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Fieldbus Non-Incendive Concept takes FISCO into Zone 2 and Division 2 hazardous areas

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Abstract: The Fieldbus Intrinsically Safe Concept (FISCO) is recognised as having significant benefits for FOUNDATION™ fieldbus networks, compared with the original Intrinsic Safety 'Entity' model: more fieldbus instruments can be connected in the hazardous area, and users need to spend less time justifying and documenting the safety of a given installation.

In Zone 2 and Division 2 hazardous areas, the principles of FISCO may be applied with equal benefit to Non-incendive (Ex n) wiring, whilst taking advantage of the relaxed factors of safety appropriate to the lower level of risk. The resulting technique, FNICO – the Fieldbus Non-Incendive Concept - has the same ease of use as FISCO, but with even more power available to the fieldbus trunk while retaining the live-workable nature of the field wiring.

The paper discusses the practical considerations of designing, installing and maintaining a FNICO fieldbus network, and compares the technique with the alternative protection methods that may be considered for fieldbus in Zone 2 and Division 2 hazardous areas. The status of the draft FNICO Technical Specification and its recognition by the national approvals authorities will also be considered.

Keywords: Foundation Fieldbus, FISCO, FNICO, Hazardous Areas, Digital Network

1. FISCO benefits for Intrinsically Safe fieldbus

The use of Fieldbus in flammable atmospheres has benefited from the recent introduction of FISCO – the Fieldbus Intrinsic Safety Concept. When compared with intrinsically safe fieldbus systems installed according to the conventional, “Entity” concept, FISCO simplifies the rules that govern energy storage in field cables, and makes more power available to the fieldbus trunk. The resulting arrangement means that a greater number of fieldbus instruments can be connected in the hazardous area, and users need to spend less time justifying and documenting the safety of a given installation.

FISCO is the result of experimental work carried out by PTB in Germany, prompted by the practical limitations of the ‘Entity’ concept when applied to intrinsically safe bus systems. PTB’s research showed that, provided the inductance and capacitance per unit length of field cables are within defined limits, the risk of spark ignition does not increase with the total length. This makes the safety of the installation independent of cable lengths, and eliminates the need to calculate cable parameters or match them to the maximum allowable figures for the source of intrinsically safe power. The safe operating levels of power supplies with electronic current limiting were also established. Such supplies, having an EEx ib (safe with one fault) category, can deliver more power than resistor-limited supplies and are safe for use with field instruments in areas where flammable gases may be present in normal operation.

2. FNICO: applying FISCO to Non-Incendive fieldbus

Although conceived for intrinsically safe fieldbus circuits, the principles of FISCO may be applied with equal benefit to bus circuits in Zone 2 and Division 2 hazardous areas, where the explosion hazard is expected to exist only in abnormal circumstances. Here, the rigours of intrinsic safety are not mandatory (although they may be applied for extra levels of security), and a lower level of protection is acceptable to match the reduced risk. Type of protection ‘n’ for Zone 2 and non-incendive protection for Division 2 are well-established techniques, and it is to these that FNICO – the Fieldbus Non-Incendive Concept – has been applied. FNICO therefore brings the benefits of FISCO into the arena of Zone 2 and Division 2, and also exploits the relaxed requirements in terms of factors of safety on voltage and current. The resulting rule set has the same ease of use as FISCO, with even more power available to the fieldbus trunk, while retaining the live-workable nature of the wiring.

3. Area Classification prompts a reappraisal

The process of ‘Area Classification’ determines the probability that a flammable atmosphere will exist in a given location in a process plant, and hence whether it is a Zone 0, 1 or 2. In very simple terms, a space in which a flammable gas occurs continuously is classified as a Zone 0, one in which the hazard may occur in normal operation is a Zone 1, and an area in which a flammable hazard is not

expected to occur (or if it does will persist for only a short period of time) is a Zone 2.

The responsibility for Area Classification rests with the plant operator, who must address the probability that flammable material will escape from the pipes and vessels. Other individuals in the organisation will be concerned with the outcome of the exercise and will ask questions such as, "How does it affect the siting of electrical apparatus?" So there is clearly a financial aspect to area classification, as well as a purely technical one.

Meanwhile, the intrinsically safe instrumentation that has been in use for many years has the advantage that it is usually certified for the most onerous area classification and is therefore independent of the Zone of use. This has the benefit that the instrument engineer does not need to be concerned about the re-zoning of an area from a Zone 2 to a Zone 1, due for example to a change in the process during the life of the plant. Intrinsic safety may also be selected as the protection technique for a new plant or installation before the result of the area classification is known, in the knowledge that it will be adequately safe whatever the outcome. These factors have to some extent reduced the emphasis on distinguishing between Zone 1 and Zone 2, and in some instances have contributed to 'blanket' Zone 1 classifications.

However, influences are at work that are causing a re-appraisal of area classification practice, with greater emphasis on realistic rather than over-cautious zoning. In particular, environmental and hazard analysis considerations are sensitive to the amount of Zone 1 hazardous area, which can have the connotation of a 'leaky' or poorly controlled process. European Directive 94/9/EC (the "ATEX" Directive) has brought with it new restrictions on the type of activity that can be conducted in Zone 1, thereby encouraging plant operators to look for ways of relaxing to Zone 2. The transition to a Zone 2 policy is also helped by the availability of a new breed of instrumentation specifically designed and certified for Zone 2. This has in turn been encouraged by the publishing in 1999 of the CENELEC standard for type 'n' electrical apparatus, EN50021. So while intrinsic safety retains its position as the safest technique for any zone of use, EEx n apparatus promises reduced capital and maintenance costs while being adequately safe in Zone 2.

The financial benefits of a Zone 2 approach for instrumentation are seen in reduced capital expenditure and lower operating costs during the life of the plant. In the case of FNICO, the capital savings are a direct result of needing fewer fieldbus power supplies for a given number of field instruments when compared with the intrinsically safe FISCO alternative, while life-cycle savings derive from relaxed working practices in Zone 2.

4. Ex n as a protection technique for fieldbus

A key requirement for any fieldbus system is the ability to add or disconnect instruments on the bus without loss of data or having to remove power from the whole bus. If the bus is in a hazardous area, this means the certification must take into account some activity on the field wiring while under power. For bus circuits in Zone 1, the choices are clear: it must either be intrinsically safe, or if protected by the flameproof (Ex d) technique, then some form of approved live-workable plug and socket must be included in the spur connections between trunk and field device. If such an arrangement is not included, then live-working must only be carried out if the area is known to be free of gas.

In Zone 2, the Ex i and Ex d approaches may also be applied, but Ex n is capable of delivering the same levels of flexibility for live working as Ex i while introducing other benefits that derive from the relaxed requirements in Zone 2. The key to the success of the Ex n apparatus standard in this respect is that it actually embraces a number of different protection methods. Among these is the 'energy limited' method, which holds to the same principles as intrinsic safety and is judged against the same set of 'ignition curves'. In North American practice, this type of wiring is known as 'Non-Incendive', as opposed to 'Non-Arcing'. Apparatus designed according to the energy-limited concept is marked Ex nL. Where Ex nL differs from intrinsic safety is in the factor of safety that is applied and consideration of faults. Table 1 illustrates the point:

Protection method	Certification code	Safe with how many faults?	Factor of safety applied to current	Zone of use
Intrinsic safety, category ia	EEx ia	2	1,5	0, 1 and 2
Intrinsic safety, category ib	EEx ib	1	1,5	1 and 2
Energy-limited	EEx nL	none	1,1	2

Table 1: Comparison of requirements for EEx i and EEx n

In practical terms, the reduction in safety factor means that the output from a Zone 2 power supply, for example, can go closer to the point of ignition on the ignition curves than an intrinsically safe supply. It can therefore deliver more power into the hazardous area, which is a very desirable characteristic for fieldbus systems. The relaxed consideration of faults has potential cost savings for manufacturers of EEx n apparatus, but importantly, the opening or shorting of energy-limited wiring is not considered as a fault and may be carried out in the presence of gas. EEx nL wiring may therefore be treated in the same way as intrinsically safe wiring as far as live-working is concerned.

The combination of the energy-limited technique and FISCO principles has a number of advantages over the alternative protection techniques that are

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commonly used in Zone 2 and Division 2 – both in terms of hardware cost and ease of use.

5. Assembling a FNICO system

A typical FNICO installation is illustrated in Figure 1. The key physical layer components are the FNICO power supply, field cables, field wiring termination components and of course the fieldbus instruments.

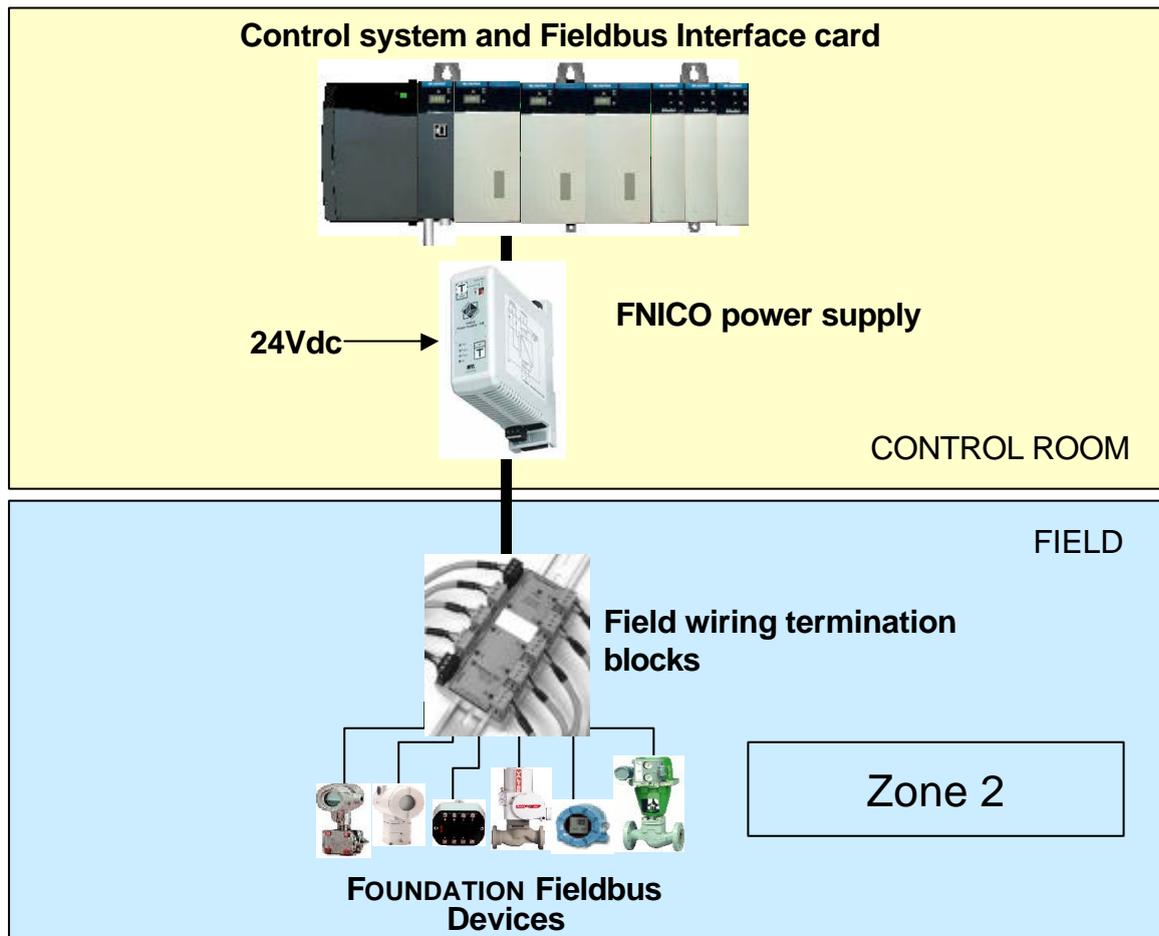


Figure 1: Typical FNICO system

5.1. The FNICO power supply

In the simplest case, the power supply is located at the interface between the safe and hazardous areas. Connections to the host control system are made at its 'safe area' terminals, and those to the field trunk at its 'hazardous area' terminals. It combines the functions required for reliable fieldbus communications (as defined by the appropriate FOUNDATION Fieldbus standards) with those of an energy-limited interface. In simple terms, this is like building an intrinsic safety barrier into the output of a fieldbus power supply, except in this case the barrier complies only with the requirements for Zone 2 as already defined in Table 1. The voltage, current and power available at its output – and hence the number of field instruments that can be supported - are determined by the Gas Group for which it is designed.



Figure 2: FNICO Power Supply

5.2. Supply modules

A typical FNICO power supply is illustrated in Figure 2. This incorporates a repeater function, connections for 24Vdc supply input, and a switchable terminator. If placed inside a suitable enclosure, it is capable of being located in a Zone 2 or Division 2 hazardous area; this expands the flexibility and allows more complex topologies to be considered.

6. Field cables

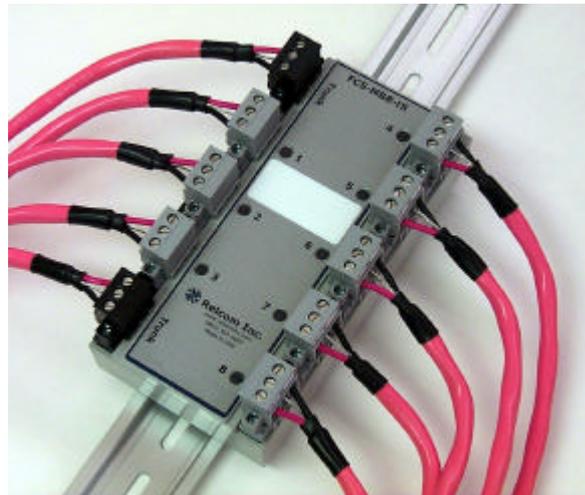
Field cables in a FNICO system are defined by the normal operational requirements for FOUNDATION Fieldbus H1, and by the energy-storage considerations required for safety – but neither imposes an onerous burden. Operationally, cables that are considered acceptable for safe area installations can be used. These can include specially-constructed types for fieldbus applications and (with some limitations on cable length), existing cable from legacy analogue installations. The safety constraints for FNICO cables are the same as those for FISCO, and are given in Table 2. These are readily met by most conventional cable types.

Parameter	Value
Loop resistance	15Ω/km to 150Ω/km
Loop inductance	0,4mH/km to 1mH/km
Capacitance	80nF/km to 200nF/km
Maximum length of each spur cable	30m in IIC and IIB
Maximum length of each trunk cable	1km in IIC and 5km in IIB

Table 2: FNICO cable requirements

6.1. Wiring components

The growth of fieldbus has prompted the introduction of specially-designed wiring hubs from a number of different manufacturers. Typically these take the form of a module with pre-assigned trunk and spur connections, possibly built into a field-mountable junction box. Such devices save the installer the time and complexity of having to assemble an equivalent unit from standard DIN-rail mounted terminals. In a FNICO system, the requirements are simple: the wiring hub and its enclosure must be certified for Zone 2 or Division 2 as appropriate, and suitable for the environment. In practice this is not difficult to achieve; suitably approved wiring components are available from a number of manufacturers for installation in a junction box of the user's choice. Under IEC practice, an increased safety (EEx e) enclosure is a good choice since this is readily available in a variety of sizes and materials. Note that Flameproof (EEx d) or US Explosion proof enclosures are *not* necessary in Zone 2 or Division 2.



7. Field instruments

Currently, there are not many fieldbus instruments, which are specifically certified for use in Zone 2 'EEx nL' circuits. The situation is somewhat different in North America, where it is not uncommon for instruments to be given 'non-incendive' field wiring parameters for Division 2 at the same time as being approved for use in intrinsically safe circuits. But FNICO again exploits the relaxed regulations for hazardous areas of abnormal or infrequent hazard by drawing on the readily available portfolio of IS certified fieldbus instruments. In short, IS instruments can

be used in a FNICO system. The safety case is easily made: an IS instrument is designed to be safe in Zone 1 or 0 and therefore exceeds any constructional requirements for Zone 2. It has maximum values of input voltage, current and power that must not be exceeded, whereas the FNICO power supply has equivalent values assigned to its output. Compatibility is established by comparing the two sets of figures, but it is in fact only the voltage parameters that need to be satisfied since the maximum current and power are never delivered *in normal operation*. FNICO systems can therefore be assembled using IS certified devices, and in practice devices with both 'Entity' and FISCO approval can be used.

Documenting the safety of a FNICO installation

The rules for describing the safety of a FNICO system closely follow those for FISCO. In line with FISCO, there is no need to calculate maximum permitted cable lengths, provided the cable complies with Table 2.

In simple terms the steps are as follows:

1. Confirm that the cable conforms to the FISCO/FNICO requirement.
2. Check that all field instruments carry an EEx nL, non-incendive or intrinsic safety approval.
3. Check that field wiring components and terminators carry suitable approval.
4. If the field instruments are not FISCO or FNICO certified, check that the maximum *safety* input voltage, U_i of each instrument is greater than the output *safety* voltage, U_o of the FNICO power supply.
5. List the components included in each trunk, noting manufacturer, model number, method of protection, ambient temperature and Temperature Classification.

Although the concept of 'simple apparatus' is not recognised in the CENELEC standard EN50021 or Code of Practice for Zone 2, the principle of non-energy storing apparatus can be applied to non-incendive systems in the same way as for intrinsic safety. Items such as passive wiring components and enclosures do not contribute energy to the non-incendive circuit and may therefore be included without modifying the safety analysis.

Figure 3 is an example of the documentation for a typical FNICO system.

7.1. Example: Safety documentation for a FNICO system

System title: Typical Installation							
Conclusion							
<p><i>This safety document demonstrates that the FNICO system described satisfies the requirements of a IIB non-incendive system in which the field devices mounted in the hazardous area all have a T4 temperature classification and can be used in the ambient temperature range of -30°C to +60°C.</i></p> <p><i>The cable used for the non-incendive trunk and spurs is UNITRONIC BUS PA blue, type 2020234 T and has parameters compatible with the FISCO/FNICO requirements, and has a useable temperature range of -30°C to +60°C.</i></p>							
Equipment used							
Item number	1	2	3	4	5	6	7
Description	Power supply	Wiring termination unit	Terminator	Field Enclosure	Temperature Transmitter	Pressure Transmitter	Flow Transmitter
Manufacturer	MTL	Relcom	MTL	Boxco	Tempex Industries	Force Instruments	Surf
Model number	9112-NI	FCS-MB8	FBT1-IS	JB-18	THC22	BAR-976	Wizwirl 323e
FISCO/FNICO	FNICO	-	FISCO	-	FISCO	-	-
Approval classification	[EEx nL]	EEx nAL	EEx ia IIC	Simple Apparatus	EEx ia	EEx ia	EEx nL
Gas Group	IIB	IIC	IIC		IIC	IIC	IIC
Temperature Classification	N/A	T4	T4	-	T4	T4	T4
Certificate number	Baseefa02 ATEXxxxx	Relcom 500-047	Baseefa02 ATEX0042	-	XXX02ATEX0001	YYY01ATE X002	ZZZ01ATE X003
Temperature range	-40°C to +70°C	-45°C to +70°C	-40°C to +70°C	-45°C to +85°C	-40°C to +85°C	-40°C to +80°C	-40°C to +80°C
Safety voltage (where applicable)	Uo=14.8V	-	-	-	-	Ui=24V	Ui=32V

Figure 3: Safety documentation for a typical FNICO system

In summary

As the take-up of fieldbus accelerates in the process industries, there will be a growing emphasis on finding workable solutions for hazardous areas. Among the available techniques, those which deliver the most flexibility and lowest life-cycle costs will emerge as favourites.

Key questions to be asked when planning a fieldbus network in a hazardous area are:

- Is the area in which the fieldbus is to be installed classified as Zone 2 or Division 2?
- Is there a site preference for non-intrinsically safe apparatus?
- Is it desirable to avoid the use of flameproof/explosionproof housings for field junction boxes?
- When connecting or disconnecting fieldbus instruments on the fieldbus trunk, is it desirable to avoid the use of specially-designed hot-pluggable connectors?
- Is it desirable to avoid using gas clearance procedures when working on the bus?

If the answer to these is 'yes', then FNICO may be considered as an appropriate technique.

The speed with which FNICO becomes established will depend on the extent to which the FNICO Technical Specification is absorbed into national standards, and recognised by field instrument manufacturers. At the time of writing (August 2003), a draft of IEC 60079-27 which includes both FISCO and FNICO requirements has been circulated for comment to the national committees represented on the IEC SC31G Intrinsic Safety committee.