

PRACTICAL EXPERIENCE IN CARRYING OUT NON-ELECTRICAL EQUIPMENT IGNITION RISK ASSESSMENTS

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Non-electrical equipment is commonly used in the handling and processing of flammable liquids, gases and powders in the process and allied industries. Typical equipment includes fans, pumps, reactor agitators, screw conveyors and bucket elevators. Such equipment items can generate sources of ignition for flammable atmospheres. Assessing the potential ignition risks from existing ("pre-ATEX") equipment located within hazardous areas is required in order to fully comply with the DSEAR Regulations and the meaning of the ATEX 137 Directive. A systematic approach to the assessment of ignition risks from non-electrical equipment has been developed in partnership between Acetate Products Ltd. and Chilworth Technology Ltd. This joint paper describes the experiences gained in developing a practical methodology for non-electrical equipment ignition risk assessments, and the subsequent improvements made to the method during assessment of a range of equipment items at the Acetate Products site in Spondon, Derbyshire. The developments include defining the scope of the assessment, the type of ignition sources under consideration, the constitution of the assessment team, information required on the flammable materials, equipment and process detail requirements, and the need to identify other layers of protection when ignition risk levels are unacceptably high. The work covered both equipment handling flammable vapours and powders across the full range of hazardous Zone designations. The assessment methodology draws from existing standards such as EN 1127-1 and EN 13463, as well as significant practical experience in explosion risk assessments, process plant operation and knowledge of the maintenance history of equipment. The mostly qualitative approach that has been derived can be applied to most common industrial applications of non-electrical equipment located in hazardous areas. The experience from this and other assessments has identified a number of key learning points which are considered well worth sharing with industry in general to improve understanding in this important area of explosion prevention.

INTRODUCTION

The requirement to assess the likelihood that ignition sources will be present and become active and effective within areas where explosive atmospheres may potentially exist is an explicit requirement in European[1] and in UK[2] legislation. For electrical equipment located in potentially explosive atmospheres, codes and standards have been available for some time. For non-electrical equipment, similar codes and standards have not been available until recently. Many operating companies now find themselves in a position where the suitability of electrical equipment such as a drive motor may be relatively easily determined by reference to design standards. However, the determination of the suitability of the connected non-electrical components, such as a centrifugal pump drive system, is not so straightforward.

The assessment of the potential ignition risks from non-electrical equipment is not, and should not be, the starting point in the DSEAR compliance process. It should be recognised that the assessment of ignition risks from non-electrical equipment is just one tool that companies can use to provide a suitable explosion basis of safety. As with any assessment that requires a high level of detail it is all too easy to concentrate on the detail and miss the overall objective of the DSEAR risk assessment process. Figure 1 below, shows an indicative flow diagram for the risk assessment required under the DSEAR regulations.

Figure 1, shows the relationship between the assessment areas covered by this paper (shaded area) and the overall assessment process. The non-electrical risk assessments consider only the ignition risk arising from the equipment and do not cover other aspects of the safety management systems that need to be in place to control other sources of ignition. Such other sources of ignition would include control of hot work etc. The paper has also not considered non-electrical ignition risks which could arise from non-electrical components of the motors themselves, as these are included in the electrical ignition risk assessment.

The hierarchy of risk reduction laid out in legislation states, in order of preference, that the following should take place:

- the prevention of the formation of explosive atmospheres, or where the nature of the activity does not allow that,
- the avoidance of the ignition of explosive atmospheres, and
- the mitigation of the detrimental effect of an explosion so as to ensure the health and safety of workers.

Therefore, the first priority should always be to determine whether or not flammable atmospheres can be avoided or their extent reduced. Non-electrical equipment ignition risk assessments only then need to be performed in areas where a basis of safety of avoidance of flammable atmospheres cannot be achieved, and hence a basis of safety of avoidance of ignition sources needs to be confirmed.

In order for operating companies that have existing “non-ATEX” equipment located in hazardous zones to meet their obligations laid down in legislation, an assessment of the ignition risks of the non-electrical equipment is required. The assessment needs to identify whether effective ignition sources can be generated by the non-electrical equipment, and where they can be, whether adequate control measures are in place to prevent them becoming an effective ignition source in relation to the hazardous area in which they are located.

With the above comments in mind, Acetate Products Ltd. and Chilworth Technology Ltd. have collaborated to develop a systematic, yet practical, risk assessment methodology for the ignition risk assessment of non-electrical equipment.

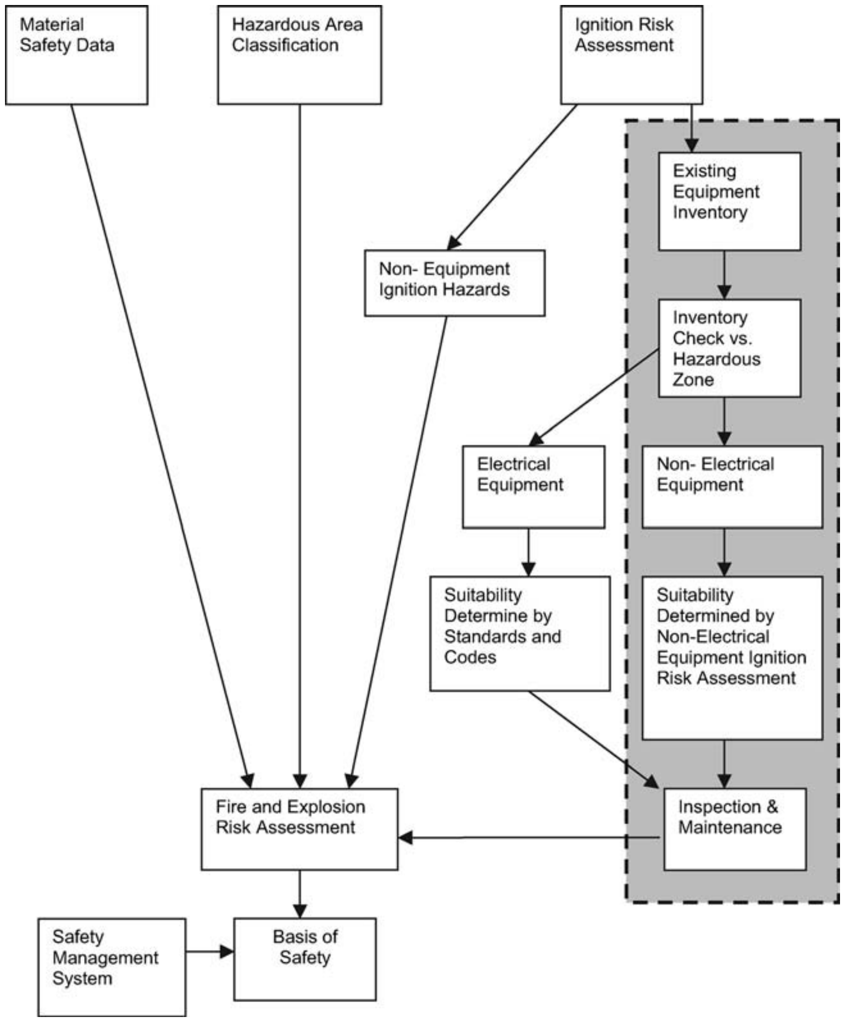

Figure 1. Indicative path to DSEAR compliance

METHODOLOGY

As with any risk assessment, in order to ensure that it is suitable and sufficient, relevant standards and codes of practice should be applied as far as possible. In the case of ignition sources in potentially explosive atmospheres, EN 1127-1[3] provides a comprehensive

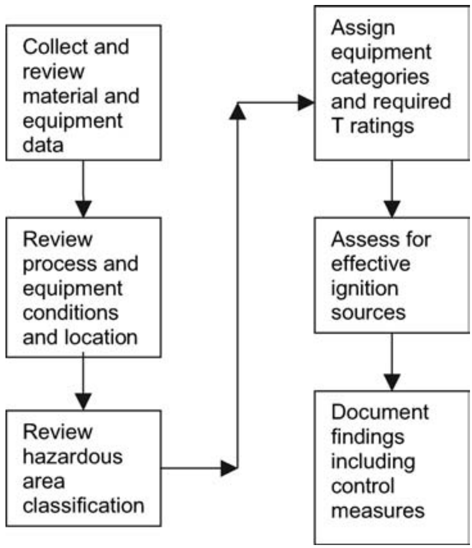

Figure 2. Basic steps of non-electrical ignition risk assessment

discussion of a wide range of potential ignition sources and how they might arise in practice. For non-electrical equipment, the new EN 13463[4] series, which is primarily aimed at equipment manufacturers rather than users, is also a useful source of information. For assessing existing equipment, utilising a similar approach to that required of the equipment manufacturers is considered to be an acceptable route to take.

The basic steps taken during the assessment process are shown below in Figure 2. Each step is then discussed in more detail.

COLLECT AND REVIEW MATERIAL AND EQUIPMENT DATA

It is important to review existing material data to ensure that the both the ignition sensitivity and the maximum temperatures that need to be adhered to are clearly defined. For gases and vapours, the most important parameter for the mechanical ignition risk assessment is the auto ignition temperature (AIT). When assessing risk from electrostatic discharge, the Minimum Ignition Energy (MIE) is important, but for most gases and vapours, the value is low (<1 mJ) and accurate data is of limited importance. For reviewing the hazardous area classification, the flash point of the liquid is also important. Material data for common liquids and gases can be found IEC 60079-20[5]. Typically, literature data can be directly used for pure liquids and gases.

For powders the layer ignition temperature (LIT), the minimum ignition temperature of the dust cloud (MIT), the minimum ignition energy (MIE) and the relevant onset temperature of decomposition (if applicable) are all important parameters. Some generic data for powders is available within the public domain[6] although care must be taken when applying this data to ensure that it is relevant to the materials under assessment. Specific data for the powders handled should preferably be determined in order to ensure its applicability.

Information on the equipment such as materials of construction, rotational speeds etc. are also important when reviewing the likelihood of ignition source generation. Records of equipment failures and corrective maintenance records are useful as they may reveal specific issues with the equipment under consideration. Planned preventative maintenance records should also be reviewed against the supplier's original instructions to investigate whether a suitably comprehensive maintenance regime is being undertaken.

REVIEW PROCESS AND EQUIPMENT CONDITIONS AND LOCATION

A visual inspection of the equipment in its working environment should also be undertaken to enable the assessment to identify any environmental factors such as dust, vibration and heat. This will also indicate any damage to the equipment such as a loose guard which might rub against a coupling. Visual inspection will also help to identify adverse environmental conditions such as equipment being located in an underground service duct that may necessitate an increased maintenance frequency to ensure continued safe operation.

The location review will also aid in the review of the hazardous area classification. For example, if powder layers are evident then an additional Zone 22 designation may be required.

REVIEW HAZARDOUS AREA CLASSIFICATION

The correct area classification around the equipment is fundamental to ensuring that a suitable and sufficient risk assessment is undertaken. If the zone designation is too high, then unnecessary control measures may need to be put in place as well as additional time and resource being wasted in the further detail required for the higher category assessment. If the zone designation is too low then there is a risk that ignition sources occurring in expected or rare malfunctions may be overlooked. It is particularly important to review the approach to hazardous area classification and whether or not a blanket approach has been used. In the experience of the authors, the majority of equipment to be assessed should be in a Zone 2 designation. If an area has been designated blanket Zone 1 for convenience rather than for the existence of a 'true' Zone 1, then time is often better spent refining the zoning to reduce the Zone 1 extent rather than undertaking a large number of category 2 assessments.

It is also important to ensure that the zoning inside the equipment has been agreed. This aspect of hazardous area classification is often overlooked.

Table 1. Relationship between the hazardous area classification and equipment category

Hazardous area classification	Equipment category
Zone 0 (gases)	Category 1 G
Zone 20 (dusts)	Category 1 D
Zone 1 (gases)	Category 2 G
Zone 21 (dusts)	Category 2 D
Zone 2 (gases)	Category 3 G
Zone 22 (dusts)	Category 3 D

ASSIGN EQUIPMENT CATEGORIES AND REQUIRED T RATINGS

Equipment categories were assigned as described in EN 13463-1[4] and shown in Table 1 below.

Based on the material data for the substances used and the defined hazardous areas, maximum surface temperatures were determined. For gases and vapours the usual nomenclature[4] shown below in Table 2 were assigned. Using the temperature class in this way allows the user to compare the non-electrical and electrical equipment within an area.

For dusts the maximum surface temperature was stated as a temperature rather than in a temperature class format. This is consistent with the approach taken by equipment manufacturers for equipment for use in flammable dust zones.

ASSESS FOR EFFECTIVE IGNITION SOURCES

The sources of ignition considered in the assessment were taken from EN 1127-1[3] and shown below:

1. Hot surfaces
2. Flame and hot gases

Table 2. Relationship between the maximum surface temperature and the temperature class

Maximum surface temperature	Temperature class
450°C	T1
300°C	T2
200°C	T3
135°C	T4
100°C	T5
85°C	T6

3. Mechanically generated sparks
4. Electrical Apparatus
5. Stray electrical currents, cathodic corrosion protection
6. Static Electricity
7. Lightning
8. Radio frequency (RF) electromagnetic waves from 10^4 Hz to 3×10^{12} Hz
9. Electromagnetic waves from 10^{11} Hz to 3×10^{15} Hz
10. Ionising radiation
11. Ultrasonics
12. Adiabatic compression and shock waves
13. Exothermic reactions, including self-ignition of dusts

In general terms, during the pilot assessment it was shown that only ignition source numbers 1, 3 and 6 were relevant to the mechanical equipment located within the areas under review. Although the other ignition sources may occur such as sparks from hot work or static discharges from personnel, these are considered in other Acetate Products Ltd. risk assessment documents, and are not specific to individual pieces of equipment.

DOCUMENT FINDINGS INCLUDING CONTROL MEASURES

As with any risk assessment the significant findings need to be recorded. The chosen format used for this assessment is similar to the tables shown in EN 13463-1[6]. Using the format that is aimed at equipment manufacturers also gives a good format for recording the assessments for existing equipment.

EXAMPLES

The best way to illustrate the methodology is to describe examples.

Two examples of the assessments performed at the Spondon site area are shown below. Both of the examples concern centrifugal pumps. The first pump is located in a Zone 2 area, whilst the second pump is located in a Zone 1 area. These have been chosen to illustrate the increase in the level of detail required for the assessment of category 3 vs. category 2 equipment.

The data for the process liquids used in the examples is shown in Table 3 below:

Example 1

The centrifugal pump in this example is pumping benzene nominally at ambient conditions. The pump is constructed from 316 stainless steel and is located within a Zone 2 area. The inside of the pump has also been designated as Zone 2 as it is normally liquid filled. The equipment is not located adjacent to sources of excessive heat, dust or vibration.

The first step in the assessment is to assign the equipment category, as shown in Table 4 below.

A temperature class of T1 (maximum surface temperature of 450°C) is appropriate for benzene.

Table 3. Safety data for the materials used in the example areas

Material	Flash point (°C)	Minimum ignition energy (mJ)	Flammability limits (vol. %)		Vapour density (Air = 1.0)	Auto ignition temperature (°C)	Temperature class	Gas group	Liquid conductivity (pS m^{-1})
			LEL	UEL					
Acetic acid	40	No data	4.0	17.0	2.07	464	T1	IIA	1.12×10^{6}
Benzene	−11	0.2	1.2	8.6	2.70	560	T1	IIA	5×10^{-3}

Table 4. 10AA quench pump equipment category

ITEM	ID	DESCRIPTION	Hazardous area classification	Equivalent equipment category
1		10AA Quench Pump	Zone 2 internally and externally	Category 3G internally and externally

In this case, for category 3 equipment, the ignition assessment is restricted to ignition sources that can arise during normal operation only. The results of the assessment are shown in Table 5 below.

The result of the assessment is that no effective ignition sources are likely to occur during normal operation of the pump provided that pump is adequately maintained in line with the manufacturer's instructions and good engineering practice. References to the clauses in EN 13463-1[4] and EN 1127-1[3] are made to show that the measures applied to prevent the ignition sources becoming effective, as far as possible meet the requirement of a relevant standard.

Whilst not shown in this example, it is advisable to assign responsibility and a time-scale to any actions arising from the assessment. An additional column on the assessment template is useful in this respect.

Example 2
In this example another centrifugal pump of stainless steel construction is used in an acetic acid environment. In this case the temperature of the process liquids is elevated to 60°C, and hence the acetic acid vapour may generate a flammable atmosphere upon release. Again the inside of the pump has been designated as Zone 2. However, the outside of the pump has been designated as Zone 1. The equipment is not located adjacent to sources of excessive dust, heat or vibration.

The relevant categories are applied to the inside and outside of the pump as shown in Table 6 below.

In this case, for the inside of the category 3 equipment, the ignition assessment is again restricted to ignition sources that can arise during normal operation only. The outside of the pump however must be assessed for expected malfunctions as well as normal operation. The results of the assessment are shown in the table below

The results of the ignition assessment for this equipment are shown below:

As can be seen from the assessment above, further manufacturer's data is required for obtaining temperatures achieved when pumping against a closed head and when running the pump dry. Whether such data exists will depend upon whether or not the manufacturer has carried out testing themselves. Such data may also be available from plant experience. Alternatively, it is possible that control measures are put into place to prevent the above conditions occurring. For pumping against a closed head using a

Table 5. Ignition assessment for item 10AA Quench pump

Potential ignition source					
Potential ignition source EN 1127- 1	Normal operation (Category 3)	Expected malfunction (Category 2)	Rare malfunction (Category 1)	Measures applied to prevent the source becoming effective	Ignition protection used
Surface temperature	Pump surface	N/A	N/A	Pump internals cooled by process fluid below 300 deg C. Motor rated T1. Mechanical friction due to wear and tear of moving components will be detected at routine inspections before they are an issue.	EN 13463-1:2001 Section 5.2.5
Mechanically generated sparks	Mechanically generated sparks	N/A	N/A	See above. No light metals used in pump construction.	EN 13463-1:2001 Clause 8
Electrical apparatus	Electrical apparatus	N/A	N/A	Motor to be rated to at least T1	EN 1127-1: 1997 Section 6.4.5
Static electricity	Static electricity	N/A	N/A	Earth bonding. Routine earthing check. No non-conductive parts.	EN 13463-1:2001 Section 7.4

Table 6. FA2 DARO pump equipment category

Item	ID	Description	Hazardous area classification	Equivalent equipment category
2		FA2 DARO centrifugal pump	2 internally and 1 externally	Category 3G internally and Category 2G externally

kickback line or relief valve are possible mitigation options. This may need to be combined with a high temperature trip if it is possible for the pump to then heat up the fluid as it circulates. To prevent a pump from running dry, a low or no flow alarm/trip are options. If instrumented systems are used as control measures, then their required safety integrity level (SIL) should be assessed in accordance with IEC 61508/11[7].

DISCUSSION

As the assessment of existing equipment is performed by operating companies, rather than equipment manufacturers, there is the potential that the scope of the assessment can deviate to include operational ignition risks that are not specific to the equipment under review. This can include the control of external ignition sources such as hot work, smoking and electrostatic discharges from personnel. These risks should be controlled by other site procedures and risk assessments, and to optimise the efficiency of the non-electrical ignition source risk assessment, should not be discussed at this stage.

The maximum surface temperatures are usually derived from the auto-ignition temperature of the gases or vapours or the minimum ignition temperature and layer ignition temperature of the powders with an appropriate safety factor in each case. In cases where thermal decomposition may occur, the onset temperature should also be taken into account when developing the safe maximum temperatures. In many cases this can dominate the maximum allowable temperature and so should not be overlooked.

The importance of regular inspection and maintenance cannot be over-stated for the reduction in ignition risks from non-electrical equipment. Minor faults with equipment can be picked up quickly before effective ignition sources are generated. If equipment is not maintained or inspected then it must be assumed that at some point within the life of the equipment that an effective ignition source will arise. This is because without maintenance, the equipment is being run to destruction. In a Zone 2 (category 3) area, a lack of maintenance would mean that abnormal and possibly even rare malfunctions may also have to be considered as these could form part of the normal operation of the equipment.

In the case of equipment in Zone 2 or Zone 22 areas (category 3G and 3D), demonstrating an appropriate level of maintenance is likely to be adequate to show that equipment is safe for continued use. In Zone 1 or Zone 21 areas (category 2G and 2D), use of maintenance alone may be adequate but is likely to require a higher frequency of inspection and maintenance than for category 3 equipment. Additional safety devices such as relief valves or instrumented protective systems may also be required for category 2 equipment. In the case of instrumented protective systems, a SIL assessment in accordance with IEC 61508/11 will be required.

Where equipment is used infrequently, use of manufacturers recommended maintenance intervals which are based upon operational hours, may not be appropriate. Some equipment may not operate for that number of hours in its entire lifetime. In these cases, more frequent maintenance intervals may need to be applied dependent upon the outcome of the risk assessment.

Most non-electrical equipment should be outside of Zone 0 or Zone 20 areas and therefore category 1G and 1D assessments should be less common. Except in the case of simple equipment, use of alternative prevention of protection systems such as inerting or explosion relief is likely to provide a more robust basis of safety than trying to demonstrate that ignition sources can be controlled where a continuous flammable atmosphere is present.

The risk of ignition from the motors associated with the non-electrical equipment has been included within the assessment in order to facilitate the assessment of their suitability, and hence allow the whole unit to be assessed at the same time.

Historically blanket zoning has been used within many companies in the chemical and allied industries. A source of release approach, as has been used by Acetate Products, ensures that a much more detailed classification is available, and hence a greater level of confidence that an appropriate level of detail has been applied to the non-electrical equipment ignition risk assessment. A large amount of detailed risk assessment work will be required for companies who continue to use artificially high blanket zoning. Additionally, there are health implications for the operators who are working in areas where Zone 1 designations are in place, as occupational exposure standards are much lower than the lower explosion limits of most flammable vapours. If ventilation inside buildings is so poor, or the number and frequency of releases so high as to require a 'true' blanket Zone 1, then this should be addressed as a priority to reduce the hazardous extents before assessing all equipment for category 2.

For the more complicated assessments i.e. category 1 and 2 equipment, it is recommended that a multidisciplinary team of people be used to complete the assessment. The team should include operations and maintenance staff who can supply information on the practical aspects of the operation of the equipment and likely failure modes. It may also be necessary to involve the original equipment manufacturer in some cases. For category 3 equipment this input may still be required to understand and properly define "normal operation". It is also recommended that a suitable assessment leader is appointed to facilitate the meetings.

Since the above methodology was developed a new draft standard for ignition hazard assessment has been introduced: prEN 15198[8]. This draft standard uses a similar basic methodology as developed (separately) by Acetate Products Ltd. and Chilworth

Table 7. Ignition assessment for item FA2 DARO

Potential ignition source EN 1127-1	Potential ignition source: Normal operation (Category 3)	Potential ignition source: Expected malfunction (Category 2)	Potential ignition source: Rare malfunction (Category 1)	Measures applied to prevent the source becoming effective	Ignition protection used
Surface temperature	Motor surface	Motor surface under overload / fault conditions	N/A	T1 category 2 equivalent motor	EN 1127-1:1997 Section 6.4.5
	Wear and tear of mechanical components	N/A	N/A	Pump internals cooled by process fluid below 300 deg C. Mechanical friction due to wear and tear of moving components will be detected at routine inspections before they are an issue.	EN 13463-1:2001, clause 15 instructions
		Running with no liquid in pump	N/A	Experience and pump design i.e. bearings not in contact with liquid, make it unlikely that temperature can reach 300 deg C ***Manufacturer's data required here***	

(*Continued*)

Table 7. *Continued*

	Potential ignition source				
Potential ignition source EN 1127-1	Normal operation (Category 3)	Expected malfunction (Category 2)	Rare malfunction (Category 1)	Measures applied to prevent the source becoming effective	Ignition protection used
		Misalignment of pump and drive - can lead to seal failure	N/A	Laser alignment used at installation. Condition Based Monitoring (CBM) used there after. Following manufacturer's instructions.	EN 13463-1:2001, clause 15 instructions
Surface temperature (cont.)		Failure of shaft seal	N/A	Failure of seal will give rise to local heating, this is unlikely to lead to an exposed surface temperature above 300 deg C. CBM routines in place. Following manufacturer's instructions.	EN 13463-1:2001, clause 15 instructions
		Pumping against closed head	N/A	***Manufacturers data required here***	

Pump running at over speed	N/A	Fixed speed drive @ 2900 rpm.	EN 13463-1:2001, clause 15 instructions and "c"
Seal failure due to incompatible materials	N/A	Failure of seal will give rise to local heating, this is unlikely to lead to an exposed surface temperature above 300 deg C. CBM routines in place. Following manufacturer's instructions.	EN 13463-1:2001, clause 15 instructions and "c"
Failure of drive shaft bearing	N/A	CBM routines in place. Following manufacturer's instructions.	EN 13463-1:2001, clause 15 instructions and "c"
Breaking of impellor	N/A	Considered to be rare failure. Not considered as part of Cat 2 assessment.	Not applicable for Category 2 equipment

(*Continued*)

Table 7. *Continued*

	Potential ignition source				
Potential ignition source EN 1127-1	Normal operation (Category 3)	Expected malfunction (Category 2)	Rare malfunction (Category 1)	Measures applied to prevent the source becoming effective	Ignition protection used
		Friction between guard and coupling	N/A	Inspection and maintenance - this would make this failure mode a rare failure and hence not required to be considered for cat 2.	Not applicable for Category 2 equipment
Mechanically generated sparks		Grinding and frictional sparks between coupling and guard	N/A	Reference frictional heating above. No light metals used in pump construction.	EN 1127-1:1997 Section 6.4.5
Electrical apparatus	Electrical sparks	N/A	N/A	Motor is rated to at least T1 Cat 2 or equivalent	EN 1127-1:1997 Section 6.4.5
Static electricity	Discharge from isolated conductors or non-conductors	N/A	N/A	Earth bonding. Routine earthing check. No non-conductive parts.	EN 13463-1:2001 Section 7.4
		Discharge from non conducting component introduced during repair		Change procedures require full assessment of any non like for like components.	EN 13463-1:2001, clause 15

Technology Ltd. The lessons learned from this exercise and described in this paper should be useful when applying the new draft standard when it is available as a final document.

CONCLUSIONS

An assessment methodology has been developed for assessing ignition risks from non-electrical equipment to demonstrate safe continued use of the equipment within hazardous areas. The assessment methodology draws from existing standards such as EN 1127-1 and EN 13463, as well as significant practical experience in explosion risk assessments, process plant operation and knowledge of the maintenance history of equipment. The mostly qualitative approach that has been derived can be applied to most common industrial applications of non-electrical equipment located in hazardous areas. The experience from this and other assessments has identified a number of key learning points which are considered well worth sharing with industry in general to improve understanding in this important area of explosion prevention. The key learning points are summarised below:

1. The assessment of the potential ignition risks from non-electrical equipment is not, and should not be, the starting point in the DSEAR compliance process. Consideration of avoidance of a flammable atmosphere e.g. by elimination of flammable materials or inerting should be given priority.
2. Always ensure that flammability data used is representative of the material under consideration. This is particularly important for dusts.
3. Records of equipment failures and corrective maintenance records are useful as they may reveal specific issues with the equipment under consideration.
4. A visual inspection of the equipment in the working location is important to identify any adverse environmental factors and to observe the equipment condition.
5. It is advisable to review the hazardous area classification particularly where there are a number of category 2 assessments required. The review should take into account the zoning for the inside of equipment as well as for the outside.
6. To maximise efficiency, it is important to focus only on those ignition sources generated by the equipment. Operational ignition sources such as hot work should not be included as part of this assessment.
7. When selecting the maximum allowable surface temperature for dusts, always consider potential for thermal decomposition which may occur at a lower temperature than layer or minimum ignition temperature.
8. Maintenance and inspection regimes are key to avoiding ignition sources from non-electrical equipment. Poorly maintained equipment could give rise to ignition sources in normal operation.
9. Category 1 and 2 risk assessments benefit from a multi-disciplinary team approach particularly to identify credible failure modes. Input from equipment manufacturers may be required in some cases.
10. An assessment leader should be appointed to facilitate an efficient assessment.

REFERENCES

1. Directive 1999/92/EC of the European Parliament and of the Council of 16th December 1999 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 Directive 89/391/EEC), commonly called the ATEX 137 Directive (formerly called ATEX 118A Directive).
2. Dangerous Substances and Explosive Atmospheres Regulations 2002, S.I.2002 No. 2776 (DSEAR 2002).
3. EN 1127-1:1997 "Explosive atmospheres – Explosion prevention and protection- part 1: Basic concepts and methodology".
4. BS EN 13463-1: 2001, "Non-electrical equipment for use in potentially explosive atmospheres Part 1: Basic method and requirements", BSI.
5. IEC 60079-20 (1996), Data for flammable gases and vapours, relating to the use of electrical apparatus, IEC 1996.
6. BIA Report 13/97, Combustion and Explosion Characteristics of Dusts, HVBG, Germany, ISBN 3-88383-469-6.
7. IEC 61508 Functional safety of electrical/electronic/programmable electronic safety related systems, Parts 1–7, 1998.
8. Draft EN 15198: "Methodology for the ignition hazard assessment of non-electrical equipment and components for intended use in potentially explosive atmospheres", BSI.