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OCCUPATIONAL HAZARDS COUNTERACTION IN INDUSTRIAL WORK ENVIRONMENT – SELECTED MANAGEMENT PROBLEMS

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Abstract: The aim of the article is to present the basic strategies for counteracting threats that are used in an industrial work environment, with particular emphasis on strategies based on the concept of safety barriers. The article presents the main categories of safety barriers and the basic safety functions implemented within the key barrier systems. In addition, the most commonly used criteria for assessing safety barrier systems as well as safety functions are presented. The most characteristic examples in this regard are given. The analysis was carried out in terms of the implementation of barrier management towards reducing the risk of adverse events in the industrial work environment.
Keywords: safety management, hazards counteraction, safety barrier

1. INTRODUCTION

The industrial work environment is most often described by the conditions of the material environment characterized by physical, chemical and biological factors. Additionally, psychophysical factors and other non-material factors are identified separately (e.g. management style or relations in the working group). The factors of the working environment constitute a threat in themselves or significantly contribute to the creation of potentially dangerous situations.

The threat has many definitions in the literature. On the one hand, a threat is a potentially dangerous factor or situation that can cause injury, disease, property damage, property damage, environmental damage, or a combination of these possibilities (Ulewicz et al., 2015). On the other hand, a threat is the possibility of certain losses arising, determined for a situation arising after the occurrence of a single undesirable event in a given system.

The literature provides very different hazard classifications. Threats can be divided according to: (a) the source of the occurrence, (b) the type of threat, (c) the

possibility of anticipation, (d) spatial extent, (e) degree of destruction, (f) elimination time, (g) determinism of causes, or also (h) the field of activity.
The threats may be natural, technical and personal. Threats may be dangerous (leading to injuries), harmful (leading to diseases) or only burdensome (reducing work efficiency). At the same time, threats can be measurable and immeasurable. They can be external or internal. They can be local (related to the place of stay), professional (related to the performed occupation) and task-related (related to the performed task).
It is impossible to ensure completely safe working conditions, i.e. the absence of any dangers. Therefore, the goal of every employer is to optimize the level of risk within the possessed resources and possibilities.
In order to properly achieve this goal, the employer, first of all, must be aware of the risks taken, i.e. he must analyze and assess the risks that are and may appear in the work environment. Second, if the level of risk is unacceptable, the employer must counteraction these risks using a variety of strategies, methods and measures.

2. STRATEGIES FOR OCCUPATIONAL HAZARDS COUNTERACTION

Activities related to ensuring safety in the work environment usually result from specific legal provisions that require the identification of hazards in work processes, as well as the investigation of both accidents at work and near misses (Klimecka-Tatar and Niciejewska, 2016).
Generally speaking, safety can be achieved through hazard elimination, preventive measures and / or protective measures. Prevention means reducing the likelihood of a hazardous event occurring, while protection means reducing the effects of this event.
In principle, prevention is better than protection because we are unable to determine the actual consequences of various events. However, there is no perfect prevention. In many situations, the elimination of the threat is not possible for technological or economic reasons.
According to Hollnagel (2004, 2008), the basic strategies in the area of counteracting threats include elimination, replacement (complete or partial), monitoring, prevention, protection and facilitation. Examples of typical activities under individual strategies are summarized in Table 1.

Table 1
Basic strategies for counteracting threats

Basic strategy	**Type (examples)**
Elimination	Cancellation (product recall from the market)
	Restructuring (removal of function through redesign)
Replacement (partial or complete)	Identical component or device (components and spare parts, backup copies)
	Improved component or device (new models, new software versions, automation)
Monitoring	Early warnings (result indicators, warnings and alarms)
Prevention	Physical barrier system (fences, buildings)
	Functional barrier system (locks, alarms, interfaces)
	Symbolic barrier system (procedures, rules, tasks)

	Incorporeal barrier system (safety culture)
Protection	Physical barrier system (wall, cover)
	Functional barrier system (airbag)
	Recovering input state (operational support, fault tolerance, system design)
	Mitigation (feedback, detection)
Facilitation	Redesigning tasks, designing the work process (improving the logic of the task, collaborative working)
	Interface design (usability, functional grouping, compatibility)
	Support (memory, attention)

Source: own study based on (Hollnagel, 2004, 2008)

Each of the strategies presented in Table 1 has its advantages and disadvantages. Prevention by eliminating the hazard (risk) requires that the risk is known or can be known. So it requires the use of an appropriate method of risk estimation.
First, it may not be possible to eliminate a threat by removing it completely from the system, due to the tasks performed by that system; and second, it may disturb the operation of this system. Disruption can be costly.
The elimination of a hazard by substitution may create new threats (risks), which is a serious problem, especially in complex systems with strong internal couplings. Substitution changes the basis for risk assessment.
Prevention and protection strategies are implemented using safety barrier systems and safety functions. More generally, prevention is the use of safety barriers and functions to block or limit preconditions or factors that initiate, trigger or contribute to an undesirable event.
In contrast, protection against undesirable effects relies on the use of barriers and safety functions to block or reduce the consequences of undesirable events.

3. SAFETY BARRIERS AND SAFETY FUNCTIONS

The safety barrier model was introduced by James Reason as early as 1990. Since then, there is no single definition of a safety barrier generally accepted in the literature. Different authors focus on different aspects of this concept (CCPS, 2001; Duijm et al., 2004; Goossens and Hourtolou, 2003; Harms-Ringdahl, 2003; Hollnagel, 2004; Johnson, 1980; Kecklund et al., 1996; Neogy et al., 1996; Rosness, 2005; Sklet and Hauge, 2004; Svenson, 1991).
The safety barrier system describes the measures (elements) by which the prevention and protection of the functioning of the industrial work environment are carried out in practice. So, the system of barriers describes what exactly a given barrier is. Table 2 lists the best known general categories of safety barriers.

Table 2
General categories of safety barriers according to various authors

Authors	**Categories**
Johnson (1980)	(a) physical barriers, (b) non-physical barriers
Reason (1997)	(a) hard defence, (b) soft defence
Svenson (1991)	(a) physical barriers, (b) technical barriers, (c) human factors/ organizational barriers

Kecklund et al. (1996)	(a) technical barriers, (b) organizational barriers, (c) human actions
Neogy et al. (1996)	(a) physical barrier, (b) management and process barrier, (c) human actions
DoE (1997)	(a) physical barriers, (b) management marriers
Bento (2003)	(a) technical barriers, (b) organizational barriers, (c) operational barriers
Hale (2003)	(a) hardware, (b) behavioral
Dianous and Fiévez (2006)	(a) active barriers, (b) passive barriers, (c) human actions, (d) symbolic barriers
Hollnagel (2004)	(a) physical barriers, (b) functional barriers, (c) symbolic barriers, (d) incorporeal barriers
Kang et al. (2016)	(a) personnel barriers, (b) organization barriers, (c) technology barriers

Source: own elaboration

The general categories of safety barriers are usually divided into more detailed, as illustrated by the example of the classification of safety barriers by Kang et al. (2016) - Table 3. Such detailed classifications of safety barriers are developed for the needs of a specific, specific industry or sector of the economy (np. CCPS, 2001; NORSOK, 2008; PSA, 2013).

Table 3
Detailed classification of safety barriers

<table>
<tr><th>Categories</th><th colspan="2">Division of categories</th></tr>
<tr><td>Personnel barrier</td><td colspan="2">(a) professional capacity, (b) professional quality</td></tr>
<tr><td>Organization barrier</td><td colspan="2">(a) safety production management institution and personnel, (b) safety production regulatory framework, (c) safety production fund guarantee, (d) safety production education and examination, (e) operation instruction, (f) safety production daily check, (g) contingency plan and measure, (h) daily risk analysis, (i) daily hidden danger investigation and correction, (j) accident statistic and analysis</td></tr>
<tr><td rowspan="6">Technology barrier</td><td rowspan="4">Technically positive barrier</td><td>Design</td></tr>
<tr><td>Technology</td></tr>
<tr><td>Equipment</td></tr>
<tr><td>Personal protective equipment</td></tr>
<tr><td colspan="2">Technically passive barrier</td></tr>
<tr><td colspan="2">Technical detection barrier</td></tr>
</table>

Source: own study based on (Kang et al., 2016)

A static barrier is a barrier with assumed, constant operating conditions (the probability of a barrier failure is precisely defined), while a dynamic barrier is a barrier with a specific indicator of deterioration of performance (Pitblado et al., 2016). Barriers can be short (e.g. procedures), medium (e.g. safety documentation) and long degradation rates (e.g. refractory partitions).

A combination of barrier systems is very often used to ensure that prevention and protection are effective. In an industrial work environment, symbolic and incorporeal

barrier systems (according to the Hollnagel classification, 2004) must be reinforced by physical and functional barrier systems.
Another key issue for the implementation of prevention and protection is the question of the function of the safety barrier, i.e. defining what a given barrier does, i.e. how it achieves its purpose.
It can be said that the barrier function describes a way by which it is possible to prevent or protect against uncontrolled flow of energy, matter or information.
The barrier functions can be active (the barrier does something) or passive (the barrier only exists). Considering their safety relevance, the functions can be either primary or critical.
In addition, Vatn (2001) distinguishes among the critical safety functions (a) critical primary functions related to technical and control systems, (b) critical secondary functions that concern maintaining the safety of primary functions and (c) tertiary critical safety functions related to safety management systems, maintenance management systems, etc. Table 4 lists examples of safety barrier functions for the four basic barrier systems proposed by Hollnagel (2004).

Table 4
Safety barrier functions for four barrier systems

	Barrier functions		Examples
Physical barrier system	Limiting or protecting. Preventing something from moving from one place (release) to another (influx)		Physical access restriction: walls, doors, buildings, railings, fences, containers, tanks, filters, valves, etc.
	The inhibition or prevention of the movement or transport of mass or energy		Distance in space (clearance, gap), seat belts, cages, harnesses, etc.
	Keeping together, ensuring consistency, resilience		Elements that are difficult to damage
	Separating, blocking		Grinding and rinsing zones
Functional barrier system	To prevent movement or activity	Mechanical, hard	Physical interlocks, locks, setting hardware, matched equipment.
		Logical, soft	Prerequisites, passwords, input codes, sequences, physiological matching, etc.
	Obstructing or disrupting activities (in time or space)		Delay, timing, distance, persistence, etc.
	Suppression, weakening		Active suspension, active noise reduction, etc.
	Energy dissipation, suppression, extinguishing		Shock absorbers, sprinklers, airbags, etc.
Symbolic barrier system	Preventing or disrupting the action, counteraction (visual, touch interface design)		Division of competences, labels and warnings, coding of functions
	Regulating activities		Procedures, instructions, interviews, etc.
	Indication of system status (audible and visual signals)		Signaling (visual, auditory), alarms, pictograms, signs (e.g. road signs), etc.
	Allow or permit something (or		Work order, work permits, etc.

	not)	
	Communication, interpersonal dependence	Certificates, admission to work (on-line, off-line)
Incorporeal barrier system	Compliance, consent to something	Ethical norms, morality, restraint, social or group pressure
	Orders, prohibitions, regulations, guidelines	Lows (conditional or unconditional), rules, restrictions

Source: own study based on (Hollnagel, 2004)

The analysis of the functions performed by the safety barriers shows that the assumed prevention or protection objective can be achieved in various ways, i.e. by using various barrier systems. Of course, as long as the barrier systems are properly selected and that they are effective.

4. EVALUATION OF SAFETY BARIERS AND FUNCTIONS AS A MANAGEMENT PROBLEM

Safety barriers and functions that are used in an industrial work environment are the result of specific employer decisions based on a wide variety of information. When making a decision, the employer should know: (a) What is the degree of risk, i.e. what is the potential amount of losses? (b) What is the probability of incurring a loss due to the analyzed threat? (c) What is the cost of risk mitigation? (d) What will be the results in terms of controlling the risk? (e) Are there alternative ways to reduce the risk and how effective are they? and (f) How can you justify the proposed solution?

The effectiveness of risk mitigation measures generally varies greatly and depends on many factors related both to the solution itself and its practical implementation and supervision. The effectiveness of barriers usually results from the combination of several barriers. Several combined different barrier systems can improve resistance to different hazards occurring simultaneously in an industrial work environment.

Therefore, it should be possible to evaluate the barrier performance both individually and in a specific system. Table 5 summarizes the most commonly used criteria for assessing safety barrier systems.

Table 5

Criteria for assessing safety barrier systems according to various authors

Authors	**Criteria**
Anderson et al. (2004)	(a) effectiveness, (b) response time, (c) level of confidence
Hollnagel (2004)	(a) adequacy, (b) availability / reliability, (c) robustness, (d) specificity
Sklet (2006)	(a) functionality (effectiveness), (b) reliability / availability, (c) response time, (d), robustness, (e) triggering event or condition
Hollnagel (2008)	(a) efficiency, (b) resource needs, (c) robustness, (d) implementation delay, (e) applicable, (f) availability, (g) independence, (h) evaluation

Hauge et al., (2011)	(a) functional requirements, (b) integrity requirements, (c) vulnerability requirements
Harms-Ringdahl (2013)	(a) importance, (b) wanted efficiency, (c) estimated efficiency, (d) monitoring needs, (e) monitoring status, (f) acceptability
Kang et al. (2016)	(a) degree of confidence, (b) effectiveness, (c) cost
Sobral and Guedes Soares (2019)	(a) independence, (b) safety barrier architecture, (c) proven concept, (d) existence of periodic tests

Source: own elaboration

The way in which the criteria from Table 5 are used in the process of assessing safety barrier systems can be very different from the practical point of view. Table 6 shows the results of the evaluation of the four primary barrier systems according to the criteria developed by Hollnagel (2008).

Table 6

An example of the assessment of barrier systems

	(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**
Physical barrier	High	Medium-high	Medium-high	Long	Low	High	Easy	High
Functional barrier	High	Low-medium	Medium-high	Medium-long	Medium	Low-high	Difficult	High
Symbolic barrier	Medium	Low-medium	Low-medium	Medium	Low	High	Difficult	Low
Incorporeal barrier	Low	Low	Low	Short	Low	Uncertain	Difficult	Low
(a) Efficiency, (b) Resource needs, (c) Reliability (robustness), (d) Implementation delay, (e) Applicable to safety critical activities, (f) Availability, (g) Independence on human, (h) Possibility of evaluation								

Source: own study based on (Hollnagel, 2008)

The criteria used for the assessment define: (a) Efficiency - how well the barrier fulfills its purpose, (b) Resource needs - What is needed to design, develop and maintain the barrier, (c) Reliability (resilience) - how well can the barrier withstand environmental variability, (d) Implementation delay - Time from concept to implementation of the barrier, (e) Applicability to critical tasks - Can it be used in the event of a critical security threat? (f) Availability - Can the barrier fulfill its role in rare conditions? (g) Independence on human - the extent to which the barrier does not depend on man to fulfill its role, and (h) Possibility of assessment - How easy it can be to tell if the barrier is working properly both in the design and in use phase.

On the other hand, Harms-Ringdahl (2013) proposed a simple assessment of the safety function performed by the barrier. This assessment uses decision rules. Parameter values are entered into decision rules to answer the question of whether improvements to the safety function are needed. The scales and codes of the parameters used in this assessment are presented in Table 7.

Table 7
Parameters used to evaluate the safety function according to Harms-Ringdahl

Parameters	**Scales and codes**
Importance of safety barriers (IMP)	0- Safety barrier has no or very small influence on safety, 1- Small influence on safety, 2- Rather large influence on safety, 3- Large influence on safety
Wanted efficiency of safety barriers (WE)	0- Very low efficiency (<50% probability), 1- Low efficiency (>50% probability), 2- Medium efficiency (>90% probability), 3- High efficiency (>99% probability), 4- Very high efficiency (>99,99% probability)
Estimated efficiency of safety barriers (EE)	0- No intended safety barrier, and no influence on safety, 1- No intended safety barrier, but influence on safety, 2- Intended safety barrier, but main purpose in something else, 3- Intended to provide an safety barrier, 4- Intended to provide an safety barrier through a formal system, 5- Uncertain intention
Monitoring needs (MN)	MN0- Not need or irrelevant, MN1- Of low interest, MN-2 Monitoring is of interest, but not a critical issue, MN3- Monitoring is necessary, at least periodically, MN4-Monitoring is essential
Monitoring status (MS)	For MN2-4: MS0- Monitoring function does not meet the requirement, MS2- Existing, but does not fully meet the requirement, MS2- Meets the requirement; For MN0-1: MS2- No need for monitoring
Acceptability of safety function (A)	0- No need for improvement, 1- Improving safety function can be considered, 2- Improving safety function recommended, 3- Improving safety function is imperative, 4- Intolerable, work should not be started or continued until the risk has been reduced

Source: own study based on Harms-Ringdahl (2013)

In contrast, Table 8 summarizes the decision rules used in the assessment of the safety functions, as well as recommendations for improving the safety functions.

Table 8
Decision rules for the evaluation of the safety functions

IMP	**EE / WE**	**MS**	**A**	**Recommendations for safety function improvements**
0	EE < WE	(-)	1	Improvement can be considered
	EE ≥ WE	(-)	0	Improvement is not needed
1	EE ≥ WE	(-)	0	
	EE < WE	1-2	1	Improvement can be considered
		0	2	Improvement is recommended – prevent degrading of safety function
2	EE ≥ WE	0-1	2	
		2	0	Improvement is not needed
	EE < WE	0	3	Improvement is imperative
		1-2	2	Improvement is recommended
	EE << WE	(-)	3	Improvement is imperative
3	EE ≥ WE	0	3	
		1	2	Improvement is recommended
		2	1	Improvement can be considered

	EE < WE	0	3	Improvement is imperative
		1	3	
		2	2	Improvement is recommended
	EE << WE	0-1	4	Intolerable situation
		2	3	Improvement is imperative
Markings according to table 7 (-) Any MS value				

Source: own study based on Harms-Ringdahl (2013)

The first three columns in Table 8 (IMP, EE / EC, MS) are used to enter the parameter values and the fourth column (A) gives the result. The basic principle is that critical safety functions must be effective and monitoring is an essential tool to achieve this goal.

Evaluation of barriers and safety functions is the basis for effective barrier management (Tabor, 2015), and is a key activity in maintaining or reducing the risk of adverse events in the industrial work environment.

5. CONCLUSION

Safety in an industrial work environment can be achieved through the elimination of hazards, through prevention and through protection against the effects of adverse events. Prevention is better than protection in many ways, but perfect prevention is impossible.

In practice, it is impossible to completely prevent the occurrence of an undesirable event, i.e. completely eliminate the risk. Therefore, it is best to use different threat prevention strategies together.

The article presents the basic strategies to counteract threats that are used in an industrial work environment, such as: elimination, replacement (complete or partial), monitoring, prevention, protection and facilitation.

Particular attention is paid to prevention and protection strategies that use the concept of safety barriers, appearing in the literature under various names: defence, protection layer, safety critical element, etc.

The article presents the main categories of safety barriers, including the best known ones: physical, functional, symbolic and incorporeal ones. The basic safety functions implemented within the key barrier systems are also presented.

The second part of the article presents the most frequently used criteria for assessing safety barrier systems, including the approach taking into account parameters such as: efficiency, resource needs, reliability, implementation, applicable, availability, independence and possibility of evaluation. An example of the safety function evaluation was also given, using decision criteria and parameters such as: importance, wanted efficiency, estimated efficiency and monitoring.

The analysis and evaluation of safety barriers and functions is a key element of safety management towards reducing the risk of adverse events occurring in an industrial work environment.

REFERENCES

Andersen, H., Casal, J., Dandrieux, A., Debray, B., De Dianous, V., Duijm, N. J., et al., 2004. *ARAMIS - user guide*. EC Contract number EVG1-CT-2001-00036.

Bento, J.-P. 2003. *Review from an MTO-perspective of five investigation reports from BP.* Norway: Stavanger.

CCPS, 2001. *Layer of protection analysis simplified process risk assessment*. New York: Center for Chemical Process Safety of the American Institute of Chemical Engineers.

DoE, 1997. *Implementation guide for use with DOE Order 225.1A, accident investigation,* DOE G 225.1A-1, Rev. 1. Washington, DC: US Department of Energy (DOE).

Dianous, V., Fiévez, C., 2006. *ARAMIS project: A more explicit demonstration of risk control through the use of bow-tie diagrams and the evaluation of safety barrier performance,* Journal of Hazardous Materials, 130, 220-233, doi: 10.1016/j.jhazmat.2005.07.010

Duijm, N. J., Andersen, H. B., Hale, A., Goossens, L., Hourtolou, D., 2004. *Evaluating and managing safety barriers in major hazard plants,* [In:] PSAM 7 - ESREL '04, Berlin, Germany.

Goossens, L., Hourtolou, D., 2003. *What is a barrier?* ARAMIS - working document.

Hale, A., 2003. Note on barriers and delivery systems, [In:] PRISM conference, Athens.

Harms-Ringdahl, L., 2003. *Assessing safety functions - Results from a case study at an industrial workplace,* Safety Science, 41(8), 701-720, doi: 10.1016/S0925-7535(02)00019-X

Harms-Ringdahl, L., 2013. *Guide to safety analysis for accident prevention,* IRS Riskhantering, AB, Stockholm, Sweden.

Hauge, S., Krakenes, T., Habrekke, S., Johansen, G., Merz, M., Onshus, T., 2011. *Barriers to Prevent and Limit Acute Releases to Sea* – SINTEF A20727Report. SINTEF.

Hollnagel, E., 2004. *Barrier and accident prevention*, Hampshire, UK: Ashgate.

Hollnagel, E., 2008. *Risk + barriers = Safety?* Safety Science, 46, 221-229, doi: 10.1016/j.ssci.2007.06.028

Johnson, W. G., 1980. *MORT safety assurance systems*, New York: Marcel Dekker.

Kang, J., Zhang, J., Gao, J., 2016. *Analysis of the safety barrier function: Accident caused by the failure of safety berries and quantitative evaluation of their performance*, Journal of Loss Prevention in the Process Industries, 43, 361-372, doi: 10.1016/j.jlp.2016.06.010

Kecklund, L. J., Edland, A., Wedin, P., Svenson, O., 1996. *Safety barrier function analysis in a process industry: A nuclear power application*, International Journal of Industrial Ergonomics, 17(3), 275–284, doi: 10.1016/0169-8141(94)00112-X

Klimecka-Tatar, D., Niciejewska, M., 2016. *The OSH management system in the "small-sized" production company,* Production Engineering Archives,13(4), 49-52, DOI: 10.30657/pea.2016.13.11

Neogy, P., Hanson, A. L., Davis, P. R., Fenstermacher, T. E., 1996. *Hazard and Barrier analysis guidance document*, Rev. 0. US Department of Energy (DoE), EH-33 Office of Operating Experience Analysis and Feedback.

NORSOK, 2008. S-001 *Technical safety* (edition 4, February 2008).

Pitblado, R., Fisher, M., Nelson, B., FlØtaker, Molazemi, K., Stokke, A., 2016. *Concepts for dynamic barrier management,* Journal of Loss Prevention in the Process Industry, 43, 741746, doi: 10.1016/j.jlp.2016.07.005

PSA, 2013. *Principles for Barrier Management in the Petroleum Industry*. Norway Petroleum Safety Authority. www.ptil.no

Reason, J. 1997. *Managing the risks of organizational accidents*, Aldershot: Ashgate.

Rosness, R., 2005. *Ten thumbs and zero accidents? About fault tolerance and accidents*. Kjeller: Institute for Energy Technology.

Sklet, S., Hauge, S., 2004. *Reflections on the concept of safety barriers*, [In:] PSAM7-ESREL 2004, Berlin.

Sklet S., 2006. *Safety barriers: Definition, classification, and performance*, Journal of Loss Prevention in the Process Industry, 19, 494-506, doi: 10.1016/j.jlp.2005.12.004

Sobral, J, Guedes Soares, C., 2019. *Assessment of the adequacy of safety barriers to hazards,* Safety Science, 114, 40-48, doi: 10.1016.j.ssci.2018.12.021

Tabor, J., 2015. *Management of Technical Prevention Systems in Manufacturing Companies*, Polish Journal of Management Studies, 12(1), 198-208.

Ulewicz, R., Mazur, M., Klimecka-Tatar, D., Niciejewska, M., 2015. *Wybrane aspekty zarządzania bezpieczeństwem i higiena pracy*, Wyd. SMJiP, Częstochowa (in Polish).

Vatn, J., 2001. *SINTEF internal memo regarding safety critical functions in the railway system in Norway*. Rev. 3. Trondheim: SINTEF.

Svenson, O., 1991. *The accident evolution and barrier function (AEB) model applied to incident analysis in the processing industries*, Risk Analysis, 11(3), 499-507, doi: 10.1111/j.1539-6924.1991.tb00635.x