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To:

All HID Inspectors & Specialists

All SG Process Safety and Electrical Specialist Inspectors

ALARM SYSTEMS GUIDANCE FOR HID INSPECTORS

PURPOSE

This SPC provides information to inspectors on alarm systems and the problem of alarm floods. This circular advises on recent developments, gives specific information on the current position in the chemical industry and advice on inspection.

BACKGROUND

1. In July 1994 an explosion occurred at the Texaco Refinery, Milford Haven. One of the causes of the explosion was the number of alarms and the poor design of the alarm systems that obscured safety information from the operators. As a result, they missed key information that could have prevented the explosion. One of the recommendations from the report (ref 1) into the explosion was:

   'The use and configuration of alarms should be such that:

   - safety critical alarms are distinguishable from other operational alarms;
   - alarms are limited to the number an operator can effectively monitor; and
   - ultimate plant safety should not rely on operator response to a control system alarm'.

2. A research report (ref 2) was also commissioned by the HSE to determine whether the problems experienced at Texaco were widespread throughout the industry and what solutions companies had developed in solving this

problem. The findings of the research indicated that the problem was widespread but that it could be solved. The conclusions and recommendations from the report are contained in Appendix 1. Please note that, based on recent inspection experience by the HID Human Factors Team and others, this is still very much a live issue. The more recent Esso Longford disaster provides an equally clear lesson on the possible **consequences** of poor alarm system management. (ref 3)

THE PROBLEM

3. An alarm "flood" is when operators are presented with too many alarms within a short space of time so that they cannot identify individual alarms and take action upon them. In these circumstances operators will often miss or ignore alarms. Alarm floods often occur during process disturbances e.g. power failure when the information they supply the operator is most critical.

4. Traditionally, alarms were used to provide safety information to plant operators. This included alarms on process conditions that could result in injury to personnel and/or equipment damage, if no action was taken. When computer control systems were introduced into process plants, alarms could be easily added, and they are now used for a much wider range of uses. This includes event logging, indication of process deviations, plant status, abnormal process conditions, etc.

5. The increase in the total number of alarms (plus nuisance/false alarms), the de-manning that took place when many processes were computerised and the change in presentation format has lead to an increase in alarm floods and has decreased the operators' ability to take appropriate action in response to an alarm.

WHY ARE ALARMS IMPORTANT

6. Alarm systems have an impact on plant safety for the following reasons:

- Good alarm systems reduce the frequency at which the shutdown systems are called upon to operate, by enabling pre-emptive action;
- On many chemical plants and some power plants there are post-trip actions required from operators to bring the plant to a steady state. Also the identification of safety-related operator actions is sometimes incomplete;
- In complex modern plant, faults do creep in (perhaps due to inadequate design or maintenance errors) that will not be protected by the automatic shutdown systems. Some of these faults can result in a major hazard if they are not detected and corrected by the operator.

BEST PRACTICE GUIDANCE

7. The research report (ref 2) indicated that to achieve an improved performance in alarm systems:

   1) a management commitment to improving performance is needed;

   2) it is necessary to apply the basic improvement methods and techniques;

   3) if the improvement in performance from using basic methods and techniques is not enough, more advanced techniques may be required.

Improvement Strategy

8. To improve performance of alarm systems, it is necessary to:

   - Assess the current performance of the alarm systems by using repeatable performance measures.
   - Set performance targets against acceptance criteria (standards and guidance).
   - Take steps to improve the performance, and reassess against the performance targets using the performance measures.

Performance Measures

9. The measurements given below can be made relatively easily, can provide good indicators of the alarm system performance, and hence can be used as targets for an improvement process. These include:

   - Operator questionnaires;
   - Average alarm rate;
   - Identification of frequent alarms;
   - Number of alarms during a major plant upset;
   - Number of standing alarms;
   - Usefulness of alarms;
   - Insufficient alarms;
   - Priority distribution;
   - Incident recording.

Improvement Techniques

10. The improvement techniques can be categorised under two headings, namely management of the process and technical methods. Both aspects are

important. The management of the process has to be effective to ensure results are achieved. Also the correct technical methods needs to be applied.

Two beneficial and widely used improvement techniques are:

1) A fundamental review of the alarm system to identify the safety (personal, environmental, or economic) significance of each alarm. Such a review needs to have an operator input, safety input and an instrumentation input. Then the review needs to address an appropriate implementation for each alarm in accordance with its safety significant (this includes issues such as, is an alarm appropriate, speed of operator response required, the priority of the alarm, etc.).

2) Measures to identify and remove the 'nuisance' alarms e.g. consideration of alarm set point, noise reduction measures, type of alarm or the use of more sophisticated techniques.

Management of the Improvement Process

11. A key aspect to achieving improvement in alarm systems - as in many other things - is for the organisation to have a culture that encourages improvement. This requires a real commitment by the senior management of the plant. The reasons and objectives for improving the alarm system needs to be made clear to all staff involved. Some of the features of a good management approach include:

- a culture of improvement;
- personal and team targets set;
- alarm review(s) carried out;
- modifications of alarms are controlled;
- there is operator involvement in reviews and no-blame reporting; and
- both technological and cultural improvements are sought.

Technical Methods

12. Some of the techniques that can be used to improve the operability of alarm systems are identified below. The individual methods have been grouped under generic headings. Some of these methods are possible on all control systems whilst others may require additional investment both in terms of resources and equipment to achieve them. A more detailed description of each of the techniques is contained in the research report (ref 2).

The techniques include:

- **average alarm rate** calculation;

- the use of **deadbands** (whereby alarms are raised at one level and cleared at another to eliminate **repeating alarms**) including the associated **limit modification and tuning**;
- **deviation alarms** (i.e. deviation from a variable set-point) and the use of **adjustable limits**;
- **re-definition** of alarms including eliminating **events** and **status** (which may not be alarms);
- presentation of alarms including **prioritisation** (e.g. high/medium/low), **dynamic re-prioritisation** (for changing process conditions);
- **grouping** alarms from a common plant or geographical area;
- **re-engineering** of alarms including digital to analogue, installation of automatic trip functions;
- **discrepancy alarming** (indicating contradictory alarms);
- managing:

  repeating alarms (i.e. frequently raised and cleared alarms) and

  fleeting alarms (i.e. raised and cleared with a short time interval), by;

  shelving (manual, temporary suppression of display of (e.g.) nuisance alarms);

  single line annunciation (repeating alarms only being displayed once on an alarm "page"); filtering (eliminating signal noise which can result in nuisance alarms);

  transient suppression (suppression of temporary but acceptable alarm conditions: e.g. overcurrent on motor start-up);

  the use of **de-bounce timers** (suppressing the display of repeated alarms);

  counter use with repeated alarms, whereby continually repeating alarms are displayed;

  and **auto-shelving**.
- **suppression** of alarms including:

  validation (identifying alarms from faulty instrumentation);

  the use of **redundancy logic** (combining the replicated alarms from different sensors into a single displayed alarm);

eclipsing (eliminating lower order alarms of the same variable in favour of a higher order alarm);

analysis of **alarm** "**modes**"**; out of service** plant, **operating** mode, and **major event**.

ACTION BY INSPECTORS

Raising Awareness

13. The inspection strategy is to concentrate mainly on providing information to companies on how they identify the problem and what actions they should take to address the problem. Inspectors are therefore asked to raise awareness of the problem with employers and draw their attention to this document, the HSE research report 'The Management Of Alarm Systems - A review of current practice in the procurement, design and management of alarm systems in the chemical and power industries'. There is also a free HID Information Sheet available which has been found useful by inspectors and industry (ref 4). This includes information on alarm management training available in the UK for e.g, alarm system engineers or alarm project managers and others.

14. When raising the issue of alarm floods during inspection activities, inspectors need to consider the different stages in the life cycle of the alarm system. This includes design, operations, maintenance, modification and management, all of which can influence the safety performance of an alarm system. Some of the key issues for each life cycle stage are described below. Inspectors should use their judgment as to which of the issues are appropriate to raise taking into consideration the type of inspection activity they are undertaking.

    1) Design - The philosophy for the role of all alarms in relation to other safety measures should be identified. This should include how the safety role of the alarm has been assessed and how alarms have been implemented technically to reflect this role. The overall alarm philosophy should be defined including the role of the human operator, the responses required and performance targets. The technical implementation of the alarms reflects the safety role of alarms, and measures and techniques used to prevent the alarm overload have been identified. Where safety critical (or safety-related) alarms are identified they should be:

       - implemented in a system which is independent from the main control system;
       - automated where practical;
       - where automation is not practical, the operator needs to be provided with unambiguous procedures, appropriate training (and

retraining). There should be monitoring and supervision systems to ensure the operator's competence in the procedures. There also needs to be consideration of the working environment including equipment ergonomics and consideration of other operator duties to ensure the operator is capable of carrying out the safety critical task when required.

2) Maintenance - There should be a system for fully testing alarms. The frequency of testing should include consideration of the safety role and the reliability of the equipment implementing the alarm.

3) Operations - There should be a system in place that identifies the circumstances where alarms can be suppressed, masked, overridden and/or bypassed. The roles and responsibilities of individuals in this system should be defined. Where such measures are used there should be a defined management responsibility for monitoring these to ensure they are not being abused.

4) Modification - There should be a unified system for controlling modifications to alarm systems in place that identifies the safety significance of the alarms and has controls in accordance with this and takes account of the operator's performance. The modification system should have clearly defined roles and responsibilities and ensure appropriate records are kept.

5) Management roles and responsibilities should be defined in connection with alarm systems and include the consideration of operator's requirements. This should include the identification of performance targets for alarm systems and formulation of an improvement strategy, if appropriate, for the alarm system.

15. Inspectors' questions should be aimed at forming a judgment as to whether the employer is approaching the issue in the right way. It is important to recognise that there is no universal answer to the problem, but rather there may be different approaches to solving it. Both management and technical aspects need to be considered. The two most important issues to raise are:

1) the purpose of the alarm system; and

2) using identification and implementation of a philosophy/fundamental review performance measures to identify circumstances where operators are overloaded and why.

16. Ideally the philosophy for the whole alarm system and its associated implementation should have been determined and implemented at the design stage. However, usually this has been omitted or carried out in an unsystematic manner and modified over the years. It is more common to find that a fundamental review has been undertaken (or is needed) post commissioning. Even a well designed philosophy and implementation may need reviewing if experience indicates that alarm floods are still occurring.

Enforcement

17. Inspectors are expected to use the usual criteria for determining when enforcement action is appropriate and what type of enforcement to take i.e. it should be proportionate, consistent, transparent and targeted on a risk-related basis.

Examples of where formal enforcement activities may be appropriate are described below:

1) Where a fundamental review has not been undertaken and there is no systematic approach for identifying the safety significance of **all** alarms and ensuring that the alarms have been implemented in accordance with their identified safety significance (see paragraphs 10 and 13).

Without this it would be difficult for a company to demonstrate that safety critical (safety-related) alarms are distinguishable from other operational alarms and that ultimate plant safety does not rely on operator response to a control system alarm.

2) Where a medium/large or complex system produces alarms and no attempt has been made either to measure the performance of the system, or the operator's ability to cope with in an emergency.

Without this it would be difficult for the company to demonstrate the alarms are limited to the number an operator can effectively monitor.

The users' duties are covered by the HSW Act ss 2 and 3, The Management of Health and Safety Regulations 1999 reg. 4, The Control of Major Accident Hazards Regulations 1999 reg. 4.

Safety Reports

18. The information contained in this circular together with the assessment criteria may also be used to determine whether an operator has provided an adequate demonstration of safety in their safety report submission.

FURTHER INFORMATION

Queries on enforcement policy should be referred to divisional line management, HID LD6 (CSSU) and HID C3A&C (MSDU).

REFERENCES

1) The explosion and fires at the Texaco Refinery, Milford Haven, 24 July 1994. ISBN 0717614131

2) '**Alarm systems, a guide to design, management and procurement**' Engineering Equipment & Materials Users Association Publication No 191. Available from EEMUA (Tel 020 7628 7878/Fax 020 7628 7862).

3) **Lessons from Longford: the Esso Gas Plant Explosion**, Andrew Hopkins, CCH Australia Ltd, 2000, ISBN 1 86468 422 4 – available in UK via Croner CCH, 145 London Road, Kingston upon Thames, Surrey KT2 6SR: Email dmckail@cch.co.uk or Tel 0161 6436133 (or 020 854 7333 or 0845 241 5719).

4) Free HSE Information Sheet '**Better alarm handling**' (Chemicals Sheet No 6) is available from HSE Books, PO Box 1999, Sudbury, Suffolk, CO10 2WA (Tel 01787 881165/Fax: 01787 313995) and via the HSE website at www.hse.gov.uk/pubns/chis6.pdf.

FURTHER READING

1) Alarm reduction, non-nuclear experience - Peter Andow, Honeywell Hi-Spec Solutions International Journal of Industrial Ergonomics 17 (1996) - 'A methodology for the construction of safety-orientated advisory systems for operators'.

2) NUREG-0700 Rev 1 Vol 2: Human-System Interface Design Review Guidelines, Reviewer's Checklist. Published June 1996. By the Nuclear regulatory Commission.

3) Advisory Committee on the Safety of Nuclear Installations - Study group on human factors - First Report on Training and Related Matters.

4) HSL Report - Brief human factors assessment of alarm handling and lighting issued in Sizewell 'A' main control room - M Anderson, C R J Horbury and D B Riley.

5) EPRI: Human Factors Guide for Nuclear Power Plant Control Room Development. EPRI-NP-3659, August 1954.

Appendix 1

ALARM SYSTEMS

A GUIDE TO DESIGN MANAGEMENT AND PROCUREMENT

A review of current practice in the procurement, design and management of alarm systems in the chemical and power industries.

EEMUA Publications

Recommendations

The following recommendations draw together the key messages on best practice from the report.

EXISTING ALARM SYSTEMS

- Sites should make efforts to become more aware of the financial and safety risks associated with the performance of their alarm systems.
- Sites should identify alarms of little value and re-engineer them.
- Sites should review the performance of their alarm systems following major upsets, determine the likelihood of alarms being missed and examine the implications of this.
- Performance measures should be considered as tools for driving an improvement program.
- In an improvement program, the first step should be determined application of proven techniques rather than the development of new techniques.
- Plant managers should review allocations of responsibility for alarm system performance improvement.

NEW ALARM SYSTEMS

- Engineers procuring new plant should review whether the process of designing the new alarm systems is managed in the best way. They should also review whether they are investing enough in the engineering of these systems.
- The system should be **operator-centred by design**.
- Strategies for **Alarm Design and Site Alarm Management** should be devised and documented.

GENERAL

Those involved in driving C & I research and development programs should review whether this focus needs to change.