Inspection and maintenance of explosion protected (EX) electrical equipment in hazardous areas

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Introduction

1. Safety Notice 1/99 (withdrawn Sept 2001) advised offshore operators and employers on the need for maintenance of EX equipment and in particular the need for relamping of EX luminaires in line with manufacturers' recommendations. This followed several incidents of overheating, component meltdown, and internal explosions of luminaires installed in hazardous areas.

Background

2. Recent HSE inspections have found examples of EX equipment in poor condition and there is concern that some duty holders' inspection and maintenance strategies and procedures are not working in practice.
3. This notice reinforces the need for periodic detailed inspections and maintenance of EX equipment in general, and luminaires in particular, in order to comply with legal requirements and avoid unsafe operation. This notice also covers the issues of water ingress into EX equipment, mono-pin or bi-pin flourescent tubes issues and problems with end-of-life overheating of flourescent tubes.
4. This notice is also applicable to onshore installations, except where stated in paragraph 6 below, and all duty holders of installations handling flammable substances, liquids and/or gases should comply with the recommendations of this notice.

Action

5. Duty holders should note the contents of this notice and take the necessary action.

Relevant legal requirements

6. The safety of explosion protected (EX) electrical equipment is subject to the following legal requirements:
    - the Management of Health and Safety at Work Regulations 1999 SI 1999/3242 The Stationery Office 1998 ISBN 0 11 025051 6;
    - the Electricity at Work Regulations 1989 SI 1989/635 The Stationery Office 1989 ISBN 0 11 096635 X;
    - the Provision and Use of Work Equipment Regulations 1998 SI 1998/2306 The Stationery Office 1998 ISBN 0 11 085625 2;
    - the Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations 1995 SI 1995/743 The Stationery Office ISBN 0 11 052751 8.

Water ingress

7. Water ingress is a major cause of failure of luminaires and can lead to short circuits, corrosion of lamp contacts and wiring connections leading to arcing. Water can also cause premature ballast failure leading to increased risk of overheating.

8. To ensure safe operation of EX equipment it is essential that the ingress protection of luminaires is adequate and is maintained. To achieve this the following requirements should be met.
    - Luminaires should be mounted in accordance with the manufacturer's recommendations in respect of locations and mounting angles in each axis.
    - Gaskets should be replaced where necessary.
    - Cover fixings should be secured correctly.
    - IP66 protection should be specified for equipment installed in the most exposed locations.
    - To reduce the adverse effects of water ingress, duty holders should ensure that inspections include checks for evidence of water ingress in luminaire and all EX equipment enclosures.
    - When new luminaires are required, ATEX certified products should be specified.
9. Those luminaires which use the induction principle have a very long life, can be sealed for life as supplied, and avoid the problems of overheating lamp holders and ballasts. These are available from a number of suppliers and no maintenance is possible or required inside the enclosure and may offer a cost-effective solution. Although such equipment is sealed and does not require to be opened up for detailed inspection, it should be inspected visually to check its condition.

Hydrogen generation

10. A small number of violent explosions of EX luminaires have recently occurred offshore and it is suspected that hydrogen generated in the luminaires was the source of the flammable mixture rather than hydrocarbons released from the process plant. Excessive ingress of sea water can result in hydrogen generation by electrolysis. Tests carried out by The Health and Safety Laboratory (HSL) have demonstrated that electrolysis of sea water is possible, but is highly dependent on luminaire component geometry and ballast design. Hydrogen generation by electrolysis is equally possible with bi-pin or mono-pin designs.
11. Evidence of water ingress such as presence of water, eg condensation or salt deposits in luminaire covers and enclosures, should receive attention as soon as possible and not be left to accumulate until the next inspection or maintenance.

Bi-pin or mono-pin?

12. In response to concerns from industry that bi-pin tubes and lampholders may be at increased risk of failure than mono-pin and capable of incendive arcing, HSL examined a sample of bi-pin luminaires recovered after use on an offshore installation. Out of 48 bi-pin lampholder contacts examined, no evidence was seen of bad contacts, overheating or arcing.
13. Two other luminaires that had suffered serious lampholder burn out were examined. Damage was extensive in each case. In one case water ingress from a damaged cover was a contributory cause but in the other the initiating cause was difficult to determine. One luminaire was bi-pin, the other was mono-pin.
14. Concerns about possible weaknesses, eg poor lampholder contact from corrosion or vibration in bi-pin lamp holders in type e luminaires, should be balanced by the two additional tests in BS EN 60079-7 2003 for bi-pin lampholder contacts to ensure adequate protection against poor contacts from these causes. However, this standard is only relevant to new luminaires certified to the standard. The safety of new and existing installed luminaires certified to earlier standards is the responsibility of the user and relies on adequate inspection and maintenance practices.

Overheating due to tube end of life

15. All fluorescent lamps enter an end-of-life condition when the electrode emitter material is depleted, ie burnt away due to the normal ignition or burning process. A symptom of emitter loss is end-blackening. When all the emitter is gone, the tungsten electrode material starts to sputter off electrons, causing severe end-blackening and ultimately the failure of the electrode. The lamp has now reached the end of its lifetime and should be replaced.
16. Without effective protection, the ballast will continue to drive the lamp or will try to ignite the lamp repeatedly. The temperature in the region of the electrode increases rapidly and causes overheating. If the electrode breaks, at temperatures reaching 800ºC for a very short time, the wire can drop onto the glass and may melt a hole in the tube or may cause discharge and high temperatures for several minutes, or longer if the lamp ring makes contact with a broken electrode.
17. One solution to the problem is an effective stop circuit in the electronic ballast. This stop circuit prevents the lamp from igniting when it has reached its end of life condition. The IEC standard for fluorescent lamps (IEC 61195) has introduced requirements to avoid the overheating of the lamp-ends by incorporating 'suitable measures in the electrical circuit'. These requirements have also been incorporated into the draft EN 60079-7 Standard for Increased Safety Equipment.
18. In order to comply with the regulations cited in paragraph 6 above, duty holders should be aware of the risks and precautions required in respect of the EX equipment on their installations, including the risks of overheating due to end of life tubes. This requires knowledge of what types of fittings are installed, and what the manufacturer's recommendations for maintenance are, and whether the ballasts fitted are likely to cause overheating in the event of failed tubes.
19. It is the responsibility of the user to ensure that existing luminaires are safe and that the lamps are replaced before the end of life conditions become critical. There are basically four options.
    - Carry out frequent inspections to identify and replace lamps that are failing or have failed. However, this will not remove all the risks. Typical symptoms to be identified are:
        - low-level light;
        - flickering;
        - red burning;
        - yellowish/reddish discharge near the electrode;
        - severe end-blackening.
    - Group replacement with fluorescent lamps with a proven low failure rate. Unfortunately, this does not remove all the risks and periodic inspections are still required.
    - Replace all ballasts of existing luminaires with a type having the new stop circuit as specified in draft standard EN 60079-7.
    - Replace the existing luminaires with a different technology not affected by 'end-of-life', eg Ex luminaires using induction technology.

Competence

20. People carrying out any aspect of the specification, design, installation, inspection or maintenance of EX electrical equipment should be competent to do so safely and without increasing risks to themselves or others. Technicians should be trained and assessed as competent by attending courses such as the COMPEX course or other equally effective methods. Employers should have a competence assurance strategy and procedures

including continuing appraisal to ensure the competence of people working on EX equipment.

Sample Inspections and BS EN 60079-17 2003

21. This standard advises that the interval between periodic inspections should not exceed three years without seeking expert advice.
22. Sampling is a technique to assess the condition of the whole population of equipment based on the findings of detailed inspections of a sample of the installed equipment. Sample inspections may be visual, close or detailed according to the purpose of the inspection but they do not reveal faults of a random nature such as loose connections and can only be used to monitor the effects of environmental or installation conditions, eg corrosion, vibration or inherent design weaknesses etc. Users should therefore have an inspection procedure in place to reveal random or installation faults.

Strategy for sample inspections

23. For sampled inspections to be valid and effective, and for the three-year recommended period between inspections to be increased, the following conditions should be satisfied:
    - 100% of equipment items should have been inspected on initial installation and before commissioning into service.
    - An inventory comprising 100% of the equipment should be provided and should be kept up to date.
    - Samples of equipment selected for a detailed inspection should be truly representative of the population of similar equipment.
    - Each item of equipment should be capable of being identified for cross- reference to the inventory or database.
    - Records of all inspections should be accessible from the installation and should include details of failures, non-compliance with BS EN 60079-17, and any evidence that there is a need for further training of maintenance staff.
    - The inspection sampling and maintenance strategy should be backed up by an audit and review procedure, the result of which demonstrates that the strategy is effective and that personnel competence is adequate.
    - If faults are revealed in a sample inspection of the equipment then a further larger sample should be inspected. If faults are again found then the whole population is suspect and needs to be inspected.
    - Faults revealed by inspections or repair and maintenance should be recorded and assigned a fault code for reliability and trend analysis and review.
    - The actual condition of the installed equipment when subject to a detailed inspection is the ultimate test of an effective inspection and maintenance strategy.

References

You can find additional information in the following publications:

- IEC 61195 (Draft) Double Capped Flourescent Lamps Safety Specification;
- BS EN 60079 – 17 2003 Electrical Apparatus for Explosive Gas Atmospheres – Inspection and Maintenance.

Further information

Any queries relating to this notice should be addressed to:

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Hazardous Installations Directorate
Offshore Division
Lord Cullen House
Fraser Place
Aberdeen
AB25 3UB
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This guidance is issued by the Health and Safety Executive. Following the guidance is not compulsory and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.