**MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE**
**NATIONAL AVIATION UNIVERSITY**
**DEPARTMENT OF AIRCRAFT DESIGN**

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**MASTER THESIS**

**ON SPECIALITY**

**"AVIATION AND SPACE ROCKET TECHNOLOGY"**

**Topic: «Concept of medical air transport»**

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«____»___________2020 year

**TASK**

**for the master thesis**

**ANDRUSHCHENKO DMYTRO OLEKSANDROVICH**

1. Topic: «**Concept of air medical transport**»,

approved by the Rector’s order № 1906/ст from 5.10.2020 year.

2. Period of work execution: from 5.10.2020 year to 13.12.2020 year.

3. Initial data: cruise speed $V_{cr}$= 430 km/h, flight range L = 1800 km, operating altitude $H_{op}$ = 6 km, max cargo weight is 5500.

4. Content: analysis of problems during transportation of injury people in the fuselage, methodology, preliminary design of an aircraft as an object of research, development medical container, analysis of hazardous and harmful production factors, calculation of noise pollution from aviation.

5. Required materials: general view of the airplane (A1×1); layout of the airplane (A1×1); general view of medical container (A1×1).

Graphical materials are performed in Auto Cad, Excel.

6. Thesis schedule:

| № | Task | Time limits | Signature |
|---|---|---|---|
| 1 | Task receiving, processing of statistical data | 5.10.2020-10.10.2020 | |
| 2 | Literature rewiev | 11.10.2020 – 15.10.2020 | |
| 3 | Aircraft take-off mass determination | 16.10.2020 –18.10.2020 | |
| 4 | Aircraft layout | 19.10.2020 – 25.10.2020 | |
| 5 | Aircraft centering determination | 26.10.2020 – 1.11.2020 | |
| 6 | Graphical design of the parts | 02.11.2020 – 8.11.2020 | |
| 7 | Calculation of medical container | 9.11.2020 – 13.11.2020 | |
| 8 | Completion of the explanation note | 29.11.2020 – 5.12.2020 | |

7. Special chapter consultants:

| Chapter | Consultants | Date, signature | |
|---|---|---|---|
| | | Task Issued | Task Received |
| Labor protection | O.V. Konovalova | | |
| Environmental protection | L.I. Pavliukh | | |

8. Date: “_____”_____________2020 year.

Supervisor: _______________ **T. P. Maslak**

Student: _______________ **D.O. Andrushchenko**

# ABSTRACT

Explanatory note to the diploma work «Concept of medical air transport» contains:

95 sheets, 8 figures, 10 tables, 8 references and 3 drawings

Object of the design is development of medical aircraft with medical containers.

Aim of the diploma work is the preliminary design of the medical aircraft and its design characteristic estimation.

The method of design is analysis of the prototypes and selections of the most advanced technical decisions.

The diploma work contains drawings of the short-range aircraft up to 5,5 tons of cargo, calculations and drawings of the aircraft layout, sanitary tape and medical container.

**AIRCRAFT, PRELIMININARY DESIGN, LAYOUT, CENTER OF GRAVITY POSITION, SANITARY TAPE, MEDICAL CONTAINER**

**CONTENT**

# INTRODUCTION

We are living in the age when there are many wars (Donbas, Yemen, wars in African countries).

For such purposes, it need to analyze and understand that military equipment will always be needed, especially rescue and evacuation aircraft (since it can also be used in peacetime, for example, in case of natural problems).

In my graduate work, I want to analyze, create and design a medical aircraft that will contain a medical container with everything necessary to save a person's life and first aid.

The aircraft is created on the basis of cargo aircraft. The peculiarity of a cargo plane is that it is designed to carry cargo, has a large capacity and can be perfectly used for re-equipment and placing of a medical container.

The purpose of this work is to develop a concept and appropriate technical solutions for the rearrangement of a cargo aircraft into a medical aircraft.

Attention to the topic of diploma work is due to the fact that in Ukraine carried out in this direction, which are relevant in world aviation.

To achieve the aims of the work it is necessary to solve the following tasks:

- to analyze modern medical aircraft;
- consider the requirements for the placement of medical equipment and ensure their operation on board the aircraft;
- to develop the preliminary design of the plane, to carry out calculations of geometrical characteristics of the new plane, calculation of weights, range of centerings, general technical characteristics;
- to offer design solutions for the installation of medical equipment on board the designed aircraft.

The diploma work considers the issues of labor protection and environmental protection. Separately, analyze of harmful and dangerous production factors and noise pollution.

# GENERAL DESCRIPTION MEDEVAC AIRCRAFT

## 1.1 Analyze of existing medevac aircraft

The beginning of air medical transport date back to the late 18th century, where hot air balloons took place into moving patients off the battlefield. This method of patient transportation hadn't been successful during 90 years. The first report of successful air transport of patients comes from the Siege of Paris in 1870, where patients were transported from the battlefield to hospitals via hot air balloons.

The Wright Brothers' development of the first flying and successful fixed-wing airplane in 1903 opened the door for significant progress in air medical transport. Less than 15 years after that first flight, in 1917, the first successful fixed-wing patient transport was conducted in Turkey using a French Dorand AR 2 aircraft. The following year, two U.S. Army officers converted a Curtiss JN-4 biplane into an air ambulance (figure 1.1).

Figure 1.1 - Curtiss JN-4 medical

Following World War, I, there was additional development of air ambulance services, and in 1928, the Royal Flying Doctor Service was established in Queensland, Australia.

Continuing advances in military aviation allowed for dedicated air medical evacuation units on fixed-wing aircraft in 1943.

The United States saw the first U.S.-based, Federal Aviation Administration-certified, air ambulance established in Los Angeles, California, in 1947.

The first half of the 20th century saw rapid development of air medical transport capabilities. Keeping with advances in military science, the U.S. Air

Force piloted a team approach to critical care air transport in 1994 at the 59th Medical Wing at Lackland Air Force Base, calling it the critical care air transport team.

As civil air medical evacuation transport is increasingly used, there is need to learn from previous experiences, both military and civilian, and improve processes, patient care and patient outcomes.

In this part of the section, I would like to analyze the scientific articles of M.C.M. Bricknell, A.G. Johnson (UK), namely "Forward Medical Evacuation", where they discuss the principles of medical evacuation planning and execution with specific consideration of the command and control arrangements for Forward medical evacuation [1].

Aeromedical evacuation (AE) usually refers to the use of military transport aircraft to carry wounded people.

Helicopter is suitable for the best option for rescue and evacuation operations. In current operations MEDEVAC is almost invariably undertaken by helicopters. The assignment of aircraft to the aeromedical mission may be ‘dedicated’ in which the particular airframe is role specific and cannot be used for other general tasks. This might include the display of the Red Cross, modifications to take stretchers and medical equipment and fitting of specific capabilities such as a winch. This is likely to result in an aircraft most suitable for the medical mission but with a risk of non-availability. An alternative is to have designated aircraft in which a general support aircraft is assigned to the task but may be re-assigned to other tasks. This gives more flexibility as the capability can be transferred to another aircraft if the designated aircraft becomes unavailable. The difference between ‘dedicated’ and ‘designated’ has been a contentious issue in the UK but need to be considered in the context of managing aircraft fleets rather than single aircraft capabilities.

The exact type of aircraft for rotary wing (RW) aeromedical evacuation varies by nation according to the performance, volume and protection requirements. As an example the UK has used the Puma and Sea King helicopter for this role in the Balkans, the Merlin helicopter in Iraq and the Chinook in Afghanistan. The US Army invariably uses the UH-60A which is marked with the Red Cross but has limited protective firepower. At the same time, the article also states that the US Air Force has a specialist aircraft the HH-60 which has a substantial night operations and protective firepower capability but does not display the Red Cross. This capability has a priority task for ‘personnel recovery’ but is primarily employed within Afghanistan to support MEDEVAC. There is also significant variation in the number and training of the medical escorts between these capabilities.

The UK standard is now the Medical Emergency Response Team comprising a paramedic and a flight nurse or the enhanced when a doctor trained in pre-hospital care is added to the team. Recent experience of opposition anti-helicopter tactics in Afghanistan has led to the requirement for a ‘gun-ship’ escort for MEDEVAC aircraft. Thus the MEDEVAC mission should be considered as aviation ‘task line’ of a minimum of two aircraft rather than just the aircraft assigned to the MEDEVAC function.

Accordingly, the previously studied variants, I picked up several aircraft that are technically similar to each other. It is necessary to analyze two domestic aircraft (namely, the aircraft were manufactured at the Antonov factory) and one foreign Brazilian aircraft.

ATR 72 Avions de Transport Regional Model 72 was founded in 1981. It has over 450 types of design. The design has seen service in both civilian and military sectors in The Pakistan Navy, Italian Air Force and The Turkish Navy. The main advantage that ATR 72 is sported a large cargo door for improved access.

An-148-201EM (figure 1.2) It has 24 sanitary stretchers and 8 medical modules. Its main advantage is that its stretchers are attached only to the floor, and not to the wall of the fuselage. Because of this, it can be quickly design it back to a cargo aicraft. Because of its size, it is convenient to operate it over long distances, up to 4,400 km. The presence of medical modules also allows for operations on board the aircraft.

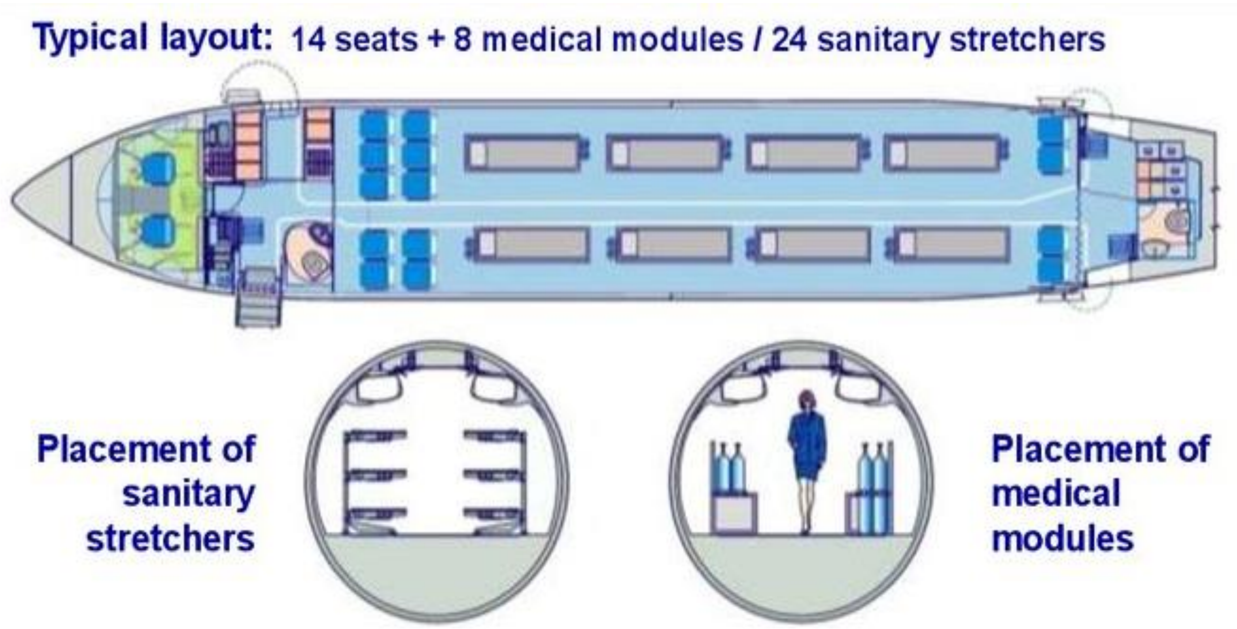



Figure 1.2 - An-148-201EM layout

Lockheed Martin C-130J Super Hercules It is one of the most important aircraft to emerge (the C-130 has been flying for over sixty years), a medium-class tactical transport used a high-wing layout and quadruple engine arrangement for excellent short take-off and landing capabilities. It can sustain up to 74 patient litters and accompanying medical staff numbering five.

Embraer KC-390. KC-390 is tactical transport aircraft developed by the Brazilian company Embraer. Compared with the C-130J, the KC-390 will be 15% faster, 18% more load-carrying and cost the customer 59% of the cost of the C-130. The KC-390 has a spacious, rectangular cargo compartment, typical of medium-sized and tactical transporters, occupying most of the length of the aircraft.

## 1.2 Medical aircraft requirements

Historically, aviation has developed in parallel in the military and civilian fields. Correspondingly, we have two types of medical rescue aircraft (medevac) - a civilian aircraft carrying seriously ill patients in peacetime and a military transport aircraft converted into a medical rescue aircraft for transporting wounded soldiers and providing them first aid.

The need to move ill or injured patients from one location to another by air isn't a new concept. Injured soldiers were among the first patients in history to be transported by air to a medical facility, beginning with the use of hot air balloons in 1784.

Since fixed-wing aircraft were developed in 1903, the use of these engineering marvels for patient transport has seen incredible advances.

Although an invaluable resource, in addition to the medical care required on the ground, there are important physiologic changes that occur at higher altitudes and must be considered by the transport personnel.

Some of the physiologic changes include, but aren't limited to, development of hypoxia, potential for gas expansion, and effects of gravitational forces. These impacts on patient homeostasis must be addressed prior to patient movement to ensure patient safety and provide for the best patient outcomes.

Patients with critical illness are at increased risk of morbidity and mortality when exposed to the stresses of air medical transport. Researchers report that "between 24 and 70% of transferred patients are inadequately stabilized prior to and during transfer."

Therefore, appropriate pre-flight patient preparation is imperative to patient safety and successful patient transport.

Knowledge of aerospace medicine and physics are vital information for air medical transport personnel. As reported, "keys to successful aeromedical evacuation are planning for and responding to any deterioration in the condition that mandated urgent transport and to conditions induced by the aerospace environment."

What about aerospace physiology, there are several physiologic areas of the atmosphere that become relevant. The efficient area is defined from sea level to 3000 meters above see level. In this area, oxygen level are usually sufficient to maintain basic physiology without a need for additional oxygen equipment.

However, once entering the area of the atmospheric deficiency at an altitude of 3,000 feet to 15,000 meters above sea level, a decrease in barometric pressure occurs as well as in the partial pressure of oxygen. The area of scarcity is where the majority of aircaft flights takes place and physiological problems arise during the medical transport of patients by air.

To better understand some of the problems that can arise during flight, it is needed to know of Boyle's Law and Dalton's Law at least.

Hypoxia is he most important physiologic consequence of flight. Dalton’s Law helps explain and make it understandable the mechanism behind in-flight hypoxia. Dalton’s law, PT = P1 + P2 + … + PN, states that “the total pressure of a mixture of gas is equal to the sum of the partial pressure of each gas in the mixture.”

Table 1.1 - Potential spaces for gas expansion during flight

| Body Cavity | Problem Phase of Flight | Potential Consiquences | Recommendations |
|---|---|---|---|
| Cranium (pheumocephalus) | Ansent | Increased intracranial pressure (ICP), decreased cerebral perfusion pressure,decreased celebral oxygenation | Avoid commercial flights; maintain see-level cabin |

Continuation of table 1.1

| | | | |
|---|---|---|---|
| Sinuses | Ascent or Descent | Severe pain, sinus block | Avoid flying with sinus inflectiom/congestion (if possible), perform Valsalva maneuver during descent, use positive pressure ventilation techniques |
| Thorax (pneumothorax) | Ascent | Tension pneumothorax, increased intrathorical pressure, decreased venous return | Diagnose pneumothorax BEFORE flight, treat all pneumothoraces preflight (regardless of size) with tube thoracostomy, ensure all tubes draining air or fluid are unclamped, have equipment available to perform emergency needle thoracostomy |
| Gastrointestial tract | Ascent | Severe pain, interference with breathing, decreased functional residual capacity of lungs, abdominal compartment syndrome, vasovagal syncope bowel perforation | Place orogastric/nasogastric/rectal Tubes and remove all potential air prior to transport |

Oxygen partial pressure decreases when increasing altitude. Modern aircraft fly in pressurized cabins, which are usually pressurized up to an altitude of 2500 meters to solve this effect,

Patients with pre-shipment hypoxia or respiratory failure may deteriorate in flight if efforts are not made to optimize oxygenation throughout the flight. Boyle's law, $P1/P2 = V1/V2$, explains that "the volume of a gas is inversely proportional to the pressure to which it is subjected."

According to this law, pressure decreases with increasing altitude, causing an increase in gas volume, which leads to the concept of gas expansion.

Some potential consequences of gastrapped or gas expansion include tension pneumothorax, dehiscence of surgical wounds (for example, tears along the surgical incision), expansion of intracranial air leading to a hernia of the brain, expansion of intestinal and gastric air, causing a decrease in functional residual lung capacity, thereby contributing to hypoxia and respiratory failure.

Another physiological consideration includes low humidity, temperature fluctuations, and gravitational forces (See Figure 1 and Table 2.) What about the low humidity of the cabin of aircraft, patients will experience drying out of secretions (nose, eyes, mouth, respiratory tract).

The risk of nosebleed is also increased. Therefore, the crew must be prepared to make deal with this complication. In addition, with an increase in altitude, the air temperature, in addition to humidity, decreases.

Finally, the forces of gravity that occur during acceleration and deceleration can influence physiologic process. The effect of gravitational forces is enhanced in seriously ill patients. Experiencing acceleration forces, patients may exhibit hypertension, arrhythmias, fluid compartment shifts, tachycardia, increased intracranial pressure, decreased cerebral oxygen pressure, and decreased venous return / cardiac output. Other less common problems associated with fixed wing airborne medical vehicles are noise and vibration. It can cause pain, nausea and anxiety in the patient and should be recognized and treated accordingly.

### 1.3 Areas need to improve

Nothing in the world is perfect. In this case, there is always something to improve or supplement with new technologies . In a medevac aircraft, you need to carry about two main things. First of all, namely, the internal structure of the aircraft, and the patient who is being transported. In this part, there will be an analysis and of the problems that need to be improved when transporting a patient.

For begining of the process of preparing for flight, historical “problem areas” must be identified. The literature demonstrates that common areas for improvement include communication, adequate equipment, airway management, IV line maintenance, and the education and experience of transport personnel.

Communication mistakes could be horrible consequences. When transporting a patient, it is imperative to use reliable and efficient communications equipment. Several of current communication mistakes that hinder patient transference today include inaccurate descriptions of the patient's condition and needs, misunderstandings, lack of standard available resources, and poor use of that resource.

To ensure the accuracy of the clinical information, it is recommended to establish a direct connection between physicians passed patient on and physicians that receive patient.

In a dialogue between these physicians, the minimum information should be transfered and include the initial / perceived clinical course, clinical condition, current clinical condition, prescribed treatment, current treatment, reason for transfer, recommended mode of transport, necessary transport equipment and medications, and recommended staff required for translation.

The plan agreed upon by the transmitting and receiving physicians should be clearly laid out and a situational and needs assessment should be carried out. This should include everything that needs to happen before, during or after transportation.

After all this information has been transmitted, a data exchange should be performed by getting back the information that will provide clarity and confirm understanding, that is, that the receiving physicians repeats what the transmitted physicians said to him. Ensuring good communication during all aspects of patient transport (before, during and after) will improve patient care and outcomes.

For the preparation of the patient for transport, its recommend an approach similar to the “primary survey” and “secondary survey” presented by the American College of Surgeons Committee on Trauma which recommends an ABCDE approach to the “primary survey” [2].

Primary examinations include airway, breathing, circulation, disability, and exposure. Once these elements have been verified, the method should continue with a thorough physical examination from head to toe to identify any other factors that may need to be eliminated or stabilized before flight.

The most important step in patient transport is assessing and stabilizing the patient's airway. If the patient is not already ventilated, the transfer physician or flight personnel should examine the patient for signs of impending respiratory distress or airway disruption. The patient should be selectively intubated prior to transport. If there is no evidence of this problem.

The best time to maintain an airway is pre-flight preparation. The best time to maintain an airway is pre-flight preparation. After fixing the airway with an endotracheal tube or laryngeal mask, this device must be held with a tube holder. Before moving the patient, the size, depth and location of the tube should be documented.

There is controversy over whether to fill the tube cuff with air or saline, but the use of an air-filled cuff is recommended as its pressure can be measured during flight with a pressure gauge.

Expansion of air or liquid bubbles can lead to huge swelling and cause necrosis under pressure. When it is determined that the airways were protected prior to movement, the staff should be aware that movement of patients may cause movement of equipment, including endotracheal tubes.

Patients on ventilators (mechanicaly) should receive adequate sedation, pain relief, and neuromuscular blockade if necessary to maintain airway safety.

It is well known that hypoxia is the most serious threat to patient safety in medical vehicles. This means that the breathing state must be optimized before transporting the patient.

It begins with an attempt to prevent hypoxia. Some potential prevention strategies are the use of low flight ways and the provision of a blood transfusion to the patient if pre-flight anemia exists.

Transport staff are responsible for predicting oxygen demand during transport and ensuring that sufficient oxygen in the aircraft.

Before moving a patient out of the hospital to which they are moving, they must be placed on a transport ventilator and be able to maintain adequate oxygenation and ventilation.

If the patient cannot be stabilized on the transport ventilator, additional equipment or other transport conditions should be considered. In some special situations, patients need unusual special settings of the ventilator, which are rarely used during transport and, therefore, before transporting the patient, it is necessary to stabilize on the transport ventilator, inform and let the crew familiarize themselves with the non-standard settings. [3].

Once the patient is stable for flight, ventilation should be monitored continuously, evaluating end-expiratory carbon dioxide and oxygen saturation measurements.

In addition, in case of a possible fan malfunction, it is imperative to have a device with a bag valve available. Physiological responses to hypoxia can be hyperventilation and increased cardiac output, which is usually tachycardia.

For this reason, it is necessary to frequently assess the patient's heart rate and respiratory rate.

The tube must remain unclamped and the transport staff must have the equipment to perform emergency needle decompression in the case of a malfunctioning thoracostomy tube or developing pneumothorax in flight.

Moreover, a nasogastric or orogastric tube should be placed in critically ill patients to prevent aspiration and help with the removal of excess gas in flight.

Ongoing discussions of respiratory status and oxygenation status should focus and address the use of portable oxygen concentrators (POCs) (figure 1.3) during air transportation aircraft.

The use of battery powered POCs is widespread nowadays.

To require POC manufacturers to obtain FAA approval for each portable oxygen concentrator model, the FAA now requires portable oxygen concentrator manufacturers to label new POC models to meet all FAA requirements.

Figure 1.3 - The Inogen One G3

Older models of POC that have already been approved by the FAA can be used as before, even if they do not have this special marking. Airlines can use the list published in Special Federal Aviation Regulations (SFAR) 106 to determine if the POC can be used in flight. [4].

Agitated, aggressive patients can pose a serious hazard to themselves and to the flight crew, therefore behavioral disturbances must be addressed prior to transport.

Pain and anxiety can be controlled with analgesics and other medications as needed. If the patient has previously taken medications prior to transportation, these medications should be resumed. Patients on mechanical ventilation may require paralysis in addition to pain and anxiolysis relief.

When the transport team arrives, they should examine the patient, the flight crew should expose and examine all parts of the patient's body for a thorough assessment.

Moreover, that the patient must look for any other problems that may not have been communicated to the transport team during the oral report, temperature control and other factors of environment should be considered.

It is also nessesary to evaluate your medication intake. The flight crew must determine which drugs are currently active and when the patient received the last dose. They should also be prepared to prescribe any pre-flight scheduled medications, and should prepare and start taking any prescribed antibiotics.

Not only should the crew have enough drugs to fly, but pending any lost drugs, he recommends that an adequate supply of drugs be available for at least 24 hours.

Other considerations when transporting a patient by airplane include IV tubing, types of fluid containers, cast management, body cavity tubing, and infectious (example COVID-19), bacterial control. Because Boyle's Law refers to gas expansion, any air trapped in the IV tubing can expand and cause the IV tubing and pumps to malfunction, restricting the flow of fluids and drugs for IV infusion. [5].

## 1.4 Aviation rules: stretcher and wounded placement requirement

Based on the Standardization Agreement (NATO) medevac aircraft must meet such requierements [6]:

1) Medical officer

A male or female, of a nation's medical service or branch, who possesses a nationally recognised qualification in medicine. A medical officer may also be specially trained in aerospace medicine and may then be referred to as a "Flight Medical Officer" or "Flight Surgeon".

2) Fitness for Air Travel

Patients selected for transportation by air must be cleared for the proposed flight by an aeromedically trained medical officer either at the originating facility, a casualty staging unit, or an en-route medical facility, or, in his absence, by other competent aeromedical authority. The medical officer must balance casualty fitness considerations with the availability of suitable in-flight medical attention; the urgency of treatment in a reception area; the operational situation; and the operational capabilities of the available airlift aircraft.

3) Forward Aeromedical Evacuation

In forward aeromedical evacuation, the paramount need is to transport the patient to the initial point of treatment as quickly as possible.

The principles for the conduct of aeromedical evacuation in forward areas, including priority of movement, scheduling, decisions as to whom should be evacuated and the provision of medical escorts, will be as established in Stanag 2087 - medical employment of air transport in the forward area.

4) Tactical (Intratheatre) and Strategic (Intertheatre) Aeromedical Evacuation

In these types of operation, the benefit to the patient of transfer to an area where appropriate medical facilities are available must be balanced against the ability of the patient to withstand the anticipated environmental conditions of the flight.

In wartime aeromedical evacuation, however, conditions may often be much less favourable. Account must be taken of the effects on the prospective passenger of significant changes in atmospheric pressure and cabin temperature, turbulence, the work load on a hard-pressed in-flight medical team with restricted facilities, and due regard paid to the aircraft type and flight plan.

5) Clinical Selection Criteria

There are no absolute contra-indications to aeromedical evacuation. Each case must be judged on its merits, weighing the advantage to the patient of transfer against the possible harmful effects of the flight. Sometimes a calculated risk must be taken. However, as a guide it would be wise to accept the following types of patients only when there is no other acceptable means of transport:

a. Patients in the infective stage of serious communicable diseases. If any are carried, appropriate precautions must be taken for the protection of other occupants.

b. Sick and wounded whose general condition is such that they may not survive the flight.

c. Patients whose upper and lower jaws are immobilized. Such patients require constant supervision by persons who are competent and equipped to remove the tie materials immediately should the patient become airsick or vomit. Fixation by intermaxillary elastics is preferable to wire because of ease of cutting.

d. Pregnant patients who are beyond the 250th day of pregnancy are not routinely acceptable for aeromedical evacuation, but may be moved if determined necessary to the patient’s mental and/or physical health by competent medical authority.

Patients with any of the following conditions require special consideration in selection for aeromedical evacuation, particularly in unpressurized aircraft:

a. Respiratory embarrassment. Patients whose unaided vital capacity is less than 900 ml should not normally be moved by air without a mechanical respirator.

b. Cardiac failure or early post-myocardial infarction.

c. Trapped gas within any of the body cavities, e.g. pneumothorax, bowel obstruction or acute sinusitis. Post-laparotomy or thoracotomy patients should not normally be moved within 10 days of operations except in pressurized aircraft.

d. Patients with psychiatric conditions require special consideration before being allowed to emplane. Past psychiatric disease, excessive nervousness, flight phobias etc must all be borne in mind. Prior to flight all patients should have been kept under observation long enough to assess their suitability for nursing care during flight.

Patients with critical medical or surgical conditions (e.g. penetrating wounds or injuries of the chest or abdomen) should be stabilized if at all possible before aeromedical evacuation. Unstable or recently stabilized patients shall be accompanied by a medical officer who should, where possible, be an appropriately qualified specialist

6) Aircraft Equipment

Aeromedical aircraft stretchers and stretcher support systems shall meet the following requirements:

a. Suitable stretcher (figure 1.4) supports will be provided, for example rigid posts or webbing straps, that are light in weight and which may be easily stowed in the aircraft when it is used for other purposes.

b. The dimensions of stretchers and stretcher supports will be as detailed in Stanag 2040 - stretchers, bearing brackets and attachment supports, except that stretchers in aeromedical use may be supported other than by their feet.

c. A satisfactory stretcher safety harness should be provided that will protect each stretcher patient against the accelerations likely to be encountered in flight, or during heavy landing or ditching.

d. The stretcher installation shall provide sufficient space to allow aeromedical personnel to care for each patient. Stretcher supports should allow the vertical tracking distance between stretchers to be at least 46 cm (18 inches). Stretchers shall be as nearly horizontal as possible in flight.

e. The stretcher support, stretcher and stretcher harness system should be capable, while loaded with a 114kg human dummy, of supporting and restraining the dummy when exposed to short duration accelerations of up to +9Gz, -6Gz, -9Gx and ±6Gy.

The aircraft shall be provided with:

a. Adequate passenger compartment lighting and power outlets for the operation of electrical medical equipment.

Figure 1.4 - Stretcher

b. A supply of oxygen of sufficient quantity to satisfy therapeutic and emergency requirements, either through the aircraft oxygen system or by suitable portable oxygen supplies.

All electro-medical equipment used in aeromedical evacuation is to be cleared by the relevant national authority for the aircraft on which it is to be used.

6) Preflight Inspection of Aeromedical Equipment

For aircraft operating in the aeromedical evacuation role, the following equipment checks appropriate to the aircraft type will be carried out:

a. Stretcher suspension straps, stanchions, and clamps will be checked to ensure serviceability and proper security.

b. All aeromedical evacuation equipment will be checked in order to ensure proper functioning. The equipment should be properly secured to withstand turbulent air conditions.

c. The loading of patients, survival equipment, etc will be carried out in accordance with safety precautions and existing instructions for the particular aircraft.

d. Stretcher patients will be secured by means of safety harnesses.

e. Any other medical equipment in the aircraft will be checked and made secure.

f. Immediately prior to take-off, the proper functioning of the cabin telephone and of other communication devices will be checked.

g. Oxygen outlets will be checked including their adaptability to therapeutic oxygen kits. The adequacy of oxygen supply will also be checked.

h. When electrically operated medical equipment is to be used, all such equipment should have been tested for electromagnetic compatibility and clearance given for the particular type of aircraft in which it is to be operated.

7) Disinfection of Aircraft

The interior of the aircraft and such articles as cutlery, crockery, stretchers blankets, sheets, medical equipment etc, will require disinfection after the carriage of patients with infectious conditions, including open pulmonary tuberculosis. Appropriate procedures are:

a. General Aircraft Disinfection. When considered necessary by the competent medical authority in order to prevent dangerous exposure to other persons, aircraft interiors should be sprayed with an approved disinfectant, closed for at least an hour, and then well ventilated.

b. Cutlery and Crockery Disinfection. This should be done by immersing the articles in a suitable dilute disinfectant for twenty minutes prior to washing in the normal manner.

c. Disinfection of Medical Equipment. Medical equipment will be sterilized.

d. Disinfection of Stretchers and Bedding. This should be done by normal washing and, where appropriate, by steam or hot air disinfection.

Other nationally approved disinfecting procedures may be used to supplement or replace any of the above procedures.

**Conclusion to the part**

In this part I have prepared the analysis of medevac aircraft, show the main requirements to the design of aircraft and transroptation of patients. Fixed-wing air transport poses some unique challenges to patient care, however, taking a holistic approach to the patient transfer and using standardized, systematic methods can improve patient safety and quality of care.

Appropriate planning for transport, ensuring adequate supplies and their functionality, thoroughly assessing the patient, and being prepared to response to any potential in-flight complications can create a positive fixed-wing patient transport experience.

# ANALYSIS OF DESIGNING AIRCRAFT

## 2.1 Initial data for the preliminary design of aircraft

My projected aircraft has 3x3 tiers on both sides, a total of 24 stretchers wounded and two attendants. The point is that if the injured are stable and able to transfer three-five hours without medical intervention, maximum injection or dropper, during this time they will be transtorted 500-1000 kilometers to the rear, where it is already possible to allow a hospital more equipped with medicines and doctors than the frontal one.

That is the main reason why we should have such aircraft.

For medical container it can take place under 2 above sctrechers, so it become 16 stretchers and 8 medical containers. Also it has additional place for adding extra stretchers (if nessesary).

The selecting of the optimum design parameters of the aircraft is the multidimensional optimization task, aimed at forming a "look" promising aircraft.

This configuration means the whole complex flight-technical, weight, geometrical, aerodynamic and economic characteristics. Forming the "Appearance of the plane" in the first stage uses statistics methods transfers, approximate aerodynamic and statistical dependence. The second stage uses a full aerodynamic calculation, aircraft specified formulas of aggregates weight calculations, experimental data.

Such aircraft will compete with projected aircraft in this market segment. Statistic data of prototypes are presented in table 2.1.

Table 2.1 - Operational-technical data of prototypes

| Basic information | Aircraft |
|---|---|
| Max payload, kg | 5500 |
| Crew | 3-5 |
| Load Master Number | 2 |
| Wing load, кH/m$^2$ | 2,6 |
| Cruise speed | 16 |

Continuation of table 2.1

| | |
|---|---|
| Range of flight з $m_{km\ max}$, km | 1100 |
| Cruise altitude, km | 6 |
| $V_{cr\ max}$/H, km/g/km | 435 |
| Power-to-mass ratio, kW/kg | 2,7 |
| Power plant | |
| Engine number | 2 |
| Take-off thrust, кN | 1650 |
| Cruising thrust, kN | 13,5 |
| Specific fuel consumption of take-off, kg / kN (kW) | 0,25 |
| Specific fuel consumption of cruising, kg / kN (kW) | 0,26 |
| Engine pressure ratio | 21 |
| Engine by-pass Ration | 0 |
| Aerodrome base class | C |
| Acceleration length, m | 870 |
| Mileage distance, m | 650 |
| Take-off distance, m | 1400 |
| Landing distance, m | 1200 |
| Basic geometric parameters | Aircraft |
| Wingspan, m | 29,2 |
| Sweep 1/4 chord, deg | 6,5 |
| Middle geometric chord, m | 3,18 |
| Wing aspect ratio | 11,37 |
| Wing taper ratio | 2,92 |
| Length of fuselage, m | 23,78 |
| Diameter of fuselage, m | 2,9 |
| Fineness ratio of the fuselage | 8,2 |
| Cabin width, m | 2,7 |
| Cabin length, m | 13 |
| Cabin height, m | 2,38 |
| Cabin volume, m3 | 310 |
| Horizontal Tail span, m | 10 |
| Sweep of Horizontal Tail for 1/4 chord, deg | 15 |

Ending of table 2.1

| | |
|---|---|
| Aspect ratio of HT | 4,065 |
| Constriction of the HT | 2,5 |
| Height of Vertical Tail, m | 4,68 |
| Sweep VT by 1 /4 chord, deg. | 21,3 |
| Aspect ratio of VT | 1,41 |
| Constriction VT | 3 |
| Base of the LG, m | 8,56 |
| Track of the LG, m | 11,196 |

The scheme is determined by the relative position of the aircraft units, their numbers and shape. An aerodynamic and operational characteristic of the aircraft depends on the aircraft layout and aerodynamic scheme of the aircraft. Succesfully chosen scheme allows to increase the safety and regularity of flights, and economic efficiency of the aircraft.

### 2.2 Brief description of the main parts of the aircraft

The plane is a twin-engined turboprop civil and military transport aircraft with tricycle landing gear which has a front single-strut landing gear and two main gears.

A swept wing with a high aspect ratio, which is based on new supercritical profile. Fuselage has circular cross section. Rudder and elevators are equipped with aerodynamic balance.

Fuselage is an all-metal, frame-stringer type of semi-monocoque. The power set consists of 51 formers. The fuselage is technologically divided into four parts: the nose - the compartment F1 (for 11 formers), the middle - the compartment F2 (from 12 to 33 formers), the hatch compartment (from 34 to 40 formers) and the tail part - compartment F3 (from 41 formers). Most elements of the fuselage construction are made of sheet and profiled duralumin.

Nose compartment is hermetic. It has a cabin of crew, between 1 and 7 formers. Cargo cabin placed behind 7th former. The fuselage nose, up to 1st former, is not hermetic and it has an antenna of the radar. Under cabin of crew it is located front ramp of landing gear. The entrance door is located in the right side and has dimention 600 × 1400 mm. It has two emergency hatches in crew cabin.

The middle part of the fuselage is hermetic, with a cargo cabin inside. There are four rounded illuminators on both sides of the cabin. On the ceiling between 29 and 39 formers there is a monorail, which moves a trolley hoist. The trolley hoist is intended for loading and unloading operations.

The cargo hatch is between 33 and 40 hinges and has a rectangular shape. The length of the hatch is 3 300 mm, and the width from 33 to 36 hinges 2 340 mm. The hatch is closed by a ramp at the end of which a wedge-shaped runway is located. The ride gradually passes into the tail section of the fuselage with a closed hatch. Opening the ramp may take such position: landing for loading / unloading wheeled equipment.

The tail unit is not pressurised; it carries a tail unit on itself. In the middle there are units of navigational and aeronautical equipment, and radio equipment. In the lower part of the compartment, between the 41 and 42 former there is an entrance hatch.

The wing is high-wing, arrow-shaped in plan. The wing consists of a longitudinal and transverse structural elements and a skin. The design of the wing - caisson type, consists of two spar and 23 ribs. The nose part of the wing is equipped with an air-thermal and an electrothermal anti-icing device. The warm air in the sock of the center wing is fed from the aircraft engine compressors.

On it there are two deflected single-clasp flaps. The total area of the flaps is 15 m², the angles of deflection are 15° (upon take-off) and up to 38° (when landing). The total area of the ailerons is 6,12 m², the angles of deviation are 24° (up) and up to 16° (down).

The wing is made swept, as a result of which it has a larger $M_{cr}$ and a weaker wave crisis, but there are a number of drawbacks:

- large tearing speeds and landing and, as a consequence, a long run and run length.

- it has smaller aerodynamic qualities than direct, greater drag of the aircraft and a shorter range, and the duration of the flight.

- have a tendency to end the flow from the wing.

- lowest coefficient of maximum lift.

- external lateral stability, leading to aircraft swinging.

- the lateral controllability is reduced at large angles of attack due to a stall from the wing ends, has a reverse roll response.

The lateral stability decreases with M> Mmax

Tail unit - free-flowing, single-haired. It consists of two consoles of a stabilizer with a steering wheel of a height, fin and rudder. Stabilizer and fin are two-cylinder design. Trimmers are installed on rudder, and on fin there is a spring trimmer-servo-compressor.

The rudder has axial aerodynamic compensation and is fully balanced. The total area of the stabilizer is 19.83 $m^2$, the keel is 13.28 $m^2$, and the dorsal fin - 2.57 $m^2$. The height of the rudder is 5.16 m 2, the angle of inclination is 25 ° (up) and 20 ° (down). The area of the rudder is 5$m^2$, the angle of inclination is ± 25 °.

The chassis is a support system that provides the required position of the aircraft during parking and its movement during takeoff, landing and taxiing on the aerodrome.

On this plane, the chassis is made according to a three-bearing scheme and is retracted back by flight. Such a scheme makes it possible to obtain a stable airplane movement through the airfield, effective maneuverability, thanks to the use of the control of the turning of the wheels of the front leg, the horizontal position when stationary and moving. The chassis with the nose wheel allows you to take off and land in a strong lateral wind, as well as rectilinear movement during the run and takeoff of the aircraft.

The base of the chassis is 7650 mm, the track is 7900 mm, the minimum turning radius is 11250 mm.

During the flight, all three chassis are moved forward, the main ones in the compartment in the motodendolas, under the engine, and the front in the compartment under the cabin of the crew.

The compartments of the chassis racks are closed, both during the flight and when driving. When the chassis is released, open small doors are located in front of the shock absorbers.

The front support has no brakes, when rolled, it returns to an angle of ± 45° and an angle of ± 9° when accelerating and running.

The main supports (struts) are located behind the center of gravity of the aircraft. They in the released position are tilted back, varying depending on the amount of compression of the shock absorbers.

The front support has two wheels, and each main one has a bogie with six paired wheels.

Pneumatics of wheels perceive the load when landing and moving on aerodrome and pass it to the supports.

Retracting the chassis back has its advantages and disadvantages. Such retcracting does not cause a significant displacement of the center of gravity of the aircraft and does not require increased capacity of the lift cylinders, since in this case it is not necessary to overcome airflow resistance.

The aircraft has a control system for steering the wheels of the front support, which greatly improves the maneuverability of the aircraft when taxiing. The steering of the wheels is controlled by deflecting the rudder pedals.

Wheels of main supports KT-157 with chamber tires 1A in size 1050 × 400 mm. Front wheels K2105 with chassis tires 6A 700 x 250 mm in size. The pressure in the tire chambers is 4 kgf / $cm^2$.

There are two turboprop engines AI-24VT with a take-off power of 2820 hp are installed. The motors are located in the motodendolas at the center plane. AI-24VT is equipped with a ten-stage compressor and a three-stage turbine. Combustion chamber with 8 nozzles. Also included in the engine are: starter generator, alternator, aerodynamic sensors, icing detector, torque transmission system, oil filter and screw speed control. For powering engines used fuel grades T-1 and TS-1. The engine is mounted on the wing center-stage with the help of a quick-release frame with shock absorbers and a power-train with front power steering.

The role of the pylon on each side of fuselage is to support the engine; to transmit the loads to the rear part of fuselage.

The fuel system includes 10 soft tanks and two tank compartments. The tanks of each half-wing are divided into 3 groups. To feed the engines first, the fuel is taken from the first group of tanks, then from the second, and then from the third. Refueling of tanks can be carried out from above through the filler flaps or centrally through the filling union in the compartment of the chassis of the left rig.

In the flight, the neutral gas system fills the space above the fuel with carbon dioxide, and also this system is used as an additional fire extinguishing.

The plane has a stationary fire system and handheld portable fire extinguishers. The stationary system is divided into a fire system of an airplane and a fire system of engines.

The fire system of the aircraft is intended for the elimination of fires in the compartments of the left and right parts of the wing and in the left and right runners. The system consists of four fire extinguishers OS-8MF or UBC8-1, two blocks of fire-prevention valves, an alarm system on the fire CCP-2A. System management is carried out, and manually with a fire extinguisher, and automatically from signaling sensors.

The hydraulic system (HS) is intended for opening/ closing the chassis, turning the wheels of the front of the chassis, braking the wheels of the main chassis towers, releasing / closing the flaps, for actuating windshield wipers, emergency switching on the spools of flipping the air propellers and stopping the engines, opening and closing the hatch of the emergency hatch and control of cargo manhole ramp. The main HS is used under normal conditions and serves all nodes that operate from the HS. The sources of the pressure for the main HS are two pumps located on the engines.

### 2.3 Analysis of projected aircraft

Layout of the aircraft consists from composing the relative disposition of its parts and constructions, and all types of the loads (luggage, cargo, fuel, and so on).

Choosing the scheme of the composition and aircraft parameters is directed by the best conformity to the operational requirements.

#### 2.3.1 Wing geometry calculation

The geometric characteristics of the wing are determined by exiting the take-off mass $m_0$ and the specific load on the wing $R_o$.

First, find the area of the wing:

$$Swing = \frac{m_0 \cdot g}{P_0} = 98{,}36\ m^2. \qquad (2.1)$$

Wing span is calculated by the formula:

$$l = \sqrt{S_{wing} \cdot \lambda_{wing}} = 33{,}44\ m. \qquad (2.2)$$

Chord of root and chord of tip:

$$b_0 = \frac{2 \cdot S_{wing} \cdot \eta}{(1+\eta) \cdot l} = 4{,}38\ m, \quad b_{wing} = \frac{b_0}{\eta} = 1{,}50\ m. \qquad (2.3)$$

The maximum thickness of the wing in any section of its width is equal $C_i = \overline{C} \cdot b_i$. The wing is determined the number of spar and their position and location of the wing.

On modern airplanes, the torsion box wing has two or three spars.

The relative position of longeron in the wing on the chord is equals:

$\overline{X}_i = \frac{X_i}{b}$ , where $X_i$ - distance i longeron from nose of wing, b - chord.

Wing with two longerons: $\overline{X}_1 = 0{,}2$; $\overline{X}_2 = 0{,}6$.

Wing with three longerons: $\overline{X}_1 = 0{,}15$; $\overline{X}_2 = 0{,}4$; $\overline{X}_3 = 0{,}65$

This determines the width of the wing and the capacity of the fuel tanks.

$b_{cax}$ = 3,18 м.

After determining of the geometric characteristics of the wing proceed to the estimation of the geometry of the ailerons and high lift devices of the wing.

The geometric parameters of the ailerons are determined:

Span of aileron:

$l_{ail} = (0,3…0, 4)·l/2;$ (2.4)

Chord of ailerons:

$b_{ail} = (0,22…0,26)·b_i;$ (2.5)

Area of ailerons:

$S_{ail} = (0,05…0,08)·S_{wing}/2$ (2.6)

**2.3.2 Fuselage layout**

Choosing the shape and size of the cross-section of the fuselage, it is necessary to proceed from the requirements of aerodynamics (flow and cross-section area). For subsound speed aircraft the nose part of fuselage should be:

$l_{nc.}=(2…3)·D_f$, where $D_f$**,** - fuselage diameter.

In addition to taking into account the requirements of aerodynamics, when choosing the shape of an intersection, it is necessary to take into account the layout conditions and strength requirements.

To ensure the minimum weight, the most appropriate form of the cross-section of the fuselage it is better to use the round section. In this case, the thickness of the lining of the fuselage is the smallest. As a kind of such an intersection you can use a combination of two or more acyclics both vertically and horizontally.

Choosing the shape of the cross-section of the fuselage, the issues of aerodynamics do not become the most important and the shape of the cross section can be rectangular, for such transport planes.

The geometric parameters of the fuselage:

-diameter of fuselage $D_f$;

-length of fuselage $L_{f;}$

-fineness ratio of fuselage $\lambda_f = \frac{L_f}{D_f}$;

- fineness ratio of nose part of fuselge: $\lambda_{nose} = \frac{L_{nose}}{D_f}$

- fineness ratio of tail part of fuselage: $\lambda_{tail} = \frac{L_{tail}}{D_f}$

where $L_{nose}$ i $L_{tail}$- length of nose and tail part of fuselage

The length of the fuselage is determined taking into account the scheme of the aircraft, the features of layout, centering, and providing a landing angle of attack $\alpha_{lnd.}$

Determining the following fuselage parameters:

$l_f = \lambda_f \cdot D_f$ = 8,2*2,9=23,78 m. (2.7)

$l_{nose} = \lambda_{nose} \cdot D_f$ = 2,9*2,9 =8,41 m. (2.8)

$l_{tail} = \lambda_{tail} \cdot D_f$ = 2,8*2,9=8,12 m. (2.9)

For short-range airplanes, can be accepted:

- height of the cabin $h_1$ =1,75 m;
- width of the aisle $b_a$ =0,45... 0,5 m;
- the distance from the window to the floor $h_2$ =1,0 m;
- height of cargo compartment $h_3$ = 0,6... 0,9m.

It is rational to have a round cross-section of the fuselage, because in this case it will be the most durable and light. However, this form may not always be optimal for accommodating cargo and illness people. It is advisable to form a transverse section of the fuselage in the form of an oval or the intersection of two circles.

The step of normal frames in fuselage designs is in the range of 360 to 500 mm, depending on the size of the fuselage and the class of cargo compartment layout. According to the layout concepts, with fuselage diameters less than 2800mm often depart from this form and use the intersection created by two intersecting circles.

The shape of the windows is circular in diameter 300 ... 400 mm or rectangular with rounded corners. The step of the windows corresponds to the steps of bulkheads - 500-510 mm.

### 2.3.3 Cargo compartment

The location of cargo compartments (figure 2.1) is determined during estimating the length of the fuselage, it is recommended to use the data of prototype aircraft.

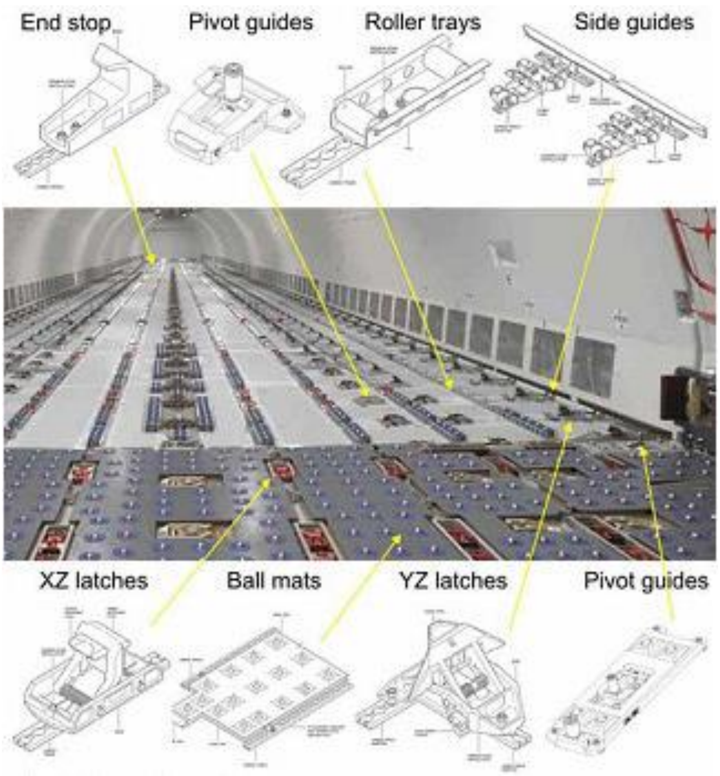



Figure 2.1 - Cargo compartment

1) Location of cargo

1.1) Cargo should be placed in the cargo compartment, taking into account the permissible limits for the location of the common center of mass, determined by the corresponding centering schedules for this type of aircraft

1.2) Locating cargo in cargo cabins (on platforms) of airplanes it should be possible to:

a) the approach to the cargo secured points for their inspection and installation cargo items;

b) the entrance (exit) into the cabin of the crew of the aircraft and into the cabin of the attendant after the installation of cargo secured;

c) entrance to the cabin and exit from the cabin of self-propelled cargo;

d) opening (closing) of entrance doors, hatches, shutters, release (installation) of emergency ramps (other devices) providing entry (exit) into the cockpit (cabin) of the crew of an aircraft.

If it is impossible to ensure the entrance to the cab (exit from the cab) of self-propelled cargo, such cargo is loaded (unloaded) as not self-propelled.

1.3) The loads on the floor of the cargo compartment (platform) from the wheels, rollers, supports of wheelless cargo should not exceed the permissible values established for each type of aircraft. The total load (force) from cargo supports located in one cross-section of the floor (platform) of an airplane should not exceed 125 kN (12.7 · 103 kgf). The pressure from the pillars of the cargo should not exceed 0.54 MPa (5.5 kgf / cm2). If the specified loads or pressures from the supports exceed the permissible values, then, as an exception, it is allowed to use flooring, cargo distributors and other devices specially made by the consignor, the design and use of which must be agreed with the aircraft designer. Such flooring, distributors and other devices should be included in the package of cargo.

1.4) The placement of the cargo should include the maximum use of the cargo floor space (platform) and the volume of the cargo compartment of the aircraft.

1.5) If it is necessary to transport different types of cargo (self-propelled, non-self-propelled, wheelless) in the same aircraft, self-propelled cargo should be placed (if possible) taking into account their priority unloading.

2) Cargo mooring

2.1) Each cargo carried in an aircraft must be securely from moving it forward (in the direction of flight), backward, sideways and upwards, taking into account the overloads acting on the aircraft

2.2). Mooring of cargo is carried out by standard onboard facilities to the mooring units located on the cargo floor (platform) or on other structural elements of the aircraft.

2.3) In order to reduce the time for mooring and maximize the use of the carrying capacity of the mooring means, the mooring should be carried out with the minimum possible number of mooring elements.

2.4) It is not recommended to moor cargo for mooring units located on the cargo floor (platform) and simultaneously for mooring items located on deviating parts.

Required cargo volume:

Vb = 0,20. ..0, 24 –fuselage $D_f \leq 4$ m;

Vb = 0,36. ..0, 38 - fuselage $D_f > 5,5$ m;

Cargo Hold Dims = 1110 x 220 x 160 LxWxH cm

Cargo Door Size = 230 x 171 WxH cm

Reduction gearbox consists of pinion-shaft, two idler pinion, and two driven gears.

Trolleys of the transversal movement are used for the carrying cargo across the cargo hold.

On the frame of the crane two transversal movement trolley are installed.

Trolley consists of the frame and two carriages.

The housing of each trolley has rollers to provide correct, light motion of the trolley on the rails.

Tips of carriages are equipped with the rubber dampers. At the extreme positions of the carriage they abut stops by the dampers, installed at the tips of the rails.

To prevent failure of the carriage at the lifting, caused by the overloading the limiter of load is used.

Mechanism for the trolley movement consists of:

- driver;
- two jaw coupling;
- two reduction gears;
- two drums with ropes.

### 2.3.4 Layout and calculation of basic parameters of tail unit

One of the most important tasks of aerodynamic layout is the choice of the location of a horizontal tail unit. In order to ensure the longitudinal stability of the airplane in relation to its overload, its centre of gravity must be in front of the aircraft's focus and the distance between these points, attributed to the value of the average aerodynamic chord of the wing, defines the degree of longitudinal stability: $m_Z^{Cy} = \overline{X}_T - \overline{X}_F < 0$, where $m_Z^{Cy}$ - momentum factor, $\overline{X}_T$ and $\overline{X}_F$ the relative coordinate of the CM and the focus. If $m_Z^{Cy}$=0, then the plane has a neutral longitudinal static stability. If $m_Z^{Cy}$>0, then the plane is statically stealthy. In the normal scheme of the plane (plumage behind the wing) the focus of the combination "wing-fuselage" in the installation of horizontal plumage shifts back, in the scheme "duck" (plumage in front of the wing) - forward.

The statistical ranges of the values of the coefficients of the static moments of the horizontal $A_{hs}$ and the vertical $A_{vs}$ of the tail unit are given in Table. 9, where $L_{hu}/b_a$ i $L_{vu}/b_a$ - the characteristic relations are side of HS and VS to AAC wing.

Usually the area of the vertical $S_{vu}$ and the horizontal $S_{hu}$ units are:

$S_{hs}$ = (0,18…0,25)·S ;  $S_{vs}$ = (0,12…0,20)·S

More exactly can be defined:

$$S_{hs} = \frac{b_{aac} \cdot S}{L_{hs}} \cdot A_{hs} = 24{,}59 \text{ m}^2; \qquad S_{vs} = \frac{l \cdot S}{L_{vs}} \cdot A_{vs} = 15{,}54 \text{ m}^2,$$

where $L_{hs}$, $L_{vs}$ – arms of horizontal and vertical TU;

*l* and *S* – span and wing area;

$A_{hs}$, $A_{vs}$ – the coefficients of static moments. Value $L_{hs}$, $L_{vs}$ depend on a number of factors. Previously, their size is influenced by:

-long nose and tail section of the fuselage;

-sweap-back angle and location of the wing, conditions for ensuring stability and controllability of the aircraft.

In the first approximation can be assumed that $L_{hs} \approx L_{vs}$=12,70 m and depending on the constructive signs can be found from the relations:

-in the normal scheme of the plane and the trapezoidal form of the wing in terms of $L_{hs} = (0,2…3,5) \cdot b_{aac}$

- for planes "duck" scheme $L_{hs} = b_{aac}$;

- for light aircraft $L_{hs} = (0,2…2,3) \cdot b_{aac}$;

- for heavy aircraft $L_{hs} = (3,2…3,3) \cdot b_{aac}$

2) Determination of the area of the rudder height and stabilizer

The area of the height rudder usually takes: $S_{rh} = (0,3…0,4) \cdot S_{hs}$=8,48 m$^2$.

The area of stabilizer is usually taken: $S_{rh} = (0,35…0,45) \cdot S_{vs}$=6,22 m$^2$.

3) Determination of the span of horizontal TU

The wingspan and the Tu span are connected by a static dependence:

$L_{hs} = (0,32…0,5) \cdot l_{ws}$=10,00 m.

In this dependence, the lower limit corresponds to aircraft with a TPD equipped with a returning stabilizer.

The height of the vertical plume $h_{vs}$ is determined depending on the position of the wing relative to the fuselage and the placement of engines on the plane.

The upper wing position relative to the fuselage in the recommended ranges should be taken upper limit. $H_{vs}$ =4,68 m;

The narrowing of the horizontal and vertical stabilizer should be chosen:

$\eta_{hs}$ = 2…3 i $\eta_{vs}$ = 1…1,33 – for planes with M<1

Aspect ratio of the TU:

$\lambda_{vs}$=0,8…1,5; $\lambda_{hs}$=3,5...4,5

Determine the chord TU $b_{end}$, $b_{aac}$, $b_k$ use formulas:

Chord of HS:

$$b_c = \frac{2 \cdot S_{hs}}{(\eta_{hs} + 1) \cdot l_{hs}} = 1{,}41 \text{ m} \qquad (2.10)$$

$$b_{aac} = 0{,}66 \cdot \frac{\eta_{hs}^2 + \eta_{hs} + 1}{\eta_{hs} + 1} b_{hschord} = \ 2{,}58 \ \text{ m} \qquad (2.11)$$

$$b_c = b_{chord} \cdot \eta_{hs} = 3{,}51 \text{ m} \qquad (2.12)$$

Chord of VS:

$$b_{chord} = \frac{2 \cdot S_{vs}}{(\eta_{vs} + 1) \cdot l_{vs}} = \ 1{,}66 \text{ m} \qquad (2.13)$$

$$b_{aac} = 0{,}66 \cdot \frac{\eta_{vs}^2 + \eta_{vs} + 1}{\eta_{vs} + 1} b_{vschord} = 3{,}56 \text{ m} \qquad (2.14)$$

$$b_{vschord} = b_{hschord} \cdot \eta_{hs} = 4{,}98 \text{ m} \qquad (2.15)$$

Relative profile thickness for horizontal or vertical stabilizers in the first approximation $\overline{C}_{hs} \approx 0{,}8 \cdot \overline{C}_{wing}$.

**2.3.5 Landing gear design**

At the initial stage of designing, when haven't centered and drawings of a general type of aircraft, only part of the landing gear parameters are determined.

Removal of the main supports of the landing gear (Figure 2.2):

$$e = (0.15 \ ... \ 0.20) \ b_A.$$

It is difficult to detach the bearing support during take-off, and if it is too small it is possible to repel the plane to the tail, when the rear salons and trunks are loaded first. In addition, the load on the front of the support will be too small and the aircraft will be steep when driving on slippery runway and sidewall.

Base of the landing gear takes from the expression:

$$B= (0{,}3...0{,}4)L_f=(6...10)\ e=8{,}56\text{m}.$$

Great significance has airplanes with engines on the wing (EotW). The last equality means that the forward resistance comes from 6 ... 10% of the mass of the plane. The removal of the front support will be equal to:

$$d = B – e = (0{,}94...0{,}9)B=4{,}60 \text{ m}.$$

The track is calculated by the formula: K=(0,7…1,2)B≤ 12 m. K=11,20 m.

The wheels of the landing gear are selected from the take-off mass of the aircraft and the load on the parking.

- main support wheel $P_{main}$=9,81(B - e)$т_o$/$B_z$=53381,68 (N);
- front wheel $P_{front}$=9,81*$D_f$ $т_o$/$B_z$=26124,80 (N),

where z - number of wheels on one support;

$D_f$=1,5...2,0 - dynamic factor.

In case the load on the parking lot is indicated in the catalog for the selected wheel $P^{K}_{ПН}$, it will be more calculated at 5% and more, then for the coordinated operation of the liquid-gas shock absorber and pneumatic, it is necessary to reduce the pressure in the pneumatic to the magnitude: $P = P_0 \dfrac{P_{CT}}{P^0_{CT}}$, (Pa)

In order to ensure the structure of airplanes operated on ground airfields, the pressure in the landing gear tires must be in the limits:

$$p = (3...5)10^5 \text{ Pa.}$$

The main langing gear are installed in the engine nacelles and in flight are retracted forward into special compartments under the engines. On each main leg, on a common fixed axle, there are two wheels with pneumatics and disc brakes. The wheels are equipped with inertial sensors.

The front langing gears is installed in the forward part of the fuselage and in flight also retracts forward into the compartment under the cockpit. On the front leg, on a common rotating axle, there are two non-brake wheels with pneumatics.

In the released and retracted positions, the legs are fixed with mechanical locks that open using hydraulic cylinders. The landing gear compartments are closed by flaps when the legs are fully retracted and extended.

The main landing gear is two-wheeled, with telescopic nitrogen-oil shock absorbers. The strut is attached to the center section of the wing through a power truss. The main LG are equipped with wheels with disc hydraulic brakes and tubular tires measuring 1050 × 400 mm. The front pillar has two brake wheels with 700 × 250 mm tube tires.

### 2.4 Determination of the aircraft center of gravity position

Mass of the equipped wing contains the mass of its structure, mass of the equipment placed in the wing and mass of the fuel. Regardless of the place of mounting (to the wing or to the fuselage), the main landing gear and the front gear are included in the mass register of the equipped wing. The mass register includes names of the objects, mass themselves and their center of gravity coordinates. The origin of the given coordinates of the mass centers is chosen by the projection of the nose point of the mean aerodynamic chord (MAC) for the surface XOY. The positive meanings of the coordinates of the mass centers are accepted for the end part of the aircraft.

The example list of the mass objects for the aircraft, where the engines are located under the wing, included the names given in the table 2.2.

The example list of the mass objects for the aircraft, where the engines are located in the wing, included the names given in the table 2.2.

The mass of AC is 91295 kg.

Coordinates of the center of power for the equipped wing are defined by the formulas:

$$X_w^{/} = \frac{\Sigma m_i^{/} x_i^{/}}{\Sigma m_i^{/}} \tag{2.16}$$

Table 2.2 - Trim sheet of equipped wing masses

| N | Name | Mass | | C.G. coordinates | Moment (kgm) |
|---|---|---|---|---|---|
| | | Units | total (kg) | | |
| 1 | Wing (structure) | 0,11908 | 10871,4086 | 2,11188 | 22959,11039 |
| 2 | Fuel system, 40% | 0,0032 | 292,144 | 2,217474 | 647,8217243 |
| 3 | Control system, 30% | 0,00174 | 158,8533 | 1,58391 | 251,6093304 |

Continuation of table 2.2

| | | | | | |
|---|---|---|---|---|---|
| 4 | Electrical equip. 30% | 0,00921564 | 841,341854 | 0,52797 | 444,2032586 |
| 5 | Anti-icing system 70% | 0,010584 | 966,26628 | 0,52797 | 510,1596079 |
| 6 | Hydraulic system, 70% | 0,010948 | 999,49766 | 3,16782 | 3166,228677 |
| 7 | Power units | 0 | 0 | 0 | 0 |
| 8 | Equiped wing | 0,15476764 | 14129,5117 | 1,980191078 | 27979,13299 |
| 9 | Nose landing gear | 0,006482829 | 591,849891 | -15,8099645 | -9357,125767 |
| 10 | Main landing gear | 0,032997171 | 3012,47671 | 3,11531896 | 9384,825808 |
| 11 | Fuel | 0,2723 | 24859,6285 | 2,270271 | 56438,09365 |
| | Equiped wing | 0,46654764 | 42593,46679 | 1,982579326 | 84444,92669 |

It is necessary to determine the center of the loaded aircraft, to understand how the weight is distributed inside the fuselage and to correct it.

Performing the volume-mass layout, the calculations of the centering of the aircraft are performed, that is, the location of such a position of the center of mass (CM) plane relative to the average geometric wing chord (GWC), in which:

1) in the case with the most rear position of the CM, the minimum allowable stock of static stability of the aircraft is provided;

2) at the option with the most forward positions of the CM, conditions for the sufficiency of the steering wheel height or stabilizer for longitudinal balancing of the airplane on all flight modes are provided.

The more effective the longitudinal control and balancing bodies of the aircraft, the more may be the permissible lateral forward center and the wider operating range of centers.

In the course of operation of the aircraft, the position of its centre of gravity changes both in terms of fuel output in flight, as well as in the result of different loading options and flight masses. Therefore, the CP must calculate the ranges of airplane centers for the most typical cases of its operation:

1) take-off mass at the LG produced;

2) take-off weight at LG removed;

3) landing mass for released LG;

4) overheating variant (without commercial loading at maximum fuel quantity) with LG removed;

Parking option (without commercial loading, fuel, crew) with released chassis.

The centering of an aircraft is usually an iterative process, which is performed by the method of successive approximation to the desired result, or the modification of the layout, or the rearrangement of mass groups, or the use of both variants simultaneously.

When performing a CP, the center is determined along the x axis, along the fuselage.

The starting data for the calculation of centers is the mass of the masses, the theoretical drawing and the preliminary layout of the fuselage, the wings, the plumage, the chassis.

The summary of masses is made in the form of a table-centered information, which includes the coordinates of the centers of masses of all components of the take-off mass of the aircraft relative to the nose part of the fuselage xi, as well as the static moments of mass moments (tables 2.3, 2.4).

To determine the coordinates xi should use the schematic drawing of the previous version of the layout of the aircraft.

1) Determination of the center of the masses of the equipped wing

The mass of the fitted wing includes the mass of its construction, part of the mass of equipment (located in the wing), the chassis and mass of fuel.

Regardless of where the main supports of the chassis (on the wing or fuselage) are located, they together with the front support are included in the center roll of the masses of the winged wing (Table 2.3). In the center marking insert the name of the object, their relative and absolute masses and the coordinates of the centers of mass.

Coordinates of fuel mass centers in each tank (group of tanks) are located (see appendix).

- behind the chord of the wings - in the middle of the caisson;

- in the width of the wing - at a distance z from the internal, relative to the plane of symmetry of the plane.

Relative mass of fuel, which can be placed in the fuselage (center wing wing)

$$\overline{m}_{ff} = \overline{m}_{f} - \overline{m}_{\text{f wing}}\ , \tag{2.17}$$

where $\overline{m}_{f}$ – total relative mass of fuel; $\overline{m}_{fwing}$ – relative mass of fuel, which can be placed in the wings consoles.

Relative weight of fuel, which can be placed in the wing

$$\overline{m}_{fwing} = \frac{\beta \overline{c}_{wing}}{\lambda_{wing}^{0,5}} \frac{m_0^{0,5}}{p_0^{0,5}}, \tag{2.18}$$

where $\beta$ = 220+15$\eta_{\text{wing}}$ – coefficient, which depends on the constriction of the wing $\eta_{\text{кр}}$;

$\lambda_{кр}$ – aspect ratio of wing;

$p_0$ – specific load on the wing at take-off;

$\overline{c}_{\text{кр}}$ – average relative thickness of the wing;

$m_0$ – take-off mass of the aircraft.

The coordinates of the centers of masses of pylons, engines, and gondolas are determined graphically along the centerline of the wing.

In table 2.3 an approximate list of mass objects and recommendations for determining the coordinates of their mass centers is given.

Table 2.3 - Centering roll of masses of the equipped wing

| № | Object name | Mass $m_i$ | | C.G coordinates $X_i$, m | Moment of mass |
|---|---|---|---|---|---|
| | | units | total mass, kg | | |
| 1. | Wing | 0,15437 | 3908,19 | 1,43 | 5584,00 |

Continuation of table 2.3

| | | | | | |
|---|---|---|---|---|---|
| 2. | Fuel system | 0,002849 | 72,14 | 1,43 | 103,07 |
| 3. | Airplane control (30%) | 0,00318 | 80,51 | 1,91 | 153,37 |
| 4. | Electrical equipment (10%) | 0,003 | 75,95 | 0,32 | 24,12 |
| 5. | Anti-icing system (70%) | 0,009261 | 234,46 | 0,32 | 74,44 |
| 6. | Hydraulic system (70%) | 0,01834 | 464,31 | 1,92 | 891,4 |
| Equipped wing (without fuel and LG) | | 0,191 | 4835,56 | 1,41 | 6830,33 |
| 8. | Nose LG (10%) | 0,004729 | 119,47 | - 6,796 | 881,92 |
| 9. | Main LG (90%) | 0,042471 | 1075,24 | 1,75 | 1881,67 |
| 10. | Engines(-APU, - fuel system) | 0.092581 | 2343,87 | 2,34 | 5484,66 |
| 11. | Fuel (including aeronautical reserve): | 0,14247 | 3606,91 | 1,344 | 4847,7 |
| Total | | 0,473251 | 11981,05 | 1,15 | 19926,28 |

1. The numbers of objects of centering information of the masses of the equipped wing must correspond to the serial numbers on the centerline drawing of the wing.

2. The calculation of all groups of masses is carried out according to the program for the computer department of the design of aircraft.

The coordinate of the CM of the equipped wing is determined by the formula

$$x_{wing} = \frac{\sum m_i x_i}{\sum m_i} \qquad (2.19)$$

2) Determination of the center of masses of the equipped fuselage

The origin of the coordinates is chosen in the projection of the fuselage's bow of the horizontal axis. The x axis of the fuselage is accepted.

An approximate list of mass objects and recommendations for determining the coordinates of their centers of mass are given in Table 2.4.

Table 2.4 - Centering of mass of equipped fuselage

| № | Object name | Mass $m_i$ | | C.G coordinates $X_i$,m | Moment of mass |
|---|---|---|---|---|---|
| | | Units | total mass kg | | |
| 1 | 2 | 3 | 4 | 5 | 6 |
| PLANE | | | | | |
| 1. | Fuselage | 0,15129 | 3830,21 | 10,70 | 40987,07 |
| 2. | Horizontal tail | 0,01613 | 408,36 | 22,87 | 9339,02 |
| 3. | Vertical tail | 0,01606 | 406,59 | 22,87 | 9298,49 |
| EQUIPMENT AND CONTOL | | | | | |
| 4. | Elevation equipment | 0,00567 | 143,55 | 10,70 | 1536,10 |
| 5. | Anti-icing system (30%) | 0,003969 | 100,48 | 10,70 | 1075,27 |
| 6. | Cargo equipment | 0,0063 | 159,50 | 10,70 | 1706,78 |
| 7. | Hydraulic system (30%) | 0,00786 | 198,99 | 10,70 | 2129,41 |
| 8. | Electric equipment (90%) | 0,027 | 683,56 | 9,51 | 6502,01 |
| 9. | Radar | 0,0045 | 113,93 | 2,38 | 270,92 |
| 10. | Navigation equipment | 0,0068 | 172,16 | 2,38 | 409,39 |
| 11. | Radio equipment | 0,0034 | 86,08 | 1,19 | 102,35 |
| 12. | Instrumental panel | 0,0079 | 200,00 | 0,95 | 190,24 |
| 13. | Flight control systems (70%) | 0,00742 | 187,85 | 11,89 | 2233,56 |
| 14. | Auxiliary power plant | 0,0066801 | 169,12 | 10,37 | 1753,61 |
| EQUIPMENT | | | | | |
| 15. | Crew | | 285,00 | 2,38 | 677,73 |
| 16. | Attendant | | 150,00 | 2,38 | 356,70 |
| 17. | Documentation and tools | 0,002 | 50,63 | 1,66 | 84,29 |
| 18. | Water (liq.) | | 10,00 | 11,41 | 114,14 |
| 19. | Additional equipment | | 506,00 | 9,51 | 4812,06 |
| Equipped fuselage without payload | | 0,270979 | 7863 | 10,62 | 83579,14 |
| 20. | Cargo | | 5500,00 | 13,08 | 71934,50 |
| TOTAL: | | | 13363 | 11,63 | 155513,64 |

The calculation of all groups of masses is carried out according to the program for the computer department of the design of aircraft.

The coordinate of the center of the masses of the fitted fuselage is determined by the formula 2.20

$$x_{ф} = \frac{\sum m_i x_i}{\sum m_i} \quad (2.20)$$

Determined centers of masses of equipped wings and fuselage is the equation of equilibrium of moments relative to the nose of the fuselage

$$m_f x_f m_{кр} (x_a + x_{wing}) = m_0 (x_a + x_c) \quad (2.21)$$

where $x_a$ - the position of the beginning of the CAC of the wings relative to the of the fuselage; c – distance from the beginning of the CAC to the center of the mass of the plane.

As you know, the center of the plane $x_p = x_a + c$ – this is the coordinate of the position of its center of mass in the projection on the CAC of the wings, It can be determined from the previous formula as 2.21

$$\bar{x}_т = \frac{m_ф x_ф + m_{кр}(x_а + x_{кр})}{m_0} \quad (2.22)$$

In practice, the center of the plane is determined, as a rule, in relative coordinates $\bar{x}_т$, that is, the position of the CM from the beginning of the SAC, expressed as a percentage (or fraction) of the CAC

$$\bar{x}_T = \frac{x_T - x_А}{b_А} 100\% \quad (2.23)$$

So, to calculate the centering of aircraft $\bar{x}_т$ it is necessary to know the position of the beginning of the CAC of the wings relative to the fuselage $x_a$. Initial value $x_a$ can be determined through the appropriate scale from the scheme of the prototype aircraft, having previously determined the size of the CAC and drawn it on the wing

As a result of the calculations, the values of the center of the aircraft should be obtained, which are given in Table 2.5.

Table 2.5 - The value of the centers of airplanes by the statistics

| Straight wing | | Sweep wing | |
|---|---|---|---|
| Low-wing | High-wing | Low-wing | High-wing |
| 13…32 | 15…33 | 18…38 | 20…42 |

In the case that these values can not be obtained, it is recommended to apply the following means of correction center:

change the location of the heaviest loads in the fuselage;

move the wing along the fuselage (with this will move not only the center of the mass of the plane, but also the CAC of the wings).

In order to determine which distance l should be moved, for example, the wing of the aircraft as the largest airplane mass, you must first determine how much you need to change the center $\overline{\Delta x_T}$ for the purpose of obtaining the following recommended values $\bar{x}_T$. Value $\overline{\Delta x_T}$ is defined as the difference between the calculated and recommended values $\bar{x}_T$. Distance l can be found by formula 2.23

$$l = \frac{\Delta \bar{x}_T b_a m_0}{m_{\kappa p}} \quad (2.24)$$

For increasing $x_T$ we need to deduct the value of l from the initial value of $x_a$ then you need to list the center of the plane with a new value $x_a$.

In order to facilitate the implementation of calculations of centrovka variants, it is recommended that the masses and corresponding coordinates of the masses be reduced to the table in Table 2.6.

Mandatory variants of calculation of the center of the aircraft for the most typical cases of aircraft operation are summarized in Table 2.7.

When performing the calculations of the center, it is necessary to check the fulfillment of the requirements:

$\sum m_o = m_{wing.} + m_{fus.}$; $L_{го} \geq 3b_a$

For the landing variant, the mass of fuel can be roughly taken 15% ... 20% (depending on the type of airplane) from the mass of fuel during take-off, and for the overhead - the mass of fuel is maximally possible (due to lack of commercial load) and is determined by the capacity of the fuel tanks of the aircraft.

Table 2.6 - Calculation of the C.G, positioning variants

| № | Name | Mass $m_i$, kg | Coordination $x_i$, m | Moment of mass $m_i$ $x_i$, kgm |
|---|---|---|---|---|
| 1. | Equipped wing (without fuel and LG) | 4835,56 | 9,91 | 47920,4 |
| 2. | Nose LG (extended) | 119,47 | 6,796 | 811,92 |
| 3. | Main LG (extended) | 1075,24 | 10,25 | 11021,21 |
| 4. | Fuel | 3679,05 | 9,77 | 35944,31 |
| 5. | Equipped fuselage (without payload) | 7363 | 10,62 | 83579,14 |
| 6. | Cargo | 5500,00 | 13,08 | 71934,50 |
| 7. | Crew | 285 | 2,38 | 677,73 |
| 8. | Nose LG (retracted) | 119,47 | 6,796 | 811,92 |
| 9. | Main LG (retracted) | 1075,24 | 10,25 | 11021,21 |
| 10. | Reserve fuel | 175,25 | 9,77 | 1711,9 |

Table 2.7- Airplanes C.G. position variants

| № | Name | Mass $m_i$, kg | Static moment of mass $m_i$ $x_i$, kgm | CM of aircraft $X_{cma\ i}$, m | Centering $\bar{X}$, % |
|---|---|---|---|---|---|
| 1. | Take off mass (LG extended) | 25317 | 168520,54 | 11,33 | 36,69 |
| 2. | Take off mass (LG retracted) | 25317 | 168401,07 | 11,33 | 36,54 |
| 3. | Landing mass (LG extended) | 25317 | 164655,36 | 11,32 | 36,24 |
| 4. | Ferry version | 19531,2 | 95998,94 | 10,98 | 25,49 |
| 5. | Parking version | 15428,7 | 90304,62 | 11,15 | 30,93 |

**Conclusion to the part**

In this part I have determined the main characteristic of projected aircraft, all of its structural elements, described them and compare with another competitive design. I have calculated and determited center of gravity of designed aircraft, center mass of equiped and not equiped aircraft.

The plane is a twin-engined turboprop civil and military transport aircraft with tricycle landing gear which has a front single-strut landing gear and two main gears.

A swept wing with a high aspect ratio, which is based on new supercritical profile. Fuselage has circular cross section. Rudder and elevators are equipped with aerodynamic balance.

Fuselage is an all-metal, frame-stringer type of semi-monocoque.

I have taken round cross-section of the fuselage, because in this case it will be the most durable and light. Wheel base of langing gear is 8,56 m. The front langing gears is installed in the forward part of the fuselage and in flight also retracts forward into the compartment under the cockpit The main langing gear are installed in the engine nacelles and in flight are retracted forward into special compartments under the engines. The tail unit is not pressurised; it carries a tail unit on itself. The most forward and most aft centre of gravity position of the plane are 25, 49% and 36,69 % from the leading edge of a mean aerodynamic cord.

# MEDICAL EQUIPMENT OF MEDICAL EVACUATION AIRCRAFT

## 3.1 Analysis of problem

Considering the medical evacuation aircraft (*next medevac*), you can see different types of variants of the design of these aircraft. For example, most of them are medical aircraft, designed to transport one or two seriously illness patients. The second type, less common, but no less useful, is aimed at middle and seriously illness patients, which can transport from 3 or more patients. I am looking about the last type of air transport.

Considering the options for medevac aircraft, I noticed that they are mainly developed from conventional cargo military aircraft, and the differences from medical aircraft, which are converted from business jets and small aircraft. They will fulfill different tasks assigned to them. A medical board saves lives in peacetime, and a medevac plane - during a war or disaster, when there are many wounded and doctors just need to support them before arriving at the hospital base.

A cargo transport aircraft is a perfect option for a medevac aircraft. It is spacious and ready to transport cargo and patients. The main problem is how to accurately place patient bunk and medical equipment. Since the plane is focused specifically on the rescue and evacuation unit, it is worth noting that there will be many patients and they will be injured.

There should be quick access to the placement of the patient and the location of medical equipment near patient.

Current international military operations have shown that medical support is an important opportunity for expeditionary forces. This swift and swift demand was highlighted in the field of warfare, such as Afghanistan, where local medical facilities (civilian and military hospitals) were completely depleted by the war, rendering the host country's medical support less than adequate by Western standards. In accordance with NATO STANAG (rules), Forward medevac is “the phase of evacuation which provides airlift for patients between points within the battlefield, from the battlefield, as far forward as the point of wounding, to the initial point of treatment and to subsequent points of treatment within the combat zone”. [9] This means that highly trained medical teams rely on aircraft to quickly reach casualties, regardless of their proximity to enemy positions. However, not all services can employ this kind of highly trained medical personnel, and often a physician, physician or nurse on board an aircraft has only basic trauma skills.

Consequently, the two main problems found in Afghanistan are in the provision of assistance to patients in flight and preparedness to rescue personnel in the war zone.

In 2010, to understand this problem, the Italian army decided to start a program to introduce advanced medical evacuation with the aim of conducting rescue operations. Meanwhile, the deployed air battalion has developed new tactics to assist units in distress or under fire. However, as this tactical update is only applicable to Army aviation, it is now needed to expand the use of advanced medical evacuation as part of a collaborative approach with medical services and the Air Force.

Due to the multinational nature of today's unforeseen circumstances, medical evacuation supports more than one national army, navy or air force and must coordinate closely the efforts of the involved medical corps, ground units, and flight crews, thus complicating the management of medical personnel.

In the ambulance version, sanitary racks and sanitary tapes are installed in the cargo compartment of the aircraft for stretcher attachment (Figure 3.2). Every rack has three locks in which stretcher handles get place. Other stretcher handle gets place in tape’s loop.

Sanitary tapes manufactured from steel pipe with cross-section 45x2 mm. The upper ends of the rack get place into the slots of the brackets mounted on the frames. The lower ends of the rack get place into the transition sockets, which screwed into the mooring sockets at right and left sides of the fuselage. Sanitary tapes fastened with fixator in the corresponding attachment points on the floor and on the fuselage frames. Buckles regulate the tension of the tapes.

The sanitary racks with sanitary tapes and straps mounted in lyre in the combat position.

The seat of the medical worker located between the frames 31-33 on the right side, and the folding table of the medical worker is located between the frames 33-34. There is a first aid kit under the table, and a hook for a medical bag on the frame 34.

The wounded are loading into the aircraft through the cargo hatch. The installation of a stretcher with wounded should be performed starting from the upper rows of the front of the cargo compartment.

Frame hoop – it is part of fuselage, metal transverse stiffening element of the shell of the aircraft

Rack mounting bracket - cantilever supporting structure, which serves for mounting on a vertical plane (the wall of the fuselage) protruding in the horizontal direction of parts of the detail. It connects the rack and the frame.

Sanitary rack - rigid structural element. It inserted into the bracket on one side and in the mooring socket on the other. It performs support functions of construction.

Rack lock - the mechanism that connects the stretcher with the sanitary rack. It opens when push it. There is a spring that closes the lock and prevents it from opening.

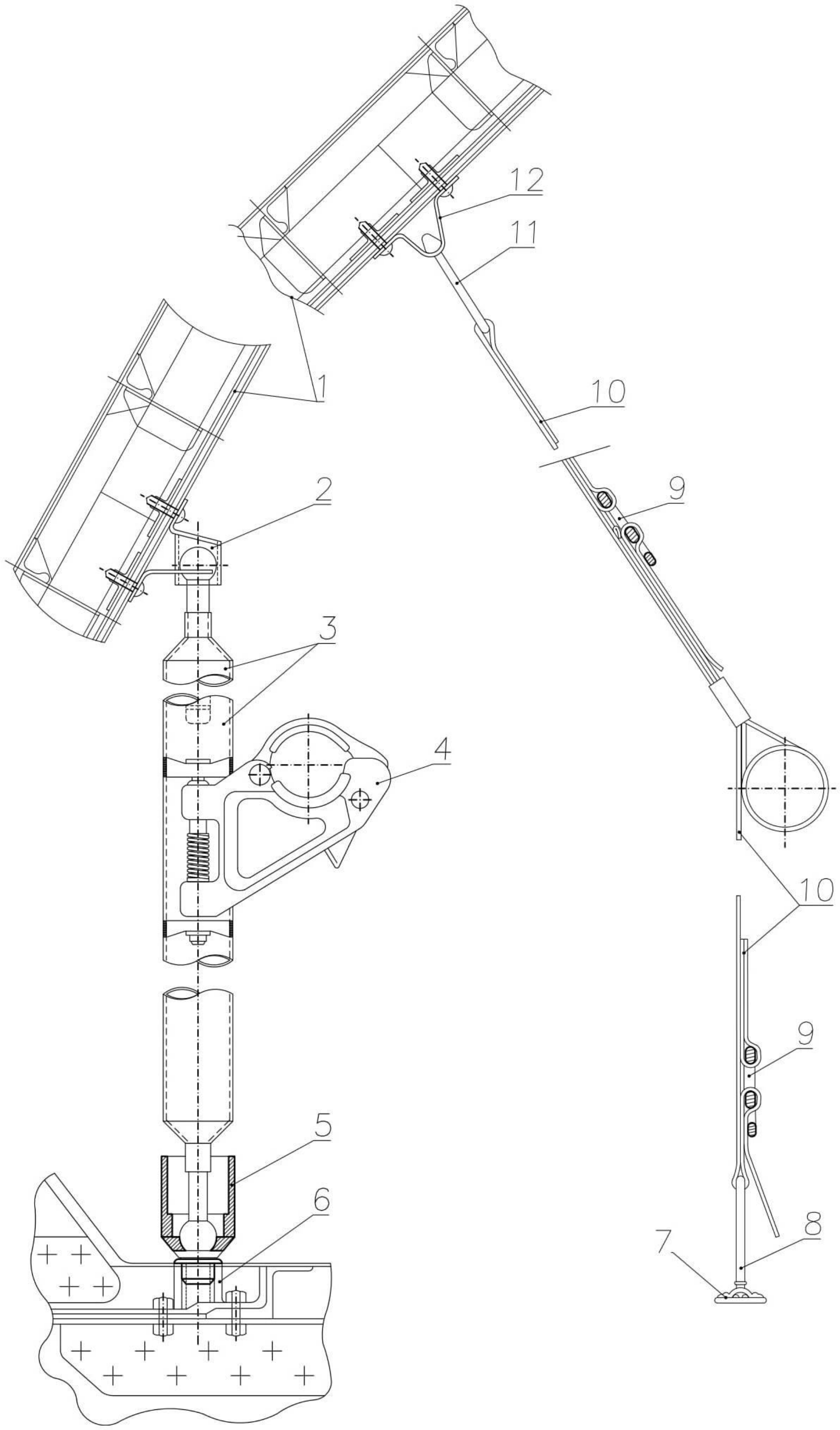
Transition socket - allows the rack to be riged fixed in mooring socket on the cabin floor.

Mooring socket on the cabin floor - connects the rack and rigid holds in the floor of the fuselage.

Bracket on the cabin floor- holds sanitary tape in the floor. It can remove the the sanitary lower fixator, curling 90 degrees to any side and pressing it to the floor.

Sanitary tape lower fixator – fix the brackets and sanitary tape. It attached to the tape using buckle

Buckles – pull, fix and hold sanitary tape.




1 – frame hoop; 2 – rack mounting bracket; 3 – sanitary rack; 4 – rack lock; 5 – transition socket; 6 – mooring socket on the cabin floor; 7 – bracket on the cabin floor; 8 – sanitary tape lower fixator; 9 – buckles; 10 – sanitary tape; 11 – top tape fixator; 12 – bracket on the rim of the frame.

Figure 3.2 - Mounting sanitary racks and tapes

Sanitary tape - attached to the fuselage and to the floor of the fuselage using fixators. It keeps stretchers in construction between sanitary rack and itself.

Top tape fixator - fixing the brackets and sanitary tape. It attached to the tape using buckle.

Bracket on the rim of the frame - hold sanitary tape in the fuselage frame. It can remove the the sanitary top tape fixator, curling 90 degrees to any side and pressing it to the frame.

## 3.2 Stress-strain analysis of sanitary tape

Sanitary tape

1) LTK-44-1500 OCT17-667-2002

$$\frac{\Delta l}{l} = 30\% \qquad (3.1)$$

2) Elongation 30%

$$\frac{\Delta l}{l} = \frac{P}{EJ} \qquad (3.2)$$

3) Rigid of tape LTK-44-1500

$$EJ = \frac{P}{\Delta l / l} = \frac{1500}{0.3} = 5000 kgf \qquad (3.3)$$

Fixator

Casting 35ХГСЛ 6,5x50x64 OCT1 90093-82

$$\sigma = 10000 kg / cm^2$$

$$P_{yT2}^{P} = 273 kgf$$

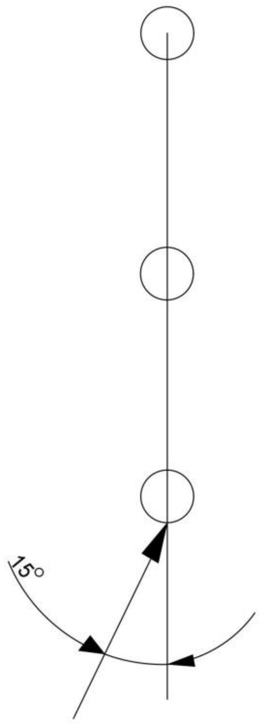



Figure 3.3 – Load angle to the sanitary tape

1) Fixator load:

$$P_{y1}^{P} = \frac{P_y^p}{\cos\beta} = \frac{273}{\cos 15^o} = 282kgf \quad (3.4)$$

The load on the fixator is transmitted through the tape (figure 3.4) LTK-44-1500 width 44mm:

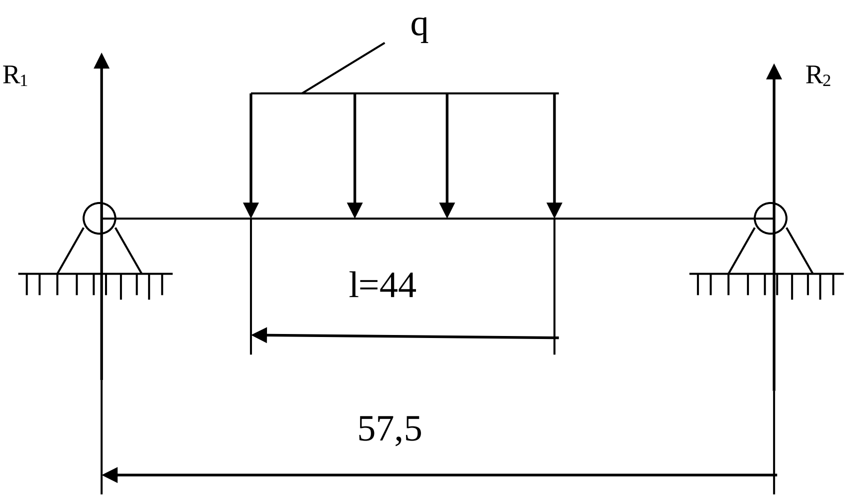



Figure 3.4 – Schema of load on the fixator through the tape

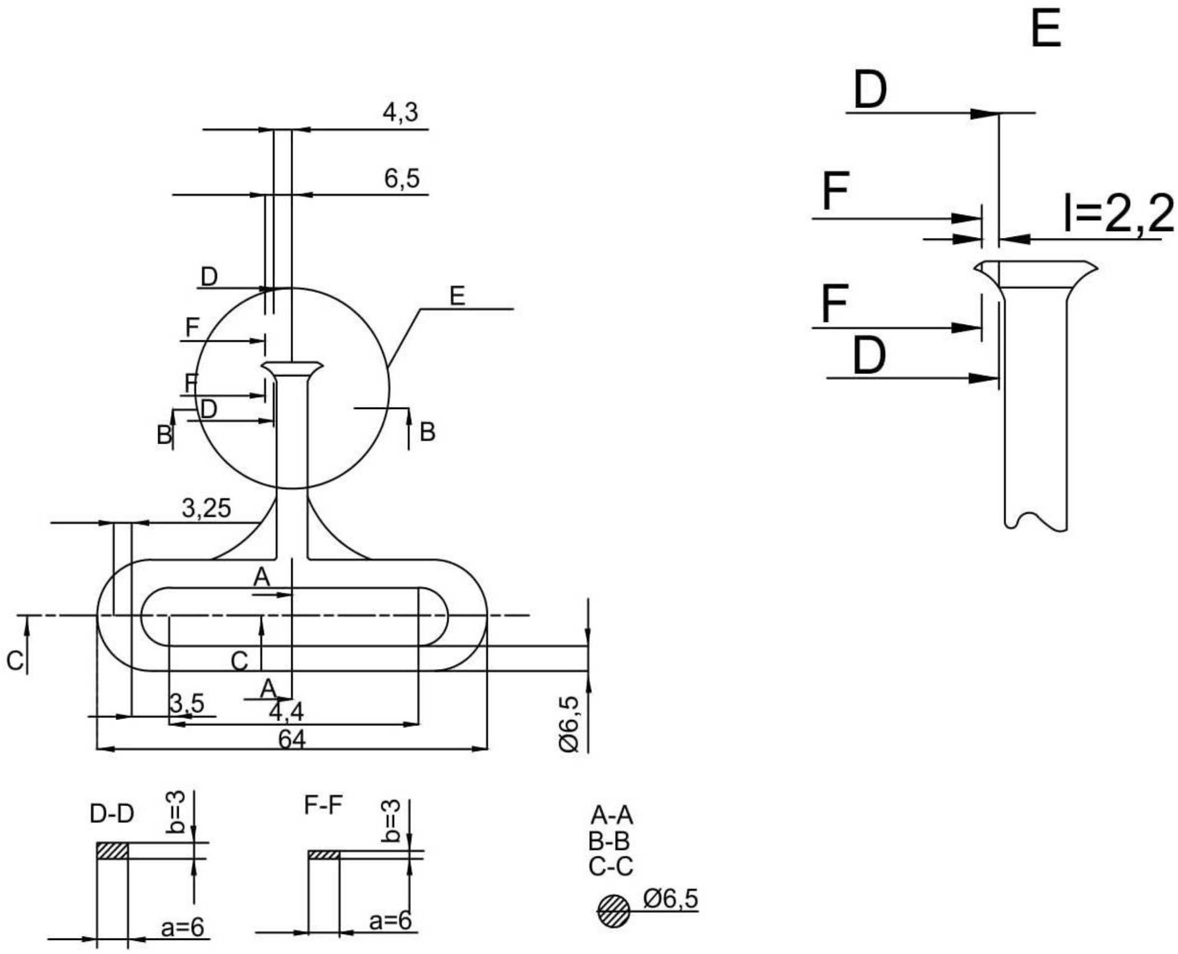



Figure 3.5 – Sanitary tape lower fixator

2) Fixator and design scheme

$R_1$=$R_2$=141kgf.

$$M^{p}_{\max} = 250kg \cdot cm$$

3) Geometrical characteristics of cross-sections A-A, B-B, C-C:

3.1) Diameter Ø6,5mm

$$F_{A-A} = \frac{\pi D^2}{4} = \frac{3{,}14 \cdot 0{,}65^2}{4} = 0{,}33cm^2 \tag{3.5}$$

$$W_{A-A} = \frac{\pi D^3}{32} = \frac{3{,}14 \cdot 0{,}65^3}{32} = 0{,}0269cm^3 \tag{3.6}$$

3.2) Determine the bending stress in cross-section A-A (formula 3.7):

$$\sigma_{A-A}^{P} = \frac{M_{\max}^{P}}{W \cdot k} = \frac{250}{0,0269 \cdot 1.7} = 5467 kg / cm^{3} \qquad (3.7)$$

k = 1,7 – coefficient of plasticity for round cross-section

Safety factor:

$$\eta = \frac{\sigma}{\sigma_{A-A}^{P}} = \frac{10000}{5467} = 1,8 \qquad (3.8)$$

3.3) Consider the cross-section B-B:

Load in cross-section:

$$P_{y1}^{P} = 282 kgf$$

Determine the stress in cross section B-B (formula 3.9):

$$\sigma_{B-B}^{P} = \frac{P_{y1}^{P}}{F_{A-A}} = \frac{282}{0,33} = 854 kg / cm^{2} \qquad (3.9)$$

Safety factor:

$$\eta = \frac{\sigma}{\sigma_{B-B}^{P}} = \frac{10000}{854} > 3 \qquad (3.10)$$

3.4) Consider the cross-section C-C:

Load in cross-section:

$$P_{y}^{P} = R_{1} = 141 kgf$$

Determine the stress in cross section C-C (formula 3.11):

$$\sigma_{C-C}^{P} = \frac{P_{y}^{P}}{F_{C-C}} = \frac{10000}{427} > 3 \qquad (3.11)$$

3.5) Consider the cross-section F-F (formula 3.12 ):

Cross-section F-F check for shear from the entire load $P_{y1}^{P}$

The geometrical characteristics of the cross-section F-F in the safety factor are taken simply:

$$F_{F-F} = a \cdot b = 0,6 \cdot 0,2 = 0,12cm^2;$$

$$W_{F-F} = \frac{a \cdot b^2}{6} = \frac{0,6 \cdot 0,2^2}{6} = 0,004cm^3 \quad (3.12)$$

$$\tau^P_{F-F} = \frac{P^p_{y1}}{F_{F-F}} = \frac{282}{0,12} = 2350kg / cm^2$$

Safety factor:

$$\eta = \frac{\sigma}{\tau^p} = \frac{10000}{2350} > 4,25 \quad (3.13)$$

3.6) Consider the cross-section D-D:

The geometrical characteristics of the cross-section D-D in the safety factor are taken simply:

$$F_{D-D} = a \cdot b = 0,6 \cdot 0,3 = 0,18cm^2;$$

$$W_{D-D} = \frac{a \cdot b^2}{6} = \frac{0,6 \cdot 0,3^2}{6} = 0,009cm^3 \quad (3.14)$$

Bending moment in cross-section D-D:

$$M^P_{bend} = P^p_{y1} \cdot l = 282 \cdot 0,22 = 62,04kg \cdot cm \quad (3.15)$$

Determine the stress in cross section D-D:

$$\sigma^P_{D-D} = \frac{M^P_{bend}}{W_{D-D}} = \frac{62,04}{0.009} = 6893kg / cm^2 \quad (3.16)$$

Determine the shear stress in cross section D-D:

$$\tau^P_{D-D} = \frac{P^P_{y1}}{F_{F-F}} = \frac{282}{0,18} = 1583kg / cm^2 \quad (3.17)$$

Find the total equivalent  load in cross section D-D (formula 3.2.18):

$$\sigma^P_{eq.D-D} = \sqrt{{\sigma^P_{D-D}}^2 + 4 \cdot {\tau^P_{D-D}}^2} = \sqrt{6893^2 + 4 \cdot 1583^2} = = 7585kg / cm^2 \quad (3.18)$$

Safety factor:

$$\eta = \frac{\sigma}{\sigma^P_{eq.D-D}} = \frac{10000}{7585} = 1,31 \quad (3.19)$$

Looking at similar aircraft designs around the world, I noticed that there are several types of medical equipment placement. The first type is the placement of this equipment directly next to the patient area. Considering this option, I realized that it is not very convenient and often there is simply not enough space to locate patient and a doctor nearby. The second type - the most popular now in modern aircraft construction - is medical units or medical blocks (containers).

In order to meet the requirements, it is listed in the following is the essential equipment required for the transportation of patients by air. All personnel need to be familiar with the use of these items:

- Resuscitation set + oxygen
- Ambu bag
- Intubation set
- Suction apparatus
- Sphygmomanometer
- Infusion & infusion set
- IV catheter & CVP Set
- Dressings
- Fixation tools & splints
- Vacuum mattress
- Injection set
- Minor surgery set
- Gastric tubes
- Portable ECG & defibrillator

Medicine and consumables need to be stored in compact boxes. Essential medical equipment has to be kept secured but in easy access to doctor. Every crew member must know exactly what is on board and where it is, so that they not dependent on other crew members in an emergency.

The Air Medical Container (AMC). The AMC provides a high tech environment in which highly skilled personnel can work during an AME mission. Within AMC, it maintains “ground level conditions”, in other words, the pressure maintained inside the container is almost identical to that at ground level, even though the container itself may be. The AMC can function as an ICU or operation room.

The AMC has been in used during 20 years and it has considerable experience with it. The AMC team should consist of doctors, highly skilled staff, and an equipment expert. Certain specialists, such as intensive care physicians, cardiologists, surgeons and internists may also be on board depending on the situation. The nursing personnel are one intensive care assistant, one OR nurse and one circulating nurse. The equipment expert is responsible for liaising with the aircrew and for the maintenance of the AMC and other medical equipment. A specialist may be appointed as head of the AMC team depending on the purpose of the mission.

Medical container (Figure 3.6) is extremely versatile in fixed and rotor wing aircraft. This system is lightweight, compact and fits smaller aircraft, yet has critical care capabilities for larger aircraft as well. Its functional, durable design lends itself to years of problem-free service for your air ambulance program. The system can be installed in single- or multiple-patient configurations depending. A stretcher for the patient can be attached to the top of the container. The container contains everything necessary to support the life of two patients, which can be placed one above the other.

The drip chamber and all the necessary accessories are attached to the supporting elements of the stretcher attachment.


Figure 3.6 – Medical container

Table 3.1 - Specification of medical container

| | |
|---|---|
| Bench Length | 75 inches (190.5 cm) |
| Width | 17 inches (43.25 cm) |
| Height | 10.6 inches (25.40 cm) |
| Base Unit Weight | 147 lbs (66.9 Kg) |
| Overhead Console Weight | 14 lbs. (6.4 Kg) |
| Dual Air Pumps | Air Pump Capacity (each) 11 lpm @ 50 psi |
| Vacuum Pump | 14 lpm @ 14 in hg (in ALS systems only) |
| Electrical Supply | (1) 28 volt DC outlet and (2) 115 volt AC outlets or (4) 230 Volt AC outlets |
| Inverter | Several 115 volt AC and 230 volt AC options |
| Oxygen Supply | 3500 Liter |

Standart equipment are mentioned in 3.4 part of work.

Unique seat rail adapter allows for quick and easy conversion of the aircraft from executive to EMS configuration in approximately 15 minutes. The aircraft is easily used for multiple roles and eliminates time-consuming conversions. No special tools are required for the conversion.

Overhead/Medwall supply panel is movable along the length of the patient or fully removable. The Medwall features an exam light and second set of pneumatic outlets, keeping aisles free from clutter and equipment.

Modular systems of container can be configured to secure a stretcher for adult patients or an infant transport deck for securing an incubator and cylinder housing for sick patients.

### 3.3 Analysis of overload of medical container

As a result of the analysis of the entire spectrum of flight and ground settlement cases of overloads (figure 3.7) acting on the medical containers (figure 3.8), the following cases of overloads are taken into account:

1. $n_X^P = 1,6,\ n_Y^P = -2,8$
2. $n_X^P = -1,2\ n_Y^P = -3,5$
3. $n_Y^P = 1,25$
4. $n_Y^P = -3,0$
5. $n_Y^P = -5,2\ n_Z^P = \pm 1,1$

Weight of medical container $M_M = 69,9kgf$

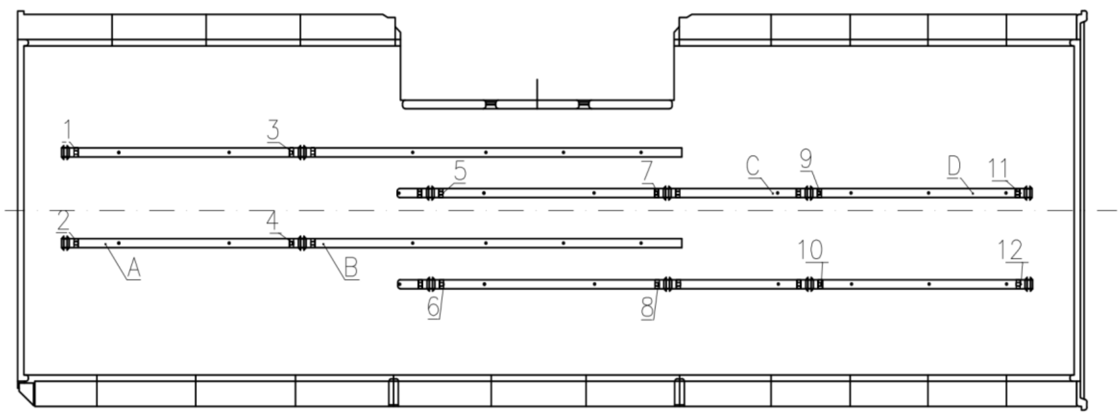



Figure 3.7 - Fastening points of medical container to inserts with studs

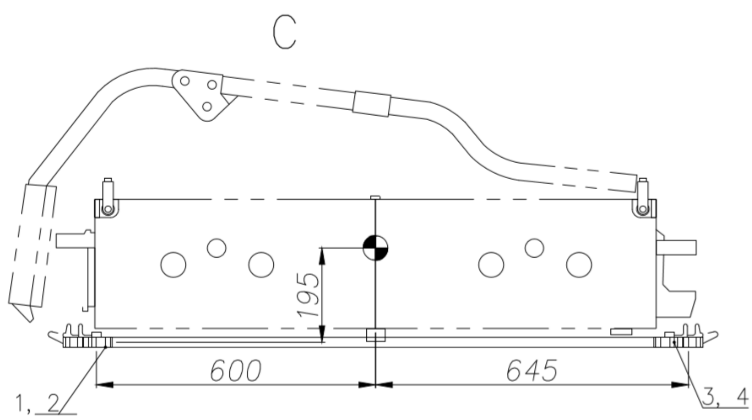



Figure 3. 8– Medical container side view

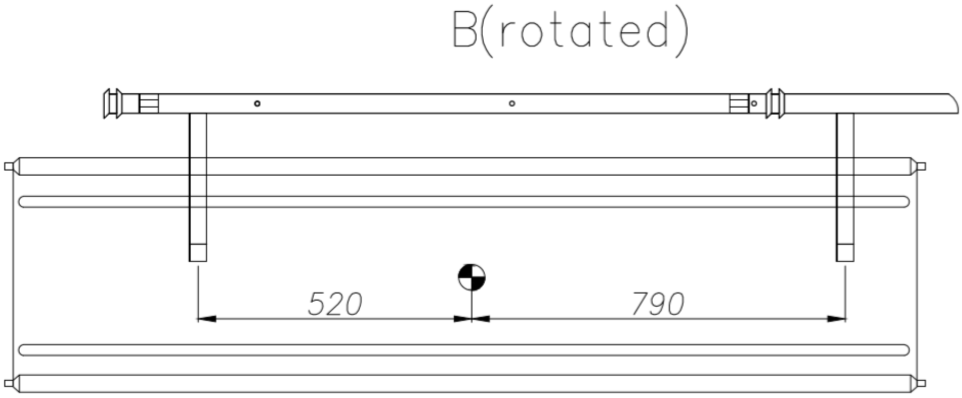



Figure 3.9 - Medical container general view

We can see the connection points of medical container for guide rails to the floor (figure 3.10)

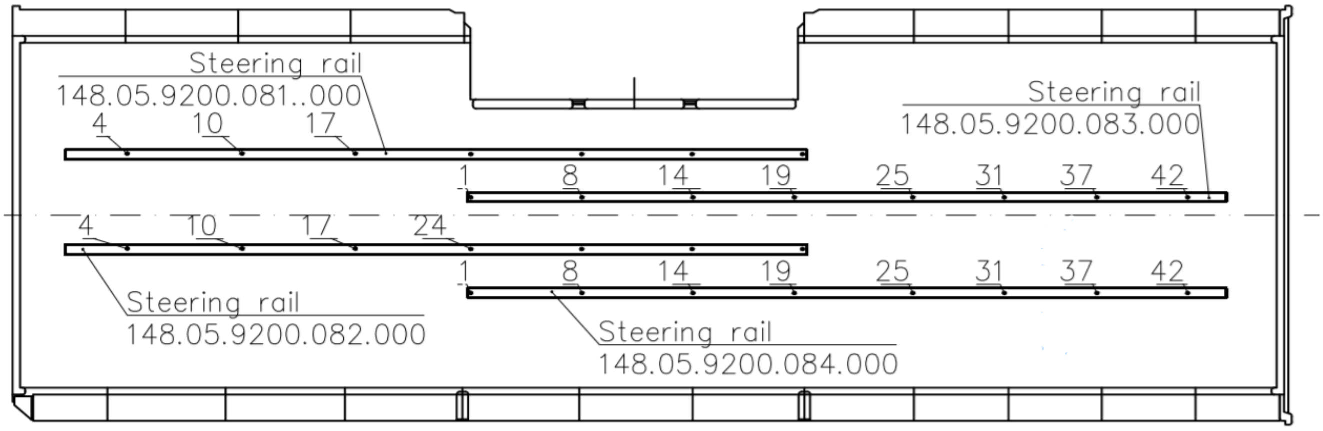



Figure 3.10 - Scheme of attachment points for guide rails to the floor

Calculated case $n_X^P = 1,6\ n_Y^P = -2,8$

Design loads:

$$P_X^P = M_M \cdot n_X^P = 69,9 \cdot 1,6 = 111,84kgf \quad (3.19)$$

$$P_Y^P = M_M \cdot n_Y^P = 69,9 \cdot (-2,8) = -195,72kgf \quad (3.20)$$

Moment from force $P_X^P$

$$M_Z^P = P_X^P \cdot l = 85,3 \cdot 19,5 = 1663,3kgf \quad (3.21)$$

Forve $P_X^P$ is perceived by the front liners with studs:

$$P^P_{X1,2} = P^P_X = 111,84kgf$$

The moment is perceived at the attachment points of the medical container to the inserts with the pins (Figure 3.10):

$$-P^P_{Y1,2\,fromPx} = P^P_{Y3,4\,fromPx} = \frac{M^P_Z}{L} = \frac{2180,9}{124,5} = 17,51kgf \qquad (3.22)$$

Load $P^P_Y$ distributed between points 1-4

$$P^P_{Y1,2\,fromP_Y} = P^P_{Y3,4\,fromPy} = \frac{1}{2}\cdot P^Y_Y = \frac{1}{2}\cdot 195,72 = -97,86kgf \qquad (3.23)$$

Calculation scheme for determining the load on points 1-4 (Figure 3.11)


Figure 3.11 - Calculation scheme

$$P^P_{X_1} = \frac{P^P_{X1,2}\cdot a}{a+b} = \frac{111,84\cdot 15,6}{15,6+34,4} = 34,9kgf \qquad (3.24)$$

$$P^P_{Y1\,fromP_x} = \frac{P^P_{Y1,2\,fromP_x}\cdot a}{a+b} = \frac{-17,51\cdot 15,6}{15,6+34,4} = -5,5kgf \qquad (3.25)$$

$$P^P_{Y1\,fromP_Y} = P^P_{Y3\,fromP_Y} = \frac{P^P_{Y1,2\,fromP_Y}\cdot a}{a+b} = \frac{-97,86\cdot 15,6}{15,6+34,4} = -30,5kgf \qquad (3.26)$$

$$P^P_{X2} = \frac{P^P_{X1,2}\cdot b}{a+b} = \frac{111,84\cdot 34,4}{15,6+34,4} = 76,9kgf \qquad (3.27)$$

$$P^P_{X2\,fromP_x} = \frac{P^P_{Y1,2\,fromP_x}\cdot b}{a+b} = \frac{17,51\cdot 34,4}{15,6+34,4} = -12,05kgf \qquad (3.28)$$

$$P^P_{Y2\,fromP_Y} = P^P_{Y4\,fromP_Y} = \frac{P^P_{Y1,2\,fromP_Y}\cdot b}{a+b} = \frac{97,86\cdot 34,4}{15,6+34,4} = -67,3kgf \qquad (3.29)$$

$$P^P_{Y3\,fromP_x} = \frac{P^P_{Y3,4\,fromP_x} \cdot a}{a+b} = \frac{17,51 \cdot 15,6}{15,6+34,4} = 5,5kgf \quad (3.30)$$

$$P^P_{Y4\,fromP_x} = \frac{P^P_{Y3,4\,fromP_x} \cdot b}{a+b} = \frac{17,51 \cdot 34,4}{15,6+34,4} = 12,05kgf \quad (3.31)$$

Since the mounting scheme of medical containers to inserts with one pin for all containers, the load:

- $P^P_{X1}$ and $P^P_{Y1}$ is the same for points 5,9 (Figure 3.10)

- $P^P_{X2}$ and $P^P_{Y2}$ is the same for points 6,1 (Figure 3.10)

- $P^P_{Y3}$ the same for points 7,11 (Figure 3.10)

- $P^P_{Y4}$ the same for points 8,12 (Figure 3.10)

Summary the load on points 1-4:

$$P^P_{Y1\Sigma} = P^P_{Y1\,fromP_x} + P^P_{Y1\,fromP_Y} = -5,5 - 30,5 = -36kgf \quad (3.32)$$

$$P^P_{Y2\Sigma} = P^P_{Y2\,fromP_x} + P^P_{Y2\,fromP_Y} = -12,05 - 67,3 = -79,35kgf \quad (3.33)$$

$$P^P_{Y3\Sigma} = P^P_{Y3\,fromP_x} + P^P_{Y3\,fromP_Y} = 5,5 - 30,5 = -25kgf \quad (3.34)$$

$$P^P_{Y4\Sigma} = P^P_{Y4\,fromP_x} + P^P_{Y4\,fromP_Y} = 12,05 - 67,3 = -55,25kgf \quad (3.35)$$

Loads $P^P_{Y1\Sigma}$ - $P^P_{Y4\Sigma}$ are perceived by the floor.

Maximum load on guide rail mounting bolts (Figure 3.11)

$$P^P_{X_{bolt}} = P^P_{X2} = 76,9kgf$$

Calculated case $n^P_X = -1,22$ $n^P_Y = -3,5$

Design loads:

$$P^P_X = M_M \cdot n^P_X = 69,9 \cdot (-1,22) = -85,3kgf \quad (3.36)$$

$$P^P_Y = M_M \cdot n^P_Y = 69,9 \cdot (-3,5) = -244,7kgf \quad (3.37)$$

Moment from force $P^P_X$

$$M^P_Z = P^P_X \cdot l = 85,3 \cdot 19,5 = 1663,3kgf \quad (3.38)$$

Forve $P^P_X$ is perceived by the front liners with studs:

$$P^P_{X3,4} = P^P_X = -85,3kgf$$

The moment is perceived at the attachment points of the medical container to the inserts with the pins (Figure 3.4):

$$P^P_{Y1,2\,fromPx} = -P^P_{Y3,4\,fromPx} = \frac{M^P_Z}{L} = \frac{1663,3}{124,5} = 13,36kgf \qquad (3.39)$$

Load $P^P_Y$ distributed between points 1-4:

$$P^P_{Y1,2\,fromP_Y} = P^P_{Y3,4\,fromP_Y} = \frac{1}{2}\cdot P^Y_Y = \frac{1}{2}\cdot 244,7 = -122,35kgf \qquad (3.40)$$

Calculation scheme for determining the load on points 1-4 (Figure 3.11)

$$P^P_{Y1\,fromP_x} = \frac{P^P_{X1,2\,fromP_x}\cdot a}{a+b} = \frac{13,36\cdot 15,6}{15,6+34,4} = 4,16kgf \qquad (3.41)$$

$$P^P_{Y1\,fromP_Y} = P^P_{Y3\,fromP_Y} = \frac{P^P_{Y1,2\,fromP_Y}\cdot a}{a+b} = \frac{-122,35\cdot 15,6}{15,6+34,4} = -38,2kgf \qquad (3.42)$$

$$P^P_{Y2\,fromP_x} = \frac{P^P_{Y1,2\,fromP_x}\cdot b}{a+b} = \frac{13,36\cdot 34,4}{15,6+34,4} = 9,2kgf \qquad (3.43)$$

$$P^P_{Y2\,fromP_Y} = P^P_{Y4\,fromP_Y} = \frac{P^P_{Y1,2\,fromP_Y}\cdot b}{a+b} = \frac{-122,35\cdot 34,4}{15,6+34,4} = -84,2kgf \qquad (3.44)$$

$$P^P_{X3} = \frac{P^P_{X3,4}\cdot a}{a+b} = \frac{-85,3\cdot 15,6}{15,6+34,4} = 26,6kgf \qquad (3.45)$$

$$P^P_{Y3\,fromP_x} = \frac{P^P_{Y3,4\,fromP_x}\cdot a}{a+b} = \frac{-13,36\cdot 15,6}{15,6+34,4} = -4,2kgf \qquad (3.46)$$

$$P^P_{X4} = \frac{P^P_{X3,4}\cdot b}{a+b} = \frac{-85,3\cdot 34,4}{15,6+34,4} = -58,7kgf \qquad (3.47)$$

$$P^P_{Y4\,fromP_x} = \frac{P^P_{Y3,4\,fromP_x}\cdot b}{a+b} = \frac{-13,36,\cdot 34,4}{15,6+34,4} = -9,2kgf \qquad (3.48)$$

Since the mounting scheme of medical containers to inserts with one pin for all containers, the load:

- $P^P_{Y1}$ is the same for points 5,9 (Figure 3.10)

- $P^P_{Y2}$ is the same for points 6,10 (Figure 3.10)

- $P^P_{X3}$ and $P^P_{Y3}$ the same for points 7,11 (Figure 3.10)

- $P^P_{X4}$ and $P^P_{Y4}$ the same for points 8,12 (Figure 3.10)

Summary the load on points 1-4:

$$P^P_{Y1\Sigma} = P^P_{Y1\,fromP_x} + P^P_{Y1\,fromP_Y} = 4{,}16 - 38{,}2 = -34{,}04kgf \quad (3.49)$$

$$P^P_{Y2\Sigma} = P^P_{Y2\,fromP_x} + P^P_{Y2\,fromP_Y} = 9{,}2 - 84{,}2 = -75kgf \quad (3.50)$$

$$P^P_{Y3\Sigma} = P^P_{Y3\,fromP_x} + P^P_{Y3\,fromP_Y} = -4{,}2 - 38{,}2 = -42{,}4kgf \quad (3.51)$$

$$P^P_{Y4\Sigma} = P^P_{Y4\,fromP_x} + P^P_{Y4\,fromP_Y} = -9{,}2 - 84{,}2 = -93{,}4kgf \quad (3.52)$$

Loads $P^P_{Y1\Sigma}$ - $P^P_{Y4\Sigma}$ are perceived by the floor.

Maximum load on guide rail mounting bolts (Figure 3.11):

$$P^P_{X_{bolt}} = P^P_{X12} = 58{,}7kgf$$

Calculated case $n^P_Y = 1{,}25$

Design loads:

$$P^P_Y = M_M \cdot n^P_Y = 69{,}9 \cdot 1{,}25 = 87{,}4kgf \quad (3.53)$$

Load $P^P_Y$ distributed between the guide rails with the scheme (Figure 3.11):

$$P^P_{Y1,3} = \frac{P^P_Y \cdot a}{a+b} = \frac{87{,}4 \cdot 15{,}6}{15{,}6 + 34{,}4} = 27{,}3kgf \quad (3.54)$$

$$P^P_{Y2,4} = \frac{P^P_Y \cdot b}{a+b} = \frac{87{,}4 \cdot 34{,}4}{15{,}6 + 34{,}4} = 60{,}1kgf \quad (3.55)$$

Load on the points 1-4 (Figure 3.4):

$$P^P_{Y1} = P^P_{Y3} = \frac{P^P_{Y1,3}}{2} = \frac{27{,}3}{2} = 13{,}65kgf \quad (3.56)$$

$$P^P_{Y2} = P^P_{Y4} = \frac{P^P_{Y2,4}}{2} = \frac{60}{2} = 30kgf \quad (3.57)$$

Since the mounting scheme of medical containers to inserts with one pin for all containers, the load:

- $P^P_{Y1}$ is the same for points 5,9 (Figure 3.10)
- $P^P_{Y2}$ is the same for points 6,10 (Figure 3.10)
- $P^P_{Y3}$ the same for points 7,11 (Figure 3.10)
- $P^P_{Y4}$ the same for points 8,12 (Figure 3.10)

**Conclusion to the part**

In this part of my diploma work I considered the main operational moments and design of medevac aircarft. I have analyzed sanitary tape, its strain-stress analysis. Also I have analyzed medical container, its equipment and overload.

Medical container is extremely versatile in fixed and rotor wing aircraft. This system is lightweight, compact and fits smaller aircraft, yet has critical care capabilities for larger aircraft as well. I have calculated loads between two points of connection. It is 13,65 and 30 kgf.

# LABOR PROTECTION

Working with a medevac aircraft, especially with medical container, soldiers, and medical personnel, maintenance workers and other units must know the correct using and follow the rules.

## 4.1 Analysis of harmful and dangerous production factors

A medical container weighing more than 60 kg each, has equipment for providing first aid and keeping the patient in a stable state, has many dangerous and harmful elements inside (see paragraph 3.4.1).

The primary danger may be in sharp objects such as scalpel, spritz or scissors.

Also, working with the resuscitation set, if you do not handle it properly, you can spill on yourself a medical liquid, acid, which, if it gets on human skin, causes a burn.

The container contains toxic and irritating chemicals that enter the human body through the gastrointestinal tract, skin and mucous membranes. High toxicity, sensitizing, allergic and irritating properties of flammable substances, increased electric field strength, increased magnetic field strength during defibrillator operation.

Working inside the aircraft, at high altitude, has big effects to the physical and psychological health of medical worker.

The work of medical person is very stressful and responsible especially at the high altitude. You need to be careful when flying, as there is a possibility of falling objects (elements of technological equipment, tools)

According to the standard 12.0.003-74 we have list of harmful and dangerous working factors, which can impact on the workers.

Let’s find out and analyze which dangerous and harmful factors working with that medical containers can take.

1) Physical factors

Medical person should work at lack or absence of natural light and insufficient lighting of the working area, increased pulsation of light flux. It must be in mind that work with the use of natural light should be at least $E \geq 5000$ lux on each square meter of the illuminated surface. In our case $E < 5000$ lux.

Also harmful physical production factors include:

- increased level of electromagnetic radiation;
- increased level of static electricity;
- increased levels of dustiness in the air in the working area;
- increased content of positive and negative ions in
- working area air;
- low or high humidity and air mobility working area;
- increased noise level;
- irrational organization of lighting of the workplace.

The worker often need endure take-off and landing, and therefore the ability to experience a state of weightlessness. The permissible norm for a person is 0.85P, but in the case of frequent take-offs and landings (while taking into account the fact that all this happens in a military environment) the level may drop to 0.35P, which negatively affects the mental and physical state of the worker.

2) Psychophysiological factors

Frequent physical overload (dynamic), mental overload, leg work in severe stress and without the opportunity to rest for more than 12 hours greatly affects the health and condition of the worker. This is the most harmful factor, to reduce which you need to regularly instruct the worker, physical and mental rest.

Psychophysiological production factors include:

- eye strain;
- tension of attention;
- intellectual and emotional stress;
- long-term static and dynamic loads;
- monotony of work;
- large information loads;

3) Chemical factors

No chemically hazardous substances.

4) Biological factors

There are no biological factors as such. Perhaps there is an option of getting a virus from a sick patient (remember coronavirus), picking up some kind of bacteria.

## 4.2 Measures to reduce the impact and dangerous production factors

Complex assessment of conditions is of practical interest labor. One of the widely used analytical indicators of working conditions is the category of labor severity. The category of labor severity characterizes the state of the human body, which is formed under the impact of working conditions

The integral point estimate of the severity of labor. It is calculated by formula 4.2.1:

$$I_p = 10\left(X_{me} + X\frac{6 - X_{me}}{6}\right), \qquad (4.1)$$

where $X_{me}$ is the main element of working conditions, that is, the element that received the highest rating;

$X$ is the average score of all elements of working conditions, except for the defining element.

The average score of all elements is calculated by the formula:

$$X = \frac{\sum_{i=1}^{n} X_i}{n - 1}, \qquad (4.2)$$

where $\sum_{i=1}^{n}$ is sum of all elements, except of main;

$n$ – number of elements.

Table 4.2 - Score of working condition elements

| № | Element of working conditions, units | Designation | Value | Factor score |
|---|---|---|---|---|
| 1 | Temperature, °C | $X_1$ | 20 | 1 |
| 2 | Pressure, MPa | $X_2$ | 100 | 3 |
| 3 | Humidity, % | $X_3$ | 50 | 1 |
| 4 | Illumination, lux | $X_4$ | 400 | 1 |
| 5 | Duration of focused observation, % | $X_5$ | 50 | 2 |
| 6 | Noise level, % | $X_6$ | 45 | 2 |

The average score of all elements of working conditions is:

$$X = \frac{1+1+1+2+2}{5} = 1,4 \qquad (4.3)$$

The integral score for the severity of labor is, respectively, equal to:

$$I_s = 10\left(3 + 1,4\frac{6-3}{6}\right) = 37 \qquad (4.4)$$

An integral score of 37 points for the severity of labor corresponds to III category of labor severity [7].

Calculate the performance of a person in these working conditions:

$$R = 100 - Y = 100 - \frac{37 - 15,6}{0,64} = 100 - 33,4 = 66,6 \qquad (4.5)$$

Assessment of working conditions showed that they are not comfortable (III category of labor severity). Therefore, it is necessary to develop measures to ensure safe and comfortable working conditions.

1) ensuring the compliance of microclimate parameters with the requirements ДСанПіН 3.3.2-007-98 "State sanitary rules and norms for robots with visual display terminals of electronic calculating machines", ГОСТ 12.1.005-88 ССБТ "General sanitary and hygienic requirements for the air of the working area" , ДСН 3.3.6.042-99 "State sanitary standards for microclimates of wild animals";

2) ensuring the compliance of air purity with the requirements of ГОСТ 12.1.005-88 ССБТ "General sanitary and hygienic requirements for the air of the working area";

3) ensuring compliance of the lighting of the working area with the requirements of ДБН В.2.5-28-2006"Nature and piece lighting"

### 4.3 Occupational safety instruction

1) General labor protection requirements

1.1) Medical person is allowed to work with medical equipment, who have reached 18 years, passed certification, have a document confirming the completion of courses on working with a medical container and its equipment.

Repeated instruction on labor protection must be carried out at least once every six months.

1.2) When working with medical container, the personal must:

1.2.1) Follow the internal labor regulation;

1.2.2) Know first aid techniques;

1.2.3) Inform the chief medical person or persons carrying out maintenance of the equipment about malfunctioning devices and other remarks on working with medical equipment, devices and tools;

1.2.4) Inform pilots in case of any dangerous incidents;

1.2.5) Follow the rules of conduct on the plane;

1.2.6) Undergo medical examinations, training (education), retraining, advanced training and knowledge testing on labor protection issues in the manner prescribed by law;

1.2.7) Correctly use personal and collective protective equipment in accordance with the conditions and the nature of the work performed;

1.2.8) Know in accordance with qualifications: technical conditions and standards for instruments and devices, apparatus and other medical equipment; design and operational features of controlled products; types of defects during assembly, installation, repair and maintenance; device and rules of operation of instrumentation; methods of control and adjustment of devices, apparatus and other medical equipment; rules for the preparation of technical documentation.

2) Labor protection requirements before starting work

2.1) Check the shelf life of the items in the medical container;

2.2) Prepare the workplace, remove foreign objects and everything that may interfere with the safe performance of work, free aisles and storage areas;

2.3) Check the completeness and serviceability of control and measuring instruments and devices, equipment, fixtures, work efficiency, lighting, collective protection means;

2.4) The detected violations of labor protection requirements must be eliminated before the start of work, if it is impossible to do this, the medical person is obliged to report the shortcomings in ensuring labor protection to the immediate chief medical person of the work and the pilot.

3) Labor protection requirements during work

3.1) When performing work, it is necessary:

3.1.1) Perform only the work for which the medical person has been trained, instructed in labor protection and to which the person responsible for the safe performance of work is admitted;

3.1.2) Be sure to entrust your work to untrained and unauthorized persons, only in case of an emergency;

3.1.3) Use serviceable equipment and tools necessary for safe work, use them only for the work for which they are intended;

3.1.3) Observe the rules for moving around the aircraft;

3.1.4) Keep the workplace clean and tidy, do not overload it with foreign objects.

3.2) When performing work, it is not allowed:

3.2.1) Get and take something through the equipment;

3.2.2) Touch medical equipment with bare hands;

3.2.3) Climb over equipment or medical container;

3.2.4) Touch the live parts of the equipment under voltage;

3.4) Carry products only in intact containers. Do not load containers over the nominal gross weight.

3.5) Do not pick up rubbish, waste, glass shards, etc.

3.6) The cleaning material must be placed in metal boxes with tight-fitting lids.

4) Labor protection requirements in emergency situation

4.1) In the event of an emergency, you should:

4.1.1) Immediately disconnect the source that caused the emergency (in case of a situation that caused the electrical equipment);

4.1.2) Stop all work which is not related to the elimination of the accident;

4.1.3) Take measures to provide first aid (if there are victims);

4.1.4) Take measures to prevent the development of an emergency situation and the impact of traumatic factors on other persons;

4.1.5) Provide a change in the patient's dislocation from the danger zone if there is a danger to their health and life;

4.1.6) Inform the chief medical person about the incident;

4.2) In the event of a fire, the pilot should be informed about the incident, and measures should be taken to extinguish the fire with the available fire extinguishing means. The use of water and foam fire extinguishers to extinguish live electrical equipment is not allowed. For these purposes, carbon dioxide and powder fire extinguishers are used located in the front and rear of the fuselage;

5) Labor protection requirements upon completion of work

5.1) Turn off the electrical equipment;

5.2) Place all equipment in a medical container and close it;

5.3) Wipe the place where the patient was lying with alcohol liquid;

5.4) Wash hands and face;

5.5) Take off the uniform and hand it over to the chief medical person for cleaning or disposal (mask and gloves).

**Conclusion to the part**

In this part of my diploma work, I considered and analyzed harmful and dangerous production factors. Considered in detail the factor of work in poor lighting, high pressure and working in extreme conditions.

He examined in detail the work with changes in temperature, pressure, humidity, the absence of normal lighting, Duration of focused observation, noise level.

Also an occupational safety instruction has been written.

# ENVIROMENTAL PROTECTION

## 5.1 Analysis of environmental protection problems

Aviation makes a significant contribution to anthropogenic pollution of the environment. Various types of environmental pollution occur in air transport processes, including flights and aircraft maintenance.

Thus, chemical pollution by various substances occurs during the exhaust gas emissions of aircraft, during the operation of aircraft repair enterprises. Mechanical pollution of the atmosphere with dust is promoted by winds that blow over the vast desert areas of airfields.

During takeoff, flight and landing of aircraft, there is a strong acoustic (noise) pollution of the environment. The operation of civil aviation radar and radio equipment results in electromagnetic pollution. Air transport processes also contribute to thermal pollution of the environment, albeit relatively small.

In this paragraph, I would like to analyze and describe the noise pollution (see Labor protection paragraph) of the developed aircraft.

Noise is any sound that is undesirable to a person that interferes with work or rest. Sounds arise as a result of disturbances in the physical state of the substance of the environment. In an elastic medium (gases, liquids, solids), these disturbances propagate in the form of acoustic (or sound) waves. External bodies that cause primary disturbance of the medium and propagation of acoustic waves are called sound sources.

## 5.2 Analysis of noise pollution

In the air, disturbances of pressure P and density ρ of air propagate in the form of sound waves. The propagation speed of these waves a (the speed of sound) depends on the pressure and density of the undisturbed gas (or its absolute temperature T):

$$a \approx \sqrt{1{,}4P/\rho} \approx 20{,}05\sqrt{T}. \qquad (5.1)$$

Under normal atmospheric conditions, the speed of sound in air is about 340 m / s (or 1225 km / h).

The nature of the perception of sound by the organs of hearing largely depends on the frequency of oscillation of acoustic waves. Waves with frequencies ranging from 16 Hz to 20 kHz are called audible sounds, since, acting on the human hearing organs, they cause sound sensations. Acoustic waves with frequencies less than 16 Hz are called infrasound, and waves with frequencies between 20 kHz and 106 kHz are called ultrasound. Waves with higher frequencies (hypersound) do not propagate in the air due to their strong absorption.

A measure of the strength of the auditory sensation is the loudness of the sound. The amount of loudness depends on the intensity and frequency of the acoustic waves. The lowest intensity at which sound is perceived by the hearing organs is called the threshold of hearing. Its value, depending on the sound frequency, reaches a minimum value of about $10^{-12}$ W / m$^2$ at frequencies of 700 ÷ 6000 Hz.

The audibility threshold is used to determine the level of the sound wave intensity L. This value is proportional to the decimal logarithm of the ratio of the sound intensity I to its audibility threshold $I_0$:

$$L = k \lg(I / I_0). \tag{5.2}$$

To compare the loudness of sounds that are a set of acoustic waves of various frequencies, a quantity called the sound loudness level $L^*$ is used. It is calculated using a formula similar to previous:

$$L^* = k \lg(I^* / I_0^*). \tag{5.3}$$

In this case, the standard hearing threshold is used, which is taken equal to $10^{-12}$ W/m$^2$, and the $I^*$ is the sound intensity of the standard frequency of 1000 Hz, equal to the sound in question.

The sound volume level, as well as the acoustic wave intensity level, is usually measured in bels (B) or decibels (dB). In the first case, the proportionality coefficient k in formulas is equal to one, in the second - ten.

Noise, the volume level of which does not exceed 30 dB, is harmless, it does not interfere with proper rest and sleep. The louder noise is harmful to a person, the more so, the stronger and longer it is.

The maximum permissible level of short-term noise is estimated at 80-110 dB (depending on the duration and frequency characteristics). Noise above 110 dB is unacceptable.

Pain threshold, i.e. The highest volume level at which the perception of sound by the hearing organs does not because pain is usually within the range of 120-130 dB. Its value depends on the frequency of the sound.

As we can see from table 5.1, the aircraft take-off loudness level is equal to the space rocket launch loudness level.

Table 5.1 - Volume levels of noise from various sources

| Source of noise | Volume level, dB |
|---|---|
| Car | 70 |
| Jackhammer | 90 |
| Train | 100 |
| Disco (music) | 110 |
| Aircraft start, 100 m | 120 |
| Thunder | 130 |
| Aircraft take-off, 25 m | 140 |
| Space rocket launch | 140 |

Much earlier, nonspecific manifestations of noise sickness can develop, caused by the destructive effect of noise on the central and autonomic nervous systems.

The main shifts in the central nervous system under the influence of noise include a slowdown in the visual-motor reaction, impairment of nervous processes, bioelectrical and biochemical activity of the brain.

Reactions from the autonomic nervous system are detected even at low noise levels (40-70 dB), regardless of its subjective perception by a person. For example, noise with a loudness level of 40-50 dB can cause a negative vegetative reaction even in sleep.

Vegetative responses to noise depend on its loudness level, frequency spectrum and nature (constant, impulsive, etc.). Impulse noise is more severe than continuous noise at the same volume levels.

The autonomic nervous system does not get used to noise. After the cessation of the effect of the noise, the disorders of the autonomic functions caused by it persist the longer, the longer the noise exposure was or the more unexpected it occurred.

Of the vegetative reactions to noise, the most pronounced is the violation of the peripheral circulation due to the narrowing of the capillaries of the skin and mucous membranes. Those working in conditions of intense noise (85 dB or more) are more likely to develop hypertensive and peptic ulcer diseases.

Aircraft engine noise contributes the most to noise pollution in an area.

Of all types of aircraft propulsion systems, the noisiest are turbojet engines. Their noise is generated in the working process by many sources with different characteristics of intensity, spectrum, directionality. Among them are jet jets of the first and second circuits, a fan, a compressor, a turbine, units, a combustion chamber.

**Conclusion to the part**

Air pollution has been considered and analyzed. Inconvenience does it bring and what kind of noise pollution. It was reviewed the permissible noise pollution standards and compared the aircraft with other noise pollutioners

So what do you need to do to reduce the impact of an aircraft on noise pollution?

- introduction of less noisy air intakes and exhaust nozzles;
- improvement of aerodynamic shapes and layout of aircraft engines;
- use of noise-absorbing and sound-insulating materials and devices;
- transition from noisy old-style turbojet engines to less noisy turbofan and bypass engines, as well as increasing the bypass ratio of the latter.

## GENERAL CONCLUSION

During this designing work I've got the next results:

- preliminary design of the low range aircraft up to 5,5 tons;
- the schematic design of the layout of the low rnge aircraft up to 5,5 tons;
- the center of gravity of the airplane calculations;
- the calculation of the main geometrical parameters of aircarft;
- the layout of medevac aicraft;
- the design of sanitary rack;
- the desigh of medical container;

The chosen design of high-wing aircraft with two engines, which are located on the wing, makes it possible to increase aerodynamic characteristics of the wing. Deep examination and analyz of this aircraft can be concluded that this aircraft has a high design quality and reliability. This cargo plane has the ability to transport cargo up to 5.5 tons for short distances up to 1800 km. The distance and weight are perfect for large companies that carry cargo to airport cargo hubs and transport them to smaller cities on such short-range aircraft.

At the moment I saw the prospect of relayout such a plane into a rescue (medevac) aircraft. In military operations at the front, such an aircraft will help to quickly and reliably transfer the wounded from the front to the rear.

The medical container was analyzed. Found its overload, description of equipment inside a medical container with a container weight of 70 kg. An instruction was developed for working with a medical container. Noise pollution from the aircraft was analyzed with propositions to reduce the impact of an aircraft on the noise pollution.

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