Technical Note

Oil & Gas UK
the voice of the offshore industry

Subject: Guidance on Corrosion Assessment of Ex Equipment

1. Introduction

Maintaining the integrity of Ex certified electrical equipment is a key barrier against Major Accident Hazards in the oil and gas industry. The integrity must be maintained to ensure that items of Ex equipment do not become potential sources of ignition in the event of a hydrocarbon release and the subsequent presence of an explosive atmosphere.

With an ageing population of assets in the UK oil and gas industry, and with the high number of items of Ex certified equipment located in exposed and harsh environments, the issue of corrosion of Ex certified equipment is a key focus area to ensure the integrity of the equipment is maintained.

This document is intended to provide guidance in the selection and maintenance of Ex certified electrical equipment so that the specific issue of corrosion is considered by personnel in all stages of the life-cycle of Ex equipment.

2. Selection of Ex equipment to Prevent Corrosion

There are several different types of Ex protection concept and different materials of manufacture.

In terms of corrosion risk, the following table shows the main types of materials used and the order of preference in minimising corrosion problems during the life cycle of the equipment.

Material	**Corrosion Risk**
Glass Reinforced Plastic (GRP)	Low
Marine Grade (316) Stainless Steel	Low
Aluminium Alloys	High
Carbon Steel	High

Note that where carbon steel is the only practical option, such as for electric motors and transformers, the selection of appropriate paint coatings can minimise the risk of corrosion. Specially formulated two-pack epoxy paint coatings are sometimes available which can improve the life expectancy of electric motors.

When the coating of aluminium alloy equipment fails, or if the equipment is uncoated, corrosion of the aluminium alloy results in expansion of the material. This has the following effects:

- Seals and ‘o’ rings fail resulting in water ingress.
- The expansion results in fasteners becoming stuck, for example stainless steel bolts in alloy lids, or brass glands and adaptors becoming ‘welded’ into threaded entries (see example in section 5).

- The corrosion can seal the lid to the equipment body making it impossible to carry out internal inspections.

Selection of the correct coating of aluminium enclosures (such as a PTFE coating) can reduce the likelihood of coating failure and subsequent corrosion.

The use of nickel plated brass glands or stainless steel glands are recommended for use with aluminium enclosures to minimise the effects of corrosion between the enclosure and gland.

The method of mounting the Ex equipment must also consider dissimilar metals and the potential for galvanic corrosion. Insulating materials should be used to separate dissimilar metals.

The Ex protection concept is also relevant when considering corrosion risks. The following table identifies the different protection concepts where the Ex integrity is more or less likely to be affected by corrosion.

Ex Protection Concept	Integrity affected by Corrosion	Performance
Ex 'i'	Little effect if IP rating maintained.	**Good** ↓ **Poor**
Ex 'e'	Little effect if IP rating of equipment is maintained.	
Ex 'p'	Little effect if enclosure pressurisation is maintained.	
Ex 'n'	Medium effect. Mainly applies to motors.	
Ex 'd'	Risk of corrosion of flame paths and wall thinning of main enclosure which would affect the equipment's ability to contain an explosion.	

3. Preservation Techniques

There are a number of preservation techniques that can be applied to Ex electrical equipment during commissioning and during inspection/maintenance to minimise the risk of corrosion affecting the equipment integrity. These include:

- Painting the equipment, and ensuring any paint chipped off during installation (such as when removing lifting eyes) are coated. There is often confusion over painting of Ex'd' equipment and whether or not it affects the certification. Standard BS EN 60079-14 Section 10.3 states:

  "Protection against corrosion of flameproof joints shall be maintained in accordance with manufacturer's documentation. The use of gaskets is only permissible when specified in manufacturer's documentation. Flameproof joints shall not be painted.
  Painting (by the user) of the enclosure after complete assembly is permitted. The application of grease to the flameproof joint faces will reduce, but not eliminate, the quantity of paint penetrating the gap. Where the manufacturer's documentation does not address joint protection, then only non-setting grease or anti-corrosive agents without evaporating solvents shall be used."

- Non-hardening grease applied to flame-paths. Note that there are copper greases and silicone based greases available. The preferred type is copper greases due to the very high melting point and the fact they do not affect gas detectors. The standards only require a non-hardening grease where the solvents do not evaporate. Standard BS EN 60079-14 Section 10.3 Note 1 states:

  "Silicone based greases are often suitable for this purpose but care needs to be taken concerning use with gas detectors. It cannot be too strongly emphasized that extreme care should be exercised in the selection and application of these substances to ensure the retention of the non-setting characteristics and to allow subsequent separation of the joint surfaces."

- Preservative grease applied to glands, name plates, and other exposed surfaces. The same type of grease as detailed above can be used.

- Denso tape. A single layer of Denso tape may be applied for equipment in gas group IIA and IIB locations only. Standard BS EN 60079-14 Section 10.3 Note 2 states:

  "Non-hardening grease-bearing textile tape may be employed outside of a straight flanged joint with the following conditions:

  – where the enclosure is used in conjunction with gases allocated to group IIA, the tape should be restricted to one layer surrounding all parts of the flange joint with a short overlap, new tape should be applied whenever existing tape is disturbed;

  – where the enclosure is used in conjunction with gases allocated to group IIB, the gap between the joint surfaces should not exceed 0,1 mm, irrespective of the flange width. The tape should be restricted to one layer surrounding all parts of the flange joint with a short overlap. New tape should be applied whenever existing tape is disturbed;

  – where the enclosure is used in conjunction with gases allocated to group IIC, the tape should not be applied."

- Vapour phase corrosion inhibitors (VCI). These can be used where they do not affect the Ex certification of the equipment.

- Use of certified breather glands. Fully certified breather glands are available to drain moisture from the bottom of enclosures. These are often used in areas of high humidity or where there is a large range of temperatures which results in condensation problems inside enclosures. These should not be used instead of good maintenance practices to prevent water ingress, i.e. checking condition of enclosure seals, or split outer sheaths of cables entering enclosures which can allow water ingress.

4. Assessment of Corrosion Levels

The assessment of corrosion and how this affects the integrity of Ex equipment is a subjective one and reliance is placed on the competence of the person inspecting or maintaining the equipment, with this judgement typically based on training and experience.

One important consideration is the frequency of inspection and maintenance. If, for example, the frequency of inspection of Ex equipment is three years, then when inspecting the item of Ex equipment, the period of time before the next scheduled inspection must be considered.

Guidance could include:

- If the level of corrosion is considered marginal, then a corrective work order should be raised to carry out a detailed inspection – if necessary on a sample of a batch of similar items, so that the level of external corrosion can be gauged against the internal condition.

- If the level of corrosion is considered acceptable at the time of inspection but the rate of degradation is felt to be quite high, then it is recommended that a corrective work order is raised for a detailed inspection at a future date, for example one year following the first inspection.

For the specific case of electric motors, due to the material of construction being typically carbon steel, corrosion of the motor housing and fan cowl are particular problems. For the case of fan cowls, the inspector should consider whether or not the cowl would prevent harm to anyone who falls against the cowl, i.e. is it physically strong enough to withstand an impact, and are there sharp edges that could cause injury.

Where fan cowl condition warrants then if the motor cannot readily be taken off-line, then additional safeguards should be put in place e.g. barrier off the area and control entry.

It is essential that the inspection and maintenance strategy includes sufficient detailed Ex inspections across all equipment types so that the internal condition of all equipment types is understood. The external condition of equipment does not always indicate the internal condition, as illustrated in Section 5.

In extreme cases it is worth considering non-intrusive techniques to check wall thickness where doubt exists, this could typically be performed by the local inspection company at site.

5. Example Photographs of Corrosion Levels

The following examples illustrate that an internal inspection is required to assess the level of corrosion. The first example in Figure 1 shows a process heater Ex'd' terminal box with a relatively high level of external corrosion. However on internal inspection, the condition of the flame paths, the internals of the terminal box, and the wall thickness of the enclosure were all considered acceptable.

Figure 1 - Example Showing External Corrosion of Ex'd' heater terminal box

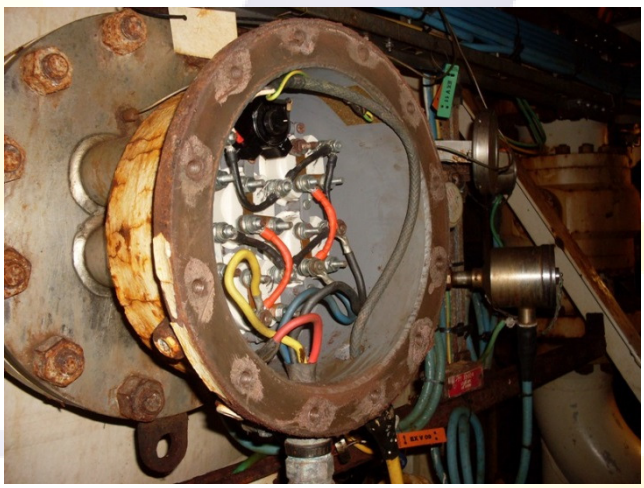

Figure 2 - Same heater as Figure 1, showing acceptable internal condition

Figure 3 - Example Showing Aluminium Alloy Corrosion which has caused brass adaptor threaded section to break off.

Figure 4 - Example of corrosion of aluminium motor housing

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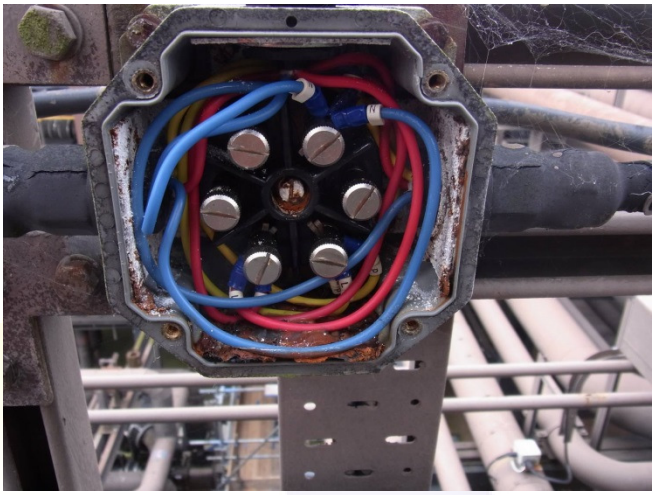

Figure 5 - Example of internal corrosion in junction box

In preparing and publishing this technical note, Oil & Gas UK gratefully acknowledges the contribution of the Oil & Gas UK Electrical Engineering Network.