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Special Article

Risk Assessment in the UK Health and Safety System: Theory and Practice

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In the UK, a person or organisation that creates risk is required to manage and control that risk so that it is reduced 'So Far As Is Reasonably Practicable (SFAIRP).' How the risk is managed is to be determined by those who create the risk. They have a duty to demonstrate that they have taken action to ensure all risk is reduced SFAIRP and must have documentary evidence, for example a risk assessment or safety case, to prove that they manage the risks their activities create. The UK Health and Safety Executive (HSE) does not tell organisations how to manage the risks they create but does inspect the quality of risk identification and management. This paper gives a brief overview of where responsibility for occupational health and safety lies in the UK, and how risk should be managed through risk assessment. The focus of the paper is three recent major UK incidents, all involving fatalities, and all of which were wholly avoidable if risks had been properly assessed and managed. The paper concludes with an analysis of the common failings of risk assessments and key actions for improvement.

Key Words: Risk assessment, UK, SFAIRP, Health and Safety Executive

Introduction

Prior to 1974 the UK had spent the preceding 150 years generating a large number of Health and Safety laws focused on individual industries, and even individual regions of the country. These laws, covering work places such as factories, offices, railway premises etc., were narrow in scope and often had inconsistencies between them.

Recognising that different laws for different industries was confusing and complex, the UK government set up a committee in 1970, led by Lord Robens, to recommend a way forward. The resulting Robens Report [1] recommended 'the unification within a single comprehensive framework of legislation of the main Statutes bearing on safety and health at work' and 'the establishment of a national Safety and Health Authority.' This gave rise to the Health and Safety at Work Act 1974 [2] and the creation of the Health and Safety Executive (HSE) as the regulatory authority for Industrial Occupational Health and Safety in the UK. The short guide to Health and Safety Regulation in the UK [3] provides a summary of the Health and Safety at Work Act 1974 and states 'The main requirement on employers is to carry out a risk assessment. Employers with five or more employees need to record the significant findings of the risk assessment.'

This article will introduce the risk assessment in the UK and analyze some cases of occupational accident with the risk assessment model.

Legal Responsibilities under the Health and Safety at Work Act 1974

The Health and Safety at Work Act 1974 places responsibility not only on employers but also on designers, manufacturers and suppliers to ensure that articles and substances are safe for use so far as is reasonably practicable, and on every employee

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while at work to take reasonable care of him or herself, and of any other person who may be affected by his or her actions. The legal responsibilities of employers are summarised in Fig. 1 [4].

It is important to note that 'Sanctions include fines, imprisonment and disqualification.' In the UK, company directors and managers can be found personally liable of negligence, or indeed manslaughter, if someone is injured or killed and HSE finds that there was no suitable and sufficient risk assessment covering the activities involved. 'Unlimited fines' are allowed in law but, depending upon the seriousness of the offence and the ability of the individual or organisation to pay, fines are usually in the range of several tens of thousands of pounds to several million pounds. In addition, individuals may be imprisoned if held personally liable. In a recent legal action, where two fire fighters were killed as a result of the incorrect storage of fireworks, two company directors were jailed for 5 and 7 years respectively [5].

A basic tenet of the UK Health and Safety System is that the person or organisation that creates risk must clearly assess that risk and ensure that it is reduced 'So Far As Is Reasonably Practicable (SFAIRP)' through design, management and procedural measures. 'Reasonably Practicable' involves weighing a risk against the difficulty, time and money needed to control it. Thus, SFAIRP describes the level to which HSE expects to see workplace risks controlled. Using "reasonably practicable" allows HSE to set goals for organisations, rather than being prescriptive. This flexibility is a great advantage but it requires judgement too. In the great majority of cases, HSE can make this judgement by referring to existing 'industry good practice' that has been established by a process of discussion with industry stakeholders to achieve a consensus about what is 'SFAIRP.' For high hazards, complex or novel situations, HSE builds on good practice, using, for example, cost-benefit analysis, to inform judgement.

The reason for placing the responsibility with the organisation creating the risk is that it is impossible for HSE to be expert in the operation of every technology and workplace, especially at the rate of technology development. HSE does provide generic advice on how to complete a Risk Assessment [6], and provides Approved Codes Of Practice [7] for specific industries e.g., construction and mining, providing more detailed guidance on how to manage common risks within those industry sectors.

A Brief Guide to Risk Assessment Methods

HSE has published a guide to Risk Assessment [8] which identifies the key steps. These are outlined in Fig. 2.

1) What could go wrong? Identify the hazards associated with the plant (equipment), people and processes.
2) How bad could it be? What harm could be caused to plant, people (employees and the public) and the environment (land, water, air, plants, animals).
3) What is already being done to minimise the risk? Identify the existing controls.
4) What new actions are required to further reduce the risk? Identify the new controls that are needed, who will take responsibility for putting them in place and by when.
5) Review and update the above 4 steps at suitable time intervals.

Legal responsibilities of employers

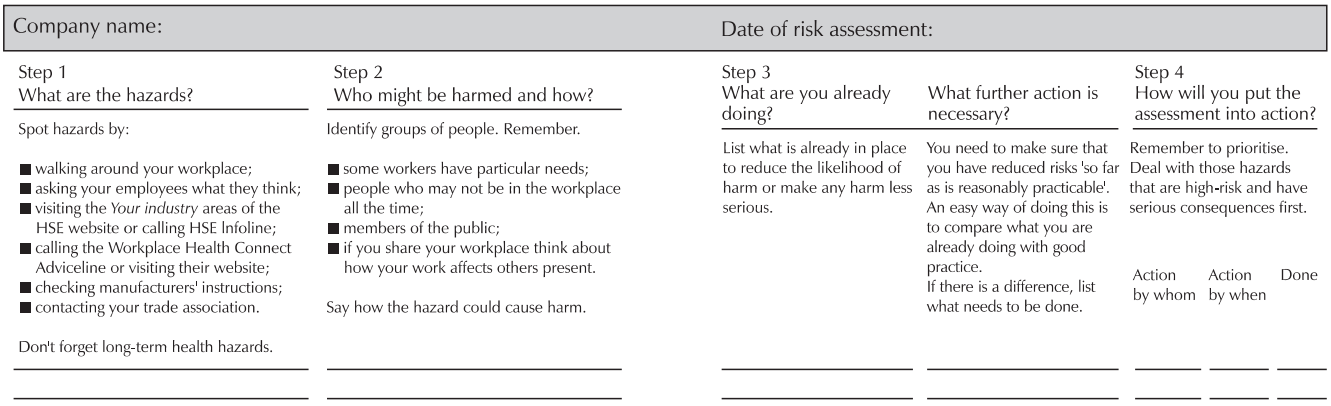
Health and safety law states that organisation must:

- provide a written health and safety policy (if they employ five or more people);
- assess risks to employees, customers, partners and any other people who could be affected by their activities;
- arrange for the effective planning, organisation, control, monitoring and review of preventive and protective measures;
- ensure they have access to competent health and safety advice;
- consult employees about their risks at work and current preventive and protective measures.

Failure to comply with these requirements can have serious consequences-for both organisations and individuals. Sanctions include fines, imprisonment and disqualification.

Under the Corporate Manslaughter and Corporate Homicide Act 2007 an offence will be committed where failings by an organisation's senior management are a substantial element in any gross breach of the duty of care owed to the organisation's employees or members of the public, which results in death. The maximum penalty is an unlimited fine and the court can additionally make a publicity order requiring the organisation to publish details of its conviction and fine (see also the back page of this guidance).

Fig. 1. The legal responsibilities of employers (From: Health and Safety Executive. The Health and Safety at Work etc Act 1974 [4]).



Company name: Date of risk assessment:

Step 1 What are the hazards?

Spot hazards by:

- walking around your workplace;
- asking your employees what they think;
- visiting the *Your industry* areas of the HSE website or calling HSE Infoline;
- calling the Workplace Health Connect Adviceline or visiting their website;
- checking manufacturers' instructions;
- contacting your trade association.

Don't forget long-term health hazards.

Step 2 Who might be harmed and how?

Identify groups of people. Remember.

- some workers have particular needs;
- people who may not be in the workplace all the time;
- members of the public;
- if you share your workplace think about how your work affects others present.

Say how the hazard could cause harm.

Step 3 What are you already doing?

List what is already in place to reduce the likelihood of harm or make any harm less serious.

What further action is necessary?

You need to make sure that you have reduced risks 'so far as is reasonably practicable'. An easy way of doing this is to compare what you are already doing with good practice.
If there is a difference, list what needs to be done.

Step 4 How will you put the assessment into action?

Remember to prioritise. Deal with those hazards that are high-risk and have serious consequences first.

Action by whom | Action by when | Done

Fig. 2. Health and Safety Executive (HSE) risk assessment process (From Health and Safety Executive. Five steps to risk assessment [8]).

	Death	Permanent significant impact on health	Temporary significant impact on health	Slight impact on health
Very likely	High	High	High	Medium
Likely	High	High	Medium	Medium
Unlikely	Medium	Medium	Medium	Low
Very unlikely	Medium	Low	Low	Low

Fig. 3. Risk matrix (From Health and Safety Executive. Risk matrix [9]).

The risk assessment steps allow the generation of a list of risks but for many people it can beg the question 'where should I focus, what are the biggest risks?' There are many tools to provide quantitative risk assessment including the Risk Matrix [9] approach shown in Fig. 3, which considers probability and impact, and the Risk Graph [10] of Fig. 4, which adds additional dimensions of exposure to the risk and the possibility of avoidance of harm.

The Risk Matrix questions the probability of certain levels of harm. Depending upon the level of harm and the probability, the risk is labelled as High, Medium or Low. The Risk Graph of Fig. 4 extends this basic approach.

Here, the risk consequence (level of harm) has its probability derived from a number of factors. In this example it includes the severity of harm, the exposure to harm (for example the amount of time per day an individual is exposed to the risk), the probability that the event will occur for the given exposure and the probability of avoiding harm should the hazardous event occur.

The best results from these tools are achieved when a team of people undertake the risk assessment together. The risk assessment team should be multi-disciplinary including, for example, those who work in the area being assessed, a manager, a health and safety specialist and a person who is not closely associated with the work area. The latter will bring a 'fresh pair of eyes' and often sees risks that those very familiar with the area being assessed overlook due to their over familiarity.

High quality risk assessments are usually achieved quite easily for individual pieces of equipment or self contained work areas. The most usual source of error is between equipment or work areas. Consider for example a small manufacturing process where Team A take raw material and prepare it for initial fabrication by Team B. Team B, once they have completed initial fabrication pass to Team C for finishing. Once Team C have finished the product it is ready for packaging and shipment by Team D. The best way for this organisation to risk assess their manufacturing process is first to have each Team A-D assess their own work and then for representatives of each Team A-D to form a new team to complete a 'whole process' risk assessment using both the information on the individual risk assessments and considering the interactions between processes. This is illustrated in Fig. 5.

It should be remembered when undertaking the risk assessments:

- What could go wrong with the plant (equipment), people or processes?
- How bad could it be?
- What actions are required to ensure risk is reduced SFAIRP?

In addition, when undertaking the Risk Assessments, the team must remember the responsibilities:

- Of the employer to ensure work activities do not endanger anybody

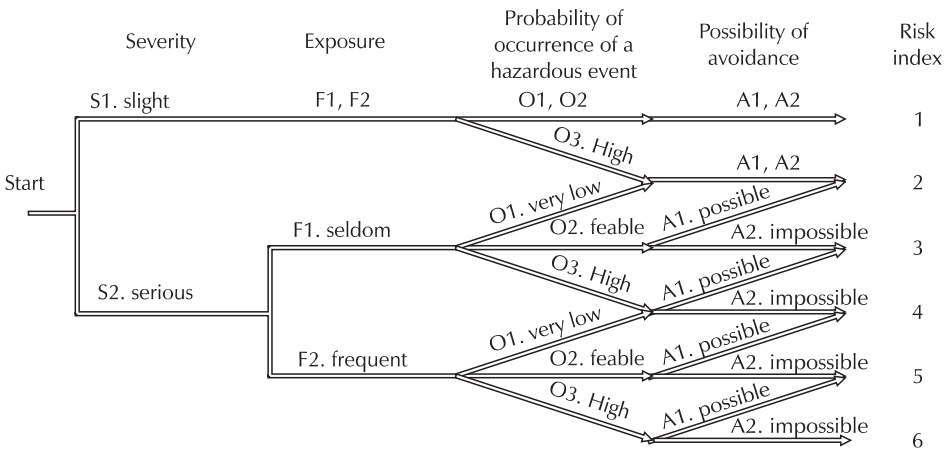


Fig. 4. Risk graph (From International Organization for Standardization. ISO/TR 1421-2. Safety of machinery: risk assessment [10]).

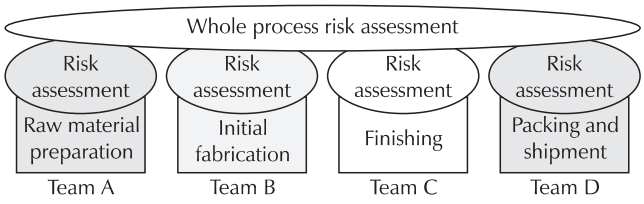


Fig. 5. How to risk assess a multi-stage process.

Fig. 6. Dreamspace in park.

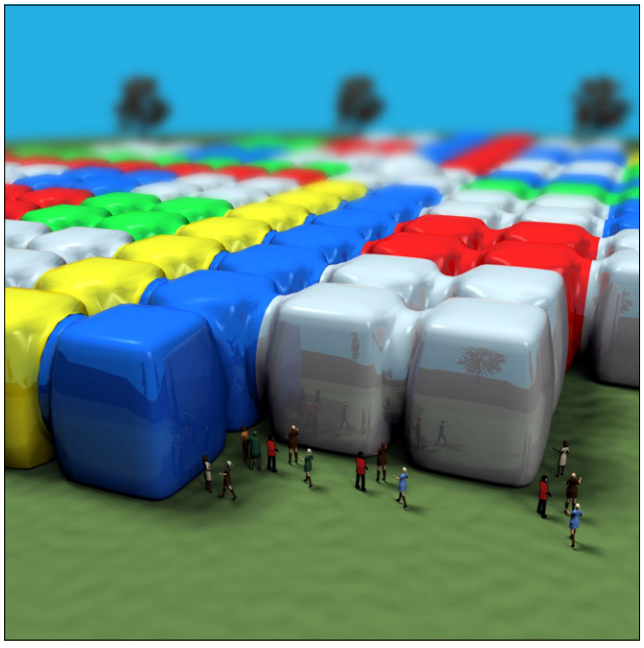


Fig. 7. DreamSpace model.

- Of anyone who designs, manufactures or supplies an article or substance for use at work to ensure that it is safe
- Of employees to ensure that they do not endanger themselves or anyone else who may be affected by their work

Case Studies: What Went Wrong When Risk Assessments Were Not Completed Correctly?

Three case studies are now presented to illustrate the consequences of not undertaking a suitable and sufficient risk assessment. In all cases, there was a loss of life that was completely avoidable if the risk assessment had been completed properly and acted upon.

Case Study 1: Dreamspace, July 2006, 2 Fatalities, 27 Injured

Dreamspace was a large inflatable structure inside which members of the public could walk around to experience a dream-like world of light and sound. The structure is shown in Figs. 6 and 7. It comprised 156 inflatable 'cells,' each 5m high. The complete structure was 50 × 50 m in area.

The structure was designed for its artistic merit and the focus of the Designer was on the dream-like experience that

participants would enjoy. The structure was assembled and inflated by a Contract Company on public land, a park controlled by a Public Park Authority. All three parties, the Designer, the Contract Company and the Public Park Authority, had legal responsibility for the health and safety of the staff who would operate the structure and the public who would visit the park.

The structure lifted up to a near vertical position, 'like a sail,' as shown in Fig. 8, when the wind unexpectedly changed direction. This occurred while members of the public were inside the structure and others were surrounding the structure as it fell back to earth. Two people were killed and 27 injured.

Health and Safety Laboratory (HSL) undertook an investigation and determined that the structure was tethered by 22 ropes and pegs distributed around the perimeter of the structure. These tethers and pegs obviously failed to hold the structure in place. HSL then investigated the risk assessments that had been undertaken asking many questions. For example; had the structure been designed to withstand wind conditions? (The wind conditions were not abnormal for the UK). Had engineering calculations been undertaken to determine the loading that various weather conditions would impose on the structure? Had these calculations determined the type (strength), number and positioning of tethers and pegs? Etc.

HSE successfully prosecuted all parties, the Designer, the Contract Company and the Public Park Authority, for failing to protect the health and safety of both workers and the public. Key failings were:

- The Designer failed to provide a full engineering specification for the structure which would have included load calculations in various wind conditions. From this the required tethering configuration could have been scientifically determined. The Designer's risk assessment stated that 40 tethers would be required for the structure distributed around the perimeter but only 22 were used by the Contract Company.
- The Contract Company did not require the Designer to supply a suitable specification containing the loading calculations to inform the location of the tethers. In addition, only 22 tethers were located after the incident. The Contract Company did not undertake a suitable and sufficient risk assessment of the stability of the structure and the likely hazard to members of the public should it become unstable.
- The Public Park Authority took advice from a Safety Advisory Group. This was a multi-agency group to provide advice on public event safety. However, the focus of the group's risk assessment was event management in terms of crowd management, people flow through the structure etc. The group did not have the structural engineering expertise to cover the stability of the structure and did not require evidence from the Designer or the Contract Company that the appropriate load calculations had been undertaken and verified, and that the structure would be appropriately secured to ensure stability.

This accident was completely avoidable. All three of the parties listed above had a responsibility to ensure the structure was safe but not one of them did so. There was also a failure of the parties involved to communicate to one another about possible risks.

Fig. 8. Dreamspace lifted up to a near vertical position.

Case Study 2: ICL Plastics, May 2004, 9 Fatalities, 33 Injured

ICL Plastics had a factory in Glasgow where there was an explosion that demolished the building killing 9 workers and injuring a further 33 people. Fig. 9 show the factory following the explosion.

HSL undertook an investigation and determined that the cause of the explosion was due to an underground pipe carrying Liquid Petroleum Gas (LPG) which had corroded. The corroded pipe allowed LPG to leak out, the LPG had collected in the basement of the building and, on reaching an ignition source, the gas ignited resulting in the explosion and demolition of the building. The corroded pipe is shown in Fig. 10.

Analysis of the maintenance records indicated that no maintenance of this buried pipe had been undertaken. In

Fig. 9. ICL plastics factory.

Fig. 10. The corroded pipe which leaked LPG causing the explosion.

addition, review of the risk assessment records indicated that corrosion of this pipe, and the subsequent hazards resulting from any corrosion, had not been identified. Investigation of the historical context indicated that the pipes were installed correctly and to the appropriate standard of the time (the pipes were installed in 1969).

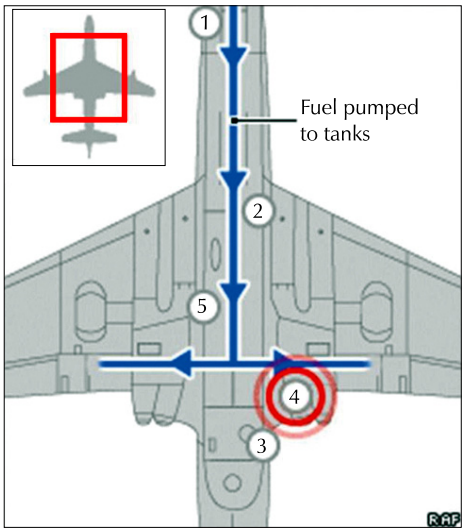


Fig. 11. Nimrod: mid air refuelling.

In this case, the employer forgot Step 5 of HSE's Five Step Risk Assessment Process, that is 'to continually review and update the risk assessment at suitable time intervals'. Once the pipes had been installed, no system was put in place to reassess the safety of the pipes as time elapsed. This accident was completely avoidable as a suitable and effective risk assessment would have identified corrosion as a hazard and a suitable maintenance regime, as the risk mitigation, would have prevented the LPG leak.

Case Study 3: Nimrod, September 2006, 14 Fatalities

The Nimrod aircraft, shown in Fig. 11, was undergoing in-flight refuelling when a fire broke out killing all on board. HSE did not undertake the investigation [11] (air accidents being outside its regulatory remit) but the lessons from the incident are very relevant to all employers. The investigation identified that fuel leaked out of a coupling during the in-flight refuelling. This leaked fuel was close to hot pipe-work (not part of the refuelling system) which provided an ignition source. This is shown in Fig. 12.

The Nimrod aircraft had been in service for over 30 years and had been modified twice. These modifications made the aircraft unsafe, but this wasn't identified. A suitable and sufficient risk assessment (called a Safety Case for large, high hazard plant) was not completed following the modifications. Subsequent maintenance records showed evidence of fuel leaks that had happened before but these were not acted upon.

As with the other case studies, this accident was completely avoidable. There were three failings in this example (1)

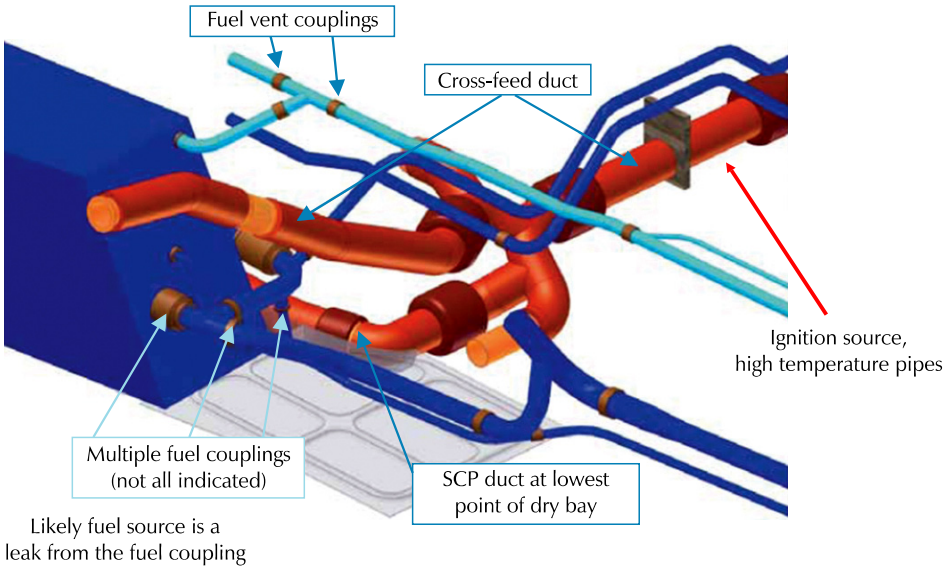


Fig. 12. Nimrod: the accident (From The Stationery Office. The Nimrod review [11]).

a failure to undertake suitable and sufficient risk assessment at the design stage of the *modifications* to the aircraft (2) a failure to review and act on maintenance data (3) when a retrospective Safety Case was undertaken some time after the modified aircraft had been in service, maintenance data was not appropriately collected and reviewed to inform the Safety Case. The Nimrod Review Report [11] stated that the failure was one of 'leadership, culture and priorities'.

Conclusion: Common Pitfalls of Risk Assessment and How to Improve

The case studies illustrate some of the common failing in undertaking risk assessments. HSL undertook a Review of Risk Assessment Practice in 2002 [12] and identified these and further common failings that are listed below:

1) Carrying out a risk assessment to attempt to justify a decision that has already been made
2) Using a generic assessment when a site specific assessment is needed
3) Carrying out a detailed Quantitative Risk Assessment without first considering whether any relevant good practice was applicable, or when relevant good practice exists
4) Carrying out a risk assessment using inappropriate 'good practice' (e.g., from another industry. A specific approach in industry A may be inappropriate in industry B)
5) Making decisions on the basis of individual risk estimates when cumulative risk to society is the appropriate measure
6) Only considering the risk from one activity
7) Dividing the time spent on the risk assessment between several individuals - this approach to risk estimation usually means that risks at interfaces between plant, people or processes are missed.
8) Not involving a team of people in the assessment, or not including employees with practical knowledge of the process/activity being assessed
9) Ineffective use of consultants
10) Failure to identify all hazards associated with a particular activity
11) Failure to fully consider all possible outcomes
12) Inappropriate use of data
13) Inappropriate definition of a representative sample of events
14) Inappropriate use of risk criteria
15) No consideration of risk reduction SFAIRP or further measures that could be taken
16) Inappropriate use of cost benefit analysis
17) Using 'Reverse SFAIRP' arguments, (i.e., using cost benefit analysis to attempt to argue that it is acceptable to reduce existing safety standards)
18) Failing to act upon the results of the risk assessment
19) Not linking hazards with risk controls

To undertake a suitable and sufficient risk assessment takes time and an appropriate multi-disciplinary team of people. There are no short cuts. Good practice is about making the commitment to ensuring that risks are as low as is reasonably practicable and maintaining that commitment, by risk review and mitigation, throughout the life of the activity being undertaken.

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