

HSE Human Factors Briefing Note No. 6

Maintenance Error

Briefing Note 1 – ‘Introducing Human Factors’ explains the background to these Briefing Notes.

Human errors and violations in servicing and repair tasks have many of the same root causes as errors in other types of task (see Briefing Notes on competence, humans and risk, procedures, communications and fatigue). However, in maintenance, a fault introduced into the system by human error today might have no effect for several months and then cause a sudden unexpected hazardous breakdown.

Case studies

A well-known loss prevention expert Professor Trevor Kletz asked for an unusual retirement gift – a filing cabinet. He put his collection of accident records in this and when he sorted them into categories, by far the largest category was ‘preparation for maintenance’.

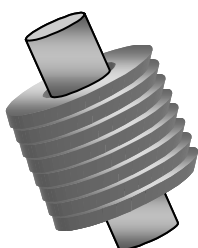
Source: OTO 01007

An example of poor preparation for maintenance is an accident that occurred during maintenance work on a fire fighting system for a tank in the benzene storage area of a petrochemical plant. Maintenance was carried out even though the tank was full of benzene. Coordination and communication between maintenance and production departments was poor. Production did not supply critical information to maintenance such as: the tank was filled with benzene; a component was missing allowing benzene into the fire fighting foam pipes and, the tank did not have nitrogen blanketing.

One person was killed and 3 injured in the explosion that occurred. Only after the accident, did the company prepare written procedures and a QA procedure for maintenance.

Source: Mars database incident no. 233

‘One way of reducing the number of accidents associated with maintenance operations is to carry out less maintenance’. Kletz in Ref. 3



A maintenance problem

There’s only one way to remove the 8 rings from the peg. Only 1 way in 40,000 puts them back in the same order and the same way up as they started! How would you make sure they went back the right way? Your answers will apply to most maintenance tasks. Example answers – see below.

HSE concerns

Companies focus their attention on accidents during maintenance that could injure the maintenance fitter rather than the major accident potential of the maintenance fitter's error. Human errors in servicing and repair can render unavailable systems needed for safety reasons or could introduce faults that make the equipment unsafe.

Maintenance checklist:

If your company manages maintenance well, you should be able to tick **most** of the boxes below.

When it comes to maintenance, we:

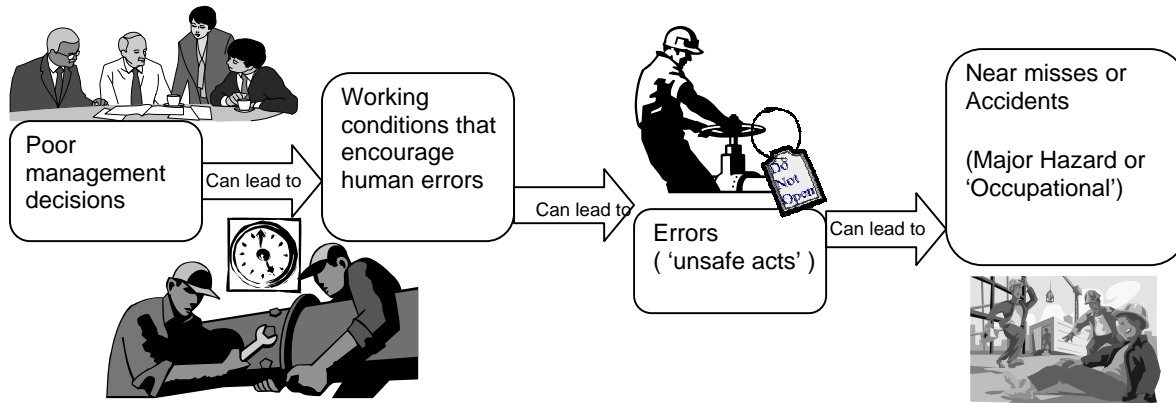
..are fully aware of what maintenance work can lead to a major hazard accident	<input type="checkbox"/>
..have good defences in place to make sure these accidents are very unlikely, including:	<input type="checkbox"/>
Physical barriers and guards	<input type="checkbox"/>
'Administrative' controls (permits, procedures, checklists)	<input type="checkbox"/>
Management controls (supervision and checking of tasks)	<input type="checkbox"/>
Highly competent maintenance teams	<input type="checkbox"/>
Well designed maintenance tasks (interesting, no time pressure, comfortable conditions)	<input type="checkbox"/>
..base our maintenance programme on major accident risk assessment	<input type="checkbox"/>
..communicate well during shifts and between shifts	<input type="checkbox"/>
..take special care of temporary or inexperienced maintenance technicians and contractors	<input type="checkbox"/>
..do walk around inspections of maintenance tasks in progress	<input type="checkbox"/>
..have considered the ease of maintaining systems and continually improve it	<input type="checkbox"/>
..look for early signs of problems (e.g. a large backlog of jobs; excessive repair times; adverse feedback from staff)	<input type="checkbox"/>
..investigate near misses and accidents to learn from human failure in maintenance and to improve our systems	<input type="checkbox"/>

The 'ring and pegs' problem:

1. Redesign to make it impossible to reassemble it incorrectly or so that ring order and direction doesn't actually matter
2. Try to make this task more interesting!
3. Put a colour code, number or other marking to show when the rings are on the right way
4. Design the task to give the person doing it enough time and low stress conditions to do it
5. Make sure a second person checks the order and direction of the rings after they have been assembled.

Learning more about maintenance error

The diagram below shows that, as with most human errors, the root cause of maintenance errors can usually be traced back to management. One way of looking at this is that management are responsible for putting in 'defences' against error. Defences are anything designed to prevent or reduce the chance of human errors or to deal with the consequences of unpreventable or unforeseen accidents. However, accident reports often show that management are responsible for breaking down defences by changes in administration.



The table below illustrates a human error analysis of a general maintenance task and shows the types of defences that should be considered to prevent major accident hazards arising from human errors in them.

Task	Need to	Physical Defences	Administrative Defences
Plan the job	Identify safety critical parts of the job and how to manage them (risk assessment)	Physical barriers around items that could be damaged by maintenance; maintainable systems (designed for easier maintenance); barriers to contain or control hazards if released (e.g. bunds; water curtains; fire detection and fighting systems; protective clothing; refuges)	Safety Management System; good safety culture and morale; permit to work system; procedures for shift handover if task extends over 2 or more shifts; good communications between maintenance and operations personnel; manage possible fatigue or time of day effects on task; team selection; site emergency plan; incident analysis system
Isolate the system	Use best means of containing hazards.	'Blinds' in pipes etc rather than rely on valves; bleed valves; remove circuit breakers rather than rely on switches; take readings to check isolation	Permit system should specify defences to be used; conduct spot checks of permits in use; procedure update system
Gain access to the system	Open up covers/hatches	Housekeeping systems to keep track of tools and components; physical protection of surrounding areas if opening up requires force	Spares, tools and consumables storage and an issuing system
Carry out service or repair task	Test by eye or using instruments; replace damaged or worn out items; replenish fluids	Mostly administrative but, could make systems more 'maintainable' (easier to maintain) and make it impossible to do key tasks incorrectly (e.g. design components that will only fit in one way)	Competent technicians; up to date maintenance procedures/ checklists/ job aids; independent checks by second technician or supervisor; system designed to accept only correct components; good calibration procedures; team training if required; stagger maintenance tasks so that multiples of the same item are not serviced at the same time by the same crew (same fault could be introduced into each item); system of reminders to ensure nothing is left out

Task	Need to	Physical Defences	Administrative Defences
Reassemble	Align the system correctly; do not leave any components out; don't leave foreign object in system	Design of system to resist errors (e.g. by providing only one means of reassembly; components that cannot be damaged by forcing)	Housekeeping system to ensure that all replacements have been fitted and all old ones accounted for. Independent checking, random checking during reassembly
Remove isolation	Make sure it is safe to refill or restart system	Isolations physically locked; barriers against the specific hazard (e.g. screens; protective clothing)	Strict procedure for reinstating equipment; observe for signs of problems; be able to re-isolate the system quickly
Commission and test the system; put back into service	Make sure the system works properly and is in the correct state (running or standby)	Allow only authorised personnel access to the system	Good test procedures; clear measures or criteria for pass/fail; independent checks

References

1. Major Accident Reporting System (MARS) entry 2335
<http://mahbsrv2.jrc.it/MARS/servlet/ShortReports>
2. HSE (2000) 'Improving Maintenance: a Guide to Reducing Human Error'. ISBN 0 7176 1818 8
3. HSE (2000) 'Maintenance - Reducing the risks'. OTO 2001/007 ISBN 0 7176 2075 1
4. Reason, J and Hobbs, A (2003). 'Managing Maintenance Error'. Ashgate. ISBN 0 7546 1591 X