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MAINTENANCE AS AN IMPORTANT ACTIVITY IN FIRE PROTECTION

Abstract: This paper present the development procedure of the mathematical model for early detection and prevention of technical systems failures. The development procedure of the mathematical model for early detection and prevention of technical systems failures is not of interest for its application, and the application is, due to its complexity, rather difficult for the final user. Because of this, the aim is to make such software that will take into account all factors of the mathematical model for early detection and prevention of failures in technical systems enabling the user a simple calculation of the optimal moment of diagnostics of the state. The output data for the user would be the optimal moment of diagnostics of the state of the technical system. This software would be applicable in most technical systems, but this paper gives an example of its usage in automatic systems for early detection of fires and alarming.

Key words: maintenance, fire, model, technical diagnostic

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INTRODUCTION

There are technical systems in which the occurrence of failure must be prevented, such as aviation, military and fire industries, where the appearance of failure brings risk to the people lives and goods [1]. These systems must have a great readiness and reliability. To prevent a failure, it is necessary to find an alternative solution. In other words, it is needed either to provide the replacement for the defective part that is activated at the moment of failure of the original one, or to predict the moment of failure and respond to it in order to prevent its appearance [2]. It is not always possible to replace the defective part with another one, so in these cases another solution should be found i.e. the failure occurrence should be predicted and prevented. An analysis of the contribution of a particular fire protection system to the achievement of specified objectives should include an assessment of the effectiveness and reliability of the proposed fire protection systems. “Reliability” is defined as the probability that a product or system will operate under designated operating conditions for a designated period of time or number of cycles. "Effectiveness” refers to the ability of a system to achieve desired objectives. Reliability data may be derived from fire incident statistics considering the entire fire protection system to be a single entity. Alternatively, the reliability of a system may be determined from an engineering analysis based on failure and repair rates of the components of the system, accounting for any redundancy in system components [3].

1.1. Maintenance of equipment

The term “maintenance“covers many activities including: inspection, testing, measurement and replacement and adjustment [4]. Maintenance is carried out in all sectors and workplaces. The purpose of maintenance are atrempt to maximize performance of production equipment efficiently and regularly, prevent breakdown or failures, minimize production loss from failures and increase reliability of the operating systems. Principle objectives in maintenance are to:

- achieve product quality and customer satisfaction through adjusted and serviced equipment,
- maximize useful life of equipment, and life of people,
- keep equipment safe and prevent safety hazards,
- minimize frequency and severity of interruptions and
- maximize production capacity – through high utilization of facility.

Problems in maintenance exist due to: failure to develop written objectives and policy, inadequate budgetary control, inadequate control procedures for work order, service requests, infrequent use of standards, to control maintenance work and absence of cost reports to aid maintenance planning and control system. Maintenance objectives must be consistent with the goals of production (cost, quality, delivery, safety) and must be comprehensive and include specific responsibilities.

1.1.1. Types of maintenance

Maintenance may be classified into four categories [5]:

- Corrective or breakdown maintenance,
- Scheduled maintenance,
- Preventive maintenance and
- Predictive maintenance.

Corrective or breakdown maintenance implies that repairs are made after the equipment is failed and can not perform its normal function anymore. Quite justified in small factories where: Down times are non-critical and repair costs are less than other type of maintenance and financial justification for scheduling are not felt. Disadvantages of corrective maintenance: breakdown generally occurs inappropriate times leading to poor and hurried maintenance, excessive delay in production & reduces output, faster plant deterioration, increases chances of accidents and less safety for both workers and machines, more spoilt materials, direct loss of profit**,** cannot be employed for equipment regulated by statutory provisions e.g. cranes, lift and hoists etc.

Scheduled maintenance is a stitch-in-time procedure and incorporates inspection, lubrication and repair and overhaul of equipment. If neglected can result in breakdown. Generally followed for: overhauling of machines, changing of heavy equipment oils and cleaning of water and other tanks etc. Locates weak spots of machinery and equipments provides them periodic/scheduled inspections and minor repairs to reduce the danger of unanticipated breakdowns.

Advantages of preventive maintenance: reduces break down and thereby down time, lass odd-time repair and reduces over time of crews, greater safety of workers, lower maintenance and repair costs, less stand-by equipment and spare parts, better product quality and fewer reworks and scraps, increases plant life and increases chances to get production incentive bonus.

In predictive maintenance, machinery conditions are periodically monitored and this enables the maintenance crews to take timely actions, such as machine adjustment, repair or overhaul. It makes use of human sense and other sensitive instruments, such as audio gauge, vibration analyzer, amplitude meter, pressure, temperature and resistance strain gauges etc. Unusual sounds coming out of a rotating equipment predicts a trouble. An excessively hot electric cable predicts a trouble. Simple hand touch can point out many unusual equipment conditions and thus predicts a trouble.

2. EQUIPMENT FOR FIRE PROTECTION

Smoke and fire detection equipment is an integral part of any building’s safety. When working properly, they alert the occupants in a building of a fire before it spreads, giving them enough time to evacuate.

2.1. Equipment for fire detection and signaling

2.1.1.Heat detectors

Heat detectors are intended for use with ionization and/or photoelectric smoke detectors. Heat detectors sense a change in air temperature and initiate alarms based on a fixed-temperature point, rate of temperature rise, or amount of temperature rise above ambient condition. Spot type heat detectors should be selected so that the rating is at least 11°C above maximum expected ceiling temperature. Ceiling height, construction, and ventilation play significant roles in detector performance and must be considered when determining detector placement. These devices are typically found in spots with fixed temperature, including heater closets, small rooms, and kitchen facilities. Fixed-temperature heat detectir consists of normally open contact held by bimetallic elements that will close the contacts when the ambient temperature reaches a fixed setting. The setting is generally designed for operation at 57^0 C, 88^0 C, or 94^0 C. Rate-of-rise detector reacts to the rate at which the temperature rises. It contains a sealed but slightly vented air chamber which expands quickly when the temperature near the device rises quickly. When the air chamber expands faster than it can be vented, electrical contacts attached to the chamber begin to close and thus initiate an alarm. Combination detector reacts to both a fixed temperature and a rate of rise [6].

2.1.2.Smoke detectors

Smoke alarms provide an early warning of a fire, giving people additional escape time. In 2009-2013, smoke alarms sounded in more than half (53%) of the home1 fires reported to U.S. fire departments. There are two main types of smoke detectors: photoelectric and ionization. Photoelectric detectors operate with the use of a light source and beam collimating system. When smoke begins to enter the optical chamber, it crosses the light beam path. This results in light being scattered by the particles in the smoke. The scattered light is then directed to the sensor, after which the alarm is activated and sounded. A photodiode or photo detector, usually placed 90 degrees to the beam, will sense the scattered infrared light and when a preset amount of light is detected, the alarm will sound. Photoelectric detectors are not as sensitive and are designed to detect cool or slow moving (smoldering) fires that produce a lot of smoke. Ionization type operates on the principle of changing conductivity of air within the detector chamber. The ionization detector uses a small amount of radioactive material to make the air within sensing chamber conduct electricity. When smoke particles or combustion gases enter the sensing chamber they interfere with the conduction of electricity, reducing the current and triggering an alarm. The ionization detector can detect even invisible combustion gases produced by an open flame and will therefore respond slightly faster to an open flame fire than a photo-electric detector [7].

2.1.3.Flame detectors

Flame detectors are used to detect the direct radiation of a flame in the visible, infrared, and ultraviolet ranges of the spectrum. When working properly, they detect fire nearly at the point of ignition. They are very useful for buildings involving with hazardous processes, as well as gas and oil refineries and manufacturing industries. Optical detectors are the most commonly used, these feature optical sensors for detecting flames. UV detectors can detect open flames, explosions, and fires within four milliseconds, due to the UV radiation emitted at the instant of ignition. However, to prevent accidental triggers, some UV detectors are designed to integrate a three second time delay. IR detectors monitor the head radiation that is generated by open flames and fire. They have a response time of three to five seconds. Accidental triggers can be caused by nearby hot surfaces and background thermal radiation.

2.1.4.Manual alarm station

A fire alarm notification appliance is an active fire protection component. A notification appliance may use audible, visible, or other stimuli to alert the occupants of a fire or other emergency condition requiring action.

2.1.5.Fire alarm systems

A fire alarm system has a number of devices working together to detect and warn people through visual and audio appliances when smoke, fire, carbon monoxide or other emergencies are present

2.2.Equipment for fire suppression systems

2.2.1.Standpipe-and – hose systems (standpipe systems)

Standpipe systems are a serious of pipe which connects a water supply to hose connections that are intended for fire department or trained occupant use. Standpipe and hose systems consist of piping, valves, hose connections, and nozzles. Standpipe systems vary in design, use, and location. Standpipes have three major classifications: class I, class II and class III. Class I a 2.5-inch fire hose connection for fire department use. These connections must match the hose thread utilized by the fire department and are typically found in stairwells of buildings. Class II serves a 1.5-inch fire hose connection and is typically found in cabinets. These are intended for trained occupant use and are spaced according to the hose length. The hose length and connection spacing is intended for all spaces of the building. Class III standpipes have both connections of Class I and II. Many times these connections will include a 2.5-inch reducer to a 1.5-inch connection. NFPA 14 is the standard which the system shall be designed, installed, and maintained to. When is determined which a standpipe system is required, the type of system should be determined. These types include: Automatic Standpipe systems are designed to provide the need pressure and water supply when the valve is opened. Automatic Dry Standpipe system is only designed to have water in the system piping when the system is in use. Manual Dry Standpipe system are exclusively for fire department use and require a fire department pumper to supply the need pressure and water supply through a fire department connection. Semi-Automatic Standpipe System are capable of providing the need pressure and water supply, after the activation of a control device or fire pump. Wet Standpipe systems are wet at all times [8].

A "wet" standpipe is filled with water and is pressurized at all times. Whenever the system is activated, water will charge into the connected hose immediately. Wet standpipes can be used by building occupants. A “Dry” standpipe is NOT filled with water. The intakes of dry standpipes are usually located near a road or driveway so that a fire engine can supply water to the system. This system can be used only by firefighters. Regulations in many countries require that standpipe systems be charged by hoses from two different pump trucks, which can be accomplished by using both sides of a Siamese connection.

2.2.2. Automatic sprinkler systems

Automatic sprinkler systems have three classifications: Wet sprinkler systems, Dry sprinkler systems and Pre-action and Deluge. Wet type systems are the most common type of sprinkler system that is installed. A wet pipe system has water in the pipes in the ambient or normal condition and has heat responsive elements on all sprinklers. In areas where low temperatures could cause a wet pipe system to freeze, a dry pipe system is intended for use. Dry pipe systems are pressurized with air in the ambient condition and experience an inherent delay in the discharge of water to allow the pressurized air in the system to escape. When a sprinkler actuates, air is released through the sprinkler, allowing water to flow into the piping system through the dry pipe valve. The time for the water to reach the most remote sprinkler be no longer than 60 seconds. A quick opening device, such as an accelerator or an exhauster, is installed to rapidly remove air from the system and speed the operation of the dry pipe valve. Pre-action systems and deluge systems required fire detectors (smoke, heat, etc.) for the actuation of the system. A deluge system uses open sprinklers or nozzles, so that all flow water is discharged when the deluge valve actuates. Pre-action systems have closed heads and pipes filled with pressurized air that supervise a piping system, and can be considered for the protection of valuable assets or irreplaceable property. The detection system for a pre-action system can be designed to prevent water discharge in cases of a false alarm from the detection system, or in case of a sprinkler whose element has encountered mechanical damage [9].

3. TECHNICAL DIAGNOSTIC

Technical diagnostics presents all the activities that are performed over a particular technical system for the purpose of assessing the current state or giving a prognosis of the behavior of the system over a certain period of time. Various National Fire Protection Association (NFPA) fire codes provide good references and guidelines in this area. NFPA 25 Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems. By performing technical diagnostic procedures, the state of that part is determined, compared to the recommended or required parameters, and based on this, the state of the part or system is determined. After that, if the value of the measured parameter is within the limits of good, regular maintenance activities are performed or, if they are not needed, no maintenance activities are performed. If the value of the measured parameter is within the limits of the satisfactory, preventive maintenance activities are carried out, and if the value of the measured parameter is in a state of unsatisfactory, in this case, the failure is most often canceled or will occur.

4. MODEL AND SOFTWARE FOR EARLY FAILURE DETECTION OF FIRES AND ALARMING

Models of technical diagnostics can point to the possibility of failure. When setting the mathematical model for determining the optimal interval or moments of the technical system state or its constituent element, the following images will be used [11-14]. The first picture is given below.

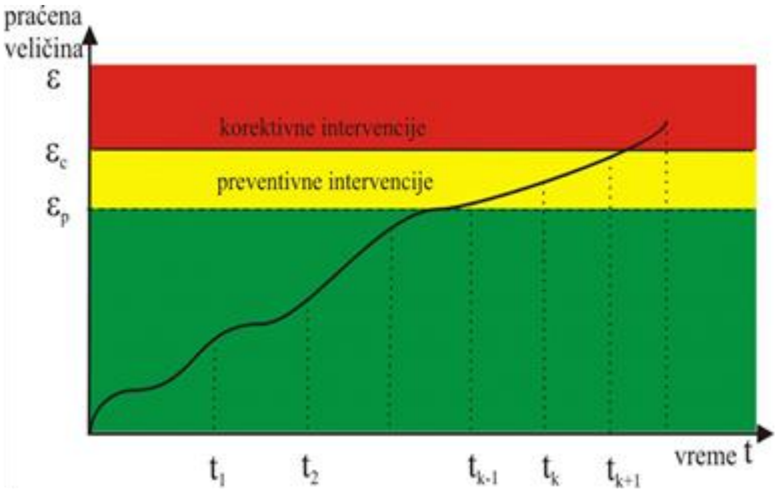

Figure 1 – The behavior of the system in time: ε_p border on which are performed prevention interventions, ε_c limit where the running corrective intervention, t – time moments in which to perform diagnostics

The picture shows that the state of the system or its constituent element in time is deteriorating, with a certain dependency. The deterioration of the system can be expressed with some measurable size, which is established by performing technical diagnostics. This size is marked with ε, and its state ranges from ε_0 to ε_p, which is the lower limit of performing preventive maintenance, to ε_c, which is the upper limit of preventive maintenance, that is, the value of the observed size, when the failure occurs . Changing the state of the system can be monitored across different sizes, such as e.g. increase vibration, increase temperature, increase fraying, increase voltage, current etc. What is important here to do is to determine where these spending limits are.

The probability of occurrence in a certain state, according to Figure 1 are equal to:

$$P_i = \int_0^{\varepsilon_c} \varphi(\varepsilon)d\varepsilon \qquad P_p = \int_{\varepsilon_p}^{\varepsilon_c} \varphi(\varepsilon)d\varepsilon \quad P_c = \int_{\varepsilon_c}^{\infty} \varphi(\varepsilon)d\varepsilon \quad P_o = \int_{\varepsilon_c}^{\infty} \varphi(\varepsilon)d\varepsilon \quad (1)$$

Where:

P_i - the probability of diagnosis

P_c - the probability of a condition in the cancellation

P_p - probability of occurrence of preventive maintenance

P_o - the probability of an undetected failure

$\varphi(\varepsilon)$ - t he size of a change in system state.

The probability that will come to inspection, P_i, can be written as without failure of the system, that is:

$$P_i = 1 - \int f(t)dt \tag{2}$$

The probability that it will come to a corrective intervention is equal to:

$$P_c = \int f(t)dt \tag{3}$$

Where:

f (t) - function of the density of occurrence of the system in failure.

In order to obtain an optimal diagnostic moment, two intervals will be considered, first from tk-1 to tk, and the other from tk to tk + 1, and the total cost in these two intervals are:

$$\begin{aligned} C_u = & \left(\left(C_i (k+1)(1 - \int_{t_{k-1}}^{t_k} f(t)dt) \right) + C_c \int_{t_{k-1}}^{t_k} f(t)dt + C_o (t_k - t) \int_{t_{k-1}}^{t_k} f(t)dt + C_p \int_{t_{k-1}}^{t_k} \int_{\varepsilon_p}^{\varepsilon_c} \varphi(\varepsilon, t) d\varepsilon dt \right) + \\ & + \left(\left(C_i (k+1)(1 - \int_{t_k}^{t_{k+1}} f(t)dt) \right) + C_c \int_{t_k}^{t_{k+1}} f(t)dt + C_o (t_{k+1} - t) \int_{t_k}^{t_{k+1}} f(t)dt + C_p \int_{t_k}^{t_{k+1}} \int_{\varepsilon_p}^{\varepsilon_c} \varphi(\varepsilon, t) d\varepsilon dt \right). \end{aligned} \tag{4}$$

The optimal moment of diagnosis is obtained by differentiating the preceding expression by tk and then equating with the zero of the expression obtained. Then the phrase becomes equal to:

$$\begin{aligned} \frac{\partial C_u}{\partial t_k} = & \left(C_i \cdot k \cdot f(t_k) + C_c \cdot f(t_k) + C_o \left(\int_{t_{k-1}}^{t_k} f(t)dt - t_k \cdot f(t_k) - t_k \cdot f(t_k) \right) + C_p \int_{\varepsilon_p}^{\varepsilon_c} \varphi(\varepsilon, t) d\varepsilon \right) + \\ & + \left(C_i (k+1) f(t_k) - C_c \cdot f(t_k) + C_o \left(-t_{k+1} \cdot f(t_k) + t_k \cdot f(t_k) \right) - C_p \int_{\varepsilon_p}^{\varepsilon_c} \varphi(\varepsilon, t) d\varepsilon \right). \end{aligned} \tag{5}$$

After shortening and equating the equation with zero, the following expression is obtained:

$$C_i \cdot f(t_k) + C_o \left(F(t_k) - F(t_{k-1}) \right) - C_o \left(t_{k+1} - t_k \right) f(t_k) = 0 \tag{6}$$

In the end, the optimal interval for performing the system state diagnostics is in the form:

$$t_{k+1} - t_k = \frac{F(t_k) - F(t_{k-1})}{f(t_k)} + \frac{C_i}{C_o} \tag{7}$$

Electronic components used in fire protection have Weibul's law distribution, with density function of failure state:

$$f(t)=\frac{\beta}{\eta}\left(\frac{t}{\eta}\right)^{\beta-1}e^{-\left(\frac{t}{\eta}\right)^{\beta}} \tag{8}$$

The general model developed by the assessment of the optimal moment is obtained

$$t_{k+1}-t_k=\frac{\frac{\beta}{\eta}\int_0^{t_k}\left(\frac{t}{\eta}\right)^{\beta-1}e^{-\left(\frac{t}{\eta}\right)^{\beta}}-\frac{\beta}{\eta}\int_0^{t_{k-1}}\left(\frac{t}{\eta}\right)^{\beta-1}e^{-\left(\frac{t}{\eta}\right)^{\beta}}}{\frac{\beta}{\eta}\left(\frac{t_k}{\eta}\right)^{\beta-1}e^{-\left(\frac{t_k}{\eta}\right)^{\beta}}}+\frac{C_i}{C_o} \tag{9}$$

4.1. Software Development

The software has been developed using Macromedia Flash Professional 8 [10]. After setting up a graphical environment, the program has been written based on the model. Thereafter object linking and the program activation have been performed what is shown in the Figure 2. Finally, after performing all the activities and tests, the executable program that is shown in Figure 3 has been obtained.

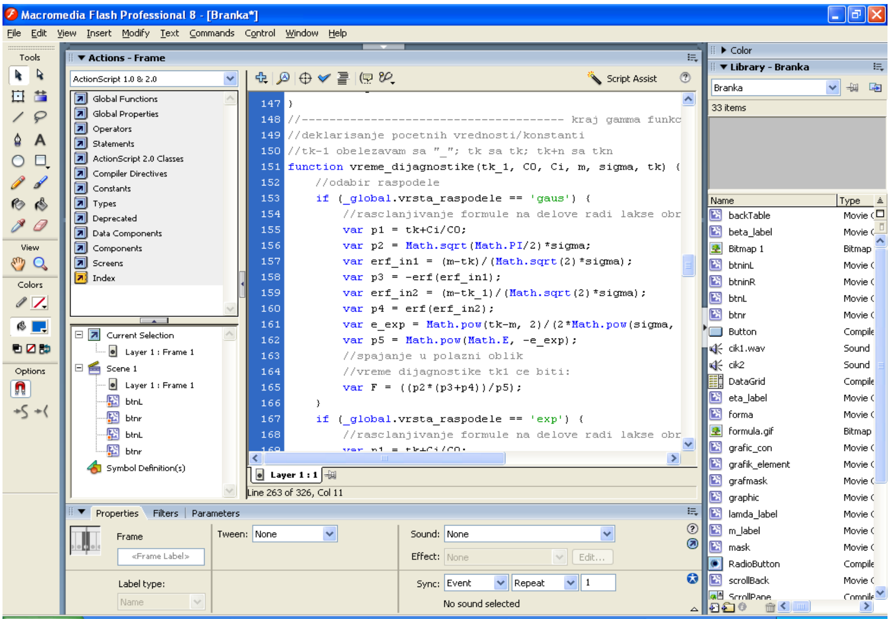

Figure 2 - A program page and objects linking in the software package

After performing all these activities, the executive program was shown as shown in Figure 3.

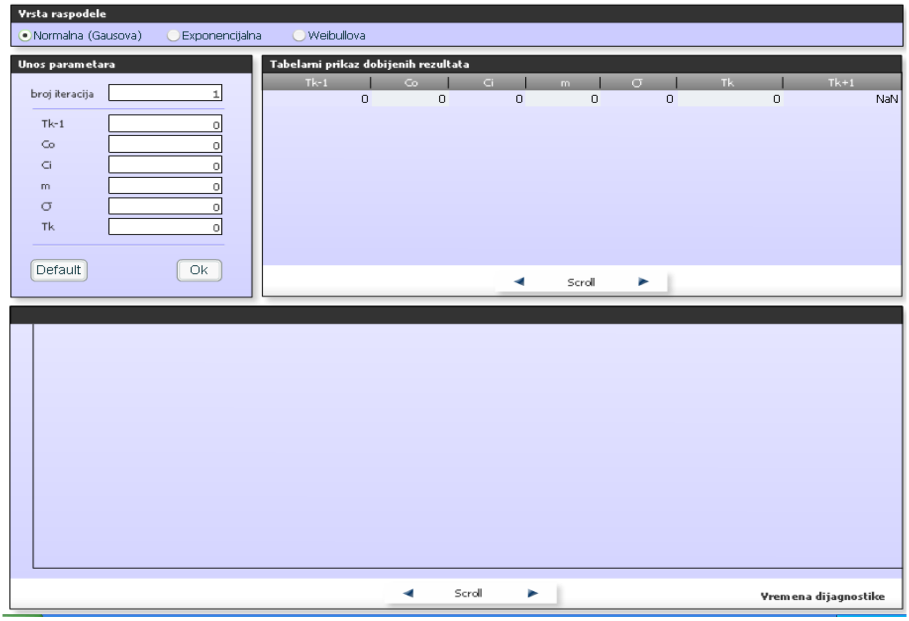

Figure 3 - User interface look of the developed software package

Figure 3 shows there are four windows in the developed software package, such as: the distribution type (normal, exponential and Weibull distribution), the data entry, the table review of the obtained results and the graphical representation of the results. Depending on the established distribution of the observed element the distribution type is selected in the field „type of distribution". The second window is used for data entry. In the field „number of iterations“ an approximate number of state diagnoses is entered, usually higher than necessary. If such a number of diagnoses is not needed, then the software will remove the excessive ones, what will be seen from interpretation of the results obtained. In the program it is necessary to determine the unknown t_{k+1}, and it is in fact the next moment of diagnosis, or rather the optimal moment of state diagnosis which is calculated. The moment t_{k-1} is taken to be equal to 0, when the first moment of state diagnosis is determined because no state diagnosis is performed until that moment. Furthermore, to determine the first moment of state diagnosis, the t_k is taken to be equal to the moment when a failure occurred for the first time on the observed part.

5. APPLICATION OF THE MODEL FOR ESTABLISHING THE OPTIMAL MOMENT FOR STATUS DIAGNOSIS OF AUTOMATIC SYSTEMS FOR EARLY DETECTION OF FIRES AND ALARMING

In respect of the examined appliance we obtained data on the moments of failures and calculated the reliability after following the status, which all is shown in Table 1. Other calculated data regarding reliability, unreliability, the intensity of breakdowns and density functions of breakdowns are also shown in the same Table 1.

Table 1 - The moment of breakdown, reliability, the function of breakdown density and intensity of breakdown [hour]

i	to	R(t)	F(t)	$f(t)\cdot\times 10^{-4}$	$\lambda(t)\cdot\times 10^{-5}$
1.	365	0,918	0,082	2,161	23,537
2.	1095	0,773	0,227	1,819	23,537
3.	1825	0,651	0,349	1,532	23,537
4.	2555	0,548	0,452	1,290	23,537
5.	3285	0,462	0,538	1,087	23,537
6.	4015	0,389	0,611	0,916	23,537
7.	4745	0,327	0,673	0,770	23,537
8.	5475	0,276	0,724	0,650	23,537
9.	6205	0,232	0,768	0,546	23,537
10.	6935	0,195	0,805	0,459	23,537
11.	7665	0,165	0,835	0,388	23,537
12.	8395	0,139	0,861	0,327	23,537

By processing the above data and testing the hypothesis of the Weibull distribution the following parameters were won: $\beta=1$, $\eta=4.248,63$ i $\lambda=23.537\cdot\times 10^{-5}$. Taking into account these values and the values of costs (C_i and C_o) of the previous formula for calculating the optimal moment for carrying out diagnostic inspections of the system's status – in this case of automatic systems for early detection of fires and alarming – for the instance of the established Weibull distribution the optimal moments for status diagnosis are going to be reached by means of the solving procedure described hereinafter. In instances such as the present, where the damage caused by failures (C_o) is considerably higher than the expenses of diagnostics (C_i), the last parameter (C_i/C_o) is lost due to the fact that its value tends to be zero. This is understandable because the costs of any diagnostics have to be considerably lower than the damages after a fire, which can in worst cases result deaths.

Assuming that the first moment of diagnosis is approximately the same moment when breakdowns start to appear, that is when the first bearing fails to function, we are going to – for the sake of greater security – presume that t_0 equals 350 hours. The further step is to partially solve a complicated function step by step, by changing the earlier formulas into the next equation for determining the optimal moment of carrying out the technical diagnosis. Thus the following formula is reached:

$$t_{k+1} = t_k + \frac{\int_0^{t_k} \left(\frac{t}{\eta}\right)^{\beta-1} e^{-\left(\frac{t}{\eta}\right)^{\beta}} - \int_0^{t_{k-1}} \left(\frac{t}{\eta}\right)^{\beta-1} e^{-\left(\frac{t}{\eta}\right)^{\beta}}}{\left(\frac{t_k}{\eta}\right)^{\beta-1} e^{-\left(\frac{t_k}{\eta}\right)^{\beta}}} + \frac{C_i}{C_o} \qquad (10)$$

From here, by using a developed software packet, we reach the first optimal moment of carrying out the technical diagnosis of the status t_1= 1071.63 hours. Thus the first moment when it is necessary to carry out a status diagnosis is established by calculation and amounts to *1071* hours counting from the point of appliance installation. Other moments of diagnosis are established in a similar manner and are shown in Table 2.

Table 2 - The calculated optimal moments for carrying out diagnoses of automatic systems for early fire detection and alarming

Moment of execution	t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}
Time of execution	350	1071	1819	2517	3244	4012	4717	5471	6150	6801	7450	8201

5.1. Fires caused by computer systems

Computer systems, especially those who work continuously, can be the cause of the fire. The computer system has electronic components that can overheat in case of failure. Extensive cables, battery adapters, monitors are potential cause of fire. Computer systems are more prevalent in developed countries; hence the number of fires caused by computer systems in these countries is higher. These fires are not fatal and most are localized on the computer itself, 40% are localized in the area of the room, and only 10% of the fire is expanding. By monitoring the temperature is enabled to control the temperature, to detect a change in temperature due to malfunction of the system component and to detect a change in the conduct of heat caused by the incorrect operation of a component. Thermography is a newer diagnostic method with a wide range of applications. In the case of laptop computers, the temperature of the computer can climb up to 80°C in the case of fan drains, which can easily lead to the cancellation of a component and the outbreak of the fire. The batteries used in them are potential fire triggers, if they are not treated according to regulations. Adapters that convert 220V alternating current, to the most common 19V DCs, are very heated and potential are the cause of the fire. Insulation damage on the cable that connects the adapter with the laptop, because it often bends when packing, may result in short circuit, sparking and causing fire. With thermal imaging camera can be monitored and detected a change in the temperature of a component. The temperature change usually leads to a pre-fault condition, after which a failure occurs.

6. CONCLUSIONS

It is evident from the described example that the developed model for determining the optimal moment for carrying out diagnostic controls of the system’s status behaves in compliance with the expected instances in case of the Weibull distribution of system failures on parts of automatic systems for early detection of fires and alarming that were taken as an example. It is apparent that diagnostic inspections are concentrated before the moment of breakdown status. This is in accordance with the expectations in respect of the Weibull distribution. From all of the above follows the conclusion that by application of the developed model, and software it is possible to establish the optimal moments for status diagnostics of systems for early detection of fires and alarming and thus avoid failures and high expenses or even save human lives.

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QUESTIONS

1. List three areas where system error is not allowed.
2. What activities does maintenance cover?
3. What is the main goal of maintenance?
4. List 4 basic maintenance categories?
5. To which two basic groups are fire protection equipment divided?