SEVESO III and the problem of industrial risk criteria in the European Union

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Published in “Technische Sicherheit”
6/2013 Springer-VDI-Verlag.

A stable economic growth is a requirement in the European Union for a successful and sustainable development of the Member States.

The basis of this growth is a safe industrial production with its manifold variety of products. In this context, the industrial safety and accident prevention become a special importance.

On 4 July 2012, the EU Parliament and the Council adopted a set of measures to control major-accident hazards involving dangerous substances along with the so-called Seveso III regulations (2012/18/EU) [1].
The Seveso III guidelines, which came into force on 13 August 2012, must be applied and implemented by the Member States into national law by 1 June 2015 at the latest.
A fundamental factor of the new guide-lines is the effective risk assessment of industrial plants or facilities with hazard potential. [2].
To ensure that the main objective is reflected in the evaluation of the results, a determination of the risk criteria is essential. The Seveso III Directive tries to converge the differences between a variety of approaches for production safety and different risk acceptance criteria in the EU into a unified set.

General principles of risk definitions

In everyday language, the terms "hazard" and "risk" are treated the same. Yet, there are fundamental differences.
Hazard is the ability or potential of an object, organism or fact to cause a negative impact or damage due to specific proper-ties.
Risk is the probability or frequency of negative effects, inconveniences or damages to occur due to an existing Hazard.

Furthermore, according to a classical definition of risk, it is defined as a product of the occurrence probability of an event and its resulting extent of damage. Recently, the risk as a triple-product of "scenario", probability and consequence extent, was often talked about and discussed. [3]
The risk is presented through the frequency / rate and the likelihood for the most part with a reference time of one year. The evaluation by frequency is based on statistical or stochastic data and represents the past. Whereas the evaluation of the probability mainly aims to describe not-yet-happened, future events. Frequency is measured by the number in a time period, and has a unit such as "1/second" or "1/year". In contrast, the probability has no units. It can only take the values from 0 to 1. Through the frequency / rate, the probability can be determined for it. Without a detailed mathematical interpretation, this can be explained in a simple description:

$Ta -$ is a positive random variable, which represents the time of the state of change of an object (e.g. from a positive into a negative)
The rate is described as $\lambda a = 1 \quad Ta$ and the probability of a negative event in a period of t-time is:

$$P \ t \ = 1 - e^{-\lambda \cdot t}$$

Furthermore, it is noted that by

$(1 - e^{-x}) \approx x$ for $x \ll 1$ is

$$P \ t \ = \lambda \cdot t$$

This requires that λ is a constant in this period and in $\lambda \cdot t \ll 1$.

For this reason, the frequency / rate and probability are often represented by the same numbers, which in many cases lead to misunderstandings for the viewers.

The main approaches of the safety requirements

Generally, there are three main approaches in the creation of safety requirements:

1.The first is based on the application of approved methods in system designs, safety equipment and the examination regarding technical norms and standard compliances. By these approaches it is commonly thought to be able to exclude existing risks.

2. In the assumption, that in case of existing danger the admission probability never will be zero, in the second approach, the goal is to identify the risks and to reduce them as much as possible. The extent of the method’s execution depends solely on the user.

3. The third approach is based on a specified limit. As long as the risk value / probability are lower than this threshold, the approach appears to be acceptable. Obviously, this variant represents the risk acceptance criteria of the broad public and those of the legislation.

In comparison of the first two methods, it is recognizable that these already define the scope of the safety and risk assessment. The third variant, which is currently being discussed the most, distinguishes itself from the other approaches, but also contains important aspects of the first two methods. For this reason, it seems to indispensably work out the reasons of threshold values too carefully to ensure the highest possible level of safety with a simultaneous acceptance.

As a general principle, as soon as a risk cannot be completely prevented, the “individual” and “social” risks are tried to be reduced by regulations to a socially viewed “tolerant”, “acceptable” and “justified” level.

But what does a socially “tolerable”, “accepted” and “justified” risk level look like?

Which risk is allowed to exist through an industrial plant or institution with a danger potential?

Public perception of risk and the definition of risk measurement units

The core of the problem of the assessment of hazards lies in the partly immense differences of the perception of individual- and social risks.
In the publication of Dr. R. Konersmann [4] it is excellently presented, how big the differences accepted by the society regarding the risks in everyday life can be. The public accepts the risk of different groups, which carry a specific risk, in various ways.

On the one hand, it depends on the statistical value, while on the other hand, it depends on the "popularity" of the regarded hazards for or in this group, as to whether a risk is considered acceptable. Thus, the hazards caused by industrial plants, have to be separately evaluated from the sum of everyday dangers.

Since the beginning of evolution, as conjectured by T.R. Lee [5], humanity is afraid of dangers. The death or injury of a person therefore determines the being’s perception. Lee defines a lethal personal injury as a hazard measurement unit, a binary event. The human is either dead or he is not. Non-fatal injuries however can occur in different forms.
In this context, the potential negative effects therefore can represent a risk and, in relation to a human, can be reviewed the easiest through the probability of the occurrence of a fatal personal injury.

Currently, the EU Member States or their regulatory authorities accept such risk-measurement units in different ways. In the Netherlands, England or the Czech Republic, the risks of deadly injuries are openly spoken about. In Germany, this is only reported about in relation to foreign sources.

Furthermore, a deadly accident outcome is often put under taboo on conferences: „We can’t take a deadly personal damage into account in our risk evaluation“.
Such or similar statements lead to a blurry risk definition.

What units are considered for the evaluation of a hazard or a risk for example in Germany? What could the solution look like in this case?

To lay this "understanding problem" to rest, the following should be considered:

- The worst negative consequence of a hazard is the death of a human. To describe such a hazard comprehensibly for all members of our society, the probability of lethal personal injury was introduced.

- The probability of a lethal personal injury is a "prediction" of an event, which not yet happened and is only used for a predictive comparison. In no way should it be viewed as a definitive statement about an actual occurrence.

- With the definition of risk limits, relations are defined to avoid the indefinable "slips" in the risk assessment or risk management.

It would be advisable to evaluate the risk of the personal injuries in three categories: fatal, heavy and light. This would bring in some "color" to the "gray zone" between two states. It would not only represent a risk evaluation but furthermore also describe a changing trend of the risks.

In case, that such assessment criteria aren’t accepted by the state’s authorities, a division into two risk criteria, heavy and light injuries, might help. The number of heavy injuries would therefore have to include lethal injuries.

The following solution could be basically neutral and yet highly versatile. An auxiliary unit of measurement will be set in accordance to the Bel-identification (after Alexander Graham Bell) of levels relative to the fixed reference value
(1B = log (P1 / Pref)). This is commonly known as dB (decibels) from the volume control of a stereo system.
This unit for "Hazard" could, for example, be referred to as “Danger” (in short "Dg"). As a derivative, it would be classified in the context of a personal injury as "Danger-person" (DGP); environmental damage "Danger-Environment" (DGE); property damage "Danger Construction" (DGC). The calculation should be similar to the "Bel" calculations [6].
Through this simple suggestion, the unclear discussion about the danger measuring units could be brought to a good end.

Individual risk and its „industrial“ components

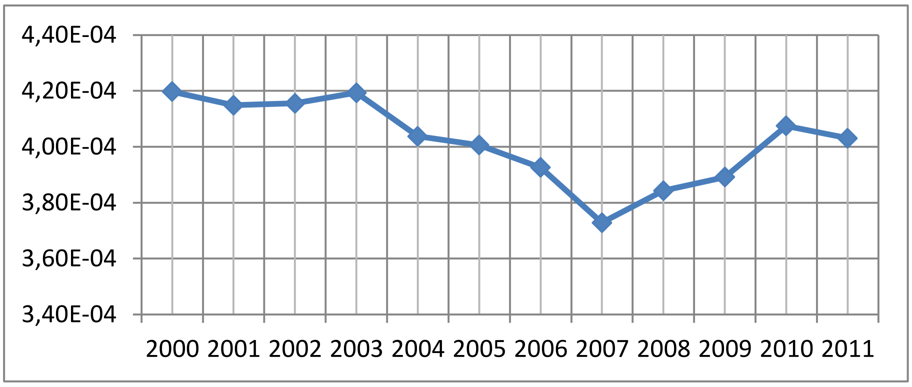
The risk of an unexpected negative event is undoubtedly a part of our life. „Life is dangerous, one can die from it“- this statement expresses the omnipresent risk of a person’s death. Every living being carries a risk to have a fatal accident or to become seriously injured. It can happen when you are swimming in a lake, driving a car or even simply climbing the stairs. Even such an exotic risk like the impact of a meteorite (e.g. recently in the Russian city Chelyabinsk) is a part of the everyday risk.
In this context, this refers to the so-called "individual risk."
The total risk of one „no name“ individual consists out of a wide range of large and small, major and minor sub-risks. Some of them are given a great amount of attention, while others are simply and unconsciously accepted every day.
A portion of this total risk is a risk posed by industrial plants or facilities with a potential hazard.
How large is this risk allowed to be to still be accepted by the population of a state and how is this established or justified?

The justification and calculation of the industrial risk criteria for Germany

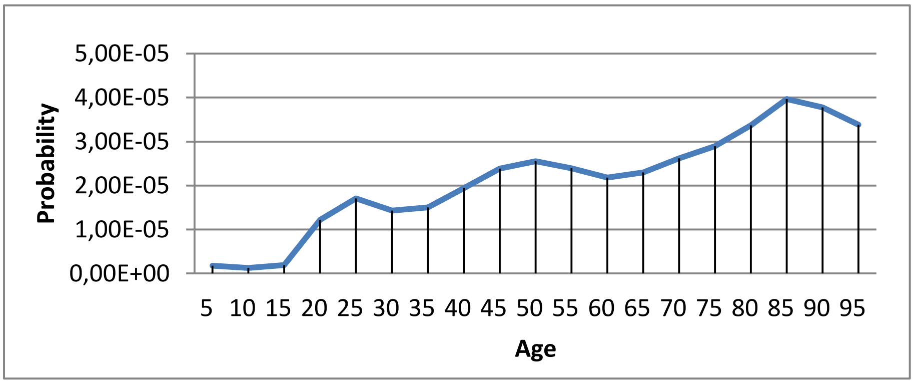
In order to describe a justification and calculation variant of industrial risk criteria, the statistical data published by the Federal Statistical Office (Destatis) [7] of deaths due

Table 1. The statistics of deaths in Germany by consequences of external causes and the resulting calculated probability.

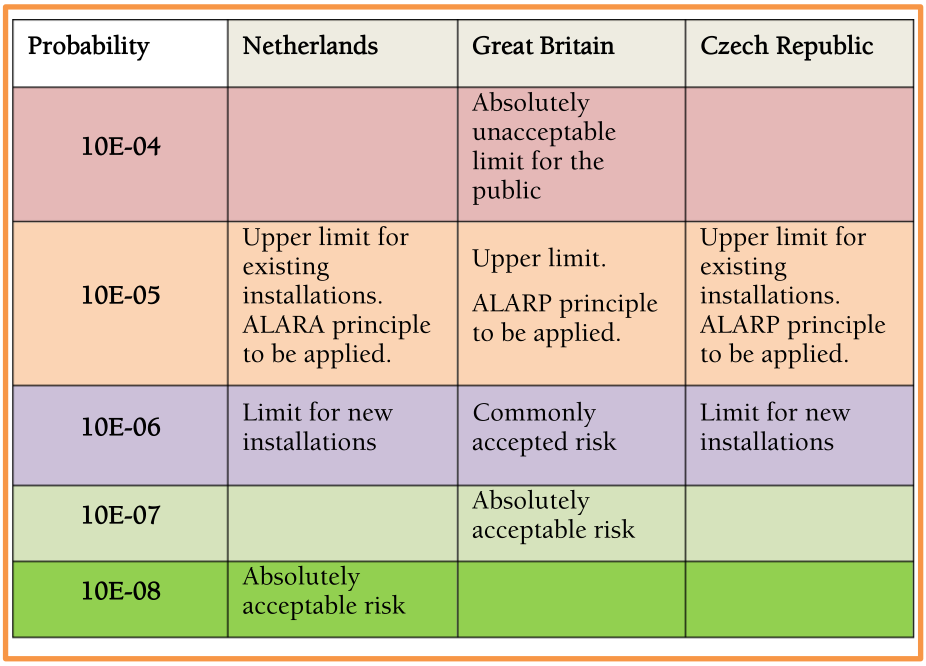
Year	Total Population	Deaths	Probability (Year)
2000	82.260.000	34.523	4,20E-04
2001	82.440.000	34.201	4,15E-04
2002	82.537.000	34.296	4,16E-04
2003	82.532.000	34.606	4,19E-04
2004	82.501.000	33.309	4,04E-04
2005	82.438.000	33.024	4,01E-04
2006	82.315.000	32.312	3,93E-04
2007	82.218.000	30.650	3,73E-04
2008	82.002.000	31.511	3,84E-04
2009	81.802.000	31.832	3,89E-04
2010	81.752.000	33.312	4,07E-04
2011	81.844.000	32.988	4,03E-04



Picture 2. The annual probability differences.



Picture 3. The probability of a death in relation to the individual's age in a period from 2000 to 2011 in Germany.



Probability	Netherlands	Great Britain	Czech Republic
10E-04		Absolutely unacceptable limit for the public	
10E-05	Upper limit for existing installations. ALARA principle to be applied.	Upper limit. ALARP principle to be applied.	Upper limit for existing installations. ALARP principle to be applied.
10E-06	Limit for new installations	Commonly accepted risk	Limit for new installations
10E-07		Absolutely acceptable risk	
10E-08	Absolutely acceptable risk		

Picture 4. Individual risk criteria in selected EU states.

to consequences of external causes are applied.

In an average case, the probability of death each year in Germany due to consequences of external causes equals 4,02 E-04. This is tacitly accepted by the population of Germany as an everyday individual risk.

Furthermore, the annual probability differences are displayed in Table 1.
The maximum difference (amplitude) from 2000 to 2011 is 4.69 E-05.

This purely stochastic component, also known as the noise component or "white noise" is about one-tenth of the probability itself. Generally, the "white noise" describes the random fluctuations and is in this case barely influenceable.
This means that the portion of "white noise" in the individual risk in Germany is also about one-tenth.

For this reason, it can be said, that all the shares, that are less than a tenth, are located in the area of the "white noise" and in this case can be described as "*not noticeable*" or "*below the threshold of perception*".

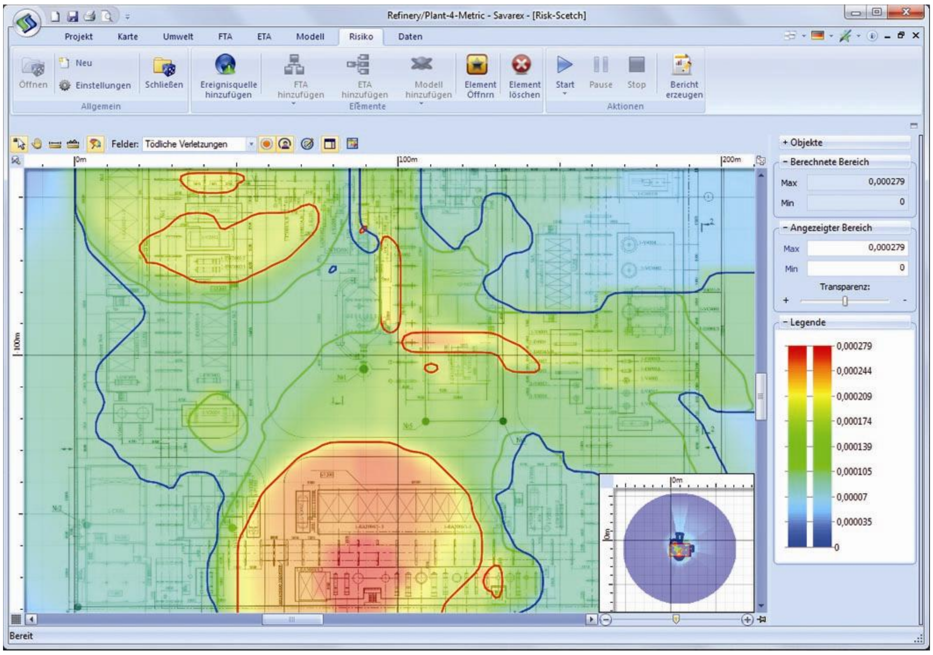
In conclusion, the assertion can be made, that the risk, which results from the operation of industrial plants, is not allowed to exceed the level of "white noise". Otherwise, it should no longer be accepted by the public and will probably be regarded as a higher risk.

To be sure, that the 'industrial' share of risk lies within the "not noticeable" range, we simply define a criterion in the value of a quarter of the above calculated maximum difference in Germany.
This means, that a maximum risk value for third parties is defined as 1E-05 (per year) for all existing industrial plants or facilities with hazard potential in Germany.

Furthermore, it can be claimed with a high probability that this value will still effectively remain for the next 10 years.

For industrial facilities, which are still under construction or planned and are expected to remain 30-40 years in operation, an in-depth method should be applied.
Based on this evaluation is a statistical analysis of deaths in relation to reached years in life.
A more refined analysis of the average data from 2000 to 2011 in relation to different age groups showed a minimal individual risk in Germany for the age group 1-15 years. It is noteworthy, that a study by S.H. Preston [8] from the early 1970s outlines almost the very same dependence.
The probability has been reduced from 2000 to 2011 in this age group by half and is in average ~ 3.0 E-06.
With consideration of the descending trend, the searched risk value for new or planned industrial plants in Germany could be

defined on this basis as a value of 1.0E-06 (per year). It is ~ 1% of the current individual risk of an individual in Germany and could be interpreted as a goal to be achieved for the next 10 years.
The individual risk components, which are caused by industrial plants or facilities with a potential risk and are under the value of 1,0E-07 (p.a.), can therefore be declared as "absolutely acceptable" or as "insignificant". Surely, one would come to these values with the help of other subjective or objective assessments, through analytical interpretations or pure mathematical calculation. However, this method includes the necessary components of both approaches.
Furthermore, the method described above could also beapplied for other states of the European Union or even worldwide. Considering the fact, that statistical data reflects the economical and sociological characteristics of a state, the corresponding results would bring out different values.



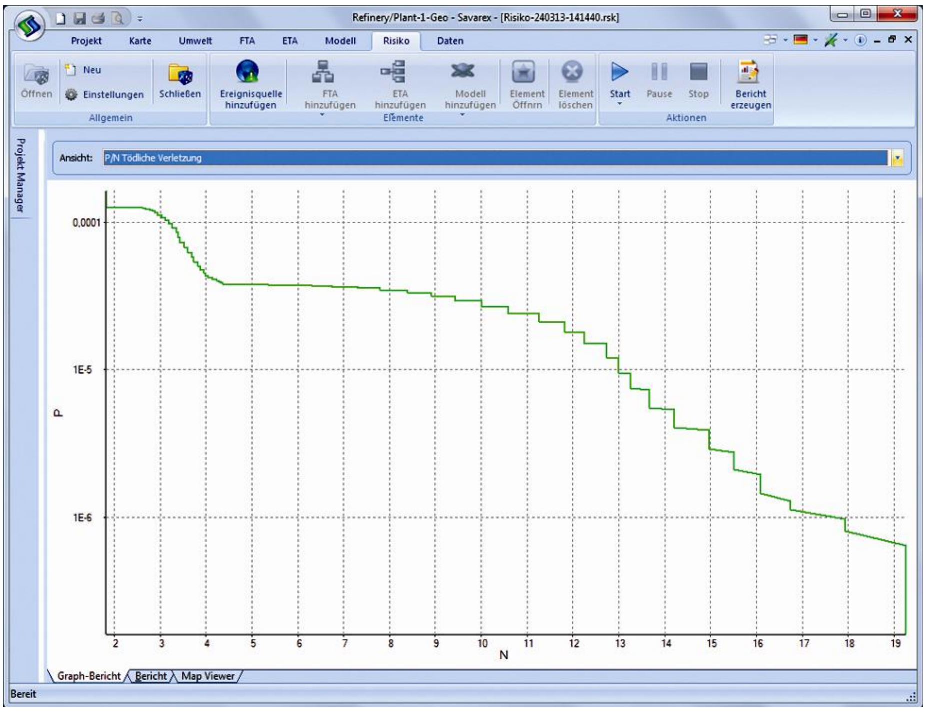
Picture 5. The presentation of an integrated territorial risk of a facility in the IT application "Savarex Studio".

Criteria for individual risk in other EU states

In contrast to Germany, several EU states have already defined the risk criteria for an "industrial" portion of the individual risk for the population by law. For Example, limits for the categories "*absolutely acceptable*" and "*absolutely unacceptable*" have been defined. Through the terms ALARP (As Low As Reasonably Practicable) and ALARA (As Low As Reasonably Achievable) an "*improvement area*" for existing risk has been defined.

Other EU states (Hungary, Poland, Romania and others) have also recognized the advantages of this method and already follow its example.

An example for different potential hazard sources of an industrial facility in terms of the so-called "territorial risk" can be seen in Picture 5.
The territorial risk would also be the "industrial contribution" to the individual risk in the case that an individual would be located 24 hours, 365 days a year in this "geographical position". The territorial risk is a value for decisions in the field of land use planning. The different risk zones are separated through isolines, which therefore mark the different risk zones.



Picture 6. The presentation of the "social risks" of a facility in "Savarex Studio".

Social risk

Another approach for risk description is the so-called "social risk", which is also named "collective" or "group risk". This risk refers to all persons exposed to the risk and is defined by the average number of expected deaths per year. In this case, the distribution (density) of the population has to be taken into account. This aspect is not considered in the individual risk. The evaluations are presented in the form of an F-N-curve, whereas "F" stands for the frequency and "N" for the number of deaths. An example of such a representation is shown in Picture 6.

The acceptance criteria will be displayed in the FN-diagram through a straight line. The straight line is defined by two points (values) or a dot (one point) and a corresponding slope. These values are to be objectively or regulatorily justified and defined.
As an example, the limit values and goal values of social risks can be defined according to similar procedures like for individual risks (through processing the necessary statistical data). Another consideration for the foundation of risk criteria is to constantly hold a certain risk level (number x frequency).

Thus, the relationship between individual and social risk criteria will be displayed simultaneously.

Summary

Through the Seveso III directives, which came into force, the opportunity is given to develop uniform and consistently applied limit- and goal- risk-criteria for all EU members. This would be an important prerequisite to obtain a comparable as well as an as high as possible safety standard among all EU states.

In the assumption, that one of the fundamental factors of the Seveso III guideline is the effective risk assessment, there's no way around this topic for the consulting and legislative institutions in Germany.

The experiences, which have been already made in other countries, regarding the reasonable determination of safety limits, could be used as a model for a national solution. Accordingly, the evaluation of own statistical data and the use of the methods outlined above could lead to a meaningful implementation of the Seveso III directives.

Now it is up to the Federal Government to carry out a quick, clear and effective implementation of the Seveso III directive, to achieve the goal of higher safety standards not only in Germany, but also for the entire European community.

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