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Dimensions in safety indicators

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Introduction

The discussion of applications and development of safety indicators is interesting and important. The paper by Andrew Hopkins (2008) has triggered a number of reflections. Hopkins has taken major hazard facilities and the chemical industry as the field of discussion. However, the reasoning might well be valid also for other industries with a potential for large consequences such as nuclear power, and transport in the air, on rail and at sea.

Purpose and use of indicators

Depending on the application situation the demands on safety indicators will vary considerably. One approach is therefore to start with the purpose of the indicators and how they will be used. Examples of themes are:

- Obtaining a value, without defining the use
- Obtained value(s) are used in an improvement feedback system
- As a part of a economic incentive program (discussed exhaustively by Hopkins)
- Demonstration that enough safety is achieved - for internal company use
- Demonstration of safety to the world outside the company
- The scope can be process safety, occupational safety, and/or economic benefits for e.g. stakeholders and insurance companies.

Hopkins has selected one aspect and states that "*the real purpose of performance indicators must be to evaluate the effectiveness of a*" system of risk controls. The OECD (2003) guidance on safety performance indicators has a wider perspective on the use, clearly pointing out the interests of different stakeholders. In the guide, it is assumed that industry, public authorities, and communities should work together in a co-operative way. Especially in circumstances where communication is essential, issues of clear definitions, transparency and trust become more important. Of course, most important is that the characteristics are relevant to the aim are measured.

Several dimensions

Hopkins has distinguished two dimensions in the description of safety indicators, and regarded them as the most fundamental ones. In my perspective, there are several other parameters to consider as essential. But of course, first there is a need to define the terms and the limits of the applications. However, this has not got a great degree of attention in the Hopkins paper. Perhaps he regarded them as self evident. For example, "safety indicator" can have several meanings depending on the circumstances. The OECD-report (2003) use the term "indicators" to mean observable measures that provide insights into a concept – safety - that is difficult to measure directly.

The dimensions in characterising safety indicators could relate to different final outcomes such as process safety or occupational safety. Indicators could also address:

- Nature and characteristics of the hazards
- Technical safety features - which are in place and their performance
- Formal safety organisation systems - which are in place and how they perform
- Informal safety issues
- Communication and co-operation issues as discussed by OECD (2003).

- Absolute values (evaluated or measured), or trends (the changes of performance over time).
- Economic consequences and probability for different outcomes.

The first two areas above can be the scope of technically oriented audits, and the third is concerned with organisational audits. As an illustration of the large variety of parameters, a study by Flodin and Lönnblad (2004) identified 36 examples of indicators used in the Swedish nuclear industry (Table 1).

Table 1. Simplified summary of indicators used in the Swedish nuclear industry based on Flodin and Lönnblad (2004).

Nuclear reactor safety	**Organisational issues**
INES classification (International nuclear event scale)	Unattended issues from safety committee (Model A and B)
Safety significance of Licensee event reports (LERs)	Temporary deviations from Technical Specifications
Risk Increase Factor, calculated mean value over one year	Temporary plant changes
Max instantaneous value of the same factor	Reporting time for LERs
Number of safety system actuations	Time for correction of safety related failures (Model A, B and C)
Unplanned automatic scrams (frequency)	Employees' attitude to safety issues
Failures revealed at reactor scrams	Recurrence of failures and errors
Unavailability of safety systems (Model A and B)	Relation between technical and human/organisational failures
Fuel Reliability Index (Model A and B)	
Leakage rate of containment valves	
Number of errors in maintenance	
Environment and work conditions	**Quality issues**
Collective Radiation Exposure	Production availability
Volume of Solid Radioactive Waste	Unplanned capability loss
Releases of radioactive substances	Thermal Performance Index
Releases of other than radioactive substances	Chemistry Performance Index
Environmental management compliance	Correction of deficiencies identified in quality audits
Industrial Safety Accident rate (Model A and B)	

Relationships between parameters and outcome

Hopkins discusses the relationships between the rate of occupational accidents and the outcome of major accidents. There appears to be the common opinion among safety researchers[1] that such connections are complicated and should be treated with prudence. Yet, accident rates are still sometimes used as an indicator for major accidents.

In a study from the nuclear industry by Flodin and Lönnblad (2004) this has been assessed. They looked at the indicator "Industrial safety accident rate" which is similar to the one discussed by Hopkins. The actual indicator has been rated as having "no or very little relevance" for nuclear reactor safety. This conclusion agrees well with what Hopkins has argued for.

There is a theoretical challenge behind this discussion, concerning models and parameters that best could explain and forecast large accidents. Complicating conditions are the large number of safety barriers which are incorporated in process industry facilities. Oversimplifications of assumptions and models might even be dangerous, if the resulting measures give rise to inappropriate actions.

[1] No references are given here, since Hopkins has discussed this quite exhaustively.

Lagging and leading indicators

Hopkins has pointed out several problems in the use of the terms lagging and leading indicators. There are further arguments that the use of the terms can easily be confused. One reason is that they are used also in other disciplines, such as electronic feedback control systems, and in economic theory, which might contribute to the confusion. In any application, the distinction between lagging and leading will depend on:

a) Where you set the point of reference in the course of events leading to an accident. Especially when changes are implemented, it might be hard to identify where "it starts".
b) The assumptions and beliefs about cause-consequence relationships will be crucial. A poor or improper assumption here can make the (leading) indicator useless or even lead to a deterioration of the safety performance if it is used a decision criterion.

Thus, the terms should be used with care, and the problem might be even larger than Hopkins suggests. The terminology might be correctly understood and used within a certain sector of industry, at least in the English-speaking area. The OECD-report (2003) has suggested two alternative types of indicators, which might be clearer. The first are called *Activities indicator*s, defined as means for measuring actions or conditions which, within the context of a programme related to chemical accident prevention, preparedness and response, should maintain, or lead to, improvements in safety. *Outcome indicators* are described as means for measuring the results, effects or consequences of activities carried out in the context of a programme related to chemical accident prevention, preparedness and response. They are designed to measure whether actions taken are achieving the intended results

Discussion

There are several other aspects of safety indicators. One is whether indicators should have a static view and look at more constant parameters and circumstances, or if a dynamic perspective should be applied, relating to more or less pronounced changes in the company. Both have their advantages. OECD (2003) has addressed some dynamic aspects such as management of change, and co-operation with other enterprises and stakeholders.

Usually formal aspects of safety management are measured, based on a top-down model of major hazard companies. The Baker report (2007) summarizes results from a safety culture survey which contains information about the opinions held about safety actions. Surveys might be used as indicators also on informal aspects, which could give complementary, but not complete information. It could be valuable to explore the importance of informal factors to an even higher degree. However, there are many challenges here. For example, complacency at senior levels, gradual deterioration and adaptation to lower safety standards might be hard to incorporate in safety indicators.

For some time my own interest has been in accident investigations, which can be used to apply a bottom-up perspective instead of the more common top-down model. Especially a focus on barriers and safety functions can give interesting insights also about informal safety features (Harms-Ringdahl, 2008), which are hard to reveal otherwise.

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