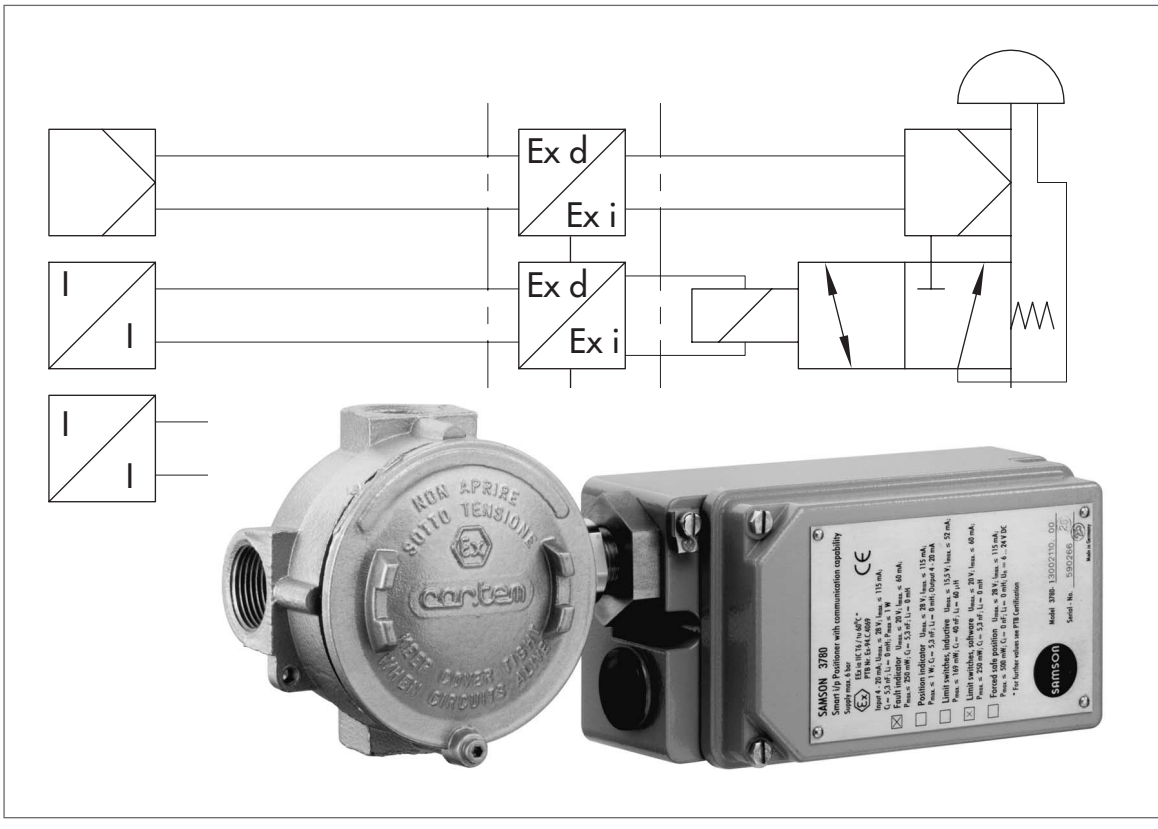
Intrinsic safety and flameproof enclosure - an impossible team in explosion protection?



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Intrinsic safety and flameproof enclosure - an impossible team in explosion protection?

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The increasing application of digital field devices in process automation has revived the discussion about the best type of protection for instrumentation used in hazardous areas. The large number of electrical components integrated in microprocessor-based devices requires more precautions to be taken per field device in order to ensure explosion protection. A positioner designed for pneumatically operated control valves is used to demonstrate different solutions.

Eigensicherheit und druckfeste Kapselung - ein unmögliches Team im Explosionsschutz?

In der Verfahrenstechnik werden Mess-, Steuer- und Regeleinrichtungen (MSR) häufig in Prozessen eingesetzt, in denen brennbare Gase, Dämpfe oder Nebel aus den geschlossenen Systemen an die Umgebung gelangen können und damit in bestimmten Mischungsverhältnissen mit dem Sauerstoff der Luft explosionsfähig sind. Die elektrischen Betriebsmittel der MSR-Technik können eine Entzündung dieser explosionsfähigen Atmosphäre verursachen, welches durch geeignete Maßnahmen des Explosionsschutzes zu verhindern ist. Grundsätzlich können primäre Explosionsschutzmaßnahmen, die eine Bildung gefährlicher, explosionsfähiger Atmosphären verhindern, und sekundäre Explosionsschutzmaßnahmen, die eine Entzündung dieser gefährlichen, explosionsfähigen Atmosphären verhindern, unterschieden werden. Elektrische Betriebsmittel mit integrierten sekundären Explosionsschutzmaßnahmen sind dort notwendig, wo primäre Maßnahmen nicht bzw. nur unzureichend anwendbar sind. Diese elektrischen explosionsgeschützten Betriebsmittel müssen nach den Baubestimmungen der jeweils gültigen Normen (beispielsweise Reihe EN 50014 ff für den Bereich der Europäischen Gemeinschaft) in einer sogenannten Zündschutzart ausgeführt werden. Da die verschiedenen Zündschutzarten sicherheitstechnisch in der Praxis als gleichwertig zu betrachten sind, ist die realisierte Zündschutzart eines Gerätes von Funktion und Art des elektrischen Betriebsmittels und der Ökonomie der Umsetzung abhängig.

1. Introduction

In process engineering, measurement and control equipment is frequently used in processes in which flammable gases, vapors or dust could escape from closed systems to the environment where they become explosive in certain ratios of mixture with oxygen. The electrical apparatus used in measurement and control technology can cause an explosive atmosphere to ignite which must be prevented by the appropriate explosion protection measures. There are basically two types of measures: primary explosion protection measures which prevent the formation of hazardous or explosive atmospheres and secondary explosion protection measures which prevent the ignition of these hazardous and explosive atmospheres. Electrical apparatus with integrated secondary explosion protection features is required for all those applications where primary measures cannot be applied or can only be applied insufficiently. The design of the explosion-protected electrical apparatus must be in accordance with the so-called type of protection as per construction regulations of the applicable standards (e.g. EN 50014 ff. series of standards for the European Union). Since the different types of protection can be practically considered the same as regards the safety, a device's actual type of protection depends on the function and the type of electrical apparatus as well as how economical the design is.

2. Types of protection in measurement and control technology

The *flameproof enclosure 'd'* and *intrinsic safety 'i'* types of protection are primarily applied for apparatus used in measurement and control technology. These two types of protection, however, are based on completely different principles. In case of a flameproof enclosure, the electrical devices, which can cause an explosive atmosphere to ignite, are placed in an enclosure which withstands an internal explosion and prevents the explosion from being transmitted to the explosive atmosphere surrounding the enclosure. The concept of intrinsic safety relies on limiting the current and voltage in the respective circuit. Thereby, the energy in the circuit is reduced so much that neither sparks nor an impermissible temperature rise of the surface of the electrical components can cause the surrounding atmosphere to ignite. Although these two types of protection provide advantages which can be directly used for the apparatus, they also have disadvantages due to the system, but these can be reduced to a minimum depending on the field device used.

3. Flexible device design

The device manufacturers' primary aim has been and still is to design devices which can be used for both types of protection because of their uniformity, modular-assembly design and mostly identical spare and wear parts. An analog electropneumatic valve positioner is used to illustrate that today's recognized state of the art makes it possible to design devices which achieve the aim mentioned above despite the basically different principles on which the different types of protection rely. A compact pneumatic positioner serves as the basic element of such a device design.

Fig. 1: Control valve with compact pneumatic positioner

In order to activate the positioner electrically, it is sufficient to equip the positioner with one i/p converter module which, for the purpose of intrinsic safety, can be designed to require especially low power because the internal positioning control loop functions purely pneumatically.

Fig. 2a: Electropneumatic positioner

The need for only one i/p converter module also has an advantage for the *flameproof enclosure* type of protection because not the whole positioner, but only the i/p converter module as the only electrical component has to be placed in a flameproof enclosure.

The positioner remains good value for money and very compact due to its relatively small, flameproof and directly attached i/p converter.

Intrinsic safety is the only type of protection which allows the apparatus to be opened and maintenance, repair, adjustment etc. to be performed in hazardous areas without having to interrupt the power supply. This special advantage of intrinsic

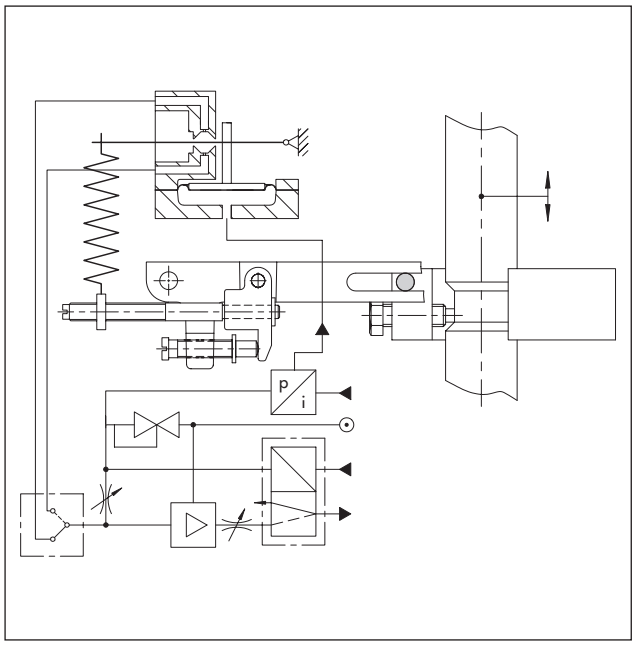

Fig. 2b: Functional diagram of electropneumatic positioner

safety is also almost completely provided by the above described device design because the Ex 'd' device allows inline access to the pneumatic positioner module. However, the capability to transmit virtually any power level, which is an advantage offered by the *flameproof enclosure* type of protection, is not required by the described positioner design.

Fig. 3: Electropneumatic positioner with flameproof enclosure

4. Digital field devices

As more and more microprocessor-based assemblies are applied in field devices for the purpose of signal processing, new challenges have to be met in order to ensure explosion protection. Although a substantially larger number of electrical components are used, the power consumption of many digital field devices roughly corresponds to that of the analog devices used so far. This ensures compatibility to the previously used input and output assemblies and an easy application of the *intrinsic safety* type of protection. Due to the 'digitalization' of field devices, however, more precautions inevitably have to be taken when designing Ex 'd' field devices. Because of the high

Fig. 4: Digital positioner with flameproof enclosure

proportion of the electrical components located in the field device, it does not pay in many cases to place only the electrical components in a separate flameproof enclosure as in the above described case of an analog positioner. It is especially not worth it when the electrical valve travel sensor has to be integrated in the flameproof enclosure, too. Such solutions, however, are commonly applied in US instrumentation technology. This is why many US manufacturers offer devices whose pneumatic output module is the only component arranged outside the flameproof enclosure. Therefore, the only alternative is to place the whole of the field device in a flameproof enclosure. Such a design, however, does not conform with the aim to design a modular and compact device.

An Ex 'd'/Ex 'i' field barrier, which is housed in a flameproof enclosure directly attached to the intrinsically safe apparatus via an anti-rotation device, represents an elegant solution for using digital field devices designed for Ex 'd' systems.

As both types of protection are equally safe, nothing opposes the idea of applying an intrinsically safe positioner together with an Ex 'd'/Ex 'i' field barrier in an Ex 'd' system. The conversion of Ex 'd' into Ex 'i' using a field barrier allows direct connection to Ex 'd' systems over suitable cable and wire entries or piping systems and supplies the necessary intrinsically safe output circuits for the directly attached field device. The field barrier is available as a single-channel version incorporating a 4 to 20 mA signal circuit and also as a 3-channel version which permits additional connection of limit switches and intrinsically safe solenoid valves.

This allows that the idea of integrable options, as implemented with modern positioner designs, can be effectively applied to the field barrier, too. As many digital field devices provide communications options via HART protocol, the field barrier also superimposes the communication signal on the 4 to 20 mA current signal.

The application of a field barrier makes the use of field devices optimally efficient to the user. This will be illustrated by using a HART positioner as an example: The application of the intrinsically safe positioner version requires only one basic device which substantially simplifies the acquisition and storage of spare parts and devices. Even when assembling or installing

Fig. 5: Control valve with integral attachment of a digital Ex 'd' positioner designed to be connected to Ex 'd' systems

the valve positioner, the user can easily select one of the types of protection *flameproof enclosure* and *intrinsic safety* for the valve positioner by simply adding or not adding the field barrier. Additional accessories such as limit switches, fault indication switches or solenoid valves do not require any additional components, but can be integrated in the positioner casing as usual. Regardless of the selected protection type of the system, maintenance and repair work can be carried out on the positioner when it is still energized although the whole wiring and connection parts are housed in a flameproof enclosure. For the purpose of planning and installing, the whole of the device consisting of a positioner and a field barrier is to be considered as an Ex 'd' device, whereas the selfsame Ex 'd' positioner can be regarded as an intrinsically safe field device for the purpose of on-site maintenance and fault recovery. Direct connection of the intrinsically safe HART Hand-held Terminal is also possible. Moreover, the positioner provides the advantage of a compact design which allows universal attachment to any control valve.

5. Summary

An impossible team – not at all. By means of innovations and ideas, it is possible to combine the contrary types of protection *intrinsic safety* and *flameproof enclosure* to form a harmonious duo which enables the advantages of both types to be completely implemented according to the economic and corporate interests of the user.