DEVELOPMENT OF A RISK ASSESSMENT STANDARD FOR EQUIPMENT FOR USE IN POTENTIALLY EXPLOSIVE ATMOSPHERES: THE RASE PROJECT - RESULTS FROM INDUSTRIAL TRIALS

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The RASE project was set up to meet the European Committee for Standardisation's requirements for developing a standard for the risk assessment of equipment for use in potentially explosive atmospheres. The methodology proposed for incorporation in the standard has recently had a number of industry trials in France, Germany Denmark and Norway. An earlier paper by Dr Rogers and Mr Maddison of Inburex gives the background to the project, describes the work plan, outlines the risk assessment methodology being developed and gives the results to date. This paper goes into more detail about the industry trials, describes the results obtained and shows how they have influenced the further development of the methodology.

Keywords: explosive atmospheres, risk assessment, industrial trials.

INTRODUCTION

Explosive atmospheres: Risk assessment of unit operations and equipment (RASE) project relates to the machinery (89/932/EC)[1] and explosive atmospheres (ATEX) 100A (94/9/EC)[2] directives, and is partially funded by the EC. The objective of the project is to produce a risk assessment methodology to aid in the design of equipment for use in potentially explosive atmospheres. Once completed the methodology will be submitted to the European Committee for Standardisation (CEN) for incorporation into a European standard, showing a recommended way for manufacturers of equipment subject to ATEX to comply with the requirement that 'Equipment and protective systems must be designed and manufactured after due analysis of possible operating faults... (Annex II of the ATEX 100a directive)'.

The project members are INERIS, the French Ministry of the Environment funded body for health and safety research and expertise; Niro, a Danish company who make spray driers and other equipment; Inburex, a German consultancy specialising in explosion and process safety hazards; FSA, the German insurance funded worker safety organisation for the food industry; Christian Michelson Research (CMR) based in Norway; and HSL the in-house research agency of the UK Health and Safety Executive (HSE). At the start of the project a questionnaire was circulated to a wide range of manufacturers and users of equipment, designed for explosive atmospheres, to identify their current knowledge and experience, and if they were interested in performing trials of the methodology. From the results of the questionnaires, and a review of existing techniques, a risk assessment methodology was developed. Industrial trials were then performed in Europe to evaluate the applicability of the methodology to industrial practices. A second questionnaire was developed to appraise the trials and to identify areas of the methodology which require further development.

INDUSTRIAL TRIALS

Once the RASE methodology was developed sufficiently it was applied to various equipment and relatively complex plants. This reflects the views of many of the partners, that the ATEX directive was not intended to just be applied to individual items (like motors and pumps) but also to systems where much more complex failure modes could exist. However it is not yet clear whether this is the intention of member states and the commission. Five sources of information are available to assess the industrial trials performed for the RASE methodology.

1) INERIS performed a worked example of the methodology on a pneumatic conveyor with the aid of an industrial manufacturer.
2) Niro performed an internal review of the methodology, and reported a review by 18 other companies.
3) Inburex applied the methodology to a coffee roaster and metal mixer.
4) CMR performed a risk assessment on an oil rig, doing most of the work themselves.
5) HSL received comments from Henry Sizer Ltd. who make solids handling equipment.

INERIS (PNEUMATIC CONVEYOR)

INERIS applied the methodology to the pneumatic conveying of crystallised sugar (Figure 1), and provided a detailed report, which is summarised in this paper. The process consisted of the pneumatic conveyance of the crystallised sugar from a lorry to a storage silo then on to a blow tank, and finally a hopper. The assessment team consisted of two people from INERIS, two from the manufacturer, and one from the Mechanical Industries Federation, and was completed within three hours.

The manufacturer received the methodology two weeks before the trial was performed, and were asked to state their initial thoughts. These included :-

1) Should a standard contain descriptions of hazard identification techniques? Could you limit the number and size of techniques described, or refer to books?
2) There must be a link between this methodology and the ATEX guidelines.
3) What do we have to do exactly?
4) Is it possible to give guidance on what are considered frequent, probable, occasional, remote, and improbable malfunctions?

Most of the remarks made by the manufacturer indicated that they found the methodology too long and complex to be easily understood, and therefore quickly applied. They would prefer a more concise document that clearly stated the steps to be performed and how they are related to the ATEX directive.

To perform the methodology the plant was initially split into functional units, which can be seen in Figure 2. Identifying what was to be considered a unit operation was found to be difficult. It was not understood if all possible operations should be included or just equipment, and further instruction was required. Each unit operation was then evaluated to identify their potential hazards. It was decided that the lorry itself was outside the scope of the risk assessment. Tables 1-4 list the possible hazards identified.

Table 1. Hazards identified for the pneumatic unloading of the lorry.

Reference	Explosive atmosphere	Frequency of release	Potential source of ignition	When/where	Effectiveness of ignition
1	Cloud of combustible dust	Present at the end of the loading	Static electricity sparks	During malfunction (no earthing)	High
2	Cloud of combustible dust	Present at the end of the loading	Mechanical sparks or heating because of foreign bodies	During malfunction (grid at the inlet present)	Low

Table 2. Hazards identified during storage in the silo.

Reference	Explosive atmosphere	Frequency of release	Potential source of ignition	When/where	Effectiveness of ignition
3	Cloud of combustible dust	Present during filling	Static electricity sparks	During malfunction (no earthing)	High
4	Cloud of combustible dust	Present during filling	Mechanical sparks or heating because of foreign bodies	During malfunction	Low
5	Cloud of combustible dust	Present during filling	Fire in the filter	During malfunction	High

Table 3. Hazards identified during the filling of the blow tank.

Reference	Explosive atmosphere	Frequency of release	Potential source of ignition	When/where	Effectiveness of ignition
6	Cloud of combustible dust	Present during filling	Static electricity sparks	During malfunction (no earthing)	High
7	Cloud of combustible dust	Present during filling	Mechanical sparks or heating because of foreign bodies	During malfunction	High
8	Cloud of combustible dust	Present during filling	Electrical sparks due to the level control	During malfunction	?

Table 4. Hazards identified during the filling of the hopper.

Reference	Explosive atmosphere	Frequency of release	Potential source of ignition	When/where	Effectiveness of ignition
9	Cloud of combustible dust	Present during filling	Static electricity sparks	During malfunction (no earthing)	High
10	Cloud of combustible dust	Present during filling	Mechanical sparks or heating because of foreign bodies	During malfunction	Very low
11	Cloud of combustible dust	Present during filling	Electrical sparks due to the level control	During malfunction	?
12	Cloud of combustible dust	Present during filling	Fire in the filter	During rare malfunction	High

Table 5. Risk estimation of the hazards.

Reference	Frequency	Severity
1	Probable	Major
2	Probable	Major
3	Probable	Major
4	Remote	Major
5	Remote	Major
6	Probable	Major
7	Probable	Major
8	Probable	Major
9	Probable	Major
10	Remote	Major
11	Probable	Major
12	Remote	Major

Table 6. Risk evaluation of the hazards.

Reference	Risk level	Reference	Risk level
1	A	7	A
2	A	8	A
3	A	9	A
4	B	10	B
5	B	11	A
6	A	12	B

This analysis has omitted the filters, though this is one of the more likely sites for an explosion to start. The consequence may be only minor or moderate if the filter is sited safely, and the explosion does not spread to other items.

The hazards identified in tables 1-4 then had their frequency and severity estimated using the categories defined in the methodology. The risk estimation was performed without taking into consideration preventative and protective measures. Difficulty in identifying the appropriate category of frequency and severity occurred, and better definitions were believed to be required. Table 5 shows the risk estimation of the hazards, and the values estimated were then applied to the frequency-severity matrix (present in the methodology) to evaluate the risk, which can be seen in table 6. The matrix categorises the risk as being in the range A to D, with A being intolerable and D acceptable.

Simple measures are available to reduce all these risks. They include:

1) Earthing of all items.
2) Explosion venting.
3) Explosion pressure resistant vessel for the blow tank.

An appraisal questionnaire was completed after the trial and the following problems were indicated, reiterating those made before the trial:

1) There was some misunderstanding about “frequency of release” and “effectiveness”.
2) Difficulty in evaluating the frequency and severity.
3) Difficulty in identifying the threshold between acceptability and unacceptability.

It was found that the methodology helped the manufacturer understand the environment in which the equipment was to be used, and the interaction between equipment, protective systems, components and the substances being handled. The industrial manufacture also noted on the questionnaire that they would rarely use the methodology, as it was too complicated. Improvements suggested were, clarify the methodology, give the most important aspects, and provide worked examples.

NIRO (METHODOLOGY REVIEW)

Niro distributed 18 reports to different companies and received 10 responses. These responses were from 5 suppliers, 2 users, and 3 consultants. General comments from Niro’s own engineers, and received from elsewhere, were rather negative, and included:

1) Clear, unambiguous guidelines with direct practical applicability were wanted.
2) The document was difficult to navigate from a practical point of view.
3) It gives the impression that it is not intended for the occasional user, who needs to be able to dip in to get guidance, but rather seems to be a summary of many techniques.
4) A simple flow chart to show how the various parts of the methodology relate to one another would help, as it was difficult to work out exactly how it should be used in practice.

APV Nordic Anhydro who also reviewed the methodology saw it as a dictionary or reference volume on the subject of risk assessment, rather than a methodology that could be incorporated into a draft standard. They particularly wanted worked examples directed towards specific applications.

INBUREX (APPLICATION OF METHODOLOGY)

Inburex applied the methodology to a coffee roaster and a metal mixer. They identified a number of benefits and drawbacks of the process, which were that it:

1) Systematically analyses the known risks, including the consequence of malfunctions of single components.
2) Identified risks mainly controlled by maintenance or improved information for use.
3) Helped evaluate options for risk reduction.

Various drawbacks were also identified.

1) The results obtained would clearly depend on the knowledge of the team either about safety measures specific to the equipment being assessed and/or on the use of the methodology. It was felt therefore that the standard would need to define in some way the required skills and competencies of the team conducting the risk assessment.
2) Individual steps of the methodology were usually not applied separately as they were closely related to one another. It was felt therefore that:
   a) Guidance needed to be included which indicated clearly that the steps of the methodology were closely linked and do not have to be executed separately.
   b) A form for recording the results of the methodology needed to be such that it can contain all the steps of methodology.

CMR (OIL RIG)

CMR described a quantitative risk assessment of an oil rig, including a well head and accommodation area. An initial assumption that a major leak would ignite was taken as the starting point, and QRA was used to estimate the consequences in terms of pressure development. The output of this was used to produce informed decisions about acceptable risks, and the design of internal partitions.

EVALUATION OF THE INDUSTRIAL TRIALS

Key conclusions from these trials were:

- Manufacturers were not familiar with existing standards in related areas such as EN 292-1[3], and EN 1127-1[4]. This was also a finding from the initial survey of manufacturers.
- Manufacturers need to do more to define the intended use of equipment they supply.
- The draft needs to make clear that quantitative risk assessment is not intended in most circumstances, so setting numerical values for foreseeable faults or rare malfunctions is not appropriate.
- The usefulness of the long list of available techniques is debatable; as improved clarity is needed on the relative responsibilities of the equipment manufacturer and user.
- The long list of risk assessment techniques incorporated into the text was questioned. Many are quite complex to use and inappropriate except in specialist circumstances. In general they are not described within the methodology in sufficient detail to allow them to be used in practice and indeed some would require training in their use. It was suggested that references to additional literature should be included. However it is not possible to supply European wide references except for the limited number described in European or International standards.

CONCLUSIONS

1) The industrial trials showed that it is very difficult to write a standard for risk assessment for the whole range of equipment that may be covered by ATEX.
2) Many manufacturers still need to do more to comply with existing requirements for risk assessment implied by the machinery directive.
3) A major concern identified by the industrial trials was the wide range of risk assessment techniques listed. Information is required on how to choose the appropriate technique, and how detailed the risk assessment is required to be.
4) Worked examples are seen as a good way of showing the level of complexity that seems appropriate for analysing the risks in particular types of plant and equipment. Six examples covering a diverse range of applications within the scope of the ATEX directive are being prepared.
5) The comments received and experience gained from the industry trials have been helpful in improving the final draft of the methodology to be presented to the CEN working group responsible for producing a standard for risk assessment under ATEX.
6) It was decided to retain the long list of techniques, as all may have value in particular circumstances. However as most of these are not standardised, nor available in a wide range of community languages, and some are only described in scientific research papers, more detailed references were not possible.

REFERENCES

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3. BS EN 292: Part 1, 1991. Safety of machinery – Basic concepts, general principles for design Part 1. Basic terminology, methodology. *British Standards Institute.*

4. BS EN 1127: Part 1, 1997. Explosive atmospheres – Explosion prevention and protection Part 1. Basic concepts and methodology. *British Standards Institute.*

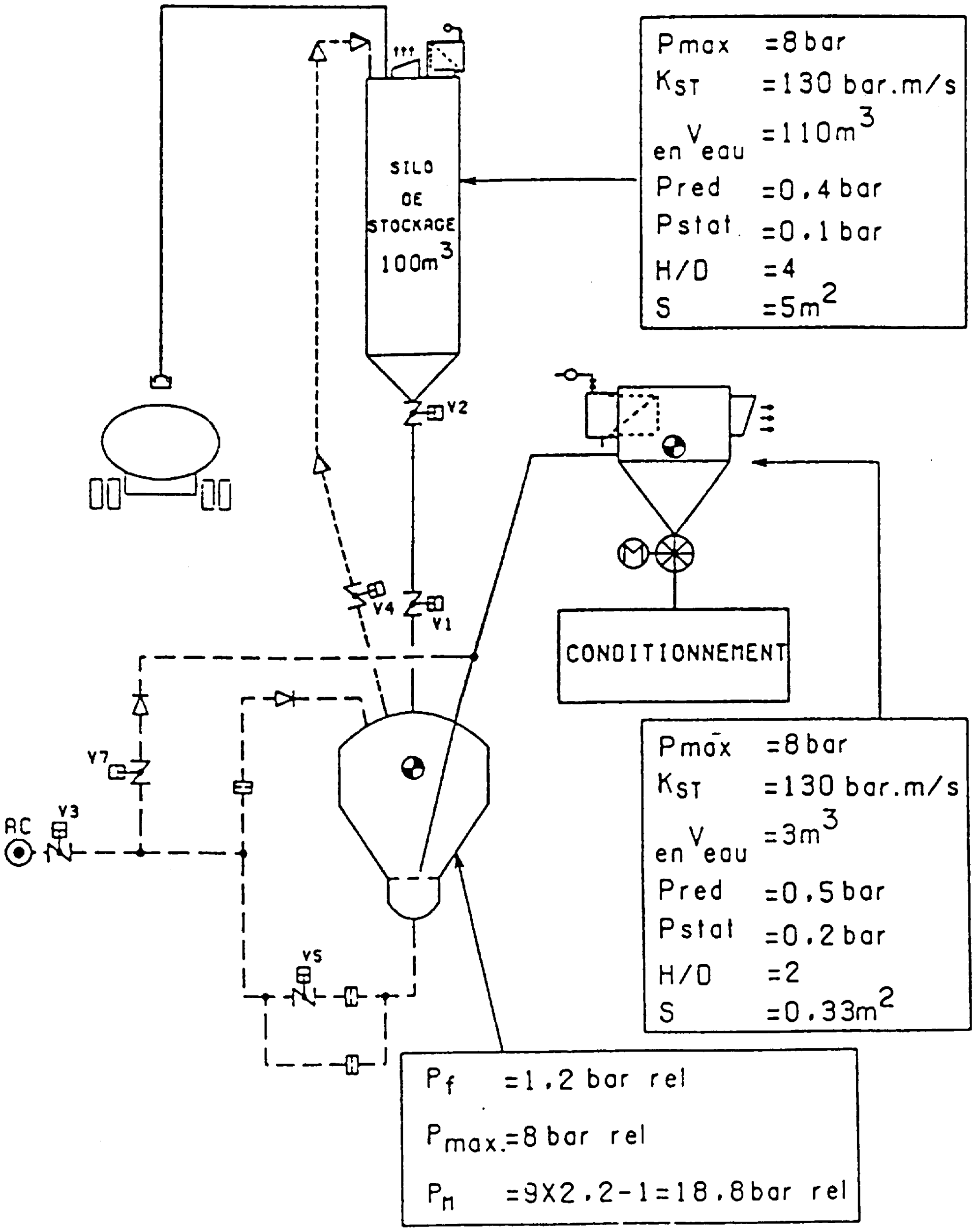

Figure 1. Schematic of the pneumatic conveying of crystallised sugar.

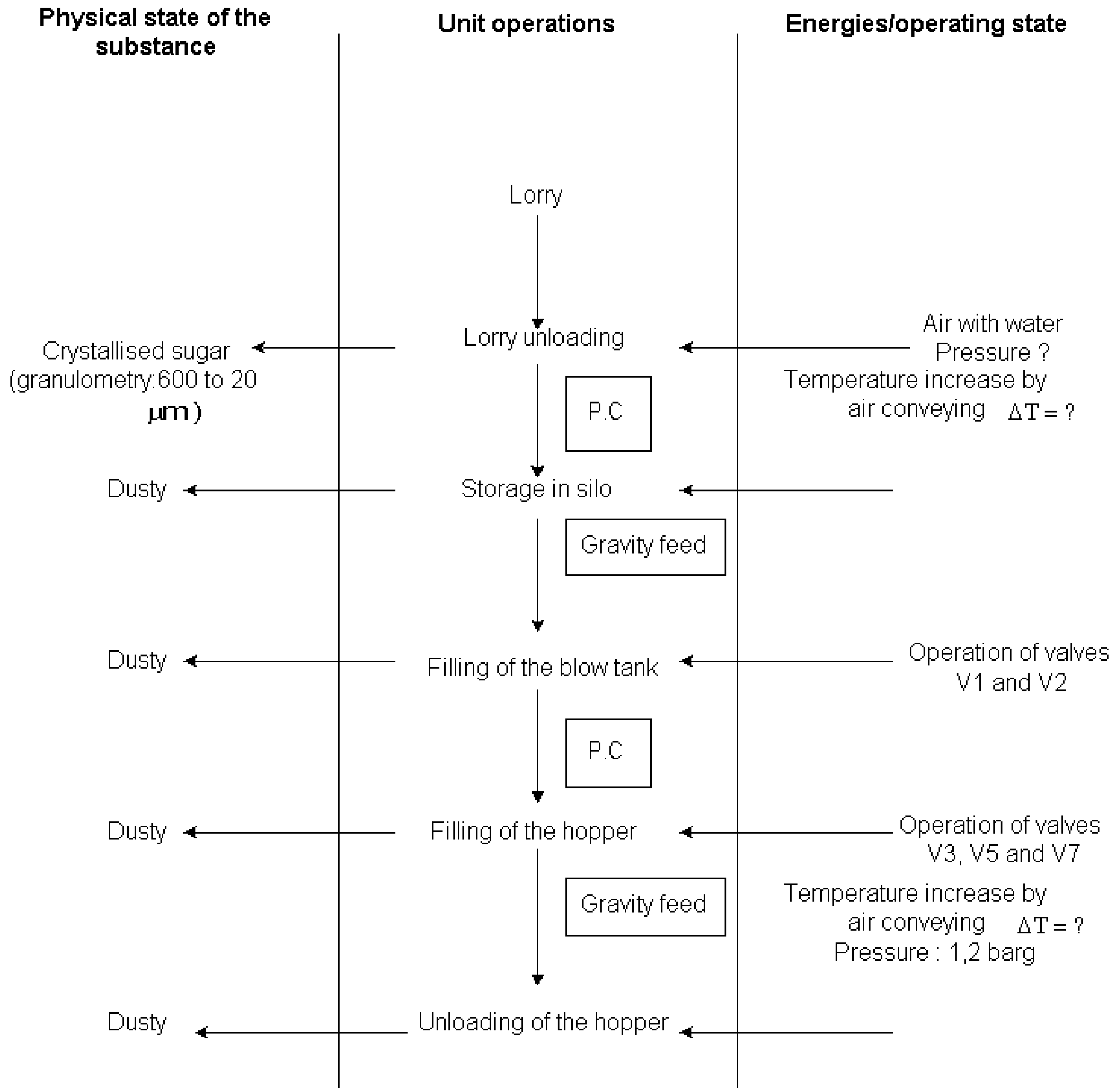

Figure 2. Functional diagram of the pneumatic conveyance of crystallised sugar.