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Development of safety management algorithms in automata theory

Abstract: In management algorithms safety is understood as a set of states, a measure of compliance with the appointment of an object. The appointment is defined as a property of an object attributed to natural origin or intended to be used. Monitoring the safety states of an object can be described using a general algorithm. The task is solved with the help of automata theory. The definition of a safety automat has been compiled, the structure and algorithms for the operation of the automaton in processes, states and events have been developed.

Keywords: algorithms, safety states, events, automata theory, safety processes

Introduction. The task is a conceptual description of the automat as a temporary structure of fixed complexity [1], showing consistent relationships and clear transitions of the object's safety states [2]. The description of the state structure of the automat assumes the subsequent development of software and a computing device for monitoring the safety of objects. The development of safety control algorithms is carried out similarly to the development of the dependability theory [3].

Automat definition. Safety automat (SA) designated as S (safety) of an object as a deterministic, fully specified finite-state automat. SA is defined by a set consisting of the following elements (Eq. 1):

$$SA = \{X, S, Y, \delta, \lambda, s_0\}, \tag{1}$$

where DA is safety automat;

X is the input alphabet of the automat (set of input symbols) (Eq. 2):

$$X = \{x_1, \dots, x_m\}; \tag{2}$$

S is the automat states (Eq. 3):

$$S = \{s_0, \dots, s_n\}, \tag{3}$$

where s_0 is the initial automat state, s_n is automat n-state;

Y is the output alphabet of the automat (set of output symbols) (Eq. 4):

$$Y = \{y_1, \dots, y_p\}; \tag{4}$$

δ is the specified indication of states at a set of input signals, the function of automat transition from one state into another (Eq. 5):

$$s_j = \delta_i(s_i, x_k), \tag{5}$$

where s_j is the subsequent state of the automat, s_i is the current state of the automat, x_k is the current input symbol, λ is the specified indication of states at a set of output signals, the output function (Eq. 6):

$$y_l = \lambda_i(s_i, x_k), \tag{6}$$

where y_l is the subsequent output symbol of the automat, λ_i is i-state in subset of output signals, s_i is the current state of the automat, x_k is the current input symbol.

The conditions are: sets X, S, Y are finite; the output symbol ($y_l \in Y$) depends on the input symbol ($x_k \in X$) and the current state of the automat ($s_i \in S$); description entries of the automat are defined at discrete instants in time. The deterministic automat: a) from state s_i under the influence of signal x_k transitions into state s_j; at the output, y_h changes to y_l; b) for $(x_i, y_i) \in (X, Y)$ δ and λ are defined.

Structure of Automat Safety States. In automata theory, the properties of elements are considered from the point of view of being in states and transitions between them. However, in the known scientific literature on the theory of automata, there are no basic descriptions and definitions of states, processes and events, their connections and directions of transitions. In [2, 3], terms, definitions and a conceptual state diagram of an automat in the form of an elementary graph were developed. Safety states change in conditions of violation and restoration of the purpose of the object (figure 1).

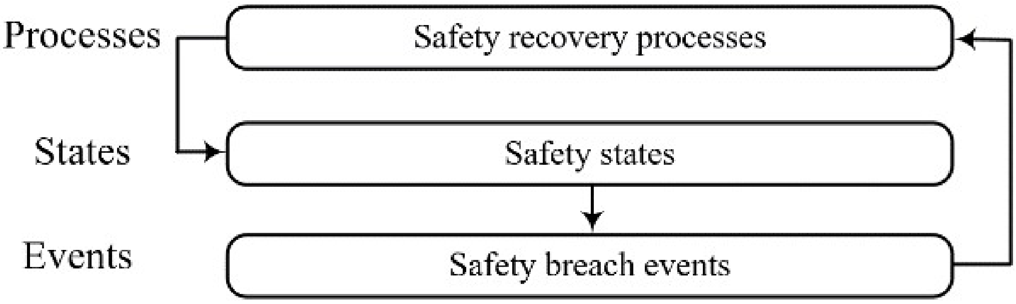

Figure 1 – Observation of safety states

Changes in the safety states of an object can be represented as a directed graph, the nodes of which correspond to states, and the edges correspond to transitions between states. As the safety *restoration* states are *deterministic*, they can be represented as processes, i.e. planned, consisting of activities, measures, procedures, operations. The states of disrupted safety are random, therefore they can be considered as events. Thus, the assignment property of an object is observed when safety *states* are observed as changes in *events* and *processes* (table 1).

Table 1 – States of the safety automat

Terms	**States**	**Ω**
Processes	Research & Development (R&D)	S_{RD}
	Regulation and Standardization (R&S)	S_{RS}
	Standard Operating Procedures (SOP)	S_{SOP}
States	Safety (security)	$s_1 \cdot s_2$
	Protection	s_1
	Protectability	s_2
	Threatened	d_2
Events	Catastrophe	S_C
	Accident	S_A
	Incident	S_I

Development of SA Algorithms. The description of the SA operation consists in the translation of the standard terms into symbolic algorithms suitable for subsequent software development. The following symbols and algorithms for the operation of the automat are introduced.

Safety processes:

$\bar{S}$ is safety;

$\downarrow S$ are safety disruptions;

$\uparrow S$ are safety restorations;

$(S_j \rightarrow S_i)$ - are the transitions from the current state into the subsequent state in safety disruption events;

$(S_j \leftarrow S_i)$ are the transitions from the current state into the subsequent state in safety restoration processes;

$\overleftarrow{S}$: $(S_{RD} \subseteq S_{RS} \subseteq S_{SOP})$ are processes: subsets of safety restoration states;

$\overrightarrow{S}$: $(S_C \subseteq S_A \subseteq S_I)$ are events: subsets of safety disruption states;

$(S_j \rightarrow S_i) \mid \overrightarrow{S}$ are transitions in safety disruption events;

$(S_j \leftarrow S_i) \mid \overleftarrow{S}$ are state transitions in safety restoration events.

$\bar{S}: \mid (S_1 \cdot S_2) \leftarrow S_1\ (S_{SOP} \leftarrow S_{RS} \leftarrow S_{RD})$ are safety restoration states when all conditions for the execution of processes $S_{SOP} \vee S_{RS} \vee S_{RD}$ are met;

States in safety disruption events:

$\downarrow S: S_I \mid \neg S_{SOP}$ is "incident" event, when at least one condition for the execution of standard operating procedures is not met;

$\downarrow S: S_A \mid \neg (S_{RS} \vee S_{SOP})$ is event "accident" when the conditions for the execution of the SOP and RS processes are not met.

$\downarrow S: S_C \mid \neg (S_{RD} \vee S_{RS} \vee S_{SOP})$ is a “catastrophe” event when the execution conditions of SOP, RS and RD processes are not met.

States in safety restoration processes:

$\uparrow S: d_2 \mid (s_1 \leftarrow d_2)$ is the process of transition from the state of a threatened object d_2 to the state of an object having means of protection s_1;

$\uparrow S: s_2 \mid (s_2 \leftarrow s_1)$ is the process of transition from the state of an object with means of protection s_1 to the state of an object with protectability properties s_2;

$\uparrow S: (S_1 \cdot S_2) \mid ((S_1 \cdot S_2) \leftarrow s_2)$ is the process of transition from the state of an object with protectability properties s_2 to the safety state $(S_1 \cdot S_2)$;

SA states are shown in the diagram (figure 2).

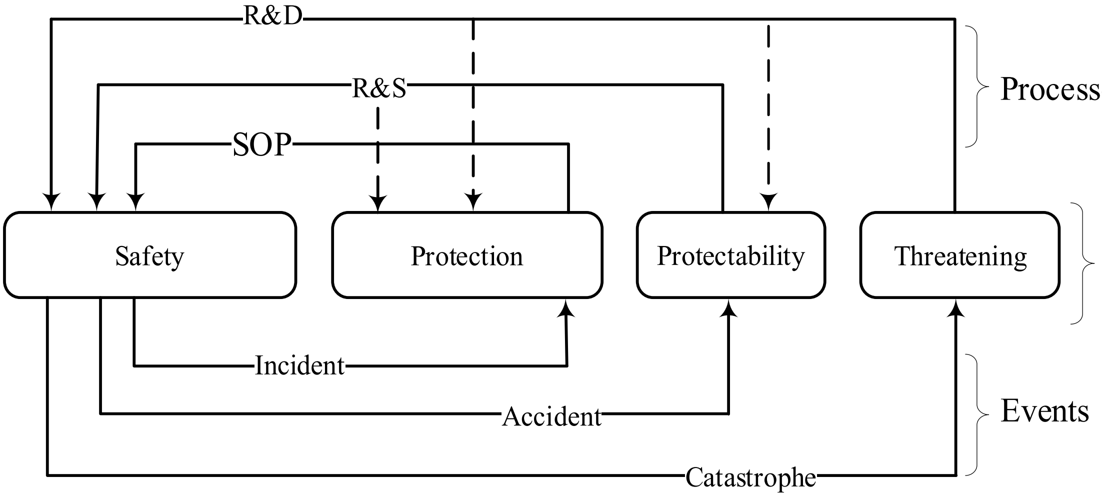

Figure 2 – Conceptual diagram of the safety automat

SA work reflects optimal and alternative transitions. Restoration and disruption of safety states are constructed as completed and partially incomplete processes.

Conclusion. Normative regulation in the development of standards begins with the derivation of definitions and terms of subject activity that meets the requirements of effective management. The development of safety management algorithms in the theory of automata for the software of a computing device for monitoring the safety of objects has been carried out. The developments were implemented in solving the terminological and logical problem of safety definitions of international standards. The practical significance of the results lies in the creation of logical foundations for technical aviation safety standards.

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Механические деформации электропроводящих материалов и электромагнитные воздействия

Аннотация: Рассмотрены вопросы унификации технологических решений в области обработки металлов и сплавов с использованием электропластического эффекта, а также с применением вибрационного и ультразвукового локального воздействия. Такие решения могут быть использованы для упрочнения и разупрочнения поверхностного слоя, снятия остаточных напряжений и снижения сопротивления пластической деформации при обработке металлов давлением: прокатке, волочении, прессовании, плющении, а также сверлении, сварке и резании металла.

Ключевые слова: электропластический эффект, деформация, металлообработка, металл, вибрация, электрический импульс

Электропластический эффект в металлах определяется как снижение сопротивляемости материала при его пластической деформации в случае воздействия на область деформации электрических импульсов. Этот эффект может быть использован при различных видах обработки металлов давлением [1]. При использовании электропластического эффекта на металл воздействуют электрическими импульсами тока с плотностью от 3 до 5000 А/мм2 м длительностью 50-200 мкс. Кроме снижения сопротивляемости деформации при электропластическом эффекте происходит релаксация имеющихся остаточных напряжений и изменение структуры поверхностного слоя металла за счет