

# Task analysis

Methods used to collect, record and analyse information about operator tasks to help understand what they are required to do and any changes that may be needed to improve human performance.

## Why task analysis?

This briefing note briefly describes three widely used methods of task analysis. These are advanced methods - the briefing note only provides an introduction, and on its own will not give sufficient detail for application of any of the methods, but will give an appreciation of their value in risk assessments, developing training, procedures and determining workloads. You should read further and attend a training course on this subject if the intention is to use any of these methods. The table below summarises the methods and what they are used for.

Method	Overview	Used to identify or develop
Hierarchical task analysis	The task is redescribed at a high level, then in increasing detail	<ul style="list-style-type: none"><li>• Human failure potential</li><li>• Selection and training needs</li><li>• Procedures</li><li>• Competence requirements</li></ul>
Timeline analysis	Estimating the time taken for each task step	<ul style="list-style-type: none"><li>• Number of staff required</li><li>• Optimal task sequencing</li></ul>
Link analysis	Shows the link between different people or between people and parts of the plant	<ul style="list-style-type: none"><li>• Allocation of functions between humans and machines</li><li>• Improved workplace and equipment layout, task improvements</li></ul>

## Why should my company use task analysis?

Task analysis provides a wide range of practical and systematic methods for collecting data on tasks which, used together, can help to:

- Define selection criteria for operators.
- Identify training requirements.
- Develop good procedures.
- Determine the best layout for equipment.
- Estimate the number of staff required for a job.
- Estimate workload.
- Investigate human error.
- Identify recommendations for improvement.
- Support the safety case.
- Provide the starting point for many types of human factors intervention.

Possible disadvantages

- Applying task analysis methods can be time-consuming.
- Methods will almost certainly require specialist help to train users or to carry out the analyses.
- Task analysis can be a resource intensive exercise. It should only be applied for analysis of safety critical tasks (i.e. based on risk) or where there is a clear need to improve a task e.g. to reduce time or cost. See Reference 1 for more information on defining safety critical tasks.

## Case study

This case study is adapted from a real problem. It concerns the need to provide emergency cooling to a pressure vessel in the event that the primary means of cooling normally provided by the plant is rendered inoperable by a switch room fire. The back-up system requires plant operators to rig a standby pump to an emergency water supply. They have to do this within two hours of the original cooling failure or the vessel contents have to be released to prevent overheating and overpressure.

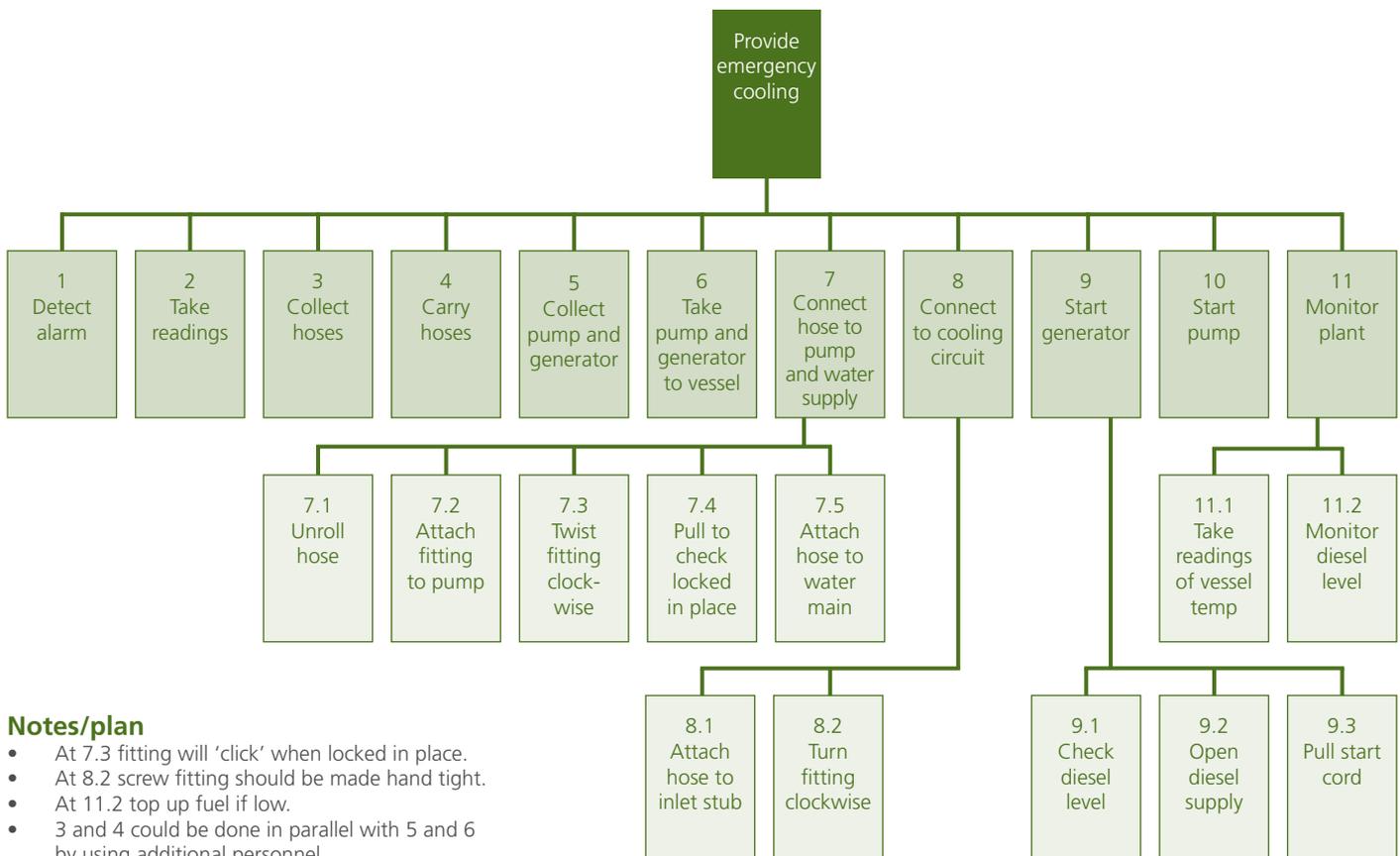
The company realised that (enhanced) reliability would be best achieved by a fully automated cooling system, but they were not in a position to install this for a few months. They needed to continue production so an interim measure was to have operators set up temporary cooling when required. The analysis was carried out in order to understand the human error potential in the task, whether it can be completed in the time available and if the equipment provided could be arranged more logically.

### Hierarchical task analysis (HTA)

The team began with a hierarchical task analysis (HTA). This sets out, in a clear structure, what each step of the task involves. This task had never been performed under real conditions, only rehearsed, however the same approach applies whether the task being analysed is well-established or new: review procedures, interview those involved with the task – operators, supervisors, trainers – and, ideally, ‘walk through’ the task at site. In this case, a basic procedure for the task was constructed and the equipment set up at site – hoses, electrical pump, diesel generator etc. – and a volunteer plant operator ‘acted out’ the task using the equipment provided and in the sequence shown in the procedure. The HTA method is probably the most widely-used and useful technique. Figure 1 shows the HTA ‘tree’ that resulted from the walkthrough exercise.

Starting at the top, the first box specifies the overall task, ‘provide emergency cooling’. The next layer of boxes (dark green) below that describes the complete task in 11 steps. Some of those steps consist of straightforward tasks such as noticing an alarm or taking a reading from a control panel. Others are not so obvious and have been described in more detail in the next layer of boxes (light green). Each layer is a complete description of the task, but each level down the hierarchy provides more detail.

**Figure 1: Provide emergency cooling HTA as a ‘tree’**



**Figure 2: Provide emergency cooling - HTA as a tabular process**

Tabular HTA (Level 1) <sup>1</sup>	Tabular HTA (Level 2)
<ol style="list-style-type: none"> <li>1. Detect alarm indicating that cooling has failed.</li> <li>2. Take readings to confirm cause of alarm and to identify affected vessel.</li> <li>3. Go to storage locker no.1 and collect hoses.</li> <li>4. Carry hoses to pressure vessel.</li> <li>5. Go to equipment room 3 and collect pump and portable generator<sup>2</sup>.</li> <li>6. Take pump and generator to vessel.</li> <li>7. <u>Connect hoses to pump and to emergency water supply.</u></li> <li>8. Connect hoses to cooling circuit via inlet (has non-return valve).</li> <li>9. Start generator.</li> <li>10. Start pump (push start button).</li> <li>11. <u>Monitor plant readings.</u></li> </ol>	<ol style="list-style-type: none"> <li>7. Connect hoses to pump and to water supply.               <ol style="list-style-type: none"> <li>7.1 Unroll hose.</li> <li>7.2 Push bayonet fitting onto discharge side of pump.</li> <li>7.3 Twist fitting clockwise.</li> <li>7.4 Pull to check locked in place.</li> </ol> </li>   <li>11. Monitor plant readings               <ol style="list-style-type: none"> <li>11.1 Take periodic readings of vessel temperature<sup>3</sup>.</li> <li>11.2 Monitor fuel level in generator, top up as necessary.</li> </ol> </li> </ol>
<b>Notes</b>	
<ol style="list-style-type: none"> <li>1. Tasks 1 to 6 and 10 are simple physical tasks or are covered by procedures and training. Preliminary analysis suggests that the operator will have no difficulty in carrying them out. No further breakdown of these tasks is considered necessary. Underlined tasks are described in more detail.</li> <li>2. The generator and pump are already connected to each other and in place on the same trolley.</li> </ol>	<ol style="list-style-type: none"> <li>3. If reading indicates vessel temperature is too high, increase pump speed; if too low, decrease pump speed.</li> </ol>

Breaking down task descriptions into increasing levels of detail continues until the analysts are satisfied that they understand the task completely. Notes are usually added to clarify the information, for example, to indicate sequences of operation (known as a 'plan'). The 'tree' format can get very wide and difficult to fit on one page. An extract from the same task analysis is shown in the alternative, tabular format in Figure 2. Note that more task details can be included in this format although software packages are available that make it easier to resize the 'tree' formats into manageable sections (not all tasks are shown here).

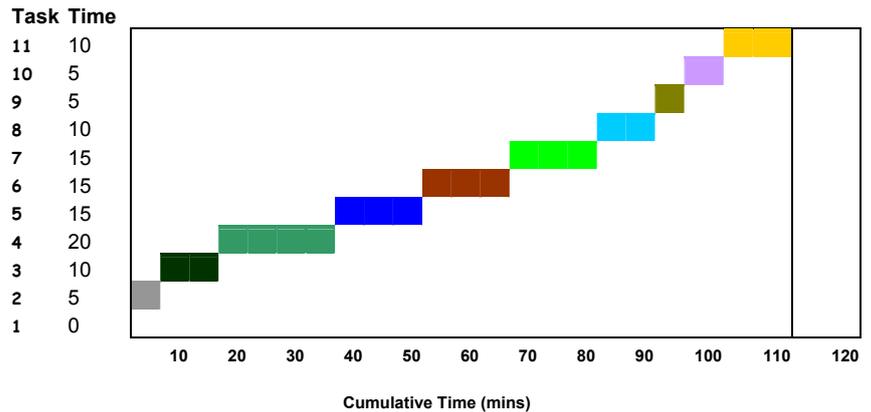
Conducting the HTA gave the analysis team invaluable insights into the proposed task. For example, the hoses were found to be too heavy for one person to carry, although the company wanted to use only a single operator to do this, if possible. Three options considered were: purchase lightweight hoses, mount on a trolley or divide the existing hoses into four segments to be assembled at site (though noting additional journey time this would add). It is clear that HTA forms a clear basis for identifying errors. For example, Task 1 – detect alarm: possible errors include fail to detect or fail to act on; Task 11.2 – monitor fuel level: possible errors include fail to monitor or misread level gauge, etc. The team can then determine whether these errors are feasible and whether additional safeguards are needed.

The team applied two further task analysis techniques to gather more information on these aspects of the task.

- Timeline analysis – used to estimate the time taken to complete a task – usually takes HTA as its starting point.
- Link analysis – used to show the number of links (communications links or movements between different parts of a plant) required to achieve a task.

## Timeline analysis

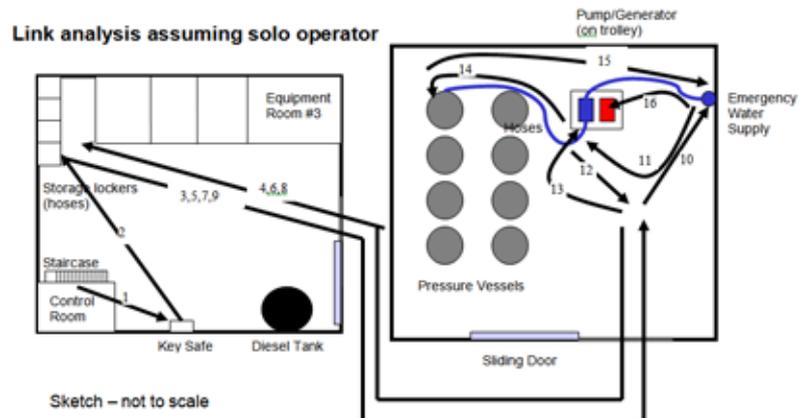
The team listed each of the sub-tasks 1 to 11 (taken from the HTA) and estimated the time taken for each. This is shown as a graph which adds up the total time. Time estimates were based on the walkdown and on discussions with plant operators. They based their estimates on similar tasks. The estimates were rounded up to the nearest five minutes to account for problems that the operators might find in performing this task (e.g. stress leading to errors that then need to be corrected) and for inaccuracies in the time estimates themselves. The results show that the task can be performed in 110 minutes, which is less than the time allowed (120 minutes), but it is uncomfortably close. The team identified that tasks 4 and 7 could be changed fairly easily. They recommended that two operators should be used to collect and set up the equipment (one to pick up hose – noting findings of the HTA that currently the hoses are too heavy for one person – and one to bring the generator and pump), or that all equipment is stowed in the same location to be taken to site on a single trolley or stowed/connected at site ready for use. This would reduce the time taken by around 20 minutes which leaves a more comfortable margin of safety.



Timeline analysis assuming one operator performs all tasks

## Link analysis

The team applied link analysis to examine more closely the number of separate movements needed to perform the task. They recorded the information onto a sketch of the plant showing the main work areas: the starting location (control room); the storage locker; Equipment Room 3 and the pressure vessel. They worked through the task steps from the HTA and showed on the diagram the number of times a single operator would have to move between these areas. They then discussed this with two plant operators and walked through some of the tasks.



It was clear that Task 4 involved making four return journeys to the storage locker to collect the segments of hose required for the task. They also found that Task 7 involved two connections to the pump and two journeys to the emergency water supply (to connect the hose then to turn the supply on). The analysis confirmed their conclusion from the HTA and the timeline analysis that some equipment and task redesign was required. They recommended that:

two lightweight hoses should be pre-connected to the pump, and the coupling that attaches to the inlet side of the pump contain a 'water stop' connector allowing the operator to open the water supply (gravity fed) when they connect the hose to it. Alternatively, the hoses could be loaded on the same trolley as the other equipment, though this would have to be powered given the additional weight. These changes would reduce the burden on a single operator and also reduce the time taken to establish cooling by up to 30 minutes. The changes would also mean that one operator could carry out the task on their own (although the team recommended that, for safety reasons and to reduce the time taken even further, it would be highly desirable to have two operators perform the task).

## References

- Energy Institute (2011), *Guidance on human factors safety critical task analysis*, <http://www.energyinst.org/SCTA>.

## Further reading

- Kirwan, B., and Ainsworth, L.K. (Eds.) (1992), *A guide to task analysis*, Taylor & Francis, Ltd.
- Annett, J., & Duncan, K. D. (1967), *Task analysis and training design*, *Journal of Occupational Psychology*, 41, pp211-221.
- Osborne, D. J. (1989), *Ergonomics at work*, 2nd ed, Wiley.
- Shepherd, A. (2002), *Hierarchical task analysis*, Taylor and Francis.
- Institute of Ergonomics and Human Factors <http://www.ergonomics.org.uk/> to find an expert to assist with task analyses.

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