



On the Method of Ignition Hazard Assessment for Explosion Protected Non-Electrical Equipment

Assistance for equipment manufacturers in analysis and assessment

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Figure 1: Explosion protected crane installation

European Standards on explosion protected, non-electrical equipment (EN 13463-1 [1] and related Standards on types of protection) are developed to allow compliance with the essential health and safety requirements of Directive 94/9/EG [2]. This is why the explosion protective measures, as demanded by the Directive, are stipulated as a function of possible ignition hazards, and fault statuses are to be allowed for. While Standards whose defined requirement profiles avoid the major types of ignition sources for a specific Equipment Category (EN 50014 ff. [3]) have already been in existence for twenty years now, this does not apply to non-electrical equipment. An ignition

hazard assessment is demanded for non-electrical equipment as a basis, and independently of the Equipment Category (EN 13463-1, Section 5 [1]). This is taken as a basis for defining appropriate protective measures to match the intended Equipment Category for each individual ignition risk identified. An assessment method, which is intended to assist product manufacturers in formal analysis and assessment of the ignition hazards is explained below. Furthermore, the article illustrates what assistance is available for defining suitable protective measures and compilation of the essential technical documentation.

1. Intended use and regulation compliant documentation

Use of the equipment as intended is an essential basis for the ignition hazard assessment of specific equipment or design. In accordance with Article 1 of the Directive [2], this means using the equipment in accordance with the Equipment Group and Category, allowing for all manufacturers' specifications required for safe operation of the equipment. These must be defined by the manufacturer and forms the starting point for the assessment of fault statuses to be conducted. The Operating Instructions must include all conditions and information required for correct commissioning and subsequent, safe operation ([2], Annex II, Section 1.0.6). Therefore, the Operating Instructions define use of the equipment intended for the basic requirement of explosion protection. Directive 94/9/EC demands that technical documentation be elaborated on (cf. [2], Annex III, VIII or IX; one of these modules must be applied). The technical documentation must include corresponding verifications for all safety-related details of each individual protective measure since the following is demanded: »The technical documentation shall enable the conformity of the equipment with the relevant requirements of the Directive to be assessed. It shall, to the extent necessary for such assessment, cover the design, manufacture and operation of the product.

Frequently, it is unclear what properties substantiate explosion protection of the product and, consequently, require special attention to design on the one hand, and a specification in the technical documentation on the other.

The extended reporting scheme explained below will allow the relevant parts of the design to be recognised more easily and, for in-

stance, a decision to be taken more easily as to what design changes are possible without impairment of explosion protection.

2. Ignition hazard assessment and reporting scheme in accordance with EN 13463-1

In Section 5.2, EN 13463-1 demands an assessment of the ignition hazards and a corresponding report in tabular form (Figure 2), as the basis for all explosion protective measures on the equipment. The reporting scheme consists of three columns. The result of the assessment of a specific ignition hazard should be listed in Column 1 in respect to the operating state. The protective measure foreseen for this should be listed in Column 2 and the Standards or other sources on which the protective measure is based should be listed in Column 3.

However, EN 13463-1 does not provide any assistance as to how to approach the assessment of the ignition hazards. The table which it requires is designed merely to document the results of an ignition hazard assessment but is not aimed at structuring the required work steps or sub-steps. Ultimately, the assessment report contains only the minimum requirements applicable to the results of an ignition hazard assessment and, thus, only some of the required, useful information.

Proceeding by analogy with the table and the minimum requirements from the Standard involves the following disadvantages and error sources for the user. These can be avoided using the method described below:

- › Potential ignition sources which must, admittedly, be evaluated but which do not require supplementary protective measures do not necessarily need to be included in the table (cf. 4.1).
- › Including misuse which can reasonably be anticipated ([2], Annex II, Clause 1.0.2) in the evaluation report is not expressly mentioned in EN 13463-1 and neither is it illustrated with examples (cf. 4.1).
- › Identification of a potential ignition source is combined with the assessment of the frequency of its occurrence. However, these work steps differ greatly in respect to their content (cf. 4.1 and 4.2).
- › The examples in the Standard may, in the case of less experienced manufacturers, lead to the assumption that the assessments can be adopted uncritically for similar products (cf. 4.2).
- › No substantiations are provided for individual assessment decisions (if applicable, lack of plausibility or intelligibility; cf. 4.2).
- › No connection is made between the stipulated protective measures and the technical documentation (cf. 4.3).
- › The resultant Equipment Category is not listed solely in relation to the individual ignition hazard considered (cf. 4.4).

3 Assessment method and extended reporting scheme

Even though there are certain fundamental differences between the ignition hazard assessment in accordance with EN 13463-1 and the risk assessment within the framework of the Machinery Directive [4], the Standard on risk assessment (EN 1050 [5]), corresponding to the Machinery Directive, can be used as a starting point for the procedure for ignition hazard assessment. However we are dealing in this case, not only with the risk assessment, as in EN 1050 but, primarily, with the protective measures which must necessarily be derived from it →

(see 4.3). This step is expressly excluded from EN 1050. The proposed method for assessment of ignition hazard (Figure 3) and the extended reporting scheme proposed below fully cover the requirements of EN 13463-1. The decision-making loops must be run through for a specific Equipment Category until all ignition hazards identified can be considered as adequately improbable as a result of appropriate protective measures or types of protection.

The assessment procedure can be subdivided into four work steps corresponding to the four columns of the extended reporting scheme (Figure 4):

- (1) Analysis of the ignition hazards and their causes
- (2) Assessment of the ignition hazards in respect to frequency of occurrence
- (3) Determining the required protection measures and documentation thereof,
- (4) Concluding assessment and determining the Equipment Category.

The extended reporting scheme for ignition hazard assessment was discussed, further-developed and thus matched to the requirements of the manufacturers within the framework of PTB workshops with the participation of manufacturers of explosion protected equipment. Its intended use is to assist in achieving a systematic procedure, achieve compliance with the requirements on the part of manufacturers, ensure subsequent traceability and allow updating in the case of design changes. The instructions presented for implementing the ignition hazard assessment with the aid of the extended reporting scheme are intended to be adequate for equipment which are 'easy to grasp', i.e. for the majority of applications. In general, more complex apparatus will need to be supplemented with specific analysis procedures when determining the causes of ignition hazards (step 1) (fault tree analysis and FMEA etc.; see also the brief descriptions of the procedures in EN 1050 [5]).

4. Implementing the assessment procedure

4.1 Analysis and identification of the ignition hazards

A complete list of conceivable ignition hazards should be elaborated on for the product in this work step (Column 1 of the table in Figure 4). When doing this, it is important to proceed systematically and, for the time being, to ignore all assessment aspects so as not to restrict the thought process in any way. Initially, one should localise what ignition hazards are generally applicable (Column 1a) with the aid of the list of known types of ignition sources (see EN 1127-1 [6] and EN 13463-1, Section 5.2.1 [1]). Moreover, the reasonably anticipated misuse in accordance with [2], Annex II, Clause 1.0.2 should be added. These potential ignition hazards should then be separately considered with a view to the special aspects of:

potential ignition source (1)			measures applied to prevent the source becoming effective (2)	ignition protection used (3)
normal operation (1a)	expected malfunction ¹⁾ (1b)	rare malfunction ²⁾ (1c)		

Figure 2: Assessment table in accordance with EN 13463-1 [1], Section 5.2.8 for equipment of Group II:

¹⁾ Column (1b) is required only in the case of equipment of Categories. ²⁾ Column (1c) is required only in the case of equipment of Category 1.

- › use as intended and other possible applications
 - › design variants
 - › operating conditions and their changes (starting, stopping and switchover etc.),
 - › external influences (temperature, pressure, light, relative humidity and power supply etc.),
 - › material selection, material parameters, material combinations and their interactions (metal, plastic, electrostatically chargeable fluids etc.), interactions with other equipment or components,
 - › interactions with persons (including operating faults),
 - › combinations of fault states, if applicable (combinations of two expected malfunctions must be rated as a rare malfunction for Category 1.
- Design features, e.g. electrostatically conductive materials, can be assumed as applicable at this point provided use of →

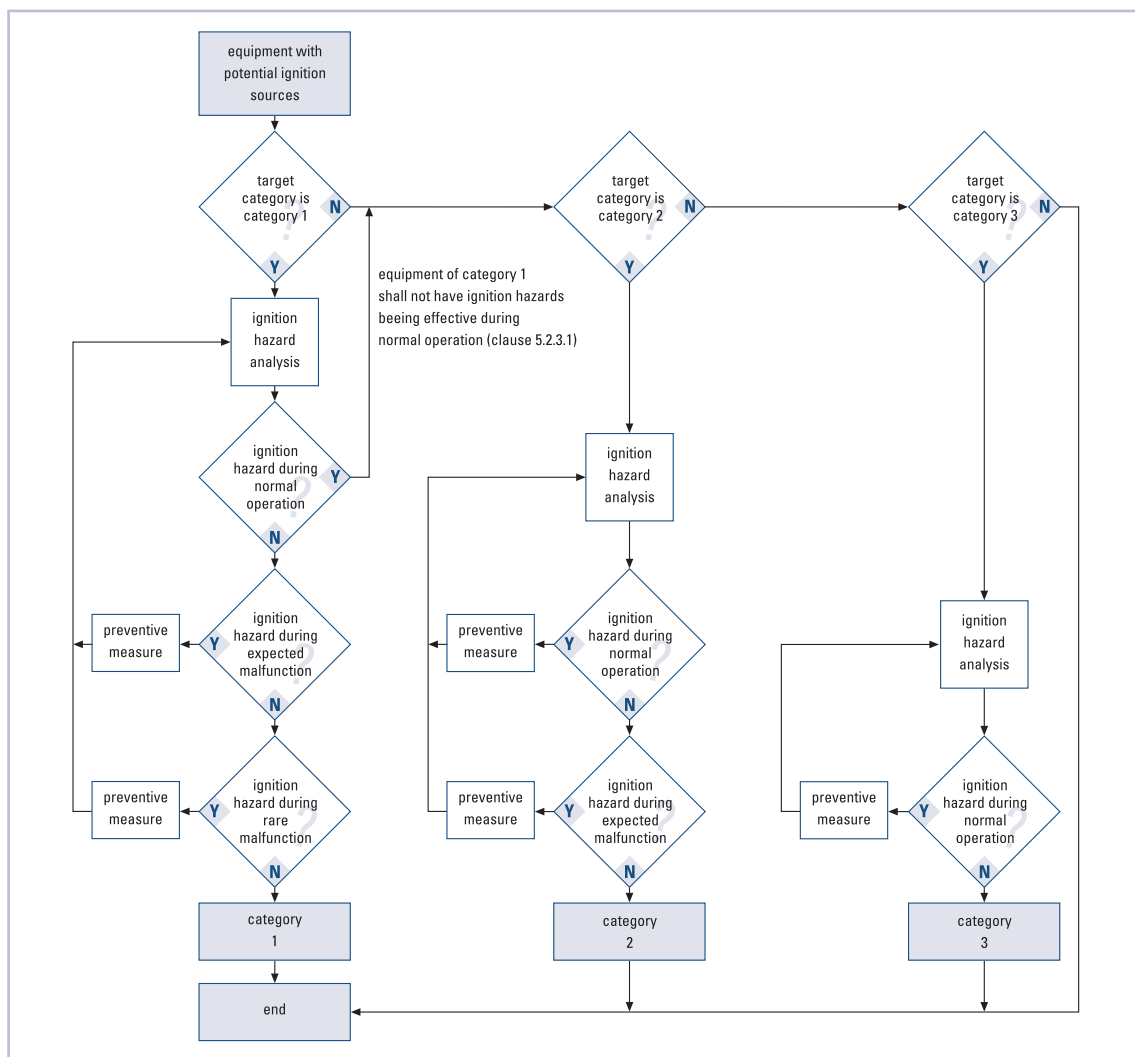


Figure 3: Flowchart of ignition hazard assessment defining Equipment Categories

such materials can be guaranteed or cannot be changed owing to design reasons. Equipment-related protective measures, such as types of protection ›Flameproof Enclosures‹ or ›Control of Ignition Sources‹, should, however, not be considered as certain in this initial step as difficulties could otherwise be encountered in the logical sequence of the assessment procedure and, if applicable more favourable or cheaper alternatives would then not be able to be identified. This work step may and should cover all useful information sources (discussions with the company's own experts and external experts such as, universities, other manufacturers, users, and testing authorities etc.) and examples systematically. These should be used to determine the possible ignition hazards without individual hazards already being rejected since they appear to be adequately improbable.

4.2 Initial assessment of the ignition hazards

In this step (Column 2), the frequency with which the potential ignition hazard may become an effective ignition source is assessed and documented by marking with a cross. This procedure should consider the ignition source precisely in the form in which it was recorded in the first step, i.e. including the specified (restrictive) conditions which may also already include design measures or features that should always be applied. The assessment results in a decision as to whether supplementary measures are to be defined in step 3 in order to achieve the Equipment Category aimed for. Column 2d is of particular importance in this case. This entry documents that an ignition hazard is, admittedly, recognised but is not considered relevant.

The assessment is an estimate of the probability with which a specific fault state

occurs. Since no quantitative definitions exist, it is difficult, in particular, to distinguish between an expected malfunction and a rare malfunction (cf. [2], Annex I). This is why we shall provide general information on assessment at this point:

- Fault statuses known from practice, i.e. fault statuses which have already occurred, must certainly be classified in the group of expected malfunctions.
- Faults which, admittedly, are basically conceivable but which have not occurred to date in practice in the case of a large number of applications should certainly be categorised in the group of rare malfunctions. However, it must be kept in mind that in this case to what extent the manufacturer receives feedback on the actual application conditions of his products and whether he systematically registers, records and evaluates these in order to provide objective evidence. When in doubt, one should opt to be on the safe side, i.e. classification as an expected malfunction.
- If an ignition source can take effect only when two expected malfunctions occur simultaneously, this must be categorised as a rare malfunction. With this in mind, all possible combinations of two expected malfunctions must be reviewed in order to establish whether they can occur simultaneously and whether there is an ignition hazard which has not been registered to date.
- Combinations of one expected malfunction and one rare malfunction or even less probable combinations (three faults etc.) do not need to be taken into consideration.

The assessment decisions affected should be substantiated in Column 2e. They may never be generally valid. In general, they

depend on the specific design of the products. Consequently, all evaluations cited as an example (even those from Standards) may be applied only with great restraint in this step - unlike the previous step. The assessment must, ultimately, always refer specifically to a certain type of design. It may even differ within the variants of one design (overall sizes or alternative fitted components etc.). In this case, this would necessitate including alternative rows in the table. Individual ignition hazards which are open to general assessment unlike what is said above are normally stated in the Harmonised Standards with specific design requirements and test algorithms, e.g. electrostatic discharges in accordance with EN 13463-1, Section 7 [1] or drop and impact test in accordance with Section 13.3.2. Assessments which are specified in the normative section of the Standards and the suitability for a specific Equipment Category may be adopted as a matter of course.

4.3 Protective measures

Appropriate protective measures which would make it adequately improbable for the relevant ignition source considered to take effect in respect of the Category aimed at should be defined in this step (Columns 3 a, b). The term ›protective measures‹ in the narrower sense means measures to prevent an ignition source taking effect by monitoring or isolating the explosive atmosphere or measures which also restrict propagation of an explosion, e.g. using a flame arrester or a type of protection in accordance with EN 13463-1, e.g. ›Control of Ignition Source‹. However, within the framework discussed in this article, it is expedient to use a somewhat broader interpretation of the term ›protective measures‹, i.e. as ›measures serving a protection aim‹. So the term should also →



Ignition Hazard Assessment Report: ... (product/type)																
1		2					3			4						
ignition hazard		assessment of the frequency of occurrence without additional application measures					measures applied to prevent the ignition source becoming effective			frequency of occurrence including all protective measures						
No.	a	b	a	b	c	d	e	a	b	c	a	b	c	d	e	f
	potential ignition source	basic cause / description (which conditions originate the ignition hazard?)	during normal operation	during expected malfunction	during rare malfunction	not to be considered	reasons for assessment	description of the protective measure	basis (standards, technical rules, experimental results)	evidence (including relevant features listed in column 1)	during normal operation	during expected malfunction	during rare malfunction	not to be considered	resulting equipment category in respect of this ignition hazard	necessary restrictions
1																
2																
3																
4																
5																
resulting equipment category including all existing ignition hazards:																

Figure 4: Extended reporting scheme for ignition risk assessment

cover all measures which would make it more improbable for a potential ignition source to become effective. This may also include several measures whose interaction achieve the protection aim. Protective measures may thus take the form of a design feature or may also be a part of the Operating Instructions (in the Commissioning, Maintenance or Warning information sections etc.), or such measures may impact on manufacturing specifications (e.g. material parameters, manufacturing tolerances or required quality assurance measures). Unless full-coverage EN Standards exist for non-electrical equipment, it is possible to use other normative documents to define appropriate protective measures (National Standards, Draft Standards and technical rules etc.). These generally provide a good basis for the technical aspects of explosion protection. However, if used, it should be checked in detail whether they are actually able to cover all essential health and safety requirements (for example the requirements in respect of the Operating Instructions or inclusion of the reasonably anticipated misuse).

4.4 Compilation of the technical documentation

The required verifications (Column 3 c) should be determined for each defined protective measure since Directive 94/9/EC demands (cf. 1) that all technical-safety details be described in the technical documentation. Ultimately, an assessment of conformity with the requirements of the Directive is possible only if appropriately detailed technical documentation has been elaborated on, indicating how the decision on compliance with this has been reached. This results in the following essential aspects for the technical documentation:

- Completeness of the design definitions;

- Verification management in relation to all required experimental test results;
- If necessary, recognising and defining required conditions for production (e.g. parameters for routine tests) and safe operation of the devices (e.g. for installation and maintenance).

The information in Columns 1b and 3a directly define what safety-related details (dimensioning, manufacturing tolerances and design definitions) need to be visible from the drawings and also what verificational and documentational evidence (measurement reports, test reports and certificates etc.) must be included in the technical documentation. If all relevant ignition hazards have been included in the reporting scheme, it is possible to determine all required product characteristics, restrictions on usage and safety information from these two columns. This must be documented in adequate detail to allow a person with corresponding technical knowledge to understand why the assessment rating has been reached. The same applies to the passages in the Operating Instructions relevant to technical safety.

4.5 Concluding assessment of ignition hazards

The resultant Equipment Category in respect to a single, specific ignition hazard and allowing for the measures described in Columns 1 and 3 is specified (Column 4e) in this step (Column 4). It necessarily results from the assessment decision (Column 4 a-d). This procedure allows identification of what ignition hazards are already adequately improbable and/or for what ignition hazards further extensive protective measures need to be defined, as in the case of a design modification or subsequent upgrading of the Category.

In addition to the Equipment Category, it is possible that restrictions in the area of appli-

cation will be necessary (Column 4 f), and this must be adopted in the product's marking. These restrictions chiefly relate to the temperature class or the maximum surface temperature occurring and, if applicable, to a specific explosion group or individual substances in whose explosive atmospheres the product shall only be operated or shall not be operated. In addition, one should also bear in mind other required restrictions of use as intended, such as ambient temperature and ambient pressure etc. The resultant Equipment Category of the product or part of the product is ultimately the least favourable of the individual assessment ratings listed in all rows.

5. Outlook

A Standard entitled »Methodology for ignition hazard assessment of non-electrical apparatus and components for intended use in potentially explosive atmospheres« is currently being elaborated in CEN TC 305 WG 4. Publication of the Draft Standard was planned for March 2005. The Standard deals with methodology for ignition hazard assessment in a more general form than outlined here. The requirements are, however, covered fully by the assessment method described.

Moreover, CEN TC 305 WG 2 recently commenced revision of EN 13463-1:2001. The assessment method outlined is to be incorporated in the second edition of this Standard. It is anticipated that the new edition of the Standard will be published in 2007. The existing Codes of Working Practice for the assessment method in the form of files are available from the author.

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