



# Inspection in Accordance with the German Operating Health and Safety Regulations

## A proposal for inspection and checking conducted on installations in hazardous areas

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Directive 1999/92/EC which defines minimum requirements for protection of health and safety of employees working in hazardous areas allows national legislatures to create more extensive regulations when adopting the Directive into national law [1]. As was done in most EU member states, the Federal Republic of Germany also made more extensive and more detailed stipulations with the new German health and safety regulations inclusive of installation in hazardous areas, the ›Betriebssicherheitsverordnung (BetrSichV)‹ [2] with which Directive 1999/92/EC, along with other EC Directives on health and safety, was adopted into German law. Besides other aspects, this also relates to the requirements for inspecting installations in hazardous areas. By comparison with the requirements of the previous German regulations ›Verordnung über elektrische Anlagen in explosionsgefährdeten Bereichen ElexV‹ (Regulation Concerning Electrical Equipment in Hazardous Areas) [3], changes have been made, both in respect of approach and detail, and requirements have also been included for further non-electrical ignition sources, for instance mechanical generated sparks, static electricity, heating by friction etc.

The German legislative objective in introducing the ›BetrSichV‹ was to create a modern and strict regulation. In doing so, the idea was to discard the old apparatus-oriented structure with doubled or contradictory regulations and proceed in a much more risk-oriented manner, while implementing a modular construction at the same time. The intention was to create additional technical flexibility for the user, so that tech-

nical improvements can be implemented immediately. Today, you no longer have to wait until these new technical improvements have been incorporated into the corresponding standards. The legislature created this flexibility by primarily drafting objectives within the technical regulations so that the users could use these objectives as a guideline in formulating and implementing them under their own responsibility, while taking into account the present state of the art. This procedure is intended to provide a reference using the example of inspection and checking conducted on electrical systems in hazardous areas.

Up until now, electrical systems have been tested by a qualified electrician according to §12 of the previous German regulation ›ElexV‹. There are various types of inspection: the initial inspection prior to the first commissioning, for new installations, the inspection following implemented modifications or corrective maintenance and the regular periodical inspection within specific intervals no longer than 3 years apart. As an alternative to this recurring inspection and while under the direction of a responsible engineer, the user may arrange for the ›continuous supervision‹ of the electrical installation in accordance with ElexV until the transitional regulations expire.

Once the German regulation ›BetrSichV‹ took effect, it required electrical installations to be inspected and checked by a competent person (or an approved supervision agency (ASA) prior to their commissioning in accordance with §14, and to also be tested, in accordance with §15, on a periodical basis with a maximal



**Excerpt from the ›Betriebssicherheitsverordnung‹ (non-authorized translation)**

**§ 14 Initial inspection prior to commissioning**

- (1) A special state-regulated and supervised installation (in this instance, an installation in a hazardous area) may be placed into service for the first time or restart after an essential modification only if the installation has been inspected by the approved supervision agency to ensure its proper working order with respect to installation, wiring, installation conditions and safe function.
- (2) After modification, a special state-regulated and supervised installation in ... may be placed back into operation only if the installation has been inspected by an approved supervision agency for proper working order if operation or design of the installation has been influenced by the modification.
- (3) In the case of inspections of special state-regulated and supervised installation pursuant to Paragraphs 1 and 2,
  1. equipment, protective systems and safety, controlling and regulating devices as defined by Directive 94/9/EC,
  2. ...may be inspected by a competent person. ...

**§ 15 Periodic inspections**

- (1) An special state-regulated and supervised installation (in this instance: an installation in a hazardous area) and its installation sections must be inspected on a recurrent basis for proper working order in respect to operation by an approved supervision agency. The user must determine the inspection intervals of the overall installation and of the installation sections on the basis of a technical safety assessment. ... § 14, Paragraph 3, Clauses 1 and 2 apply accordingly. (The last sentence means that installations in hazardous areas may, alternatively, also be inspected by a competent person of the company unless the installations comprise storage installations or refuelling and filling points for inflammable, readily inflammable and highly inflammable liquids).
- (2) Inspections in accordance with Paragraph 1, Clause 1 consist of a technical inspection that is conducted on the installation itself using the inspection regulations, and a check of documentation and organisation. ...
- (3) ...
- (15) On installations in hazardous areas, ... inspections during operation must be conducted at the latest every three years.
- (16) ...

*Text in italics added by author*

inspection interval of 3 years. At this point, the ›constant supervision‹, which was primarily used in larger-scale chemical companies, was not adopted from the ElexV. In order to apply the ›BetrSichV‹, it was necessary to define inspection modalities so that the objectives of the ›BetrSichV‹ were incorporated while taking into account the Technical Rules (TRBS). This had to be

carried out without considerably increasing the inspection costs, but while still simultaneously maintaining the high level of security. The following article describes a possible proposal that would allow all of these objectives to be accomplished.

**Inspections and checks**

To conduct periodical inspection in accordance with § 15 of ›BetrSichV‹, the user must have the special state-regulated and supervised installation (in this case: installations in hazardous areas) inspected by a competent person (or an ASA) for proper working order. In accordance with § 14 Clause 1 and 2 as well as § 15, the inspections primarily consist of a documentation and organisation check and a technical inspection. The documentation and organisation check entails checking the completeness of the documentation required for safe operation. For example, this includes: the result of the risk assessment, public authority requirements, testing parameters (inspection interval, scope of inspection, the level of inspection intensity) equipment documentation, etc. For the subsequent on-site technical inspection, there are three different inspection intensities: the visual inspection, close inspection and detailed inspection.

**Visual inspection**

The visual inspection is an optical and acoustic verification measure for detecting recognisable defects in the equipment. Generally, this simple inspection allows equipment and installation defects (e.g. missing screws, bearing noises, dangling cables) to be detected during operation and without using access equipment (e.g. ladders, scaffolding) and measuring equipment.

**Close inspection**

The general inspection initially involves all aspects of the visual inspection. In addition to the aforementioned aspects, access equipment is utilised during this inspection measure to inspect each installed apparatus more closely. This inspection measure can gener-

ally be carried out while the system is operating. At this stage, loose screws as well as defective glands can now be detected, for example. Tools or measuring instruments are not used.

### Detailed inspection

Naturally, the detailed inspection contains all the aspects of the close and visual inspection. In addition, tools and testing equipment are used to detect hidden faults as well (e.g. short-circuit, cable breakage). Normally, this inspection cannot be carried out while the system is operating. For this reason, the installation must be shut down to safely open and test the equipment.

### Safe operation

As part of these different inspection measures, the safe operation of the equipment is also tested. In doing so, the equipment is inspected in accordance with 94/9/EC according to the category and ignition-source variance. The technical effectiveness of the protection systems, safety, controlling and regulating devices is tested in accordance with 94/9/EC. The technical effectiveness of the other technical equipment (e.g. ventilation) that is required for explosion safety is also tested.

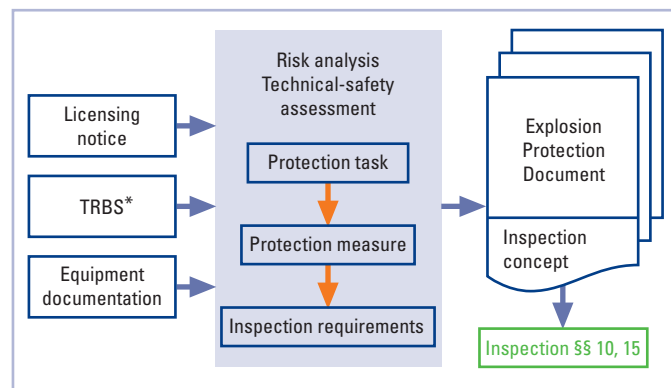


Figure 1: Inspection concept (\*TRBS: Technical Rules BetrSichV)

### The inspection concept

These inspections are based on a technical safety assessment that is defined in the inspection concept (Figure 1). This inspection concept can also be created as part of an assessment of explosion risk.

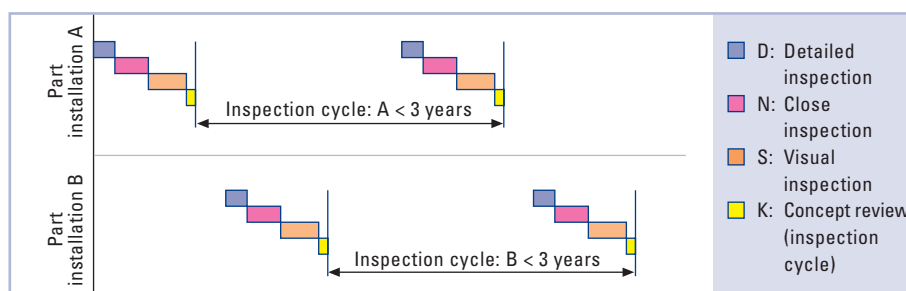
The inspection intensity (such as the visual, close and detailed inspections, ...), inspection scope (quantity and type of test articles), inspection intervals (that means, the cycle in which the articles are tested), the qualification of the inspector (the requirements that a competent person must have, such as a qualified electrician with sufficient knowledge of the electrical inspections to be carried out) as well as the inspection rules

(under which limiting conditions the inspections must to be conducted) are defined in the inspection concept. In addition to the basic operational conditions, for example: hazards, protection duties, interactions, environmental loads, etc, the equipment manufacturer instructions for the normal operating conditions must be matched with the real operating conditions, while complying with the special conditions. Furthermore, any licensing notice requirements, technical rules and state-of-the-art technology must be adhered to.

The result of these considerations is described in the inspection concept and adopted into the explosion protection document. Two possible conceptual examples will be introduced below.

For the fixed-cycle procedure, the old procedure is described according to »ElexV« in which the inspections are grouped together and completely carried out at the end of the specified inspection cycle. This procedure is especially suitable when there are only a few test articles to be tested in one plant. The adaptive cycle procedure, which chemical companies have used to a similar extent up until now, is also described as an alternative below.

Figure 2: Fixed-cycle procedure



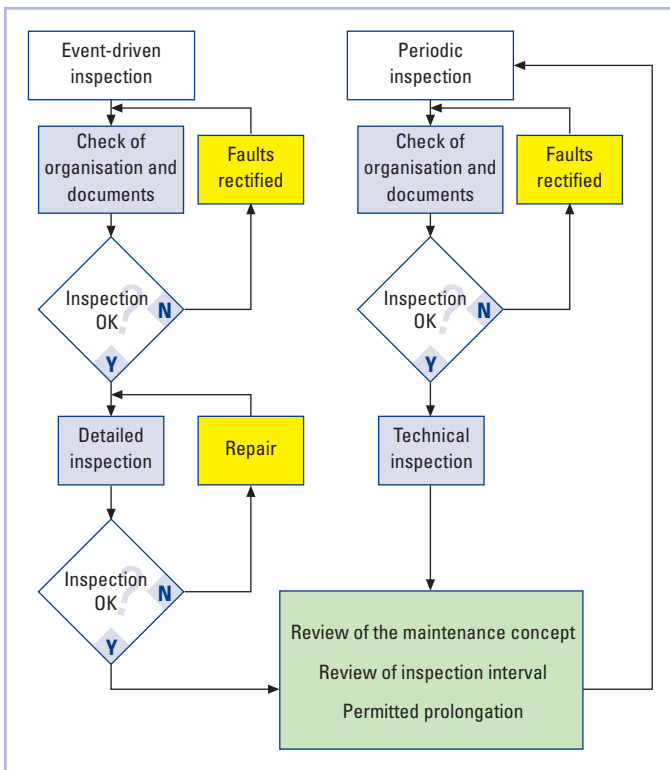


Figure 3a: Inspection flowchart, fixed-cycle procedure

### Fixed-cycle procedure

As part of the technical safety assessment or risk analysis, the systems to be checked are divided into observation units (e.g. sub-systems) so that the system elements can be subjected to the same loads (e.g. environmental influences, idle times, ...), where possible. These sub-systems are then inspected before the end of the specified cycle (Figure 2).

All inspection results are analysed and evaluated in a concept declaration. The next cycle can be scheduled for the maximum legally stipulated term of three years once the inspector determines that there are no deviations from the specified concept. If it is determined that a cycle reduction would allow damage to be detected at an earlier stage, the cycle must be reduced accordingly. The next inspection is carried out prior to the end of the specified term. By skillfully limiting the sub-systems, the various sub-systems can be inspected in an efficient manner.

The actual inspection is conducted in two steps. First, the organisational measures are checked for completeness and the documentation is checked for accuracy (Figure 3a).

This primarily includes the documents in which the safety-relevant parameters are found, such as operating instructions in accordance with 94/9/EC, the intrinsic safety verification, circuit diagrams with target specifications as well as the documents required for the inspection. The on-site technical inspection is only carried out once the documentation is determined to be complete and accurate. At this point, the documentation is checked for compliance with the technical reality and then the defined explosion protection inspection features. These technical inspections are firmly scheduled. Within the framework of the modifications, changes, small-scale enlargements or other additional measures, initial inspections can also be carried out within an inspection cycle in accordance with § 14 of ›BetrSichV‹. These test results are then submitted to the competent

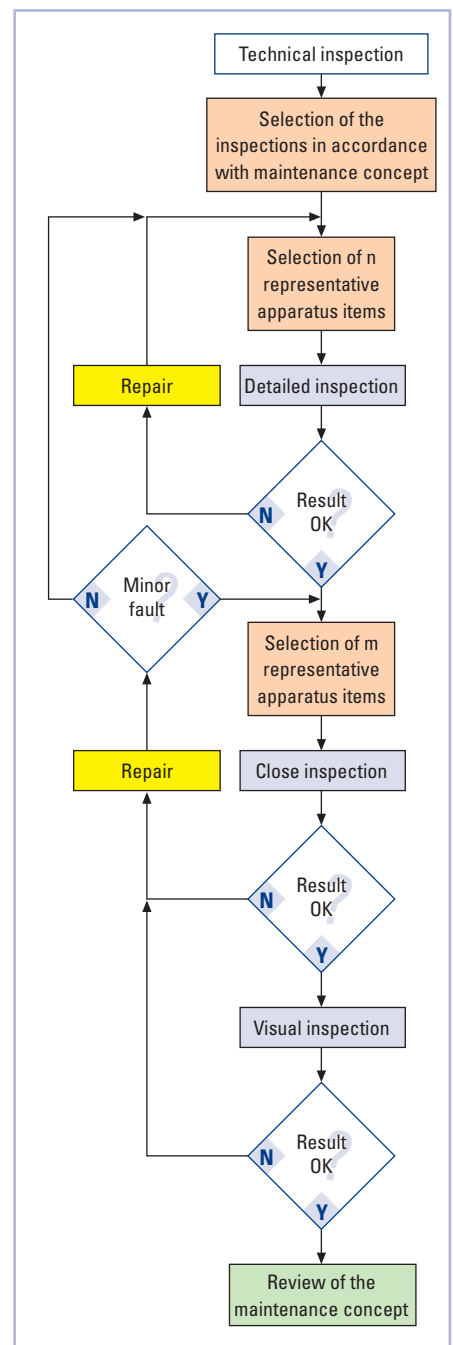


Figure 3b: Technical inspection, fixed-cycle procedure

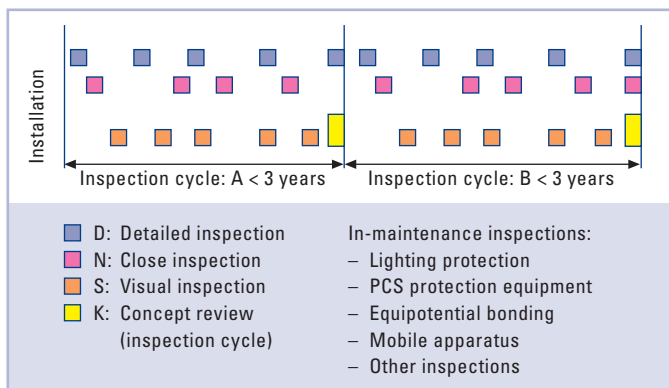


Figure 4: Adaptive-cycle procedure

person who must carry out the scheduled inspections. All results can now be used to provide insight on the technical safety condition of the tested equipment, thus allowing an informative concept declaration to be made. Based on the technical inspection, the competent person must verify the technical safety condition of the system. In order to reach this conclusion, the system is divided into straightforward sub-systems that are subjected to the same process- and environmental-based loads, where possible. This allows a basic quantity of inspection articles to be defined. Those on-site elements that are subjected to the highest load are selected from this quantity of elements to be checked. This allows a column of 10 identical temperature measurements to be created. At this point, a temperature measurement should be selected that is subjected to both the highest process-based as well as environmental-based loads. Generally, trained specialists should be consulted for this selection. →

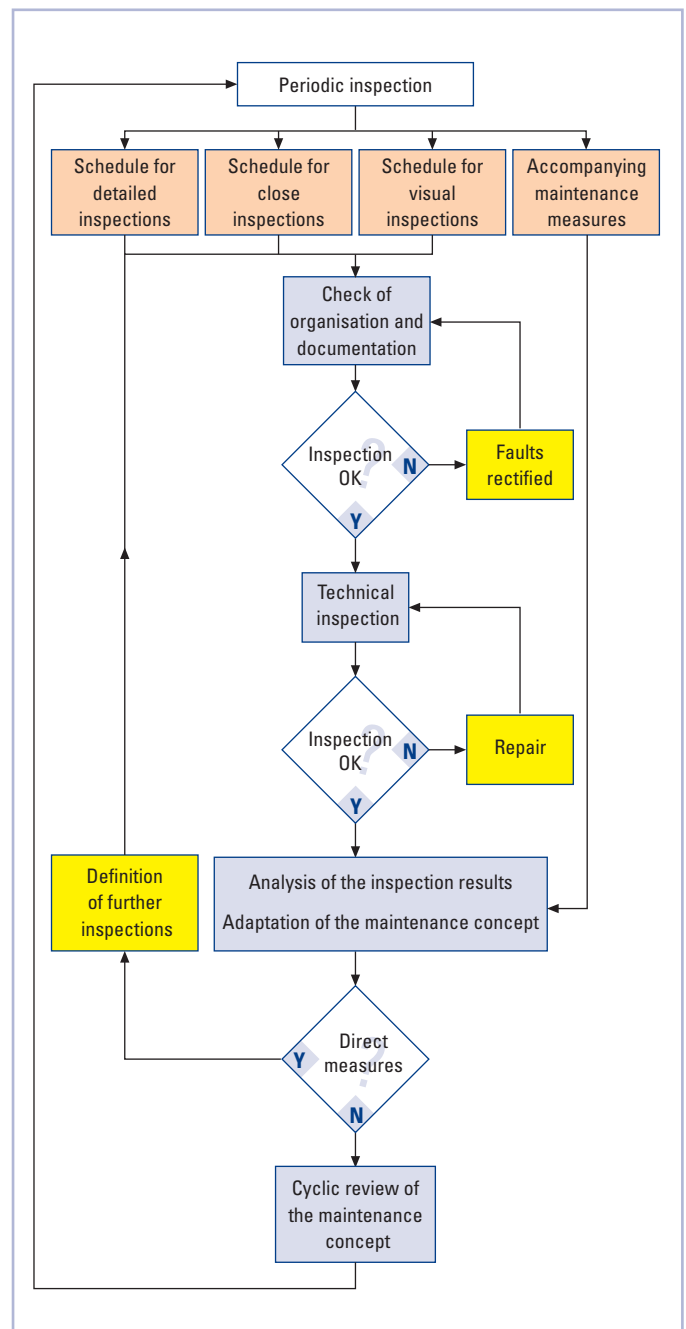


Figure 5: Inspection flowchart, adaptive-cycle procedure

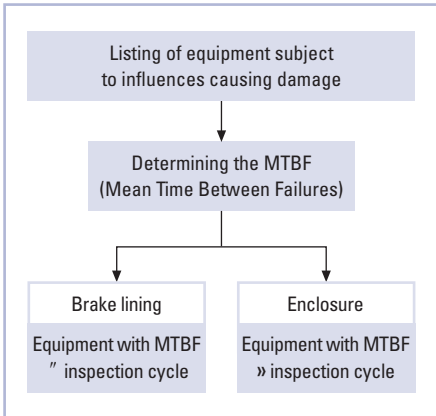


Figure 6: Selection dependent on inspection cycle

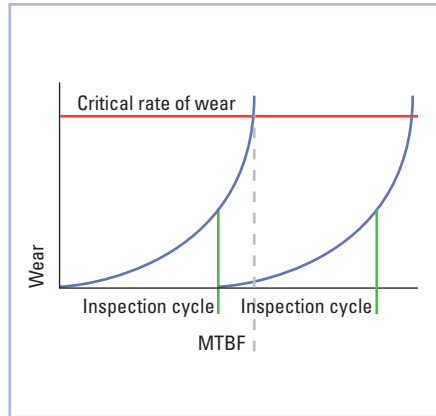


Figure 7: Equipment with short inspection cycle

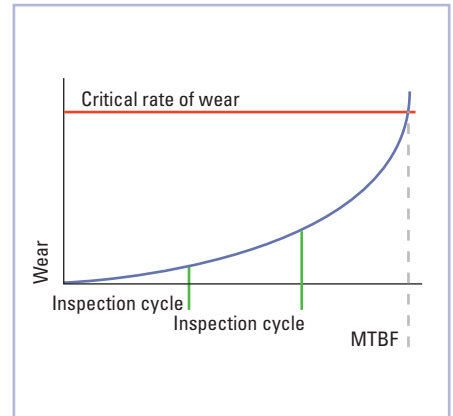


Figure 8: Equipment with long inspection cycle

A partial quantity with a lower number  $m$  is selected from this representative quantity (Figure 3b). According to an inspection schedule, a detailed inspection is carried out using this equipment, including their installation. The detailed inspection is the most intensive inspection type that generally requires opening enclosures using tools and testing equipment while the system is shut down. If any defects are detected during this inspection, they must be repaired immediately. Based on the defects, the competent person must decide whether it is a systematic or individual defect. In case of a systematic defect, all elements that could have been potentially affected must be inspected, and the cause must be analysed. This may involve modifying the system or modifying the inspection concept. In the event of an individual defect, this defect must be confirmed by increasing the random testing  $n$ .

Once the detailed inspection has been successfully carried out, another random test  $m$  ( $m > n$ ) is selected according to the equipment, including their installation, that has been selected to undergo a close inspection. Generally, no procedures must be carried out inside the equipment and facilities during the close inspection. However, access equipment, such as ladders may be used. Furthermore, these inspections can generally be carried out while the system is operating. This inspection must be carried out according to the inspection schedule. If defects are detected during this inspection, they must

be remedied immediately. If the error analysis verifies an understandable cause, which also cannot involve any other undetected defects, this explanation must be verified by increasing the random testing  $m$ . If any other concealed defects cannot be ruled out, the corresponding detailed inspection must be carried out.

If no defects are detected during the inspections, the sub-system in question is subjected to a visual inspection. During the visual inspection, the equipment, facilities and installation undergo a visual and acoustic inspection for defects using a checklist. Discovered defects are then documented according to the area and remedied immediately. If any defects are discovered, the competent person must initiate additional inspection measures analogous to the close inspection.

### Adaptive cycle procedure

For the alternative adaptive cycle procedure, it makes sense to summarise the systems to be inspected according to the process-based or operational requirements. This method is also based on the results of a technical safety assessment or the risk assessment. Similar to the fixed-cycle procedure, representative test articles are selected for a detailed and close inspection. For this adaptive procedure, the quantity and dates of the detailed and close inspections to be carried out are generally coordinated according to the operational specifications at the beginning of the inspection cycle (Figure 4). Furthermore, dates for rotational visual inspections and the accompanying maintenance measures are scheduled.

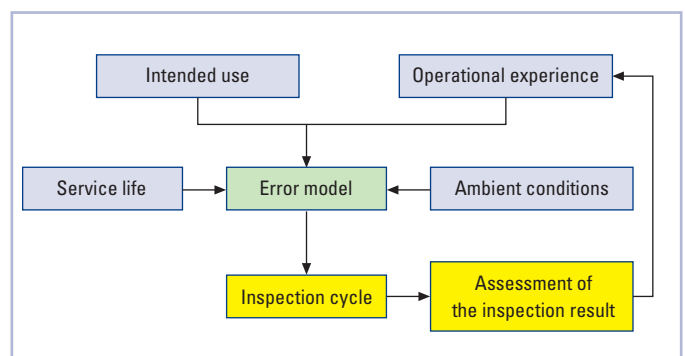


Figure 9: Error model



Figure 10: Example of nonconforming equipment (e.g.: open cable glands, direct connecting wire from Ex i to Non Ex i side)

This maintenance measures include, for example, calibrations, quality inspections or inspections that increase the system availability. Prior to each technical inspection, the required organisation and documentation check (with correctional measures as required) must be carried out first. The competent person then carries out the technical inspection (Figure 5). Analogous to the fixed-cycle procedure, the competent person analyses each inspection result, including the results of the accompanying maintenance measures. Immediate decisions are now made as to whether additional measures are required and if so, they are carried out immediately. Depending on the results of the analysis, these measures can directly affect the inspection concept, which must then be adjusted to the requirements accordingly. At the end of the specified inspection cycle, the competent person evaluates all results and measures conducted on the subject matter. At this point, an inquiry must be conducted to determine whether the documented inspection concept has been completely carried out or whether additional inspections are required, on the one hand, to ensure the security of the system and, on the other hand, to issue a verified statement con-

cerning the next inspection cycle within the legally stipulated limits. The next cycle is initiated by means of a concisely documented concept check.

### Inspection cycle

The process of determining the individual inspection cycles also poses another challenge. If equipment is subject to detrimental influences that could lead to hazardous situations, the employer must commission the respective competent person to inspect and if necessary, test the operating equipment in accordance with the terms stipulated by ›BetrSichV‹ §3, Close 3. This can include the following detrimental influences: corrosive internal media in storage containers, wear on the coupling and brake pads or UV radiation that causes damage to the plastic parts. The employer must first list all of the operating equipment that is subject to such detrimental influences (Figure 6). In a second step, the time in which a failure is to be expected must

be determined. Classes are now created to develop inspection structures. For each class, an inspection cycle that lies within a level of critical wear can now be defined. Generally, two classes can be created for this purpose. All operating equipment for which the times to failure fall below the legally stipulated cycles is summarised in the first class. A cycle is now defined for which the expected rate of wear is below the critical level of wear (Figure 7). For the following technical inspection, the real degree of wear is compared with the expected rate of wear, thus allowing the cycle to be adjusted. For the second class, the time to failure is considerably greater than the specified inspection cycle (Figure 8). During the inspection, a comparison is made as to whether the wear allowance during the next cycle is still sufficient. In general terms, the time until the critical degree of wear can be estimated based on the usage, the previous operating period, the prevalent ambient temperatures as well as personal operational experience. While taking →

Figure 11: Inspection database

Inspection of special state-regulated and supervised installation in accordance with German regulation ›Betriebssicherheitsverordnung‹ [2]	
	Check of organisation and documentation in the Ex area
	Checklist for visual inspections in explosion protection of (electrical) equipment
	Checklist for visual inspections in explosion protection of mechanical equipment
	Inspection reports, visual inspection
	Inspection reports, close inspection
	Inspection reports, detailed inspection for types of protection d, e in Zone 1
	Inspection reports, detailed inspection for types of protection d, e, n, in Zone 2
	Inspection reports, detailed inspection for type of protection i in Zones 1 + 2
	Determination of faults detected (maintenance list)
	Pocket PC synchronisation

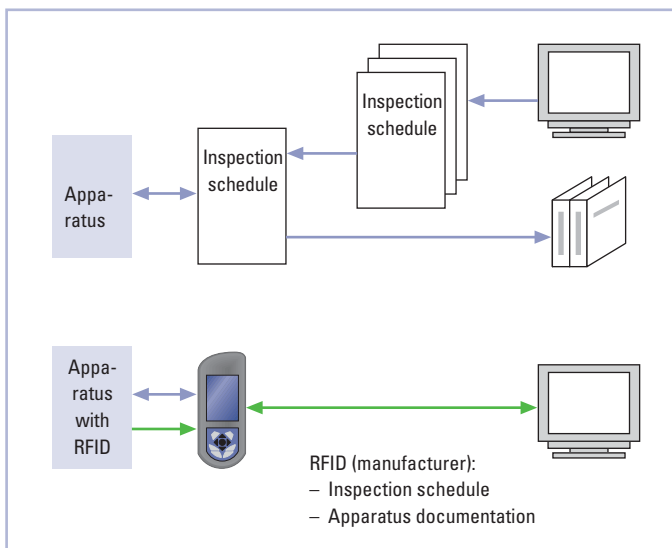


Figure 12: Interface problems

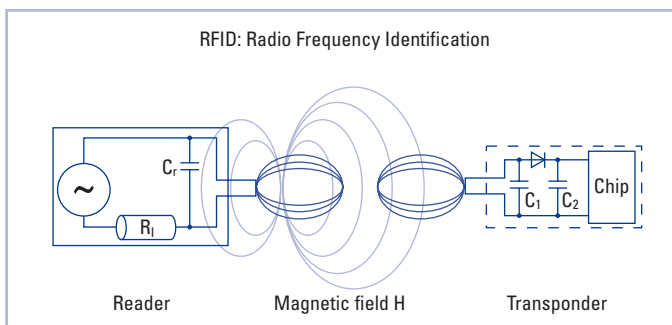


Figure 13: RFID mode of operation

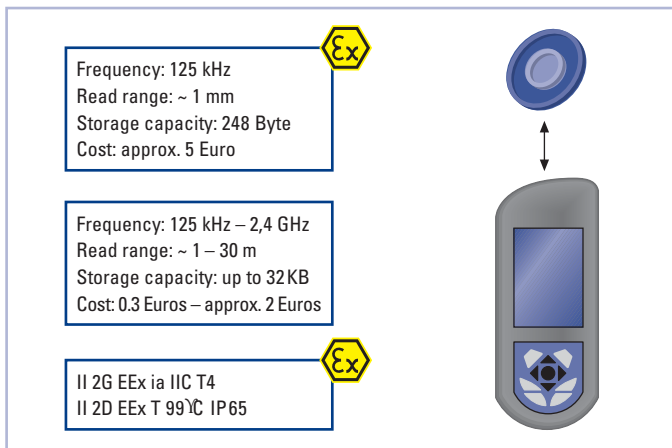


Figure 14: Technical data Transponder/reader

a contingency reserve into account, the inspection cycle is created using this error model (Figure 9).

Inspecting and evaluating the determined wear contingency provides you with additional operational experience that you can use to continually improve the error model.

### Inspection documentation

Users of installations in hazardous areas must either commission an approved supervision agency or a competent person to check that the installations are in proper working order in accordance with ›BetrSichV‹. The inspection results must be documented.

Depending on the equipment to be checked (Figure 10), the tailored inspection schedules must be compiled according to the inspection intensity, type of protection and while observ-

Figure 15: Proposed rating plate standardisation

Proposed standardisation	
Manufacturer	Endress + Hauser
Product type	Deltabar-S
Product name	PMD75
Serial number	6500D90109D
Year of construction	05.2004
Temperature class	T4 – T6
Explosion group	IIC
Category	II 1/2 GD
EC test examination No.	KEMA 03 ATEX 1561
Type of protection	ia
Special conditions	XA243P-A/00/a3/09.03

ing the manufacturer's specifications. These inspection schedules can be very easily prepared using a database (Figure 11). This database can quickly and clearly accommodate these requirements, even without exact prior knowledge of the equipment.

The compiled inspection schedules are printed for carrying out the inspections to be conducted (Figure 12). All of the organisation inspection tasks are first carried out and the results are documented on the inspection schedules. These inspection schedules are normally assigned a unique plant identification code (PIC). At this point, the competent person takes the inspection schedules required for the technical inspection and proceeds to the site. Normally, since several inspection schedules must be processed at this stage, the correct inspection schedule is first assigned to the correct item. After the equipment characteristics have been compared for compliance, the additional inspection steps are carried out and the result are documented. Depending on the ambient conditions, the results can be rendered illegible or the schedules can be contaminated. Corrections or subsequent changes are later very difficult to understand. The filled out inspection schedules are then evaluated and must be stored. If, during a technical inspection, it is determined that the spatial conditions do not coincide with the documentation, the variation must be recorded and then a new or additional inspection schedule must be drafted at your office and then used at a later date.

Using new technologies allows these problems to be solved more effectively. Mobile computing makes problem solving considerably easier. This type of mobile computing involves an explosion-protected handheld PC that is interfaced to a host computer. This allows you to transfer the inspection

schedules to be processed with the utmost of ease.

At the site, the competent person now selects the correct inspection schedule using the unique PIC and can easily fill in the check boxes using the keypad. If there is additional equipment or other check articles at the site, a new inspection schedule can be created thanks to the database integrated into the handheld PC. The new inspection schedule can then be immediately filled out at the site. Only the organisation and documentation check must be subsequently compared with the documentation. Once the handheld PC has been connected with the host system, all filled out inspection schedules can be stored in the system.

The introduction of RFID technology (Radio Frequency Identification) provides another optimised feature (Figure 13). Even in hazardous areas, this technology allows data to be read from a chip (tag) using radio waves (Figure 14).

It is already possible to read the PIC assigned to equipment from a tag. The inspection schedule is assigned automatically.

Currently, 32 characters can be permanently stored using this tag. Developers are currently attempting to increase the capacity to 2000 characters, thus simplifying additional tasks. This would allow the manufacturer to store various types of prepared data on the tag, for example, the rating plate data (Figure 15) as well as additional data required by the user, such as safety-relevant limit values, special conditions, installation instructions or replacement part lists. Within the framework of a NAMUR working group, stipulations are being compiled for the required data structures so that a succinct standardisation can be implemented.

#### Literature

- [1] Directive 1999/92/EC of the European Parliament and of the Council of 16 December on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (15th individual Directive within the meaning of Article 16(1) of the Directive 89/391/EEC). Official Journal of the European Communities 2000 L 23/57-64
- [2] Verordnung über Sicherheit und Gesundheitsschutz bei der Bereitstellung von Arbeitsmitteln und deren Benutzung bei der Arbeit, über Sicherheit beim Betrieb überwachungsbedürftiger Anlagen und über die Organisation des betrieblichen Arbeitsschutzes (Betriebssicherheitsverordnung – BetrSichV). BGBl. Teil I, No. 70, page 3777-3816
- [3] Verordnung über elektrische Anlagen in explosionsgefährdeten Bereichen (ElexV) vom 13.12.1996, BGBl. Teil I, No. 65, page 1932