DOI: https://doi.org/10.37434/tpwj2024.07.05

PRACTICE OF IMPLEMENTING THE METHODOLOGY OF RISK ANALYSIS OF THE OPERATION OF WELDED METAL STRUCTURES IN UKRAINE

V.M. Torop

E.O. Paton Electric Welding Institute of the NASU
11 Kazymyr Malevych Str., 03150, Kyiv, Ukraine

ABSTRACT

The development of standard approaches, regulatory response measures and coordinated actions at the international, regional, national and local levels is the best and perhaps the only means of influencing the risk, which can have negative consequences in the form of failure, accidents, and catastrophes. This task requires an urgent solution, because the number of risks in the modern world is increasing. One of the main goals established by the ISO 31000 standard is the continuous improvement of risk management in organizations based on a general model intended for adaptation to a wide range of risks. This publication is devoted to a historical overview of the state of affairs regarding the implementation of the risk analysis methodology in Ukraine and the practice of its use for welded metal structures.

KEYWORDS: risk, standardization, integrity management, E.O. Paton bridge

INTRODUCTION

Full-scale war with the Russian Federation, drone attacks on energy and infrastructure objects, missile, artillery and mortar shelling of border areas and territories in the area of hostilities, terrorism, cyberattacks, raiding, reputational damage, etc. is only a small list of threats that fill our lives daily. Each of these threats has a risk to be realized. And realization of a threat affects the related losses. The scale of losses depends on the subject for which this threat exists. It can be the world, a country, an organization, a person.

There risk always exists, but obviously making management decisions on risk reduction requires a structured approach. In the fundamental article [1], the urgency of implementing the risk assessment system in Ukraine is attributed by the author to the problem of national security. Let's bring a very eloquent quote from it: "A gap of our state in this field becomes threatening. This results not only in discrediting of the Ukrainian science, but also in the inefficiency of the national industry, its high accident rate and, which is more frightening, in unreasonable human victims. Due to the fact that the task of risk assessment can be considered as a task of making a multicriteria collective decision, which requires studying of a wide range of issues in the technical, economic and social areas of life, there is a need to create a system of administrative risk management in Ukraine.

This state of affairs is partially predetermined by the lack of a state approach to the risk management in the former Soviet Union, where the price of human safety and ecology was by no means high. As the authors noted [2]: "... in the ten-volume edition "Reliability and efficiency in engineering", published during 1987–1990, the concept of risk analysis is not even mentioned. Similarly, many of its important components are not described, for example, the techniques for calculating the consequences of accidents manifested in their impact on human health or economic indicators, the techniques for assessment of the probability of failure on the basis of physical models both with the help of approximate analytical approaches as well as numerical modeling by the Monte Carlo method or its derivatives. At the same time, the responsibility for the absence of both standards on risk as well as reliability (one of the risk components) of industrial objects in Ukraine is equally held both on scientists in the field of strength and reliability, as well as on officials who should provide supervision of labor safety".

The concept of risk is extremely broad and in the article cited above [1] and fundamental works [3–5], some of its aspects, definitions and use in various fields of science, engineering and human activity are given. The task of technical specialists consists in disclosing its content and implementation in certain industries. It is important here to take into account international experience, real technical capabilities of industry and modern achievements of scientists.

IMPLEMENTATION OF RISK ANALYSIS METHODOLOGY IN UKRAINE

The practice of implementing the risk analysis methodology in Ukraine originates with the adoption of the Law of Ukraine "On objects of increased danger" (Vidomosti Verkhovnoyi Rady Ukrainy, 2001, No. 15, Article 73 with the following amendments) [6]. According to the procedure for declaring the safety of objects of increased danger, which is determined by the Decree of the Cabinet of Ministers of Ukraine dated July 11 2002 No. 956 [7], the level of risk is assessed in accordance with the Methodology for determination of risks and their acceptable levels for declaring the safety of objects of increased danger, which is approved by the Order of the Ministry of Labor and Social Policy No. 637 dated December 04 2002.

The government of Ukraine in the framework of the Kyoto Program of 2005–2015 in January 2014 approved the "Concept of risk management of man-made and natural emergencies", approved by the Decree of the Cabinet of Ministers of Ukraine No. 37-p dated January 22 2014 [8].

The main purpose of the Concept is to achieve the acceptable levels of risks throughout the Ukraine, which is implemented in the next stages:

1) to determine the risk levels for all sectors of the economy and the most dangerous sources of emergencies and ensure their reduction to accepted risk levels;

2) to reach the risk level throughout the Ukraine in accordance with terms used in economically developed countries.

The Concept implementation plan for 2015–2020 provided the creation of the following guides:

● organizational guide: workshops, scientific conferences on the implementation of danger management system in Ukraine during emergency situations of man-made and natural character;

● guide of normative legal acts: improvement of legislative norms on implementation of approaches based on risks;

● methodical guide: development of risk assessment methodology by research institutions, systematization according to the types of emergency situations;

● educational guide: curricula for experts on risk management in the field of man-made and natural safety.

In order to implement the Sendai Framework for Disaster Risk Reduction for 2015–2030 [9], adopted by the III UN World Conference in Sendai, Japan on March 18 2015, the Cabinet of Ministers of Ukraine approved the Strategy for Reforming the State Emergency Service of Ukraine, which, among other things, envisages a full-scale reformation of the state system for response to emergencies and improvement of its ability to struggle natural and man-made threats. The Sendai Framework for Disaster Risk Reduction for 2015–2030 outlined seven clear goals and four priorities for preventing new and reducing existing risks of natural hazards:

● understanding the risk of natural hazards;

● strengthening in management of risks of natural hazards;

● investments in reducing the risks of natural hazards;

● increase in readiness to natural hazards for effective response and obtaining the best practices during restoration, rehabilitation and reconstruction.

The Sendai Framework is aimed at achieving a significant reduction in the risk of disasters and losses of life, livelihoods and health, as well as economic, physical, social, cultural and environmental assets of people, enterprises, communities and countries over the next 15 years.

In addition, in the framework of the Association Agreement between Ukraine, on the one hand, and the European Union, the European Atomic Energy Community and their member states, on the other hand, a plan for implementation of some EU legislative acts was developed (approved by the Cabinet of Ministers of Ukraine on October 25 2017, No. 1106), [10] that envisages the execution of:

● Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 "On the control of major-accident hazards involving dangerous substances";

● Directive 2007/60/EU of the European Parliament and of the Council of October 23 2007 "On the assessment and management of flood risks".

In order to reduce losses and trying to standardize the algorithm of actions in case of manifestation of one or another risk, summarizing the world experience, in 2009 ISO — the International Organization for Standardization (https://www.iso.org) adopted a series of international standards for risk management, in particular:

● ISO Guide 73:2009 Risk management — Vocabulary (https://www.iso.org/standard/44651. html);

● ISO/IEC 31000:2009 Risk management — Principles and guidelines (https://www.iso.org/ standard/43170.html);

● ISO/IEC 31010:2009 Risk management — Risk assessment techniques (https://www.iso.org/ standard/51073.html).

In 2013, the guidance for the implementation of ISO 31000 ISO/TR 31004:2013 Risk management — Guidance for the implementation of ISO 31000 (https://www.iso.org/standard/56610.html) was published.

The above standards are the standards of the "upper-level" risk management. They were adopted as national standards by more than 50 national standardization bodies covering more than 70 % of the world's population. They were also adopted by some UN organizations and national governmental organizations as a basis for the development of the own risk-oriented standards and techniques.

According to the plan of implementation of the international legislative framework, in accordance with the Law of Ukraine "On Standardization" dated June 05 2014, No. 1315-VII [11], analogues of international standards of 2009 were adopted in Ukraine:

● DSTU ISO Guide 73:2013 "Risk management. Vocabulary" [12];

● DSTU ISO 31000:2014 "Risk management. Principles and Guidelines" [13];

● DSTU ISO/IEC 31010:2013 "Risk management. General risk assessment techniques" [14].

DEVELOPMENT OF RISK ANALYSIS IN THE WORLD

The development of international standards, regulatory response measures and coordinated actions at international, regional, national and local levels is the best and perhaps the only means of influencing the risk that has potentially global consequences. This task requires an urgent solution, as far as a number of risks on a global scale is growing. One of the main goals established by ISO 31000 [13] is the constant improvement of the risk management in the organizations on the base of a general model intended for adaptation to a wide range of risks.

Although according to the ISO regulations, any standard should be revised every five years, the ISO 31000 Basic Risk Management Standard has been valid for almost nine years. During this time, a considerable experience in the field of risk management was accumulated. Yesterday's risk management practices are not adequate to struggle today's threats. These mechanisms need to be upgraded. Such derivatives became a cause for revision of the ISO 31000 standard [13].

A new guide was published in 2018 to help users to fully optimize its meaning. ISO 31000:2018 "Risks management" is a practical guide that helps organizations to integrate an effective decision-making structure into their management, leadership and culture by the optimal use of ISO 31000.

The standard itself explains the fundamental concepts and principles of risk management, simultanoeusly describing the structure and outlining the processes for risk identification and management. It provides extended information and context to the sections of ISO 31000, including guidelines for developing a plan for risk integration into the existing organization's document management, communications with concerned parties, monitoring and revision of the risk management plan and many other.

ISO 31000:2018 [13] was elaborated in cooperation with UNIDO (the UN Industrial Development Organization). ISO 31000:2018 is a brief guide to help organizations in appplying risk management principles to improve planning and making more effective solutions.

At the official site of ISO [https://www.iso.org/home.html], the main changes to the previous version of the standard are presented, such as:

1. Analysis of the risk management principles is carried out that are hyper-significant success criteria.

2. Attention is focused on the leadership of senior management, which should ensure the integration of risk management, extend it to all processes, starting with the organization management.

Hence, ISO 31000 is the standard of risk management, which was adopted in 90 % of the greatest world economies.

In June 2019, on the website of the International Organization on Standardization (ISO), the second issue of the International Standard IEC 31010:2019 (Risk management — Risk assessment techniques) is available [14]. According to the ISO website "... this document provides guidelines on the choice and application of risk assessment techniques in a wide range of situations. The techniques are used to assist in making decisions with uncertainty, to provide information on certain risks and as a part of the risk management process. This second issue cancels and replaces the first issue, published in 2009. In the document, the process of planning, implementation, verification and confirmation of the use of techniques is considered in more details; a number and scope of techniques was increased.

IEC 31010 was prepared by the 56^{th} Technical Committee "Reliability" of the International Electrotechnical Commission (IEC) together with 262 T3 ISO. This standard complements the ISO 31000 provisions [13].

ISO/IEC 31010 focuses on concepts, processes and the choice of a risk assessment technique, provides a basis for making decisions on applying the most appropriate approach to specific risk assessment. The standard provides examples of different risk assessment techniques (including brainstorming, Delphi method, "preliminary hazard analysis", HAZOP, HACCP, FMEA, FTA, Decision Tree, Swift Technology, Monte Carlo Method, etc. — 31 techniques in total) and references to other international standards are given, describing their application in more detail.

INFORMATION AND ANALYTICAL SYSTEM FOR MANAGEMENT OF TECHNICAL CONDITION AND INTEGRITY OF PIPELINE TRANSPORT NETWORK OBJECTS "ITT-PIMS"

Ukraine has to build a new management system on the basis of an approach based on a risk assessment that is a part of the management process and also has a fundamental importance for organisation management at all levels.

For example, the Operator of the gas transportation system of Ukraine (OGTSU) since 2021 introduces the Information and Analytical System for Management of Technical Condition and Integrity of Pipeline Transport Network Objects "ITT-PIMS". This software complex offers information system to manage processes for gas transportation systems PIMS (Pipeline Integrity Management Systems). The software product will allow implementing a comprehensive assessment of the technical condition and safety of functioning of main gas pipelines, determining the technical condition of infrastructure, assessing risks, developing plans for their prevention and reduction of the consequences of possible accidents.

The information-analytical system consists of 52 modules and three subsystems aimed at the following processes and tasks:

- formation of a spatial database of objects of a linear part of main gas pipelines (LPMG) and their objects in the environment, development of tools for management of spatial data;
- certification of basic and auxiliary equipment and systems, development of tool for management of technological information;
- graphical display of data on LPMG and objects in the environment;
- management of spatial and monitoring data of air patrol (including photos /video fixation of violations of security zones of a main gas pipeline (MG);
- technological document management of units from the direction of LPMG operation, documentation management, reporting;
- land registry of the territories of MG passage;
- management of results of diagnostics and repairs of LPMG objects, interpretation of results;
- analytical assessment of the technical condition of LPMG objects (including integrated assessment by a defined group of criteria);
- LPMG operation risk management;
- repair planning;
- LPMG repair budget management;
- integration of the system with the "Complex automated management system" (CAMS) based on SAP ERP etc.

It should be noted that in the practical application of the risk analysis methodology, a number of problems arises related to the uncertainty of choosing mathematical methods, physical models and input data. This is especially true for the uncertainty in the real distribution of probabilistic values characterizing the object condition or external factors, amplitudes and the frequency of certain natural disasters. This casts doubt on the confidence in absolute initial numerical values. Without a detailed description and discussion of all uncertainties and ambiguities accepted in the analysis, the practical application of such absolute values should be quite limited. For example, comparison of the results with the admissible risk criteria declared in norms or standards (which finds ever more widespread use in the world) becomes simply mathematical exercises. Therefore, the specification of input data, creation of an appropriate correct calculation model, the use of modern technologies, algorithms, systematic approach and standardization of principles for implementation of risk analysis for each specific industry or human activity becomes an urgent need. One of the examples of the practical implementation of the above approaches is the "Methodology for determination of the risk of operating physically worn or morally obsolete welded metal structures that do not meet the requirements of labor protection and pose a potential threat to the life and health of workers" developed at the PWI of NASU [15].

USE OF RISK ANALYSIS IN THE INSPECTION OF THE TECHNICAL CONDITION OF THE E.O. PATON BRIDGE

The results of inspecting the corrosion damage to the main beams of the E.O. Paton bridge across the Dnipro River in Kyiv indicates that as a result of draining rainwater and water formed as a result of snow melting (contains salts) through deformation welds on welded metal structures of the main beams, whose metal of the end sections of the spans is adjacent to the deformation welds, was exposed to local and, in some places, significant corrosion damages. Due to corrosion, the thickness of the metal in the structural elements, namely in the lower girths, lower horizontal stiffeners and in the lower part of the walls of the main beams decreased significantly. In some cases (for example, in the spans F10 and F15 of the main beam No. 1 and the spans F1 and F3 of the main beam No. 4), the thickness of the walls decreased by 40–50 % [16, 17]. The presence of such corrosion damages can significantly reduce the fatigue failure resistance of welded joints with detected defects, which indicates an increase in the risk of failure of

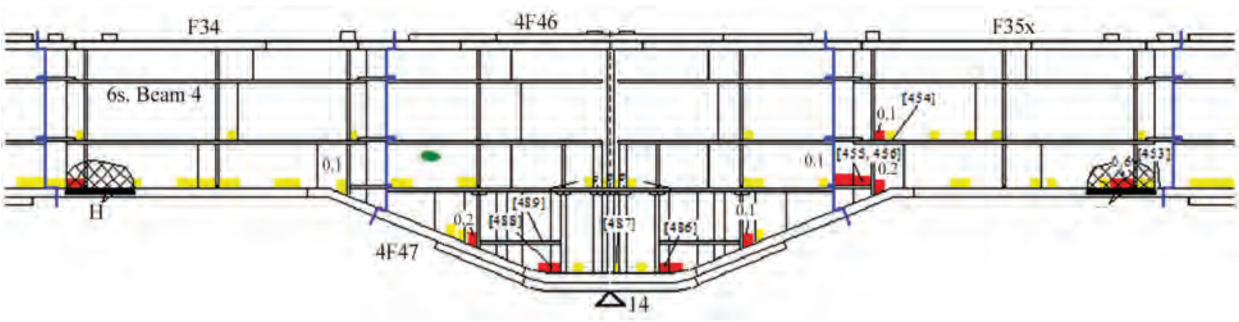

Figure 1. Results of measuring thickness of the span wall and voute for the span F46 of the main beam No. 4 [17]

Figure 2. Crack formed in the zone of corrosion thinning of the weld in the span F46 of the main beam No. 4

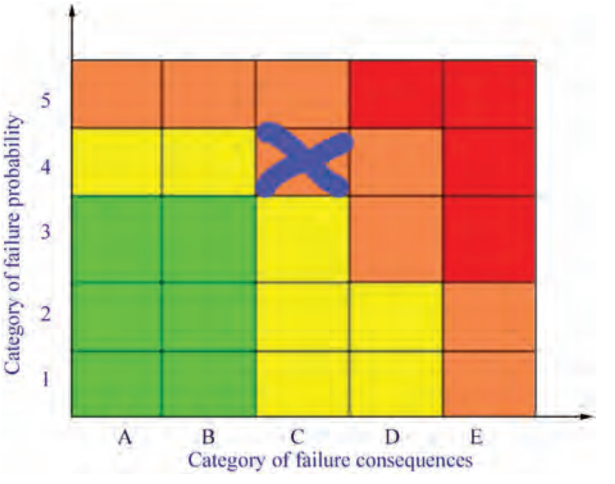

Figure 3. Risk matrix for the operation of the span F46 of the main beam No. 4 of the E.O. Paton bridge

the span structure in case of further propagation of corrosion processes.

For example, Figure 1 presents the results of 133 measurements of the span wall thickness and 113 measurements of the thickness of the voutes for the span F46 of the main beam No. 4 [16, 17]. Corrosion damages of 2–4 mm depth were detected (marked with a yellow marker) and of more than 4 mm (red). Nonmetallic inclusions are marked with a green marker.

The smaller the number of measurements, the greater the risk of missing a defect. In addition, corrosion thinning in the weld zone can serve as an additional source of corrosion cracks, which is illustrated by Figure 2.

According to our developed "Methodology for determining the risk of operation of welded metal structures..." [15], the risk of operation of the span F46 of the main beam No. 4 is determined by the 4C index at the risk matrix, which is shown in Figure 3 and corresponds to the pre-accident condition of the main beams of the E.O. Paton bridge, the probability of failure reaches a value of 0.8.

According to the recommendations [15], the orange area of the risk matrix provides for the need to develop and approve the "Security Declaration" with the regulator (Department of Supervision in Industry and at Objects of Increased Danger of the State Labor of Ukraine) including a report, a plan of measures to eliminate drawbacks and carry out improvement measures for the operation of the main beams of the E.O. Paton bridge. In addition, it is necessary to develop a plan, to justify the choice of techniques, to determine and to agree the term of diagnostics and technical inspection, which also provides a mandatory detailed analysis of the risk for the further operation of the main beams of the E.O. Paton bridge.

CONCLUSIONS

1. Ukraine should build a system for management of the integrity of welded metal structures for objects of increased danger based on the approach using modern technologies and algorithms of system analysis, standardization of principles to implement risk analysis for each specific industry.

2. Risk assessment is a part of the management process, and has a fundamental importance for the enterprise management at all levels of its activity. Therefore, the introduction of the Methodology [15] can serve as an example of the practical implementation of the best modern world practices in providing reliable and safe operation of welded metal structures for objects of increased danger.

3. Implementation of risk analysis will provide new partner relations between the operator, operating potentially dangerous objects and the regulator — supervisory body of the state.

REFERENCES

1. Kachynsky, A.B. (2002) Development of the risk problem in Ukraine: Theory and practice. *Strategic Panorama*, **4**, 14–25 [in Ukrainian]
2. Torop, V.M., Torop, O.V. (2004) Implementation of risk analysis in the system of ensuring the integrity of main pipelines. In: *14th Inter. Business Meeting on Diagnostics 2004,* Moscow, 81–85 [in Russian].
3. Horbulin, V.P., Kachynskyi, A.B. (2010) *Strategic planning: Solving national security problems.* Kyiv, NISD [in Ukrainian]
4. Ivanyuta, S.P., Kachynskyi, A.B. (2012) *Ecological and natural and man-made security of Ukraine: Regional dimension of threats and risks.* Kyiv, NISD [in Ukrainian]
5. Makhutov, N.A., Gadenyn, M.M., Yudina, O.N. (2019) Scientific analysis of risks in life support of a person, society and state. *Problems of Risk Analysis,* 16(**2**), 70–86 [in Russian] DOI: https://doi.org/10.32686/1812-5220-2019-16-2-70-86
6. Law of Ukraine "On objects of increased danger" https://zakon.rada.gov.ua/laws/show/2245-14#Text [in Ukrainian].
7. Decree of the Cabinet of Ministers of Ukraine of July 11, 2002 No. *956 "On identification and declaration of safety of objects of increased danger"* [in Ukrainian]. https://zakon.rada
8. *The concept of man-made and natural emergency risk management.* Approved by the order of the Cabinet of Ministers of Ukraine No. 37 dated January 22, 2014 [in Ukrainian]. https://zakon.rada.gov.ua/laws/show/37-2014-%D1%80#Text
9. The Sendai Framework for Disaster Risk Reduction 2015-2030, Sendai, Japan, March 2015. https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030
10. Resolution of the Cabinet of Ministers of Ukraine dated October 25, 2017 No. 1106 "*On the implementation of the Association Agreement between Ukraine, on the one hand, and the European Union, the European Atomic Energy Community and their member states, on the other hand"* [in Ukrainian]. https://zakon.rada.gov.ua/laws/show/1106-2017-%D0%BF#n36
11. Law of Ukraine on standardization (Vedomosti Verkhovna Rada (VVR), 2014, No. 31 [in Ukrainian]. https://zakononline.com.ua/documents/show/357896_693333
12. DSTU ISO Guide 73:2013: *Risk management. Dictionary of terms* [in Ukrainian]. https://khoda.gov.ua/image/catalog/files/dstu%2073.pdf
13. DSTU ISO 31000:2014: *Risk management. Principles and guidelines*. New version from 2018. DSTU ISO 31000:2018 *Risk management. Principles and guidelines* (ISO 31000:2018, IDT) [in Ukrainian]. https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=80322
14. DSTU ISO/IEC 31010:2013: *Risk management. General risk assessment methods.* https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=66723 or DSTU EN IEC 31010:2022 *Risk management – risk assessment methods* (EN IEC 31010:2019, IDT; IEC 31010:2019, IDT)
15. (2024) *Methodology for determining the risk of operating physically worn or morally obsolete welded metal structures that do not meet the requirements of labor protection and pose a potential threat to the life and health of workers.* Kyiv, PWI [in Ukrainian].
16. Poznyakov, V.D., Dyadin, V.P., Davydov, Ye.O., Dmytrienko R.I. (2021) Evaluation of damage of all-welded longitudinal main beams of the E.O. Paton bridge across the Dnipro river. *The Paton Welding J.*, **7**, 30–38 [in Ukrainian]. DOI: https://doi.org/10.37434/tpwg2021.07.06
17. Lobanov, L.M., Dyadin, V.P., Davydov, E.O., Lytvynenko, V.A. (2021) Selection of nondestructive testing methods for evaluation of the technical condition of metal structures of the main beams of E.O. Paton bridge across the Dnipro in Kyiv. *Tekh. Diahnost. ta Neruiniv. Kontrol,* **4**, 47–53 [in Ukrainian]. DOI: https://doi.org/10.37434/tdnk2021.04.05

ORCID

V.M. Torop: 0000-0002-8807-9811

CORRESPONDING AUTHOR

V.M. Torop

E.O. Paton Electric Welding Institute of the NASU

11 Kazymyr Malevych Str., 03150, Kyiv, Ukraine.

E-mail: v.torop@gmail.com

SUGGESTED CITATION

V.M. Torop (2024) Practice of implementing the methodology of risk analysis of the operation of welded metal structures in Ukraine. *The Paton Welding J*., **7**, 29–34.

DOI: https://doi.org/10.37434/tpwj2024.07.05

JOURNAL HOME PAGE

https://patonpublishinghouse.com/eng/journals/tpwj

Received: 02.05.2024
Received in revised form: 11.06.2024
Accepted: 29.07.2024