Safety Science 92 (2017) 138–147

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/ssci

Classification of risk acceptability and risk tolerability factors in occupational health and safety

Derrick Nanda Tchiehe, François Gauthier *

Industrial Engineering Department, Université du Québec à Trois-Rivières, CP 500, Trois-Rivières, Québec G9A 5H7, Canada

ARTICLE INFO

Article history:
Received 22 April 2016
Received in revised form 11 July 2016
Accepted 5 October 2016

Keywords:
Risk
Acceptability
Criteria
Occupational health and safety

ABSTRACT

Risks are omnipresent in most human activities. Risk analysis helps to establish the level of risk of a given situation, and to determine if the risk is acceptable, tolerable or unacceptable. At this stage, the consideration of individual or societal factors becomes very important in the decision-making process regarding the acceptability or the tolerability of a risk. In the occupational health and safety (OHS) field, these factors are often implicit and poorly defined. In this work, the risk acceptability influential factors in the domain of OHS are indexed, and a typology of these factors is suggested. In total, 8 parameters regrouping 19 criteria and 14 variables that influence the risk acceptability process are presented, and their scope in OHS is discussed.

1. Introduction

1.1. Risks

Risks are omnipresent in most human activities, and there are studies conducted with the purpose of assessing and comprehending risks in almost all disciplines. Both human science and applied science have actively addressed this topic, generating a broad diversity of concepts related to risks.

Generally speaking, the notion of risk allows to put human efforts in perspective regarding their capacity to prevent and protect themselves against harmful events, whether they result from natural causes or human activities. According to the Standard ISO 3100 (2009) *Risk management – Principles and guidelines*, a risk is the effect of uncertainty on objectives; it is the unknowable aspect of the risk that lies in the succession of elements that are not fully controllable (Desroches et al., 2003). Moseman (2012) defines the risk as the quantification of economic and human losses in terms of the likelihood of an incident to happen and the importance of the damage. Woodruff (2005) suggests that a risk is the possibility that an individual or something of value is affected by a hazard. Regarding machine safety, a risk is defined as being the combination of the severity of a potential damage and the probability of this damage to occur (ISO, 2010).

Risks often have a limit that is not well understood, but that can be defined using risk management methods. These methods generally aim at analyzing the risks, i.e. identifying and assessing their severity, in order to inform decision-making processes towards the mitigation of the risk to an acceptable or tolerable level (ISO, 2010). At this stage, the consideration of individual or societal factors becomes very important in the decision-making process regarding risk acceptability or tolerability. This process is complex and blurred, but it is implemented anyway on a daily basis by managers and engineers all around the world.

1.2. Risk acceptability and risk tolerability

The assessment of the level of severity of a risk allows to determine if this risk is acceptable, tolerable or unacceptable. In the literature, however, there is a certain ambiguity regarding the definition of the acceptable risk and the tolerable risk. Indeed, for numerous authors, the terms "acceptable risk" and "tolerable risk" are seen as synonyms (Main, 2004). Nevertheless, the UK's *Health Safety Executive* (HSE) establishes, in a certain extent, the difference between the two concepts: *"'tolerable' does not mean 'acceptable'. It refers instead to a willingness by society as a whole to live with a risk so as to secure certain benefits in the confidence that the risk is one that is worth taking and that it is being properly controlled*" (HSE, 2001). According to Schjølberg and Østdahl (2008), the tolerable risk always refers to the acceptable risk, and the acceptability of a risk would represent a subset of the risk tolerability. These authors define the tolerable risk as an "accepted" risk in a given context, depending on the existing values in the society. As for

* Corresponding author.
E-mail addresses: derrick.nanda.tchiehe@uqtr.ca (D.N. Tchiehe), francois.gauthier@uqtr.ca (F. Gauthier).

http://dx.doi.org/10.1016/j.ssci.2016.10.003
0925-7535/

Finlay and Fell (1997), they suggest that a risk can be tolerated, and hence lived with, without necessarily fundamentally being accepted.

In the context of this article, the following definitions are proposed to distinguish the concepts of acceptable risk and tolerable risk: the "acceptable risk" is a risk that is worth taking based on the expected benefits, and for which the efforts invested in finding new ways to reduce it are marginal or nonexistent. The utilization of a kitchen knife can be a good example. As for the "tolerable risk," it consists in a risk that is worth taking based on the expected benefits, but that remains under surveillance, and for which attenuation means continue to be sought. For instance, measures allowing to mitigate the risks emanating from driving have been proposed for decades. It is how the safety belts, the air bags, the ABS brakes, the collision avoidance systems, etc., have been introduced.

According to those definitions, the acceptable risk constitutes a subset of the tolerable risk. Both concepts imply the decision to admit that a risk is sufficiently "low" or "controlled" in a given situation, by taking into account the laws, the values, the culture, and the context of the environment or society in which one find itself. Moreover, in order to simplify the text, the notion of risk acceptability will be used indistinctly in the remaining of this article to talk about both concepts.

1.3. The general principles of risk acceptability

Risk acceptability is a judgment that takes root in the perception of the risk, even if the perception of the risk is a complex variable in the extent where it varies according to the societies and individuals involved. The HSE (2001) suggests three fundamental criteria in the judgment of the acceptable or tolerable risk: the equity-based criterion, the utility-based criterion, and the technology-based criterion. These are in fact ethical reasoning principles that allow to lay the basis of the risk acceptability decision-making process.

The equity-based criterion is based on the fact that all individuals have a right to a minimal protection. It is a moral and ethical reasoning that is materialized by a maximal limit that cannot be crossed in order to ensure a minimal safety to everybody. Vanem (2012) also focuses on the ethical aspect, and claims that fair actions versus bad actions and good values versus bad values consist in the basis of a good ethical judgment. The equity-based criterion defines somehow the red zone that should not be crossed, no matter what the expected benefits are.

The utility-based criterion is based on the relation between the expected benefits of the risk attenuation measures and the costs related to these measures. It consists in determining if the benefits resulting from these measures, whether on the chapter of human lives saved or in economic terms, are worth the required investment.

The technology-based criterion stipulates that the level of the acceptable risk or the tolerable risk is reached when the rules of practice in the field are respected. Abrahamsen et al. (2013) claim that this principle can be accomplished through the utilization of best practices, for instance, standards and professional codes of practice. Nonetheless, best practices remain quite a vague concept due to the variety rules and the differences found from a country to another. However, this gap is more and more filled with the alignment and the quasi-globalization of these rules through international standardization. The standards, even though written by different organizations, usually inspired one another, and hence share common basis. Nevertheless, it is important to note that this principle can lead to ignoring the costs related to complying with all the proper rules.

The cost-benefit notion is actually a fundamental principle in most of the approaches linked to risk acceptability. To what extent can the benefits generated counterbalance the potential negative consequences of the risk to the point of being considered acceptable? Cost-benefit is hence an element that cannot be completely dissociated from the perception of the risk (Hergon et al., 2004). According to French et al. (2005), the costs linked to a risk can be divided in three parts, i.e. (i) the costs linked to safety (implementation of risk reduction measures); (ii) the costs linked to the impacts of the risk on the workers (professional diseases and accidents); and (iii) the costs linked to the consequences of the risk to the public.

The cost-benefit analysis needs to lead towards a balance between the costs (current or potential) and the benefits associated with the decision made regarding the acceptability or the tolerability of a risk (Jones-Lee and Aven, 2011). Consequently, the cost-benefit analysis becomes a necessary tool in the decision-making process, and ensures avoiding major disparities. Moreover, it provides a useful approach to compare different options, as well as the related risk reduction measures. The assessment of the monetary value of the non-financial consequences of the risk, for instance human life losses or environmental damage, remains, however, an issue within the cost-benefit notion (Aven, 2009).

1.4. The main approaches of risk acceptability

In the literature, there are many models or approaches that allow to define the limits of risk acceptability or risk tolerability. The ALARP approach – *As Low As Reasonably Practicable* (Fig. 1) seems to represent the most widely known and studied approach (HSE, 2001). Abrahamsen et al. (2013) consider this approach as vital in the identification of the proper methods aiming at reducing risks.

According to this approach, there is an unacceptable level of risk, no matter what the expected benefits are (*Unacceptable Region*). Within this zone, taking the risk cannot be justified, regardless of the reasons. Under this unacceptable zone, there is the *Tolerable Region*, where risks can be tolerated depending on the benefits that could be derived. Within this zone, the risks are tolerated if they cannot be more attenuated or if the costs of imple-

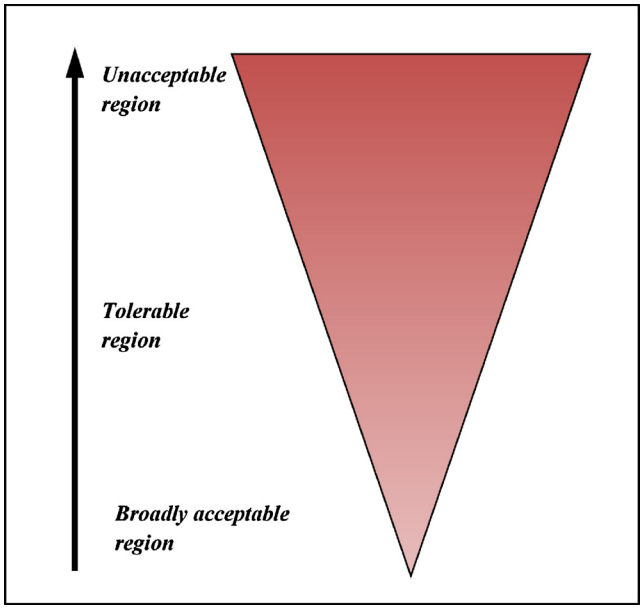

Fig. 1. ALARP approach. *Source:* adapted from HSE (2001).