

Instructions For Safe Use – How Good Are They?

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There are thousands, if not millions, of items of equipment intended for use in potentially explosive atmospheres fitted in various hazardous facilities throughout the world from simple junction boxes to more complex machinery. In Europe, these items must be supplied under the framework of the ATEX Directive 2014/34/EU. This Directive requires, among many other things, that the manufacturer bears responsibility for providing marking and instruction for safe use, maintenance etc. as described within the Directive. Essential Health and Safety Requirement 1.0.6 outlines the expected content of the instructions but doesn't specify the form of the instructions.

This paper summarises a review of ATEX certified fan instructions against a set of ATEX and HSE Audit criterion to determine the standard of information being supplied to the end user. This paper looks at whether the ATEX requirements have been met and the overall content to consider whether suitable and sufficient information is being supplied. The incident at ExxonMobil in 2016 relating to the incorrect maintenance/ operation of a valve and the fact that the instructions provided helpful information also raises the question of even if the instructions are comprehensive, will organisations adopt the information and integrate it into work procedures.

Keywords: ATEX, Instruction, Hazardous Areas, DSEAR, Explosive Atmospheres

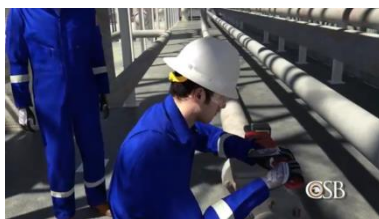
1. Introduction

Prompted by the CSB safety bulletin “Key Lessons from the ExxonMobil Baton Rouge Refinery Isobutane Release and Fire”¹ (Incorrect removal of an inoperable valve gearbox on a plug valve (reference Figure 1)) and information gained from training sessions relating to the use of mechanical equipment in hazardous areas, there is a need to consider the adequacy of information provided by equipment manufacturers.

Figure 1 – Brief Time Line of ExxonMobil Incident 2016



Four bracket retaining bolts removed which also secure the pressure retaining parts of the valve.



When the operator then attempted to move the valve with a wrench the valve came apart.



The valve released isobutene into the area.



The isobutene released for 30 seconds forming a significant vapour cloud.



After 30 seconds the cloud reached an ignition source resulting in a fire that severely burnt four workers who were unable to exit the vapour cloud before ignition.

There is a requirement that manufacturers provide a sensible amount of information to enable users to select and use the equipment correctly but is this information suitable and sufficient and furthermore can users disseminate the information into written procedures. The CSB report outlined that Flowserve provided the following warning on page 4 of their instructions².

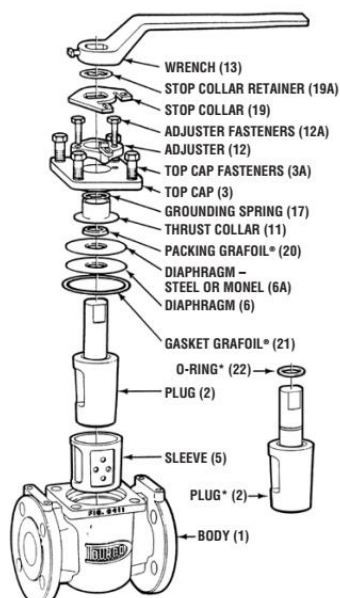
WARNING: Do not loosen or remove top cap fasteners (Part 3A) when removing an operator or accessory. Remove the operator by unfastening it from the bracket.

The image (Figure 2) for the Part 3A is provided on pages 3 and 12 of the instructions³ and photographs from the instructions are illustrated in Figure 3.

¹ On November 22, 2016 an isobutene release and fire seriously injured four workers in the sulphuric acid alkylation unit at ExxonMobil.

² Flowserve, User Instructions, Installation Operation Maintenance, G4, G4ZHF and G4R Sleeve Plug Valves, Non-Lubricated Plug Valves for Chemical Service, 2014

³ It was noted that Figure 2 does not align with the valve body photographs in the same instructions (Figure 3) as the mounting holes on the valve body are not present.

Figure 2 – Image from Flowserve Instructions**Figure 3 – Image from Flowserve Instructions**

The CSB found that the warning had not been communicated to the workers and the Baton Rouge refinery operator training material lacked information about the potential consequences of attempting to remove an inoperable plug valve gearbox.

From facilitation of training courses it is evident that information presented in ATEX equipment instructions is not taken forward into equipment maintenance procedures and there is a disconnect between procurement, installation and maintenance personnel. There are issues with instructions presented in numerous languages, too much and too little information. Personnel are also concerned with ambiguous requirements (i.e. check bearings). Furthermore, personnel have shared experiences where equipment has been ATEX approved for use in Zone 1 areas and control devices, such as temperature and vibration monitoring devices have not been connected during installation. This is believed to be due to the numerous options outlined in the instructions as the equipment can be used in various locations and it is the responsibility of the user to ensure it is suitable for use.

It is clear from experience of reviewing ATEX instructions that there is a wide spectrum in quality and content; therefore, this paper looks at a review of a small selection of ATEX fan instructions. The review looked at instruction content and ‘how good they are’ within the scope of a bespoke scoring system.

2. ATEX Requirements

So what are the ATEX requirements? Directive 2014/34/EU (relating to equipment and protective systems intended for use in potentially explosive atmospheres) outlines the requirements for instructions that manufacturers must supply with the equipment and protective systems. The requirements of the Essential Health and Safety Requirement (EHSR) 1.0.6 (Instructions) include:

- A recapitulation of the information with which the equipment or protective system is marked.
- Instruction for safe:
 - Putting into service.
 - Use.
 - Assembling and dismantling.
 - Maintenance (servicing and emergency repair).
 - Installation.
 - Adjustment.
- Where necessary:
 - Indication of the danger areas in front of pressure relief devices⁴.
 - Training instructions.
 - Special conditions for use, including particulars of possible misuse which experience has shown might occur.
 - The essential characteristics of tools which may be fitted to the equipment or protective system⁵.
- Details which allow a decision to be taken beyond any doubt as to whether an item of equipment in a specific category or a protective system can be used safely in the intended area under the expected operating conditions.
- Electrical and pressure parameters, maximum surface temperatures and other limit values.

⁴ Not included in review as very specific requirement.

⁵ Not included in review as very specific requirement.

- The instructions must contain the drawings and diagrams necessary for the putting into service, maintenance, inspection, checking of correct operation and, where appropriate, repair of the equipment or protective system, together with all useful instructions, in particular with regard to safety.
- Literature describing the equipment or protective system must not contradict the instructions with regard to safety aspects.

The ATEX 2014/34/EU guidelines (paragraph 151) provide limited information to support the EHSR requirements but does consider the form of the instructions and states: *“It is generally agreed that all health and safety related instructions must be supplied in paper form, since it cannot be assumed that the user has access to the means of reading instructions supplied in electronic form or made available on an internet site. This is particularly relevant for instructions that might need to be read whilst the plant is operational, in the presence of a potentially explosive atmosphere. However, it is often useful for the instructions to be made available in electronic form and on the Internet as well as in paper form, since this enables the user to download the electronic file if he so wishes and to recover the instructions if the paper copy has been lost. This practice also facilitates the updating of the instructions when this is necessary.”*

The guidance also goes on to state: *“The instructions must contain drawings and diagrams necessary for repair of the equipment.”...“However, where necessary, the manufacturer can include in his documentation a statement that specific repair, maintenance and/or overhaul of the equipment shall only be conducted by the manufacturer himself, or by a repairer he has qualified or authorized.”*

BS EN 60079-0⁶ Clause 30 also outlines the instruction requirements and pretty much echoes the requirements identified in EHSR 1.0.6. The notable difference being that the standard refers to the list of requirements as the minimum level of information and includes the following minimum requirement:

- A list of the standards, including the issue date, with which the equipment is declared to comply. The certificate prepared can be used to satisfy this requirement.

In addition, there is reference to BS EN 14986 which provides further requirements for instructions specifically for fans, including:

- Clause 4.3.3 - The manufacturer's instructions shall include the minimum and maximum air flow rates which are required to maintain the temperature rating.
- Clause 4.4.2 - The manufacturer's instructions shall include where necessary the appropriate maintenance instructions to maintain the clearance.
- Clause 4.7.1 - Where the gap between fixed and moving parts can be checked, as part of routine maintenance, on a fan once it is installed and any ducting fitted to inlet and outlet, the manufacturer shall include in the instructions for use how this should be done, and the acceptable minimum gap. Recommendations for the frequency of checking this gap shall also be included.
- Clause 4.9 – For fans with variable speed drives, any known speeds which may induce resonance shall be identified in the instructions for use.
- Clause 4.12 – Drive motors, or if not supplied by the fan manufacturer, their mounting arrangement, shall be positioned to ensure adequate cooling air is available, that ventilation openings cannot be blocked and the motor's declared maximum surface temperature cannot be exceeded. If the motor depends on thermal protective devices to prevent its maximum surface temperature being exceeded the instructions for use shall include instructions as to how they shall be connected into the control circuit.
- Clause 4.22 – Where a fan is intended to be fitted with inlet ducting as part of a larger system, instructions for use shall make clear that the ingress of particles or objects which can cause ignition shall be prevented in other ways. Normally this would be the responsibility of the installer and/or end user.
- Clause 7.2 – Further to the general requirements specified above, the supplier shall furnish his customer with the following documents:
 - Shipping instructions
 - Storage instructions
 - Fan erection and commissioning manual
 - Operation and maintenance manual
 - Particle limitations
 - Routine inspections, service and cleaning

3. Methodology

3.1 Why ATEX Fans

ATEX Fans were selected for this review as there are numerous manufacturers and a variety of instructions accessible on the internet. It would be a future aspiration to review instructions for alternative types of equipment, both electrical and mechanical. Due to the scope of reviewing hundreds of instructions it was considered appropriate to tighten the scope for this paper with the view of continuing research in the future. Also as fans have a specific standard it was considered that this type of mechanical equipment would represent a benchmark for ATEX information.

⁶ BS EN 60079-0, Explosive Atmospheres, Part 0: Equipment – General Requirements, 2012 +A11:2013.

3.2 Scoring

The bespoke scoring system used for this review focuses on the EHSR 1.0.6 set of requirements outlined in 2014/34/EU and additional criterion relating to the format of the instructions which have been developed using the HSEs Procedures Audit Tool (Style / Layout / Language) checklist⁷. Upon review of the HSE Audit tool it seems reasonable to modify the checklist to specifically relate to instructions. It is evident that instructions are meant to provide the user with sufficient information to enable them to understand the safe use, installation and maintenance of the equipment hence the ATEX requirements and the HSE audit tool adaption enables the content to be scored accordingly. Table 1 through to Table 7 provide lists of questions and the scoring protocol. It then split the scores according to ATEX criterion (Table 1) and HSE Audit criterion (Table 2 through to Table 7).

Table 1 – ATEX EHSR 1.0.6 Criterion

Technical EHSR 1.0.6 with amendments	ATEX1 (EN) ⁸ - Do the instructions include a declaration of conformity?	Y/N	N = 0 & Y =3
	ATEX 2 (EN) - Do the instructions include a copy of certificates?	Y/N	N = 0 & Y =3
	ATEX 3 - Do the instructions include recapitulation of the ATEX marking?	Y/N	N = 0 & Y =3
	ATEX 4 - Do the instructions include information for putting into service?	Scale	1 to 6
	ATEX 5 - Do the instructions include information for use?	Scale	1 to 6
	ATEX 6 - Do the instructions include information for assembling and dismantling?	Scale	1 to 6
	ATEX 7 - Do the instructions include information for maintenance?	Scale	1 to 6
	ATEX 8 - Do the instructions include information for installation?	Scale	1 to 6
	ATEX 9 - Do the instructions include information for adjustment?	Scale	1 to 6
	ATEX 10 (WN ⁹) - Do the instructions include training information?	Scale	1 to 6
	ATEX 11 - Do the instructions include details to ensure a decision can be made beyond any doubt as to whether the equipment can be used in the intended area?	Scale	1 to 6
	ATEX 12 (WN) - Do the instructions include special conditions for safe use?	Y/N	N = 0 & Y =3
	T1 -Is the technical information easy to understand with a basic knowledge of ATEX?	Scale	1 to 6
	T2 - Is the technical information easy to understand with a basic knowledge of equipment type?	Scale	1 to 6
	T3 - Do the instructions include pass/ fail criteria?	Y/N	N = 0 & Y =3

Table 2 – Layout & Text Criterion

Layout & Text	LT 1 - Do the instructions make good use of open space, avoid clutter, and remove unnecessary information?	Scale	1 to 6
	LT 2 - Are the instructions laid out using margins and the text justify text to the left (or at least consistently)	Scale	1 to 6
	LT 3 - Is the font size (12 min) appropriate for all users and conditions (e.g. users with impaired eyesight; poor lighting; PPE with restricted visibility). General used on plant?	Scale	1 to 6
	LT 4 - Do the instructions include the use of colour? If they do is it appropriate (availability & reliability of suitable printers; colour-blind personnel; contrast of text under artificial lighting etc.)	Scale	1 to 6
	LT 5 - Are the instructions consistent (i.e. abbreviations, acronyms, type-face and spacing, colour, jargon, explanations, etc.)	Scale	1 to 6
	LT 6 - Page breaks are used to ensure key instructions are not split across pages.	Scale	1 to 6

Table 3 – Actions Criterion

Actions	A 1 - Key steps are numbered and are easy to follow?	Scale	1 to 6
	A 2 - Are steps differentiated clearly?	Scale	1 to 6
	A 3 - Does each step cover one action?	Scale	1 to 6
	A 4 - Do the instructions state who does what and when ?	Scale	1 to 6

Table 4 – Language Criterion

Language	L 1 - Do the instructions use present tense and the active voice?	Scale	1 to 6
	L 2 - Do the instructions use short and simple sentences?	Scale	1 to 6
	L 3 - Do the instructions use conventional terms and vocabulary (i.e. Avoid abbreviations and acronyms)?	Scale	1 to 6

Table 5 – Embedded Warnings Criterion

Embedded Warnings	EW 1 - Do the instructions include clear warnings that the information is ATEX related (i.e. EX symbol)?	Scale	1 to 6
	EW 2 - Are warnings highlighted (i.e. consistent format throughout the instructions)?	Scale	1 to 6
	EW 3 - Are there other warnings provided in the instructions, such as, hazardous to health, environment, etc.	Scale	1 to 6

⁷ www.hse.gov.uk/humanfactors/topics/procedures-audit-tool.pdf.

⁸ BS EN 60079-0 requirement.

⁹ WN – Where Necessary EHSR requirement.

	EW 4 - Do ATEX warnings include explanatory information (not actions)?	Scale	1 to 6
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Table 6 – Job Aids Criterion

Job Aids	ATEX 13 - Do the instructions include simplified schematics, line-diagrams, photographs etc. where appropriate (Also listed in EHSR 1.0.6 criterion)?	Scale	1 to 6
	JA 1 - Do the instructions include the use of flow-charts and decision-tables to help problem-solving and decision-making	Scale	1 to 6

Table 7 – General Criterion

General	G 1 - Do the instructions include running headers and footers (description of procedure; reference number; revision number and date; page X of Y etc.?)	scale	1 to 6
	G 2 - Do the instructions provide tick lists to ensure essential steps are not missed?	scale	1 to 6

Note: some of the results are presented as percentage values to indicate the score versus the available maximum score.

Each of the instructions was reviewed using the scoring criterion outline above. The scoring was based purely on how the information was interpreted by the author and would be subject to variations if others were to undertake the review which could be conducted in the future. An initial screening of instructions was conducted and thirteen instructions were selected to try to get a cross section of industry data for ATEX fans of a similar type but manufactured by various organisations. Once again it is likely that a bigger selection of instructions and equipment types would improve the output data and provide further discussion points and it is envisaged that this will be completed in further phases of this project.

Each of the thirteen instructions was then given a reference number to protect the identity of the manufacturer and equipment type reference. Each of the instructions was then reviewed and the score recorded. Based on the scoring it was possible to obtain maximum scores of 66 and 138 for ATEX and HSE Audit requirements respectively.

The Yes/ No question scoring gave 3 or 0 respectively, whereas the scale based questions had more qualitative outlook as outlined in Table 8 below.

Table 8 – Scale Scoring Range

Excellent	Good	Average	Poor	Very Poor
6	4	3	1	0

In addition to the scoring the total instructions number of pages was recorded and whether or not an illustration (photograph or drawing) of the equipment was provided on the front cover or within the instructions.

4. Findings

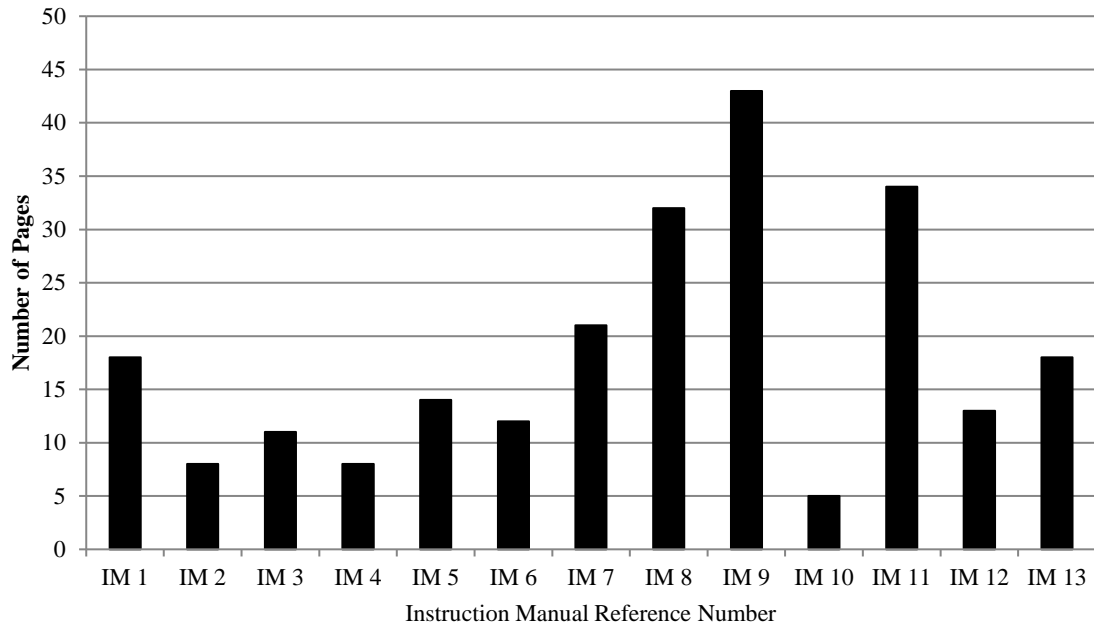
4.1 Instruction Front Covers

It is not a specific requirement to have an illustration of the equipment on the front cover of the instructions but definitely advantageous as it provides a positive starting point to compare the instruction with the equipment, thus ensuring the equipment being fitted, maintained and/ or inspected is the correct item. Of the thirteen instructions reviewed eight had an image on the front cover; of those instructions with no image on the front cover one of the instructions didn't have any image. Two of the instructions reviewed had the ATEX information in a separate supplementary document and of these neither had an image of the equipment.

4.2 Number of Pages

It is often stated that it's 'QUALITY not QUANTITY' but it seems reasonable to compare the amount of data provided by each of the manufacturers for essentially the same item of equipment; therefore, Figure 4 has been compiled to illustrate the variation from 5 to 43 pages.

Figure 4 - Number of Pages per Instructions



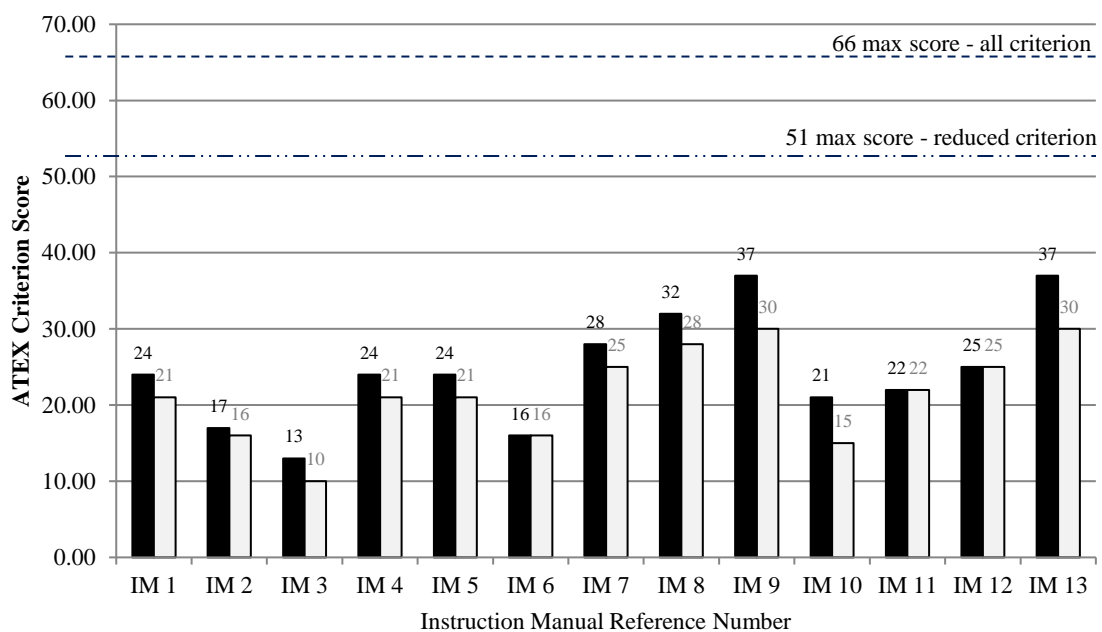
The instructions with the least pages (IM 10 scored) 32% and 33% for ATEX criterion and HSE Audit criterion respectively. The score for the ATEX criterion wasn't the lowest score as this was IM 3 (11 pages) with a score of 20%, whereas it was the joint lowest with IM 3 (11 pages) and IM 4 (8 pages) for the HSE Audit criteria with 33%. It was clear from the results that there was a trend of lower scores for less pages, which is probably to be expected but the lowest scoring for ATEX criterion had very good examples of mounting instruction which is discussed later (i.e. IM 6 with a score of 24% for ATEX criterion).

4.3 ATEX Criterion

4.3.1 General

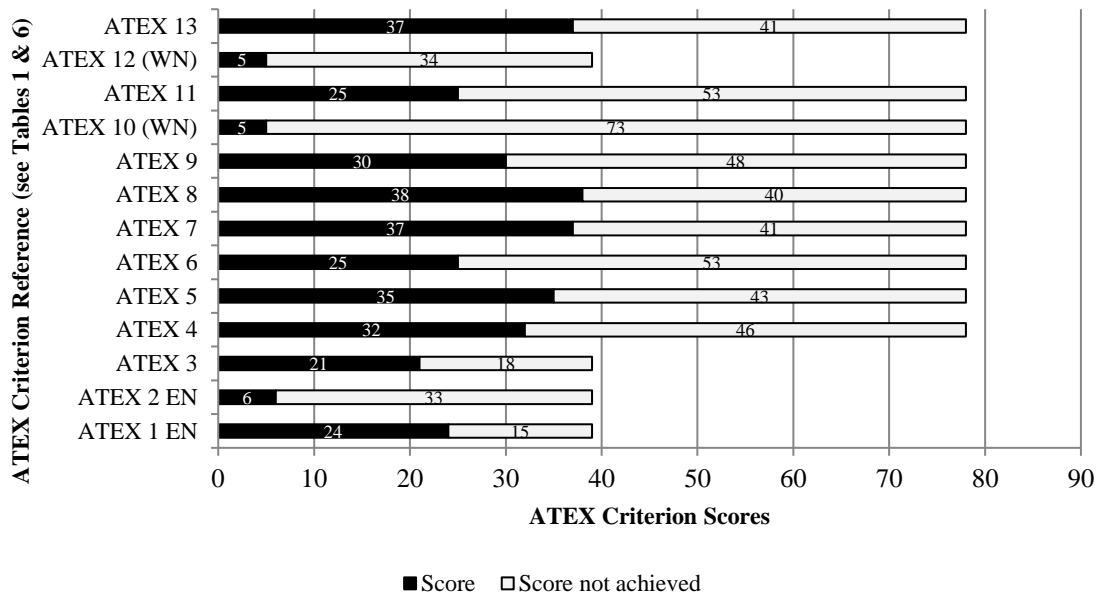
The chart below has been compiled based on the review conducted in accordance with the scoring regime outlined above for ATEX criterion. The first series (darker columns) represents all ATEX requirements, whereas the second series (lighter columns) represents ATEX criterion considered to be mandatory (i.e. "where necessary" requirements not considered in the scoring).

Figure 5 – ATEX Criterion Scores per Instructions



It is clear to see that the instructions did not fully meet the ATEX Criterion (with or without mandatory requirements) and were lacking significant amounts of information. The total scores for each of the ATEX criterion are provided below in Figure 6.

Figure 6 - ATEX Criterion Scoring per Requirement



The highest scoring ATEX criterion was related to installation, maintenance and availability of diagrams, photographs, etc. This could be the reason why end users are not complaining about the level of information because in most cases an average amount of information is available in the instructions relating to its installation and maintenance. The following sections provide further information relating to specific information gained during the review.

4.3.2 Marking

One of the main issues when conducting ATEX equipment inspections is ensuring the equipment is suitable for the zone of use. It is not unusual to be conducting periodic inspections of equipment installations and finding items with labels that have degraded, been damaged, painted over or removed. In all cases the next step is to review the instructions to find the marking information to compare the information with the hazardous area classification documentation. Based on the information found within the sample of instructions reviewed the EHSR requirement stating “A recapitulation of the information with which the equipment or protective system is marked” is simply not adhered to. There is once again a large spread of information supplied, including those illustrated below in the three examples (Figure 7, Figure 8 & Figure 9).

Figure 7 illustrates a good example of the marking information provided in IM 9; this is supported by additional information relating to ATEX Categories, Temperature Classifications, Installation types, Material Pairings and Clearances. This all assists the user to understand the installation capability but is the bare minimum.

Figure 7 - IM 9 – Marking Information

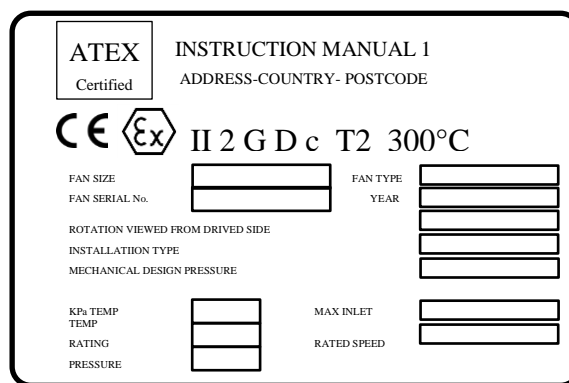


Figure 8 illustrates the marking information provided in IM 2. It is clear to see that this is unlikely to be the only marking affixed to the equipment and does not provide sufficient information to enable the equipment to be compared with the hazardous area temperature classification; hence its suitability would be continually questioned during equipment inspections. Unfortunately this level of marking on the equipment and within the instructions is common.

Figure 8 - IM 2 – Marking Information

Ex II 2 G/D c

Figure 9 illustrates a very good example of what should be provided in the instructions (from IM 7) as it identifies where the equipment marking can be found on the actual equipment and also lists the information required by the ATEX requirements. This type of information ensures that personnel working with this equipment can determine if the marking is present and correct. Furthermore this example of marking was supplemented with lists of the ATEX marking (Example provided in Table 9) for each of the models covered by the instructions, thus once again providing the user with an excellent level of information to enable them to make judgements on whether it is suitable for the area of use.

Figure 9 - IM 7 – Marking Information

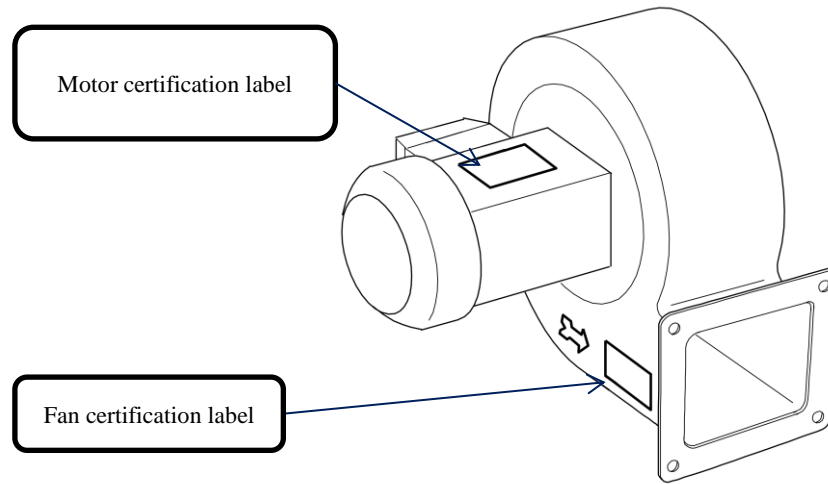


Table 9 – IM 7 – Example of Supporting Marking Information

Type 1, 1-1, 1-2 and 1-3	⊕ _X	II 2 G c IIB (T3 or T4)
	And	
Type 2, 2-1, 2-2 and 2-3	⊕ _X	II 3 D c IIB T125°C
	⊕ _X	II 3 G c IIB (T3 or T4)
	And	
Type 3, 3-1, 3-2 and 3-3	⊕ _X	II 3 D c IIB T125°C
	⊕ _X	II 2 G c IIB T4
	And	
	⊕ _X	II 3 D c IIB T115°C

ATEX 2014/34/EU guidance states¹⁰ “User instructions shall explain *in detail* the meaning of the marking on the product.” Therefore all instructions would benefit from additional explanatory information.

4.3.3 Instruction for safe...

When reviewing these requirements it was pretty clear that the headings provided in EHSR 1.0.6 are not followed consistently by manufacturers within their instructions contents list. A comparison of EHSR 1.0.6 requirements for safe... versus the instructions heading for each of the thirteen instructions (i.e. their contents list) are tabulated in Table 10. In addition the totals scored for the information relating to each of the headings is provided in the final row. The amount of headings considered in each of the instructions reflected the overall score in most cases (i.e. those with less sections defined had less overall data). There were instances where putting into service was reflected under a commissioning heading (depicted by C in Table 10).

Table 10 – Comparison of Instruction for Safe..... Versus Instructions Content Headings

Requirement	Instruction Manual Reference												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Putting into service	x	x	x	x	x	x	C	C	C	x	C	x	C
Use	✓	x	✓	x	x	x	✓	✓	x	x	✓	✓	x

¹⁰ ATEX 2014/34/EU guidance page 144.

Requirement	Instruction Manual Reference												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Assembling and dismantling	x	x	x	x	✓	x	x	x	x	x	x	x	x
Maintenance	✓	✓	✓	✓	x	✓	✓	✓	✓	✓	✓	✓	✓
Installation	✓	✓	x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Adjustment	x	x	x	x	x	x	x	x	x	x	x	x	x
Information provided ¹¹ (max score 36)	15	14	7	16	16	12	14	18	20	11	18	18	18

It is considered reasonable to have a section within the manufacturer’s instructions for each of the EHSR 1.0.6 requirements rather than providing the necessary information in other sections. This would have numerous benefits including:

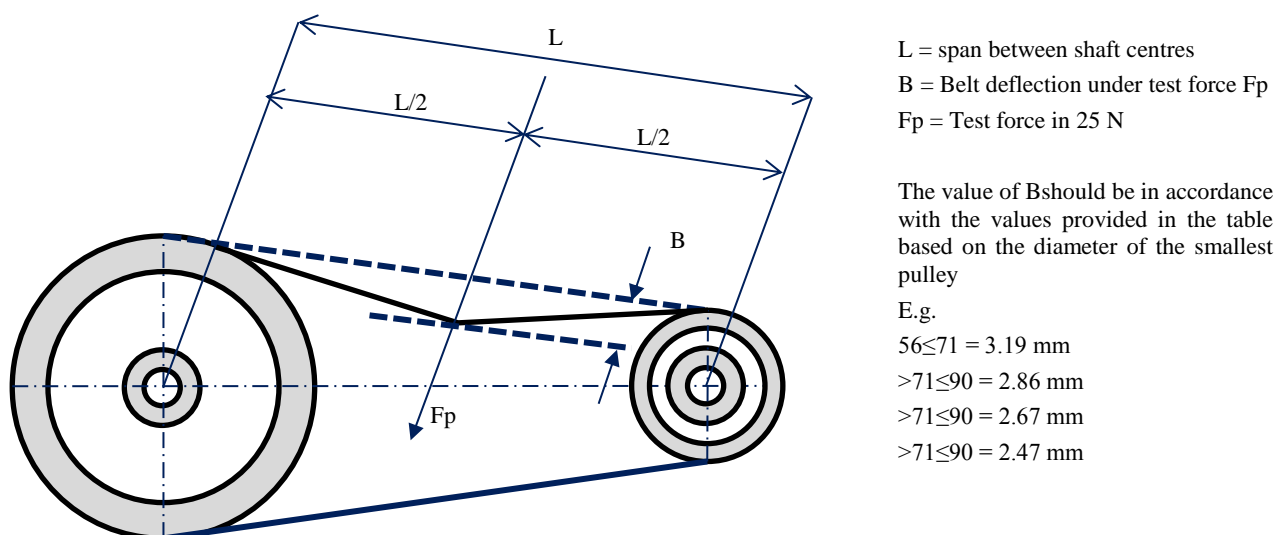
- The manufacturer could clearly show that they have met the requirements of the ATEX Directive.
- Where appropriate Notified Bodies could easily check the information in accordance with the requirements.
- End users could familiarise themselves with the information to enable the equipment to be used safely and the information would be simple to find.

The CSB¹² outlined that information that appears to be perfectly acceptable in the design process may not be a clear to the end user which could be reason enough for information to be missing from instructions. The CSB example provided relates to the lack of dedicated connection points for the valve gearbox support bracket which resulted in the end user removing the bracket and gearbox in one operation rather than the user removing only the gearbox retention bolts. As the designers understand their design they wouldn’t consider that an end user may remove the entire bracket/ gearbox resulting in the release of isobutene from the valve body. In essence human factors should be considered in the design of equipment and also in the compilation of the instructions to aid the safe use of the equipment. Simple improvements that follow the required level of information would be a start.

There is an argument that a fan is not a particularly sophisticated item of equipment and suitably trained and experienced personnel should be able to determine if the equipment is fit for purpose and be capable of installing, commissioning, inspecting, maintaining and removing from service. In a perfect world this maybe the case but the manufacturer should provide the user with sufficient information to enable them to select the most appropriate item of equipment for the duty. This will come down to communication between the potential end user and the manufacturer/ supplier. The end user will need to ensure they request items that are to be used in hazardous areas with certain characteristics to enable the manufacturers/ suppliers to determine whether their equipment will be suitable not only for the ATEX requirements but also the overall environment (i.e. substances, duty, etc.).

As can be seen from Table 10 the level of information provided under the heading adjustment was minimal even though numerous instructions provided a very similar section on V-belt tension adjustment, an example of which is illustrated in Figure 10. The level of detail for this adjustment was also varied.

Figure 10 – IM 8 - V-Belt Drive Tensioning



In the example provided in Figure 10 the manufacturer also provided a background to the fact that belts stretch over time and especially during the installation phase and therefore suggested regular retightening. They recommended the following intervals:

- Check 2 to 3 hrs after start-up

¹¹ This score represents the information provided in the instructions versus the instruction for safe:... criterion (i.e. the six headings).

¹² CSB, Safety Bulletin, ExxonMobil, Baton Rouge, Louisiana, 2016 page 16.

- Check 8 to 12 hrs after start-up
- Check 1 week after start-up
- Further checks according to requirements and operating conditions.

This type of information is typical. It provides part of the story. There is no advice on how the checks should be carried out or safety warnings which may seem very obvious (i.e. “WARNING – ENSURE THE FAN IS ISOLATED PRIOR TO CHECKING THE TENSION OF THE V-BELT”) but could reduce the risk of harm to personnel conducting the task. Once again it seems evident that manufacturers are not providing information that they considered to be obvious as it is their equipment and they are the experts. Without labouring the point, manufacturers should assume personnel to be new users of the equipment.

Maintenance requirements are similar to the adjustment information discussed above, as there are numerous examples of maintenance checks that are proposed by manufacturers (outlined in Table 11) that would require a certain level of competence or would be disregarded. The examples provided from IM 4 are more informative and provide additional information to assist the end user, including durations, vibration acceptance criteria and reference to supporting standards. This type of information is more in line with the HSE Audit criterion that looks for pass/ fail criteria. Although these examples are improvements on the majority of instructions they are still missing key information on how to conduct the vibration monitoring and whether the equipment should be fitted to make the measurements. Once again there is a reliance on the end user having competent personnel.

Table 11 – Overview of Maintenance Requirements for Various Instructions

IM Ref	Maintenance Request	Comment
1	Safe operation of ATEX fans rely on clearances between rotating and stationary parts being maintained.	No further information provided in the section referencing the clearance required or the procedure for checking the clearance.
	Every fan must be inspected regularly and cleaned as needed to avoid a build-up of materials.	Where specifically should the inspection be focused and how often is regularly.
2	To avoid early faults and stops, each bearing should be checked regularly. Avoid the presence of unwanted elements, dirt and humidity.	This type of requirement is common to ATEX mechanical equipment but puts a heavy burden on end users. How should they be checked? Checking the bearing regularly could impart faults. How often in regularly?
3	Repair of the fan should only be performed by qualified and skilled workers in accordance with applying regulations.	It is clear that manufacturers will supply to numerous countries and regulations will change and the guidelines do allow this sort of statement but it is not very clear how to comply as an end user other than using the manufacturer to conduct repairs.
	General checking Bearing clearance to large? Emerg lubricant on the bearing Unusual noise	This is generic information and not helpful to the end user. What is the bearing clearance?
4	Cleaning must be done at least quarterly. The intervals may have to be adjusted, dependent on the operation and operating conditions. Corrosion and dust filled atmospheres typically reduce the intervals. Please note that deposits of dust can be ignited by high surface temperatures and constitute a safety risk.	Good level of information as this informs the user of the actual interval and the reasons for cleaning the equipment.
	After every 1000 hours of operation the vibration level must be checked. It must be less than 7.1 mm/s for motors up to 37 kW, and 4.5 mm/s for motors over 37 kW. Investigate and remove the causes, if the limits are exceeded. Refer to ISO 14694. For variable speed fans the maximum vibration level is likely to be exceeded at certain speeds. Continuous operation at these speeds must be avoided. A curve showing vibration levels at different speeds is part of the fan documentation for variable speed fans and should be reviewed by the user. Notice: The vibration levels depend on the installation and should be measured after completing the installation. IMPORTANT: Constant vibration monitoring is mandatory for ATEX category 2D fans, i.e. fans operating in zone 21	Good level of information and ATEX specific information relating to the requirement for constant vibration monitoring for cat 2D fans. Although this is highlighted as important there is no further information on what comprises the constant vibration monitoring equipment, levels to be alarm/ trip and/or requirements to respond to alarm/ trip.
6	After first month functioning, the fan must be maintained as follows:	Average level of information and no

IM Ref	Maintenance Request	Comment
	<ul style="list-style-type: none"> • Check the smooth running of the fan • Check the motor temperature • Remove any dusts deposits on the impeller and the motor. <p>The fan may only be maintained by trained personnel who are authorised to carry out such work.</p>	<p>guidance to assist the checking of smooth running. What is the expected motor temperature?</p> <p>Furthermore who authorises trained personnel?</p>

An example of fan maintenance provided by a mechanical engineer during a training course outlined fantastic interpretation of how to maintain fans in hazardous areas. Firstly, referencing the instructions (IM 9) for the equipment the following information is listed:

“Section 23.3 Selection of personnel and qualifications; basic duties

Work on the machine/plant must be undertaken only by reliable personnel. Adhere to legally permissible minimum age.

Employ only trained or instructed personnel, fix clearly the responsibilities of the personnel for operation, set-up, maintenance and repair work!

Ensure that only authorized personnel work on the machine!

Work on the electrical devices of machine/ plant must be undertaken only by a skilled electrician or by instructed persons under the supervision and guidance of a skilled electrician in accordance with the electro-technical rules.

Working on gas-technical devices (gas consuming devices) must be undertaken only by trained personnel.

Work on hydraulic systems must be carried out only by personnel with specialized knowledge and experience in hydraulics!”

Unfortunately these instructions were not available to the personnel when the equipment failed but they were very experienced mechanical engineers, familiar with the equipment and the area of use and quickly determined that the fan was located in a hazardous area on a hazardous duty. The fan was considered to be a critical item for the overall safe operation of the plant; therefore, even though the failure occurred out of hours it needed to be fixed to get the plant back online. The engineers identified a spare fan in the stores but although this was considered to be an identical unit it didn't have the ATEX approval marking affixed. The next step was to replace the broken components on the plant fan with the components from the spare unit in the stores as it was considered that the components were similar and appropriate but it was considered incorrect to put in a non-ATEX unit into service.

This was considered to be acceptable until the ATEX responsible personnel were made aware of the situation weeks later. As the equipment was still marked there would be no way of knowing the equipment had been modified. The users then embarked on liaising with the manufacturer to rectify the repair. The personnel who conducted the original repair had over 50 years of experience of working in hazardous areas maintaining and repairing equipment pre and post ATEX. It is clear that the instructions probably wouldn't have changed the overall approach to getting the fan running again due to its criticality but it might have at least ensured the repair was recorded.

From the thirteen instructions only two (IM 8 and IM 9) were considered to have more than average amounts of information relating to maintenance. IM 8 provides the following headings:

- Safety instructions for maintenance
- Observing regular inspection intervals
- Preparing for maintenance
- Maintenance recommendations for centrifugal fans
- Belt drives
- Fan bearings
- Flexible connections

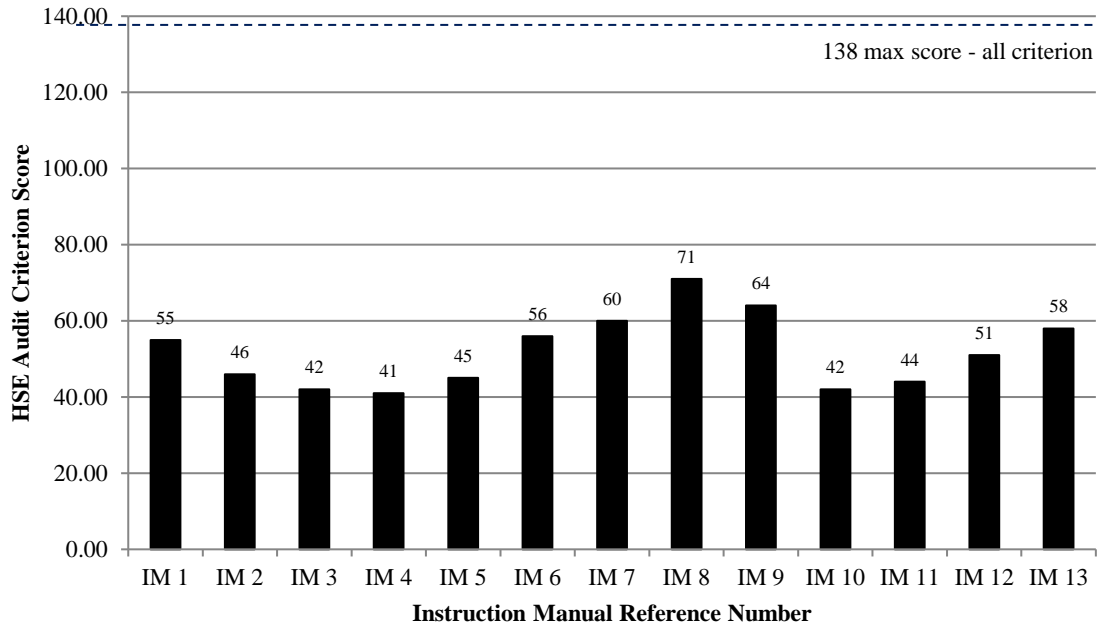
The maintenance recommendation for centrifugal fans provides a table of requirements for the fan, motor and belt drive. Unfortunately once again the level of information in this table is lacking clear and concise requirements when compared with the adapted HSE Audit criterion.

4.4 HSE Audit Criterion

4.4.1 General

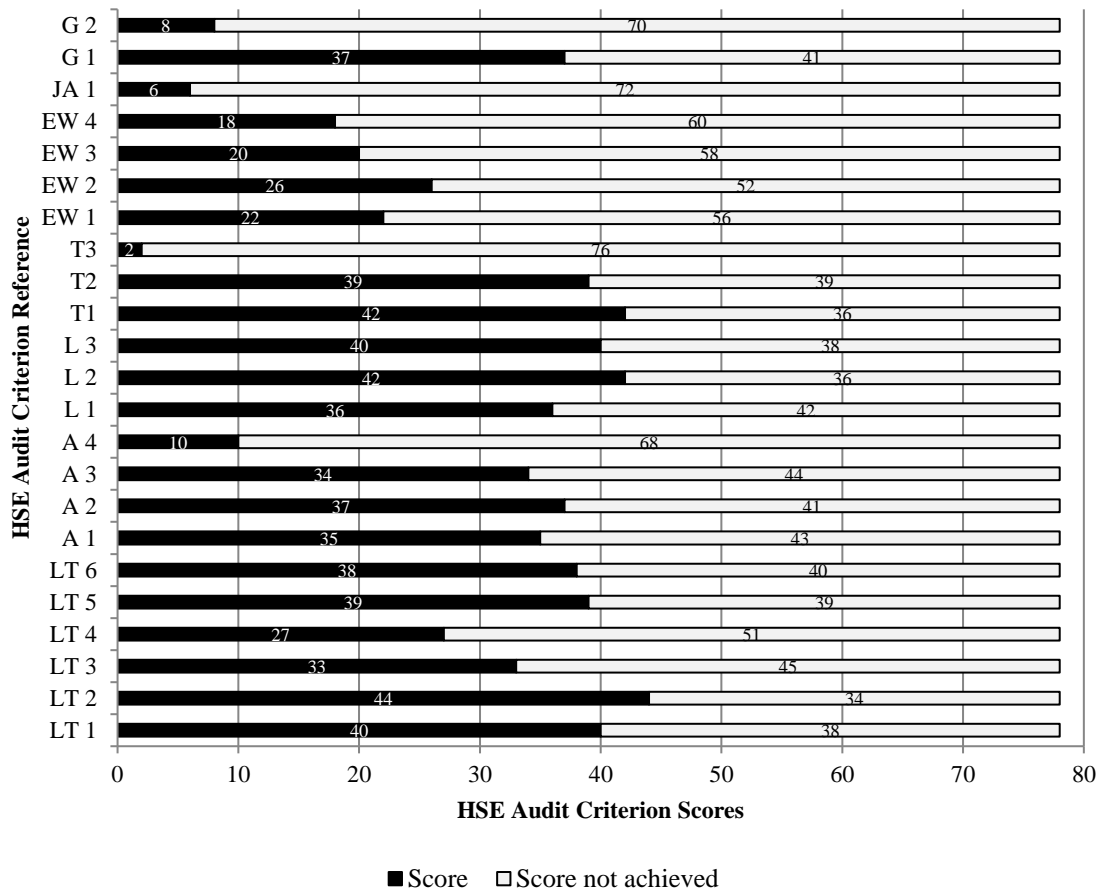
The chart below has been compiled based on the review conducted in accordance with the scoring regime outlined above for HSE Audit criterion.

Figure 11 – HSE Audit Criterion Scores per Instructions



It is clear to see that the instructions did not fully meet the adapted HSE Audit criterion and were lacking significant amounts of information and guidance for the end user. The total scores for each of the HSE Audit criterion are provided in Figure 12.

Figure 12 – HSE Audit Criterion Scoring per Requirement



The HSE Audit criterion scores overall were average. There were examples of good and bad data as discussed in the following sections. Criterion T3 (do instructions include pass/ fail criteria) was not used within the instructions, there were examples of values that could have been more clearly identified as pass/ fail criteria but they were typically embedded within other information and not clear for an end user (i.e. IM 4 states: “After every 1000 hours of operation the vibration level must be checked. It must be less than

- Belt drive

Each example is accompanied by a list of the significant parts; an example of this is given in Table 12.

Table 12 – Example of Fans Parts List

Arrangement of Fan 3			
Part	Description	Part	Description
1	Fan Casing	9	Inlet flexible Connection (Opt)
2	Fan Pedestal	10	Inlet flexible backing flange (opt)
3	Inlet Cone	11	Outlet flexible connection (opt)
4	Front Plate	12	Output flexible backing flange (opt)
5	Impeller	13	Cooling disc (opt)
6	Impeller Centre Boss	14	Cooling disc guard (opt)
7	Motor	15	Earthing boss (opt)
8	Shaft Seal	16	AV Mount (opt)

Inadequate font size (LT3) was also a key fact identified during the study as many of the instructions were written in font less than 11 point and in fact the a significant portion of the instructions were very congested (LT1) and would be difficult to read if on plant with goggles on and dirty hands smudging the text even further.

5. Conclusions

ATEX guidelines state that “*Manufacturers have to look beyond what they consider the intended use of the equipment and place themselves in the position of the average user of a particular product and envisage in what way they would reasonably consider to use the product.*” Therefore an average user should be the benchmark, not an expert (i.e. designer of the equipment). It is clear to see that the selection of ATEX certified fan instructions used for this study have a lower level of information versus the developed criteria. It is expected that a review of other types of equipment will be completed to gain a greater perspective of instructions for ATEX equipment.

Experience has shown that no matter how good instructions are, additional work needs to be done to translate the instructions information into company procedures, maintenance regimes and personnel training assisting with competence. There are numerous examples where items of equipment that have been damaged due to personnel not reading the instructions supplied with the equipment. Although not related to fans, a simple example of this is finding damaged luminaires, during ATEX inspections, due to incorrect removal of the lens cover from an Ex e fittings.

In some cases, these luminaires require access to the release mechanism via specific holes provided on the body of the luminaire, which when operated enable the cover to be removed. This allows then allows access to the bulbs which can then be replaced. Unfortunately it is common to find damaged lens covers due to the fact the personnel conducting the task don't read the instructions and try to prise the lens cover from the luminaire body using a screw driver or similar tool. This incorrect operation either cracks the lens cover, luminaire body or both. It is at this point that the personnel then embark on finding the instructions and removing the lens cover correctly but unfortunately the damage is already done and in some cases the damage will invalidate the concept of protection afforded.

Further investigation will be conducted for other types of ATEX equipment to determine whether the instructions are of better quality or are similar to those reviewed for this study. The scoring may be weighted to ensure the important issues are highlighted and other personnel are used to undertake the scoring to obtain additional opinions.

6. Disclaimer

The contents of this paper, including any opinions and/ or conclusions expressed, are those of the author alone.

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