SAFETY MANAGEMENT SYSTEM OF MACHINE-BUILDING PRODUCTION

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Abstract:

The article is devoted to the problem of fulfilling the Customs Union technical regulations requirements. The authors have proposed a model of the safety management system of machine-building production. The authors offered hierarchical model of documentary information. Programs of safety was developed on various stages of product lifecycle. The rating scale of risk level was offered. The important task was solved of improvement of quality of machine-building products based on providing the requirements to its safety containing in technical regulations

1 Introduction

The products safety, under which, as it is known, is understood such a state (object and subject of the action), under which there is no unacceptable risk associated with causing harm to citizens' life and health, individuals or legal entities' property, state or municipal property, environment, life and health of animal and plant, to a certain extent, describes the quality of the products.

Safety is one of the most important characteristics of a product, which is understood as an unacceptable risk associated with causing harm to life and health, property of natural or legal persons, state or municipal property, environment, life and health of animals and plants.

Security is a product feature that causes the least risk as limited to valid norms. In the production, storage, transportation, operation, or consumption goods must be safe, it. should not harm the life and health of the consumer [1-3].

Absolute security cannot be achieved in the operation or consumption of any goods. For example,in the operation of electrical appliances there is always a certain probability for the consumer to suffer from high voltage. There is always a chance of injury when using sharp objects.

When considering security, this refers to the minimizing the risk of injury when using the product in strict accordance with the rules of safe operation, which should be set out in the relevant instructions, rules, norms, included in the complex information, be sure to bring to the attention of the consumers.

Many of these indicators can be measured or calculated with the use of statistics. In the absence of such, an indirect assessment of the safety performance indicators can be applied to qualitative characteristics. The quality of the product, including its safety, confirmed by the certificate for the products. It only indicates that the requirements in respect of quality and safety responsible product samples submitted for testing, the results of which the certificate was issued. The stability properties of the products evidenced by a certificate for quality management system. However, given the special importance of indicators of security, is to implement and certify the safety management system of products.

Many authors have offered approaches to providing certain elements of security products such as security

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at the production stage, at the stage of execution of individual transactions, etc. There are different methods to determine the probability of occurrence of risk at stages of production.

Currently, there are widespread systems of safety management, such as management system in the sphere of food production safety, safety management system, and health management system, and traffic safety in Russian Railways, the system of information security. Organizations conduct activities to ensure compliance with the requirements of technical regulations (regulations, terms of contracts).

The safety management system of products for organizations should be established to guarantee the implementation of the requirements of technical regulations. In terms of global trends, in the implementation of integrated management systems in the organization it can be integrated with elements of other systems such as quality management system or system safety [4-7].

In organizations that produce, in particular, engineering products, execution of production requirements often receives little attention, it (production) automatically satisfies all consumers and meets the most advanced requirements. The presence of the QMS ensures that products meet declared level of quality, however, there is the issue of evidence of compliance with important requirements for security products.

In this regard, of course, relevant studies are aimed at creating a safety management system of engineering products (SMBMP), as a subsystem of an organization's quality management system, which can be a part of supporting documentation, supplier's declaration of products conformity to the security demands.

2 Safety management system of machine-building production

To ensure the performance of SMBMP functions and its use in the integrated management system all processes should be divided into four categories: management leadership; SMBMP core processes; provision of resources; planning, risk analysis and risk management, critical control points, production and testing; measurement, analysis and improvement. The internal organization of the system is based on the famous series «Plan-Do-Check-Act» (PDCA), and on the analysis of risks and opportunities in the field of product safety [8].

Safety management system of engineering products as a subsystem of the quality management system (QMS) with the system of industrial safety (SIS) and labour safety system (LSS) can be combined into a common, integrated enterprise management system.

The model of products safety management system is built based on quality management system models and HACCP (Fig. 1). Documented information, divided by levels of government, according to its intended use forms the structure of the documentation SMBMP (Table. 1), reflecting the hierarchy of management and processes levels.

To meet the technical regulation requirements under the products safety management system it is encouraged to develop and implement a safety maintenance program (SMP) - a document that establishes a set of interrelated organizational and technical measures, methods, tools, requirements and standards to be performed on the stages of the products life cycle and aimed at implementing technical regulations defined in the safety requirements. The program consists of the following parts:

1. Safety maintenance program is developed for a new (upgraded) product at the design stage.

1. Analysis of the regulatory requirements. In order to form a single set of product requirements in the field of security there is formed an expert group composed of representatives of the chief designer department, chief technologist department, as well as product quality and safety service (it is possible to include the representatives of other services and departments in the group). The experts form the requirements lists from all the technical regulations are related to this product [9, 10].

Of many technical regulations requirements $T = \{t_{ij}\}$ (where i - requirement of j regulation; $i = 1, 2, \ldots M$; $j = 1, 2, \ldots N$) is formed by a plurality of $T_k=\{t_{ij}\}$,, referring to a specific product. At the same time $T_k = T \cap X$, with $k = 1 \ldots B$; $X = \{x_i\}$, ($i = 1, 2, \ldots L$) - the set of anticipated product characteristics. To avoid the requirements duplication there is carried out a check by the following rule: if $\forall t_{i1j1} = \forall t_{i2j2}$, in the set T_k only one of them is included. The requirements to production can be divided by 2 categories: requirements relating to the product design (for example, requirements for rotating parts or design requirements for tightness) and requirements that are not related to the design (eg. packaging requirements or operation manual requirements).

Table 1. The structure of the documentary information

Level	Document
A	Policy to ensure product safety. Security guide
B	Information process cards. Documented procedures. Operating instructions
C	Documents on planning
D	Organizational, legal and methodological documents
E	Records on security
F	Legal, regulatory and technical documents

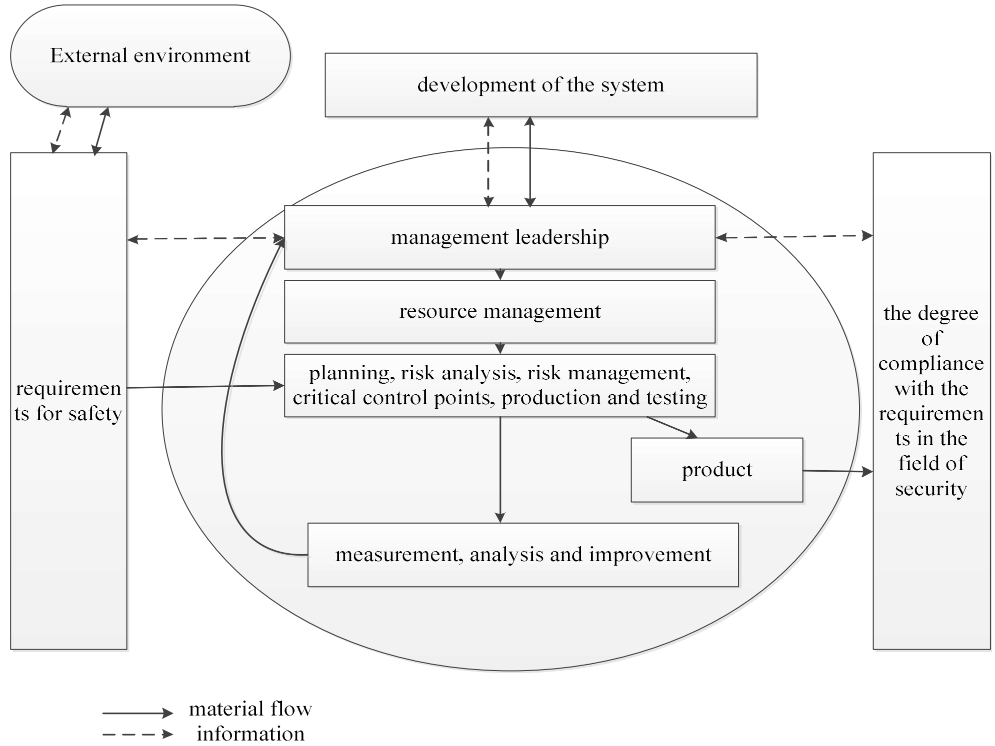

Figure 1. Model of the product safety management system

2. Hazard Analysis. Hazard Analysis is designed to provide management with objective and timely information on the products safety level. The order of the hazard analysis is the following (Fig. 3): 1) preparing for the hazards analysis; 2) hazards analysis: the formation of the team; examination of the product technical documentation; identification of potential defects; comparison of potential defects and their causes; integrated risk assessment; 3) preparing and approving the report. Indicated by analyzing discrepancies are recorded (indicating corrective and / or preventive actions).
The risk of structural elements is evaluated by two 10-point scales (feasibility and consequences; 1 - 16 - disparagingly low level of risk; 17 - 32 - low; 33 - 48 - average, 49 - 64 - high, 65 - 100 - disastrous.) (Table 2). The risk assessment is to compare the risk level with acceptable risk criteria and set initial priorities for risk treatment.
The proposed risk assessment method is implemented on the example of the lifting platform with vertical movement of the BK 450, designed for transporting disabled people who are in wheelchairs on a vertical trajectory.

3. Risk management. There is considered a process consisting of *n* series of operations performed. At the same time *i* operation, which is performed with probability $p_i = N_i^N / N$ (where N_i^N - the number of products with the waste on *i* operations, *N* - release program), can lead to rework with the costs of correcting $S_{waste\ i}$; with probability *1-p-q* may turn out to be successful. The magnitude of risk on *i* operation is like $R_i=p_iS_{rework\ i}$ (for rework), $R_i=q_iS_{waste\ i}$ (for

waste) and $R_i=0$ (for operations without waste). If the individual process steps are independent, the probability of non-defective product output is $p_{qual.}=(1-q_i)\dots(1-q_n)$. Accordingly, the average number of good products $N_{qual} = Np_{qual} = N(1-q_i)\dots(1-q_n)$.

Table 2. Scale of risk assessment

		Feasibility									
		Incredibly		Unlikely		Likely		Very likely		Almost certainly	
Consequences	Insignificant	1	2	3	4	5	6	7	8	9	10
		2	4	6	8	10	12	14	16	18	20
	Small	3	6	9	12	15	18	21	24	27	30
		4	8	12	16	20	24	28	32	36	40
	Moderate	5	10	15	20	25	30	35	40	45	50
		6	12	18	24	30	36	42	48	54	60
	Significant	7	14	21	28	35	42	49	56	63	70
		8	16	24	32	40	48	56	64	72	80
	Catastrophic	9	18	27	36	45	54	63	72	81	90
		10	20	30	40	50	60	70	80	90	100

2. Security maintenance at the production stage. This process includes the activities of the design analysis and output products technology. It is divided into two sub-processes regulated by information cards, "Security maintenance on the stage of the pre-production design", "Security maintenance at the stage of production technological preparation." Each of the sub-processes consists of several elements (activities): the documentation development (design and technology, respectively); analysis of the developed documentation to meet the requirements in the field of product safety; expertise; approval of the document final version.

The result of this phase implementation becomes the approved technical documentation, taking into account the safety requirements of both the product design and the technological equipment used in the production [11-13].

3. Security maintenance at the production stage. This process is divided into two sub-processes "Mandatory pre-production activities" and "Cure lack of products conformity to its security requirements."

The process of "mandatory pre-production activities" consists of the following activities: exploring the possibility of production; implementing critical control points, the control of potential hazards that may be made in the design at the production stage; approval of the program production.

The process of "Cure lack of products conformity to its security requirements" includes the activities of the production data analysis (for a new production - the initial production batch), design and implementing corrective measures, the analysis of a product safety new level.

One of the safety areas in the production process is implementing quality tools and systems of critical control points (CCPs), which are carried out at these stages of production, where adding an element of danger to the structure can be prevented or the danger can be eliminated or reduced to an acceptable level [14-16].

4. Conducting testing of finished products. The products tests are conducted with aim of setting compliance characteristics of the products properties to the technical regulations, standards or conditions of contracts. There is issued a report at the end of the test.

To assess the processes perfection level of SMBMP there has been developed a special qualimetric scale that describes three levels. These three levels of perfection correspond to a 6-point numeric scale (from 1 to 6 points): 1 - 2 (the first level – definitions. It is characterized by setting goals and objectives process, as the resources themselves, taken separately, the results are not pre-determined. The task of management is to make material resources efficient and productive. The quality of results in any area depends on the two fundamental elements: quality objectives and quality performance. A distinctive feature of this level is the goal-setting process. Questions of effectiveness and efficiency of processes are not specified. Activities description of organization's processes is completed.); 3 - 4 (the second level – effectiveness. It is characterized by realization of planned activities and achieving planned results.); 5 - 6 (the third layer - the efficiency. efficiency – the relationship between the reached result and used resources. The main activities of the organization aimed at identifying and minimizing activities that do not add value for consumers). This allows you to move from a qualitative assessment of the relevant sub-criteria to their quantitative assessment at a 6-point numeric scale.

Empirical verification of production management method on the basis of critical control points has been held at the JSC "Centre of technical means of the disabled people's prevention and rehabilitation" (Table 3).

The economic effect from implementing product safety management system ("Centre of technical means of the disabled people's prevention and rehabilitation") amounted to 11,309,450 roubles. While the defect level in the assembly operations fell by 87%, the number of claims on manufactured goods fell by 15%.

3 Results and Discussion

Table 3. Production losses results by types of defects in the assembly

Number of defect	Implementation percent of engineering products safety management system	Percent after implementing engineering products safety management system	Difference, %
Geometrical parameters of products and structures do not conform to the project parameters	52,3	7,3	45
Gap absence of the desired value between internal and external surfaces of the pillars	29,5	2	27,5
Malfunctions of electrical equipment	12,2	2,2	10
The deviation in the shafts alignment	1,8	0,3	1,5
Locking nuts is not secured	1,5	0,4	1,1
Violations of mechanical isolation	1,4	0,3	1,1
Excessive rigidity of the flexible shaft	1	0,4	0,6
Other	0,3	0	0,3
The resulting reduction in assembly defects			87,1

4 Conclusion

The validity and adequacy of the developed model of engineering products security management system and methodological approach to its construction are confirmed by its implementation results at several enterprises of mechanical engineering.

The important task was solved of improvement of quality of machine-building products based on the requirements to its safety contained in technical regulations (provisions of standards or conditions of agreements).

Corporations should develop (implement and enhance) the system of management of safety of products which is based on the offered model (according to the series ISO standards 9000 versions of 2015 and HASSP) for safety, therefore, quality of machine-building products, and also certification according to requirements of technical regulations (provisions of standards and/or conditions of agreements).

The scientific -based approach to creation of management of safety system is developed. It is based on programs of safety in stages of product lifecycle (the analysis of requirements of technical regulations (provisions of standards and/or conditions of agreements), risk management, search and implementation of opportunities for production of required level on indicators of its safety).

The scientific and methodical providing system of machine management safety-building products is developed. It consists of:

– Safety program .

– Technique of requirements forming contained in various technical regulations and regulating documents, guaranteeing that any of requirements will not be passed.

– Documentary information (assessment of levels of enhancement of processes, analysis of dangers, risk management).

The risk assessment technique in case of production of machine-building products was offered.

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