МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
АЕРОКОСМІЧНИЙ ФАКУЛЬТЕТ
КАФЕДРА ПІДТРИМАННЯ ЛЬОТНОЇ ПРИДАТНОСТІ ПОВІТРЯНИХ СУДЕН

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач кафедри
к.т.н., доцент
_________________О. В. Попов
«_____»_______________2022 р.

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ МАГІСТРА

ЗА ОСВІТНЬО-ПРОФЕСІЙНОЮ ПРОГРАМОЮ
«ТЕХНІЧНЕ ОБСЛУГОВУВАННЯ ТА РЕМОНТ ПОВІТРЯНИХ СУДЕН І АВІАДВИГУНІВ»

Тема: «Методологічні основи підтримання експлуатаційної надійності баків-кесонів чотиримоторного турбогвинтового вантажного літака»

Виконав: _______________ **Козолій В.О.**

Керівник: к.т.н., доцент _______________ **Ругайн О. В.**

Консультанти з окремих розділів пояснювальної записки:

охорона праці: к.б.н., доцент _______________ **Кажан К.І.**
охорона навколишнього середовища: к.т.н., доцент _______________ **Павлюх Л.І.**

Нормоконтролер: _______________

Київ 2022

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
AIRSPACE FACULTY
AIRCRAFT AIRWORTHINESS RETAINING DEPARTMENT

ADMIT TO DEFENCE
Head of the Department
Ph. D., associate professor
___________ O.V. Popov
«____» __________ 2022

MASTER DEGREE THESIS
(EXPLANOTARY NOTE)
GRADUATE OF EDUCATIONAL DEGREE "MASTER"
FOR EDUCATIONAL AND PROFESSIONAL PROGRAMS
"MAINTENANCE AND REPAIR OF AIRCRAFT AND AIRCRAFT ENGINES»

Topic: "Methodical bases for maintaining the operational reliability of caisson tanks of a four-engine turboprop cargo plane"

Fulfilled by: _____________ **Kozolii V.O.**
Supervisor:
Ph.D., associate professor _____________ **Rugain O.V.**
labour precaution:
Ph.D., associate professor _____________ **Kazhan K.I.**
environmental protection:
Ph.D., associate professor _____________ **Pavlyuh L.I.**

Standards Inspector: _____________

Kyiv 2022

NATIONAL AVIATION UNIVERSITY

Airspace Faculty
Aircraft Airworthiness Retaining Department
Educational Degree "Master"
Speciality 272 “Aviation Transport”
Educational and professional programs "Maintenance and repair of aircraft and aircraft engines»

APPROVED BY
The Head of the department
Ph.D., associate professor
______________________O.V. Popov
“_____”________________2022

Graduation Project Assignment

Kozolii Viacheslav

1. Topic: “Methodical bases for maintaining the operational reliability of caisson tanks of a four-engine turboprop cargo plane” approved by the Rector’s order of “29”__09__2022 №_1786/CT.

2. The Graduation Project to be performed between: 26.09.2022__ and __30.10.2022__

3. Initial data for the project: statistics operation the aircraft data failures and malfunctions fire and fuel system plane, regulatory, operational and design documentation.

4. The content of the explanatory note: analysis of factors and causes of fire in fuel tanks; development of measures to improve the operational reliability of fuel tanks; develop measures to protect labor and the environment.

5. The list of mandatory graphic materials: Diagram of the fuel and fire protection system of the aircraft.

6. Календарний план-графік

№ пор.	Завдання	Термін виконання	Відмітка про виконання
1	Отримання теми, вибір матеріалу	26.09.22 – 28.09.22	Виконано
2	Основна частина	29.09.22 – 04.10.22	Виконано
3	Спеціальна частина	05.10.22 – 10.10.22	Виконано
4	Проектна частина	11.10.22 – 17.10.22	Виконано
5	Охорона праці	18.10.22 – 22.10.22	Виконано
6	Охорона навколишнього середовища	23.10.22 – 26.10.22	Виконано
7	Оформлення пояснювальної записки	26.10.22 – 27.10.22	Виконано
8	Підготовка до захисту дипломної роботи	27.10.22 – 30.10.22	Виконано

7. Консультанти з окремих розділів

Розділ	Консультант	Дата, підпис	
		Завдання видав	Завдання прийняв
Охорона навколишнього середовища	канд. техн. наук, доцент Павлюх Л.І.		
Охорона праці	канд. техн. наук, доцент Кажан К.І.		

8. Дата видачі завдання: «_____»___________ 202__ р.

Керівник проекту __________ Ругайн О. В.
(підпис керівника)

Завдання прийняла до виконання _____________ Козолій В.О
(підпис випускника)

6. Time and work schedule

#	Stages of Graduation Project Completion	Stage Completion Dates	Remarks
1	Task receiving, selection of material,research of statistical data	26.09.22 – 28.09.22	Done
2	Main part	29.09.22 – 04.10.22	Done
3	Special part	05.10.22 – 10.10.22	Done
4	Project part	11.10.22 – 17.10.22	Done
5	Labour precaution	18.10.22 – 22.10.22	Done
6	Environmental protection	23.10.22 – 26.10.22	Done
7	Arrangement of explanatory note	26.10.22 – 27.10.22	Done
8	Preparing for project defend	27.10.22 – 30.10.22	Done

7. Advisers on individual sections of the project:

Section	Adviser	Date, Signature	
		Assignment Delivered	Assignment Accepted
Labour precaution	Candidate of science, assoc. professor Kazhan K.I.		
Environmental protection	Candidate of science, assoc. professor Pavlyuh L.I		

8. Assignment issue date “_____”___________ 202_.

Degree work supervisor: ___________ Rugain O.V.
(signature)

Assignment is accepted for fulfillment ___________ Kozolii V.O.
(signature)

РЕФЕРАТ

Пояснювальна записка по дипломній роботі “Підтримання експлуатаційної надійності баків – кесонів вантажного літака” 128 сторінок, 18 малюнків, 9 таблиць, 18 посилань.

Важливість теми

18 липня 1996 близько 00:31 за UTC, літак Boeing 747-131 (бортовий номер N93119) авіакомпанії Trans World Airlines, вибухнув в повітрі і впав в Атлантичний океан поблизу East Moriches, штат Нью-Йорк. Всі 230 осіб, які перебували на борту загинули, а літак був зруйнований.Експерти з National Transportation Safety Board провели розслідування по даній катастрофі, і в 1997 році прийшли до висновку, що вибух літака компанії TWA стався через детонацію парів палива, що змішаличася з киснем, що був над паливовм в паливному баці в районі центроплана. В наступні роки Федеральне управління цивільної авіації звернулося до авіакомпаній з вимогою забезпечити кращу теплоізоляцію, переміщення проводки, перевіряти паливні насоси, і вживати інших заходів. 7 травня 2001року FAA випустила постанову під назвою SFAR 88, для того щоб мінімізувати джерела загоряння в паливних баках. Після чого в грудні 2002 року виробники провели ретельний огляд кожної моделі літака і виявили понад дві сотні раніше невідомих джерел загоряння. Головним джерелом загоряння паливних баків є скупчення вибухонебезпечних парів в паливному баку. Для усунення цієї проблеми необхідно знизити концентрацію кисню,що міститься в повітрі в над паливному просторі.

Цілі та задачі дослідження

Метою даної роботи є дослідження надійності паливної системи літака,а саме баків кесонів. А також підвищення експлуатаційної надійності баків-кесонів шляхом впровадження системи нейтрального газу з активною системою індикації її стану.

Об’єкт дослідження – дослідження баків – кесонів літака на пожежну безпеку та умов винекнення пожежі баків-кесонів.

Предмет дослідження – протипожежна, паливна та дренажна системи їх агрегати і вузли.

Методи дослідження – аналітичне та ілюстративне оброблення матеріалів з теми забезпечення вибухопожежо безпеки баків – кесонів літака.

Наукова новизна дипломної роботи визначається тим, що в ній представлено впровадження системи нейтрального газу, що дозволить підвищить рівень безпеки експлуатації повітряних суден та їх систем.

Практична значимість. Результати дослідження відображають опис фізичних основ і сутності запобігання скупчення вибухонебезпечних парів в паливних баках. Рішенням проблеми пов'язаної з підвищенням безпеки паливних баків, може стати модернізація паливної системи системою нейтрального газу.

БАКИ-КЕСОНИ, ПАЛИВНА СИСТЕМА, ВИБУХОНЕБЕЗПЕЧНІ ПАРИ ПАЛИВА, ГЕНЕРАТОР НЕЙТРАЛЬНОГО ГАЗУ, ДРЕНАЖНА СИСТЕМА, ПОВІТРЯНЕ СУДНО, ПРОТИПОЖЕЖНА СИСТЕМА, СИСТЕМА НЕЙТРАЛЬНОГО ГАЗУ, СТАТИЧНА ЕЛЕКТРИКА, ТЕХНІЧНА ЕКСПЛУАТАЦІЯ.

ABSTRACT

Explanation of the diploma thesis "Maintaining the operational safety of tanks - caissons of a cargo plane" 128 pages, 18 figures,9 tables, 18 references.

The importance of the topic

On July 18, 1996, at approximately 00:31 UTC, a Trans World Airlines Boeing 747-131 (flight number N93119) exploded in mid-air and crashed into the Atlantic Ocean near East Moriches, New York. All 230 people on board died and the plane was destroyed. Experts from the National Transportation Safety Board investigated this disaster and in 1997 concluded that the TWA plane's explosion was due to the detonation of a mixture of fuel vapors with oxygen, which was located above the fuel in the fuel tank in the midplane area. Over the next few years, the Federal Aviation Administration urged airlines to provide better insulation, route wiring, inspect fuel pumps, and take other measures. On May 7, 2001, the FAA issued a rule called SFAR 88 to minimize ignition sources in fuel tanks. After that, in December 2002, the manufacturers conducted a thorough investigation of each aircraft model and discovered more than two hundred previously unknown sources of ignition. The primary source of fuel tank ignition is the accumulation of explosive vapors in the fuel tank. In order to eliminate this problem, it is necessary to reduce the concentration of oxygen contained in the air in the space above the fuel.

Research Goals and Goals

The purpose of this work is to study the reliability of the aircraft fuel system, namely the cassette tanks. In addition to increasing the operational safety of caisson tanks by introducing a neutral gas system with an active system for status indication.

The subject of the study is the investigation of aircraft tank caissons for fire protection and the conditions of fire-fighting tank caissons.

The subject of the study is fire, fuel and drainage systems, their units and assemblies.

Research Methods - Analytical and illustrative processing of materials on the topic of explosion safety of aircraft tanks - caissons.

The scientific novelty of the work is determined by the fact that it presents the introduction of the neutral gas system, which will increase the safety in the operation of aircraft and their systems.

Practical Significance. The results of the study reflect the description of the physics and essence of preventing the accumulation of explosive vapors in fuel tanks. Retrofitting the fuel system with a neutral gas system can be a solution to the problem of increasing fuel tank safety.

CAISSON TANKS, FUEL SYSTEM, EXPLOSIVE FUEL VAPORS, NEUTRAL GAS GENERATOR, PURGE SYSTEM, AIRSHIP, FIRE EXTINGUISHING SYSTEM, NEUTRAL GAS SYSTEM, STATIC, MAINTENANCE.

CONTENT

THE LIST OF ACCEPTED ABBREVIATIONS, SYMBOLS, UNITS, AND TERMS

AC – Aircraft;

AC – Alternating Current;

APU – Auxiliary Power Unit;

CA – Civil Aviation;

CNI – Coefficient of Natural Illumination;

CO – Carbon Monoxide;

DC – Direct Current;

ECU – Electronic Control Unit;

ICAO - International Civil Aviation Organization

HS – Harmful Substances;

LCD – Liquid Crystal Display;

NG – Neutral Gas;

NTSB – National Transportation Safety Board;

PTM - Periodic Technical Maintenance;

SHF – Super-High Frequencies;

OBIGGS - On-board Inert Gas Generation System

TM – Technical Maintenance;

TO – Technical Operation;

TC – Technical Condition;

TPE – Turboprop Aviation Engines;

TLC – Take-off-Landing Cycle;

UV – Ultraviolet;

UHF – Ultrahigh;

INTRODUCTION

The development of civil aviation in the world makes it possible to meet the needs of the civilian population in comfortable conditions of movement over long distances with minimal time spent in comparison with other types of transport. But it is worth realizing that in the pursuit of a low cost, which would allow attracting a large number of both new and regular customers, and a low cost of organizing such transportation, which is of interest above all to companies seeking to develop in the aviation sector, the safety and comfort of customers should not be neglected . After all, the blind pursuit of the opportunity to increase one's fortunes eventually leads to terrible disasters with a large number of human victims. At the same time, companies bear correspondingly terrible losses.

In order to increase the level of flight safety, international organizations have been created that have undertaken the implementation of the issue of regulation, standardization of the conditions for servicing the fleet of aircraft, rules for flight operations, requirements for the safety and reliability of both new and already manufactured aircraft, as well as supervision of compliance with these rules by all companies engaged in commerce in the field of aviation and the manufacture of aviation equipment. In turn, the companies undertake to provide complete information, which is necessary to increase the safety of flights and the reliability of aviation equipment.

But one way or another, various factors lead to the occurrence of various incidents and disasters. That is why aviation designers, when developing new types of aviation equipment, lay down new engineering solutions, solve a number of certain problems, which in turn will increase the reliability and safety of the operation of the aviation fleet of equipment. In addition, designers and engineers are engaged in the modernization of elements and systems of already existing aircraft.

The purpose of this diploma project is to analyze the design of the fuel system of the An-70 aircraft in order to identify factors that affect the probability of a fire occurring in the fuel tanks-caissons of four-engine turboprop cargo aircraft and to carry out the necessary modernization of the identified weak points of the fuel system in order to increase the operational reliability of the system, and flight safety in general.

Chapter 1. ANALYSIS OF FUEL SYSTEM DESIGN AND FACTORS AFFECTING OPERATIONAL RELIABILITY OF AIRCRAFT CASSON TANKS

1.1 General information and block diagram of the aircraft fuel system

The fuel system ensures the provision of reserve fuel required for flight and its uninterrupted supply to the engines (and DSU if on the aircraft) in all flight modes.

In some aircraft, the fuel system performs additional functions such as balancing and maintaining optimal centering of the aircraft by pumping fuel from tank to tank; The fuel can be used as a coolant to cool the on-board systems in the technical rooms.

The fuel system can be conditionally divided into the following interconnected subsystems: fuel tanks (fuel tanks, tank emptying, fuel pump systems); fuel distribution system (engine fueling and refueling systems); fuel drain (emergency in-flight drain, bottom drain, condensate drain); Devices and devices for monitoring the operation of the fuel system.

Depending on the aircraft's purpose and required LTH, the fuel mass is 10-60% of the aircraft's take-off weight, so bringing fuel on board is a complex design and engineering problem.The schematic diagram of the fuel system of an airliner is shown in Fig. 1.1.

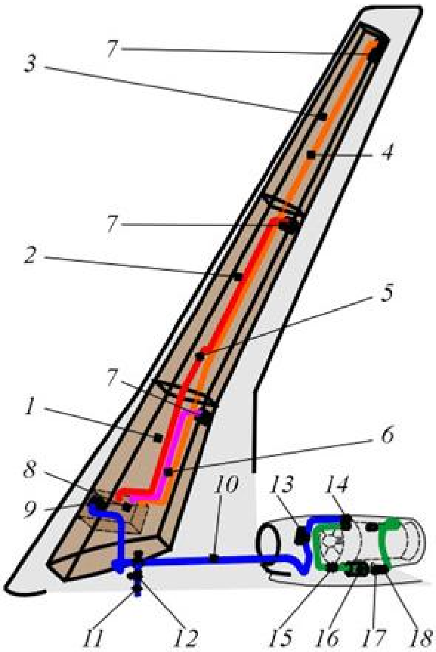

Figure 1.1. Schematic representation of the fuel system of an aircraft

The aircraft's fuel system consists of two self-contained, similar system designs: the right and left, each supplying fuel to the appropriate engine.

In each half (console) of the wing, the front and rear spars together with the upper and lower wing panels and the sealing ribs form three boxes 1, 2 and 3.

The caisson tanks of each console are connected by a pipeline 11, in which a ring valve (cross supply valve) 12 is installed, which ensures the supply of fuel from the left group of tanks to the right and vice versa. The fuel system lines are made of aluminum and steel tubes.

Fuel from the caisson tanks is pumped through the pipelines 4, 5 and 6 using paired (replicating) 7 transfer pumps in a certain order to the 8 outlet compartment located inside the caisson tank 1, from which it is discharged by pair pumps 9 under a certain pressure is supplied through the pipeline 10 through the overhead valve 13 to the units of the fuel system on the engine (suction pump 14, sensor of the flow meter 15, fuel oil cooler 16, fuel filter 17, control pump 18, after which it is supplied to the nozzles of the high-pressure chamber through the distributor.

In modern aircraft, fuel is fed into the fuel tanks centrally under pressure (through one or more refueling nozzles). Fuel filters ensure the release of fuel from accidental mechanical impurities. The system of valves and taps automatically ensures a certain sequence of filling the tanks, producing fuel from the compartment tanks so that the center of gravity of the aircraft does not deviate from the established limits during fuel production, and draining fuel from on-board tanks before an emergency landing .

The reliability of the fuel system depends on the pressure of the mixture of air and fuel vapors in the premium fuel compartment of the tanks.

Dilution (negative pressure) can lead to flattening of tanks, cavitation of fuel at the inlet of pumps and pipes, i.e. the formation of cavities in the fuel filled with air, fuel vapors or their mixtures, and as a result, malfunction of pumps and engines.

The increase in pressure in the premium fuel compartment can lead to permanent deformations of the structure: swelling of the integrated fuel tanks and even deformation of the wing tanks.

Shortages in the premium fuel compartment can occur during the process of fuel production or emergency emptying, pressure increase - during the process of centralized refueling with pressurized fuel.

The drainage system ensures the maintenance of the required pressure difference in the premium fuel space of the tanks and the surrounding atmosphere and the reduction of the concentration of explosive kerosene vapors by pressurizing (and venting) the tanks with air through piping leading to the upper points guiding the tanks through high-velocity air pressure from engine compressors or shipboard cylinders, neutral gases from shipboard cylinders or special systems.

The tank pressure system with neutral gases increases the fire and explosion safety of the aircraft.

1.2 General requirements for fuel tanks

In order to determine the main operating factors affecting caisson tanks, it is necessary to become familiar with the requirements placed on them. Cassette tanks, like all types of aviation fuel tanks, must meet the following requirements:

1. Withstand work loads and vibration without damage.
2. At full refueling each tank shall have a free volume of at least 2% of its thermal expansion capacity or means shall be provided to prevent fuel overflow and spillage in the event of thermal expansion.
3. It is necessary to ensure the drainage of sediment from the lower points of the tanks or fuel sump with the minimum possible number of drain cocks, the volume of the sump must be at least 0.1% of the volume of the tank and the drain valves must be in the closed state to be fixed.
4. Fuel tanks and their units located adjacent to engine compartments and other electrical and/or thermal installations must be separated from them by fireproof partitions or screens, the distance between tank and partition must be at least 15 mm.
5. Pedestal tanks should have hatches for inspection and repair of fuel system units and elements located in the tanks.
6. Tanks with fuel units installed are tested as follows:

- a pressure equal to 125% of the maximum inflation pressure plus the pressure occurring at maximum overload when the tanks are completely filled, but not less than 0.0025 MPa;
- Vibration test under corresponding vibration loads with simultaneous boost empty and filled to 75% volume. For caisson tanks, vibration tests are replaced by flight endurance tests on test aircraft.

7. Aircraft with a total fuel capacity of more than 3,000 liters must have a central fueling system.

1.3. Analysis of the causes of fires in fuel tanks

Aviation gasoline is a combustible and combustible liquid whose vapors, mixed with air, are explosive. When fuel is consumed, it leaves behind an explosive mixture of air and kerosene vapor. Explosive mixtures with air-fuel vapors are, depending on the sources of exposure:

- ❖ flame;
- ❖ electric spark;
- ❖ discharge of static electricity;
- ❖ -Self-ignition (of the heating elements when the temperature is higher than the ignition temperature).

The formation of an explosive concentration of fuel vapors and oxygen, which affects the operating conditions of the flight and the chemical composition of the fuel. PS operating conditions:

- ❖ Above sea level;
- ❖ rate of climb;
- ❖ ambient temperature;
- ❖ Number of liquid and gaseous phases.

The explosive mixture of fuel vapors with air is measured according to the following criteria:

- ❖ explosion temperature limits;
- ❖ Explosiveness of limit concentrations.

The formation of an explosive mixture of fuel vapors with air is only possible in certain temperature ranges. In this regard, it is accepted to consider the lower and upper limits of the explosion temperature. The lower temperature of the explosion limit is the minimum fuel temperature at which the vapor pressure of the fuel reaches such a value that an explosive mixture forms in the tank. Additional cooling makes the fuel mixture so lean that it is practically non-flammable. The upper temperature limit of the explosion is considered to be the maximum fuel temperature at which the mixture of fuel vapors and air still retains its explosive properties. If the temperature increases further, the mixture becomes so enriched with fuel vapors that it becomes combustible. Thus, the lower and upper limit of the temperature of the explosive substance form the so-called explosion temperature zone. The concentration below the explosive limit is the concentration of fuel vapors in air at which the mixture can ignite.

In order to ignite the fuel mixture, a certain ratio of fuel and air and a temperature at which rapid oxidation is possible is required. Very rich and very poorly non-flammable mixtures, since in these cases the reaction rate decreases due to heat release to the environment with limited excess heat, due to lack of oxygen or d fuel oxidation. Therefore, the height is an important factor in the ignition process. With increasing altitude, many parameters that most affect the ignition process of the fuel-air mixture change - the concentration of oxygen and the amount of vapor per unit volume. Figure 1.3.1 shows the temperature dependence of the formation limits of a combustible mixture on the height and the oxygen concentration in the space above the fuel.

Apparently, the lower limit of concentration, indicated by the lower temperature limits, does not depend on altitude above sea level, giving rise to a sufficient concentration of vapors and oxygen mixture for ignition. The upper temperature limit is strongly dependent on the oxygen concentration due to the increased altitude, so the enriched fuel vapor mixture is non-flammable and only creates stoichiometry for ignition with increased oxygen concentration, therefore the temperature limit increases with increasing oxygen concentration. However, a temperature of 10 °C or less between the lower limit and the upper limit of the ignition temperature of 15 °C should be considered safe in view of the possibility of the formation of explosive vapour-air mixtures.

As the aircraft's altitude increases, the temperature explosion zone moves in the direction of temperature decrease as atmospheric pressure decreases and fuel evaporation increases. Explosive mixtures are formed as the temperature decreases as the altitude increases.

1.3.2 shows the dependence of the oxygen concentration on altitude.

As can be seen from the graph, the explosion concentration of oxygen on the ground (height 0 km) is 12 ... 14% vol.

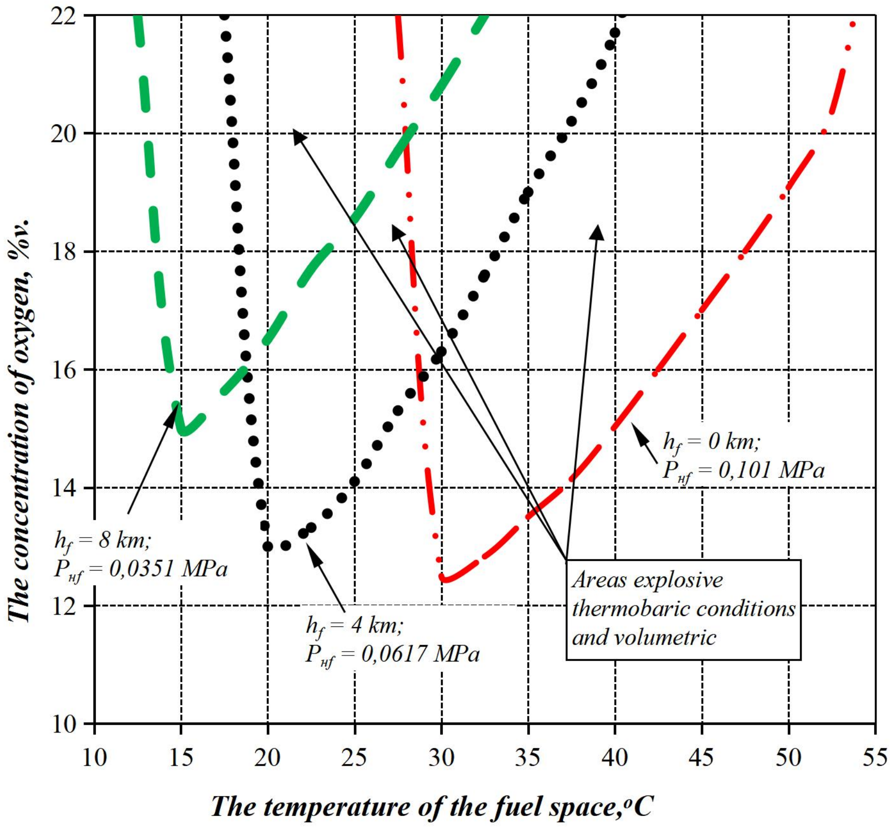

Figure 1.3.1 - Temperature border explosive gas mixtures in the fuel tank space caisson depending on the volume of oxygen concentration at different heights flight

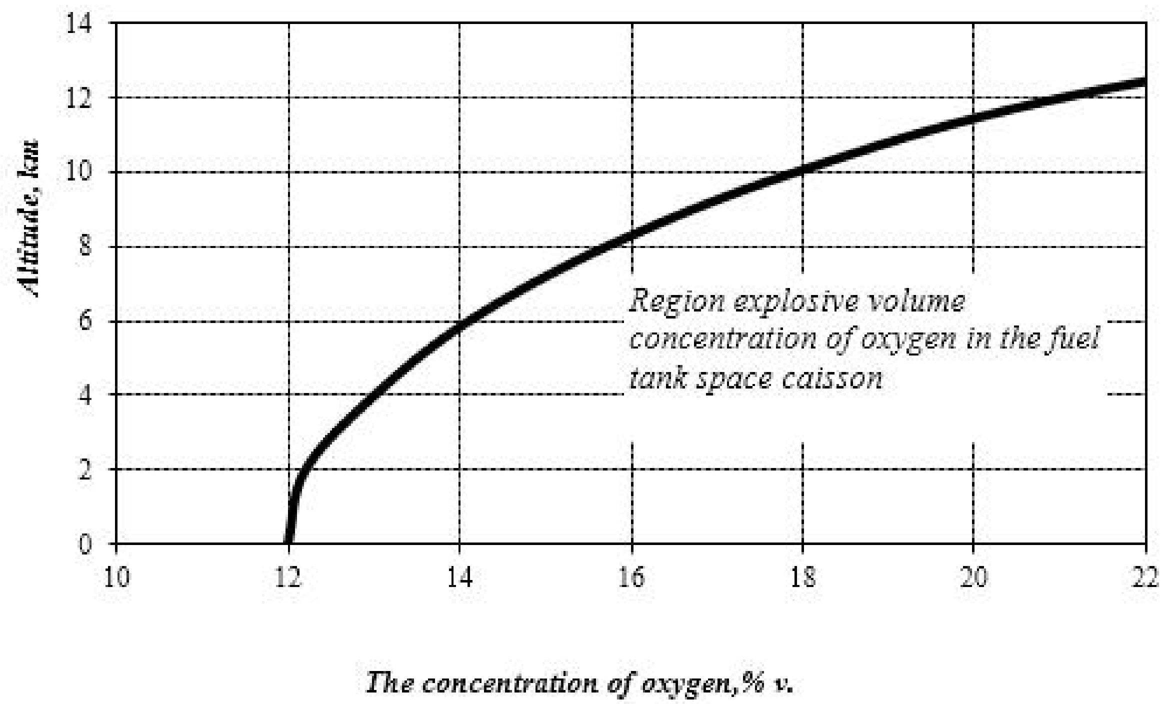

Figure 1.3.2 - Maximum allowable concentration of oxygen in the space of fuel tank depending on the altitude of the aircraft

As the altitude increases and the concentration range decreases, an explosion occurs at 12.5 km as the mixture of fuel vapors becomes so enriched and oxygen-depleted that it becomes combustible. However, it should be borne in mind that different batches of the same type of fuel may differ in fractional composition, so the temperature limit may vary slightly. Table 1.1 contains data on the maximum explosive concentrations of various brands of fuel.

Table 1.1 Explosion hazard concentration boundaries

Fuel	Density, g/ cm3	Concentration boundary explosion hazard	
		lower	upper
T-1	0,813	1,4	7,5
TC-1	0,779	1,2	7,1
T-2	0,765	1,1	6,8

The turbulent environment, the concentration and family of inert solvents, the adequacy of surface fuel tanks will also affect the development of the aircraft, increasing evaporation from the surface, but oxygen concentration and temperature remain the determining factors. .

Depending on the environmental conditions, the combustion process is characterized by a change in the rate of chemical reaction. In the initial period, the process occurs at a low speed and is accompanied by a slight heating and, accordingly, a slight increase in temperature and pressure. In the absence of heat, the reaction occurs with great acceleration. When the heat is removed, the combustion reaction stops.

The initial state and the burned mixture differ in temperature, density and chemical composition, so that heat exchange and mass transfer take place in the flame zone. The interface between the two media is called the flame front (Fig. 1.3.3).

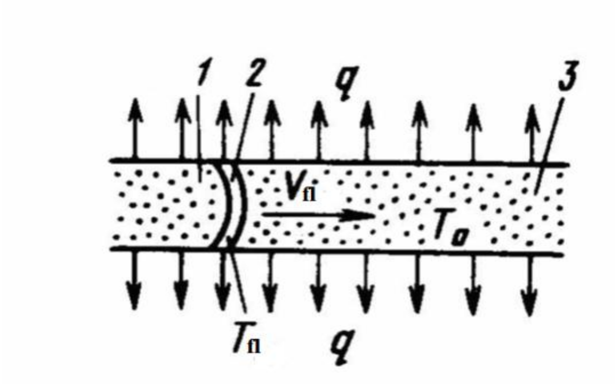

Figure 1.3.3 Physical process image:

Vfl - propagation speed of the flame front; T0, Tfl - absolute temperature of the feed mixture and the mixture in the flame zone; 1 - combustion products; 2 - flame front; 3 - fuel + oxidizer.

The propagation speed of the flame front Vfl is a complex function of many variables. The most important are the initial pressure, the temperature and the composition of the starting mixture of the mixture.

α = mfuel/mair - where mfuel is the mass of fuel; mair - air mass.

Flame propagation becomes impossible when the fuel-air mixture is significantly lean or rich, which is characterized by concentration of the mixture. The concentration of the mixture at which the flame front stops spreading is called the ignition limit. The limit concentration α = 1/25 ... 1/5 applies to aviation fuels. The dependence of the essential physical properties of ignition and combustion on the concentration of the air-fuel mixture is shown in Figure 1.3.4

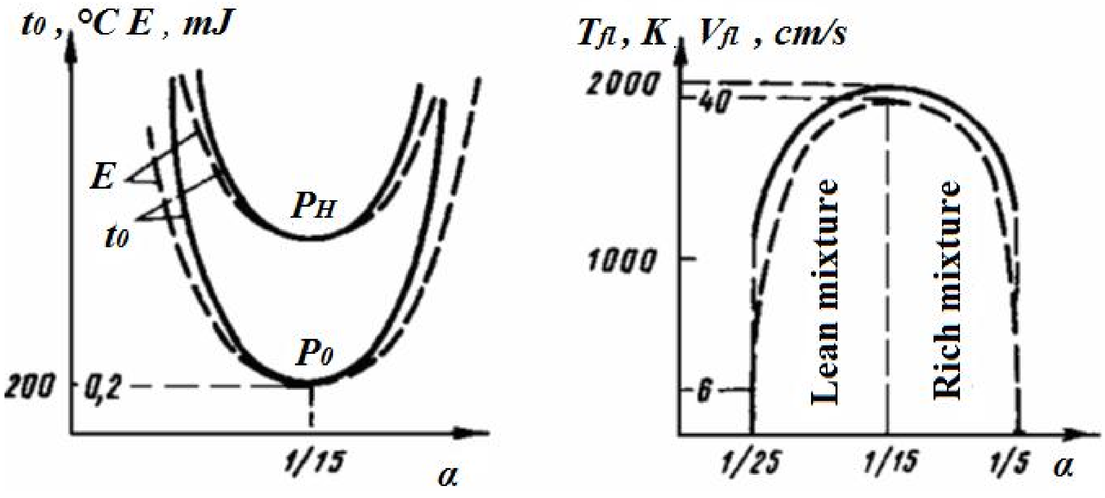

Figure 1.3.4 The dependence of the activation energy, the ignition and flame temperatures, the flame propagation velocity of fuel-air mixture concentration

From a general survey of combustion characteristics

It follows that the fire can be stopped by changing the concentration of the combustible mixture, by chemically influencing the reaction or by removing the heat of combustion from the fire.

1.4 Causes of fires in an aircraft and design methods for preventing and extinguishing fires

In the event of a fire on an aircraft, access to the compartments where the seat of the fire is directly developing is usually impossible due to the difficult accessibility of the relevant parts of the aircraft, the imminent danger to the crew and technical personnel performing maintenance work. and other specialists. In addition, extinguishing a fire that has broken out requires the use of sophisticated technical means specially designed for these tasks, since the use of portable hand-held fire extinguishers is in most cases not effective when the fire has already started to spread. In addition, if we consider situations when a fire occurs during a flight, it is impossible to influence the fire of technical means and specialists in this way.

The task of locating and extinguishing fires therefore depends on specially designed structural solutions and additional systems that reduce the likelihood of a fire breaking out and limit its spread. These solutions and systems are developed by designers at the appropriate stages of aircraft design and manufacture. Therefore, before delving into the principles of operation and structural implementation of these systems and design solutions, it is necessary to consider the reasons and circumstances under which a fire can occur on an aircraft and its elements.

Causes of fire in the aircraft:

1. Ignition of aviation fuel vapors:

- ❖ Ignition due to fuel ingress on the hot parts of aircraft engines in violation of the tightness of nodes and pipelines of engine systems and engine fuel supply systems.
- ❖ Ignition of fumes from fuel spillage during maintenance of engine compartments.
- ❖ Ignition in the event of destruction of components of the fuel supply system of the engine.
- ❖ Ignition of fuel vapors by discharge of static electricity.
- ❖ Ignition of fuel vapors due to violation of fire safety regulations during aircraft maintenance.

2. Fat ignition:

- ❖ by destroying the components of the engine oil system.
- ❖ Ignition of lubricating vapors due to engine overheating.
- ❖ Ignition of the lubricant by discharge of static sparks.
- ❖ Ignition from oil falling on hot engine parts or spread of flames

3. Hydraulic mixture ignition:

- ❖ due to overheating of the brake pads.
- ❖ as a result of a hard landing with subsequent destruction of elements.
- ❖ as a result of the destruction of the aircraft and the spread of fire from other elements.

- failure of hydraulic units with subsequent overheating of the hydraulic mixture.

The most dangerous main part of the aircraft is shown in Figure 1.4

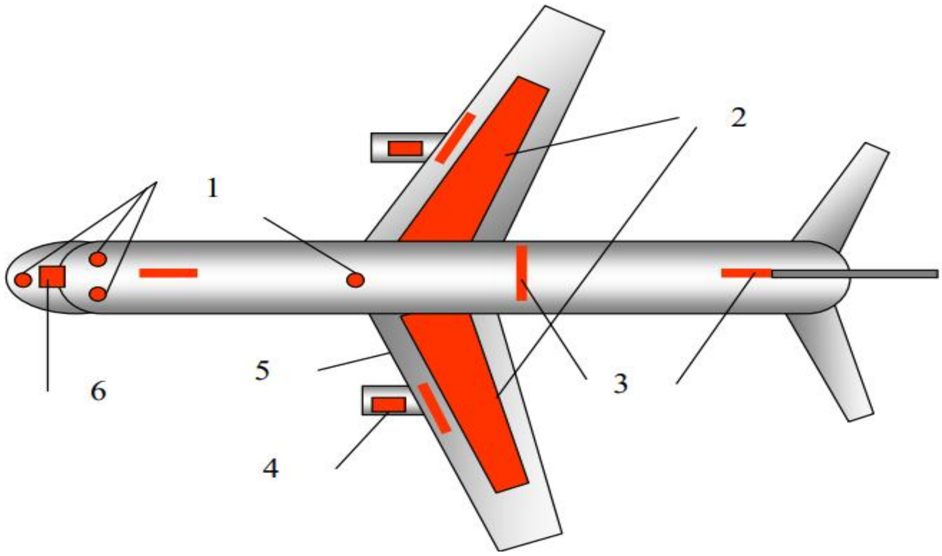

Figure 1.4 The most dangerous part of the aircraft

1.4.1 Designing solutions to increase fire resistance

According to the project, aircraft fire protection measures include:

- Separation of engine compartment in powered nacelles using fire barriers to separate areas to allow and prevent the spread of fire and eliminate it if it occurs;

- Divide the space occupied by the fuel tanks into separate compartments, isolated by hermetic partitions, which eliminates fuel spillage.

- the impossibility of placing fuel tanks in the fuselage and in the middle of the fuselage, that is, near the passenger living quarters, in the space above the fuel tanks and voids where fuel vapors and inert gases (nitrogen, carbon dioxide) can enter. accumulate;

- Considering the components of the power plant, due to which elements of the fuel system, including tanks, can be damaged in the event of a failure of the rotating components of the engine (blades and discs of the turbine and compressor, etc.).) .);

- Ensuring sufficient vibration resistance of pipelines and tanks (use of flexible pipes and elastically suspended tanks), use of metallization of pipelines to avoid overload from static electricity;

- use heat-resistant materials in the manufacture of the power plant, which are most sensitive to fuel and oil vapors, high temperatures.

1.5 Aircraft Fire Protection

To locate and extinguish a fire, a fire extinguishing system is used, which includes signaling and control means (fire detection and control of its extinguishing) and fire extinguishing means (means for extinguishing fire).

The fire protection system must:

- ❖ be reliable in all flight modes and at all altitudes;
- ❖ give fire signals in time, quickly activate fire-fighting equipment and effectively extinguish the fire;
- ❖ ensuring the supply of extinguishing agents in one of the protected areas, including the nacelle and the internal cavity of the engine, which are most vulnerable to fire;
- ❖ control the “Fire” alarm automatically, then manually at the discretion of the crew;
- ❖ be sealed and have a device protecting it from destruction if the pressure in the fire extinguishers exceeds the permissible value;
- ❖ the management and control of the alarm equipment is concentrated in one place on the dashboard, so you can easily determine and control the place of fire extinguishing.
- ❖ small size, anti-corrosion, convenient to operate and use.

Signaling and control devices are used to give fire signals and to control the supply of fire extinguishing agents to the seat of the fire. It consists of the following basic elements (Figure 1.5.1):

- sensors installed in protected fire compartments and intended to report a fire in the event of an increase in the ambient temperature above the permissible ambient temperature;
- Solenoid valve blocks for opening access to fire extinguishing;
- traffic lights (panel), rocker switches, control buttons and controls installed on the dashboard and cabin for fire alarm.

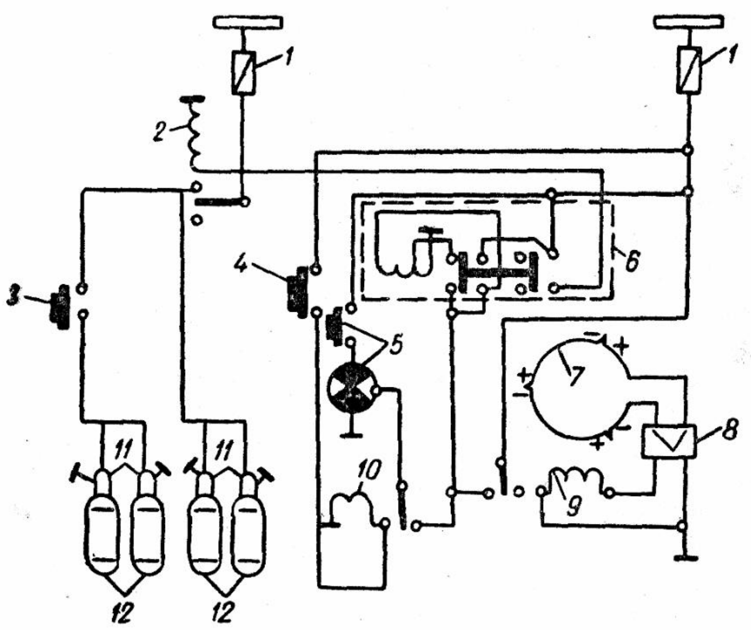

Figure 1.5.1 - Schematic diagram of signaling and control equipment fire protection system

1 – automatic circuit breakers; 2 – relays include cylinders extinguishers first; 3 – fire extinguisher cylinders button on the second stage; 4 – button check of the alarm system; 5–button lamp; 6–block electromagnetic cranes; 7 – sensor alarm fire; 8 – amp; 9 – relays include fire protection system; 10 – relays to check the functioning signal lights; 11 – pyro cartridges bolting cylinders; 12 – cylinders fire extinguishers

Signaling and control devices must:

- be reliable, completely exclude false alarms;
- sound the “fire” signal and activate the extinguishing means as soon as possible after the fire;

- ❖ to ensure the implementation of comprehensive measures, the automatic transfer of fire extinguishing agents in the shortest possible time from the moment of fire elimination;
- ❖ have the required mechanical strength and durability under load and fire.

The sensor element of any alarm system are sensors that can work on one of the following principles:

1. ignition of the TVEL sensor;
2. metal expansion under the influence of high temperature;
3. melting of metals at high temperature;
4. change the temperature with temperature sensors.

Sensors using the first three principles, including thermal sensors and membrane detectors, are not currently used because they often malfunction and lead to premature activation of the system. Modern aircraft fire protection systems, mainly sensors, operate on the latter of these principles. These sensors are based on using the thermal electromotive force that develops in them when the ambient temperature changes. They are used, among other things, in the KKP-2A fire detection system, which is widely used in the external fire extinguishing systems of domestic passenger aircraft. Several different designs of sensors based on the same principle, used in the CCP-7 alarm system, in internal fire protection systems (to extinguish fires in the turbine rotor gearbox area and in the front cover area).

The SSP-2A fire detection set includes fire detectors and an executive unit. The differential speed sensor is designed to generate thermoelectric energy. When the room temperature increases, the room sensor increases at a rate that exceeds the rate of temperature change during normal operation. The sensitive element of the sensor is a differential battery composed of 8 Chromel-Copel thermal sensors welded in series. The evaluation unit is designed to receive signals from sensors and relays in order to supply the appropriate compartment of the sprinkler system from which the fire signal originates. The low-impedance switching relay RPS-5 is connected directly to the evaluation unit. The executive units are installed as reference units to calibrate the total resistance of the sensor chain to ensure the specified operating temperature of the PKU-2A system.

The principle of operation of the system as a whole is as follows. When the sensors are exposed to an air environment that is changing in temperature at a rate of at least 2°/s, these thermoelectric sensors generate thermoelectric energy that induces sufficient current in the coil of the biased relay to operate the relay. A biased relay is activated, the contact of which closes the relay circuit of the aircraft fire system. The last of its ends contains a light (alarm panel) and at the same time an audible alarm in the cabin in the event of a fire in the corresponding compartment. In addition to sending a signal, the firefighting equipment is automatically turned on, an impulse is sent to the solenoid of the electromagnetic valve, which closes the circuit of the fire extinguisher pyrocartridge lock. The fire extinguisher head valve is opened, and at the same time, the compressed carbon dioxide and air in the fire extinguisher tank are released through the pipeline through the manifold into the fire area. This is how automatic fire extinguishers were used first. In the event of a fire being extinguished, the alarm center on the first extinguisher line is activated. If the warning sign does not go away after a certain time (specified in the device's operating instructions), the second row of fire extinguishers must be switched on manually.

This will discharge the remaining fire extinguishers. After the fire is extinguished, with a sharp drop in ambient temperature, the signal from environmental sensors and the fire alarm disappears, and the system returns to the state of readiness. The consideration of the alarm system can be divided into so-called point alarm systems, in which alarm sensors are located in predetermined zones at risk of fire and thus each sensor reacts individually to a specific temperature of the enclosed volume of air surrounding it. Due to this, the number of point detectors in each fire compartment must be installed in specific rooms (e.g. in a complex system CCP-2A has 20 sensors). In recent years, so-called linear fire alarm systems for firefighting aircraft have begun to be widely used.

The basis of the system is a heat-sensitive conductive coaxial cable, the outer sheath of which (diameter 1.8-2.3 mm) is made of stainless steel and filled with a ceramic semiconductor material with a large negative coefficient of electrical resistance. Inside the cable (strictly along its geometric axis) a thin metal wire is placed with good adhesion to the semiconductor. Loops are attached to the cable that cover the entire flame protection compartment (for example, a cable length of 90-100 m is required for the engine compartment). The ends of the wires are attached to the executive unit. If a fire breaks out in the fire zone, the cable heats up, the resistance of the semiconductor material decreases, thereby closing the electrical circuit and the central tube of the wire. A short-circuit causes activation of the polarization relay and therefore activation of the execution and signaling devices. After extinguishing the fire, the system returns to its original position.

This system has several advantages, including:

- a significant increase in the fire fighting area;
- high operational reliability;
- high survivability (the system works even if individual sections of cable are destroyed);
- low weight;
- high efficiency;
- easy and convenient installation and maintenance.

The disadvantages of the system include:

- complex technology for the production of heat-sensitive yarn;
- limit the heating temperature of the heat-sensitive wire;
- relatively large time delays (2 or more).

Linear type fire alarm systems are equipped with engines with Pratt & Whitney engines on aircraft j-57, "Boeing-707" and "Douglas DC-8", with

Rolls-Royce engines on aircraft "Comet" and "Caravella". Rolls Motors - Royce "Dart" airplane to "Vicount".

Currently, most commercial aircraft, as well as direct fire sensors, are equipped with inertial sensors that fire on certain overloads and activate fire extinguishing means during an emergency landing of the aircraft. Some fire warning systems for foreign aircraft also include means to extinguish normal flames in the combustion chamber and to cool the hot parts of the engine water circuit in the event of an accident.

Fire-fighting equipment designed to store and spray extinguishing agents in the seat of the fire are specifically designed to extinguish fires. The composition of firefighting equipment includes the following main elements (Figure 1.5.2):

- Fire extinguishers for storage and provision of extinguishing agents;
- Lines for transporting extinguishing agents from cylinders to sprayers;
- Spraying devices for spraying extinguishing agents in the seat of the fire.

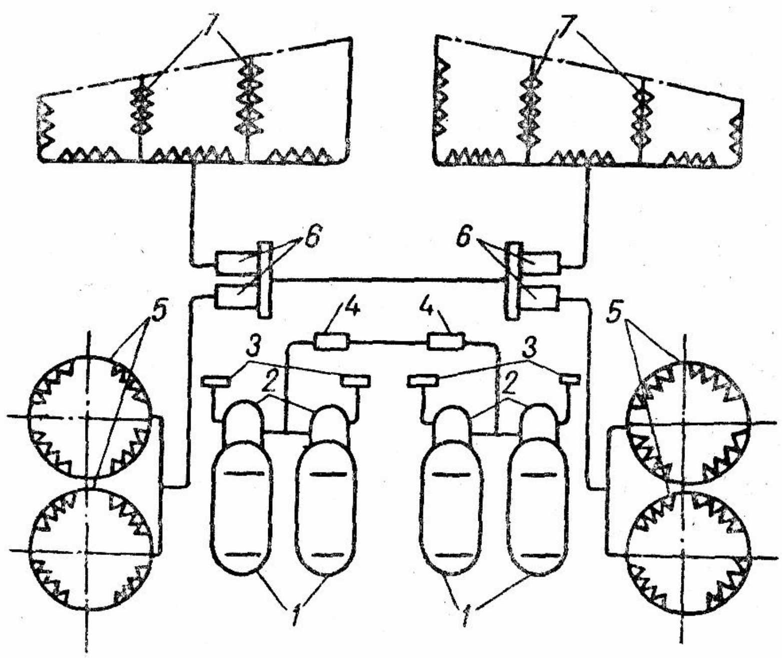

Figure 1.5.2 - Schematic diagram of the fire-fighting aircraft equipment

1– cylinders with liquid extinguishing (fire extinguishers); 2–gates of fire extinguishers; 3– signaling discs; 4– non-return valve; 5– spraying collector engine compartment; 6– blocks electromagnetic valves; 7– spray manifold fuel tanks compartment

Flame retardants act on the seat of the fire by spraying chemical substances that are formed during the evaporation of gases and isolating the fire zone from the air. Combustion stops due to lack of oxygen.

The chemicals used must be:

- sufficiently effective and operational in all weather conditions;
- chemically neutral with respect to engine and aircraft components;
- non-toxic, should not emit toxic compounds (gases, liquids, etc.) when interacting with fire;
- low specific weight.

This meets the requirements of the chemical composition traditionally referred to as "3.5" consisting of 95.8% ethyl bromide and 4.2% chloroform. In recent years, the extinguishing agent "Khladon 114b2" began to find new applications. Compared to composition "3.5", this composition has the following advantages:

- greater efficiency (about 80%) of fire extinguishers;
- semi-toxicity;
- inactive against the corrosion of aluminum and magnesium alloys;
- easy storage and loading of your fire extinguishers.

The following methods can be used to protect the fuel tank from explosion:

- specific treatment of the fuel (cooling, desaturation and nitration of the fuel);
- creation of a space above the inert fuel tanks;
- fuel gelatinization and emulsification;
- fill and protect the fuel tank with open cell foam.

Fuel nitration is achieved by "purging" the fuel with liquid nitrogen prior to refueling and maintaining the nitrogen concentration in the fuel during flight. Create an inert environment in the space above the fuel tank using special systems divided into standard systems that work throughout the flight and emergency systems that are activated in difficult situations, such as a crash or emergency landing. Nitrogen and carbon dioxide are used as neutral gases. Figure 1.5.3 shows the schematic representation of the system with the contents of a natural gas cylinder. The pressure in the tank is 15 ... 20 MPa.

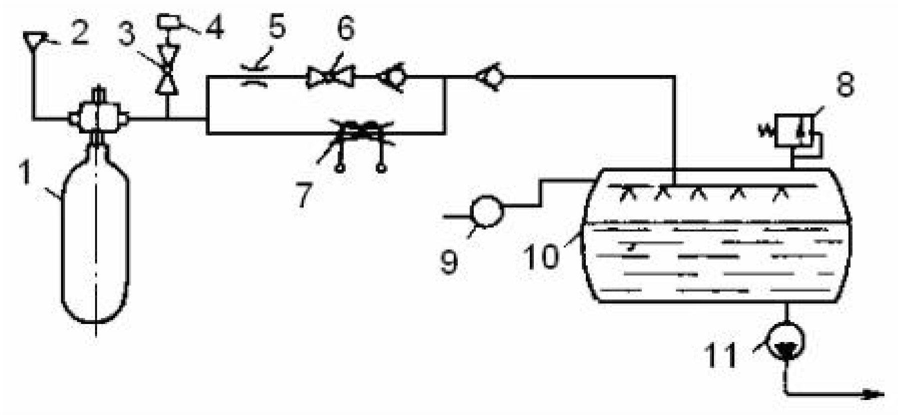

Figure 1.5.3 – Scheme of neutral gas, which is stored in cylinders under high pressure

1– cylinder NG;2– Signal disk discharging balloon;3– bleed valve;4– the union;5–throttle; 6– valve shut; 7– calibrated nozzle with a heater; 8–a safety valve; 9– a pressure sensor; 10– the fuel tank; 11–booster pump

During system operation (valve 6), natural gas from the cylinder is directed into the space above the fuel tank. When an overpressure of 0.015 ... 0.02 MPa is reached in the tank, the pressure switch 9 is activated and gives a signal to open and close the valve 6,3. The NG etching residue from the cylinder is vented to the atmosphere. It is also possible to inject NG into the tanks throughout the flight through the nozzle 7 with a heater. Nozzle 7 provides the necessary pressure, flow rate and time to empty the bottle.

The physical nature of pasteurized fuel is that when organic aluminum acid, magnesium, or soap is added, it becomes a pseudocrystalline structure and is less prone to ignition and explosion when heated because it has a lower evaporation rate per unit area. Emulsified fuel is a discrete liquid containing up to 97% fuel. The evaporation rate of the emulsion is 10 times higher and the flame propagation rate of the emulsion is 100 times lower than that of conventional fuel. However, the use of pasteurized and emulsified fuel requires an overhaul of the fuel systems. The use of foams to completely or partially fill fuel tanks ensures the explosion protection of fuel tanks.

Conclusion to Chapter 1

1. In this section we considered the main aspects affecting the operational reliability of caisson tanks for air transport. The main requirements for a number of structures and systems have been defined, which in one way or another affect the operational safety, the specifics of maintenance and fire safety of aircraft.

2. The main failures that occur in caisson tanks are a violation of hermetics due to the destruction of the structure, the formation of microcracks, the destruction of gaskets and sealants. All of these malfunctions and structural injuries can lead to fires on board the aircraft.

3. Studies on different types and groups of factors that cause fires show that the main cause of fires is system leakage.

4. After considering the constructive solutions used, it can be concluded that no solution can give the maximum result when implemented separately. Only a complex complex of design improvements and advanced fire detection, warning and extinguishing systems can achieve a fairly high, but not maximum level of fire safety.

5. Each type of fire detection and extinguishing system has its advantages and disadvantages, and taking into account each of them, it is necessary to develop a system that covers the disadvantages of other systems with its advantages, only in this way it is possible to raise the level of safety to be kept at an acceptable level.

Chapter 2. MEANS OF IMPROVING THE FUEL SYSTEM WITH THE PURPOSE OF MAINTAINING THE OPERATIONAL RELIABILITY OF INTEGRAL FUEL TANKS OF A CARGO AIRCRAFT

2.1 Basic design information for prototype aircraft fuel systems

Before proceeding with the modernization of the fuel system of the prototype aircraft, it is necessary to take into account the specifics of the design and operation of the corresponding system.

The An-70 four-engine turboprop cargo aircraft is considered a prototype whose fuel system is not equipped with a neutral gas system, so the An-22 four-engine turboprop heavy cargo aircraft is used as an additional source of necessary design information. It should be noted that its fuel system is additionally equipped with a neutral gas system equipped, which increases the operational reliability of this system.

So, let's consider the fuel system and its features of each prototype aircraft.

2.1.1 An-70 aircraft fuel system

The An-70 aircraft is a universal transport aircraft designed by the Antonov Design Bureau in the 90s of the 20th century. The first flight took place on December 16, 1994. It can transport cargo weighing up to 47 tons at various distances from 1,350 km to 11,600 km.

Aircraft payload capacity is related to flight autonomy due to the mass of fuel consumed in flight, calculations of which allow estimating the aircraft's energy efficiency, characterized by fuel consumption per tonne-kilometer. For this aircraft, this indicator is 0.100-0.126 kg/t*km, i.e. H. 2 times less than on the Boeing 767.

The fuel circuit includes:

- integrated fuel tanks;

- -drainage system;
- fuel filling and draining system;
- a combustible sludge evacuation system;
- engine fuel system;
- Management and operational control system.

On the An-70 aircraft, fuel is placed in a two-belt wing box, which is divided into 13 fuel compartments by hermetic ribs.

The An-70 fuel system diagram is shown in Figure 2.1.1.

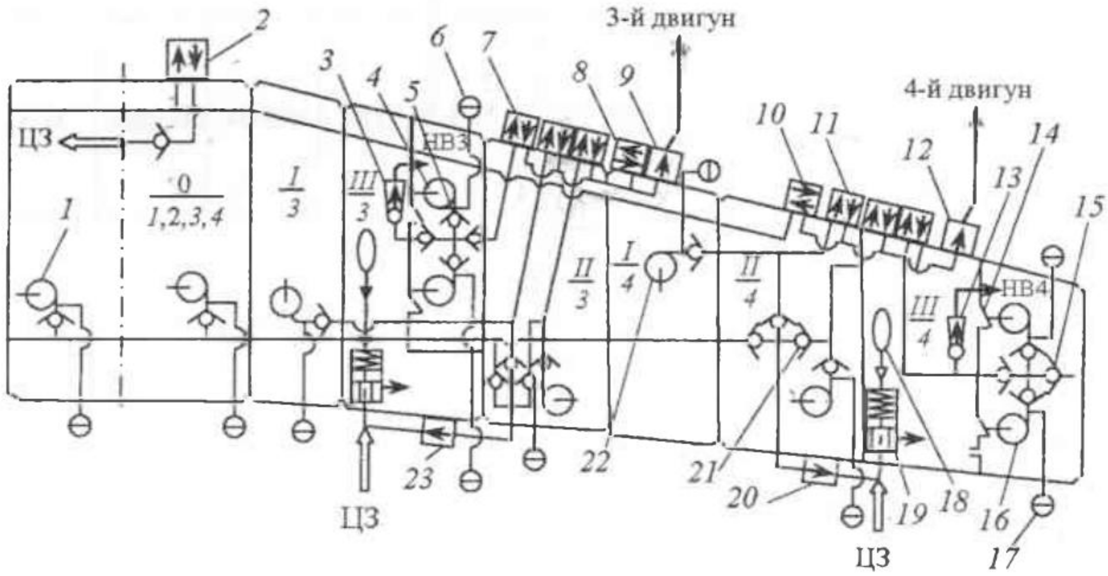

Fig. 2.1.1 An-70 fuel system

The fuel tanks are divided between the engines into four corresponding groups, in turn, in each group, the tanks are divided according to the order of smoke production into I, II, III stages.

In addition, there is a center-plane tank of the zero stage of production from which fuel is produced for all engines at the beginning of the flight. The tank of the central plane is a reserve, it is refueled only in case of the need for an ultra-long flight to a distance of more than 10,000 km.

To ensure symmetrical refueling and fuel production, the volumes of the caisson tanks of the same rows of tanks of the 1st and 4th and 2nd and 3rd engines are the same.

The fuel system of the An-70 aircraft is built according to the autonomous principle, that is, each engine has its own group of tanks and its own supply line. The autonomous supply lines of all 4 engines are connected by a cross-feed line through the ring taps 8,10.

The cross-feeding main is connected to the centralized filling system through tap 2 to ensure the possibility of draining fuel from the aircraft tanks through the on-board fittings of centralized refueling into the fuel injectors.

Each stage III tank in its group is expendable and divided by a partition into a pumping compartment and a pre-expendable compartment. In the pump compartment, there are 2 priming pumps 4,16 of the EVNGR-5 type, connected in parallel through non-return valves 5 to the engine power line. Jet nozzles 3, 13, hydro-controlled valve 19 and float valve 18 for pumping and refueling are installed in the pre-dispensing compartment.

The fuel system of the An-70 aircraft is built taking into account the AP-25 requirements for system fail-safe backup. There are two modes of fuel production from tanks and engine power:

- regular mode;
- reserve mode;

In regular mode, fuel is produced by successively pumping it from the tanks of the 0-I-II lines to the tanks of the III line, which are expendable tanks. Pumping takes place by pumping pumps 1,22 through the pumping main, in which pumping taps 20,23 are installed. At the same time, the fuel enters the pre-expenditure compartments of the tanks of the III stage through the hydro-controlled valve 19, connected to the float valve 18, the joint operation of which ensures the maintenance of the specified level of fuel in the pre-expenditure compartment, that is, it does not allow it to be emptied or overflowed during pumping. From the pre-spend compartment, the fuel flows into the pump compartment through plate check valves 14. The pump compartment of each group of tanks is filled with fuel throughout the flight due to uninterrupted pumping of fuel into the pump compartment from the pre-spend compartment by 3,13 jet pumps of the CH-13 type.

In the event of damage to the fuel tanks, backup power supply of the engines is realized by direct fuel supply from the tanks of the I and II stage by pumps 22, which are installed in these tanks. At the same time, fuel is supplied from tanks I, II of the queue to the engine power supply line through the reserve power taps 11.

In standby mode, the engine power supply line from the pump compartment of the waste tank is blocked by an additional valve 7. Backup power supply from the centerplane tank is not provided. A fire (overhead) valve 12 is installed in the engine power supply line, which opens before starting the engines and closes already after it stops or in case of fire.

A 6,17 type STG-0.25 pressure alarm is installed behind each fuel pump, which provides light signaling of pump operation if the pressure behind the pump exceeds 0.025 MPa.

One ESNGR-5 pump can supply fuel to 4 engines in cruising mode, thus ensuring a high level of system fail-safe.

Powering the auxiliary power unit (APU) is possible using a separate pump tank located on the third stage of the second power unit, and other pumps from any tank. The plane is equipped with central refueling. Filling with two on-board connectors of the international standard.On a typical commercial flight, refueling time is no more than 15 minutes. The time to completely fill the tanks is 20 minutes. The maximum amount of fuel with central refueling is 48.4 m3. Working pressure - 0.45 MPa. The average speed of refueling is 2700 l/min.

The central refueling system is connected to an electric motor that allows the plane to plant pumps that pump fuel from the plane's fuel tanks to a tank on the floor. Fuel sludge is drained if there is free water in the fuel tanks. Active draining from the lower points of fuel tanks through drain taps or central fuel drain.

The drain system of the fuel tanks is open and connected to the atmosphere through two inlets. The design of the drainage system excludes the release and flow of fuel through the drainage onto the ground, into the air, and fuel vapors entering the crew cabin.

The fuel system management system provides:

- continuous measurement of the mass of fuel in each tank with output of the results in processed form through a multi-screen display system of aircraft indicators;
- signaling of buffer fuels;
- working out command signals for refueling the tank;
- generation of fuel pump control signals;
- detecting free water in the sump and sending a remote filling signal;
- provision of a condition monitoring system.

System controls consist of Refueling on the aircraft system display panel and signaling devices on the control panel. Management and control of the refueling of the aircraft was carried out through the refueling console installed in the right fairings of the chassis. The program offers the possibility of automatic or manual remote refueling. Automatic refueling is carried out by a mounting device installed on the suspended mass of refueled fuel, and the system controls the distribution of refueled fuel into tanks.

2.1.2 An-22 aircraft fuel system

Heavy turboprop wide-body aircraft An-22 was created by KB Antonov, made its first flight on February 27, 1965.

A total of 66 aircraft were produced from 1965 to 1976. Since 1980, "Antey" has been used as an air transport for the transportation of oversized units for An-124 "Ruslan" and An-225 "Mriya" aircraft.

The fuel system of the An-22 aircraft provides fuel for four NK-12MA turboprop engines, engine turbostarters, a turbogenerator and a neutral gas generator, in addition, fuel from the fuel system can be supplied to the hydraulic system of the aircraft as a working fluid in case of an emergency.

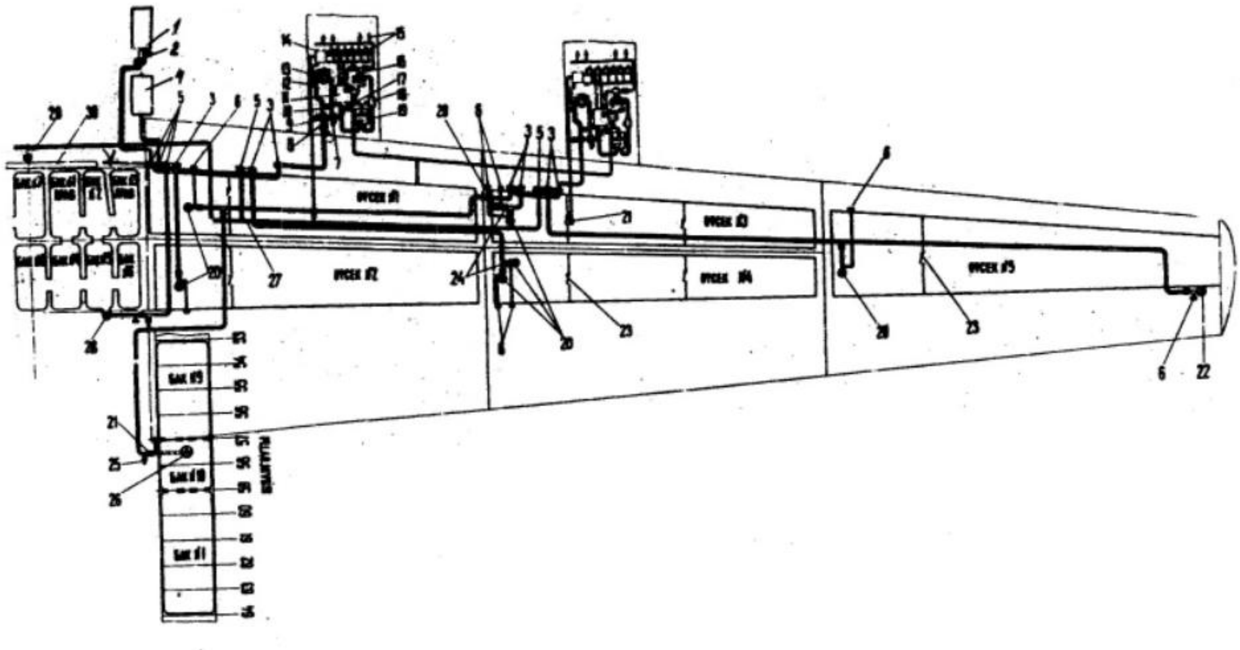

Fig. 2.1.2 Schematic of the An-22 fuel system

1 - Neutral gas generator, 2 - pressure alarm SDU-6A-4, 3- overhead valve, 4- turbogenerator, 5- overhead valves, 6- pressure alarms SDU-3A-0.35, 7- drain valve, 8- fine filter , 9- coarse filter, 10 - pressure signal SDU-5A-1.35, 11-KTA-14MA, 12- engine conservation fitting, 13 - priming pump driven by the engine, 14- turbo starter, 15- fuel injectors, 16- main fuel pump, 17- manometer sensor, 18- flow meter sensor, 19- air separator, 20- fuel pumps ESN-77 with electric drive, 21- non-return valve, 22- fuel pumps 463, 23- fuel overflow valve, 24- spring-loaded return valves, 25- drain valve, 26- pumping pump ECS-11, 27- ring pipeline, 28- pumping pump ECS-T, 29- transfer valve, 30- pipeline of central refueling

The aircraft's fuel capacity is represented by twenty soft tanks and ten fuel tanks-compartments.

The tanks are placed as follows: fourteen soft tanks (1-6 left, 1-6 right, 7 and 8) are located in the center plane, in the compartments between the spars and ribs and six tanks in the fuselage - three in each fairing chassis, in compartments between frames 53-64.

Compartment tanks are located between wing spars: 2 compartment tanks (1-2 and 3-4) are placed in the first and second middle parts of the wing, and one tank compartment (5) in the end part. Each of these tank-compartments is a separate waste capacity.

Left central tanks 1-6 and tank 7 are connected to each other and create a flow capacity, right tanks 1-6 and 8 are also combined and create a flow capacity. In addition, tanks 9-11 in each chassis fairing are also combined into common containers.

Wing fuel tanks are divided into four groups, each of which feeds one engine.

Each group consists of three tanks that create three stages of fuel production. The tanks of each group are connected to the supply line of the corresponding engine through overhead valves 3 installed in the pipelines after the pumping pumps.

The groups of tanks in the fairings of the chassis represent the zero stages of fuel production by the engines and feed the engines of the left (1-2) and right (3-4) half-wings. The zero groups of tanks are connected to the power supply lines of the engines through the overhead taps of the first-line tanks.

Due to the conditions of the strength of the aircraft and compliance with the permissible alignments for flight, a strict queue of fuel production from the tanks is established.

The production of fuel is automated - the control of the priming pumps and shut-off valves is carried out from the signals of the fuel gauge sensors. It is also possible to manually control the pumps and overhead cranes from the control panel of the fuel system.

To increase reliability, the fuel system has a ring line 27, connecting the power supply lines of the engines to each other with the help of ring taps. This allows you to feed the engines from any tank. In addition, the ringing line allows you to pump fuel on the ground within the wing tanks and from the fuselage tanks to the wing tank.

The fuel system of the An-22 aircraft is equipped with:

- a refueling system, which allows you to refuel each fuel tank through the filler neck from above or from below under pressure through a centralized refueling system;
- the fuel sediment drain system, which allows draining the sediment separately from each group through the drain taps, and from the wing tanks - centrally;
- drainage system;
- a neutral gas system that fills the superfuel space of containers;
- a ringing system with a fuel pumping system for supply pipelines;
- air ventilation system.

To measure the amount of fuel and automatically control the fuel system on the plane, a complex software control system for fuel consumption and measurement of the fuel reserve SPUT-2 is installed.

All units and pipelines of the fuel system in the wing and fairings of the landing gear are placed symmetrically relative to the area of symmetry of the aircraft.The fuel system supplies fuel to the neutral gas generator, as well as the TA-4FE turbogenerator. The fuel is supplied through pipelines laid from the block of electromagnetic valves, installed on the front spar on the right near rib 5 and connected to the power supply line of engine No. 3. The pipelines go from the wing, through the fuselage into the chassis fairing, where they are already connected to the neutral gas generator and the turbo unit. A pump is installed in the supply line of the neutral gas generator, which increases the pressure at the entrance to the neutral gas generator to 4 kg/cm2.

2.1.3 Neutral gas system of An-22 aircraft

The neutral gas system is designed for the generation of neutral gas that does not enter into chemical reactions with fuel vapors and does not support the combustion of these vapors. After generation, the gas is cooled, dried and cleaned of mechanical impurities and fed into the fuel tanks in order to create a safe environment in the tank.

The neutral gas system consists of:

- ❖ gas generating station;
- ❖ distribution mains;
- ❖ electrical control and management system equipment;

Neutral gas is a product of fuel combustion in the gas-generating chamber of the gas-generating station. Fuel is supplied from the aircraft's fuel system, and air is supplied from the engine's compressor.

The cooling and cleaning system includes:

- condenser-desiccant;
- moisture separator;
- electric switching valve;
-pneumovalve and jet for discharging excess neutral gas;

The drying system includes:

- dryers;
- electric switching valves;
- pneumatic valves;
- nozzle for discharging excess neutral gas;
- jets in the dehumidifier regeneration line;
- pressure signals SDU-3A-0.57.

2.2 Improvement of the fuel system by installing a neutral gas system

By comparing the fuel systems of the two prototypes of the An-70 and An-22 aircraft, we can conclude that although the An-70 system is more modern, some design decisions of the An-22 make it safer The operational safety and reliability of modern aircraft The transport category is that the neutral gas system is actually part of a single integrated system, the absence of which is a serious disadvantage for the An-70. Therefore, it is necessary to modernize the aircraft and equip it with a neutral gas system and related equipment and solutions. These include the fuel tank drain system, air conditioning, fire suppression system, and power plant air intake subsystem.

Depending on the functional purpose, pipe fittings from common energy and gas sources are used in these systems, depending on one another. A neutral gas system designed to prevent the formation of flammable vapors in the fuel tanks of a fuel system by reducing the oxygen content of the fuel tanks. The oxygen in the space above the fuel tanks is regenerated by supplying neutral, i.e. non-flammable, gas. The following gases were used as neutral gas on board the aircraft:

- air enriched with nitrogen;
- pure nitrogen;
- carbon dioxide;
- air from the combustion of aviation fuel;
- freons from fire extinguishing systems.

When the neutral gas system is placed in the space above the fuel tank and filled with fuel upon exit, the movement of air and fuel vapor creates an explosion-proof environment. Most other sources of natural gas are neutral gas generators. The neutral gas system consists of air. Air is supplied to the air conditioning system, fuel to the fuel system. The main component of the neutral gas is nitrogen from the air (80%). In addition, neutral gas must contain at least 11% carbon dioxide CO2 and oxygen and CO must contain no more than 2% carbon monoxide.

2.2.1 Brief technical characteristics of the neutral gas and its operation

Structurally, the system consists of a nitrogen-enriched air generation system and a distribution system. Air in the neutral gas of the air conditioning system after pre-cooling.

The neutral gas generation system penetrates the wing and fuselage fairings. The elements of the control system are located in the central fuel tank. The external check valve is installed in the wing-fuselage fairing at the inlet of the fuel tank. Internal check valve built into the fuel tank.

The neutral gas system consists of two subsystems that work together to produce hot air in a nitrogen-enriched gas mixture that is drawn in by the engine and delivered by the onboard air conditioning system. At a relatively low temperature, this gas mixture is introduced into the space above the fuel tanks and distributed there.

The air is released, the system enters the neutral gas subsystem through the inlet valve. The inlet valve (Figure 2.3) is electric. This item shuts off the system when the selected air pressure falls below an acceptable level.

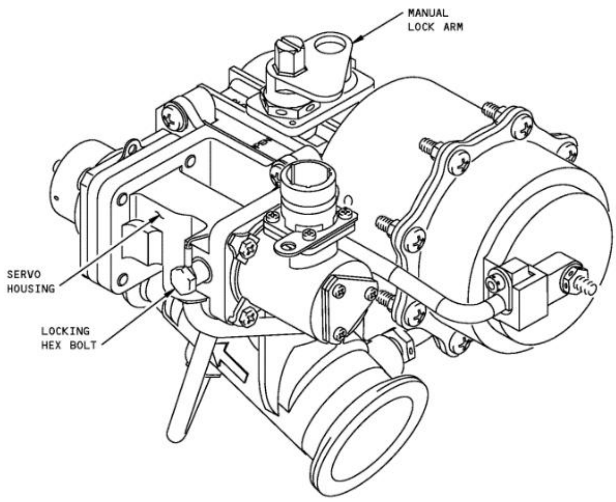

Figure 2.3 - Outlet valve

An ozone filter is installed on the inlet valve. It converts reactive ozone into oxygen, protecting the membrane material from damage and blocking air filtration. The ozone filter reduces the amount of ozone in the supply air and thus serves to protect the separator from ozone damage. The pure ozone filter uses a catalyst. The main reason for the failure of this type of filter is the slow and progressive deactivation of the catalyst due to its fouling. Deactivation occurs when atmospheric pollutants, particularly phosphorus, silicon and/or sulfur, are attracted to the surface of the catalyst. Impurities coat the surface of the catalyst and reduce its effect on the ozone, enabling O3 to O2 conversion reactions. The filter is welded, so on-site maintenance is not possible. The cleaning time of the ozone filter is 6000 hours. Shelf life is not limited as there are no restrictions on storage conditions, temperature and humidity.

A heat exchanger unit with control valve is installed for ozone converters. In the heat exchanger, the air entering the system is cooled by cold air from the air conditioning system. A separate electronic system controller controls the operation of the flow control valve through the heat exchanger to ensure the optimum operating temperature of the separator. The permanent air filter included in the scope of delivery cleans the air of moisture, oil and solid particles.

The air filter is designed to retain solid and liquid contaminants in the airflow from the atmosphere. The design of the filter unit is designed for periodic replacement of its element depending on scheduled maintenance and aircraft operating conditions. On average, filter elements should be changed every 7,000 operating hours. The filter consists of a solid, dirt-absorbing filter element made of corrugated fiberglass paste. Ability to filter 99.997% of particles 0.1 microns and larger. The filter can retain dust particles, aerosols and liquids such as oil and water.

The line's neutral gas supply system is equipped with a temperature sensor, a temperature controller and a thermal shut-off valve. The term is connected to the thermal blocking valve via an electronic control unit. If the displayed air temperature is higher than the allowed temperature, the thermostat will send an electrical signal to close the thermal shut-off valve. It overlaps and thus protects the removable film material from damage. A pressure sensor is also installed in the pipeline, which serves to protect the system from excessive pressure. When the pressure reaches a lower or higher value, the sensor sends a signal to the electronic control unit, which sends a signal to close the thermal shut-off valve.

The main component of the membrane block in the neutral gas system is the oxygen branch. The block consists of a sleeve, which is a cartridge with a special fiber. The air separation module (Figure 2.4) consists of three parallel aluminum tubes, each about 40 cm long and 20 cm in diameter. Tubes filled with fiber modules. The width of the fiber corresponds to the maximum width of a human hair. Modules are fittings for attaching pipes. The air separation module includes an inlet chamber, a high nitrogen content air supply chamber, and a high oxygen content outlet chamber. The compressed air entering the air distribution module is composed of 78% nitrogen, 21% oxygen and 1% inert gases. For the separator, the fibers are selected in such a way that their permeability to oxygen is greater than to nitrogen. So when air flows through the membrane, separation takes place, only oxygen passes through the fiber walls, nitrogen cannot pass through, the general flow of air entering the separator separates high quality air into nitrogen - the product of a pressurized neutral gas system leaving the separator and the current flowing through the walls and fibers is jettisoned. It has a higher oxygen content than normal air.

The maximum oxygen content is around 32% at maximum feed intake. The maximum oxygen content of the air is nitrogen-enriched from 0.6% in low-flow mode at altitude to 9% at maximum flow at sea level. Separator air is nitrogen-enriched air and 90% oxygen. While the maximum airflow through the percentage distribution of the separator is 35% and 65% respectively.

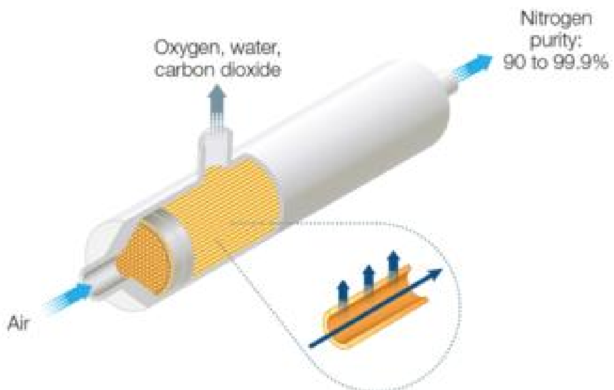

Figure 2.4 - Air separation module

An oxygen sensor and a pressure sensor are installed for the air separation module. An oxygen sensor is used to measure the oxygen concentration in nitrogen-enriched air. The pressure sensor measures the pressure of the nitrogen-enriched air leaving the separator. A pressure sensor and an oxygen sensor are used to check the separator. Air enriched with nitrogen enters the fuel system tanks through a check valve and flame. The check valve is designed to prevent fuel and its vaporization system from entering the neutral gas. Fire extinguishers to prevent the spread of flames in fuel tanks in the event of fire.

2.3 Design improvements to eliminate potential static electricity from fuel system structural elements

2.3.1 General information on static electrification processes

Airplanes are characterized by two types of electrostatic charge:

Charges that are on the metal surface and create a potential difference between the surface and the surrounding air;

the generated charges are isolated and interact on the surfaces (glass cabins, antenna covers, composite cell surfaces).

A large potential difference can occur not only between the surface and the surrounding air, but also between two points on the surface, even very close.

The process of eliminating electrostatic charges on aircraft is well studied. When electrically neutral particles hit the surface of an airplane and bounce off, they fly away charged and the airplane acquires a charge of the opposite sign. The values of the resulting loads are determined by the properties of the surfaces and particle coatings. The greater the difference in the distribution of elementary charge carriers (electrons, ions) in the colliding bodies, the more charges they contain after the particles are separated from the planes. Current load is proportional to airspeed cubed, so it is believed that the main source of page count is airspeed.

The loading on the aircraft is always negative and varies with altitude and airspeed. Another important factor when creating a static plan is the recording of already existing loads (inductive load). Clouds can have a positive or negative charge. An airplane in flight passes through an area of positive charge, an area of negative charge, an area of electrical charge, an area of alternating charge, and an area of mixed charge. These loads are bulky and can almost entirely be transported on the plane. This means that the aircraft can be charged positively or negatively with respect to the surrounding air and can be subjected to high voltage. In addition, there is the influence of external electric fields. In an uncharged conductive atmosphere with no electric field, there is always a potential difference between the body and the atmosphere. The load is important.

In all of the above cases, the capacity of the aircraft increases significantly. increasing the charging current of the electrostatic potential of the aircraft compared to the environment; that is, the same electrical capacitance remains approximately the same during flight. Since the amplitude of this potential cannot increase indefinitely, the phenomenon of electrical breakdown occurs and the associated discharges that cause electromagnetic disturbances (interference). In this case, the disturbance significantly exceeds the load, since it is accompanied by a larger current and even glowing. The courses are divided into two types:

- emissions between the aircraft and the atmosphere;
- the plane between the different elements of the aircraft structure.

Because the design of the aircraft is not an exponential surface, the load on the surface of the body will be distributed unevenly. This discrepancy leads to an appearance category between design elements. On insulating surfaces it looks like streamlines between individual points. Add to this the accumulation of charges on non-conductive surfaces (antenna covers, cockpit windows, structural members made of composite materials) that can quickly dissipate electrostatic charges into the atmosphere, and even small currents of static electricity under these conditions lead to the accumulation of a large charge in the dielectric. As a result, the potential difference between this area and the surrounding metallic body begins to increase until the adjacent layers of air collapse.

Protection against the influence of electrostatic interference emanating from the antenna system:

- ❖ antistatic coating of dielectric surfaces of aircraft (enamel or conductive paint of structural elements in composite materials, metallization on glass);
- ❖ Metallization of aircraft design elements;
- ❖ Passive ESD adaptation switches, carefully designed for maximum antenna pull-in;

Application of antistatic polymer composite materials with steel fibers with a diameter of 2-20μm and a fiber length of 3mm or more. The great effectiveness of antistatic agents is explained by the intensity of the electrostatic field on the surface of the fibers due to their small size, which leads to the formation of a corona even at very low potentials;

Application of radiation absorbing composite materials based on finely dispersed powder of iron carbonyl, magnesium oxide, aluminum, graphite and epoxy resin. Alternating polymer coating layers (up to 20 layers) are used to improve radioabsorption.

Passive switches and special devices are used for stable electrical connection of doors and hatches of the aircraft body. Install shielding and grounding devices designed to drain static electricity from the fuselage of the aircraft only when touching the runway during landing and ground parking. Used passive static dischargers, tires and lightning protection cables. Sharp-edged wing and fuselage elements eliminate electrostatic charges that build up in the atmosphere, but are less effective than modern passive antistatic eliminators. The massive use of composite materials in aircraft structures does not guarantee even distribution of surface loads without the use of specific structural devices and tools (antistatic coating). Technical protective measures to protect against static electricity are therefore necessary in aircraft. First of all, this concerns the fuel system, in particular the integrated fuel tanks.

2.3.2 The process leading to the accumulation of static electricity in the structural elements of the fuel system

Static electricity is generated when fuel comes into contact with other materials. This usually occurs during operations such as piping and mixing, filling, pumping, spraying, filtering or mixing. Under certain conditions, static electricity can build up in the fuel. A static arc can occur when enough static electricity builds up. Ignition can occur if the combustible vapor-air mixture bends. The charging speed depends on the consumption. The higher the fuel consumption in pipelines and other technological equipment, the more it is charged. The degree of fuel electrification depends on the speed of the process in which it participates. In a laminar flow, the speed of movement of the charges is relatively low, especially since it is turbulent.

Fuel electrification depends on its main support. Most pure organic liquids are dielectrics. However, like airplanes and inorganic liquids containing salts and other contaminants, they can dissociate. Aviation Gasoline - Dielectrics have a greater tendency to accumulate static electricity and this tendency depends on specific power consumption. If the installation maintains a volume (Pv) of the order of 10 16 - 10 18 ohm*cm, the fuel (if it contains no impurities) is practically not electrified. As volume resistance decreases, electrification first increases, reaches a maximum at the value of Pv = 5 * 1012 Ω * cm, and then decreases. On the order of Pv = 10 Om * cm there is practically no electrification.

The resistivity of aviation gasoline is between 1011 and 1013 ohms * cm or close to the zone of maximum electrification. It also made them extremely vulnerable to electrification. Sometimes there is a tendency to characterize the electrification of the fuel not by the value of the electrical conductivity, but by the inverse electrical conductivity. The conductivity range in which the electrification phenomenon can be pronounced and create the risk of electrical discharges that can ignite the hydrocarbon vapors is between 0.05 and 30 pSm/m compared to jet fuel. At a conductivity of less than 0.05 pSm/m, there are very few charge carriers in the fuel, but their slow relaxation to a density sufficient for the formation of a static discharge is practically impossible. With a conductivity greater than 30 pSm/m, fuel fillers dissolve quickly and create dangerous electric fields.

The carrier of the electrical charge in the fuel is not the fuel itself (they are dielectrics), but the impurities it contains. Clean fuel with sufficiently low electrical conductivity will not be electrified. Conductivity increases as the amount of various contaminants in aviation fuel increases. Therefore, with a fairly high resistivity (1010 - 1012 ohms * m) and a sufficient number of active impurities, the greatest electrification is observed. With a further increase in impurities, the resistivity of aviation fuel decreases significantly, and despite the increase in the number of active particles, a rapid charge leak occurs.

In addition to the main factors affecting the degree of electrification, the viscosity and temperature of the fuel, the type of impurities and the presence of water are important. However, the electrical conductivity of the fuel and the dynamics of the solid-wall interaction in the electrification process are of crucial importance.

The process of filling the cassette tanks results in heavy electrification of fuel and propulsion system components, including the cassette tanks. Thus, the potential power from the tip of the injector to the bottom (or to the tank) is 1.5 to 14 kW, depending on consumption, if no metallization is assumed .

2.3.3 Device for protecting integrated fuel tanks against static electricity

The device is used to provide a reliable electrical connection between mobile units made of different materials and built-in fuel tanks in order to protect them from static charging. The protection of composite fuel tanks from static electricity is achieved by partially replacing the mechanical connections of the current-carrying elements of the components during their contact and collision, while ensuring a stable electrical connection. The current-carrying element is elastically and structurally in contact with the elements of the fence, for which it has no direct mechanical attachments, at least at two points, for which the contact zone is divided into several parts. The device provides a full guarantee of maintaining the effectiveness of the coating of this design.

This creates a simple, reliable and stable electrical connection between the components of the integrated fuel tank, bringing them to the same electrical potential and avoiding metallization of the assemblies attached to the side of the component. The technical result of this device, which comprises the components of the current-conducting element and its fastening nodes, is that the current-conducting element is constructively elastic. It is in the form of elastic sheets, one end of which is always attached to one of the components of the tank body, and the other is divided into several elastic parts, each of which presses on the components of the conductor with the force of elasticity layer. For example, a plastic sleeve in a cassette tank with different shapes, sizes and relative volumes.The principle of operation of the device is shown in Figure 2.5, which shows the integral connection of the fuel tank with a metal flange. Between the flange and the plastic container, which has a conductive coating on the outside, an electrically conductive element is installed in the form of a spring leaf, one end of which is firmly connected to the flange and the other is divided into several elastic contacts. each of which is attached to the conductive layer. (lid) the tank.

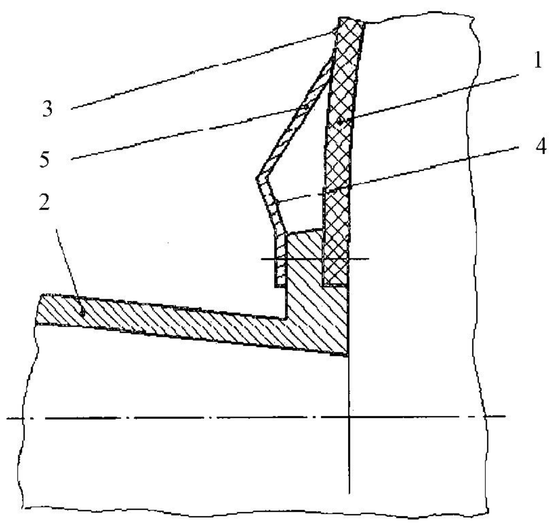

Figure 2.5 - Integrated fuel tank with metal flanged inlet

1 - one-piece fuel tank; 2 - flange; 3 - conductive layer; 4 - plate; 5 - coordinates

Thanks to the integrated fuel tank, a tight, strong and stable electrical connection is created between the metal flange 2 and the plastic container 1, which, with the help of the elastic spring plate 4, changes the shape, size and movement of the existing flange 2, repeatedly moving the contact plate 4, 5 the whole thing the tank housing 1 and establishes a permanent electrical connection with the conductive layer 3 of the tank housing 1 at several points. Such a simple construction of the conductive metallization element with resilient contacts and node attachment eliminates structurally complex and unreliable node attachment to relatively movable and partially variable shape and size components of the tank shell. Metallization is much simpler, it increases the reliability and stability of the electrical connection between components.

Conclusion to Chapter 2

1. In this section, a comparative analysis of the fuel systems of the An-70 and An-22 prototype aircraft was carried out. Their manufacturability and advantages were determined.

2. An analysis of the principles of operation of the neutral gas system, its components and the conditions that must be met for reliable operation of the system

3. Proposal to modernize the fuel system of the An-70 prototype aircraft by installing a neutral gas system

4. Design methods considered to combat the build-up of static voltage with additional protection against the occurrence of static discharges that can lead to the formation of fire.

Chapter 3.FEATURES OF TECHNICAL OPERATION OF THE FUEL SYSTEM AND OPTIMIZATION OF THE NEUTRAL GAS SYSTEM

3.1.1 Features of aircraft fuel system maintenance

When servicing the aircraft's fuel system, it is necessary to pay particular attention to the safety instructions.

Work to replace units, lines and other work related to the possibility of an open flow of fuel to the ground or structure of the aircraft must be carried out when the aircraft power supply is de-energized. It is forbidden to put fuel on the power lines and electrical equipment of the aircraft.

Work in tank boxes must be carried out in combination with a mask or gas mask in the presence of an observer.

Overalls must be cotton fabric with non-sparking fasteners or buttons. The person in charge of observation must be able to see the worker in the tank and receive signals throughout the work to intervene in the event of an emergency signal. When working in the tank, remove all unnecessary tools and personal items from your pockets, do not bring metal objects with open edges into the tank.

To avoid fire when refueling the aircraft, the aircraft, refueling hoses, and fuel tanks must be securely grounded. Install the brake pads under the fuel tank wheel. It should be borne in mind that the source of fire can be discharges of statistical electricity and sparks arising from the impact of metal objects on each other. Therefore, in order to avoid the occurrence of discharges of static electricity, it is forbidden to use woolen or textile materials during the washing process.

The necks of caisson tanks and other containers containing combustible materials must be opened by hand without striking them with metal objects to avoid sparks. It is forbidden to rub or drag metal objects (ladders, boxes, etc.) near or under the aircraft when the fuel tanks are open. Stepping on shoes filled with nails and metal plates in the immediate vicinity of open tanks is prohibited.

The main maintenance work on the fuel system is: checking the condition of the lines and system units; Check the operation of the pump and transfer pumps, the APU fuel pump. Check the tightness of the power supply system of the main engines and overhead cranes. refueling and removal work; Determine the performance of the units of the anti-icing liquid supply system and its filling.

During operation, it is necessary to carefully monitor the tightness and reliability of all pipeline connections. If there are leaks from the fittings, replace the sealing rings on them.

When disassembling the connecting metal couplings of the pipelines, it is necessary to drain the fuel from the pipeline and loosen the coupling nuts with a special key, loosen one nut, and completely unscrew the other.

After that, move the coupling towards the loosened nut. Remove the sealing rings. With the sealing rings removed, the facing coupling should move freely along the ends of the pipes.

When installing the connecting coupling, the nuts must be turned on the coupling without twisting the rubber rings of the seals.

Parts with dents, scratches and burrs on the sealing surfaces are not to be installed on the aircraft.

When connecting pipelines using a coupling, it is necessary to ensure the alignment of the pipelines at the joints. The gap between the ends of the connecting pipelines should be 9+3 mm.

Inspect the mains of the fuel and drainage system. There should be no dents, scratches, or abrasions on the pipelines. Contact between pipelines and elements of the aircraft frame is not allowed.

Make sure that there is no fuel flow in the places of laying the pipelines and attaching them to the units.

Check the integrity of metallization jumpers and their fastening.

To fasten the pipelines inside the caisson tanks, to avoid corrosion, use only clamps with galvanized steel tape.

When inspecting the units of the fuel system, it is necessary to make sure that there are no leaks, leaks, cracks, dents, damage to the paint coating, loosening of the bolts and violations of the counter.

When inspecting the portioner's float device, pay special attention to the condition of the floats and their levers.

During the work, it is necessary to ensure that foreign objects, water, snow, dirt do not get into the caisson tanks, pipelines and units.

To dismantle the pumps, you need to drain the fuel from the tanks. It is forbidden to lift the pumps.

In case of installation of the pump, damage to the protective cover of the electric motor is not allowed.

Before assembling the units, it is necessary to check the integrity of the seals, to ensure that the rubber rings do not have bites, cuts, dents, or deformation of aging meshes. After installing the pumps, check their efficiency by turning them on manually in the cockpit and listening to them.

After repairing and disassembling the fuel system pipelines and units, it is necessary to flush the fuel supply pipelines to the engines before the first start of the engine, by turning on the fuel system.

At any time of the year, it is necessary to monitor the cleanliness of the air intake of the fuel tank drainage system.

The drain pipe of the filler neck should not be clogged, as the condensate in it can freeze, break it, and fuel will flow out of the tank through this break.

Checking the operation of the pumping pumps and the tightness of the power supply system of the main engines is carried out by alternately turning on the pumps of the waste tank.

To check the tightness of the power supply system of the main engines, open the shut-off valve and after 5 minutes (at least) of the pumping pumps, inspect the fuel lines and make sure of their tightness. If there is a leak in the pipeline connections between each other and the units, replace the sealing rubber rings.

The aircraft is refueled in accordance with the flight task using a pressure refueling system. The main fuel for aircraft engines and APUs is T-1, TS-1, RT kerosene and mixtures of these brands.

About 15 minutes later. after refueling, drain the sediment from each caisson-tank by 0.5-1 l into a clean glass container through the fuel drain valves. The sediment is drained using a special hose with a tip, which is connected to the tap of the drain tank.

Refueling from above is carried out through the filler necks of the right and left tanks No. 2 and 3.

In the process of refueling, you can walk on the wing only in special shoes. The hose used for refueling must be free of dirt and sand. Before starting refueling, metallization must be installed between the neck of the tank and the refueling gun. Refueling can be done simultaneously with any number of guns from one or two refuelers. After 15 min. after refueling, drain the sediment by 0.5-1 l through the fuel drain valves.

Fuel drain can be made in three ways:

- Through the drain valves with the help of fuel pumps, both with automatic and manual control of them. In both cases, draining should be done in the order of priority of fuel consumption.
- Drain fuel with special pump through the tank filling system.
- Through the drain valves of the tanks.

3.1.2 Features of operation of the fuel system in the autumn-winter period

When refueling an aircraft, careful control of the fuel and fuel filler is necessary. At negative temperatures, the water in the fuel crystallizes. getting such fuel into the aircraft tanks can lead to clogging of fuel filters, fuel automatics, failure of aircraft engines. therefore, before refueling the aircraft, the senior flight engineer must check at the refueling station:

- the presence and correctness of the execution of the fuel control coupon (the control coupon must contain a record of the fuel content of at least 0.1% by volume of liquid "I", the signature of the fuel and lubricant service laboratory technician;

- the presence of a mark of the representative of the aviation engineering service (IAS) on the admission of the refueler to use; in the absence of this signature, it is necessary to check the fuel for the absence of water (frost) and mechanical impurities. The sample is taken from the tank itself and from the fuel filter. after refueling, it is necessary to take a fuel sample from the aircraft tanks in the amount of 0.5-1.0 liters from each drain point. if mechanical impurities, water, ice crystals are detected in the fuel sediment, a drain should be produced before the contaminated fuel is removed.

Another feature mainly concerns the engineering and technical staff. In winter, it is necessary to pay attention to the cleanliness of the drainage holes of the aircraft. If this is not done, then the water that gets into the cavities of the aircraft accumulates there, freezes, which leads to freezing of fuel pumps, failure of units, rupture of pipelines, cracks in the cladding.

Condensation and freezing of moisture in power plant systems can lead to clogged pipelines and failure of units, which is especially dangerous for fuel systems. To reduce the condensation of moisture and the formation of frost and ice, it is necessary to keep the tanks fully filled with fuel when storing the aircraft. At the same time, when servicing the fuel system at low outside temperatures, careful control of fuel quality and prevention of ice formation in the fuel, especially on fuel filters, which can stop the supply of fuel to the engines, is required.

To prevent the formation of ice crystals, a number of methods are used to remove water from fuel both in ground containers and in aircraft tanks. Fuel freezing, sedimentation in special sedimentation tanks or using centrifuges, fuel dehydration using an electric field together with a centrifugal method, mass exchange when the fuel is in contact with air (nitrogen) at a certain temperature and pressure in the above-fuel space of the tanks (bubbling), filtration with the use of special porous partitions, etc.

To prevent the formation of ice in the fuel systems of aircraft, two methods have become the most common: adding anti-icing additives to the fuel (type "I" or "PGF" liquid) and heating fuel filters or other areas where ice crystals can cause the fuel system to fail. Adding additives to the fuel lowers the freezing point and prevents the formation of ice crystals in the fuel. Usually, the fuel is injected with 0.3% additives every 0.1 hours, which ensures the absence of crystal formation in the operating temperature range.

To ensure the reliable operation of air defense systems at low outside air temperatures, technical staff and aviation equipment (seasonal maintenance) are prepared for winter operation every year in the autumn, by organizing technical training and testing the knowledge of the flight and engineering staff on the features of operation and maintenance of air defense systems in winter . period. Seasonal maintenance of military equipment is usually combined with a periodic form of maintenance, and readiness for winter operation is checked by engineers.

3.1.3 Assessment of the technological time of operations during preparation for the autumn-winter period of operation

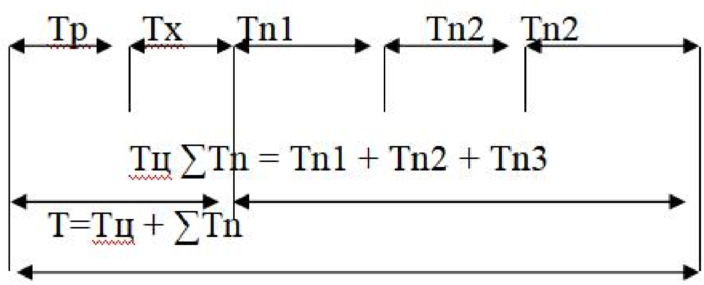

Fig. 3.1.3 Scheme of the production process

Tц - operational time. It is called cycle time and is defined as the amount of time an executor spends on performing operations.

It includes main time and auxiliary time.

The main time is the time spent on work;

Auxiliary time is cyclic losses.

∑Tn – off-cycle losses;

Tn1 - losses on preparation and arrangement of the workplace and material resources;

Tn2 – Rest;

Tn3 - time spent waiting for operations.

When the JSC is transferred to the autumn-winter period of operation, the list of works specified in the post-operational information of the transfer of the JSC is performed:

1. Auto wash;

2. Checking the completeness of refueling the aircraft with special fluids (if necessary, their replacement);

3. Interior cleaning;

4. Replacement of lubricants in movable joints;

5. Aeration of the AT;

6. Checking the performance and serviceability of the aircraft systems;

7. Implementation of JSC soda plant.

14 days (two weeks) are allotted for the transfer of aviation equipment (AT), during which the specified list of works must be completed within the allotted time, two days off are included in the total transfer time. After the translation is completed, the engineering and technical staff of the operating unit carries out the acceptance of the JSC and, based on the results of in-depth inspections, admits it to the further autumn-winter period of operation.

Below is a calculation of the time taken to complete the production process.

$T = Tц + \sum Tn$

where ∑Tn is determined by the formula:

$\sum Tn = Tn1 + Tn2 + Tn3$

The start time of the working day begins at 8:45 a.m. with meetings and distribution of order cards, at 8:55 the technical staff is reduced to workplaces. At 9:30, the engineering and technical team arrives at the aviation equipment and organizes the workplace, prepares the necessary tools, adjusts the ground maintenance equipment to the aircraft, and connects the aircraft to the power supply.

From 10:00 a.m. to 12:00 p.m., the aircraft is washed and the interior is cleaned. From 12:00 to 13:00 airing of the plane. From 1:00 p.m. to 2:00 p.m. (technical break-lunch) From 2:00 p.m. to 2:30 p.m., a technical briefing on the further course of work will be held, from 2:30 p.m. the engineering and technical staff will begin further translation of aviation equipment. From 2:40 p.m. to 4:00 p.m., the engineering and technical warehouse replaces lubricants in movable joints. From 4:10 p.m. to 5:20 p.m., specialists of the engineering and technical staff, by specialty, begin to check the operability of all aircraft systems. At 17:25, the engineer of the group informs the higher authorities about the transfer of this aircraft and its preparation for the gas station. Thus, one day is spent on one plane. After the completion of the work on the transfer of the aircraft carrier, two days are allocated for the gas-up of the aircraft, after which the senior engineers by specialty perform the acceptance of the aircraft in a four-day period and make a decision on the admission of the aircraft carrier for the autumn-winter period of operation

Let's calculate the time of the technological process for one aircraft according to the above schedule of work:

Tr = 330 minutes (5 hours 30 minutes);

It follows that Tc = 330 min + 60 min = 390 (6 hours 30 minutes) - cycle time.

Next, we define out-of-cycle losses for one aircraft:

Tn1 = 30 minutes;

Tn2 = 60 minutes;

Tn3 = 75 minutes.

$\sum Tn$ = 30 min + 60 min +75 min = 165 minutes (2 hours 45 minutes) - time of out-of-cycle losses.

In this way, having found the cyclical and non-cyclical losses, we determine the time of the production process of the engineering and technical team for execution:

$T = Tц + \sum Tn$ (3)

T(1) = 330 min + 165 min = 495 minutes (8 hours 15 minutes). Having determined the time of the production process for one aircraft, we determine it for six:

T(6) = 495 X 6 = 2970 minutes (49 hours 30 minutes)

Based on the calculation of the time of the production process, we determined that 6 days (week) were spent on the translation of JSC.

The second part of the translation consists in the performance of gas stations and acceptance of aircraft by senior engineers of the enterprise.

3.2 Modification of the fuel system by installing an On-board Inert Gas Generation System

To ensure flight safety, as well as increase the operational reliability of fuel reliability, it is proposed to improve the fuel system of the An-70 aircraft by installing a neutral gas system, using the experience of Western partners, namely the On-board Inert Gas Generation System, developed by the Federal Civil Aviation Administration team.

3.2.1 General information

Since 1996, three plane crashes and four flight incidents have occurred due to a short circuit in the central tank and ignition of the fuel-air mixture. As a result, the issue of flight safety is acute (and flight safety is the main task), the solution to this issue can be the modernization of the fuel system by installing a neutral gas system.

In 2005, an on-board neutral gas system was developed. Which was able to meet the requirements of the Federal Civil Aviation Administration. The technology "effectively eliminates the possibility of ignition of the air-fuel mixture in the fuel tank by filling the above-fuel space with a neutral gas such as nitrogen.

The military has used inversion systems for decades to reduce the possibility of fires from bullet impacts. But such systems are expensive, very heavy, take up a lot of space, and require extensive support, making them impractical for most commercial aircraft.

A FAA team led by engineer Ivor Thomas has succeeded in developing a prototype ONBOARD INERT GAS GENERATION SYSTEM that weighs less than 200 pounds. The system uses a small amount of air from the engines. Air passes from the engine through a 1.5-inch pipe to the heat exchanger, which lowers the temperature to 180 degrees Celsius, at which the system most efficiently separates nitrogen and oxygen.

Cooled air passes through a filter that removes all but the smallest particles of dirt and oil, then enters the heart of the system, the Air Separation Module.

The Air Separation Module consists of three parallel aluminum tubes, each about 40 cm long and 20 cm in diameter. The tubes of the module are filled with fiber. The width of one fiber is no wider than a human hair, it looks like a rope.

Compressed air entering the Air Separation Module consists of 78 percent nitrogen, 21 percent oxygen, and one percent trace elements. Air at the entrance to the module enters the empty part of the fibers, only oxygen passes through the walls of the fibers, nitrogen cannot pass, as a result of which the air leaving the far end of the module consists of 99.9 percent nitrogen. Fuel tanks have vents for pressure equalization at different heights, nitrogen is constantly supplied to the tank to displace the fuel-air mixture.

Federal Aviation Administration (FAA) prototype tests have shown that the nitrogen is distributed quickly and fills the entire above-fuel space, so no fans are needed to circulate the gas. The system works in two modes; with low consumption and high. During takeoff, climb and cruise mode, the system operates in low performance mode. During the decrease, the pressure increases and more outside air enters the tank, the oxygen concentration increases. To compensate for this, OBIGGS goes into high-performance mode, drastically reducing the oxygen concentration.

In table 3.2.1 shows the performance of one air separation module during the entire flight.

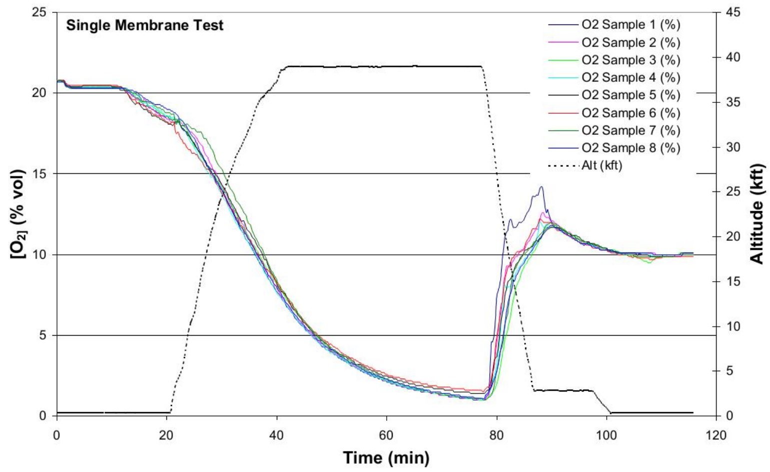

Table 3.2.1 Performance of ASM

In table 3.2.2 the dependence of pressure indicators and oxygen concentration on different operating modes of the OBIGGS system is shown.

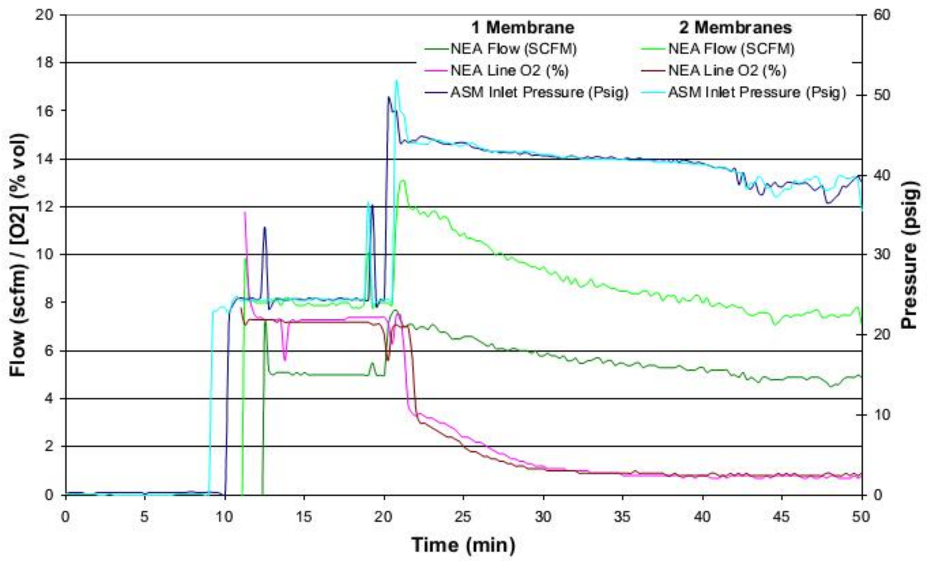

Table 3.2.2 Operation of OBIGGS in different modes of operation

3.2.2 System operation

The system uses air sampling from the engine and APU (right manifold). Air consumption is controlled by a shut-off valve, which is automatically adjusted using the control unit.

The inlet shutoff valve is an electrically operated valve that closes when there is no current in the solenoid coil or when the system pressure drops below 15 psi. This element shuts off the system if the pressure of the extracted air drops below the permissible values.

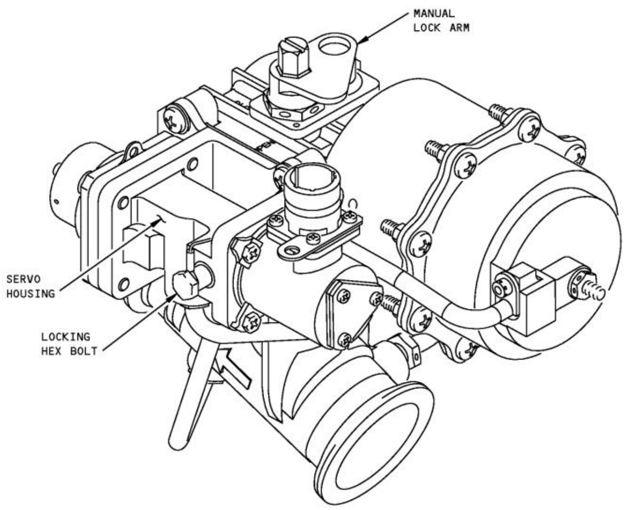

Fig. 3.2.2.1 shut-off valve

At the entrance to the system, a pressure sensor is installed, which transmits information about the bottom temperature to the control unit. Based on this, the control unit controls the pressure using a shut-off valve.

The shutoff valve performs two roles, controlling system pressure and being a system deactivation valve. The diameter of the valve is 51 mm, in the neutral position the valve is closed. The valve also has a manual deactivation control and open and closed limit switches. The shut-off valve maintains a pressure of about 61±6 psig (5bar).

Next, the selected air passes through an ozone converter. It transforms incoming chemically active ozone into oxygen, thereby protecting the membrane material of the air separation unit from damage. The content of ozone in the air reduces the performance of the air separation unit.

A heat exchanger unit with a temperature control valve is installed behind the ozone converter. In the heat exchanger, the air entering the system is cooled with the cold air of the VKV air intake, since hot air can damage the membrane material of the separator unit. Therefore, the electronic control unit of the system controls the operation of the temperature regulator valve, which is designed to regulate the flow of air passing through the heat exchanger so that the air temperature ensures the optimal functioning of the separator.

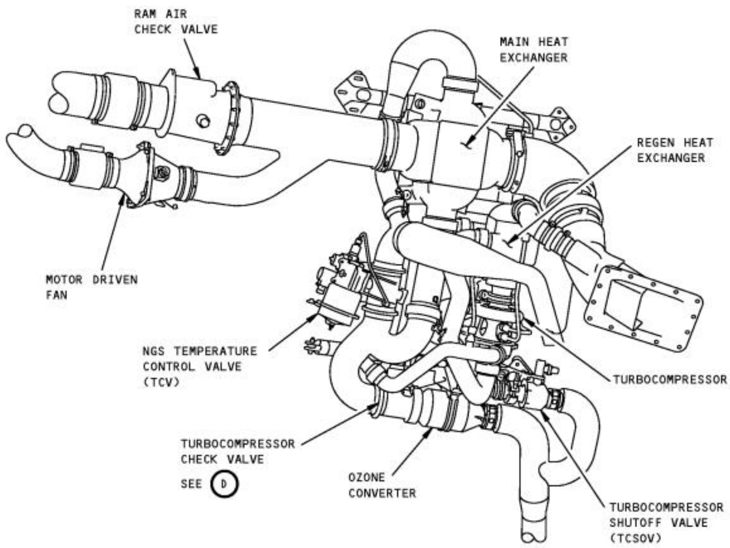

Fig. 3.2.2.2 temperature control unit

To achieve this, the first temperature sensor measures the temperature of the air downstream from the heat exchanger. This temperature sensor transmits to the OBIGGS ECU the deviation from the ASM inlet temperature set point to ensure the optimum air flow temperature. The temperature deviation estimation function is independent of the OBIGGS overheat shutdown function. The heat exchanger reduces the air temperature to 99 degrees Celsius. The turbocharger compresses and is removed before it is fed to the air separation unit. The turbocharger consists of a shaft and two impellers. When the control unit sends a signal to the turbocharger valve, the valve opens and the air drawn off spins the inlet part of the turbine. The extracted air is sucked in through the outlet part of the turbine. The power of the turbine is used to drive the compressor. The air at the exit from the turbine is cooled due to the permission and assistance of the air cooler.

Next, the air passes through a filter that removes various impurities, dust particles, various impurities, before entering the heart of the system, the air separation unit.

A differential pressure switch located at the filter inlet monitors the condition of the filter by measuring the pressure before and after the filter.

Next, a thermal relay and a thermal shut-off valve are installed. The thermorelay is connected through an electronic control unit with a shut-off thermovalve. If the temperature of the sampled air is higher than the permissible temperature, the thermal relay sends an electrical signal to close the shut-off thermovalve. The thermal shut-off valve overlaps, protecting the membrane material of the separator from damage.

A temperature sensor is installed behind the thermal shut-off valve, which additionally protects the system from overheating. It measures the temperature of the air coming after the shut-off thermovalve. When the air temperature is below or above the set value, the sensor sends a signal to the electronic control unit. The electronic control unit closes the thermal shut-off valve and the two-flow valve by cutting off their electrical power.

A pressure sensor is installed behind the temperature sensor, which serves to protect the system from excess pressure. When the pressure in the system is below or above the set values, the sensor sends a signal to the electronic control unit, which sends a signal to close the shut-off thermovalve.

Compressed air entering the Air Separation Module consists of 78 percent nitrogen, 21 percent oxygen, and one percent trace elements. Air at the entrance to the module enters the empty part of the fibers, only oxygen passes through the walls of the fibers, nitrogen cannot pass, as a result of which the air leaving the far end of the module consists of 99.9 percent nitrogen. Air containing oxygen that has not passed through the module is thrown overboard.

An oxygen sensor and a pressure sensor are installed behind the separator. The oxygen sensor is designed to measure the concentration of oxygen in nitrogen-enriched air; the measurement is made at cruise flight when the flow of air passing through the neutral gas system is minimal and the oxygen concentration is maximal. The pressure sensor is designed to measure the pressure of nitrogen-enriched air at the exit from the separator. Both the pressure sensor and the oxygen sensor serve to monitor the operation of the separator (estimation is based on the difference in pressure at the inlet and outlet of the separator and the percentage of oxygen at the outlet of the separator).

The OBIGGS system has two normal operating modes - low flow mode and high flow mode. In low flow mode, the OBIGGS system provides the lowest NEA flow rate and consumes the smallest volume of extracted air. At the same time, it is possible to ensure the highest level of flow purity in the sense that under this mode of operation, the O2 concentration in the NEA will be the lowest. This mode is usually used when during cruise flight it is desirable to create the lowest possible O2 concentration in the above-fuel tank space to start the descent with the highest N2 concentration and the lowest O2 concentration in the above-fuel tank space.

The high-flow valve is designed to select the mode of supply of neutral gas to the fuel tank. The pipeline from the air separation module is divided into two nozzles of different diameters. The high flow valve is mounted on a larger diameter nozzle. During normal operation, neutral gas is supplied to the tank through a nozzle of a smaller diameter. When the supply of air to the fuel tank from the atmosphere increases, the high flow valve opens and the supply of neutral gas to the tank increases.

Nitrogen-enriched air enters the central tank of the fuel system through a non-return valve and a flame fuse. The non-return valve is designed to prevent fuel and its vapor from entering the neutral gas generation system. The flame stopper is designed to prevent the spread of flames into fuel tanks in the event of a fire.

Description of the electronic control unit

The OBIGGS system is managed and monitored using an electronic control unit (ECU). The ECU unit receives data from various sensors of the system, the unit processes them using analog and digital circuits, and with the help of this processed information ensures adequate operation of the system.

General: The ECU is designed to ARINC 600 and is 3MCU in size. It has a size 2 ARINC 600 adapter that handles both receiving and transmitting data. There is a visual feedback device on the front of the unit, which (on the ground) allows you to see that the unit is working normally. The unit has one button that is used to reset the unit in the event of a malfunction and for self-testing.

The control unit collects data from the aircraft systems and controls the components of the neutral gas system.

The control unit provides:

- Temperature control valve control
- Controls the position of the heat exchanger damper
- Shut-off valve control
- Control of the turbocharger valve
- Overheating valve control
- High pressure valve control
- Display readings
- Receiving data from the pressure drop sensor
- System testing
- Control of oxygen in the fuel tank.

3.2.3 Main components of the Neutral Gas System

Ozone converter

The ozone filter mesh utilizes a catalytic converter and design that has been proven on commercial aircraft filters currently in use. The main type of failure of this type of filter is gradual, slow deactivation of the catalyst due to contamination. Quantitatively, this is manifested in the inability of the catalyst to convert O3 into O2. Deactivation occurs when pollutants contained in the extracted air, especially phosphorus, silicon, and/or sulfur, reach the surface of the catalyst. Pollutants cover the surface of the catalyst and reduce its impact on ozone, thereby preventing the reaction of converting O3 into O2. The required levels of contamination at which failure occurs are low, so there are no visible deposits on the catalyst and no noticeable increase in pressure drop. The speed of deactivation of the catalyst is largely regulated by its technological features, therefore this technology has a patent character.

The filter is an all-welded structure and cannot be repaired on site. Physical damage such as dents, cracks, etc., which may cause the filter to fail, can only be assessed on site. Periodicity of ozone filter cleaning is 6000 hours of operation. During cleaning, pollutants are removed from the catalyst, preventing ozone from reaching the active areas of the catalyst. For the reaction to occur, ozone must come into contact with the catalyst. It is not necessary to remove the grid from the filter for cleaning, after cleaning the filter, it is tested for operability as part of the filter. Its shelf life during storage is not limited, as there are no restrictions on storage conditions in terms of temperature and humidity.

Filter

The design of the filter assembly provides for periodic replacement of its element in accordance with the maintenance schedule and operating conditions of the aircraft. The filter element should be replaced approximately every 7000 hours of operation.

The filter assembly consists of a filter element for trapping particles of impurities and made of corrugated glass fiber glued with resin with a filtering capacity of 99.997% for particles of 0.1 μm and larger. The filter is able to trap dust particles, aerosols and liquids such as oil and water.

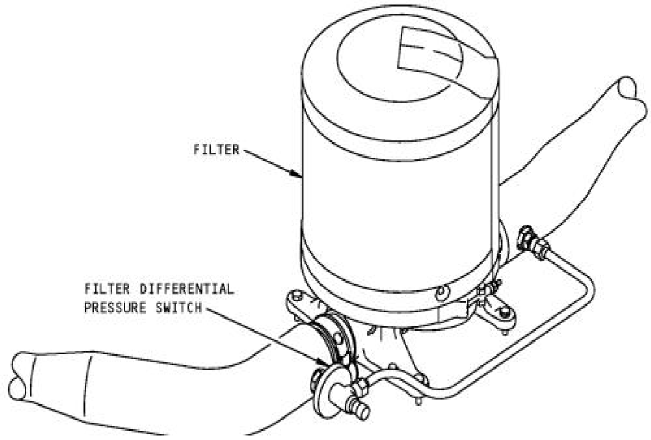

Fig. 3.2.2.3 Filter

The filter element is mounted on stainless steel and aluminum grids and has aluminum caps on the ends. The filter material and grids are installed in the end caps and poured into them with a compound based on epoxy resin. The cartridge assembly, which includes the filter, is housed inside a two-piece aluminum housing held together by a clamp that provides service access. The enclosure also features I/O ports to provide interfaces and a means of mechanical attachment.

Air separation module

The Air Separation Module (ASM) consists of three parallel aluminum tubes, each about 40 cm long and 20 cm in diameter. The tubes of the module are filled with fiber. The width of one fiber is no wider than a human hair. The modules have fittings for attaching pipelines. The ASM has an inlet chamber, a nitrogen enriched air (NEA) chamber, and an oxygen enriched air outlet chamber. Compressed air entering the Air Separation Module consists of 78 percent nitrogen, 21 percent oxygen, and one percent trace elements. Air at the entrance to the module enters the empty part of the fibers, only oxygen passes through the walls of the fibers, nitrogen cannot pass, as a result of which the air leaving the far end of the module consists of 99.9 percent nitrogen. Air containing oxygen that has not passed through the module is thrown overboard.

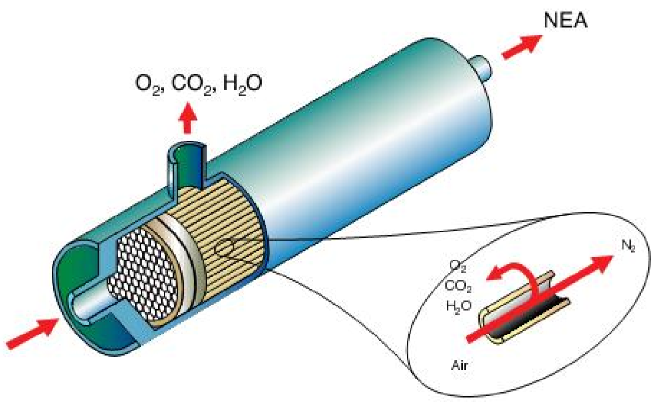

Fig. 3.2.2.4 Air Separation Module

3.2.4 Built-in diagnostic tools of the controller

The controller can monitor the status of OBIGGS components by directly monitoring the amount of electric current or voltage on the component, monitoring the status of position switches or backup sensors, if provided by the component.

The controller provides four types of checks for internal diagnostics:

- Power On Diagnostics (PBIT)
- Continuous monitoring (CBIT)
- Oxygen Control (OBIT)
- Enforcement/Operational Control (IBIT)

The controller performs mains power diagnostics immediately after input power is applied (PBIT). The ECU also continuously monitors system status, analog signals, discrete input signals (CBIT). During cruise flight, the ECU checks system operation by measuring the oxygen content and providing information on the oxygen content of the low-oxygen gas mixture entering the fuel tanks (OBIT).

Maintenance and repair personnel may also conduct PBIT along with other activities to identify system malfunctions. Diagnostic results are transmitted to the ECU by the aircraft via the ARINC 429 interface.

The BITE display is designed to identify existing faults, in-flight faults, ground tests and other functions.

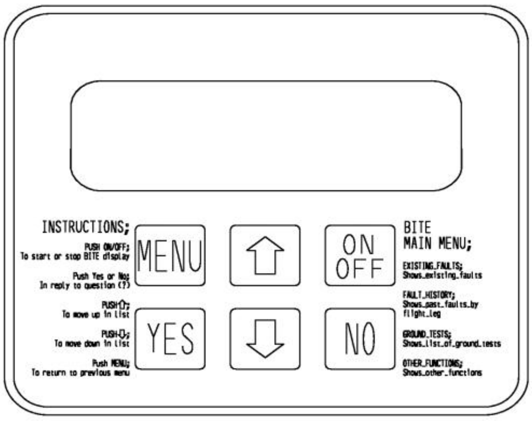

Fig. 3.2.2.5 BITE display

The performance indicator shows the visual state of the neutral gas system. The health indicator has three light indicators that show the status of the system.

- Operational - green
- Deterioration of work - blue
- INOP - amber

The green light shows the working state of the system and does not require maintenance. Blue indicates that the system is healthy, but not working at full capacity. Amber does not indicate that the system is faulty. In this case, it is necessary to manually switch the shut-off valve to the "closed" position.

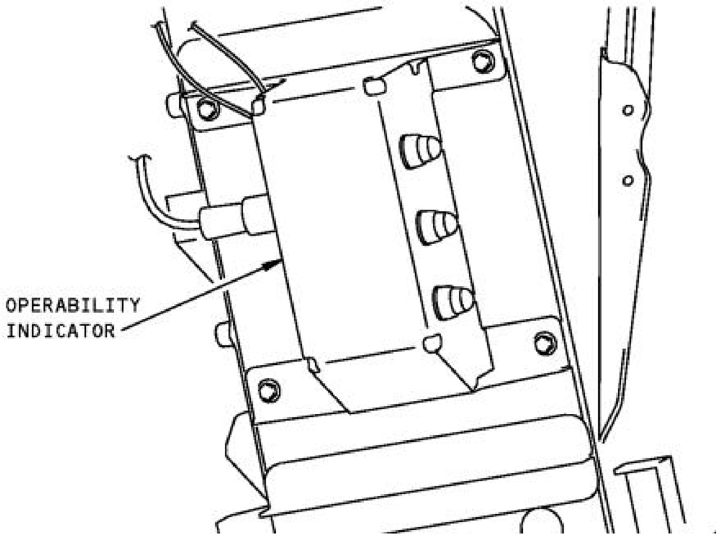

Fig. 3.2.2.6 performance indicator

The overheating valve provides back-up protection of the elements of the air distribution module. A temperature relay is installed at the input of the module. The overheating valve is electrically controlled and pneumatically operated. The valve is closed when the aircraft is powered off.

The distribution system is designed to distribute neutral gas inside the fuel tank. The distribution system includes:

- Drain valve
- Check valves
- Ventilation valve
- Float valve
- Flame extinguisher

The drain valve is located between the air separation system components and the distribution system. Designed for draining liquid from the pipeline. There is a drain hole in the lower part.

The non-return valve prevents fuel from entering the air separation module when the fuel tank is full. One valve is located at the inlet of the central tank, the second valve is located at the outlet of the air separation module.

The flame extinguisher is installed at the end of the ventilation pipe and protects against the ignition of flammable vapors.

3.2.5 Structure of the system

The structure of the OBIGGS system is made taking into account the security requirements of the system. The functional characteristics of the system and the design of the components that enable the system to perform these functions were considered during the System Security Analysis (SSA). As a result of this analysis, it was determined that all risks relevant to the system were properly addressed and brought into compliance with documents CS 25.981 and CS 25.1309.

Three conditions identified as "catastrophic" and one identified as "dangerous" defined the final OBIGGS architecture. Such conditions include:

An explosion inside the OBIGGS system is a catastrophic situation

Self-ignition of fuel/fuel vapors is a catastrophic situation

Excess pressure/restriction of the flow of gas supplied to the fuel tank is a catastrophic situation

An increase in the oxygen content in the free space of the tank compared to what would occur if the neutral gas system were not used is an emergency situation.

3.2.6 Modes of operation

The OBIGGS system has four modes of regular operation:

- OBIGGS system is off (no power)
- If power is not supplied, all valves in the system are closed.
- OBIGGS system is off (power on - ground mode)

In this mode, the system is in a state where power is applied to the controller, but the system is turned off. In this mode, all valves are closed, and the controller is in a state of waiting for the command to turn on the system. must be true for the system to run the following parameters:

- Wheel Crimping (WOW) = FALSE
- Mach > = 0.2
- Air intake pressure = True

The system may be shut down due to an internal failure, and the system is locked. To restart the system, press the TEST/RESET button on the front panel of the Electronic Control Unit. The system can also be disconnected due to an external failure. And here it will be restarted after the elimination of the external failure.

When power is supplied, the controller performs PBIT diagnostics. Power is then applied to the temperature sensors and pressure sensors, and their operation is checked within the specified range of values. The sensor data and valve position are checked for correctness (the correct position of the valve is closed), after which the system is ready for start-up.

OBIGGS system on (low flow mode - climb and cruise)

The first flight mode is a low consumption mode during climb and cruise flight. In this mode, the system produces the least amount of nitrogen-enriched air and withdraws the least amount of air. This is the state of the highest efficiency of the system, while the concentration of O2 in the gas mixture in this mode will be the lowest. This mode is normally used to create the lowest possible O2 concentration in the fuel tank headspace during cruise flight to start the descent with the highest possible N2 concentration and the lowest possible O2 concentration in the fuel tank headspace.

OBIGGS system is enabled (maximum flow mode - decrease)

The second flight mode is the mode of maximum flow during descent. This is the maximum consumption mode during the descent phase of flight. Maximum flow mode is engaged when the rate of descent exceeds 600 ft/min for 3 seconds. When the rate of descent is less than 300 ft/min for 2 seconds, the maximum flow mode is disabled.

During the maximum flow mode, the maximum amount of nitrogen-enriched air mixture is produced, but the purity of the mixture is low. This mode prevents as much as possible the entry of outside air into the aircraft's fuel tanks.

Normal operating mode of the neutral gas system

The OBIGGS system remains on and operates in low power mode during takeoff, climb and cruise. At these stages, the system fills the free volume of the fuel tank with nitrogen, which increases as a result of fuel production, diluting the oxygen released from the fuel and reducing the oxygen concentration as much as possible until the end of the cruise flight.

During the cruise flight, the OBIGGS system undergoes diagnostics of its operational status. The cruise phase is chosen to perform such diagnostics for two reasons:

during a cruise flight, the system operates in a mode of low consumption and the characteristics of its operation have the greatest stability;

OBIGGS operates in a low-flow mode, and at the same time, during the cruise phase, a nitrogen-enriched mixture of the highest purity is produced.

At this stage, it is easier to detect serious malfunctions in operation, since the concentration of oxygen in the nitrogen-enriched gas mixture will be higher than expected. The oxygen sensor is turned on during its warm-up period, which is approximately 5 minutes. After the sensor emits a signal confirming its normal operation, within a few minutes the main operating parameters of the system are checked to ensure the normal operation of the separator and the system as a whole. System performance check is performed during each flight after warming up the system and stabilizing its operating parameters. It takes at least 20 minutes for the separator to warm up during the cruise phase.

After the start of reduction, the system is transferred to the maximum flow mode. In doing so, the ECU checks the vertical speed value transmitted from the aircraft avionics system, and the vertical speed during descent must be 600 ft/min or more within 3 seconds. In the maximum flow mode, the volume of nitrogen-enriched air entering the fuel tank increases as much as possible, which prevents external air from entering internally through the drainage fence. During lowering, the pressure constantly increases, which leads to an increase in the pressure in the drain tanks, as a result of which outside air enters the fuel tank. Increasing the flow of nitrogen-enriched air reduces the amount of air entering the fuel tanks and increases the concentration of oxygen in the nitrogen-enriched gas mixture.

3.2.7 Regular shutdown of the system

The official shutdown of OBIGGS is carried out under the following conditions:

Mach <= 0.2;

Wheel crimping (WOW) == TRUE;

Abnormal shutdown of the system

Abnormal disconnection of the OBIGGS system is carried out in the following cases:

1) Excessive heating (the system is blocked in the disabled state):

- ❖ Blocking of the system in the disconnected state by an analog protection circuit when registering a temperature of 85°C and above.
- ❖ Locking of the system in the disabled state by a digital protection circuit when registering a temperature of 90°C and above.
- ❖ The thermal relay opens at a maximum value of 130°C and closes at a minimum value of 96°C. The thermal shut-off valve is closed using a thermal relay. The system is locked in the off state because a valve misalignment or system failure is detected.

2) Excess pressure (the system is blocked in the disconnected state):

- ❖ Lockout of the system in the disarmed state by a digital protection loop when registering at P1 60 psi for 15 seconds or more.
- ❖ Lockout of the system in the disabled state by the analog protection loop when registering at P1 90 psi.

3) Internal failure, other than failure of the oxygen sensor (the system is blocked in the disabled state), such as:

- ❖ Discrepancy in valve positions or failure of the solenoid.
- ❖ The thermorelay is in the open position.
- ❖ Sensor failure or out of range reading.
- ❖ After locking in the disabled state, you need to restart the system manually to start it.

The OBIGGS system may also shut down, but will not be blocked. This can happen for the following reasons:

- ❖ Low inlet pressure.
- ❖ Communication with the aircraft's avionics has been lost.
- ❖ Power outage.

After reestablishing communication with the avionics or eliminating the interruption in the power supply or normalizing the pressure at the inlet, the OBIGGS system starts automatically.

Interface with other systems

The neutral gas system interfaces with the following aircraft systems and structural elements:

- Air conditioning system
- Operational drive, emergency parametric drive.
- Power supply system
- Fuel system
- Glider design

For correct operation of the neutral gas system, a CROSS VENT VALVE must be installed in the clearance tank.

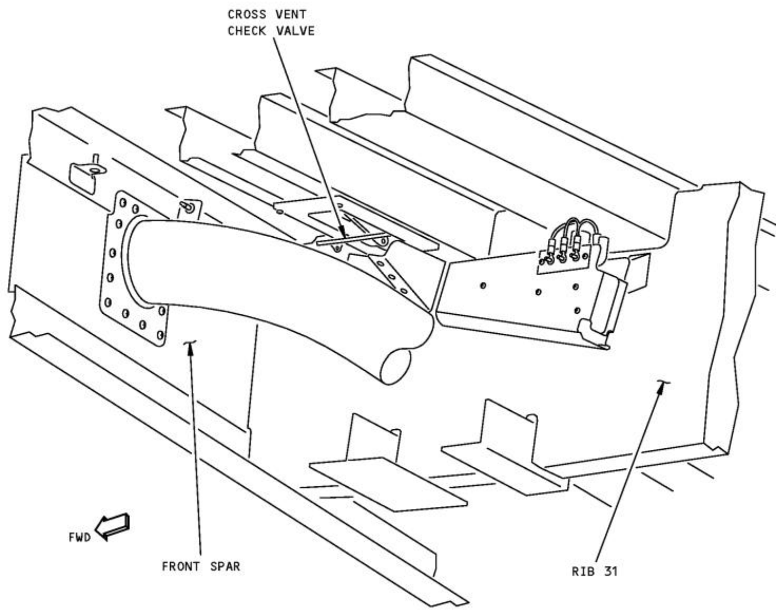

Fig.3.2.2.7 Cross vent valve

Cross vent valve prevents atmospheric air from entering the central tank. The valve opens to drain fuel from the overflow tanks when overflowing.

Conclusion to Chapter 3

1. In this section, the peculiarities of the operation and maintenance of the fuel system of the aircraft, both periodic and seasonal, are considered. The time spent on seasonal transfer for the autumn-winter period of fuel system operation was calculated and estimated.

2. The proposed modernization of the fuel system of the An-70 prototype aircraft by installing an On-board Inert Gas Generation System of foreign production by partner countries

3. Statistics of the system's usefulness are provided, supporting the system's work schedules at various stages of the flight and its impact.

4. Detailed information on the design and principle of operation of the On-board Inert Gas Generation System is given

5. Considered features and system indication system.

6. In general, it can be concluded that the integration of this system will significantly increase the reliability of the fuel system and ensure the safety of operation, making it impossible to extinguish a fire on board the aircraft. The integration of analog and digital elements will allow convenient and quick analysis of system operation both during maintenance and during flight.

Chapter 4. LABOR PROTECTION

4.1 General provisions and legal provisions

Ukraine has laws that determine the rights and obligations of its residents, as well as the organizational structure of government and industry. The Constitution of Ukraine - the main law of the state - declares equal rights and freedoms for all residents of the state: to freely choose work that meets safe and healthy conditions, to rest, to social protection in case of loss of working capacity and in old age, and some others. All laws and normative documents must be coordinated, based on and correspond to the articles of the Constitution.

The legislative base of labor protection of Ukraine includes a number of laws, the main ones of which are the Law of Ukraine "On Labor Protection" and the Labor Code of Ukraine.. The legislative framework also includes the Laws of Ukraine: "On mandatory state social insurance against accidents at work and occupational diseases that caused the loss of working capacity", "On health protection", "On fire safety", "On ensuring sanitary and epidemic well-being of the population", "On the use of nuclear energy and radiation safety", "On road traffic", "On universally obligatory social insurance in connection with temporary loss of working capacity and expenses caused by birth and burial", they are supplemented by state interdisciplinary and sectoral normative acts are standards, instructions, rules, norms, provisions, statutes and other documents, which are given the validity of legal norms, which are mandatory for all institutions and employees of Ukraine.

4.1.1 General definitions

Labor protection is a system of legal, socio-economic, organizational-technical, sanitary-hygienic and medical-prophylactic measures and means aimed at preserving the life, health and working capacity of a person in the process of work.

Industrial sanitation is a system of organizational, hygienic and sanitary-technical measures and means of preventing the impact of harmful industrial factors on workers.

Occupational hygiene is a field of practical and scientific activity that studies the state of health of workers in its dependence on working conditions and, on this basis, justifies measures and means for preserving and strengthening the health of workers, preventing adverse effects of working conditions.

A dangerous factor is an industrial factor, the impact of which on an employee under certain conditions leads to injuries, acute poisoning or other sudden and sharp deterioration of health or death.

A harmful factor is a production factor, the impact of which under certain conditions can lead to illness, reduced work capacity and negative impact on the health of offspring.

Industrial injury is an injury caused by industrial factors.

Industrial injury is a phenomenon characterized by a combination of industrial injuries and accidents at work.

An accident at work is a sudden deterioration in the state of health or death of an employee during the performance of his work duties as a result of short-term exposure to a dangerous or harmful factor, lasting no longer than one work shift.

An occupational disease is a pathological condition of a person caused by excessive stress on the body or the effect of a harmful production factor during work.

Security - The state of being protected from the risk of harm to an individual and society.

Security Level - An assessment of security by reference to accepted risk.

Hygienic standard is a quantitative indicator that characterizes the optimal or permissible level of exposure to environmental and production environment factors.

Working conditions are a set of factors of the production environment and work process that affect the health and working capacity of a person during the performance of his work duties.

Difficulty of work - Characteristic of human labor activity, which determines the degree of muscle fatigue and reflects the physiological costs due to physical exertion.

Workplace - the place of permanent or temporary stay of an employee during the performance of his work duties.

Work zone - a defined space in which the workplaces of permanent or temporary (temporary) stay of employees are located.

Risk is the probability of harm, taking into account its severity.

Unacceptable risk – The probability of damage to an employee's health during the performance of his work duties, which is determined by the degree of harmfulness and danger of working conditions and the scientific and technical state of production.

Production risk is the probability of damage depending on the scientific and technical state of production.

4.2 Analysis of working conditions and factors affecting aviation specialists during the operation, maintenance and repair of aviation equipment

Taking into account the topic of the diploma project "Methodological basis of maintaining the operational reliability of caisson tanks of a four-engine turboprop cargo plane", it is necessary to consider the factors and factors that directly affect aviation specialists during the performance of professional activities on aviation equipment.

The first factor that needs to be noted is the place of performance of maintenance, repair and operation of aviation equipment. Mostly, the work is performed on open air parking lots, less often in hangars and special boxes. Therefore, aviation personnel are directly affected by environmental conditions: workplace lighting, ambient temperature, humidity, and others.

Focusing on the topic of the diploma project and the specifics of the systems under consideration, namely maintenance of the aircraft fuel system, neutral gas systems and digital and analog control systems, the second factor should be noted that aviation specialists, performing aircraft maintenance, come into contact with fuel and lubricants in one way or another , special liquids that have a negative effect on the body due to the content of toxic chemical elements and solutions.

The next important factor that has a serious effect on the body is noise and vibration. This is justified by the fact that aviation specialists perform their duties at facilities with a high level of noise and vibration pollution: airfields, airports, aviation factories. In addition, an important stage of the work is testing, which requires specialists to be in close proximity to aircraft with working aircraft engines, various special equipment used for maintenance, as well as various possessions that are also generators of noise and vibrations of a dangerous level.

Fire safety should also be highlighted as a separate important factor. Aviation transport requires careful compliance with fire safety rules and regulations due to the fact that the maintenance process requires contact with various flammable substances, electrical equipment, complex equipment, open flames and high operating temperatures of elements of aircraft systems and aircraft engines. And careless performance of one's duties can lead to a fire.

Lighting is also an important factor that directly affects the performance of duties by aviation personnel. It affects both the quality of the work and the health of the specialist, and above all, it can both lead to incidents with each of the factors listed above, and prevent them.

4.2.1 Sanitary and hygienic requirements for working conditions

Hygienic standards for the parameters of the microclimate in the work area are given in DSTU 3038-95. The work area is considered to be the space at a height of up to 2 m above the floor or the ground, in which the workplaces are located. Jobs in which she worked more than half of her working time or more than 2 hours continuously are considered permanent. If people work in different places of the work area, then this is all to think about permanent work.

The microclimate in the working area is determined by the combinations of temperature, humidity, air movement speed and the temperature of the surrounding surfaces acting on the human body. Excessive humidity prevents heat transfer from the body by evaporation at high temperature and promotes overheating at low temperature and, conversely, increases heat transfer, contributing to hypothermia. Optimum climatic parameters are such that with long-term and systematic influence on a person, they ensure the preservation of normal function and thermal state of the body without stress reactions of thermoregulation, which creates a feeling of thermal comfort, and is a prerequisite for high performance.

Hygiene standards depend on the degree of physical exertion, as well as on the warm or cold season and excess heat from the entry of equipment, heated materials, heating devices, people and sunlight into the room, i.e. the difference between heat and Heat loss when calculating outdoor air parameters takes into account all measures to reduce heat loss.

The engineering and technical staff of airports often have to service aviation equipment on open platforms under the influence of direct sunlight, when the temperature of the outside air rises to 40-50°C. To prevent overheating, special canopies are arranged to protect workers from direct sunlight. In combination with the use of air conditioners, such canopies often ensure the creation of weather conditions within the permissible values of the parameters, which allows maintaining the optimal thermal state in the workers' bodies.

A large number of professions in civil aviation are associated with work at low temperatures throughout the year, so measures to prevent hypothermia of workers become especially relevant. In the cold periods of the year, it is necessary to protect workplaces in production conditions from cold air streams that enter the shop through open openings for transport (doors, gates) and through windows. For this, they arrange airlocks and air curtains that prevent the access of cold air, automate the processes of opening and closing transport openings and block them with air thermal curtains. During the prolonged stay of workers in conditions of low temperatures in closed rooms and outside them, additional rooms that are heated should be arranged for the periodic stay of workers there.

It is also necessary to use personal protective equipment: gloves, warm shoes, jackets, suits. It is recommended to use clothes that reflect the radiation of human heat in the opposite direction. At the same time, it should be light, not stiff, moisture-absorbing and breathable.

4.2.2 Harmful substances

In aviation, a large number of harmful substances are used, which differ in their composition, aggregate state, method and degree of action on the human body.

A harmful substance is a substance that, when in contact with the human body, in case of violation of safety requirements, can cause industrial injuries, occupational diseases or deviations in the state of health, which are detected by modern methods both in the work process and in the distant terms of the present and future lives generations Toxic (poisonous) substances are called substances that, entering the body even in relatively small quantities, cause disruption of normal vital activity up to poisoning. They can be in the form of gas, vapor, liquid and dust.

In aviation, these include: liquids used as fuel and their additives for aircraft engines; mineral lubricants; liquids used for aircraft hydraulic systems; acids and bases; alcohols, varnishes, paints, some cleaning liquids; steam of some metals; dust, which is formed in the process of mechanical processing of materials, etc.

In production conditions, harmful substances are used either as raw materials (nickel sulfate salts, chromic anhydride, etc.), or as an auxiliary material (acetone, some paint thinners, glass fiber, etc.). Harmful substances are also formed as by-products in the process of work itself. Zinc and acids used in galvanizing have a slight toxic effect, but as a result of their interaction with arsenic, in case of contamination, arsenic-containing hydrogen can be formed - a substance of high toxicity.

Chemically dangerous and harmful production factors are classified according to the nature of their effect on the human body:

- toxic (lead, mercury, etc.);
- irritants (chlorine, gasoline, kerosene, acids, alkalis, etc.);
- sensitizing agents (gasoline, kerosene, etc.);
- carcinogenic (products of incomplete combustion of aviation fuels, etc.);
- mutagenic (lead, mercury, etc.);
- those that affect the reproductive function (alcohols, creolin, etc.);
- by the way of penetration into the human body:
- through respiratory organs (chlorine, ether, nitrogen, helium, carbon monoxide, etc.);
- through the gastrointestinal tract (lead, chromic anhydride, cyanide compounds, etc.);
- through the skin and mucous membranes (kerosene, gasoline, etc.).

According to the degree of action on the human body, harmful substances are divided into the following classes of danger: the first - extremely dangerous; the second - highly dangerous; the third - moderately dangerous; the fourth - low risk.

During aircraft maintenance, a large amount of aviation fuel and lubricants are used. These fuels and lubricants, when evaporated, contaminate the atmospheric air of the working area on the territory of airports with carbohydrates.

The danger of atmospheric air pollution with carbohydrates is increased by the possibility of formation of such highly toxic products as ozone, aldehydes, ketones, organic peroxides. These products are formed in the air in a mixture with nitrogen oxides under the influence of ultraviolet radiation from the Sun as a result of photochemical reactions. The accumulation of these products leads to the formation of photochemical fog - smog, which is characterized by a sharply increased oxidizing effect.

The sources of air pollution at the airport parking lot are, in particular, exhaust gases from aircraft engines and special vehicles. Since they contain a large amount of nitrogen oxides, the conditions for the formation of highly toxic products are created in the aircraft maintenance area during operational maintenance.

Atmospheric air in the parking lot is also polluted by fuel vapor of high concentration, which is formed during refueling of fuel tanks. A significant source of airport pollution is also boiler plants that run on liquid fuel oil and solid fuel, etc.

The main routes of penetration of toxic substances into the human body are the respiratory tract, skin, and digestive organs. The respiratory tract is considered the most important of them. Being absorbed by the mucous membrane of the respiratory tract, toxic substances enter the bloodstream, bypassing the liver, which acts as a mechanical and biochemical barrier in the body. Toxic substances that are soluble in fats and lipids easily penetrate the body through intact skin. When absorbed through the skin, sometimes in large quantities, such substances can cause more dangerous poisoning than when inhaling poisonous vapors or dust. Such toxic substances include gasoline, benzene, tetraethyl lead, kerosene, etc.

Toxic substances enter the digestive organs through dirty hands when smoking and eating. They are absorbed by the mucous membrane of the gastrointestinal tract, penetrate into the liver, where these substances are retained and returned with bile to the digestive tract, as well as partial neutralization. The effect of toxic substances depends on their physical state. So, for example, trivalent arsenic compounds are more poisonous than pentavalent ones. The most dangerous poisons are those in a highly dispersed state. Zinc in its solid state is harmless, but in vapor form and highly dispersed it can cause the so-called foundry fever. The combined action of toxic substances can lead to an increase in the toxicity of each of them (for example, with the simultaneous action of CO and H2S).

The degree of poisoning depends on the working conditions. The high temperature of the room increases the evaporation of poisons (mercury, gasoline, tetraethyl lead), strengthens their toxic effect. Significant muscle tension leads to an increase in the volume of breathing, contributes to greater penetration of the poison into the respiratory tract. Therefore, a person who is at rest gets poisoned more slowly than a person who performs heavy physical work.

The action of toxic substances depends on the individual characteristics of the body. Elderly people, teenagers, persons whose body is weakened by any disease (influenza, bronchitis, tuberculosis, etc.) are more prone to poisoning. The phenomenon of sensitization – increased sensitivity of individuals to some poisons – is often encountered. In such cases, their stay at this production becomes impossible.

According to the nature of the occurrence and duration of the course, acute and chronic poisoning are distinguished. Acute poisoning occurs when the body is exposed to a large concentration of toxic substances for a short period of time; chronic - characterized by more or less persistent diseases that occur after long-term exposure to small doses of poison, which gradually accumulates in the body, or the changes caused by the poison are summed up. The victims are given first aid and inpatient treatment.

In case of acute occupational diseases, the patient is immediately isolated from the harmful effects of toxic substances, the contaminated clothes are removed, the toxic substance that has entered the body is removed with the help of artificially induced vomiting, and an antidote is given.

The higher the concentration of toxic substances in the air of the workplace, the stronger their effect on the human body. The maximum permissible concentrations of harmful substances in the air of the working area are such concentrations that during daily work during the shift and during the entire working experience do not cause diseases or deviations in the state of health of employees both during the period of work and in the further life of the present and future generations.

Substance	MPC	Value, mg/m³, *mkg/m³
Natural gas	In working zone for alkanes (methane-dekane) in terms of carbon	300
	Maximum single, the same	100
	Average daily (on pentane), the same	25
	Maximum single (for butane)	200
Hydrogen sulphide	In working zone	10
	In the same place, in mix with hydrocarbons (methane-pentane)	3
	The maximum single	0.008
Carbon oxide	In working zone, during the working day	20
	In the same place, within 60 min	50
	In the same place, within 30 min	100
	In the same place, within 15 min	200
	The maximum single	5
	The average daily	3
Nitrogen oxides	In working zone, for mixes of nitrogen oxides	5
	Maximum single, for nitrogen oxide	0.4
	Average daily, for nitrogen oxide	0.06
	In working zone, for nitrogen dioxide	2
	Maximum single, for nitrogen dioxide	0.085
	Average daily, for nitrogen dioxide	0.04
Sulfur dioxide	In working zone	10
	The maximum single	0.5
	The average daily	0.05
Benz(a)pyrene	In working zone	0.15*
	The average daily	0.001*

Table 4.2.2

Maximum permissible concentrations in the air of the working area of some harmful substances

4.2.3 Noise

Noise that exceeds sanitary standards has a negative effect on the human body. The main sources of production noise can be conditionally classified by groups. Noises occur during operation:

- aircraft taking off or landing;
- aircraft engines when moving the aircraft on the airfield;
- aircraft engines during their testing;
- aircraft engine testing stations;
- technological equipment of civil aviation repair and maintenance enterprises.

They counteract noises of the second and fourth groups of this classification now quite effectively. A problematic issue that requires study is the countermeasure against the noises of the first, third and fifth groups.

The impact on the human body of the noises that arise during the operation of the air conditioner depends to a large extent on their intensity and character. Under the influence of noise, the decrease in labor productivity can reach 20%, depending on the intensity of the noise, its nature and the type of work performed. Steady constant noise affects the human body less than noise that occurs irregularly, and noise of lower frequency - less than high-frequency noise. The latter also contributes to the rapid onset of a feeling of fatigue in a person, since low-frequency intense noises have a less pronounced unpleasant effect than high-frequency ones of lower intensity. Irregular noises, for example, during the non-synchronous operation of propellers on airplanes with several engines, further increase a person's feelings of irritation and fatigue. In this regard, aircraft are subject to strict requirements regarding the synchronization of their engines.

Observations have shown that noise whose intensity level exceeds 60 dB can inhibit normal digestion of the stomach, and with noise of 80-90 dB, the number of stomach contractions per minute decreases by 37%. It was also established that at a noise intensity of more than 60 dB, the secretion of saliva and gastric juice decreases by 44%. A temporary and sometimes permanent increase in blood pressure, increased irritability, reduced work capacity, mental depression are the consequences of noise. Indefinite noises that do not reach consciousness also cause exhaustion of the central nervous system, as a result of which they can cause disturbances in the body that are imperceptible until a certain time.

People who perform repair work while the aircraft engines are running often complain of headaches and loss of balance. In most of the spectrum of audible frequencies, the noise level of aircraft with gas turbine engines is higher than with piston engines. The high level of noise from aircraft with gas turbine engines refers to those noises that especially affect the intelligibility of speech, that is, noises with frequencies of 300-3000 Hz.

People who are near a working power jet or turboprop plant are exposed to noise that exceeds the permissible level by many times.

When the level of noise intensity reaches 160 dB, a rupture of the tympanic membrane may occur (at a noise level of about 180 dB, the riveted and welded joints of the PS begin to collapse).

As the worker moves away from the jet nozzle, the noise decreases, but even at a distance of 30 m, the level of noise intensity of a modern passenger plane with jet engines reaches approximately 125-135 dB, and at a distance of 100 m -115-124 dB.

The results of noise measurements of aircraft with jet engines also confirmed the presence of ultrasound and infrasound. The study of the effect of noise, ultrasound and infrasound on the human body is also necessary for flight safety. For example, industrial noise can affect the central nervous system, as a result of which attention can be reduced and reactions slow down. In the process of work, noise and vibration also have a negative impact on such human functions as memory, thinking, and others. Some researchers note that noise distracts a person's attention from performing accurate work.

Technical regulation of noise involves limiting the level of noise created by a specified unit or mechanism. It reflects technical capabilities that may change with the development of science and technology.

Noise spectra are divided into broad-band with a continuous spectrum more than one octave wide and narrow-band or tonal in the spectrum of which there are pronounced discrete tones.

The tonal nature of the noise is established by measuring the radiation in three-octave frequency bands by exceeding the noise level in one band over the adjacent ones by at least 10 dB.

Intermittent noises are divided into: variable, the level of which changes continuously over time; intermittent, the noise level of which changes gradually by 5 dBA or more during the measurement on the time characteristic of the noise meter "slowly" on the A scale, while the length of the intervals during which the level remains constant is 1 s or more; pulses, which consist of one or more sound signals, each of which is less than 1 s in length, while the noise levels in decibels and dB, measured on the time characteristics of the "pulse" and "slow noise meter", differ by at least 7 dB.

When developing departmental normative documents, acceptable noise are established for certain types of labor activity, taking into account the difficulty and intensity of work according to the table.4.2.3.1

Regularization of constant noise is carried out by the method of normalization according to the limit spectrum. In this case, the sound pressure levels in octave bands with geometric mean frequencies are normalized, and the set of normative sound pressure levels for nine octave bands is called the limit spectrum

Technical regulation of noise is carried out in accordance with the requirements of the system of labor safety standards and standards for specific types of production equipment. The same type of regulation also includes regulatory requirements for the noise generated by the aircraft in the area. In this case, normalized noise levels

are considered as one of the technical and operational characteristics of a specific are considered as one of the technical and operational characteristics of a specific class and type of aircraft.

Permissible sound pressure levels in octave frequency bands, equivalent sound levels at workplaces are given in the table 4.2.3.1[18]

	Type of work, workplace	Sound pressure levels in dB in octave bands from the average geometric frequencies, Hz									Noise levels and equivalent noise levels, dBA, dBAeq.
		31,5	63	125	250	500	1000	2000	4000	8000	
1	2	3	4	5	6	7	8	9	10	11	12
Passenger and transport planes and helicopters											
19	Workplace of Crew and flight attendant	107	95	87	82	78	75	73	71	69	80

Table 4.2.3.1

Класи, умови та характер праці	Допустима важкість	Шкідлива та небезпечна важкість праці		
		1 ступінь	2 ступінь	3 ступінь
	Рівень шуму, дБА			
Допустима напруженість	80	до 80	75	до 75
Швидкість та небезпечність напруженості				
1 ступінь	70	до 70	65	до 65
2 ступінь	60	до 60	-	-
3 ступінь	50	до 50	-	-

Table 4.2.3.2

4.2.4 Vibrations

Vibration refers to the reciprocating motion of a solid body. This phenomenon is widespread in the operation of various mechanisms and machines. Vibration sources: bulk material conveyors, drills, gears, tires, internal combustion engines, electric motors, etc. D.

The most important vibration parameters: frequency (Hz), vibration amplitude (m), vibration duration (s), speed (m/s), vibration acceleration (m/s2).

Depending on the nature of the worker's contact with the vibrating device, local and general vibrations are distinguished. Local vibrations are mainly transmitted through the limbs and toes. General - in the musculoskeletal system. There is also a mixed vibration that affects both the limbs and the entire human body. Local vibrations occur mainly when working with hand tools or devices with a vibrating table. General vibration is widely used in transportation machinery in heavy machinery factories, elevators, etc. E. Where floors, walls or appliance bases vibrate.

Effects of vibration on the human body. The human body is considered as a set of masses with elastic elements that have their own frequency, which is 4 ~ 6 Hz for the shoulder girdle, hips and head relative to the support surface ("standing"), head over the shoulders (" sitting") - 25-30 Hz . For most internal organs, their own frequencies are between 6 and 9 Hz. General vibrations with a frequency less than 0.7 Hz, which is defined as pitch, are uncomfortable but do not lead to vibration sickness. The consequence of this vibration is motion sickness, which is caused by a violation of the normal functioning of the vestibular apparatus due to resonance phenomena.

At the frequency of workplace vibrations close to one's own frequency, internal organs can be damaged or even broken. Regular exposure to general vibrations, characterized by high vibration speeds, leads to a disease characterized by a violation of physiological functions related to the central nervous system. These disorders cause headaches, dizziness, trouble sleeping, reduced ability to work, deterioration in well-being and heart failure.

With increasing intensity of vibrations and the duration of their exposure, changes appear, which in some cases lead to the development of an occupational pathology - vibration disease.

A manual machine that has the maximum vibration energy at low-frequency vibrations (35 Hz) causes pathologies that mainly affect the neuromuscular and musculoskeletal systems. When working with manual machines, the vibration of which has a maximum level of energy in the high-frequency range (above 125 Hz), vascular diseases appear with a tendency to spasm of peripheral vessels. With low-frequency vibration, the disease appears at 8-10 years (trainers, drills), with high-frequency vibration at 5 years or younger (mills, mixers).

Permissible Vibration Levels. A distinction is made between hygiene regulations and vibration-related regulations. Hygiene - limiting the vibration parameters of workplaces and surfaces in contact with workers' hands according to physiological requirements, eliminating the possibility of vibration sickness.

Technically – the vibration limit parameters take into account not only these requirements, but also the level of vibration achievable for this type of equipment today. Normative documents establishing permissible values and methods of evaluating vibration characteristics, which include a special system of labor safety (safety) standards.

Machines with manual drive. Permissible vibration levels (Table 4.2.4.1). Assessment of the degree of harmfulness of vibrations generated by the vibration velocity spectrum of manual machines in the frequency range 11-2800 Hz. For each frequency of the octave range, within the specified limits, the rms value of the vibration velocity and its levels related to the threshold of 5·10-8 m/s are defined.

The mass of the vibrating device or its hand parts does not exceed 10 kg, and the compressive force - 20 kg.

The total vibration is normalized according to the type of source of its occurrence and divided into vibrations:

- transport created by the movement of cars on roads and rural areas;
- transportation technological process that occurs when the working process is performed by the machine in a stationary position or when it moves along a specially prepared part of the production site, industrial site or distribution centers;
- the process that occurs during the operation of stationary or relocated machines at workplaces without sources of vibration (e.g. cooling, filling and packaging machines).

Table 4.2.4.1

Effect of vibration on the human body

The oscillation amplitude of vibration, mm	Vibration frequency, Hz	Feedback
To 0.015	Different	No effect on the body
0,016-0,050	40-50	Jitters with depression
0,051-0,100	40-50	Changes in the central nervous system, heart and ear
0,101-0,300	50-150	Possible disease
0,101-0,300	150-250	Causes vibro disease

Table 4.2.4.2

Permissible values of vibration in industrial premises of undertakings

The oscillation amplitude of vibration, mm	Vibration frequency, Hz	Speed oscillating movements, cm / s	Acceleration of vibrational motions, cm /s2
0.6-0.4	To 3	1.12-0.76	22-14
0.4-0.15	3-5	0.76-0.46	14-15
0.15-0.05	5-8	0.46-0.25	15-13
0.05-0.03	8-15	0.25-0.28	13-27
0.03-0.009	15-30	0.28-0.17	27-32
0.009-0.007	30-50	0.17-0.22	32-70
0.007-0.005	50-75	0.22-0.23	70-112
0.005-0.003	75-100	0.23-0.19	112-120
1.5-2	45-55	1.5-2.5	25-40

To reduce the effects of vibration mechanisms and devices on the human body, the following measures and means are used:

- ❖ Replacing tools or equipment with vibrating working bodies with non-vibrating bodies in processes where possible (e.g. replacing electromechanical cash registers with electronic cash registers);
- ❖ Use vibration isolation vibration machines in relation to the base (such as the use of springs, rubber gaskets, springs, shock absorbers);
- ❖ Using remote control in production processes (e.g. using telecommunications to control vibration of neighboring areas);
- ❖ Use of automation tools in production processes using vibration machines (e.g. control of a specific program);
- ❖ Use hand tools with vibration-proof handles, shoes and gloves.

In addition to technical means and methods of reducing the effects of vibration on a person, it is necessary to take medical, sanitary and preventive measures. According to the provisions of the regime of workers in vibration professions, the total duration of contact with vibrating machines, the vibration of which meets sanitary standards, should not exceed 2/3 of the working day. Production operations should be distributed among workers in such a way that the duration of continuous exposure to vibration, including a micro-pause, does not exceed 15-20 minutes. It is recommended with two regular breaks (for active rest, special gymnastics complex Hydro-procedure): 20 minutes - 1-2 hours after the start of the shift and 30 minutes - 2 hours after the lunch break.

4.2.5 Fire Protection

The dangerous factors that arise during a fire and affect people and Material values are:

- ❖ flames and sparks;
- ❖ increase in ambient temperature;
- ❖ toxic combustion and thermal decomposition products;
- ❖ Smoke;

- low oxygen concentration.

At secondary manifestations of dangerous fire factors affecting people and property, including fragments, parts of destroyed devices, aggregates, installations, structures, radioactive and toxic substances and materials released from damaged devices and installations originating from electric current as a result of the removal of high voltage from live parts of structures, devices, assemblies, fire extinguishing means.

The classification of objects by fire and explosion properties should be carried out taking into account the permissible fire hazard, as well as the probability of fire (explosion), taking into account the mass of fuel and combustible substances and materials. In emergency situations, there are explosion and fire hazard zones as well as possible damage to people and property.

It must be ensured that the formation of a combustible environment is prevented by one of the methods or their combination:

- Technically and structurally to the maximum, which limits the mass
- and/or the volume of combustible substances, materials and the safest way to place them;
- the greatest possible use of non-combustible and non-combustible substances and materials;
- Isolation from the combustible environment;
- maintaining a safe concentration of the environment in accordance with norms and regulations and other regulatory, technical, regulatory documents and safety regulations;
- maintaining the temperature and pressure of the environment to which the flame spreads is excluded;
- Maximum mechanization and automation of related technological processes with the circulation of combustible substances;
- Installation of fire-hazardous equipment, if possible, in isolated rooms or on open ground.

The requirements for decisions on the construction and planning of industrial facilities and other questions of their fire and explosion hazard are largely determined by the categories of land and buildings according to fire and explosion hazard. The category of premises is determined taking into account the fire hazard indicators of available (used) explosive substances and materials and their quantity. According to the explosive power of the premises, 24-86 ONTP are divided into five categories (A, B, D, C, E).

Category A. Combustible gases, combustible liquids with a flash point not exceeding 28 °C in quantities capable of forming explosive air-gas-vapour mixtures which flash at a nominal excess room pressure of more than 5 kPa. Materials and substances which, on contact with water, oxygen or with each other, can explode and burn to such an extent that the nominal explosion pressure in space exceeds 5 kPa.

Category B. Combustible dust or fibers, flammable liquids with a flash point above 28°C, and flammable liquids in quantities capable of forming explosive mixtures. The air vapor is dusty or when the flash produces a nominal explosion pressure in space greater than 5 kPa.

Category C. Flammable liquids and heavy fuels, solids and heavy fuels, and materials and substances that may come into contact with water, oxygen, or with each other, will not ignite unless the premises in which they are located or used do not include the categories A and B.

Category D. Non-combustible substances and materials in the hot, hot or molten state, the processing of which gives off radiant heat, sparks, flames; combustible gases, liquids and solids are burned or converted into fuel.

Category E. Non-combustible substances and materials in the cold.

Select the type and determination of the required number of fire extinguishers according to Table 4.2.5 according to their fire extinguishing capacity, boundary zones, class of flammable substances and materials in the premises or on the object to be protected (DSTU 8828:2019 standard):

Class A - combustion of solid substances, mainly of organic origin, accompanied by slow combustion (wood, textiles, paper);

Class B - Fires involving flammable liquids or melting solids;

Class C - fire gas;

Class D - refractory metals and their alloys;

Class (E) - Fire from burning electrical installations.

Recommendations for portable fire extinguishers premises equipment

Room category	Limiting the protected area, m^2	ire class	Foam and water extinguishers capacity of 10 liters	Powder extinguishers with the charge, kg			Fire extinguishers refrigerant capacity of 2 (3)liters	Carbon dioxide fire extinguishers capacity, liters	
				2	5	10		2(3)	5(8)
A, B, C (combustible gases and liquids)	200	A	2++	-	2+	1++	-	-	-
		B	4+	-	2+	1++	4+	-	-
		C	-	-	2+	1++	4+	-	-
		D	-	-	2+	1++	-	-	-
		(E)	-	-	2+	1++	-	-	2++
C	400	A	2++	4+	2++	1+	-	-	2+
		D	-	-	2+	1++	-	-	-
		(E)	-	-	2++	1+	2+	4+	2++
D	800	B	2+	-	2++	1+	-	-	-
		C	-	4+	2++	1+	-	-	-
D,E	1800	A	2++	4+	2++	1+	-	-	-
		D	-	-	2+	1+	-	-	-
		(E)	-	2+	2++	1+	2+	4+	2++
Industrial buildings and structures	800	A	4++	8+	4++	2+	-	-	4+
		(E)	-	-	4++	2+	4+	4+	2++

4.2.6 Workplace lighting

Natural light comes from direct sunlight or diffused light from the sky. It must include all production, storage, sanitary and administrative rooms.

The spectrum of natural light is the most favorable for the human eye. Ultraviolet radiation, which is part of the solar spectrum, is important for human health, but it is almost completely blocked when passing through ordinary glass, so it does not penetrate the room.

Natural light cannot be the only method for most jobs as it varies greatly depending on the time of day, season and weather conditions. Considering that this is the main factor in the nominal natural light incidence e, which is the ratio of workplace illuminance to ambient illuminance measured in an open space,

e = 100Er / Yen, %

Daylight Coefficient does not depend on time of day and other reasons for daylight variability. The hygiene standards included in the building code establish the required value of the CNI depending on the accuracy of the work and the type of lighting.

The basis for determining the category of work by the degree of accuracy is the smallest size of the distinguishing object, the minimum size of the object that the eyes will distinguish during this work, for example, the distance between two adjacent strokes when using a measuring tool, point diameter (delimiter) the smallest font size for reading and writing, etc.

In addition to the intensity of natural lighting, its uniformity is regulated, which should be at least 0.3 in industrial premises for works of categories I, II, III and IV and compatible with overhead lighting. Uniformity is characterized by the ratio of the minimum etip value to the maximum etax value on the work surface in a typical area of the part.

A typical section of the central find of the room, which is perpendicular to the plane of the skylight (in the case of lateral lighting) or to the longitudinal axis, covers the room (in the case of lighting from above). If it is possible to reduce the distance between the lamps and increase their number in the rooms for category I and II work, it is recommended to increase the lighting uniformity by at least 0.5.

4.3 Calculation of the required level of artificial lighting to ensure a safe and efficient maintenance process

Artificial lighting is provided in all rooms of buildings, as well as in open workplaces in places where people pass and move in the dark. Artificial lighting is designed in the form of two systems: general (uniform or local) and combined (added in a specific place). General lighting involves placing lamps in the upper part of the room (at least 2.5 m from the floor). Local lighting is provided by lamps that produce light directly at the workplace.

The normal room illumination (Emin) depends on the visual work in the room, which in turn is determined by the minimum size of the search object. Not for a lighting designer at the lowest lighting level DBN V.2.5-28-2018 "Natural and artificial lighting" less than 400 (lux).

The actual light value is 200-250 lux. The total luminous flux is determined by the formula:

$$E_{gen} = \frac{E_n \cdot S \cdot k_1 \cdot k_2}{V}$$

Where:

En - standard lighting, En = 400 lux;

S - room area;

k1 - a coefficient that takes into account the aging of lamps and light pollution

(k1 = 1.2);

k2 - coefficient taking into account the unevenness of the lighting space (k2 = 1.1);

V is the luminous flux coefficient, which is determined by the reflection coefficient of walls, countertops, ceilings, room geometry and types of lamps (V - 0.75).

Room dimensions: A - 20 m, B - 30 m, H - 2.75 m The area of the room is:

S=A B

S=20·30= 600 (м2)

$$E_{gen} = \frac{400 \cdot 600 \ \cdot \ 1.2 \ \cdot 1.1}{0.75} = 422400 \ (lk)$$

Selection of luminous flux ratio coefficients:

1. The reflection coefficient of the ceiling painted with white paint (RCeiling is 70%);

2. Refractive index of white walls (Rwall is 55%);

3. Reflection coefficient of dark floors (Rfloor = 10%);

4. Place index (i).

The effective room height is equal to:

hp= H - hn

where hn is the height of the worktop above the floor (hn = 0.7 m).

*h*p=2.75-0.75=2(m)

The room index is equal to:

$$\mathrm{i} = \frac{\mathrm{A} \cdot \mathrm{B}}{\mathrm{h_p} \cdot (\mathrm{A} + \mathrm{B})}$$

$$\mathrm{i} = \frac{20 \cdot 30}{2 \cdot (20 + 30)} = 6$$

To provide full artificial lighting, T8SE - 180 LED incandescent lamps were selected, replacing 18W fluorescent lamps with 990lm.

The luminous flux of a T8SE-180 20W lamp is El = 1650 lm.

The required number of lamps can be determined using the following formula:

$$\mathrm{N} = \frac{\mathrm{E_{gen}}}{\mathrm{E_l}}$$

$$\mathrm{N_{fluo}} = \frac{422400}{990} = 427$$

$$\mathrm{N_{LED}} = \frac{422400}{1650} = 256$$

$$\mathrm{W_{Total}} = \mathrm{W} \cdot \mathrm{N}$$

$$\mathrm{W_{fluoTotal}} = \mathrm{W_{fluo}} \cdot \mathrm{N_{fluo}} = 18 \cdot 427 = 7686 \text{ (watt)}$$

Where: Wfluo is the power of one fluorescent lamp;

Nfluo - the number of fluorescent lamps.

The power of 256 LED lamps is equal to:

$$\mathrm{W_{LEDTotal}} = \mathrm{W_{LED}} \cdot \mathrm{N_{LED}} = 20 \cdot 256 = 5120 \text{ (watt)}$$

Where: WLED is the power of one LED lamp;

NLED - the number of LED lamps.

$$W_{opt} = W_{fluo} - W_{LED} = 7686 - 5120 = 2566\ (watt)$$

Optimization of artificial lighting is done. Thanks to the introduction of a new type of lamps, we reduced their required number.Thus, a saving of 2566 Watt and a reduction in the number of required lams can be reached due to optimization.

Conclusion

1. In this section, the organization of labor protection during the maintenance of aviation equipment, namely the maintenance of the fuel system and the neutral gas system, is considered. The issues of regulatory and legal provision of labor protection at the enterprise and factors affecting the body of aviation specialists are considered.

2. The regulations and normative documents regulating the issue of sanitary and hygienic standards for service in open parking lots were studied, the influencing factors and means of improving the sanitary and hygienic conditions of employees were considered. Namely, the provision of specialists with work clothes suitable for the season, the development of a procedure for rest and recovery of the body.

3. Considered the main issues of the harmful effects of substances with which workers may come into contact, the effects of these substances on the body, the classification of substances and means of reducing the negative impact on the body.

4. Work was carried out to study the sources of noise and vibration pollution, the impact of these factors on the body of employees, methods of reducing harmful effects and features of body recovery.

5. The issue of fire safety was considered, the main concepts and possible sources of fire spread, methods of fighting and the necessary means of fire fighting that should be at workplaces were determined.

6. The influence of the lighting of the workplace on the safety of the performance of duties by workers is considered, the main aspects and the most profitable sources of lighting are determined. The calculation of the necessary lighting of a medium-sized work room was carried out and optimization was carried out, taking into account the use of more technological and economical lamps from the point of view of energy consumption.

Chapter 5. ENVIRONMENTAL PROTECTION

5.1 Initial information about types of environmental pollution and sources of their occurrence

The intensive development of the aviation sphere in the world leads to the expansion of the air fleet and technological innovations. Therefore, in order to increase profitability, new types of aircraft are being developed, in which more powerful aircraft engines are installed, which require a larger volume of fuel and, as a result, lead to an increase in emissions into the atmosphere. Substances used in these aircraft are under development, such as new aviation oils, fluids that are not always environmentally safe. These aspects make the impact of civil aviation on the environment clearer and more significant. These effects include:

- Air pollution from the combustion products of aviation fuels;
- aircraft noise;
- electromagnetic radiation from radar stations;
- Contrails.

Air transport has a three-fold impact on the quality of the natural environment, ie its degree of environmental safety: impairments resulting from the reasonable operation of aircraft systems; the interaction of aircraft with the external environment, leading to damage, malfunctions and failures; Impairment of ability to work resulting in an emergency or catastrophic impact. Given the sanctity of this study of the growth law of entropy in aircraft systems, the civil aviation environmental security system is functionally divided into stages: operational measures maintain the quality of aircraft equipment over time, thereby minimizing the rate of entropy production; when overhauling, quality is restored, entropy is reduced to a safe level; Analysis of aviation events allows for experience feedback, further development and adjustment of operational and recovery processes. By negatively affecting the environment, flying machines amplify the harmful effects of the environment on themselves.

This cycle reinforces mutually harmful factors, making their development in geometric progression increasing.

Like any system that uses the energy of hydrocarbon oxidation, an aircraft releases products of this process into the atmosphere, which alter the natural composition of the atmosphere and are considered pollutants. Two types of hydrocarbons are used in aviation - kerosene and gasoline. The main difference in the composition of the combustion products is that leaded gasoline used in piston aircraft produces lead in the exhaust gases, which is one of the undesirable components of air pollution. However, the role of piston engine aircraft in modern aviation is insignificant and steadily decreasing.

In addition to carbon dioxide, water vapor, nitrogen, as well as some other natural components of atmospheric air, kerosene combustion products contain carbon monoxide, various hydrocarbons, aldehydes, nitrogen and sulfur oxides, soot particles, which form a smoke plume behind the engine nozzle . , as well as a number of other components that are formed in small amounts from impurities present in kerosene. The concentration of various pollutants in the air is regulated by maximum allowable concentrations. Emission limit values are currently being set for four harmful components in aviation: carbon monoxide (CO), unburned hydrocarbons (CnHm), nitrogen oxides (NOx), soot particles.

Aircraft noise is noise pollution caused by every aircraft or its components. Aircraft noise arises from three main sources:

- aerodynamic noise;
- mechanical noise and noise from aircraft engines;
- Noise from other aircraft systems - One of the most important sources of noise in commercial aircraft is the auxiliary power unit.

5.2 Control of emissions from aircraft engines

In 1981, the Committee on Aircraft Engine Emissions (ICAO) developed and approved draft emission standards and summarized them in Appendix 16

“Environmental Protection”. The appendix is prepared on the basis of Circular 134-A N/94 “Aircraft Engine Emissions Standards”, as amended by ICAO Member States.

Emission standards set limit values for gaseous emissions of carbon monoxide (CO), carbon (CxHy) and nitrogen oxides (NOx) as well as smog from aircraft engines and exhaust gases into the atmosphere. The standards limit emissions separately for turbofans and turbofan engines in subsonic aircraft and for aircraft engines in supersonic aircraft. Emission standards are only set for turbofans and turbofans of long-range subsonic aircraft with a thrust greater than 26.7 kN. Emissions from piston aircraft engines and engines fitted to light aircraft are not standardized because they consume a small amount of fuel compared to long-haul aircraft engines.

Standards for turboprop aircraft engines have not been established due to the low volume of transport carried out by the aircraft on which they are located. Air Auxiliary Power Unit (APU) pollutant emissions are not standardized as the cost of improving them would be much higher compared to the efficiency of the emissions reduction achieved. The purpose of the emissions is to reduce the pollution of the area near the earth's surface.

Bench certification tests are provided to determine compliance of aircraft engine emissions to established standards. The test conditions are the same for all engines of the same type. The tests are carried out under conditions that correspond to the operating conditions of aircraft engines in the airport area. After testing the engine, the relevant body issues a document - a certificate certifying the compliance of its emission characteristics with the standards established by ICAO.

A scheme was developed for these certification tests, which provides for compliance with real operating conditions. The scheme includes an emissions certification cycle that corresponds to the operation of the aircraft engine during takeoff and climb to 1000 m and landing from an altitude of 1000 m.

A comparison of two aircraft engines based on the integral of emissions over a single takeoff-landing cycle for all engines allows for an objective and easy assessment of the level of atmospheric air pollution from those engines.

Certification tests are performed on fuels with specific properties and on specific test benches to test these types of engines.

Engine smoke in the bench test is determined by the decrease in the reflectivity of the paper filter in the smoke values.

The ICAO standards for emission control parameters are currently as follows:

- MCO/R0 ≤ 118 g/kN;
- MCxHy/R0 ≤ 19.6 g/kN;
- MNOx/R0 = (40...80) g/kN;
- MSox/R0 ≤15 g/kN;
- MS.P/R0 ≤ 11 g/kN.

The ICAO emission standards for jet fuel propose that aircraft engine designers include a scheduled spray of fuel from jets in the event of an engine shutdown following the completion of normal flight and ground take-off and shut-down operations.

During engine certification tests, the following analyzers are used to measure the concentration of pollutants: total carbon (CxHy) is measured by a fire ionization detector; Carbon monoxide and carbon dioxide (CO and CO2) are measured by a non-dispersive infrared analyzer with differential energy absorption in parallel elements; Nitrogen oxides (NOx) are measured using the chemiluminescence method.

5.3 Airport pollution during maintenance of aircraft and their systems

Sources of pollution on the ground can be conventionally divided into “inside the airport” or “inside the factory”, when the harmful emissions are mainly distributed in the area of the airport, airport or repair shop and "out of town" whose atmospheric air is polluted outside of airline or factory territory.

The sources of “inside the airport” pollution are: the ventilation systems of the manufacturing plants; airport composition of fuel and lubricants; special vehicles. The plant's boilers are said to be sources of "outside the airport" pollution. These sources can significantly increase the concentration of pollutants in the atmospheric air of airlines, especially under adverse conditions.

The plant's boilers run on different types of local fuels, so the type of pollution is determined by the type of fuel, its combustion methods, and its methods of removing emissions.

The main pollutants in boiler furnace flue gases, which belong to solid particles and gaseous substances, are sulfur dioxide (SO2), carbon monoxide (CO) and nitrogen oxides (NOX).

One of the most important conditions for the minimum emission of harmful substances from the furnaces into the atmosphere is the choice of the type of fuel combustion that achieves its complete combustion in the furnaces.

Ventilation systems of civil aviation companies are used in defined areas of aeronautical bases and aircraft repair shops where pollutants can be released. Supply, exhaust and local ventilation systems are used. If the air taken from workplaces contains pollutants in high concentrations, it may be cleaned in dedusting and gas cleaning systems before being released into the atmosphere.

Pollutants emitted from manufacturing facilities spread near businesses, initially polluting the air of the airline itself and creating elevated levels of pollutants in poorly ventilated spaces between envelopes. Emissions are diverse in their physical and chemical composition.

Atmospheric air is rejected by the ventilation systems of the atmosphere of the production facilities where maintenance or repair of aviation equipment is carried out: vapors of petroleum products, solvents, paints and varnishes, alkalis, acids, aerosols, aqueous solutions of caustics, carbon dioxide and sodium phosphate, sulfur dioxide , nitrogen oxides, carbon monoxide, dust.

The quantities of pollutants released into the atmosphere from the production facilities of aeronautical bases and aeronautical resonator factories through ventilation systems can exceed the maximum permissible values. This can be especially true with a grouped arrangement of ventilation ducts, when it is possible to combine harmful emissions and even the formation of new pollutants with increased toxicity.

Fuel and lubricant stores pollute the atmospheric air, mainly on the territory of aviation fuel airports, with special lubricants and liquids. Fuel vapors enter the atmosphere: when they are expelled from program tanks and aviation (aircraft) tanks during the refueling process, during the process of "easy breathing" of tanks, as well as when they evaporate due to fuel leaks at joints and due to -compliance with the rules for aircraft refueling, storage, transportation and filling of fuel and lubricant canisters.

When filling the tank with 1 m3 of air, an average of 0.015 m3 of saturated fuel vapor is emitted with a density of 10 kg / m3. This means that filling a PO-22 tank truck, for example, releases up to 3 kg of volatile fuel fractions into the atmosphere. If we consider that practically the amount of fuel consumed by an airplane is pumped at least three times:

Storage tank - aircraft refueling system - aircraft tank. If an airplane uses 1,000 m 3 of fuel per day, its emissions enter the airport in the form of vapour. Air can reach 450 kg. Such a mass of fuel can pollute the maximum permissible average daily concentration for gasoline of 1.5 mg/m3 per 3 × 108 m3 of air.

The essence of "weak-breathing" tanks is that when the temperature of the outside air rises, the saturated fuel vapors and the fuel itself inside the tank heat up, expand, and the fuel vapors are expelled by breathing. valve, otherwise the tank will swell and consequently deform, and at night, when the temperature drops, the fuel vapors compress and condense, drawing outside air into the tank. When a tank with a capacity of 5000 m3 “breathes a little”, up to 100 kg of gasoline vapors are emitted into the atmospheric air per day.

The special equipment used by civil aviation companies pollutes the air with carbon oxides, hydrocarbons and nitrogen oxides.

5.4 Requirements for aircraft maintenance organizations

The availability of information about the activity and working conditions of the enterprise contained in the environmental passport, draft GPP standards, the environmental justification of the license and other regulatory and legal documents.Including:

- aircraft types and engines serviced;
- the forms of technical maintenance in which the engines and auxiliary units are manufactured;
- the frequency of completed maintenance forms and their number for the reporting period;
- the location of ground run of engines in combination with the production and technical area of the base and the nearest settlements or other protected areas;
- Building scheme of the flue gas monitors;
- Statistics of repetition of weather conditions throughout the year and per month.

Calculations are performed based on data from the aircraft flight certificate, a compiled and approved engine test program. They are carried out every half hour for a stationary aircraft, taking into account the approved engine test program and taking into account the type of device that displays the exhaust gases.

The calculation availability is averaged over a 30 minute interval of unit pollutant concentrations resulting from engine runs.

Calculations are performed for the following conditions:

- the most intense profile in motor races in half an hour and in combined races of several engines if it takes place within 30 minutes;
- average monthly and unfavorable meteorological conditions for the hottest month of the year;

- for wind directions towards communities and other protected areas located in the zone of influence of the spread of pollutants.

The calculation results should include calculation tables with data at ground nodes and contours of equal concentrations in two-dimensional space, and clearly represent air pollution in residential areas and other protected areas.

The calculation elements are sent to the airport's environmental services when the aeronautical base is located in its production and technical area, for inclusion in the consolidated documents and in the accounting sheet.

Availability of calculations of aircraft noise influence zones in adjacent areas, taking into account the requirements of GOST 22283-88.

The presence and location of acoustic screens or other devices affecting the propagation of noise in the ATB site area. In the case of conservation and false-start engines, it is necessary to use special devices that exclude emissions of conservation oils and fuels, as well as their mixtures, into the atmosphere and into the ground or into sewers and gullies.

5.5 Effects of engine noise emission

Engine noise is known to increase during takeoff and climb, and it is these modes that affect acoustic comfort in residential areas. Despite advances in silencers, power plants remain the main source of aircraft noise on the ground. The main causes of noise are in the area of the aerodynamics of the working medium of the engine.

Due to the enormous speed, the jet stream disturbs the surrounding air, which leads to noise. In addition, there are noisy mechanical parts: the compressor and turbine, the blades of which also create significant turbulence. So far, replacing the conventional turbojet with a dual-circuit turbojet has created significant noise reduction reserves. Turbine noise is caused in principle for the same reasons as fan noise, but it has specific characteristics, the main of which is associated with large and small irregularities and fluctuations in the flow speed leaving the combustion chamber.

This dramatically improves all broadband and discrete components of turbine noise. As a result, the turbine generates broadband noise at both low and high frequencies. Discrete components occur at compressor and fan blade frequencies, as well as at multiple and combined frequencies.

A high degree of turbulence and inhomogeneity, high speed and sometimes vortices of the flow behind the turbine are the causes of the exit duct noise of a twin-circuit turbojet engine. There are two types of noise here. Eddy noise occurs when flowing around racks and other obstacles, and turbulent noise is the sound of gas flow interaction with duct walls, etc.

Currently, scientists from different countries are making great efforts to reduce the turbine noise of existing and potential civilian aircraft. Of course, external calibration methods are now widespread. At the same time, the widespread use of so-called sound-absorbing structures has become an important means of reducing engine noise.

Life-size sound measurements are taken at certain points in and around the airport to clarify the danger.

By using modern measuring devices (sound level meters), it is possible to determine sound pressure levels at control points with sufficient accuracy according to the ICAO standard.

It is a point on the side of the runway at a distance of 450 m from its axis, a point along the axis of the runway at a distance of 6.5 km from the start of the run (at takeoff) and at a distance of 2.0 km away from the start of the route.

These measurements are used for noise certification of different aircraft types. They also measure the noise level in the hall, on the runway and in aircraft parking lots. If there are residential areas nearby, noise measurements are also carried out there, with the greatest attention being paid to hospitals, children's institutions, etc.

5.6 Effects of harmful emissions from aircraft engines

Aircraft emissions are the main contributor to air pollution from civil aviation. This determines the importance of a comprehensive review of the process.

Without knowledge of the emissions legislation for aircraft engines, it is not possible to calculate the entry of pollutants into the atmosphere during flight operations. These laws are also used in the standardization of the maximum permissible emission values of aircraft engines, in the development of processes for reducing pollutant emissions from civil aviation aircraft.

Emission sources associated with aviation can spread and degrade air quality in nearby settlements. These emissions pose a potential risk to public health and the environment as they increase ground-level ozone concentrations and can lead to acid rain. National and international air quality monitoring programs require authorized aviation and government organizations to monitor air quality around airports. Particular attention is also paid to the impact of air transport on the environment.

During aircraft flight at cruising altitude, aircraft engine exhaust is primarily distributed into the upper troposphere and lower stratosphere. Therefore, at this stage of aircraft flight, exhaust gas flow to the lower atmosphere can be neglected.

During the takeoff and landing phases of the cycle, aircraft engine exhaust falls primarily into the surface layer of the atmosphere.

In order to assess the pollution of the upper air layer in the airport area, it is necessary to determine the contribution of aircraft emissions to this process in different phases of the take-off and landing cycle.

During the take-off, climb (up to 900 m) and descent (less than 900 m) phases, the relative thrust and the duration of the phases change little depending on the operating conditions.

In order to reduce environmental damage, civil aviation sets limit values for the emission of pollutants into the atmosphere during the operation of aircraft engines.

When developing emission limit values, the ecological consequences of above-ground air pollution in the airport area are taken into account. Currently, civil aviation has set emission limits for the four exhaust components from aircraft engines that have the greatest impact on ground air quality around airports. These are carbon monoxide CO, unburned hydrocarbons CnHm, nitrogen oxides NOx and soot particles.

When regulating aircraft emissions, not only environmental requirements are taken into account, but also the technical possibilities to reduce the pollutant emissions from aircraft engines.

For this purpose, the influence of the technical characteristics of the aircraft on the loading of the airport area for the standard take-off and landing cycle is considered. Such consideration leads to the concept of emission control parameters, which play an important role in standardizing the maximum allowable emissions in civil aviation.

Conclusion to Chapter 5

1. Based on the research results, we can conclude that the development of the aviation sector directly affects the environmental situation, and further development will only aggravate the environmental problem.

2. There is a need to regulate permissible emission standards and monitor compliance with them, although the relevant legal documents were adopted by ICAO a long time ago, aircraft that do not meet these standards are still quite actively used around the world.

3. In addition, it is necessary to further promote the development of the so-called "green fuel", this will help to significantly improve the environmental situation in the world.

4. The main focus is on ensuring normal environmental conditions in areas where airports, aviation technical bases and aviation repair shops are located, since these places are areas with an increased concentration of the dangerous influence of corrosive substances and factors from the aviation sphere.

GENERAL CONCLUSIONS

In this diploma project, an analysis of the fuel system of the An-70 prototype aircraft, its units and elements was performed in order to find the most vulnerable parts that could be the sources of fire in the fuel tanks. According to the analysis of factors that directly affect the probability of a fire, the greatest danger is caused by a combination of increased oxygen content in the above-fuel space in the tank, which mixes with fuel vapors and such a mixture when in contact with an electrostatic arc that occurs during a static discharge leads to an explosion and further ignition of fuel. It is almost impossible to localize a fire that occurs under such conditions, because there is a rapid destruction of the tank structure, an increase in the contact area of the heated fuel with air, which increases the area covered by the flame in leaps and bounds. As a result, other integral tanks located nearby are damaged, and the fire spreads uncontrollably throughout the plane.

An electrostatic charge occurs on an airplane during the entire cycle of the airplane's operation, both on the ground and in flight. And this charge releases its energy at the moment when an object with a smaller electrostatic charge flies by, an electric arc occurs, the temperature of which is sufficient to not only to ignite vapors of fuel and lubricant materials, if they are nearby, and in order to hit the aircraft skin and burn it.

In order to exclude the occurrence of a fire under such circumstances, this project proposes to modernize the fuel system in order to exclude the possibility of a fire. The modernization method is to supplement the fuel system and its elements with an on-board system for generating inert neutral gas, which will be supplied to caisson tanks and potentially dangerous elements . The inert gas produced in the neutral gas generator has a higher density and displaces air containing oxygen from the above-fuel space into the fuel system drainage system. Ignition of fuel in an inert gas environment is impossible, so fuel vapors cannot pose a fire hazard.

This neutral gas generation system is proposed to be equipped with an indication system on a liquid crystal display, with the help of which it will be possible to accurately identify the state of the system and its operation at any time.

In addition, as an additional modernization of the power part of the tank-caisson, it is proposed to introduce a special nozzle, the so-called filter, which will reduce the creation of a static charge in the fuel in the tank-caisson, due to the slowing down of the flow of fuel during pumping and transfer of the charge that arose through the elements metallization of the tank to safer areas of the aircraft.

In addition, the work on the development of measures for the operation of the fuel system, peculiarities of the seasonal operation of the fuel system, the calculation of the necessary resources for the performance of seasonal maintenance was performed.

Measures for labor protection of the technical staff operating aviation equipment, developed measures to ensure safe operation, prevention of damage to the health of personnel, and factors affecting personnel at work are also considered.

A separate section deals with the protection of the environment, the very factors that affect the environment, the danger they pose, and possible recommendations for reducing this dangerous impact.

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