IP THE INSTITUTE OF PETROLEUM

HUMAN factors no15
briefing notes

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

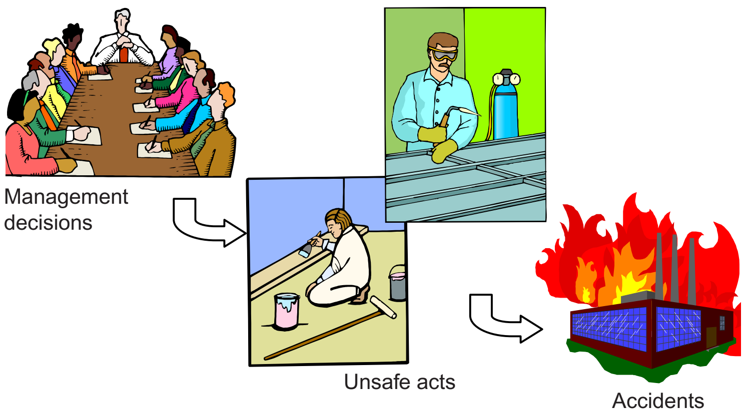
ROOT CAUSE: *accidents happen at the end of a chain of events. Very often, the immediate cause, just before the accident, is a human error. But before that, there will be other actions, decisions or events influenced by various conditions that are part of the overall cause of the accident. By finding the root causes, it may be possible to prevent future similar accidents.*

root cause analysis

Purpose of this briefing note

This briefing note introduces root cause analysis methods. These are used as a means of tracing the origin of accidents and incidents (near misses). They help organisations to learn from these experiences and indicate what steps to take to prevent future occurrences. A large number of techniques exist. You are advised to read further or to attend a training course before using any of them.

Companies should develop a policy for when to conduct root cause analysis; it may be applied to all incidents or only those with major accident potential.



Case study and analysis

Sparks from a welding torch fell onto solvent and paint-soaked rags left in the work area causing a small fire. This was quickly extinguished by the welder. Paintwork and cable ducting were damaged with repair costs of around £2 500.

Many companies would review this information and look no further than the immediate causes: litter was left in the workplace and adequate fire blanketing was not used. The result would be to discipline the welder and painting crew and perhaps issue a notice to all workers to pay more attention to housekeeping.

Such a basic analysis does not explore the true underlying causes of this event provided by the three root cause analysis methods which are applied to the above accident in this briefing note.

Why root cause analysis?

The Health and Safety Commission issued a consultative document on the subject of accident investigation, but rather than introduce a legal duty, it plans to develop guidance to help employers to conduct investigations.

Many accidents are blamed on the actions or omissions of an individual who was directly involved in operational or maintenance work. This typical but short-sighted response ignores the fundamental failures which led to the accident. These are usually rooted deeper in the organisation's design, management and decision-making functions.

Source: *Reducing error and Influencing behaviour* HSE HSG48 HSE Books (1999) ISBN 0 7176 2452 8

HSG65 approach

HSE's *Successful health and safety management* (reference 5), provides good practical advice on accident investigation. It suggests that the investigation team should:

1. Collect evidence
   - Visit the site and directly observe the conditions where the accident occurred noting the layout (in this case, the location of the welder, flammable materials, safety equipment, etc)
   - Review documents: procedures for the painting and welding work; permits; policy documents; risk assessments, etc.
   - Interview: those involved; witnesses to the accident or its outcome; and those involved before the accident (e.g. supervisors, inspectors, maintenance crew).
2. Assemble and consider the evidence
   - Using HSE's model of human factors (see briefing note 8) identify the:
     - 'Immediate causes' of an accident i.e. those concerned with 'personal factors' and 'job factors'; e.g. behaviour of the painting crew, the welder and the supervisor who signed off the permit to work, work conditions, adequacy of guards, separation distances etc.
     - 'Underlying causes' i.e. those concerned with 'management and organisational factors' e.g. pressure on paint crew to complete too many jobs in a shift, failures in safety policy and risk assessment, etc.
3. Compare findings with legal and company standards
   - Were the standards applied (e.g. is there a standard for housekeeping; is it enforced)?
   - Were the standards themselves adequate?
4. Draw conclusions based on the evidence
5. Make improvements and track progress against these by regular monitoring and checking (e.g. are they in place; are they working?)

HSG65 provides further guidance on how to conduct the investigation logically. Starting with 'premises' consider if workplace problems were significant in the accident. Then consider 'plant and substances;' was there sufficient guarding of equipment or containment of substances? Were 'procedures' adequate and used correctly? Consider 'people' and their behaviour etc.

SCAT (Systematic cause analysis technique)

This method is based on the International safety rating system (ISRS), which is extensively used in the petroleum industry. ISRS measures the safety management system in a plant against a number of control 'elements': SCAT helps the user to interpret accidents and incidents in terms of which of the elements failed. The software version (E-scat), allows the user to enter:

- A description of the accident (date, time, what happened)
- Details of the 'loss potential' which comprises the following factors:
  - loss severity potential - i.e. how bad could it have been? In the example - 'serious' - the fire could have been worse
  - probability of reoccurrence - 'moderate' - a similar problem could arise until measures are taken to remove the causes
  - frequency of exposure - 'moderate' - welding is a common task but not a daily occurrence
- Type of contact - SCAT provides various choices. In the example, the contact is, 'with heat' (other choices are with: cold; radiation; caustics; noise; electricity etc)

From lists the user then selects the immediate causes (ICs) - substandard acts or substandard conditions. These include: 'failure to follow procedure/policy/practice' and 'failure to check/monitor'. These were both causes of the fire in the example. The user then selects the basic underlying causes (BCs) which are split into 'personal factors' and 'job factors'. The user can choose to see only the most probable BCs that apply to the ICs chosen in the last step. BCs include: 'abuse or misuse' which can be described as 'improper conduct that is not condoned'. Or, 'improper motivation' which leads to 'improper attempt to save time or effort'. From the ICs and BCs identified, SCAT will suggest a number of 'control actions needed' (CANs) based on ISRS principles, that will help to remove or reduce the impact of the underlying causes of the accident. CANs include, for this example: 'task observation' - the need for a scheme to carry out 'spot checks' on tasks; 'rules and work permits' - review of how compliance with rules is achieved; and, 'general promotion' (of safety) - promotion of critical task safety and promotion of housekeeping systems.

MORT (Management oversight risk tree)

The following is a simplified description of MORT, as this technique can be quite complex.
In general, MORT views an accident as occurring because an unwanted 'energy flow' reached a 'target'. So, in the example, sparks (a form of heat energy) from welding fell onto flammable materials (the target) leading to a fire. The fire, i.e. more heat energy, then burned paintwork and cable ducting (another 'target') causing damage. Energy flows can only be stopped by some form of 'barrier' and 'barrier analysis' is a key part of MORT. In the example, there should have been a barrier to contain the flammable material (e.g. put the rags in containers and take them away). A second barrier, fire blankets, should have covered a larger area.

MORT provides a 'tree' structure that guides the analyst to consider whether:

- similar (worse) events could happen in future
- the accident had been assumed and already considered as an inevitable given the type of operations carried out (MORT calls this an 'assumed risk'), or,
- the accident is unacceptable, and the underlying causes need to be investigated

The investigation then proceeds to identify what specifically went wrong and why. The analysis considers:

- what happened
- what elements of the protection system were 'less than adequate'
  - recovery mechanisms (where they failed to reduce the consequences of the event. In the example, they did work as the fire was extinguished)
  - 'barriers' that failed to stop the event occurring (flammable materials were not contained; protective blankets badly positioned)
  - management factors that did not protect against the event (permit system and supervision/checking not carried out effectively).

Summary of main components

According to reference 1, there are three key components of root cause analysis systems:

1. A method of describing and representing the incident sequence and its contributing conditions (e.g. a 'tree' diagram)
2. A method of identifying the critical events and conditions in the incident sequence (often a checklist to stimulate ideas)
3. Based on the identification of the critical events or active failures, a method for systematically investigating the management and organisational factors that allowed the active failures to occur

The three example methods described here show how these components are used in practice.

Useful reference information

1. *Root causes analysis: literature review* HSE Contract Research Report CRR 325/2001 HSE Books (2001) ISBN 0 7176 1966 4
2. *Accident investigation - the drivers, methods and outcomes* HSE Contract Research Report CRR 344/2001 HSE Books (2001) ISBN 0 7176 2022 0
3. MORT User's Manual: www.nri.eu.com/
4. SCAT demonstration/purchase: www.dnvcert.com/DNV/trainingandconsulting/products/software/e-scat/default.asp
5. *Succesful health and safety management* HSE HSG65 HSE Books (2000) ISBN 0 7176 1276 7