Safety 2.1

The Safety Envelope

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Excerpt from Part 2 – for the complete chapters, illustrations, and examples, see the book.

Part 2

Risk Management

Chapter 5

Introduction to Risk Management

Managing risks is a key part of keeping people safe at work. It is about finding, understanding and controlling hazards that could cause accidents or harm. The main aim is to plan safety measures in a way that prevents accidents and reduces harm. This means looking at all aspects of safety management and working to prevent, or at least mitigate, harm.

Risk Matrix

A tool commonly used to do this is a five-by-five risk matrix. It helps to classify risks based on two factors: how severe potential harm could be (ranging from “insignificant” to “catastrophic”) and how likely it is that somebody could be harmed (ranging from “highly unlikely” to “highly likely”). It serves to translate abstract safety principles into concrete, actionable steps.

Variable Risk Tolerance		LIKELIHOOD RATING				
		1	2	3	4	5
		EXTREMELY RARE	RARE	POSSIBLE	LIKELY	ALMOST CERTAIN
SEVERITY RATING		Highly unlikely; cannot rule it out	Conceivable but unlikely	Might happen at some time	Likely would happen sometime	Highly likely/ expected to happen
5	CATASTROPHIC Fatality	15	19	22	24	25
4	MAJOR Permanent Incapacity or Life-changing injury	10	14	18	21	23
3	REVERSIBLE Requires time off work	6	9	13	17	20
2	MINOR Medical treatment/ restricted duties	3	5	8	12	16
1	INSIGNIFICANT Only first aid treatment	1	2	4	7	11

Figure 1. Typical 5x5 Risk Matrix.

While the risk matrix is a useful tool, it has several challenges:

Ambiguous Definitions of the Axes: The matrix's scale, especially the likelihood scale, which measures how probable an event is, often lacks clarity and precision. This vagueness hampers the process of making objective assessments. While statistical probabilities are frequently employed in these assessments, their interpretation varies significantly among different users. This variability in interpretation contributes to the ambiguity in assessing the likelihood of risks, making the process less definitive and more subjective.

Subjectivity in Rating Risks: The process of risk assessment is influenced by various subjective factors, such as the individual risk tolerance of those involved in the assessment and the overarching culture of the organisation. These subjective elements can lead to inconsistencies in risk ratings, thereby affecting the reliability and uniformity of the assessments across

different scenarios and departments within the same organisation.

Size of Risk Reduction: A common issue in risk assessment is the tendency to overestimate the effectiveness of certain safety controls, particularly those that are less tangible, like administrative controls. This overestimation can result in a skewed perception of the residual risk that remains even after the implementation of these controls. Consequently, this can lead to a false sense of security regarding the safety measures in place and an underestimation of the actual risk that persists.

Misunderstanding the ALARP Principle: The principle of 'As Low as Reasonably Practicable' (ALARP) is an acknowledgement that some level of risk is inevitable and cannot be entirely eliminated. However, this principle is often not represented in risk-assessment matrices, leading to confusion regarding whether additional controls are necessary. The lack of visibility of the ALARP principle in these matrices can result in either excessive or insufficient safety measures, as it becomes challenging to determine the point at which risk reduction has been maximised within reasonable bounds.

Difference between Hazards and Risks: There is often a misunderstanding or confusion between the concepts of hazards and risks, with these terms being used interchangeably. However, they represent fundamentally different elements within the realm of safety and risk management. Hazards refer to potential sources of harm or adverse health effects, while risks are concerned with the likelihood and impact of these hazards manifesting. Misconstruing these terms not only affects the accuracy of communication but also influences the approach to risk management, as strategies for addressing hazards might differ significantly from those for managing risks. This subtle yet significant distinction warrants further exploration and clarification to enhance the effectiveness of risk-management practices.

Assessing Risk Through the Lens of the ‘Reasonable Person’

As mentioned before, when assessing risk, it is important to understand that people have different risk tolerance levels regarding how much risk is acceptable. Some people may have an overly pessimistic view of risk and expect the most severe outcomes. It is a very cautious approach, but it can make risks seem bigger than they are. Another group of people may be over-optimistic and expect the best possible outcome. This view might miss some important risks because it is too hopeful.

The third possibility is to find a middle ground. It uses evidence and realistic thinking to establish the most likely level of harm. This method is similar to how a ‘reasonable person’ would think about risk, and it is usually the best way to assess risks accurately.

It is important to approach the concept of ‘middle ground’ with caution. This term does not simply imply a halfway point between the best and worst scenarios. Rather, it represents a search for a balanced perspective, combining elements of optimism and pragmatism. It is about identifying the ‘realistically probable scenario’, which comes from carefully considering all possible options.

Using experts with specialised knowledge of the hazards can help to improve assessments. However, the decision is not simply based on data; it is ultimately a managerial judgement that could improve over time.

Chapter 6
Risk Tolerance

Risk tolerance is not only an individual reality; that is, some people are less risk averse than others. It is also an organisational phenomenon that should be considered during risk-assessment processes.

Risk mitigation often comes at a cost. In fact, there is an ever-present and inevitable conflict between safety controls and production; safety control measures almost always inhibit production. When these controls do not interfere with production, the course of action is straightforward: eliminate or significantly lower the risk. However, this simplicity is not common. The introduction of stricter safety controls often detrimentally impacts production, eliciting resistance from production managers who naturally challenge any reductions in productivity. This dynamic raises the essential question of the optimal balance: what is the organisation's risk tolerance?

'Tolerable safety risk' refers to an acceptable level of risk within a specific context, striking a balance between the necessity of certain activities and the inherent safety hazards they present. This concept involves a thorough evaluation of the potential harm versus the benefits of the operational activity in question, alongside the practicality and effectiveness of risk-mitigation measures. This concept acknowledges that when complete risk elimination is

impossible, risks must at least be reduced to a socially and organisationally acceptable level. It must also satisfy legal expectations.

Importantly, embracing tolerable risk is not an acceptance of sub- par safety standards. Rather, it calls for informed decision-making that judiciously weighs risks against benefits in a manner that is ethically sound, economically viable and socially responsible.

Despite the widespread recognition that a level of residual risk will remain after mitigation controls are implemented, a challenge emerges in its application: many organisations fail to explicitly define their threshold of tolerable risk. This often leads to reliance on subjective judgements of what ‘feels right’, as opposed to striving to reach a predefined level of risk acceptance.

This issue is further complicated by the common use of risk matrices that do not specify the point at which risk remains intolerable. Consequently, the effectiveness of risk-mitigation strategies can be misjudged, sometimes presuming significant risk reduction when, in reality, only marginal safety measures have been implemented, and the risk is not sufficiently reduced.

Specific Definition of Tolerable Risk

Safety 2.1 proposes to explicitly define the level of risk tolerance on the risk matrix, for example:

Risk Tolerance		LIKELIHOOD RATING				
		1	2	3	4	5
		EXTREMELY RARE	RARE	POSSIBLE	LIKELY	ALMOST CERTAIN
SEVERITY RATING		Highly unlikely; cannot rule it out	Conceivable but unlikely	Might happen at some time	Likely would happen sometime	Highly likely/ expected to happen
5	CATASTROPHIC Fatality	15	19	22	24	25
4	MAJOR Permanent Incapacity or Life-changing injury	10	14	18	21	23
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2	MINOR Medical treatment/ restricted duties	3	5	8	12	16
1	INSIGNIFICANT Only first aid treatment	1	2	4	7	11

Intolerable Risk

Tolerable Risk

Figure 2. Risk Tolerance.

The implications of what is defined as tolerable and intolerable risk is fully exploited in the book. It includes both how organisations can, under the legal cover of "all practicable steps", decide what their risk appetite is and how their specific definition of intolerable risk impacts on risk management in the organisation

Maximum Tolerable Risk

When assessing the maximum risk an organisation can accept for a particular hazard, the organisation uses the Risk Tolerance Matrix it adopted as a template, as discussed above. As will be discussed in the next chapter, the severity rating – how severe potential injuries could be – is the more enduring feature of the hazard. It therefore provides a more stable foundation for determining the maximum tolerance level; once the severity rating for the hazard is determined, the organisation identifies the corresponding maximum likelihood rating on the matrix, as illustrated below.

In this example, the hazard is assessed to present a potential for causing reversable harm and, as a result, the organisation's acceptable maximum likelihood level would be categorised as Possible. This implies that the organisation is unwilling to tolerate a probability higher than possible for an individual to sustain permanent injuries. Any assessment greater than this possible level would surpass the risk-tolerance threshold, prompting the need for risk-mitigation measures.

Likelihood Conversion		LIKELIHOOD RATING				
		1	2	3	4	5
		EXTREMELY RARE	RARE	POSSIBLE	LIKELY	ALMOST CERTAIN
SEVERITY RATING		Highly unlikely; cannot rule it out	Conceivable but unlikely	Might happen at some time	Likely would happen sometime	Highly likely/ expected to happen
5	CATASTROPHIC Fatality	15	19		24	25
4	MAJOR Permanent Incapacity or Life-changing injury	10	14		21	23
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Figure 6. Likelihood Conversion.

The assessments of both the severity of potential harm and the likelihood of this level of harm occurring are the topics of the next three chapters.

Chapter 7
Workplace Hazards

The terms ‘hazard’ and ‘risk’ are often used interchangeably in the safety profession, even though they do not describe the same construct. First, it is important to distinguish between a ‘hazard’ and a ‘risk’, and then to understand how the differences influence the overall risk-management process.

A hazard denotes any potential source of harm, injury or adverse health effects in a workplace setting, while a risk refers to the probability of the harm occurring.

What are Workplace Hazards?

As mentioned above, a hazard is any potential source of harm but it does not consider the probability of the harm occurring. It can be an object, condition or activity/inactivity that poses a threat of injury or illness. For instance, live electricity is a safety hazard due to its potential to cause electric shocks. However, a description of the hazard – ‘live electrical wires’ – does not address the probability of the harm. An exposed electrical wire will increase the chances of harm, but the hazard stays the same: an electrical shock could kill a person.

The importance of identifying hazards, therefore lies in the evaluation of their potential for causing or contributing to harm.

While it is true that all workplaces have inherent safety hazards, the type and severity of these hazards vary with the work carried out in the environment. Settings like manufacturing plants, construction sites or forestry operations typically present more, and significantly greater, hazards compared to relatively safer environments like a corporate office.

The process of hazard identification in organisations is often similarly variable. There is a tendency in some organisations either to over-report minor hazards by reporting typical housekeeping issues as hazards, or to under-report major hazards due to a low perception of risk. Additionally, some organisations use hazard identification as a lead indicator of health and safety performance, assuming that reporting more hazards equates to a more proactive safety-management system. This is a misconception.

In reality, within any specific industry, there is a finite number of significant hazards, typically ranging between 30 and 40 types. These hazards can manifest differently across various parts of a business. For instance, the risk of falls can vary significantly: falling on the same level (commonly called ‘slips, trips and falls’), falling from a two-metre ladder, and falling from a six-metre scaffolding. While all are fall hazards, they are very different.

Classifying hazards into categories such as physical, chemical, biological, ergonomic, and psychosocial is also a commonly used approach. However, the practicality of this classification can be debated. Each hazard, regardless of its category, is unique. Simply categorising them in classifications does not necessarily enrich the

understanding of the specific risks or management strategies required.

The following is a typical list of hazards in an industrial environment. It is not intended to be exhaustive but rather to provide examples of a typical list of hazards.

- **Manual handling**: Manual handling resulting from load overweight, load oversize, poor grip, unstable load, posture, twist, duration and frequency of the task, cold muscles, lack of fitness, poor technique, etc. Musculoskeletal injuries.
- **Forklift operation**: Pedestrian within forklift operating area hit by a moving forklift or the load. At risk forklift operation (speed, turning with raised load, etc.) with injury to forklift operator or pedestrian. Environmental hazards (e.g., unguarded loading dock, uneven surface, conflicting traffic movement, etc.). Carbon monoxide (CO) exposure.
- **Noise (+ 85 dBA/8 hr or impulse noise + 140 dBA)**: Exposure to noise at work, including continuous noise (constant and stable over a period of time), variable or intermittent noise (fluctuates between quiet and loud over time), and impulse or impact noise (very high intensity and very short duration, e.g., explosion).
- **Objects falling from height**: Falling objects, e.g., tools falling from work platforms, unstable and over-stacking of goods, unsecured loads on vehicles, etc.
- **UV radiation**: Prolonged exposure to the sun or artificial sources of UV light. It can cause skin damage and cancer, eye damage and immune system suppression.
- **Elevated work (between 1 m/3 ft and 2 m/6 ft)**: Fall onto the floor level, e.g., ladder use, carrying items up/down a ladder, working on a ladder.

A further 26 hazards are included in the book, including hazards like travelling at speed, colliding with another object, stress, bulling, violence, cold and heat stress. It brings the total number of the most common hazards to the low/mid-thirties.

Some specialised situations, such as firefighting, underwater operations, working on fishing boats, oil rigs, etc., will undoubtedly pose hazards not listed. It is always advisable to involve multidisciplinary specialists to identify the special hazards in these cases.

Furthermore, each of these hazards may also be present at multiple places in a workplace but not always in the same way. For example, a motor vehicle travelling at 30 km/h poses a different hazard than the same vehicle travelling at 160 km/h. Working at heights close to overheard electrical lines will require different controls than other cases of working on scaffolding.

Understanding Hazard Severity Assessment

Identifying the hazards enables the organisation to assess the potential severity of these hazards. Most people do not find this assessment difficult; they instinctively understand that being hit by a slow-moving vehicle may only cause relatively minor injuries, whereas a vehicle travelling at 160 km/h will almost certainly kill the person.

The difference may not always be as big as the above example, but most of the time an assessment team can come to a consensus on what the level of potential harm is.

Levels of Potential Harm

The following five levels of potential harm caused by a hazard are commonly recognised and should be sufficient:

1. **Insignificant Harm (First Aid Injury):** Exposure to this hazard might result in minor injuries requiring only first aid treatment. Typically, the individual can immediately resume normal duties.
2. **Minor Harm (Medical Treatment Injury):** This level involves injuries that necessitate professional medical treatment. However, recovery is relatively swift, and the nature of the injury allows the person to return to work immediately or by the next rostered workday.
3. **Moderate Harm (Lost Time Injury):** Here, significant but non-permanent injuries or illnesses occur, necessitating absence from work for one or more shifts subsequent to the injury.
4. **Major Harm (Disability Injury):** Exposure could result in permanent impairment or life-changing injuries, like vision/hearing loss, amputation, spinal cord injuries, severe burns, or organ damage. Recovery, if possible, is often prolonged and complex.
5. **Catastrophic Harm (Fatality):** This is the most severe level, where incidents could result in the death of one or more individuals.

When the potential harm is known and the assessment team came to a consensus of the potential severity, the next aspect on the risk matrix can be assessed: the likelihood that the assessed level of harm will occur, the topic of the next chapter.

Controlling Hazards

It is a common misconception that administrative controls in the Hierarchy of Control can lower the severity rating on the Risk Matrix. This belief is incorrect. Administrative controls, by their nature, cannot directly mitigate the hazard itself; they modify only the risks associated with a particular hazard.

The book continues to explore the common but flawed overreliance on administrative controls when managing hazards. This remains one of the biggest blind spots for safety practitioners, especially when they are unsure how best to deal with a specific hazard. The real problem is the belief that administrative measures can reduce the severity of harm—a myth the book addresses in detail. This includes providing specific guidance how to reduce the potential severity of harm.

Chapter 8
Workplace Risks

Risk, in the context of workplace health and safety, is defined as the likelihood of harm or adverse health consequences resulting from exposure to a hazard. It is important to understand that risks are inherently tied to hazards – they represent the probability that these hazards could cause harm.

The Role of Risk in the Risk Matrix

In the Risk Matrix, the risk is categorised along the likelihood axis. This axis reflects the probability that exposure to a hazard will result in harm. Risk assessment is more nuanced than hazard assessment. As mentioned before, most people understand the levels of potential harm, such as when an injury requires first-aid treatment, versus having to visit a doctor. However, the chances that a person will place their hand inside a rotating machine is more subjective, making consistent and accurate evaluation of risk more challenging.

Currently, many organisations have one-line descriptions of likelihood, including phrases like “expected to occur frequently”, “will probably occur in many circumstances”, “might occur at some time”, “could occur but is considered rare”, and “not expected to occur”. Consistently interpreting these terms is very difficult, and these short descriptions do not provide much guidance. It is even debatable if the spacing between the descriptions is equal; is the gap between “expected to occur” and “probably occur” the same as between “might occur” and “could occur”?

Critical Factors Influencing Risk Assessments

Safety 2.1 recognises this problem and the reality that there is no simple solution. However, it believes that using a multifaceted approach increases the quality of the decision. Instead of relying on a solitary, overarching statement, it introduces eight interconnected factors to assess likelihood. The interplay among these factors is crucial, and their collective impact should be considered to form a comprehensive assessment of likelihood. These factors are:

The book provides detailed definitions and rating guidance for each of the eight likelihood factors.

Likelihood Ratings and Factor Definitions

Each of the above factors should be carefully evaluated against the ‘Likelihood’ ratings on the Risk Matrix, which range from 1 (Highly Unlikely) to 5 (Highly Likely). The following definitions for each level of likelihood may assist the final decision.

The book examines why administrative controls are often overused and clarifies how true severity reduction requires deeper, practical measures.

As mentioned before, the individual ratings on these eight factors are not the point, as they all provide information to make the overall likelihood rating on the Risk Matrix more accurate.

Having said that, the information should not be discarded either. Knowing what the main risk-contributing factors are will be valuable information when the risk is controlled. For example, if the problem is that the hazard is not obvious and very hard to identify in advance, risk controls may be aimed at making it more obvious, such as adding alarm systems.

Risk Controls

Controlling risk is not straightforward. Not all controls work equally well, and safety practitioners sometimes under- or over-estimate the effect controls may have on the risk. Furthermore, although risk controls span the entire Hierarchy of Control, they often lean heavily on what is known as administrative controls. These include safety procedures, meetings, scheduling, shift rotations, personal protective equipment (PPE), emergency plans, safety signs, access restrictions, and maintenance. However, with a few exceptions, these mainly aim to modify human behaviour rather than tackle the hazard directly. There is typically a very heavy reliance on safety procedures like safe operating procedures (SOPs), safe work method statements (SWMS), and job safety analyses (JSAs). Perhaps a more fitting name for administrative controls would be 'human controls'.

Safety 2.1 criticises over-reliance on procedures. Traditionally, these procedures dictate the safest way to perform tasks, a concept rooted in Safety 1. This approach often leads to stricter regulations following incidents, aiming to correct or prevent deviations from the procedures. Yet, this approach may lead to more prescriptive procedures that, ironically, are increasingly ignored by frontline operators in a complex adaptive system.

In contrast, Safety 2.1 follows a different approach: employ all available controls to bring risk down to an acceptable level, resorting to procedures only as a last resort. The idea is to prescribe just enough to manage the risk, leaving room for frontline workers to apply their knowledge and skills within what is called the 'safety envelope'. This concept encourages a balance between control and flexibility, enabling workers to determine the safest course of action within a defined risk threshold. Part Three of the book will explore the safety envelope in more detail.

Word of Caution

A serious word of caution: Do not use these eight factors to develop a mathematical calculation of pre- or post-control risk. Even worse, do not develop a software solution to calculate the risk. Safety 2.1 explicitly opposes linearity; hazards are complex systems, and the influence of any one factor on the level of risk varies each time a risk presents itself. Integrating these factors into an overall risk rating and subsequently developing controls are expert tasks that should not be delegated to non-human artificial intelligence.

Additionally, these factors are not an exhaustive list of potential elements in understanding risk. For example, a switching schedule when energising an electrical network does not fit neatly into any of these factors, even though many of these factors will either explicitly or implicitly be included. However, a well-developed switching schedule, supervised step-by-step by an external party, such as a control room, is an irreplaceable control when operating switchgear in a substation.

Chapter 9
Spider Diagram

This chapter introduces a visual tool designed to simplify the risk-control process. It predominantly focuses on the likelihood aspect of risk control. As elaborated in Chapter 7, the only way to minimise the potential severity of harm that a hazard could cause is by altering the hazard itself, which is fundamentally an engineering challenge. However, reducing the likelihood of harm can not only be achieved through engineering solutions but often requires administrative measures as well. The Spider Diagram has been developed specifically to facilitate the management of these more variable controls.

It is important to clarify that emphasising the likelihood factor through this tool does not diminish the significance of hazard severity. Indeed, when measures aimed at lowering or eradicating the potential for serious harm prove effective, the consideration of ‘likelihood’ naturally becomes less critical.

The tool proves especially valuable when modifying the hazard did not sufficiently lower the risk score on the Risk Matrix below an acceptable threshold, as discussed in Chapter 7.

Spider Matrix Template

The template below is used to record the risk assessment and the impact that various controls could have on the likelihood. It is not so much intended to be a reporting tool but rather a visual guide for the team doing the risk assessment.

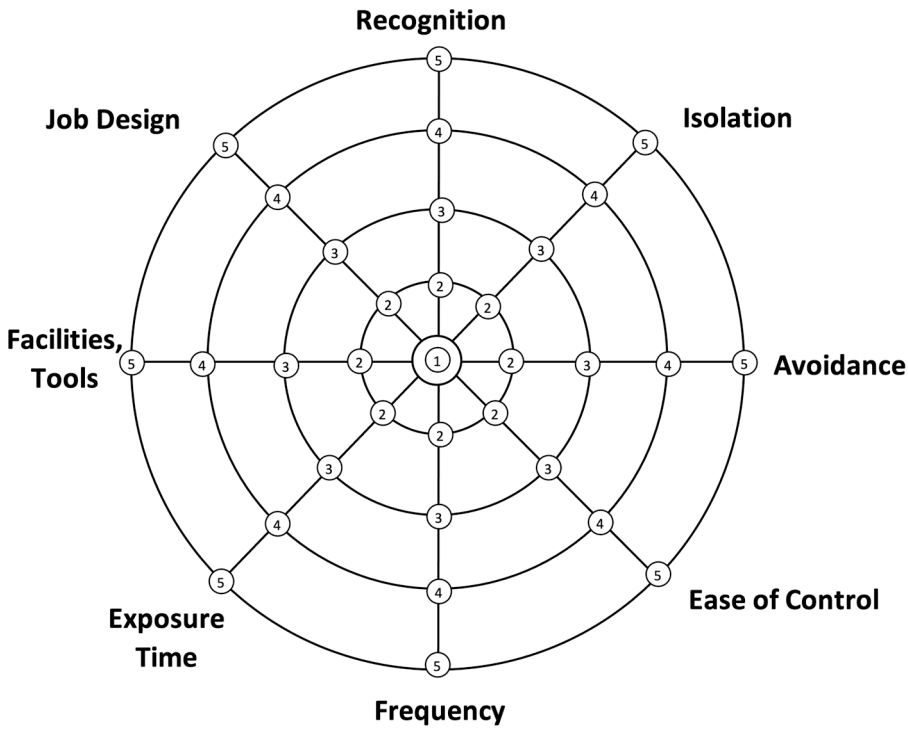

Figure 8. Spider Diagram.

The Spider Diagram visually records the individual ratings of the eight factors contributing to the likelihood of harm, as discussed in the previous chapter. This offers the opportunity for the assessment team to consider each of the assessments but, importantly, allow them to consider the interplay between these factors. The factors do not only individually contribute to the likelihood of harm; they also often combine with other factors, increasing or decreasing their impact on the overall level of likelihood.

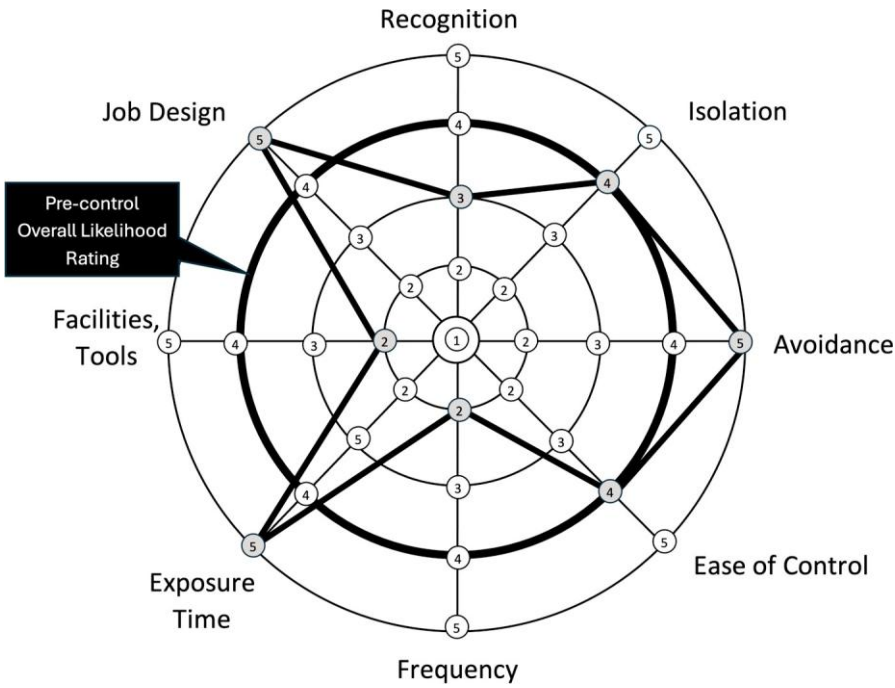

Figure 9. Spider Diagram: Eight Factors and Overall Rating.

Likelihood Reduction

The topic of likelihood reduction, also covered in Chapter 8, presents a challenge. One common issue is the overestimation of the effectiveness of controls in reducing the likelihood of a hazard. In other instances, less obvious factors may be overlooked, leading to a reliance on procedures and instructions as their primary control mechanisms. This is indicative of a traditional safety management response, which often fails to consider the broader spectrum of control options.

Safety 2.1 advocates for a more expansive approach to identifying potential controls. This involves considering controls to each of the eight factors contributing to the overall likelihood rating, as well as the interplay between these factors. For example, if it is difficult to avoid a hazard, but it is possible to make recognising the hazard earlier, it could create more opportunities to avoid the hazard.

By addressing these aspects, Safety 2.1 moves beyond traditional safety practices, promoting a more holistic and effective approach to reducing the likelihood of hazards in the workplace. This shift involves a thorough assessment of work processes, hazard characteristics and control mechanisms, ensuring a comprehensive strategy for risk mitigation.

Navigating Control Effectiveness

The book explains how the Spider Diagram strengthens risk control effectiveness and helps overcome the limitations of administrative controls.