be used if the apparatus is re-classified as 'nA' apparatus and the justification of this change is included in the system documentation. Consideration must be given to impact rating and ingress protection as well as electrical parameters. Since the electrical requirements of any intrinsically safe level of protection ['ia', 'ib' or 'ic'] are more onerous than those for 'nA' then this is usually acceptable. The only relevant input parameter is the permitted input voltage [Ui] and the circuit voltage should not exceed this. Temperature classification is done in normal operation and a T4 [135ºC] classification can be assumed.

There is always a debate as to whether the labelling of apparatus, which is no longer relevant should be obscured. A solution, which is more practicable, is for the plant identification to carry a reference to the safety documentation and to encourage technicians to refer to this and only rely on the label to identify apparatus. In all hazardous installations the information on the label is only informative and can be misleading. Re-classification of intrinsically safe apparatus requires intimate knowledge of both the intrinsically safe and 'nA' standards and it is not advisable to undertake this exercise if any alternative solution exists.

A major difficulty is that the Type 'n' standard is written by electrical engineers with relatively high voltage and power equipment in mind. The lack of expertise in the light current field was a significant factor in causing 'nL' to be changed to 'ic'. To a lesser extent the same criticism can be levelled at the code of practice document IEC 60079-14. This document occasionally contains proposals which are not directly in line with IEC 60079-15 but are intended to provide a similar level of protection. Where proposals deviate from IEC 60079-14 they are clearly identified so that whoever is responsible for the installation can decide whether they are acceptable or not.

The requirements for field wiring for 'nA' circuits are identical with those for all other electrical systems in explosive atmospheres with the exception of intrinsic safety. The fundamental requirement is to have secure and protected cabling so that the probability of a dangerous fault is minimised. The Code of Practice IEC 60079-14 clause 9 permits the use of a number of types of cable but the majority of installations [other than in the US] use steel wire armored cable or cable with a toughened outer sheath on cable trays. The vulnerable section is always the short length of cable making the final connection to the field instrument and additional protection in the form of flexible conduit is frequently used. For operational reasons it is usual to use screened cables for instrument systems. Armoured cable does provide some protection against low frequency magnetically induced interference but is not very effective against high frequencies.

The glands used are required to be compatible with the cable and to maintain the integrity of the ingress protection [IP rating] of the enclosure. The usual solution is to use an Exe certified gland. The exception is where flameproof apparatus is used flameproof glands must be used [barrier glands are not essential in Zone 2]. Similarly appropriate stoppers must be used to seal unused entries.

The cable armor is bonded to the plant structure by the terminating glands. Screens are bonded to the point in the plant system which is most effective in reducing the effect of interference usually the plant reference potential point. Screens do make a contribution to safety by providing a fault return path and this is ensured by the interconnection of this reference point with the plant bonding network,

3. EDITORIAL NOTES

This document uses the term 'safe area' as the designation for a location where there is no significant risk of a flammable, ignitable or hazardous mixture of gas and air being present. It is recognized that the relevant standards use the term 'non-hazardous area' but 'safe area' is simple and clear. For the pedantic neither term is precise since the location is not safe against all hazards nor is it a two dimensional area.

This document refers to mounting equipment in Zones rather than using the 'Equipment Protection Level [EPL] preferred by the IEC standards or the Categories of the ATEX Directive. The subtle implications of the use of these designations are fully explained elsewhere and touched upon in section 4.5. Usually EPL Gb and Cat 2 apparatus is intended for use in Zone 1 and EPL Gc and Cat 3 in Zone 2. Both Categories and EPLs were devised to encourage a risk analysis approach to the use of equipment in hazardous areas [although they are not quantitatively defined] but their correlation with Zones predominates.

Where readers prefer this format then these simple substitutions can be made but this document avoids the use of these terms so as to avoid the complexities and repetitions which their use introduces. Figure 4 illustrates some aspects of the use of categories and levels of protection.

This document refers to the ingress protection [IP] code of IEC 60529 when considering the environmental protection offered by an enclosure. This is summarised in the following table

FIRST NUMBER Protection against solid objects		SECOND NUMBER Protection against liquids	
0	No protection	0	No protection
1	Objects greater than 50mm	1	Vertical (90°) dripping water
2	Objects greater than 12mm	2	70° to 90° dripping water
3	Objects greater than 2.5mm	3	Sprayed water
4	Objects greater than 1mm	4	Splashed water
5	Dust-protected	5	Water jets
6	Dust-tight	6	Heavy seas
7		7	Effects of immersion
8		8	Indefinite immersion

Table 1 Ingress protection [IP] codes [IEC 60529]

4. INSTALLATION PRACTICE FOR 'nA' CIRCUITS

4.1 Safe area apparatus

The choice of equipment for use in an 'nA' circuit in the safe area is quite simple. It must be reasonably reliable and considered adequately safe for maintenance personnel to touch. In European terms if the equipment is CE marked it is almost certainly acceptable.

The power supply for this type of instrumentation is usually a 24V power supply with some form of voltage and current regulation It must meet the requirements for personnel safety so that ‘live maintenance’ can safely be carried out. The implicit requirement for galvanic isolation from the mains supply ensures that the possible difficulties from circulating earth currents caused by mains faults is minimised. The need for operational reliability ensures that the probability of failure to a dangerous condition is acceptably low.

The requirements of other apparatus connected into an ‘nA’ circuit within the safe area such as a computer are similar to that of the power supply. In normal operation this type of equipment absorbs energy but if it does have a significant voltage or current output in normal operation then these must be taken into account when assessing the voltage and current applied to the hazardous area. In the absence of any official guidance, significant in this context can be taken as the values used in the ‘simple apparatus’ clause of the intrinsic safety apparatus standard, that is 1.5V, 100mA and 25mW. The calculation of available voltage and current is done with the circuit connected as intended and faults are not considered.

Since power supplies are usually common to a number of circuits the maximum value of the current is usually determined by a fuse and the value of the permitted current is determined by the lowest permissible current of the equipment in the hazardous area. Similarly the permitted voltage is the lowest permitted voltage of the equipment in the hazardous area and the value determined by the regulation of the power supply

Sometimes the circuit is ‘earthed’ in the safe area. Unlike intrinsically safe circuits there is no requirement for ‘nA’ circuits only to be earthed at one point. However operationally it is usually desirable to earth instrument circuits at one point so as to avoid interference from circulating earth fault currents. Avoiding these circulating currents is desirable from a safety viewpoint but not a requirement for this type of circuit.

4.2 Use of multi-cores

There is no guidance on the use of multi-cores for Type ‘n’ circuits in IEC 60079-14 or in any other code of practice. However a multi-core is frequently the neatest solution to an installation which has several Type ‘n’ instrument loops in a small area. It might be considered excessive for a method of protection, which only considers normal operation but if the criteria used to select multi-cores for intrinsically safe circuits which may enter a Zone 0 are used they will prove more than adequate for Type ‘n’ circuits. The basic requirements are that ‘the radial thickness of the conductor insulation shall be appropriate to the conductor diameter and the nature of the insulation. The minimum radial thickness shall be 0.2mm. Also the conductor insulation shall be such that it will be capable of withstanding an r,m,s, a,c. test voltage of twice the nominal voltage of the circuit with a minimum of 500V.

There are two forms of multicore which are not considered to develop faults between circuits. The multicore which can be used in all circumstances [including flexible cables] is where the individual circuits are segregated from one another by being contained within individual screens.The other multicore which is more frequently used does not use individual screens but requires a voltage test of 500V rms or 750V dc between the cores and the outer screen and/or armour and also a 1000V rms or 1500V dc test between two bundles of the cores connected together. In addition this type of multi-core must be in a fixed installation effectively protected from damage, for example on a cable tray and only carry circuits with voltages less than 60V. It might be argued that higher voltages could be permitted for Type ‘n’ circuits but this could be considered a step too far and consequently is not proposed in this document. In practice the instrument circuits contained in a multi-core are normally restricted by the necessity to avoid interference between circuits causing operational malfunctions.

The current IEC 60079-14 does not permit intrinsically safe circuits to be contained in the same multi-core as other circuits. However it does seem reasonable to mix ‘ic’ circuits [‘ia’ or ‘ib’ circuits would be downgraded to ‘ic’] with low voltage type ‘n’ circuits in multi-cores of the type described. If this advice is followed then this action should be carefully documented and it should be recognized that this is not in accordance with IEC 60079-14.

4.3 Isolation and over current protection

Since only restricted live maintenance of Type ‘n’ circuits is allowed, a means of isolation becomes a requirement and this requirement is embodied in IEC 60079-14. Live maintenance is usually permissible under the protection of a ‘gas clearance’ certificate or on the basis of a risk analysis. Isolation must be provided in all leads so as to avoid the possibility of a common mode voltage creating an incendive spark by a short to earth.

There is also a requirement to ensure that each lead is protected against a current overload which is usually done by a fuse. The two requirements are frequently satisfied by using fuse holders with easily removable fuses and removing the fuses to achieve isolation. This is a satisfactory method at the low voltages and currents common in instrumentation systems. Clear identification of, and easy access to the means of isolation is essential for their effective use. It is also necessary to ensure that the maintenance procedure makes sure that unauthorised reclosure of the switches does not occur. It is not considered necessary to have a means of isolation or electrical protection for the screen. Interconnections are made using a conventional terminal block. Figure 2 illustrates an example of the type of switch fuse terminal block frequently used.

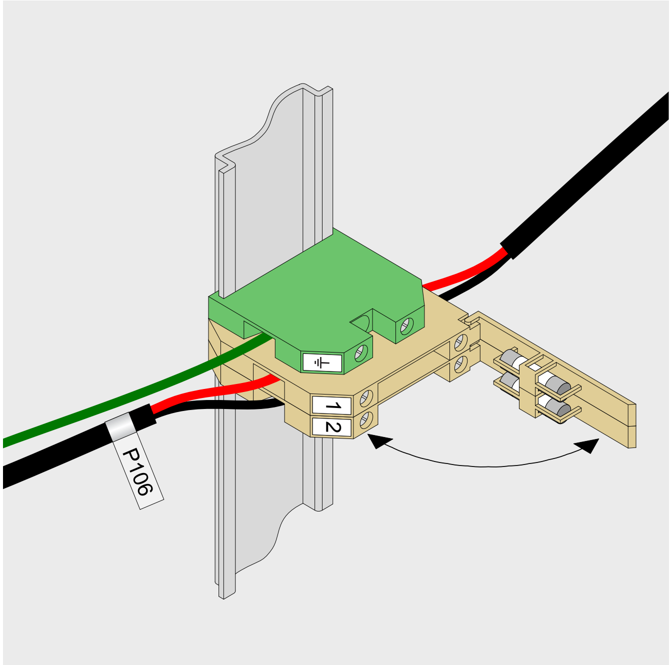


Figure 2 Typical switch fuse terminal block

The switch-fuse can be a convenient point to monitor circuit currents since they are in the safe area and breaking circuits in the hazardous area may create and incendive possibility.

This type of switch fuse terminal block is not favoured by everyone and the use of an appropriately rated m.c.b. or any other reliable form of current limitation combined with a means of isolation is equally acceptable.

These requirements are created with higher voltage and currents in mind and some instrument installations achieve the intentions by using electronic limiting of the current and turning off the source of power to achieve isolation. This is considered acceptable by some end users and is adequately safe but is not strictly in accordance with IEC 60079-14. In practice electronic current limiting is frequently used to prevent a single loop fault pulling down a common power supply. However isolation of individual systems is still often required because it is not considered desirable to turn off a supply to several loops just to service one loop.

4.4 Junction boxes

Junction boxes for use in Zone 2 are required to provide adequate protection against the environment. The minimum ingress protection requirement is IP54, however the majority of certified enclosures achieve IP 65. The usual solution is to use Exe certified enclosures, terminals and glands, because this is convenient, economic and safe. There is no need to be concerned with the temperature classification of the junction box provided that the terminals are used within their normal rating and a T4 classification is acceptable.

A common error is to choose a small box, which makes the tidy routing of the wiring difficult and the fitting of the glands in the gland plate extremely difficult. It is always worthwhile considering fitting spare terminals and drilling spare gland holes in the gland plate, since this is difficult to do retrospectively.

The unused entries do need to be sealed with an appropriate plug, A reasonable 'rule of thumb' is always use a box at least one size bigger than you think is necessary.

The choice of material of the box is usually decided by local preference but it should ensure adequate resistance to corrosion, for example by the use of stainless steel. If plastic enclosures are preferred then it is usual to use an Exe certified enclosure to ensure that the possibility of a hazardous build-up of static electricity does not occur. Plastic enclosures are marmite like in that they are loved or hated by end users.

The usual practice is to use Exe certified terminals since this ensures an adequate level of safety and is an economic readily available solution. Additional terminals should be included so that spare cores of multi-cores can be correctly terminated and can be readily brought into service at a later date if necessary. Similarly provision should be made for terminating screens and for their cross connections if they are to be carried through. Where armoured cable is to be used then the gland plate should ensure that the armours are interconnected. Whether the junction box is 'earthed' by bonding to a local structure or not is a matter of local practice and frequently much debate.

Usually the box is adequately bonded by its method of mounting, but making provision for the connection of a bonding strap is recommended since then any local preference can be satisfied. Provision should be made within the enclosure so that the wiring is secure and tidy. In addition the box should be mounted so that the cables entering the enclosure are supported so as to ensure that the stress on the glands is minimized.

There are many widely differing opinions on the most secure way of making off individual wires. A satisfactory method of terminating stranded cables is to use crimped-on ferrules. Where it is unavoidable that two wires have to use the same terminal the preferred technique is to use a ferrule which joins the two wires together and presents a single prong to the terminal. However using two correctly sized ferrules in one terminal usually provides an adequately secure connection, but this is not a technique favoured by everyone and may not be permitted.

Some installations in high humidity situations suffer from condensation problems, and in these locations it is advisable to fit drain plugs. These plugs must maintain the ingress protection rating [at least IP 54] of the enclosure.

It is not good practice to mix high and extra low voltage circuits in a junction box [and in some countries it may be illegal to do so] because of the possibility of problems being created during 'live maintenance'. It is permitted to mix all methods of protection within the same Zone 2 mounted junction box provided that they are all using an extra low voltage. If intrinsically safe circuits are included then the terminals associated with those circuits must be segregated from those of other circuits by at least 50mm. It is important that the enclosure and all the circuits should be clearly identified to ensure that during maintenance procedures the chances of making a mistake are minimised.

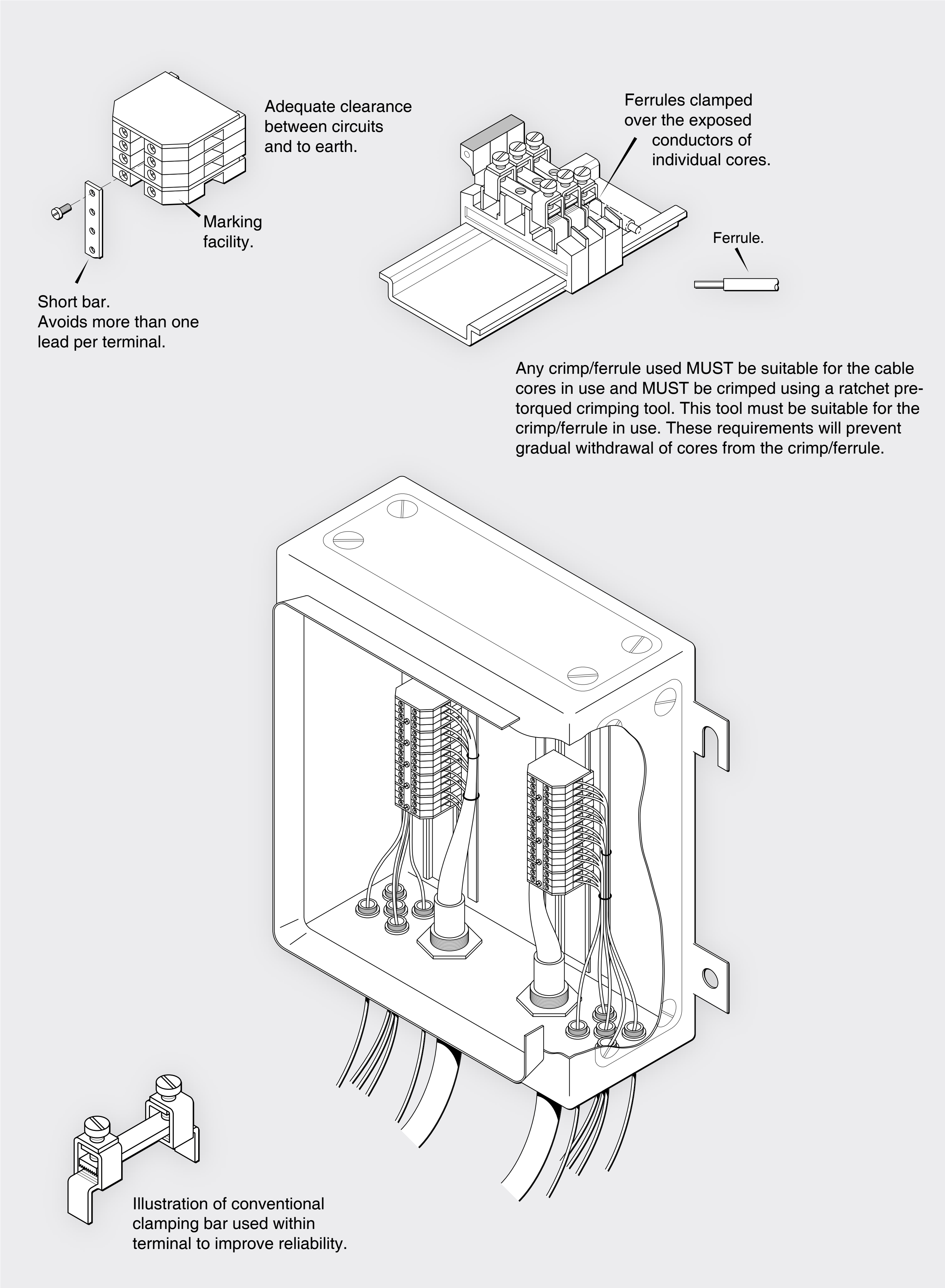


Figure 3 Typical Zone 2 Junction Box

There is a need to clearly mark junction boxes and terminals so that they can be readily identified for inspection and installation purposes. The location of junction boxes always requires careful consideration. It is nearly always possible to locate them in Zone 2 thus avoiding the need to temperature classify them under fault conditions and to avoid the use of a flameproof enclosure if Ex d techniques are preferred. Since the junction box is frequently the most useful point for fault finding it is important that it should be readily accessible, preferably without the need to use additional access equipment such as ladders. A location where the light is adequate and there is somewhere to rest test equipment is also desirable.

A well designed junction box can save a considerable amount of time and provide facilities which make maintenance easier.

Figure 3 illustrates some of the desirable features.

4.5 Area classification

The object of area classification is to evaluate the probability of a hazardous mixture of gas and air being present on a plant. The subdivisions used are Zone 0 gas continuously present, Zone 1 frequently present and Zone 2 infrequently and for a short time. There is no authorized numerical definition of these zones but 1000hrs/annum, and 10 hrs/annum and presumably 0.1hrs/annum are frequently used as the boundaries. These numbers are not in favour with the area classification cognoscenti. However they do help in quantifying the risk but are not to be worshipped. Area classification is not an exact science and there is often a divergence of opinion. The relevant IEC standard is IEC 60079-10-1 and there are a significant number of industry codes which suggest acceptable interpretations for commonly occurring situations such as road tanker loading bays. Almost all well ventilated areas not in the immediate vicinity of a source of release are Zone 2. Figure 4 summarizes some aspects of area classification

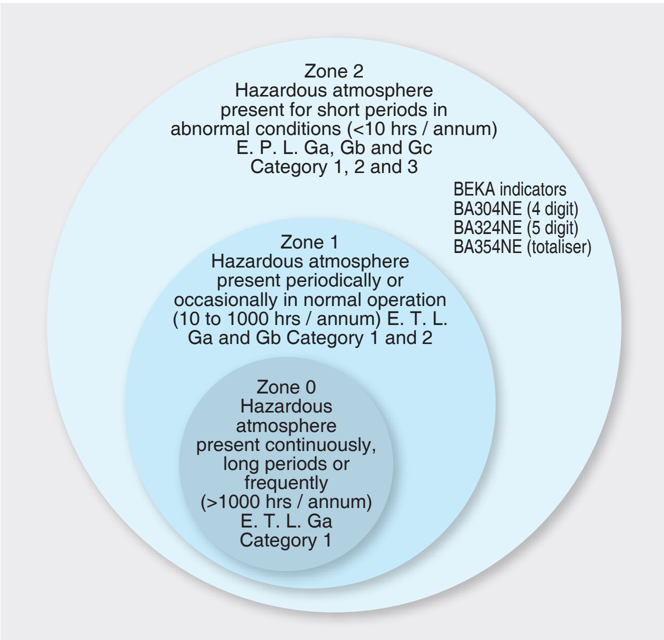


Figure 4 Summary of area classification concepts

The ATEX user directive requires a risk analysis of plants, which almost always uses area classification as a basis for the analysis. In the past it was quite common to classify large areas as Zone 1 in order to play safe. However the more logical approach of risk analysis is one factor leading to the major part of most plants being classified as Zone 2. since human beings are not compatible with most hazardous gases. The desire to minimize product loss, environmental concerns and the improvements in glands, flanges and other possible sources of release have also reduced the size and numbers of Zone 1's. In practice, plants with large areas of Zone 1 are almost impossible to justify because of the possible risk to personnel and the environment.

In the particular case of indicators they should where possible be mounted in Zone 2 so that they are readily accessible without exposing any user to unnecessary risk whatever the certification. It is difficult to generalize about area classification because so many factors influence the decisions on a particular installation. Figure 5 shows a typical diagram of a storage tank of liquid whose vapour is heavier than air and flash point below atmospheric temperature. This illustrates that Zone 0's are usually inside process vessels. [Arguably the vapour space has a mixture above the flammable level but it is usual to make it Zone 0 . This covers the conditions of filling and emptying the tank when air may be introduced and the location of the hazardous atmosphere is unpredictable] The Zone 1 is small, in the immediate vicinity of the vent and the Zone 2 is much the larger volume. The probable position of an indicator on this location is inside the bund in a Zone 2

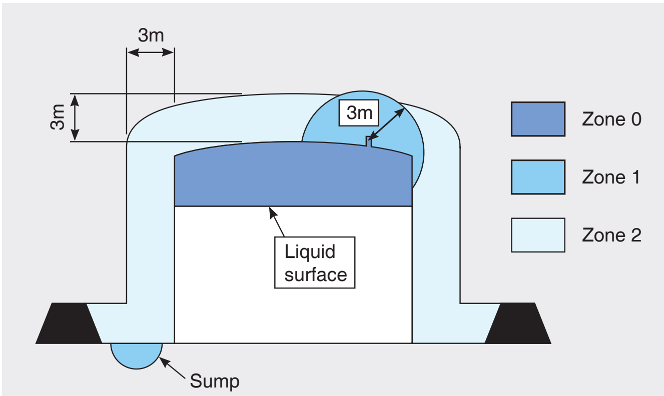


Figure 5 Typical area classification of storage tank

5. CONSTRUCTIONAL REQUIREMENTS

The ‘nA’ method of protection relies heavily on the apparatus enclosure protecting the equipment. The requirements are contained in IEC 60079-0 and set a very high standard. There is always a problem in writing standards in that the standard must allow for the possibility of the equipment being used in almost all circumstances. This inevitably means that the equipment is over designed for most locations but it does achieve a high level of reliability for both operational and safety reasons. However the cost is increased. The requirements for plastic enclosures are very detailed, largely because early plastic enclosures were not very good. This does create an anomaly in that metallic enclosures are not subject to the same rigorous testing. In theory they could corrode away in a few weeks and the certification bodies would not mind. The temptation to submit an oak chest for certification is considerable. The following is intended to illustrate how extensive and comprehensive the testing required is but it is not a precise statement of the required tests which are best derived directly from the standards.

All types of enclosure have to meet the impact test of a 1 kilogram weight dropped from 70cm. The test is done in two places on two samples. The sadistic skill of the certifying engineer is the choice of the point of impact which is most destructive. For some completely illogical reason light transmitting parts are subject to a lower impact test of dropping the 1 kilogram from 40cm. Life is made more difficult for enclosures intended for use at lower ambient temperatures since the impact tests are done at a temperature some 5 to 10ºC below the minimum operating temperature. The most surprising materials become brittle at -45ºC.

The intended operating temperature range determines the acceptability of many constructional materials. The standard tests are applicable for equipment intended for use between -20 and +40ºC. However most field mounted instruments have to survive a wider temperature range. For example BEKA indicators have a specified range of -40 to +70ºC and consequently many of the tests become more severe.

An important test is for ingress protection against the ingress of water and dust. The requirement is to test in accordance with IEC 60529 and to achieve a minimum level of IP 54, which is a modest requirement. In practice many manufacturers including BEKA achieve a higher level of protection of IP66 which affords complete protection against both methods of contamination. This test is done after all the other tests, The difficult part is to maintain the level of protection over a long time and when installing the necessary cables and glands

The material used for a plastic enclosures is subject to a considerable list of requirements and tests. The most searching test is a prolonged exposure of test samples to a high temperature and high humidity test, which does the most surprising things to many commonly used plastics. The material also must have a temperature index [TI] which is not always readily available and is expensive to obtain. There is also a test with ultra-violet light to check resistance to the effect of exposure to light. To alleviate concern about the risk of an electrostatic charge causing an ignition risk the material must be slightly electrically conductive and this is usually achieved by loading the plastic with a conductive material. Unfortunately this also modifies the mechanical properties of the moulding compound.

There is no requirement for vibration testing in the relevant standards but many manufacturers carry out tests to ensure equipment reliability. For example BEKA test to an in-house standard which has been found to ensure adequate performance in the conditions normally experienced.

This description is not complete in detail but does indicate how comprehensive the testing required is. A fortunate by-product is a very reliable industrial product. Nevertheless when locating any equipment, choosing a location which avoids extremes of environment and risk of impact is a common sense precaution, which increases reliability. In the particular case of indicators consideration of the user determines that the indicator is not usually located in a very uncomfortable position.

Where a product is offered for sale in the European Community it must have a Document of Conformity which confirms that it complies with all the relevant directives. One of the directives covers the rejection of EMC and consequently all equipment which complies has been tested and has a reasonable performance in the presence of the level of radio interference normally encountered.

6. CERTIFICATION

6.1 General

There is no requirement to have ATEX Category 3 equipment (such as ‘nA’) certified by an Notified Body and self-certification is acceptable. However some end-users prefer the reassurance of independent certification and consequently the majority of ‘nA’ apparatus is third party certified to meet the requirements of the ATEX directive and IECEx certified for non-European use. This is the practice adopted by BEKA and the certification of their indicators is analysed to illustrate the requirements which follow from this choice.

6.2 Certification of indicator

The BEKA indicators covered by the certification are BA304NE 4 digit indicator, BA324NE 5 digit indicator and BA334NE rate totaliser.

The certification confirms that the indicator is certified Ex nA IIC T5 which means that it can be used in Zone 2 in all gases from a spark ignition viewpoint. The temperature classification T5 means that it can be used with almost all gases. The exceptions listed in IEC 60079-20-1 [The IEC standard which lists the relevant data on gases] are carbon disulphide and ethyl nitrite which have ignition temperatures of 90ºC and 95ºC respectively. There are other gases with a low ignition temperature not listed in IEC60079-20-1 such as ethyl nitrate and arsine,[which are used in the semiconductor industry] and consequently a check is always necessary.

The small component relaxation for T5 of 150ºC was derived using experimental evidence, which used carbon disulphide as the test gas [which was at the time classified as T5] and hence is relevant to carbon disulphide. The T5 [100ºC] rating relates to an ambient temperature of 70ºC and it is therefore reasonable to use the indicators with this gas at lower ambient temperatures [below 50ºC]. However, this use would need to be covered by a risk analysis since it is not in strict accordance with the IEC code of practice.

Ethyl nitrite is a powerful oxidising agent, suffers explosive decomposition above 95ºC and can also be decomposed by light. It is a IIA gas but is flammable over a wide range [3 to 50 % by volume]. The use of these indicators with ethyl nitrite is only possible following a detailed analysis by someone having the necessary expertise and documented in a risk analysis. This use would not be in strict accordance with the IEC code of practice.

There are three documents relevant to the use of the 'nA' BEKA indicator in hazardous areas:

a) The IEC Ex certificate. This type of certificate is issued by a certification body accredited by an organisation spawned by the IEC and using IEC standards as a basis of the certificate. The ambitious hope is that in the foreseeable future an IEC Ex certificate will be acceptable throughout the world, Unfortunately there is a long way to go, but increasingly this is the certification directly or indirectly acceptable in large parts of the world. The most recent copy of this certificate can be downloaded from http://www.beka.co.uk/loop_powered_indicators_typen.html.

b) The ATEX Ex certificate. This type of certificate is issued by a certification body recognised by a European country, usually the same one as issues the IEC Ex certificate. ATEX certificates use CENELEC standards as a basis for certification, Fortunately IEC and CENELEC standards are identical in their requirements. The relevant directive EC 94/9/EC does not require third-party certification of Category 3 equipment such as 'nA' apparatus. However not all end-users are happy with self-certification and consequently certification bodies issue certificates on the same basis as Category 1 and 2 equipment. A copy of this certificate can be donwloaded from www.beka.co.uk/loop_powered_indicators_typen.html.

c) The ATEX Document of Conformity is created by the manufacturer so as to confirm that the apparatus satisfies the requirements of all relevant directives and is manufactured under a recognized quality control system. The use of the CE mark requires this statement. This document is available by contacting BEKA's sales department.

6.3 Analysis of marking requirements

For completeness [inevitably repetitive] an analysis of the marking requirements is included.

The IEC Ex marking requirement is as follows.

IECEx ITS 11,0016
Ex nA ic IIC T5 Gc
-40ºC < Ta < +70ºC
Ex tc IIIC T 80ºC Dc IP66
-40ºC < Ta < +70ºC

The marking related to a gas hazard is explained as follows:

IEC Ex This confirms that the certificate is issued by the international certifying set up by the IEC.

ITS Intertek Testing & Certification Ltd. An approved certification body by IEC Ex.

11,0016 Certificate number, The 11 is the year of issue.

Ex nA Type n non-arcing method of protection which is the principal method of protection.

ic Intrinsically safe method of protection suitable for Zone 2. Applies only to calibration switches and does not affect installation practice.

IIC Surface industry gas group. Representative gas hydrogen.

T5 Temperature classification

Gc Equipment protection level [EPL] indicating suitability for use in a Zone 2 gas hazard.

-40ºC< Ta<+70ºC
Ambient temperature range, including affect of adjacent equipment.

The last two lines of marking requirement relate to the use in dust atmospheres.

The ATEX marking requirements are:

ITS11ATEX47255
Ex II 3 GD,
Ex nA ic IIC T5 Gc, -40ºC ≤ Ta ≤ +70ºC

Ex tc IIIC T80ºC Dc
IP66 -40 ºC ≤ Ta ≤ +70 ºC

The marking related to a gas hazard is explained as follows:

(Ex)	This mark indicates compliance with the apparatus directive.
II	Surface industry
3 GD	Category 3 for use in gas and dust hazards, usually in Zones 2 and 22.
Ex nA	Type n non-arcing method of protection which is the principal method of protection.
ic	Intrinsically safe method of protection suitable for Zone 2. Applies only to calibration switches and does not affect installation practice.
IIC	Surface industry gas group. Representative gas hydrogen.
T5	Temperature classification
Gc	Equipment protection level [EPL] indicating suitability for use in a Zone 2 gas hazard.

-40ºC< Ta<+70ºC

Ambient temperature range, including affect of adjacent equipment.

The last line of marking requirement relates to the use in dust atmospheres

The Document of Conformity justifies the CE mark which is required if equipment is to be marketed in the EEC

The actual label is based on these requirements and avoids repeating information. The label looks like this:

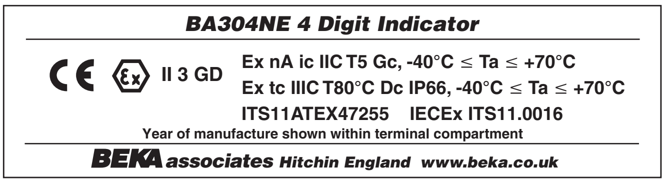


Figure 6 Certification label

In addition to this label which is positioned on the top surface of the instrument, there is a label inside the terminal compartment which is as illustrated.

Figure 7 Cautionary label

This gives the instrument serial number and year of manufacture. The warning of the elevated cable entry temperature at high ambient temperatures is so that at these high temperatures then cables which are not subject to plastic flow at this temperature are chosen.

The need is to preserve the effectiveness of the gland. This is only a problem at high ambient temperatures and these are usually associated with exposure to direct sunlight [which should be avoided because the indicator will be difficult to read] or the effect of adjacent process equipment. There are other cable problems at low ambient temperatures and at any extreme temperature care must be taken to choose compatible cables.

Although not part of the marking requirements both the IEC Ex and ATEX certificates specify the same input limitations. The only input limitation on the indicator [with or without its loop powered back lighting] is a maximum input current [Ii] of 100 mA. When the backlight is separately powered then a maximum input voltage [Ui] of 30V is applicable to that circuit. If the alarm contacts are used a voltage limit [Ui] of 30V and a current limit [Ui] of 200 mA both apply.

7. DOCUMENTATION

7.1 General

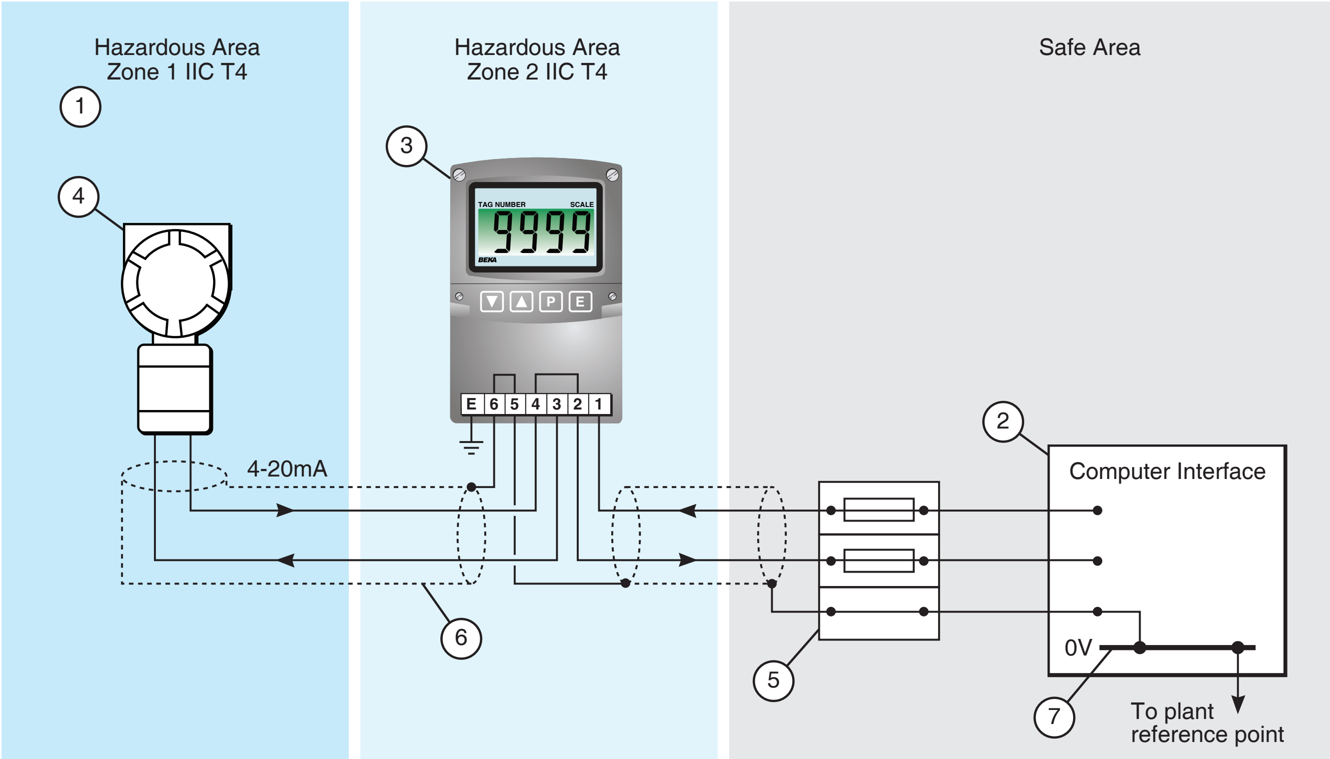
The documentation for any installation should provide a source of information on two aspects. One it should provide a reference as to why the system is adequately safe. Secondly it should provide the information to ensure that a technician can safely install the intended system. In general it is easier to separate the two requirements and produce two drawings. It must be recognized that creating adequate safety documentation is time consuming and expensive but is a legal requirement in the majority of countries.

Some installers prefer to file copies of certificates relating to equipment used. However the majority of certificates are available on the internet. IEC Ex certificates are listed on their website and ATEX certificates are usually listed on the company websites. Clear instructions on how to find certificates are preferable to copies since then a current copy of the certificate can be used. The BEKA instruction manuals carry a 'three dimensional' QR barcode ,which when scanned by an appropriate device such as a mobile telephone leads directly to the website and copies of the certificates, instruction manuals and other relevant literature.

7.2 Example of system documentation

The safety documentation can be just a series of notes but is possibly better presented as a drawing and a series of notes as illustrated by the drawing for the imaginary installation of Figure 8

The format of the installation drawing is usually determined by the preference of the end-user. It must ensure that the installing technician has clear instructions on what equipment to install and where and what cables and accessories to use. The drawing should contain a reference to the safety documentation, but should not repeat the safety arguments. The installing technician should have access to the safety documentation so that he can more readily understand the safety arguments and reassure himself if something causes any misgivings.



NOTE 1: The hazardous area contains a Zone 1 adjacent to process vessel No 3 and a Zone 2 comprising the nearby well-ventilated area.[area classification drawing No ABC 123]. The gas hazard is caused by a combination of hydrogen [IIC T1] and ethyl methyl ether [IIB T4] requiring IIC T4 equipment.

NOTE 2: The Alpha computer interface provides a regulated 24V d,c.for the transmitter and accepts the 4-20 mA return signal.

NOTE 3: The BEKA indicator Type BA304NE is certified 'Ex nA T5' certificate number IECEx ITS 11.0016 and is suitable for mounting in the Zone 2 IIC T4 location. The limiting input parameter is an input current [Ii] of 100mA and this requirement is met by the use of the 100 mA fuses [see NOTE 5]. The mounting position has an ambient temperature range of -20ºC to +40ºC, which is within the permitted ambient temperature range of -40ºC to +70ºC.

NOTE 4: The ALPHA pressure transmitter Type YYYY is certified 'Exd IIC T4' certificate number yyyy and is suitable for mounting in the Zone 1 IIC T4 location. The adjacent process equipment creates a service temperature range of -20ºC to +60ºC, which is within the permitted temperature range of -40ºC to +70ºC.

NOTE 5: The 100 mA fuses are mounted in terminal blocks within the cable termination cabinet. They provide over-current protection for the cables and hazardous area equipment. They also provide a means of isolation and they are clearly identified and easily accessible to ensure safe use.

NOTE 6: The cables are screened twisted pairs, 22 AWG with toughened outer sheath installed on cable trays. The glands used on the transmitter and indicator are all Exde glands to ensure against incorrect installation.

NOTE 7: The screens are carefully terminated to ensure inter-connection and avoid unintended earth connections. The safe area end is directly connected to the computer 'O' volt rail and subsequently to the plant reference point. The transmitter end of the screen is carefully finished but isolated from earth.

Figure 8. Descriptive System Document for pressure transmitter 02 process vessel No. 3

8. TYPICAL CIRCUITS USING INDICATOR IN ZONE 2

8.1 Common factors

All the diagrams use a power supply and receiving equipment block to illustrate the equipment used in the safe area. In practice there are no significant limitations on the permissible apparatus in the safe area. The indicator has no maximum voltage rating only an input current limitation [Ii] of 100 mA. The maximum voltage permitted in the circuit is determined by the lowest voltage rating of any of the equipment connected within the circuit. The fuses used to provide protection and isolation for the hazardous area equipment are normally rated at 250V a.c. with a given rupturing capacity and these should not be exceeded under anticipated fault conditions The required integrity of the power supply is not defined in any hazardous area standard but this does not usually cause any problem because the equipment is required to be safe for personnel touching the live low voltage terminals, In European terms compliance with Low Voltage Directive ensures that this requirement is met.

The equipment shown as safe area equipment can be mounted in the Zone 2 if suitably protected and constructed. For example it is not unusual to mount such apparatus in a pressurized enclosure with the indicator mounted nearby.

The fuses shown are 100 mA rated and mounted in terminal blocks. The 100 mA input current rating of the indicator [Ii] is the rating in normal operation and in practice the current in this type of circuit is usually limited to less than 30 mA. A 100mA fuse can allow a current greater than 100 mA to flow for a short time but this is a transient situation. A 100mA fuse which effectively limits the transferred power is considered to provide the required level of protection. Fuses must be included in both leads so as to ensure complete isolation when required. It is important that the fuses are clearly identified so that correct isolation is readily accomplished. Where other equipment in the circuit has an input current limitation it should be not less than 100mA or the fuse rating must be changed to an appropriate value.

The circuit can be fully floating but is more usually 'earthed' at one point in the safe area by the common power supply and/or the receiving equipment. This earth [usually combined with the screen earth] and the plant reference potential should be bonded together. Earthing at more than one point should be avoided since the possible circulating currents cause both safety and operational problems. In those rare cases where multiple earths cannot be avoided then the use of bonding conductors as reluctantly permitted in intrinsically safe circuits provide a possible solution. The enclosure of the indicator is moulded from a loaded plastic which is slightly electrically conductive.

This satisfies the requirements of the standard which are intended to prevent the build up of an incendive electrostatic charge. The enclosure can be bonded to a conductive part of the local structure by using the 'earth' terminal provided. However this connection is only necessary when the mounting of the indicator does not provide a discharge path for any hypothetical electrostatic charge.The indicator contains a gland plate which is also bonded via the 'earth' terminal. If metallic glands are used with armoured cables then the armour is bonded at this point.

NOTE: The bonding connection is not required by the IEC standard but is required by some certification bodies.

The cable screens are all shown to be 'earthed' in the safe area and isolated elsewhere. The screen is earthed or bonded to the plant reference point which should be as electrically quiet as possible. In particular it is desirable to avoid the bond sharing any interconnections which carry the fault or leakage currents from power equipment This is the practice commonly used to ensure safety and to minimize interference but other techniques may be used. Provision is made within the indicator to carry the screen through the indicator and maintain continuity without earthing the screen at this point.

With the exception of the flameproof equipment the glands used are Exe glands. In practice some end-users prefer to use Ex de glands so as to avoid possible misuse. The cables are normally 22 AWG or 0.5mm² with a screen and with a toughened outer sheath supported on cable trays, but other types of cable installation can be used if there is a local preference.

Where pressurized equipment is used in Zone 1 then Type px or py equipment is required. For Zone 2 Type px or pz is used.

Figures 9 to 13 illustrate situations where the field equipment is loop-powered by the 4-20 mA signal. Figure 14 illustrates the situation where the 4-20 mA signal is derived from hazardous area equipment containing a separate source of power. In these circumstances the field wiring and indicator is shown protected by an additional set of fuses within the hazardous area equipment. A similar arrangement is required whenever the hazardous area equipment contains a separate source of power. It may not be necessary to use fuses but some reliable form of current limitation of the 4-20 mA circuit is essential. The procedure for using the isolating switches within the pressurised enclosure [or any other similar hazardous area equipment] needs to be carefully documented, since opening the enclosure should only be done under carefully controlled conditions.

The following figures illustrate the use of the indicator in Zone 2 with equipment using other methods of protection. The examples shown are the combinations most frequently occurring, but other combinations do occur.

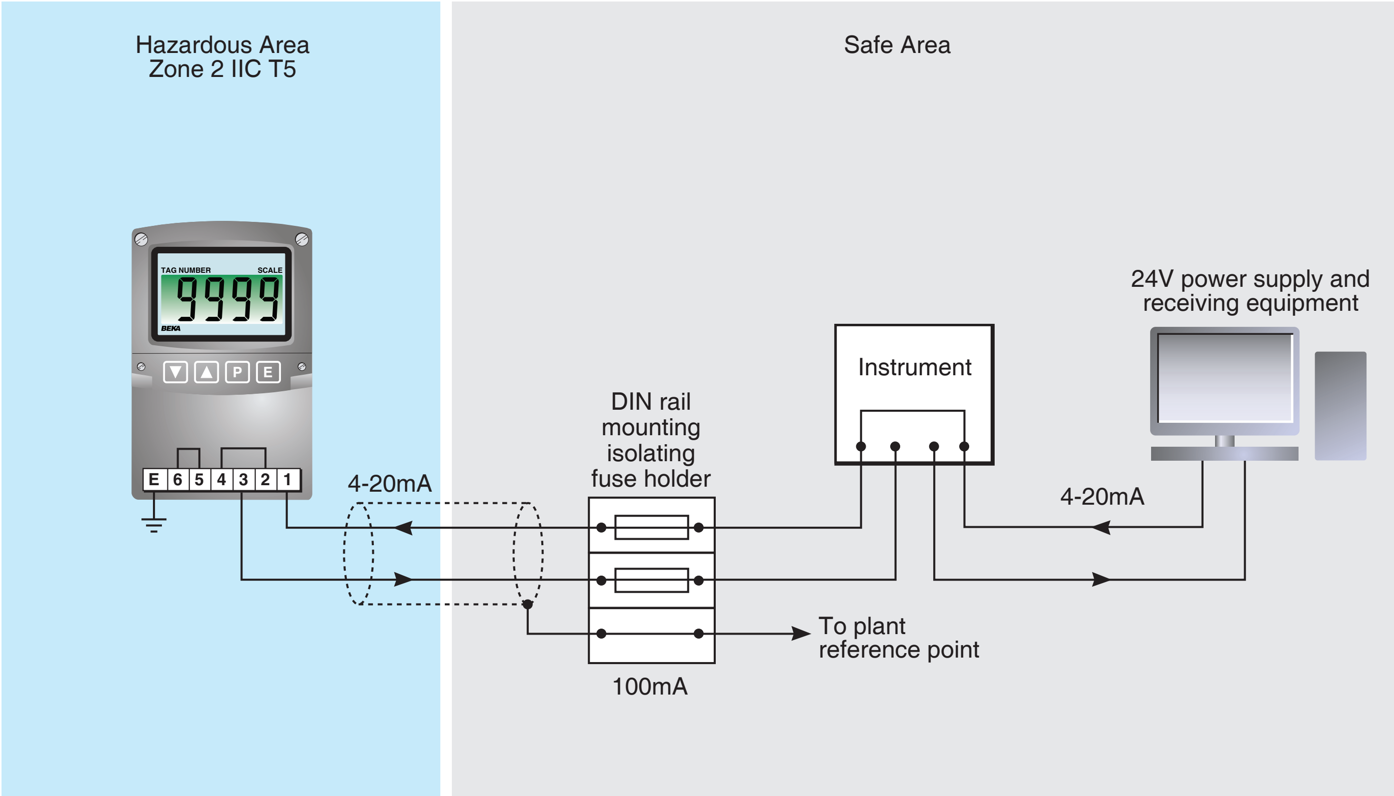


Figure 9. Indicator in Zone 2 monitoring safe area instrument

NOTE: Hazardous gas must be compatible with the T5 requirement of the indicator.

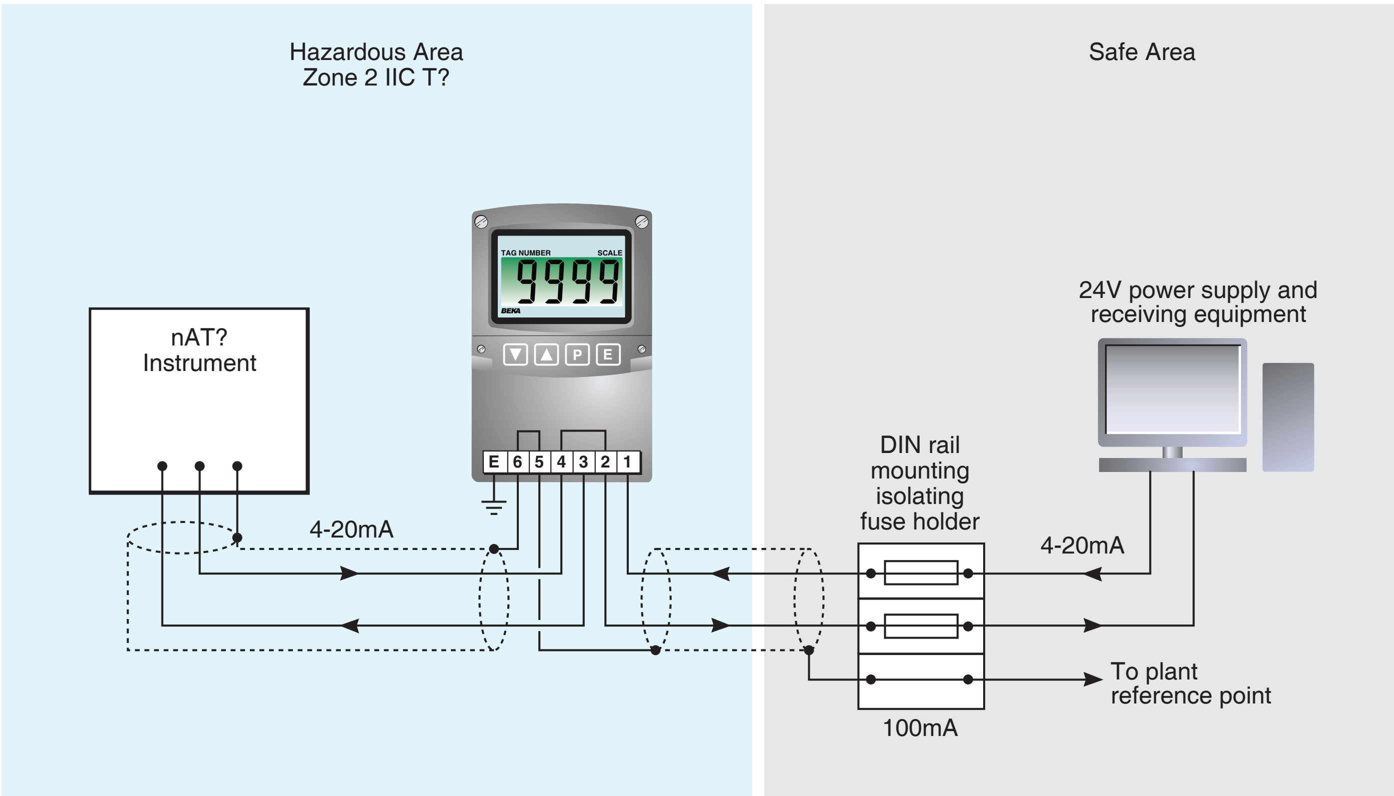


Figure 10. Indicator in Zone 2 monitoring non-arcing instrument in Zone 2

NOTE: Hazardous gas must be compatible with the T5 requirement of the indicator and the temperature classification of the ‘nA’ equipment.

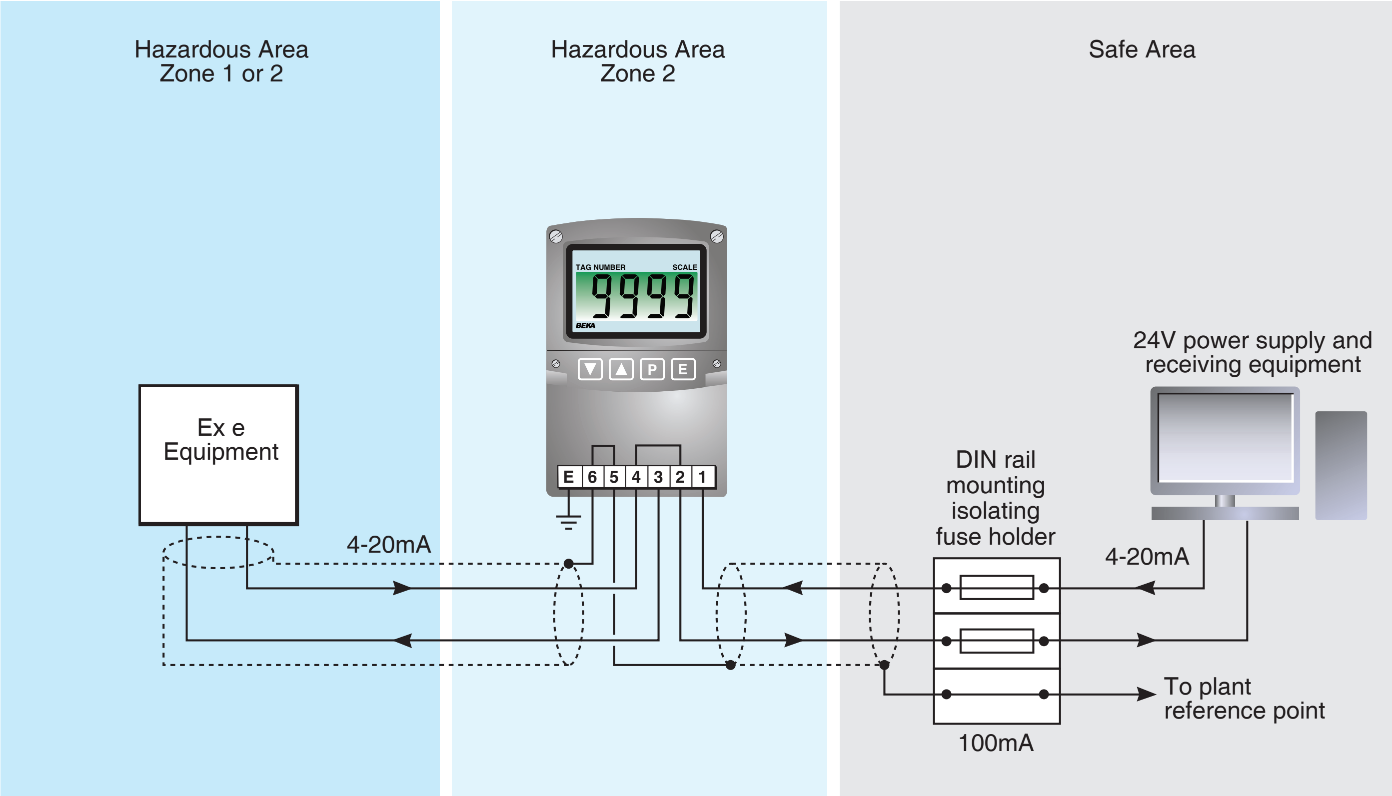


Figure 11. Indicator in Zone 2 monitoring Ex e equipment in Zone 1

NOTE: Hazardous gas must be compatible with the T5 requirement of the indicator and the temperature classification of the 'Exe' equipment.

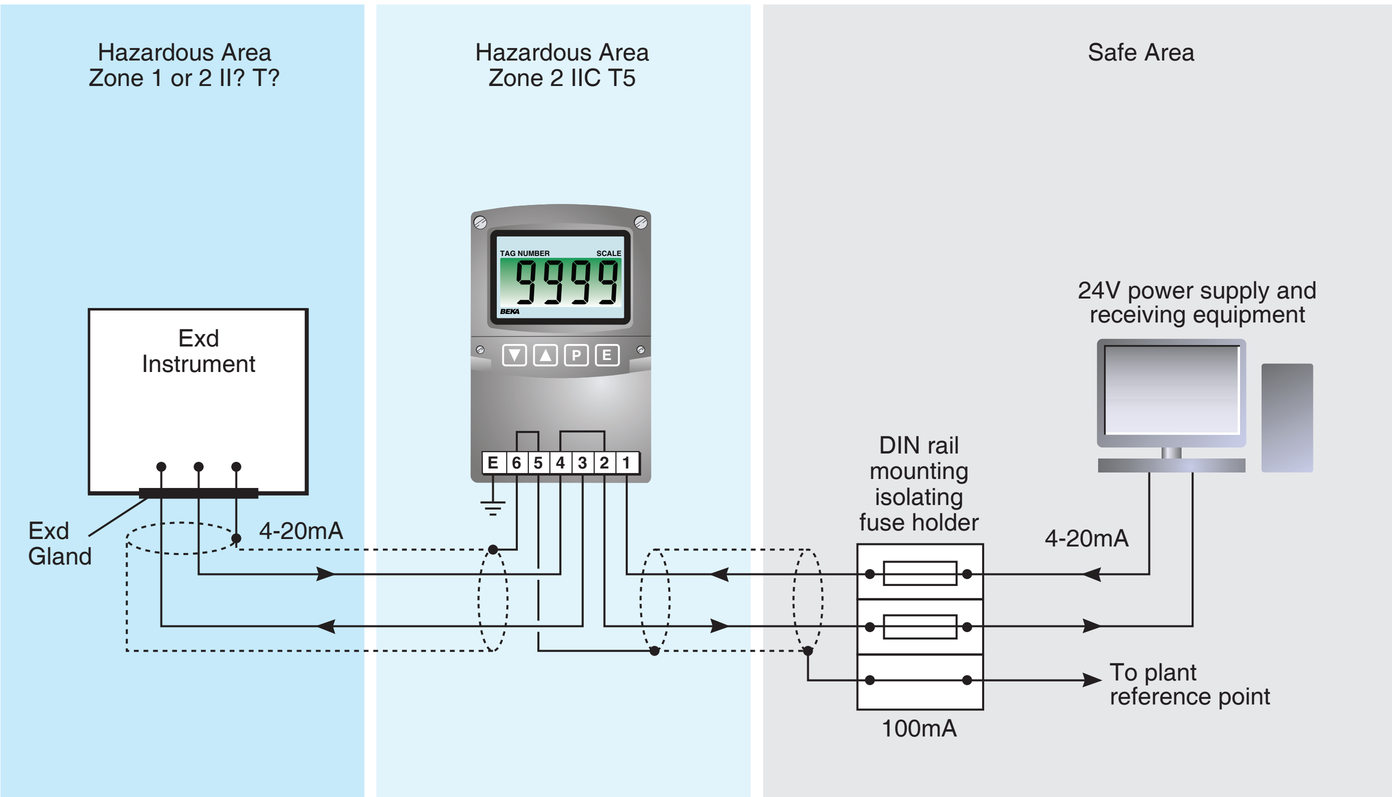


Figure 12. Indicator in Zone 2 monitoring Flameproof instrument in Zone 1 or 2

NOTE: Hazardous gas must be compatible with the T5 requirement of the indicator and the temperature classification and the gas classification of the flameproof equipment. The flameproof equipment must use an appropriate flameproof gland.

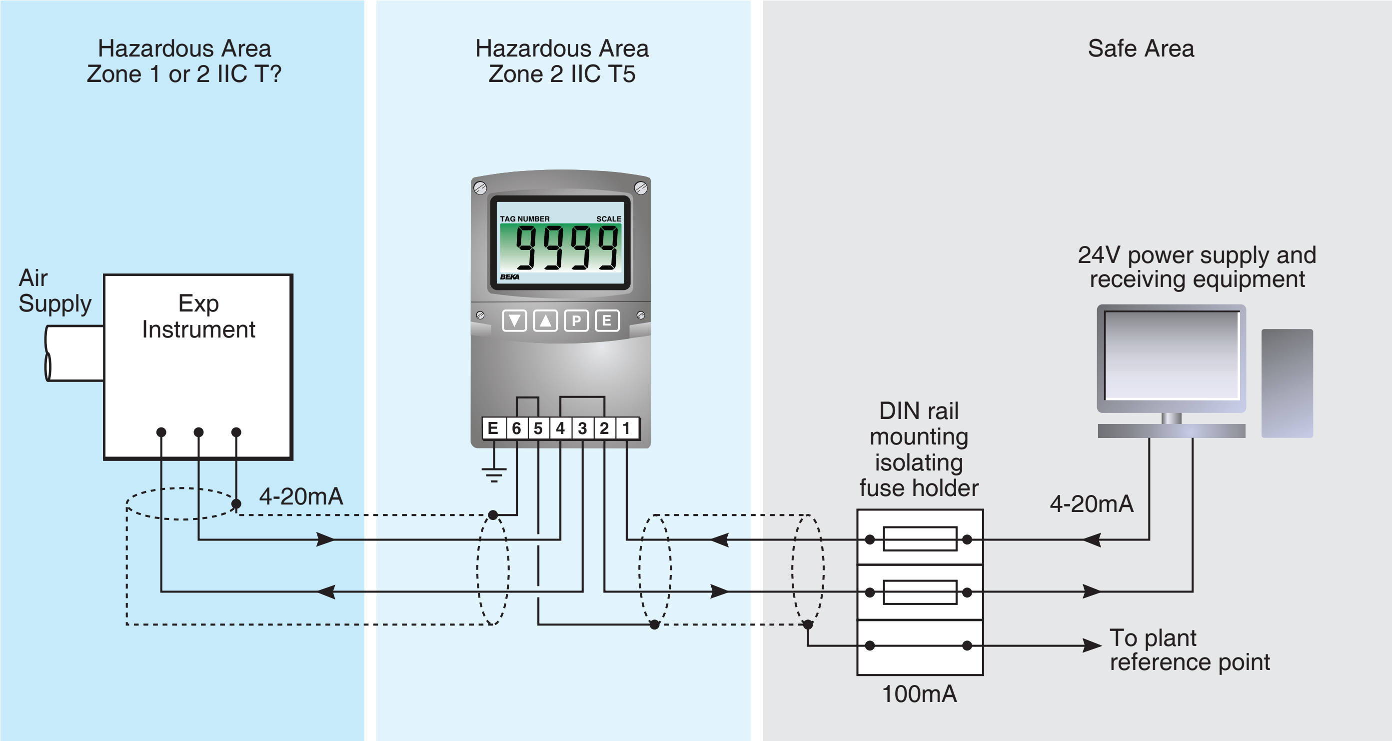


Figure 13. Indicator in Zone 2 monitoring signal powered pressurized equipment

NOTE: Hazardous gas must be compatible with the T5 requirement of the indicator and the temperature classification of the pressurized equipment. The type of pressurized equipment must be appropriate to the Zone of use.

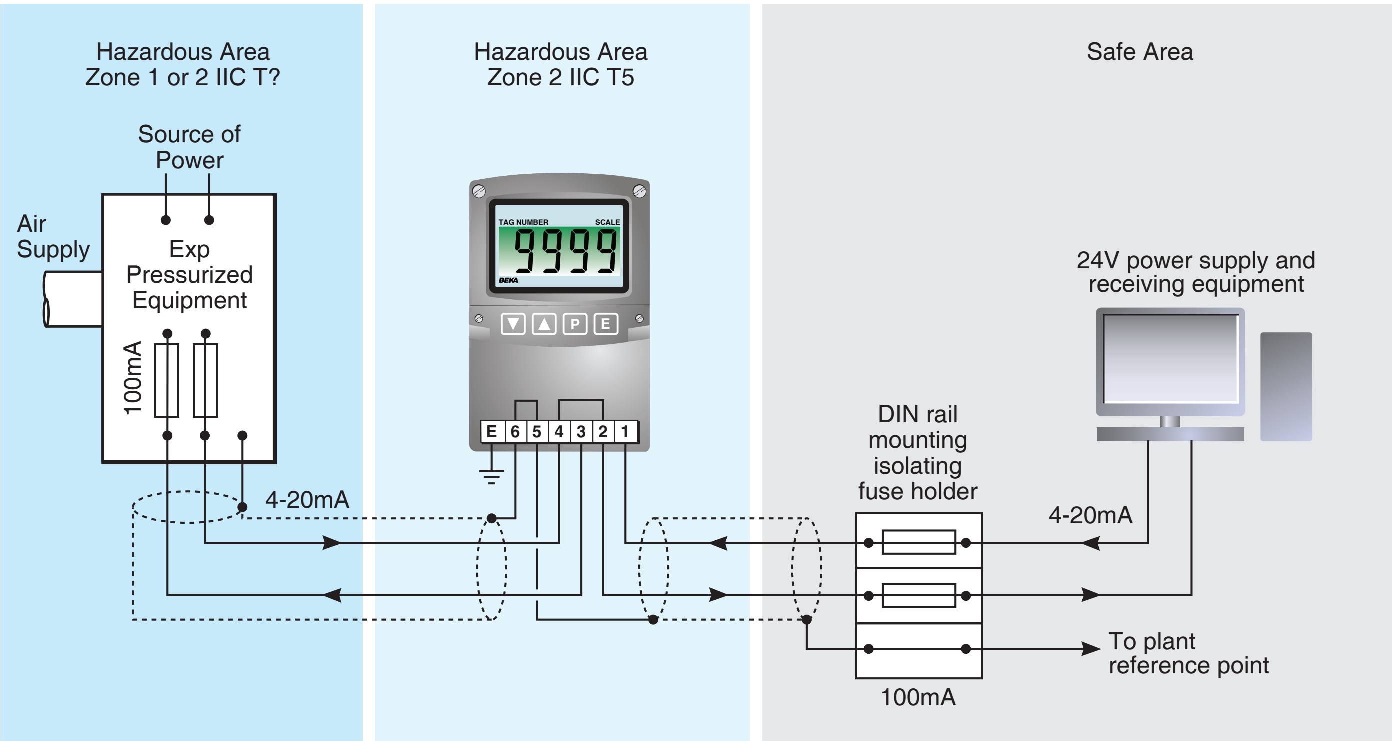


Figure 14. Indicator in Zone 2 monitoring signal from powered pressurized equipment with a source of power

NOTE: The additional set of fuses within the pressurized equipment is to protect the field wiring and indicator from faults within the equipment. Hazardous gas must be compatible with the T5 requirement of the indicator and the temperature classification of the pressurized equipment. The type of pressurized equipment must be appropriate to the Zone of use.

9 COMPETENCY

The need for anyone involved in designing, installing, maintaining or inspecting hazardous area systems to be competent is very obvious. The need is emphasised in IEC 60079-14 where a competent body is defined as ‘individual or organisation which can demonstrate appropriate technical knowledge and relevant skills to make the necessary assessment of the safety aspect under consideration’ The requirements are fully expanded in Annex F of that document.

Competency is a difficult thing to define and is probably never completely achieved. There are many ways of becoming accepted as adequately competent.The process can be aided by attending one or more of the available courses. For example the IEC Ex accreditation scheme is gaining increasing international recognition. In the United Kingdom the Compex course organised by EEMUA is well established and frequently used.

If contractors are used for any purpose then some measure of their competency is desirable. For example the NICEIC have an accreditation scheme for some contractors. A service they can provide is to do inspections. There is some merit in their independence and they provide a certificate of the form illustrated on completion

Figure 15 Typical inspection certificate

10. INSPECTION

The recommended inspection procedures for this type of installation are contained in IEC 60079-17. Some of the systems discussed contain more than one method of protection and the inspection procedures have to be adapted to this multiplicity. This note concentrates on the requirements of the indicator.

Three grades of inspection are proposed, detailed, close and visual. A detailed inspection is usually carried out if there is some reason to suspect that there is a significant problem. It would involve removing the indicator to a safe area and removing the covers, checking the gaskets, removing any pollution and looking for any damage or obvious deterioration in condition. A functional check would confirm that there was not significant electrical damage. This type of inspection should only be necessary on very rare occasions. For example it is not necessary on initial installation since the indicator will have been subjected to a detailed final inspection.

The initial detailed inspection should confirm that the indicator is being installed in accordance with the installation drawing or instructions. The questions of where to install it and choice of cables glands should all have been decided by the compiler of the installation drawing. The installing technician should be encouraged to question any aspect which he has cause to doubt and should have access to the safety documentation and the relevant certificates if he wishes.

Close inspections are not relevant to indicators. If the indicator is of the required type and is working then a visual inspection is all that needs to be done. Removing covers and attempting to check the status of the electronics except when absolutely necessary is to be discouraged.

Visual inspections are inspections looking for obvious faults and do not require the use of tools or the removal of covers. In the case of the indicator a check that the indicator is the intended model, is reasonably clean and undamaged and the glands and immediately adjacent cable are in good condition is all that is necessary.

11. MAINTENANCE

Any maintenance should only be attempted in accordance with the permitted work practice of the particular site, which should ensure personnel and plant safety but may not permit ‘live working’. All maintenance work should be carried out subject to the precautions which would be applied in a safe area.

There is no requirement for routine maintenance of the indicator. If the indicated value becomes obscured cleaning the window with a damp cloth is the recommended solution.

If the indicator appears not to be functioning then this should be confirmed by measuring the current in the safe area. Live maintenance of type ‘nA’ apparatus is not permitted except when a risk analysis demonstrates that it is acceptably safe to do so. Clause 4.8.1 of IEC 60079-17: 2007 sets out the requirements of the risk analysis in detail.

The principles to be followed are that the maintenance procedure shall not cause incendive sparks or expose or create hot surfaces. However if the indicator malfunctions the only universally acceptable recourse is to remove it for examination in the safe area and this is frequently the most practical solution, It is necessary to isolate the hazardous area circuit before disconnecting the indicator. Isolation can be achieved by opening the switches in the switch-fuse terminal blocks and unauthorised re-energising prevented by removing and retaining the fuses. It is always worthwhile to check that the circuit is isolated before working on it. This can be done by using an intrinsically safe multimeter such as the Fluke 87V. This is quite safe if the meter is used only on the voltage range [input impedance 10 megohms] since the current drawn is non-incendive even if the circuit is not isolated. A comprehensive check can be made by using the screen as the reference potential and checking the voltage on all the other terminals. While it is safe to make voltage measurements, an energized circuit should not be broken in the hazardous area to make current measurements since there is a slight possibility of an incendive spark being created. It is usually possible to conveniently monitor circuit currents at the fuse–switch isolator in the safe area.

If the indicator is removed and not replaced by a spare indicator the continuity of the circuit can be restored by using a three-way terminal block to make the appropriate interconnections. Using such a terminal block ensures that the circuit leads do not stray and enables the circuit to be energized and used without the indicator. Such a terminal block must be protected from the environment at all times. If the circuit functions without the indicator this further confirms that the indicator is malfunctioning.

Fault finding on a live circuit in Zone 2 can be done safely using an intrinsically safe multimeter on the voltage range, The voltage measurements listed in the indicator manual can be safely used. Each circuit is slightly different but most faults can be diagnosed by measuring the voltages on the indicator terminals using the screen as the zero volt reference, It is permissible to temporarily remove the terminal cover to permit these measurements to be made. Care must be taken to avoid contaminating the interior during the temporary relaxation of the ingress protection and the gaskets checked as the cover is replaced. It is possibly hazardous to disconnect any of the wiring and hence the circuit should be isolated or a gas clearance certificate obtained before loosening terminals.

If it is necessary to reconfigure the indicator this can be done safely in situ. If the push buttons are available on the outside then there is obviously no problem since the switch circuits are intrinsically safe. When the push buttons are internal then it is safe to temporarily remove the separate cover to make the adjustments. If recalibration of the indicator is considered necessary this can be done in the hazardous area using an intrinsically safe calibrator. This is not simple since the indicator must be disconnected to allow this operation. Alternatively the instrument may be moved to the safe area. More easily calibration using the internal reference of the indicator can be done in situ without disconnecting the indicator.

12. THE USE OF BACKLIGHTING

Backlighting is a factory fitted option and where backlighting is fitted to an indicator it can be used in one of two ways and both of them are covered by the 'nA' certification. The choice of method can be made or changed on-site but any disconnection should only be done with the circuit isolated. The more common use is to connect the backlighting in series with the indicator as illustrated in Figure 16. This increases the voltage drop across the combination from 1.2 to 5V and provides sufficient light for most purposes. The certification limits the voltage normally applied to the back-light to 30V and the current to the indicator to 100 mA and both limitations should be applied to the series combination. Since the voltage drop across the equipment in series with the indicator is usually less than 12V and the supply voltage a nominal 24V there is usually no problem. Figure 16 shows the back lighting being used with flameproof equipment but it can be used in all the possible applications of the indicator provided that the combined voltage drop of 5V does not cause a problem.

In circumstances where either the increased voltage drop is not acceptable or a higher light level is thought to be necessary then the backlighting can be separately powered. It requires a constant current of 35 mA and the certification limits the voltage from which this is derived to 30V. There are two possible circuits as illustrated in Figures 17 and 18.

Both diagrams show the indicator being used with flameproof equipment but a similar configuration can be used with all the other possible applications of the indicator.

Where the power supply is common to the signal and back-light then a three wire connection as shown in Figure 17 can be used. All three leads should be fused and capable of being isolated as shown. The common lead can carry currents up to 60 mA but the voltage drop in the field wiring is not likely to cause a problem for lead lengths less than 1km if 18 AWG or 0.75 sq mm cable is used.

Where separate power supplies are used or it is thought desirable to keep the signal and backlighting circuits isolated from each other, a four lead interconnection as illustrated in Figure 18 can be used. The wiring can be two separately screened pairs as illustrated or combined in a multi-core.

The backlighting does not create a maintenance or inspection problem. When connected in series with the display there is a voltage drop of 4V which can be safely measured between terminals 12 and 13. When separately powered the indicator draws a constant current of about 35mA if the available voltage is greater than 10.5V. The back-light functions but with reduced light output at lower voltages. The current is most conveniently and safely monitored at the fuse-isolator.

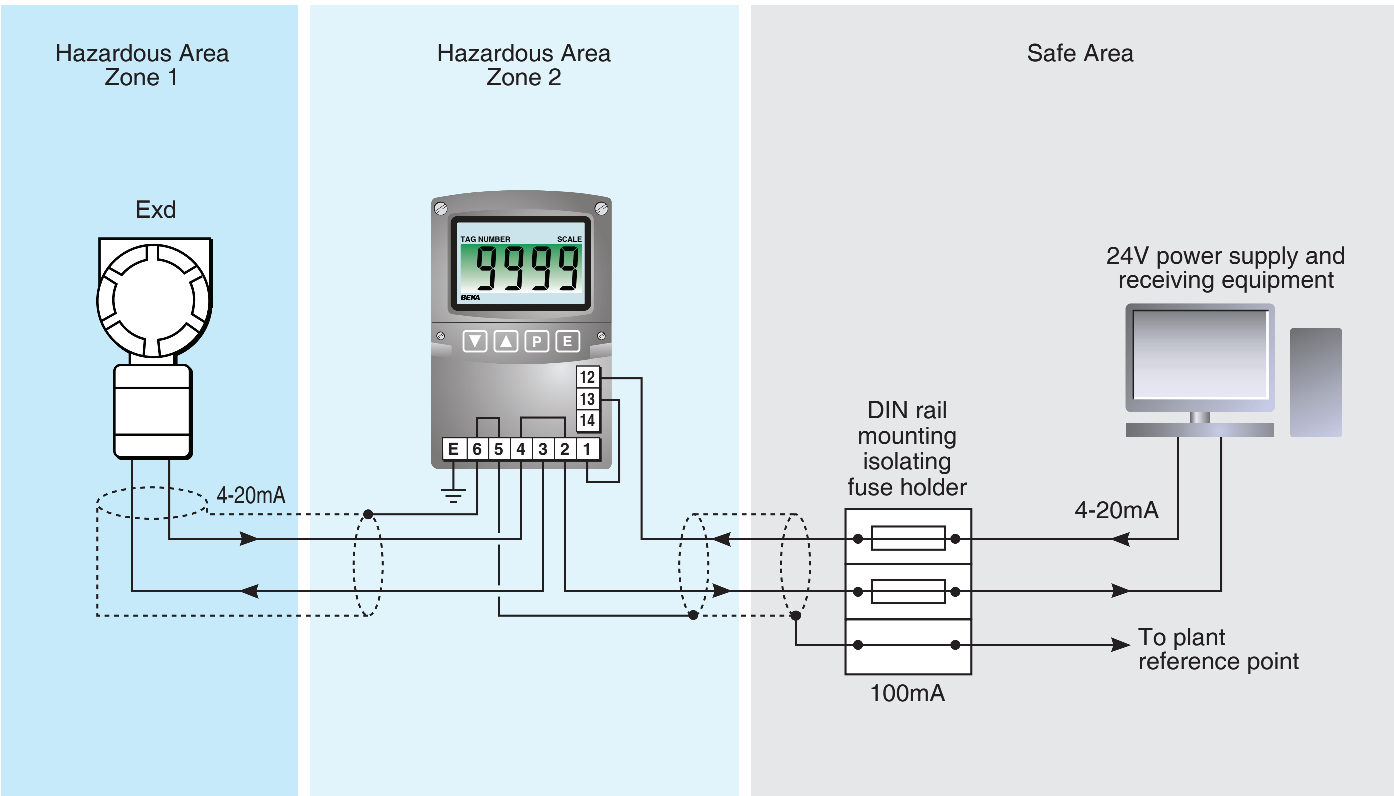


Figure 16. 4-20mA circuit and backlighting measuring loop powered

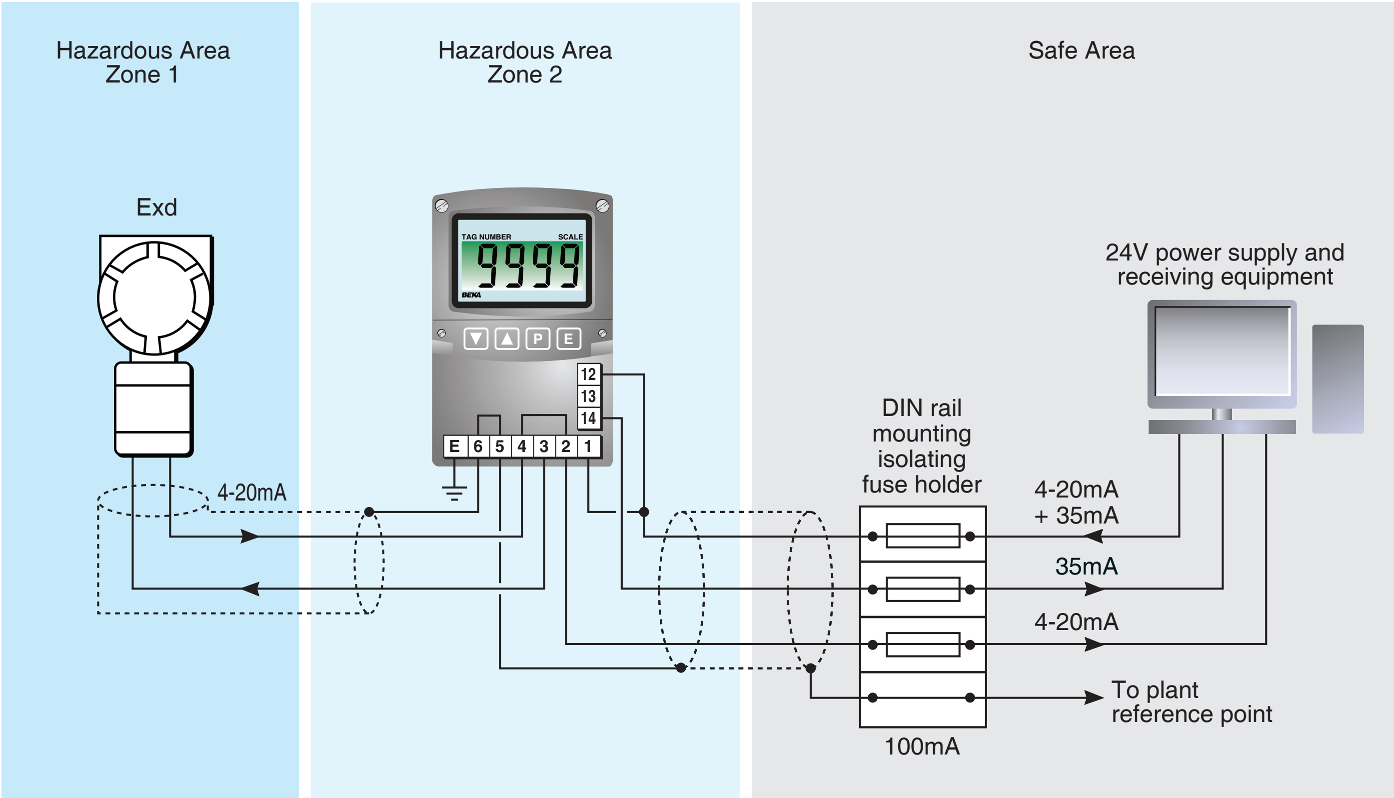


Figure 17. 4-20mA circuit and backlighting separately powered from a common power supply

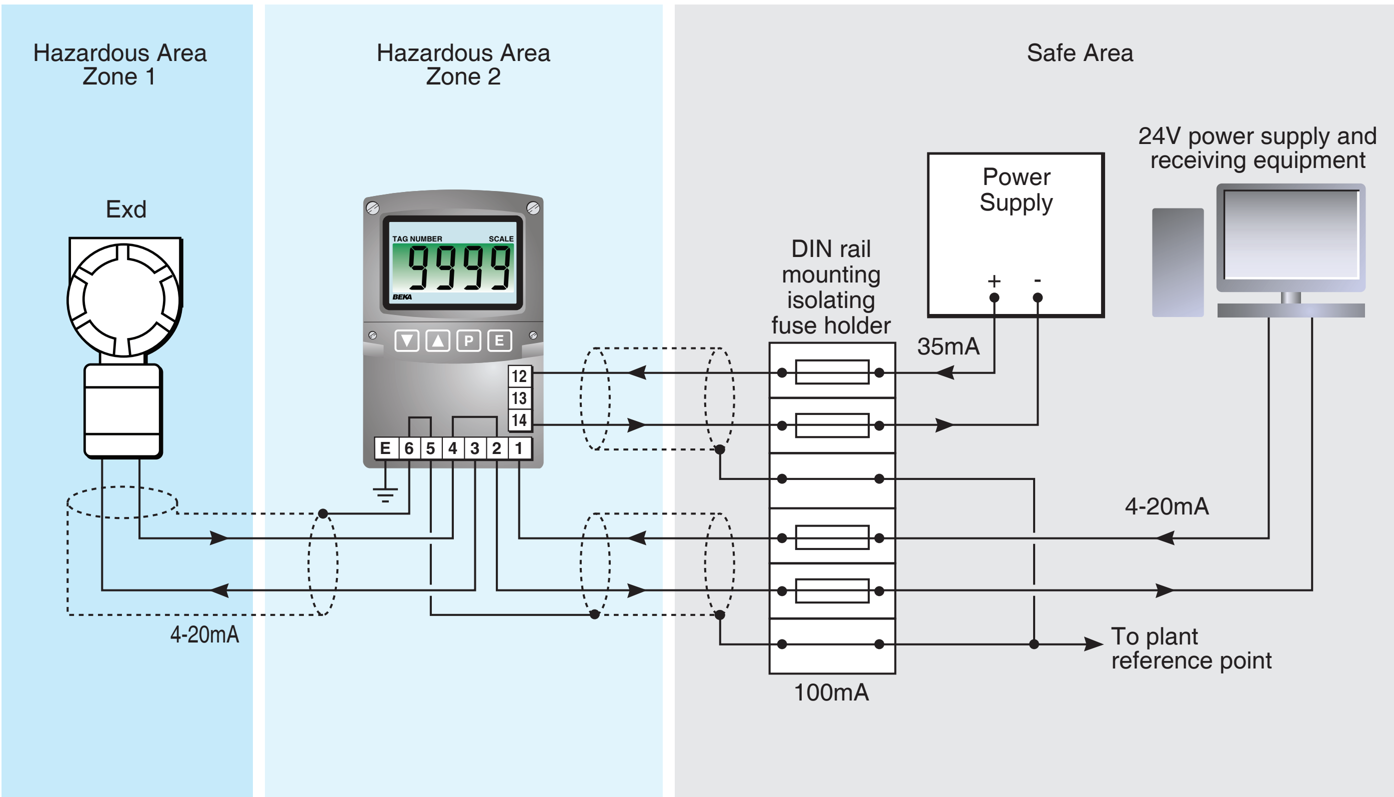


Figure 18. 4-20mA circuit and backlighting separately powered and isolated from each other

13. THE USE OF ALARMS

13.1 General

There are a large number of ways that alarm circuits are configured. Figure 19 shows the most commonly used circuit with the switch configured to be in the closed state in normal operation and opening on alarm. It is positioned in the 'live' side of the circuit so that any open circuit or fault to the screen or earth in the field wiring and a failure of the power supply will have the same effect as an open circuit switch and produce an alarm. This configuration is usually described as 'fail safe'.

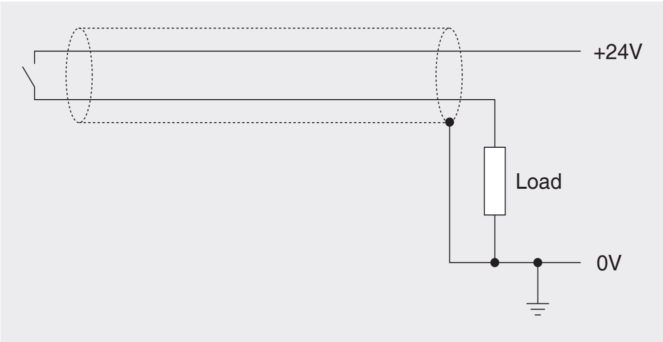


Figure 19. Basic alarm circuit

The fault that is not 'fail safe' is a short circuit of the cable which does not at the same time produce a fault to the screen, but this is not very probable. This problem can be removed by mounting two resistors near the switch as indicated in Figure 20 which simulates a proximity detector. This circuit requires the use of more complex receiving equipment and a means of mounting the resistors and consequently is not commonly used.

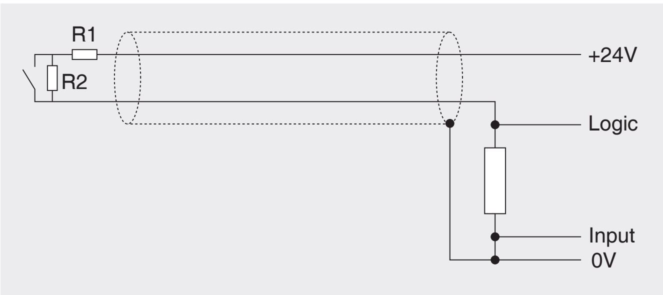


Figure 20. Higher integrity circuity

13.2 Indicator alarms

The indicators can be supplied with two factory fitted alarm modules, each with a single pole solid state switch output. Each output can be independently configured to act as a high or low alarm with a normally open or closed position in the alarm condition. When the power is removed by the 4-20mA signal failing, both alarm outputs fail to open circuit. This is a further reason for choosing to use the open circuit switch as the alarm condition as illustrated in Figures 19 and 20. When an alarm occurs an annunciator on the front panel is activated and if preferred the numerical display can be configured to alternate between the measured value and the alarm channel identification 'ALr1' or ALr2. The other configurable functions for each alarm are adjustable setpoint, hysteresis, alarm delay and alarm accept.

The switch is a galvanically isolated semi-conductor which provides complete isolation from other circuits and hence can be used in almost any location within an alarm circuit. The equivalent circuit of the switch is as illustrated in Figure 20 and its rating is decided by the Type nA certificate as 200mA, 30V. The switches only control a d.c. supply of the correct polarity, the positive being connected to terminal 8 or 10.The switches have a high voltage rating but they should not be used to switch highly inductive loads which are not adequately suppressed.

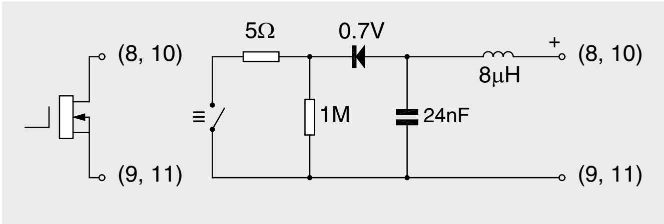


Figure 21. Equivalent circuit of each alarm output

13.3 Alarm circuits

The isolation of the switches is such that they can readily be used in many different ways and this document illustrates some of the more commonly occurring applications. The alarms are not usually suitable for use in the highest integrity shut-down circuits because circuits using the indicator alarms inevitably would have a large number of components in series and all the possible failures are very difficult to anticipate. However the alarms when used to monitor the status of an instrument or measured value provide a useful method of improving the detected failure rate in a SIL rated system. The examples which follow indicate typical applications of reasonable use of the alarms

It is important to recognise that provided that the indicator is mounted in a Zone 2 the switches can control equipment mounted in the safe area or in any of the hazardous area Zones. This concept is illustrated by the examples showing the use of 4-20mA indicators with various forms of explosion proof equipment. However the alarm switches cannot be used in an intrinsically safe circuit because the segregation provided by the galvanic isolator is not certified as being adequate for that purpose. Theoretically it is possible to devise techniques which would allow their use in intrinsically safe circuits but these are complex and not generally practicable and usually a better solution is to use an intrinsically safe indicator.

Figure 22 illustrates the alarm circuits being separately powered and wired so as to isolate the circuits from each other. The loads being driven illustrate the fact that these can be located in both the safe and hazardous area. The load in the hazardous area is shown as a valve in the Zone 2 but this load can be in any type of hazardous area provided that it is suitably protected. The hazardous area equipment and wiring is protected by 200mA fuses positioned at the safe to hazardous area interface so as to satisfy the certification requirements of the indicator. The value of the fuse is determined by the lowest permissible input current [Ii] of any of the equipment in the hazardous area.

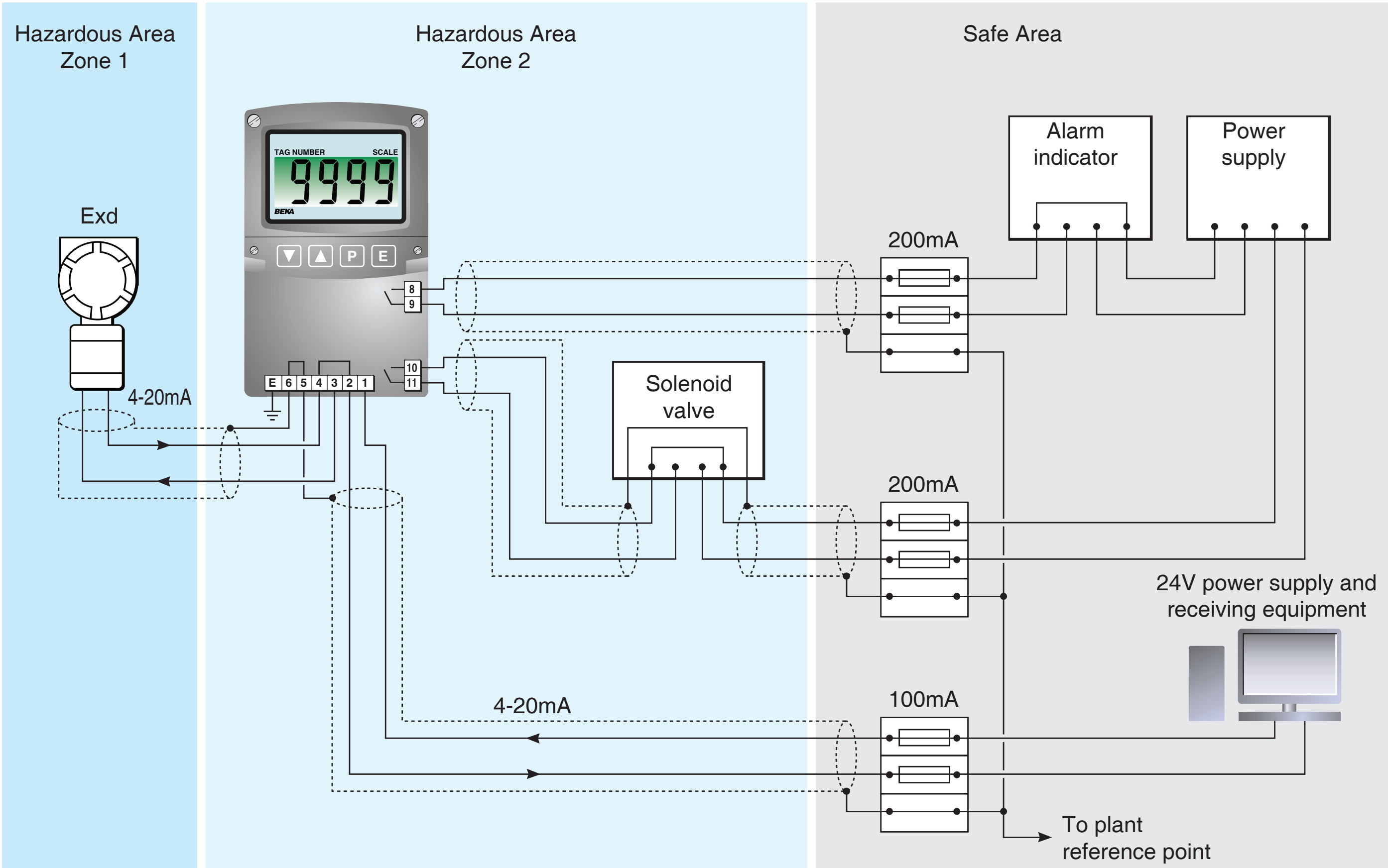


Figure 22. Possible application of indicator alarms

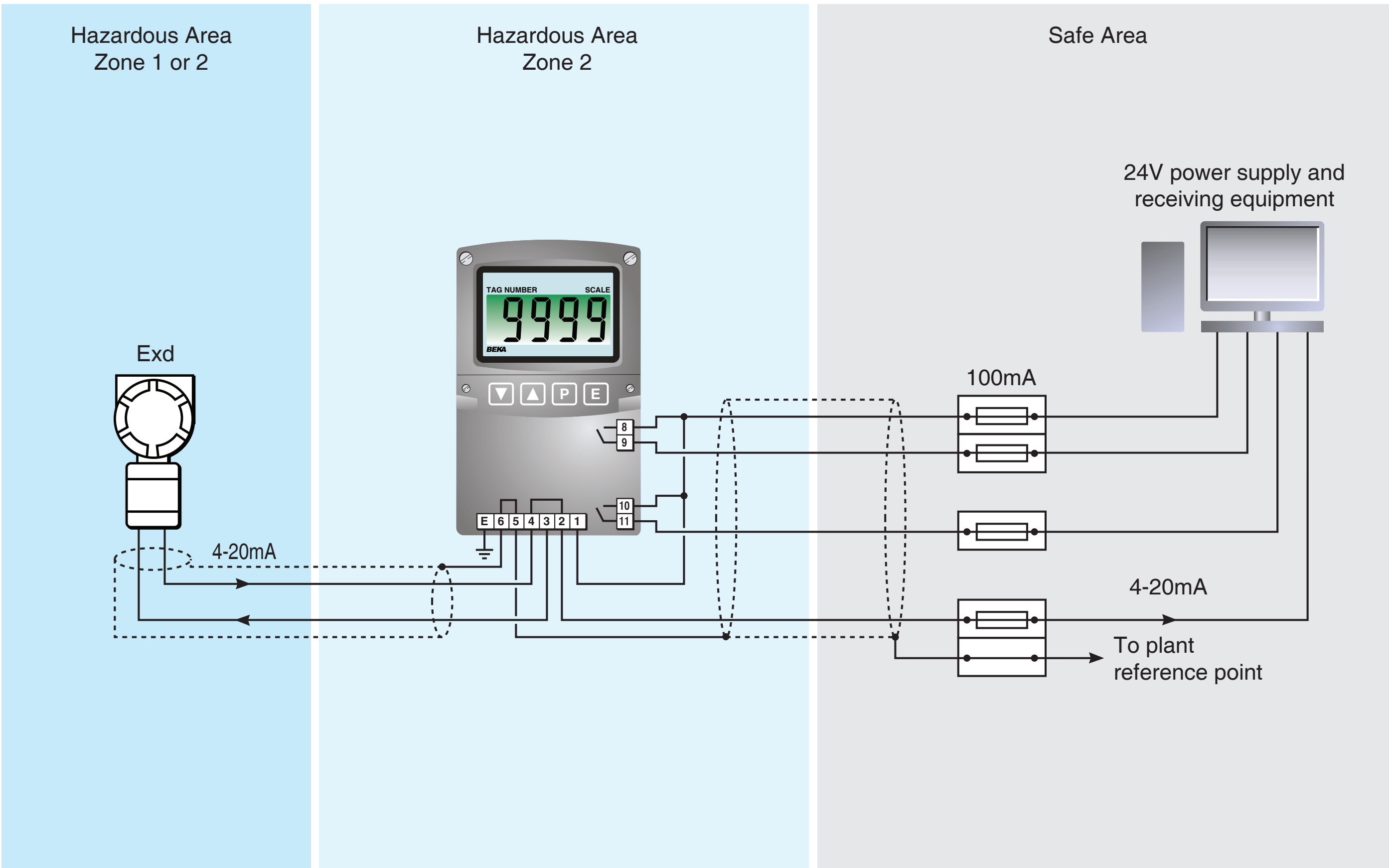


Figure 23. Alarms used with common supply

Figure 23 shows a commonly used configuration which transmits the alarm status back to the safe area. This circuit is frequently used to monitor deviations of the monitored value and if both alarms are open to show failure of the transmitter circuit. This example illustrates the use of a common lead to provide power to all three circuits so as to use fewer wires and fuses than if all the circuits where separately connected. The fuse value is reduced to 100mA as required by the indicator certification.

Figure 24 illustrates a possible technique which can be used for switching higher powers in the safe area. The suggested interface is the conventional intrinsically safe switch isolator which is an economic solution available from a number of suppliers.

It is not unusual to use these interfaces for non-intrinsically safe purposes and the normal practice is to indicate by some form of plant labeling that they are not being used in an intrinsically safe mode.Something simple such as 'Used in 'nA circuit ABCD' suffices. It is not necessary to use fuses in the input to the isolators since this is adequately defined by the isolator and 'live maintenance' can be safely carried out. The isolator illustrated is a two channel switch isolators, however there is available a large range of isolators with different capabilities any of which can be used in this type of application

13.4 Summary

The alarm functions available are an extremely flexible additional tool which can provide the solution to a number of indication and simple control problems.

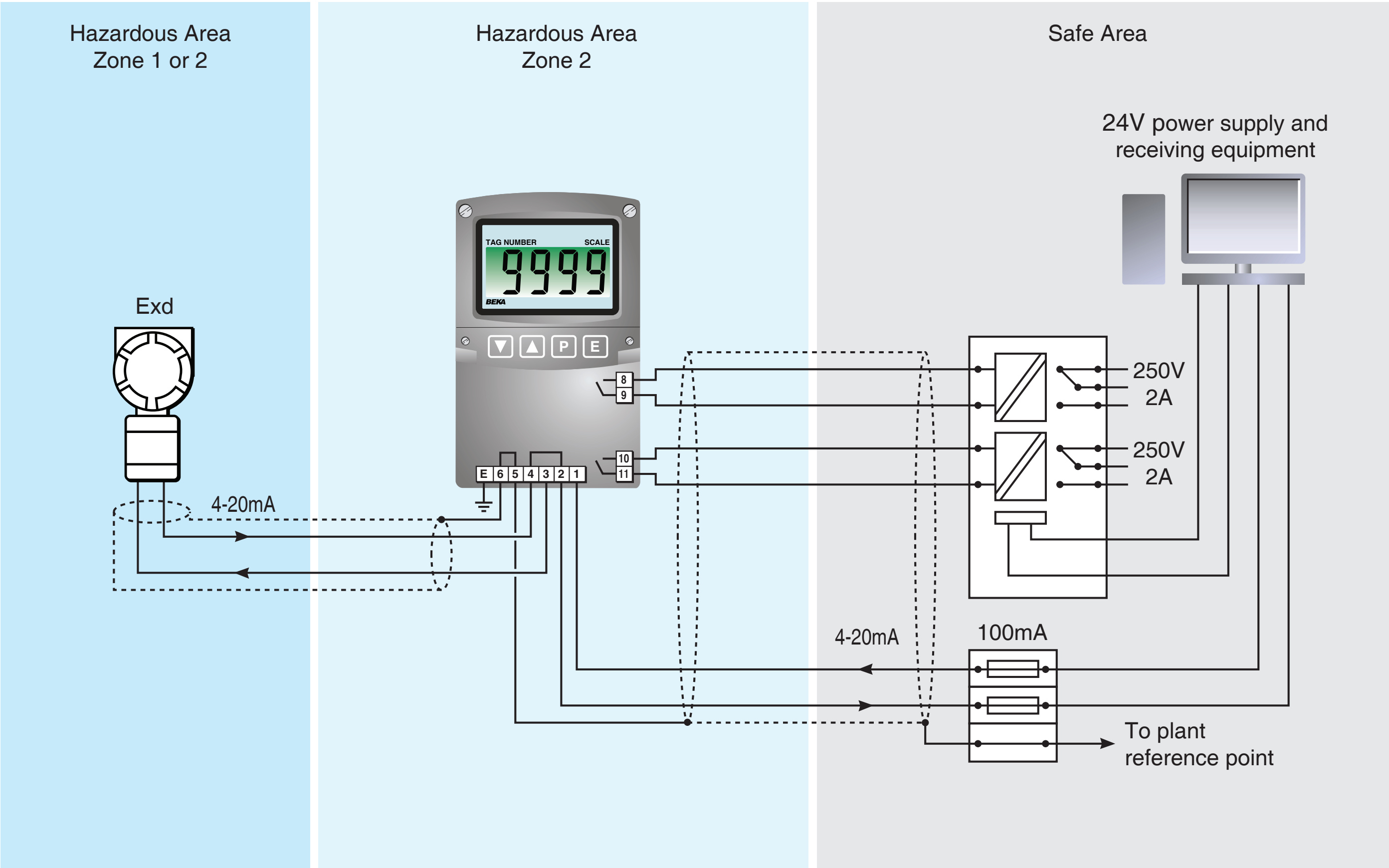


Figure 24. Alarms switching power apparatus in safe area

14. PANEL MOUNTING INDICATORS

In addition to the BEKA BA304NE and BA324NE field mounting 4-20mA indicators used to illustrate the installation requirements of extra low voltage d.c. 'nA' apparatus in this document, 'nA' panel mounting indicators BA307NE (4 digit) and BA327NE (5 digit) are also available. These instruments are electrically identical to the field mounting models, but are housed in a 'nA' component certified stainless steel panel mounting enclosure with unprotected rear terminals. A BA307NE is shown in Figure 25.

Figure 25. Picture of BA307NE

These indicators are frequently mounted in the door of an Ex e or Ex p enclosure together with suitably approved equipment such as switches and panel lamps to perform a specific function and it is this 'one-off' type of application that is discussed in this section.

The indicators are used to monitor 4-20mA signals which may be derived from equipment using any appropriate method of protection as described for the field mounting instruments. The panel mounting indicator enclosure must satisfy the requirements of the method of protection used and also preserve the ingress protection rating [IP] of the panel in which it is mounted. Figure 26 shows the enclosure mounted in a panel and illustrates the method of maintaining the integrity of the enclosure in which it is mounted.

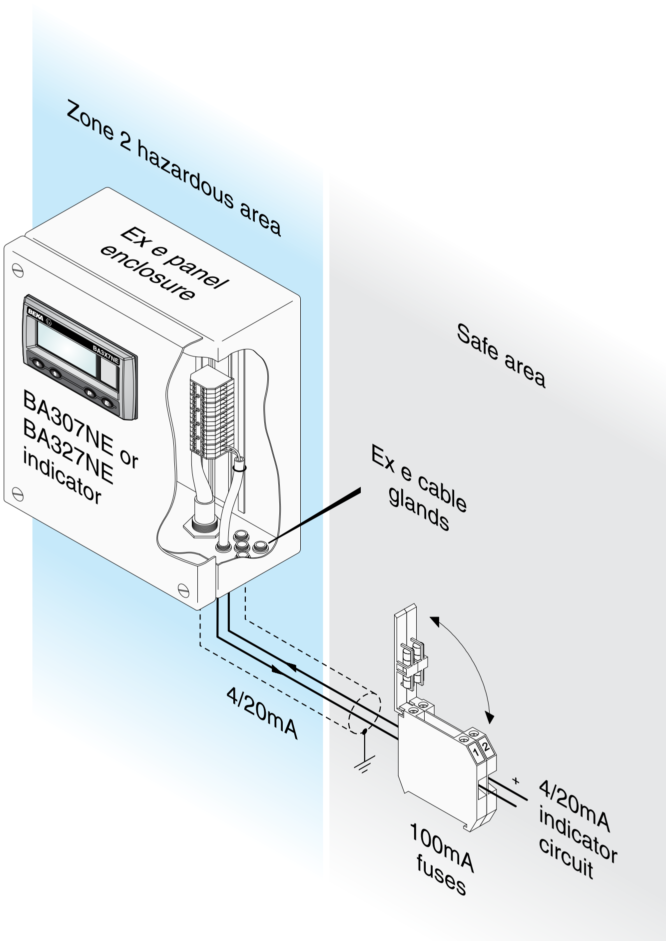


Fig 26. Typical Zone 2 installation in Ex e panel enclosure

14.1 Panel enclosure requirements

The requirements and test procedures for enclosures for use in hazardous areas are contained in IEC 60079-0 and are applicable to all methods of protection. Each of the methods of protection specifies its particular requirement for enclosure integrity based on the common requirements. The specified requirements are intended to give adequate protection against the industrial environment creating pollution, which impairs the safety of the electrical equipment. Inevitably the requirements are severe for some environments, but they have proved adequate for the majority of situations over a long period of time. Equipment surviving these tests also provides a reliable solution for use in non-hazardous harsh industrial environments.

The principal requirement is to achieve a level of protection against the ingress of dust and moisture. The tests applied determine an IP [ingress protection] rating, the meaning of which is summarised in Table 1 of this document.

The indicator enclosure is a stainless steel casting but uses a captive silicone rubber gasket to make a seal between the front of the casting and the panel in which it is mounted. In addition the keypad on the instrument face uses an elastomeric material. These items have to comply with the requirements for plastic enclosures and materials and their use means that the stainless steel panel mounting enclosure has to meet the requirements of both metallic and plastic enclosures. It is difficult to summarise the tortuous series of tests that are required but the flowchart of Figure 27 gives some indication of the severity and complexity of the required tests. It is fortunate that the personnel using the equipment are not subject to the same tests.

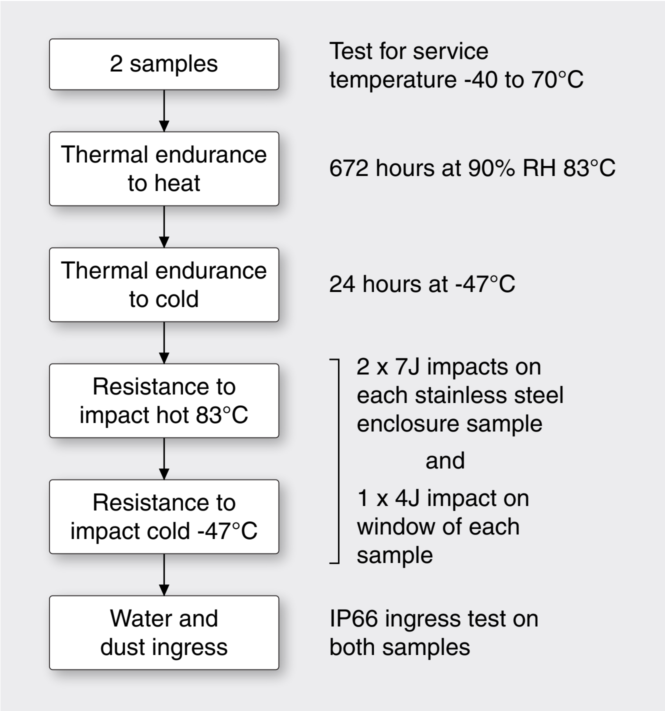


Fig 27. Sequence of enclosure tests

14.2 Use with specific methods of protection

The tests carried out demonstrate that when the BEKA stainless steel panel mounting enclosure is correctly installed, the combination results in a level of protection IP66 and satisfies the requirements of IEC 60079-0 which is confirmed by the Intertek test report G101377532, provided that the indicator is operating within the 'nA' input requirements.

The certificate calls for a 'limited energy circuit' but unfortunately this term is not defined in any IEC or CENELEC document. Since this supply is effectively the 'Um' of the 'ic'circuit, a reasonable interpretation is to determine the voltage by using a regulated 24V supply with adequate isolation from the mains supply. [clause 16.2.1 of IEC 60079-14 gives further guidance]. Any CE marked supply must comply with the Low Voltage Directive and can be considered adequate. Since short transient overloads are acceptable in Zone 2 locations the current limitation can be achieved by using a 200mA fuse. If the power supply is mounted within the Zone 2 enclosure it should be certified [nA] as suitable for that purpose. Non-rewirable fuses are permitted to be used in a Zone 2 enclosure since the rupture of the fuse is not considered as 'normal operation'.

The push buttons, which provide the means of configuring the indicator, have a level of protection 'ic' provided by circuitry within the instrument. The switches are not within the IP66 protected volume and consequently when used in a circuit which is not part of an intrinsically safe system the indicator can only be used with IEC Equipment Protection Level [EPL] Gc or ATEX Category 3 G enclosures, which are normally intended for use in Zone 2 locations.

For Zone 2 applications, the safety of the complete equipment is normally covered by a safety analysis created by the constructor, supported by copies of the certificates of the equipment used. ATEX requirements are satisfied by the documents being created by a competent person but Documents of Conformity can be obtained from third-parties if these are preferred. IEC standard IEC 60079-17 gives some indication on the compilation of the desired documentation but IEC Ex approval requires a Notified Bodies document.

Guidance on the preparation of a suitable document can be taken from Annex C of IEC60079-17 which discusses the creation of 'Fitness-for-purpose assessments'. It proposes an analysis of the risk based on existing standards by a 'competent person' and a compilation of the relevant certificates. It also proposes labelling the equipment with a label of the form shown in Figure 28.

SIRCH Ltd TYPE 16 LC
LU33 2ZX UK
Assessed as: II3G Ex nA e ic IIC T4
Assessment Report No: 14 0000 X

Figure 28 Typical equipment label

In addition consideration should be given to creating a test and fault finding procedure and the need for labelling and segregation so as to assist in carrying out this procedure safely.

The temperature classification of this type of system is awarded in normal operation and since the dissipation within the indicator is negligible [40mW] then the classification of the whole is not likely to be affected. The T5 temperature classification of the indicator has to be taken into account and sets the lower limit for the system. The service temperature of the indicator [-40°C to 70°C] is usually determined by the internal temperature of the system enclosure.

The BEKA panel mounting indicators BA307NE and BA327NE may be added to any non-intrinsically safe circuit illustrated in Section 8 provided that the 'nA' input parameters of the indicator and the parameters of the circuit are compatible. Provided compatibility is established then the Intertek certificate ITS14ATEX48028X adequately confirms the safety status of the instrument and its suitability for use in the applications discussed. It should be stressed that it is only the location of the indicator which is restricted to Zone 2. Other parts of the circuit may be in Zone 1 if suitably protected for their location.

Where the factory fitted optional alarms functions are used then Section 13 discusses their use and is applicable. The following notes consider the specific requirements when panel mounting indicators BA307NE and BA327NE are used with other methods of protection in Zone 2.

14.2.1 Ex nA EPL Gc/Cat 3G systems

The majority of EPL Gc or Cat 3G systems are combinations of Ex e enclosures and Ex e components such as push buttons, terminals and panel lamps. The method of mounting the panel indicator maintains an ingress protection level of IP66, however the usual requirement for 'nA' equipment is IP54 and the use of the indicator should be regarded as maintaining the IP rating of the system. It does not improve it.

All the requirements of the previous section are applicable and the need for labelling of terminals and the door of the enclosure should be considered. A common mistake is to make the enclosure too small. It is usual to use 'Ex e' glands and provide the holes for additional glands [suitably plugged] and possibly drain plugs consequently the size of the gland plate frequently defines the enclosure size. Similarly it is desirable to segregate the wiring and terminals of low voltage instrument wiring from higher voltage wiring and terminals. In addition terminals to permit the termination or feed-through of screens are necessary. All these factors require space and the folk lore that you should carefully work out the size of the enclosure and specify the next larger size is fully justified if a little conservative.

14.2.2 Ex ec EPL Gc/Cat 3G systems

If a BEKA indicator, which is not part of an intrinsically safe system is added to an Ex e system then the system may only be used in Zone 2 applications because of the 'ic' rating of the push buttons. The system becomes a hybrid nA/e system and is effectively an 'nA' system.

14.2.3 Ex p EPL Gc/Cat 3G systems

The indicators can be used with Zone 2 pressurised enclosures since they are adequately ventilated by four vents in the rear surface as illustrated in Figure 29. The integrity of the enclosure [usually IP4X] is maintained and the indicator can be used in any circuit that is acceptable in Zone 2. The power dissipation within the indicator has negligible effect on the temperature within the enclosure

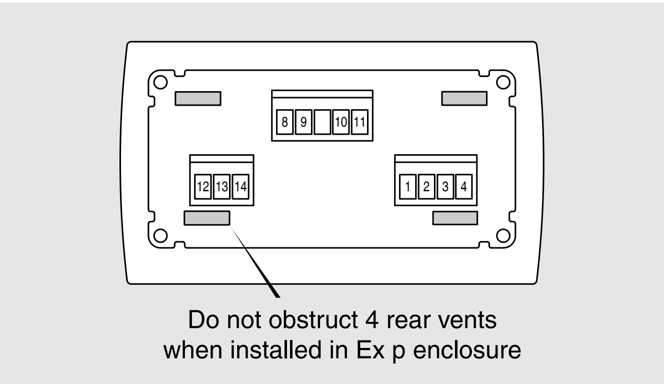


Figure 29. Rear of indicator venting holes

14.3 Conclusion

A loop powered indicator contained in a robust panel mounting enclosure and operated within Ex nA input paramters can be used with almost all other methods of protection. A successful application is ensured by the careful documentation of the complete assembly which should explain how an acceptable level of safety has been achieved.

15. FUTURE PROOFING

The IEC and CENELEC are in the process of replacing the Zone 2 techniques with variations of the other methods of protection. For example 'Ex ic' has replaced 'Ex nL' equipment and the intention is to replace 'Ex nA' apparatus with 'Ex ec'. The timescale for this change is not well defined, possibly the relevant 'Exe' standard will emerge in 2015-16 and the transition will occupy the next 5 to 10 years. It is hoped that the changeover will take place with the minimum of change but some difficulties will probably emerge. Rewriting standards is never accomplished without pain. However it is unlikely that the techniques discussed in this document will need to be changed significantly since the fundamental requirements for Zone 2 are not being changed.

Perhaps more importantly it is almost certain that existing installations will still be considered adequately safe. The transition will also be managed over a period of time so that systems under construction can be completed and the supply of spares assured. There will be a need for recertification and possibly dual certification. Fortunately the transition from 'Ex nL' to 'Ex ic' has preceded this change and with luck most of the problems will have been solved and will not be repeated.

Appendix A

Relevant Standards

The design and installation of equipment for use in hazardous areas is covered in international standards created by the International Electrotechnical Commission, the IEC. The applicable standards are all contained in the IEC 60079 Series. For European purposes these standards are then converted to Cenelec standards known as EN standards. These standards have an identical 60079 number and content plus Annexes which clarify the interaction of the standard with the requirements of the ATEX apparatus directive EC 94/9/EC. For this reason if compliance with the ATEX directive is required it is better to use the EN version of the standard. BSI produce the English language version of the EN standard as a BS EN. It is important to realise that the standards are a statement of the requirements and are not intended as a primer on the subject. The assumption is made that the user of the standard has some expertise in the use of electrical equipment in hazardous atmospheres.

The list which follows is not comprehensive but concentrates on the standards which are relevant to 'nA' instrumentation, The list uses the IEC numbers but these can be converted to Cenelec standards by replacing the IEC by EN and to British standards by replacing the IEC with BS EN

IEC 60079-0 Explosive atmospheres - Part 0: Equipment - General requirements
Contains all the requirements which are common to more than two methods of protection. For example the requirements for impact resistance and the avoidance of static risk relevant to 'nA, apparatus are included in this standard. Some requirements of this standard are excluded in the standards for the particular methods of protection

IEC 60079-10-1 Explosive atmospheres – Part 10 – 1: Classification of areas - Explosive gas atmosphere
Contains guidance on area classification with some examples.

There are a number of other documents created by organisations such as the Institute of Petroleum which provide guidance on the area classification of particular locations which are very useful in making what can be a very difficult decision.

IEC 60079-11 Explosive atmospheres - Part 11: Equipment protection by intrinsic safety 'i'
Contains the tables and curves needed to analyse whether 'live maintenance' is adequately safe

IEC 60079-14 Electrical apparatus for explosive gas atmospheres - Part 14: Electrical installations in hazardous areas (other than mines)
This standard attempts to be comprehensive so that installers do not need to obtain all the other standards. The section on 'nA' apparatus is brief, but the general information on wiring is comprehensive and applicable,

IEC 60079-15 Electrical apparatus for explosive gas atmospheres- Part 15: Construction, test and marking of type of protection 'n' electrical apparatus.
Base document

IEC 60079-17 Explosive atmospheres - Part 17: Electrical installation inspection and maintenance.
Contains details of 'live maintenance' permitted in Zone2.

IEC 60079-20 Electrical apparatus for explosive gas atmospheres – Part 20 Data for flammable gases and vapours relating to the use of electrical apparatus.
Does what it says in the title.

These are the 'explosive atmosphere' standards particularly relevant to this document. There are many more related standards covering other aspects which affect the design and use of this type of indicator.