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
____________ Попов О.В.
«____» __________ 2022

КВАЛІФІКАЦІЙНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ЗДОБУВАЧА ОСВІТНЬОГО СТУПЕНЯ МАГІСТРА

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

Тема: "Методологічні основи підтримання експлуатаційної надійності гідравлічної системи повітряного судна злітною масою 20-25 тон. "

Виконав: ______________ Погорілий О.О.

Керівник:
к.т.н., доцент ______________ Ругайн О. В.

Консультанти з окремих розділів пояснювальної записки:

охорона праці:
к.т.н., доцент ______________ Кажан І.К.

охорона навколишнього середовища:
к.т.н., доцент ______________ Павлюх Л.І

Нормоконтролер: ______________

Київ 2022

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL AVIATION UNIVERSITY

AIRCRAFT AIRWORTHINESS CONTINUING DEPARTMENT

PERMISSION TO DEFEND

Head of the Department

Ph.D., Assoc. Professor

____________ O.V. Popov

«____» __________ 2022

MASTER DEGREE THESIS

(EXPLANATORY NOTE)

APPLICANT FOR ACADEMIC DEGREE OF MASTER

FOR EDUCATIONAL PROFESSIONAL PROGRAM

«MAINTENANCE AND REPAIR OF AIRCRAFT AND AIRCRAFT ENGINES»

Topic: "Methodological bases for maintaining the operational reliability of the hydraulic system of an aircraft with a take-off weight of 20-25 tons"

Performed by: __________ Pohorilyi O.O.

Supervisor:

Ph.D., assoc. prof. __________ Rugain O.V.

Consultants from separate sections of the explanatory note:

Labour precaution advisor:

Ph.D., assoc. prof. __________ Kajan K.I.

Environmental protection advisor:

Ph.D., assoc. prof. __________ Pavlyukh L.I.

Standards Inspector: __________

Kyiv 2022

NATIONAL AVIATION UNIVERSITY

Faculty: Aerospace faculty
Aircraft Continuing Airworthiness Department
Educational level: «Master Degree»
The specialty: 272 «Aviation transport»
Educational-professional program «Maintenance and Repair of Aircraft and Engines»

PERMISSION TO DEFEND
Head of the department
Ph. D., Assoc. Professor
_____________ O. V. Popov
«____”_______________ 2022

GRADUATE STUDENT'S DEGREE WORK ASSIGNMENT

Pohorilyi Oleh

1. The Work topic: «**Methodological bases for maintaining the operational reliability of the hydraulic system of an aircraft with a take-off weight of 20-25 tons**» approved by the Rector's order of September 29, 2022 No. 1786/st.
2. The work fulfillment terms: since September 26, 2022 till November 30, 2022.
3. Initial data for the project: searching for data and identifying faults that occur in the hydraulic system and reducing them to maintain the safety of the aircraft.
4. The content of the explanatory note: introduction, analytical part, structural design and description of hydraulic system units project part, scientific part, occupational safety and health, environmental protection, conclusions.
5. The list of mandatory graphic materials: shows the work of the hydraulic system, aircraft scheme and landing gear parts.

6. Time and Work Schedule

#	Stages of Graduation Project Completion	Stage Completion Dates	Remarks
1	Task receiving, selection of material	26.09.22 - 28.09.22	
2	Analytical part, detailed analysis of negative factors influencing on aircraft operational reliability, serviceability	29.09.22 - 04.10.22	
3	Project part	05.10.22 - 10.10.22	
4	Scientific part	11.10.22 - 17.10.22	
5	Labor precautions	18.10.22 - 22.10.22	
6	Ecology	23.10.22 - 26.10.22	
7	Arrangement of explanatory note	26.10.22 - 27.10.22	
8	Preparing for project defend	27.10.22 - 30.10.22	

7. Advisers on individual sections of the project:

Section	Adviser	Date, Signature	
		Assignment Delivered	Assignment Accepted
Labor precaution	Ph.D., associate professor K.I. Kajan		
Environmental protection	Ph.D., associate professor Pavlyukh L.I.		

8. Assignment issue date 26.09.2022.

Degree work supervisor: __________ Rugain O.V.

(signature)

Assignment is accepted for fulfillment __________ Pohorilyi O.O.

(signature)

ABSTRACT

The explanatory note to master's degree work "Methodological bases for maintaining the operational reliability of the hydraulic system of an aircraft with a take-off weight of 20-25 tons":

71 pages,4 figures, 11 tables.

Object of study – is optimal method of maintaining the operational reliability of the hydraulic system of a middle-range aircraft with two turboprop engines and its components.

The purpose of the explorations is to provide the usefulness and scientific applications of the hydraulic system**.**

Purpose of the qualification work is to improve the quality and efficiency of the hydraulic system and the system management units to maintain the safety of the operation**.**

The basic principle of this qualification work is to ensure that the output data is an influence on the flying experience nowadays**.**

The method for ensuring the effects will be described by the principle of hydraulic system efficiency**.**

Qualification work materials are recommended to use in educational process and practical activity of specialists of development laboratory.

Keywords**: RELIABILITY, HYDRAULIC SYSTEM UNITS, BRAKING SYSTEM, FAILURES, REFUSAL, TECHNICAL OPERATION, CONTROLLABILIY, EFFCIENCY.**

CONTENT

LIST OF ACRONYMS AND TERMS

AC – aircraft;

ICAO – International Civil Aviation Organization;

MP – Maintenance programme;

SAA – State Aviation Administration;

APU – auxiliary power unit;

NTSB – National Transportation Safety Board;

NA – not accessible;

ECS – engine control system;

ACMF – aircraft condition monitoring function;

EHM – engine health monitoring;

APM – aircraft performance monitoring;

EASA – European Aviation Safety Agency;

FAA – Federal Aviation Administration;

AMM – aircraft maintenance manual;

FOHE – fuel/oil heat exchanger;

FMU – fuel metering unit;

FMC – flight management computer;

FDR – flight data recorder;

FQIS – fuel quantity indication system.

INTRODUCTION

For the operation of the aircraft and the engine control system and other systems and units of the aircraft, various types of energy are used with significant energy costs. Depending on the type of energy used, they are hydraulic, gas and electric. In modern aircraft, the hydraulic system plays an important role, the rapid development and exponential growth of performance of which is due to the widespread use of hydraulic control surfaces. The hydraulic system provides control of the aircraft by systems and mechanisms that determine flight safety. Reliability, survivability and durability are achieved by the perfection of the design of hydraulic units, multiple redundancy of both the energy source and hydraulic drives, automation of control, monitoring and operational information of the crew. The use of hydraulic drives in aircraft is due to relatively small weight and size indicators, high speed and low inertia of the drive (unlike electric motors).

The mass and dimensions of the hydraulic unit are approximately 10-20 percent of the mass and dimensions of the electric machine of the same purpose and the same performance. Hydraulic systems can create significant forces at high speed, provide easy fixation of intermediate positions of the cylinders. Hydraulic systems are used to control the stabilizer and rudder, to retract and extend the landing gear, to mechanize landing and other consumers.

The disadvantages of the hydraulic system include the relatively small weight of the units, pipelines and working fluid, the dependence of the units on the ambient temperature. Damage to components and piping associated with loss of integrity can cause fluid to leak from the hydraulic system, resulting in hydraulic system failure.

The working body of the hydraulic system of most aircraft is aviation hydraulic oil АМГ-10. The nature of the system largely depends on the properties of the liquid. It is neutral with respect to steel and duralumin, and its viscosity varies slightly with temperature. However, there is a risk of fire at temperatures above 120 degrees.

For aircraft of civil aviation is currently the most commonly used hydraulic pumps with variable performance-driven engines, electric or air driven. Less commonly used hydraulic pumps with constant performance. Many consumers are fed simultaneously from multiple hydraulic systems. This increases the reliability of their work, since the failure of one of the systems the consumer continues to receive power from another system. Each control surface is controlled by the maximum amount of hydraulic systems available on the aircraft and responsible consumers (flaps, landing gear, etc.) - at least two hydraulic systems. Less responsible consumers and consumers who work only on land controlled by a hydraulic system. Each addition to the main hydraulic pumps available with redundant power supplies. As such torque converters are used, arranged between the hydraulic system, as well as installation and electrically driven turbo pump pumping station. Torque converters are designed to create pressure in the hydraulic system in case of failure in her main pumps or engine failure due to power adjacent the hydraulic system. The transfer of power from one system to another occurs without exchange of working fluid. Based on the foregoing, we see that the hydraulic system has a very important place in the management of the aircraft and its operation as a whole. Therefore, this system need to pay attention and do all sorts of structural technological improvements.

PART 1. AIRCRAFT MAXIMUM TAKE-OFF MASS OF 20-25 TONS HYDRAULIC SYSTEM FAILURES AND MALFUCTIONS ANALYSIS

1.1 General information about the aircraft An-26

The Antonov An-26 is a twin-engined turboprop civilian and military transport aircraft, produced from 1969 to 1986.

The An-26 is characterized by high stability, ease of operation, simplicity of piloting technique and a good view from the cockpit, which makes it accessible to mid-level pilots. High takeoff and landing qualities and chassis passability, provide the aircraft unpretentious to the runways and allow it to operate all year round on ground, grass, pebble, sandy, snowy and wet airfields of relatively small size.

The aircraft is an full-metal cantilever monoplane with a high wing, a single-keel vertical tail unit with a fork and two ventral ridges.

Glue and glue-welded joints, monolithic large-sized panels, high-strength aluminum alloys and steels are widely used in the manufacture of the airframe. Chemical milling was used to lighten the weight of the fuselage and tail panels. Non-metallic materials are widely used on the aircraft - fiberglass, press powder, oriented organic glass, foam plastic, etrol-paronite, laminated plastics and fiberglass, polyamide resins, polyethylene, fluoroplastic, foam rubber, etc.

The fuselage of the aircraft is an all-metal beam-stringer semi-monocoque. The transverse power set consists of 50 frames, the longitudinal one consists of 74 stringers and a number of longitudinal beams. The lower parts of the frames together with the longitudinal profiles form the frame of the fuselage floor. The fuselage skin is made in the form of separate technological panels of duralumin sheets with a thickness of 0.8…1.8 mm. The skin of the lower part of the fuselage between frames 11…27 is made of bimetallic sheets, consisting of inner duralumin and outer titanium layers. The cockpit canopy is glazed with oriented organic glass. In front of the pilot, one triplex glass with electric film heating is installed. On the left and on the right, the lantern has one window, sliding back. The fuselage has 9 windows and a navigator's blister. On the starboard side, between frames 7…9, there is an entrance door. For emergency escape of the aircraft, the lower, upper and 2 onboard emergency hatches are provided in the fuselage design. Loading and unloading of military cargo, as well as landing of cargo and personnel is carried out through a cargo hatch located between frames 33 ... 40.

The wing of the aircraft is direct, high aspect ratio, trapezoidal in plan. It is divided into a center section, two middle and two detachable parts.

The center section is rectangular in plan, the rest of the wing is trapezoidal. The center section carries two deviating single-slotted flaps, the middle parts of the wing - one retractable double-slotted flap, detachable parts - two sections of the ailerons. The wing is of the caisson type and consists of two spars, twenty-three ribs, skin and stringers forming panels, nose and tail parts and end fairings. In the caissons of the center section there are 10 soft fuel tanks. The caissons of the middle part of the wing are sealed fuel tanks-compartments. Most of the wing structure elements are made of aluminum alloys.

The tail unit is cantilever, single-fin. It consists of two stabilizer consoles, two halves of the elevator, fin, rudder and forkil. The stabilizer and fin are of a two-spar design with a working duralumin skin. A trimmer is installed on each half of the elevator, and a spring trimmer-servo compensator is installed on the rudder. The elevator and rudder are axially aerodynamically compensated and 100% balanced.

The aircraft landing gear is retractable in flight, made according to a three-bearing scheme. Consists of two main and one front support. The main supports are installed in the engine nacelles and in flight, they retract forward into special compartments. On each shock strut of the main support, two wheels with low-pressure pneumatics and disc brakes are installed on a common fixed axle. The wheels are equipped with inertial skid sensors. The front support is installed in the forward fuselage and in flight also retracts forward into the compartment under the cockpit. On the shock strut of the front support, two non-braking wheels with low-pressure pneumatics are installed on a common rotating axle, having taxiing and takeoff and landing control. In the released and retracted positions, the shock struts are fixed by mechanical locks that open with the help of hydraulic cylinders. Chassis compartments are closed with flaps when the shock struts are fully retracted and extended. The release and retraction of the landing gear, the opening of locks, the braking of the wheels of the main supports and the rotation of the wheels of the nose support are carried out by hydraulic cylinders. In the event of failure of the hydraulic system, the retracted locks of all landing gear shock struts can be opened manually using a mechanical system. The main power parts of the chassis are made of chrome steel.

The aircraft control system provides control of the rudders, ailerons, their trimmers, and flaps. An autopilot is connected to the aircraft control system, as well as control systems for turning the wheels of the front landing gear and braking the wheels of the main landing gear. To fix the steering surfaces in the parking lot, a system for locking the rudders and ailerons is provided. The control of the rudders and ailerons is direct, double, that is, carried out from the seats of both pilots. The rudder and aileron control wiring is a system of rods and rocking chairs. Elevator trimmer control - cable, aileron and rudder trimmers - electric. Flap control is electrohydromechanical. The flaps are extended and retracted hydraulically by means of a transmission shaft and six screw lifters.

The fuel system provides fuel for АИ-24ВТ and РУ19А-300 engines. The fuel tanks of the aircraft consist of ten soft tanks and two compartment tanks, each of which is divided by a partition into two tanks. Tanks are located symmetrically in the wing. Soft tanks No. 1,2,4,5 and 6 are located in the center section interspar space, five each between ribs 1 ... 6. Tanks-compartments No. 3 and No. 3a are caissons of the middle part of the wing. The tanks of each semi-wing form three groups. The first group includes five soft tanks, the second group - tank No. 3 and the third group - tank No. 3a (consumable tank). The total capacity of the fuel tanks is 7316 liters. Operational refueling, taking into account underfilling of 3% of the volume of tanks for thermal expansion, is 7080 liters. Each engine is powered from a supply tank by two booster pumps. The РУ19А-300 engine is powered from the tanks of the right half-wing. Fuel from the first and second groups is produced by pumping into the supply tank. Fuel production can be controlled automatically or manually. Refueling of tanks with fuel can be carried out from above through the filler necks or centrally, from below, under pressure. Drainage system of open type, it provides air filling of volumes released from fuel in all flight modes, including during emergency descent.

The fire fighting equipment of the aircraft consists of a stationary fire fighting system, hand-held portable fire extinguishers and constructive protection. Freon 114V2 is used as an extinguishing agent in fire extinguishers of a stationary fire-fighting system. Portable fire extinguishers are charged with carbon dioxide. The stationary fire fighting system is designed to detect and extinguish fire in the most fire hazardous places: in engine nacelles, in engines and in the wing at the locations of fuel tanks. The fixed fire fighting system consists of an aircraft fire fighting system and an engine fire fighting system. Both systems have a common electrical system and a fire extinguishing shield.

The hydraulic system provides power to the actuators of aircraft systems cleaning and landing gear, braking wheels, taxi devices, control flaps and spoilers, cleaning entrance stairs.

The main power plant of the aircraft consists of two АИ-24ВТ turboprop engines with a takeoff power of 2820 hp each. and four-bladed vane propellers АВ-72Т with an operating speed of 1300 rpm. The engines are installed in gondolas located on the center section. Each engine is attached to a truss mounted on the front spar of the wing with the help of a frame through the power frame of the nacelle. On the engine, in addition to the propeller, the following are mounted: a gearbox fairing, a hood, an anti-icing system, an outlet device, oil system units, a blowing system for generators and an engine, a fuel supply system and a fire system. The hot part of the engine and the outlet device are separated from the wing structure by special fire baffles and screens.

The auxiliary power unit is made on the basis of the РУ19А-300 turbojet engine, which is installed in the tail section of the right gondola. It provides: additional thrust (up to 800 kgf) during takeoff and climb, the necessary thrust-to-weight ratio of the aircraft in case of failure of one АИ-24ВТ engine, on-board launch of the АИ-24ВТ engine, power supply to the aircraft on-board network when the engines are not running, power supply to the aircraft on-board network in flight in case of failure of СТГ-18ТМО generators.

1.2 Basic data and characteristics

Table 1.1 - Basic geometric data

Named of parameter	Modification of aircraft
	An-26
Aircraft length, m	23.8
Wingspan, m	29.2
Height (empty aircraft), m	8.58
Fuselage diameter, m	2.9
The base chassis, m	7.65
Track chassis, m	8.48
The scope of the horizontal tail, m	10.135
The length of the transport cabin, m	15.68
The volume of transport cabin, m^3	60
Wing area, m^2	74,98
The front door, mm	600x1400
Cargo door mm	2400x3150
Onboard escape hatch, mm	500x600
Bottom escape hatch, mm	950x1260
The maximum width of the transport cab and us, m	2.78

Continuation of Table 1.1

The width of the floor of the transport cabin, m	2.25
The height of the transport cabin, m	1.88
Minimum crew: - captain; - copilot; - flight engineer	 1 1 1
Maximum number of passengers	40

Table 1.2 - Basic weight data

Named of parameter	Modification of aircraft
	An-26
The maximum taxi weight, kg	24230
Maximum take-off weight, kg	24000
Maximum landing weight, kg	24000
Empty weight, kg	15020
The maximum weight of the loaded airplane, kgf	22000
The maximum weight of a commercial loading, kgf	5500
The maximum weight of fueling (γ = 0,775 kg / cm^3) kgf	5487
Weight equipment, kgf	450

Table 1.3 - Flight performance

Named of parameter	Modification of aircraft
	An-26
Maximum take-off weight, kg	24000
Maximum level flight speed, km / h	440
Cruising altitude,	6000
Time set cruising altitude, min	28
Flight range at H = 6000 m, cruiser speed of 450 km / h with “AH3” for 45 minutes. $G_{take\text{-}off}$ =24000 kgf km:	
- with the maximum load (4680 kg)	1120
- ferry	2496
Fuel consumption, g / pass.km	27.2
Take-off data (N = 0, Gtake-off =19150 kg, t = +15°C)	
- lift-off speed, km / h	220
- the length of the run, m	870
- take-off distance to H = 10,7m, m	1040
- required runway length, m	1300
Landing data (N = 0, Gland =18,000 kgf)	
- approach speed, km / h	200
- landing speed, km / h	190
- required runway length, m	1295

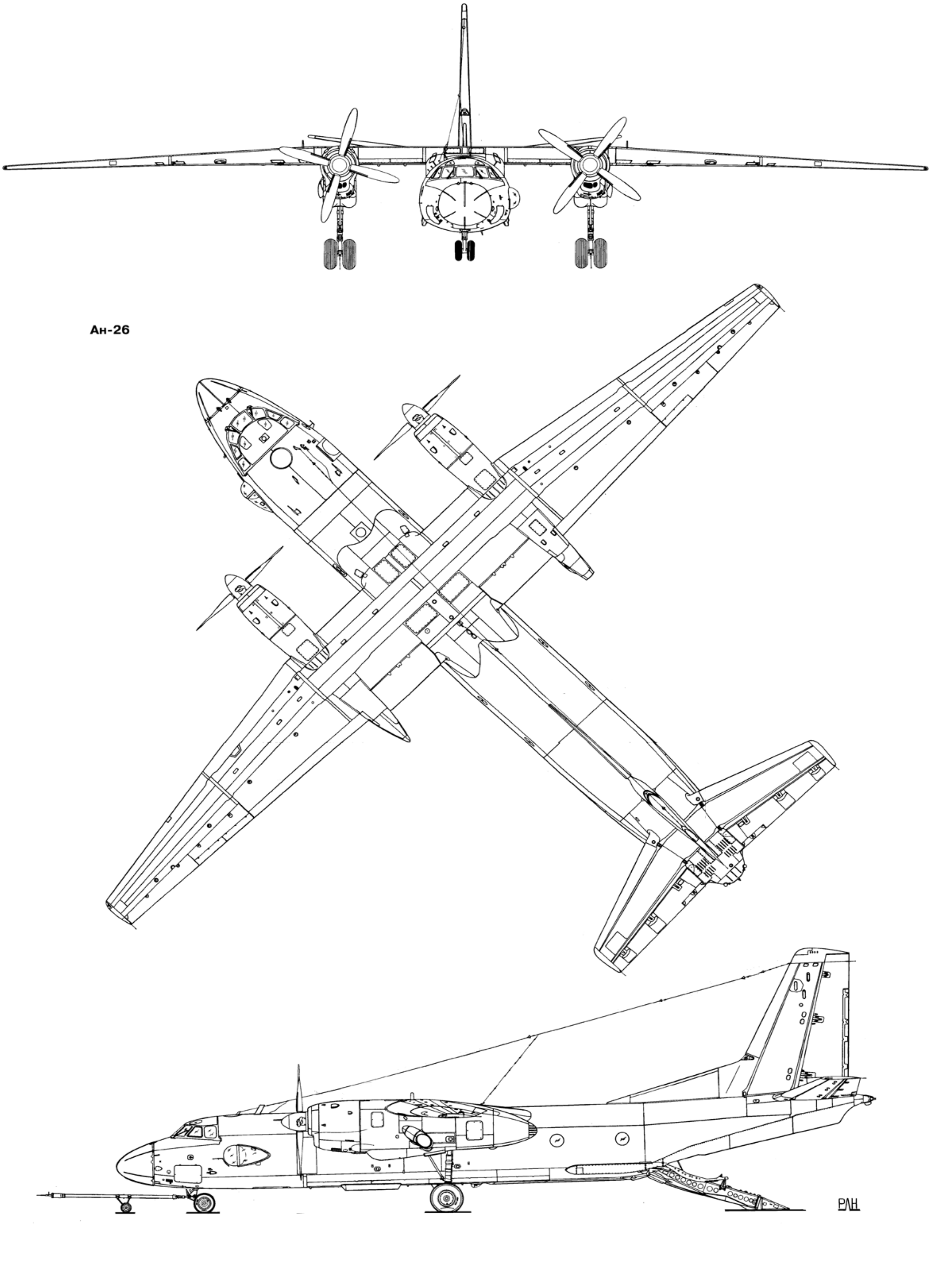

Fig.1 - Scheme of the An-26 aircraft

1.3 Reliability analysis of hydraulic system elements of the An-26 aircraft

The quantitative assessment of the reliability of hydraulic system elements was carried out in the following order:

• Determining the failure intensity of elements of the hydraulic system, which characterizes the number of failures per unit of time;

• the probability of trouble-free operation of hydraulic system elements is determined;

• The intensity of the failures was determined by the formula:

$$\lambda_{(t)} = \frac{r(t + \Delta t) - r(t)}{N(t) * \Delta t}; \quad (1.1)$$

Where: r(t) - the number of product failures over a certain period of time t;

r(t+Δt) - the number of rejected products during the period of time (t+Δt);

N(t) - the total number of products under supervision.

The average value of the failure rate was determined by the formula:

$$\lambda_{(t)cep.} = \frac{1}{K}\sum_{i=1}^{k}\lambda(t); \quad (1.2)$$

The probability of failure-free operation was determined as for non-recoverable systems every 0.5 hour of a typical flight, equal to t = 2.5 hours. It was assumed that during a typical flight, a failed product does not restore its performance.

Then the probability of trouble-free operation for the considered time interval t_i can be determined by the formula:

$$P_{o(t)} = e^{-\lambda_{cep.}t_i}; \quad (1.3)$$

Statistical data on failures and malfunctions of the elements of the hydraulic system that occurred during the considered period of operation of the An-26 aircraft are presented in Table 1.4.

To calculate the failure rate ($\lambda(t)$) of the elements of the hydraulic system, we determine the number of intervals (K) and the operating time in the interval (Δt) according to the formula:

$$K = \frac{n}{1 + 3,3 \lg N}; \quad (1.4)$$

Where: n- the number of failures of system elements;

N - the number of controlled serviceable units.

$$\Delta t = \frac{(t_{max} - t_{min})}{K}; \quad (1.5)$$

Where: t_{max} - the maximum working time of the product in total, h;

t_{min} - minimum working time of the product before failure, h.

The results of the calculations are summarized in Table 1.5. After determining the failure rate x(t)cp. We determine the probability of failure-free operation of the elements of the hydraulic system p(t) as for a non-recoverable system during a typical flight equal to 2.5 hours. The results are summarized in Table 1.6.

Table 1.4 - Statistical data on failures and malfunctions of the elements of the hydraulic system of An-26 aircraft

Name of element	Operating time of elements to failure, h	Number of failures	Estimated number of failures	Cause of failures
1. Hydraulic pump unit 623AH	4188, 4887, 4993, 5407, 6077, 6023, 6146, 6377, 6813	9	0,114	Destruction of the cuff
2. Disconnect valve	1370, 1885, 2492, 3614, 3592	5	0,063	Leakage
3. Electrohydraulic crane ГА-140	427, 2417, 2439, 3673, 4736, 4977, 5520, 6922, 6926, 7212, 7498, 8072	12	0,152	Leakage; unretracted landing gear after takeoff.
4. Hydraulic accumulator of the brake network	721, 922 179, 1596, 2066, 2136, 2407, 2513, 3059, 3302, 3342, 3929, 4031, 4067, 4124, 4187	16	0,203	Diaphragm destruction; nitrogen pressure drop
5. Pipelines of the high pressure	2622, 2730, 3385, 3884, 4562	5	0,063	Leakage of АМГ-10
6. Flow restrictor	1721, 1733, 2722, 3687, 4682, 4757, 4981, 5486, 5962, 5987	10	0,127	Throttle grid clogged
7. Pulsation damper	3346, 4643, 4824, 5074, 5171, 5216, 5281, 5311	8	0,101	Destruction of the membrane
8. Secondary filter	1116, 1512, 1646, 1864 195, 2286, 2330, 2730	8	0,101	External leakage of bypass valve operation
9. Check valve	674, 1418, 2141, 2768, 3287, 4695	6	0,076	Internal leakage

Table 1.5 - Values of the failure rate of the elements of the front landing gear

1. Hydraulic pump unit 623AH: K = 3 Δt = 876 h				
t+Δt	4188÷ 5062	5062 ÷ 6538	6538 ÷ 6813	
n(t)	3	5	1	
N(t)	42	39	34	
λ(t).10-4	0,815	1,464	0,338	
λcp(t).10-4 = 0,872				
2. Disconnect valve: K = 3 Δt = 741 h				
t+Δt	1270 ÷ 2211	2211 ÷ 2852	2852 ÷ 3592	
n(t)	2	1	2	
N(t)	154	152	151	
λ(t).10-4	0,175	0,089	0,179	
λcp(t).10-4 = 0,148				
3. Electrohydraulic crane ΓA-140: K = 4 Δt = 1911 h				
t+Δt	427 ÷ 2338	2338 ÷ 4249	4249 ÷ 6160	6160 ÷ 8072
n(t)	1	3	3	5
N(t)	14	13	10	7
λ(t).10-4	0,374	1,208	1,570	3,738
λcp(t).10-4 = 1,722				
4. Hydraulic accumulator of the brake network: K = 4 Δt = 867 h				
t+Δt	721 ÷ 1588	1588 ÷ 2455	2455 ÷ 3321	3321 ÷ 4187
n(t)	3	4	3	6
N(t)	42	39	35	32
λ(t).10-4	0,824	1,183	0,989	2,163
λcp(t).10-4 = 1,290				
5. Pipelines of the high pressure: K = 3 Δt = 647 h				
t+Δt	2692 ÷ 3269	3269 ÷ 396	3916 ÷ 4562	
n(t)	2	2	1	
N(t)	56	54	52	
λ(t).10-4	0,552	0,572	0,297	
λcp(t).10-4 = 0,474				

Continuation of Table 1.5

6. Flow restrictor: K = 4 Δt = 1067 h				
t+Δt	1721 ÷ 2788	2788÷ 3855	3855 ÷ 4921	4921 ÷ 5987
n(t)	3	1	2	4
N(t)	84	81	80	78
λ(t).10-4	0335	0,116	0,234	0,481
λcp(t).10-4 = 0,292				

7. Pulsation damper: K = 3 Δt = 655 h			
t+Δt	3346 ÷ 4001	4001 ÷ 4656	4656÷ 5311
n(t)	1	1	6
N(t)	56	55	54
λ(t).10-4	0,273	0,278	1,70
λcp(t).10-4 = 0,750			
8. Secondary filter: K = 3 Δt = 538 h			
t+Δt	116 ÷ 1654	1654 ÷ 2192	2192 ÷ 2730
n(t)	3	2	3
N(t)	42	39	37
λ(t).10-4	1,33	0,953	1,51
λcp(t).10-4 = 1,264			
9. Check valve: K = 3 Δt =1340 h			
t+Δt	674 ÷ 2014	2014 ÷ 3354	3354 ÷ 4695
n(t)	2	3	1
N(t)	14	12	9
λ(t).10-4	1,07	1,87	0,829
λcp(t).10-4 = 1,256			

Table 1.6 - Values of the probability of failure-free operation of hydraulic system elements

Name of element	Time of the flight, h			
	0.5	1.0	2.0	2.5
1. Hydraulic pump unit 623AH	0,999956	0,999913	0,999826	0,999782
2. Disconnect valve	0,999993	0,999985	0,99970	0,999963
3. Electrohydraulic crane ΓA-140	0,999914	0,999828	0,999656	0,999570
4. Hydraulic accumulator of the brake network	0,999936	0,999871	0,999742	0,999678
5. Pipelines	0,999976	0,999953	0,999905	0,999882
6. Flow restrictor	0,999985	0,999971	0,999942	0,999927
7. Pulsation damper	0,999963	0,999925	0,999850	0,999813
8. Secondary filter	0,999937	0,999874	0,999747	0,999684
9. Check valve	0,999937	0,999874	0,999749	0,999686

Analysis of the Table 1.4. shows us that such units as - hydraulic pump unit 623AH, hydraulic accumulator of the brake network and electrohydraulic crane ΓA-140 should be included among the unreliable An-26 hydraulic units.

Also, among the unreliable units of the system, it is possible to single out the flow restrictor, pulsation damper and secondary filter, which have a fairly high percentage of failures.

Conclusions to part 1

This section provided general information about the aircraft, its main geometries, mass and flight technical characteristics. Statistical data on failures and malfunctions of hydraulic system units were collected. The aircraft's hydraulic system provides control of systems and mechanisms that determine flight safety. Reliability, survivability and durability of hydraulic units is achieved by perfection and multiple redundancy. Therefore, statistical data collection is very important to maintain reliability.

After analyzing statistical data on failures and malfunctions, weak points were identified, which should be paid special attention to during maintenance and determining the technical condition of the system.

PART 2. DESCRIPTION, STRUCTURAL IMPROVEMENT AND MODIFICATION OF HYDRAULIC SYSTEM UNITS

2.1 Brief description of the hydraulic functional system

The hydraulic system of the aircraft consists of the main, emergency systems and a hand pump system. The sources of pressure in them are:

- two hydraulic gear pumps arp.623AH (main system);
- hydraulic accumulator of the common injection network (main system);
- brake accumulator (main system);
- emergency pumping station HC-14 (emergency system);
- hand pump HP-01/1 (manual pump system).

The main hydraulic system provides:

- release and removing of the landing gear;
- release and retraction of flaps;
- braking of the wheels of the main landing gear;
- control of the rotation of the wheels of the front landing gear;
- wiper drive;
- lower emergency hatch control;
- emergency feathering of propellers and engine shutdown;
- conveyor drive;
- rollback and rolling of the ramp;
- opening and closing of threshold locks of the cargo hatch;
- opening and closing of the side (beam) locks of the cargo hatch;
- opening the locks of the cargo hatch rail.

The emergency system provides:

- emergency release of flaps;
- emergency braking of the main landing gear;
- emergency opening of the lower emergency hatch;
- emergency rollback and ramp rolling;
- emergency opening and closing of cargo hatch threshold locks;
- emergency opening and closing of side locks of cargo hatches;
- raising and lowering the ramp;
- supply through the cross-feed valve of the main hydraulic system.

The hand pump system provides:

- opening side locks, rail locks and threshold;
- closing side locks and threshold locks;
- ramp lifting;
- rollback and rolling of the ramp;
- refueling of the hydraulic tank;
- power supply through the seven-position valve of the emergency hydraulic system**.**

All systems are fed from one hydraulic tank. To increase the cavitation reserve of pumps and increase the height of the hydraulic system, the hydraulic tank is pressurized with air taken from the engine compressors. For maintenance of the hydraulic system when it is operated from ground hydraulic sources, a panel of side split valves is installed on the inside of the right engine nacelle.

Management and control of the operation of the hydraulic system is carried out from the left panel of the cockpit.

Basic data

1. Working fluid АМГ-10

2. Pressure in the main hydraulic system .... 120±5…155±5 kg/cm^2

3. Maximum pressure in the emergency hydraulic system .... 160+15 kgf/cm^2

4. Maximum pressure in the hand pump system .... 162…167 kgf/cm^2

5. Hydraulic tank boost pressure .... 1±0.1 kgf/cm^2

6. Accumulator charging pressure:

common injection network .... 85±5 kgf/cm^2

brake circuits .... 60±3 kgf/cm^2

7. Total system capacity .... 65 l

8. The amount of liquid in the hydraulic tank:

with discharged hydraulic accumulators .... 27…28 l

with charged accumulators .... 21…22 l

minimum for operation of the emergency hydraulic system .... 8 l

9. Continuous work time of emergency pumping station .... 15 minutes

10. Pump performance:

main hydraulic system .... 16-19.5 l/min

emergency hydraulic system .... 8 l/min

hand pump (10 double strokes (cycles) at a swing speed of 1 cycle per second) at a pressure of 35(150) kgf/cm2 .... 0.3 (0.09) l

2.2 Device and elements for monitoring the operation of the network of pressure sources of the main hydraulic system

2.2.1 Description of the main components of the aircraft hydraulic system

The network of pressure sources of the main hydraulic system includes elements, shown on the schematic diagram (Figure 2.1):

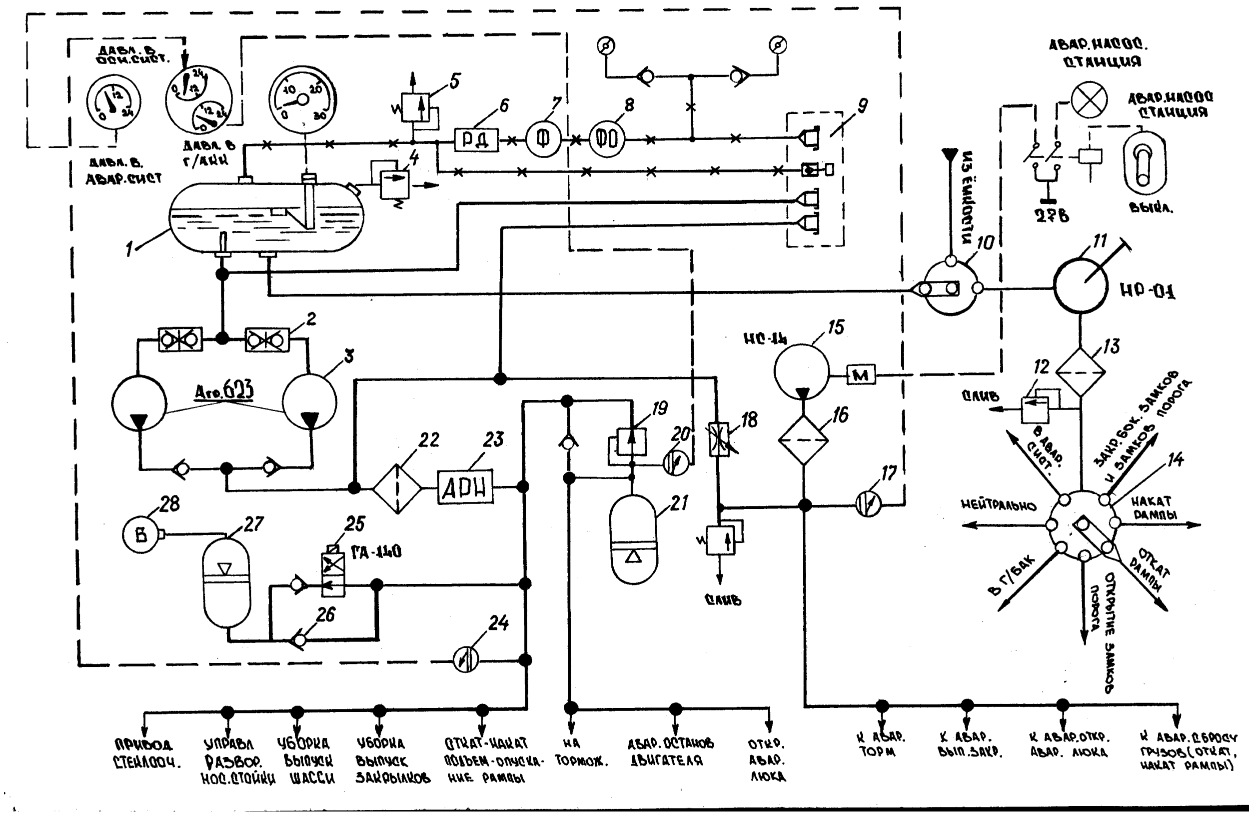

Figure 2.1 - Hydraulic system Schematic Diagram:

1 – hydraulic tank (reservoir) ; 2 – disconnect valve; 3 – hydraulic pump unit 623АН; 4, 5, 12 – safety valve; 6 – reducing valve; 7 – air filter; 8 – Dehydrating filter; 9 – onboard suction and discharge valves;10 – valve for turning on the power supply of the hand pump;11 – manual pump НР-01/1; 13, 16, 22 – hydraulic filter; 14 – seven-position distribution valve; 15 – emergency pump station НС-14; 17, 20, 24 – induction pressure sensor ИД-240; 18 – cross-feed valve; 19 – by-pass (back-up) valve; 21 – hydraulic accumulator of the brake network;23 – hydraulic pump unloading automat ГА-77Н; 25 – electrohydraulic crane ГА-140; 26 – check valve; 27 – hydraulic accumulator of the common injection network; 28 – ballon.

Arrangement of the hydraulic system accessories units and aggregates is shown in Table 2.1

Table 2.1 - Arrangement of units

Accessory unit	**Qty, pc**	**Location**	**Access in maintenance**
Hydraulic tank (reservoir)	1	The hydraulic tank is installed under the left fairing of the wing center section	Wing center section detachable panel
Onboard suction and discharge valves	1	Installed on the left side of the right engine nacelle	Engine nacelle cowl panels
Hydraulic pump unit 623AH	2	Installed on engine drive boxes, left	Engine nacelle cowl panels
Hydraulic filter	3	Installed under the right fairing of the wing center section	Wing center section detachable panel
Hydraulic pump unloading automat ГА-77Н	1	Installed under the right fairing of the wing center section	Wing center section detachable panel
Hydraulic accumulator of the common injection network	1	Installed on the back part of the left engine nacelle	Engine nacelle cowl panels
Electrohydraulic crane ГА-140	1	Installed on the back part of the left engine nacelle	Engine nacelle cowl panels
Hydraulic accumulator of the brake network	1	In the landing gear compartment	LG compartment doors
Induction pressure sensor ИД-240	2	In the nose landing gear compartment	LG compartment doors
Disconnect valve	2	Installed on the engine firewalls	Engine nacelle cowl panels
By-pass (back-up) valve;	1	In the landing gear compartment	LG compartment doors

Hydraulic tank, with a capacity of 37 liters, welded from a high-strength aluminum alloy, has a cylindrical shape. The tank is equipped with a filler neck, with a mesh filter and an oil measuring line, an oil gauge sensor, fittings for the withdrawal of liquid into the main and emergency hydraulic systems, two safety valves of the supercharging system, a drain valve and a slot filter of the drain line with a filter fineness of 120 ± a valve that operates at pressure drop across the filter element is 1.5...1.9 kgf/cm^2.

The main system fluid intake connector is located in the tank slightly above the bottom, and the emergency system is flush with the bottom, which provides a reserve of liquid (about 8 liters) for the operation of the emergency system in case of depressurization of the main system. The hydraulic tank is installed under the left wing of the center plane.

The system of pressurizing the hydraulic tank, which ensures cavitation-free operation of the hydraulic pumps in the entire range of flight altitudes of the aircraft. Air is drawn into the system through engine compressors. Air purification from mechanical impurities and its drying is carried out by an air filter 7 and a filter-drier 8 with a silica gel absorber. The air pressure entering the hydraulic tank decreases to 1.0±0.1 kgf/cm^2. The connection of the airfield source of compressed air during the operation of the hydraulic pumps of the ground hydraulic installation is provided. The units of the system are installed in the right motor nacelle. The pressure relief valve 9 from the hydraulic tank is installed on the left side of the right motor nacelle.

On-board intake suction and discharge valves designed to connect a ground hydraulic installation. Installed on the left side of the nacelles of the right engine.

Two hydraulic pumps agr. 623AH, designed to create working pressure in the main hydraulic system. They are high-pressure gear pumps with hydraulic compensation of gear end clearances. The pump productivity at a pressure of 120...150 kgf/cm^2 is 16...19.5 l/min, in idle mode due to the reduction of internal flows (increase in efficiency) - increases to 22...23 l/min. Installed on the engine drive boxes, on the left side.

Hydraulic filter intended for cleaning oil from mechanical impurities. The filtering element of the mesh type ensures a filtration fineness of 12...16 microns. Filter throughput is 60 l/min. The bypass valve is triggered when the pressure drop across the filtering element is greater than 7±1 kgf/cm^2. There is a shut-off valve in the filter housing, which allows you to change the filter element during operation without first draining the oil from the system. It is installed under the right wing of the central plane.

Hydraulic pump unloader ГА-77Н designed to switch pumps to idle operation when the pressure in the system reaches more than 155 ± 5 kgf / cm^2 and switch pumps to operating mode when the pressure in the system drops below 120 ± 5 kgf / cm^2. A check valve is installed in the unloader, which prevents the discharge of the hydraulic accumulator of the general network when the pumps are not working. In case of failure of the switching system of the automatic unloader, a safety valve comes into operation, which prevents the pressure in the system from rising above 170 + 10 kgf / cm^2. The automatic unloader is installed under the right fairing of the center section.

Hydraulic accumulator of the general pressure network designed to maintain pressure in the discharge line in order to increase the time of operation of the pumps at idle, ensure the operation of individual consumers in the event of a pump failure, and also reduce the pulsation of fluid pressure. Piston-type hydraulic accumulator, has capacity of 2900 cm^3. This achieves an increase in the amount of working fluid entering the system. The pressure of charging the gas cavity with nitrogen is 85±5 kgf/cm^2. Installed in the tail section of the engine nacelle of the left engine.

Electrohydraulic crane ГА-140 intended for covering the charging line of the hydraulic accumulator of the general network during retracting of the landing gear. It is a two-position electrohydraulic crane with servo control. Installed in the tail part of the left nacelle of the engine.

Hydraulic accumulator of the brake system intended for the accumulation of energy, its consumption in the general network, as well as the main and emergency braking of the wheels of the main landing gear supports, the emergency stop of the engines with the flapping of air propellers and the opening of the lower emergency hatch, when the pressure in the general network drops below 120±3 kgf/cm^2. Piston-type hydroaccumulator, gas cavity charging pressure with nitrogen 60±3 kgf/cm^2. It is installed in the compartment of the front support of the chassis. Compressed nitrogen from the airfield power source is supplied to charge the nitrogen chambers through charging valves installed near the accumulators of the general network and the brake network, at the same time, the pressure in the liquid chambers must be completely released.

Bypass (intensifier) valve intended for covering the charging line of the hydraulic accumulator of the brake network in the general pressurization network when the pressure in it decreases less than 120±3 kgf/cm^2. It is installed in the compartment of the front support of the nose landing gear.

Disconnect valves designed for quick disconnection and connection of suction line pipelines without draining liquid from the tank and system pipelines. Installed on the fire walls of the engines.

Check valves designed to create a certain direction of fluid movement in the system. They are installed in the pump discharge lines, hydraulic accumulator charging lines and in the common discharge line.

Two induction pressure sensors ИД-240 designed to issue a signal to the pressure indicator in the main hydraulic system discharge line and in the brake accumulator. They are connected to the pipelines through dampers that protect the sensors from pressure pulsations. Installed: first under the floor of the crew cabin of frame № 5 ... 6 (common pressurization line), the second in the compartment of the nose landing gear (brake network).

2.2.2 Elements of control system

1. The indicator of the amount of hydraulic liquid in the tank of the hydraulic system (Figure 2.2). The signal comes from a rheostat sensor with a float mounted on the hydraulic tank. The scale is calibrated in liters of hydraulic licquid. The error of the oil gauge at a temperature of 20°C and a supply voltage of 27 V does not exceed ±5% on the main part of the scale. Rated indications 21 ... 22 l. Installed on the vertical panel of the left control panel

2. Two-pointer pressure gauge indicator UI-2-240, designed to control pressure in the common supply network and the brake network (in the hydraulic accumulator) of the main hydraulic system, power supply 36V 400 Hz. Installed on the vertical panel of the left control panel.

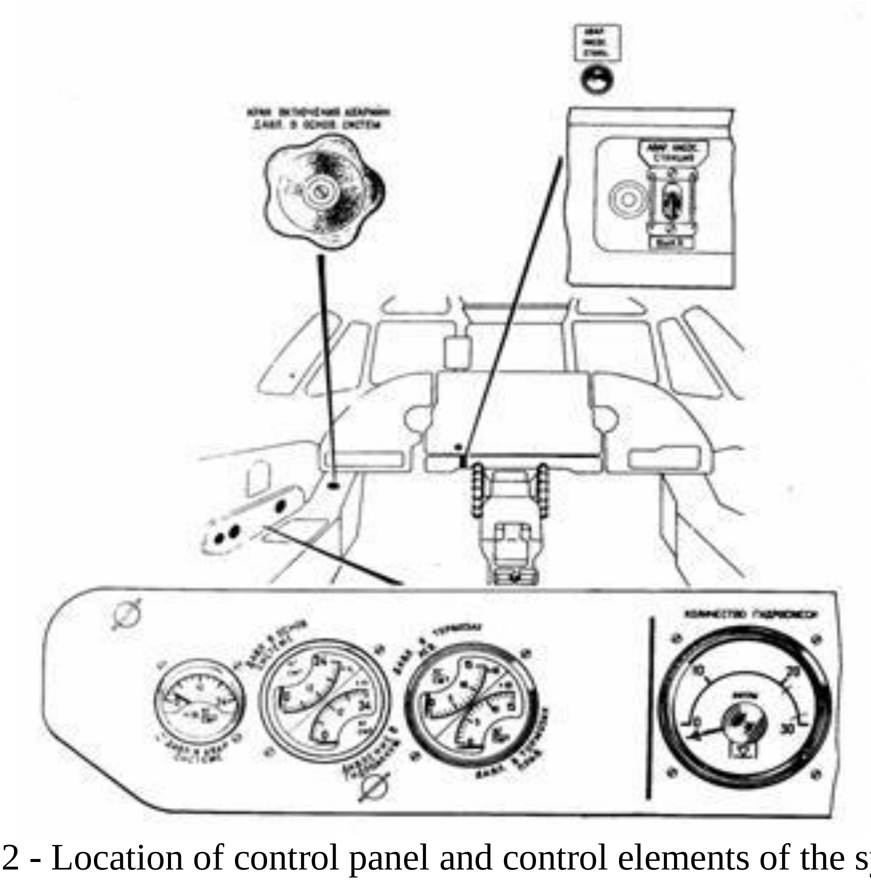

Figure 2.2 - Location of control panel and control elements of the system in the cabin crew.

2.3 Operation of the main hydraulic system

Oil from the hydraulic tank is supplied through disconnect valves to the hydraulic pumps and then, through a filter, to the automatic pump unloader for charging the hydraulic accumulators of the general network and brakes, as well as to the discharge line of the main hydraulic system. At the same time, the ГА-140 crane does not interfere with the charging of the hydraulic accumulator of the general network.

When the pressure in the general network reaches 155±5 kgf/cm^2, the automatic unloader switches the pumps to idle. In this case, the pressure downstream of the pumps does not exceed 5...15 kgf/cm^2, and in the common discharge line it will be equal to the charging pressure of the hydraulic accumulators, i.e. 155±5 kgf/cm^2.

In case of failure of the switching device of the automatic unloader, at a pressure of 170 ± 10 kgf/cm^2, its safety valve is activated, which ensures the bypass of liquid to drain into the hydraulic tank. In this case, the pumps will operate at high pressure, which will lead to overheating of the fluid in the system.

When the pressure of the common network drops to 120 ± 5 kgf /cm^2, the unloading automat connects the pumps to the common discharge line and the system is charged to a pressure of 155 ± 5 kgf /cm^2.

The brake accumulators charged through the check valve in all cases when the pressure in the common discharge line is higher than the pressure in the accumulator. Discharge of the accumulator into the general network is possible only through the bypass (back-up) valve at a pressure in the accumulator of more than 120 ± 3 kgf /cm^2. This connection of the accumulator ensures its operation both on the general network and on the braking network, emergency hatch and emergency feathering.

When the landing gear is retracted, the ГА-140 valve disconnects the accumulator of the common network from the charging line, excluding the consumption of fluid from the common network to fill the accumulator. This reduces the retraction time of the landing gear, because liquid enters the retraction line simultaneously from a common discharge line and a hydraulic accumulator.

When the landing gear is extended, the fluid consumption briefly exceeds the pump supply due to the effect of the high-speed pressure on the struts. In this case, the pressure in the brake accumulator decreases to 120 ... 3 kgf /cm^2, and in the common network to 30 ... 60 kgf /cm^2 and is restored to 155 ± 5 kgf /cm^2 at the end of the landing gear cycle.

When the pumps are not working, the hydraulic accumulator of the common network can be completely discharged to all consumers. The brake accumulator is also discharged to all consumers, but when the pressure in it decreases to 120 ± 3 kgf /cm^2, the bypass (back-up) valve is triggered, and its further discharge is possible only in the network: wheel braking; opening the lower escape hatch; emergency shutdown of engines with propellers feathering.

2.4 Operation in case of failures and malfunctions

If the pumps of the main hydraulic system do not work, and the system itself is sealed, then an emergency pumping station is used to power it, for which it is necessary:

open the cross-feed valve “КРАН ВКЛЮЧЕНИЯ АВАРИЙН. ДАВЛ. В ОСН. СИСТ.”, located on the control panel of the crew commander;

install the emergency switch. “АВАР. НАСОС. СТАНЦИЯ”, located on the СППД, to the upper position, while the emergency pumping station НС-14 is turned on and the yellow signal lamp lights up.

The pumping station can be used to supply all consumers of the main system. In this case, the time required to perform individual operations increases due to the different performance of the pumps of the main and emergency systems.

On aircraft equipped with a conveyor with a hydraulic drive ГМ-36, in the absence of pressure in the main hydraulic system, emergency discharge of cargo from the emergency pumping station is prohibited due to the low productivity of its pump.

When using an emergency system to supply its consumers, the cross-feed valve must be closed, because. otherwise, the discharge line in the emergency hydraulic system will be connected by the automatic unloader to the drain line, and, consequently, the pressure in it will be close to zero.

In the absence of pressure in the main and emergency hydraulic systems, the manual pump hydraulic system can be used for emergency flap extension and crew escape hatch opening in flight.

Conclusions to part 2

The hydraulic system is an important component for the supply of all components and assemblies associated with the control of the plane. In this section are listed components and assemblies that are directly connected to the hydraulic system. A brief description of each unit and work and table that let sees it all more clearly.

Also provided is a short list of hydraulic deficiencies that were discovered during testing of the aircraft's hydraulic system. In addition, the operation of the system in the event of failures and malfunctions is described.

PART 3. SCIENTIFIC - RESEARCH

3.1 Analysis and calculation of accessibility coefficients of easy removal of hydraulic units

To calculate the availability coefficients $К_д$ and $К_л$ of easy removal, we use the formula:

$$К_д = 1 - \frac{Т_{доп}}{Т_{осн} + Т_{доп}}, \quad (3.1)$$

where:

$Т_{доп}$ - the complexity of additional work, man/hours.

$Т_{осн}$– the complexity of performing the main target work, man/hours.

Coefficient of ease of removal of aggregates and structural elements $К_л$ of the system we can calculate by the formula:

$$К_л = 1 - \frac{\Delta Т_{дм}}{Т_{дм}}, \quad (3.2)$$

Where:

$\Delta Т_{дм}$ - excess complexity dismantling and assembly work on this unit compared to the reference value , man/hours

$Т_{дм}$ - the complexity of dismantling and assembly work on this unit man/hours

Indicators of easy disassembly of increased operational requirements for ensuring the manufacturability of civil aviation were taken as reference values for the labor intensity of disassembly and assembly work when replacing nodes.

Evaluation of the operational suitability of the manufactured hydraulic units according to the coefficient of ease of removal and comparative values (estimated) coefficient of availability:

$$К^{оц}_д = \frac{К^р_д}{К^{эт}_д}, \quad (3.3)$$

where: $К^р_д$- accessibility coefficient aggregate consideration plane.

$К^{эт}_д$- accessibility coefficient reference plane.

In this case, the more important evaluation factor, the better the performance accessibility which is considered in aggregate.

The calculation is made in tabular form (Table 3.1.), only for the main hydraulic units that require replacement during operation.

Data on labor used in the calculation were obtained by flight test operational complex and database normalization operations to replace hydraulic units An-26.

The estimated coefficients and standards of accessibility and ease of dismantling for the main hydraulic units are given in Table 3.1.

3.2 Calculation and analysis of control of the suitability of units and functional zones in the hydraulic system of the An-26 aircraft

Since hydraulic units are not removed from the aircraft during the control of their inoperability, but are checked directly operation of the system, it is recommended to evaluate the suitability of the control according to the formula:

$$K_K = \frac{n_{зам}}{n_{потр}} \quad (3.4)$$

where:

$n_{потр}$ - required parameters necessary for determining the technical condition and troubleshooting of aircraft hydraulic system.

$n_{зам}$ - the number of parameters measured the existing control system and used to determine the technical condition of units and functional areas of the hydraulic system.

3.3 Operational and technological indicators Кл Кд for established hydraulic units

Table 3.1 - Coefficients of hydraulic system

Name, type of unit	The complexity, man/hours.					Кл	K_{∂}^{p}	$K_{\partial}^{эт}$	$K_{\partial}^{оц}$
	Т*доп*	Т*дм*	Т*дм*+*Тдоп*	$T_{дм}^{эт}$	$\Delta T_{дм}$				
Pump agg.623AH	0.27	0.4	0.67	1,1	-0.7	2.75	0.7	0.85	0.823
Filter-Dehydrator 24.5603.290	0.09	0.6	0.69	0.36	0.24	0.6	0.78	0.9	0.86
Hydraulic Accumulator 24.5636.22	0	0.75	0.75	0.55	0.2	0.74	1.1	1.0	1.1
Hydraulic switching unit УГ34/2	0.3	0.8	1.1	0.67	0.13	0.84	0.84	1.0	0.84
Hydraulic tank	0.2	1.6	1.8	0.8	0.8	0.5	0.63	0.8	0.787
Braking system unit	0.4	1.3	1.7	0,9	0.4	0.7	0.69	0.85	0.811
Cylinder retracting and release the front support	0	0.75	0.75	0.45	0.3	0.6	1.0	1.0	1.0
The cylinder retracting and release of main support	1.3	1.1	2.4	0.61	0.49	0.55	0.45	0.95	0.47
Safety valve 638600/Ф	0.2	0.6	0.8	0.5	0,1	0.84	0.87	1.1	0.79

Table 3.2 - Calculation of $K_к$ suitability indicator

Functional area	***Kк***
Plot power I discharge line	0.58
Plot II power discharge line	0.41
The site collection and production of landing gear	0.5
The area of production and assembly of flaps	0.59
Plot braking wheels	0.7
Plot turn the front wheels	0.62
Land management intertceptor	0.8
Plot control door-ladder	0.7

Higher $K_к$ means better suitability of control areas

Analysis of table 3.2, allows to establish that suitability of control functional areas within mean value equals 0.61.

For the final conclusion about the suitability of the existing control system to determine the technical condition of the functional areas and finding faulty hydraulic units, the analysis time of search and removal of whack. Analysis is performed on the main faulty conditions encountered in operation of An-26. The calculation results are summarized in Table 3.3.

Table 3.3 - Main failures

Defective status functional areas	The unit, which led to failure	T *Search* man-hours.	T *Device* man-hours.
Internal hydraulic leakage location	Hydraulic switching unit УГ34/2 Electrohydraulic crane ГА-140 Safety valve 638600/Ф Braking system unit Filter-Dehydrator 24.5603.290	4.3 4.2 1.8 1.5 1.8	0.6 1.4 0.6 0.7 1.2
The rapid drop the pressure in the systems	Hydraulic Accumulator Failure of other units	2.5 4.2	0.8 0.6
External leaks	Hoses, pipelines Other units	1.3 0.4-0.8	0.4 0.1-0.9
No pressure increase in the system	Pump agg.623AH Other units	2.1 3.5	0.9 0.7
Loss of efficiency some units	Individual units	0.1-0.5	0.3 -0.7

3.4 Seal of the lower bearing of a shock-absorber strut

One of faults which frequently meet in operation is leakage oils АМГ-10 on a rod of the shock-absorber. The reason of they be wearing of seals of the lower bearing. At wearing of seals appears leakage liquids from the upper chamber. At a leakage, the pressure buildup of nitrogen in the upper chamber and incomplete compression is possible. In the given activity it is offered to replace existing seal with seal which actuates two fluoroplast rings and two rubber rings of a different degree of hardness.

Fluoroplastic rings do not allow to be extruded to a rubber ring in a gap between a rod and the cylinder of the shock-absorber. Tightness of offered seal is reached due to the installation of two rubber rings with different hardness. On softer rubber ring with a small tension firmer ring is set. In such a way implements constant pressing firmer ring to a cylindrical part of a shock-absorber strut.

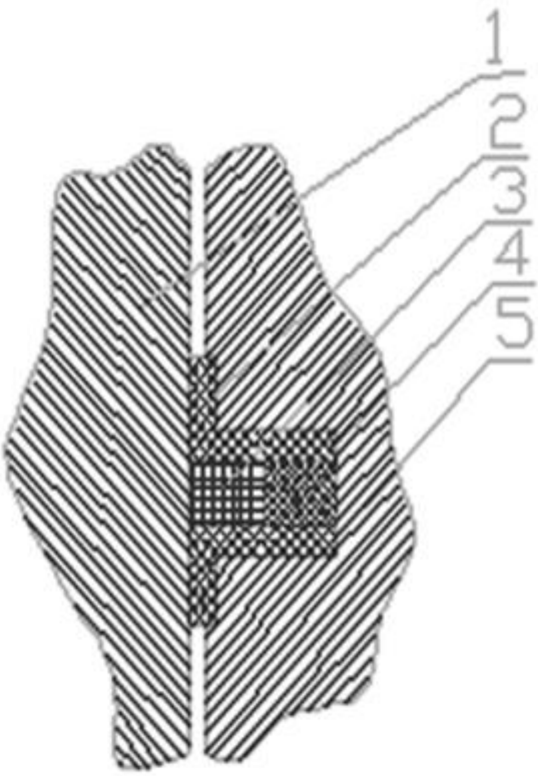

Figure 3.1 - Seals of the lower bearing of the shock-absorber:

1- Shock strut; 2 - fluoroplastic ring; 3 -ring rubber; 4 - ring rubber 5-rod of the shock-absorber

On a measure of wearing of firmer ring, the ring with smaller hardness will extend supporting value of pressing in allowable borders. Such type of seal provides up to 100000 power strokes of a rod of the shock-absorber and seals an interface seal at pressure about 30-50 MPa.

3.5 Operational maintenance and assessment of the hydraulic system

The maintenance of hydraulic and pneumatic systems should be performed in accordance with the aircraft manufacturer’s instructions.

The servicing of hydraulic and pneumatic systems should be performed at the intervals specified by the manufacturer. Some components, such as hydraulic reservoirs, have servicing information adjacent to the component. When servicing a hydraulic reservoir, make certain to use the correct type of fluid.

Contamination, both particulate and chemical, is detrimental to the performance and life of components in the aircraft hydraulic system. Hydraulic systems are inspected for leakage, worn or damaged tubing, worn or damaged hoses, wear of moving parts, security of mounting for all units, safetying, and any other condition specified by the maintenance manual. A complete inspection includes considering the age, cure date, stiffness of the hose, and an operational check of all subsystems

Assessment of the operation of the hydraulic system being made in actual weather conditions during operational service and periodic service after 500 hours of flight.

During maintenance of the hydraulic system, access to such components must be provided:

- threaded joints;

- unit filters;

- panel mount hydraulic units;

- pipelines of brake system;

- hydroaccumulators charger;

- any desired point while survey work areas.

Thus, access through the performance hatches to all units, joints and components that require in control of the operation, adjustment and maintenance, lubrication, mounting and dismounting components and pipelines, both in summer and in winter provided.

The convenience and speed of servicing the hydraulic tank with the working fluid, filling the cavities of the hydraulic accumulators with gaseous nitrogen, the completeness of draining the working fluid from the hydraulic tank and backing up the drainage system is ensured without overflowing and spraying the working fluid.

Controls, signaling and control hydraulic are situated in cockpit provides easy and convenience checks the status and readiness for flight, allowing crew and technical staff objectified cheats serviceability and performance, and time to find rejection.

All aggregates and hydraulic pipes correspond to the type and construction according to their functional purpose, provided with appropriate marking and inscriptions indicating their purpose and operational limitations.

During the system testing, external tightness is ensured. Individual cases of leakage of the working fluid are eliminated by tightening the corresponding connections. There were no cases of destruction of hydraulic pipeline units under the influence of internal and external factors.

During the tests, there was no destruction or performance of structural elements of the hydraulic system due to weathering, corrosion, erosion and abrasion. All compartments in which units and hydraulic pipelines are located are equipped with appropriate means of ventilation and drainage, there is no unacceptable accumulation of moisture, dust and dirt. Under proven operating conditions, the adopted maintenance system ensured reliable operation of both the hydraulic system and its individual components.

Analysis of the search and repair of damage shows that the operating system has sufficient access for a visual inspection of malfunctions and allows the malfunction of only certain parts of the hydraulic system and makes it possible to quickly and accurately identify the malfunctioning parts of the hydraulic system units.

Conclusions to part 3

To choose the optimal maintenance strategy for the hydraulic system of the An-26 aircraft, the ratio availability - operational suitability and the suitability of managing the easily removable system are generally accepted.

With the help of various methods of determining accessibility factors, ease of removal, on the one hand, and other suitability control factors, the calculation and analysis of individual elements of the hydraulic system was carried out. There is a table that summarizes suitability control for various functional areas. The higher the coefficient, the better the suitability of the area.

For a final conclusion on the suitability of the existing control system for determining the technical condition of functional areas and detecting faulty hydraulic units, an analysis of the time of search and repair of damage was carried out.

PART 4. OCCUPATIONAL SAFETY AND HEALTH

4.1 Introduction

The theme of my diploma work is connected with developing methodological bases for maintaining the operational reliability of the hydraulic system of an aircraft. That is why, as a labour precaution subject I have chosen the aircraft technician and an object is aircraft hangar, where an aviation technician specialist spends the most time during his work.

When completing the desired procedures, the technician in charge encounters several challenges. Continued work on hydraulic fluid-containing components and assemblies, or direct usage of it, requires strict compliance with safety regulations and rules for handling hazardous substances to prevent harmful effects on the body.

In this section, we will consider information related to dangerous working conditions and ways to prevent dangerous situations during the performance of official duties.

4.2 List of dangerous and harmful production factors during maintenance of the hydraulic system of the aircraft (ДНАОП 5.130-1.06.98)

During the maintenance of the aircraft, harmful and dangerous factors may appear, which can lead to harmful consequences and injury, complete or partial loss of working capacity of the service personnel.

The following dangerous factors may occur during maintenance of the aircraft:

– increased gassiness and dustiness of the air in the maintenance area;

- moving vehicles, special vehicles and self-propelled mechanisms;

- leakage of gases and liquids from containers and pipelines under pressure;

- increased or decreased temperature of surfaces of aviation equipment, equipment, aggregates and materials;

- high level of noise and vibration;

- insufficient lighting of the working area;

- air humidity in the working area of maintenance of the aircraft;

- cutting edges, burrs and roughness on the surfaces of aircraft, equipment and tools;

- high speed of atmospheric air flows;

- the location of the workplace or work area at a distance of less than two meters from protected drops in height of 1 m to 3 m or more;

- increased voltage of the electrical network during maintenance of aircraft systems;

- speed of movement of special vehicles outside the platforms and parking places of the railway station.

The aircraft maintenance process includes harmful and dangerous production factors that can affect the maintenance personnel. These factors include the occurrence of uncomfortable working conditions associated with the uncomfortable position of the employee during maintenance work:

- maintenance work is often performed in a bent position or sitting;

- increased sliding due to icing or wetting;

- greasing the surface of the platform, where maintenance is performed and on which service personnel move;

- chemicals included in FH-51 or АМГ-10 and mineral oils that enter the body through the respiratory system and skin;

- shock wave (explosion of vessels operating under pressure, liquid vapors);

- highly located parts of the a/c;

- increased level of static electricity.

4.3 Measures to reduce the impact of harmful and dangerous production factors

4.3.1 Safety instructions for working at height (НПАОП 0.00-1.15-07)

Work on parts of the aircraft located high above the ground is carried out by the engineering and technical staff of AMB in special hangars. Only ladders, lifts, and ladders specially designed for this type of aircraft are used for this work. The working areas of the specified lifting devices with a height of platforms and ladders from 1 to 2 meters must have a fence with a height of 100-200 mm on three sides, a height of 2 to 2.5 - fences with a height of 600-800 m on four sides (the bottom side of the fence, on the side input - detachable).

It is possible to use attached ladders. Such ladders must be equipped with rubber tips on the bottom or be pointed, each step must have grooves, on the upper side the ladder must have straps or a special device for the possibility of fastening to the structure of the aircraft (hooks, vacuum suction cups, clamps).

It is forbidden to work on parts of the aircraft that are located high without special safety devices. It is necessary to use safety belts. Each belt must have a tag with a unique number and the date of the next scheduled test. When working on the wing, it is also necessary to use safety nuts. Thanks to this, there is a sufficient opportunity to check the condition of units and their assembly and disassembly without the use of additional lighting. Sealing and control of all hydraulic elements of the system is ensured, thereby eliminating situations of leakage of the working fluid. Units of the electrical system are reliably isolated. This eliminates the possibility of injury due to the action of electric current when the power is on.

4.3.2. Protection against operating noise and vibration

The main sources of aircraft noise are: the power plant, aerodynamic noise flow around the airframe structural elements, wing mechanization elements, landing gear. The aerodynamic noise of the airframe flow exists due to the interaction of the air flow with the structural elements of the aircraft (with the wing, landing gear, wing mechanism, etc.). Jet noise is the most important sound source for supersonic transport aircraft. For helicopters, the main sources of noise are propellers and internal engine sources.

A common noise background for a healthy person is the range of sound pressure with frequencies of 15-36 decibels (dB). With an increase in sound pressure up to 40-70 dB, there is a slight decrease in labor productivity and a deterioration in well-being. Sound pressure in the range of 75-120 dB can cause damage to the hearing organs and the cardiovascular system. Continuous monotonous noise with a sound pressure level above 120 dB can cause acoustic injury (significant hearing loss).

Aircraft noise is regulated by international standards developed within the framework of ICAO. When certifying aircraft with respect to noise, the requirements for acoustic characteristics are regulated: subsonic jet aircraft (depending on the time of filing an application for an airworthiness certificate) - in accordance with section 2 of Appendix 16, supersonic aircraft - in accordance with section 4 of this Law. Annex 16, propeller-driven aircraft in accordance with Sections 5 and 6 of Annex 16 (depending on mass), helicopters - in accordance with Section 8 or 11 (depending on take-off mass) of Annex 16, auxiliary power plants - in accordance with Section 9 of Annex 16.

ДСТУ-Н Б В.1.1-35. establishes the requirements for human protection against the sound power level of noise. It is found that the level of aviation noise exceeds the norm and worsens the quality of life of people who work at the airport/airfield, live near it or near the flight routes, the following measures can be taken:

- installation of sound-reflecting screens;
- use of sound-absorbing materials in the construction of premises;
- changing the train traffic schedule;
- use of individual means of means (headphones, sleeves, tabs, helmets).

In addition, modern scientific and technical developments are aimed at reducing a/c noise. Engineers are calculating various ways to improve the structures, which would make it possible to reduce the noise level of gas turbine engines, the flow of air flowing around the body of the a/c.

4.3.3 Justification of the calculation of illumination and requirements for it.

Bad lighting of the production area can lead to a deterioration in the quality of the performed work, for example, cracks that have appeared, abrasions, fuel and oil leakage, mechanical impurities in the fuel, etc., may remain unnoticed, which, in turn, leads to a decrease in labor safety. Poor lighting in production areas can cause many serious and fatal accidents, such as collisions with moving self-propelled machinery.

Rational lighting must satisfy a number of requirements and conditions. It should be:

- sufficient so that the eyes can distinguish the details under consideration without strain;
- stable - for this purpose, the voltage in the electrical network should not fluctuate by more than 4%;
- evenly distributed on work surfaces so that the eyes do not have to go from a very dark place to a light one and vice versa;
- soft, so it does not cause a blinding effect on the human eye, both from the light source itself and from reflective surfaces in the worker's field of vision. Reducing the reflection of light sources is achieved by using lamps;
- safe - not to cause an explosion, fire in production premises.

4.3.4 Calculation of illumination of the working area

The standard luminance in the laboratory room depending on the condition of the executed work is chosen in accordance with the sanitary regulations of luminance of working surfaces in working environment (ДБН В.2.5-28- 2018), and in our case for the application of luminescent lamps with degree I is E_n = 400 l_x.

The total luminous flux is determined by the formula:

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

where:

E_n - standard lighting, E_n = 400 лк;

S – room area;

k_1 - coefficient taking into account lamp aging and light pollution (k_1 = 1.2);

k_2 - coefficient that takes into account the unevenness of the lighting space (k2 = 1.15);

V - light flux coefficient, which is determined by the reflection coefficient of walls, work surfaces, ceilings, geometry of the room and types of lamps (V – 0.7).

The length of the equipment room A = 15 m, width B = 25 m, the height h = 4 m.

The area of the room is equal to:

S=A·B

S=15·25= 375 (m^2)

$$E_{gen} = \frac{400 \cdot 375 \cdot 1.2 \cdot 1.15}{0.7} = 293348.571\ (lk)$$

Selection of luminous flux ratio coefficients:

1. The reflection coefficient of the ceiling painted with white paint ($R_{Ceiling}$ is 70%);

2. Refractive index of white walls (R_{wall} is 55%);

3. Reflection coefficient of dark floors (R_{floor} = 10%);

4. Space index (i)

The effective height of the room is equal to:

H_p = h - (hw + h_l)

where, h - height of the room, h = 4 m;

hw- the level (height) of the working surface, h_w = 1.5 m;

hl - distance between the lamp and the ceiling, h_l = 0.5 m.

Then: H_p = 4 - (1.5 + 0.5) = 2 m.

The index of the space ***i*,** is given by:

$$i = \frac{A \cdot B}{H_p \cdot (A + B)} = \frac{15 \cdot 25}{2 \cdot (15 + 25)} = 4.6$$

As a lamp, we choose Kanlux Rolso LED15W which provides a color temperature of 4000K, which is similar to daylight. The luminous flux of this lamp is El = 1080 lumens.

The required number of lamps can be determined by the formula:

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

$$\mathrm{N} = \frac{293348.571}{1080} = 271$$

During the calculation, it was found that in order to ensure the illumination rate in the production room of the required size with artificial lighting to ensure work related to the hydraulic system, 271 LED lamps Kanlux Rolso LED15W with a luminous flux of 1080 lumens and a power of 15W should be used.

4.4 Fire and explosion safety in the working area of maintenance of the hydraulic system of the aircraft (ДСТУ 8828:2019, НАПБ А.01.001-2014)

Dangerous factors affecting people and property during a fire are:

1) flames and sparks;

2) increased ambient temperature;

3) toxic products of combustion and thermal decomposition;

4) smoke;

5) reduced oxygen concentration.

Secondary manifestations of oxidizing factors of fire include:

1) debris, parts of aggregates and structures that are collapsing;

2) electric current, which occurs as a result of the transfer of high voltage to current-conducting parts of the structure and aggregates;

3) dangerous factors of an explosion that occurs as a result of a fire;

4) carbonaceous substances.

The main measures to prevent fire on the aircraft:

- isolation of dangerous compartments/objects;

- installation of fire partitions in the compartments;

- effective cooling of overheated parts of the engine and its systems;

- avoiding leakage of system pipelines;

- periodic cleaning of the hangar and parking lots from fuel waste, garbage, waste, etc;

- the maximum possible use of non-flammable and non-flammable materials and substances;

- the maximum possible limitation of the mass of combustible substances and materials and the safest means of their placement;

- use of fire extinguishing means and corresponding types of fire equipment;

- use of automatic fire alarm and fire extinguishing devices.

During the maintenance of the elements of the hydraulic system of the aircraft, there is a need to use fuel and lubricants, varnishes, paints, gases and other substances.

In the manufacture of the hydraulic system of the aircraft, the following materials are used, in which the possibility of fire is inherent:

1) lubricant, which is used to lubricate parts of hydraulic elements before assembling them into assemblies and mechanisms;

2) lubricant used for testing hydraulic system mechanisms;

3) paint materials, etc.

The main measures for fire protection of aircraft:

- serviceability of the fire extinguishing system;

- availability of portable fire extinguishing equipment both at the station and at the maintenance sites;

- parking lots and hangars must be equipped with a centralized fire extinguishing system and/or special shields with fire-fighting equipment.

In the process of maintenance and repair of the hydraulic system, it is forbidden to open the caps of tanks with flammable liquids, hitting them with mechanical objects, use open flames and smoke at the places where hydraulic systems are filled.

In the event of a fire, there is an alarm about its presence and automatic activation of the fire extinguishing system, and it is also possible to use manual fire extinguishers.

There are such fire extinguishers:

1) ВП–8Б, , ВП–10 – hand chemical foam fire extinguishers:
2) ВВК 1.4, ВВК 3.5 – hand carbon dioxide fire extinguisher;
3) ВПП–10 and ВПП–5 – hand air-foam fire extinguishers;
4) ВВБ–3 and ВВБ–7 – hand ethyl bromide, carbon-dioxide fire extinguishers are designed to extinguish small sources of fire of fuel materials.

Conclusions to part 4

In the section "Occupational safety and health" there is a list of dangerous and harmful factors that may arise during maintenance of aircraft. After the analysis of dangerous and harmful factors arising during maintenance of the aircraft, namely its hydraulic system, specific and constructive safety requirements for maintenance processes were developed, which will increase the safety and efficiency of the engineering staff of the aviation technical base. The developed set of requirements excludes injuries and improves the health and working conditions of technical personnel when servicing aircraft airframe.

The impact of workplace lighting on the safety of workers' performance of duties was considered, the main aspects and the most beneficial sources of lighting were determined. The calculation of the required number of lamps for lighting a medium-sized workplace was carried out. As a result, the obtained data shows that chosen lamp appliance satisfies the norms for high accuracy work.

In addition, during the work on this section, the issue of fire safety was considered, the main concepts and possible sources of fire spread, methods of fire fighting and the necessary means of distinguishing equipment that should be at workplaces were defined.

CHAPTER 5. ENVIRONMENTAL PROTECTION

5.1. Analysis of aviation impact on environment

Aviation impacts the environment because aircraft engines emit noise, particulates, and gases, contribute to climate change and global dimming. Despite emission reductions from automobiles and more fuel-efficient and less polluting turbofan and turboprop engines, the rapid growth of air travel in recent years contributes to an increase in total pollution attributable to aviation. In the EU, greenhouse gas emissions from aviation increased by 87% between 1990 and 2006.

There is an ongoing debate about possible taxation of air travel and the inclusion of aviation in an emissions trading scheme, with a view to ensuring that the total external costs of aviation are taken into account.

Like all human activities involving combustion, most forms of aviation release carbon dioxide (CO2) into the Earth's atmosphere, very likely contributing to the acceleration of global warming. Exceptions include hang gliding, paragliding, winch-launched gliders — where the winch is not powered by fossil fuels — and human- or other non-combustion powered flight.

In addition to the CO2 released by most aircraft in flight through the burning of fuels such as Jet-A (turbine aircraft) or Avgas (piston aircraft), the aviation industry also contributes greenhouse gas emissions from ground airport vehicles and those used by passengers and staff to access airports, as well as through emissions generated by the production of energy used in airport buildings, the manufacture of aircraft and the construction of airport infrastructure.

While the principal greenhouse gas emission from powered aircraft in flight is CO2, other emissions may include nitric oxide and nitrogen dioxide, (together termed oxides of nitrogen or NOx), water vapor and particulates (soot and sulphate particles), Sulphur oxides, carbon monoxide (which bonds with oxygen to become CO2 immediately upon release), incompletely-burned hydrocarbons, tetra-ethyl lead (piston aircraft only), and radicals such as hydroxyl, depending on the type of aircraft in use.

The contribution of civil aircraft-in-flight to global CO_2 emissions has been estimated at around 2%. However, in the case of high-altitude airliners which frequently fly near or in the stratosphere, non-CO_2 may increase the total impact on anthropogenic (man-made) climate change significantly — this problem is not present for aircraft that routinely operate at lower altitudes well inside the troposphere, such as balloons, airships, helicopters, most light aircraft, and many commuter aircraft.

Subsonic aircraft-in-flight contribute to climate change in four ways:

• Carbon dioxide (CO_2)

CO_2 emissions from aircraft-in-flight are the most significant and best understood element of aviation's total contribution to climate change. The level and effects of CO_2 emissions are currently believed to be broadly the same regardless of altitude (i.e they have the same atmospheric effects as ground based emissions). In 1992, emissions of CO_2 from aircraft were estimated at around 2% of all such anthropogenic emissions, though CO_2 concentration attributable to aviation in 1992 was around 1% of the total anthropogenic increase, because emissions occurred only in the last 50 years.

• Oxides of nitrogen (NO_x)

At the high altitudes flown by large jet airliners around the tropopause, emissions of NO_x are particularly effective in forming ozone (O_3) in the upper troposphere. High altitude (8-13km) NO_x emissions result in greater concentrations of O_3 than surface NO_x emissions, and these in turn have a greater global warming effect. The effect of O_3 concentrations are regional and local (as opposed to CO_2 emissions, which are global).

NO_x emissions also reduce ambient levels of methane, another greenhouse gas, resulting in a climate cooling effect. But this effect does not offset the O_3 forming effect of NO_x emissions. It is now believed that aircraft Sulphur and water emissions in the stratosphere tend to deplete O_3, partially offsetting the NO_x-induced O_3 increases. These effects have not been quantified. This problem does not apply to aircraft that fly lower in the troposphere, such as light aircraft or many commuter aircraft.

• Water vapor (H2O)

Very large aircraft-in-flight at high altitude emit water vapor, a greenhouse gas, which under certain atmospheric conditions forms contrails. Contrails are visible line clouds that form in cold, humid atmospheres and are thought to have a global warming effect (though one less significant than either CO2 emissions or NOx induced effects). Contrails are extremely rare from lower-altitude aircraft, or from propeller aircraft or rotorcraft.

Cirrus clouds have been observed to develop after the persistent formation of contrails and have been found to have a global warming effect over-and-above that of contrail formation alone. There is a degree of scientific uncertainty about the contribution of contrail and cirrus cloud formation to global warming and attempts to estimate aviation's overall climate change contribution do not tend to include its effects on cirrus cloud enhancement.

• Soot and aerosols

Sulphate aerosols and soot from combustion also have small temperature effects on the atmosphere. Traces of sulphur are present in fuel oil, and form aerosols of sulphate compounds. These reflect incoming solar radiation back into space and so have a small cooling effect. Conversely, small particulates produced from combustion (soot) trap outgoing infrared radiation within the atmosphere and so have a small warming effect. These are both poorly quantified but are believed to be small effects that roughly cancel each other out.

5.2 Negative impact of the operation of aircraft and its systems on the environment

For today, the environmental issues of AC use are more acute than ever. Not surprisingly, the consequences of human technological advances are so obvious that they are difficult to overlook. By conquering the skies, we have forgotten our impact on nature and the environment. Of course, air contact is not the most polluting activity in the human environment.

Consequences of almost all human environmental activities. However, because habitats are directly related to the environment, it is not all that people who pollute the environment are poisoning themselves. Therefore, our task is not only to develop new alternatives, but also the environment.

AC emits toxic gases from airport belts and airport engines. Gas turbine engine exhaust components include the following main components: carbon monoxide, hydrocarbons (methane CH4, acetylene C2H2, ethane C2H6, ethylene C2H4, propane C3H8, benzene C6H6, toluene C6H5CH3, etc.), nitric oxide, alkaline oxide, aldehyde, aldehyde CH2 = CH = CHB, acetaldehyde (CH3CH, etc.), sulfur oxides, soot (smoke lamps visible behind engine nozzles), benzopyrene.

Running a turbojet or turbocharged engine for 1 minute releases 2-4 mg of carcinogens into the atmosphere, mainly benzopyrene. ICAO regulations do not allow the release of draining fuels into the AC atmosphere, so they should be excluded during the design of new AC motors and variables.

The noise situation of the airline and the surrounding area is determined by many sources of noise, the main of which are AC power plants and special vehicles for airport services for various purposes. In the territory of most airlines and in the territory of the airline, the noise created by the aviation facilities is predominant, and the reduction affects the interests of a large number of people.

The main source of engine noise is the fan. The main components of propeller noise are rotational noise and spiral. 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. Whirlwind noise occurs when there are racks and other obstacles flowing around, and turbulent noise is the sound of the interaction of the gas flow with the walls of the duct, 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.

Advances in science and technology have created an artificial electromagnetic field, the source of which is the transmitters of radar, radio navigation, and broadcasting stations. The amount of electromagnetic radiation emitted by these devices exceeds the natural area several times and affects human health.

Medical and biological studies have shown that the degree of exposure to heavy electromagnetic fields depends on the frequency range, radiation intensity, nature, and duration of exposure.

The nervous system is the most vulnerable to electromagnetic fields and its changes have been observed. The changes are characterized by conditioned reflex function disorders, electroencephalogram transitions, and pathomorphological disorders of the brain and spinal cord. Electromagnetic fields radio frequencies directly affect the structure of the anterior lobe and interstitial brain, the nature of some biomechanical changes that cause conditioned reflex function, and the course of neural processes. Changes in the nervous system affect the functioning of the cardiovascular, endocrine and other systems. The effect of electromagnetic fields causes cataracts in the eye - blurring the lens..

The economic activities of airlines are related to AC services and contribute to the deterioration of environmental conditions.

As a result of such operations in apron areas, parking lots, as well as hangars and large airports, up to 40 tons of hydrocarbons, solar, organic and mineral oil washing chemicals and phenols enter the soil per hour. The cause of such effects on the soil is the loss of fuel and lubricants during AC charging. However, not only does the soil spill flammable lubricants, it is also damaged by air.

The number of losses should be reduced to minimize damage to the soil and atmosphere.

5.3 Calculation of the emissions of carbon monoxide and nitrogen oxides by aircraft engines

Aircraft is transient organized sources of exhausts of harmful substances (HS) into atmosphere air. In accordance to the norms of ICAO there are regulated exhausts by aviation engines of the following harmful substances:

- carbon monoxide (CO);
- carbon compounds, which didn't burn (C_xH_y);
- nitrogen oxides (NO_x)
- smoke in the form of carbon solid particles, which didn't burn.

The aim of the part is calculation of the weight of HS, which get into the atmosphere during engine operation in the zone of the airport.

Emission of HS with exhaust gases depend on emission characteristics of the engine, modes of its operation on different stages. Weight of HS exhausts in the zone of the airport is calculated in one take-off-landing cycle (TLC), which parameters are determined by ICAO.

Aircraft take-off-landing cycle that is made in the zone of the airport consists of the following stages:

- start and warming up of the engines;
- taxiing on the start;
- take-off;
- climbing to the height of 1000 m;
- landing;
- taxiing to the stop of the engines.

But aircraft engines on these stages work on different modes. That's why for convenience of calculation take-off-landing cycle of the aircraft is divided into two kinds of the operations:

- ground operations;
- operations take-off - landing.

$$M_i = M_{ig} + M_{it\text{-}l} \qquad (5.1)$$

Ground operations are engines start, their warming up, taxiing of the aircraft before take-off and after landing.

This circumstance simplifies calculation.

Determination of M_{ig} is made by the formula:

$$M_{ig} = K_{ig} \cdot G_{fg}, \qquad (5.2)$$

where K_{ig} – coefficient of exhaust of i-th ingredient during ground operations (kg_{ingr}/kg_f).

It is evident that $K_{ig} = 10^{-3} \cdot EI_{ig}$ (by definition, it is the same index of emission). Like EI_i, K_i is determined during certification tests of the engines.

G_{fg} – fuel weight, which is spent by the engine during ground operations of take- off- landing cycle:

$$G_{fg} = C_{sp\ idle} \cdot R_{idle} \cdot t_{idle}. \qquad (5.3)$$

where $C_{sp\ idle}$ – specific fuel consumption during the engine operation on the idle mode (it is given in the log book of the engine as its one of the most important technical characteristics);

R_{idle} – engine thrust on the idle mode (it is given in the log book of the engine as its one of technical characteristics);

t_{idle} – time of operation on the idle mode.

Operations take-off - landing are take-off, climbing to the height of 1000 m and landing. In this case of calculation of aircraft engine emission, which is in the air, emission characteristic is weight speed of the emission W_i (not index of emission), which shows how much harmful substance is exhausted on the given operational mode during time unit. W_i is determined during certification tests of the engine.

Then determination of $M_{it\text{-}l}$ is performed by the formula:

$$M_{it\text{-}l} = W_{i1} \cdot T_{1t\text{-}l} + W_{i2} \cdot T_{2t\text{-}l} + W_{i3} \cdot T_{3t\text{-}l}, \qquad (5.4)$$

where $W_{i1,2,3}$ – weight speed of ingredient emission in correspondent engine operational modes: take-off, climbing to the height of 1000 m and descend from the height of 1000 m;

$T_{1,2,3}$ – mode time of the engine correspondently on take-off, climbing to the height of 1000 m and descend from the height of 1000 m.

Values t_{idle} are got from the table of the modes of engine operation in the zone of the airport. After calculation of $M_i = M_{ig} + M_{it\text{-}l}$ it is necessary to calculate control parameter of the engine emission $\frac{M_i}{R_0}$ (R_0 – take-off thrus) and it is compared with ICAO norms, then it is made conclusion about correspondence of given engine to modern requirements of emission in relation of given ingredient.

Initial data for calculation:

R_0 = 105.21 kN;

R_{idle} = 14.72 kN;

Specific fuel consumption on idle mode $C_{sp\ idle} = 0.046\ \frac{kg}{N \cdot h}$.

Emissions of CO and NO_x at the airport zone are calculated for takeoff and landing cycle. Characteristics of regimes and their duration are given in Table 5.1.

Table 5.1 - The typical takeoff and landing cycle of aircraft engine power conditions

Number of regime	Characteristics of regimes	Relative thrust $\overline{R}$	Duration of regime ***t***, min
1	Start, idle running before takeoff (regime of low gas)	0,07	15,0
2	Takeoff	1,0	0,7
3	Climb	0,85	2,2
4	Approach landing from a height of 1000 m	0,3	4,0
5	From landing taxiing (regime of low gas)	0,07	7,0

1. Define values of coefficient K_{ig} of harmful substances exhaust during ground operations of the engine and weight speed of ingredient emission W_i:

   $K_{CO} = 0.0277\ kg_{ingr}/kg_f$;

   $K_{CxHy} = 0.0029\ kg_{ingr}/kg_f$;

   $K_{NOx} = 0.0055\ kg_{ingr}/kg_f$.

2. Determination of fuel weight, spent by the engine during ground operations of take-off - landing cycle according to the formula 5.3:

   $G_{fg} = 14720 \cdot 0.046 \cdot 0.4 = 270.848$ kg.

3. Determination of harmful substances weight, thrown by the engine during ground operations according to formula 5.2:

   $M_{CO\ g} = 0.0277 \cdot 270.848 = 7.51$ kg;

   $M_{CxHy\ g} = 0.0029 \cdot 270.848 = 0.78$ kg;

   $M_{NO\ g} = 0.0055 \cdot 270.848 = 1.48$ kg.

4. Determination of harmful substances weight, thrown by the engine during take- off - landing operations according to formula 5.4:

   $M_{CO\ t\text{-}l} = 12.5 \cdot 0.0117 + 11 \cdot 0.0367 + 20.5 \cdot 0.067 = 1.923$ kg;

   $M_{CxNy\ з\text{-}п} = 0.5 \cdot 0.0117 + 0.65 \cdot 0.0367 + 0.55 \cdot 0.067 = 0.066$ kg;

   $M_{NO\ з\text{-}п} = 110 \cdot 0.0117 + 85 \cdot 0.0367 + 10 \cdot 0.067 = 5.076$ kg.

5. Determination of harmful substances weight, thrown by the engine during take- off - landing cycle according to formula 5.1:

   $M_{CO} = 1.923 + 7.51 = 9.425$ kg;

   $M_{CxHy} = 0.066 + 0.78 = 0.852$ kg;

   $M_{NOx} = 5.076 + 1.48 = 6.566$ kg.

6. Definition of control parameter of emission and comparison it with ICAO norms:

   $M_{CO}/R_0 = 9.425/105.21 = 89.6\ g/kN < 118\ g/kN$;

   $M_{CxNy}/R_0 = 852/105.21 = 8.09\ g/kN < 19.6\ g/kN$;

   $M_{NO}/R_0 = 6566/105.21 = 62.41\ g/kN < 80\ g/kN$.

Based on the results of calculations, we can conclude that our engine fully complies with ICAO tandarts according to Control emission parametrs for modern engines:

$M_{CO} / R_0 = 118$ ***g/kN***, $M_{NOx} / R_0 = (40...80)$ ***g/kN***

Conclusions to part 5

In connection with the ever-increasing impact on the man-made environment, the problem of its protection is one of the most acute and includes many aspects. Recently, the issue of environmental protection has become increasingly common. Gradually, it became a global problem, and every day this issue is becoming more and more relevant.

The reason for this situation is various anthropogenic factors. This is a demographic explosion, rapid growth of urbanization, etc. The human factor also has a great impact on the environment: disposal of waste, pollution of water bodies and forests, increasing the load on arable land - all this is the work of man.

Reducing fuel consumption and CO2 emissions is becoming a priority for the development of aviation technology, according to a large number of innovations and developments in this field in recent years. Moreover, aviation has progressively improved its environmental performance. Fuel economy, which is one strong indicator of environmental performance, has consistently improved. Aircraft engines have gotten more efficient and been designed with environmental performance in mind. Regulatory frameworks have developed to constrain emissions growth from many aviation sources. And increasing the efficiency of the complex aviation network will have a positive effect on the environment over time.

GENERAL CONCLUSIONS

The aircraft hydraulic system is designed to control the mechanisms and systems responsible for flight safety. The durability, survivability and reliability of the hydraulic system are guaranteed by the perfection of the design of the units, the multiple redundancy of the power source as a hydraulic drive, the automation of the control and the control of the crew.

To select the optimal maintenance strategy for the hydraulic system of the An-26 aircraft in the form of a relationship of availability: operational suitability and control suitability of an easily removable system, statistical data on failures and malfunctions of the system units were collected.

With the help of various methods for determining availability coefficients, ease of removal and other suitability control factors, the calculation and analysis of the individual elements of the hydraulic system was carried out.

For the final conclusion on the suitability of the existing control system to determine the technical status of functional areas and identify faulty hydraulic units, an analysis of the search time and damage removal was performed.

After analyzing the statistical data on failures and malfunctions, the weak points of the system and their shortcomings were identified. These are the components of the system that require special attention when carrying out maintenance and determining the technical condition of the system.

In the section responsible for labor protection, a list of dangerous and harmful factors that may arise during the maintenance of aircraft was considered. Based on this data, specific and design safety requirements for maintenance processes have been developed that will improve the safety and efficiency of the aviation technical personnel of the aircraft maintenance base.

In the part that correspond for environmental protection, the negative aspects associated with the aviation industry were considered. These include emissions of carbon monoxide and nitrogen oxides from aircraft engines, the negative impact of the operation of aircraft and their systems on the environment. Possible ways to reduce their negative impact were also considered.

REFERENCES

1. Dmitriev S.O. Technical operation of aircraft / S. Dmitriev, O. Tuharinov, A. Rugain, Yu. Kazarinov // Manual. – К: НАУ, 2014. – 192 с.

2. Dmitriev S.O. Continuing Aircraft Airworthiness / S. Dmitriev, O. Tuharinov, A. Rugain, Yu. Kazarinov // Manual. – К: НАУ, 2015. – 104 с.

3. Aircraft Technical operation: Laboratory work / Compilers: T 382 M. F. Molodtsov, O. V. Rugain, I. S. Kozeletska, D. V. Popov. – K. : NAU, 2019. – 72 p.

4. Zhuravlova L.A. Aviation Maintenance Technician Handtools / L.A. Zhuravlova, A.S. Kryzhanovsky, O.V. Rugayn, P. Chamegh, A. Eyo // Theory Guide. – К.: Osvita Ukrainy, 2013. – 90 p.

5. Літак Ан-26. Посібник з технічної експлуатації. Частина 4. Гідравлічна система.

6. Виробництво, технічне обслуговування та ремонт повітряних суден та авіадвигунів: методичні рекомендації до виконання дипломних робіт (проектів)/ уклад. В.Г. Докучаєв, О.В. Попов. – К.: Вид-во Національного авіаційного університету «НАУ – друк» , 2010. 48с.

7. Технічне обслуговування та ремонт повітряних суден та авіадвигунів: методичні рекомендації до виконання кваліфакаційних магістерських робіт/ уклад. О.В. Попов,В.І. Закієв,С.І. Йовенко, А.М. Хімко – К.: Вид-во Національного авіаційного університету «НАУ – друк» , 2021р. 44с.

8. Смірнов Н.Н. і ін. Технічна експлуатація літальних апаратів.- М.: Транспорт, 1990.

9. Комаров А.А. Надійність авіаційної техніки.КМУГА.1997.

10. Башта Г.М., Бабинський В.Д., Головко Ю.(і ін.). Надійність ГС.ВР. М.Транспорт.1986.-278с.

11. Охорона праці в авіації – Буріченко Л. А.Гулевець В.Д,Вид - во НАУ, 2003.–448с.

12. ДНАОП 5.1.30-1.06-98 Правила безпеки праці при технічному обслуговуванні і поточному ремонті авіаційної техніки

13. ДСТУ 2293-99 Охорона праці. Терміни та визначення основних

понять.

14. ДСН 3.3.6.037-99 Санітарні норми виробничого шуму, ультразвуку та інфразвуку.

15. *НПАОП* 63.23-1.02-08 Правила безпеки праці під час обслуговування спецтранспорту та засобів механізації в аеропортах цивільної авіації. - Держгірпромнагляд України, 2008.

16. *НПАОП* 62.0-7.13-78-ОСТ 54 72001-78 Шум. Общие требования безопасности труда в эксплуатационных предприятиях гражданской авиации. - Министерство гражданской авиации от 14.06.78 № 72/1—599.

17. *НПАОП* 62.0-3.01-08 Норми безплатної видачі спеціального одягу, спеціального взуття та інших засобів індивідуального захисту працівникам авіаційного транспорту. – Держгірпромнагляд України від 25.03.2008 № 57.

18. *НПАОП* 63.23-1.06-98 Правила безпеки праці при технічному обслуговуванні і поточному ремонті авіаційної техніки. - Держнаглядохоронпраці України - 18.05.1998. Наказ № 92.

19. *ДСН* 3.3.6.042-99 Санітарні норми мікроклімату виробничих приміщень. - :МОЗ України, 1999. Скасовує ДНАОП 0.03-3.15-86

20. *Christian N. Jardine*. Calculating the Environmental Impact of Aviation Emissions. - Oxford: University of Oxford, 2005.

21. *Green JE.* Civil aviation and the environmental challenge. – Aeronautical Journal 107: 281-99, 2003.

22. International standards and recommended practices. Environmental protection. Annex 16 to the convention on international civil aviation. Volume 2. Aircraft engine emission. First edition – 1981, 60p.

23. International Civil Aviation Organization, Air Transport Bureau (ATB) (undated). "Aircraft Engine Emissions". Retrieved 2008-03-19

24. Law of Ukraine “On Air Protection” (enacted by parliament decree № 2708 ВР-XII (2708-12) of 16.10.92, the, BD, 1992, № 50, p. 679).