THE INSTITUTE OF PETROLEUM

HUMAN factors no12
briefing notes

For background information on this series of publications, please see Briefing Note 1 - Introduction

HUMAN RELIABILITY ANALYSIS: *Methods for determining the reliability of human performance in specific tasks. Can be 'qualitative' (describes reliability in words only) or 'quantitative' (estimates the probability of human error in a task).*

human reliability analysis

Quote "…..studies show that '*human factors*' contribute to up to 80% of workplace accidents and incidents."
Source: Dr Paul Davies, HSE's Chief Scientist, Head of Hazardous Installations Directorate, Press Release E140:00 - 3 August 2000, www.healthandsafety.co.uk/E14000.html

Introduction

The likelihood of a human error in a task is directly related to the way the task itself is designed and the quality of the following key factors:

- Workplace design (including the working environment, tools, controls, displays etc),
- Documentation (written procedures, signs, labels) and
- Operator competence (level of training, qualification, experience etc in the task)

Human reliability analysis is used to gather and present information on these factors in a logical way. Organisations use human reliability analysis to examine the extent to which they have those factors under good control. If the level of control (and therefore human reliability) can be improved, the analysis will point to how this can be achieved. Certain techniques can generate 'human error probabilities' for tasks giving an estimate of the chance of a human error.

How do I carry out a human reliability analysis?

The basic steps are:

1. Define the problem ('critical tasks')
2. Perform a Task Analysis
3. Identify errors, consequences and defences
4. Estimate human error probabilities (optional)
5. Develop conclusions and make recommendations for reducing error.

Purpose of this briefing note

This briefing note will give an introduction only to the methods of human reliability analysis. It will not provide you with all the skills needed to conduct an analysis, but will help you to understand the basics.

Why carry out a human reliability analysis?

One reason is that human error is a major cause of 'disruption' (not just injuries, but plant downtime, defects in product quality, environmental damage etc) and needs to be controlled. Near miss reports may indicate an unacceptable level of human error in the company. Safety cases required by the Health and Safety Executive must show that the organisation is acting responsibly to reduce human errors. In general, it is a positive advantage for an organisation to understand better what might be causing errors and to take steps to reduce their likelihood.

Advantages of human reliability analysis

- Provides a logical comprehensive analysis of factors influencing human performance
- Leads to recommendations for improvement
- Supports the safety case: forces attention on safety critical tasks.

Disadvantages of human reliability analysis

- Can be time-consuming and costly given the level of risk from human error in a task
- May require specialist input
- Some of its methods are not fully validated.

1. Define the problem

Errors happen every day at work and whilst most are harmless, some can result in fatalities, injury or plant damage. Errors can occur in operations, maintenance or emergency tasks. You can identify these 'critical' errors in several ways:

- Through formal 'HAZOPs' (hazard and operability studies) which inevitably raise 'human error' as a source of hazards
- From probabilistic safety assessment (PSA) which may identify specific errors that need to be controlled
- By examining historical data, accident and near miss records and asking 'what happened in the past - is it under control now?'
- By 'brainstorming' - ask experts (designers or users of systems and equipment) which errors would cause a major problem
- By behavioural safety observation

The above may result in a large list. You may need to further screen this so that you examine in detail only a sample of the tasks, but make sure you choose examples of all types of task performed in your workplace.

2. Perform a hierarchical task analysis

This technique is explained in more detail in briefing note 11. Essentially, it consists of describing a task in terms of all the sub-tasks needed to carry it out. A task, for example, moving a load by crane, can be shown in either a 'tree' structure, or as a set of headings and sub-headings (see Worked example on page 2 of this briefing note).

3. Identify errors, consequences and defences

Using the task analysis as a starting point, identify feasible types of error in the task. Put this information in a table. This should also record the possible consequences of the error and the safeguards and recovery mechanisms in place to prevent errors or to detect and correct them (an example table is shown next).

Human error table

Task	Possible error	Consequence	Safeguards	Recovery	Comments
Cut section of pipework using angle grinder	Cut wrong section or wrong pipe Cut too far – damage other equipment Fail to protect other equipment from sparks etc.	Leak/ignition of flammable materials	Double check procedure to identify pipework Supervisor to check also Clear labelling of pipework will reduce possibility of confusion Protect other equipment with physical barriers/ guards/ blankets	None identified	Pipework carrying flammable gas and liquids are close together and it can be difficult to identify the correct one. Recommend that final check is introduced to ensure pipes are fully blown down and inerted

4. Estimate human error probabilities (HEPs)

The techniques for generating HEPs are highly specialised and should be used only by an expert. Techniques fall into two types: Data-based and expert-judgement based (although both types require expert judgement). The data-based techniques provide lists of types of tasks, e.g. 'complex task requiring high level of comprehension and skill'; or for more basic tasks, e.g. 'select valve'. For each task, they provide an error probability (or a range of probabilities) that are typical for such tasks. The analyst can then adjust this probability based on how he/she judges the design of the task and the conditions influencing the task will affect human performance.

Expert judgement techniques require a panel of experts to estimate the error probability from information given about the task. None of the 'quantitative' techniques has been fully validated, but a few do seem to produce good results.

5. Develop conclusions and make recommendations for reducing error

The information gathered in steps 1 to 4 will show whether the task is under good control or not. It will also show what could be done to improve human performance in the task by indicating any factors (e.g. task design, workplace design, competence or procedures) that are particularly poor.

Worked example

The example below is an extract only of an analysis performed for a crane operation. It shows how the five steps in the analysis are actually conducted, but some of the detail has been removed. Before attempting a full analysis, you would need more detailed familiarisation and training.

1. Define the problem

The task is to move a container by crane to a new location. This task is 'critical' because the only available route for the load is over a production area. If the load drops during transit, it could break vessels and pipework releasing highly flammable gas.

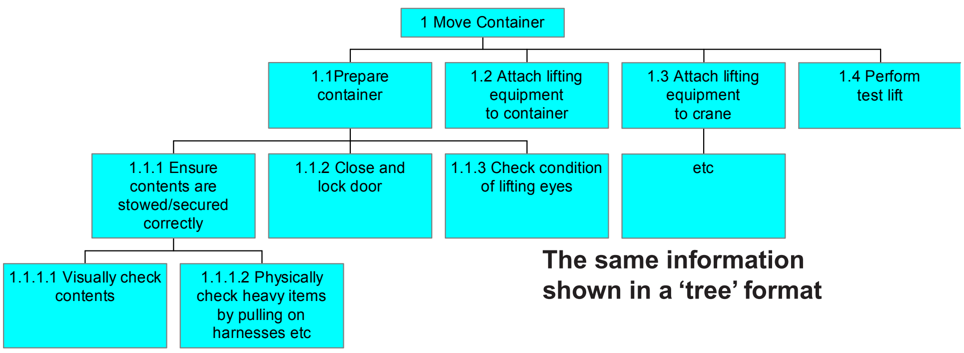
2. Perform a hierarchical task analysis

1 Move container
1.1 Prepare container for lifting
1.2 Attach lifting equipment to container
1.3 Attach lifting equipment to crane
1.4 Perform test lift
1.5 Lift container
1.6 Traverse container
1.7 Lower container to new position

1.2.1 Attach lifting shackle to lifting eye
1.2.2 Tighten retaining bolt
1.2.3 Pull on shackle to check firmly attached
1.2.4 Repeat steps 1.2.1 to 1.2.3 for three more shackles

Task 1.2 shown broken down into 'sub tasks'.
Other tasks would be similarly broken down and then into further detail e.g. 1.2.1.1 as necessary

To perform the task analysis, the analysis team went to the site where these tasks are carried out, accompanied by a crane operating crew, and noted the main tasks and sub-tasks. The information was recorded on paper and later checked by the crew who corrected and clarified some of the detail - what order they are performed in, who carries out each one etc. This resulted in the final task analysis description.



The same information shown in a 'tree' format

3. Identify errors, consequences and defences

An expert group (crane operators, supervisor, trainers etc) considered each sub-task to identify errors. They used a checklist - found in reference books - as a prompt ('can the task be omitted?', 'can the task be carried out on the wrong equipment?' etc). The findings from this group were then presented in a human error table (extract shown next):

Extract of human error table for moving container by crane

Tasks	Possible Error	Consequence	Defences		Comments
			Safeguards	Recovery	
1.3 Attach lifting equipment	Use incorrectly rated sling	Load drops because sling is too light for the load	Procedure requires supervisor to check and sign off that equipment is appropriate and 'in date'. Equipment is colour-coded and the codes are well known	Test lift (raising load 0.5 m initially to check that the load hangs level and that lifting equipment is sound	Lifting containers is a common task Data show that errors are rare at this site
1.6 Traverse container	Move too rapidly	Lose control of load and crash into equipment. Load shifts within container	Crane is set at slow speed by key system which supervisor retains. Operator competence	None if load impacts vulnerable equipment or plant	The consequences of error in such lifts are well-known to crane operators. Emergency arrangements will reduce severity of consequences
1.2.3 Pull on shackle to test	Omit to check attachment	Shackle fails during lift	Check is simple, routine. Final visual check before lift will show any major problems	Test lift should reveal any problems	

4. Estimate human error probabilities (HEPs)

HEART (the Human Error Assessment and Reduction Technique), was used to produce an HEP for this task. In the HEART data tables, moving a load is described as 'Task F - Restore or shift a system to original or new state following procedures, with some checking'. The HEP given for this is 0.003, that is, in 1000 lifts, three errors 'on average' can be expected. Taking this as a starting figure, the analysis team felt that the task of moving the container in this case, would be done under time pressure. HEART describes anything that can increase the probability of error as an 'error producing condition' (EPC). HEART contains a long list of EPCs with associated multiplying factors. For example, extreme time pressure in a task could multiply the HEP by as much as 17 times. It was decided by the team that the effect of time pressure in this case would increase the likelihood of error by a factor of 10 (HEART provides guidance on how to make this judgement). Thus, for every 1000 movements of a container under the conditions that exist at this site, 30 errors can be expected.

As an alternative to HEART, expert judgement could be applied to take advantage of the organisation's knowledge of how it conducts crane operations. An HEP can be generated in this way using the APJ (Absolute Probability Judgement) expert judgement method.

THERP could also be used (Technique for Human Error Rate Prediction): this provides probabilities for individual parts of a task (for example, the probability of failing to perform a check correctly (sub-task 1.2.3 in the example) could be, according to THERP, around 0.05 (i.e. five in a hundred)). THERP describes many different types of check, however, and many different possible conditions under which checks could be performed. Interpreting THERP data and finding an overall probability from the individual probabilities of all of the sub-tasks requires a great deal of skill and experience. The novice user should not attempt a full THERP analysis although the THERP handbook is very useful to read for general information on human reliability.

Having generated an HEP, the team concluded that this rate of error in such a critical task was unacceptable and that the task or working conditions must be improved.

5. Develop conclusions and recommendations for reducing error

The process of breaking down the task for a task analysis and gathering information on safeguards and recovery mechanisms (defences) provided the analysis team with a clear insight into the problems with this task. Their recommendations focused on relieving the time pressure problem but also on improving communications between those involved in the task and making changes to the procedure for checking lifting equipment. Experts in crane tasks were asked to check these recommendations to ensure that they were acceptable and realistic. All of the above material can be presented in a safety case to provide a clear history of the decisions made about this task and possible errors that could arise.

Useful reference information

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8. *Reducing error and influencing behaviour* HSE HSG48 2nd edition HSE Books (1999) ISBN 0 7176 2452 8 (see Chapter 3).