Proceedings of the 33rd European Safety and Reliability Conference (ESREL 2023)
Edited by Mário P. Brito, Terje Aven, Piero Baraldi, Marko Čepin and Enrico Zio

doi: 10.3850/978-981-18-8071-1_P068-cd

Resiliency of Industrial Complexes Powered by Small Modular Reactors

Dana Prochazkova

Czech Technical University in Prague, Technicka 4, 166 00 Praha 6, Czech Republic, Danuse.Prochazkova@fs.cvut.cz

Jan Prochazka

Czech Technical University in Prague, Technicka 4, 166 00 Praha 6, Czech Republic, Jan.Prochazka@fs.cvut.cz

Vaclav Dostal

Czech Technical University in Prague, Technicka 4, 166 00 Praha 6, Czech Republic, Vaclav.Dostal @fs.cvut.cz

Industry is the engine of development of the States when it is safe and competitive. However, it is energy-exigent, which is why the current problems in the energy sector are forcing the businesses to look for other sources of energy. Due to the increasing availability and safety of small modular reactors, in the present article, we propose to connect industrial facilities with a small modular reactor in a certain area. This will create very complex systems that can only be given the expected performance if they have high resiliency. This means that they will be composed of safe objects and the whole will be safe and have the ability to quickly perform a qualified response and maintain performance at a specified level even under critical conditions. With regard to the variability of the world, both, the safety and the resiliency must be managed. In the article, we present the methodology for safety and resiliency management on a real example that we solve in practice.

Keywords: Industrial complexes, SMR, risks, safety, resilience, resilience management model.

1. Introduction to Problem

Industry is an important sector of the economy of developed countries. It applies various technologies that contribute to economic development and human prosperity. The supply of products and services must, therefore, be of high quality and safe. The safe operation of industry requires raw materials, energy, well-managed technology, qualified personnel and qualified management, as well as measures to reduce unacceptable impacts, such as pollution of environmental components and damage to the health of humans who work in hazardous operations and possibly in their surroundings. From an economic point of view, industry must also be competitive, and therefore, it is highly dependent on available resources.

At present, there are problems in the area of material and energy resources in Europe, which seriously threaten the operation of industry. In the present article, we, therefore, deal with the energy base for the operation of industrial plants concentrated in a certain area. Due to the development and advantages of small modular reactors (*further SMRs*), we propose to insert the SMRs into the area with industrial plants. In practice, this means the creation of complex units (systems), where a number of technologies powered by SMRs are located in a certain area. It is a fact that every technical installation and SMR has its limitations and, moreover, they influence each other. It is also a fact that from certain conditions onwards, interactions will become unacceptable, and lead to distortions in the performance of the whole.

In order to ensure sufficient performance of the industrial complex, it is necessary to ensure immediate response and then recovery, so as not to cause problems in the State that could also trigger problems in the social field. To avoid major problems, industrial complexes powered by SMRs need to be managed so that they are both, safe and highly resilient. Resiliency means that they are resistant to failures and have the ability to react quickly, take the right response measures and return to their original condition soon.

Resiliency of an industrial complex powered by an SMR means adjusting a complex SoS (*Open System of Interconnected Open Systems*) system so that during the operation: it is robust; redundant; inventive; and fast. The insertion of the properties in question guarantees the optimal operation of the industrial complex, i.e. the required level of safety, performance and reliability (Prochazkova et al. 2019). Because the conditions for operation change due to the dynamic development of the world (i.e. changes in internal and external conditions), and sometimes by leaps and bounds, resiliency must be managed competently.

Based on current knowledge, the resiliency management of industrial complexes powered by SMRs must be integrated and strategic. Its aim is to optimize the operation of the industrial complex over time so that under all conditions that must be considered in the design, the risks of the both, the whole complex and its individual parts would be acceptable and functional failures in the complex weree not tolerated (Prochazkova et al. 2019).

The paper proposes a model of management of both, the safety and the resiliency of industrial complexes powered by SMRs on an example. It is based on models based on risk management in favor of safety for individual industrial units and sets limits for the operation of individual units so that the safety and the resiliency of the entire complex powered by SMRs is maintained under all design conditions.

2. Energy Need of Industrial Complexes

Among energy exigent industries, they belong the production of metals, including the metallurgical processing, the chemical industry, the production of mineral products, the processing the non-metallic materials, mechanical engineering, glass and ceramics, paper, pulp and printing, which together account for almost 70% of the total final consumption of fuels and energy in industry; the food industry is also energy-intensive. According to Eurostat statistics (EU 2022), these sectors cover 95 % of total industrial consumption. Although the operations in question are becoming more and more improving, they need energy.

Promising sources of energy are small modular reactors - SMRs (ARIS 2020, Pannier, Skoda 2014), which have been tested in submarines and icebreakers. Their risk-based design projects, we permanently follow (Prochazkova, Prochazka, Dostal 2021) and their safe operation must be regulated by international safety standards developed by the IAEA (2022). The choice of SMR depends on the supply in the market; currently, commercial Generation IV SMRs are still not available. The advantage of the Czech Republic is the high technical education of the population and experience with the operation of nuclear power plants.

3. Safety and Resiliency of Interconnected Complex Systems

An analysis of the literature (Ale, Papazoglou, Zio 2010, ASIS 2010, Baraldi, Di Maio, Zio 2020, Beer, Zio 2019, Bérenguer, Grall, Guedes Soares 2011, Briš, Guedes Soares, Martorell 2009, Castanier et al. 2021, Cepin, Bris 2017, Haugen et al.2018, Hollnagel 2014, 2020, Hollnagel, Woods 2017, IPSAM 2012, ISO 2017, Leplat 1987, Leva et al. 2022, Leveson 2004, Leveson et al. 2003, Leveson et al. 2006, Nemeth, Hollnagel 2022, Nowakowski et al. 2014, Podofillini et al. 2015, Prochazkova et al. 2019, Rasmaussen 1997, Steenbergen et al. 2013, Sterman 2002, Walls, Revie, Bedford 2016) shows that there is a disagreement among experts in concepts for good management of entities aimed at safety and performance.

In some works, the traditional concept of safety is called Safety-I, and for use in complex socio-technical systems, it is recommended to use the concept of Safety-II and resiliency engineering because they have practical approaches; they emphasise the role of preparedness, response and recovery. In other works, which address the issue of tightly connected systems, in which they consider various technologies, organizational management and automatic control, the emphasis is on performance management and on mana-gement of the risks associated with nonlinear, indirect and feedbacks. However, when solving the practical tasks, theoretical ideas and models are not enough, but a practical solution is needed that also meets the requirements of applicable legislation. Legislation demands safety and economics demands performance. Since the objecti-ves are in many cases conflicting, it is necessary to find an area of harmony and operate the industrial complex there in.

Since the 90s, safety has been considered an essential sign of system quality (EU 1992, UN 1994). It is created by using the technical and other norms and standards that ensure that systems are resilient to design disasters. Since the safety of the system depends on the resiliency of the system, which is given by the limits that are in the design for: the structure and form of the composition of the elements of the system; the form, direction and intensity of the system's links; the form, direction and intensity of system flows; and the creation of new or loss or significant change of interdependences, i.e. links across the system and its surroundings, so the change of conditions often leads to disruption of elements or links of the system or to the emergence of unacceptable interdependencies that disrupt the required level of system safety.

Due to the complexity of industrial complexes (Prochazkova 2017, Prochazkova et al. 2019), specific characteristics such as: interoperability; safety integrity (SIL); criticality; and reliability, must be followed. Therefore, there are three priority guidelines, the factors of which need to be monitored when protecting workers of technical installation: to carry out an effective way of protecting a person; to implement environmental protection; and to establish limits and conditions for the operation of the monitored equipment.

Because due to the dynamic development of the world, the size of risks changes and new risks arise, it is necessary to manage risks. The system resiliency is determined by the system design and its increase by technical measures during operation can be achieved only in a small range (Prochazkova 2017, Prochazkova et al. 2019). Therefore, when operating the system, it is necessary to reduce the level of vulnerability and increase resiliency also through organizational measures and education. This means managing the risks over time to ensure the required level of safety and system performance.

The concept OECD (2002) has brought great progress in ensuring the safety of industrial facilities. In work (Prochazkova 2017), based on experience from practice, a model of risk management of object, which is a complex system, was created in favor of integral safety, based on the integrated management of six processes and their subprocesses, which was later supplemented by a process that ensures not only physical security, but also cyber security of the object (Prochazka, Prochazkova 2022).

If we connect several disparate objects in the form of complex systems, a control problem arises, because the vulnerabilities and resistances of individual objects to disasters of all kinds are usually not the same. It is, therefore, clear that ensuring the required performance and safety management of a unit consisting from disparate objects in the form of complex systems is not easy, because each object is subject to certain limits and conditions given by the design, which are not the same. Therefore, it is also necessary to use the concept of resiliency management. Resilience or rather resilient performance is about how an object works and not about how safe it is.

System resiliency expresses the potential of a system, which lies in a specific system design that maintains system functions and feedbacks, which include the ability of the system to reorganize itself in response to changes induced by failures (Prochazkova et al. 2019). Resilience management is the process of integrating all of an organization's protection activities into a single, clear governance structure. It has two goals: to prevent the object from getting into unacceptable conditions due to external faults and external loads; and to preserve the elements triggering the systemic reorganization and renewal as a result of massive changes. It means: safety defines the condition of entity in case when it is protected from danger, risk, or injury; and resilience defines the capacity to recover quickly from difficulties, i.e. toughness.

Based on above cited works, the resilience management is the process of integrating all of an organization's protective activities under one, clear, management structure. The methodology is subdivided into two areas: readiness and response. Readiness activities are the things that an organization has in place to prepare for or to prevent an incident from happening. There are numerous readiness activities, and no organization will carry them all out; organizational leaders will determine those that are most appropriate for their organization. Examples of readiness activities include operational resilience, business continuity, disaster recovery, and various governance, risk, and compliance processes (Prochazkova et al. 2019).

Whereas traditionally these activities were carried out in their own separate silos, with resilience management these areas are all centrally directed. Response activities, such as crisis management and emergency notifications, are capabilities that an organization has in place to manage an accident or crisis. They are designed to ensure that the organization can quickly and effectively respond to any event to minimize the impacts and to manage a rapid return to business. Taking a resilience management approach ensures that all response activities are coordinated holistically and efficiently.

4. Method of Management of Safe and Resilient Industrial Complexes

Engineering techniques to ensure system reliability, safety and toughness are based on risk management. However, the objectives of risk management are not the same for the mentioned disciplines and their fulfilment is associated with a number of random and knowledge uncertainties (Procházková 2017). Therefore, making the decisions about them requires the application of system analysis principles. It is necessary to use multi-criteria evaluation of items that determine the behavior of the industrial complex from a number of areas that are not easily commensurable. In practice, the concept of Maldistributed Utility Theory (Keeney, Raiffa 1993) has proven itself as it makes it possible to determine numerical values of the aggregate utility function (or integral risk) for a given combination of items. The result of the application of the theory are decision support systems (*further DSS*), which are a tool for managing the monitored entity.

Practical experience (CVUT 2023, Prochazkova et al. 2019) shows that in order to quickly and qualitatively address problems of response to unacceptable situations of individual parts of industrial complex and the whole, risk management plans (ISO 2010) based on the total quality management (Zairi 1991) should also be drawn up, which consider the priority risks of the given entity that could not be dealt with by the measures in the design. They contain the measures for minimizing the seriously damage of considered entities and must be interconnected with recovery plans (Prochazkova et al. 2019) .

5. Data on Industrial Complex

Analysis and detailed study of 7289 accidents and failures of technical installations (Prochazkova et al. 2019) showed that 80% of accidents and failures are caused by a combination of several sources of risks; highly vulnerable are the interconnections between elements, not only between those that are intentionally inserted in the design, but mainly those that arise unplanned under certain conditions and that were not considered in the design. It follows from the logical reasoning that the more complex the object, the more possibilities of interconnections that are not considered in the design. A particularly great danger arises in cases where we connect existing objects into a complex system.

In order to ensure an economically acceptable energy base for the Czech industry, we plan to build industrial units powered by SMRs. Figure 1 shows a model example of one of the units that is in preparation. Locally specific sources of risks, their size and frequency of occurrence, the magnitude of their maximum impacts on the territory in which the monitored industrial complex is located are in the archives (CVUT 2023). The industrial complex includes highly energy-intensive operations such as: foundry (about 4 GWh); metal processing (approx. 4 GWh); and surface treatment (approx. 4 GWh); in total, the power requirement is 20 GWh.

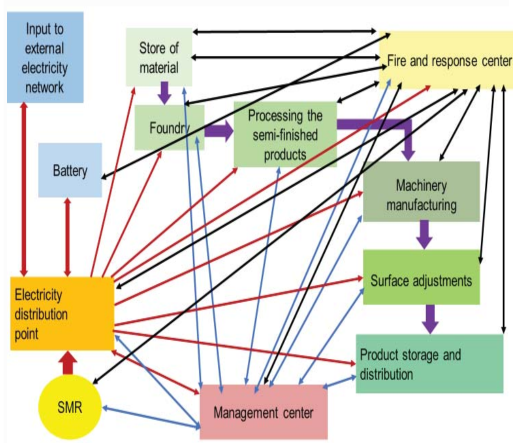

Fig. 1. Model of the monitored complex object. Red arrows indicate energy transfer; purple arrows indicate the manufacturing process; blue arrows indicate management processes; and black arrows indicate the emergency links in place; real dates are in (CVUT 2023).

6. Management of Safety and Resiliency

In the integrated management of the safety and resilience of the system in question, it is necessary to consider the facts and requirements of legislation. It goes on operational safety of the SMR, which depends on both, its risk-based design and its risk-based operation, which requires continuity and long-term stability of performance (Prochazkova et al. 2019). It is necessary to respect the working process of industrial plants, which has an alternating schedule; e.g. two-shift operation, free Saturdays and Sundays, holiday breaks (CVUT 2023). Further, it is necessary consider that downtime of individual plants cannot be ruled out, e.g. from a maintenance point of view (CVUT 2023), and this brings another problem to such a complex management of this industrial complex.

Therefore, from the point of view of sustainability and resiliency, it is necessary so the industrial complex contains not only specific facilities, namely: response center; storage of excess energy; and interconnection to the external network, but also high cooperation requirements of all involved at management of safety and resiliency. From the point of view of the management of safety and resiliency of the followed complex, which should ensure the stable performance of the industrial complex and prevent contamination of the environment by radioactive or toxic substances, it is a matter of setting requirements for:

- high safety of SMR operation, because it is not only about performance, but also about preventing the leakage of radioactive and toxic substances,
- high safety of the operation of the control center and the links between the control center and the SMR, because it is the highest level of complex control, on which depends not only the performance of the industrial complex, but also the prevention of leakage of radioactive and toxic substances,
- high safety of: operation of the response center; link between the control center and the response center; and the link between the SMR and the response center, as this is the second level of management of the industrial complex, on which not only the performance of the industrial complex but also the prevention of radioactive and toxic releases depends,
- safe operation of partial parts and other partial links that are important for the performance of both, the individual units and the complex operation,
- setting the limits for operation of component parts so that the performance of the industrial complex is safe and smooth under normal and abnormal conditions,
- readiness and response to all expected critical conditions that will impair the performance of the industrial complex so as to ensure the internal ability of the industrial complex to maintain or regain steady conditions.

The aim of managing the safety and resilience of a whole consisting of disparate objects in the form of complex systems is to find such thresholds for individual objects and such a way of cooperation of the management of individual objects that ensure the properties of the whole, which are: robustness; redundancy; ingenuity; and the speed of starting the correct response if necessary (Prochazkova et al. 2019). From the point of view of the management of a complex consisting of disparate objects in the form of complex systems, it is necessary to determine the limits and conditions for operation for each object so that: the failure of one object does not interfere with the operation of the other objects and that the failure is as short as possible.

Based on the knowledge and experience summarized in (CVUT 2023, Prochazkova et al. 2019) for each item marked in Figure 1, DSS is created to support decision on risks with respect to safety and resilience. The DSS for risk decision of the whole complex with respect to safety and resilience is in Table 1. The above mentioned items, the safety of which is the most important are written by red color.

Table 1. Industrial complex decision support system; A- assessment.

Criterion		A
Rate of risk of	industrial complex with regard to organization accident	
	management centre	
	management link between management centre and SMR	
	management link between management centre and object for store of material	
	management link between management centre and foundry	
	management link between management centre and object for processing the semi-finished products	
	management link between management centre and object for machinery manufacture	

Table 1 (continued)

management link between management centre and object for surface adjustments
management link between management centre and object for product storage and distribution
SMR energy supply between SMR and electricity distribution point
energy transfer between electricity distribution point and battery
energy transfer between electricity distribution point and external electricity network
fire and response centre
energy transfer between electricity distribution point and fire and response centre
electricity distribution point
energy transfer between electricity distribution point and store of material
energy transfer between electricity distribution point and foundry
energy transfer between electricity distribution point and objects for processing semi-finished products
energy transfer between electricity distribution point and object for machinery manufacturing
energy transfer between electricity distribution point and object for surface adjustments
energy transfer between electricity distribution point and object for product storage and distribution
store of material
product transfer between store of material and foundry
foundry
product transfer between foundry and object for processing the semi- finished products
object for semi-finished products
product transfer between object for processing the semi-finished products and object for machinery manufacturing
machinery manufacturing
product transfer between object for machinery manufacturing and object for surface adjustments
surface adjustment
product transfer between object for surface adjustments and object for storage and distribution
product storage and distribution
emergency link-up between fire and response centre and management centre
emergency link-up between fire and response centre and SMR
emergency link-up between fire and response centre and electricity distribution point
emergency link-up between fire and response centre and battery
emergency link-up between fire and response centre and store of material
emergency link-up between fire and response centre and foundry
emergency link-up between fire and response centre and object for processing the semi-finished products
emergency link-up between fire and response centre and object for machinery manufacturing
emergency link-up between fire and response centre and object for surface adjustments
emergency link-up between fire and response centre and object for product storage and distribution
Total

Responses to the status assessment criteria for expected operation scenarios (CVUT 2023) are classified on a scale of 0-5 according to the concept "the higher the value, the higher the risk". To items written by red color in Table 1 we allocate weight 2. The evaluation of the criteria is carried out by a team of specialists independently who are from different fields. In this case, we use a team: a public official responsible for the safety of the territory; a public administrative employee responsible for supervising the operation of technical installations in territory; a technician of technical complex responsible for risk management; an employee of the Technical Inspection or SÚJB; and an employee of the Integrated Rescue System responsible for responding to accidents and failures of technical installations in the territory. The resulting value for each criterion is the median, and in the case of a large dispersion of values for one criterion, it is necessary for the public administration officer responsible for the safety of the territory to ensure further investigation, at which each evaluator provides the justification for his evaluation in the case in question and the final evaluation is determined on the basis of a panel discussion or brainstorming.

To evaluate the overall risk of each item, we will use the scale shown in Table 2. According to the risk values identified, the results of the risk assessment are divided into three groups: acceptable risk – categories 0 and 1; ALARA risk, i.e. conditionally acceptable – categories 2 and 3; and risk unacceptable – categories 4 and 5. Results are in (CVUT 2023).

Table 2. A value scale to determine the risk rate of an item; N is quintuple of criteria in the DSS item.

Risk rate	Value in % N
Extremely high – 5	More than 95 %
Very high – 4	70–95 %
High – 3	45–70 %
Medium - 2	25–45 %
Low – 1	5–25 %
Negligible – 0	Lower than 5 %

In order to ensure the performance of items, we create risk management plans (ISO 2010, Prochazkova et al. 2019) that include: sources of risk; the impact of risks; the magnitude and frequency of the risks; prepared measures, the executor of the measures and the person responsible for the quality and timely implementation of measures; and the renovation plans. Results are in (CVUT 2023). This not only ensures fast and high-quality responses, but also reduces downtime to a minimum, and thus the possibility of unacceptable effects on other items. This means that the resilience of the industrial complex is also be strengthened.

7. Conclusion

In industrial practice, both the safety and the resiliency of objects are important. To ensure this, it is necessary to perceive the management of objects and entire industrial complexes as a dynamic process that constantly adapts to achieve its goals in order to respond well to changes inside and outside the industrial complex. As the objectives identified as safety and performance are not commensurable, multi-criteria utility-based approaches must be used.

In the presented example, failure to meet the goals of the industrial complex is considered as a failure of processes that involve interactions among humans, organizational structures, engineering activities and physical and cybernetic components. During operation, the feedbacks on immediate conditions are important. Basic feedbacks are inserted into risk-based designs of items. Experience from the operation of technical installations shows that, however, as a result of the dynamic changes of the world, obsolete reactions need to be eliminated during the operation and replaced by new ones that are efficient. Therefore, it is important to have a risk management plan that is updated regularly or after each critical condition of the industrial complex.

The paper contains a proposal for a model of safety and resiliency management of industrial complexes powered by SMR. It is based on models based on risk management in favor of safety and performance for individual industrial units and SMR. It sets limits for the operation of individual industrial and service units so that the safety and resiliency of the entire complex powered by SMRs is maintained under all design conditions. The responses to expected emergency situations including the beyond design accidents from safety reasons of the country stability are ensured by measures in prepared risk management plans which are situation-specific; at present we consider 9 variant situations (CVUT 2023).

Acknowledgement

Authors thank for support to TK02030125 project.

References

Ale, B., Papazoglou, I., Zio, E., eds (2010). *Reliability, Risk and Safety*. London: Taylor & Francis Group, 2448 p.

ARIS (2020). *Advances in Small Modular Reactor Technology Developments.* Vienna: IAEA.

ASIS (2010). SPC.1-2009**.** *Organizational Resilience: Security, Preparedness, and Continuity Management Systems - Requirements with Guidance for Use.*

Baraldi, P., Di Maio, F., Zio, E., eds (2021). *Proceedings of the 30th European Safety and Reliability Conference and 15th Probabilistic Safety Assessment and Management Conference.* Singapore: ESRA, Research Publishing, 5067 p., enquiries@rps online.com.sg

Beer, M., Zio, E., eds (2019). *Proceedings of the 29th European Safety and Reliability Conference.* Singapore: ESRA, Research Publishing 2019, 4315 p., e:enquiries @rps online.com.sg

Bérenguer, C., Grall, A., Guedes Soares, C., eds (2011). *Advances in Safety, Reliability and Risk Management*. London: Taylor & Francis Group, 3035 p.

Briš, R., Guedes Soares, C. & Martorell, S., eds (2009). *Reliability, Risk and Safety. Theory and Applications*. London: CRC Press, 2362 p.

Castanier, B., Cepin, M., Bigaud, D., Berenguer, C., eds (2021). *Proceedings of the 31st European Safety and Reliability Conference*. Singapore: Research Publishing, 3473 p., enquiries@rpso nline.com.sg

Cepin, M., Bris, R., eds (2017). *Safety and Reliability – Theory and Applications*. London: Taylor & Francis Group, 3627 p.

CVUT (2023). *Archives of: Project Data; Disasters; Accidents; and Failures.* Praha: ČVUT.

EU(1992). *Maastricht Treaty*. C 191, 29.7.pp.1–112.

EU (2022). Archives. https://ec.europa.eu

Haugen, S., Vinnem, J., E., Barros, A., Kongsvik, T., Van Gulijk, C., eds (2018). *Safe Societies in a Changing World.* London: Taylor & Francis Group, 3234 p.; https://www.ntnu.edu/esrel2018.

Hollnagel, E. (2014). *Safety-I and Safety-II: The Past and Future of Safety Management.* Farnham: CRC Press 2014, 200 p.

Hollnagel, E. (2020). *Synesis: The Unification of Productivity, Quality, Safety and Reliability*. London: Taylor & Francis 2022, 122 p.

Hollnagel, E., Woods, D.D. (2017). *Resilience Engineering*. London: CRC Press 416 p.

IAEA (2022). *Lessons Learned in Regulating Small Modular Reactors.* TECDOC-2003. ISBN 978-92-0-125022-3. Vienna: IAEA, 516 p.

IAPSAM, eds (2012). *Probabilistic Safety Assessment and Management Conference*.Helsinki: IPSAM & ESRA, 6889 p.

ISO (2010). *ISO 31 000. Risk Management.*

ISO (2017). *ISO 22316:2017. Security and Resilience -- Organizational Resilience.*

Keeney, R. L, Raiffa, H. (1993). *Decision with Multiple Objectives*. Cambridge: Cambridge University Press 569 p.

Leplat, J. (1987). Occupational Accident Research and Systems Approach. In: *New Technology and Human Error.* New York: John Wiley & Sons, pp. 181–191.

Leva, M.C., Patelli, E., Podofillini, L., Wilson, S. (2022). *Proceedings of the 32nd European Safety and Reliability Conference*. Singapore: ESRA, Research Publishing, 3413 p., enquiries@rpson line.com.sg

Leveson, N. (2004). A New Accident Model for Engineering Safer Systems. *Safety Science*, 42,4, pp. 237–270.

Leveson, N., Daouk, M., Dulac, N., Marais, K. (2003). Applying STAMP in Accident Analysis. *Workshop on the Investigation and Reporting of Accidents.* Massachusetts: MIT, pp. 177-198.

Leveson, N., Dulac, N., Zipkin, D., Cutcher-Gershenfeld, J., Carroll, J., Barrett, B. (2006). *Engineering Resilience into Safety-Critical Systems.* Massachusetts: MIT, 122 p.

Marais, K., Leveson, N. (2003). Archetypes for Organizational Safety. *Workshop on the Investigation and Reporting of Accidents.* Massachusetts: MIT, pp. 199-207.

Nemeth, C. P., Hollnagel, E., eds (2022). *Advancing Resilient Performance*. Springer-Verlag 2021, 158 p.

Nowakowski, T., Mlyňczak, M., Jodejko-Pietruczuk, A., Werbiňska-Wojciechowska, S., eds (2014). *Safety and Reliability: Methodology and Application.* London: Taylor & Francis Group, 2453 p.

OECD (2002). *Guidance on Safety Performance Indicators. Guidance for Industry, Public Authorities and Communities for developing SPI Programmes related to Chemical Accident Prevention, Preparedness and Response*. Paris: OECD, 191 p.

Pannier, C. P., Skoda, R (2014). Comparison of Small Modular Reactor and Large Nuclear Reactor Fuel Costs. doi:10.4236/epe.2014.65009Panier,Škoda 2014

Podofillini, L., Sudret, B., Stojadinovic, B., Zio, E., Kröger, W., eds (2015). *Safety and Reliability of Complex Engineered System*. London: CRC Press, 4560 p.

Prochazka, J., Prochazkova, D. (2022). *Risk Management of Traffic Management Systems.* Praha: ČVUT,129 p. doi:10.14311/BK.97880010 69950

Prochazkova, D. (2017). *Principles of Management of Risks of Complex Technological Facilities.* doi: 10.14311/BK.9788001061824.

Prochazkova, D., Prochazka, J., Dostal, V. (2021). *Risks of Power Plants with Small Modular Reactors*.doi:10.3850/978-981-18-2016-8_125-cd

Prochazkova, D., Prochazka, J., Lukavsky, J., Dostal, V., Procházka, Z., Ouhrabka, L. (2019). *Management of Risks Connected with Technical Facility Opera-tion.* Praha: ČVUT, 465 p. doi:10.14311%2FBK.9788001066751

Rasmussen, J. (1997). Risk Management in a Dynamic Society. *Safety Science*, 27, 2, pp.183-213.

Steenbergen, R., Van Gelder, P., Miraglia, S., Ton Vrouwenvelder, A., eds (2013). *Safety Reliability and Risk Analysis: Beyond the Horizon*. London: Taylor & Francis Group, 3387 p.

Sterman, J. (2002). *Business Dynamics: Systems Thinking and Modelling for a Complex World.* Massachusetts: MIT,

UN (1994). *Human Development Report*. New York . www.un.org

Walls, L., Revie, M., Bedford, T., eds (2016). *Risk, Reliability and Safety: Innovating Theory and Practice: Proceedings of ESREL*. London: CRC Press, 2942 p.

Zairi, M. (1991). *Total Quality Management for Engineers*. Cambridge: Woodhead Publishing Ltd.