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BASIC DATA NECESSARY FOR THE SAFE COMPLEX TECHNOLOGICAL FACILITIES

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Abstract
Based on current knowledge and experience, it is necessary to first identify the disasters that occur in the place in which we want to locate or in which is situated the complex technological facility. Then it is necessary to determine the damage and losses that the disaster with the largest expected size (i.e. size that is normatively determined) will cause to this facility and to the public assets in the facility surrounding when they fail its systems to prevent the harmful impacts of its activity on its surroundings. Therefore, by the specific way there are defined specifications (terms of references) for a facility and its operation and on their basis there shall be determined risks which may significantly affect the operation and cause of the accidents, which damaged facility, and in the worst case, even surrounding the facility. ***The technological processes are the sources of their own risk and also amplify the impacts of risks originating in the surrounding in which processes are underway.*** *Therefore, there are performed in the foundation of facility objects, building and construction of objects and equipment. During the construction there are installed passive restraints / barriers and they are processing the active procedures, i.e. the operating rules, so the object was safe under normal, abnormal and critical conditions. Basic input data, therefore, set out in a specific way, which will be discussed further.*

Key words
disasters, hazard, risk, attenuation of impacts, anomalies in disaster impact scenarios

1. Determination of hazard of individual disasters

Procedures for determining the hazard posed by individual disasters for humans, a real territory and real complex technological facilities have been evolved over time. From the estimates based on the selection of the maximum observed size of the disaster in the place since the historic to the present, through the application of: the methods of mathematical statistics; algorithms of theory of limit / marginal values; theory of large numbers; mathematical modelling; analysis based on the probability of boundary values; analysis based on the upper and lower estimates of the values of the occurrence probability; the theory of fuzzy sets; the theory of options until after the theory of Dempster-Shafer [1,2], which combines accurate calculations and heuristics, and in this way, it is considering the random uncertainty and epistemic uncertainty in the mode of occurrence of the disasters. At the end of paragraph 3, it is given an example for the earthquake, which shows the variance between values obtained by different approaches.
It is to be noted that when determining the hazard the incorrect data are used (incomplete or short time series) or incorrect calculation procedure is, of course, it is endanger the safety of the followed facility, see the examples for the earthquakes, which are referred to in [3].
The impacts of disasters on the territory and on the complex technological facilities depend on the type of disaster [5,6], and on the vulnerability of given assets [7-9]. From safety reasons, we need in accordance with the practices of major reinsurance undertakings, such as Swiss Re, Munich Re and others, to know the size and properties of the maximum sizes of the disasters. By the methods used in the cases of long time series on the occurrence of disasters we are able to specify just the size of the maximum expected disasters (and it is still subject to certain restrictions), because of extreme disasters come irregularly and rarely; their return periods range from a few hundred to a few thousand years. It is true that each method has a discrimination capability [10].
After each major disaster the engineers responsible for safety of complex technological facilities put questions [11]:

- may such a disaster occur in our country?
- how are our territory and our facilities protected in the case of the impacts of such large disasters?
- are ready support teams and the means for timely and adequate response?

Due to completeness it is necessary to note, that we do not have a methodology for the evaluation of phenomena that are typical for the evaluation of hazards which represent real disasters for the interconnected systems with different sizes; for

example, the reality is that a large disaster associated with processes in a hierarchically higher system will undermine the regimes of all systems at a lower hierarchy (see planetary earthquake, large solar flares). The consequence is both, the failure of modes of processes in the hierarchically lower systems and the occurrence of unusual disasters, i.e.. with unusual sizes or unusual characteristics. Many such examples it shows a detailed study of the seismic regime [12,13].
For obvious reasons, when determining the specifications for terms of references of the facilities from the well-known disasters, the list of which is in [4,8], there are considering only those that can have impacts in a given site. Because of the extreme disasters occur irregularly and sparse, so it cannot be used for determination of their size the common methods of mathematical statistics, and therefore since the 1980s they have been used use the methods based on the theory of extremes. A thorough analysis of the procedures applied to associate with applications on the existing knowledge of the physical medium [14] showed that the theory of extreme values is based on the following assumptions:

- the conditions that prevailed in the past, shall also hold in the future,
- the largest observed phenomena in a given time interval are independent,
- the behaviour of the greatest phenomena in a given interval will be the same in the future as in the past.

In practice, according to the theory of extreme values there are determined two quantities, namely: the return period; and the annual probability of excess.

1.1. Determination of size of maximum expected disaster

The theory of extreme values is a specific sector of mathematical statistics, which deals with the development of methods and techniques for describing, modelling and prediction of unusual and little frequent phenomena, which may occur in many areas of human activity. In these cases, it is always necessary to estimate or predict the level of values for some of the real process, usually outside the range of the observed data yet.

On the basis of theoretical studies [13-16], described in the works carried out for real time series of observed values, which have expressed the occurrence frequency given by relationship

$$\log N_{ci} = a - b\, M_{oi}$$

in which ***for i = 1,2, ..., n*** they indicate N_{ci} cumulative frequency M_{oi} the size of the disaster, ***a***, ***b*** the numerical parameters, provided that the above mathematical terms it is a hazard ***H = value of*** $M_{o\,i}$, for which the probability of not exceeding the level is $R_t (M_o \;\; M_{oi}) = 0.05$ for the chosen time interval and they hold relationships

$$R_t(M_0 \geq M_{0i}) = 1 - \left[\frac{T}{T + t \cdot P(M_0 \geq M_{0i})}\right]^{n+1}$$

$$P(M_0 \geq M_{0i}) = \frac{e^{-\beta M_{0i}} - e^{-\beta M_{0max}}}{e^{-\beta M_{0min}} - e^{-\beta M_{0max}}}$$

The format of the results is shown in Figure 1 for time intervals ***t = 0.5 in, 1 year up to 1000 years***.

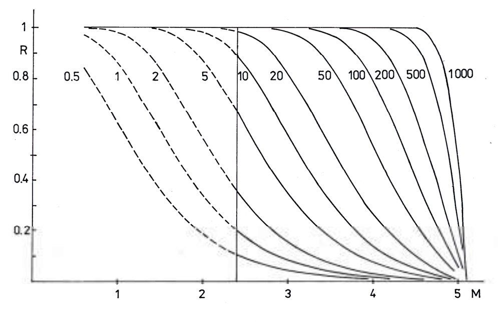

Fig. 1.The course of the function describing the probability of not exceeding for the time intervals 0.5, 1,2, ..., the 1000 years

The size of the largest expected disaster ***M*** is determined as the intersection of the curves on Figure 1 with the chosen level of significance. Significance level reflects the inaccuracy with which we determine the conclusion – the most commonly it is chosen ***v = 0.05*** or ***0.01.*** Value of 0.05 means the possibility of error 5%, ***p = 1 - v*** is the probability with which the result is correct.
The mean return period for disaster with the size M_o = ***time t,*** for which it holds the equality

$$R_t = 0.633.$$

In cases in which the time series is not available, they are made the estimates; for example: the size of the largest observed disaster; for technological facilities — the participation of all hazardous substances in the stack, object, etc. The estimates are very imprecise, because it usually is in the accident involved only some part of the substances, or observations are from a very short time, and therefore, it cannot be determined nor mathematically variance of the values.

At determining the hazard, there are used the deterministic and probabilistic approaches with the fact that when the application it is usually added the safety reserve. This means that in practice they are only considered random uncertainty, i.e., no epistemic uncertainty.

For the place in which is located the complex technological facility from the specified maximum size of maximum expected disaster it needs to determine the disaster size for the place, in which is located the facility, i.e. it needs to consider the attenuation of size of impacts with distance and other physical factors that for real disaster affect the size of the impacts in a particular site.

1.2. Attenuation of size of disaster impacts with distance and influence of anomalies in medium

On the basis of knowledge about individual disasters [5,6,11-14,16,17] the attenuation of the impacts sizes of the disaster with the distance depends on:

- the nature of the phenomenon (natural disaster, fire, explosion, technological accident, etc.),
- the mechanism of the origin of the phenomenon (usually it determines the distribution of impacts in the near zone),
- structure and properties of physical medium (that usually prevail in the far zone).

Examples of dependencies used in practice are:

- empirical – Figures, 2 - 4,
- mathematical relations:

$I_n = I_o \cdot e^{-D_n}$ - very rough estimate

$$I_0 - I_n = v \log \frac{D_n}{h} + 3\beta(D_n - h) \log e$$

in which I_0 is the size of the impact of disasters in the place of origin, I_n the size in place far away from the place of origin by D_n , ***h*** is the distance of place of origin from the Earth's surface locations, r_n, the distance measured along the Earth's surface ($D = \sqrt{(r^2 + h^2)}$), , ***v*** and ***β*** are numerical parameters. The first relation is just a very rough estimate, which applies only to the homogeneous and isotropic physical medium [6,14,16].

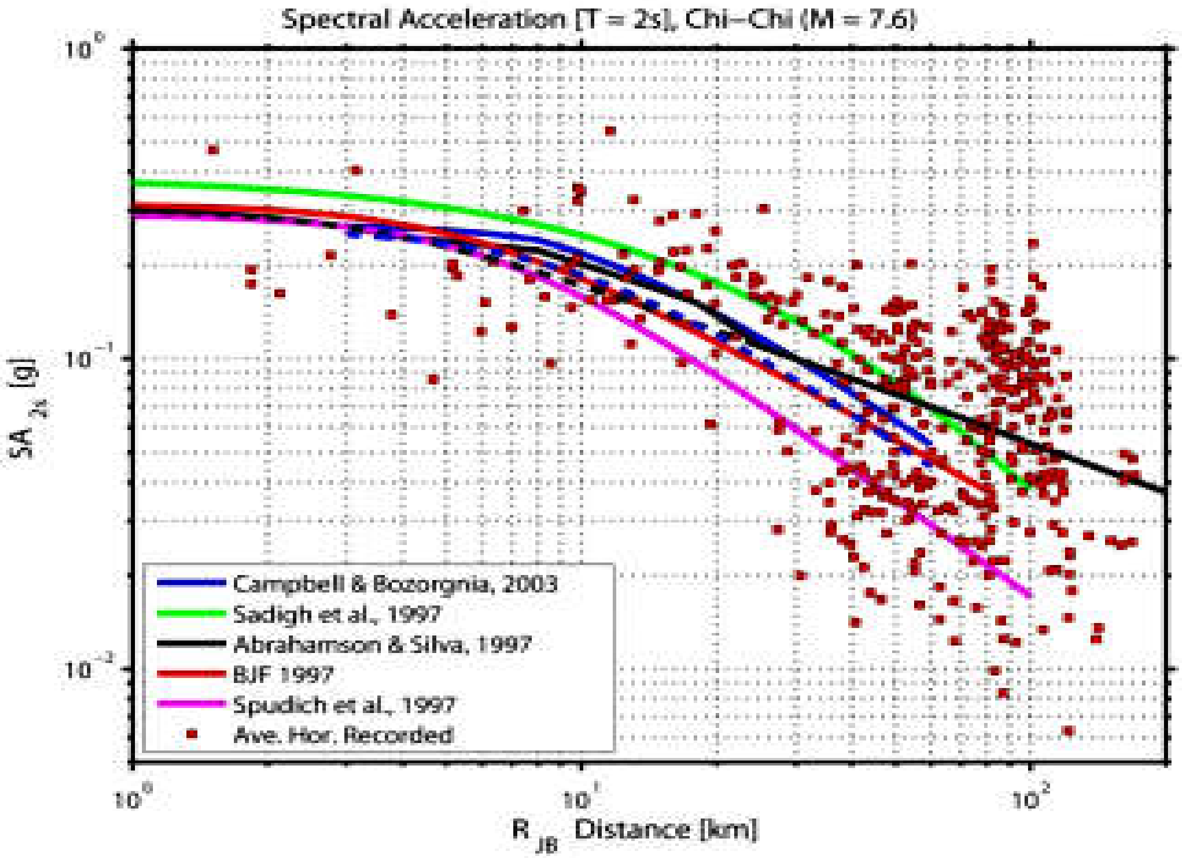

Fig. 2. Attenuation of earthquake acceleration from the origin place with the distance [18]

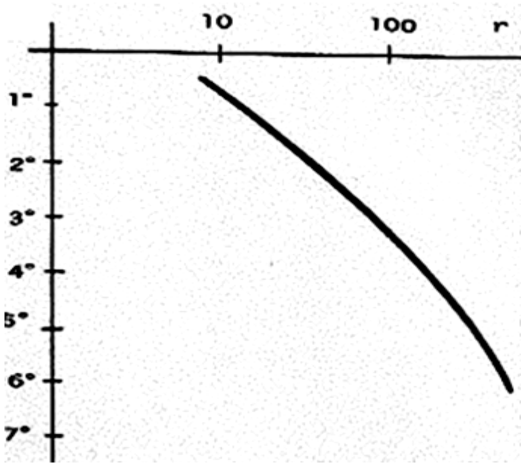

Fig. 3. Attenuation of earthquake intensity from the place of origin with distance [12]

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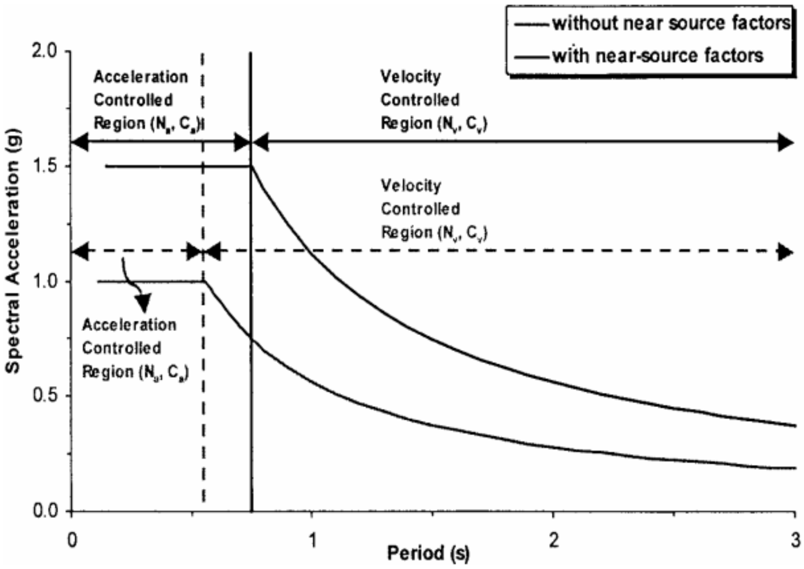

Fig. 4. Attenuation of earthquake acceleration from the place of origin with the distance [19]

Since no real system, i.e. territory and human society is not homogeneous and isotropic, there are regional and local dependencies (see examples above) and also there are anomalies (for example in detail for the earthquakes in [6,11-14]. The causes of the anomalies are:

- structural inhomogeneity,
- sources of domino effects,
- causes of synergies and accumulations.

Therefore, it needs to be carried out when are setting the terms of references the thorough investigation of vicinity of the complex technological facility and on its basis, then it is set the value of a site specific hazard for a specific disaster.

1.3. Determination of size of design disaster for terms of references

Damages, losses and harms associated with disasters of all kinds, depend not only on hazards posed by the disaster, which are calculated on the basis of the characteristics for the occurrence of disasters, but also on the vulnerabilities of site and of its surroundings in which the facility is located, and on the vulnerabilities of the technological facility itself [4,6,12,14,20-22]. Therefore, the credible specifications (terms of references) for the safe technological facilities are not only compiled on the basis of the results of the calculations which were characterized in the previous paragraphs, but they are corrected on the basis of a detailed study of the conditions in the surrounding territory, namely in several levels: regional, near vicinity, vicinity, and the site itself. Their exact destination substantially depends on the disaster and on the real technological facility [21-24].

To the value of the local hazard obtained by calculating or by estimation according to relationship specifically derived for the given disaster and the territory, it is added the safety reserve, which shall be determined by a thorough investigation around the place, which is selected for the complex technological facility. According to the nature of a real disaster, there are pursued the specific features in the territories bounded by radii: 1 km; 5 km; 25-50 km; and greater than 150 km. In the case of significant structural anomalies they are added the safety reserves on the basis of good engineering practice. The complexity of the analyses they show the analysis that have been made to the earthquakes [6,22]:

- Regional research covers the territory within a radius of 150 - 400 km around the site of a technological facility and its aim is to assess the ability of the geodynamic structures because the greater impact of earthquake under certain real conditions. The research is carried out by expert assessment and in relevant cases to the calculated site hazard value is added the safety reserve; a number of examples is in [24].
- Investigation of the near vicinity covers the territory within a radius of 25 - 50 km around the site of a technological facility and its aim is to assess the ability of geological structures to invoke the higher impacts of disaster on the technological facility from the perspective of stratigraphy, structural geology and tectonic history under certain real conditions. The research is carried out by expert assessment and in relevant cases, to the calculated site hazard value is added the safety reserve; a number of examples is in [24].
- The investigation of the vicinity is carried out in the territory of about 5 - 10 km radius around the site of a technological facility and its aim is to assess the ability of the subsoil and its fabric composition cause higher impacts of disaster on the technological facility under certain real conditions. The research is carried out by expert

assessment and in relevant cases, to the calculated site hazard value is added the safety reserve; a number of examples is in [24].

- The investigation of the site is carried out in the territory of about 0.5 - 1 km radius around the site of a technological facility and its aim is to assess the ability of the conditions of the hydrological, meteorological, hydrogeological and geotechnical characteristics, subsoil liquefaction and the composition of the slide material cause greater impact on technological facilities under certain real conditions. The research is carried out by expert assessment and in relevant cases, to the calculated site hazard value is added the safety reserve; a number of examples is in the [24].

Similarly, large territories as at the earthquakes are taken into account when evaluating the tornados, hurricanes, extreme rainfalls, etc. [11,24].

By that way, the resulting values of criticality for each disaster include in terms of references, which therefore summarize the parameters of design disasters. Using the terms of references the designers propose the parameters for design of technological facility (a way of foundation, specification of materials used, method of building, method of construction, types of equipment, fastening devices, etc.), so that it was ensured against the impacts of all the disasters with sizes less than or equal to the sizes of design disasters. Then, the criticality assessment is completed by calculation of the hazard from the downs of aircraft and from possible explosions in the immediate surroundings.

On the basis of the interface of design parameters with the parameters of technological processes it is then provides possible malicious processes for the actual technological facility and their risks [4,11,12,14,16,21-23], namely either, provided that the process is deterministic or random.

Deterministic processes are described by analytical functions of time, and therefore, it can be at any point in time determined their values. ***Random processes*** are described by the probability function, that in each moment determines the probability of the possible values, which it can accidentally acquire process realization.

Random process is stationary, when the probability density function is independent of the choice of the beginning of the timeline (i.e. the mean value does not depend on time). The statistical properties of no stationary processes are variable in time.

Random process is ergodic, when all of its implementations have the same statistical properties (it allows to estimate the parameters of the process from one implementation or the long-term process of the use of data from several different starting conditions); this is often tacitly assumed at calculations - and it can be a source of errors.

Example demonstrating the distinctions of results obtained by different methods

Values of seismic hazard for town in Central Bohemia

- **Reading the map of maximum observed intensities** for the CR compiled on data on earthquakes from last 800 years [25] – **hazard value 5.5 MSK-64.**
- Data – earthquake catalogue [88,97]. **Deterministic determination according to theory of extremes**:
  - time interval 50 years - **hazard value 5.5 MSK-64.**
  - time interval 100 years - **hazard value 5.7MSK-64.**
  - time interval 10 000 years - **hazard value 6.1MSK-64.**
- Data – earthquake catalogue [6,25]. **Probabilistic determination according to theory of extremes** – 81 variants:

  median
  - time interval 50 years - **hazard value 5.0 MSK-64.**
  - time interval 100 years - **hazard value 5.2MSK-64.**
  - time interval 10 000 years - **hazard value 5.5MSK-64.**

  median + standard deviation
  - time interval 50 years - **hazard value 5.1 MSK-64.**
  - time interval 100 years - **hazard value 5.3MSK-64.**
  - time interval 10 000 years - **hazard value 5.6MSK-64.**
- Data – earthquake catalogue [6,25]. Application of the PSA methods:
  - time interval 50 years - **hazard value 5.3 MSK-64.**
  - time interval 100 years - **hazard value 5.5MSK-64.**
  - time interval 10 000 years - **hazard value 5.9MSK-64.**

From above given data it follows that comparison is only allowed for the results of the same methods.

2. Risks and instructions for their getting over in benefit of safety

Damages, losses and harms caused by the disaster to the asset or of the system, i.e. to the facility depend on the physical, chemical, biological and temporal characteristics of disaster and the characteristics of the followed facility, namely the

technical and social ones. Direct damages are due to direct exposure to the disaster. Indirect damages are caused by the domino effects, i.e. by other disasters, which trigger the original disaster and by disorders of the infrastructures, which lead to a disruption of life sustaining services.
To ensure the safe territory and safe facility it is in practice for management needs (see the procedures for insurance companies and designers) computed the expected average annual damage

$$OPR = \Sigma_i\, OPR_i * N(i),$$

where the OPR_i is the expected damage when ***i***-the phenomenon and the ***N (i)*** is the annual occurrence frequency of the phenomenon.
At the critical complex facilities it is in process management [86] counted the so-called ***RPN* value** – i.e. the order of priority of risk with regard to the potential failure by help of the relationship

$$RPN = S * O * D,$$

where ***S*** is the severity of the impact ***O*** the occurrence probability and ***D*** is detection. Criticality is determined by

$$C = S * O * B,$$

where ***S*** is the severity of the largest impact , ***O*** the occurrence probability of the, and ***B*** the conditional probability that it occurs the most serious impact.
When design and operation of each complex technological facility it is necessary to consider the total risk ***R***, which includes both, the direct and the indirect losses on assets. Analysis of the emergency situation caused by disasters [6,11,24] shows that indirect losses are increased by:

- delays or errors in the response,
- cascades of failures caused by synergic and cumulative effects, which are caused by links and couplings among assets
- domino effects.

According to [4,20] the total (integral) risk, which it is the need to cope can be mathematically expressed by a relationship
S

$$R(H) = \left[\sum_{i=1}^{n} A_i(H)Z_i(H) + \sum_{i=1}^{n}\int_0^T\int F(H, A_i, P_i, O, t)\,\mathrm{d}S\mathrm{d}t\right]\cdot\tau^{-1}$$

where: ***H*** - hazard; A_i – the value of assets, $i = 1,2, ..., n,$ where ***n*** is the number of monitored assets; Z_i – the vulnerability of assets, $i = 1,2, ..., n$; ***F*** --loss function; P_{ij} – the occurrence probability of asset damage – conditional probabilities; ***O*** – vulnerability of safeguard measures; ***S*** – followed territory / facility; ***t*** – time that is measured from the origin of the harmful phenomenon; ***T*** – time for which they arise losses; and - return period for the disaster.
For the management and trade-off with risks, it needs to use the procedure shown in [28], which is the result of detailed research [26,27]. In practice, however, simpler procedures are used, namely the PSA method based on the application of the trees, which copied the architecture of the facility production devices, and this cause that it does not see the interdependences, nor in the facility, nor among the facility and its surroundings [11,21-2,29].

The risks are getting over by:

- Technical measures by:
  - selection of material for construction and equipment,
  - ways of structure,
  - embedding of passive barriers, which prevent the phenomena as an expansion of fragments or dispersion of dangerous substances when the loss of cohesion of a device or construction (e.g., envelopes of different types),
  - insert the backup devices and systems, i.e. several devices having the same role, and respectively, using the different physical principles to achieve a task,
  - inserting the protections of safety critical elements (e.g. containment, shelters).
- Different types of control systems that according to continual monitoring results adapt the operation.

- Organisational measures to protect both, the employee, labour environ and also surroundings from the harmful impacts, and the construction and equipment from the great destruction because the complex technological facilities are not cheap and for preservation of the capability of development there are their products desirable.

3. Selected findings for management of critical facilities

As mentioned above, they are not in the design, construction and operation of technological objects considered all of the factors, which are the source of the risk, i.e.:

- emergent links and couplings, which are possible only under certain conditions,
- the sizes of the disasters that are larger than the size of design disasters
- failure of safety elements, components, equipment and systems,
- unusual or deliberate failures of human factors, etc.

Critical conditions of system are the conditions for which the system was not designed, which can lead to situations that threaten the system itself and surrounding the system.
Safety of the system is a property of a system which ensures that even in critical conditions, the system will not endanger itself or its surroundings. This means that safety is put above the reliability.
In the next it is given the supplement to theoretical results the assessments of which are given above:

- Each dynamic process develops over time and it can be described by ordinary differential equations for continuous systems or algebraic equations in the case of discrete time periods. A linear system is a system that can be to describe by a linear function. If they are dynamic processes of linear and time-invariant, so for their description it can be used: Laplace transformation for continuous systems; the z-transform for discrete systems, and according to the transfer function to determine whether the system is stable, unstable, or at the interface [20]. The non-linear systems are e.g. systems with the hysteresis. Under certain conditions they demonstrate the phenomenon that is sensitive to initial conditions, i.e. called deterministic chaos.
- The system stability is the capability of system to return into original state after removing the disorder. The second law of thermodynamics says that in every system there is a tendency for the growth of entropy, i.e., to the rough-and-tumble. The fact that a number of systems, there is a long time in an ordered state, i.e., it has low entropy is given by the fact that the tendency to growth of entropy, according to the second law of the thermodynamic is applied to homeostasis. ***System homeostasis*** is the capability of the system to maintain a relatively constant internal medium, even when the external medium changes.
- An attractor is the trajectory of the system in the system of phases, to which the dynamic system in the long term is going. The behaviour of the system is the way of the system's response to stimuli, or the way of the realization of the objectives of the system. Interoperability is the capability of all systems creating the SoS performs processes so that functions are fulfilled.
- Not only in monitoring the disasters, but also in engineering practice, the available data are often available in small quantities and are not of good quality. In some cases, it is the fundamental problems because there is no accurate models and the exact values of the parameters; the information is inaccurate, dispersed, incomplete, sketchy, vague, non-homogeneous, or just a verbal. Among the basic types of uncertainties it includes [14,53]: randomness as the natural characteristics of basic variables, the statistical uncertainty due to limited range of data, a model of uncertainty caused by imperfections of computational models of uncertainty caused by the inaccuracy of definitions of the limit states, gross errors caused by shortcomings in the activities of the persons, and ignorance of the actual behaviour of materials and structures. Because of deterministic and probabilistic methods gradually replacing when designing critical facilities and equipment. However, even these have limitations, because even the exact observance of the norms and standards for the time being all the uncertainties that exist in the real world.
- Probabilistic methods of designing structures are generally only work with the first three types of uncertainties. It turns out that a fourth type, uncertainty, can partly be described on the basis of the theory of fuzzy sets [31]. Theoretical tools for the description of the blunders, however, are very limited, for the description of ignorance of the actual behaviour of new materials and structural systems are not in advance of any. The other three types of uncertainties the probabilistic methods do not involve practically at all and the only way to alleviate their consequences is to check the quality. Possibility of application of theoretical tools for the description of the different types of uncertainty is therefore limited. This situation also approximately corresponds to the shares of the causes of breakdowns, whose informative values are listed in table 1 [30]. The first row of table 1 shows the origins of disorders from the perspective of basic activities related to construction and design throughout its lifetime, the second line then suggests addiction shares these activities at lapses in the activities of people (about 80%) and on the influence of the environment (around 20%), which are not directly dependent on the activities of the persons. Environmental influences include randomness and some dangerous situations (fire, explosion,

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collision). Randomness is involved in the formation of only a small proportion of disorders (about 20%) and the refinement of the classic probabilistic methods have limited reach.

Table 1. Designation of origin and causes of disorders in technological units derived in the Czech Republic [30]

Origin	Designing 20%	Implementation 50%		Operation 15%	Other 15%
Causes	Gross errors caused by the activities of persons (human failures) 80%			Environmental influences 20%	

According to the cited work of probability can be determined on the basis of several basic methods: accurate analytical method (exceptionally for a small number of fundamental quantities); numerical integration (for a small number of fundamental quantities); approximate analytical method (FORM, SORM, the method of moments); simulation methods (simulation of a direct allocated, adoptive); and the combination of the previous methods (with approximations of the resulting quantities). Practical application of probabilistic methods interferes with many of the shortcomings of the [30], which are gradually eliminated. The most important shortcomings are: uncertainty in the definition of the limit State function (presence, above which it loses the ability to meet the functional requirements of construction); the uncertainty of theoretical models of fundamental quantities; and insufficient consideration to the consequences of failure. Some uncertainty is difficult, if not impossible to describe, in theory, others suffer from a lack of experimental data. It is therefore necessary to proceed with caution [30].

The probability that a certain event occurs, is not ***the fact itself***, that we discover, but it is ***estimated*** on the basis of the facts. Recently, increasingly used in calculations of probability Bayesian approach [32], which can be characterized as a means of learning efficiency in the face of uncertainty, using the relation

P (event A |observations B) = P (observation B|event A) P (event A) / P(observation B),

where P (event A | observation B) is the ***aposterior*** probability P (event A) is ***the a priori*** probability of the event, P (observation B | event A) is the ***conditional*** probability or the option / the credibility (likelihood) of observation B, if the event A occurred and, P (observation B) is the probability of observing B independently on event A. The Bayesian approach is also known as subjective, because apriori probability expresses the degree of beliefs, which may be expressed by a distribution function probability.

- On the basis of a very detailed analysis of the methods used to ensure the safety of objects, the Beer and the team 33 recommend to apply the methods of risk engineering, and especially in complex technological systems, the model of which is "system of systems", whose characteristic features are random and epistemic uncertainties, which are the results of the different natures of individual systems and the fact that no system is stable in all conditions. Random uncertainty, the authors considered to be property of the system, which can be dealt with applications of probability theory. Knowledge uncertainties follow from the fact that the information is objective or subjective, and this is true even for expert opinions, or team consensus. Sources of information for the engineer may differ, the essence of and the trust, include maps, plans, measurements, observations, professional experience, knowledge and so on. It also must take into account the changes in boundary conditions, and environmental conditions, which are often just a hypothesis [34]. For the engineering solutions are then used in numerical models for quantitative manner when they ignore relevant information or theoretical models with application of undue assumptions. In both cases, the calculated results can significantly deviate from reality, and related decisions can lead to serious consequences.
- Because the necessary knowledge comes from measurements or estimates of experts; the measurements are never completely accurate, and expert estimates are not absolutely accurate, solutions to the problem are described in the literature from various perspectives – the Bayes estimation of the probability interval approach, random sets theory options fuzzy stochastic concept and the theory of chaos 20,35-38. Different approaches provide considerable flexibility in modelling uncertainty and ambiguity. Realistic mathematical approach can be formulated only by analysing the nature of the information available in each individual case. To support this analysis and modelling is necessary to carry out the classification of the available information according to established criteria.
- In situations when we have a large number of observations, we can determine the distribution of the probability of having observed and determine the value of random uncertainty. As has already been said, so the real observations show that disasters with extreme sizes occur irregularly in time and rarely. For the security solution can be used as good engineering practice and real expertise (e.g., each material has specific physical limits for the deformation of each tank contains only a certain quantity of dangerous substances, etc.).
- In this context, it is sometimes argued that expert knowledge can compensate for the lack of data and the limitations of information using Bayesian methods. Bayesian approach is dedicated to still greater attention in the engineering disciplines. It is usually on the basis of expert knowledge will determine the appropriate model and according to the knowledge of the group creates a subjective distribution function.

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- Bayes' theorem is a theorem from probability theory, which indicates how the conditional probability of a phenomenon related to the reverse conditional probability [38]. Consider two random phenomena, thus A and B with probabilities ***P(A)*** and ***P(B)*** and ***P (B) > 0.*** Then ***P(A | B) = P(B | A)*** (P(A) / P(B), where P(A|B) is the conditional probability of the phenomenon A, provided that a phenomenon B occurred, on the contrary, P (B | A) the probability of the phenomenon B is conditional on the occurrence of the phenomenon A. Bayesian Networks are probabilistic models of graph-based representation [39]. They are used in decision making in cases where the data are uncertain, i.e. they are loaded with random and epistemic uncertainty. It is based on the theory of probability and allows work with the many bulky probabilistic distributions. It uses the conditional probability.
- ***The theory of possibilities is*** also called theory of Demster-Shafer, and it can be seen as a generalization of the traditional theory of probability. According to [40] it goes on the axiomatic characteristics of random sets. It uses for probability the assumption about the additivity, i.e.

$$P\,(U\,A_i) = \Sigma\,P\,(A_i).$$

On its basis it holds for the rate of uncertainty $M\,(A_i)$ that $M\,(A_i) \leq M\,(A_k)$, when $A_i \quad A_k$ which, according to [2] leads to the monotonous rate.

The most popular is the Demster´s rule for the combinations, which can be interpreted as a generalization of Bayes' theorem [41], i.e.

$$M\,(B) = M\,(B_1B_2) + M\,(B_1) + M\,(B_2) + \;.\; M\,(B_1)\;.\;M\,(B_2), \quad -1, \text{ when } \quad B_1B_2 = .$$

It is known, however, that this rule can yield conflicting results when there is a fundamental conflict between the estimates, since it excludes the conflict when the specification of measures [42], which could be problematic in the safety analysis in particular. Some experts argue that the rule is correct, but that it may be largely irrelevant in probabilistic reasoning [43]. Areas of use are very broad, Detailed discussions and p engineering applications [33]. The critical point in the practical application of the reference theory is the realisation of basic probability assignment in each individual case. The traditional statistical methods of estimation and test theory are not usually used for this purpose. Results of the subsequent analysis of uncertainty, however, basically depend on the quality of the basic probability assignment.

- ***Interval estimation*** the population parameter is called an estimate using the numeric interval, in which the value of the parameter is the probability close to 1 (100%). Significance level reflects the accuracy of pronunciation and speech conclusion – most often in $v = 0.05$, or ***0.01***. The value 0.05 means the possibility of error 5%, the value $p = 1- v$ is the probability that the result is correct. The interval estimate is based on the probabilistic analysis of the boundary, which is another approach for the quantification of uncertainty, which is considered part of the theory of imprecise probability [43]. The theory is based on the idea that the value of the variable x are, de facto, the values from the marquee of the interval, and the interval of the probability is based on the idea that the probabilities are bounded, then a probabilistic analysis based on interval estimation is the combination of these two ideas [33]. It is a numerical approach, which allows the calculation of the boundaries of an arithmetic combination of the probability distributions are known only for the input distribution. Access allows you to perform calculations without having laid down very precise assumptions about the value of the parameter or variable dependencies. In principle, access allows you to decide which assumptions are reasonable and which are not [4,10]. When information about distribution is very good, the boundary between the split are very tight and the Monte Carlo simulation can be used. Otherwise, the interval will be wide and will be hard to find credible layout.

Method of P-boxes uses the assumption that the proper distribution of the cumulative probability of $F(x)$ lies between the two border divisions, which are defined by cumulative probability distribution functions, $F_1(x)$ and $F_2(x)$, i.e.

$$F_1(x) \leq F(x) \leq F_2(x),$$

for which it holds the following:

$$\overset{\infty}{\underset{-\infty}{}}\; x\,dF_i(x)\;\; m_i,$$

$$\Big(\overset{\infty}{\underset{-\infty}{}}\; x^2\,dF_i(x)\Big) - \Big(\overset{\infty}{\underset{-\infty}{}}\; x\,dF_i(x)\Big)^2\;\; v_i,$$

for $i = 1,2$ and $F_i \;\; F$.

Restriction means that the distribution function ***F*** falls within the prescribed limits, i.e. the mean value is between the values of m_1 and m_2 and the dispersion between values v_1 and v_2. The example in [33] shows that the application has been successfully used in a number of areas, for example. in: the analysis of the failure of the systems; the analysis of the reliability of the system; the quantification limit of the method of finite elements, uncertainties; the application of differential equations for chemical reactions; study design; risk assessment in the pharmaceutical industry, health and the environment, and even the global circulation models.

If we look at its assumptions and its limitation is that it cannot be used, when the inputs are stochastic or functional dependency, i.e. in cases there where there are interdependences, which are the basis for a system of systems, which represent complex technological objects.

From the above follows that, once again, we accept the fact that complex technological systems, the systems are i.e. socio-technological systems, on the formation and operation of participates in man and his finances so they appear completely new problems, because we have to consider the intention of the investor and the issues of legal, financial, insurance, business, political and social, natural, and even some more. Therefore, in accordance with 44 is true, however, that the problem is in this expanded conception of the complicated, because you can't simply to abstract mathematical, statistical and mathematical-probabilistic solution of resulting in system reliability factors into the design likely disorders or other variables with which we work in the design of building structures. When we add still corruption, so ... perhaps we can provide safety only in exceptional cases. Therefore, we have to apply the methods of risk engineering and real people's choices.

4. Grounds for solving the conflicts in management of safety of complex technological facilities

Because the problems of transparent solution of conflicts have not been sufficiently used in practice yet, we give some data from the theory of conflicts. Technological facilities are open systems which are composed from mutually interconnected subsystems which play in fulfilling that objective and at the same time, an important role in the critical states can seriously endanger people's basic goal. Practical experience shows that the solutions to their critical conditions arise often, conflicts of interest and the whole theory, how to resolve conflict in the management of technological systems, for example. [45-47]. According to above work it is necessary to resolve conflicts constructively, so that they were the most satisfied and achieve the strategic objectives of the human society. ***It is therefore seen as a conflict management process planning, how to achieve a mutually advantageous solution of serious problems***.

The tool requires that both parties to the conflict have agreed in advance to deal with the expected contentious issues with regard to the established interests and goals [8], which are in our case, the public interest, i.e. ensuring the safety and development of the people, now and in the future [48].

On the basis of pro-active approach, which is own to project and process management [49], it can be a quick and effective solution to the conflicts in critical situations in advance to prepare a risk management plan for the Assembly, which is the agreed projected stakeholders [50], because each time the delay leads to further damage.

5. Summary of findings for work with risks

Good governance and correct decision making is possible only when we have the correct data, and we can take advantage of the instruments that we have available [51]**.** Often, there is not verified the quality of the data files, the relationship between the accuracy of the data and the sensitivity of the method, and the assessments do not respect the system nature of facilities, i.e. the influence of links and flows.

Risks were, are and will be and will constantly discover new. Management and trade-off with risks that are caused by disasters requires the range and measurement of risk that take into account not only the physical damages, the victims and the equivalent of the economic losses, but also social, organisational and institutional factors. It is the reality that most of the techniques on the determination of the risk does not represent a holistic approach, and does not respect that the risk is divided into local, regional and state level.

The basic principles for the work with the risks are: to be proactive; imagine the possible consequences; properly determine priorities from the perspective of public interest, think about mastering the unacceptable impacts, consider synergies, and be alert, which corresponds to the philosophy promoted by in work [4,52]. Therefore, when determining the risk for strategic decision-making it needs to use a hierarchical multi-criteria approach.

When assessing the acceptability of the risk this is a comparison of the value/risk level risk analysis found the reference system with the limit of acceptability or limit functionality of acceptability. The position of the individual to the risk depends on the perception of risk and the risk of stress, which causes the individuals (death, injury, loss of employment, etc.). The attitude of society to the risk also depends on the overall perception of risk, the risk-averse, for example, one accident with a greater number of victims in one case is less acceptable than a higher number of accidents with victims, and despite the fact that the total sum of the victims for a specific period is the same. The company accepts, when a group of people is exposed to the risk in order to obtain benefits for different groups of people. The role plays the ratio between the costs for increasing the safety and the number of lives saved, media attention, etc. The acceptability of the risk depends on the

social, economic and political factors and the perceived benefit from the activities for which the benefits are substantially higher than the cost of the rescue and clean-up work in the realisation of the risk.
From the viewpoint of practice it is the need to agree on what the requirements will be output from the risk assessment meet. At risk assessment it is necessary to try to comply with the requirements and possible non-compliance reasons. These are mainly of compliance: the execution of the evaluation in the breadth and quality, in accordance with the accepted methodology of evaluation; the completeness of the evaluation; the inclusion of the latest knowledge of science; an estimate of the random and epistemic uncertainties in the case of the use of extrapolation; uniform representation of the characteristics of the risks; and transparency in the implementation of the risk assessment process.
It is clear that when we are not capable to identify and analyse the risk, we are not capable to defend effectively against it. The error, which allowed for the identification, analysis and evaluation of the risk is transferred to the emergency and crisis plans, business continuity plans and reduces their value in relation to the planned measures aiming in particular to the protection of human life and health, but also in the area of operational rescue forces involved in the implementation of the rescue operations.
The world is, however, a complex system of systems in both vertical and horizontal plane, and therefore, its behaviour is a heuristic, i.e. it is highly variable, depending on the internal and external conditions, which means that in certain situations they arise unexpected phenomena that in real life can bring appreciable losses and damage, because they are the consequences of the phenomena with which the humans on the basis of their knowledge do not count [4,53], because they are not detectable by stochastic methods that only work with random uncertainties. Only today, especially for complex systems of systems to prevent: atypical accidents and cascade failures of the infrastructures, we are trying to cope with the risks, the sources of which are epistemic uncertainties, i.e. vagueness'. We use multicriterial approaches [4,10].
Systematic work aimed at reducing risks is documented since the 1930 's. years of the last century. On the basis of a critical assessment of the present knowledge, the results of which are:

- The choice of relevant parameters (dimensions, factors, characteristics) disasters
- The identification of measurable items (indicators) that represent the various parameters of the disaster for specific cases.
- Scoring of each parameter on the basis of collected data.
- Evaluation of using weights and formulation of the multiparametric profile of the disaster.

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