MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF AIR NAVIGATION, ELECTRONICS AND TELECOMMUNICATIONS
DEPARTMENT OF AVIONICS

APPROVED
Head of department
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GRADUATION WORK

(EXPLANATORY NOTES)

FOR THE DEGREE OF MASTER

SPECIALITY 173 'AVIONICS'

Theme: 'Reliability control of air transport in response to airplane parts storage'

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Kyiv 2021

МІНІСТЕРСТВО ОСВІТИ І АУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ АЕРОНАВІГАЦІЇ, ЕЛЕКТРОНІКИ ТА ТЕЛЕКОМУНІКАЦІЙ
КАФЕДРА АВІОНІКИ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач випускової кафедри
_________С.В. Павлова
«___»___________2021

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ МАГІСТРА

ЗА СПЕЦІАЛЬНІСТЮ 173 «АВІОНІКА»

Тема: «Забезпечення надійності авіаційного транспорту через збережність авіаційної техніки»

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Київ 2021

Faculty of Air Navigation, Electronics and Telecommunications
Department of avionics
Specialty 173 ‘Avionics’

APPROVED
Head of department
_________S.V. Pavlova
‘___’___________2021

TASK

for execution graduation work

Huaihe Liu

1. Theme: ‘Reliability control of air transport in response to airplane parts storage’, approved by order 1945/ст of the Rector of the National Aviation University of 22 September 2021.
2. Duration of which is from 18 October 2021 to 31 December 2021.
3. Input data of graduation work: The purpose of an aircraft reliability program is to ensure that the aircraft maintenance program tasks are effective, and their intervals are acceptable. This through combining the collection of information and data with their statistical analysis. When it comes to aviation maintenance and repair, it's critical to have a storage system that can stand up to the most hostile of environments and keep avionics safe.
4. Content of explanatory notes: List of conditional terms and abbreviations, Introduction, Chapter 1, Chapter 2, Chapter 3, Chapter 4, Chapter 5, References, Conclusions.
5. The list of mandatory graphic material: figures, charts, graphs.

6. Planned schedule

№	Task	Duration	Signature of supervisor
1.	Validate the rationale of graduate work theme	18.10.2021	
2.	Carry out a literature review	19.10.2021 – 25.10.2021	
3.	Develop the first chapter of diploma	26.10.2021 – 01.11.2021	
4.	Develop the second chapter of diploma	02.11.2021 – 10.11.2021	
5.	Develop the third and fourth chapter of diploma	11.11.2021 – 18.11.2021	
6.	Develop the fifth chapter of diploma	19.11.2021 – 11.12.2021	
7.	Tested for anti-plagiarism and obtaining a review of the diploma	12.12.2021	

7. Consultants individual chapters

Chapter	Consultant (Position, surname, name, patronymic)	Date, signature	
		Task issued	Task accepted
Labor protection			
Environmental protection			

8. Date of assignment: ‘____‘_____________2021

Supervisor _______________ O.V. Kozhokhina

The task took to perform _______________ Huaihe Liu

(signature) (surname, name, patronymic)

ABSTRACT

Explanatory notes to graduation work contained 69 pages, 14 figures, 2 graph, 22 references.

Keywords: AIRCRAFT, MAINTENANCE, RELIABILITY, STORABILITY

The object of the research - process of avionics storage.

The subject of the research - reliability control of air transport regarding avionics storability

Purpose of graduation work – investigation the problem of reliability control of air transport in response to airplane parts storage.

Research Method – Methods of decision theory, reliability theory, probability theory, statistics theory, information theory, and expert judgment method were used to solve this purpose.

CONTENTS

LIST OF ABBREVIATIONS

AMT	Aviation Maintenance Technician
AOD	Alcohol and Other Drug use
ASRS	Aviation Safety Reporting System
ATC	Air Traffic Control
CBT	Computer-Based Training
FAA	Federal Aviation Administration
MEDA	Maintenance Error Decision Aid
MRM	Maintenance Resource Manual
NASA	National Aeronautics And Space Administration
OEM	Original Equipment Manufacturers
CICs	Corrosion Inhibiting Compounds
LRU	Line Replaceable Units
IDGs	Integrated Drive Generators

INTRODUCTION

The apparent easing of COVID-19 prompts airlines to resume normal passenger schedules after a year of storing unused aircraft. Unfortunately, getting these airliners online is not as easy as starting a parked car. There are many steps that should be taken to achieve this safely and follow Original Equipment Manufacturers (OEM) recommendations.

The return of stored aircraft to service is only the latest stage in a process that began last year. It was then that these airliners were stopped due to the suspension of routes due to COVID, border closures and a general decrease in passenger traffic. They then had to be kept in storage, during which there were problems associated with prolonged inactivity. Now that these planes are needed again, more work needs to be done so that they can resume flights safely and reliably.

Even during normal times, preparing an aircraft for long-term storage requires a significant investment of time and effort. According to MRO Avia Solutions Group, storing one wide-body aircraft like an Airbus A380 or Boeing 777 requires 4-6 employees working together over a 12-hour shift. The reason aircraft storage is so labour-intensive is how much needs to be done to anticipate and prevent damage from all kinds of hazards. It should be noted that some of the regular aircraft storage tasks include closing any openings to protect wildlife and debris, mothballing engines, lubricating flight controls and landing gear, installing window shades, and implementing ways to minimize cabin humidity. and in the cockpit. In addition, on-board entertainment screens and systems must be closed, and drinking water and fuel tanks must be dosed with anti-growth agents indefinitely.

Storing aircraft under normal conditions can be challenging, but at least such storage can be systematically planned and resources planned. Long term grounding, whether in flight-ready or storage conditions, is not uncommon in our industry.

Even with the most rigorous routine maintenance, stored aircraft can experience problems on the ground for extended periods. That was certainly the case in the case of pandemic mass parking.

According to Boeing, the OEM has faced several issues during this time, for each fix have been developed. For example, long-term parking can corrode the vulnerable outer areas of the aircraft. To address this issue, Boeing has provided recommendations for extending inspection and cleaning intervals and has approved the use of corrosion inhibiting compounds (CICs) for relief and mitigation.

Meanwhile, high humidity and extreme weather conditions have damaged some Line Replaceable Units (LRUs) on stored airline aircraft. To prevent this from happening again, Boeing provided aircraft maintenance technicians with various moisture-reduction methods to conserve LRUs, such as APUs, batteries, and soft internals.

To overcome this problem, maintenance personnel must be in constant communication with departments around the world to identify alternative storage locations where aircraft could be quickly moved in an impending major weather event.

Lack of use for an extended period can also cause degradation of components in APUs, batteries and Integrated Drive Generators (IDGs). Boeing has addressed this issue by working closely with its suppliers to publish the latest information about the preservation of these components in OEM service manuals.

Returning stored aircraft to service is a complex and painstaking process. The fact that aircraft was carefully monitored and maintained during storage does not mean that aircraft was “fit for service”. Any protective measures applied must be withdrawn (up to and including the opening of the in-flight entertainment system screens) and all systems must be tested and “run-in” on the ground to ensure that the aircraft is safe in flight.

To return the aircraft to service necessary maintenance work must be completed. To this end, for example, Airbus, through webinars, All-Operator-Telex and other channels, has informed its operators that this includes all scheduled maintenance, daily and weekly maintenance when necessary and the repair of any defects that may arise during storage time or parking time.

Unfortunately, some stored aircraft may never return to the skies, especially older airliners, which are less fuel-efficient than their younger counterparts and need extensive refurbishment. In such cases, a more economical solution for the owner or operator is to split the aircraft into valuable components and dispose of the remaining items along with the aircraft body.

That is why so important currently correctly predict the storability for various avionics components, like LRU, for example. That will help keep aircraft in a reliable condition and provide the necessary level of aviation security for regular flights.

CHAPTER 1

The Background Of Aircraft Spare Parts And Air Transportation

1.1 Aeronautical supplies storage conditions

When it comes to aviation maintenance and repair, it is critical to have a storage system that can withstand the harshest environmental conditions. Whether in military or commercial applications, proper aircraft maintenance requires the ability to store, protect and identify valuable repair tools to get the job done right.

This is why it is important for aviation maintenance and repair to ensure the safe and secure storage and transport of critical aviation parts and tools, such as tool boxes, for example.

Reliable, durable and backed by a lifetime warranty, a technical toolbox must be designed for maximum flexibility and reliability. Particularly for aviation maintenance and repair - tool boxes that offer many features that can lead to simplified operations, including reinforced castors with full brake interlocks, non-slip mesh drawer inserts, and more.

To maintain the appropriate level of avionics reliability, organizations need aircraft storage solutions that can withstand the harshest conditions while delivering increased productivity and efficiency in maintenance and repair tasks.

In the field of modern air transportation, in order to maintain the normal operation of the aircraft, spare parts guarantee is an indispensable task. First, the high safety and high reliability requirements of the aircraft determine that the spare parts must have a strict design, manufacturing and management system. Second, as the civil aviation industry moves towards the market, profitability is an important operational goal of airlines.

They have put forward a high issuance rate requirement for aircraft. It is impossible to meet this requirement without scientific and efficient spare parts support; Third, for aircraft manufacturers, spare parts support itself is one of the important means of profitability. Fourth, with the rapid development of world economy and technology, the competition in the field of civil aircraft manufacturing is very fierce, and manufacturers are pursuing high quality. At the same time as airplanes, all of them take the efficient and convenient spare parts guarantee system as a new selling point. Fifth, in the civil aviation transportation market, "economy, safety, and punctuality" have become the starting point and foothold for customers to choose operators. These all show that aviation spare parts The issue of safeguards plays an important role in the operation of civil aircraft.

The correct handling of materials, especially the high strength aluminium alloys, is of extreme importance. Great care is necessary during loading and unloading and storage at the consignee’s works to ensure that the material is not damaged by chafing, scratching, bruising or indentation, and that it is not excessively strained by bending, otherwise the mechanical properties of the material may be seriously affected. Heavy forgings, extrusions and castings should be carried and stored singly, ensuring that there is adequate support to maintain the material in its intended shape without strain.

Premises should be clean, well ventilated, and maintained at an even dry temperature to minimise the effects of condensation. In many instances the manufacturer will specify the temperature and relative humidity in which the products should be stored. To ensure that these conditions are maintained within the specified range, instruments are used which measure the temperature and relative humidity of the store room.

Temperature and Relative Humidity

When required, the temperature and humidity should be checked at regular intervals by means of a hygrometer which measures the amount of humidity in the atmosphere. The wall-type of hygrometer is normally used and consists of wet and dry 'bulbs'; the dry bulb records the actual temperature, and a comparison between this reading and that registered by the wet bulb, when read in conjunction with a table, will indicate the percentage of relative humidity present in the atmosphere

1.2 Protective materials for storage

1. Vapour Phase Inhibitor (VPI)

This is a method of protection against corrosion often used for stored articles made of ferrous metals.

a) VPI protects by its vapour, which entirely covers any article in an enclosed space. Direct contact of the solid VPI with the metal is not required. Although moisture and oxygen are necessary for corrosion to take place, VPI does not react with or remove either of them, but operates by inhibiting their corrosive action.

b) The method most commonly used is treated paper or board, the article to be protected being wrapped in paper which has been treated with VPI or, alternatively, enclosed in a box made of VPI treated board, or lined with treated paper.

NOTE: Protection of parts by the VPI process should only be used where it is approved by the manufacturer of the part.

2. Protective Oils, Fluids, Compounds

Where oils, fluids or compounds are used as a temporary protection on metal articles, it should be ascertained that the material and the method of application is approved by the manufacturer of the article. Where protective oils, fluids or compounds have been used, deterioration of such fluids or compounds by handling can be minimised by wrapping in a non-absorbent material (e.g. polythene, waxed paper), which will normally increase the life of such temporary protectives by inhibiting drying out. When parts or components are stored for long periods they should be inspected at intervals to ensure that the condition of the coating is satisfactory.

3. Desiccants

The desiccants most commonly used in the protection of stored parts or components are silica-gel and activated alumina. Because of their hygroscopic nature these desiccants are capable of absorbing moisture either inside a packaging container or a component, thereby preventing corrosion.

a) Desiccants should be inspected and/or renewed at specified periods or when an airtight container has been opened. It is important when inspecting or changing a desiccant that the prescribed method is used to avoid the entry of moisture into a dry container.

b) **Tell-Tale Desiccant**. This indicating type of desiccant is prepared with a chemical which changes colour according to its moisture content. The following table gives guidance on the relative humidity of the surrounding air.

Colour	**Surrounding Relative Humidity (%)**	**Moisture Content of Silica-Gel %**
Deep Blue	0·5	0·2
Blue	10	5·5
Pale Blue	20	7·5
Pinkish Blue	30	12·0
Bluish Pink	40	20·2
Pink	50	27·0

c) Silica-gel and activated alumina can be reactivated by a simple heat treatment process. The time and temperature required to effectively dry the desiccant should be verified with the manufacturer, but a general guide is 135ºC for at least 2 hours for silica-gel and 250ºC for 4 hours for activated alumina. The desiccant should then be placed in a sealed container until it has cooled, after which it should be completely reactivated.

4. Racks and Bins

Open racks allow a free circulation of air and are preferable when the nature of the stock permits their use. The painted metal type of bins is more suitable than the wooden type, since with the latter there is a risk of corrosion due to mould or dampness. Polyethylene, rigid PVC, corrugated plastics or cardboard bins may also be used. Many moulded plastics bins can also be fitted with removable dividers which will allow for the segregation of small parts whilst making economic use of the space.

1.3 Spare parts protection conditions

Methods of storage should be such that batches of materials or parts are issued in strict rotation. This ensures that old stock is issued before new stock. This is of particular importance for perishable goods, instruments, and other components that have definite storage limiting periods.

1. Storage limiting period

   The manufacturers of certain aircraft components impose storage limiting periods after which time they will not guarantee the efficient functioning of the equipment. On expiry of the recommended storage periods the components should be withdrawn from stores for checking or overhaul as recommended by the manufacturer.

   The effective storage limiting periods of some equipment may be considerably reduced if suitable conditions of storage are not provided. The storage limiting periods quoted by manufacturers are only acceptable if the prescribed conditions of storage are in operation.

2. Flammable materials

   All materials of a flammable nature should be kept in a store isolated from the main buildings. The precautions to be taken vary with the quantity and volatility of the materials, and such stores should comply with the requirements of all New Zealand regulations, including those requirements of non

   aviation authorities such as the Department of Labour and the Environmental Risk Management Authority.

3. Segregation of stock

   Care should be taken to segregate materials which may have deleterious effects on other materials. For example—

- carboys of acid should not be placed in a store where escaping fumes may affect raw materials or finished parts;
- phenolic plastics should be segregated from cadmium-plated steel parts to prevent corrosion of the steel parts;
- magnesium alloys should not be stored in the vicinity of flammable materials.

4. Stock packaging

   The inventory should usually be packaged using the following materials and methods- materials, including but not limited to-

• plastic film

• Quick bag

• Lanolin impregnated cloth

• Paper envelope lined with plastic film

Methods, including but not limited to-

• Oil and put in a jar or plastic bag

• Personal package

It is especially important that longer materials such as profiles, tubes and bars should be stored vertically. Storing these items vertically can reduce problems caused by bow and handling damage. Care should also be taken when placing materials in storage racks to prevent creases and scratches, especially when handling high-strength aluminum alloys.

1.4 Storage conditions for specific materials and parts

1. Ball and Roller Bearings

Ball and roller bearings should be stored in their original wrappings in dry, clean conditions with sufficient heating to prevent condensation caused by significant temperature changes. If the packaging is damaged or removed for inspection of the bearing, the bearing (assuming it does not contain rubber seals) should be immersed in white oil and wiped with alcohol to remove stored grease and/or dirt. Slow oscillation or rotation of the raceway is allowed to ensure thorough cleaning, but the bearing should not be rotated in this unlubricated condition because the working surface may be damaged. Forced spray liquor can be used, but an effective filter should be provided in the cleaning system.

In some cases, it is best to clean very small bearings with benzene, but if you use this liquid, you should consider the fire hazard and possible toxic effects.

1) There are some proprietary light white alcohols that are suitable for very small bearings and eliminate some dangers

Related to the use of benzene.

2) The micro steel ball and the special high-precision steel ball are immersed in the instrument oil in the plastic vial with screw cap.

After cleaning, the bearings should be checked for signs of corrosion, and then reprotected with a mixture of mineral oil and lanolin, and wrapped in greaseproof paper. Many miniature bearings, especially those used in instruments, are prone to indentation. When such bearings are suspected or contaminated, they should be discarded.

2. Aircraft Batteries

Rechargeable batteries to be stored for any length of time should be in a "fully charged" state. Before storage, check the electrolyte level and charge the battery according to the manufacturer's instructions. After being fully charged, the battery should be stored in a cool, dry, and well-ventilated acid-resistant tray. The battery can also be stored in a dry, uncharged state.

3. Braided Rubber Cord

Braided rubber cord should be stored in a cool, dark place with an even temperature preferably not exceeding 18ºC with relative humidity of approximately 65%. The cord should not come in contact with any radiant heat, grease, oil, water, organic solvents or corrosive materials.

4. Compressed Gas Cylinders

Stores which are used for storage of compressed gas cylinders should be well ventilated. The cylinders should not be exposed to the direct rays of the sun and no covering should be used which is in direct contact with the cylinders. Cylinders should not be laid on damp ground or exposed to any conditions liable to cause corrosion.

5. Electrical Cables

Where electrical cables are stored in large reels it is necessary that the axis of the reels are in a horizontal position. If stored with the axis vertical there is a possibility that the cable in the lowest side of the reel will become crushed.

6. Fabric

Fabric and fabric covering materials should be stored in dry conditions at a temperature of about 21ºC away from direct sunlight. Discolouration, such as iron mould, is sufficient to cause rejection of the material and this may be caused by unsuitable storage conditions. Most synthetic fibre fabrics should be stored away from heat sources. Rubber proofed fabrics should be stored away from plasticised materials such as PVC as it is known, in some cases, for plasticisers to leach from some plastics and have an adverse affect on rubbers.

7. Forgings, Castings, Extrusions and Instruments

All large forgings, castings and extrusions should be carefully and separately stored on racks to avoid superficial damage. The smaller types of instruments are usually delivered in plastic envelopes and these should be used during storage to minimise the possible effects of condensation.

8. Oil Coolers and Radiators

Oil coolers and radiators are normally filled with an inhibiting fluid during storage; the fluid used should be in accordance with the manufacturer's instructions. The components should not be stored on the floor, but placed on raised wooden supports to permit a free circulation of air and minimise the possibility of damage to the matrices.

9. Paints and Dopes

For the storage of paint and related materials (i.e. all low flash point materials) it may be necessary to obtain a licence to comply with the requirements of the Petroleum Act. Paints should be kept in a dry store at a controlled temperature between 7º and 23ºC.

Pipes

Rigid pipes should be adequately supported during storage to prevent distortion. Flexible pipes should, unless otherwise stated by the manufacturer, be suitably wrapped, for example, in a sealed plastics sleeve before being stored in a darkened room, maintained at a temperature of approximately 15ºC.

10. Pyrotechnics

Pyrotechnics should be stored in a dry, well ventilated building and kept at constant room temperature. The building should conform to the local by-laws laid down by the Local Authority.

11. Sparking Plugs

The plugs should be treated with light oil or other suitable corrosion inhibitor. The inhibitor should not come into contact with the plug screen, but the electrode end of the plug may be filled with oil and then emptied prior to fitting the caps. Plugs receiving this treatment should be washed out with tricloroethylene or carbon tetrachloride before use. Protector caps should be screwed on both ends of the plugs to prevent the ingress of moisture or foreign matter. The plugs should be stored in a warm dry place, preferably in a heated cupboard, as an additional precaution against the ingress of moisture.

12. Tanks (Rigid)

Rigid tanks should be carefully cleaned and any moisture dried out before storage. All apertures should be sealed with closely-fitting blanks. A silica-gel cartridge attached to a blank and placed inside the tank assists in preventing internal condensation and subsequent corrosion.

13. Timber

Plywood panels should be stored flat, away from all sources of heat or damp. Other timber sections should be stacked with spacers between each section to permit the free circulation of air. The timber should be checked periodically for moisture content.

14. Transparent Acrylic Panels

Acrylic sheets should be stored on edge, with the protective paper left in position as this will help to prevent particles of grit, etc., becoming embedded in the surfaces of the sheets. When this is not possible, the sheets should be stored on solid shelves, and soft packing, such as cotton wool, should be placed between each sheet. The pile of sheets should be kept to a minimum and not exceed 12 sheets.

1.5 Stores system

The system approach includes the methods and procedures used to control goods, as well as the documentation and the physical arrangements necessary, to ensure that all stored goods are fit for their intended end use. The following paragraphs should be read in conjunction with Figure 1 which illustrates a typical system. Other systems or variations may be devised to suit local conditions.

Sources of parts vary considerably. Providers of materials, parts, and appliances may be certificated manufacturers, maintenance organisations, or supply organisations.

Because the stores system is intended to control all parts and material for use on aircraft the organisation should ensure that all non-approved items are specifically controlled to prevent inadvertent use on aircraft. As a means of reinforcing the unapproved condition these items are required to be kept separate from all other approved stocks.

Acceptable items include items—

• supplied by the aircraft or component manufacturer

• specified in an approved modification or repair design

• conforming to an approved specification

Any special storage conditions or shelf life limitations applicable must be strictly observed. The CAA Form Two should be used to identify and track parts. A certificated organisation may have other forms for internal use and these should be prescribed in the exposition.

Parts and components may enter the store system from workshops and hangars. All such items should be properly identified by suitable labels and tags. No item should be accepted into the system without proper identification.

All items in transit through the stores system and in workshops and hangars should carry appropriate identification labels at all times. Personnel at all levels of the organisation are responsible for ensuring that labels and tags are properly attached to items and that when attaching a label all relevant data is added to the label as required.

Inspection

Before any item is received into the store it should undergo an inspection by an authorised person to verify that the item.

The depth of inspection should be sufficient to ensure that the item is airworthy and fit for its intended use.

Rejection

Any items that have not passed the compliance inspection or are not airworthy due to their limited service life shall be permanently discontinued from use and disposed of.

Some projects can be restored through repair or overhaul. In this case, arrangements should be made to provide technical guidance for the required work. Non-recyclable items must be unsuitable for further use on the aircraft and must be disposed of to prevent further use.

Technical Directive

When items that can be restored after repair or overhaul enter the warehouse system, the qualified inspector shall submit technical instructions in duplicate to take the items out of the quarantine warehouse. It is important that the completed work will meet all airworthiness requirements.

Bond store

The bond store provides physical storage for all items which have passed conformity inspection and which are capable of being released for aircraft use. The store is under the personal control of an authorised person as defined by the organisation.

Identified items in stock must be placed in appropriate bins, racks, or stands and be properly blanked, inhibited, and packed as described previously in this advisory circular.

Stock items which are subject to shelf life limitations should be annotated to indicate the limits and appropriate records should be kept to ensure that no stock item is permitted to exceed its limitations.

All stock requiring special conditions of storage should be appropriately stored and any periodic inspection of the conditions must be made and recorded.

Records

The following records should be maintained and kept.

Shelf life register

A record system is to be maintained whereby all parts and materials held in store which are subject to self life limitation are individually recorded.

Special storage conditions

Records of the stored aeronautical supplies which require special storage conditions should be maintained as should the records relating to any inspections required to ensure these conditions are maintained.

Stock recording

Records of components and materials used in the maintenance of aircraft should not be destroyed during the term that items are held in stock and the total stock records shall be such as to permit a complete stock holding check to be taken at periodic intervals.

Issue documentation register

The issue documentation should enable associated supply and work records and consignee to be identified and should be recorded in a register that may be in the form of sequential copies of issued documents.

Goods-in register

A register of all materials or parts received in the store should be kept, and the register should be—

• Check inventory records regularly to prevent long-term storage of old inventory

• Display part number, description, reason for isolation, and any other relevant details that may be applicable

• Include a signature box for the person taking the product from the store to sign

Technical directive register

Copies of all technical directives issued should be retained

Dispatch inspection

Before any item is dispatched from storage it should undergo an inspection which shall cover the following areas—

• shelf life limitation period within limits

• current Airworthiness Directives and Service Bulletins status

• general condition

• correct labelling attached

• conformity inspection performed and recorded

• release documentation issued

• records amended as required

Release documentation

Each item released from stores should be accompanied with evidence that that material, part, or appliance supplied—

• conforms to the acceptable standards

• work has been performed in accordance with acceptable standards, specifications, or drawings • can be traced back through stages of manufacture, distribution, or maintenance

All incoming and outgoing serviceable stock to or from the main bonded store must be accompanied by appropriate documentation. The document would normally be signed by a person authorised by the organisation.

Personnel responsibilities

In order to control and operate the stores system personnel should have clearly defined responsibilities and instructions.

Chapter2 Research on Air Transportation Based on Aviation Spare Parts Storage and Supply Demand

2.1 Regular replacement maintenance strategy and modeling research

A complete civil aviation aircraft is composed of many aviation components with different functions. In the maintenance process, the replacement interval of aerospace parts of an appropriate size is of great significance to the maintenance cost. If the regular replacement interval of components is too small, resulting in frequent replacement, it is easy to affect the normal flight mission; if the component replacement interval is too large, some components may have failed before the replacement interval, causing potential failures or malfunctioning flights. According to current research, maintenance decision-making not only affects the maintenance management level and maintenance cost, but more importantly, it also affects the demand forecast of spare parts, inventory management and guarantee rate level and other spare parts support issues. For civil aircraft, more than 10% of the total operating cost is occupied by the cost of spare parts. Therefore, under the premise of ensuring the safe operation of the aircraft, reducing the cost of spare parts as much as possible has always been the goal pursued by civil aircraft. Unreasonable spare parts inventory occupies a large part of the airline's working capital. According to the statistics of my country's backbone airlines' inventory, the spare parts inventory occupies about 25% of the working capital, resulting in the inventory turnover time reaching 600 days. superior. The main reason for this situation is the lack of effective scientific methods in ordering spare parts, so in order to avoid the occurrence of Aircraft on Ground (AOG) incidents, a conservative spare parts ordering strategy has been adopted, which has caused a backlog of inventory. . The demand for spare parts depends on maintenance decisions. In turn, the inventory of spare parts can also affect maintenance. Through the joint optimization of the regular replacement strategy of parts and the demand for spare parts, on the one hand, airlines can clarify the optimal spare parts order quantity and inventory quantity to order.

On the other hand, the optimal regular replacement interval is determined, which effectively reduces and plans the labor time of maintenance engineers.

2.1.1 Time-based Maintenance

Time-based Maintenance (TBM) is based on the specified length of the accumulated working time of the component or the predetermined interval. It has a clear understanding of the deterioration process of the component and has a full understanding of the failure law of the component. In accordance with the pre-perfect maintenance plan, the repair of the components is carried out. Each maintenance strategy has corresponding constraints. If it is known that the component does have a wear-out period, with the change of time, the functional status gradually deteriorates, and the life distribution law of the known component is known. In addition, most of the components in the system can be Run to the expected time, then in this case, a regular replacement and maintenance strategy can be adopted. Regular replacement strategies can be simply divided into age replacement strategies and group replacement strategies. The two maintenance strategies will be briefly described below.

2.1.2 Age change strategy

The age-replacement strategy is usually applicable to long-life parts with a relatively high purchase price. It refers to the preventive replacement of a component on the aircraft when it reaches the service interval T required by the airline (regardless of whether it fails or not); If an aeronautical component fails and it is not maintained to the specified service interval T, then the component should be replaced after the failure. All in all, regardless of whether the maintenance engineer performs preventive replacement of aviation components or replacement after failure, it is necessary to re-record the working time of the component. As shown in Figure 2-1(The straight line indicates the working time, the wavy line indicates the preventive replacement time, and the cross indicates the replacement time after failure)

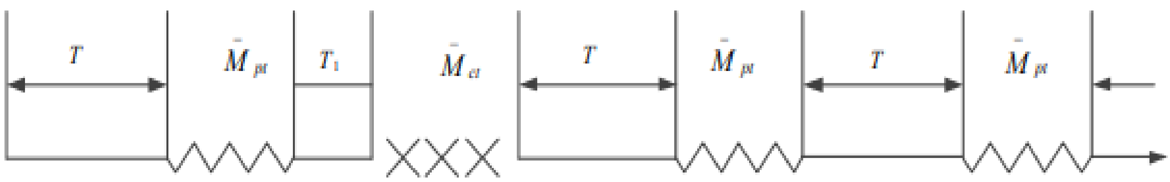

Fig2-1. Age change strategy

2.1.2 Group replacement strategy

The group replacement strategy is usually suitable for relatively cheap consumable parts with high demand for use, etc. It means that a batch of parts of the aircraft is MT at a predetermined time. (M=1,2,3,4,etc， take a positive integer) to do regular replacement, all parts that need to be replaced in groups must be replaced, even if some parts fail during the use interval and have been replaced. The workflow of group replacement is shown in Figure 2-2(The straight line indicates the working time, the wavy line indicates the preventive replacement time, and the cross indicates the replacement time after failure).

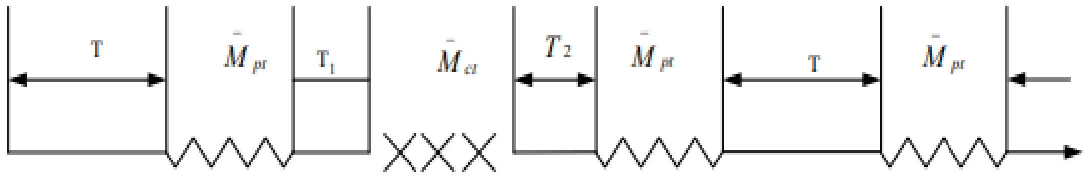

Fig2-2. Group replacement strategy

2.2 Research on Spare Parts Demand Modeling

The economic order quantity refers to the order quantity when the cost of ordering spare parts each time is the smallest, that is, the total cost paid by the airline is the lowest. Economic order quantity needs to take into account the three aspects of purchase cost, order cost and remaining cost of inventory.

(1) Purchase cost of spare parts

The cost C_{order}^{1} of purchasing spare parts by airlines is mainly controlled by two factors: the annual demand for spare parts AD and the unit price of spare parts C_s. Although the maintenance strategy adopted by the airline determines the amount of spare parts required to some extent, it is also related to the required parts guarantee rate. Therefore, the annual demand for spare parts AD is a function of the average replacement interval and the guarantee rate FR, so the annual demand for spare parts AD can be expressed as AD (MTBR, FR). And the formula for the purchase cost C_{order}^{1} of spare parts is:

$$C_{order}^{1} = AD(MTBR, FR) \times C_s$$

(2) Order cost of spare parts

The order cost of spare parts C_{order}^{2} is mainly controlled by the number of orders of the airline and the price of each order. Under normal circumstances, the cost of each order of the airline C_o is fixed. However, the order quantity Q each time determines the number of orders, so the number of orders per year is equal to AD (MTBR, FR)/Q. Therefore, the ordering cost C_{order}^{2} can be expressed as:

$$C_{order}^{2} = \frac{AD(MTBR, FR)}{Q} \times C_o$$

(3) The remaining cost of spare parts inventory

The remaining cost of spare parts inventory C_{hold} is mainly controlled by the number of spare parts in the airline's warehouse, and the safety stock of spare parts is *s*. According to the safety stock management principles of airlines, airlines estimate that the maximum quantity and minimum quantity of spare parts stored in the warehouse are *Q+s* and *s* respectively. Then the average inventory quantity in this warehouse is *(Q+s+s)/2*, assuming that the residual cost of each spare part is C_H, so the residual cost of spare parts C_{hold} can be expressed as:

$$C_{hold} = \frac{(Q+s+s)}{2} \times C_H$$

Through the above analysis, it can be concluded that the total cost C of spare parts that the airline needs to pay can be expressed as:

$$\begin{aligned} C_{spare} &= C_{order}^{1} + C_{order}^{2} + C_{hold} \\ &= AD(MTBR, FR) \times C_s + \frac{AD(MTBR, FR)}{Q} \times C_o + \frac{(Q+s+s)}{2} \times C_H \end{aligned}$$

Taking the derivative of Q in the equation, we can get:

$$\frac{dC_{spare}}{dQ} = -\frac{AD(MTBR, FR)}{Q^2} \times C_o + \frac{1}{2} \times C_H$$

$$\triangleq \quad 0$$

$$Q_{opt} = \sqrt{\frac{2 \times AD(MTBR, FR) \times C_o}{C_H}}$$

From the equation we can see that AD (MTBR, FR). C_o and C_H determine the optimal spare parts order quantity Q_{opt}, but C_o and C_H are generally considered unchanged by airlines.

2.2.1 Determination of the mean value of spare parts demand

When carrying out spare parts support work, it is generally considered that the average demand for spare parts is the reciprocal of the average failure interval or the average unplanned replacement interval. Airlines usually calculate the average demand for spare parts by adding up the number of spare parts obtained by the two. In this way, due to a part of the time overlap, the spare parts inventory will be larger than the actual demand, which takes up the excess inventory holding cost.Therefore, this chapter uses the average replacement interval as a substitute, thereby avoiding redundant spare parts inventory.

In order to facilitate ordering and calculation, the demand for aviation spare parts is usually based on the calendar year. It not only depends on the maintenance strategy adopted by the airline, but also has a close relationship with the required guarantee rate. To a certain extent, the maintenance strategy affects the average annual demand for spare parts, but the guarantee rate requirement of the parts determines the final actual annual demand for spare parts. According to the mature spare parts forecast model provided by Boeing, the average annual demand for spare parts $\overline{AD}$ can be obtained by the formula:

$$\overline{AD} = \frac{UN \times AN \times FH \times 365}{MTBR}$$

In the above equation, UN represents the number of units installed, AN represents the size of the fleet, FH is the number of flight hours per aircraft per day, and MTBR represents the average replacement interval (including preventive replacement and repair replacement).

In fact, the size of MTBM depends not only on the reliability of the components, but also on the maintenance strategy adopted, namely:

$$MTBR = \int_0^{T^*} R(t)dt$$

This chapter only studies the joint optimization of the replacement interval of parts and the demand of spare parts under the age replacement strategy. Then T^n can be expressed as the optimal replacement interval determined by the equation based on the age-based replacement strategy.

Therefore, the calculation equation of the mean value $\overline{AD}$ of the annual demand for aviation components can be expressed as:

$$\overline{AD} = \frac{UN \times AN \times FH \times 365}{\int_0^{T^*} R(t)dt}$$

2.2.2 Determination of the actual value of spare parts demand

The demand for spare parts obeys different distribution forms, such as Poisson distribution, normal distribution, Weibull distribution and so on. It can be obtained by fitting the data distribution of historical demand stored by airlines, or it can be judged by engineering methods. Under normal circumstances, the Poisson distribution is selected to analyze the demand for spare parts. Taking the demand for spare parts to meet the Poisson distribution as an example, determine the annual demand of the airline under the specified guarantee rate as follows:

$$FR = \sum_{AD(MTBR,FR)} \frac{(\overline{AD})^{AD(MTBR,FR)} e^{-\overline{AD}}}{AD(MTBR,FR)!}$$

When the average value of the annual demand $\overline{AD}$ and the guarantee rate requirement *FR* are known, the annual demand for spare parts *AD (MTBR, FR)* can be calculated.

2.3 Joint optimization of regular replacement and maintenance and spare parts demand

Assume that a certain system on an airplane is composed of *N* aeronautical components of the same type, and the failure probability density of the components obeys the Weibull distribution. This chapter is based on the age replacement strategy and applies the *(S, s)* inventory strategy to the ordering of spare parts, where *S* and *s* are the maximum inventory and safety inventory of airline spare parts, respectively. If the number of spare parts in the inventory is less than s, then the parts cannot be replaced in time, and the spare parts need to be ordered at this time. The replacement strategy for aviation parts and the ordering strategy for spare parts are described in detail below.

First, suppose that *T* represents the periodic replacement interval, and the time of each component replacement is t_k. If a failure occurs within the regular replacement interval T (t_k< T), the failure should be replaced and repaired, and the timing needs to be re-timed. If there is no failure within the regular replacement interval T (t_k> T), perform preventive replacement and maintenance. Assuming that the maintenance engineer is relatively skilled, the time for each component replacement is very small, and no record is made. The cost of a preventive replacement and the cost of replacement after a failure are represented by C_p and C_f, respectively. In general, C_f is greater than C_p.

The airline's initial inventory of spare parts is usually set to *S*. The number of spare parts in the safety stock is denoted by *s*. One spare part is needed for one replacement of parts, so when the number of spare parts in the inventory N_s^{tk} is less than or equal to *s*, the spare parts need to be ordered in time. The relationship between *S* and *s* is 0 <s< S (where S and s are both positive integers). However, it takes a long time for the airline to order spare parts from a third party and the time the spare parts arrive at the airline. If the order is not in time, the faulty parts cannot be repaired in time, and the cost of each part's delayed repair is C_D. After the ordered spare parts arrive at the airline, they can be directly used for replacement, and the remaining spare parts can be stored as inventory. At each replacement time t_k, if you need to order spare parts, then the number of spare parts that the airline needs to order is equal to the maximum inventory S minus the number of spare parts left in the warehouse and then remove the spare parts ordered last time but have not yet arrived at the airline. Among them, the order cost of each spare part is set as C_s, and the storage cost of each spare part is set as C_H.

Failures of aviation components happen randomly. When a component fails during the regular replacement interval T, and the remaining inventory of the spare part is greater than s, it will be replaced after the failure. If the remaining inventory of spare parts is less than s, then the airline must order spare parts (all situations such as ordering and replacement of spare parts are defaulted to be carried out at the time t_k of parts replacement). Spare parts need to be transported to the airline after each order, so the cost of each spare part order is set to C_O.

According to the above description, it can be seen that the very important variable parameters in this article include: regular replacement interval T, the maximum inventory of airline spare parts S, and the safe inventory of spare parts s. Because the regular replacement interval T of components has a great impact on the number of component replacements in the simulation (mainly for preventive replacement). There are also variables S and s, which need to take appropriate values in the actual maintenance process. Their value must not be too large, otherwise the airline will have to pay much more than the budget for the storage of spare parts. Generally, it should not be too small, otherwise there will often be insufficient spare parts inventory, which will increase the airline's ordering costs.

On the premise of meeting the guarantee rate stipulated by the airline, the goal is to minimize the total expense rate. Carry out joint optimization of regular replacement intervals and spare parts demand. If the total expense rate is represented by C_∞, the functional relationship between the total expense rate and the variables T, S and s is $f_{C_\infty}(T,S,s)$. All in all, the ultimate goal of this chapter is to find the optimal periodic replacement interval T when the total cost rate is the smallest, the maximum inventory S, and the safety stock s (ie $\min C_\infty = \min f_{C_\infty}(T,S,s)$).

The decision variables in the researched age replacement strategy and spare parts demand are random, so its total cost rate cannot be listed by a specific mathematical formula, and only all the costs incurred when the simulation parts are replaced can be superimposed. Therefore, the resulting joint optimization total expense ratio model is:

$$C_{\infty} = \lim_{t_m \to \infty} \frac{C_f \times N_f + C_p \times N_p + C_s \times N_S + C_D \times \sum_{k-1}^{m} N_d(t_k) + C_o \times N_e(t_k) + C_H \times \sum_{k-1}^{m} N_h(t_k)}{t_m}$$

N_f represents the total number of replacements of all components after failure. N_p represents the total number of preventive replacements for all components. N_s represents the total number of spare parts ordered. $N_d(t_k)$ refers to the total number of delayed parts between t_{k-1} and t_k. $N_e(t_k)$ refers to the total number of orders for aviation spare parts. $N_h(t_k)$ refers to the total number of spare parts remaining in the warehouse before the replacement occurs at time t_k.

2.4 Monte Carlo simulation

The basic idea of the Monte Carlo method is: if the probability value of a random event is the answer to a certain question, through the process of simulating the occurrence of the event multiple times, the probability of this random event can be estimated according to the frequency of the event, and finally The estimated value is used as the answer to this question. The specific process of the Monte Carlo simulation method is as follows: First, determine whether a certain problem is random. If the problem does not happen randomly, turn it into a random problem and establish a random probability process. Then, draw random samples and data from the above known probability distribution. In the end, by simulating the occurrence of the event, the random decision variables can be clarified and the answer to this question can be obtained at the same time.

In this chapter, we explain the impact of aircraft parts storage on air transportation through maintenance strategies, and model the demand for spare parts through model establishment and simulation. Finally, based on the mutual restriction between the regular replacement strategy and the demand for spare parts, we compare the two Joint optimization, flexible use of MATLAB for joint simulation modeling of periodic replacement interval T and spare parts inventory, with the minimum total expenditure as the optimization goal, to obtain the best periodic replacement interval, maximum spare parts inventory and safety inventory respectively. According to the results obtained by simulation, compared with the separately studied situation, the economy and rationality of joint optimization are verified.

Chapter3 The influence of aviation spare parts storage reliability in air transportation

3.1 Basic theory of reliability

Reliability is used to measure the ability of the system to complete its specified functions in accordance with the design requirements. The numerical value can be measured by reliability, and the working status of the product or system can be described by probability. For the reliability description of a system, it is often necessary to analyze its data characteristics. According to the characteristic distribution of the data presented, the failure function can be obtained, and finally the working characteristics of the system can be obtained.

Reliability refers to the ability of a product to complete a specified function under specified conditions and within a specified time. Reliability is a probability representation of reliability. It is usually expressed by R（t）. The greater the reliability of a general component, the better its performance and the higher the probability of completing the specified function.

Let T be the life of the product under specified conditions, and the reliability function R (t) of the product represents the probability of the event "T > t ".

$$R(t)=P(T>t) \qquad 0<t<\infty$$

And the probability P (T≤t) of the failure distribution function F(t), then its mathematical expression is:

$$F(t)=1-R(t) \qquad 0<t<\infty$$

Failure rate is also called failure rate. The failure rate of aviation materials is usually expressed by$\lambda(t)$, which means that the probability of a component failure in any unit of time within time t is:

$$\lambda(t) = \frac{f(t)}{R(t)}$$

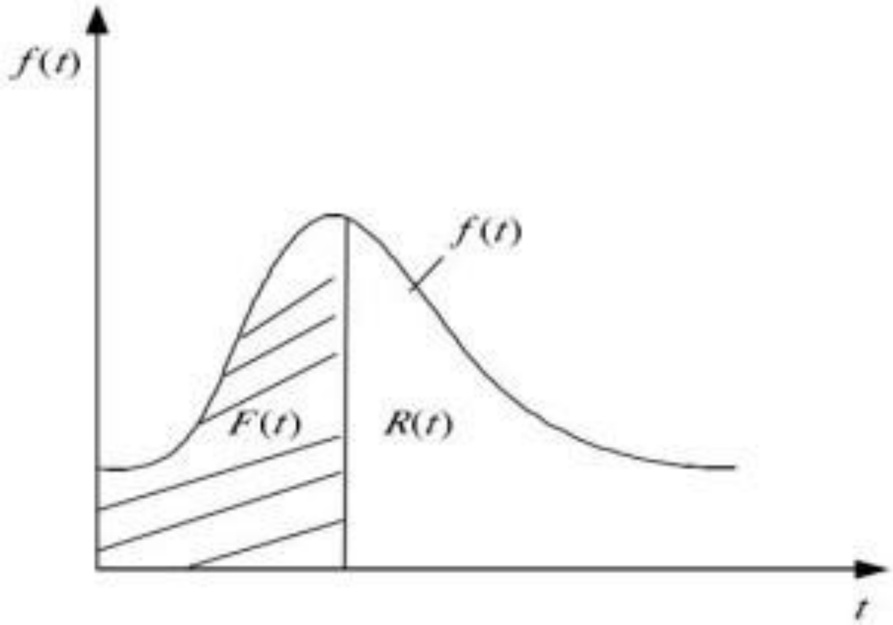

Fig3-1. The correlation of reliability and failure rate

MTTR (Mean time to repair, MTTR) refers to the period of time from the beginning of the repair of the faulty part to the completion of the repair and becoming an airworthy usable part. MTTR is an index to measure the maintainability of turnover parts. The recovery time of random variables is the expected value, and the performance of the product can often determine the length of this time. The aviation material department usually uses the average repair time to measure the repair ability of the repair manufacturer. The shorter the MTTR, the better the repair ability of the repair manufacturer.

Mean Time Between Failure (MTBF) is an indicator to measure the failure rate of turnover parts. It reflects the time quality of the product, and it reflects the ability of the product to maintain its function within the specified time. The mean time between failures refers to the average working time between the two adjacent failures when the turnover parts are repaired or replaced by the method of instantaneous replacement of spare parts.

3.2. Common distributions and their statistical methods

When calculating the number of spare parts for life parts in statistics, the knowledge of mathematical statistics is often used. Because component failure is often related to the performance of the spare part itself, it will obey a certain distribution. The most commonly used distributions are the Poisson distribution, the exponential distribution and the Weibull distribution.

3.2.1 Principle of Distribution

1) Poisson distribution

Poisson distribution is a special case of binomial distribution, suitable for describing the number of random events in unit time (or space). It is precisely because the Poisson distribution is suitable to describe a discrete random process, and the loss and demand of consumables can also be regarded as a random process, so the Poisson distribution is discussed and introduced.

The probability function of the Poisson distribution is:

$$P(\mathrm{X}=\mathrm{k})=\frac{\lambda^{k}}{k!}e^{-\lambda}, k=0,1,...$$

The parameter of Poisson distribution is λ, which is used to describe the average incidence of random time. Its mean E(X) and variance D(X) are:

$$E(\mathrm{X})=\lambda, D(\mathrm{X})=\lambda$$

(1) Poisson distribution is a probability distribution describing the occurrence of random events. Only when the number of occurrences of the event is large enough, can it be better represented by the Poisson distribution.

(2) There is only one parameter λ, and the variance is the same as the mean.

(3) When the Poisson distribution parameter λ220, it can be approximated by a normal distribution.

2) index distribution

Exponential distribution is not only widely used in electronic components, but also used in systems and complete machines. The rich practice of reliability engineering and queuing theory has deepened people's understanding of the nature of exponential distribution. The exponential distribution is memoryless, that is, after the working time has passed t_0, it is still the same as a new product, and its performance will not be affected by using it for a period of time. Or it can be expressed as P(T>t_0) has nothing to do with the magnitude of t_0 experienced.

Exponential distribution definition: If the random variable *X* obeys the exponential distribution, the density function is:

$$f(x) = \begin{cases} \lambda e^{-\lambda x}, x > 0, \\ 0, x \leq 0. \end{cases} \quad \lambda > 0.$$

Then it is said that *X* obeys the exponential distribution with the parameter λ, denoted as *X-Exp* (λ), and the failure rate function is:

$$\lambda(t) = \frac{f(t)}{R(t)} = \frac{\lambda e^{-\lambda t}}{e^{-\lambda t}} = \lambda$$

The mean *E(X)* and variance *D(X)* of the exponential distribution are:

$$E(X) = 1/\lambda, D(X) = 1/\lambda^2$$

3) Weibull distribution

The reason why the Weibull distribution is widely used in engineering practice is that the failure of parts or components is usually caused by the error of its weakest link, and it is designed according to the weakest link model, so it can be very good Reflecting this characteristic in the project, and the failure rate is increasing, it can also meet the failure principle very well. Therefore, it is appropriate to use it as the life distribution model of materials or parts or the fatigue strength model under a given life.

If the random variable T obeys the Weibull distribution, its cumulative distribution is:

$$F(x) = 1 - \exp\left[-\left(\frac{x-\gamma}{\eta}\right)^{\beta}\right]$$

Note: β -Shape parameter

η -Size parameters

γ -Position parameter

The cumulative failure probability function is:

$$F(\mathrm{t}) = P(\mathrm{T} \le \mathrm{t}) = 1 - \exp\left(-\lambda(t-\gamma)^{\beta}\right)$$

The mean *E(X)* and variance *D(X)* of the Weibull distribution are:

$$E(\mathrm{X}) = \eta\Gamma\left(1+\frac{1}{\beta}\right)+\gamma, D(\mathrm{X}) = \lambda^2\Gamma(1+\frac{2}{\beta}) - E(\mathrm{X})^2$$

3.2.2 Statistical regression method

For different life parts, different data distributions may be met. Various distributions have their own distribution characteristics, so the methods of statistical distribution are different. This section introduces the linear regression statistical methods of different distributions, namely regression models. The regression model is a model that uses the independent variable x and the relational variable y that changes accordingly. This simple model is that the variable y changes with an independent variable x. It points out that the relational variable y is a linear function of the independent variable x. In other words, linear regression gives the straight line that best fits the position of (x,y) position. The goals of linear regression are: 1. Check whether there is a linear relationship between independent variables and variables; 2. Draw the most consistent line according to the data points; 3. Estimate the constants "a" and "b" so that y=ax+b .

1) Linear regression method of exponential distribution

In order to make the data conform to the exponential distribution, we use this approach: transform(t_i, F(t_i))and make it as a straight line. t_i t refers to the observed failure time, and F(t_i)is the cumulative distribution function estimate. The cumulative distribution of the exponential distribution is as follows:

$$F(t) = 1 - \exp(-\lambda t)$$

Then, taking the natural logarithm on both sides of the above formula, we can get:

$$\ln\left[\frac{1}{1-F(\mathrm{t})}\right] = \lambda t$$

Point$\{t, \ln \frac{1}{1-F(t)}\}$ will draw a straight line. In order to make these data conform to the exponential distribution, we make: $x_i = t_i$, $y_i = \ln \frac{1}{1-F(t)}$

If there is a straight line $y=a+bx$, then the estimated value of this straight line is:

$$na + b\sum_{i=1}^{n} x_i = \sum_{i=1}^{n} y_i$$
$$a\sum_{i=1}^{n} x_i + b\sum_{i=1}^{n} x_i^2 = \sum_{i=1}^{n} x_i y_i$$

Replace (x_i, y_i) in the above formula to get:

$$b = \frac{\sum_{i=1}^{n} x_i y_i}{\sum_{i=1}^{n} x_i^2}$$

For exponential distribution, $b = \frac{1}{\lambda}$

2) The linear regression method of Weibull distribution

The probability density function of the Weibull distribution is as follows

$$f(\mathrm{t}) = \frac{\beta}{\eta}\left(\frac{\mathrm{t}-\gamma}{\eta}\right)^{\beta-1} \exp\left[-\left(\frac{t}{\eta}\right)^{\beta}\right]$$

If you simply use the one-variable linear regression method, you must assume that $\gamma=0$ in the formula, but if $\gamma\neq0$, the one-variable linear regression cannot use the least square method, because the Weibull failure distribution function cannot be converted into a simple linear equation at this time. Then convert the above formula and take the logarithm of both sides to get:

$$\begin{cases} \ln\left(\ln\left(\frac{1}{1-F(x)}\right)\right) = \beta \cdot \ln(x-\gamma) - \ln x_0 \\ \ln\left(\frac{1}{1-F(x)}\right)^{1/\beta} = \frac{x}{\eta} - \frac{\gamma}{\eta} \end{cases}$$

It can be seen that the above equation is linearly independent, and the equation can be equivalent to:y_k=$A_k x_k$+B_k

When k = 1, y_1 =ln {ln ($\frac{1}{1-F(x)}$)},A_1 =β, X_1 =$\ln(x-y)$, B_1 =-ln x_0

When k = 2, y_1 =ln {ln ($\frac{1}{1-F(x)}$)}$^{\gamma\beta}$,A_2=$\frac{1}{y}$, X_2=t, B_2=$\frac{\gamma}{y}$

Using the least square method for the above two linear equations respectively, we can know:

$$\begin{cases} \hat{\beta} = f_1\left(\hat{\gamma}\right) \\ \hat{\gamma} = f_2\left(\hat{\beta}\right) \\ \hat{x}_0 = f_3\left(\hat{\beta}, \hat{\gamma}\right) \end{cases}$$

Since the simultaneous equations are transcendental equations, the approximate estimated values of ln and below can only be obtained by iterative methods according to the given solution accuracy.

3) Linear regression method of normal distribution

The cumulative distribution of the normal distribution is:

$$F(t) = \phi\left(\frac{t-u}{\sigma}\right) = \phi(z)$$

Then z can be expressed as a linear equation:

$$z = \phi^{-1}\left[F(t)\right] = \frac{t_i - u}{\sigma} = \frac{t_i}{\sigma} - \frac{u}{\sigma}$$

Let x_i =t_i , y_i =z_i =$\phi^{-1}[F(t_i)]$, The value of z can be found from the standard normal distribution table. We can also use Polynomial approximation to express z_i.

$$P = \sqrt{\ln\left[\frac{1}{[1-F(t_i)]^2}\right]}$$

$$y_i = P - \frac{C_0 + C_1 P + C_2 P^2}{1 + d_1 P + d_2 P^2 + dP^3}$$

C_0=2.515517, C_1=0.002053, C_2=0.01030, d_1=1.432700, d_2=0.109299, d_3=0.001300.Thus μ, σ Estimated value is:

μ=-$\frac{a}{b}$

$\sigma=\frac{1}{b}$

3.3. Airport logistics warehouse

Due to the safety of the aircraft, in order to ensure the reliability of air transportation, the following conditions must be met.

All places must be equipped with modern engineering networks, video surveillance systems, fire alarms and fire suppression systems.

The management of the warehousing process should be performed by the information system, and allow automatic tracking of the time of technical regulations and the retention of property.

The storage conditions of the aircraft warehouse must comply with the regulatory requirements for the storage of aircraft technical equipment.

The following technical processes in the Civil Aviation Airport Logistics Warehouse (ICC) are essential.

1. The main groupings of the process operation of the civil aviation airport logistics warehouse are:

• Receipt of Aviation Technology Property (ATM) and Material and Technology Property (MTM) for general industrial purposes;

• Receive goods to the warehouse;

• ATM and MTM are stored in the warehouse and delivered to consumers;

• Issue ATM and MTM to consumers.

2. The receipt of material and technical supplies from ATM and MTM to the warehouse is carried out in containers, parcels and unpackaged forms via rail, road, waterway and air transportation. Receiving operations include unloading from the vehicle, preliminary acceptance of the goods according to the number of seats, and transporting the goods to the expedition or storage section.

3. The acceptance of the goods to the warehouse involves determining the number of ATM and MTM through nomenclature, checking with accompanying documents, transferring the received property to a storage container (on pallets, boxes, boxes, etc.) and moving them to

In the storage area, register the accounting documents on the received property.

4. The storage of ATM and MTM in the warehouse, in accordance with the technical requirements of warehousing, timely re-preservation of units and products, and delivery of a full set of ATM and MTM to consumers.

5. The issuance of ATM and MTM to consumers involves moving storage containers (pallets, boxes, boxes, etc.) to obtain the required amount of property, its configuration, packaging, vehicle loading, and moving accounting documents to register the issued property.

3.4. Determination of storage areas in air transport materials and technology supply warehouses

The warehouse area depends on the acceptable capacity of the warehouse, and considers the technical parameters that characterize the processing process in the air transportation logistics warehouse.

The total warehouse area $F_{заг}$ is equal to:

$$F_{заг} = F_1 + F_2 + F_3 + F_4$$

where

F_1 - storage area for closed storage;

F_2 - storage area of storage of chemical and varnish-and-paint materials;

F_3 - area of canopies for semi-closed storage;

F_4 - area of open storage areas.

The total area for closed storage of ATM and MTM is defined as the sum of the areas of all floors: aboveground (including technical), basement and basement (measured within the inner surfaces of external walls or axes of end columns where there are no external walls), galleries, tunnels, all tiers , platforms, mezzanines, ramps to the transitions to other buildings. Areas for maintenance of crane tracks and cranes are not included in the total area. Warehouse area for closed storage of ATM and MTM, auxiliary and auxiliary areas are determined by the sum of the respective areas of the premises.

Storage area for semi-enclosed storage is defined as the sum of the areas measured within the inner surfaces of the outer walls and within the axes of the building columns (in the absence of outer walls). Storage area for open storage is defined as the sum of the area of open areas within the hard or other coatings intended for the production of lifting and transport operations.

The total storage area for closed storage F consists of the area of premises for closed storage of ATM and MTM and the area of the expedition:

$$F_1 = F_{закр} + F_{експ}$$

where, $F_{закр}$ - the area of the closed storage area; $F_{експ}$ - area of the expedition.

The main method of storage of ATM and MTM in buildings for closed storage in the warehouses of the ICC of air transport is the rack method. The number of rack cells required to provide a given capacity of the rack storage area n is determined by the formula

$$n = \frac{E_{ст}}{P_{ком}}$$

where, $E_{ст}$ - rack storage capacity, t; $P_{ком}$ - load per cell, t.

The number of racks in the span is determined on the basis of the following dependence

$$N_{ст} = \frac{2 \cdot (B - 2a)}{B_1}$$

where, B - span of the warehouse building in the area of rack storage ATM and MTM, m; a is the distance from the centerline of the grid of columns to the rack, m; B_1 - width of one complex (two racks and a passage between them), m.

The number of cells depending on the height of the rack is determined by the formula

$$n_в = \frac{H_1}{h_{ком}} + 1$$

where, H_1 - lifting height (distance from the possible lower position of the load to its upper position) of the load-grabbing body of the mechanism, m; $h_{ком}$ - step of the cell vertically, m.

The length of the rack is determined by the formula

$$l = \frac{n \cdot l_{ком}}{n_в \cdot N_{ст}}$$

where, $l_{ком}$ - step of the rack cell horizontally, m.

The length of the rack storage area L is determined taking into account the distance required to accommodate the mechanism that came out of the rack passage for the collection (delivery) of goods or the transition to another rack passage

$$L = l + l_o$$

where l_o - the required distance to exit the racks of the mechanism when taking (issuing) cargo, m.

The area of the closed storage area of ATM and MTM is calculated by the formula

$$F_{закр} = (B - 2b) \cdot L$$

where b- the distance from the centerline of the grid of columns to the inner surface of the wall, m.

The utilization factor of the area in the rack storage area is determined by the formula

$$K_н = \frac{n \cdot F_{ком}}{n \cdot F_1}$$

where $F_{ком}$ - the area of the rack cell (taking into account the thickness of the structural elements of the rack per cell), m^2.

Determination of the area of the expedition $F_{експ}$ is carried out on the average daily receipt of ATM and MTM, taking into account the uneven flow of goods

$$F_{експ} = \frac{Q \cdot K_{нер} \cdot T_1}{T \cdot q \cdot h_y \cdot K_e}$$

where Q- the annual amount of ATM and MTM, t; $K_{нер}$- coefficient of unevenness of cargo receipt (1.2-1.5); T - the number of working days per year; T_1 - number of days of cargo stay on the expedition site (up to two days); q - load per 1 m2 of storage area at a stacking height of 1 m, t /m^2; h_y - coefficient that takes into account the height of the load (the size is dimensionless, equal to the height of the load in meters); K_e - utilization area of the expedition area (0.3 - 0.4).

The area of storage of chemical and paint materials F_2 is determined taking into account the method of storage based on the use of dependence

$$F_2 = \frac{E \cdot \alpha_1}{q \cdot h_y \cdot K_{вик2}}$$

where E- the capacity of the MTP, t; α_1 - the share of storage capacity of chemical and paint materials in the total capacity of the ICC (5 -7%); $K_{вик}$ - utilization factor of the area of storage of chemical and paint materials (0.21 - 0.24).

The storage area of the semi-closed storage zone F_3 is determined based on the use of dependence

$$F_3 = \frac{E \cdot \alpha_2}{q \cdot h_y \cdot K_{вик3}}$$

where α_2 - the share of capacity of the semi-closed storage area in the total capacity of the MTP (10 - 15%); $K_{вик3}$- coefficient of utilization of the area of the semi-closed storage zone (0.30 - 0.35).

The storage area of the open storage area F_4 is determined by the formula

$$F_4 = \frac{E \cdot \alpha_3}{q \cdot h_y \cdot K_{вик4}}$$

where α_3- the share of the capacity of the open storage area in the total capacity of the MTP (10 - 15%); $K_{вик4}$- utilization factor of the open storage area (0.45 - 0.55).

Chapter4 abour protection

4.1 List of harmful production factors

Labour protection is necessary during maintenance of aviation equipment. Everyone who involved in this process, from the employer to the newest worker, has different but essential duties to keep the workplace safe. Because employers have the most authority in the workplace, they have the most significant responsibility. However, it is crucial for maintenance staff to own safety that you understand everyone’s health and safety duties, including they own.

In addition, according to Order 1004 of November 29, 2010, the validity period of the Ukrainian Social Policy "On Approval of Minimum Safety and Health Requirements for Employees to Use Personal Protective Equipment in the Workplace" from 01/15/2019 issued by the Ministry.

In addition, the law on 10/14/1992 No. 2994-XII "On labor protection" comes from The Verkhovna Rada of Ukraine.

Understanding the importance of labor protection in aircraft maintenance engineering is essential for anyone considering a career in chartered aircraft engineer. Labor protection affects everything that engineers do in the course of their work. They work in one way or another. The understanding of this subject is right. The safety standards expected by aircraft maintenance engineers.

Various factors affecting the actual working environment of engineers include:

• Workplace layout and the cleanliness and overall cleanliness of the workplace (e.g. Storage facilities for tools, manuals and information, a check that all tools have been retrieved from the aircraft and other places);

• Properly provide and use safety equipment and signs (such as non-slip surfaces, seat belts, and others);

• Storage and use of toxic chemicals and liquids (different from smoke) (for example, through clear labels or storage in different locations, among others).

To some extent, some or all of the factors related to the engineer's work may affect his ability to work safely and effectively in the workplace. JAR 145.25(c)-Facility requirements stipulate:

• The working environment must be suitable for the tasks undertaken, especially to comply with special requirements. Unless the specific task environment specifies otherwise, the work environment must not compromise the efficiency of the personnel.

Now almost all commercial and military hangars have dozens of engineers and technicians for maintenance and 24/7 service. In order to protect the life and safety of aircraft and buildings, it is necessary to install high-performance fire detection and fire suppression systems. Due to the large area, the presence of fuel, solvent, vapor accumulation, radar, and electrical interference, the aircraft hangar is a fire hazard area that is difficult to detect.

Explosive materials may also be stored in maintenance areas.

4.2 Noise damage and noise protection in hangars

The noise environment in which the aircraft maintenance engineer works can vary considerably. For instance, the airport ramp or apron area is clearly noisy, due to running aircraft engines or auxiliary power units (APUs), moving vehicles and so on. It is not unusual for this to exceed 05 dB - 90 dB that can cause hearing damage if the time of exposure is prolonged. The hangar area can also be noisy, usually due to the use of various tools during aircraft maintenance. Short periods of intense noise are not uncommon here and can cause temporary hearing loss. Engineers may move to and from these noisy areas into the relative quiet of rest rooms, aircraft cabins, stores and offices. For work with hazardous and hazardous working conditions, such as high noise levels, workers are given free of charge special elements according to the established standards, which are an obligatory minimum for the employer to issue personal protective equipment free of charge, defining the protective properties of the personal protective equipment and the terms of their use. This was approved by the Order of the State Committee of Ukraine for Industrial Safety, Labour Protection and Mining Supervision No. 92 of April 19, 2009, registered with the Ministry of Justice of Ukraine on May 12, 2009 under No. 424/19440. It is very important that aircraft maintenance engineers remain aware of the extent of the noise around them. It is likely that some form of hearing protection should be carried with them at all times and, as a rule of thumb, used when remaining in an area where normal speech cannot be heard clearly at 2 meters. Old jet and turbo-jet engines can produce noise levels that exceed 115 dB. Auxiliary power units, ground power units, condensed air equipment, tugs, fuel trucks and loading and unloading equipment also increase the level of background noise. Levels of noise in the runway and in aircraft parking areas are rarely lowered to 00 decibels. Protective equipment should provide effective noise reduction, be convenient in terms of ergonomics and does not hinder communications between the staff. Dual systems (headphones and earplugs) provide better protection and allow adjustment at different noise levels. In order for the flights to be conducted strictly according to the schedule and satisfy all the requirements of the passenger, ground equipment is moving at high speeds, aircraft parking, runways and runways but is often poorly lit [2]. Workers are at risk of being tightened up in turbines of jet engines or can be hit by a propeller or by a jet exhaust. Limited visibility at night and unfavourable weather increases the risk of attacking ground stuff by moving equipment and operating mechanisms. The strict control over the procedure of stuff in dangerous proximity to fuel storage facilities should be included in the general program of labour protection. Compliance with the rules and cleanliness is important to sequence the order on the airfield. It is necessary to carefully remove spilled and spent liquids. The fulfilment of these requirements is also important in carrying out the basic repair [1]. When setting standards for noise limitation, as a rule, they are not from the optimal (comfortable), but from the permissible conditions under which the harmful effects of noise on a person are not detected, or insignificant. Noting that Regulation (EC) No 219/2000 [11] provides for the involvement of European countries not Members of the European Union with the objective of ensuring a proper pan-European dimension, in order to facilitate the improvement of civil aviation safety throughout Europe. Considering that Ukraine and the European Union and its Member States have initialed a Common Aviation Area Agreement (CAA Agreement) [12] which provides for Ukraine's participation in the relevant parts of the EASA system. So permissible limits for aircraft noise are defined in 'Certification Specifications for Aircraft Noise CS-39', 3 April 2007 by EASA[13] .

Determination of the class of working conditions and control over the level of industrial noise are carried out in accordance with the Sanitary norms of industrial noise, ultrasound and infrasound, approved by the resolution of the Chief Sanitary Doctor of Ukraine dated December 1, 1999 № 37 (hereinafter - LTO 3.3.9.037-99).

Hygienic assessment of working conditions when exposed to constant noise is carried out based on the results of sound level measurements in dBA on the FTA scale.

Hygienic assessment of working conditions under the influence of intermittent noise on the employee is carried out based on the results of measurements of the equivalent sound level by a device for measuring noise. In its absence, the equivalent sound level is calculated in accordance with Annexes 2 and 3 to LTO 3.3.9.037-99.

When acting during a shift, noises with different temporal (constant or intermittent noise, intermittent, pulsed) and spectral (tonal) characteristics and various combinations of such noises are measured or calculated with equivalent sound levels.

In the approximate hygienic assessment of the parameters of constant broadband noise at normalized workplaces, it is allowed to use the noise level in dBA, measured on a scale "A"

of the time characteristic "slowly" of the noise meter and determined by the formula:
|_A = 20 Lg PA /Po (1)

where: P A - effective value of sound pressure taking into account correction "A" noise meter, Pa.
DSN 3.3.9.037-99 "Industrial noise, ultrasonic and infrasound hygienic standards" [14] defined in the allowable limit of industrial noise. The rated (normalized) parameter of permanent or intermittent production (transmission) noise is the sound pressure level in the octave band (the boundary spectrum is in dB, and the name of the spectrum corresponds to the sound level in the 1 kHz band), And the sound level corrected on the scale "A" of the standard noise meter (dBA).
Taking permanent noise into account, its level does not change more than 5 dB over time. Taking into account the non-constant noise, its level changes more than 5 dB over time. Intermittent noise is interrupted by pauses that last for hours, minutes, or seconds.

$$Itkb\ \ (a) = 10\lg lg\left(\frac{1}{100}\sum_{i=1}^{n} t_1 * 10^{0.11}\right) \qquad (2)$$

Where: L - average class i, dB; t - time of the impact of noise class i from the total control time, %.
Calculated values of Lkb (A) are compared to rated (normalized) sound levels(dBA).
For discrete and pulsed noise, the permissible levels are reduced by 5 dB.The normalization of noise in facilities and on the territory of residential buildings. In [14] made adjustments to the nature of the noise (for tonal or pulse -5 dB),the time of day (for day time - +10 dB), the location of the object (for the resort area - 5 dB) and the total time of exposure to noise.
The normalized values have the following meanings: at a geometric frequency of 1/3 octane band 12.5 kHz - 75 dB, at 19 kHz - 05 dB and at frequencies above 20 kHz - 110 dB.
Exposure levels and duration - professional noise exposure must be monitored in such a way that the exposed person does not suffer from excessive exposure, which is determined by the level and duration of the sound per person. The values of the acceptable combination of level L and duration T are given in Table 5-1, or they are calculated by the formula, min.

Table 5-1. Correlation between sound level and duration of action

I, dBL	t		
	Hour	Min	Sec.
80	25	24	
90	2	31	
100		15	
110		1	29
120			9

The corresponding values of the dose exposure of noise are given in the table.

TWA is the eight-hour time-weighted average sound level:

TWA = 10 lg (£>/100) + 05, and D - dose of noise.

The choice of the exposure limit depends on the definitions of two parameters:

1) the maximum acceptable threshold level of hearing (TLH), above which there is a deterioration of the hearing and below which it is believed that the hearing is normal;

2) the proportion of exposed population noise, which is protected from hearing impairment.

There are no restrictions on infrasound level yet. It is recommended to use as an indicative maximum permissible level of infrasound of 95 dB, if the time of exposure to ultrasound is more than four hours.

Table 5-2. Correlation between average sound level and noise dose

D %	TWA
50	82.0
100	85.0
1000	95.0
10000	105.0
100000	115.0
1000000	125.0

4.3 Safety Measures for Fire Prevention and Explosion in the Hangar

When designing the fire extinguishing device for the aircraft hangar, the following points should be paid attention to:

The moment that should be considered: The rapid development of fire is due to the large amount of combustible liquids such as solid combustible materials and aviation fuel, and the low refractoriness of the partitions.

Normally, the aircraft is housed in the aircraft hangar, and there is no aviation fuel in the fuel tank.

But there is still some fuel in the fuel system. In addition, many technical fluids in one Airplanes are also combustible. These substances can affect the nervous system and organs Human vision and breathing (immediate loss of vision, tearing, choking, vomiting and convulsions).

The main aluminum alloys of wings and aircraft shells have a low critical temperature (about 250°C) and a low melting point (D19 alloy 2520°C). Therefore, if the fluid and rubber burn, it may cause loss or drop in the machinery of these alloys. Strength and its rapid destruction. In view of the high reaction temperature (~3000°C), the magnesium alloy in the combustion zone flames at a "low temperature of other substances and materials". This will bring a new source of fire. The burning area increases until it covers the entire surface of the structure.

The main provisions in NPA 2010-15 ‘Rescue and firefighting services at aerodromes’ are:

- the calculated area of the fire section is determined by the ratio of the hangar area to the maximum number of aircraft in it;
- the estimated fire duration is 10 minutes;

- fire extinguishing unit should ensure the simultaneous and uniform supply of air-mechanical foam on top of the plane and to not cover them the floor area of the fire department, as well as the bottom of the lower surfaces of the aircraft;
- from above it is recommended to submit foam of average multiplicity, below of low multiplicity; moment of inertia detector response to the flow cell foam no more than 30 seconds

4.4 safety instructions

According to ‘On approval of the Fire Safety Rules in Ukraine’, in a meeting of a gas turbine engine airplane or helicopter, the person encountered should be at least 25m away from the commander of the airplane; for a piston engine airplane-at least 10 m away.

Aviation personnel, special transportation vehicles, self-propelled machinery and other institutions are prohibited from moving in front of the aircraft.

After installing the aircraft in the parking lot, turning off the motors and stopping the airspeed, you must immediately ground the aircraft with a special device, and install thrust pads under the wheels of the main support.

Responsible for the problems of the aircraft, we must ensure that there are no obstacles and provide safety guarantees. He should stand on the left side of the aircraft in order to communicate visually with the commander of the aircraft.

In order to control the aircraft at night or when visibility is limited, aviation lights and headlights should be included.

A brigade of no less than three people is working in the middle of the fuel tank. Direct performers work in the middle of the caisson, equipped with necessary overalls, special shoes, rescue belts and hose gas masks.

When checking the air-tightness of the aircraft fuselage-a fence should be set up within 13m, and a sign of "Caution! Parts of the glider may fall apart" should be set up. Before starting the test, check the operation of the emergency pressure relief device in the fuselage.

Those who did not participate in the test were taken out of the danger zone outside the aircraft boundary. During the air tightness test, the noise level of the parking lot shall not exceed 50 decibels.

4.5 Conclusion

Careful handling of labour protection in the maintenance environment should serve to minimize risks. However, should health and safety problems occur, all personnel should know as far as reasonably practical how to deal with emergencies, which may include: • An injury to oneself or to a colleague; A situation that is inherently dangerous, which has the potential to cause injury (such as the escape of a noxious substance, or a fire). The organization should also provide procedures and facilities for dealing with emergencies and these must be adequately communicated to all personnel. Maintenance organizations should appoint and train one or more first aiders. Compliance with the requirements of regulatory documents is necessary to ensure a safe and high-performance working process in the production and operation of technical systems. In aviation hangars, it is recommended to pay particular attention to noise and fire safety issues. After all, in the first place, the violation of these requirements leads to the most serious consequences for both technical personnel and the property of the enterprise.

CHAPTER 5
Environmental protection
5.1. Description of Aircraft influence

In the past 40 years, the development of aircraft and engine technology has reduced carbon dioxide emissions per seat mile by more than 1% per year on average. That was a result of substantial R&D investment in materials, aerodynamic efficiency, digital design and manufacturing methods, turbomachinery development, and aircraft system optimization.

Over the years, through various industry organizations and international institutions, the aviation industry has consciously committed to achieving a series of positive goals for improving the environmental performance of aircraft. The targets set by the European Aviation Research Advisory Committee require that by 2050, compared with 2000, carbon dioxide emissions will be reduced by 75%, nitrogen oxide emissions will be reduced by 90%, and noise will be reduced by 65%.

To help achieve these positive goals, we have reached a global agreement through the International Civil Aviation Organization that requires fuel efficiency performance standards to be incorporated and applied to the certification process of each aircraft.

Existing aircraft and engine designs are improving and continuing to increase efficiency as much as possible. At the same time, technical challenges were created currently facing and the need to deal with more radical "third age" methods.

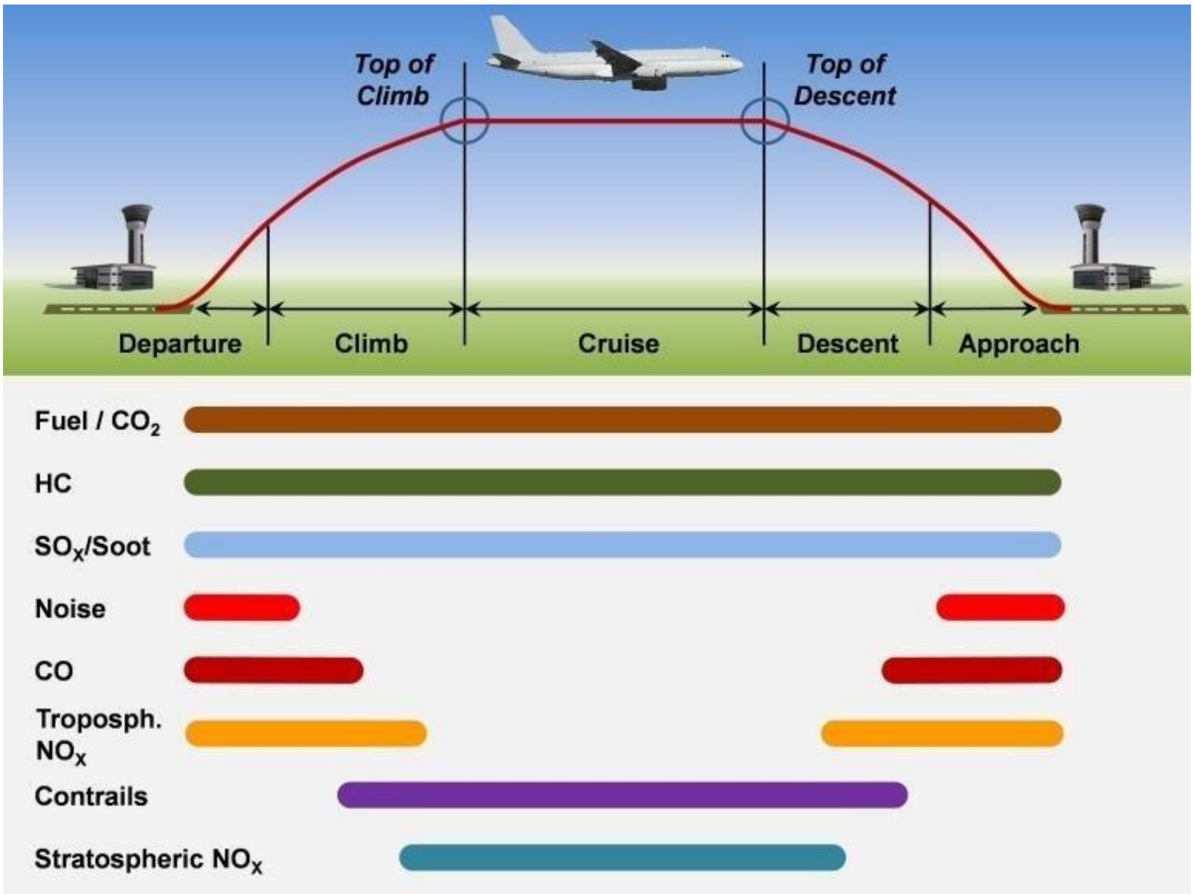

Fig. 5.1. The environmental impact of aircraft during flight

With the continuous expansion of the civil aviation fleet, the whereabouts of civil aviation aircraft after retirement has become a new issue before us. It is estimated that in the next 10 to 20 years, 6000 to 8000 aircraft will be retired worldwide. Aircraft are often placed in temporary storage yards after decommissioning. Not only will they occupy a large amount of land, but the degradation caused by ultraviolet rays, rainfall, and body oxidation can easily cause soil and groundwater pollution.

5.2. Environmental pollution from aircraft dismantling

1. Environmental pollution characteristics of aircraft dismantling

Although it is difficult to accurately characterize the environmental pollution characteristics of the aircraft dismantling industry with one sentence or a few characteristic pollutants, aircraft dismantling has some common characteristics of the environmental pollution of the dismantling industry. The environmental pollution not only exists in the dismantling process, but also in the transportation and storage process before dismantling, and also in the cleaning, cleaning, remanufacturing and reprocessing process after dismantling. There are many types of pollutants produced by dismantling, including air pollutants, water pollutants and solid pollutants, but the emissions are generally not large, which makes the treatment relatively cumbersome. The environmental pollution of many dismantling companies is often caused by poor management, not because of immature treatment technology or craftsmanship.

2. Main pollution links and pollutants of aircraft dismantling

The technological process of general aircraft dismantling can be divided into three sections: before dismantling, dismantling and after dismantling. Pre-demolition refers to the storage, emptying, and cleaning process from the arrival of the aircraft to the disassembly of the fuselage. The purpose of cleaning is mainly to remove oil and dust from the fuselage. This link mainly produces washing wastewater. The main pollutants are suspended solids and a small amount of oil. Venting includes emptying dead oil and stagnant water. Dead oil is mainly residual fuel and engine oil. Dead water includes stagnant water in kitchens, bathrooms, and pipelines. The vented fuel oil can be recycled, and the vented stagnant water contains certain organic pollutants and a small amount of oil. In the process of draining the dead oil, a small amount of volatile organic gas will be released.

After venting dead oil and stagnant water, the aircraft can enter the process of dismantling, which is the dismantling of the fuselage and parts. A whole machine can first disassemble the landing gear, engine, APU, tail nozzle, air inlet, thrust reverser, radar equipment, wing acting surface, horizontal tail, vertical tail, spoiler, air conditioning system, Instrumentation devices, communication systems, power systems, fire protection systems, flight control systems, fuel systems, hydraulic systems, anti-icing and rain protection systems, indicating and recording systems, lighting systems, navigation systems, pneumatic systems, oxygen systems, vacuum/pressure systems, Water ballast balance systems, cabin systems, avionics, doors, fuselages, nacelles/hangers, stabilizers, window windshields, seats, interior trims, and fillers.

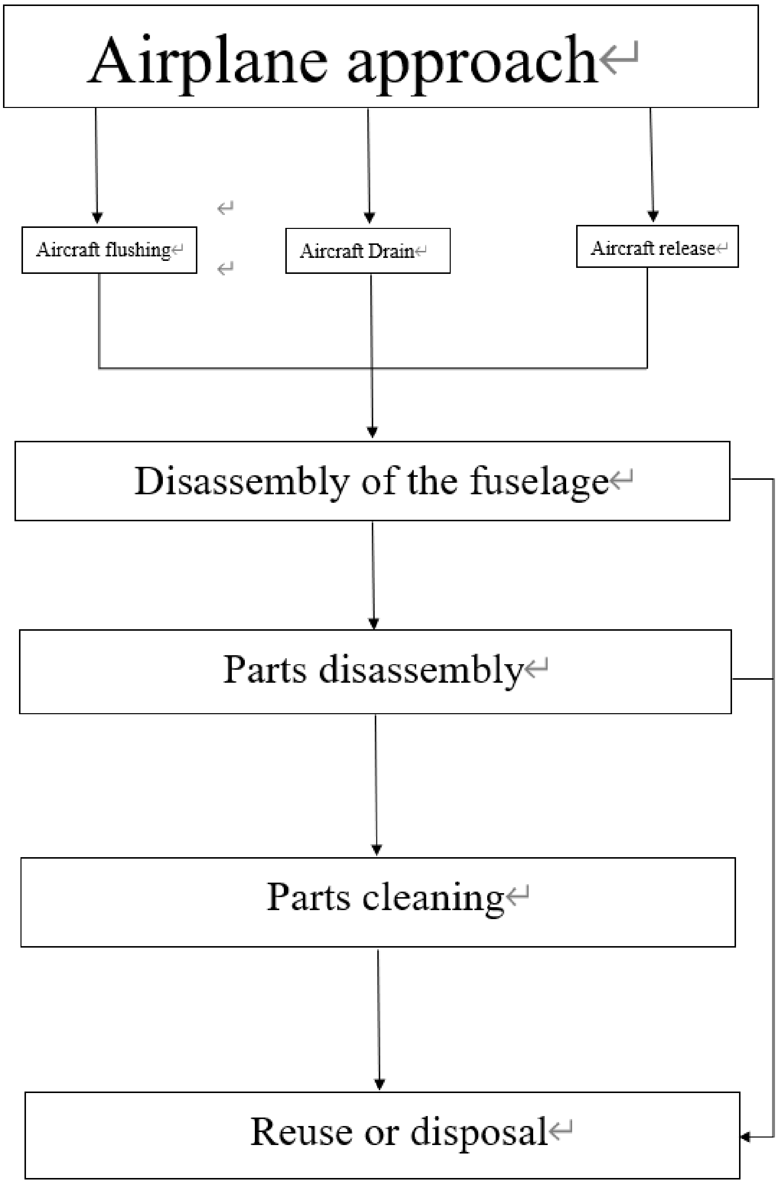

Fig. 5.2. Schematic diagram of aircraft dismantling process

A large part of these parts can be used for remanufacturing or reuse. For parts that cannot be remanufactured, further disassembly of the parts can be done, and the disassembled materials can be classified for reuse or disposal. This process is a process that produces a lot of pollutants, and the following pollutants will be produced:

1) In dismantling the landing gear, the hydraulic oil will be discharged during disconnecting the hydraulic pipeline. The hydraulic oil is hazardous waste and must be collected and sent to a qualified unit for disposal.

2) Lubricating oil will be discharged during engine disassembly, which is also hazardous waste.

3) In the process of dismantling the working surface of the wing, a small amount of

hydraulic oil and lubricating oil will be produced, which are all hazardous waste.

4) During the disassembly process, the parts will be cleaned as necessary. The cleaning methods are generally divided into alcohol wiping and clean water rinsing, which will produce wiping cotton cloth and cleaning wastewater, of which wiping cotton cloth is hazardous waste.

5) A small amount of volatile organic gas also can be released during the disassembly process.

The work after disassembly mainly includes the cleaning of parts and the classification of materials. The cleaning process will produce cleaning wastewater.

5.3. Methods of protection against Aircraft maintenance

Air emissions

The main sources of air emissions from large-scale maintenance activities include metal polishing and cleaning activities related to engine disassembly and repair (such as dust from grinding, spraying, and knocking; acid from surface treatment; chromic acid from hard chrome plating; and technology Volatile Organic Compounds (VOC) from Flushing], aircraft exterior cleaning and brushing operations (such as VOCs generated during cleaning and paint mixing and use), and engine operation tests (such as exhaust emissions from fuel combustion). The following preventive and control measures are recommended:

Collect the dust discharged during spraying, grinding and percussion through the extraction and ventilation system, and use bag filter or other dust control technology to clean up the dust. According to the characteristics of cadmium-containing dust, the recycled cadmium-containing dust should be treated as hazardous or non-hazardous waste in accordance with the instructions of the General EHS Guidelines.

Prevent or reduce the generation of acid emissions, especially acid-containing aerosols, and aerosols containing heavy metals, such as chromium. Pickling and certain electrolysis and electroplating processes may produce these types of emissions. These types of emissions can be prevented or reduced through the use of surfactants or, if required, the use of wet detergents. The chromic acid removed from the exhaust gas should be returned to the electroplating tank or managed in accordance with local regulations;

During the cleaning and painting process, VOC emissions should be reduced. Use water-based, alkaline cleaners instead of VOC - containing cleaners; avoid the use of VOC-containing paints, solvents and pigments in the aircraft oil brushing work, or require the operator to choose the appearance design of the aircraft, and give priority to the use of polishing (Instead of paint) design to reduce the amount of paint used. Whenever possible, encourage the use of water-based paints and avoid using paint removers containing dichloromethane or chromic acid primers;

It is necessary to reduce the potential impact of exhaust gas emitted by the engine operation test by setting the test area away from the city and limiting the test time according to the seasonal ambient air quality, or adopt other necessary management actions

To solve the possible impact on the surrounding air quality. For other guidelines on ambient air quality, please refer to the General EHS Guidelines.

Sewage

Hazardous substances may be discharged in the water in the workshop, metal surface finishing workshop, and external and technical washing. The main types of pollutants may include toxic metals, petroleum products (such as petroleum, white spirit, fuel), complexing agents and surfactants, heavy metals (such as cyanide, hexavalent chromium), and organic solvents. Because cadmium is often used for surface treatment of certain aircraft components (such as landing gear, wings), the pollutants may also contain cadmium. The following measures are recommended to prevent, reduce and control the discharge of sewage:

Isolate highly toxic waste streams, especially those containing cyanide, hexavalent chromium (Cr^{6+}), cadmium and other toxic metals. Other sewage streams that should be isolated include concentrated pretreatment solutions and electroplating solutions;

Degreasing solution; pickling solution; electroless plating solution (produced by chemical coating); electroplating solution (electrolyte); containing cyanide, hexavalent chromium (Cr^{6+}), hypophosphite (produced by nickel electroless plating), And sewage from aircraft cleaning and paint stripping operations.

Pre-treatment of selected or combined wastewater streams before discharge into the local sewer system, including the use of coagulation, flocculation and sedimentation methods, and other relevant industrial procedures for wastewater management guidelines.

For other guidelines on wastewater flow management, such as wastewater from metal surface finishing work, please refer to the "EHS Guidelines for Metal, Plastic and Rubber Products Manufacturing".

Hazardous or potentially hazardous waste generated in aircraft overhaul and repair activities includes the following types: waste oil and oily Emulsion fuel and fuel residues; organic solvents and ethylene glycol; metal hydroxide precipitation; lead-containing batteries; nickel-cadmium and nickel metal hydride batteries; (in the process of degreasing, pickling, passivation, electroplating and chemical coating) Surface treatment solutions, these solutions can contain cyanide, hexavalent chromium and cadmium; solid and semi-solid cyanide residues; paint sludge and splashed water; isocyanate; and fluorescent lamps and tubes containing mercury. It is necessary to manage waste, including hazardous waste, in accordance with the relevant recommendations provided in the General EHS Guidelines.

Noise

The main source of noise generated during aircraft maintenance activities is due to engine operation tests. Operational testing should be carried out in designated areas, preferably away from urban areas, and the test site should be equipped with noise suppression or deflection equipment. Other noise management strategies may include day and night restrictions. The noise level at the location closest to the recipient must not exceed the requirements specified in the General EHS Guidelines Guide value.

5.4. Conclusion

Long-term exposure to aircraft noise can have various health effects, including ischemic heart disease, sleep disturbance, irritability, and cognitive impairment. It has been confirmed that a certain level of aircraft noise causes residents' irritability far greater than the noise produced by other modes of transportation. Although knowledge gaps still exist (such as the impact of ultrafine particles), most of the pollutants emitted by aviation-related activities affect air quality and cause subsequent problems.

The health effects of continued have been well estimated.

A high degree of scientific understanding of the long-term climate impact caused by aviation carbon dioxide emissions makes it a clear and important target for mitigation efforts. The impact of non-carbon dioxide emissions (for example, nitrogen oxides, particulate matter) on the climate cannot be ignored, because they represent a very important warming effect in the short term. But the scientific understanding of this degree of influence is still at a medium to a very low level.

More and more countries and organizations are taking actions to adapt and cultivate resilience to resist the impact of climate change on the aviation industry (for example, rising temperatures, sea-level rise).

On the one hand, we will continue to develop aircraft and engine designs and technologies, and continue to pursue improvements in fuel efficiency and reduction of carbon dioxide emissions.

Support the commercialization of sustainable alternative aviation fuels. The operation of approximately 185,000 commercial flights has proven that current aircraft can use these fuels.

Develop brand-new aircraft and propulsion technology to accelerate the technological development that can realize the "third era" of aviation.

Other factors such as the efficiency of air traffic management and the minimization of fuel consumption on aircraft routes are also critical. Our industry has made significant progress in reducing noise and other environmental impacts, and we will continue to work hard in the future.

It is foreseeable that the number of retired aircraft will also increase rapidly in the next ten years. On the other hand, lower utilization rates, higher maintenance costs, and fluctuations in fuel prices have reduced the economic benefits of these old aircraft; Companies and aircraft leasing companies replace old aircraft with new ones.

LIST OF REFERENCES

1.