Ministry of Education and Science of the Republic of Kazakhstan
Non-profit JSC "Almaty University of Power Engineering and Telecommunications named after Gumarbek Daukeev"
Institute of Space Engineering and Telecommunications
Department: Electronics and Robotics

“ACCESSED TO PROTECTION”
by the Head of the Department ass.prof. Chigambaev T.O.
_______________ “___” ______ 2020 year
(signature)

# GRADUATION PROJECT

On the topic: Development of an automated sensor data monitoring system
Specialty: Instrument making – 5B071600
Completed: Gusmanova Saida Group: PSa-16-3
Scientific adviser: ass.prof. Chigambaev T.O.
Consultants:
on the economic part: Ph.D. docent Tuzelbaev B.I
________________ "___" _________ 2020 y.
(signature)

on life safety: Ph.D. docent Begimbetova A.S.
________________ "___" _________ 2020 y.
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Normative controller: Fazylova A.
________________ "___" _________ 2020 y.
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Reviewer: Ph.D. docent Kasymbek Adilbekovich
________________ "___" _________ 2020 y.
(signature)

Almaty 2020

Non-profit JSC "Almaty University of Power Engineering and Telecommunications named after Gumarbek Daukeev"
Institute of Space Engineering and Telecommunications
Department: Electronics and Robotics
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**TASK**

for the implementation of the graduation project

To Student Gusmanova Saida
On the topic: Development of an automated sensor data monitoring system
Approved by University Order No. ___ of "____" _____ 2020.
Deadline for completion of the completed project is "____" ________2020.
Initial data for work (required parameters of the research (design) results and initial data of the object):

a) Object of study: the production cycle of the preparation of raw materials at the refinery;
b) Operating mode - continuous;Objects of the process: fuel gas separator, electric valve, heat exchanger, pumps;Increased facility security requirements.

List of questions to be developed in the thesis, or summary of the thesis:

a) ACS TP of the production cycle for the preparation of raw materials at the Oil Refinery;
b) The choice of measuring instruments, controllers and actuators;
c) Development of process control algorithms at a refinery;
d) PLC software development;

List of graphic material (with an exact indication of the required drawings):

a) Flow chart;
b) Circuit diagram;
c) Functional schemes of automation;
d) External wiring diagrams;
e) Wiring diagrams for external wiring.

Main recommended literature:

1 Gromakov E.I., Design of automated systems.Course design: teaching aid: Tomsk Polytechnic University. - Tomsk, 2009.

2 Klyuev A.S., Glazov B.V., Dubrovsky A.H., Klyuev A.A .; under the editorship of A.S. Klyueva. Design of process automation systems: a reference guide. 2nd ed., Revised. and add. - M .:Energoatomizdat, 1990 .-- 464 p.

3 Komissarchik V.F. Automatic regulation of technological processes: a training manual. Tver 2001 .-- 247 p.

Consultations on the work (project) indicating the sections of the work (project) related to them

| Section | Consultant | Terms | Signature |
|---|---|---|---|
| Life safety | Begimbetova A.S. | 17.04.2020 | |
| The economics section | Tuzelbaev B.I | 05.05.2020 | |
| Main part | Chigambaev T.O. | 15.05.2020 | |

Schedule for preparation of a graduation project (work)

| Name of sections | list of issues to be developed | Name of sections, list of issues to be developed |
|---|---|---|
| Technical part | 21.02.20 | |
| Life safety | 20.03.20 | |
| Main part | 15.05.20 | |
| Development of software and algorithmic software | 29.05.20 | |
| | | |
| | | |

Date of assignment «02» february 2020 y.

Head of the department _____________ ass.prof. Chigambaev T.O.
(signature)

Scientific supervisor of the project ____________ ass.prof. Chigambaev T.O.
(signature)

Student accepted _______________ ass.prof. Chigambaev T.O.
(signature)

## Аңдатпа

Дипломдық жобаның тақырыбы: «деректерді бақылаудың автоматтандырылған жүйесін құру».

Зерттеу нысаны күрделі мұнай өңдеу қондырғысының бөлу блогы болып табылады. Бұл жобада өнеркәсіптік контроллерлерге негізделген процестерді басқару жүйесі жасалды.Әзірленген жүйені әртүрлі өнеркәсіптік кәсіпорындарда бақылау және деректерді жинау жүйесінде қолдануға болады. Бұл жүйе өнеркәсіптік өндірісте өнімділікті арттырады және де дәлдікті жақсартады.

## Аннотация

Темой дипломного проекта является «разработка автоматизированной системы мониторинга сенсорных данных».

Объектом исследования является блок сепарации установки комплексной подготовки нефти. В данном проекте была разработана система контроля и управления технологическим процессом на базе промышленных контроллеров. Разработанная система может применяться в системах контроля, управления и сбора данных на различных промышленных предприятиях. Данная система позволит увеличить производительность, повысить точность.

## Annotation

The theme of the graduation project is: «development of an automated sensor data monitoring system».

The object of study is the separation unit of the complex oil treatment unit. In this project, a process control and management system based on industrial controllers was developed. The developed system can be used in monitoring, control and data collection systems at various industrial enterprises. This system will increase productivity, improve accuracy.

## Content

# Introduction

Nowadays, new technologies and installations are appearing that are not always useful for the environment. Due to the rapid development of industry, a lot of combustible materials and electricity are used. The problem of the efficiency and safety of oil production is an acute problem throughout the world. Monitoring and predicting these processes is a complex process. Specialists around the world are constantly monitoring. They are interested in both quantitative and qualitative indicators. Automation of technological processes is one of the decisive factors for increasing productivity and improving working conditions. All existing and under construction industrial facilities to one degree or another are equipped with automation. However, creating an effective automated process control system is a very difficult task. The main ways to increase the efficiency of enterprises are to optimize and modernize production, reduce production losses and technological consumption of energy carriers, increase the reliability and speed of obtaining information necessary for making managerial decisions.

At present, typical schemes for a complex oil treatment, unit have a sufficient degree of automation and provide the maximum level of control of technological parameters, with the exception of the separation unit. In this diploma work, it is proposed to replace existing solutions with new devices, using other types of primary converters that have unified signals and the HART protocol, using equipment for modern operating systems.

To implement the automation system, a software and hardware complex was selected: the Simatic S7-300 controller, its programming and configuration tool Step7.

# 1 Technical part

## 1.1 The main tasks and goals of creating industrial control system

The aim of the thesis is to develop an automated data monitoring system. During development, you should consider all the latest equipment devices to choose the most suitable one. During development, the main tasks will be the selection of device components and the purpose of ensuring safe and efficient process control (TP) in real time.

The main goals of creating an automated control system are:

– stabilization of operational indicators of technological equipment and operational parameters of the plant's technological processes;
– providing the opportunity to analyze critical situations (emergency shutdown, etc.) and identify the causes of their occurrence;
– ensuring the stability of the operation of the facility;
– improvement of working conditions of technological and service personnel.

These principles should be used as a guide for project teams who plan to expand, modernize and modify the existing management system.

## 1.2 History of the development of an automated system

Automated monitoring systems are used to control sensors at a large distance from the place of data collection and processing. The system operating in automatic mode allows you to perform measurement cycles at high speed and eliminate errors associated with the human factor. The intervals between measurement cycles can vary from a few minutes or hours to months and years. In the list of tasks solved by man, there remains a qualitative analysis of the collected results, the choice of the necessary monitoring tools, their location and connection to a common network. Having constantly updated parameters of the observed object, it is possible to predict the state of the observed object with a high degree of reliability, prevent accidents, or calculate the economic indicators of the consequences of incidents [3, 4].

The main advantages of using automated monitoring systems:

– real-time data monitoring from a remote location;
– continuous monitoring of facilities;
– affordable location of the sensors of the measuring system, independent of manual operator control;
– data collection, preliminary analysis of information and its sending to any place via the Internet;
– automatic notification of persons of any displacement beyond the specified range;
– saving money, because automatic observations allow you to refuse human participation;

– elimination of operator errors, since automatic observations are more reliable.

The above tasks must be addressed by various services of enterprises operating or designing an appropriate type of engineering network. Today it is impossible to imagine that these tasks were solved without the use of modern computer technologies, which implies the creation of an automated system for managing the engineering network.

### 1.3 Purpose of the system

The main purpose and purpose of the system is to ensure safe and efficient process control (TP) in real time. This system is designed to:

– to improve the reliability and quality of automatic regulation, control and management of the operation of technological facilities;

– to reduce product losses and reduce environmental impacts;

– to stabilize the specified modes of the process by controlling the values of the process parameters, visual presentation both in automatic mode and as a result of the actions of the operator-technologist;

– to prevent emergencies at technological facilities by interrogating sensors connected to the System in automatic mode, analyzing the measured readings and switching the technological process to a safe state by issuing control actions in automatic mode, or on the initiative of operational personnel;

– for archiving information with a view to its subsequent use for analysis and reporting documentation;

– to achieve a high level of stability modes.

The purpose of the system is to design an automated process control system for a separation unit for an integrated oil treatment unit. Industrial control system should provide:

– automated monitoring and control in real time of the technological process of receiving, cleaning from dropping liquid, gas dispensing;

– safety of the technological process of receiving, cleaning from dropping liquid, dispensing gas;

– automatic and remote carrying out of the technological process in a safe state in case of emergency (fire, failure of technological equipment, etc.);

– monitoring the level of the product, its location within the specified regulatory limits and the transfer of the oil preparation unit to a safe state when the level goes beyond the range;

– control of technological parameters of gas-liquid mixture pumps and gas.

– gas-liquid mixture pump control.

#### 1.3.1 Purpose of creating a system

The purpose of creating an automatic process control system is:

– improving the quality of the process and its safety;

– increasing the effectiveness of the actions of technological personnel on the basis of increasing the level of awareness and reliability of data;

– improvement of technical and economic performance indicators of UKPN (reduction of operating costs, improving quality and reducing losses, reducing the complexity of monitoring and process control);

– improving working conditions for technological personnel;

– improving the organization of process control.

### 1.3.2 System and Technical Requirements

The control system should consist of a distributed control system (DCS) and an automatic emergency protection system (EPS). The purpose and purpose of the systems is to ensure safe and effective control of TP in real time.

The software and hardware included in the system must have certificates of conformity.

The communication carried out between the equipment of the lower and middle levels should be using wired communication, through digital and unified analog, discrete electrical signals.

Between the middle and upper level, the use carried out of specialized industrial computer networks. Wiring of redundant fiber-optic cables and twisted pair cables provided of category no lower than 5e.

The structure of the DCS and EPS should be excluded from the presence of nodes. To ensure the minimum probability of occurrence of events, it is necessary to ensure the backup of critical elements and network systems via input / output channels of at least 20%. The hardware and software complex of the AS should provide the ability to create, modernize and develop the system.

The system should provide for the safety of information:

– in case of abnormal technological situations, failure of system components and abnormal power failure;

– saving the system configuration, application software (software), trends and event logs in case of failure of system components, abnormal power outages or incorrect actions of technological personnel.

All external elements of the technical means that are under voltage must have protection against accidental contact, and the technical means themselves must have protective grounding.

The sensors used in the system must comply with the requirements for explosion safety. When choosing sensors, use equipment with intrinsically safe circuits. Sensitive elements of sensors in contact with hydrogen sulfide-containing or other aggressive media should be made of corrosion-resistant materials or media separators should be used to protect them.

Controllers must have a modular architecture that allows free placement of I / O channels. If it is necessary to input signals from sensors located in an explosive atmosphere, it is allowed to use both modules with intrinsically safe input circuits and external intrinsically safe barriers placed in a separate design.

For the period of replacement of elements of the system, measures and means must be provided that ensure the safe conduct of the process in manual mode.

1.3.3 Requirements for the levels of the hierarchy of the System

The system should have a three-level structure:

At the lower level - the level of placement of instrumentation (I&C) and MI - includes field equipment installed on process pipelines and devices;

At the middle level - the level of information collection from the lower level,the issuance of control actions on the actuators, devices for receiving / transmitting data to the upper level and should include: cross cabinets; automation cabinets.

At the upper level - a level that includes a server cabinet, workstations:

– AWP of the senior operator;
– workstation operator-technologist;
– AWP of the pumping equipment operator;
– AWP compressor driver;
– AWP of the installation manager;
– AWP engineer DCS and PAZ;
– Workstation of instrumentation engineer;
– AWP visualization panels.

At this level, access to technological information is provided for service personnel, technological personnel, engineering and technical personnel, and administrative and managerial personnel.

1.3.4 Requirements for communication methods and means for information exchange between System components

Data exchange between the equipment of the middle and upper levels should be carried out using redundant specialized industrial computer networks of high performance.

The physical medium for data transfer should be Category 5e shielded twisted-pair cable or fiber optic cable using specialized network equipment.

1.3.5 Requirements for the operating modes of the System

The system should provide continuous operation of the facility in normal mode. In case of emergencies in the system, algorithms must be implemented to transfer the equipment to a safe state.

System operation modes:

– system startup mode, during which debugging, diagnostics, complex testing of software and hardware are carried out, putting the System into experimental and industrial operation;

– regular mode, during which all automated functions are implemented in full;

– abnormal mode in which individual components completely or partially cease to be implemented due to failures of the TCP system;

– service mode, during which routine maintenance is provided for maintenance, changes in the process of operation of the alarm settings, locks and coefficients of the control loops of the System.

1.3.6 Prospects for the development and modernization of the System

The system should provide the ability to connect additional controllers, modules, converters, spark barriers and other components in an amount up to 20% of the used.

In all cabinets and panels, the chassis of the controllers must provide at least 20% of the free space for equipment.

It is necessary to ensure the possibility of expanding the system by directly supplementing, rather than changing the hardware and minimizing changes in the software and system configuration.

## 1.4 Requirements for the safety of information in case of accidents

Possible main situations leading to the loss of information and measures to ensure its safety:

– for AWS and system servers, you must periodically back up data to external drives;

– non-volatile memory of the controllers must ensure the preservation of the full configuration and all operating parameters without time limit. Non-volatile memory of controllers should not use replaceable batteries (accumulators);

– complete shutdown of the entire system. The operability of the system in this case should be maintained through the use of uninterruptible power supplies for at least 60 minutes;

– communication channel failure. In this case, all information should be accumulated in the local buffer for at least 24 hours, the equipment should function independently, and when restoring the communication channel, the accumulated information should be transferred for archiving to the database.

Emergency information should automatically displayed on the AWP display, as well as recorded and stored in the system message protocols on external memory devices.

After restoring the operability of communications, the exchange between the controller and the AWP should be restored automatically with the issuance of the corresponding message to the AWP.

## 1.5 Requirements for metrological support

For a node for measuring the pressure of a gas-liquid mixture and gas in a pipeline, flow meters based on orifice plates are used. The main relative measurement error of the flow meter should be no more than 1%.

The main relative error of temperature sensors, vibration, signaling devices should be no more than 0.2%.

To set the measurement of the level of the gas-liquid mixture in the separator, a level gauge is used, the main error of the level measurement of which should be no more than 0.5%.

## 1.6 Software Requirements

The software (software) of the AC includes:

- system software (operating systems);
- tool software;
- general (basic) application software;
- special application software.

The set of configuration functions in the general case should include:

- creation and maintenance of a configuration database (BDK) for input / output signals;
- configuration of control, regulation and protection algorithms using standard function blocks;
- creation of mnemonic diagrams (video frames) for visualizing the state of technological objects;
- configuration of reporting documents (reports, protocols).

Tools for creating special application software should include technological and universal programming languages and appropriate development tools (compilers, debuggers). Technological programming languages must comply with IEC 61131-3.

The basic application software must ensure the implementation of standard functions of the corresponding AS level (interrogation, measurement, filtering, visualization, alarm, registration, etc.).).

Special application software should ensure the implementation of non-standard functions of the corresponding AS level (special control algorithms, calculations, etc.).

## 1.7 Software Requirements

Algorithms of the system should be determined at the stage of system design and provide a regulated mode of operation and trouble-free shutdown of the control unit, as well as reducing or eliminating the possibility of erroneous actions of production personnel during the process. Algorithms for the system should be developed on the basis of approved technological regulations. The emergency situation must be determined upon reaching the emergency boundary parameter. In cases where a physical parameter is controlled by several sensors, the definition of an emergency should be based on the readings of at least two sensors (discrete or analog).

The pre-emergency situation the achievement of a variable by the analog signal of the technological boundary or the appearance of the corresponding discrete signal should only give a message to the operator without automatic control of the actuators.

The emergency protection algorithms should be a sequence of actions on the actuators with control over their implementation in automatic mode to prevent the occurrence of an emergency.

Algorithms for regulating technological parameters should provide optimal operating conditions for the unit.

Algorithms that prevent the development of emergencies should be a sequence of actions for controlling actuators, changing the parameters of the process, etc. in order to stabilize the operation of the unit in case of a violation of the normal technological regime, but the parameters did not reach emergency values.

In the algorithms should also provide for the automatic inclusion of a reserve of technological equipment (where necessary).

When developing the software, the diagnostic procedures for the software and hardware of the control system should be taken into account.

### 1.8 Requirements for the tasks performed by the System

The scope of automation is determined by the list of signals.

The main functions of the DCS: collection, processing and display for process personnel of the current values of technological parameters and equipment status.

Collection, processing and display for process personnel of the current values of technological parameters and equipment status.

The display of the technological process should be organized in the form of mnemonic diagrams, tables, screen fields for various purposes in real time;

– issuing control actions on actuators and equipment in accordance with specified control and regulation algorithms or on instructions from the operator;

– generation of reports, automatic accounting of raw materials, product and auxiliary flows at the installation boundary;

– display for process personnel an alarm about the output of technological parameters beyond acceptable values and about a change in the state of equipment;

– accumulation of information on the values of technological parameters,

– about the state of equipment, alarms and operator actions in long-term memory for a configurable period of time;

– registration of operation and control over the operational state of emergency protection (EP) means;

– issuing the necessary information to a higher system;

– the ability to make changes to the system configuration in the online mode (without stopping the control process and without making disturbances to the control and lock loops that are not affected by the changes);

– the ability to replace failed equipment and add new components and boards without turning off the power;

– the ability to synchronize the exact time;

– the execution cycle established for each of the control, monitoring, and blocking algorithms must be fixed (independent of the size of the program).

The system should be focused on working in hard real-time mode, that is, on ensuring the fulfillment of all specified functions with a given frequency and at a given time.

Emergency protection should ensure the protection of personnel, technological equipment and the environment in the event of an emergency, the development of which can lead to an accident.

Emergency protection teams should have priority action on actuators in relation to commands from DCS.

Information on the operation of emergency protection should be transmitted to the DCS and displayed on the operator’s workplace, stored in memory, the protocols of its operation should be printed out. The operation of the locks should be recorded with the time.

Emergency protection must meet all safety requirements.

To replace, repair and calibrate the lock sensors, service keys (implemented by software) must be provided.

For analog I / O modules, the function of detecting an open, shorting the line and leaving the parameter out of range should be provided.

### 1.9 Information Software Requirements

According to the design results should be submitted:

– composition, structure and ways of organizing data in the AS;
– the order of information exchange between the components and components of the AS;
– structure of the process of collecting, processing, transmitting information to the AS;
– information on visual presentation of data and monitoring results.

The information support should include:

– unified system of electronic documents, expressed in the form of a set of statistical reporting forms;
– distributed structured database storing a system of objects;
– database maintenance and management tools.

## 2 Main part

### 2.1 Description of the process

A functional diagram of the separation unit is given in Appendix A.

The separation unit is a two horizontal separator I and II stages of separation of a gas-liquid mixture. Oil separated in the first compartment of the NGS flows to the second compartment, and water from the first compartment is sent to the block cluster pump station (BCPS). Pumping water is regulated by the position of the level of the separation of media. Pumping oil from the second compartment is regulated by the level of spill in this compartment.

The traditional solution to the problem of controlling the separation process is to equip the NGS with a set of sensors equal to the number of monitored parameters. Installing such sensors requires at least four hatches for level gauges, as well as a level switch and a flange connection for the pressure sensor.

Based on level measurements, the controller generates control signals for the stop valves. Thus, in the first compartment of the separator, two control circuits are implemented according to the water level, and in the second compartment - according to the oil level. A third circuit for regulating the pressure of the exhaust gases to the burner has also been introduced. The regulation procedure is based on the principle of local automation, when the necessary regulation law is carried out by specialized controller modules from the controller, while the general control of the state of non-gas systems lies with the processor module of this controller. Separation of the tasks of regulation and control at different levels of the architecture of the complex leads to increased reliability and simplifies local visualization of the current state of NGS.

Each of the regulators can operate in two modes - automatic and remote. The choice of control modes determines the position of the corresponding "Remote control / AUT" switches. Regulation of regulators (selection of the regulation law, operating range, etc.) is carried out individually for each of them using arrays of settings available in the control controller. The configuration process can be carried out both from the local console and from the operator's workstation (if any).

### 2.2 The choice of architecture of the automated system

The development of the user interface architecture of the AS project is based on the concept of its profile. A profile is a set of standards focused on a specific task. The main goals of the use of profiles:

– reducing the complexity of nuclear power plant projects;
– improving the quality of NPP equipment;
– ensuring the extensibility (scalability) of the AS for a set of applied functions;
– providing the possibility of functional integration of the tasks of information systems.

Speaker profiles include the following groups:

a) application software profile;

b) AC medium profile;
c) AC information security profile;
d) speaker tool profile.

An open and ready-to-use Simplight SCADA system will be used as an application software profile. The speaker environment profile will be based on the WindowsXP operating system. An information security profile will include standard Windows security features. The tool profile will be based on the OpenPCS environment.

The conceptual architecture model of the OSE / RM separation unit is shown in figure 1.

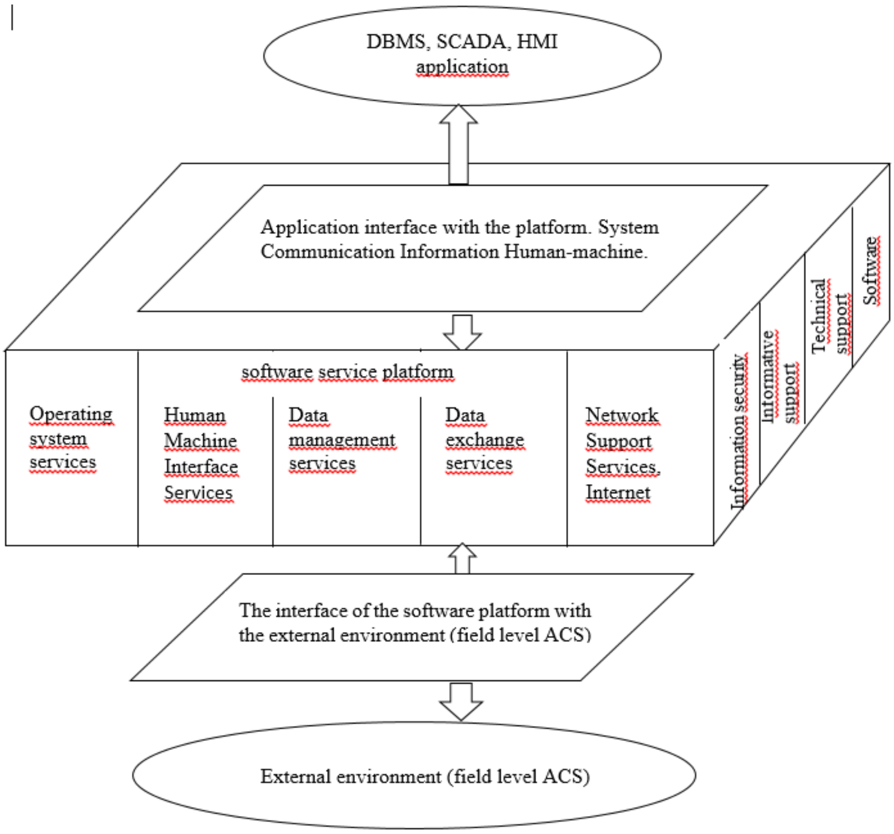


Figure 1 - Conceptual Architecture Model of OSE / RM Separation Unit

OSE / RM architecture conceptual model software breakdown into three levels:

– software breakdown into three levels:
– external environment;
– service platform;
– application software.

Levels communicate (interact) with each other through interfaces.

The external environment of the speaker is the field level of the speaker.

The service platform provides API and EEI class services through their respective interfaces.

The upper level (application software) includes SCADA-systems, DBMS and HMI.

The most relevant application software systems are open distributed speakers with a client-server architecture. To solve the problems of client-server interaction, OPC standards are used. The essence of OPC is as follows: to provide developers of industrial programs with a universal interface (a set of functions for exchanging data with any acoustic devices).

Figure 2 shows the structure of the photosensitive interaction of the automated control system of RP.

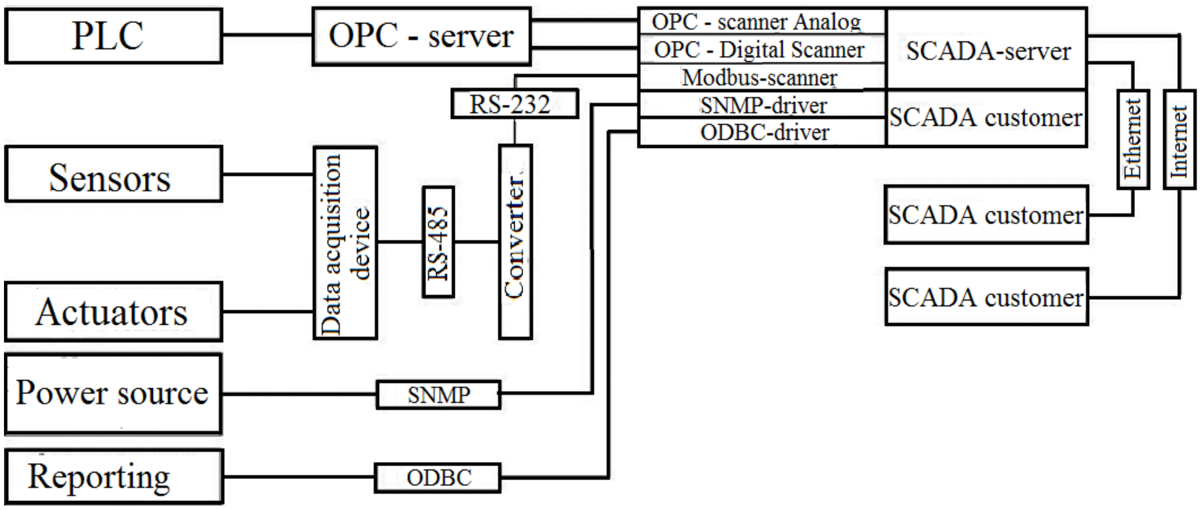


Figure 2 - Structure of OPC interactions SCADA RP

PLC interacts with SCADA through an OPC server.

Sensors and actuators are connected to SCADA via a unified 4 ... 20 mA current signal. Widely used for organizing communications of industrial electronic equipment. It uses serial communication lines RS-485, RS-422, RS-232, as well as TCP / IP networks for data transmission. Access to field level devices (sensors, actuators) from all levels of enterprise management is carried out using the PROFINET standard (IEC 61850), which supports almost all existing field level networks (PROFIBUS, Ethernet, AS-I, CAN, LonWorks, etc.).

The uninterruptible power supply is connected to SCADA via the SNMP protocol, which allows you to control the entire network infrastructure by controlling various types of network equipment, monitor the operation of OSE / RM services and analyze reports on their work for a given period. SNMP is designed to monitor the status of the speaker network and manage network devices.

Reporting, information exchange of AS data is built using the ODBC protocol, which allows for uniform operation with different data sources. The main OPC standards are as follows:

– OPC DA (DataAccess), which describes a set of functions for real-time data exchange with PLCs and other devices;

– OPC AE (Alarms & Events), which provides on-demand notification functions for various events;

– OPC DX (DataeXchange), which provides the functions of organizing the exchange of data between OPC-servers via Ethernet;

– OPC XML-DA (XML-DataAccess), which provides a flexible, rule-driven data exchange format through an Intranet environment.

The speaker environment profile should include a protocol standard

Modbus transport layer, local network standards (Ethernet IEEE 802.3 standard or FastEthernet IEEE 802.3 u standard), as well as standards for connecting the designed AC to general-purpose data networks (in particular, RS-485, CAN networks, ProfiBus, etc.).

An information security profile should ensure the implementation of an information security policy. The functional area of information security includes the security functions implemented by various components of the AS:

– protection functions implemented by the operating system;
– anti-tamper protection functions implemented at the middleware level;
– data management functions implemented by the DBMS;
– software protection functions, including virus protection;
– information protection functions during data exchange in distributed systems;
– security administration features.

The fundamental document in the field of information security of distributed systems is the X. 800 recommendations adopted by CCITT (now ITU-T) in 1991. A subset of these recommendations is the information security profile in the AU taking into account the distribution of information protection functions by the levels of the conceptual model of the AU and the relationship of functions and applicable information protection mechanisms.

The profile of the tools embedded in the speakers should reflect decisions on the choice of methodology and technology for the creation, maintenance and development of a particular speaker. The functional area of the profile of tools embedded in AS covers the functions of centralized management and administration related to:

– with monitoring the performance and correct functioning of the system as a whole;
– configuration management of application software, replication of versions;
– control of user access to system resources and resource configuration;
– reconfiguration of applications in connection with changes in the application functions of the speakers;
– customization of user interfaces (generation of screen forms and reports);
– maintaining database systems;
– restoration of system performance after failures and accidents.

## 2.3 The development of the structural diagram of the AS

The horizontal separator is a control object, in particular, in accordance with the statement of work, we will develop an automated control system. In the separator, oil level, temperature, pressure are measured, and in pipelines - pressure, liquid or gas flow. Actuators are electric valves.

The specifics of each specific control system is determined by the software and hardware platform used at each level. The three-level structure of the speakers is given in Appendix C.

The lower (field) level consists of primary sensors (level indicator, one temperature sensor with indication and registration (TIR), two level gauge, three flow meters, 2 pressure sensors of actuators (electric valves).

The lower level performs the following functions:

– measurement of process parameters and equipment
– In converting them into a unified signal;
– collecting and transmitting information on the progress of the technological process and the state of technological equipment to an average level;
– execution of regulation and management teams;
– the formation of light and sound signals.

The middle (controller) level consists of a local controller.

The middle level of the System consists of programmable logic controllers (PLCs) of DCS and PAZ, uninterruptible power supplies (UPS), cross cabinets and the controller network RS-485 (Modbus RTU).

The middle level of the System performs the following functions:

– collection, initial processing (filtering, linearization and scaling) and control of information on the condition of equipment and process parameters;
– automatic control of technological equipment;
– regulation of the parameters of the technological process;
– execution of commands coming from the upper level;
– formation of control actions on the MI of the System;
– exchange of information with the upper level;
– maintaining a single time in the system;
– offline work in case of communication failures;
– formation of warning and pre-alarm signals;
– automatic diagnostics of the complex.

The upper (information and computing) level consists of a communication controller, which plays the role of a hub, as well as computers and a database server, connected to a local Ethernet network.

The generalized control structure of the speakers is given in the diagram album in Appendix G.

The upper (information and computing) level of the System consists of a firewall, database servers (primary and backup), switches, UPSs, printers and MFPs and AWPs.

The upper level of the System performs the following functions:

– receiving information about the state of equipment and process parameters from the middle level of the system;

– formation and real-time display of information in real time in the form of mnemonic diagrams with dynamic elements, tables and graphs reflecting the current state of the process;

– formation and maintenance of a technological database;

– selection of information from a real-time database and archive;

– formation and display of event protocols;

– formation and issuance of remote control commands;

– data exchange with the middle level of the system;

– printing of reporting documentation, reports, trends, event protocols, lists of malfunctions and / or failures;

– uninterrupted power supply of technical equipment of the upper level.

Information from the field level sensors is fed to the middle control level of the local controller (PLC). It performs the following functions:

– collection, initial processing and storage of information on the condition of equipment and process parameters;

– automatic logical control and regulation;

– execution of commands from the control point;

– exchange of information with control points.

Information from the local controller is sent to the control room network through a top-level communication controller that implements the following functions:

– data collection from local controllers;

– data processing, including scaling;

– maintaining a single time in the system;

– synchronization of subsystems;

– organization of archives according to the selected parameters;

– information exchange between local controllers and the upper level.

BS includes several control stations, which are the dispatcher / operator AWP. A database server is also installed here. Computer screens of the dispatcher are designed to display the progress of the process and operational control.

All control system hardware is interconnected by communication channels. At the lower level, the controller interacts with sensors and actuators. Communication between the local controller and the upper-level controller is based on the Ethernet interface.

The communication of the workstations of the operating personnel with each other, as well as with the upper level controller, is carried out via the Ethernet network.

## 2.4 Functional diagram of automation

A functional automation scheme is a technical document that defines the functional block structure of individual nodes for automatic control, management and regulation of the technological process and equipping the control object with instruments and automation equipment. The functional diagram depicts automatic control, regulation, remote control, and alarm systems.

All elements of control systems are shown in the form of conditional images and are combined into a single system by functional communication lines. Functional diagram of automatic control and management contains a simplified image of the technological scheme of the automated process. Equipment on the diagram is shown as conditional images.

A functional automation scheme is a technical document that defines the functional block structure of individual nodes for automatic control, management and regulation of the technological process and equipping the control object with instruments and automation equipment. The automation circuit diagram depicts systems of automatic control, regulation, remote control, alarm, protection and interlocks.

When developing a functional diagram of the automation of the technological process, the following tasks were solved:

– the task of obtaining primary information about the state of the process and equipment;
– the task of direct impact on the process to control it and stabilize the process parameters of the process;
– the task of monitoring and recording technological parameters of processes and the state of technological equipment.

In accordance with the task, a functional automation scheme was developed in accordance with GOST 21.404-13 “Automation of technological processes. Conventional designations of devices and automation means in schemes ”and GOST 21.408-13“ System of design documentation for construction. Rules for the implementation of working documentation for the automation of technological processes ”

The automation functional diagram is made in accordance with the requirements of GOST 21.404–13 and is given in Appendix A. The measurement channels (1,2,3,8,11,12) and control channels (4-5, 6-7, 9-10 are highlighted in the diagram) Circuits 4-5 and 9-10 realize automatic stabilization of the levels in the first and second compartments of the separator, Circuit 6-7 implements automatic pressure maintenance in the gas outlet pipeline to the torch.

### 2.5 Development of the scheme of information flows BPG

The information flow diagram includes three levels of information collection and storage:

– lower level (level of collection and processing);
– average level (current storage level);
– upper level (archive and CIS storage level).

At the lower level, data from physical I / O devices is presented. They include data of analog signals and discrete signals, data on calculation and conversion.

The middle level is a buffer database, which is also a receiver that requests data from external systems, and their source. In other words, it acts as a router for information flows from automation systems and telemechanics to graphical on-screen forms of AWP applications. At this level, the PLC generates packet information flows from the received data. Signals between the controllers and between the top-level controller and the operator's workstation are transmitted via Ethernet.

Parameters transmitted to the local area network in the OPC standard format include:

– outlet water volume, m3 / h,
– gas volume at the outlet, m3 / h,
– oil level separator, mm,
– temperature of the gas-liquid mixture in the flare separator, o C
– pressure in the separator, MPa,
– outlet gas pressure, MPa,
– water level in 1 compartment, mm,
– water level in 2 compartment, mm

Each control and management element has its own identifier (TEG), consisting of a character string. The cipher structure is as follows:

AAA_BBB_CCCC_DDDDD,

– AAA - parameter, 3 characters, can take the following values:

DAV - pressure;
TEM - temperature;
URV - level;
RAS - flow rate;
UPR - control signal;

– BBB - code of the technological apparatus (or facility), 3 characters:

TRB - pipeline;
K01 - level control K-1;
K02 - pressure regulator K-2;
K03 - level controller K-3;
SPR - separator;

– UDP - specification, no more than 4 characters:

VHOD - inlet pipe to the separator;
VYHD - output pipeline;
GAZ - gas;
GJSM - gas-liquid mixture;
VODA - water;
URV1 - level 1 compartment;
URV2 - level 2 compartment;

– DDDDD - note, not more than 5 characters:

REG - regulation;
AVARH - upper alarm;

The underscore _ in this representation serves to separate one part of the identifier from the other and does not carry any other meaning.

The coding of all signals in the SCADA system is present in table 1.

Table 1 - Encoding of all signals in the SCADA system

| Encoding | Decoding encoding |
|---|---|
| RAS_TRB_GAS | Exhaust gas flow rate |
| RAS_TRB_VODA | Outflow rate |
| DAV_TRB_GAS | Outlet gas pressure |
| UPR_K01_URV1_REG | Compartment Level 1 Gate Valve |
| UPR_K02_GAS_REG | Gas pressure valve control |
| UPR_K03_URV2_REG | Gate valve level 2 compartment |
| DAV_SPR_GJSM_AVARH | Separator emergency pressure limit |
| TEM_SPR_GJSM | The temperature of the gas-liquid mixture in the separator |
| RAS_TRB_NEFT | Outflow oil consumption |
| URV_SPR_GJSM_AVARH | Separator emergency level limit |

The upper level is represented by the CIS database and the database

APCS. Information for specialists is structured by sets of screen forms of workstations. The operator’s workstation monitor displays various information and control elements. Various types of reports are automatically generated on the dispatcher’s workstation; all reports are generated in XML format. Report generation is performed according to the following schedules:

– every even / odd hour (two-hour report);
– every day (two-hour report at 24.00 every day);
– every month;
– at the request of the operator (operational report).

Reports are generated according to the given templates:

– summary of the current state of equipment;
– summary of current measurements.

The historical AC subsystem stores information on changes in technological parameters for signals with predetermined detail. Data is saved to the database using the SimpLight History module. Data stored for more than three months is thinned out to provide the necessary discreteness.

### 2.6 The choice of means of implementation BS

The task of choosing hardware and software for the implementation of an automated system project is to analyze options, select components of an automated system and analyze their compatibility.

The hardware and software of the BS automated system includes: measuring and actuating devices, control equipment, as well as alarm systems.

Measuring instruments collect information about this process. Actuators convert electrical energy into mechanical or other physical quantity to act on the control object in accordance with the selected control algorithm. Controller equipment performs the tasks of computational and logical operations.

Devices and sensors are selected taking into account the provision of explosion safety during operation, that is, explosion-proof equipment with a degree of protection “fireproof housing” or “intrinsically safe electrical circuit”, which is provided with the same type of explosion protection of the controller input units, was used.

2.6.1 Selection of BS controller equipment

The following types of controllers were considered as controller equipment:

- Siemens SIMATIC S7-300,1200;
- Allen-bradley 1756 ControlLogix 5560;
- Omron CJ2M.

SIMATIC S7-300 from Siemens (Germany) was chosen as the controller.

This system is built on a modular basis, which allows the replacement of components or their expansion without affecting the operation of other parts of the system.

The communication between the local controller and the higher-level controller (communication) is based on the Ethernet interface.


Figure 3 - Siemens SIMATIC S7-300 controller

Siemens SIMATIC S7-300 is a modular programmable controller designed to build automation systems of low and medium complexity.

The modular design of SIMATIC S7-300, work with natural cooling, the possibility of using local and distributed I / O structures, wide communication capabilities, many functions supported at the operating system level, ease of operation and maintenance provide the possibility of obtaining cost-effective solutions for building automatic control systems in various areas of industrial production. The effective use of Siemens SIMATIC S7-300 controllers is facilitated by: the possibility of using several types of central processors of various capacities, the presence of a wide range of discrete and analog signal input-output modules, functional modules, and communication processors.

Siemens SIMATIC S7-300 controllers have a modular design and can include:

– The module of the central processing unit (CPU);
– Modules of power supplies (PS);
– Signal modules (SM);
– Communication processors (CP);
– Functional modules (FM);
– Interface Modules (IM).

All modules work with natural cooling.

The selected PLC (Siemens SIMATIC S7-300 with CPU module CPU 315-2 PN / DP) satisfies the following parameters.

Peripherals (display, printer): not used.

I / O : 8 channels of input of analog signals and 1 channel of output of analog signals (input / output module SM 334), 4 channels 40 of input of discrete signals (input / output module SM 323) (all unified current signals).

Control algorithms include numerical and bitwise operations.

The total amount of manipulations for one PLC: at least 100 teams.

PLC control: by interruptions, by availability or by human commands. You must control at least one device.

Monitoring and control of the following types of I / O devices: sensors (temperature, pressure, level, vibration).

Power supply to the controller: 230V AC voltage.

Fault tolerance voltage source: high.

PLC ability to work with the supply voltage of the technological platform: yes.

Voltage retention in a narrow fixed range of changes: yes.

Operating current: 140 mA.

The ability to operate the controller from the network: yes.

The ability to operate the controller on battery power: yes.

Battery life without recharging: at least 24 hours in operating mode and at least 12 months when operating in standby mode.

Restrictions on size, weight, aesthetic parameters: no.

Environmental Requirements:

– temperature: -40 oC to +70 oC;
– atmospheric pressure: from 1080 hPa to 660 hPa (corresponds to a height of-1000 m to 3500 m);
– relative humidity: from 10% to 95%, non-condensing.

The user software is based on: flash memory (Flash EPROM). AS works in real time and for this it is necessary to purchase the core of real-time programs.

For the development of its own core staff programs and time: not enough.

Degree of protection - IP-65 according to GOST 14254-96 "Degrees of protection provided by shells (IP code)".

The block diagram of the USO PLC is shown in figure 4.

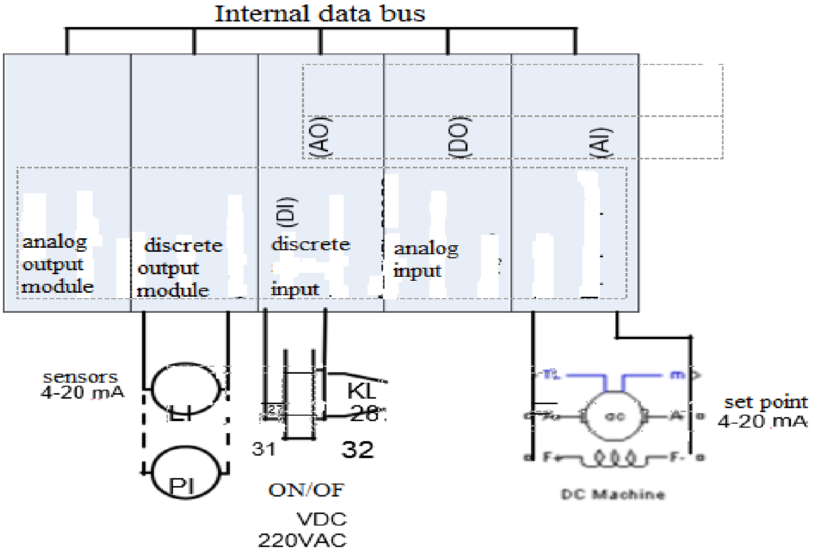


Figure 4 - Block diagram of the USO PLC

Technical characteristics of the processor module CPU315-2 PN / DP are given in table 2

Table 2 - Module Specifications

| Technical Parameters | | Value |
|---|---|---|
| Minimum lead time | logical operations<br>word operations | 0.1 / 0.2 µs<br>word operations time |
| | fixed / floating point arithmetic operations | 2/3 µs |
| Interface Types | | RS 485, PROFINET, Ethernet |
| Supply voltage | Rated | = 24V |
| | permissible | 20.4 ... 28.8 V |
| Current consumption | idle | 100 mA |
| | Rated | 0.8 A |
| | Launcher | 2.5 A |
| Power Consumption | | 3.5 W |
| Dimensions WxHxD (mm) | | 80x125x130 |
| Weight (kg) | | 0.46 |
| Operating temperature range | | -40 ... + 70 ° C |

The choice of this controller model is explained by its architecture and characteristics: the ability to increase the number of input / output ports, a wide variety of modules for almost any purpose. Having your own software development environment makes working with it easier and more convenient.

This controller meets the requirements for the temporal characteristics of the impact treatment. The controller and its modules are well established in production.

SIEMENS SITOP POWER power supply = 24B / 10A. The reliability of the power supply depends on the fault tolerance of the entire control system as a whole.

In the automated process control system of the refinery workshop to provide uninterrupted stabilized power to devices requiring external power 24 V DC, the SIEMENS SITOP POWER power supply = 24V / 10A is used (Figure 5).


Figure 5 - External view of the SIEMENS SITOP POWER supply24V/10A

2.6.2 Sensor selection

2.6.2.1 Flowmeter selection

The flowmeter was selected from the following instrument variants: Rosemount 8800D vortex flowmeter, Metran-300PR vortex-acoustic flowmeter and Kobold TMU-R (Figure 6). As a result of the analysis, Kobold TMU-R was selected because it is suitable for working with aggressive environments and has a suitable range of flow measurement, and also allows you to remotely work with the device due to SmartWireless technology. SmartWireless wireless solutions allow you to remotely configure flow meters and transfer data, which increases their efficiency.

Figure 6 - Rosemount 8700 Electromagnetic Flowmeter Kobold's Coriolis

Mass Flowmeter TMU-Rworks on the Coriolis principle of measuring mass flow. The device simultaneously monitors the temperature and density of the measured medium, and also calculates the volumetric flow. The TMU-R is available with a combined and remote transmitter. The device can be used to measure almost all liquid and gas environments, and can also be used in many traditional applications. The device is widely used in various industries. The TMU-R Coriolis Mass Flowmeter is used for both precise dosing and loading and unloading.

The measured potential difference is amplified and processed by the converter, after which the output signals of the flowmeter are formed. The main characteristics of the flow meter are presented in table 3.

Table 3 - Key Features of the Rosemount 8700

| | |
|---|---|
| Measured environment | liquid, oil, gas |
| Degree of protection | IP 66/68, intrinsically safe |
| Measuring Principle | Coriolis |
| Measured flow rate | 60 kg / h |
| Reduced measurement error | ± 0.1 scale |
| Temperature of the measured environment | –40 ... + 260 ° C |
| 4-20 mA output signals with digital signal based | HART Protocol |

2.6.2.2 Selection of pressure sensors

The pressure gauge was selected from the following instrument variants: pressure gauge for the oil industry MGS37 of the NACE standard, pressure sensor ТЖИУ406-1Ex, United Electric Ex-120 and Kobold PAD-R. As a result of the analysis, the Kobold PAD-R pressure sensor (Figure 7) from Kobold was chosen because it has an analog 4-20 mA output, unlike the United Electric Ex-120 and MGS37, it is suitable for working with aggressive oil environments in the desired range temperatures.

Figure 7 - Rosemount 3051 Pressure Transmitter

Kobold's PAD-R differential pressure transmitter is a highly efficient microprocessor-based transmitter. The sensor has a flexible pressure and outlet calibration system, an automatic system for compensating the ambient temperature and the process variable, supports HART® communication, is characterized by the optimal combination of different parameters. The differential pressure sensor is characterized by a wide range of applications - it can be used to measure pressure, flow, level. All data arriving at the sensor is processed and stored in the EEPROM. Kobold's PAD-R-F pressure transmitter is also designed for flow measurement. In this modification, the sensor has a summing function, which allows not only to determine the flow rate, but also to calculate the summed flow. The sensor measures the flow rate using differential pressure without taking into account temperature compensation and static pressure. In appearance, the PAD-R-F sensor does not differ from the standard sensor of the PAD model, -R but has a different terminal block with two additional terminals for reading the pulse output. The specifications for the Kobold PAD-R pressure transmitter are shown in table 4.

Table 4 - The specifications for the Kobold PAD-R pressure transmitter

| | |
|---|---|
| Measured environment | liquid, oil, gas |
| Working temperature | –40 ... + 120 ° C |
| measurement range | 0.75 - 413.7 bar |
| Reduced measurement error | ± 0.075% of calibrated range(optional: ± 0.04% calibrated range) |
| Output signals | 4-20 mA with a digital signal on HART protocol base |

The LCD meter provides local indication of the output, and abbreviated diagnostic messages governing transmitter operation. The meter is located on the electronics board side of the transmitter, and receives its output information directly from the electronics board microprocessor. An extended cover is required to accommodate the meter.

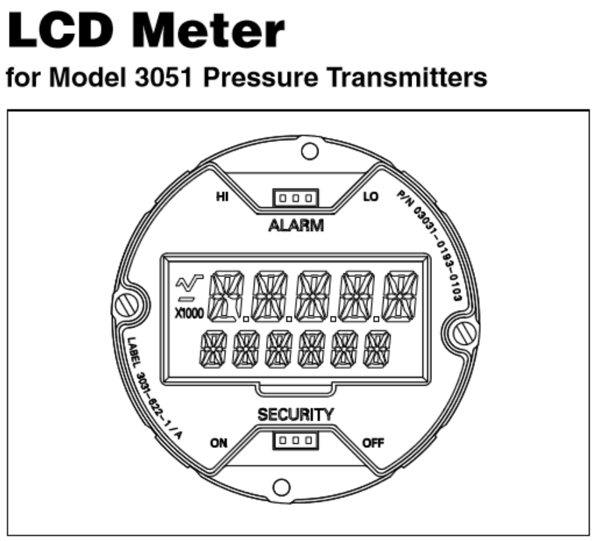


Figure 8.1 - Model 3051C with the Optional LCD Meter.

The meter features a two-line display that accommodates five digits for reporting the process variable on the top line, and six characters for displaying engineering units on the bottom line. And in addition to units of pressure, the new LCD meter is capable of displaying flow and level units. The meter uses both lines to display diagnostic messages. You can configure the meter to display the following information:

– engineering units;
– percent of range;
– user-configurable LCD scale;
– alternating between any two of the above.

The user-configurable scale is a new feature that enables you to configure the LCD meter to a custom scale for flow or level. You can configure the meter using a Model 275 HART Communicator or AMS. With the user configurable scale feature, you can define the decimal point position, the upper range value, the lower range value, the engineering units, and the transfer function. The user-configurable meter scale transfer function is independent of the transmitter analog output transfer function, which allows the meter to display square root flow output while the analog output remains linear with the pressure input.

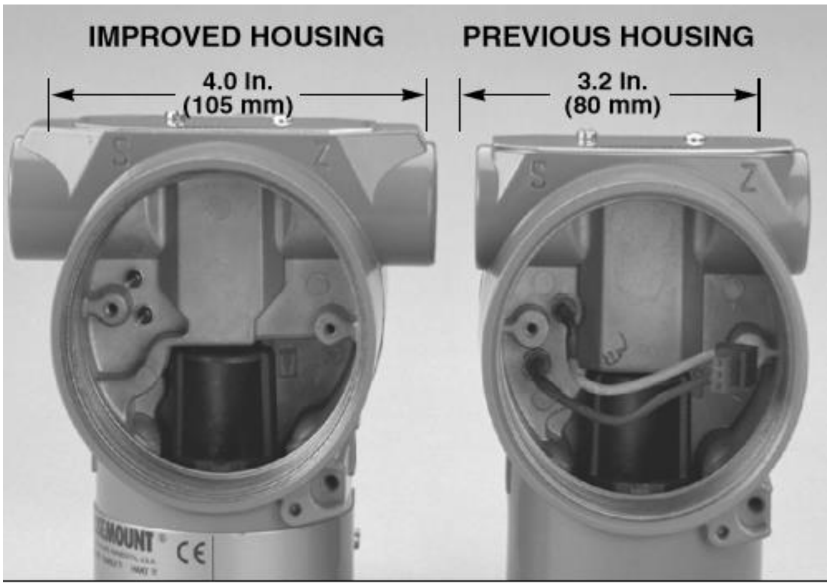


Figure 8.2. - Improved and Previous Styles of the Model 3051Transmitter Housing.

Safety messages. Procedures and instructions in this manual may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol . Refer to the following safety messages before performing an operation preceded by this symbol.

The installation procedures vary depending on the style ofhousing and the meter kit. Examine your meter part numbersclosely to ensure that you perform the appropriate procedure.

The meter kit includes:

– one LCD meter display
– one extended cover with O-ring
– two captive screws
– one ten-pin interconnection header

Use the following procedure and figure 8.3. to install the LCD meter.

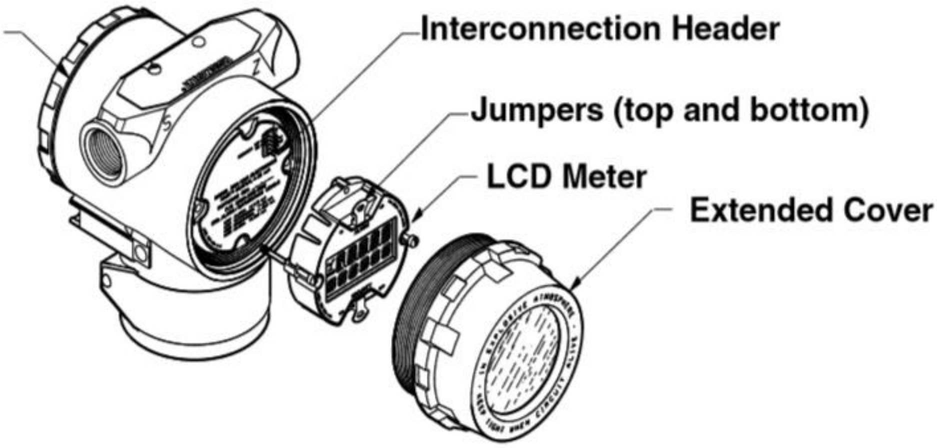


Figure 8.3 - Exploded View of the Transmitter and LCD Meter.

If the transmitter is installed in a loop, secure the loop and disconnect power. Rotate the electronics housing up to 180 degrees (left or right) to improve field access to the two compartments or to better view the LCD meter. To rotate the housing, release the housing rotation set screw and turn the housing not more than 180 degrees from the orientation. To rotate the housing greater than 180 degrees, refer to the Model 3051 product manual, publication number 00809-0100-4001.

LCD temperature limits:

Operating: –4 to 175 ° F (–20 to 80 ° C)

Storage: –40 to 185 ° F (–40 to 85 ° C)

The meter kit includes:

– one LCD meter display
– two captive screws
– one ten-pin interconnection header

2.6.2.3 Temperature sensor selection

As a temperature sensor, we will use Kobold TWL-R-Exd (Figure 9). Resistance thermometers (the rmo converters)

KOBOLD's production consists of an impact-resistant installation fitting made of stainless steel with a threaded, flanged or welded connection, as well as a connecting head made of cast aluminum and a replaceable measuring element. The measurement element can be changed without stopping the process, since the thermowell is not dismantled and isolates the process. The devices are equipped with an Exd flameproof enclosure and, accordingly, can be used in rather harsh conditions. A PT100 temperature sensor complying with IEC 751, category A or B, respectively, is mounted in the measuring element.

The temperature sensor can be manufactured in two-, three- and four-wire versions. These sensors can be performed both as simple and as dual resistance thermometers. An exception is a four-wire resistance thermometer, which is manufactured only in a simple design due to lack of space. Optionally, resistance thermometers can be equipped with a sensor mounted in the head of the thermometer. In this case, the customer can choose a standard sensor (4-20 mA output signal) with HART® protocol, as well as a sensor with PROFIBUS® protocol or Fieldbus protocol. In addition to resistance thermometers conforming to the DIN standard, it is possible to manufacture thermometers on order with the immersion depth specified by the customer, connection head, process connections, tolerance class made of materials selected by the customer.

Figure 9 - Kobold TWL-R-Exd Temperature Sensor

Measurement range: -80 ... + 600 ° C

Pt 100 class A sensor, class B sensor

Output: resistance or analog 4-20 mA

Thermowell up to 1000.3000, as well as 5000 mm (depending on model)

Options: sensor for mounting in a housing with HART protocol or PROFIBUS® protocol / Fieldbus protocol, display

ATEX certificate, Exd explosion protection

2.6.2.4 Level gauge selection

The choice of the level gauge passed from the following instrument variants: Nevelco Nivotrack, MPU100 capacitive level gauge, and ISU100I. As a result of the analysis, Nevelco Nivotrack was selected (Figure 10), because it is immune to environmental factors (temperature, pressure, etc.), the 4-20 mA output signal, as well as the implementation and maintenance, are much cheaper.

Figure 10 - Nevelco Nivotrack Level Gauge

Table 5 - Key Features of Nevelco Nivotrack

| | |
|---|---|
| Measured environment | liquid, oil, gas |
| Measuring range | 0,5-10м |
| Absolute measurement error | ±1мм |
| Measured flow rate | 60 kg / h |
| Working temperature | –40…+130°C |
| Temperature of the measured environment | –40 ... + 70 ° C |
| Output signals | 4-20 mA with a digital signal on HART protocol base |

2.6.2.5 Selecting a sensor - level switch

At high filling speeds, a limit level switch is additionally installed in the separators, giving a signal when filling the separator. This signal can be used to automatically turn off the pumps, as well as to open and close valves on pipelines. In addition to the alarm

The separator automation circuit provides for the supply of warning signals about the achievement of the lower and upper levels from level sensors.

To signal the level, we will use a sensor, a vibrating liquid level indicator, a float-level sensor-relay RIZUR DRU-1PM.

Figure 11 - level sensor-relay RIZUR DRU-1PM. Liquid level sensors-relays on-off RIZUR DRU-1PM

DRU-1PM-1, DRU-1 is designed to control the upper or lower level of fresh water with chrompeak, oils, low-freezing coolant, fecal, diesel fuel. Relay sensors are designed for use in automatic control circuits of diesel-electric units, and can also be used in stationary conditions.

– differential response no more than 25 mm.
– working pressure from 0.054 to 0.2 MPa.
– operation error - not more than 12.5 mm relative to the nominal operation level.

2.6.3 Selection of actuators

2.6.3.1 Control valve selection

An actuator is a device in a control system that directly implements a control action from the regulator on the control object by mechanical movement of the regulatory body.

The regulatory effect from the actuator must change the process, in the required direction, to achieve the task - stabilization of the controlled variable.

As a control valve, the valve regulating the saddle checkpoint VS2 will be used (Figure 12).


Figure 12 - Control valve seat straight through passage VS2

We can see application conditions in figure 13:

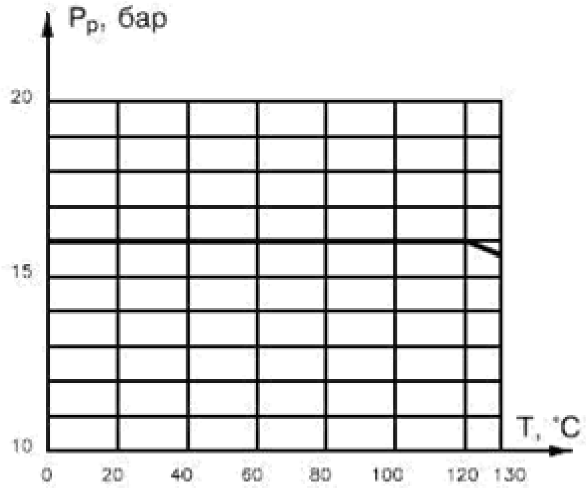


Figure 13 - Conditions of use

When mounting the valve, make sure that the direction of movement of the controlled medium coincides with the direction of the arrow on its body. Sufficient space must be provided around the motorized valve for dismantling and maintenance.

In figure 14 shown overall dimensions:

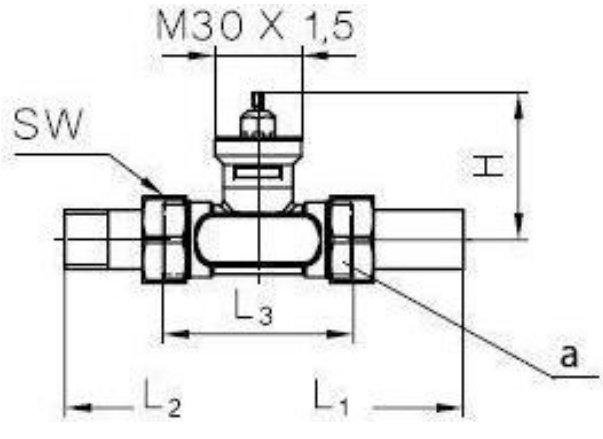


Figure 14 - Overall dimensions

AME 10 gear motor selected for control valve (Figure 15):

Figure 15 - AME 10 gear electric drive

Technical specifications of the drive are given in table 6.

Table 6 - Drive Specifications

| Technical Specification | Value |
|---|---|
| Type of control signal | 4-20 mA |
| Protection class | IP 67 |
| Motor Type | Asynchronous |
| Temperature range, ° C | From -40 ... to +90 |

Process plants consist of hundreds, or even thousands, of control loops all networked together to produce a product to be offered for sale. Each of these control loops is designed to keep some important process variable such as pressure, flow, level, temperature, etc. within a required operating range to ensure the quality of the end product. Each of these loops receives and internally creates disturbances that detrimentally affect the process variable, and interaction from other loops in the network provides disturbances that influence the process variable.

To reduce the effect of these load disturbances, sensors and transmitters collect information about the process variable and its relationship to some desired set point. A controller then processes this information and decides what must be done to get the process variable back to where it should be after a load disturbance occurs. When all the measuring, comparing, and calculating are done, some type of final control element must implement the strategy selected by the controller.

The most common final control element in the process control industries is the control valve. The control valve manipulates a flowing fluid, such as gas, steam, water, or chemical compounds, to compensate for the load disturbance and keep the regulated process variable as close as possible to the desired set point.

Many people who talk about control valves or valves are really referring to a control valve assembly. The control valve assembly typically consists of the valve body, the internal trim parts, an actuator to provide the motive power to operate the valve, and a variety of additional valve accessories, which can include positioners, transducers, supply pressure regulators, manual operators, snubbers, or limit switches. Other chapters of this handbook supply more detail about each of these control valve assembly components.

Whether it is called a valve, control valve or a control valve assembly is not as important as recognizing that the control valve is a critical part of the control loop. It is not accurate to say that the control valve is the most important part of the loop. It is useful to think of a control loop as an instrumentation chain. Like any other chain, the whole chain is only as good as its weakest link. It is important to ensure that the control valve is not the weakest link.

Following are definitions for process control, sliding-stem control valve, rotary-shaft control valve, and other control valve functions and characteristics terminology.

### 2.6.4 Development of external wiring diagram

Temperature has a built-in converter of the signal of thermal resistance into a unified current signal 4-20 mA. At the flowmeter, the signal is converted into a unified 4-20 mA current signal. The pressure sensor converts the signal from the sensor based on the capacitive cell into a unified 4-20 mA current signal.

The cable design consists of the following parts: core (soft copper wire), insulation (PVC plastic), belt insulation (PET film tape), sheath (low flammability PVC plastic). KVVGng cables are designed for fixed connection to electrical devices, apparatuses, terminal assemblies of electrical switchgears with rated alternating voltage up to 660V frequency up to 100Hz or constant voltage up to 1000V.

When laying automation system cables, the requirements of chapter 2.3 must be observed. “Cable lines with voltage up to 220 kV” PUE and additional rules for separation of circuits:

– control and signaling circuits with voltage of 220 V AC and 24 V DC must be laid in different cables;
– analog signals must be transmitted using shielded cables separately from the control and alarm signal circuits;
– serial data signals (interface connections);
– control and monitoring signals for mutually redundant mechanisms, devices must be transmitted in different cables;
– the circuits of individual fire alarm loops must be laid in different cables.

### 2.6.5 The choice of control algorithms AC BS

In an automated system at different levels of control, various algorithms are used:

– start-up / start-up / shutdown algorithms for process equipment (relay start-up circuits) (implemented on a PLC and SCADA form);

– relay or PID algorithms for automatic control of technological parameters of technological equipment (control of the position of the working body, pressure control, etc.) (implemented on the PLC);

– control algorithms for the collection of measuring signals (algorithms in the form of universal logically complete program blocks placed in the ROM of controllers) (implemented on the PLC);

– automatic protection algorithms (PAZ) (implemented on the PLC);

– centralized control algorithms for speakers (implemented on PLC and SCADA-form), etc.

In this final qualifying work, the following AS algorithms are developed:

– measurement data acquisition algorithm;

– algorithm for automatic control of a technological parameter.

To represent the start / stop algorithm and data collection, we will use the rules of GOST 19.002.

#### 2.6.5.1 Algorithm for collecting measurement data

As the measurement channel, we choose the temperature measurement channel in the separator. We will develop an algorithm for collecting data for this channel. The algorithm for collecting data from the temperature measuring channel in the separator.

#### 2.6.5.2 Automatic process control algorithm

As a control algorithm, we will use the PID control algorithm, which allows us to provide good control quality, a sufficiently short time to enter the mode, and a low sensitivity to external disturbances. The PID controller is used in automatic control systems to maintain the set value of the measured parameter.

The PID controller measures the deviation of the stabilized value from the set value (setpoint) and generates a control signal, which is the sum of three terms, the first of which is proportional to this deviation, the second is proportional to the integral of the deviation and the third is proportional to the derivative of the deviation.

The pressure control process is as follows. The input of the control unit receives the set (setpoint) $y^*(t)$ and the current $y(t)$ value of the controlled variable. The control unit calculates the mismatch $e(t) = y^*(t) - y(t)$, on the basis of which it generates a control signal $u(t)$ supplied to the input of the actuator.

The pressure reference is compared with the current pressure value obtained using the pressure sensor. According to the mismatch, the level controller forms a task according to the position of the regulatory body. The set position is compared with the current one received from the position sensor of the regulatory body. Based on the position mismatch, the control unit generates a control signal to the actuator.

The system of differential equations describing the operation of the system:

Converter:

$$T_1 \frac{df}{dt} + f = K_1 U_1 \quad (1)$$

Electric drive:

$$T_2 \frac{d\omega}{dt} + \omega = K_2 f \quad (2)$$

Gate valve:

$$\frac{dx}{dt} = \omega \quad (3)$$

Reduction gear

$$x_1 = k_p x \quad (4)$$

Separator

$$T_3 \frac{dP}{dt} + P = x_1 \quad (5)$$

In the figure, a block diagram of the regulation in the Matlab environment is presented.

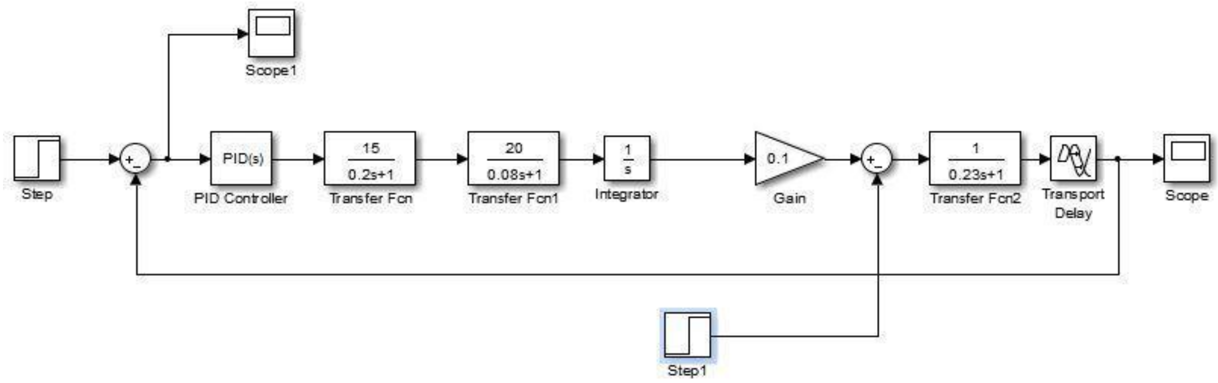


Figure 16 - Block diagram of regulation

PID controller parameters were selected by using automatic tuning of the PID controller in the Matlab environment to obtain an acceptable transient response. The approximate values are:

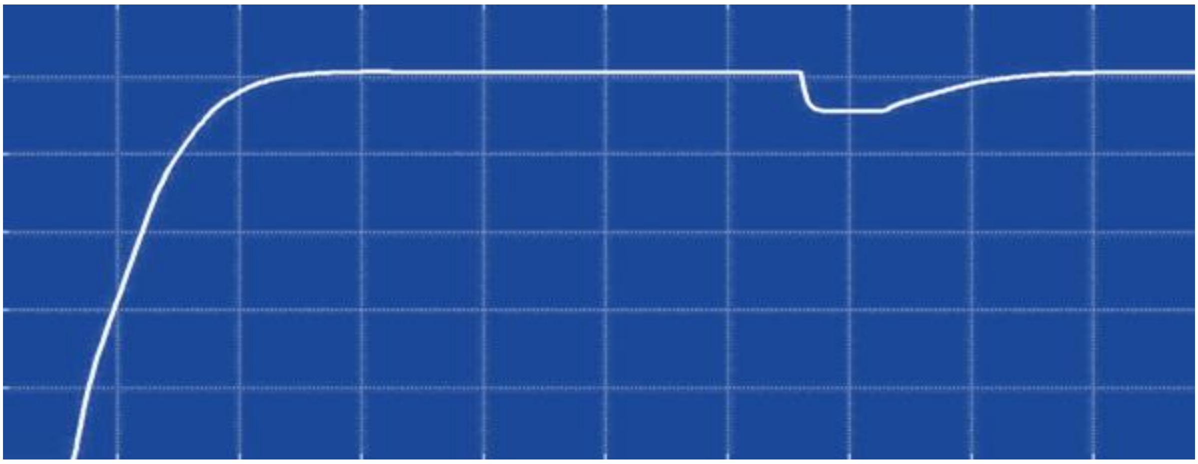

Figure 17 - Transition Graph

As a result of the process simulation, we obtain a transient time of 12 seconds. We also observe the maintenance of the set value of the flow rate when a disturbance occurs, in the form of the inclusion of a control line for the verification mode of metrological characteristics.

2.6.5.3 Development of control algorithms

The development of control algorithms has the following objectives:

– increasing the level of staff awareness and reliability of data on the status of technological equipment;
– improving the quality of the technological regime and its safety;
– increasing the efficiency of personnel actions;
– improving the environmental situation at the facility;
– improving management reliability is ensured.

Functional algorithms allow you to process incoming signals, and operators - operators, as well as operators.

The input to the algorithms is:

– PLC configuration data;
– the values of analog and discrete signals supplied to the PLC input modules from sensors and converters;
– data arriving at the interface;
– data generated during the management of technological equipment with the operator's workstation.

In addition, the data of the algorithm are used.

The adopted model for building an automatic process control system corresponds to the real process and ensures the consistent operation of its parts (executive images) in the following modes:

– autonomous inclusion, setup and check of a network of controllers;
– inclusion, configuration, verification and launch of the control and management system;
– current system operation in modes:

a) local (manual);
b) remote;
c) automatic;
d) settings;
– restore system operation.

When representing the algorithms in the form of flowcharts, the following elements were used:

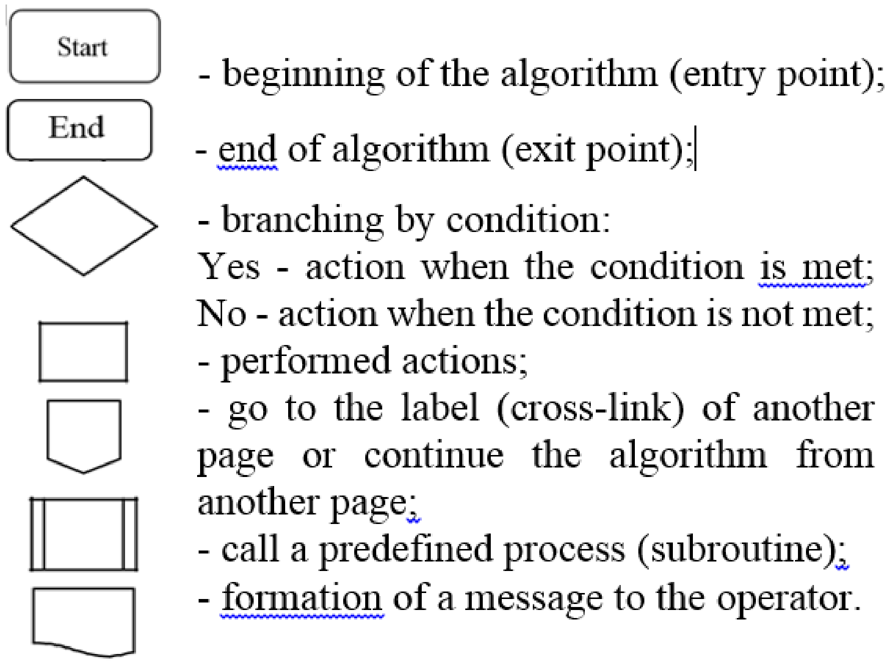


Figure 18 - The algorithms elements

2.6.5.4 Electric Gate Control Algorithm

The input status signals are the signals “Open”, “Closed”, “Failure”.

The output signals are the signals “Open”, “Close”, “Stop”, “Local control”, “Remote control”.

If the signals “Open” and “Closed” are active at the same time, the alarm “Error of the status of the electric valve” is generated.

If the signal “Failure” is active, the alarm “Failure of the electric valve actuator” is generated.

If the “Open” and “Closed” signals are inactive at the same time, the valve is in the “Intermediate” position.

By the “Open” command, the “Open” output signal is set to the active state for a specified time. In this case, the valve starts to move towards the opening. A command is considered executed when the state of the “Open” signal becomes active. If in a given time the “Open” signal does not go into the active state, the alarm “Failure to open the electric valve” is generated. The “Open” command is enabled if the remote mode is set, the “Close” command is not executed, there are no active alarms “Error of the status of the electric shutter”, “Failure of the drive of the electric shutter”.

By the command “Close”, the output signal “Close” is set to the active state for a given time. In this case, the valve starts to move towards the closing. The command is considered executed when the state of the signal “Closed” becomes active. If the signal “Closed” does not go into the active state in a given time, the alarm “Failure to close the electric valve” is generated. The “Close” command is enabled if the remote mode is set, the “Open” command is not executed, there are no active alarms “Error of the status of the electric shutter”, “Failure of the drive of the electric shutter”.

By the “Stop” command, the value of the “Stop” output signal is set to the active state for a time sufficient to break the starter circuit and remove the self-pickup. The Stop command is enabled if the remote mode is set.

The position of the valve is controlled locally and remotely. Remote control of the valve includes either opening, closing and stopping the opening or closing according to the operator’s instructions from the valve control panel or by condition, or automatic control of the valve (for valves with automatic control). In local mode, remote control of the valve is blocked, and control is carried out locally.

Installation of the remote mode is carried out by the Remote command. As a result of the command, the “Remote control” signal is set to the active state, the “Local control” signal is set to the inactive state. Remote mode is basic.

The local mode is set by the “Local” command. As a result of the command, the “Local control” signal is set to the active state, the “Remote control” signal is set to the inactive state. In local mode, the remote control of the valve is blocked.

| | Name | Data type | Address | Retain | Visibl... | Acces... | Comment |
|---|---|---|---|---|---|---|---|
| 1 | vlv_stop_end | Bool | %I0.6 | | ☑ | ☑ | |
| 2 | vlv_stop | Bool | %Q0.6 | | ☑ | ☑ | |
| 3 | vlv_rem_end | Bool | %I0.4 | | ☑ | ☑ | |
| 4 | vlv_rem | Bool | %Q1.0 | | ☑ | ☑ | |
| 5 | vlv_open_end | Bool | %I0.7 | | ☑ | ☑ | |
| 6 | vlv_open | Bool | %Q0.4 | | ☑ | ☑ | |
| 7 | vlv_on | Bool | %I0.1 | | ☑ | ☑ | |
| 8 | vlv_off | Bool | %I0.2 | | ☑ | ☑ | |
| 9 | vlv_mask | Bool | %I0.0 | | ☑ | ☑ | |
| 10 | vlv_loc_end | Bool | %I0.5 | | ☑ | ☑ | |
| 11 | vlv_loc | Bool | %Q0.7 | | ☑ | ☑ | |
| 12 | vlv_fail | Bool | %I0.3 | | ☑ | ☑ | |
| 13 | vlv_close_end | Bool | %I1.0 | | ☑ | ☑ | |
| 14 | vlv_close | Bool | %Q0.5 | | ☑ | ☑ | |
| 15 | Tag_2 | Counter | %C1 | | ☑ | ☑ | |
| 16 | Tag_1 | Bool | %M0.1 | | ☑ | ☑ | |
| 17 | t_o_reset | Bool | %Q0.2 | | ☑ | ☑ | |
| 18 | t_o_reach | Word | %IW0 | | ☑ | ☑ | |
| 19 | t_o_pusk | Bool | %Q0.0 | | ☑ | ☑ | |
| 20 | t_o_count(1) | Word | %IW2 | | ☑ | ☑ | |
| 21 | t_o_count | Counter | %C0 | | ☑ | ☑ | |
| 22 | t_c_reset | Bool | %Q0.3 | | ☑ | ☑ | |
| 23 | t_c_reach | Word | %IW1 | | ☑ | ☑ | |
| 24 | t_c_pusk | Bool | %Q0.1 | | ☑ | ☑ | |
| 25 | t_c_count | Word | %IW3 | | ☑ | ☑ | |

Figure 19 - The algorithm inputs are the signals

In the figure 20 shows a block diagram of an algorithm for opening an electric valve (subroutine “Opening an electric valve”) and a block diagram of an algorithm for closing an electric valve (subroutine “Closing an electric valve”).

The inputs of the algorithm are the signals shown in table 7.1.

The outputs of the algorithm are the signals shown in table 7.2, as well as alarms and messages to the operator.

Table 7.1 - Algorithm inputs

| Designation | Data Type | Description |
|---|---|---|
| vlv_on | bool | The status of the electric valve “Open” |
| vlv_off | bool | The status of the electric valve “Closed” |
| vlv_mask | bool | The “Masking” electric shutter mode is on |
| t_o_pusk | bool | Start watchdog timer to open the electric valve |
| t_o_reach | bool | Trigger timer to open the electric valve |
| t_o_reset | bool | Reset watchdog to open the electric shutter |
| t_c_pusk | bool | Start watchdog timer to close the electric shutter |
| t_c_reach | bool | Trigger timer to close the electric valve |
| t_c_reset | bool | Reset watchdog timer to close the electric shutter |

Table 7.2 - Outputs of the algorithm

| Designation | Data Type | Description |
|---|---|---|
| vlv_open | bool | Open valve control signal |
| vlv_close | bool | Close valve control signal |

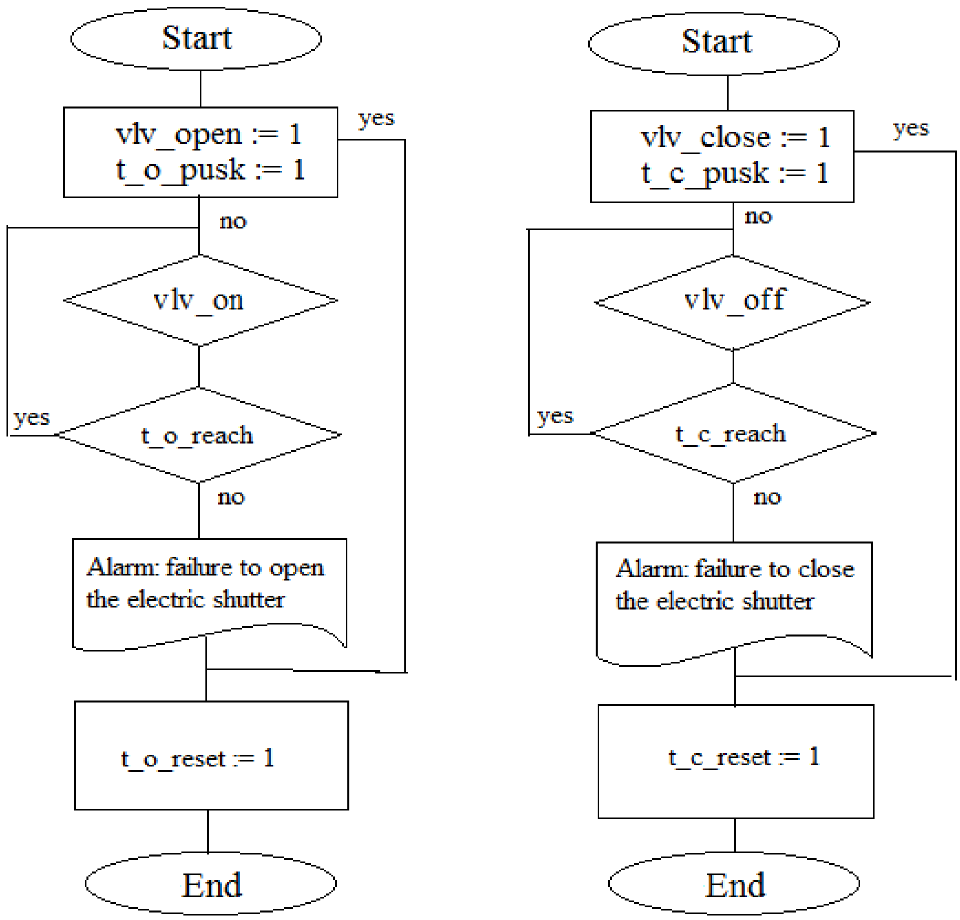


Figure 20 - Block diagram of the gate valve opening algorithm (left) and a block diagram of the gate valve closing algorithm (right)

2.6.5.5 Development of software and algorithmic software

Simatic Step 7 is Siemens software for developing automation systems based on the Simatic S7-300 programmable logic controllers. Programming in Simatic Step 7 was done using LAD line charts.

LAD (ladder diagram) - ladder diagrams. The editor displays the program in a graphical representation similar to the wiring diagram. Logic circuits allow the program to simulate the flow of electric current from a voltage source through a series of logical conditions at the inputs that activate the conditions at the outputs. The voltage source is the bus on the left.

The main elements are normally closed and normally open contacts.

Accordingly, closed contacts allow the signal flow to flow through them to the next element, open contacts prevent the signal from flowing. The logic is divided into segments, the so-called network (Network), the program runs from left to right and from top to bottom.

Features of the LAD editor is ease of use and understanding for novice programmers.

In figure 21 an electric valve control algorithm is implemented using the Simatic Step 7 software in the language of relay-contact logic LAD.

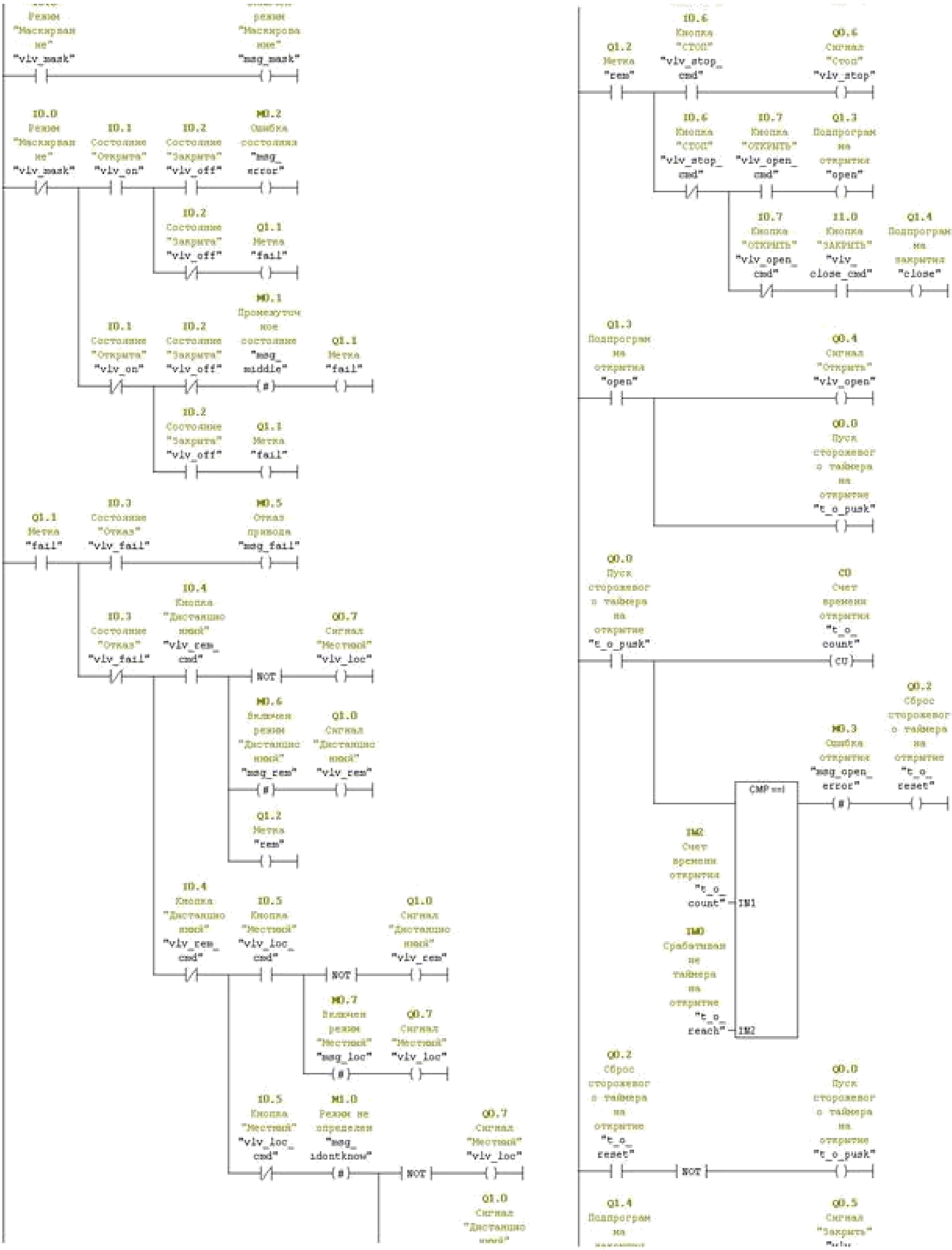

Figure 21 - The control algorithm for the electric valve on the LAD, Step 7 (sheet 1 of 2)

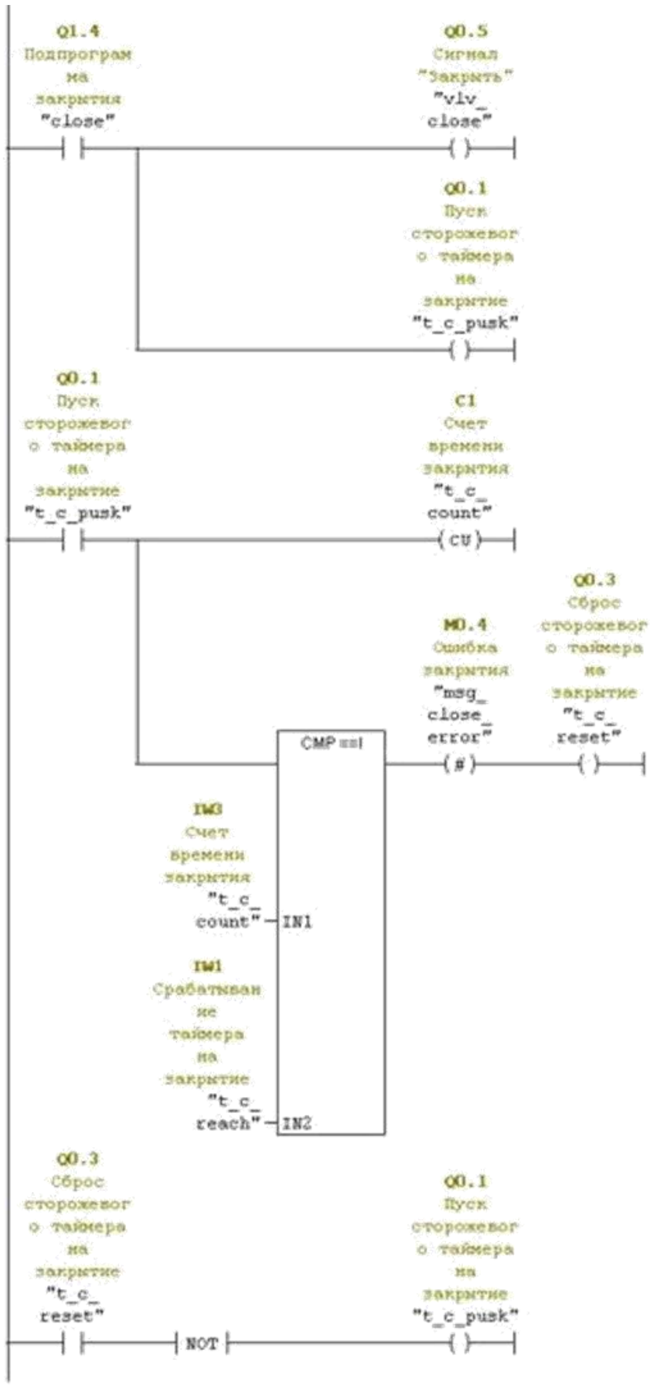


Figure 21.1 - LAD control algorithm on LAD, Step 7 (sheet 2 of 2)

### 2.6.6 Screen forms of AC BS

Control in the AC of the separation unit is implemented using the SCADA-system Simplight. It is intended for use in existing technological installations in real time and requires the use of computer equipment in industrial design that meets stringent requirements in terms of reliability, cost and safety, and also provides the ability to work with equipment from various manufacturers using OPC technology. In other words, the selected SCADA-system does not limit the choice of low-level hardware, because it provides a set of drivers or input / output servers. This allows you to connect external, independently working components to it, including third-party software and hardware modules developed separately.

2.6.6.1 Development of a tree of screen forms

The user (service dispatcher, senior dispatcher, manager) has the ability to navigate screen forms using direct call buttons. When the project starts, the user authorization screen appears, in which it is proposed to enter the login and password. After entering the login and password, if they turn out to be correct, a mnemonic diagram of the main BS objects appears: Separator of the first stage, separator of the second stage and channels for regulating pressure and level. In addition, the mimic diagram of the main objects the user has direct access to the map of the standard parameters of the separator.

2.6.6.2 Video frame area

Video frames are designed to control the state of technological equipment and control this equipment. Video frames include:

- mimic diagrams displaying basic technological information;
- pop-up windows for managing and setting object modes and parameters;
- tabular forms designed to display various technological information that is not part of the mnemonic diagrams, as well as to implement cards for manual input of information (settings, etc.).

In the area of the operator’s workstation video frame, the following mimics are available:

- stage I separator;
- stage II separator.

On the mnemonic diagram “Separator of the 1st stage” the work of the following objects and parameters is displayed:

- measured and signalized parameters;
- measured parameters of pipelines;
- condition and operation mode of gate valves.

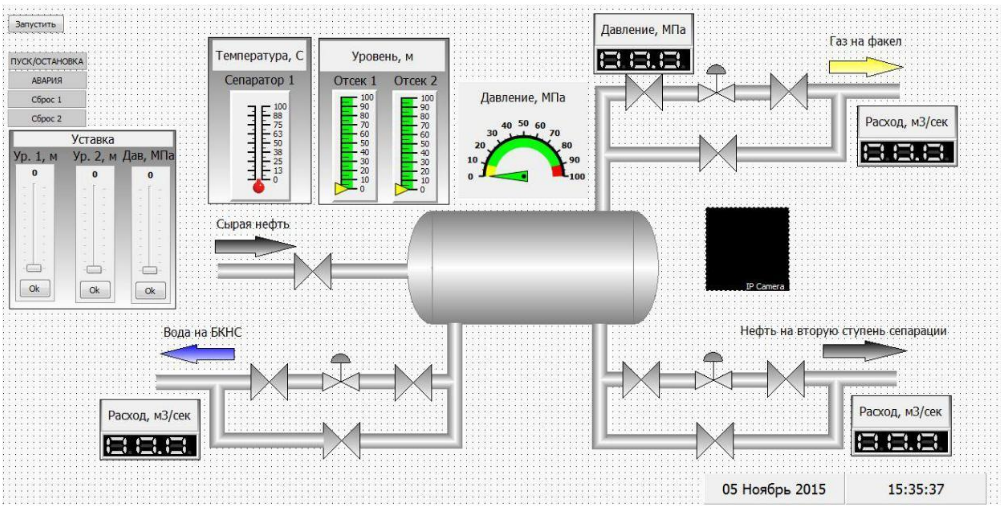

Figure 22 - Mimic diagram

2.6.6.3 Signs

Figure 23 shows the mnemonic sign of the analog parameter:

Figure 23 - Mnemo sign of the analog parameter

The lower part displays the value of the analog parameter. The following primary colors are accepted for displaying an analog parameter:

– gray color - the parameter is reliable and normal;
– yellow color - the parameter is reliable and has reached an acceptable (maximum or minimum) value;
– red color - the parameter is reliable and has reached the limit (maximum or minimum) value;
– dark gray color - the parameter is unreliable;
– brown color - the parameter is masked.

The red color of the main part is accompanied by blinking until the operator completes the acknowledgment operation, i.e. will not confirm the fact of setting the alarm condition of the analog parameter.

The unit of the analog parameter is displayed in the upper part.

The mnemonic sign has the following color coding:

– green color - the valve is open;
– yellow - the valve is closed;
– periodic change of green and yellow colors - the valve opens / closes;
– gray color - undefined state.

The white background rectangle is used to display both discrete states and limit values of the analog parameter, and takes the following form:

– state 1 - red color - limit lower level (value of a discrete parameter).
– state 2 - yellow color - permissible lower level (value of a discrete parameter);
– state 3 - green - normal;
– state 4 - yellow) - permissible upper level (value of a discrete parameter);
– state 5 - red) - the upper limit level (value of the discrete parameter).

The mnemonic sign light has the following color designations:

– red color - the maximum level;
– yellow - acceptable level;
– gray color - the parameter is normal.

### 3. Life safety

This section of the dissertation is devoted to the identification and study of dangerous and harmful production factors in the labor process that have an adverse effect on human health; assessment of working conditions, microclimate of the working environment; weakening the action of these factors to safe limits or eliminating them, if possible. The issues of safety, fire safety and environmental protection are also considered.

The object of research is the process of developing a graduation project by a design engineer.

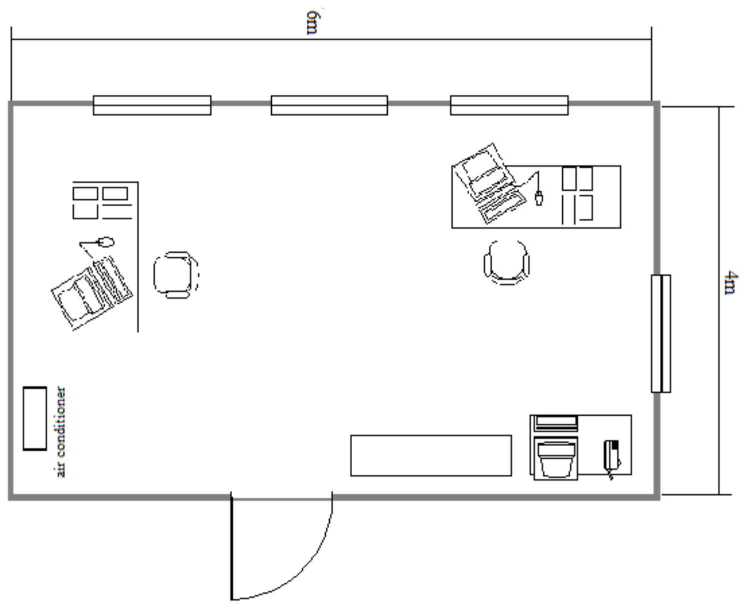


Figure 3.1 - Floor plan

#### 3.1 Harmful and hazardous production factors

The main danger at this workplace is the risk of electric shock from wiring, cables, switchgears, and also from the computers themselves.

Harmful production factors in the audience in question are:

– industrial noise, ultrasound, infrasound from the work of a computer, monitor power supply;

– non-ionizing electromagnetic fields and radiation: electrostatic fields, constant magnetic fields (including geomagnetic), electric and magnetic fields of industrial frequency (50 Hz), electromagnetic radiation of the radio frequency range, electromagnetic radiation of the optical range (including laser and ultraviolet), sources which are monitor, laser printer and scanner;

– ionizing radiation from the monitor and laser printer.

#### 3.2 Microclimate

3.2.1 Gas analysis of industrial premises

During various technological processes, a significant amount of harmful substances is released into the air of industrial premises.

Harmful are substances which, in contact with the human body, can cause work-related injuries, occupational diseases or deviations in the state of health, detected by modern methods both during work and during the long life of current and subsequent generations (GOST 12.1 .007-88).

Harmful substances can enter the human body through the respiratory system, gastrointestinal tract, skin and mucous membranes.

In the absence of special preventive measures, harmful substances can cause occupational poisoning. Industrial poisoning can be acute and chronic. Poisoning is acute when exposed to large concentrations of harmful substances (for example, in an accident) and chronic, due to the penetration of harmful substances into the body for a long time at low concentrations.

By the degree of impact on the human body, all harmful substances are divided into 4 classes (GOST 12.1.007-88):

– substances are extremely dangerous (benz (a) pyrene, mercury, lead, Ozone, phosgene, etc.);
– highly hazardous substances (nitrogen oxides, benzene, iodine, manganese, caustic alkali, chlorine, etc.);
– substances moderately hazardous (acetone, sulfur dioxide, methyl alcohol, etc.);
– low toxic substances (ammonia, carbon monoxide)

The maximum permissible concentrations of harmful substances in the air of the working area are those concentrations which, during daily work for 8 hours or with various durations, but not exceeding 41 hours a week, during the entire working experience cannot cause diseases or deviations in the state of health revealed modern research methods during or during the long life of the current or subsequent generations, MPCs are measured in mg / m3.

The working area should be considered space up to 2 m above floor level or temporary stay of workers.

It is desirable that optimal microclimatic conditions created in the room, which established according to the criteria of the optimal thermal and functional state of a person. Optimal microclimatic conditions provide a general and local sensation of thermal comfort during an 8-hour shift, do not cause deviations in the state of health and create the prerequisites for high working capacity according to.

All categories of work are distinguished on the basis of the intensity of energy consumption in kcal / h (W). The work of an engineer-developer belongs to category Ia (work with an intensity of energy consumption of up to 120 kcal / h (up to 139 W), performed while sitting and accompanied by insignificant physical stress).

In order to calculate the air conditioning system, we better proceed from the need to remove all harmful factors from the room, such as excess heat, moisture, steam, gases and dust.

The room must provided with optimal microclimate parameters, which are established according to the criteria of the optimal thermal and functional state of a person and are presented in table 3.1.

Table 3.1. – Optimum microclimate indicators

| Period of the year | Category of work on the level of energy consumption, VT | Air temperature , $^{0}C$ | Relative air humidity, |
|---|---|---|---|
| Cold | Ia (till 139) | 22-24 | 60-40 |
| | Iб (140-174) | 21-23 | 60-40 |
| | IIa (175-232) | 19-21 | 60-40 |
| | IIб (233-290) | 17-19 | 60-40 |
| | III (above 290) | 16-18 | 60-40 |
| Warm | Ia (till 139) | 23-25 | 60-40 |
| | Iб (140-174) | 22-24 | 60-40 |
| | IIa (175-232) | 20-22 | 60-40 |
| | IIб (233-290) | 19-21 | 60-40 |
| | III (above 290) | 18-20 | 60-40 |

In production it is recommended to create a dynamic climate with certain differences in performance. The air temperature at the floor surface and at the level of the head should not differ by more than 5 degrees. In industrial premises, in addition to natural ventilation, supply and exhaust ventilation is provided. The main parameter that determines the characteristics of the ventilation system is the exchange rate, i.e. how many times per hour the air in the room changes.

Vreq - the amount of air required for exchange;

Vroom - the volume of the working room.

For calculation, we accept the following dimensions of the working room:

length B = 6 m;

width A = 4 m;

height H = 3 m.

Accordingly, the volume of the room is:

$$Vroom = A * B * H = 72 \text{ м}^3 \tag{3.1}$$

The amount of air Vreq required for exchange is determined from the heat balance equation:

$$Vreq * C( t_{exit} - tparish ) * Y = 3600 * Q_{excess} \tag{3.2}$$

where Qexcess - excess heat (W);

C = 1000 - specific thermal conductivity of air (J / kgK);

Y = 1.2 - air density (mg / cm).

The temperature of the exhaust air is determined by the formula:

$$t_{exit} = t_{р.м.} + ( H - 2 )t, \quad (3.3)$$

where t = 1-5 degrees - excess t by 1m of the height of the room;

tr.m. = 25 degrees - temperature at the workplace;

N = 3 m - the height of the room;

tparish = 18 degrees.

$$t_{exit} = 25 + (3 - 2) 2 = 27 \quad (3.4)$$

$$Q_{excess} = Q_{exces.1} + Q_{exces.2} + Q_{exces.3} , \quad (3.5)$$

where $Q_{excess}$. - excess heat from electrical equipment and lighting.

$$Q_{exces.1} = E * p, \quad (3.6)$$

where E - the coefficient of electric energy loss on the fuel drain (E = 0.55 for lighting);

P - the power, p = 60 W * 5 = 300 W.

$$Q_{exces.1} = 0.55 * 300=165 W \quad (3.7)$$

$Q_{exces.2}$ - heat gain from solar radiation,

$$Q_{exces.2} =m * S * k * Qc , \quad (3.8)$$

where m - is the number of windows, take m = 2;

S - window area, S = 2.3 * 2 = 4.6 m2;

k - coefficient taking into account glazing. For double glazing k = 0.6;

Qc = 127 W / m - heat input from windows.

$$Q_{exces.2} = 4.6 * 2 * 0.6 * 127 = 701 W \quad (3.9)$$

$Q_{exces.3}$ - heat dissipation of people

$$Q_{exces.3} = n * q , \quad (3.10)$$

where q = 80 W / person , n is the number of people, for example, n = 2

$$Q_{exces.3} = 2 * 80 = 160 W \quad (3.11)$$

$$Q_{exces} = 165 +701 + 160 = 1026 W \quad (3.12)$$

From the heat balance equation it follows:

$$Vreq = 3600 * 1026 / (1000* (27-18)) = 410,4 \text{ м3} \quad (3.13)$$

The best option is air conditioning, that is, automatic maintenance of its condition in the room in accordance with certain requirements (set temperature, humidity, air mobility) regardless of changes in the state of outdoor air and conditions in the room itself.

Carefully consider the location of the air conditioner in the office. You can install a ducted air conditioner ( figure 3.2) behind a suspended ceiling and dissolve air at different points in the room through the ducts. This will ensure a uniform distribution of air and temperature. If the height of the false ceilings does not allow the installation of duct air conditioning (as in this case), then two or even three indoor units located at different points in the room can be provided. This option is especially justified in rooms of irregular or elongated shape. Semi-industrial air conditioners allow you to connect up to three indoor units of different types to one outdoor unit. This will reduce the cost of the entire system and save it.

Figure 3.2 - A duct system

**3.3 Fire safety**

A fire in a room causes material damage, since it threatens to destroy computers, equipment, tools, documents, which are of great material value, and also endangers the life and health of people in this room.

The occurrence of a fire in the laboratory can be caused by the following factors:

– the occurrence of a short circuit in the wiring due to a malfunction of the wiring itself or the electrical connections and electrical switchboards;

– ignition of devices of computing equipment due to violation of isolation or malfunction of the equipment itself;

– fire of furniture or floor due to violation of fire safety rules, as well as improper use of additional household electrical appliances and electrical installations;

– ignition of artificial lighting devices.

Laboratories in accordance with the classification of production for fire safety classified as fire-safe premises, i.e. to the room with solid combustible substances. In this connection, the following activities should carried out in the audience:

a) fire prevention:

1) organizational activities related to the technical process, taking into account the fire safety of the facility;

2) operational measures considering the operation of existing equipment;

3) technical and constructive, associated with the proper placement and installation of electrical equipment and heating appliances.

b) organizational activities:

1) fire briefing for staff;

2) personnel training in safety regulations;

3) publication of instructions, posters, evacuation plans.

c) operational measures:

1) compliance with operational standards of equipment;

2) providing a free approach to equipment.

In the audience, the workplaces of programmers are placed in such a way as to exclude mutual contact of cables and power cords of neighboring computers, which is in accordance with the standards.

Technical measures include compliance with fire safety requirements when installing electrical wiring, equipment, heating, ventilation and lighting systems.

In the event of a fire, first of all, it is necessary to call the fire brigade, to ensure the complete evacuation of people from the premises where the fire occurred, and then take fire extinguishing measures.

The cheapest and easiest fire extinguishing agent is water coming from a regular water supply. To implement effective fire extinguishing, fire shields are used that are within reach

The need for strict compliance with fire safety measures when working with equipment and household appliances requires regular training of fire safety personnel and their actions in the event of a fire in a room or in neighboring classrooms.

Fire escape plan is shown in the figure. 3.3. reference designation

Table. 3.2.

| | |
|---|---|
| telephone |  |
| escape route | |
| fire extinguisher portable, powder | |

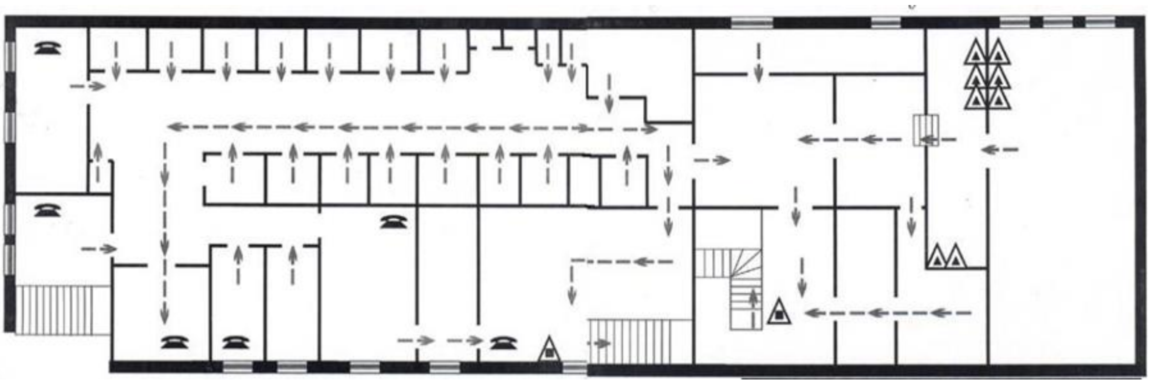

Figure 3.3 – Fire escape plan

3.3.1. Determination of the category of premises for fire and explosive safety

Room area F = 24,0 m2, room length l = 6 m; width y= 4 m; height h = 3 m.

In the room are plastic cable channels, plastic corrugations, insulation of cable and wire products. The main fire load in the room consists of the following combustible materials (plastic - 40 kg) and (EIR - 30 kg) which are located on an area of 10 sq. M.

Substances and materials located in the room do not form an explosive environment, so this room does not belong to categories A and B.

The lowest calorific value for plastic - 24.15 MJ / kg.

The fire load will be equal to:

$$Q = 30 \cdot 14{,}31 + 40 \cdot 24{,}15 = 1395 \text{ MJ}. \quad (3.14)$$

The minimum distance from the surface of the fire load to the coating H is 1 m. The area of placement of the fire load is S = 10 m2. The specific fire load will be:

$$g = Q/S = 1395 / 10 = 140 \text{ MJ/m2}. \quad (3.15)$$

In accordance with the table. B.1. SR12.13130.2009 the premises can be classified as category B4.

In accordance with clause 7.4.5 of the EMP, the zone in the room refers to the zone:

Class P-IIa, where solid combustible substances are treated.

3.3.2 Evacuation of people from buildings and constructions under fire

The time of occurrence of a dangerous situation for a person is called the critical duration of the fire. This time depends on many factors. Taking into account the critical duration of the fire and safety factors, the necessary time for evacuating people from buildings and structures for various purposes was established.

Estimated time is the time during which all people can leave the room or building, it is determined by calculation.

The estimated time of evacuation of people $t_p$ is defined as the sum of the time of movement of the human flow over individual sections of the path $t_i$ according to the formula, min:

$$t_p = t_1 + t_2 + t_3 +, ..., t_i \ , \tag{3.16}$$

where $t_1$ is the time of movement of the human flow in the first (initial) section, min;

$t_2$, $t_3$, ..., $t_i$ - time of movement of the human flow on each of the following after the first leg, min.

The movement time of the human flow in the first section of the path t1, min:

$$t_1 = l_1 / v_1 \tag{3.17}$$

$$t1 = l1 \div \nu1 = \frac{6}{3} = 2\text{min} \tag{3.18}$$

where $l_1$ is the length of the first section of the path, m;

$v_1$ - the speed of the human flow along the horizontal path in the first section, m / min, is taken according to the table. 2 depending on the density of human flow D1.

The density of human flow D1 in the first section of the path, m2 / m2:

$$D_1 = \frac{N_1 f}{l_1 \delta_1} \tag{3.19}$$

where N1 - the number of people in the first section, people;

f - is the average horizontal projection area of a person, m2: adult in summer clothes - 0.1; adult in winter clothes- 0.125; adolescent - 0.07;

$\delta_1$ - the width of the first section of the path, m.

$$D1 = \frac{N1 * f}{l1 * \delta 1} = \frac{2 * 0.125}{6 * 4} = 0.01\text{m2 / m2} \tag{3.20}$$

The speed of human flow vi in the sections of the path following the first is taken according to table. 1 depending on the intensity of movement of the human flow.

The intensity of human flow can be calculated by the formula, m / min or people / min:

$$q_{i=} D_i * v_i \tag{3.21}$$

$$q_{i=} D_i * v_i = 0.01 * 100 = 1 \tag{3.22}$$

The intensity of movement does not depend on the width of the stream and is a function of the density of the human stream.

Then the flow rate is calculated for all subsequent sections of the path, including for doorways, according to the formula, m / min or people / min:

$$qi = q_{i-1} * \delta_{i-1}/\delta i \quad (3.23)$$

where $\delta_{i-1}, \delta i$ width of the considered i-th and the preceding i-1 sections of the path, m;

qi, qi-1 are the values of the intensity of human flow along the considered i-th and previous i-1 sections of the path, m / min.

The value of qmax should be taken equal, m / min:

– for horizontal tracks - 16.5;
– for doorways - 19.6;
– for stairs down - 16;
– for stairs up - 11.

condition: $q_i \leq q_{max}$

Table 3.3. Values of speed and intensity of human flow depending on the density of human flow

| | Horizontal way | | Door opening |
|---|---|---|---|
| The density of the flow D, m2 / m2 | Speed v, m / min | Intensity q, m /min | Intensity q, m / min |
| 0,01 | 100 | 1 | 1 |
| 0,05 | 100 | 5 | 5 |
| 0,1 | 80 | 8 | 8,7 |
| 0,2 | 60 | 12 | 13,4 |
| 0,3 | 47 | 14,1 | 16,5 |
| 0,4 | 40 | 16 | 18,4 |
| 0,5 | 33 | 16,5 | 19,6 |
| 0,6 | 27 | 16,2 | 19 |
| 0,7 | 23 | 16,l | 18,5 |
| 0,8 | 19 | 15,2 | 17,3 |
| 0,9 over | 15 | 13,5 | 8,5 |

To ensure safe evacuation of people, it is necessary that the estimated time is less than the necessary evacuation time:

$$t\ p \leq t_{нб}\ , \quad (3.2)$$

where tp is the estimated evacuation time, min;

tnb - necessary evacuation time, min.

The time during which it is still possible to evacuate people in safe conditions is called the necessary evacuation time and is determined by tables 3.3, 3.4.

Table 3.4. The necessary evacuation time (min),from industrial buildings of I, II and III degree of fire resistance.

| Production category | Volume of the room, thousand m3 | | | | |
|---|---|---|---|---|---|
| | up to 15 | 30 | 40 | 50 | 60 and more |

| | | | | | |
|---|---|---|---|---|---|
| А,Б,Е | 0,5 | 0,75 | 1 | 1,5 | 1,75 |
| В | 1,25 | 2 | 2 | 2,5 | 3 |
| Г, Д | Not limited | | | | |

Category B4. Class P-IIa

From this we can conclude that it is necessary to strive to reduce energy consumption, that is, to develop and implement systems with low energy consumption. In modern computers, widely used modes with reduced power consumption during long idle.

Having assessed the working conditions of the analyzed room, including lighting and determining compliance with the ergonomic requirements of the workplace, and determining fire safety measures, we can draw the following conclusions on industrial and environmental safety of a person, as well as the work performed by him:

– in terms of occupied space and volume, the room meets regulatory requirements;
– microclimatic conditions correspond to permissible;
– determination of the category of premises for fire and explosive safety;
– according to the fire safety condition, the room complies with the standards,
– evacuation of people from buildings and constructions under fire.

When considering the issue of environmental protection, we can say that the premises are not environmentally hazardous.

## 4 The economics section

### 4.1 Goals and objectives.

Feasibility study of theses related to the development of automated control systems.

The purpose of this diploma work is to reequip the refinery shop with a three-phase separator. Re-equipment is carried out in connection with the need to optimize and improve the safety of production. In this regard, the necessary equipment will be selected.

Re-equipment will improve the reliability of technological equipment, as well as prevent accidents, thereby achieving a continuous flow of the technological process with less labor. These indicators will lead to a positive economic effect.

The purpose of a feasibility study of an automated system is to provide quantitative and qualitative evidence of the economic feasibility of creating or developing an automated system, as well as to determine the organizational and economic conditions for its effective functioning.

The content of the AS feasibility study is as follows:

– calculate and analyze the costs necessary for the creation or development of an AS for individual items;

– compare the cost of creating and operating an AS with the results obtained during its implementation;

– on the basis of calculations of technical and economic indicators that characterize the results of the functioning of the created AS, and comparing them with comparable indicators of the option selected as a base for comparison (analog), give a quantitative and qualitative assessment of the economic feasibility of creating or developing an AS.

The tasks of the "Economics" section include the following:

– Calculation of one-time costs for creating an AS
– Organization and planning of the complex of works
– Calculation of conditional annual savings from automation

### 4.2 Calculation of one-time costs for creating an AS

The one-time cost of creating is determined an AS ($K^A$) by the formula:

$$K^A = K_P^A + K_C^A \tag{4.1}$$

where $K_P^A$ -pre-production costs, Tg;

$K_C^A$- capital expenditures, Tg.

You will need 750 thousand tenge to create the necessary software. This amount is attributed to the total production costs.

Thus, $K_P^A$=750 thousand tenge

The amount of capital expenditure

$$K_C^A = K_{KTM} + K_M - K_R + K_T + K_S + K_{DM} \tag{4.2}$$

$K_C^A$ - is determined by the formula

where $K_{KTM}$ cost of purchasing KTMr, Tg.;

$K_M$ costs for installation, installation and start-up of devices and automation (accepted in the amount of 20 % of the cost of KTM), Tg.;

$K_R$ estimated cost of technical resources released as a result of the implementation of as, Tg.;

$K_T$ transportation costs (accepted in the amount of 5 % of the cost of purchasing KATS and spare tools and accessories), Tg.;

$K_S$ costs for the purchase of spare parts (there are 3% of the value of KTM), Tg.;

$K_{DM}$ the costs of dismantling the released hardware (taken in the amount of 7 % of KATS), Tg.

The estimated cost of the KTM is shown in table 4.1.

Table 4.1-Estimated cost of KTM

| Name of equipment | Quantity,per | Price (unit) tenge. | General pieces, tenge. |
|---|---|---|---|
| Measuring devices and sensors | | | |
| Pressure gauge | 9 | 35972,1 | 323748,9 |
| Overpressure sensor Metran | 1 | 173330 | 173330 |
| Rosemount Level Gauge | 1 | 2632320 | 2632320 |
| Temperature sensor Metran | 6 | 69380 | 416280 |
| Rosemount Flow Meter | 1 | 3195843,75 | 3195843,75 |
| Measuring devices and sensors | | | |
| Coriolis flow meter | 3 | 8429343,75 | 25288031,25 |
| Gas detector | 8 | 841867,25 | 6734938 |
| Actuator | | | |
| Pneumo Valve with Servo Drives | 1 | 24252212,2 | 24252212,2 |
| positioner | 2 | 19099312,9 | 38198625,8 |
| Electric drive | 47 | 162120 | 7619640 |
| Post push-button PVC-125U | 3 | 17650 | 52950 |
| Signal light VS-4-S | 6 | 21750 | 130500 |
| The audio alarm device | 3 | 21750 | 65250 |
| Other components | | | |
| Cable products | 10 (km) | 2019000(per 1 km) | 20190000 |
| Total: | - | - | 130779499,9 |

The calculation of the main expenditure items of capital expenditures is shown in the table 4.2 the Calculation is made using the formula. (4.1)

Table 4.2-Calculation of capital expenditures for re-equipment of the refinery shop

| Expenditure item | Flow rate, tg. |
|---|---|
| Cost of purchasing KTM ($K_{\text{KTM}}$) | 130779499,9 |
| Costs for installation, installation and start-up of instrumentation ($K_{\text{M}}$) | 26155900 |
| Released the cost of technical means ($K_R$) | 52311799,95 |
| Transport expenses ($K_{\text{T}}$ ) | 6735144,25 |
| The cost of ZIP ($K_S$ ) | 3923385 |
| The costs of dismantling redundant equipment ($K_{DM}$) | 9154565 |
| The amount of capital expenditures ($K_C^A$) | 124436694,2 |

Thus, capital investment for re-equipment of the System ($\text{K}_\text{C}^\text{A}$ ) will amount to 124436694,2 tenge

Therefore, the one-time cost of re-equipping the AS according to the formula (4.1) will be:

$$K=750\ 000+124436694,2=125186694,2 \text{ tenge} \qquad (4.3)$$

### 4.3 Calculation of operating costs for the operation of the AS.

The calculation of annual operating costs for the operation of the Automated System ($З_{\text{OC}}$) is carried out using the formula:

$$З_{\text{OC}} = З_{\text{AE}} + З_{\text{EC}} + З_{\text{A}} + З_{\text{M}} + З_{\text{ER}} \qquad (4.4)$$

where $З_{\text{AE}}$ - annual expenses on the salary of specialists in the conditions of functioning of the AS with deductions for social tax, Tg;

$З_{\text{EC}}$ - the annual cost of electricity consumed by the AS, Tg;

$З_{\text{A}}$ -annual amount of depreciation charges, Tg;

$З_{\text{M}}$ - the annual cost of materials required for the operation of the AS (2% of the cost of the KTM), Tg;

$З_{\text{ER}}$ - the annual cost of equipment repair (7% of the cost of the KTM), Tg.

The salary of specialists in the conditions of functioning of the AS depends on their number, time of work and the tariff rate. The social tax for 2020 is 9.5% of wages, net of pension contributions of 10%.

The basic salary depends on the number of personnel involved and the established salary. Data on employees and annual wages are presented in table 4.3.

Table 4.3 - Salaries of employees [24].

| Name of employee category | Number of staff, people | monthly salary tenge | Total by category, tenge | Annual salary, tenge |
|---|---|---|---|---|
| Chief engineer | 1 | 200000 | 200000 | 2400000 |
| LeadEngineer-Instrumentation | 1 | 150000 | 150000 | 1800000 |

Continuation of table 4.3

| Name of the category of workers | Statewide, people | Month ZP, tenge | Total by category, tenge | Annual RFP, tenge |
|---|---|---|---|---|
| Service engineer network | 2 | 110000 | 220000 | 2640000 |
| Instrumentation Engineer | 1 | 90000 | 90000 | 1080000 |
| Operator | 6 | 50000 | 300000 | 3600000 |
| Total | - | - | - | 11520000 |

The basic salary for the year will be:

$$З_{BS} = 11520000 \text{, tenge} \quad (4.5)$$

Additional salary will be 10% of the main:

$$З_{Add} = 0{,}1 \cdot З_{BS} \text{ ,} \quad (4.6)$$

$$З_{Add} = 0{,}1 \cdot 11520000 = 1152000 \text{ ,tenge} \quad (4.7)$$

The total payroll for the year will be:

$$З_{TP} = 11520000 + 1152000 = 12672000 \text{, tenge} \quad (4.8)$$

In accordance with Article 385 of the Tax Code of the Republic of Kazakhstan, social tax amounts to 9.5% of accrued income and is calculated by the formula:

$$З_{STP} = 0{,}11 \cdot (З_{TP} - ПО), \quad (4.9)$$

where software - contributions to the pension fund;

$З_{STP}$ - wage fund;

0.095 - a bet on social needs.

Contributions to the pension fund amount to 10% of the payroll, social taxes are not taxed and are calculated according to the formula:

$$PO = 0{,}1 \cdot З_{STP} \text{ ,} \quad (4.10)$$

$$PO = 0{,}1 \cdot 12672000 = 1267200 \text{, tenge} \quad (4.11)$$

Then the social tax will be equal to:

$$З_{STP} = 0{,}95 \cdot (12672000 - 1267200) = 10834560 \text{, tenge} \quad (4.12)$$

The annual cost of electricity consumed by the AS is determined by the formula:

$$З_{EE} = W*T_{EF}*C_E \quad (4.13)$$

where W is the installed power of the KTM, kW;

$T_{EF}$ -effective Fund of KTM working time, hour;

$C_E$ -the cost of 1 kW×hour of electricity, Tg.

W = 500W;

T = 8760ch / year;

$C_E$ = 16.65 tenge / kW×hour

$$З_{EE} = 0{,}5 \cdot 8760 \cdot 16{,}65 = 72927 \text{, tenge} \quad (4.14)$$

The cost of additional needs is 5% of the cost of electricity equipment and are calculated by the formula:

$$З_{Add.needs.} = 0{,}05 \cdot З_{EE} \quad (4.15)$$

where Electro Equipment - the cost of electricity for equipment;

Electricity costs for additional needs:

$$З_{Add.needs.} = 0{,}05 \cdot 72937 = 3646{,}35 \text{, tenge} \quad (4.16)$$

Then the total cost of electricity will be equal to:

$$З_{EC} = 72927 + 3646{,}35 = 76573{,}35 \text{, tenge} \quad (4.17)$$

The annual amount of depreciation is calculated using the formula:

$$З_A = \frac{K_K^A \cdot H_A}{100} \quad (4.18)$$

where $H_A$ -depreciation rate, % (depends on the useful life of the KTM, agreed with the consultant on the economic part).

Depreciation charges are taken based on the fact that the depreciation rate on communication equipment is 25%, since we use digital equipment.

Then the depreciation charges are:

$$З_A = H_A \cdot \Sigma K = 0{,}25 \cdot 27792240 = 6948060 \text{, tenge} \quad (4.19)$$

Based on the information obtained from the source data, the amount of material costs is calculated:

$$З_{МАТ} = (З_{осн} * Н_{рмз}) / 100\%, \quad (4.20)$$

where $Н_{рмз}$ -the rate of expenditure of materials from the main salary on average is from 2 to 5%.

According to this formula the cost of materials is equal:

$$З_M = (11520000 * 2\%)/100\% = 230400 \text{ tenge}, \quad (4.21)$$

Calculation of the annual cost of equipment repair

$$З_{EP} = K * 7\% \quad (4.22)$$

$$З_{EP} = 7\% * 125186694,2 = 8763068,594 \text{ tenge} \quad (4.23)$$

Thus, the annual operating costs for the formula (4.4) will be:

$$З_{OC} = 12672000 + 1254528 + 76573.35 + 6948060 + 230400 + 8763068,594 = 37525391,594 \text{ tenge} \quad (4.24)$$

The results of the calculation of the annual operating costs of the project in table 4.4

Table 4.4 - Annual Operating Costs

| The name of indicators | Sum, tenge |
|---|---|
| Annual expenses on the salary of specialists in the conditions | 12672000 |
| Deductions for social needs | 1254528 |
| Depreciation deductions (Dd) | 6948060 |
| The annual cost of electricity consumed | 76573,35 |
| Materials required | 230400 |
| Equipment repair | 8763068,594 |
| Total | 37525391,594 |

Thus, the share of the wage fund is 34.4%, social tax 3.5%, depreciation charges 18.9%, energy costs 0.21%, materials required and equipment repair are 42.7% of the total operating costs.

### 4.4. Organization and planning of the complex of works

To build a line graph, we divide all the work into stages, the number and content of which is determined by the specifics of the topic. Objective economic calculation allows you to evenly distribute the work time and load on the performers, as well as increase the efficiency of work.

The planning system is based on a graphical representation of the complex of works required to achieve the set tasks: determining the performers of the work, setting the duration of the work.

The development process is divided into three stages: preparatory, main, and final.

The performers of the work are: design engineer (hereinafter referred to as Engineer); scientific supervisor (hereinafter referred to as Supervisor).

The labor intensity of work is determined by the sum of the labor intensity of stages and types of work evaluated experimentally in man-days, and is probabilistic in nature, since it depends on a variety of factors that are difficult to account for, so the expected value of labor intensity is calculated using the formula (6.12):

$$t_{ec} = \frac{3*t_{min}+2*t_{max}}{5} \quad (4.25)$$

where $t_{ec}$ - the expected complexity of execution of work, person-days.;

$t_{min}$ - minimum possible labor intensity of work (optimistic assessment: assuming the most favorable combination of circumstances), people-days.;

$t_{max}$ - the maximum possible labor intensity of work (pessimistic assessment: assuming the most unfavorable set of circumstances), people-days.;

Terms $t_{min}$and $t_{max}$ are set by the method of expert assessments. Terms X and Y are set by the method of expert assessments.

Due to the fact that when performing the work,there is a probability that the performers will not meet the specified deadline, for each work according to the formula (4.25) the variance is estimated ($\sigma(t)$)that is the average value of the square

Deviations of the work duration from its expected value:

$$\sigma^2 = 0{,}04 * (t_{max} - t_{min})^2 \quad (4.26)$$

To build a linear scale, the duration of stages in working days ($T_{wd}$), and then translate the resulting number of working days into calendar days ($T_{кд}$). The duration of stages in working days ($T_{wd}$) is calculated using the formula (4.27):

$$T_{wd} = \frac{t_{iw}}{c*p*K_{ВН}} * К_D \quad (4.27)$$

where $t_{iw}$-labor intensity of work, people-days.;

c- number of employees engaged in this work, c=2

p- number of shifts per day, p=1

$K_{ВН}$ - rate of compliance with the norm $K_{ВН} = 1$

$К_D$ - coefficient that takes into account additional time for consultations and approval of works $К_D = 1.2$

The duration of work stages in calendar days ($T_{KD}$) is calculated using the formula (4.28):

$$T_{KD} = T_{wd}*К_к \quad (4.28)$$

where $T_{KD}$ – the duration of the stages of work in calendar days;

$К_к$ – the coefficient of calendar.

The calendar factor ($К_к$) is calculated using the formula (4.29):

$$К_К = \frac{Т_К}{Т_К - Т_{d.o} - Т_{h.d}} \quad (4.29)$$

where $T_{d.o}$- days off, days off.;

$T_{h.d}$- holidays, days.

Substituting the values of calendar days, weekends, and holidays, we get the value of the calendar coefficient ($K_К$)

$$K_К = \frac{365}{365-92-28} \approx 1{,}5. \qquad (4.30)$$

The remaining results of calculations using formulas (4.25) – (4.29) are shown in table 4.5.

Table 4.5 - labor costs for conducting a diploma project

| Content of the stage | The complexity of the work, people.- days. | | | Variance | Duration of the work, days. | |
|---|---|---|---|---|---|---|
| Preparatory stage | | | | | | |
| Obtaining and analyzing TK | 1 | 2 | 1,4 | 0,04 | 0,84 | 1 |
| Development and approval of TOR | 5 | 8 | 6,2 | 0,36 | 3,72 | 6 |
| Domain analysis | 4 | 6 | 4,8 | 0,16 | 2,88 | 4 |
| Source overview | 4 | 5 | 4,4 | 0,04 | 2,64 | 4 |
| Main stage | | | | | | |
| Analysis of TP | 3 | 4 | 3,4 | 0,04 | 2,04 | 3 |
| Analysis of existing developments | 3 | 4 | 3,4 | 0,04 | 2,04 | 3 |
| Development of the structural scheme ACS | 2 | 4 | 2,8 | 0,16 | 1,68 | 3 |
| Development of the FSA | 5 | 8 | 6,2 | 0,36 | 3,72 | 6 |
| Kats selection | 10 | 12 | 10,8 | 0,16 | 6,48 | 10 |
| Development of connection diagrams and external wiring connections | 6 | 7 | 6,4 | 0,04 | 3,84 | 6 |
| Development of control algorithms | 3 | 6 | 4,2 | 0,36 | 2,52 | 4 |
| Modeling of SAC | 8 | 14 | 10,4 | 1,44 | 6,24 | 9 |
| Development of screen forms of ACS | 9 | 12 | 10,2 | 0,36 | 6,12 | 9 |
| Technical and economic rationale for research | 4 | 5 | 4,4 | 0,04 | 2,64 | 4 |
| Safety rating and environmental friendliness of the project | 4 | 5 | 4,4 | 0,04 | 2,64 | 4 |
| Final stage | | | | | | |
| Summing up | 2 | 3 | 2,4 | 0,04 | 1,44 | 2 |
| Writing an explanatory note | 12 | 15 | 13,2 | 0,36 | 7,92 | 12 |
| Graphic design material's | 7 | 9 | 7,8 | 0,16 | 4,68 | 7 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Total: | 92 | 129 | 106,8 | - | 64,08 | 95 |

### 4.5 Calculation of conditional annual savings from automation

The notional annual savings represent an increase in profit that can be obtained in the main production due to the reduction of current production costs after automation.

For the refinery shop under consideration, the conditional annual savings are expressed in production automation, that is, at the moment, the automation of the refinery shop is built exclusively on obsolete pneumatic devices and devices. Thus, now, full automation of production has not been achieved. There is no visual representation of the process flow. This, in turn, is achievable by commissioning a new automated control system.

Therefore, the introduction of a new automated control system will allow faster and more effective identification of dangerous and safe equipment failures and most effectively eliminate them. Therefore, the need for frequent stops of the technological process in connection with TR and TO will be eliminated. Consequently, the capacity of the refinery shop will be increased.

## Conclusion

In conclusion, I want to say that as a result of the work, an automated control system for the separation unit of the integrated oil treatment unit, namely the first stage separator, was developed. During the final qualifying work, the technological process of oil preparation was studied. Structural-functional schemes of automation of the oil separation unit UKPN have been developed, which allow determining the composition of the necessary equipment and the number of data and signaling transmission channels. Automation systems for the separation unit UKPN, supervisory control and management were developed on the basis of Rosemount field devices, Allen-Bradley industrial controllers and Simplight SCADA software. During the final qualification work, an external connection scheme was developed, which allows to understand the signal transmission system from field devices to the automatic control panel of the operator and in case of malfunctions it is easy to eliminate them. To control technological equipment and data collection, algorithms for starting / stopping technological equipment and data collection control have been developed. To maintain the level in compartment 2 of the separator, an automatic level control algorithm was developed (a PID controller was developed). In the final part of the diploma work, a tree of screen forms and simulation schemes of the first stage separator were developed.

Thus, the designed self-propelled gun of the oil preparation separation unit not only meets modern requirements for the automation system, but also has high flexibility, which allows you to change and upgrade the developed self-propelled guns in accordance with the requirements that increase throughout the life cycle.

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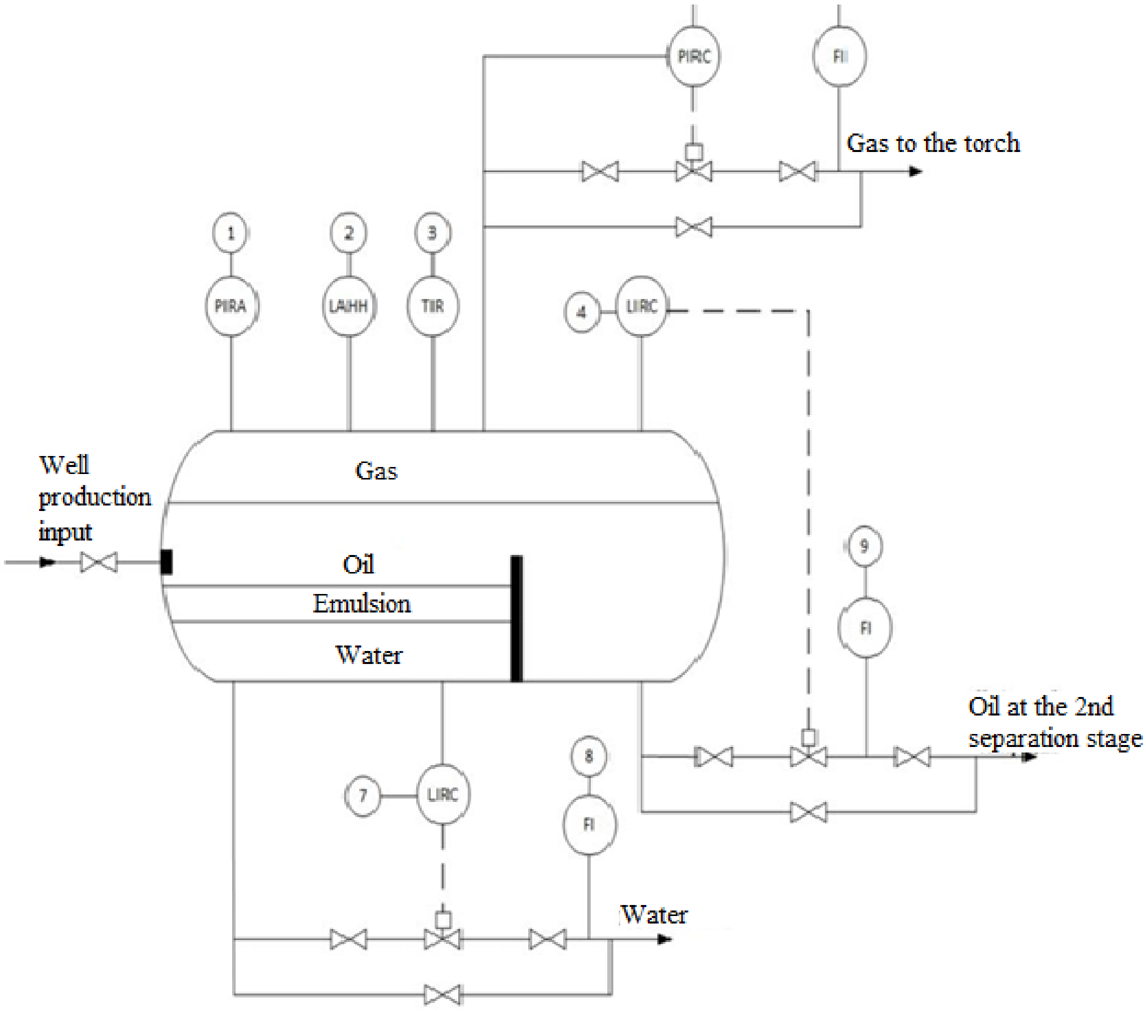
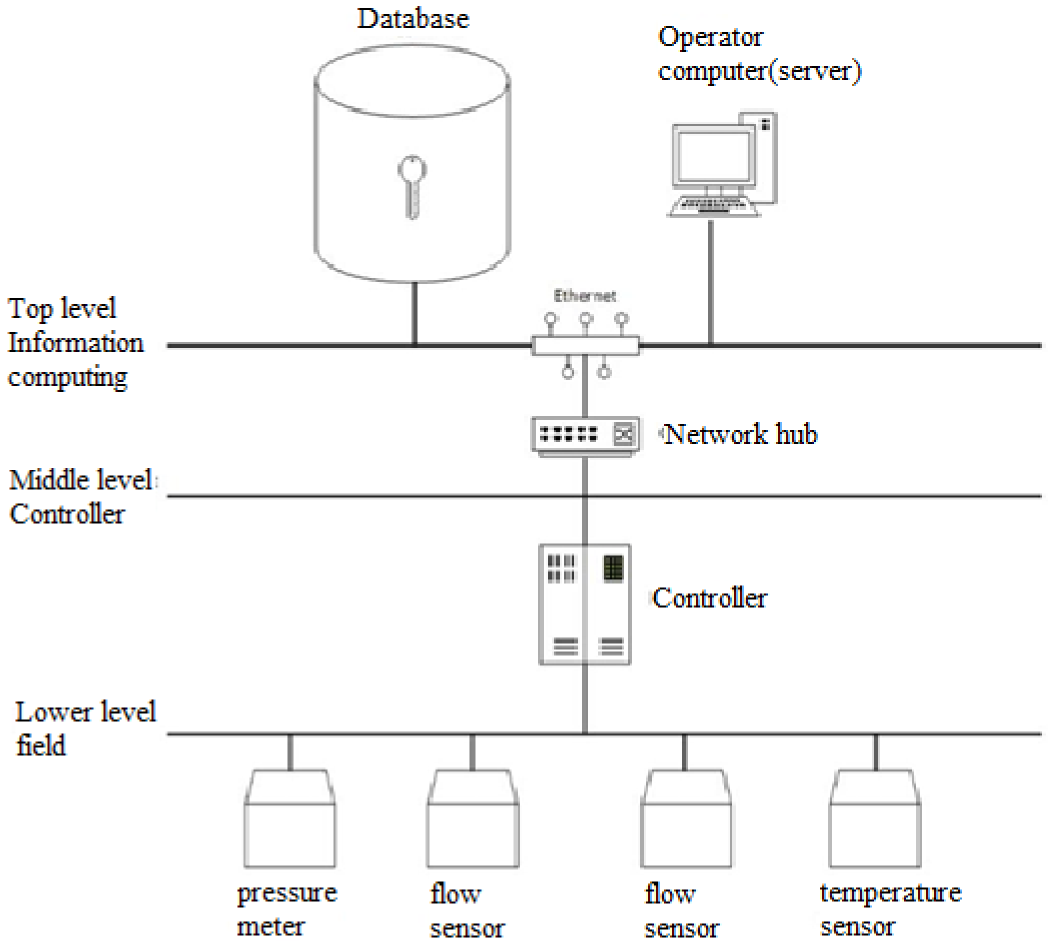
## List of abbreviations

AS - an automated system;
ACS - automated control system;
A computer - an electric computer;
DCS - distributed control system;
PAZ - emergency protection; Software - software;
AWP - workstations;
UPS - uninterruptible power supply;
ShRP - cupboard regulatory point;
LAN - local area networks;
AC - air compressor;
PLC - programmable logic controllers;
PTS - software and hardware;
SCADA – Supervisory Control And Data Acquisition.

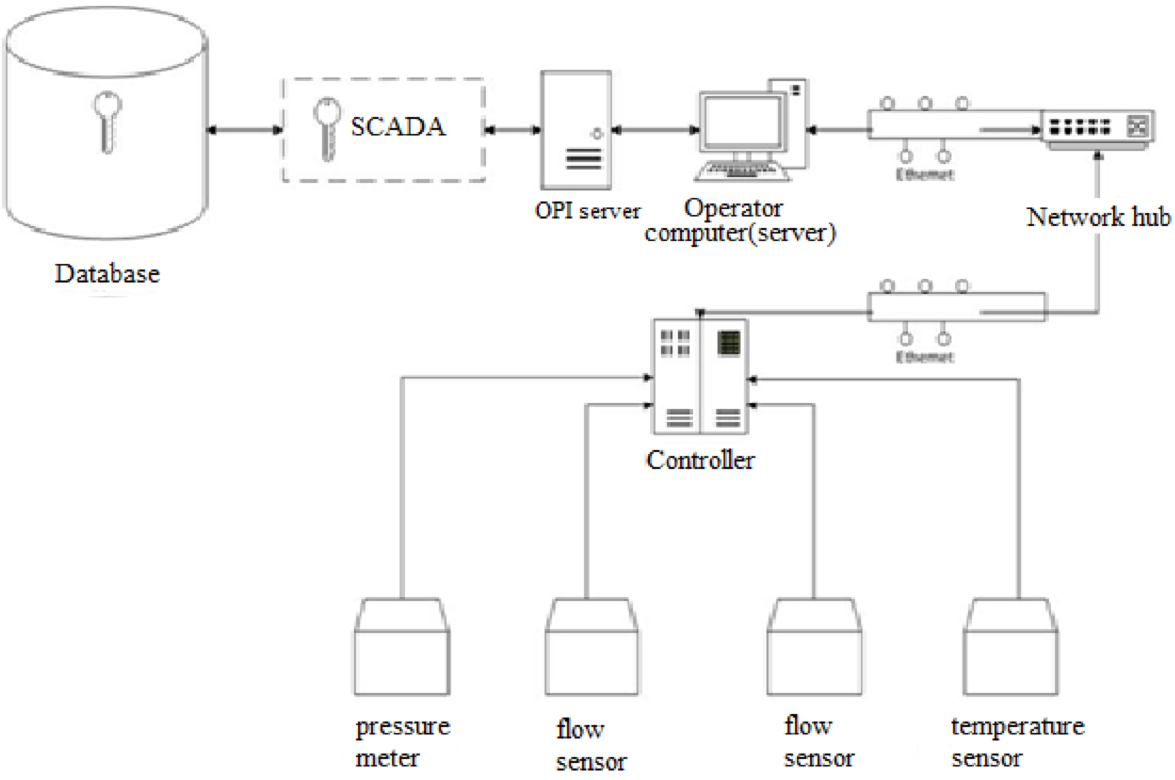
# Appendix A  Functional diagram of the separation unit



# Appendix C The three-level structure of the speakers



# Appendix G The generalized control structure of the speakers



# Appendix D Block diagram of automation