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The Use of voice Messages Generators in the Integrated Control and Supervision Systems Installed in Laboratory Rooms

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Summary. The correct communication between the system and user is an important symptom of correct functioning of the control and supervision system. The system status should be precisely determined by means of transferred message on the request of user or in certain situations. In case of detected hazard, the system is required to inform the user about emergency status. Such signal should make it possible to commence the hazard neutralization process or to initiate evacuation process. Often the signals informing about detected hazards are transmitted by means of acoustic signaling devices or optical – acoustic signaling devices. However, the signal does not contain any information about the type of detected hazard. The procedure to be followed in occurred situation often depends on the type of detected hazard. The laboratory room has been used in the present study as an example in order to present the cooperation of the control and supervision system based on programmable logic controllers (PLC) with the voice messages generators. The voice messages generators installed in the control and supervision system make it possible to inform the user about detected hazard and to create the voice reports informing about the status of the room being protected.

Key words: control systems, supervision systems, voice messages generators, PLC controllers.

INTRODUCTION

The basic task to be performed by devices operation control systems is to ensure the correct power supply for individual devices – i.e. to perform the control and power supply function. Another task consists in the checking for the correct course of control process and in reaction to control parameters changes occurred in the actual situation – i.e. in monitoring and regulation function. The third task is to ensure the correct data exchange process in the system as well as to ensure the communication between the user and the system – i.e. management function [5,6,11,18,19]. It is possible to ensure the correct working conditions and performance of aforesaid tasks in various configurations of control system. It is also possible to apply independent autonomous control systems to control the operation of individual devices or to apply an integrated control system based upon a centralized or distributed decision making system [9, 10, 20, 21, 22].

The control and supervision systems suitable to meet the assumed needs are frequently used to manage the operation of devices installed in building structures [2, 6, 8, 9, 14]. Such systems are selected in accordance with the object's destination, user's preferences and technical capabilities of the system elements. Their task is to create the correct working conditions for installed devices, to make it possible to perform the assumed technological processes and to ensure the required safety level in the object associated with the use of the devices [11, 12, 16, 23, 24]. In the framework of the last task it is necessary to install the elements in the system in order to neutralize the occurred hazards and to warn the user about the occurred hazard. This task is performed by dedicated alarm circuits in the control and supervision systems [1, 4, 5, 12, 16]. The alarm circuits respond to manual or automatic hazard detection in the object being protected. From a technical point of view, it is defined as an assembly of cooperative devices (including wiring installation) in order to detect the hazard, to generate alarms and to initiate the undertakings intended to eliminate such hazard [1, 4].

The generally used acoustic signalling devices or optical – acoustic signalling devices belong to the basic elements making it possible to inform the user about the detected hazard. Their disadvantage consists in the generation of an identical warning signal for all the detected hazards [1, 13, 16]. The present article emphasizes the possibility to use the systems enabling the generation of voice messages adapted to current hazards and actual conditions existing in the object. The laboratory room will be used in the present study as an example in order to present the analysis for potential use of voice messages generators. The laboratory room has been

selected due to its specific working conditions, large quantity of potential hazards and various procedures to be followed in order to neutralize individual hazards. The potential use of voice messages generators will be presented on the basis of control and supervision system containing the decision making circuits based on EASY class programmable logic controllers (PLC) manufactured by Moeller. Said controllers are frequently used in the objects with defined destination and make it possible to combine the controllers together in order to increase their functional capabilities. They are capable of performing complex functions and creating complex control algorithms. The voice messages generators cooperating with the control system will perform two functions. The first one will be associated with the information transfer process to inform about the detected hazard. Another function will be associated with the creation of voice messages informing about the current object status.

INTEGRATED CONTROL AND SUPERVISION SYSTEMS

The tasks to be performed by the modern electric installations in the buildings are not limited to the reliable supply of electricity with required parameters. Currently, there are specialized systems exercising the control over the object status and controlling the operation of devices installed therein. Therefore, the electric installations are equipped with control circuits enabling the performance of functions and procedures intended by the user. The purpose of such circuits is to accomplish the assumed goals associated with the operation of lighting, heating and ventilation functions as well as to perform the role of alarm systems informing the user about the current object status. Therefore, it is possible to improve the comfort of use, to increase the safety of work, frequently with simultaneous reduction of operation costs of such installations [5,8,9,11].

Currently there are three types of electric control system devices in the building objects:
– manual control system,
– system performing the building management functions,
– system performing an intelligent building functions.

There are two principal types of systems performing the building management functions [9]:
– island system – the system based on autonomous circuits, performing only precisely determined functions (e.g. controlling the building heating only or performing the alarm system functions only),
– integrated system – the system based on consolidated management system with concentrated or centralized structure and with open or closed architecture.

The system integration process consists in the cooperation of individual installations performing autonomous functions in the object as an integrated system performing all tasks to be performed by individual parts functioning as the components of the system. The integrated system makes it possible to control several functions and to exercise the control over several actuators in the building [8, 18, 19]

The integration of autonomous systems is possible in the following manner:
– in the form of information exchange between autonomous systems,
– in the form of detecting and actuating elements shared by the systems,
– in the form of all the control functions performed by one control system.

The problems associated with autonomous systems are eliminated in case of all the control functions performed by one control system. All elements are connected to the same controller. In case of such solution, there is only one supervising system provided with the access to all data originating from detecting elements. This system performs the assumed functions depending on operation mode (status) established by the user. The system is characterized by the lack of duplicated procedures and the fastest response to recorded events. There are much greater opportunities associated with the building of algorithm controlling the system operation but usually there is a necessity to familiarize with programming languages or to cooperate with specialized service.

PROGRAMMABLE LOGIC CONTROLLERS USED AS DECISION MAKING CIRCUITS IN THE CONTROL AND SUPERVISION SYSTEMS

The Programmable Logic Controllers (PLC) are microprocessor based systems dedicated to devices operations and processes control. These controllers perform all functions performed by the contactor and relay control systems as well as by logics systems, programmers and discrete and continuous signals processing systems [3, 15].

PLC controllers make it possible to perform any control algorithm; obviously in the scope anticipated by the resources of said PLC controller and are associated with the number of inputs and outputs and their types as well as with the functions existing in this type of the controller (timers, clocks, counters, arithmetical and logical functions, regulators etc.). The execution of an assumed algorithm is commenced from the entry of program algorithm into its operating memory. The controller programming is possible in the local mode, directly on the controller. The built-in function buttons of the controller are used for this purpose. However, controller programming is more frequently carried out in the indirect mode. The application creation process is carried out by means of a computer on the software dedicated to the specified controller. Then the program is recorded in the controller memory. The program reading from PC computer is possible by means of communication port of the controller and appropriate conductor [3, 15].

An important feature of PLC controllers consists in their openness and versatility of use. PLC controllers are used for controlling the working processes in case of single devices as well as in the case of the whole processes and process plants [7, 9, 12, 17, 23, 24]. The applications of PLC controllers is not limited to industrial processes monitoring only but sometimes it is also used in smaller installations particularly wherever it is necessary to adapt the decision

making circuit to specific features of the object or to the requirements of specified process [7,9,17]. Wide scope of possible PLC controllers application as associated with their modular structure. Each PLC controller is equipped with the circuits enabling data acquisition and processing as well as decision making and actuating of controlling systems. Additionally, in order to increase their functional capabilities, PLC controllers are provided with appropriate communication interfaces enabling the connection of large numbers of controllers with each other. Therefore, they are easy to extend and make it possible to perform the assumed control objectives suitably for the existing needs.

Due to their modular construction, the operation of PLC controllers in management system is based on the principle of centralized supervising system with distributed architecture. Each module performs its own control algorithm. The control algorithms of individual modules may be limited to the use for data processing within their own resources only. They may also use their connections with other elements of the system in certain situations determined in their control algorithms. PLC controllers integrated in common structure make it possible to exchange the information about current statuses of inputs and outputs as well as about results obtained from inner processes associated with data processing. The block diagram of an integrated control and supervision system based upon the use of PLC controllers as decision making elements is illustrated in Fig. 1.

The control and supervision processes assumed in working algorithms may be carried out in individual management system modules and may constitute designated structures containing the control, supervision and safety modules.

THE ESSENCE OF CONTROL AND SUPERVISION SYSTEMS IN THE RESEARCH AND LABORATORY ROOMS

The rooms and objects used for research purpose are specific type of rooms. Often it is necessary to ensure rigorous and precisely determined working conditions in order to achieve the correct flow of research process in such rooms. On the other hand, the proper conditions required to ensure safe work for the personnel is another important aspect of the use of the research and laboratory rooms. Further features of such rooms consist in the possibility of the presence of many various factors, including hazardous factors and factors jeopardizing the human life or health. Also, the essence of a scientific experiment consisting in not completely foreseeable result of the research works contributes to the potential occurrence of certain hazards. Additionally, the research and laboratory rooms may constitute the whole of a building object or only a part of available resources.

From the presented specific features of laboratory rooms it appears that in the case of such rooms:

– it is required to ensure special working conditions in order to enable the correct execution of experiments and scientific studies,
– it is required to ensure correct operation for testing devices and apparatuses as well as measuring equipment,
– it is required to ensure proper working conditions for the operating personnel,
– it is required to ensure special safety measures.

Therefore, the designed and installed control and supervision processes dedicated for the research and laboratory rooms shall anticipate possibility of the presence of various hazardous factors. Said rooms must also have implemented safety procedures to enable automatic responding to hazards identified in the object. These procedures shall be diversified in accordance with various types of hazards. It is important to provide the user with information about the detected hazard sufficient to initiate a correct reaction.

Due to the required features of such objects, their control and supervision systems have to involve not only information transfer procedures but also hazard neutralizing procedures. The functioning of such hazard neutralizing procedure shall anticipate the presence of human factor. The constructive or destructive type is possible in case of human factor occurring in automatic hazard neutralizing procedures. The constructive type occurs in the case of human action aiding the automatic hazard neutralizing process, and the destructive type occurs in the case of human action disturbing this process. Therefore, it is important to

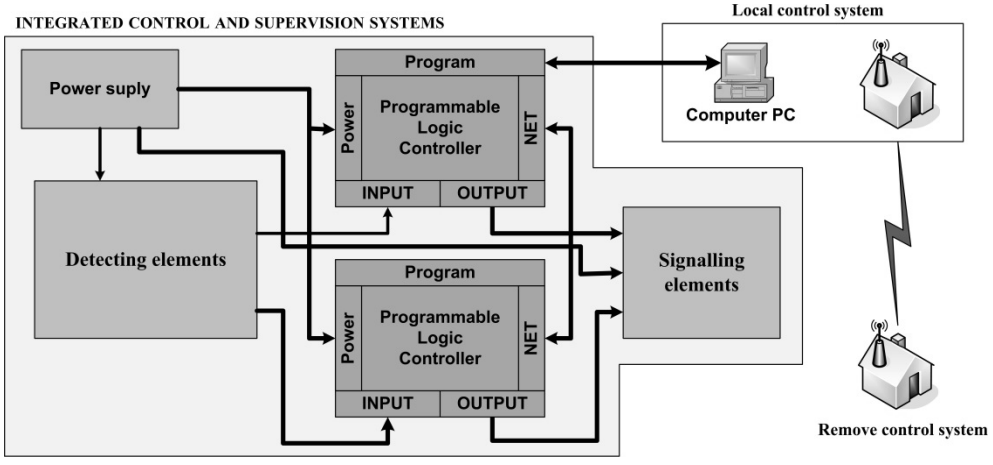

Fig. 1. Block diagram of an integrated control and supervision system based upon the use of PLC controller as a decision making unit [own materials]

precisely determine the hazard and to precisely transfer the information about thedetected hazard to the persons who are present in this room or object.

The cooperation of elements performing the tasks of power supply systems, fire protection systems, air-conditioning and lighting systems as well as alarm and access control systems constituting a part of an integrated control and supervision system shall be determined by the hazard detection and neutralizing procedures in the research objects in their operation algorithm.

THE ROLE OF VOICE WARNING SYSTEMS AIDING THE OPERATION OF SYSTEMS SUPERVISING THE STATUS OF AN OBJECT BEING PROTECTED

The warning system belongs to essential elements of the system supervising the status of an object or area being protected. The task to be performed by the warning system consists in the informing of the occupants of the endangered area about the detected hazard. The warning systems may be characterized by many features, their goals may be achieved by means of various methods and measures. The basic types of warning systems are [1, 4, 12, 13, 16, 17]:

- the hazard warning systems used by the Civil Protection – signals from alarm sirens informing about an air – raid alarm or about land contamination. The system is supported by means of messages broadcast in media,
- the system warning of the approaching privileged vehicle – modulated signal from alarm sirens installed in vehicles. The system is supported by means of red or blue light signals,
- intrusion and hold-up alarm systems – acoustic signal from indoor and outdoor acoustic signalling devices or from optical – acoustic signalling devices,
- acoustic warning systems installed in public utility objects and informing about the detected fire hazard – acoustic signal from *public-address* systems.

The purpose of the presented above warning systems is to perform the warning tasks by generation of a specific alarm signal. This signal is usually generated as a continuous or modulated signal. Its features, duration and broadcasting method contains encoded information about the detected hazard. Generally, such information is knowingly or unknowingly underestimated and often is understood by a limited number of persons only. On one hand, such phenomenon is associated with the specific features of a generated signal (sirens and signals used by the Civil Protection) but on the other hand with a huge number of occurring and frequently repeating in public area of alarm signals originating from alarm systems installed in apartments, shops, offices as well as from automatic alarm systems installed in motor vehicles.

Currently, the warning systems are aided by means of information transfer systems which are new, unknown or expensive at the time of signal entry or standardization. Thanks to technological progress occurred in the scope of information transfer it is possible to apply other more understandable methods of information transfer on local or national or even global level. In the new supervision systems and alarm installations, the acoustic signalling devices are more and more often substituted or additionally aided by means of systems making it possible to transfer the voice commands informing about the detected hazard. Such elements constitute the voice warning systems. The voice warning systems respond to the hazards detected by the control and supervision system installed in the object and inform the system user in an understandable manner about a procedure to be followed in the occurred situation. Most often the voice warning systems are installed in the buildings in order to support the evacuation systems operation (evacuation voice systems) or alarm systems (alarm systems with voice communication).

The task of voice warning systems is to increase the safety of objects occupants in course of performance of the tasks associated with the detected hazard neutralization and to increase the effectiveness of evacuation from the endangered area. These systems may contribute to the reduction of panic frequently occurring in case of chaotic and disordered plan for leaving the area of danger or escaping from the area of danger.

Due to their transparency in the scope of information transfer, the voice warning systems may be successfully used in the special purpose objects e.g. in laboratory rooms. Such objects are often characterized by limited staff, the personnel are highly skilled and trained. However, the number of potential hazard is high and additionally the character of hazards may be different. Therefore, the procedures to be followed in case of hazard may be diversified and certain activities shall be performed in a precise manner. It is possible to transfer the information about the procedures to be followed and about the type of detecteded hazard by means of voice warning systems aiding the control and supervising systems in laboratory rooms.

CONTROL AND SUPERVISING SYSTEM MODEL – TEST STAND

According to the concept of this article, the authors assumed to build a model and to check the functional capabilities of an integrated control and supervising system dedicated to working processes, information transfer processes and safety assurance processes management in an object incorporating the rooms for research and laboratory purposes. The tasks to be performed by the control and supervising system consists in the performance of processes associated with the control for lighting system, heating system, air – conditioning system, airlock control system, exhaust system, emergency and evacuation lighting system, smoke extract system, firefighting and fire protection system.

The execution of individual actions is associated with the performance of procedures assumed in control algorithm. Said procedures are recorded directly from the computer into programmable logic controllers (PLC) constituting the decision making circuits in the presented control and supervising model. The control and supervising system has

been based on EASY class and MFD class programmable logic controllers (PLC) manufactured by Moeller (Fig. 3). The decision making circuit based on programmable logic controllers (PLC) cooperates with VMG-16 voice messages generators manufactured by SATEL. VMG-16 modules are responsible in the system for generation of relevant messages in voice public address system and in voice reporting system. Relevant messages have been recorded and saved in the memory of VMG-16 voice messages generator. Output system of VMG-16 modules has been provided with loudspeakers for messages listening. It is also possible to control VGM-16 systems operations modes by means of PLC controllers operating in the system as the notification and reporting circuits. Refer to Fig. 2 for the block diagram of an integrated control and supervising system dedicated for laboratory rooms.

In accordance with the block diagram (Fig. 2), apart from PLC controllers, detecting and signalling elements as well as voice messages generators, the model consists of a simulation block and control (intermediate) block. Said blocks make it possible to connect individual alarm sensors and signalling devices as well as to simulate proposed algorithm operation without connecting the real elements to the inputs and outputs.

Thanks to such structure of the integrated control and supervising system model, it is possible to perform the full simulation and to present the system capabilities and functionalities of individual elements of the control and supervising system. It is also possible, as a result of proper model configuration, to perform the assumed scenarios associated with the completion of control process as well as with hazards detection and elimination process in laboratory rooms and with safety procedures checking.

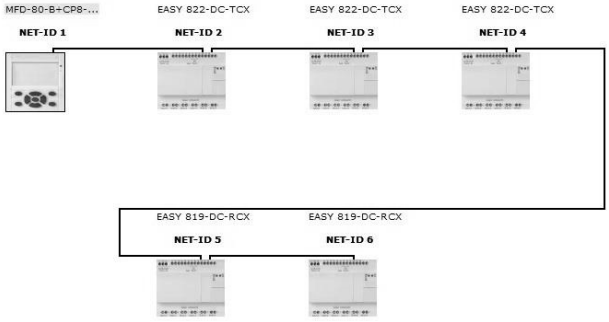

Fig. 3. The decision making system structure based on Easy module and on MFD modules [own materials]

The model, as the circuit performing the function of configuration system and the system communicating with the user, contains MFD-Titan controller manufactured by Moeller and consisting of the following subassemblies (Fig. 4): CPU module – MFD-CP8-NT, display module – MFD-80-B, inputs/outputs module – MFD-R16.

The model, as the circuit performing the function of control system, of the supervision system and of alarm system, contains EASY-822-DC-TCX controller (Fig. 5.a) and EASY-819-DC-RCX controller (Fig. 5.b) in order to

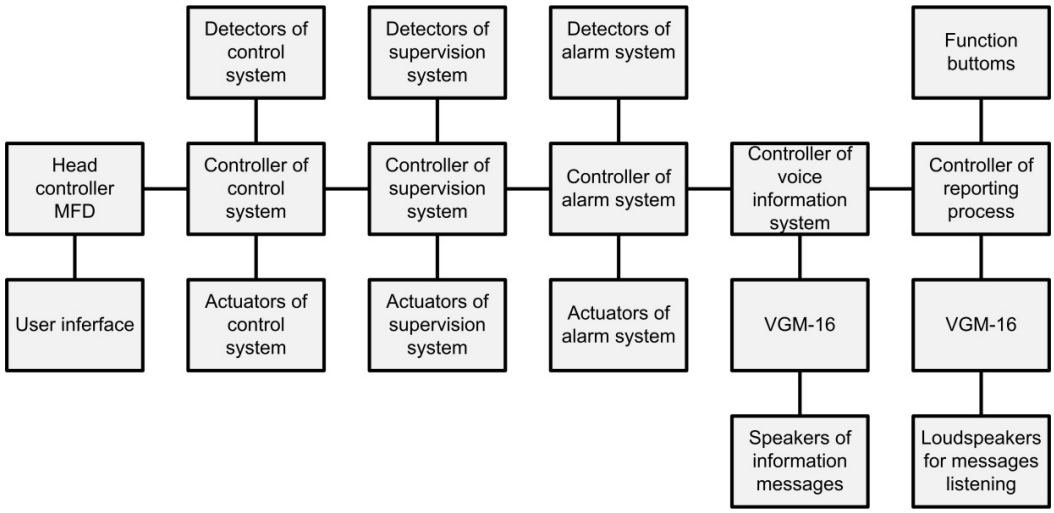

Fig. 2. The block diagram of an integrated control and supervising system [own materials]

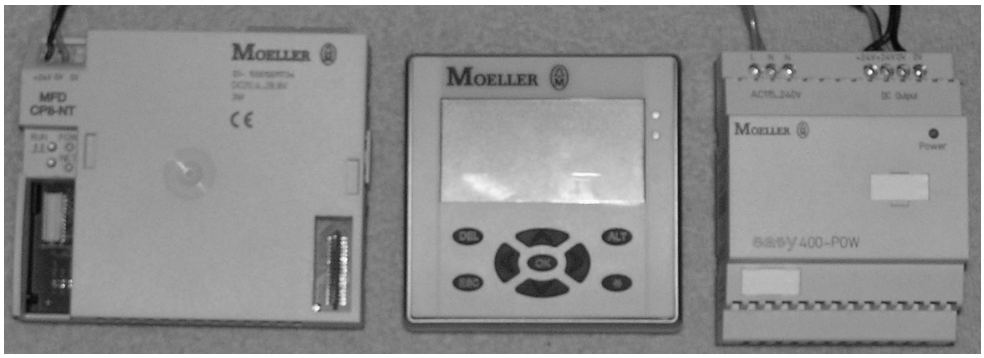

Fig. 4. MFD-Titan programmable controller modules [own materials]

perform the functions associated with the management of public address voice system and voice reporting system.

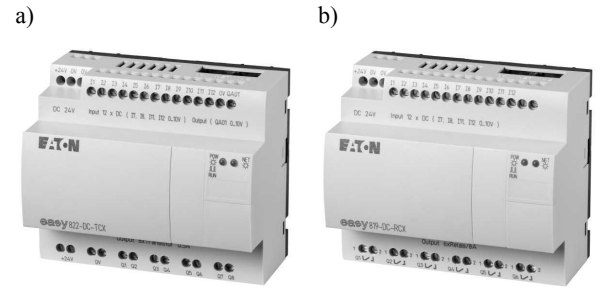

Fig. 5. PLC programmable controllers used for the construction of decision making circuit in the control and supervising system model [26]: a) type EASY-822-DC-TCX; b) type EASY-819-DC-RCX

Refer to Fig. 6 for the view of VMG-16 system manufactured by Satel and making it possible to generate prepared voice messages.

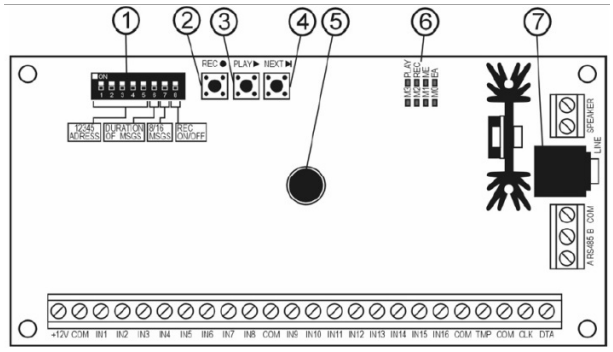

Fig. 6. Schematic view of VMG-16 voice messages generator board [25]; 1 – DIP-switch micro-switches assembly, 2 – REC button, 3 – PLAY button, 4 – NEXT button, 5 – microphone, 6 – LED signalling diodes

SYSTEM OPERATION DESCRIPTION

The operation of the control and supervising system has been verified by means of a few theoretical examples but potentially occurring in real conditions:

1. System reaction to smoke presence,
2. System reaction to the lack of air flow in ventilation duct,
3. System reaction to use of HELP button,
4. Events register review and voice reporting about system status.

The individual elements of the control and supervising system which perform the tasks of this system are responsible for:

– coordination of work of the whole control and supervising system –NET-ID-1 controller – is responsible for the supervision of the correct flow of the whole management process and contains the procedures associated with the supervision of the inner communication between PLC controllers, enabling the communication with the user by means of graphical display,
– the control system –NET-ID-2 controller – is responsible for running the devices included in the laboratory equipment, contains the elements used for controlling by means of buttons and potentiometers,
– the supervising system – NET-ID-3 controller – is responsible for hazards detection in the laboratory rooms and for running the devices neutralizing said hazards, contains the elements used for detection; hazards sensors,
– the alarm system – NET-ID-4 controller – is responsible for the performance of the intrusion and hold-up alarm system tasks; contains detection elements and actuators used in conventional burglary and attack alarm systems,
– the information about hazard – NET-ID-5 controller – is responsible for VMG-16 generator control and public address system control in the laboratory rooms,
– reporting – NET-ID-6 controller – is responsible for VMG-16 generator control and for control of the system loudspeaker used for generation of voice reports informing about the actual object status and about abnormalities detected before.

CONTROL ALGORITHMS SEQUENCES

SYSTEM REACTION TO SMOKE PRESENCE

The supervising system (NET-ID-3) consists of smoke sensors as its elements using the resources of binary inputs of this controller (DI1 – DI3). In case of detected smoke presence, the status of signal transmitted to the controller is changed from 1 to 0. This information is interpreted by the controller as an abnormal status and relevant message is sent to the network in the form of properly prepared MB1 byte marker. Said transmitted information is received and interpreted by other controllers. The exhaust fans are started by the control system controller (NET-ID-2). These devices are controlled by means of outputs (DO1-DO2). Simultaneously, the notifying system controller (NET-ID-5) enables the output (DO1) actuating the message (K1) in the generator in order to inform about the occurred hazard in the form of excessive smoke presence.

SYSTEM REACTION TO THE LACK OF AIR FLOW IN THE VENTILATION DUCT

The initial phase of the event is identical to the system reaction to smoke presence. However, in this case there is no indication of increased air flow on anemometers installed inside ventilation ducts and connected to analogue inputs (AI1-AI2) of the supervising system controller (NET-ID-3). This status is interpreted by the system as the exhaust fans failure. The information about the lack of increased air flow is sent to the controllers network and interpreted in the control system (NET-ID-2) controller. This controller enables the additional fans connected to the outputs of the controller (D03). Due to the operation of additional fans constituting the system reserve, the next message (K2) about necessity to leave the laboratory room is generated as a result of infor-

mation about their operation by means of notifying system (NET-ID-5) controller.

SYSTEM REACTION TO USE OF HELP BUTTON

The initial phase of the event is identical to the system reaction to the lack of air flow in ventilation duct. However, the further phase is associated with the use of HELP button in order to call for help by the member of personnel inside a smoke – filled room. Help buttons as the alarm system elements use the resources of digital inputs (DI1-DI2) of the alarm system (NET-ID-4) controller. Relevant message is sent by the system to the network in the form of properly prepared MB2 byte marker. The operation of automatic extinguishing system (in case of additional response of fire sensor) is delayed or prevented as a result of proper interpretation of a signal contained in MB2 and a voice message is generated (K3) to inform about the necessity to provide assistance to the occupant in the laboratory room.

EVENTS REGISTER REVIEW AND VOICE REPORTING ABOUT SYSTEM STATUS

MFD (NET-ID-1) controller coordinates the operation of individual devices and makes it possible to supervise the control process. This controller is provided with proper graphical display creating its own masks. These masks may create a managing application and act as communication interface with the user. It is possible to interpret the actual system status, working conditions in the laboratory and control processes sequence by means of information visible on the display. Relevant messages are generated through the analysis of messages sent from the controllers in the form of markers. The process of ongoing analysis of the system status makes it also possible to generate the messages interpreted by the reporting system controller (NET-ID-6). This controller, using the functional resources including the counters and comparators, creates relevant information byte (MB3) in the memory in order to replay the object status messages saved in VGM-16 generator on request. In case of MB3 status equal to 1, the following message is generated "correct system status, lack of events". The voice message replay is requested by pressing the button connected to DI1 input of NET-ID-6 controller. The pressing will result in the resetting of MB3 byte settings and in the commencement of procedure associated with listening and with updating of MB3 byte parameters for the next report.

CONCLUSIONS

1. In order to maintain the required and precisely determined working conditions in laboratory rooms and in order to ensure work safety, it is necessary to ensure the constant monitoring for laboratory devices operation and for processes occurring in the research entity. In case of abnormalities, the monitoring system shall be provided with security measures to eliminate the hazard and to enable correct evacuation process for the users.
2. The integrated control and supervision systems with structure based on PLC controllers make it possible to create the complex management systems dedicated for precisely determined working conditions and making it possible to adapt to specific features of the object and its destination. Such systems may successfully perform the role of decision making circuits and data processing systems for the objects with rigorous technical and climatic requirements, i.e. the rooms used for research and laboratory purposes.
3. The systems used for hazard information transfer perform an essential role in safety systems. The correct completion of hazard elimination procedure without exposing the users to unnecessary additional danger is possible only in case of clear and properly transferred information. The voice warning systems have such capability, because they make it possible to communicate information in the form of understandable voice messages.
4. The complete test research demonstrated the suitability of voice messages generators constituting the basic elements of public address system in the laboratory rooms and in scientific – research entities. Such objects are exposed to many different hazards. Such hazards may be diversified in individual rooms. Therefore, the supervising process becomes more complex. The voice messages generators constituting the component of the control and supervising system make it possible to transfer precisely determined information in order to adapt the user's behaviours to the conditions actually existing in the objects.

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WYKORZYSTANIE GENERATORÓW KOMUNIKATÓW GŁOSOWYCH W ZINTEGROWANYCH SYSTEMACH STEROWANIA I NADZORU W POMIESZCZENIACH LABORATORYJNYCH

Streszczenie: Prawidłowa komunikacji systemu z użytkownikiem to ważny przejaw właściwego działania systemu sterowania i nadzoru. Na żądanie użytkownika lub w określonych sytuacjach przekazywana wiadomość powinna precyzyjnie określić stan systemu. W razie wykrycia zagrożenia system zobligowany jest do przekazania użytkownikowi informacji o stanie awaryjnym. Taki sygnał powinien umożliwiać rozpoczęcie procesu neutralizacji zagrożenia lub procesu ewakuacyjnego. Często sygnały o wykryciu zagrożenia przekazywane są za pomocą sygnalizatorów akustycznych lub optyczno-akustycznych. Taki sygnał nie zawiera żadnej informacji o rodzaju wykrytego zagrożenia. Od rodzaju zagrożenia często zależy sposób postępowania w zaistniałej sytuacji. W artykule, na przykładzie pomieszczenia laboratorium chemicznego, przedstawiono współpracę systemu sterowania i nadzoru opartego na układach sterowników programowalnych PLC z generatorami komunikatów głosowych. Zainstalowane w systemie sterowania i nadzoru generatory komunikatów głosowych umożliwiają komunikowanie użytkownika o wykrycia zagrożenia oraz tworzenia raportów głosowych o stanie zabezpieczanego pomieszczenia.
Słowa kluczowe: systemy sterowania, systemy nadzoru, generatory komunikatów głosowych, sterowniki PLC