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APPLICATION OF THE TACTICS OF DEPENDABILITY CONSECUTIVE CHECK TESTS OF CAM ELEMENTS AND AUTOMATED SIS UNDER OPERATING CONDITIONS FOR USE OF RESULTS IN FMEA ANALYSIS

The paper considers the technique based on the tactics of consecutive check tests of dependability and applied for the equipment of computer-aided manufacturing (CAM) and automated safety instrumented systems (SIS) of oil refineries under operating conditions, with subsequent use of testing results in failure mode and effects analysis (FMEA). It is supposed that operation conditions for various types of equipment correspond to a mode of system "regular" functioning and to the exponential law of distribution of mean time to failure. The IDEF3 notation of structural modeling describes the testing process, analysis of failure causes, and development of measures to prevent them. A common database on dependability check tests is kept in PDM (Product Data Management) system.

Keywords: *oil refining, automated control system, dependability, failure causes and effects, analysis.*

The maintenance of CAM and automated SIS technological complexes brings necessity in control of engineering means as to compliance of their dependability parameters to the values stipulated in regulatory documents and specifications. To establish such control, application of the tactics of dependability consecutive check tests under operating conditions is considered for the exponential law of failure probability distribution [1].

Application of this technique is considered using the example of P-2/3 furnace pressure sensors of the 37-10 oil refining installation for selective oil cleaning for the following initial data:

- total of pressure sensors;
- lifetime t = 4392 h;
- consumer risk α = 0.05;
- producer risk β = 0.05;
- rejection value of the controllable parameter – time to failure T_β=10000 hours (accepted on the basis of specifications for equipment or as agreed with the customer of products);
- acceptance value of the controllable parameter T_α=20000 hours (accepted on the basis of specifications for equipment or as agreed with the customer);
- ratio (T_α / T_β) = 2.

Boundaries of compliance are determined according to technique [1]:

$r^{+} = a(t_{\Sigma} / T_{\alpha} - t_{o} / T_{\alpha})$,

and boundaries of discrepancy are determined as follows

$r^{-} = at_{\Sigma} / T_{\alpha} + r_{o}$,

where α is the tangent of inclination of line; r is the number of failures or failed objects; r_{o} is the point of discrepancy line crossing with ordinate axis; t_{Σ} is the expected total time to failure before decision-making; t_{o} is the point of line compliance crossing with abscissa axis.

According to the plan of control of average dependability indices by a consecutive method for exponential distribution presented in [1] for the case $T_{\alpha} / T_{\beta} = 2$ and $\alpha = \beta = 0.05$, the values are determined as a = 1.44; $r_{o} = 4.25$; $t_{o} / T_{\alpha} = 2.94$; $t_{\Sigma} / T_{\alpha} = 8.64$; $r_{yc} = 25$ (r_{yc} is the limiting number of negative outcomes at the truncated consecutive control).

The expected total time to failure before decision-making about compliance (discrepancy) is determined under the following formula

$$t_{\Sigma} = Nt - \sum_{j=1}^{r} t_{вj}, \tag{1}$$

where $t_{вj}$ is the recovery time of upstate after the j-th failure from r failures or duration of the j-th specimen replacement from r failed specimens by new ones; t is the time to failure measured in hours.

For the interval of time to failure $t = 4392$ hours, there have not been registered any failures of pressure sensors in the experiment, and the expected total time to failure calculated under formula (1), has made up $t_{\Sigma} = Nt - \sum_{j=1}^{r} t_{вj} = 14 \cdot 4392 = 61488$ and, accordingly, the ratio $t_{\Sigma}/T_{\alpha} = 61488/20000$ has made up 3.0744.

The diagram of consecutive check tests for the exponential law of distribution, constructed according to technique [1], is presented in fig. 1.

The presented figure illustrates that pressure sensors in the example under consideration have passed check tests at operation and can be used at an oil refining enterprise.

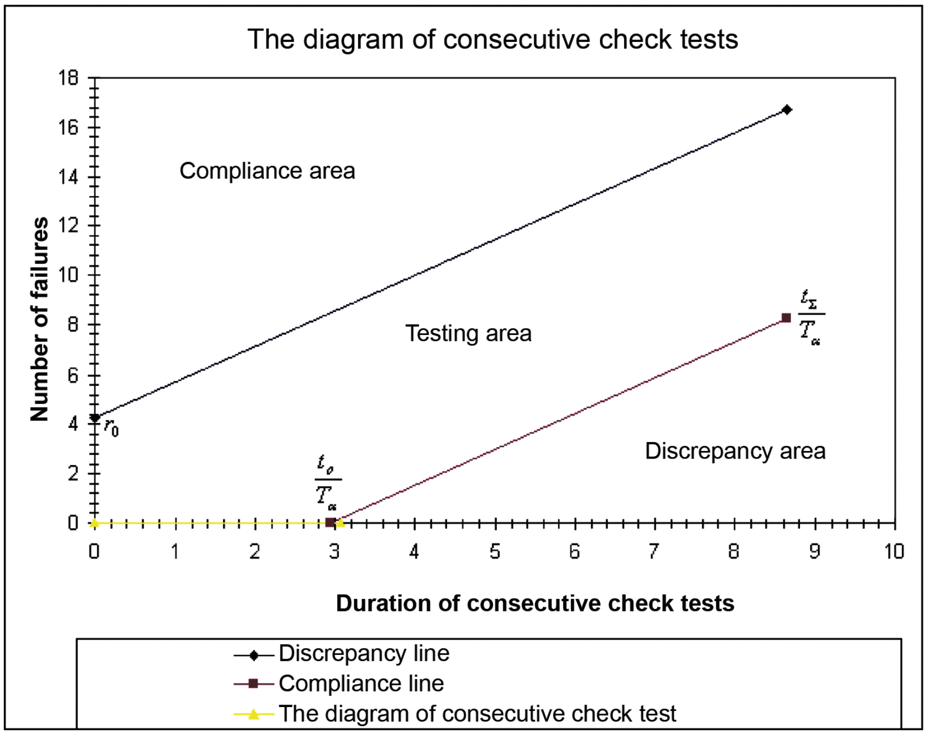

Fig. 1. The diagram of consecutive check tests for pressure sensors

The information about the results of control observations accumulated in the common database allows us to use the data to select equipment for newly designed and reconstructed technological installations of oil refining, to reduce off-schedule stops as a result of technological complex element failure due to respective maintenance.

In case the equipment has not passed check tests, it is necessary to analyze failure causes and to develop actions for their elimination. It is possible to use FMEA-methodology as a methodology for failure causes analysis and their effects. The table of the FMEA-analysis has the following form:

Table 1. Example of FMEA table

Equipment type	Potential failure mode	Failure effects	Failure significance	Potential failure cause	Failure occurrence	Actions of failure detection	Failure detection	Recommended actions	Consumer risk parameter
Temperature transducer failure	Failure of measurement component	Absence of data on operator monitor	4	Thermocouple break of resistance thermometer	2	Visual survey of the thermocouple, thermocouple ringup, measurement of resistance	1	Studying the causes of breakage. Probably, causes of breakage are connected to installation works on technological object	8
Temperature transducer failure	Malfunction of HART converter	Absence of data on operator monitor	10	Conversion device failure	3	Visual survey, diagnostics by HART- communicator or AMS	2	Presence of spare parts	60

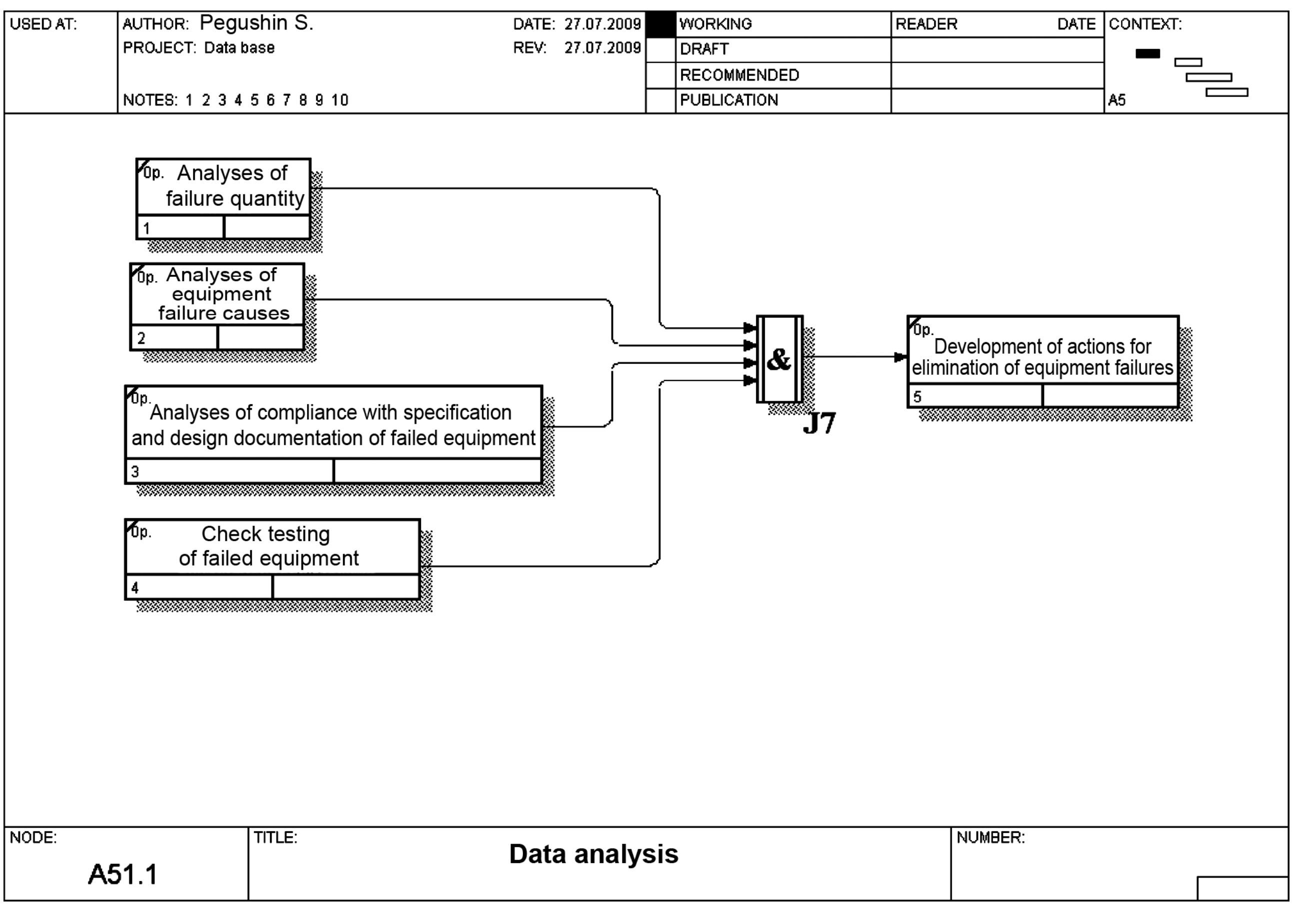

Fig. 2. IDEF3 scheme of consecutive check test process

The value of the factor “Consumer risk parameter” in the table is defined as product of factors «Importance», “Failure occurrence” and «Failure detection». Factors for the fields «Importance», “Failure occurrence” and «Failure detection» are established based on expert estimations [2].

The description of the check test process, the analysis of failure causes and development of actions on their prevention, schematically is presented in fig. 2 in the IDEF3 notation of structural modeling.

Results of check tests are stored in a common database. Application of a common database allows us to use a lot of samples for carrying out check tests, which reduces a probability to make a mistake of the 1-st or 2-nd kind at decision-making on compliance (discrepancy) for each type of equipment.

For creation and introduction of a common database it is possible to use PDM-system, whose «window» fragment is shown in fig. 3.

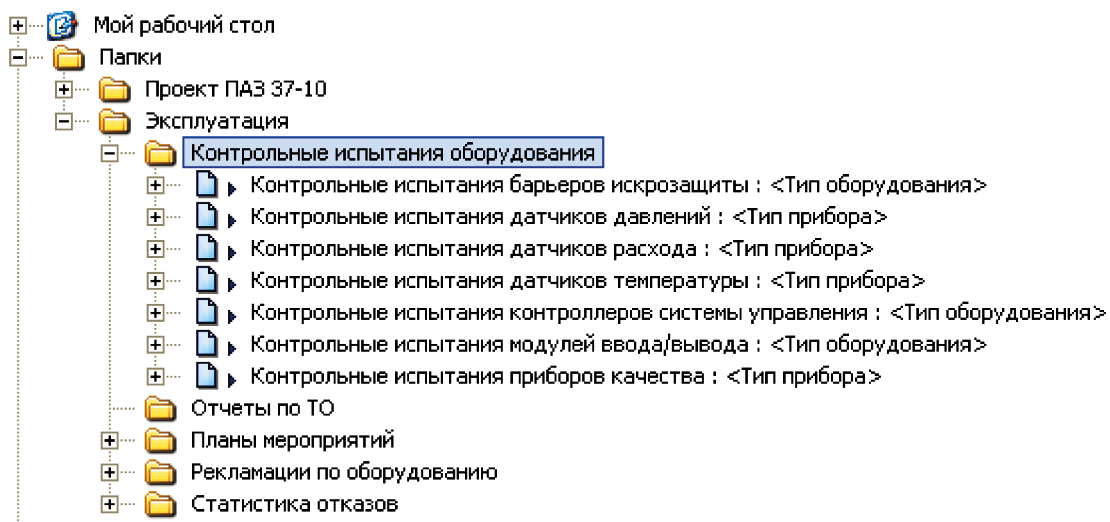

Fig. 3. A fragment of check tests in PDM-system

Carrying out control tests allows us to estimate in real conditions the dependability of operating equipment in automated SIS, to developing actions for elimination of revealed malfunctions and to bring appropriate alterations to designing and operational documentation with the purpose of perfection of a system configuration and maintenance regulations.

References

1. GOST 27.410-87. Dependability in technology. Methods of control of dependability indices and plans of dependability check tests.

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3. Rostechnadsor Order of 11.03.2013 No.96 “About the adoption of Federal regulations and rules in the field of industrial safety “The general explosion safety rules for explosion and fire-hazardous chemical, petrochemical and oil refining manufactures” (It is registered in Ministry of Justice of Russia 16.04.2013 No.28138).