Safety Information — Human Factors

Prepared by the Safety Advisory Council

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Task

Maintenance Error

Maintenance Error: failing to perform a task or performing it incorrectly during routine testing, checking, servicing or breakdown repair.

Errors can result in equipment malfunction or in an incident causing damage to plant or harm to people or to the environment.

Human errors and violations in servicing and repair tasks have many of the same root causes as errors in other types of task. However, with 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 or incident.

Learning more about maintenance error

If the answer to any of the questions below is 'no', then you need to take action

1.	Are maintenance tasks risk assessed including identification of consequences of maintenance errors?	☐
2.	Are you fully aware of what maintenance errors could lead to an incident?	☐
3.	Is there a clear strategy and plan for maintenance?	☐
4.	Are resources allocated and roles, responsibilities and accountabilities clearly identified?	☐
5.	Are there effective defences in place to ensure maintenance errors are unlikely to result in incidents? Examples of best practice defences, which may be included in industry guidance or law, are: • Administrative controls (permits, procedures, checklists, lock-out tag-out, independent verification or 'four eyes' checks). • Management controls (supervision and checking of tasks). • Competent maintenance teams. • Physical barriers and guards.	☐
6.	Are maintenance tasks well designed in terms of environment, surroundings, access, lighting, time allocated, and individual or collective protection measures?	☐
7.	Do managers and supervisors perform walk around inspections of maintenance tasks whilst in progress?	☐

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8.	Does the incident investigation process include human factor lessons learned, from maintenance near misses and accidents?	☐
9.	Is progress of maintenance work, including status of equipment, communicated well during and between shifts?	☐
10.	Is there a training and competence management system for maintenance teams?	☐
11.	Is there a process to assess the capabilities of contractors for specific tasks?	☐
12.	Do plans take consideration of the supervision of temporary or inexperienced maintenance technicians and contractors?	☐
13.	Is the ease of maintaining systems considered during design of installations or equipment?	☐
14.	Do managers or supervisors look for early signs of problems (for example a large backlog of jobs; excessive repair times; adverse feedback from staff)?	☐
15.	Are maintenance requirements assessed during Management of Change?	☐
16.	Are there measures in place that monitor safety and effectiveness of maintenance activities?	☐
17.	Is there a program to address continuous improvement in maintenance activities?	☐
18.	Are human factor learnings taken into account when reviewing maintenance instructions?	☐

What can we do about it?

Management responsibility:

The factors that can lead to human error in maintenance are basically the same as for other types of job.

To avoid such errors and encourage good performance in maintenance work, it is important that management should, as a minimum, ensure that there are:

- Enough people competent to perform and to check the specific maintenance task.
- Adequate supplies of spares and consumables to enable work to progress as planned.
- Good communications so that maintenance teams (and others who might be affected by maintenance, including contractors) know what work has to be done and where (particularly important at shift handover).
- Effective work permit system and isolation procedures in use. These are crucial and should be 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 problems that occur and for making improvements.
- Structured processes to identify and assess human error potential especially in safety critical maintenance tasks (and to reduce this potential).

And that:

- All preventive maintenance work is carefully planned and scheduled.
- Breakdown maintenance, although not scheduled is also carefully planned.

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- Maintenance plans can be safely, promptly and effectively executed.
- Particular attention is given to
  - whole plant shutdowns where the company has to manage a large number of contractors,
  - work in which any safety systems may be taken out of service.
- The design of equipment to be maintained, and its location, doesn't encourage errors.
- Work conditions are acceptable (for example lighting, ventilation, noise and weather protection including adequate breaks in extreme conditions).
- Suitable tools and equipment (including safety equipment and PPE) are provided for the work.
- Written instructions, permits, diagrams and other paperwork, and labels or notices are clear and up to date.
- The impact of any proposed change in maintenance is properly assessed.
- Up to date industry standards and guidelines are implemented.

Defences against maintenance error:

Defences are in this context any technical or organizational measures intended to prevent or reduce the likelihood of human errors and to mitigate the consequences of accidents. Management are responsible for implementing effective defences. However, accident reports often show that management decisions contributed to breakdown of these "defences against error".

The table below illustrates an analysis of a general maintenance task and shows the types of defenses that should be considered to prevent hazards arising from human errors.

Task step	Task success criteria	Technical Defences	Organization (administrative) Defences
Plan the job	Identify the hazards of the job and how to manage them (risk assessment)	• Physical barriers to protect people and around vulnerable equipment items that could be damaged; • Systems designed for ease of maintenance; • Safeguards to mitigate consequences of a release of hazardous substances (for example bunds, water curtains, gas detection, fire detection, warning or evacuation alarms, firefighting systems, PPE, "toxic refuge").	• Piping and Instrumentation drawings are current; • Safety data sheet for substances; • Document control; • Work permit system; • Team selection (training, competence, supervision); • Maintenance work instructions and risk assessments; • Procedures for shift handover if task extends over 2 or more shifts; • Spares and consumables inventory control system; • 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);

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Task step	Task success criteria	Technical Defences	Organization (administrative) Defences
			• Good communications between maintenance and operations personnel; • Plans to manage effects of possible fatigue or time of day on task or decision making; • Welfare arrangements (food, shower, toilet, rest facilities); • Good safety culture and morale; • Site emergency plan; • Incident reporting and analysis system.
Isolate the system	Use best means of containing hazards.	• Technical isolations using the hierarchy of controls (spools > blinds > block and bleed valves > valves); • Safe electrical isolation devices.	• Work permit system and lock-out tag-out procedures; • Confirm no residual energy by test and try; • Walk around inspections by managers and supervisors; • Systematic use of personal locks; • For complex equipment provide specific isolation plan (devices and sequence).
Gain access to the system	To safely reveal the parts to be inspected, maintained or repaired	• Physical protection of people and vulnerable equipment if opening up requires effort or force; • Provide lifting equipment or hoist.	• Housekeeping systems to keep track of tools and components; • Provide temporary access / work platform • Mark position/orientation of parts, cables, record values of parameters (clearances, distances, counting of turns open/close on valve etc.) to facilitate reassembly and recommissioning
Carry out service or repair task (for example test visually or using instruments; replace damaged or worn out	Safe execution of the task. Equipment is safe to operate until the next planned inspection.	• System designed to accept only correct components; • Equipment manufacturers can reduce the possibility of human error for example by designing components that will only fit in one way.	• Team selection (training, competence, supervision); • Up to date maintenance procedures, drawings, parts specifications; • System of reminders or checks to ensure all tasks are completed; • Independent checks by second technician or supervisor; • Calibration procedures;

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Task step	Task success criteria	Technical Defences	Organization (administrative) Defences
items; replenish fluids)			• Ensure that distractions are minimized in particular in critical phases.
Reassemble	Align the system correctly, Do not leave any components out. Do not leave foreign object(s) in the system.	• Design of equipment to resist errors (for example by providing only one means of reassembly; components that cannot be damaged by forcing).	• System or practice to ensure that all replacements have been fitted, all old parts accounted for and nothing is left out; • Independent checks by second technician or supervisor; • Ensure that distractions are minimized in particular in critical phases.
Remove isolations	Safe to refill or reenergise the system		• Strict compliance with the procedure for removal of lock-out tag-out; re-energisation; including temporary restoration of energy for test purposes; • For complex equipment provide specific de-isolation plan (devices and sequence).
Re-commission and test the system; put back into service	The system operates properly and is left in the correct state (running or standby)	• Physical barriers to protect people and around vulnerable equipment items that could be damaged; • Safeguards to mitigate consequences of a release of hazardous substances (for example bunds, water curtains, gas detection, fire detection, warning or evacuation alarms, fighting systems, PPE, “toxic refuge	• Work permit procedure; • Re-commissioning procedure including clear measures or criteria for pass/fail; • Start-up procedure with clear handover of responsibilities back to the operating team.

Additional considerations related to major accidents (Seveso):

Maintenance activities errors have been shown to have caused or contributed to many major accidents globally. It is therefore important, especially for Seveso sites, to assess and address the hazards of errors during planned and corrective maintenance work, because the consequences (immediate or delayed, to people, property and the environment) can be huge. These include:

- Understand what maintenance tasks can result in a major accident in case of error. These can be considered as safety critical maintenance tasks;
- Analyse the procedures for safety critical maintenance tasks to minimize the risk of human error (mistake);
- Ensure that safety critical maintenance tasks are risk assessed;
- Ensure that site emergency plans adequately address the failure of safety critical maintenance tasks;

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- Document reviews of human performance during maintenance (for example independent supervisor's checks and incident investigations);
- Ensure that critical safety systems (relief valves, safety instrument systems, UPS, etc) are included in preventative maintenance programs;
- Be able to provide documented evidence of the competence of persons performing these maintenance tasks

Useful Reference Information

1. Institute of Petroleum, *Maintenance Error*, Human Factors Briefing Notes No 4. Energy Institute. http://publishing.energyinst.org
2. *Maintenance Error.* HSE Human Factors Briefing Note No 6. Health and Safety Executive. www.hse.gov.uk
3. *HSE Human Factors Inspectors Toolkit,* Health and Safety Executive. www.hse.gov.uk
4. EIGA Info HF 01 *Human Factors – An Overview*. www.eiga.eu
5. EIGA Info HF 02 *Individual- Training and Competence.* www.eiga.eu
6. EIGA Info HF 04 *Task Factor - Design and Effectiveness of Procedures.* www.eiga.eu
7. EIGA Doc.40 *Work Permit Systems*. www.eiga.eu

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