PRACTICAL RISK ASSESSMENT FOR MINING

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SUMMARY

While risk assessment, as part of safety management, has been practised in many technological industries for some time, its use in Mining is relatively recent and the early experience has not been altogether positive.

The identification of hazards and the assessment of risks are the essential precursors to the development of systems and controls to manage risk. The new ILO convention requires signatories to create legislation to achieve this three step approach and the new South African Mine Health and Safety Act embodies clear requirements to conduct risk assessment. Faced with reported difficulties elsewhere, the South African mining community have therefore been very careful to develop an approach to risk assessment which is simple yet effective.

This paper describes a practical approach to the establishment of a risk assessment process. It deals with setting up such an approach, how to structure the process, the development of a team and the critical role of the safety professional. One of the areas of greatest concern has been the approach to 'risk measurement'. Effective and efficient approaches are described..

The approach is being used to build awareness, create motivational stimuli, develop management systems and controls which support and reinforce positive behaviour and, therefore, ultimately to lead to sustained culture change.

1 INTRODUCTION

There is a new Mine Health and Safety Act in South Africa. The has arisen from the recommendations of a commission into Mining Safety and the need to implement the ILO Convention. The creation of the new law was given impetus by the Vaal Reefs disaster of last year.

Central to the new act, which is largely based on similar Australian and European legislation, is the conduct of risk assessment as a means to determine the hazards within a mine, the relative risk associated with each hazard, the adequacy of the existing protection measures, and the need for additional controls. The conduct of the risk assessment is therefore the cornerstone of the new act which lead to the establishment of a risk management approach to health and safety.

While risk assessment is not new, its application to mining, especially in South Africa is novel and this has produced many concerns that:

- it will be done incorrectly and will become another 'game';
- it will be just regarded as this year's 'quick fix';
- government inspectors will use it to force the industry to adopt practices and standards which are not 'practical' and this will hasten the industries demise.

There was a need, therefore, to develop an approach for Risk Assessment in mining which was simple to use, yet effective: if it looked too difficult, then it would not be adopted; if it became too simplistic, it would not lead to meaningful improvements in health and safety performance. It was necessary, therefore, to publish a 'layman's guide to risk assessment which would remove some of the 'mystique' while explaining the principles of the process so that those developing their own approaches are aware of

the key ingredients and some of the potential pitfalls. It needed to emphasise the essential role of risk assessment to create a safety culture.

This paper described that guide which was written by a tri-partite group, facilitated by the author.

2 THE GUIDE

One of the first problems we faced, was confusion arising out of a lack of agreed definitions of special terms. This is not unusual with risk assessment, but was particularly unhelpful when introducing an approach which was regarded with such suspicion. In Appendix 1 is the Glossary we developed which is now being used throughout the industry.

It was important to state that many people already carry out risk assessments on a day to day basis during the course of their work. Already they note changes in working practices, they recognise unsafe working conditions and practices as they develop and they take the necessary corrective actions. The new act requires that this process should become more systematic and should be recorded so that the results are reliable and so that the analysis is complete. In particular, employers will have to undertake a systematic general examination of the work activities and then record the significant finding of the risk assessments conducted.

The risk assessment process at a mine should be continuous and should not be regarded as a one-off exercise. While it will be necessary to establish a baseline, the requirements of the new act will not be satisfied by the creation of a single risk assessment report which stands for all time.

We decided that there are essentially three forms of risk assessment all are one part of a safety management system and need to be carried out in mines under the new legislation. These are (not in order of priority):

Baseline Risk Assessments

With the introduction of the new act, mines have to assess where they are in terms of risk, identifying the major risks and thereby establishing their priorities and a programme for future risk control. This baseline risk assessment needs to be comprehensive and may well lead to further, separate, more in-depth risk assessment studies. The baseline risk assessment should be periodically reviewed, say every one to two years, to ensure that it is still relevant and accurate. Any other studies (see 2 and 3 below) will need to be incorporated to achieve the 'complete picture'.

Issue Based Risk Assessments

As circumstances and needs arise, separate risk assessment studies will need to be conducted. These will normally be associated with a system for the management of change. An additional risk assessment will need to be carried out when, for example:

- a new machine is introduced into a mine;
- a system of work is changed or operations alter;
- after an accident or a 'near-miss' has occurred;
- as new knowledge comes to light and information is received which may influence the level of risk to employees at the mine. An example of this is when the scientific knowledge about the toxicity of the substance changes and therefore previous risk assessment exercises dealing with that substance may be invalid.

Continuous Risk Assessments

This is the most important form of risk assessment which should take place continually, as an integral part of day to day management. It may not use the more sophisticated hazard identification and risk assessment tools which are deployed in Forms 1 and 2 (above), but in terms of ensuring safety and absence of health risks in the workplace, this form of risk assessment is the most powerful and important.

It will mainly be conducted by front-line supervisors and it is essential that formal training is provided to enable this process to be efficient. Examples of continuous risk assessment include:

- audits;
- general hazard awareness linked to a suggestion scheme;
- pre-work assessments using checklists.

In this latter case, the checklists will need to be developed following risk assessment exercises such as those described in 1 and 2 above. One outcome of the risk assessment process can be the development of a checklist which deals with the critical parts and critical processes, concentrating on the key performance indicators which show the effectiveness of the underlying systems of control. Pre-work risk assessments will be conducted daily, by the supervisor and the team from the area of work, in consultation with safety representatives. Also, as part of good management practice, those same supervisors will undertake Critical Task Analysis and Planned Task Observation, on an ongoing basis.

In this type of risk assessment, the emphasis is on hazard awareness through hazard identification. The prioritisation of hazards by thinking about risks will not be so important as this will already have been accomplished through the risk based techniques during Forms 1 and 2.

In general, a risk assessment involves identifying the hazards present in some work activity or associated with the layout of premises, the construction of machinery and so on. This is followed by an evaluation of the extent of the risk involved taking into account those precautions already being taken. We define:

a) A HAZARD is something that has the potential to cause HARM. This includes substances, machines, methods of work or other aspects of work organisation;

b) RISK is the LIKELIHOOD that the harm from a particular hazard will occur;

c) The extent of the risk depends on not only the severity of the harm to a person but also the number of people who will be harmed.

Risk therefore reflects both the likelihood that the harm will occur and its severity in terms of the degree of harm and the number of people harmed.

3. PRACTICAL RISK ASSESSMENT

There are no fixed rules about how the risk assessment process should occur. However, there are some general principles that should be followed to ensure that it is suitable and sufficient. The assessment carried out very much depends on the nature of the work and the type and extent of the hazards and risks. The process needs to be very practical and involve management and all employees, whether or not advisors or consultants assist with the process. Those involved in the risk assessment process have a duty of care to make sure that they and their colleagues do not make errors.

For a simple situations, where only a few hazards exist or the hazards are simple and well known, suitable and sufficient risk assessment can be a very straight forward process, based on judgement, which requires no specialist skills or complicated techniques. When dealing with complex, technical safety systems, more detailed and specialist techniques will need to be applied which actually quantify the levels of risk.

In all cases, specialist advice may be necessary so that the team carrying out the risk assessment thinks as widely as possible in terms of the potential hazards, some of which they may be unfamiliar with. The preparation of the team carrying out the risk assessment is very important to ensure that they do not just ignore events because of their lack of personal experience.

In most cases, several risk assessments will need to be carried out for a particular workplace or activity. This approach will need to be carefully structured to ensure that all potential hazards are considered. A different team using different techniques will approach the assessment of a workplace from different

points of view, to ensure a complete assessment. The use of a systematic approach to risk assessment makes sure that all similar risk assessments produce the same results.

The following general principles should be followed when conducting risk assessment:

1. It should be ensured that all the relevant risks or hazards are systematically addressed;

    - the aim is to identify the major risks in the workplace and not obscure those risks with an excess of information or by concentrating on minor risks;
    - consider those aspects of the work such as the substances, or equipment used, work process or the work organisation, which have the potential to cause harm;
    - take into account what safety controls and other measures already exist. The effectiveness of these controls needs to be carefully reviewed;
    - be systematic in looking at hazards and risks. Remember that risk assessment is a process;
    - it should be ensured that all aspects of the work activity are reviewed;

2. The risk assessment should address what actually happens in the workplace during the work activity:

    - actual practice may differ from what is supposed to happen in written instructions, procedures etc. This is frequently the way risk creeps into an operation unnoticed;
    - especially consider non-routine operations. For example, maintenance operations and changes in methods of work;
    - pay attention to interruptions or changes to the workplace (equipment, substances or methods of work and people) as these are a frequent cause of accidents. Changes need to carefully managed.

3. All employees and those who may be affected must be considered including maintenance staff, security guards, visitors and contractors;

4. The risk assessment should highlight those groups and individuals who may particularly be at risk, such as the young or inexperienced, and those who are required to work alone or with disabilities;

5. The risk assessment process should take into account the existing safety measures and controls. For example, codes of practice, procedures, guards, special instructions and so on. These may be adequate to reduce the risk sufficiently so that the law can be complied with, but they may not be working properly. It is particularly important that this is objectively assessed;

6. The level of detail on a risk assessment should match the level of risk. The purpose is not to deal with every minor hazard. A suitable and sufficient risk assessment reflects what employers might reasonably foresee in terms of hazards in their workplaces;

7. In most cases it is better first to make a rough assessment to prioritise the risks. Then, the second assessment can use more sophisticated techniques to deal with the major risks.

4. HAZARD IDENTIFICATION

The first, and most important stage in the risk assessment process is the identification of hazards. In other words, the adoption of some systematic way of allowing us to 'see' the hazards present in the workplace. If the hazard identification is not carried out carefully, then the subsequent analysis of risk and the development of risk control measures becomes pointless. The identification of hazards is not

only an essential part of the risk assessment process, but also acts very effectively to change the way that people think, causing them to act more safely and so become more proactive in hazard awareness.

Safety professionals have an important role in the risk assessment process. However, they should not themselves carry out risk assessments, but should act as facilitators. They should advise management on the gathering of data, the selection of the team and in the development of the risk assessment process. During that process, their role will be to guide and advise. After the risk assessment has been completed, the safety professional may assist in the development of the codes of practice which follow.

The first task, when establishing a risk assessment process, is to define the scope of the separate risk assessment exercises. The intention should be that, through the risk assessment process, all the mine and its activities are comprehensively reviewed and assessed. Some care is therefore needed, in laying down the scope of the separate risk assessment exercises, to ensure that no areas or activities are missed. In general, risk assessments are scoped in three different ways:

Geographically based, such as looking at shafts, haulage's, workshops etc.;

Functional based such as, trucking and tramming, blasting, winding operations etc.;

'Hazard' based such as, the hanging wall, electricity, machinery etc.

Some care should be taken if the approach to risk assessment is a mixture of the above three. Also, considerable care is needed when approaching the risk assessments from a 'Hazard' point of view because of the danger that a particular hazard will fail to be identified because the approach is based on a preconception of the areas of greatest risks.

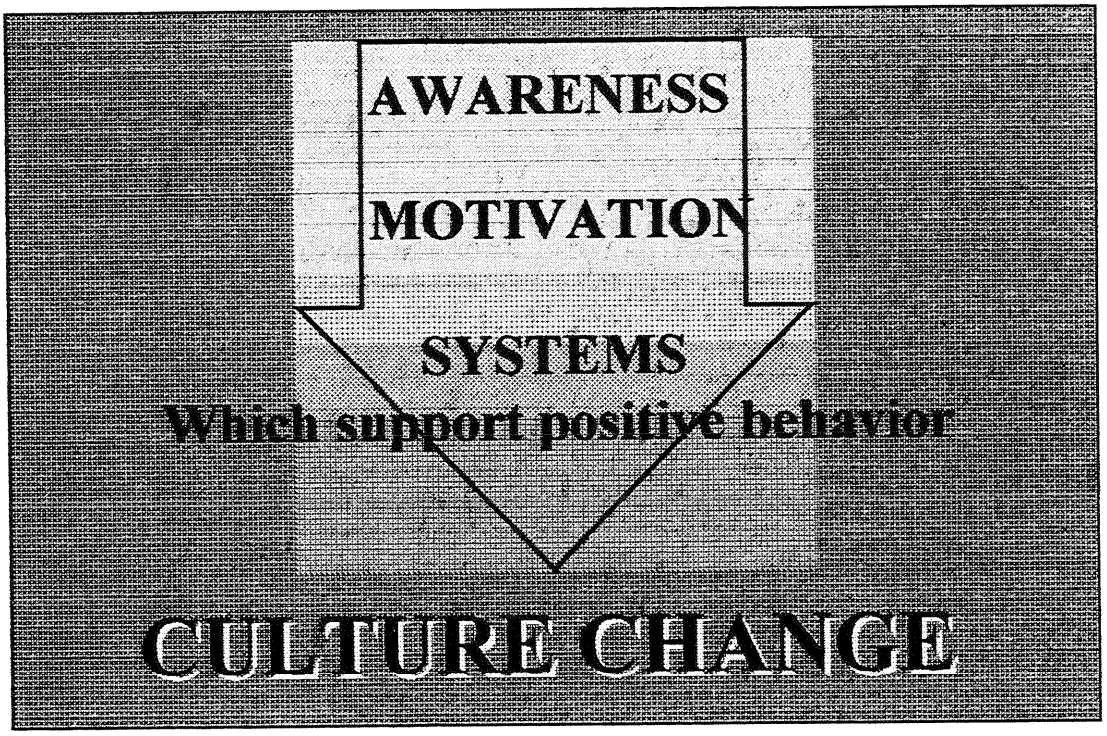
It is normally found that the first two of the above bases are most effective in ensuring a comprehensive and complete risk assessment of an operation or activity.

Before any risk assessment exercise can proceed, a team has to be selected, background information has to be gathered and processed and the team has to be prepared for the task ahead. It is vitally important that all these, and the subsequent hazard identification and risk assessment exercises, are carried out within a participative framework, by involving employees and their representatives.

The gathering and analysis of information from on-mine sources and externally is an essential task before the risk assessment can start. This would normally be conducted by the safety professional on the mine and, it is one of his more important duties. He should access the databases on the mine, to assess the types and major underlying causes of past accidents and incidents. He should also review accident reports and investigations together with other records such as those maintained by engineering staff, log books and audit reports. Externally, he may be able to gather information from government and industry organisations or from publications and databases. Increasingly, the Internet or World-Wide Web is a valuable means of gathering international data. All this data needs to be assimilated, analysed and converted in a useful format so as to prepare the team who undertake risk assessment.

The creation of a team for the risk assessment exercise is essential, to ensure their 'ownership' of the work and thereby help bring about a cultural change. The importance of this is shown in Figure 1, where each of the elements which build up to culture change are outputs from the risk assessment process.

Figure 1 **Three Steps to Culture Change**



It is normal to select a team from the workplace being reviewed, by taking a vertical slice through the management structure, to the lowest levels in the organisation. Practically, this will mean the front line supervisor and the team from the workplace being assessed. Where necessary, specialist expertise should also be brought in, for example, in the area of human factors or ergonomics. The assembling of the risk assessment team is another important role for the safety professional.

Once the team has been assembled, it has to be conditioned for the work in hand. This will involve the safety professional presenting the analysed data, describing the scope of work and, by discussing the potential hazards the team might encounter and encouraging them to consider not just the superficial but also the underlying causes, thereby increasing their awareness. The whole purpose of this preparation phase is to ensure that the team 'see' the hazards clearly when they go out into the workplace.

While visiting the workplace and seeing things more clearly, are valuable parts of hazard identification, it is also necessary to use a systematic approach to ensure a comprehensive and complete approach. There are a variety of tools available, from simple checklists through to the most sophisticated quantitative techniques, to assist the team in identifying the hazards. The team should agree the appropriate tools and approaches which they will use for hazard identification, in keeping with the scope of the exercise. Where necessary, the safety professional will be able to advise and guide the team on the selection of the correct tools. He should also be able to advise them where additional training is required in the use of a technique or tool, before the team can proceed with the hazard identification exercise.

It is important that those conducting risk assessments should be competent and should receive formal training in order to be so. For example, it is essential that all front line supervisors are trained in Critical Task Analysis, Planned Task Observation and workplace inspections.

These are great benefits from extending the causal analysis of accidents to, so called, 'near-misses'. In any workplace, there are a larger number of near-misses than accidents, and thorough analysis of these can be very informative. However, this does require a near-miss reporting system and these are only effective in those companies where barriers such as a 'Blame Culture' have been removed. It can be seen from the definition of 'hazard' as a potential for harm, that near-miss investigation is a powerful form of hazard identification. A near-miss is a revealed hazard.

Whichever method is adopted, the approach to hazard identification should be holistic, that is, it should not concentrate on one type of hazard but should be broadly based and should seek to identify all possible hazards to those at work or who may be affected by the work activities. A convenient way to categorise hazards is to either consider whether they are due to some energy source or a chemical agent. Energy source hazards include electricity, radiation, gravity, noise and momentum. Chemical type hazards include those which can be inhaled, ingested or absorbed through the skin or damage the skin by contact.

5. RISK MEASUREMENT

Once hazards have been identified, it is necessary to prioritise them so that action can be programmed and so that they can be dealt with in a way which will satisfy the REASONABLY PRACTICABLE requirement in the new act. The aim of risk assessment is to enable management to make better decisions. Risk assessment itself does not make decisions, it only provides the basis for the decision making. The setting of priorities is an important way to change employee understanding and to build hazard awareness. It also sets the direction for management.

The approach to risk measurement does not have to be complex or sophisticated. It should be sufficient to allow good decisions to be made, with confidence, and in a form that can be communicated to employees, inspectors and to other stakeholders to demonstrate competent and responsible management.

There are several approaches which can be used for the measurement of risk. These include Risk Matrix type approaches, whereby those who are carrying out the risk assessment categorise the consequences of the hazard and its likelihood separately and then combine them on a matrix to produce a priority. A simple example is shown in Figure 2. This example has been provided to show what a risk matrix looks like. It is essential that mines generate their own. Such approaches have to be supported by clear explanations and descriptions so that the risk assessment team can all agree and can use the tool consistently. Alternatives include nonogrammes or risk ranking tables and equations and many of the hazard identification techniques such as FMECA and Structured What-if already include their own approach. These all achieve the same objective, they provide the risk assessment team with a means of deciding on consequence and FREQUENCY and then help them arrive at a decision on priority.

Figure 2 Example Risk Matrix

Multiple Fatalities	1	2	3	4
Fatality	2	3	4	5
Reportable Accident	3	4	5	6
Loss Time Accident	4	5	6	7
	One a month	Once a Year	Once Every 10 Years	Once in a Lifetime

The numbers on the matrix indicate priority.

Whatever system is used it should have the following basic components:

Consequence Assessment

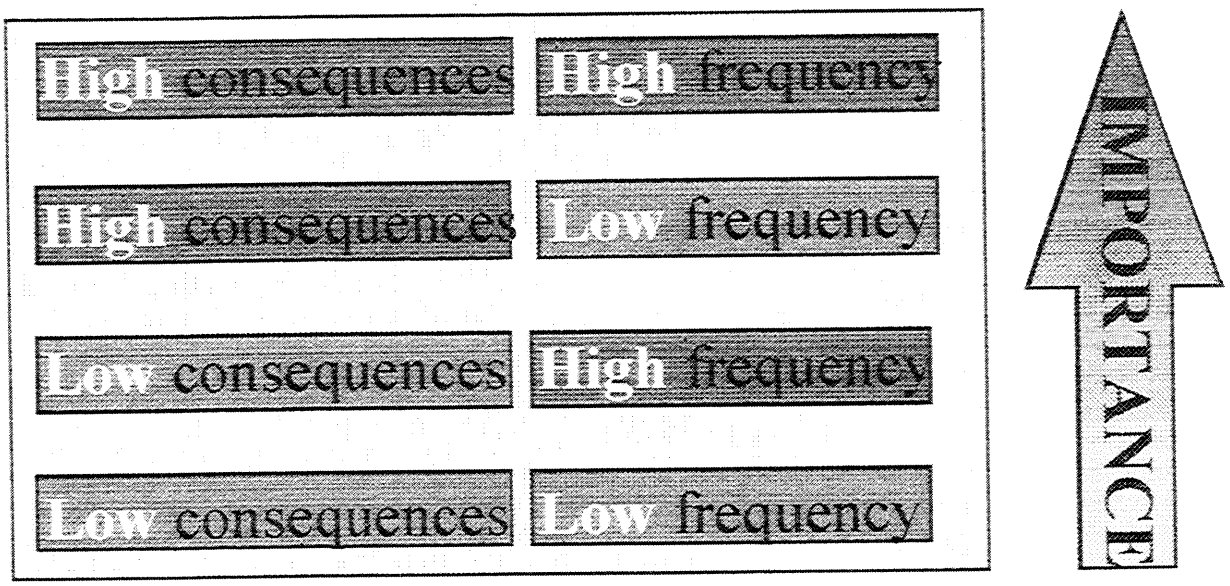
Here the degree of harm from the identified hazard is assessed in terms of the potential severity of the injuries or ill health and/or the number of people potentially effected.

Frequency (Likelihood) Assessment

This is normally a compound of two separate factors. Firstly, EXPOSURE which is an analysis of how often and for how long the employees involved are exposed to the hazard. Secondly, it includes an analysis of PROBABILITY, that is the chance that a person or persons will be harmed during the exposure period.

Whichever approach is taken prioritise risks, it should be ensured that high frequency and high consequence hazards are allocated the highest priority. Those with a low frequency and low consequence are given low priority and those with either high frequency and low consequence or high consequence and low frequency are considered as medium priority. This is shown in Figure 3. It is particularly important that high consequence events with a low frequency are not ignored.

Figure 3 Prioritising Risks



6. PREVENTATIVE AND PROTECTIVE MEASURES

If possible, risks should be eliminated. If this is not possible then either they should be mitigated/controlled or minimised or, if all else fails, then personal protection should be provided. The types of preventative and protection measures that need to be provided for a particular risk will be one of the most important outcomes of the risk assessment process. In deciding upon those measures, the following principles may provide guidance:

a) It is always best, if possible, to **avoid a risk altogether**. By using a different approach, or substance or method of work;

b) Risks should be **combated at source** rather than by adopting secondary measures. For example, if steps are slippery, treating or replacing them is always better than providing a warning sign;

c) Wherever possible, **work should be adapted to the individual** rather than the individual adapted to the work. This means that the design of the job and the workplace, including the choice of equipment and working methods, are important considerations. Particular care taken to alleviate monotonous work and to set up a work rhythm. These are very important approaches to reduce risk;

d) When treating risks, **advantage should be taken of technological and technical progress**. Just because the solutions attempted in the past failed, does not mean that we should not look for new opportunities for improving working methods and making them safer;

e) The adoption of risk prevention measures must be **part of a coherent policy** and approach to safety management which acts to progressively reduce those risks which cannot be prevented or avoided altogether. This must take into account the way the work is organised, the working conditions, the working environment and, importantly, relevant social factors. Risk reduction measures taken in isolation are likely to fail. They must be part of an ongoing cycle

of risk management that involves performance measurement, goal setting, feedback and analysis;

f) Those measures which **protect the whole work force** should be given a priority to yield the greatest benefit. In other words, collective protection measures should be given priority in the interests of net benefit;

g) Whatever the protection provided, employees and those effected **need to understand** what they need to do to make sure the protection works. All controls will fail unless they are backed up with adequate training and supervision;

h) Of greatest importance is that measures to avoid, prevent and reduce risks need to be an **accepted part of the approach and attitudes**, at all levels of the organisation, applied to all its activities. Without an active health and safety culture supported by all levels of the organisation, single risk reduction initiatives will fail.

7. TEN STEPS TO EFFECTIVE RISK ASSESSMENT

This approach to risk assessment can be summarised in the following ten steps:

- Make sure the risk assessment process is practical and realistic;
- Involve as many people as possible in the process, especially those at risk and their representatives;
- Use a systematic approach to ensure that all risks and hazards are adequately addressed;
- Aim to identify the major risks, don't waste time on the minor, don't obscure the process in too much detail;
- Gather all the information you can and analyse it as best as possible, before starting the risk assessment;
- Start by identifying the hazards;
- Assess the risks arising from those hazards taking into account the effectiveness of the existing controls;
- Look at what actually occurs and exists in the workplace and, in particular, include non-routine operations;
- Include all employees at risk, including visitors and contractors;
- Always record the assessment in writing, including all assumptions you make, with the reasons why.

8. ACKNOWLEDGMENTS

I would like to thank my colleagues on the tripartite working group, who helped me prepare the guide on which this paper is based.

APPENDIX 1. GLOSSARY

The following terms have been used in this paper and are those recommended for use by those conducting risk assessments in South African mines.

CONSEQUENCES	the degree of harm, the potential severity of the injuries or ill health and/or the number of people potentially affected.
EXPOSURE	how often and for how long employees are exposed to a hazard.
FREQUENCY	chance per unit time (usually per year).
HARM	injury or loss.
HAZARD	something with the potential to cause harm.
LIKELIHOOD	chance per unit time (usually per year).
PROBABILITY	chance that a person or persons will be harmed during the exposure period.
REASONABLY PRACTICABLE	means practicable having regard to: the severity and scope of the hazard or risk concerned; the state of knowledge reasonably available concerning that hazard or risk and of any means of removing or mitigating that hazard or risk; the availability and suitability of means to remove or mitigate that hazard or risk; and the cost of removing or mitigating that hazard or risk in relation to the benefits deriving therefrom.
RISK	the likelihood that the harm from a particular hazard will occur ('the chance of harm or loss').