# HUMAN FACTORS

BRIEFING NOTE No. 4

# Maintenance

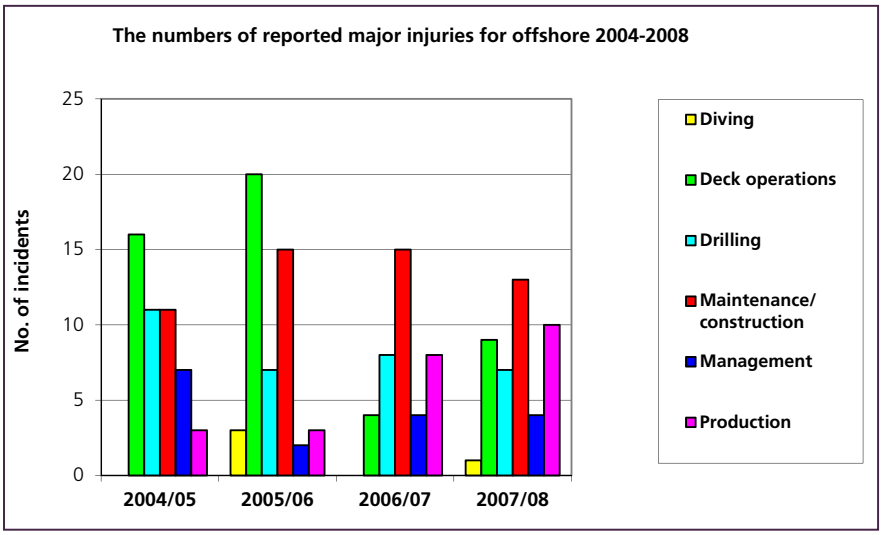
A task entailing the routine testing/checking, servicing or breakdown repair of plant or equipment. Failures in maintenance tasks can lead to injury to the fitter or to others, or to equipment malfunctions/ system unavailability and to major accidents.

## Why maintenance?

Maintenance work in major hazard industries could involve isolating process streams of dangerous substances, then stripping down and rebuilding a system - perhaps removing or disabling safety systems to do this - or, the task could be as simple as changing a fuse in a plug. Irrespective of the work undertaken, maintenance is a human activity and its quality depends upon the performance of the people who undertake it.

## Are you aware of any of the following problems with maintenance in your company?

| If the answer to any of the following questions is 'Yes', then you should take action! | Yes | No |
|---|---|---|
| 1. Are lots of items of equipment difficult to maintain – e.g. they are hard to access or strip down/ reassemble? | | |
| 2. Do fitters often have problems finding or using the right tools or spares? | | |
| 3. Is there little or no checking of jobs in progress or at the end to make sure they're done properly? | | |
| 4. Is there no priority rating of jobs – do maintenance crews just do the next one on the list? | | |
| 5. Have maintenance crews had problems where electricity or pressurised pipes haven't been isolated properly? | | |
| 6. Are some maintenance procedures out of date or just poorly written and don't relate to the equipment in its current state? | | |
| 7. Are conditions usually less than ideal for doing maintenance tasks – it's hot, noisy or cramped, etc? | | |
| 8. Is there any evidence that sometimes fitters take shortcuts on a job – especially if they have been pushed for time? | | |
| 9. Would it be easy to start work on the wrong system - things look similar, labelling is not that good and piping and instrumentation diagrams (P&IDs) are not up-to-date? | | |
| 10. Are lots of maintenance jobs badly planned? | | |
| 11. Could methods of protecting the fitter or anyone near the job be improved (through guards, barriers, warnings, personal protective equipment (PPE), isolation methods, etc.)? | | |
| 12. Are contractor procedures and processes rarely monitored to ensure they meet company standards? | | |




Note: maintenance/construction levels in red.

Source: HSE, 2008, Offshore Injury, Ill Health and Incident Statistics

## CASE STUDY 1

"Gas was released from a flange on a vent line which was overpressured when a compressor relief valve vented. A block valve in the vent line was found to be closed. The valve had been left shut by mistake following maintenance two weeks previously... inspection/condition monitoring was identified in nearly a third of all incidents, suggesting that checking and maintaining the condition of the plant was one of the most important ways of preventing leaks."

Source: HSE Offshore Technology Report 055/2001.

# What should my company do about it?

A human error in maintenance processes can lead directly to injury (of the fitter or someone near his/her work area) or to a major accident. More seriously, an error could introduce a fault into the system which then malfunctions at a later date leading, for example, to loss of containment of dangerous substances. Such undetected faults are known as 'unrevealed errors'. If it is a safety-related system that fails, this could cause more extensive injury or damage.

Piper Alpha was the starkest example of a maintenance error within the petroleum industry. There are many examples of disasters outside the industry in which maintenance errors were the root cause, for example, those that took place at Flixborough, Bhopal and Clapham Junction. To help avoid such disasters, companies should establish a maintenance policy and maintenance programme and should clearly define roles and responsibilities for maintenance.

The HSE's *Key programme 3* report focusing on offshore installations noted that among the worst performing areas in terms of preserving asset integrity were: maintenance of safety critical elements; backlog (of maintenance); deferrals; measuring compliance with performance standards; and corrective maintenance.

The report also noted many examples of good practices – some relating to maintenance.

Source: HSE, http://www.hse.gov.uk/offshore/

# Management responsibility

The factors that can lead to human failure in maintenance are basically the same as for other types of tasks. Human reliability is covered more extensively in Briefing notes 12 and 13. However, to encourage good human performance in maintenance work specifically, your company should make sure, as a minimum, that there are:

- Enough competent people to carry out maintenance work and to check work done.
- Adequate supplies of spares and consumables.
- Good communications so that maintenance crews (and others who might be affected by maintenance – including contractors) know what work has to be done and where (particularly important at shift handover).
- Good safe systems of work/permit arrangements developed against formal safety analyses so that major hazards, as well as personal/occupational safety are considered.
- Contingency plans, for example, if a job looks as if it might overrun or if other problems arise.
- Systems for investigating incidents and accidents that occur during maintenance and for making improvements.
- Structured processes to identify and assess human error potential in safety critical maintenance tasks (and to reduce this potential).

The company should also ensure that:

- Maintenance tasks are realistic and achievable.
- Maintenance work is carefully planned and scheduled including unanticipated maintenance tasks.
- Particular attention is given to whole plant shutdowns where the company has to manage a large number of contractors, work under permit and in which many safety systems may be taken out of service.
- The design of equipment to be maintained, and its location, doesn't encourage errors.
- Suitable tools and equipment (including safety equipment) are provided for the work.
- Working conditions are tolerable (e.g. enough light, not too noisy, not too hot or cold, well ventilated and clean).
- Written instructions, permits, diagrams and other paperwork, as well as labels are clear and up-to-date.
- The impact of any proposed change in maintenance arrangements is assessed.
- Maintenance practice is assessed against standards – see References.

## CASE STUDY 2

"Between 2002 and 2007 there were a number of failures of hydrocarbon risers inside caissons, I tubes or J tubes giving rise to potentially serious hydrocarbon releases."

Source: HSE website – Pipelines Health and Safety

For example: "The gas release occurred from a gas lift riser pipe within the riser caisson on the platform after being shut in… the gas release was found to have occurred from a corroded section of riser above the water-line which was not accessible to internal or external inspection…as the design of the facility did not readily facilitate inspection, testing and maintenance of this particular section of pipe, the ongoing integrity of the riser could not be ensured."

Source: Step Change in Safety incident alert 974 (http://www.stepchangeinsafety.net).

## CASE STUDY 3

A gas compressor was being re-started after corrective maintenance. The train was slowly being pressurised when a leak was noticed around the recycle pipeline on the scrubber skid. The scrubber had been cooling down from normal operating temperatures. It is suspected that thermal expansion and contraction had loosened bolts on one of the flanges resulting in the release. A new maintenance routine has been created to check the torque settings after significant maintenance work.

Source: Step Change in Safety, SADIE Record no. 237 (10/05/2002).

# Measuring performance

Below is a sample of performance indicators that could potentially be used to monitor how effectively maintenance is being managed, divided into leading indicators (showing that a problem may occur in future) and lagging indicators (showing that there is currently a problem). See Briefing note 17 *Performance indicators* for more information on using performance indicators.

| Leading indicators | Lagging indicators |
|---|---|
| Maintenance backlog (percentage of equipment not maintained against prioritised targets).<br><br>Percentage of maintenance jobs not checked (that require to be checked).<br><br>Relative percentage of reactive (corrective) versus proactive (planned) maintenance.<br><br>Timescale for closure of work orders, against targets.<br><br>Number or percentage of equipment inspections/tests undertaken against target schedule. | Number of loss control reports/ reported failures, including key component failures, attributable to lack of maintenance.<br><br>Total number of critical system breakdowns.<br><br>Percentage of reported maintenance errors/number of tasks requiring re-work.<br><br>Number of times issues reported with equipment that has been maintained or repaired (i.e. maintenance incorrectly performed leading to latent defects/ maintenance induced failure). |

## CASE STUDY 4

Total Lindsey Oil Refinery was fined £14 000 for their failure to manage risks during maintenance on a crude oil storage tank. The tank had been drained - taking its floating roof to the bottom of the tank - and the space below that was purged of all remaining crude oil. When the company's contractors began to cut into the roof brackets using oxyacetylene cutting equipment, there was an explosion of flammable vapours powerful enough to knock several of the workers off their feet. One of the hollow pontoons in the floating roof had been leaking and contained oil which vaporised when heated. The company had identified this leak in 1988 – 16 years before the incident – but the information had not been preserved and therefore not passed to the contractors. The procedure for checking all pontoons prior to working on them had also been breached.

Source: HSE press release http://www.hse.gov.uk/press/2006/e06034.htm.

## Further reading


- Human Factors in Reliability Group, (2000), *Improving maintenance: A guide to reducing human error*, HSE.
- Reason, J. & Hobbs, A. (2003), *Managing maintenance error: A practical guide*, Ashgate Publishing.
- HSE Human factors briefing note no. 6, *Maintenance error*, http://www.hse.gov.uk/humanfactors/comah/briefingnotes.htm.
- HSE (1992) *Dangerous maintenance - a study of maintenance accidents and how to prevent them*, HSE Books.
- *Maintenance - reducing the risks,* a joint industry/HSE seminar & workshop 17 & 18 January 2001, http://www.stepchangeinsafety.net.
- HSE, Level 3 *Guidance for the assessment of COMAH safety reports technical measures relating to maintenance procedures*, http://www.hse.gov.uk/comah/sragtech/techmeasmaintena.htm.


For background information on this resource pack, please see Briefing note 1 *Introduction*.