航空类专业职业教育系列“十三五”规划教材

飞机部件修理专业英语

主　编◎高　婕　吴成宝　陆　轶

西北工业大学出版社

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西　安

【内容简介】 本书侧重于介绍飞机部件维修专业的英语知识，包括航空维修基础知识，飞机部件维修介绍，飞机机械部件维修，飞机电气部件维修，飞机电子部件维修以及飞机起落架部件维修和飞机动力装置（主要指发动机）维修等7章。内容上从飞机和部件的维修基础知识逐步深入到各类别典型部件的具体修理知识，基本涵盖了航空维修尤其是飞机部件维修各岗位所需的英语知识。

本书可作为高等职业院校飞机大类（机械、电气、电子、起落架、发动机）部件修理相关专业以及航空维修类专业的教材，也可供机务维修人员参考。

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前　　言

本书是为满足飞机部件维修领域日益增长的技术工作与交流需要，根据中国民用航空规章《民用航空器维修单位合格审定规定》(CCAR-145-R3)和《民用航空器维修人员执照管理规则》(CCAR-66-R2)相关要求而编写的。

本书围绕技术应用型人才的培养目标，结合管理规章和维修手册的内容要求，广泛吸取近年来航空院校的教改经验和维修企业的先进做法，本着适用和实用的原则，着力使框架清晰，内容明确。本书可作为高等职业院校民航飞机维修大类相关专业的教材，也可作为机务维修在职人员的参考用书。

参加本书编写工作的均是具有丰富飞机维修专业教学经验的优秀教师。全书由高婕、吴成宝和陆轶主编，具体分工如下：吴成宝和魏娜编写第 1 章，高婕编写第 2 章，高婕和吴成宝编写第 3 章，赵勇编写第 4 章，闵莹编写第 5 章，陆轶编写第 6 章，吉小兵和陆轶编写第 7 章，吴成宝编写词汇总表并负责统稿。

本书的编写得到广州民航职业技术学院张建超、王舰、符双学、刘艺涛等专家的大力支持，还得到南京航空航天大学顾铮教授的热情帮助，以及广州飞机维修工程有限公司刘明德总监和李志强、黄雄、金尧明、资雯、郑建成等经理的有力协助，在此一并表示衷心感谢。

由于水平有限，书中难免会有不足之处，恳请广大读者批评指正。

编者
2018 年 1 月

Preface

The rapid development of China's civil aviation promotes foreign relations of the civil aviation gradually. The purpose of this book is to meet the requirement. This book is compiled referring to the requirement of *Approval of Civil Aircraft Maintemance Organization* (CCAR-145-R3) and *Management Rule of Civil Aircraft Maintnance Personnel License* (CCAR-66-R2).

As the common language of international civil aviation communication, the usage of English is increasing, especially for the graduated students of aircraft maintenance who are working for airlines. It is inevitable to contact a lot of information in English about the aircraft. Therefore, it is very important for the students of aircraft maintenance to master the understanding of technical vocabularies and be able to use English documents during work. This book is also fit for maintenance personnel for reference.

With the lead of Gao Jie, Wu Chengbao and Lu Yi, we invited several professional teachers compiled collaboratively. Chapter 1 was compiled by Wu Chengbao and Wei Na; Chapter 2 was compiled by Gao Jie; Chapter 3 was compiled by Gao Jie and Wu Chengbao; Chapter 4 was compiled by Zhao Yong; Chapter 5 was compiled by Min Ying; Chapter 6 was compiled by Lu Yi; Chapter 7 was compiled by Ji Xiaobing and Lu Yi; the Vocabulary was compiled by Wu Chengbao.

Highly appreciate the strong support offered by Zhang Jianchao, Wang Jian, Fu Shuangxue and Liu Yitao in our college, and highly appreciate the strong help provided by Liu Mingde, Li Zhiqiang, Huang Xiong, Jin Yaoming, Zi Wen, and Zheng Jiancheng in Gameco and professor Gu Zheng in Nanjing University of Aeronautics & Astronautics. Thanks to the efforts of them made to promote the improvement of the book and publishing.

As the knowledge is limited and the rapid development of civil aviation, omissions, impropriety and errors are inevitable in the book, we are looking forward to your feedback and comments.

Editors

Jan, 2018

Contents

Chapter 1
Basic Knowledge about Aviation Maintenance

Chapter 1　Basic Knowledge about Aviation Maintenance

1.1　Classification of Aviation Maintenance

Aviation maintenance is roughly divided into three categories, line maintenance operation, hangar maintenance (on-Aircraft) and maintenance overhaul shop (off-aircraft).

1.1.1　Line Maintenance Operation

Figure 1.1－1 shows the typical flight line activities for a given flight. An aircraft may or may not experience any faults or discrepancies during the flight. When the aircraft arrives at the gate, normal services (fuel, food, etc.) will be provided as well as the exchange of passengers, their baggage, and any cargo. If a failure or discrepancy did occur in flight, there are two possible scenarios. Normally the problem is written up in the aircraft maintenance logbook and addressed by the ground crew upon flight arrival. Maintenance actions would be as indicated by the center column blocks of Figure 1.1－1. To minimize delay on the ground, however, it is recommended that advance warning be given to the maintenance personnel by the flight crew through flight operations and the MCC (Maintenance Control Center). This allows maintenance to spend time before the aircraft arrives to review past records and troubleshoot the problem. Thus, the actions shown in the left hand column of Figure 1.1－1 are employed. In many cases, the maintenance crew can meet the aircraft with a solution in hand thus minimizing maintenance downtime and delays. This may be accomplished by a separate team or the same team that handles any other logbook items. Note that both sign-off of all discrepancies (or deferrals) and servicing of the aircraft must be completed prior to returning the aircraft to flight service.

1.1.2　Hangar Maintenance (on-Aircraft)

Hangar maintenance are the maintenance activities on the plane of stopping operation, including any major maintenance and modification for the airplane. The actual business types of Hangar maintenance contains: higher than the planning check of "A" check (i.e. "C" check, "D" check, the major repair check); according to the service bulletin, Airworthiness Directives or engineering instruction modified aircraft or aircraft system; the special check by the airlines, the Federal Aviation Administration or other operation state requirements; aircraft painting; as well as the aircraft interior modification.

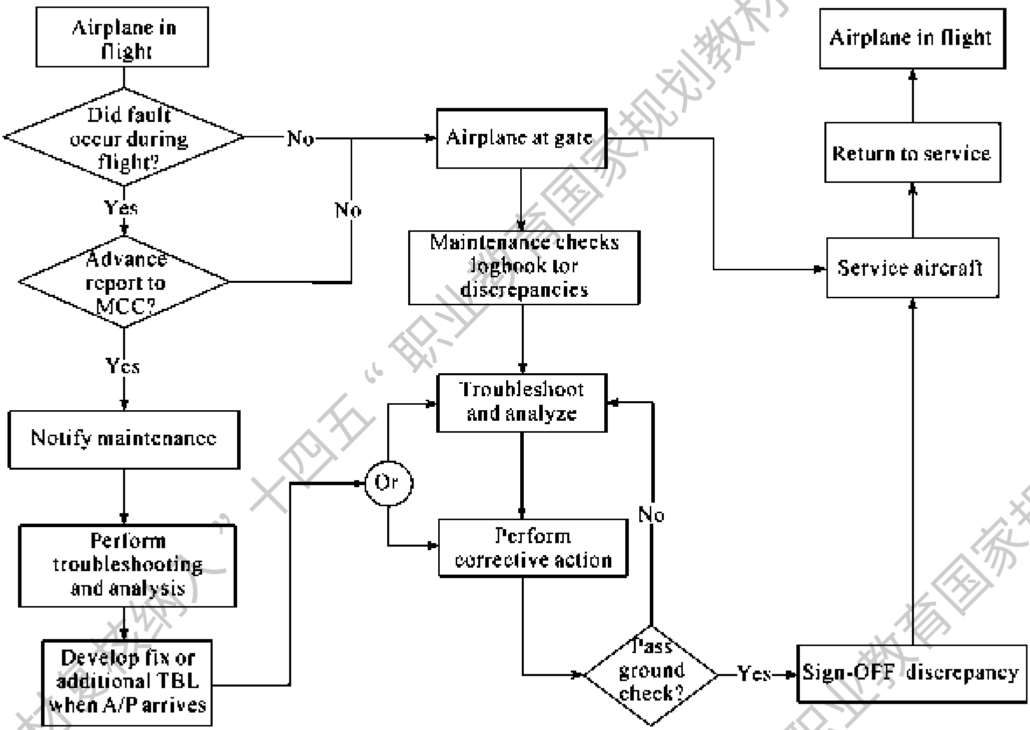

Figure 1.1-1　Line maintenance operations — turn around

The content of a "C" check will vary from one airline to another, from one aircraft to another, even from one check to another for the same aircraft or type. The typical check into five sections: ①preparation; ②preliminary activities; ③conduct of the check; ④completion and sign-off; and ⑤return to service.

1.1.3　Maintenance Overhaul (off-Aircraft)

There are two types of shop maintenance activities in an airline maintenance organization. The functions and relationship to other organizations differ somewhat. There are support shops, which include such special skills and activities as welding, sheet metal, composite materials, aircraft interiors, etc. These shops are usually part of the hangar maintenance organization. The work they do is primarily in support of out-of-service aircraft, although some support is given to line maintenance as needed.

The other type of maintenance shops at an airline, the overhaul shops, involve support for the specialized equipment on the aircraft such as engines; avionics, hydraulic and pneumatic systems; structures; etc. The work performed in these shops is on equipment that has been removed from the aircraft during line or hangar maintenance operations.

Work on a flight line is hectic, at times, subject to flight schedules, maintenance emergencies, foul weather, and the ever-irritating "time limitations". Hangar work may be less hectic with more time to accomplish each job, but there is still a time limitation and other pressures. In shop maintenance, however, the pressures of time and schedule are somewhat lessened by the nature of the shop operation.

Items come in for servicing, repair, or overhaul and are addressed, usually by specialists in the type of equipment or system involved. Some of the basic troubleshooting has already been done to indicate such-and-such a unit is bad and has to be replaced. This done, the mechanic turns the errant item into materiel and draws a good one for installation. Materiel, then, sends the properly tagged incoming unit to the appropriate shop. The shop mechanic or technician then uses his or her standard bench check procedures to determine problem, make the necessary repairs, and perform some cheek to ensure that the job has been successful. Once maintenance is completed, the proper paperwork filled out and attached and the serviceable unit is sent back to materiel for placement in stores for reissue when needed.

Each maintenance shop will have a work area, a storage area with adequate separation of serviceable, unserviceable, and discarded units. Usually they will have a spare parts area, maintained by materiel, for the small parts needed for the work. Again, proximity of these areas to the work area minimizes the tune a mechanic spends in "part chasing". Of course, each shop will be equipped with the necessary tools, work benches, test stands, and test equipment for the type of equipment to be worked on. Appropriate safety equipment for the work performed and hazardous materials handled (if any) should be readily available and accessible to the employees. Suitable office space will be provided for administrative and management functions.

The overhaul shops generally work a standard shift, with or without overtime; night shift and weekend work depends on the airline and its workload. The pace may be slower than on the line or in the hangar, but short turnaround for maintenance (mean time to repair, MTTR) is still important. The number of items held in stock is based not only on the failure rate for your fleet, but also on the amount of time it takes to pass the repairable item through maintenance. The sequence goes like this: ①remove unit from the aircraft; ②turn the unit into materiel for replacement; ③route unit to the repair facility (in-house or third party); ④return serviceable unit to stores for reissue.

1.1.4 Two Types of Maintenance

Figure 1.1 – 2 is a graph showing the level of perfection of a typical system. One hundred percent perfection is at the very top of the y-axis. The x-axis depicts time. There are no numbers on the scales on either axis since actual values have no meaning in this theoretical discussion. The left end of the curve shows the level of perfection attained by the designers of our real world system. Note that the curve begins to turn downward with time.

This is a representation of the natural increase in entropy of the system — the natural deterioration of the system — over time.

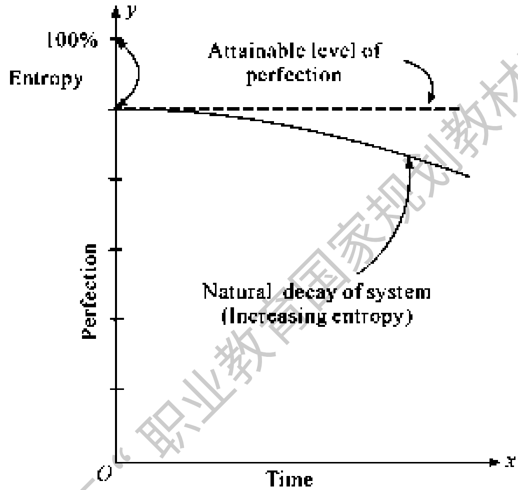

Figure 1.1 - 2 The difference between theory and practice

When the system deteriorates to some lower (arbitrarily set) level of perfection, we perform some corrective action: adjusting, tweaking, servicing, or some other form of maintenance to restore the system to its designed-in level of perfection. That is, we reduce the entropy to its original level. This is called preventive maintenance and is usually performed at regular intervals. This is done to prevent deterioration of the system to an unusable level and to keep it in operational condition. It is sometimes referred to as scheduled maintenance. This schedule could be daily, every flight, every 200 flight hours, or every 100 cycles (a cycle is a takeoff and a landing). Figure 1.1 - 3 shows the system restored to its normal level (curves *a* and *b*).

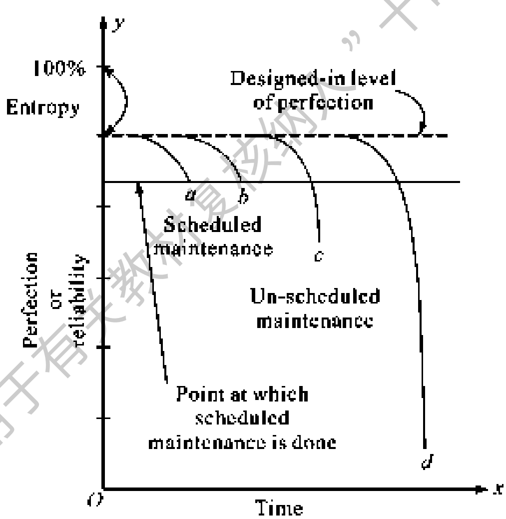

Figure 1.1 - 3 Restoration of system perfection

There are times, of course, when the system deteriorates rather rapidly in service to a low level of perfection (curve *c*). At other times the system breaks down completely (curve *d*). In these cases, the maintenance actions necessary to restore the system are more definitive, often requiring extensive testing, troubleshooting, adjusting, and, very often, the replacement, restoration, or complete overhaul of parts or subsystems. Since these breakdowns occur at various, unpredictable intervals, the maintenance actions employed to correct the problem are referred to as unscheduled maintenance.

1.1.5 Documentation for Maintenance

1.1.5.1 Types of Documentation

This chapter will focus on documentation that identifies the aircraft, its systems, and the work to be done on them. Some of the documents will be customized for the operator by the supplier, others will be generic. Most of these documents have standard revision cycles and changes are distributed on a regular basis by the airframe manufacturer. Some documents are designated as "controlled" and some are "non-controlled" documents. A controlled document is one that is used for operation and/or maintenance of the aircraft in accordance with FAA (Federal Aviation Administration) regulations. Such documents have limited distribution within the airline and require regular revision cycles with a list of revisions and active and rescinded page numbers recorded in the document. The operator is required to use only up-to-date documents.

This bounty of written information includes the documentation provided by the airframe manufacturer and the manufacturers of systems and equipment installed on the aircraft; the documentation provided by the regulatory authorities; and the documentation written by the airline itself for the purpose of detailing the individual maintenance processes. We will discuss each of these in turn.

1.1.5.2 Manufacturer's Documentation

Table 1.1 - 1 lists the documentation provided to an operator by the airframe manufacturer for the maintenance of an aircraft. The form and content of the documents sometimes varies from one manufacturer to another. The table identifies, basically, the type of information which airframe manufacturers make available to their customers. Some of the documents can be customized for the operator to include only the operator's configuration and equipment. These are called "customized" documents by the manufacturer and are marked in the table with an asterisk as shown in Table 1.1 - 1. Some documents, such as the illustrated parts catalog (IPC) may be customized at customer request (usually for a price). These are identified with the dagger symbol. The other documents are generic for all models or all airplanes of a specific model. This, too, may vary among airframe manufacturers. Each document and the type of information supplied are discussed below.

Table 1.1 - 1 Manufacture's Documentation

Title	Abbreviation
Airplane Maintenance Manual*	AMM
Component Maintenance Manual	CMM
Vendor Manuals	VM
Fault Isolation Manual*	FIM
Fault Reporting Manual	FRM
Illustrated Parts Catalong*	LPC
Storage and Recovery Document*	SRD
Structural Repair Manual	SRM
Maintenance Planning Data Document	MPD
Schematic Diagram Manual*	SDM
Wiring Diagram Manual*	WDM
Master Minimum Equipment List	MMEL
Dispatch Deviation Guide	DDG
Configuration Deviation List	CDL
Task Cards*	TC
Service Bulletins	SBs
Service Letters	SLs
Maintenance Tips	MTs

1. Airplane Maintenance Manual (AMM)

The AMM contains all the basic information on the operation and maintenance of the aircraft and its on-board equipment. It starts with an explanation of how each system and subsystem works (description and operation) and describes various basic maintenance and servicing actions such as removal and installation of LRUs(Line Removal Units); the various tests performed on the systems and equipment such as functional tests, operational tests, adjustments, the replenishing of various fluids, and other servicing tasks.[1]

2. Component Maintenance Manual and Vendor Manual(CMM & VM)

Any components built by the airframe manufacturer will be accompanied by a component maintenance manual written by the manufacturer. Vendor manuals (VM) are written by the manufacturer of components and systems built by outside vendors who supply electronics, computer, and other systems to be installed on the aircraft. These components are either supplied to the airframe manufacturer for equipment offered as options (seller-furnished equipment, SFE) or purchased by the operator and installed by the airframe manufacturer before delivery or installed by the operator after delivery (buyer-furnished equipment, BFE).[2] These component and vendor manuals are for components that have to be removed from the aircraft for maintenance in the shop. The manuals provide the same type of information on these components that the AMM provides for the aircraft and its systems.[3]

3. Fault Isolation Manual (FIM)

The FIM contains a set of fault isolation trees for the purpose of pinpointing and fixing numerous problems related to the various systems and components on the aircraft. These flow diagrams are designed to locate many of the problems within the various systems but may not be inclusive. The FIM is sometimes used in conjunction with the fault reporting manual (FRM) discussed below.

4. Fault Reporting Manual (FRM)

The FRM was designed to be used by the flight crew to provide maintenance with advanced warning of malfunctions and an indication of where to begin looking (in the FIM and AMM) for a solution prior to the aircraft's arrival. The flight crew identifies their problem using a series of questions and diagrams of system operation and instrument indication. This leads to an eight-digit code which is reported to the ground station. Maintenance people then use this code to determine the appropriate solution. This can either be a "quick fix" listed in the FRM cross-reference list or it can direct them to a specific fault tree in the FIM for more detailed troubleshooting.

5. Illustrated Parts Catalog (IPC)

The IPC is produced by the airframe manufacturer and includes lists and location diagrams of all parts used on the aircraft model. This includes all parts for all systems and is usually not customized to the airline's configuration. It does, however, indicate applicability of parts (i. e., engine, airframe model, etc.) and also provides information on part numbers, vendors, interchangeability of parts, and whether or not the part can be used with or without certain service bulletin incorporation.

6. Storage and Recovery Document (SRD)

The SRD contains information needed to address maintenance and servicing of aircraft that are to be out of service and stored for long periods of time. This includes the procedures for draining certain fluids, moving the aircraft so that tires will not go flat, and protecting components from the weather. In the older model aircraft, this document was produced separately by the airframe manufacturer. For more recently manufactured aircraft, this information is included in the applicable AMM (ATA, Chapter 10).

7. Structural Repair Manual (SRM)

The SRM is a manual that provides the operator with information needed to effect certain repairs of the aircraft structure. These repairs are simple and are approved by the FAA for operator completion. Other structural repairs must be done by the airframe manufacturer or some other FAA designated repair facility.

8. Maintenance Planning Data (MPD) Document

This document (called the on aircraft maintenance program by McDonnell-Douglas) provides the airline operator with a list of maintenance and servicing tasks to be performed on the aircraft. It contains all items of the MRB report along with other information. Some of these tasks are identified as certification maintenance requirements (CMRs) and are required by the FAA in order to maintain certification of the aircraft. All other tasks, which were developed by the MSG(Maintenance Steering Group) process, are included along with other tasks recommended by the manufacturer. The tasks are divided into various groupings for older aircraft models—daiy, transit, letter checks, hourly limits, and cycle limits—and are used for planning purposes by the airline.[4] Later models do not group the tasks by letter checks, only by hours, cycles, and calendar time.

9. Schematic Diagram Manual (SDM)

This document contains schematic diagrams of electrical, electronic, and hydraulic systems on the aircraft as well as logic diagrams for applicable systems. The diagrams in the AMM and other manuals are usually simplified diagrams to aid in describing the system and assist in troubleshooting. The schematic manual, however, contains the detailed information and identifies wiring harnesses, connectors, and interfacing equipment.

10. Wiring Diagram Manual (WDM)

The wiring diagram manual provides information on the wiring runs for all systems and components having such elements. The wiring diagram shows the complete run of wiring, including cable bundle numbers and routing, plug and connector numbers and locations, bulkheads, and other structural elements through which the wiring is routed.

11. Master Minimum Equipment List (MMEL)

The MMEL is identified by the airframe manufacturer and approved by the FAA to identify the equipment which may be degraded or inoperative at dispatch of the aircraft. These are systems that the flight crew, under certain circumstances, may agree to accept at dispatch in a degraded or inoperative condition, provided that the system is fixed within the prescribed time limit set by the MMEL. The manufacturer's flight engineering group develops the MMEL. The MMEL contains information on all equipment available on the aircraft model to which it applies. It is the airline's responsibility to develop their own manual tailored to their specific equipment. This document, called the MEL, is discussed later, in the section Airline Generated Documentation.

12. Dispatch Deviation Guide (DDG)

Some of the MMEL items that are inoperative or degraded at dispatch require maintenance action prior to the deferral and dispatch. This may be the need to pull and placard certain circuit breakers, disconnect power, tie up loose cables for removed equipment, and various other actions to secure the aircraft and the system against inadvertent operation. The instructions necessary for these actions are provided in the DDG. This guide is written by the manufacturer's AMM staff and is coordinated with the MMEL.

13. Configuration Deviation List (CDL)

The CDL is similar to the DDG but involves configuration of the aircraft rather than aircraft systems and equipment. The CDL provides information on panels, fairings, and similar variations in configuration that can be nonstandard at dispatch as long as it does not affect the safety of flight.

14. Task Cards (TC)

Certain tasks in the AMM for removal/installation, testing, servicing, and similar maintenance items are extracted from the AMM and produced on separate cards or sheets so that the mechanic can perform the action without carrying the entire maintenance manual to the aircraft.[5] (The Boeing 767 manual is about 20000 pages.) These task cards can be used "as is" or they can be modified by the operator for reasons discussed in the section Airline Generated Documentation.

15. Service Bulletins, Service Letters and Maintenance Tips (SBs, SLs & MTs)

Whenever the airframe manufacturer or the engine manufacturer has modifications or suggestions for improving maintenance and/or servicing, they will issue appropriate paperwork to the affected airlines. A service bulletin (SB) is usually a modification of a system that will provide improved safety or operation of a system and includes a detailed description of the work and parts required.[6] An SB is usually optional and the airline makes the choice, except in certain cases involving an FAA airworthiness directive (AD) discussed below in regulatory documentation. A service letter (SL) usually provides information to improve maintenance actions without equipment modification. The maintenance tip is a suggestion for maintenance personnel to assist in their work or improve conditions.

1.1.5.3 Regulatory Documentation

The FAA issues numerous documents related to maintenance of aircraft and their systems. Table 1.1-2 lists the more significant of these documents.

1. Federal Aviation Regulations (FARs)

In the United States, federal laws are collected into a document known as the code of federal regulations or CFEs. Those laws related to commercial aviation are under title 14 of this code, aeronautics and space, parts 1 through 200. The regulations relating to certification and operation of large, commercial aircraft—part 21—would be noted as 14CFR 121. We usually refer to this as FAR part 121. In this book we will use the FAR terminology and form since it is so common in the industry. These FARs address all aspects of the aviation field including private, commercial, and experimental aircraft; airports; navigational aids; air traffic control; training of pilots, controllers, mechanics, etc.; and other related activities.

Table 1.1-2 Regulatory Documents

Title	Abbreviation
Federal aviation regulations	FARs
Advisory Circulars	ACs
Airworthiness directives	ADs
Notice of proposed rule making	NPRM

2. Advisory Circulars (ACs)

An advisory circular is a document issued by the FAA to provide assistance to operators on meeting the requirements of various FARs. These ACs are not binding as law but are merely suggestions as to how to comply with other requirements. An AC often states that it is "a means", but not the only means for complying with a regulation. The FAA allows some leeway in how its regulations are met in order to achieve the desired results without trying to micro-manage the operator.

3. Airworthiness Directives (ADs)

The airworthiness directives are substantial regulations issued by the FAA to correct an unsafe condition that exists in a product (aircraft, aircraft engine, propeller, or appliance) and a condition that is likely to exist or develop in other, similar products.[7] An AD, whose incorporation is mandatory, may be issued initially by the FAA when an unsafe condition is noted or it may result from FAA action after the airframe manufacturer has issued a service bulletin (SB) relative to some noted problem. Incorporation of an SB is optional but, if it is made into an AD by the FAA, incorporation becomes a mandatory requirement.

Aircraft owners or operators are required to maintain the aircraft in compliance with all ADs. Typically, an AD will include ①a description of the unsafe condition; ②the product to which the AD applies; ③the corrective action required; ④date of compliance; ⑤where to get additional information; and ⑥information on alternative methods of compliance if applicable.

4. Notice of Proposed Rule Making (NPRM)

Whenever the FAA intends to change or amend any FAR, it will issue an NPRM in advance in order for the industry to have ample time to study and comment on the proposed rule change. These documents allow the operators to participate in the change and assist the FAA in developing workable and acceptable rules.

1.1.5.4 Airline Generated Documentation

Table 1.1-3 lists the documentation that the airline will generate in order to carry out its maintenance activities. Again, these documents may vary in name and actual content from one operator to another, but the information identified here must be addressed by airline documentation.

Table 1.1－3　Airline Generated Documentation

Title	Abbreviation
Operations specifications	Ops Specs
Technical Policies and Procedures Manual	TPPM
Inspection Manual	IM
Reliability Program Manual	RPM
Minimum Equipment List	MEL
Task Cards*	TC
Engineering Orders*	EOs

1. Operations Specifications(Ops Specs)

The operations specifications document is written by the airline in accordance with strict FAA requirements and usually with the help of an FAA representative. The Ops Specs is required for each aircraft type flown by the airline. It is a parent document, which refers to numerous other documents to avoid duplication and details the airline's maintenance, inspection, and operations programs.

2. Technical Policies and Procedures Manual(TPPM)

The TPPM is the primary document for the airline's M&E operation and, with other documents supplied by the airframe manufacturer, serves as the FAA requirement for a maintenance manual per AC 120-16D. It is usually written by engineering, to ensure technical accuracy, from inputs supplied by management of the various M&E organizations. It should define exactly how all M&E functions and activities will be carried out. The TPPM is a detailed document and may be several volumes. Personnel in all units of M&E must be trained on the TPPM, especially those parts that relate directly to that unit's operation so that the operation will go smoothly.

3. Inspection Manual(IM)

The inspection manual may be a separate document distributed primarily to QC personnel, or it can be a chapter in the TPPM (usual approach). Contents of the IM relate to all inspection activities within M&E(Maintenance & Engineering): ①mechanic inspection tasks from the MPD/OAMP or the MRB report; ② QC inspector's tasks; ③ special inspections (hard landings, bird strikes, etc.); ④the airline's required inspection item (RII) program; and ⑤ the paperwork, forms, and reports required to carry out these functions. Some IMs may indicate details on the calibration of tools and test equipment, since these are QC functions, or these may be in a separate chapter of the TPPM.

4. Quality Assurance (QA) Manual

The QA manual could be a special manual for QA auditors only, it could be part of the inspection manual or it could be a separate chapter in the TPPM as desired. The QA manual defines the duties and responsibilities of the QA organization and defines the processes and procedures used in the annual quality assurance audits conducted on the M&E units, suppliers, and outside contractors. Forms used and reports are also covered along with the procedures for follow-up and enforcement of QA write-ups.

5. Reliability Program Manual(RPM)

An airlines reliability program, under FAA rules, must be approved by the regulatory authority, so it is usually published as a separate document. This document defines the reliability program in detail so that the FAA can evaluate and approve all its elements at one time.

6. Minimum Equipment List (MEL)

The MMEL provided by the airframe manufacturer includes all equipment and aircraft configurations available for the model to which it applies. With up to three manufacturers supplying engines (customer option) on some models, and the multitude of auxiliary systems available as buyer options, this manual includes much information that is not applicable to some operators. To eliminate confusion, the operator is required to customize the MMEL for his or her particular airframe/engine configuration. This copy is referred to as the airline's minimum equipment list or MEL. The operator must carry copies of this MEL in each aircraft for flight crew reference. The applicable items in the DDG and the CDL should also be included with the MEL.

7. Task Cards(TC)

The task cards produced by the air frame manufacturer are usually for one action only. These procedures may call for the mechanic to open panels, set certain circuit breakers "in" or "out", turn other equipment "on" or "off", etc., prior to the work and to reverse these processes at the completion. Much of the work done at an airline during an aircraft check, however, involves the combination of several tasks to be performed by the same mechanic or crew within the same area or on the same equipment. To avoid unnecessary duplication of certain actions, and the unnecessary opening and closing of the same panels, etc., most airlines write their own task cards to spell out exactly what to do, using the manufacturer's cards as a guide.[8] This eliminates the duplicated or wasted efforts. Some airlines find it sufficient, or perhaps more expedient, to provide mechanics with all the manufacturer's task cards for a given work project and allow him or her to avoid the duplications during the work activity. Often there will be an airline task card attached to this package of cards with special instructions for working the group of cards. Whichever approach is used, the engineering section is responsible for creating these cards to ensure technical accuracy.

8. Engineering Orders (EOs)

Any maintenance work not covered in the standard maintenance plan developed by engineering from the MRB report or Ops Specs data must be made official by the issuance of an EO. This is official paper work, issued by engineering and approved by QA, and is usually implemented through the production planning and control (PP&C) organization. In some airlines, the document may be called simply a "Work Order".

New Words/ Phrases/ Expression

1. discrepancy [dis'krepənsi] *n.* 不一致之处
2. reissue [riː'isjuː] *v.* （使）重新发行
3. overhaul [ˌəuvə'hɔːl] *v.* 大修
4. arbitrarily set 主观设定
5. maintenance ['meintinəns] *n.* 维修
6. documentation [ˌdɔkjumen'teiʃən] *n.* 文件
7. manual ['mænjuəl] *n.* 手册
8. vendor ['vendə] *n.* 供应商
9. diagram ['daiəgræm] *n.* 图表
10. component [kəm'pəunənt] *n.* 部件
11. tweaking [twiːking] *n.* 校正，调整

Notes

【1】It starts with an explanation of how each system and subsystem works (description and operation) and describes various basic maintenance and servicing actions such as removal and installation of LRUs(Line Removal Units); the various tests performed on the systems and equipment such as functional tests, operational tests, adjustments, the replenishing of various fluids, and other servicing tasks.

翻译：手册一开始就对每个系统和子系统的工作原理进行解释说明(结构说明和工作原理),并对各种基本的维修和养护措施加以说明,例如,对航线可更换组件的拆卸和安装;还对在系统和设备上进行的各种试验分别给予叙述说明,例如,功能试验、运营试验、调试、各种油液的补充添加以及其他各种养护任务。

【2】These components are either supplied to the airframe manufacturer for equipment offered as options (seller-furnished equipment, SFE) or purchased by the operator and installed by the airframe manufacturer before delivery or installed by the operator after delivery (buyer-furnished equipment, BFE).

翻译：这些部件要么作为任选项目提供给飞机制造商(称为卖方提供的设备,简称 SFE),要么由营运人采购并由飞机制造商在飞机交付之前安装到飞机上或者飞机交付之后由营运人自己安装到飞机上(称为买方提供的设备,简称 BFE)。

【3】These component and vendor manuals are for components that have to be removed from the aircraft for maintenance in the shop. The manuals provide the same type of information on these components that the AMM provides for the aircraft and its systems.

翻译：销售方的这种部件维修手册便于各部件从飞机上拆卸下来再在车间里进行维修,该手册为这些部件提供的资料类型与飞机维修手册为飞机及其系统规定的资料类型相同。

【4】All other tasks, which were developed by the MSG process are included along with other tasks recommended by the manufacturer. The tasks are divided into various groupings for older aircraft models—daily, transit, letter checks, hourly limits, and cycle limits—and are used for planning purposes by the airline.

翻译：除了制造商推荐的其他任务外，本文件还包括所有其他任务，这些任务是按照 MSG 程序制定的。对于较旧型号的飞机，这些任务划分为各种类型——日检、过站检查、用字母表示的检查、按小时计算的检查和按周期限制的检查——并且这些任务由航空公司作计划安排。

【5】Certain tasks in the AMM for removal/installation, testing, servicing, and similar maintenance items are extracted from the AMM and produced on separate cards or sheets so that the mechanic can perform the action without carrying the entire maintenance manual to the aircraft.

翻译：飞机维修手册中规定的某些任务，诸如拆卸/安装、试验、养护以及类似的维修项目，可从飞机维修手册中摘录出来并填写在不同的卡片或者单子上，以便于机务人员执行该维修措施，而不需要将整个维修手册带到飞机上。

【6】A service bulletin (SB) is usually a modification of a system that will provide improved safety or operation of a system and includes a detailed description of the work and parts required.

翻译：服务通告通常就是为改进系统安全或运营而提出的对一个系统的更改，在通告中详细规定了所要做的工作和所需要的零件。

【7】The airworthiness directives are substantial regulations issued by the FAA to correct an unsafe condition that exists in a product (aircraft, aircraft engine, propeller, or appliance) and a condition that is likely to exist or develop in other, similar products.

翻译：适航指令实际上是美国联邦航空局颁布的条例，以便克服产品(指航空器、航空发动机、螺旋桨或设备)存在的不安全状态和有可能在其他类似产品存在或产生的不安全状态。

【8】To avoid unnecessary duplication of certain actions, and the unnecessary opening and closing of the same panels, etc., most airlines write their own task cards to spell out exactly what to do, using the manufacturer's cards as a guide.

翻译：为了避免某些任务的不必要的重复作业，不必要的打开及关闭相同的检查口盖等，多数航空公司编写自己的工卡以便确切地写明要做些什么，而把制造商的工卡作为指南。

Exercises

Ⅰ. Answer the following questions:

1. What the Airplane Maintenance Manual contains?

2. Who drawed up the Component Maintenance Manual?

3. What is called Airworthiness Directives?

Ⅱ. Translate the following sentences into Chinese:

1. Any components built by the airframe manufacturer will be accompanied by a component maintenance manual written by the manufacturer.

2. The IPC is produced by the airframe manufacturer and includes lists and location diagrams of all parts used on the aircraft model.

3. The SRM is a manual that provides the operator with information needed to affect

certain repairs of the aircraft structure.

4. Whenever the airframe manufacturers or the engine manufacturer have modifications or suggestions for improving maintenance and/or servicing, they will issue appropriate paperwork to the affected airlines.

5. An advisory circular is a document issued by the FAA to provide assistance to operators on meeting the requirements of various FARs.

6. Line maintenance people for most airlines, especially those doing contract maintenance for other carriers, will have the opportunity to work on a wide variety of aircraft during the course of their shift or work week.

Ⅲ. Fill in the following blanks according to the text:

1. ________ are required to maintain the aircraft in compliance with all ADs. Typically, an AD will include (a) ________; (b) ________; (c) ________; (d) ________; (e) ________; and (f) ________.

2. ________ issues numerous documents related to maintenance of aircraft and their systems.

(1) The full name of the CMM is ________.

(2) The full name of the AMM is ________.

(3) The full name of the IPC is ________.

(4) The full name of the MPD is ________.

(5) The full name of the TC is ________.

1.2 Aeronautical Materials and Corrosion Control

1.2.1 Aeronautical Material

The materials used for aircraft construction can be split into two broad categories: airframe materials and engine materials, and these will be considered separately. However, selection of materials for both applications is based on the design constraints. These are defined by the mechanical, chemical and thermal property requirements of each component. Typical design constraints include weight, stiffness, strength, fatigue performance (high/low cycle), corrosion resistance and cost.

Of major consideration is the specific stiffness (stiffness to density ratio E/r), and specific strength (strength to weight ratio σ/ρ). The broad aim for aircraft design is to maximize payload in relation to cost. By increasing specific stiffness and strength, the weight of a given component can be decreased and fuel consumption and running costs decreased.[1] For example when a fully loaded aircraft takes off, 20% of the weight is payload, 40% is aircraft structural weight and 40% is fuel. Therefore, a saving in aircraft weight can increase the possible payload or decrease the power required for a given payload.

1.2.1.1　Airframe Materials

1. Aluminum and Aluminum Alloys

Aluminum is one of the most widely used metals in modern aircraft construction. It is vital to the aviation industry because of its high strength-to-weight ratio and its comparative ease of fabrication. The outstanding characteristic of aluminum is its light weight. It is nonmagnetic and is an excellent conductor.

The various types of aluminum may be divided into two general classes: ①The casting alloys (those suitable for casting in sand, permanent mold, or die castings), and ② the wrought alloys (those which may be shaped by rolling, drawing, or forging). Of these two, the wrought alloys are the most widely used in aircraft construction, being used for stringers, bulkheads, skill, rivets, and extruded sections. Wrought aluminum and wrought aluminum alloys are divided into two general classes, non heat-treatable alloys and heat-treatable alloys.

Aluminum alloys have a low density (2.7 g/cm^3) and, while their tensile properties are low compared to steels, they have excellent strength to weight ratios. They have excellent thermal and electrical conductivity and have excellent resistance to oxidation and corrosion. The chief limitation of aluminum alloys is their low melting temperature (about 660℃) that limits their maximum service temperature. However they remain the major materials for civil airframe construction and are used for many applications, see Figure 1.2-1.

(1) Aluminum and Aluminum Alloy Designations

Wrought aluminum and wrought aluminum alloys are designated by a four-digit index system.

(2) Effect of Alloying Element

1000 series: 99% or higher, excellent corrosion resistance, high thermal and electrical conductivity, low mechanical properties, excellent workability. Iron and silicon are major impurities.

2000 series: Copper is the principle alloying element. Solution heat treatment, optimum properties equal to mild steel, poor corrosion resistance unclad. It is usually clad with 6000 or high purity alloy. Its best known alloy is 2024.

3000 series: Manganese is the principle alloying element of this group which is generally non-heat treatable. The percentage of manganese which will be alloy effective is 1.5%. The most popular is 3003 which is of moderate strength, and has good working characteristics.

4000 series: Silicon is the principle alloying element. This lowers the melting temperature. Its primary use is in welding and brazing. When used in welding heat-treatable alloys, this group will respond to a limited amount of heat treatment.

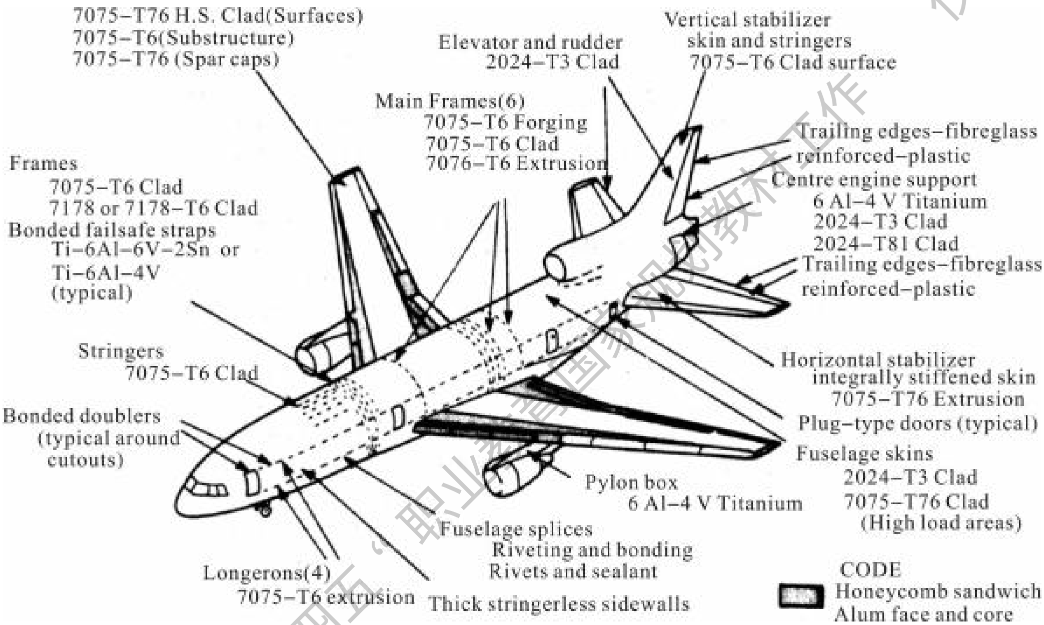

Figure 1.2-1 Materials in airframe construction

5000 series: Magnesium is the principle alloying element. It has good welding and corrosion resistant characteristics.

6000 series: Silicon and magnesium form magnesium silicide which makes alloys heat-treatable. It is of medium strength, good forming and has corrosion resistant characteristics. The most popular alloy of the series is 6061.

7000 series: Zinc is the principle alloying element. When coupled with magnesium, it results in heat-treatable alloys of very high strength. It usually has copper and chromium added. The principle alloy of this is 7075.

2. Titanium Alloys

Titanium alloys are strong, stiff, corrosion resistant and have a low density (density of pure Ti is 4.5 g/cm^3). Titanium alloys are stronger and stiffer than aluminum alloys and thus titanium components can be smaller in size than a comparable aluminum component.[2] Thus, they are used in applications where volume is important, such as landing gears and attachment points.

Titanium alloys can also be used in applications where the temperature is too high for aluminum, such as near the engine or in high-speed aircraft. The biggest restrictions on titanium are its higher density than Al, and high cost (approximately seven times that of aluminum or steel).

The most common titanium alloy in airframe construction is Ti-6Al-4V, otherwise known as Ti-6-4. Titanium has been used for compressor blades and discs (see Figure 1.2-2), fans, space vehicles, storage tanks, undercarriage components, flap tracks, engine mountings and fasteners, and has the potential to be used for supersonic passenger aircraft skin and structure (the proposed speed of Mach 2.4 is too high for Al-alloys).

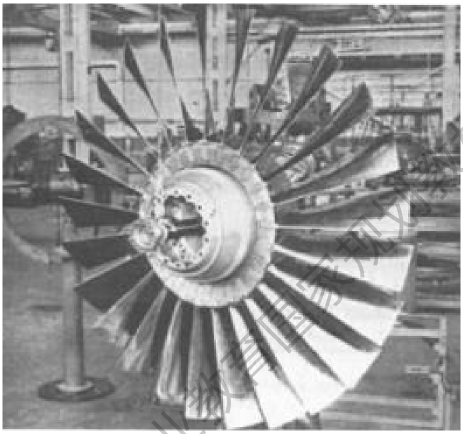

Figure 1.2-2 Ti-6Al-4V fan blades

3. Steels

Like titanium, steels are stronger and stiffer than aluminum alloys and thus are used in applications where volume is important, such as landing gears, attachment points, gears and bearings. They are used in parts where the required tensile strength is greater than can be supplied by Ti-alloys. The high density of steel is the limiting factor in their use, which has been declining with time (now down to approximately 10% of the structural weight). The most commonly used steels are ultra high strength low alloy steels, maraging steels and precipitation hardening (PH) steels.

4. Magnesium and Magnesium Alloys

Magnesium, the lightest aircraft structural metal, is a silvery-white material weighing only two-thirds as much as aluminum. Magnesium does not possess sufficient strength in its pure state for structural uses, but when alloyed with zinc, aluminum, and manganese it produces an alloy having the highest strength-to-weight ratio of any of the commonly used metals.[3]

Some of today's aircraft require in excess of one-half ton of this metal for use in hundreds of vital spots. Among the aircraft parts that have been made from magnesium with a substantial savings in weight are nose wheel doors, flap cover skin, aileron cover skin, oil tanks, floorings, fuselage parts, wingtips, engine nacelles, instrument panels, radio masts, hydraulic fluid tanks, oxygen bottle cases, ducts, and seats.

Magnesium alloys are subject to such treatments as annealing, quenching, solution heat treatment, aging, and stabilizing. Sheet and plate magnesium are annealed at the rolling mill. The solution heat treatment is used to put as much of the alloying ingredients as possible into solid solution, which results in high tensile strength and maximum ductility.

Magnesium embodies fire hazards of an unpredictable nature. When in large sections, its high thermal conductivity makes it difficult to ignite and prevents it from burning. It will not burn until the melting point is reached, which is 651℃ (1,204℉). However, magnesium dust and fine chips are ignited easily. Precautions must be taken to avoid this if possible.

5. Composites

Composites consist of two or more materials combined to give a material with properties distinct from the original constituents.[4] Composites can be designed to produce a material with desired combinations of properties such as stiffness, strength and density. Typically, composites consist of a matrix material and a reinforcing material. The matrix and fiber materials may be metals, ceramics or polymers, but the composites used in airframe construction are fiber reinforced polymer matrix composites. These have the advantages: the high specific strength and stiffness, tailored directional properties, non-corroding in salt environments, excellent fatigue resistance, dimensional stability and reduced number of parts required (compared to metal components).

But they are susceptible to impact damage, moisture pick-up and lightning strikes, have a relatively high cost, do not yield plastically in regions of high stress concentration and are subject to random property variation due to the nature of composite manufacturing.

The use of these advanced composites in airframe construction has increased substantially over the past few decades. They are used as floor beams, doors, aerodynamic fairings and for control surfaces, such as rudders, elevators and ailerons, due to their low weight and high stiffness. These applications can be seen in Figure 1.2 - 3 and Figure 1.2 - 4 and Table 1.2 - 1.

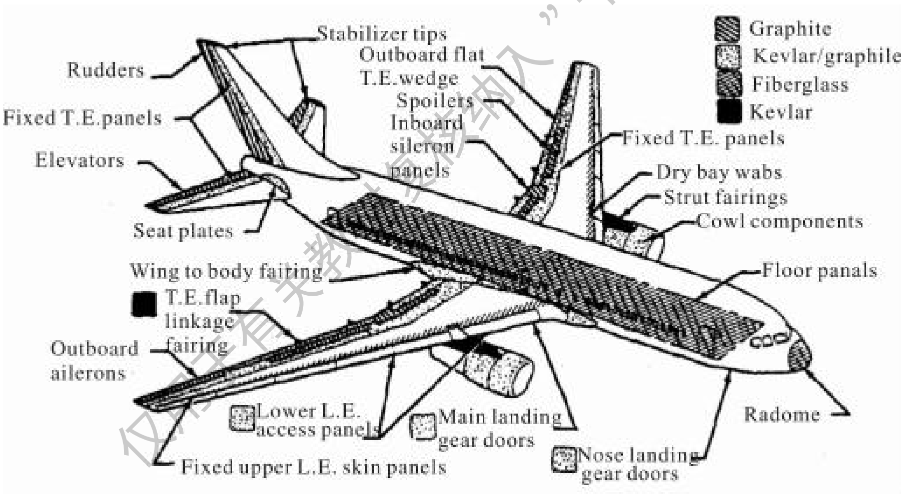

Figure 1.2 - 3 Composite applications in the Boeing 767

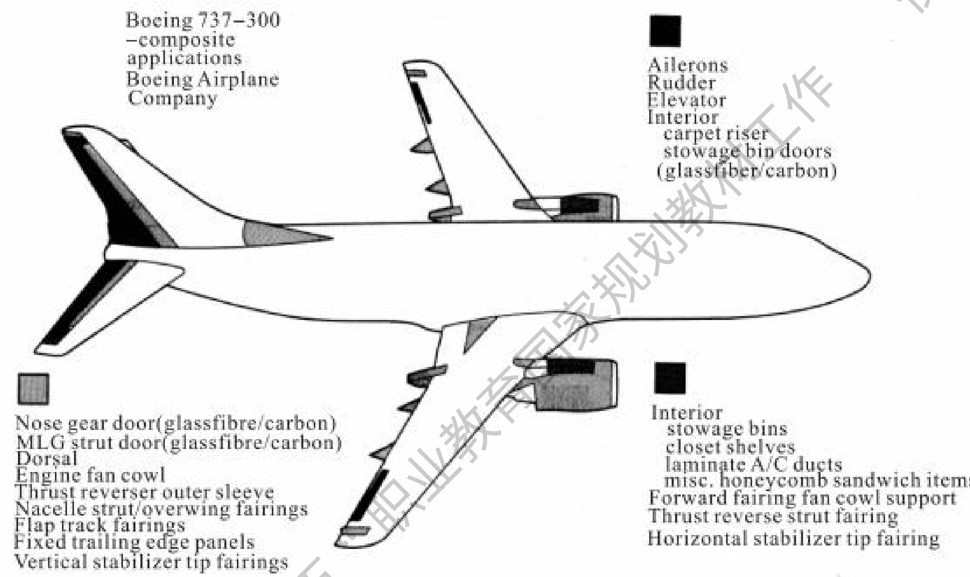

Figure 1.2-4 Composite applications in the Boeing 737-600

Table 1.2-1 Composite Applications in Selected Aircraft

Composite Component	F-14	F-15	F-16	F-18	B1	727	757	767	Lear Fan* (non production)
Doors	✓			✓	✓		✓	✓	✓
Rudder		✓					✓	✓	✓
Elevator						✓	✓	✓	✓
Vertical Tail		✓	✓	✓	✓				✓
Horizontal Tail	✓	✓	✓	✓	✓		✓	✓	✓
Aileron							✓	✓	
Spoiler							✓		
Flap					✓				
Wing Box				✓					✓
Body									✓
Miscellaneous									✓
Miscellaneous	Fairings	Speed Brake		Speed Brake, Fairings	Slats, Inlet		Fairings	Fairings	Propeller Blades

1.2.1.2 Engine Materials

One of the main differences in material requirements for engine components as opposed to airframe components is the operating temperature. This is due to the high temperatures encountered inside the engine. Thus the primary requirements of engine materials are:

(1) High specific strength (strength/weight ratio) at the relevant operating temperature;

(2) Creep resistance;

(3) Oxidation/corrosion resistance;

(4) Micro-structural stability at high temperature;

(5) Low density;

(6) High stiffness;

(7) Good fabricatability;

(8) Acceptable cost;

(9) Reproducible performance.

The materials used in the turbine engine are mainly related to the different operating temperatures. In the forward section, where the temperature is low to medium, titanium parts are often used. In the high temperature rear combustion areas nickel based super-alloys and some ceramics are used. The outer casing experiences low temperatures and thus aluminum and composites are suitable materials. The materials used are summarized in Table 1.2-2.

Table 1.2-2 Materials Used in the Gas Turbine Engine

Component	Materials
Fan Blades	Super-plastically formed titanium alloy skin diffusion bonded to a titanium honeycomb core
Compressor Vanes, Discs and Blades	With Increasing temperature the materials change from titanium alloys to 12% Cr steel to nickel based super-alloys
Combustor	High temperatures means nickel based super-alloys are used
Turbine Blades Discs and Vanes	High temperatures means nickel based super-alloys are used
Shafts	The shafts are made of steel
Casings	Aluminum alloys and composites

1.2.2 Corrosion

Corrosion control is of extreme importance to the aircraft industry because of its potential impact on human safety and expensive aircraft structures. Thus, corrosion resistance is a vitally important factor to consider when choosing aircraft materials. Corrosion is experienced as aircraft may be in service for up to 30 years in exposure to many varied environments: subzero temperatures, high humidity, tropical conditions, rain, salt spray, ice, UV radiation, atmospheric oxygen and pollutants.[5] For the airframe, corrosion in the form of stress corrosion cracking, pit, and crevice corrosion are the most important factors. For engine components, high temperature oxidation is the most important consideration due to the high temperature operating conditions.

Corrosion resistance is often improved by adding a coating to the material to protect the surface. For example, the anodizing of aluminum promotes a thick alumina coating on the surface of the material. These both protect the aluminum from the atmosphere and corrosive chemicals. Chromate conversion coating of aluminum is a similar technique widely used in aircraft structures, again to prevent corrosion. The main types of aircraft corrosion are detailed below.

1.2.2.1 Surface Corrosion

Surface corrosion is a superficial, uniform corrosion that is only objectionable from an aesthetic viewpoint. Dulling of a bright surface or discolouration are examples of this. However, surface corrosion can be an indication of a protective barrier breakdown and thus should be examined closely to avoid the development of more serious corrosion.

1.2.2.2 Stress Corrosion Cracking (SCC)

This is a process whereby a typically ductile alloy fails in a brittle manner when subject to the simultaneous effects of a tensile surface stress and a corrosive environment—neither of which would cause major damage if acting alone. Where alternating stresses are involved, it is known as corrosion fatigue. The cracks grow from stress induced flaws (therefore a threshold stress is required) but may have origins in features such as corrosion pits. The stress does not need to be applied externally, but may be the result of residual manufacturing stresses or thermal stresses. SCC is the major source of corrosion failure in thick aircraft structures such as thick plate and forgings. In aluminium alloys, the cracking is intergranular and only occurs in alloys when appreciable amounts of solute elements such as Cu, Mg, Si, Zn and Li are present after certain heat treatments are applied. The factors thought to contribute to the SCC effect in Al-alloys include:

(1) Precipitate free zones at the grain boundaries;

(2) Peak aged microstructures (due to Guinier Preston/GP zones);

(3) Dispersion of precipitates at the grain boundaries;

(4) Differences in solute concentrations at boundaries;

(5) Dydrogen embrittlement at the grain boundaries;

(6) Chemisorption of atomic species at the crack tip.

Titanium was considered immune to SCC for a long time though it has been shown to be susceptible in specific environments. However, titanium SCC failures in service are rare. Nevertheless, care must be taken during manufacture and overhaul of titanium parts as some alloys are embrittled by common degreasing solvents (such as organic chlorides).

1.2.2.3 Galvanic Corrosion

This occurs when two different metals of different galvanic potential are in contact in the presence of water (electrolyte). The more anodic material will corrode at an accelerated rate resulting in a build up of corrosion product near the contact area. Galvanic corrosion can be a problem for aluminum alloys as it is anodic to most other structural metals. However, the occurrence of galvanic corrosion depends on factors other than just the electrode potential. Impurity elements and alloying elements can pose problems in aluminum alloys. At localized regions of high or low alloying element concentration, localized regions of high and low corrosion resistance (electrode potential) form. This leads to pitting type corrosion in the areas where the corrosion resistance is lowest. In addition, segregation of certain elements can lead to intergranular corrosion (where the corrosion follows the grain boundaries) and exfoliation where corrosion products force surface layers and grains to delaminate.

1.2.2.4 Crevice Corrosion

An example of crevice corrosion is shown in Figure 1.2-5. This is where local differences in electrolyte ionic concentrations on the metal surface cause corrosion to occur. In the crevice or gap in a structure the electrolyte is deprived of oxygen and thus oxidation reactions occur within the crevice. Crevice corrosion often occurs at rivets and metal joints. Crevice corrosion is the major corrosion problem with titanium alloys.

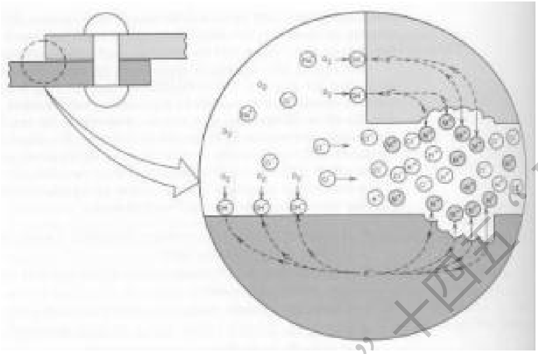

Figure 1.2-5 Crevice corrosion

1.2.2.5 Pitting Corrosion

Pitting corrosion is a form of localized corrosion in which small pits form in the material surface (see Figure 1.2-6). Pitting can occur due to chemical variations within the base material or due to a crevice corrosion type effect in preexisting flaws. An example of pitting corrosion occurs when a water droplet shields the underlying metal from oxygen. It is most common in marine environments as Cl^- ions locally attack protective oxide layers. Titanium is stable in most corrosive environments but is subject to pitting corrosion in halide containing aqueous solutions at high temperature.

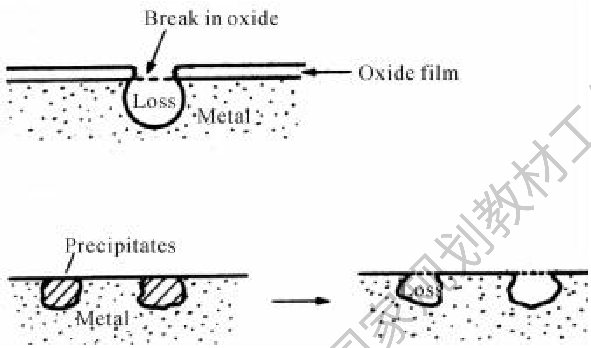

Figure 1.2-6 Pitting corrosion

1.2.2.6 Exfoliation Corrosion

Exfoliation corrosion, as shown in Figure 1.2-7, occurs in high strength aluminum alloys where the grains have become elongated and flattened during processing. The corrosion is intergranular (occurs along grain boundaries) and proceeds along planes parallel to the surface. The corrosion products, which have greater volume than the metal from which they formed, then cause delamination of the surface metal. This is the main corrosion problem in airframe sheet materials.

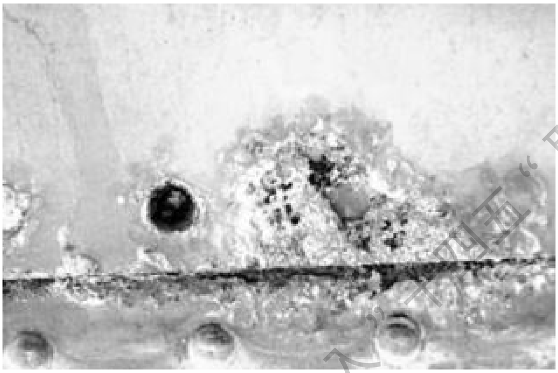

Figure 1.2-7 Exfoliation corrosion

1.2.2.7 Stress Corrosion

The rate at which corrosion proceeds may be accelerated by a number of mechanical factors. Stress on aircraft parts may be residual within the part as a result of externally applied cyclic loading or as a result of the production process. Corrosion fatigue is caused by the combined effects of cyclic stress and corrosion. No metal is immune to some reduction in its resistance to cyclic stressing if the metal is in a corrosive environment. Fracture of a metal part due to fatigue corrosion generally occurs at a stress level far below the fatigue limit. The amount of external corrosion is a poor indicator of the strength of the part. For this reason, corrosion protection of all parts subject to alternating stresses is particularly important, even in environments which are only mildly corrosive. Fretting is another mechanical factor which contributes to the speed of destruction. Damage can occur at the interface of two highly loaded surfaces which are not designed to move against each other. The most common type of fretting corrosion is caused by vibration. The protective film on the metal surfaces is removed by the rubbing action and exposes fresh, active metal to the corrosive action of the atmosphere.

1.2.2.8 Micro-Organism Corrosion

Microbial attacks on metallic surfaces include the actions of bacteria, fungi, and molds. Micro-organisms occur nearly everywhere. Those organisms causing the greatest corrosion problems are bacteria and fungi.

Aerobic bacteria accelerate corrosion by oxidizing sulfur to produce sulfuric acid. The metabolism of aerobic bacteria requires them to obtain part of their sustenance by oxidizing inorganic compounds such as iron, sulfur, hydrogen, and carbon monoxide. The resultant chemical reactions cause corrosion.

New Words/ Phrases/ Expression

1. aeronautical material 航空材料
2. airframe material 飞机框架(骨架)材料
3. engine material 发动机材料
4. stiffness ['stifnis] *n.* 刚度
5. fatigue performance 抗疲劳性能
6. corrosion resistance 耐腐蚀性
7. payload ['peiˌləud] *n.* 载重量,载重
8. Aluminum [ə'ljuːminəm] *n.* 铝
9. casting alloy 铸造合金
10. wrought alloy 变形铝合金
11. rolling ['rəuliŋ] *n.* 扎(件),轧制,滚压
12. drawing ['drɔːiŋ] *n.* 拉(件),拉拔
13. forging ['fɔːdʒiŋ] *n.* 锻造,锻件
14. stringer ['striŋə(r)] *n.* 纵梁,纵桁,长桁
15. bulkhead ['bʌlkhed] *n.* 舱壁,隔板,隔墙
16. rivet ['rivit] *n.* 铆钉,包头钉
17. extruded section 挤压成型
18. not heat-treatable alloy 不可热处理合金
19. heat-treatable alloy 可热处理合金
20. thermal conductivity 导热性能
21. electrical conductivity 导电性能
22. wing box 翼盒
23. longeron ['lɔndʒərɔn] *n.* (飞机机体的)纵梁

24. elevator ['eliveitə(r)] *n*. 升降舵
25. rudder ['rʌdə] *n*. 方向舵
26. Titanium [tai'teini:əm, ti-] *n*. 钛
27. designation [ˌdezig'neiʃən] *n*. 牌号;番号
28. Copper ['kɔpə] *n*. 铜
29. solution heat treatment 固溶处理
30. Manganese ['mæŋgəni:z] *n*. 锰
31. Silicon ['silikən] *n*. 硅
32. welding ['weldiŋ] *n*. 焊接性
33. Magnesium [mæg'ni:zi:əm,-ʒəm] *n*. 镁
34. Zinc [ziŋk] *n*. 锌
35. Chromium ['krəʊmi:əm] *n*. 铬
36. Steel [sti:l] *n*. 钢
37. compressor blade 压缩机叶片
38. fastener ['fa:snə(r)] *n*. 紧固件
39. maraging steel 马氏体时效不锈钢
40. annealing [ə'ni:liŋ] *n*. 退火
41. quenching ['kwentʃiŋ] *n*. 淬火
42. aging ['eidʒiŋ] *n*. 时效
43. ignite [ig'nait] *v*. 点火,点燃
44. composite ['kɔmpəzit] *n*. 复合材料
45. matrix material 基体材料
46. reinforcing material 增强材料
47. super alloy 超合金
48. ceramic [sə'ræmik] *n*. 陶瓷
49. combustor [kəm'bʌstə] *n*. 燃烧室,燃烧器,火焰筒
50. anodizing ['ænəudaiziŋ] *n*. 阳极化
51. Alumina [ə'lju:minə] *n*. Al_2O_3(三氧化二铝)
52. superficial [ˌsju:pə'fiʃəl] *adj*. 表面的,表面的,肤浅的
53. surface corrosion 表面腐蚀
54. stress corrosion cracking 应力腐蚀开裂
55. alternating stress 交变应力
56. corrosion fatigue 腐蚀疲劳
57. Lithium ['liθiəm] *n*. 锂
58. galvanic corrosion 电偶腐蚀,接触腐蚀,电化腐蚀
59. crevice corrosion 缝隙腐蚀
60. pitting corrosion 麻点腐蚀,点蚀
61. halide ['hælaid] *n*., *adj*. 卤化物(的)
62. exfoliation [eksˌfəuli'eiʃən] *n*. 剥离

63. delamination [diːˌlæmiˈneiʃən] *n*. 分层
64. intergranular [ˌintəˈgrænjulə] *adj*. 晶粒间的，粒间的
65. micro-organism corrosion 微生物腐蚀
66. microbial [maiˈkrəubiəl] *adj*. 微生物的；由细菌引起的
67. fungi [ˈfʌŋgai] *n*. (fungus 的复数)真菌；霉菌
68. metabolism [miˈtæbəˌlizəm] *n*. 新陈代谢；代谢作用
69. sustenance [ˈsʌstənəns] *n*. 食物，营养，养料
70. hydrogen [ˈhaidrədʒən] *n*. [化]氢
71. carbon monoxide [ˈkaːbən məˈnɔkˌsaid] *n*. 一氧化碳

Notes

【1】By increasing specific stiffness and strength, the weight of a given component can be decreased and fuel consumption and running costs decreased.

分析：本句子为倒装长句，句子的前段为一个介宾短语做状语，后段则是由两个并列的具有主谓结构的短句组成，是整个句子的主体部分。句子中第一个"and"连接介宾短语中的两个宾语，第二个"and"连接两个短句，第三个"and"则连接句子后段第二个短句的两个主语。

翻译：可以通过提高材料的比刚度①和比强度②来降低某一特定部件的质量，进而减少飞机的燃油消耗和运营成本。

【2】Titanium alloys are stronger and stiffer than aluminum alloys and thus titanium components can be smaller in size than a comparable aluminum component.

分析：本句为两个比较句(短句)组成的具有因果关系的长句。两个短句的结构为"名词 1＋形容词比较级＋than＋名词 2"，表示"名词 1 比名词 2 更为……"。

翻译：钛合金的强度和刚度比铝合金的大。因此，与铝合金部件相比，用钛合金制造的同一部件具有更小的体积。

【3】Magnesium does not possess sufficient strength in its pure state for structural uses, but when alloyed with zinc, aluminum, and manganese it produces an alloy having the highest strength-to-weight ratio of any of the commonly used metals.

分析：本句为转折句。结构为"…，but…"，表示"虽然……，但是……"。

翻译：纯镁不具有足够的强度以制造飞机结构，但是，在其与锌、铝和锰元素形成合金后，它与其他常用材料相比，具有最大的比强度。

【4】Composites consist of two or more materials combined to give a material with properties distinct from the original constituents.

分析：简单陈述句。

翻译：复合材料是由两种或两种以上的材料组合而成的并具有原始成分所不具有的性能的材料。

【5】Corrosion is experienced as aircraft may be in service for up to 30 years in exposure

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① 比刚度：材料的弹性模量与其密度的比值。

② 比强度：材料强度除以其表观密度，单位为 N·m/kg。

to many varied environments: subzero temperatures, high humidity, tropical conditions, rain, salt spray, ice, UV radiation, atmospheric oxygen and pollutants.

分析:整个句子的结构为"主语+be+done+as 状语从句";本句为被动语态。

翻译:航空器在将近 30 年的服役过程中,可能暴露在零下温度、高湿度、酷热条件、大雨、盐雾、冰雪、紫外线辐射、大气氧化和污染物环境中而不断遭受腐蚀。

Exercises

Ⅰ. Answer the following questions:

1. What are the primary requirements of airframe materials?

2. What are the primary requirements of engine materials?

3. How many main types of aircraft corrosion are detailed?

Ⅱ. Translate the following sentences into Chinese:

1. Aluminum is one of the most widely used metals in modern aircraft construction. It is vital to the aviation industry because of its high strength-to-weight ratio and its comparative ease of fabrication.

2. Titanium alloys are stronger and stiffer than aluminum alloys and thus titanium components can be smaller in size than a comparable aluminum component.

3. Like titanium, steels are stronger and stiffer than aluminum alloys and thus are used in applications where volume is important, such as landing gears, attachment points, gears and bearings.

4. Corrosion control is of extreme importance to the aircraft industry because of its potential impact on human safety and expensive aircraft structures.

Ⅲ. Fill in the following blanks according to the text:

1. When a fully loaded aircraft takes off, ______% of the weight is payload, ________% is aircraft structural weight and 40% is ________. Therefore, a saving in aircraft weight can ________ the possible payload or decrease the power required for a given ________.

2. Titanium has been used for compressor blades and discs, fans, space vehicles, storage tanks, ________, flap tracks, ________ and ________, and has the potential to be used for supersonic passenger aircraft ________ and structure (the proposed speed of Mach 2.4 is too high for Al-alloys).

3. The use of these advanced composites in ________ has increased substantially over the past few decades. They are used as floor beams, doors, ________ fairings and for control surfaces, such as rudders, elevators and ______, due to their low weight and high ________.

4. Corrosion control is of extreme importance to the aircraft industry because of its potential impact on ________ and ________ aircraft structures. Thus, corrosion resistance is a vitally important factor to consider when choosing aircraft materials. Corrosion resistance is often improved by adding a ________ to the material to protect the surface.

1.3　Introduction of Aviation Fasteners

Common aircraft fasteners can be divided into two main categories: thread fastener and unthreaded fastener. Thread fastener can be reused. These fasteners include threaded hardware such as bolts and screws and the various types of nuts that secure them. The most common unthreaded fasteners are the different kinds of rivets.

Beside common aircraft fasteners mentioned here, there are many types of special fasteners used in aviation industrial, you may learn them in the further detailed course.

1.3.1　Thread Fasteners

The advantage of the threaded fasteners is that they may be disassembled and reassembled an almost infinite number of times.

In addition to being identified as either coarse or fine, threads are also designated by class of fit from one to five. Aircraft bolts are usually fine threaded with a Class 3 fit (medium fit), whereas screws are typically a Class 2 (free fit) or 3 fit.[1]

1.3.1.1　Bolt

Bolts are identified by their diameter and length. A diameter represents the shank diameter while the length represents the distance from the bottom of the head to the end of the bolt. A bolt's grip length is the length of the unthreaded portion (see Figure 1.3－1).

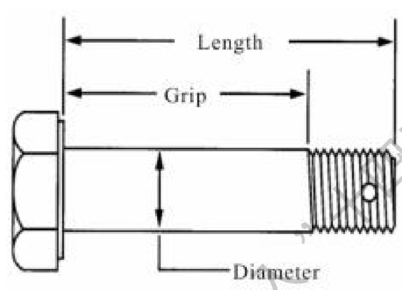


Figure 1.3－1　The diameter, length, and grip length of an AN(Airforce Nawy) bolt

In addition to the designation code, most aircraft bolts have a marking on their head identifying what the bolt is made of and, in many cases, the manufacturer. For example, a standard AN bolt has an asterisk in the center of its manufactured head. A raised dash means corrosion-resistant steel and two raised dashes means 2024 alloy aluminum (see Figure 1.3－2).

Here is an example of close tolerance bolt. Close tolerance bolt carry a triangle mark on their heads and are ground to a much tighter tolerance than standard bolts (a tolerance of 0.000－0.000,5 inch①). Close tolerance bolts must be used in areas that are subject to

① 1 inch≈25.4 mm.

pounding loads or in a structure that is required to be both riveted and bolted (see Figure 1.3－3).

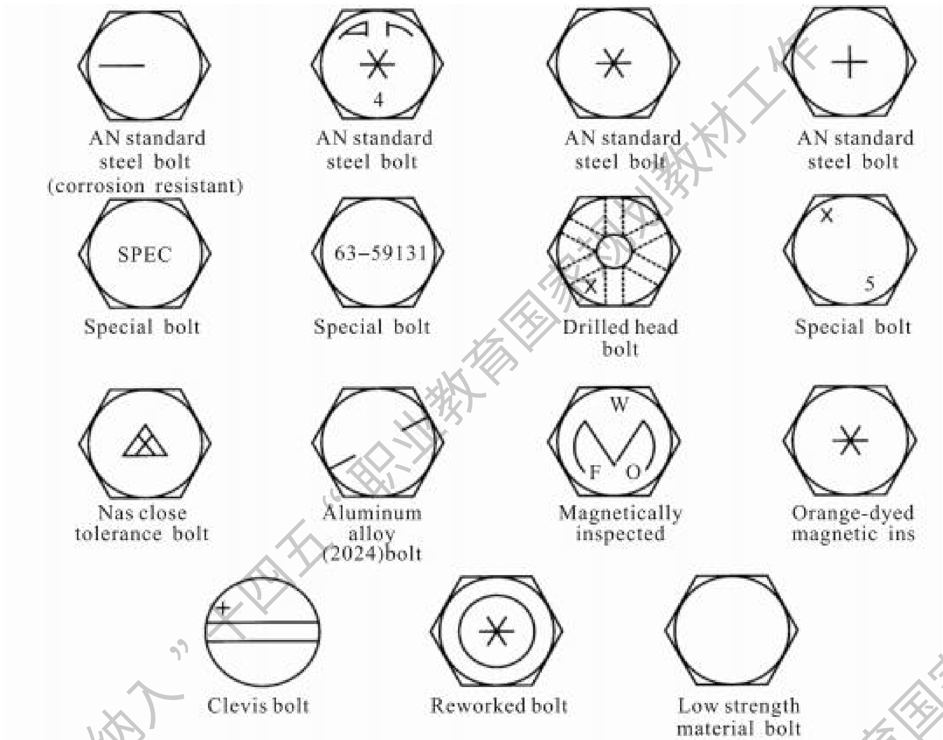


Figure 1.3－2　Bolt heads are marked with symbol

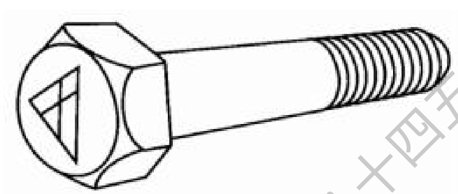


Figure 1.3－3　Close tolerance bolts

Bolt selection and installation: When joining two pieces of material, their combined thickness determines the correct length of bolt to use. If the grip length is slightly longer than this thickness, washers must be added to ensure that the nut can provide the proper amount of pressure when it is tightened. On the other hand, if the grip length is substantially less than the thickness of the materials the bolt's threads will extend into the material, resulting in a weaker joint. Unless otherwise specified in an assembly drawing, bolts should be installed with their head on top or forward. Placing the head in either of these positions makes it less likely that a bolt will fall out of a hole if the nut is lost. An acronym to help remember the proper direction for bolt installation is "IDA", which stands for inboard, down, or after.

1.3.1.2 Nuts

All nuts used in aircraft construction must have some sort of locking device to prevent them from loosening and falling off.

Many nuts are held on a bolt by passing a cotter pin through a hole in the bolt shank and through slots, or castellation, in the nut (see Figure 1.3-4).

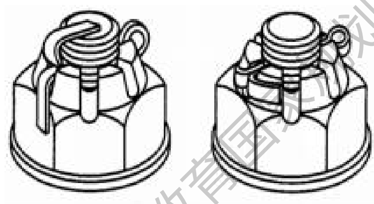


Figure 1.3-4 Two methods to use cotter pin to safety castellated nuts

Others have some form of locking for a variety of applications insert that grips a bolt's threads or relies on the tension of a spring-type lock-washer to hold the nut tight enough against the threads to keep it from vibrating loose(se Figure 1.3-5).

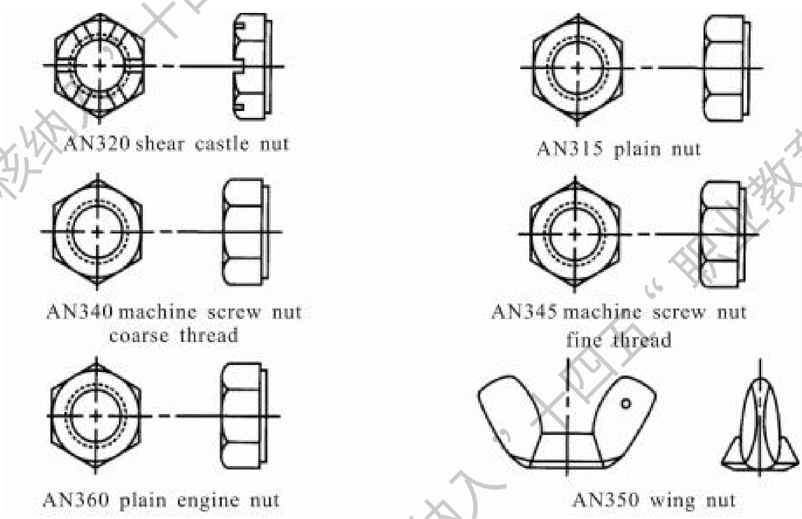


Figure 1.3-5 Standard aircraft nuts are available

The nuts could be divided into two basic types: self-locking and non self-locking. As the name implies, a self-locking nut locks onto a bolt on its own while a non self-locking nut relies on either a cotter pin, check nut, or lock washer to hold it in place.[2]

1. Self-Locking Nuts

The two general types of self-locking nuts used in aviation are the fiber, or nylon type, and the all metal type.

The fiber, or nylon type self-locking nuts are used in lower temperature area not exceed to 121℃ (250 ℉). For instance, AN365 self-locking nuts are used on bolts and machine screws and are held in position by a nylon insert above the threads (see Figure 1.3-6). This insert has a hole slightly smaller than the thread diameter on which it fits. This creates friction between the threads and nut to keep the nut from vibrating loose.

All metal type self-locking nuts used in higher temperature area. Some of these nuts have a portion of their end slotted and the slots swaged together. This gives the end of the nut a slightly smaller diameter than its body allowing the threads to grip the bolt. Others have the end of the nut squeezed into a slightly oval shape, and as the bolt screws up through the threads it must make the hole round, creating a gripping action[3] (see Figure 1.3-6).

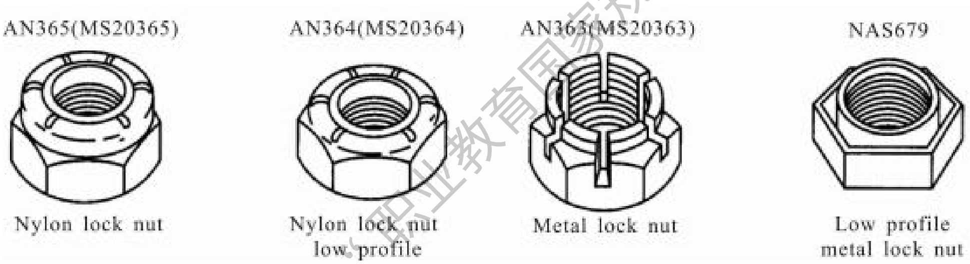


Figure 1.3-6　Self-locking nuts available for multiple applications

2. Anchor Nuts

Anchor nuts are permanently mounted nut plates that enable inspection plates and access doors to be easily removed and installed (see Figure 1.3-7).

Figure 1.3-7　Anchor nuts

1.3.1.3　Screws

Screws are probably the most commonly used threaded fastener in aircraft. They differ from bolts in that they are generally made of lower strength materials. Screws are typically installed with a loose-fitting thread, and the head shapes are made to engage a screwdriver or wrench. There are three basic classifications of screws used in aircraft construction: machine screws, which are the most widely used; structural screws, which have the same strength as bolts; and self-tapping screws, which are typically used to join light weight materials. Figure 1.3 – 8 shows some kinds of style of machine screw.

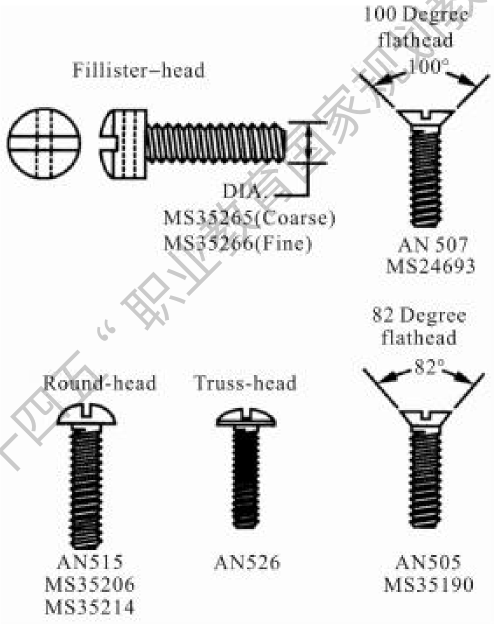


Figure 1.3 – 8 Machine screws

1.3.1.4 Washers

Washers provide a bearing surface area for nuts, and act as spacers or shims to obtain the proper grip length for a bolt and nut assembly. They are also used to adjust the position of castellated nuts with respect to drilled cotter pin holes in bolts as well as apply tension between a nut and a material surface to prevent the nut from vibrating loose. The three most common types of washers used in airframe repair are the plain washer, lock washer, and special washer (see Figure 1.3 – 9).

1.3.2 Rivet

A rivet is a metal pin with a formed head on one end. A rivet is inserted into a drilled hole, and its shank is then deformed by a hand or pneumatic tool. Rivets create a union at least as strong as the material being joined.

The use of rivets is governed by the materials of which they are made. Another factor in determining which rivet to use for a particular job is the strength required of the riveted joint. It is important that the aviation maintenance technician be able to correctly identify the different types of rivets and understand the application of each type.

Rivets are identified by the shape of the manufactured head, the marking on the head, the rivet part number, and the size.

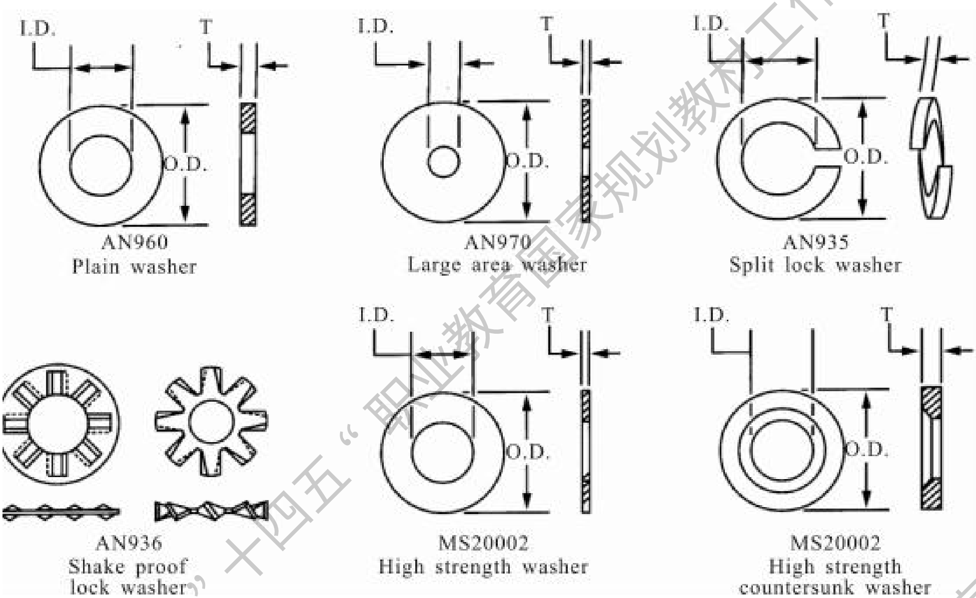


Figure 1.3-9 Aircraft washers

Rivets are given part codes that indicate their size, head style, and alloy material. Two systems are in use today, the Airforce Navy, or AN system, and the Military Standards 20 system, or MS20. While there are minor differences between the two systems, both use the same method for describing rivets. A typical part number under current standards would be MS2047 AD4-5. Using the Airforce Navy, or AN, part number, we find the same rivet would be identified as AN470AD4-5. You can see that under the MS part numbering system, the number 20 has been added in front of the 470.

Each set of letters and numbers has its own meaning. Let's break the part numbers down into their various components.

The MS or AN is the standard to which the rivet is manufactured. The 20470 or 470 indicate the head style. There are two basic rivet head styles that are manufactured for aircraft construction, the universal head with number 470 and the 100 degree countersunk head with number 426 (see Figure 1.3-10). The length of a universal head (AN470) rivet is measured from the bottom of the manufactured head to the end of the shank. However, the length of a countersunk rivet (AN426) is measured from the top of the manufactured head to the end of the shank. Universal and countersunk rivet diameters are measured in the same way, but their length measurements correspond to their grip length.

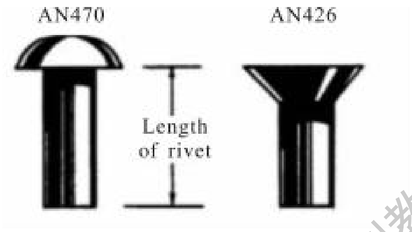


Figure 1.3 - 10 The universal head and the 100 degree countersunk head rivet

The AD indicates the material composition or alloy. The number 4 tells us the diameter of the rivet shank in thirty second (1/32) of an inch. And the last number(s), separated by a dash from the preceding number, expresses the length of the rivet shank in increments of 16ths (1/16) inch. Therefore, in this example the rivet has a diameter of 4/32 inch and is 5/16 of an inch long (see Figure 1.3 - 11).

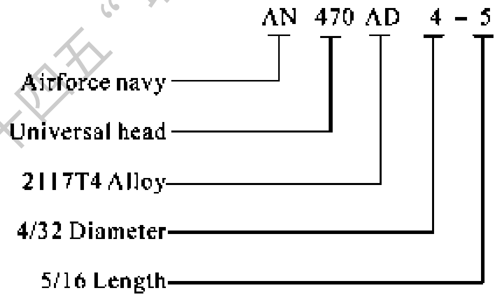


Figure 1.3 - 11 Rivet identification

Conventional solid shank rivets require access to both ends to be driven. However, special rivets, often called blind rivets are installed with access to only one end of the rivet. While considerably more expensive than solid shank rivets, blind rivets find many applications in today's aircraft industry (see Figure 1.3 - 12).

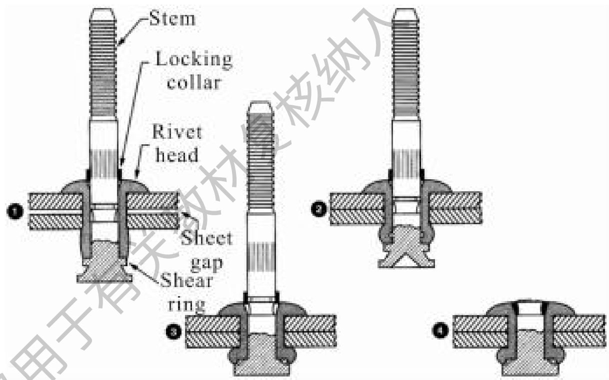


Figure 1.3 - 12 A kind of blind rivet: the Cherry mechanical-lock rivet

New Words/ Phrases/ Expression

1. fastener [ˈfaːsnə] *n.* 紧固件
2. thread [θred] *n.* 螺纹
3. bolt [bəult] *n.* 螺栓
4. screw [skruː] *n.* 螺钉，螺丝
5. nut [nʌt] *n.* 螺母
6. pin [pin] *n.* 销钉，销子
7. disassemble [ˌdisəˈsembl] *v.* 分解
8. diameter [daiˈæmitə] *n.* 直径
9. asterisk [ˈæstərisk] *n.* 星号
10. tolerance [ˈtɔlərəns] *n.* 公差
11. close tolerance bolt 高精度螺栓
12. triangle [ˈtraiæŋgl] *n.* 三角形
13. subject to 遭受
14. washer [ˈwɔʃə; ˈwɔːʃə] *n.* 垫片
15. substantially [səbˈstænʃəli] *adv.* 本质上，实质上
16. acronym [ˈækrənim] *n.* 首字母缩略词
17. cotter pin 开口销
18. castellation [ˌkæstəˈleiʃən] *n.* 堞形
19. self-locking 自锁
20. vibrate [ˈvaibreit] *v.* 振动
21. squeeze [skwiːz] *v.* 挤压
22. oval [ˈəuvəl] *adj.* 椭圆形的
23. grip [grip] *v.* 夹紧
24. anchor nut [ˈæŋkə] *n.* 托板螺母
25. engage [inˈgeidʒ] *v.* 啮合，配合
26. shim [ʃim] *n.*，*v.* 薄垫片；用垫片填
27. shank [ʃæŋk] *n.* 杆，柄
28. pneumatic tool 气源工具
29. govern [ˈgʌvən] *v.* 控制，支配
30. technician [tekˈniʃən] *n.* 技师
31. application [ˌæpliˈkeiʃən] *n.* 运用，用途
32. manufactured head (铆钉)制造头
33. shop head (铆钉)墩头
34. break down 分解
35. universal head 通用头
36. countersunk head 沉头
37. conventional [kənˈvenʃənl] *adj.* 常规的，传统的

38. solid shank rivet 实心铆钉
39. blind rivet 盲铆钉

Notes

【1】In addition to being identified as either coarse or fine, threads are also designated by class of fit from one to five. Aircraft bolts are usually fine threaded with a Class 3 fit (medium fit), whereas screws are typically a Class 2 (free fit) or 3 fit.

分析:"in addition to"和"beside"同义,都可翻译成"除……之外",但和"except"有所不同。

翻译:除了可将螺纹分为粗螺纹和细螺纹以外,螺纹还可按配合等级分为 1～5 级。航空螺栓通常是 3 级配合(中度配合)的细螺纹,而螺钉通常是 2 级配合(自由配合)或 3 级配合。

【2】As the name implies, a self-locking nut locks onto a bolt on its own while a non self-locking nut relies on either a cotter pin, check nut, or lock washer to hold it in place.

分析:此句的"while"之后应翻译出转折的意思。

翻译:就像名字里隐含的,自锁螺母通过自身锁紧在螺栓上,非自锁螺母则需靠开口销、防松螺母或锁紧垫片使它上紧在紧固件上。

【3】Others have the end of the nut squeezed into a slightly oval shape, and as the bolt screws up through the threads it must make the hole round, creating a gripping action.

分析:此句为"have sth. done"的句型,此句中的"screws up"应翻译为"旋合"。

翻译:其他的(全金属式自锁螺母)是将其螺母尾部挤压成轻微的椭圆形,当螺栓旋合入(螺母的)螺纹时,它必须使螺母的孔撑圆,这样就形成了夹紧作用。

Exercises

Ⅰ. Translate the following sentences into Chinese:

1. The advantage of the threaded fasteners is that they may be disassembled and reassembled an almost infinite number of times.

2. Close tolerance bolt carry a triangle mark on their heads and are ground to a much tighter tolerance than standard bolts.

3. Many nuts are held on a bolt by passing a cotter pin through a hole in the bolt shank and through slots, or castellation, in the nut.

4. The two general types of self-locking nuts used in aviation are the fiber, or nylon type, and the all metal type.

5. Washers provide a bearing surface area for nuts, and act as spacers or shims to obtain the proper grip length for a bolt and nut assembly.

6. It is important that the aviation maintenance technician be able to correctly identify the different types of rivets and understand the application of each type.

7. For a rivet part code AN 426 D 4 - 6, AN is the standard to which the rivet is manufactured. The 426 indicate the head style, the D indicates the material composition or alloy, the number 4 tells us the diameter of the rivet shank in thirty second (1/32) of an

inch, and the last number, 6, separated by a dash from the preceding number, expresses the length of the rivet shank in increments of 16ths (1/16) inch.

Ⅱ. Fill in the following blanks according to the text:

1. Thread fasteners include threaded hardware such as ________ and ________ and the various types of ________ that secure them. The most common unthreaded fastener are different kinds of ________.

2. An acronym to help remember the proper direction for bolt installation is "IDA", which stands for ________, ________, ________.

3. There are three basic classifications of screws used in aircraft construction: ________, which are the most widely used; ________, which have the same strength as bolts; and ________, which are typically used to join light weight materials.

4. The three most common types of washers used in airframe repair are ______, ______, ________.

5. The length of a universal head (AN470) rivet is measured from the ________ of the manufactured head to the ________ of the shank. However, the length of a countersunk rivet (AN426) is measured from the ________ of the manufactured head to the ________ of the shank.

1.4 Common Hand Tools and Measuring Tools

The term "hand tools" encompasses all of the handheld tools most commonly used in everyday maintenance and repair. Some of these tools are common, while others have a very specialized usage. Regardless of how common the tool, the subtleties for their proper use are not always known. Therefore, the most common uses are listed in the following text. Hand tools will fall into four basic categories: turning tools, holding tools, pounding tools, and cutting tools.

Turning tools and holding tools are more often used in line maintenance to install or remove the aircraft components, while pounding tools and cutting tools are more often used in shop maintenance such as making sheet metal parts.

Also some common used measuring tools are introduced in this text. Measuring tools are precision tools. They are carefully machined, accurately marked and, in many cases, are made up of very delicate parts. When using these tools, be careful not to drop, bend, or scratch them. It is very important to understand how to read, use, and care for these tools.

1.4.1 Turning Tools

1.4.1.1 Screwdrivers

The screwdriver is perhaps the most abused and miss used tool in the mechanics' toolbox. Although its shape lends itself to used as a pry bar, a punch, or a chisel, the screw driver is designed for one purpose: turning screws. The two most common types of screwdrivers are the plain or the slotted blade and the cross point. When choosing a screwdriver for a slotted screw, the blade should fill it at least 75% of the slot. The most common of the cross point screwdrivers is the Phillips head. The slot in the Phillips head screw is cut with a double taper and the bottom of the slot is nearly flat. The Phillips head screwdriver is designed with a blunt point to fill the screw slot for maximum turning force. The reed and prince screw slot is cut with a single taper. The sides of the slot are nearly parallel and form a near perfect cross. The bottom of the slot in the reed and prince screw comes to a fairly sharp point. The screwdriver is designed to match this point. Interchanging screwdrivers between reed and prince, and Phillips head screws could damage both the screw and the screwdriver. Screwdrivers are available in several different types and sizes. The technician should always match the screwdriver to the job being done (see Figure 1.4－1).

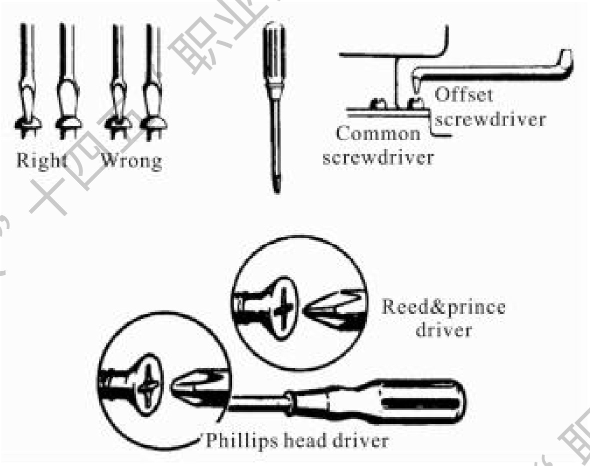


Figure 1.4－1　Screw drivers and their uses

1.4.1.2　Wrenches

Most of the threaded fasteners on modern aircraft require wrenches to turn them. The assortment of wrenches available to the aviation maintenance technician is almost endless, but a few basic types are essential.

The open-end wrench has an opening with parallel sides, and is designed to accommodate specific sizes of nuts and bolt heads. The opening is usually off-set at an angle of about 15°. This allows the wrench to be turned over to fit the fastener in spaces where room for the handle is limited (see Figure 1.4－2).

The box-end wrench is used mainly for breaking fasteners loose. The box-end wrench has a six or twelve point opening which is off-set from the axis of the handle by about 15°. The twelve point wrench may be repositioned on the nut or bolt head every 30° while there must be at least 60° of swing space in order to reposition the six point wrench (see Figure 1.4－2).

The combination wrench incorporates an open end wrench on one end and the same size box end wrench on the other (see Figure 1.4－2).

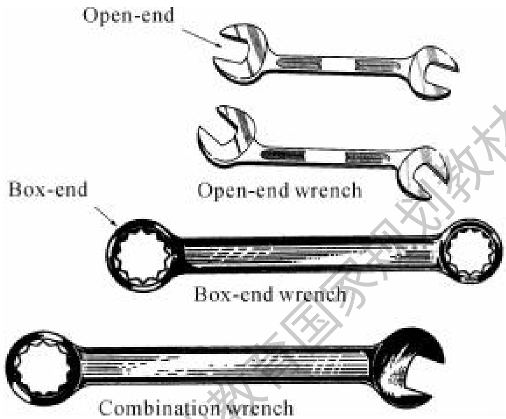


Figure 1.4－2 Open-end, box-end and combination wrenches

The socket wrench is one of the most versatile tools in the mechanic's tool box. It has a six or twelve point opening on one end, and a square opening on the opposite end to accommodate any of several different handles, including the speed handle, the breaker bar, the nut driver, and the ratchet handle. These handles may be used with various extensions and universal joints to reach fasteners located in awkward positions. The ratchet handle is a special useful because it may be turned and repositioned without removing the wrench from the fastener. The ratchet locks the handle so it will turn in one direction but will slip or ratchet in the other direction. It may be adjusted for turning or ratcheting in either direction. The socket may also be used with a special handle designed for measuring the twisting force used when tightening a fastener (see Figure 1.4－3).

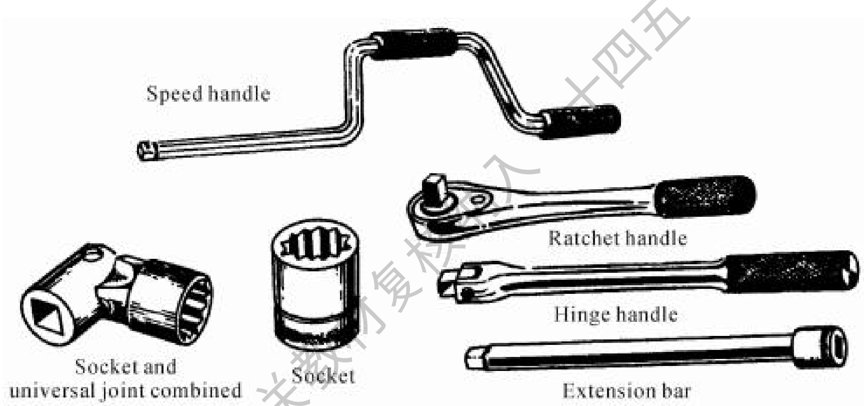


Figure 1.4－3 Socket wrench set

The Allen wrench is designed for internal wrenching bolts or Allen screw. There is a six-sided hole machined into the center of the head of this kind of bolt and screw. They are used in the place where outside wrench space is limited.[1] (see Figure 1.4－4)

The torque wrench is calibrated so that a handle of specified length will apply a measured force or torque to the fastener as it is turned. This force can be measured and indicated in different ways.

The torsion bar torque wrench uses a specially ground and calibrated bar attached to the lug, and to a gear system. As the wrench is turned, the torsion bar inside the wrench is twisted; the amount of twist is translated into a reading on a dial through the gear system.

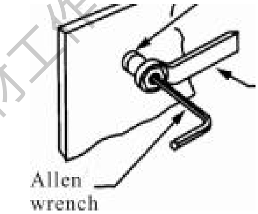


Figure 1.4-4 Allen wrench

Torsion bar torque wrenches requires that the technician be in a position to see the torque readings on the wrench. There are times, however, that the location of a fastener will not allow the technician a clear view of the indicator. To solve this problem, the toggle type torque wrench may be the answer.[2] The desired torque value is set into the wrench by turning the handle. This compresses a spring inside the handle. When the wrench is turned until the desired torque is reached, a unique toggle mechanism in the handle overcomes the spring tension, torque is released momentarily to allow a few degrees of handle rotation. The operator feels the release as a click or thump in the handle. This gives the technician a positive indication that the preset torque value has been reached but does not require a visual display.

Extensions may be used with torque wrenches to reach awkward locations, but on the certain circumstances, use of an extension will change the torque value of the wrench. Text books and Maintenance Manuals usually include the proper formula for determining the accurate torque value when an extension is used (see Figure 1.4-5). As with any precision tool, the accuracy of the torque wrench should be checked and recalibrated at regular intervals.

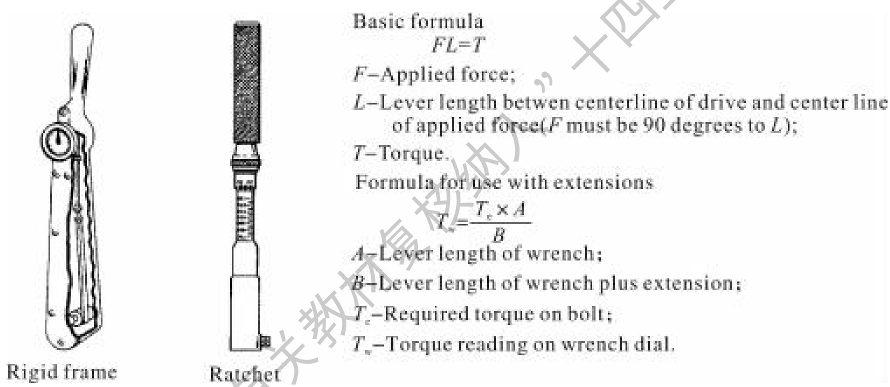


Figure 1.4-5 Common types of torque wrench

1.4.2 Holding Tools

Pliers are perhaps the most familiar of the holding tools, used in the home and industry.

Slip-joint pliers: the six inch slip joint pliers are probably the most popular of the holding tools. The pivot point between the jaws may be moved into one of two different holes in one of the jaws. This provides a wide range of grip sizes (see Figure 1.4-6).

Interlocking joint pliers are also adjustable for various grip sizes. Here, one jaw may be slipped from one channel to another in the opposite jaw. Sometimes called water pump pliers, they are also known by the trade name, channel locks (see Figure 1.4-6).

Visegrips: another familiar trade name is given to a special set of high leverage pliers called vise grips. The vise grip is adjustable and may be locked into place by a specially designed toggle in the handles. A small lever on one of the handle is used to unlock the vise grip. These tools may be used for gripping pipe, bending metal, pinching tubing, or clamping metal for welding (see Figure 1.4-6).

Duckbill pliers are valuable tools to the aviation maintenance technician. The long handles and flat jaws are well suited for twisting safety wires. The serrations in the jaws of the duckbills are not as deep or sharp as in many other pliers. This feature helps prevent nicking and weakening of the safety wire as it being installed (see Figure 1.4-6).

Diagonal pliers are usually referred to as diagonals or "dikes". The diagonal is a short-jawed cutter with a blade set at a slight angle on each jaw. This tool can be used to cut wire, rivets, small screws, and cotter pins, besides being practically in removing or installing safety wire (see Figure 1.4-6).

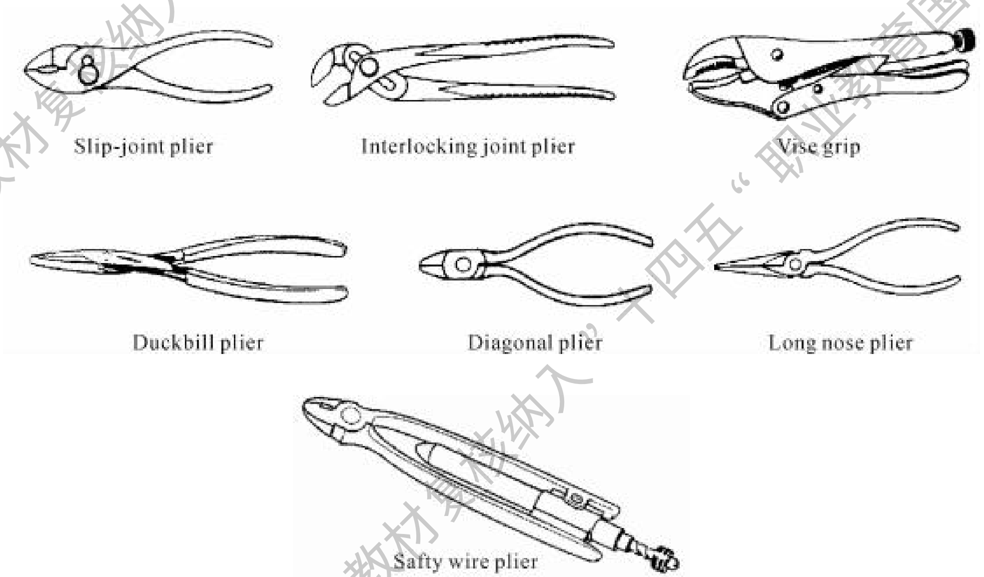


Figure 1.4-6 Types of pliers

The duckbill pliers and the diagonal cutting pliers are used extensively in aviation for the job of safety wiring.

Long nose or needle nose pliers are a special useful in tight quarters. They are also helpful in gripping small parts and are ideal for electrical soldering work. These versatile tools are found in several different styles to perform a variety of jobs (see Figure 1.4-6).

Safety wire pliers: Special safety wire pliers have been designed specifically for the aviation industry. The jaws are flat with slight serrations. The handles are equipped with twisting mechanism. The safety wire is passed through the fastener, for instance, a bolt head. The two ends are brought together and trimmed to the proper length with the built-in cutter. The jaws are locked in place over the ends of the wire. Pulling the handle creates a twisting motion that wraps the two wires around each other. When the handles are unlocked, the safety wiring is completed, and the ends may be trimmed (see Figure 1.4-6).

1.4.3 Pounding Tools

Pounding tools include different types and weights of hammers and mallets, each with a very specific use. Since misuse of pounding tools can result in damage to aircraft components and injury to personnel, it is important that you always choose the one best suited for the job and use these tools properly.

1.4.3.1 Hammers

Figure 1.4-7 shows some of the hammers that the aviation mechanic may be required to use. Before using a hammer, you should make sure the handle is secure and in good condition. When using any hammer or mallet, always take advantage of all the mechanical force available to you, swing the hammer from the elbow, not the wrist, and hold the hammer as far out on the end of the handle as possible while maintaining a firm grip. Always strike the work squarely using the full face of the hammer. To prevent marring the work, keep the face of a hammer or mallet smooth and free of dents.

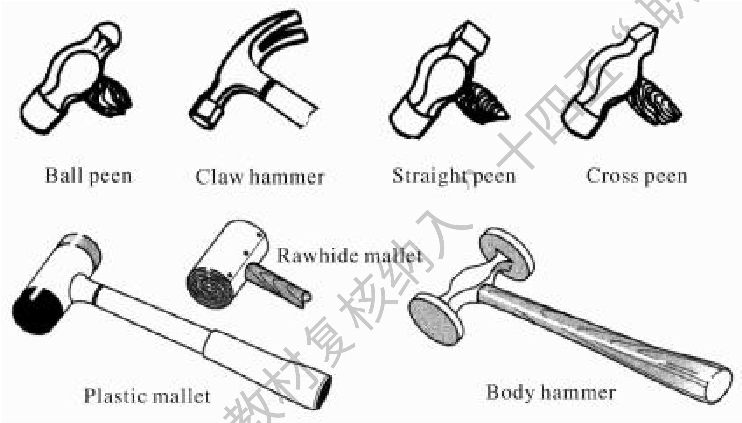


Figure 1.4-7 Hammers

Metal-head hammers are usually sized according to the weight of the head without the handle.

Ball peen hammers range in weight from about one ounce to about three pounds. One hammer face is always flat while the other is formed into the shape of a ball. The flat hammer face is used for pounding on hard steel, but should not be used to drive a nail, since the curved face of a claw hammer is better shaped for nail driving control. The ball end of the hammer is typically used to peen over rivets in commercial sheet metal work. However, this is not the method used for securing rivets in aircraft sheet metal work (see Figure 1.4-8). A claw hammer is a tool primarily used for pounding nails into, or extracting nails from, some other object. The head of a claw hammer is typically hardened, making it more brittle and susceptible to chipping. Therefore, a claw hammer should not be used on hardened steel parts. Commercial sheet metal often requires metal to be bent by hammering. This is typically accomplished by using either a cross peen or straight peen hammer. Unlike the ball peen hammer, the cross and straight peen hammers have a wedge-type end that is used to either crease metal to start a bend, or to straighten out a rolled edge (see Figure 1.4-7).

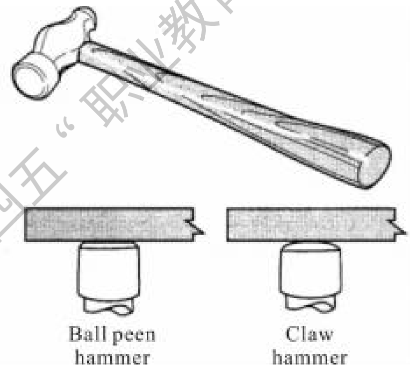


Figure 1.4-8 A ball peen hammer has a flat face and a ball-shaped end

The soft faced hammer, or mallet, is used for forming and shaping soft aluminum. Plastic mallets have replaceable tips and should never be used to drive nails or punches. The plastic head would be ruined in a short time. The body hammer, or planishing hammer, is also used for sheet metal work. The large smooth face of the planishing hammer distributes the force of the hammer blow over a large area making it ideal for forming and shaping sheet metal to a smooth flat finish (see Figure 1.4-7).

1.4.3.2 Punches

Punches are grouped with pounding tools because they concentrate the force of a hammer blow in a small area. The prick punch has a sharp point, and is used to mark dimensions and locations on sheet metal. The center punch also has a sharp point, is usually more massive than the prick punch and is ground to a much shallower angle. The center punch is used to make an indentation in sheet metal as an alignment mark for start a drill. Care must be taken when using a centre punch, that the hammer blow is not hard enough to distort the metal, but is enough to make an indentation that will prevent the drill bit from wandering. The automatic centre punch has a point that telescopes inside a handle. The handle has a spring loaded impact mechanism inside that is tripped when the correct amount of pushing force is applied. The trip mechanism may be adjusted for the desired force. Pointed punches should never be used to drive out fasteners such as rivets. They will only enlarge the end of the fastener and make it more difficult to remove. The starting punch has a blunt tip and a tapered shank. This punch is used for starting fasteners from their holes. When the holes are nearly filled by the starting punch, a pin punch is used to finish the job. When using a pin punch to drive a rivet from thin sheet metal, the metal must be supported from behind to prevent distortion. The transfer punch is usually about 4 inches long. It has a point that tapers, then turns straight for a short distance in order to fit a drill locating hole in a template. The tip has a point similar to that of a prick punch. As its name implies, the transfer punch is used to transfer the location of holes through the template or pattern to the material (see Figure 1.4-9).

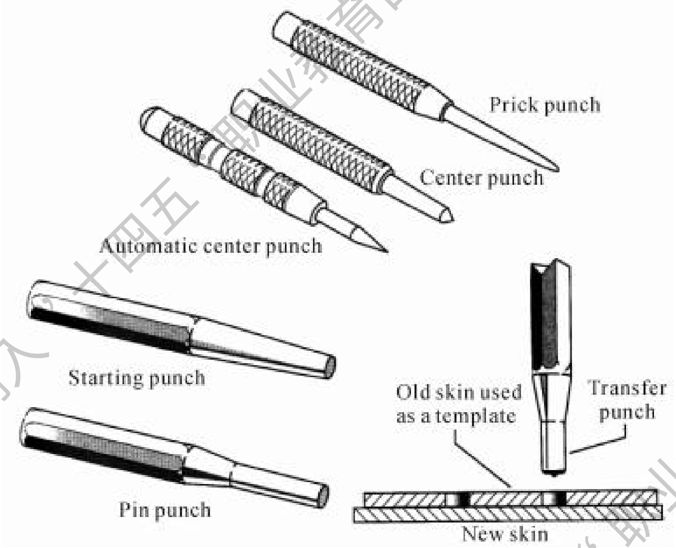


Figure 1.4-9 Punches

1.4.4 Cutting Tools

The cutting tools used in aviation maintenance go far beyond the snips and saws that probably come to mind. In fact, cutting tools include any tool that removes or separates material.

1.4.4.1 Chisels

Chisels are the most common and simplest of the cutting tools. They are usually made of high grade tool steel and are heat treated and tempered for maximum performance on a variety of materials. The cold chisel is used for cutting metal and has its cutting edge ground to an angle of about 70°. The chisel is ground slightly convex. With this design, most of the force of the hammer blow is directed to the centre of the cutting edge. This convex shape also holds the corners of the chisel away from the work. This helps prevent nicking the metal near the actual cutting point. The cape chisels come in either single-bevel, or double-bevel. The cape chisel has a much narrower cutting edge than the cold chisel and is used to cut channels or key ways. The cape chisel is also the preferred tool for cutting the heads of rivets. The narrow cutting area helps prevent extraneous metal damage to the area around the rivet. A diamond-point chisel is forged into a sharp-cornered square section and then ground to an acute angle. This forms a cutting edge that is similar in shape to a diamond. These chisels are used to cut V- grooves and sharp corners in square or rectangular grooves (see Figure 1.4-10).

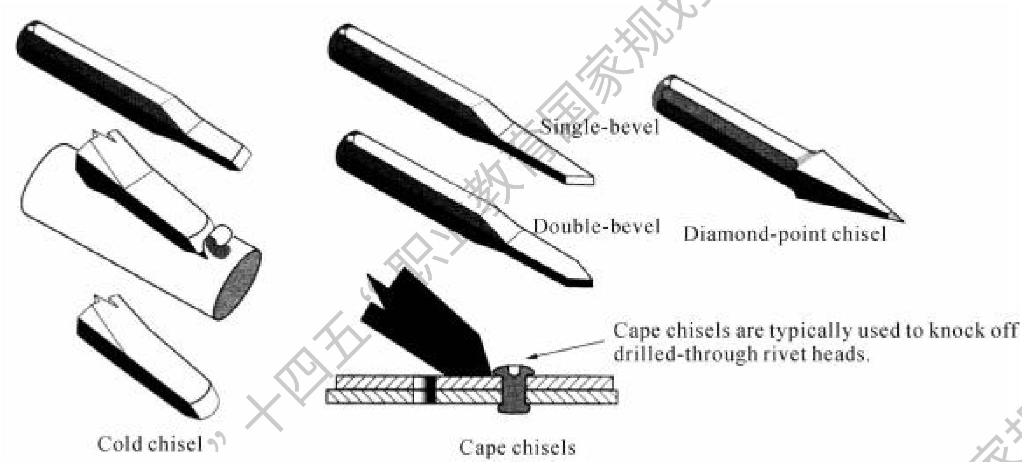


Figure 1.4-10　Chisels

1.4.4.2　Files

It is impossible to do quality sheet metal work without the aid of a file. This cutting tool has rows of teeth shaped like tiny chisels cut diagonally across its face. A file with all of its teeth cut in the same direction is a single cut file, and is used to produce a smooth finish on the material being cut. The double cut file has two sets of teeth cut at angles to each other, and is designed to cut more metal with each path than the single cut file (see Figure 1.4-11).

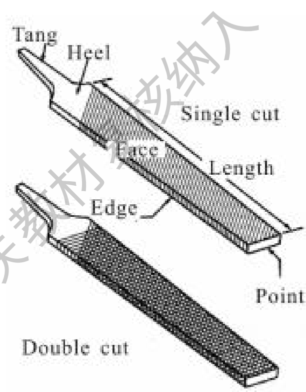


Figure 1.4-11　Single-cut and double-cut files

Files are classified as to coarseness of cut, ranging from coarse, to dead smooth.

Different types of file are designed for different jobs (see Figure 1.4-12). Be sure you select the proper file for the work at hand. When using the file, pressure should be applied on the forwards stroke only, drawing the file backward while maintaining pressure will dull or damage the teeth. Each stroke should use the full length of the file, and the pressure should be even throughout the stroke. Each stroke should be smooth and slow. The material should be held firmly in a vise or clamp to prevent it from chattering. Files should be cleaned often during use. Metal chips left in the teeth can score and damage the work. A wire brush called a file card and a metal pick are designed for the job. Files are made of high carbon steel which makes them fairly brittle. They should be covered and stored where they will not come in contact with each other or with other metal tools. This will help prevent breakage of the teeth. Never oil files, always store them dry and in a dry place. The high carbon steel makes file susceptible to rust. A rusty file is worthless as cutting tool.

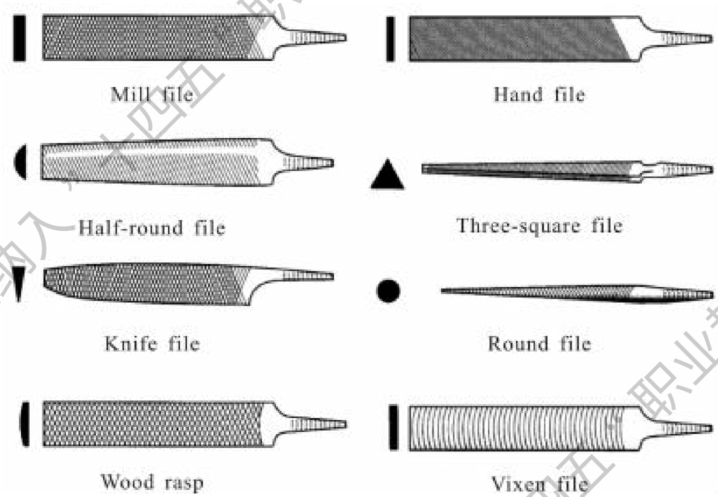


Figure 1.4-12　Files are classified with regard to their kind, their length, and their cut

1.4.4.3　Hand Snips

Shears are another type of cutting tool used on aircraft sheet metal. Tin snips are basically used for making straight cuts, they are also used to cut curves to either the left or right. The aviation maintenance technician will occasionally fabricate sheet metal parts requiring cutting and trimming. Special aviation snips designed with serrated blades and compound leverage make such work fairly simple. Aviation snips are designed to make straight cuts for cutting to the right and cutting to the left. The straight snips are color coded with a yellow handle, the right-hand snips have a green handle, and those that cut to the left have a red handle. In addition to being color-coded, aviation snips can be identified by their shape. For example, a straight snip has a relatively straight nose. However, with right-cut snips, when held in your hand, the lower jaw is on the right whereas the lower jaw is on the left with left-cut snips (see Figure 1.4-13).

1.4.4.4　Hacksaw

The hacksaw is the standard metal cutting saw used by most technicians (see Figure 1.4-14). Hacksaws usually have replaceable blades with any where from 18 to 32 teeth for every inch of blade length. This is called blade pitch. Normally, the harder the material to be cut, the higher the pitch of the blade. The sheet stock, or thin wall tubing, should be cut with a blade which allows at least two teeth to contact the work at any time. This helps prevent the material from dropping between the teeth of the saw, causing the blade to skip or break. Make long slow cuts with a hacksaw, and use the full length of the blade. Cutting takes place only on the forward stroke, so pressure should be eased as the blade is drawn backward. Maintaining the pressure on the back stroke will dull the blade and may cause it to break.

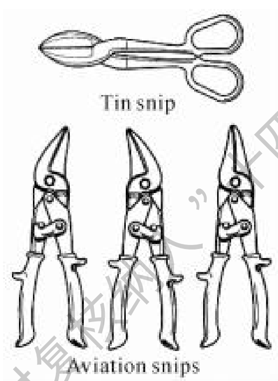


Figure 1.4-13　Hand snips

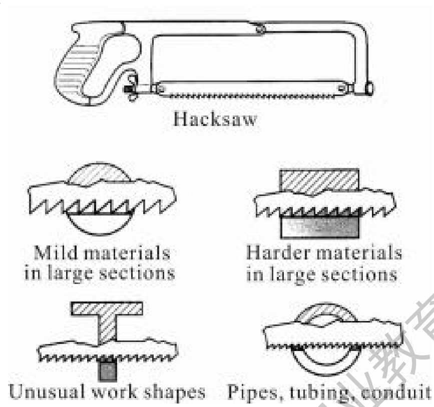


Figure 1.4-14　Typical uses for various pitch hacksaw blades

1.4.4.5　Twist Drills

The most important tool to any one who does any amount of sheet metal work on an aircraft is the twist drill (see Figure 1.4-15). The twist drill is inserted into the chuck of a drill motor and secured with a chuck key. The chuck grips the drill by the shank. The body of the drill is cut with spiral flutes that help carry metal chips away from the point and allow lubrication to reach the point. The land between the flutes is ground so that only a small portion called the margin is actually in contact with the side of the hole during the drilling operation. The remainder of the land is smaller than the hole to help prevent the drill from bending. For drilling most aircraft aluminum, the point of the drill is ground to 50°on either side of the centre line for an included angle of 118°. The lip relief or heel angle is ground back from the cutting edge by 12°-15°. Too flat an angle here would not allow the cutting edge to cut. It would act the same as a knife blade placed flat on the surface to be cut. No cutting can take place until the blade is given some angle and allow to dig into the material. Always wear eye protection when drilling, and check the recommended drill speed for the material being cut. Higher speeds are required for drilling soft materials while the lower speeds are used for hard metals such as stainless steel. Cutting oil should be used when drilling steel while no lubrication is generally required for drilling aluminum.

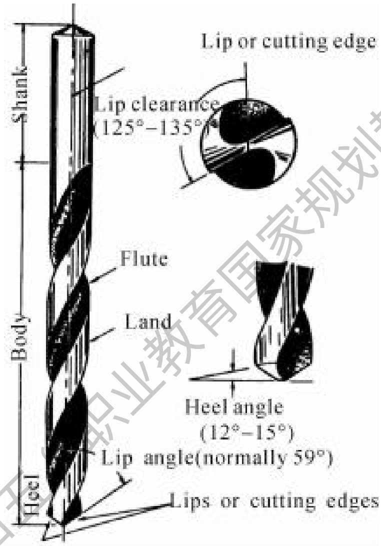


Figure 1.4 – 15　Twist drill

1.4.4.6　Reamers

Where tolerances are critical, holes are drilled slightly smaller than the fastener's being used, then are finished to exact dimensions with a reamer. The reamer has precision ground cutting blades that remove small amount of metal as it is turned into the hole. Reamers are always turned in the cutting direction both entering and leaving the hole. Once the hole has been reamed to exact dimensions, the fastener is pressed or tapped into position (see Figure 1.4 – 16).

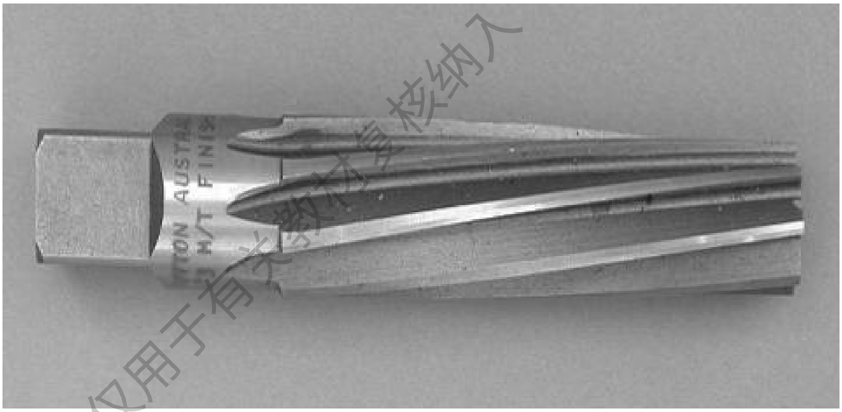


Figure 1.4 – 16　Morse taper reamer

1.4.5 Measuring Tools

1.4.5.1 Vernier Calipers

The digital, dial, and vernier calipers (see Figure 1.4-17 to Figure 1.4-19) give a direct reading of the distance measured to high accuracy. They are functionally identical, with different ways of reading the result. These calipers comprise a calibrated scale with a fixed jaw, and another jaw, with a pointer, that slides along the scale. The distance between the jaws is then read in different ways for the three types.

Figure 1.4-17 Dial Caliper

Figure 1.4-18 Digital Caliper

The simplest method is to read the position of the pointer directly on the scale. When the pointer is between two markings, the user can mentally interpolate to improve the precision of the reading. This would be a simple calibrated caliper; but the addition of a vernier scale allows more accurate interpolation, and is the universal practice; this is the vernier caliper (see Figure 1.4-19).

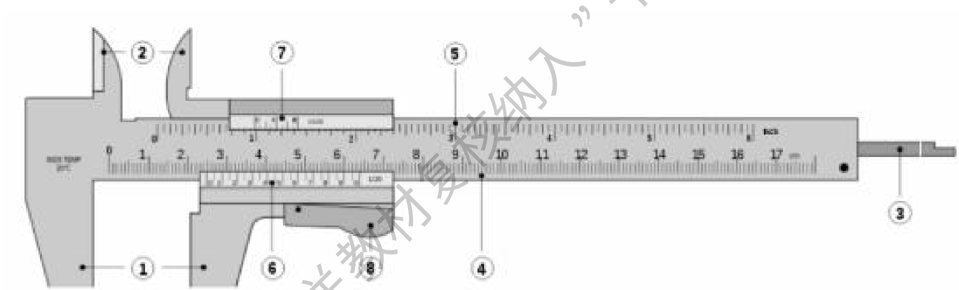


Figure 1.4-19 Vernier caliper

Vernier, dial, and digital calipers can measure internal dimensions, external dimensions using the pictured lower jaws, and in many cases depth by the use of a probe that is attached to the movable head and slides along the centre of the body. This probe is slender and can get into deep grooves that may prove difficult for other measuring tools.

The vernier scales may include metric measurements on the lower part of the scale and inch measurements on the upper, or vice versa, in countries that use inches. Vernier calipers commonly used in industry can provide a precision to 0.02 mm and 0.05 mm, or one thousandth of an inch.

1.4.5.2 Micrometers

A micrometer, sometimes known as a micrometer screw gauge, is a device incorporating a calibrated screw used widely for precise measurement of small distances in industry.

There are three basic types of micrometers, each designed for a specific use. The three types are commonly called outside micrometer, inside micrometer, depth micrometer (see Figure 1.4-20). Micrometers are available in a variety of sizes.

Figure 1.4-20 Outside, inside and depth micrometer

The outside micrometer (see Figure 1.4-21) is used by the mechanic more often than anyother type. It may be used to measure the outside dimensions of shafts, thickness of sheet metal stock, diameter of drills, and for many other applications. The inside micrometer is used to measure the diameter of holes, and the depth micrometer is used to measure the depths of slots and steps. All three types of micrometers are read in the same way. Micrometers commonly used in industry can provide a precision to 0.01 mm or one thousandth of an inch.

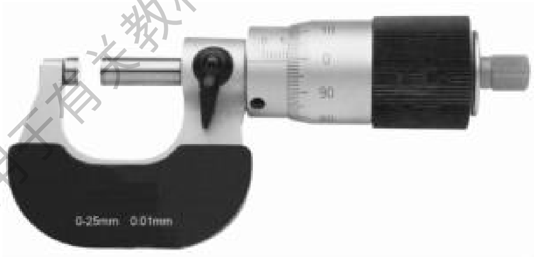


Figure 1.4-21 Outside micrometer

1.4.5.3 Calipers

A caliper is a device used to measure the distance between two opposing sides of an object. A caliper can be as simple as a compass with inward or outward-facing points. The tips of the caliper are adjusted to fit across the points to be measured, the caliper is then removed and the distance read by measuring between the tips with a measuring tool, such as a ruler. The common used calipers include outside caliper and inside caliper (see Figure 1.4 - 22 and Figure 1.4 - 23). The Outside calipers are used to measure the external size of an object. The inside calipers are used to measure the internal size of an object.

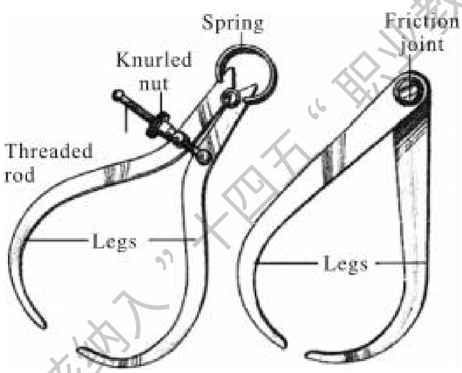


Figure 1.4 - 22 Outside caliper

Figure 1.4 - 23 Inside caliper

1.4.5.4 Dial Indicators

In various manufacturing contexts, an indicator is any of various instruments used to accurately measure small distances, and amplify them to make them more obvious. The name comes from the concept of indicating to the user that which their naked eye cannot discern; such as the exact quantity of some small distance, a small height difference between two flat surfaces, a slight lack of concentricity between two cylinders, or other small physical deviations.

Many indicators have a dial display, in which a needle points to graduations in a circular array around the dial. Such indicators, of which there are several types, therefore are often called dial indicators (see Figure 1.4 - 24).

Indicators may be used to check the variation in tolerance during the inspection process of a machined part, measure the deflection of a beam or ring under laboratory conditions, as well as many other situations where a small measurement needs to be registered or indicated. Dial indicators typically measure ranges from 0.25 mm to 300 mm (0.015 in to 12.0 in), with graduations of 0.001 mm to 0.01 mm (metric) or 0.000,05 in to 0.001 in (imperial).

Figure 1.4 - 24　Dial indicator

1.4.5.5　Feeler Gauges

A feeler gauge (see figure 1.4 - 25) is a tool used to measure gap widths. Feeler gauges are mostly used in engineering to measure the clearance between two parts.

Figure 1.4 - 25　Feeler gauge

They consist of a number of small lengths of steel of different thicknesses with measurements marked on each piece. They are flexible enough that, even if they are all on the same hinge, several can be stacked together to gauge intermediate values. It is common to have two sets for imperial units (typically measured in thousandths of an inch) and metric (typically measured in hundredths of a millimetre) measurements.

The lengths of steel are sometimes called blades, although they have no sharp edge.

A taper feeler gauge (see figure 1.4 - 26) is a feeler gauge of tapered, as opposed to parallel shape. The blade of the gauge is of a constant thickness, and the two types of gauge are used in a similar way.

Figure 1.4-26 Taper feeler gauge

1.4.5.6 Thread Pitch Gauges

A thread pitch gauge, also known as a screw pitch gauge or pitch gauge, is used to measure the pitch or lead of a screw thread (see Figure 1.4-27). Thread pitch gauges are used as a reference tool in determining the pitch of a thread that is on a screw or in a tapped hole. This tool is not used as a precision measuring instrument. This device allows the user to determine the profile of the given thread and quickly categorize the thread by shape and pitch. This device also saves time, in that it removes the need for the user to measure and calculate the thread pitch of the threaded item.

Figure 1.4-27 Thread pitch gauge and use of it

1.4.5.7 Multimeter

A multimeter or a multitester, also known as a VOM (Volt-Ohm meter), is an electronic measuring instrument that combines several measurement functions in one unit. Atypical multimeter may include features such as the ability to measure voltage, current and resistance. Multimeters may use analog or digital circuits—analog multimeters (AMM) and digital multimeters (often abbreviated DMM or DVOM) (see Figure 1.4-28). Analog instruments are usually based on a microammeter whose pointer moves over a scale calibrated for all the different measurements that can be made; digital instruments usually display digits, but may display a bar of a length proportional to the quantity being measured.

Figure 1.4－28　Digital multimeter and analog multimeter

A multimeter can be a hand-held device useful for basic fault finding and field service work or a bench instrument which can measure to a very high degree of accuracy. They can be used to troubleshoot electrical problems in a wide array of industrial and household devices such as electronic equipment，motor controls，domestic appliances，power supplies，and wiring systems.

New Words/ Phrases/ Expression

1. encompass [inˈkʌmpəs] *v.* 包含
2. subtlety [ˈsʌtlti] *n.* 精细、细微的差别
3. turning tool 拧动工具
4. holding tool 夹持工具
5. pounding tool 敲击工具
6. cutting tool 切割工具
7. line maintenance 航线维修
8. shop [ʃɔp] *n.* 车间
9. sheet metal 钣金工
10. abuse [əˈbjuːz] *v.*，*n.* 滥用
11. taper [ˈteipə] *n.* 锥度
12. parallel [ˈpærəlel] *adj.*，*n.* 平行的；平行线
13. interchange [ˌintəˈtʃeindʒ] *v.*，*n.* 互换
14. offset [ˈɔfˌset] *v.*，*n.* 偏置
15. pry bar 撬杆
16. punch [pʌntʃ] *n.* 冲子
17. chisel [ˈtʃizl] *n.* 凿子
18. screw driver 螺丝刀
19. slotted screw 带槽螺钉(一字螺钉)
20. cross point screw driver 十字螺丝刀
21. blunt [blʌnt] *adj.* 钝的

22. wrench [rentʃ] *n.* 扳手
23. open-end wrench 开口扳手
24. solid wrench 呆扳手(开口扳手的别称)
25. box-end wrench 梅花扳手
26. socket wrench 套筒扳手
27. Allen wrench 内六角扳手
28. Allen screw 内六角螺钉
29. accommodate [əˈkɔmədeit] *v.* 容纳
30. speed handle 快速摇把
31. ratchet [ˈrætʃit] *n.* 棘轮,棘齿
32. awkward [ˈɔːkwəd] *adj.* 别扭的,难操纵的
33. calibrate [ˈkæliˌbreit] *v.* 校准
34. torsion bar torque wrench 扭力杆式力矩扳手
35. desire [diˈzaiə] *v.*,*n.* 渴望
36. visual [ˈvizjuəl] *adj.* 目视的,视力的
37. circumstance [ˈsəːkəmstəns] *n.* 情况,环境,条件
38. torque value 力矩值
39. accurate [ˈækjurit] *adj.* 精确的
40. accuracy [ˈækjurəsi] *n.* 精确性,准确性
41. interval [ˈintəvəl] *n.* 间隔时间
42. pliers [ˈplaiəz] *n.* 钳子
43. slip joint pliers 鱼口钳
44. interlocking joint pliers 内锁支点钳
45. leverage [ˈlevəridʒ] *n.* 杠杆作用,杠杆效率
46. vise grip 大力钳
47. toggle [ˈtɔgl] *n.* 开关;触发器
48. duckbill pliers 鸭嘴钳
49. nick [nik] *n.* 刻痕;凹隙
50. needle nose pliers 尖嘴钳
51. versatile [ˈvəːsətail] *adj.* 万向的;万能的
52. jaw [dʒɔː] *n.* 颚,钳口
53. clamp [klæmp] *v.*,*n.* 夹紧;夹钳
54. serration [seˈreiʃən] *n.* 锯齿
55. diagonal [daiˈægənl] *adj.* 对角线的;斜的
56. solder [ˈsɔldə] *v.*,*n.* 焊接;锡焊
57. trim [trim] *v.* 修整,配平
58. wrap [ræp] *v.* 卷,裹
59. vernier caliper 游标卡尺
60. dial [ˈdaiəl] *n.* (仪器等的)刻度盘,示数盘

61. digital [ˈdidʒitəl] *adj*. 数字的,数字显示的
62. scale [skeil] *n*. 刻度;尺度;刻度尺
63. precision [priˈsiʒən] *n*. 精确;精密度,精度
64. micrometer [maiˈkrɔmitə] *n*. 千分尺;测微计
65. screw [skruː] *n*. 螺钉,螺旋状物;螺旋形
66. gauge [geidʒ] *n*. 测量仪器;规,表,计
67. caliper [ˈkælipə] *n*. (常用复数)卡钳;卡尺
68. dial indicator 百分表
69. amplify [ˈæmpliˌfai] *v*. 放大,增强
70. concentricity [kɔnsenˈtrisiti] *n*. 中心度,同轴度(同心度)
71. deviation [ˌdiːviˈeiʃən] *n*. 偏差
72. graduation [grædʒuˈeiʃən] *n*. 分级,刻度
73. feeler gauge 塞尺,厚薄规,间隙片
74. gap [gæp]*n*. 缺口,空隙,间隙,缝隙
75. imperial [imˈpiəriəl] *adj*. 英制的
76. thread pitch gauge 螺距规,螺纹规
77. multimeter [ˈmʌltimiːtə] *n*. 万用表
78. voltage [ˈvəultidʒ] *n*. 电压,伏特数
79. current [kʌrənt] *n*. 电流
80. resistance [riˈzistəns] *n*. 抵抗,反抗,电阻(值)
81. analog [ˈænəlɔːg] *adj*. 模拟的

Notes

【1】The Allen wrench is designed for internal wrenching bolts or Allen screw. There is a six-sided hole machined into the center of the head of this kind of bolt and screw. They are used in the place where outside wrench space is limited.

分析:"Allen wrench"直译为"艾伦扳手",实际是指"内六角扳手"。

翻译:内六角扳手是为内六角螺栓或内六角螺钉设计的,在这类螺栓和螺钉的头部中央,开有六边形的孔。这类螺栓和螺钉用于(螺栓头或螺钉头)外部的扳手空间很有限的地方。

【2】To solve this problem, the toggle type torque wrench may be the answer.

分析:"the toggle type torque wrench"应按中国对此类工具的习惯称谓翻译为"定力矩扳手"更为准确易懂。

翻译:为了解决这一问题,可用触发式力矩扳手(定力矩扳手)。

Exercises

Ⅰ. Answer the following questions:

1. List some hand tools before you view the text.
2. Why the Phillips headscrew driver is designed with a blunt point?
3. List some wrenches that can measure and indicate the force.

4. Which tool may be turned and repositioned without removing the wrench from the fastener?

5. How does the slip joint pliers to provide a wide range of grip size?

6. What kind of jobs could the needle nose pliers be used for?

7. Why should the plastic mallets never be used to drive nails or punches?

8. Which condition is best for planishing hammer?

9. Why pointed punches should never be used to drive out fasteners such as rivets?

10. Is right to draw the files backward while maintaining pressure?

11. How to choose a hacksaw to cut a sheet stock?

12. What function the convex shape of chisel is?

13. List some common measuring tools.

14. What's the function of dial indicator?

15. What's the function of feeler gauge?

16. What's the function of thread pitch gauge?

Ⅱ. Translate the following sentences into Chinese:

1. Hand tools will fall into four basic categories: turning tools, holding tools, pounding tools and cutting tools.

2. Although its shape lends itself to be used as a pry bar, a punch, or a chisel, the screw driver is designed for one purpose: turning screws.

3. Interchanging screwdrivers between reed and prince, and phillips head screws could damage both the screw and the screw driver.

4. The torque wrench is calibrated so that a handle of specified length will apply a measured force or torque to the fastener as it is turned.

5. The socket wrench has a six or twelve point opening on one end, and a square opening on the opposite end to accommodate any of several different handles.

6. The torsion bar torque wrench uses a specially ground and calibrated bar attached to the lug, and to a gear system.

7. The pivot point between the jaws may be moved into one of two different holes in one of the jaws. This provides a wide range of grip sizes.

8. When using any hammer or mallet, always take advantage of all the mechanical force available to you, swing the hammer from the elbow, not the wrist, and hold the hammer as far out on the end of the handle as possible while maintaining a firm grip.

9. When using a pin punch to drive a rivet from thin sheet metal, the metal must be supported from behind to prevent distortion.

10. Cutting takes place only on the forward stroke, so pressure should be eased as the blade is drawn backward. Maintaining the pressure on the back stroke will dull the blade and may cause it to break.

11. Higher speeds are required for drilling soft materials while the lower speeds are used for hard metals such as stainless steel.

12. Where tolerances are critical, holes are drilled slightly smaller than the fastener's being used, then are finished to exact dimensions with a reamer.

13. The vernier, dial, and digital calipers give a direct reading of the distance measured to high accuracy. They are functionally identical, with different ways of reading the result. These calipers comprise a calibrated scale with a fixed jaw, and another jaw, with a pointer, that slides along the scale. The distance between the jaws is then read in different ways for the three types.

14. A typical multimeter may include features such as the ability to measure voltage, current and resistance. Multimeters may use analog or digital circuits—analog multimeters (AMM) and digital multimeters (often abbreviated DMM or DVOM).

1.5 Introduction of Non-Destructive Test (NDT)

NDT methods are techniques used both in the production and in-service environments without damage or destruction of the item under investigation. The fundamental NDT inspection methods are: visual inspection, liquid penetrant inspection, magnetic particle inspection, eddy current inspection, ultrasonic inspection and radiographic inspections (also called photographic inspection).

1.5.1 Visual Inspections

The most fundamental method of inspecting aircraft structures and components is through visual inspection. This method is irreplaceable in certain circumstances and limited in others.[1] In any case, nothing can be inspected visually unless it is uncovered and made visible.

The basic tools required to conduct a visual inspection include a good light, a mirror, and some form of magnifying glass. Flashlights are typically used to give spot-type illumination to the inspection area.

When searching for surface cracks with a flashlight, direct the light beam at a 5 to 45 degree angle to the inspection surface, towards the face (see Figure 1.5－1). Do not direct the light beam at such an angle that the reflected light beam shines directly into the eyes. Keep the eyes above the reflected light beam during the inspection. Determine the extent of any cracks found by directing the light beam at right angles to the crack and tracing its length. Use a 10-power magnifying glass to confirm the existence of a suspected crack. If this is not adequate, use other NDI (Non-Destructive Inspection) techniques, such as penetrant, magnetic particle, or eddy current to verify cracks.

A borescope is an optical device similar in principle to a telescope in that it enlarges objects like a magnifying glass. However, a borescope has a small lens mounted on a shaft with a built-in light source that illuminates the area being inspected. Borescopes are typically used to inspect inside engines using the plug hole for access. This optical device allows inspection without disassembly (see Figure 1.5－2).

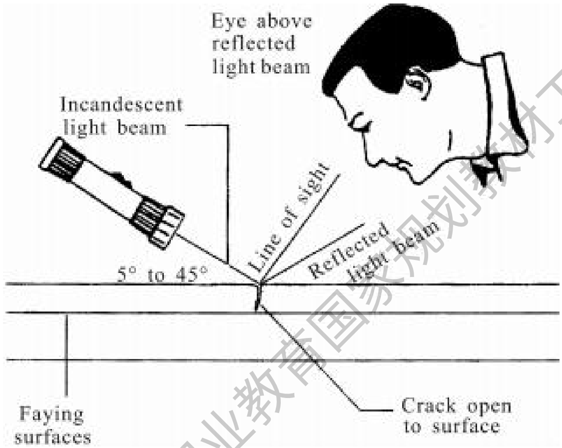


Figure 1.5－1　Using a flashlight to inspect

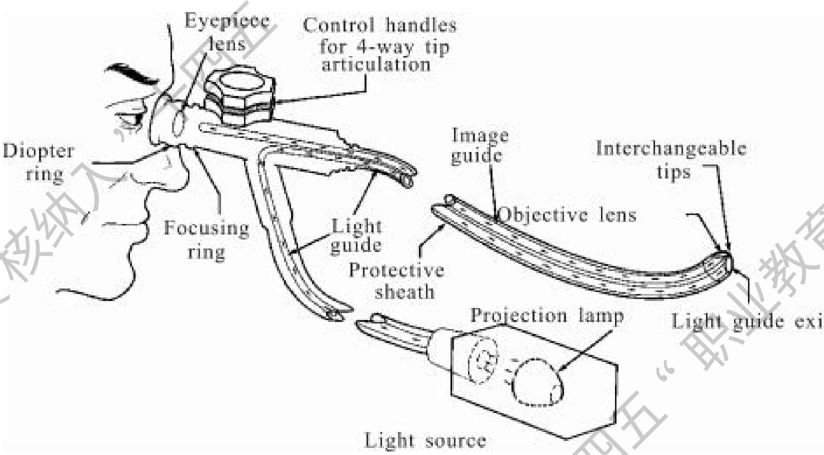


Figure 1.5－2　Fiberoptic borescope

1.5.2　Liquid Penetrant Inspection

Liquid penetrant inspection is a method of nondestructive inspection suitable for locating cracks, porosity, or other types of faults open to the surface in parts made of any nonporous material. Penetrant inspection is usable on ferrous and nonferrous metals, as well as nonporous plastic material. The primary limitation of dye penetrant inspection is that a defect must be open to the surface. Liquid penetrant inspection use a series kind of liquids: cleaner, penetrant, developer.[2]

Liquid penetrant inspection is based on the principle of capillary attraction. The area being inspected is covered with a penetrating liquid that has a very low viscosity and low surface tension. This penetrant is allowed to remain on the surface long enough to allow the capillary action to draw the penetrant into any fault that extends to the surface. The smaller the defect, the longer the penetrating time is. After sufficient time, the excess penetrant is washed off and the surface is covered with a developer.

The developer, by the process of reverse capillary action, blots the penetrant out of cracks or other faults forming a visible line in the developer.

The main procedures for the liquid penetrant inspection are as follow:

(1) When performing a liquid penetrant inspection, cleaning the surface of the works by the cleaner.

(2) The penetrant is spread over the surface of the material being examined and allowed sufficient time for capillary action to take place.

(3) The excess penetrant is then washed from the surface, leaving any cracks and surface flaws filled.

(4) An absorbent developer is sprayed over the surface where it blots out any penetrant. The crack then shows up as a bright line against the white developer (see Figure 1.5-3).

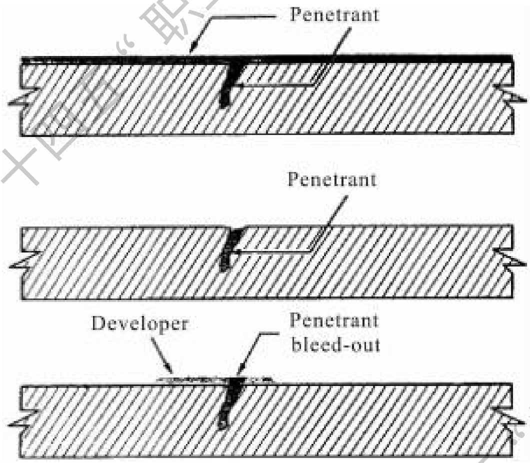


Figure 1.5-3 Procedure of liquid penetrant inspection

There are two types of dyes used in liquid penetrant inspection: fluorescent and colored. An ultraviolet light is used with the fluorescent penetrant and any flaw shows up as a green line. With the colored dye method, faults show up as red lines against the white developer.

1.5.3 Magnetic Particle Inspection

Magnetic particle inspection is a method of detecting invisible cracks, laps, seams, voids, pits, subsurface holes, and other surface, or slightly subsurface, discontinuities in ferromagnetic materials, such as iron and steel. It is not applicable to nonmagnetic materials.

When a material containing large amounts of iron is subjected to a strong magnetic field, the magnetic domains within the material align themselves and the part becomes magnetized. When this happens, the part develops both a north and south pole and lines of flux flow in a continuous stream from the north pole to the south pole. If a break occurs within the part, another set of magnetic poles appears, one on either side of the break. Therefore, when an oxide containing magnetic particles is poured or sprayed over the part's surface, any discontinuities in the material, either on or near the surface, create disruptions in the magnetic field around the part; these poles attract the magnetic particles in the oxide thereby giving you an indication of the break.

In order to detect a crack with magnetic particle inspection, the part must be magnetized in such a way that the lines of flux are perpendicular to the fault. To ensure that the flux lines are nearly perpendicular to a flaw, a part should be magnetized both longitudinally and circularly (see Figure 1.5-4).

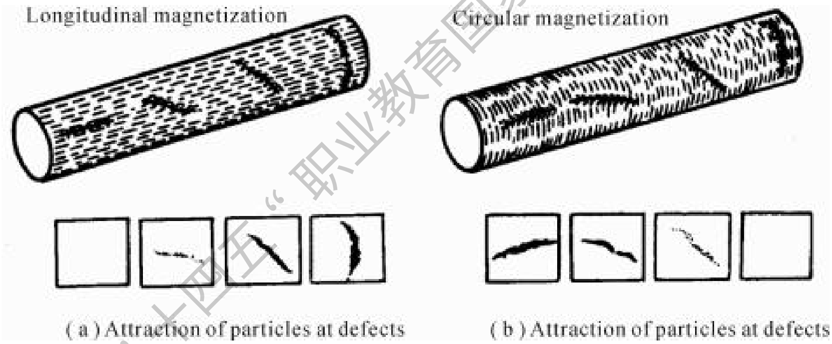


Figure 1.5-4 Effect of flux direction on strength of indication

The permanent magnetism remaining after inspection must be removed by a demagnetization operation if the part is to be returned to service.

1.5.4 Eddy Current Inspection

Eddy current is used to detect surface cracks, pits, subsurface cracks, corrosion on inner surfaces, and to determine alloy and heat-treat condition. Eddy current techniques are particularly well suited for detection of service-induced cracks in the field. Service-induced cracks in aircraft structures are generally caused by fatigue or stress corrosion. Both types of cracks initiate at the surface of a part. If this surface is accessible, a high-frequency eddy current inspection can be performed with a minimum of part preparation and a high degree of sensitivity.

If the surface is less accessible, such as in a subsurface layer of structure, low-frequency eddy current inspection can usually be performed. Eddy current inspection can usually be performed without removing surface coatings such as primer, paint, and anodic films. Eddy current inspection has the greatest application for inspecting small localized areas where possible crack initiation is suspected rather than for scanning broad areas for randomly-oriented cracks. However, in some instances it is more economical to scan relatively large areas with eddy current rather than strip surface coatings, inspect by other methods, and then refinish[3] (see Figure 1.5-5).

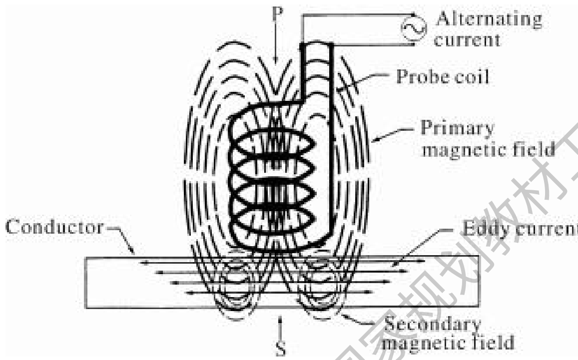


Figure 1.5－5　Eddy current inspection

1.5.5　Ultrasonic Inspection

One inspection method that is effectively used for corrosion inspection is that using ultrasonic energy. In this method of inspection, high-frequency pulses of energy, similar to sound waves, only at frequencies far above the audible range, are introduced into the airplane structure. There are two types of ultrasonic indications which may be used for corrosion detection: the pulse-echo and the resonance method.

In the pulse-echo method, a pulse of ultrasonic energy is directed into the structure by a device known as a transducer. This energy travels through the material to its opposite side and then bounces back. When the return pulse is received by the transducer, it is displayed on the screen of a cathode-ray oscilloscope as a spike which establishes a time base, representing the thickness of the material. If there is any change in thickness, such as may be caused by corrosion, the return will occupy a shorter space and will indicate the extent of damage. If there should be a crack or other flaw within the material, such as may be caused by inter-granular corrosion, a second spike will appear on the oscilloscope screen which indicates the approximate position of the flaw within the material[4] (see Figure 1.5－6).

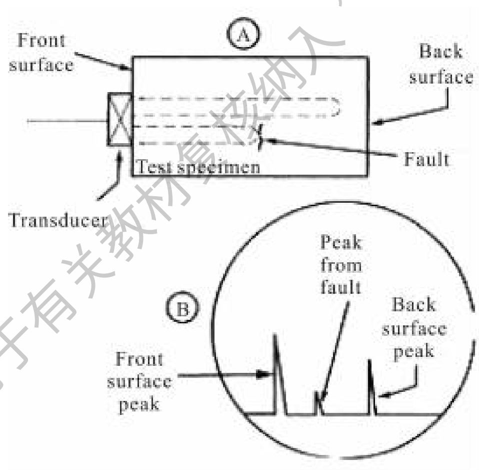


Figure 1.5－6　Pulse-echo method

The second method of inspection using ultrasonic energy is the resonance method. This method operates on the principle that for any given thickness of material, there is a specific frequency of ultrasonic energy that will resonate, or produce the greatest amount of return. Variable frequency ultrasonic energy is fed into the transducer, and the output is monitored visually with a meter or audibly with a set of head phones. When the resonant frequency is reached, the meter will read the highest value or the tone will be the loudest in the phones. If the metal has been eaten away by corrosion, its resonant frequency will be different from that of sound metal, and the meter reading or tone volume will be lower. The resonance method can be used to determine the actual thickness of the material by calibrating the probe with a test specimen of the same type material being tested.

1.5.6　Radiological Inspection (Photographic Inspection)

X-ray and gamma radiations, because of their unique ability to penetrate material and disclose discontinuities, have been applied to the radiographic inspection of metal fabrications and nonmetallic products. This inspection medium, in a portable unit, provides a fast and reliable means for checking the integrity of airframe structures and engines.

Radiographic inspection techniques are used to locate defects or flaws in airframe structures or engines with little or no disassembly. This is in marked contrast to other types of nondestructive testing, which usually require removal, disassembly, and stripping of paint from the suspected part before it can be inspected. Due to the nature of X-ray, extensive training is required to become a qualified radiographer, and only qualified radiographers are allowed to operate the X-ray units.

For a permanent record of a radiographic inspection, a sheet of photographic film is placed on one side of the object being inspected, and the radiation source on the other. The film is placed as close to the specimen as possible and the source is oriented so that the radiation penetrates and passes an amount of radiation proportional to the specimen's density. The denser the specimen, the less radiation passes through, and the less the film is exposed. The specimen is then exposed to the radiation source (see Figure 1.5－7).

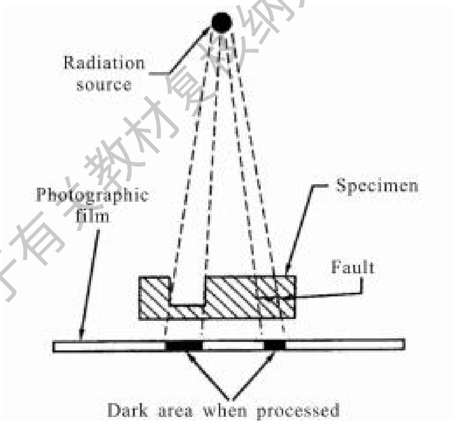


Figure 1.5－7　Radiation from X-rays penetrates a specimen and exposes a photographic film

New Words/ Phrases/ Expression

1. visual inspection 目视检查
2. liquid penetrant inspection 液体渗透检查
3. magnetic particle inspection 磁粉检查
4. eddy current inspection 涡流(探伤)检查
5. ultrasonic inspection 超声波检查
6. radiographic inspections 放射照相检查
7. lens [lenz] *n.* 镜头,镜片
8. illumination [iˌljuːmiˈneiʃən] *n.* 照明
9. borescope [ˈbɔːskəup] *n.* 内窥镜
10. built-in light source 内置光源
11. porosity [pɔːˈrɔsiti] *n.* 多孔性
12. dye [dai] *v.* 染色
13. developer [diˈveləpə] *n.* 显影剂
14. capillary [ˈkæpiləri] *n.* 毛细管
15. viscosity [visˈkɔsiti] *n.* 黏度,黏性
16. fluorescent [fluːəˈresənt] *adj.* (发)荧光的
17. sufficient [səˈfiʃənt] *adj.* 充足的
18. ultraviolet [ˈʌltrəˈvaiəlit] *n.* 紫外线
19. lap [læp] *n.* 搭接
20. seam [siːm] *n.* 缝;接缝,缝合处
21. void [vɔid] *adj.*, *n.* 空隙的,缩孔
22. pour [pɔː] *v.* 倒,倾注
23. perpendicular [ˌpəːpənˈdikjulə] *adj.* 垂直的,呈直角的
24. demagnetization [ˌdiːmægnitaiˈzeiʃən] *n.* 退磁
25. fatigue [fəˈtiːg] *n.* 疲劳
26. primer [ˈpraimə] *n.* 底漆
27. anodic film 阳极化膜
28. pulse-echo[pɔːzˌekəu] *n.* 脉冲-回波
29. resonance [ˈrezənəns] *n.* 共振,谐振
30. cathode-ray oscilloscope 阴极射线示波器
31. spike [spaik] *n.* 尖峰脉冲
32. radiation [ˌreidiˈeiʃən] *n.* 辐射,放射线
33. marked [maːkt] *adj.* 显著的
34. strip [strip] *v.* 剥除,褪除
35. specimen [ˈspesimən] *n.* 样本,标本
36. expose [ikˈspəuz] *v.* 使(胶片,胶卷)曝光

Notes

【1】The most fundamental method of inspecting aircraft structures and components is through visual inspection. This method is irreplaceable in certain circumstances and limited in others.

分析:此句从整句话来看,意思存在转折。

翻译:对飞机结构和部件进行的最基本的检查手段是目视检查。这一检查方法在有的情况下是无可代替的,但在另一些情况下是有局限性的。

【2】Liquid penetrant inspection use a series kind of liquids: cleaner, penetrant, developer.

分析:“developer”一词在渗透检查中有专门的含义:显影剂。不要想当然地根据平时的经验翻译成“开发者”。

翻译:液体渗透检查用到一系列的液体,如清洁剂、渗透剂、显影剂。

【3】Eddy current inspection has the greatest application for inspecting small localized areas where possible crack initiation is suspected rather than for scanning broad areas for randomly-oriented cracks. However, in some instances it is more economical to scan relatively large areas with eddy current rather than strip surface coatings, inspect by other methods, and then refinish.

分析:这个句子里出现两次比较“rather than”,注意比较的对象和意思的转折。

翻译:涡流检查最适合用在检查有可能出现裂纹的小范围区域内,而不适用于检查大面积范围内的方向随机的裂纹。但是,在有的情况下,用涡流探伤扫描检查相对较大的面积还是比用其他方法来得经济。其他方法通常先要褪除表面涂层,检查完毕后还要恢复涂层。

【4】If there should be a crack or other flaw within the material, such as may be caused by inter-granular corrosion, a second spike will appear on the oscilloscope screen which indicates the approximate position of the flaw within the material.

分析:此句是典型的“if…should”虚拟语气句型。“should”不能被翻译成“应该”。

翻译:如果材料内有裂纹或其他瑕疵,如由晶间腐蚀造成的裂纹,则第二个尖峰脉冲会出现在显示器屏幕上,它可大致显示出裂纹在材料里的位置。

Exercises

Ⅰ. Answer the following questions:

1. List the procedure for liquid penetrate inspection.

2. What is the working principle of magnetic particle inspection?

3. Make a table to list the advantages and disadvantages of common NDT methods mentioned in this article.

Ⅱ. Translate the following sentences into Chinese:

1. A borescope has a small lens mounted on a shaft with a built-in light source that illuminates the area being inspected and are typically used to inspect inside engines using the plug hole for access.

2. In order to detect a crack with magnetic particle inspection, the part must be magnetized in such a way that the lines of flux are perpendicular to the fault. To ensure that the flux lines are nearly perpendicular to a flaw, a part should be magnetized both longitudinally and circularly.

Ⅲ. Fill in the following blanks according to the text:

1. The basic tools required to conduct a visual inspection include a ______, a ______, and some form of ________.

2. Liquid penetrate inspection use a series kind of liquids: ________, ________, ________.

3. There are two types of ultrasonic indications which may be used for corrosion detection: ________ method.

4. ________ and ________ radiations, because of their unique ability to penetrate material and disclose discontinuities, have been applied to the radiographic inspection of metal fabrications and nonmetallic products.

Chapter 2
Aircraft Component Maintenance

2.1 Requirement and Classification
2.2 Component Work Flow
2.3 Manuals and Documents
2.4 License for the Component Maintenance Personnel

Chapter 2 Aircraft Component Maintenance

2.1 Requirement and Classification

Component repair is a kind of aviation maintenance work. It ensures continued airworthiness like other aviation maintenance work. It can do different repair work about many components which are removed from aircrafts due to different causes. But the repair work must be done under relative requirements which are ruled by ICAO, FAA, EASA, CAAC and other organizations.[1] We place emphasis on the requirements of CAAC.

According to the regulations of CAAC, component repair is classified into six categories. And most components have four types of repairing in real maintenance work. You may learn them in the further detailed descriptions.

2.1.1 Requirement of Component Repair

2.1.1.1 Continued Airworthiness

Continued A/W(Airworthiness) Definition: Any activity, after the type certification of an aircraft, which is necessary to ensure a certain level of safety. We should use proper maintenance to ensure continued airworthiness. It encompasses:

(1) The verification that any change made on an aircraft won't introduce a risk.

(2) The check that a damaged aircraft will recover its basic airworthiness after having been repaired.

(3) The verification that a specific aircraft is compliant with the approved type design.

All the actions implemented after an incident/accident in order to avoid a reoccurrence of this incident/accident.

"Aircraft Component" means any part and appliance installed or to be installed on aircraft other than the aircraft airframe, including the complete engine/APU, propeller and any operational/emergency equipment, etc.

Definition of "repair": Elimination of damage and/or restoration to an airworthy condition following initial release into service by the manufacturer of any product, part or appliance. In service feedback experience: correctives actions, airworthiness directives and others.

Importance of service experience feedback:

(1) Necessary to maintain the level of safety defined by the certification requirements, and to correct unsafe conditions not addressed by requirements applicable at time of TC (type certification).

(2) Used at several levels: To correct type design deficiencies of an A/C (aircraft) type; To modify certification requirements or methods to improve the safety level of all types.

2.1.1.2 Requirements of ICAO Annex

"… the State of Design shall transmit information necessary for the continuing airworthiness and safe operation of the aircraft". "The operator shall provide, for the use and guidance of maintenance and operational personnel concerned, a maintenance programme, approved by the State of Registry …". Maintenance tasks and the intervals at which these are to be performed, taking into account the anticipated utilization of the airplane. "… inspections or other procedures must be established as necessary to prevent catastrophic failure and must be included in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness."

The life limited parts are those having not achieved tests and that have not been demonstrated to the full design goal and whose failure could result in catastrophic failure of the airplane. Replacement of these parts is mandatory at the latest at the given limit Flight Hours or Landings to maintain the aircraft airworthy. Non compliance may lead to suspend the validity of the continued airworthiness. As such, it is mandatory to ensure traceability and monitoring of these parts. The life limited parts are provided in an appropriate and clearly identified document.

Note: The engine time limits are incorporated in the relevant manual of the engine manufacturer.

Certification Maintenance Requirements: The CMR's (Certification Maintenance Requirements) tasks arising from Systems Safety Assessment which are associated with the most significant failure conditions. They are allocated to two categories according to the failure condition consequences and the sensitivity of the safety objective to interval increase.

2.1.1.3 Requirements of CCAR-145

Component repair should be done under the approval of CCAR-145. This regulation is formulated in accordance with "The People's Republic of China Civil Aviation Law" and "The People's Republic of China Regulations for Airworthiness of Civil Aircraft". It is for the purpose of standardizing the administration and supervision of civil aircraft maintenance and to ensure the continued airworthiness and flight safety of civil aircraft.

For the purpose of this regulation, the applicability herein is defined as follows:

(1) The General Administration of Civil Aviation of China (hereinafter referred as "CAAC") or CAAC Regional Administration (hereinafter referred as "CAAC RA") certifies the maintenance organization applying for maintenance of aircraft component (hereinafter referred as "maintenance organization").

(2) The CAAC Headquarter Office or the CAAC RA administrates and supervises the maintenance organization which has been granted the CAAC Maintenance Organization Certificate (hereinafter referred as "CAAC MOC").

The CAAC MOC consists of the "Maintenance Organization Certificate" page and the "Limitation of Maintenance Items" page (refers to attachment 3 of this regulation). The name and address of the organization together with the approved Maintenance Rating(s) are specified on the "Maintenance Organization Certificate" page, whereas the limited approved Maintenance Items and maintenance functions are specified on the "Limitation of Maintenance Items" page.

Maintenance organizations shall at all time take appropriate corrective actions to rectify any defects and deficiencies against this regulation to ensure continued compliance with the requirements of this regulation. When requested by the operators or other organizations (hereinafter referred as "job sender") to provide maintenance services for aircraft components, the maintenance organization shall inform the job sender of its approved scope of work as specified in the CAAC MOC prior to the maintenance work.

The CAAC is solely responsible for issuing the CAAC Maintenance Organization Certificate (MOC).

The CAAC Headquarter office is responsible for certifying and supervising the aircraft component maintenance organizations, as well as for issuing and administrating the CAAC MOC issued to the foreign and regional maintenance organizations.

The CAAC RA is responsible for issuing the CAAC MOC to the domestic maintenance organization whose main management and maintenance facility is located within its respective administrative region as well as regular supervision and administration thereof and also carries other responsibility for certifying and supervising maintenance organizations so authorized by the CAAC Headquarter office.

The maintenance organization shall be provided with the appropriate working environment and maintenance facilities, office, training and storage facilities that comply with the relative requirements for components repair.

The maintenance organization shall determine the tools and equipment necessary for the maintenance work according to the approved scope of work as specified in the CAAC MOC and the relevant airworthiness data, and fulfill the following requirements to effectively control and keep the tools and equipment to ensure that the tools and equipment are in good and serviceable conditions.

The maintenance organization shall fulfill following requirements to keep the material necessary for the intended maintenance work, have effective control and management over it to ensure its conformity.

The maintenance organization shall have sufficient maintenance and management personnel, certifying and supporting staff that complies with the relative requirements.

The maintenance organization shall keep the sufficient documents related to the aircraft component maintenance.

The maintenance organization shall establish a quality system which is under the charge of the Accountable Manager. The quality system shall fulfill the relevant airworthiness requirements.

The maintenance organization shall establish an independent self-quality audit system that complies with the following requirements, or endow the quality department with the function to designedly assess the compliance of the maintenance work with the requirements of this regulation, verify the effectiveness of the quality management system and make self-improvements.

The maintenance organization shall establish the engineering and technical system to fulfill the engineering and technical management responsibilities, including the establishment of the relative maintenance technical documents.

The maintenance organization shall establish production control system within the organization itself, which shall consist of all associated production departments and maintenance workshops, the production system so established shall fulfill the relative requirements.

The maintenance organization shall establish the training program for each post pursuant to the requirements as prescribed in the § 145.23 of this regulation, set up the technical record for each post-holder and fulfill the relative requirements.

Besides above requirements, there are other requirements for component repair such as Maintenance Organization Manual (MOM) which includes Maintenance Management Manual (MMM) and the Working Procedures Manual (WPM), Maintenance Criteria while carrying out maintenance work, Maintenance Records, the maintenance release certificate on completion of maintenance work on the aircraft component shall be issued by the certifying staff in such a way that is approved or accepted by the CAAC and unairworthy conditions or other important incidents report during maintenance or occurring with maintenance that affect the operation safety of the aircraft and the airworthiness of the civil aircraft components.

2.1.2 Classification of Component Repair

2.1.2.1 Classification of CCAR-145

According to CCAR-145, "Maintenance" means any inspection/test, repair, defect rectification, scheduled maintenance, overhaul and modification of aircraft component. The repair under warranty claim for the brand-new OEM products or repair under compensation claim due to design and/or manufacturing fault provided by the aircraft component manufacturer falls outside the scope of maintenance so defined.[2]

Maintenance levels of component are divided into four types: inspection, repair, overhaul and modification.

Maintenance functions, in the context of this regulation, are classified as follows:

(1) Inspection/Test: Verifying serviceability of removed civil aircraft components without disassembling by examination and functional check in accordance with the standards specified in the airworthiness data.

(2) Repair: The restoration of unserviceable aircraft component to a serviceable condition in accordance with the airworthiness data.

(3) Overhaul: Restore aircraft component, by disassembling, cleaning, inspecting, necessary repairing or replacing, reassembling and testing in accordance with the airworthiness data, to its serviceable life or airworthy conditions.

(4) Modification: The general alterations of an item performed in conformity with the airworthiness data approved or accepted by the CAAC. For major alterations, details of the alterations shall be respectively addressed. Modification hereby does not include the approval of the type design change involved in the alternation program.

Maintenance ratings, in the context of this regulation, are classified as follows:

(1) Airframe;

(2) Power plant;

(3) Propeller;

(4) Component other than complete engine/APU or propeller;

(5) Specialized services;

(6) Other maintenance ratings acceptable to the CAAC.

The maintenance of airframe, engine/APU and propeller may include maintenance on its respective components which are fitted or removed according to the relevant applicable continuous airworthiness data. For such components which are removed and not bound for re-installation on the airframe, engine/APU and propeller that is under maintenance, the maintenance organization shall submit the application to the CAAC Headquarter Office or the CAAC RA to apply for the maintenance rating of component other than complete engine/APU or propeller.

The CAAC Headquarter Office or the CAAC RA may impose necessary limitations on the maintenance rating(s) as appropriate under the specific circumstances, including those limitations in terms of manufacturer, type, designation, etc. listed in "Maintenance Function and Maintenance Rating(s) Classification Table", or any other limitations if the CAAC feels necessary.[3]

For the maintenance rating of component other than complete engine/APU or propeller, the company maintenance capability list (Form F145－2) prescribed in the attachment 2 of this regulation shall be provided.

2.1.2.2　Classification of CCAR-66

According to CCAR-66, the basic portion of the license for the component maintenance personnel is classified in accordance with the following categories (see Figure 2.1－1).

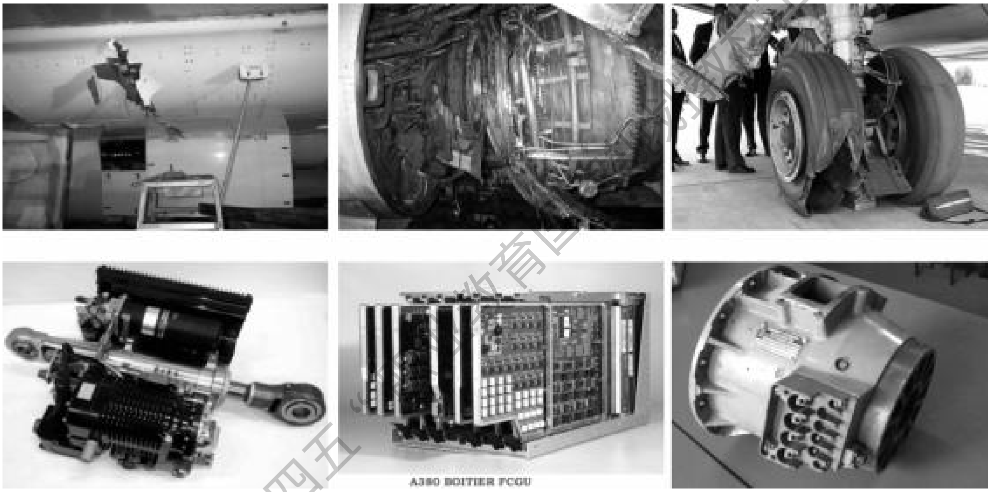


Figure 2.1－1　Typical components of six categories

(1) Aircraft structure, English code: STR;
(2) Aircraft power plant, English code: PWT;
(3) Aircraft landing gear, English code: LGR
(4) Aircraft mechanical accessories, English code: MEC;
(5) Aircraft avionics accessories, English code: AVC;
(6) Aircraft electric accessories, English code: ELC.

The authorization items of the license for the component maintenance personnel are classified in details in accordance with Annex Ⅷ of the Regulations, e. g. General Code Table for Aircraft Component Authorization Form (F66－8). The detailed requirements about the license for the component maintenance personnel please refer to Section 2.4.

New Words/ Phrases/ Expression

1. component [kəm'pəunənt] *n.* (机器,设备等)构成要素,零件,成分
2. requirement [ri'kwaiəmənt] *n.* 要求,必需品
3. classification [ˌklæsifi'keiʃn] *n.* 分等,分类;类别,等级
4. continued [kən'tinjuːd] *adj.* 连续不断的;继续不变的
5. airworthiness ['eəwəːðinəs] *n.* 适航性;适航
6. regulation [ˌregju'leiʃn] *n.* 规章,条例,规则,规定
7. category ['kætəgəri] *n.* 类别,种类
8. certification [ˌsəːtifi'keiʃn] *n.* 证明,证实,证书
9. encompass [in'kʌmpəs] *v.* 包括
10. verification [ˌverifi'keiʃn] *n.* 证实,核对(某事物);检查

11. compliant [kəm'plaiənt] *adj*. 顺从的,应允的
12. approve [ə'pruːv] *v*. 赞成,批准
13. implement ['impliment] *v*. 使(某事物)生效;履行,实施
14. avoid [ə'vɔid] *v*. 避免,预防
15. appliance [ə'plaiəns] *n*. 工具,器械,装置
16. install [in'stɔːl] *v*. 安装,安置
17. propeller [prə'pelə(r)] *n*. 推进器,螺旋桨
18. emergency [i'məːdʒənsi] *n*. 紧急状态
19. elimination [iˌlimi'neiʃn] *n*. 排除,除去
20. restoration [ˌrestə'reiʃn] *n*. 修复,整修
21. initial [i'niʃl] *adj*. 最初的,初步的
22. release [ri'liːs] *v*. 释放, 放行
23. manufacturer [ˌmænju'fæktʃərə] *n*. 制造商,制造厂;厂主,厂商
24. feedback ['fiːdbæk] *n*. 反馈;回复;自动调节
25. corrective [kə'rektiv] *adj*. 矫正的;修正的
26. applicable ['æplikəbl] *adj*. 适当的;可应用的
27. deficiency [di'fiʃənsi] *n*. 缺乏,不足;缺点,缺陷
28. modify ['mɔdifai] *v*. 修改;变更;改进
29. anticipate [æn'tisipeit] *v*. 预期,预料,预计
30. utilization [ˌjuːtilai'zeiʃθn] *n*. 利用,使用,效用
31. catastrophic [ˌkætə'strɔfik] *adj*. 灾难的;惨重的,悲惨结局的
32. failure ['feiljə] *n*. 失败,不及格;缺乏,不足
33. demonstrate ['demənstreit] *v*. 证明;论证;表明;说明
34. mandatory ['mændətəri] *adj*. 法定的,强制的
35. traceability [ˌtreisə'biləti] *n*. 可描绘,可描写,可追溯
36. monitor ['mɔnitə] *v*. 监控;监视;监督
37. significant [sig'nifikənt] *adj*. 重要的;有意义的
38. allocate ['æləkeit] *v*. 分配,分派;划拨
39. formulate ['fɔːmjuleit] *v*. 构想出,规划;阐述;用公式表示
40. administration [ədˌminis'treiʃən] *n*. 管理;实行;(法律的)施行
41. supervision [ˌsjuːpə'viʒən] *n*. 监督;管理;监督的行为或过程
42. grant [grɑːnt] *v*. 承认;同意,准许;授予
43. rating ['reitiŋ] *n*. 等级;评估,评价
44. solely ['səʊliː] *adv*. 唯一地;仅仅
45. domestic [də'mestik] *adj*. 家庭的,家的;国内的
46. respective [ris'pektiv] *adj*. 各自的,分别的
47. authorized ['ɔːθəraizd] *adj*. 权威认可的,审定的,经授权的
48. scope [skəup] *n*., *v*. (处理、研究事务的)范围;审视
49. fulfill [ful'fil] *v*. 履行,执行;达到;使结束

50. serviceable [ˈsəːvisəbəl] *adj*. 有用的，可供使用的
51. sufficient [səˈfiʃənt] *adj*. 足够的，充足的
52. endow [inˈdau] *v*. 捐赠，资助；赋予，赐予
53. pursuant [pəˈsjuːənt] *adj*. 追踪的，依照的
54. criteria [kraiˈtiəriə] *n*. （批评、判断等的）标准，准则
55. rectification [ˌrektifiˈkeiʃən] *n*. 矫正，纠正
56. warranty [ˈwɔrənti] *n*. 保证，担保
57. compensation [ˌkɔmpenˈseiʃən] *n*. 补偿，赔偿；修正
58. overhaul [ˌəuvəˈhɔːl] *n*. 修检，大修
59. restoration [ˌrestəˈreiʃən] *n*. （规章制度等的）恢复；复原
60. alteration [ˌɔːltəˈreiʃən] *n*. 变化，改变；变更
61. bound [baund] *v*.，*adj*. 给……划界，限制；有义务的
62. impose [imˈpəuz] *v*. 强制，实行；强加
63. capability [ˌkeipəˈbilitiː] *n*. 才能，能力；容量；性能
64. portion [ˈpɔːʃən] *n*. 一部分
65. license [ˈlaisəns] *n*. 许可证，执照；特许
66. accessory [ækˈsesəri] *n*.，*adj*. 附件；附加的，附属的

Notes

【1】But the repair work must be done under relative requirements which are ruled by ICAO, FAA, EASA, CAAC and other organizations.

分析：此句的“ICAO”是“International Civil Aviation Organization”的缩写形式，意思是“国际民用航空组织”；“FAA”是“Federal Aviation Administration”的缩写形式，意思是“美国联邦航空局”；“EASA”是“European Aviation Safety Agency”的缩写形式，意思是“欧洲航空安全局”；“CAAC”是“Civil Aviation Administration of China”的缩写形式，意思是“中国民用航空局”。

翻译：但是部件修理工作必须在国际民用航空组织、美国联邦航空局、欧洲航空安全局、中国民用航空局和其他单位规定的相关要求下进行。

【2】The repair under warranty claim for the brand-new OEM products or repair under compensation claim due to design and/or manufacturing fault provided by the aircraft component manufacturer falls outside the scope of maintenance so defined.

分析：此句的“OEM”是“Original Equipment Manufacturer”的缩写形式，意思是“原始设备制造商”“原制造厂家”；此句的“falls outside”应翻译出“超出”的意思。

翻译：航空器部件的原制造厂家的保修或者因设计制造原因的索赔修理不属于本规定所称的维修范围。

【3】The CAAC Headquarter Office or the CAAC RA may impose necessary limitations on the maintenance rating(s) as appropriate under the specific circumstances, including those limitations in terms of manufacturer, type, designation, etc. listed in “Maintenance Function and Maintenance Rating(s) Classification Table”, or any other limitations if the

CAAC feels necessary.

分析：此句中的"in terms of…"应翻译为"对……而言""就……来说"。

翻译：民航总局或者民航地区管理局可以根据具体情况对以上维修项目类别进行必要的限制，包括按本规定《维修工作和项目类别划分表》所列的对制造厂家、型号、名称等的限制或者民航总局认为必要的其他限制。

Exercises

Ⅰ. Translate the following sentences into Chinese:

1. Component repair is a kind of aviation maintenance work. It ensures continued airworthiness like other aviation maintenance work.

2. All the actions implemented after an incident/accident in order to avoid a reoccurrence of this incident/accident.

3. Maintenance tasks and the intervals at which these are to be performed, taking into account the anticipated utilization of the airplane.

4. Non-compliance may lead to suspend the validity of the continued airworthiness. As such, it is mandatory to ensure traceability and monitoring of these parts.

5. Maintenance organizations shall at all time take appropriate corrective actions to rectify any defects and deficiencies against this regulation to ensure continued compliance with the requirements of this regulation.

6. According to CCAR-145, "maintenance" means any inspection/test, repair, defect rectification, scheduled maintenance, overhaul and modification of aircraft and aircraft component.

Ⅱ. Fill in the following blanks according to the text:

1. According to the ________ of CAAC, component repair is ________ into six ________. And most components have ________ types of repairing in real maintenance work.

2. "Aircraft Component" means any ________ and ________ installed or to be installed on aircraft other than the aircraft ________, including the complete engine/APU, propeller and any ________/________ equipment, etc.

3. The ________ parts are those having not achieved tests and that have not been ________ to the full design goal and whose ________ could result in catastrophic failure of the airplane.

4. It is for the ________ of standardizing the ________ and ________ of civil aircraft maintenance and to ensure the continued ________ and flight ________ of civil aircraft.

5. Maintenance ________ of component are ________ into four types: ________, repair, ________ and ________.

Ⅲ. Answer the following question according to the text:

1. What is the continued airworthiness?

2. What is the definition of "repair"?

3. What are the requirements to the maintenance organization according to CCAR-145?

4. How is the basic portion of the license for the component maintenance personnel classified according to CCAR-66?

2.2　Component Work Flow

In accordance with CCAR-145, only when the component items of maintenance organization have been approved by CAAC, the maintenance shop can receive and repair those components. After repairing those components will be released to service.

When different components in the "CCAR-145 Component Capability List" are sent to the corresponding shop for repair, the basic requirements and procedures are same.

2.2.1　Component Maintenance Capability

Shops can only make application for component maintenance approval after verifying that the facilities, equipment, tooling, material, personnel, technical publications and job cards appropriate to the items to be applied are in place.

Notes:

(1) Technical publications can be provided by the company or made available when required by the work.

(2) Alternate tooling and equipment must be identified in the shop tooling/equipment list.

(3) Special tooling and equipment must be evaluated in accordance with FP2440-01 to ensure the equivalency.

(4) The corresponding drawing and documents must be kept for fabricated tooling/equipment that are not produced in accordance with the manufacturer's drawing.

(5) Special equipment of low use frequency or large investment can be rent or loaned, but its serviceability must be verified.

(6) When the maintenance item to be applied includes sub-contracted maintenance, the contracted maintenance item and the subcontractor must be listed in the company authorized List of Subcontractors.

Maintenance levels in component application are divided into four types: inspection, repair, overhaul and modification. Non-time-controlled components or components not required to be overhauled in the reference document shall not apply for "overhaul".[1]

When a component has been approved for "repair" or "overhaul" capability, the component is regarded to possess the authorization for "modification". Shop and shop inspector need not to apply for its modification capability approval as a new item. However, vendor SB (Service Bulletin) modification can not be carried out until shop has done an evaluation and verified that personnel, tooling, equipment and technical documents are available. Modification scheme not included in the vendor SB must be submitted to the airworthiness authorities for approval.【2】

In accordance with CCAR-145 and related functional procedures, the audit group performs on-site inspection per requirements detailed in the applicable current maintenance data, including working environment, special tools, fixtures and equipment list (Table 901 in CMM), material, personnel, technical publications and job cards required information, etc. of the newly-applied items and makes records on the "Aircraft Component Maintenance Capability evaluation Form" accordingly.

Upon receipt of the CCAR-145 Component Maintenance Substantiation and Validation Record approved by CAAC, Airworthiness Department will: ① Update the controlled "CCAR-145 Component Capability List"; ② Notify the Shop QC (quality control), Shop, Commercial Department, Library and Engineering about the approved "Component Maintenance Substantiation and Validation Record", relevant component repair and release can be performed.

2.2.2 The Receiving of Repairable Part

For rotable components removed from aircraft, mechanics shall send unserviceable components to the Material Department with a proper completed Unserviceable-Repairable Tag or an equivalent customer parts identification tag as required by the customer.

For rotable components removed from aircraft and independent components for repairing, Material Department checks the exterior of the components and the documents attached, and receive the components. The Material Department shall arrange the components to be returned or disposed per the customer request. If the customer requests a shop visit, then ship the components to the authorized maintenance organization. As for repairable parts delivered through cargo shipment by customer, the Material Department takes delivery of parts and passes them over to the shop PC (Production Control) for the shipment to the shop.

The shop PC checks the appearance of repairable parts, makes sure they are identical with the attached documents. Based on the Shop Capability List, the shop PC shall also check to find out whether parts are in the Capability List.

If parts are in the Capability List, the shop PC shall receive the parts in the management system as per customer's repair order and requirement. If parts are not in the List, CBC PC shall inform the shop sales personnel for assistance in writing, and return parts back to the original place where they are shipped.

The shop PC sends parts to the shops for repair with the following documents: ①Shop Work Order; ②A proper completed Unserviceable-Repairable Tag.

Issue the shop work order about the details job by the shop PC when implement aircraft extended item in shop. Use the workshop job card to record the step for the complexity project when necessary.[3]

Shops check and verify documents are correct, accept parts, generate work order and arrange repair.

If Shop work order with AD (Airworthiness Directive) review requirement, engineer should confirm the AD compliance status pertaining to the component first of all. If necessary, ask customer for assist. Relevant engineer should write the estimation result in the Shop work order. If the AD hasn't been performed before, workshop should inform the production controller immediately. Only after the customer agrees to perform the AD and the engineer provide component AD/SB worksheet can we go on with the maintenance.

Note: Shop PC shall ensure that the work order specifies the customer's component releasing requirement.

2.2.3 Shop Repair

As per the requirement of work order, mechanic shall complete the inspection, repair, overhaul and modification of part according to CMM (Component Maintenance Manual) and relevant documents.

Shop Work Requirements are as follow:

(1) Workshops are demanded to begin the work task as soon as possible. They should draw the parts that need to be replaced from Material Department and order those in shortage correctly in time so as to avoid second purchase.

(2) Workshops should pay more attention to such components owned by only one customer that two or more with same P/N are sent to workshop for repair at the same time. If necessary, workshop should repair some of them as prior as urgent parts. And arrange workers for working plan.[4]

(3) Worker shall record actual main work stages of the maintenance component or troubleshooting such as repeated disassembly or check or assembly or test as failing to pass test after first repair process record sheet. Not applicable section shall be lined with bias.

Details of Work Process are as follow:

(1) Confirming: Confirm whether the part number and serial number recorded in the Shop Work Order and Job card are the same as the component. In case of any mistake inform the production controller to correct it. Confirm whether the Rev. No. and content of the job card is in accordance with CMM. In case of any mistake inform the production controller.

And then the production controller should inform the authorized engineering personnel to correct it. Check corresponding "Post Certificate". Anyone without the authorization of the component is prohibited from signing off or stamping in related Job card. Furthermore such personnel should perform the repair only under the guidance of an employee who is authorized.

(2) Pre-test: Perform pre-test according to CMM and record the data in detail for further reference.

(3) Disassembling: Perform disassembling according to the situation of pre-test and CMM. Note the use of special tools and do not damage components and parts.

(4) Cleaning: Perform cleaning to the disassembled parts according to CMM. Note the use of cleaning materials and clean after classification in order to avoid damaging components and parts.

(5) Checking: Perform visual inspection and detailed inspection to the parts according to CMM after cleaning, and must record checking results in job cards.

(6) Repairing: Perform repairing according to repair methods that are recommended by CMM. Do not repair beyond allowance of CMM freely. Make sure all the repair work is in accordance with the certification requirement of the airworthiness authority.

(7) In case of any abnormal condition during above procedures, take a photo, report by "Component Abnormal Condition Report" to production controller or sale department, manager in writing by a uniform workshop report and save it.

(8) Replacement: Go to the Material Department and fetch the parts. Confirm the parts are the products of the original manufacturer and the part numbers are the exact ones provided in CMM. Replacing of all life limit parts when no satisfactory evidence of life used is available and/or the parts are in an unsatisfactory condition. Record replacement parts to ensure parts traceability checks.

(9) Assembling: Perform this job strictly according to CMM. Note assembled techniques, dimensional requirements, partial calibrations and relevant checkpoints.

(10) Final test: Perform functional tests to whole components strictly according to CMM. Make sure they can pass each requirement of test. In case of failure analyze and judge the cause of the failure and return to the disassembly, cleaning, check and repair steps.

(11) Completion: Lockwire the screws, cap the ports and pack the component. The additional parts of the component should be packed in too if necessary. Place tools, special tools back to their primary location and check the tool cabinet and test bench. Recover the test bench to available status.

2.2.4 Release of Component Repair

On completion of maintenance work on the aircraft component, the maintenance release certificate shall be issued by the certifying staff in such a way that is approved or accepted by the CAAC. The release of aircraft components shall be in the form of the ARC (Authorized Release Certificate)/AAT (Airworthiness Approval Tag) issued by the certifying staff so authorized by the maintenance organization.

Worker submits the completed Job Card, Shop Visit Report and Shop Work Order to certifying staff. The compliance status of the AD should be recorded at the Shop Visit Report and corresponding ARC/AAT.

Authorized certifying staff shall issue an ARC/AAT and Serviceable Tag to release part. Before releasing, authorized certifying staff must make sure that repair work and the following documents are properly completed:

(1) Shop Job Cards;

(2) Serviceable Tag;

(3) Shop Visit Report;

(4) ARC/AAT.

Note: When the component is used for another complete maintenance in its own facilities and ARC/AAT is not required by the customer, the component may be released by the Serviceable Tag only (see Figure 2.2-1).

Figure 2.2-1　A Component with the Serviceable Tag

2.2.5　Sending & Shipping of Components

Place the completed components with corresponding Serviceable Tags (original), Shop Visit Reports (original) and Authorized Releasing Certificate/Airworthiness Approval Tags (original) on the "Serviceable Component Shelf" for deliveryman. Shop deliveryman sends component with all necessary documents to shop PC person and ask the person to sign on the list.

If the repaired component is for installation on aircraft undergoing hangar maintenance, shop PC shall immediately return the part to the Material Department with the following documents:

(1) Shop Visit Report;

(2) ARC/AAT;

(3) Serviceable Tag.

If the customer requires returning back through domestic shipment, shop PC shall pack the part properly and ship back as per customer's requirement with the above documents.

If the component needs to be shipped oversea, shop PC shall deliver the properly packed part and related documents to the Material Customs Group, who will then arrange the shipment.

Shop PC makes a record for all parts back to the customers for follow-up purpose.

Workshop Component Controlled Flow Chart is shown in Figure 2.2-2.

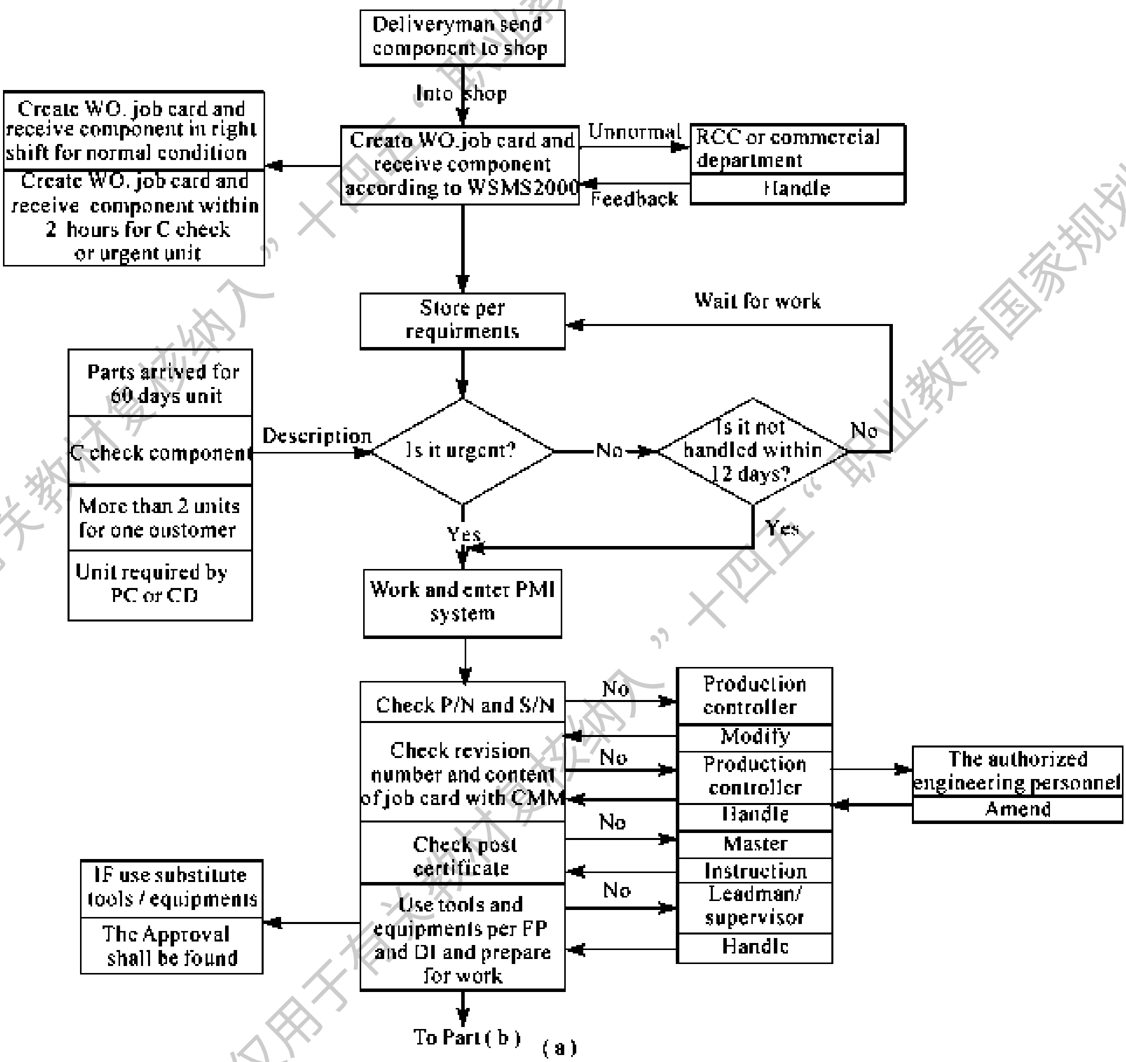
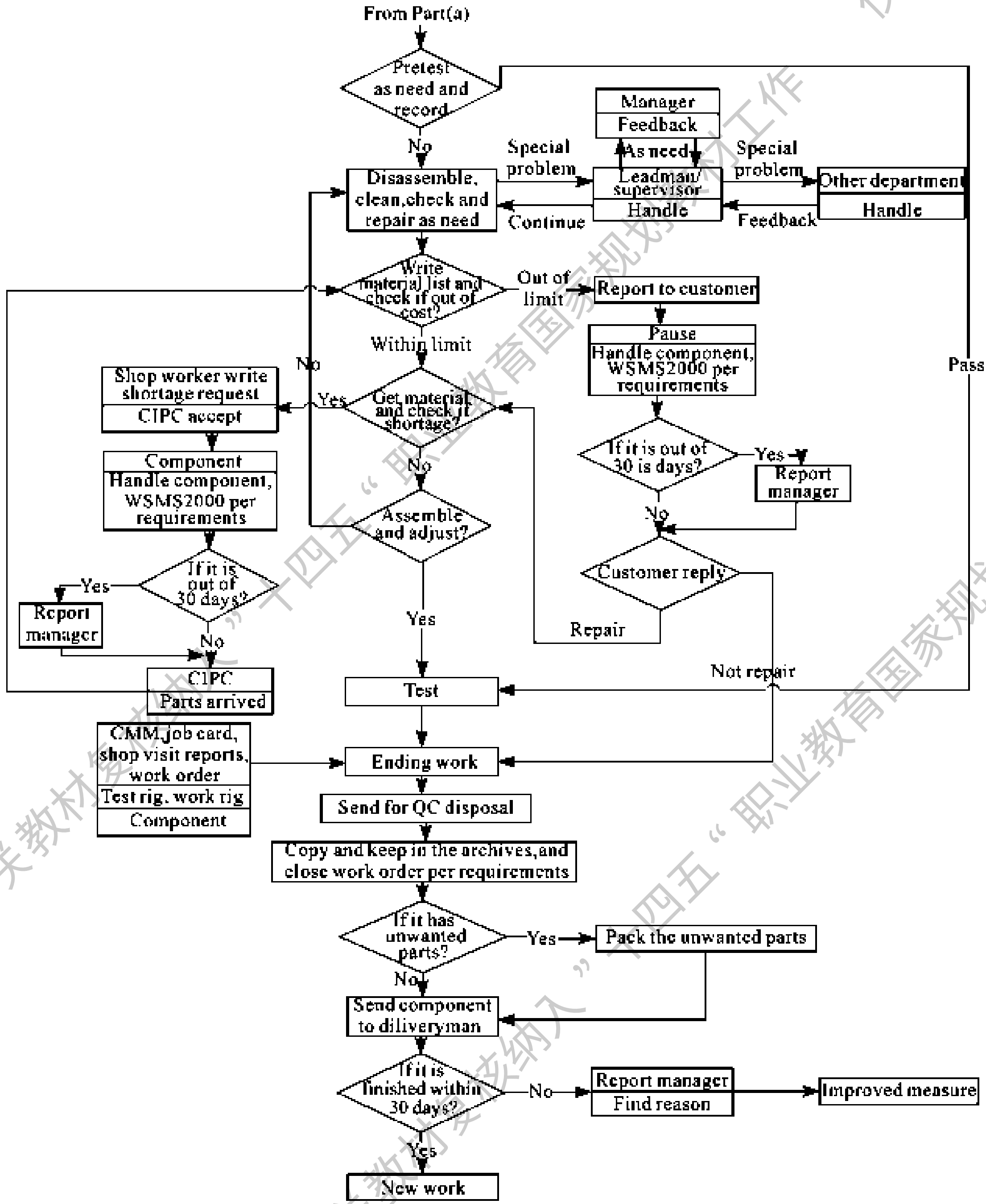


Figure 2.2-2 Workshop component controlled flow chart



(b)

Continued Figure 2.2－2　Workshop component controlled flow chart

New Words/ Phrases/ Expression

1. corresponding [ˌkɔrisˈpɔndiŋ] *adj*. 相当的，对应的
2. procedure [prəˈsiːdʒə] *n*. 程序，手续；工序，过程，步骤

3. application [ˌæpliˈkeiʃən] *n*. 适用,应用,运用;申请,请求
4. available [əˈveiləbl] *adj*. 可用的;有空的
5. identify [aiˈdentifai] *v*. 识别,认出;确定
6. evaluate [iˈvæljueit] *v*. 评价,评估
7. equivalency [iˈkwivələnsi] *n*. 相等,等价
8. fabricate [ˈfæbrikeit] *v*. 制造;装配
9. frequency [ˈfriːkwənsi] *n*. 频繁性;频率
10. investment [inˈvestmənt] *n*. 投资,投入
11. inspector [inˈspektə] *n*. 检查员,检察官
12. vendor [ˈvendə] *n*. (正式)供应商,厂家
13. scheme [skiːm] *v*., *n*. 策划;计划;体系
14. audit [ˈɔːdit] *v*., *n*. 审计,审核
15. current [ˈkʌrənt] *adj*. 现在的;最近的
16. fixture [ˈfikstʃə] *n*. 装置,定设施
17. accordingly [əˈkɔːdiŋli] *adv*. 因此;依据;照着,相应地
18. substantiation [səbˌstænʃiˈeiʃən] *n*. 证实,证明
19. validation [væliˈdeiʃən] *n*. 确认
20. tag [tæg] *n*. 标签;标牌
21. dispose [disˈpəuz] *v*. 处理,处置;安排
22. deliver [diˈlivə] *v*. 递送;投递;运送
23. cargo [ˈkaːgəu] *n*. (船或飞机装载的)货物
24. shipment [ˈʃipmənt] *n*. 装运;运输
25. original [əˈridʒinəl] *adj*., *n*. 原始的;最初的;原文;原件
26. issue [ˈisjuː] *v*. 发行;签发
27. complexity [kəmˈpleksitiː] *n*. 复杂性;复杂的事物
28. pertain [pəˈtein] *v*. 与……相关;属于;适用(于)
29. estimation [ˌestəˈmeiʃən] *n*. 估计;评价;判断
30. shortage [ˈʃɔːtidʒ] *n*. 不足,缺点;缺少
31. prior [ˈpraiə] *adv*. 在前;居先
32. urgent [ˈəːdʒənt] *adj*. 急迫的;紧急的
33. bias [ˈbaiəs] *n*. 倾向;斜线
34. prohibit [prəˈhibit] *v*. 禁止,阻止,防止;不准许
35. analyze [ˈænəlaiz] *v*. 分析;解释

Notes

【1】Non-time-controlled components or components not required to be overhauled in the reference document shall not apply for "overhaul".

分析:此句的"Non-time-controlled"可翻译成"非时控的";"apply for"是"申请"的意思。

翻译:对于非时控件或者其依据文件中没有翻修依据的部件不用申请"翻修"。

【2】However, vendor SB(Service Bulletin) modification can not be carried out until shop has done an evaluation and verified that personnel, tooling, equipment and technical documents are available. Modification scheme not included in the vendor SB must be submitted to the airworthiness authorities for approval.

分析：此句的"However"之后应翻译出转折的意思。

翻译：但车间及车间检验必须对厂家服务通告改装能力进行评估，只有在人员/工具/设备/技术文件都具备条件时，方可实施。超出厂家服务通告范围的改装方案必须报适航当局审批。

【3】Issue the shop work order about the details job by the shop PC when implement aircraft extended item in shop. Use the workshop job card to record the step for the complexity project when necessary.

分析：此句的"Issue"是"发行、开出"的意思；"extended"应翻译为"延伸的"。

翻译：飞机维护延伸至车间工作的项目，车间生产控制可以开出车间工作指令表，用于明确车间需要执行的工作内容。对于工作内容复杂的项目，按需采用车间工卡记录工作步骤。

【4】Workshops should pay more attention to such components owned by only one customer that two or more with same P/N are sent to workshop for repair at the same time. If necessary workshop should repair some of them as prior as urgent parts. And arrange workers for working plan.

分析：此句的"pay more attention to"是"更加关注"的意思；"prior"应翻译为"优先"。

翻译：车间要关注同一客户送修两件或两件以上相同件号的部件，如有需要应先修理一部分急件，并做好人员计划安排。

Exercises

Ⅰ. Translate the following sentences into Chinese:

1. Shops can only make application for component maintenance approval after verifying that the facilities, equipment, tooling, material, personnel, technical publications and job cards appropriate to the items to be applied are in place.

2. When a component has been approved for "repair" or "overhaul" capability, the component is regarded to possess the authorization for "modification". Shop and shop inspector need not to apply for its modification capability approval as a new item.

3. For rotable components removed from aircraft and independent components for repairing, Material Department checks the exterior of the components and the documents attached, and receive the components.

4. The shop PC checks the appearance of repairable parts, makes sure they are identical with the attached documents. Based on the Shop Capability List, the shop PC shall also check to find out whether parts are in the Capability List.

5. Workshops are demanded to begin the work task as soon as possible. They should draw the parts that need to be replaced from Material Department and order those in shortage correctly in time so as to avoid second purchase.

6. Authorized certifying staff shall issue an ARC/AAT and Serviceable Tag to release

part. Before the releasing, authorized certifying staff stall must make sure the repair work and the following documents are properly completed.

Ⅱ. Fill in the following blanks according to the text:

1. In ________ with CCAR-145, only when the component items of maintenance organization have been ________ by CAAC, the maintenance shop can receive and repair those components. After ________ those components will be ________ to service.

2. For ________ components removed from aircraft, Mechanics shall send unserviceable components to the ________ Department with a proper completed Unserviceable-Repairable ________ or an ________ customer parts identification tag as required by the customer.

The shop PC sends parts to the shops for repair with the following documents: ①Shop ________; ②A proper completed ________ Tag.

3. Worker shall record ________ main work stages of the maintenance component or ________ such as repeated disassembly or check or assembly or test as failing to ________ test after first repair process record sheet. Not ________ section shall be lined with ________.

4. If the component needs to be shipped ________, shop PC shall deliver the properly ________ part and ________ documents to the Material ________ Group, who will then ________ the shipment.

Ⅲ. Answer the following question according to the text:

1. How many types are maintenance levels in component application divided into?

2. What will Airworthiness Department do when they receive the receipt of the CCAR-145 Component Maintenance Substantiation and Validation Record approved by CAAC?

3. What should the shop PC do when they check to find out some parts are in the Capability List and some not?

4. If the AD of the component hasn't been performed before, what should the workshop do?

5. What are the details of work process for components maintenance?

6. Which documents should be made sure that are properly completed by authorized certifying staff before releasing?

2.3 Manuals and Documents

Compliance with the above mentioned requirements is shown through establishment and approval of several manuals and documents. These data may be incorporated in the general information of the aircraft components in different ways according to the practices of each manufacturer however they shall be clearly identifiable.

It contents many detailed information about the description of the aircraft component, its structure and its function. It also provides instructions as testing, disassembling, cleaning, checking, repairing, replacing of parts, assembling, and application of special inspection techniques.

2.3.1 Types of Airworthiness Data

The maintenance organization shall keep the following manuals and documents related to the civil aircraft component maintenance.

(1) The civil aviation regulation of the People's Republic of China, Civil Aviation Administration Procedure, Advisory Circulars, administration documents and other documents regarding the civil aircraft component maintenance issued by the CAAC, including the relevant national standards quoted in the aforementioned documents;

(2) The relevant airworthiness data prescribed by the civil aircraft component manufacturer(s) or other documents approved or accepted by the CAAC which are necessary for the maintenance work, including all kinds of manuals, documents, service bulletins, service letters as well as the relevant international or industrial standards quoted in the aforementioned documents;

(3) The relevant documents provided by the "job sender" pursuant to the maintenance rating (s)/item (s) specified in the maintenance contract, including the operator's maintenance program, manual and worksheet, etc.[1]

2.3.2 Management of Airworthiness Data

The maintenance organization shall fulfill the following requirements to establish the effective control over the airworthiness data to ensure the airworthiness data is valid and ready for use.

(1) The maintenance organization shall keep the master of the airworthiness data under centralized control, establish a relevant management procedure to control the airworthiness data effectively and ensure the distributed copies are identical to the master. An effective backup system shall be available when using a computer system to save airworthiness data.

(2) The maintenance organization shall review the index of the valid airworthiness data catalog issued by the publisher periodically or check with the publisher directly to verify the status of validity of the airworthiness data. In the case that the validity of the airworthiness data in use is controlled by the "job sender", the maintenance organization shall obtain of a formal statement on validity of the airworthiness data from the "job sender" prior to the use.

(3) The non-valid airworthiness data and other uncontrolled reference data shall be distinctively marked and segregated to avoid being mixed up with the valid and controlled airworthiness data.[2]

(4) The maintenance organization shall ensure that the maintenance personnel can readily get access to the necessary airworthiness data for the maintenance, and the necessary reading device so required shall be provided.

2.3.3 Introduction of CMM

Components maintenance work must be done according to CMM. And CMM is the most important reference data of all. Each component has its own CMM. Most parts have their CMMs together with IPL(Illustrated Parts List). This kind of situation is written or called as "CMM&IPL". Because some parts are very complicated, they have their separated IPC (Illustrated Parts Catalog) (see Figure 2.3-1).

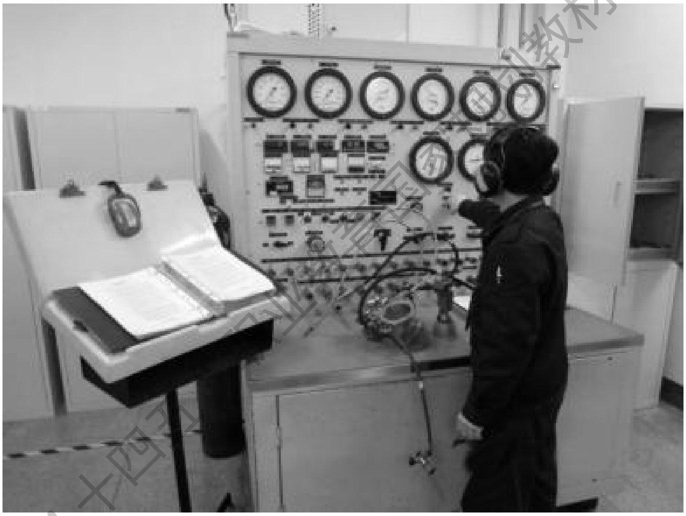


Figure 2.3-1 Testing components per CMM

CMM can provide very many detailed information for components maintenance, including component structure, working description, all kinds of repair procedures and information for parts replacement. Besides, it also has some useful figures and tables. Though parts are different and variable, their CMMs are still similar in compiling.[3]

So let us see the compiling structure of CMM. We can see the structure from content of CMM. Components vendors are different, but they write CMMs as a fixed rule. The rule is that a CMM must include title page, record of revisions, record of temporary revisions, service bulletin list, list of effective pages, table of contents, list of illustrations, introduction, description and operation, testing and fault isolation, disassembly, cleaning, inspection/check, repair, assembly, fits and clearances (except for most avionics components), special tools, fixtures and equipment, storage and IPL. In addition, IPL has its instruction, alpha/numeric index, vendor codes and detailed parts list.

The page range also has a fixed rule just like PB (page block) of AMM (aircraft maintenance manual). The page range started from "1" is for testing and fault isolation. The page range started from "2" is for automatic test requirements. The page range started from "3" is for disassembly. The page range started from "4" is for cleaning. The page range started from "5" is for check. The page range started from "6" is for repair. The page range started from "7" is for assembly. The page range started from "8" is for fits and clearances. The page range started from "9" is for special tools, fixtures and equipment. The page range started from "10" is for IPL. This rule makes the usage of CMM easier and it is helpful to our maintenance work.

The instruction part of each CMM can tell you how to use this manual. We see an example of BLEED VALVE (Part Number: 6774E Series):

(1) Make sure that the manual contains the applicable data for your component. Look for the part number on the Title Page.

(2) To identify a part or to find a part number, refer to the IPL, which has an Introduction to show the procedure.

(3) You must use the instructions in this manual for all the maintenance steps of a component. Read all the applicable WARNINGS and CAUTIONS before you do the work on the component.

(4) When you use consumable materials, these materials are identified by a code number from a list in the Consumable Materials Table.

(5) When you use special tools, these tools are identified by a code number which is in a list in the Special Tools Table.

(6) For the tightening torque values of the parts, refer to the Table of Tightening Torques.

The instruction part of each IPL can tell you how to use this IPL. We also see the example of BLEED VALVE (Part Number: 6774E Series):

(1) You can find the illustration for a part, if you know the part number. Refer to the Numerical Index and look for the part number and the related figure and item number. Refer to the Detailed Parts List and look for the first figure and item number found in the Numerical Index for this part. It is possible that this figure shows the part in a section or a system of the component other than the one necessary. If it does, refer to the other figure numbers which are given in the Numerical Index.

(2) To determine the part number of a given part, refer to the illustration which shows the assembly with this part. Record the item number of the illustrated part and refer to the Detailed Parts List, which gives its part number and its description.

For customer convenience, CMM is available in both electronic copy and hardcopy forms. The manual for release to service of the component shall be the electronic copy published on the library server. Before using the hardcopy manual for maintenance, users shall check the electronic copy published on the library server and make sure that the hardcopy manual and the electronic one are at the same revision. Use the electronic copy published on the library server when new revision of the hardcopy manual has not been completed within required time limit.

2.3.4 ATA Specification 100

The ATA (Air Transport Association of America) issued specifications for the organization of manufactures technical data. The ATA specification calls for the organization of an aircraft's technical data into individual systems which are numbered. Each system also has provisions for subsystem numbering.[4] For example: all of the technical information on the Fire Protection system has been designated as Chapter 26 under the ATA 100 specifications, with fire detection equipment further identified by the sub-chapter number 2610, and fire extinguishing equipment as 2620. Because of this specification, maintenance information for all transport aircraft is arranged in the same way (see Figure 2.3-2).

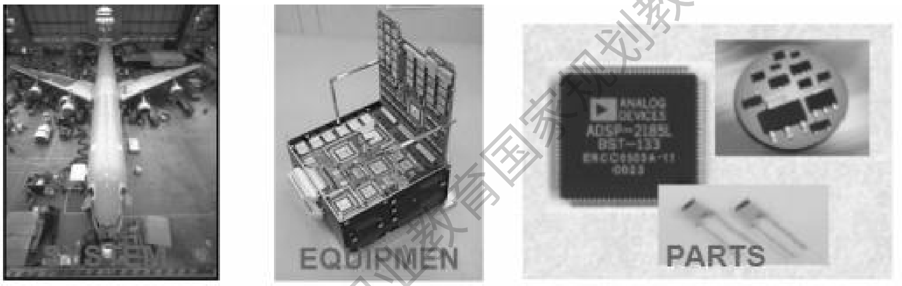


Figure 2.3-2 System, equipment and parts

General aviation aircraft and aircraft component manufactures are in the process of standardizing their maintenance information and ATA Specification 100 will be used as the format for this standardization. The CMM developed in accordance with ATA Specification 100 provide procedures for component maintenance. Each CMM has its corresponding ATA number. For example, the ATA number of the CMM for bleed valve (Part Number: 6774E Series) is 36-11-06.

In accordance with ATA-100, the CMM is divided into chapters and groups of chapters. These represent a functional break-down of the airplane and its systems. And each page of CMM is identified by a three element number. The first element is the chapter number representing the functional system of the airplane. The second element identifies a section or sub-system of this chapter. And the third element identifies a subject or the component within the same system. From the experiences with ATA numbering system, you may know that information related to air-conditioning is located in chapter 21. All ATA chapter classifications are shown in Attachment 2.3-1.

2.3.5 Introduction of AD/SB

When an unsafe condition exists with an aircraft, engine, propeller, or accessory, the airworthiness administration issues an AD (Airworthiness Directive) to notify concerned parties of the condition and to describe the appropriate corrective action. No person may operate an aircraft to which an AD applies, except in accordance with the requirements of that AD. AD compliance is mandatory, and the time in which the compliance must take place is listed within the AD. Information provided in an AD is considered approved data for the purpose of the AD. The compliance record for ADs must be entered into the aircraft's permanent records.

ADs are issued biweekly. The biweekly listings are published for small general aviation aircraft and accessories in one volume, while the large aircraft and their accessories are published in a separate volume. This separation of different aircraft categories provides operators with a much simpler means of filing ADs.

One way that manufactures communicate with aircraft owners and operators is through SBs(Service Bulletins). SBs are issued to inform aircraft owners and technicians of possible design defects, modifications, servicing changes, or other information that may be useful in maintenance an aircraft or component. Generally SBs are not mandatory. Whether they are done or not depends on owners. On occasion, SBs are made mandatory and are incorporated into ADs to correct an unsafe condition.

2.3.6 Workshop Job Card & AD/SB Worksheet

The compilation, revision and approval of the Workshop Job Card and AD/SB worksheet ensure that the Workshop Job Card and AD/SB worksheet properly record the necessary steps in component repair or modification.

Workshop Job Cards and AD/SB worksheets are used as maintenance record for recording the sequences and steps in component repair. They are not the guidance for mechanics to carry out the maintenance.[5] The component must be repaired in accordance with applicable maintenance data described above.

The Workshop Job Card and AD/SB worksheet shall be developed based on the maintenance data and the customer's requirements as applicable.

Note: The maintenance data includes but is not limited to the Component Overhaul Manual (OHM), Component Maintenance Manual (CMM), Engine Manual (EM), Wiring Diagram Manual (WDM), Illustrated Parts Catalogue (IPC), Structure Repair Manual (SRM), AD/CAD, SB/SL and any other data that approved by the applicable regulatory authorities.

Workshop Job Cards shall be developed and approved by personnel granted with Job Card writing and approval authority. Personnel who are granted with both task card writing & approval authority cannot write and approve the same task card.

The Workshop Job Card and AD/SB worksheet shall be written in both Chinese and English language. Content of Job Card includes:

(1) Generally, the Job Card shall include the major steps, such as: Pre-test, disassembly, cleaning, test, check, repair, assembly, and test.

(2) The referenced manual chapters and page number for the major steps carried out accordingly shall be quoted. In case alternative tools/equipment is used, reference to the "Alternative Tools & Equipment Illustration Manual" shall be identified.

(3) A mechanic signature block shall be provided for each major step. An additional inspector signature block shall be proved for Check, Repair, Assembly and Test steps as well.

(4) The serial number of work steps in the Job Cards shall be continuous.

(5) The measurement unit shall be provided if the test result is required to be recorded.

The Workshop Job Card and AD/SB worksheet routine revision is based upon the amendment of the applicable manuals. The technical process supervisor shall ensure the Job Card and AD/SB worksheet be revised in a timely manner starting from the date of the manual amendment or the temporary revision is received. The Job Card and AD/SB worksheet revision number shall be upgraded if any routine revisions are incorporated.

Note: In case that temporary revision or the manual is revised and the Job Card based on the old manual is being used in the workshop, the workshop shall inform the technical process engineer who shall determine the impact on the undergoing repair caused by the new changes. In case the changes do not affect the repair, the old version of Job Card may be used until the completion of the affected component repair. However in such case, the affected component shall be released to service per the newly revised manual. If the manual changes affect the repair, the old version of Job Card shall be used after a temporary revision or replaced by the updated Job Card.

New Words/ Phrases/ Expression

1. compliance [kəm'plaiəns] *n.* 服从,听从;承诺
2. technique [tek'niːk] *n.* 技巧;方法;工艺
3. circular ['səːkjulə] *n.*, *adj.* 通知,通告;圆形的;环行的
4. quote [kwəut] *v.* 引用;报价
5. aforementioned [ə'fɔː ˌmenʃənd] *adj.* 上述的;前述的
6. pursuant [pə'sjuːənt] *adj.* 追踪的,依照的
7. fulfill [ful'fil] *v.* 履行;执行
8. distribute [dis'tribjuːt] *v.* 分配,散布;散发,分发
9. catalog ['kætələg] *n.* 目录;登记
10. illustrated ['iləstreitid] *adj.* (用图等)说明的,图解的
11. separated ['sepəreitid] *adj.* 分开的
12. fixed [fikst] *adj.* 固定的,不变的
13. revision [ri'viʒən] *n.* 修订,修改
14. temporary ['tempərəri] *adj.* 临时的,暂时的
15. effective [i'fektiv] *adj.* 有效的;起作用的
16. clearance ['kliərəns] *n.* 空隙,间隙
17. consumable [kən'sjuːməbl] *adj.* 消耗性的
18. convenience [kən'viːnjəns] *n.* 方便,便利
19. hardcopy ['haːd'kəpi] *n.* 硬拷贝
20. specification [ˌspesifi'keiʃən] *n.* 规范,规格
21. provision [prə'viʒən] *n.* 规定,条项,条款
22. subsystem ['sʌbsistəm] *n.* 子系统,分系统
23. extinguish [iks'tiŋgwiʃ] *v.* 熄灭(火)

24. standardize [ˈstændəˌdaiz] *v.* 使标准化；用标准校检
25. element [ˈelimənt] *n.* 成分,组成部分
26. mandatory [ˈmændəˌtəːriː] *adj.* 强制性的;法定的;义务的
27. permanent [ˈpəːmənənt] *adj.* 永久(性)的,永恒的
28. biweekly [baiˈwiːkli] *adv.* 两周一次地,双周地
29. volume [ˈvəljuːm] *n.* 卷,册
30. occasion [əˈkeiʒən] *n.* 机会；场合；理由；需要
31. sequence [ˈsiːkwəns] *n.* 序列；顺序
32. guidance [ˈgaidəns] *n.* 指导,引导
33. grant [grɑːnt] *v.* 承认；同意；准许；授予
34. continuous [kənˈtinjuəs] *adj.* 连续的；延伸的
35. amendment [əˈmendmənt] *n.* (法律、文件的)改动；修改
36. upgrade [ˌʌpˈgreid] *v.* 改良;更新;升级

Notes

【1】The relevant documents provided by the "job sender" pursuant to the maintenance rating (s)/item (s) specified in the maintenance contract, including the operator's maintenance program, manual and worksheet, etc.

分析:此句的"operator"可翻译成"航空营运人"。

翻译:由送修人按照维修合同中的维修项目提供有关资料,包括航空营运人的维修方案、手册和工作单卡等。

【2】The non-valid airworthiness data and other uncontrolled reference data shall be distinctively marked and segregated to avoid being mixed up with the valid and controlled airworthiness data.

分析:此句的"non-valid"意思是"非现行有效的"。

翻译:非现行有效的适航性资料及其他非控制性的参考资料应当与现行有效的适航性资料明确地区分标识并避免混放。

【3】Besides, it also has some useful figures and tables. Though parts are different and variable, their CMMs are still similar in compiling.

分析:此句的"besides…"是"除……之外还有"的意思;"similar"应翻译为"相似的"。

翻译:除此之外,CMM 还有一些有用的图和表。虽然部件是千变万化的,但是它们的 CMM 在编排上是相似的。

【4】The ATA specification calls for the organization of an aircraft's technical data into individual systems which are numbered. Each system also has provisions for subsystem numbering.

分析:此句的"call for"是"要求"的意思;"individual"应翻译为"单独的"。

翻译:ATA 规范要求一架飞机的技术资料必须归类到被编号的单独系统。每个系统也有为子系统编号的规定。

【5】Workshop Job Cards and AD/SB worksheets are used as maintenance record for recording the sequences and steps in component repair. They are not the guidance for mechanics to carry out the maintenance.

分析:此句的"be used as"是"用作、用于"的意思;"carry out"应翻译为"进行、开展"。

翻译:车间工卡及AD/SB工作记录单仅用于记录部件维修的工作顺序和步骤,不作为指导工作者进行维修的依据。

Exercises

Ⅰ. Translate the following sentences into Chinese:

1. It contents many detailed information about the description of the aircraft component, its structure and its function. It also provides instructions as testing, disassembling, cleaning, checking, repairing, replacing of parts, assembling, and application of special inspection techniques.

2. The maintenance organization shall fulfill the following requirements to establish the effective control over the airworthiness data to ensure the airworthiness data is valid and ready for use.

3. Before using the hardcopy manual for maintenance, users shall check the electronic copy published on the library server and make sure that the hardcopy manual and the electronic one are at the same revision.

4. Because of this specification, maintenance information for all transport aircraft is arranged in the same way.

5. No person may operate an aircraft to which an AD applies, except in accordance with the requirements of that AD. AD compliance is mandatory, and the time in which the compliance must take place is listed within the AD.

6. Workshop Job Cards shall be developed and approved by personnel granted with job card writing and approval authority. Personnel who are granted with both task card writing & approval authority cannot write and approve the same task card.

Ⅱ. Fill in the following blanks according to the text:

1. The relevant ________ data prescribed by the civil aircraft component manufacturer(s) includes all kinds of ________, documents, ________, and service letters as well as the relevant international or industrial ________.

2. An effective ________ system shall be ________ when using a computer system to save airworthiness data.

3. For customer ________, CMM is available in both ________ copy and ________ forms. The manual for ________ to service of the component shall be the electronic copy published on the ________ server.

4. In accordance with ________, the CMM is divided into ________ and groups of chapters. These represent a functional ________ of the airplane and its ________.

5. SBs are issued to inform aircraft ________ and ________ of possible design ________, ________, servicing ________, or other information that may be ________ in maintenance an

aircraft or component.

Ⅲ. Answer the following question according to the text:

1. What are the types of Airworthiness Data? What do they include?
2. What is the compiling structure of CMM? What is each page range used for?
3. How can we use CMM&IPL?
4. What does the three element number of CMM identify?
5. What's the difference between AD and SB? And why?
6. What does the content of Job Card include? When will the Job Card be revised?

Attachment 2.3-1 is shown in Table 2.3-1.

Table 2.3-1 ATA Chapter

Item	ATA Chapter	Title
Aircraft System	21	Air Conditioning
	22	Auto Flight
	23	Communications
	24	Electrical Power
	25	Equipment/Furnishings
	26	Fire Protection
	27	Flight Controls
	28	Fuel
	29	Hydraulic Power
	30	Ice and Rain Protection
	31	Indication/Recording Systems
	32	Landing Gear
	33	Lights
	34	Navigation
	35	Oxygen
	36	Pneumatic
	37	Vacuum/Pressure
	38	Water/Waste
	39	Panels and Multipurpose Components
	41	Water Ballast

Continued

Item	ATA Chapter	Title
Aircraft System	44	Cabin Systems
	45	Central Maint. System
	46	Information Systems
	49	Airborne Aux. Power
	50	Cargo and Accessory Compartments
Structure	52	Doors
	53	Fuselage
	54	Nacelles/Pylons
	55	Stabilizers
	56	Windows
	57	Wings
Propeller/Rotor	61	Propellers
	62	Rotor(s)
	63	Rotor Drive(s)
	64	Tail Rotor
	65	Tail Rotor Drive
	66	Folding Blades/pylon
	67	Rotors Flight Control
Power Plant	71	Power Plant
	72	Engine
	73	Engine Fuel & Control
	74	Ignition
	75	Bleed Air
	76	Engine Controls
	77	Engine Indicating
	78	Engine Exhaust
	79	Engine Oil
	80	Starting
	81	Turbines (Reciprocating Eng.)

Continued

Power Plant	82	Water Injection
	83	Remote Gear Boxes (Eng. Dr.)
	84	Propulsion Augmentation

2.4 License for the Component Maintenance Personnel

In accordance with CCAR Part 66: "Management Rule of Civil Aircraft Maintenance Personnel License", licenses and certificates for civil aircraft maintenance personnel include the following two types:

(1) The license for the civil aircraft maintenance personnel;

(2) The license for the civil aircraft component maintenance personnel.

Here we will learn the license for the civil aircraft component maintenance personnel in detail.

2.4.1 Categories and Types of License for the Component Maintenance Personnel

The license for the civil aircraft component maintenance personnel (referred to as the license for the component maintenance personnel) shall includes the basic portion and authorization list portion.

Component maintenance personnel shall, through examinations, obtain the basic portion of the license in question. The basic portion of the license in question may be issued without any authorization items. Applicants for the authorization items of the license in question shall obtain the basic portion first.[1]

The basic portion of the license for the component maintenance personnel are classified in accordance with the following categories:

(1) Aircraft structure, English code: STR;

(2) Aircraft power plant, English code: PWT;

(3) Aircraft landing gear, English code: LGR;

(4) Aircraft mechanical accessories, English code: MEC;

(5) Aircraft avionics accessories, English code: AVC;

(6) Aircraft electric accessories, English code: ELC.

The authorization items of the license for the component maintenance personnel are classified in accordance with Annex Ⅷ of the Regulations: General Code Table for Aircraft Component Authorization Form (F66-8).[2] (Note: This form is too detailed to mention in this text.)

2.4.2 Application Requirements on the Basic Portion

Applicants for the license for the component maintenance personnel shall comply with the following requirements:

(1) Being not less than 18 years old and in healthy conditions;

(2) Having at least one of the following experiences:

1) They shall have diplomas issued by technical secondary schools or educational institute of higher levels with the majors relevant to aviation technology, have the experience of being engaged independently in the aircraft component maintenance work consistent with the respective categories for which they apply for more than two years in total (including two years) and, in addition, and have been engaged in the aircraft component maintenance work consistent with the categories concerned during the one year prior to the date of application.[3]

2) They shall have at least three years' engagement (accumulative) in the specific aircraft component maintenance work consistent with the categories for which they respectively apply. They shall have been continuously engaged in the work for the one year prior to the date of application.

3) They shall have received training from training organizations approved by CAAC and obtained the certificate of completion for basic knowledge training of the categories they respectively apply for.

4) They shall be capable of reading and writing relevant technical documents & management procedures of the categories they respectively apply for.

2.4.3 Examinations for the Basic Portion of the License

The examinations for the applicants of the basic portion of the license for the component maintenance personnel shall be carried out in accordance with the syllabus for the examination in question released by CAAC. The subjects included in the examination shall be in accordance with the examination syllabus. The examination shall include the written examination and examination on basic skills. The applicants shall score 70 or higher in such examinations so as to be rated as "qualified".[4] Those who fail in the examination may take makeup examinations. The results of the examination are valid within 5 years. Those who have cheated or conducted any other unendorsed dishonest acts shall be deprived of the right to take the examination going on and shall not be allowed to attend the examination within the two years commencing from the date of deprivation.

2.4.4 Applications and Issuance for the Basic Portion of the License

Applications for the basic portion of the license for the component maintenance personnel shall follow the following procedures:

(1) Applicants who satisfy all the conditions specified in the Regulations may submit the Application for the Issuance/Renewal of the License for the Civil Aircraft Component maintenance personnel (F66 - 4) stipulated in Annex Ⅳ thereof and the other documents stipulated in the application to CAAC.

(2) CAAC shall, in accordance with the Regulations, examine & review the

qualifications of the aforementioned applicants, the application in question and the other documents which the applicants are required in the application to submit; the applicant who conforms to the Regulations shall be granted with the license for the civil aircraft component maintenance personnel, as stipulated in Annex Ⅴ (F66 - 5), within 30 working days commencing from the date upon which the application is received; while in case of the applicant whose submitted documents are incomplete or not in the prescribed forms, they shall be notified, instantly or within 5 working days, of all the other documents that shall be submitted. CAAC shall notify the unqualified applicant in written form within 20 working days of the application decline, return their application documents, expound the reasons and apprise them of the lawful rights they are entitled to.[5]

(3) The applicant shall pay relevant fees in accordance with the Regulations.

2.4.5 Granting of Basic Portion

The basic portion of the license for the component maintenance personnel shall be signed by relevant personnel authorized by CAAC.

2.4.6 Application Requirements of the Authorization Items

The authorization items of the license for the component maintenance personnel shall be signed in accordance with the following requirements:

(1) Applicants for the authorization item list of the license for the component maintenance personnel shall meet the following requirements:

1) Having obtained the basic portion of the license for the component maintenance personnel;

2) Having acquired the certificate of completion issued by a CAAC approved training organization or a training organization accepted by CAAC concerning the correspondent component maintenance items;

3) Have had engaged with the repair work for the item applied for at least one year (accumulative) in the preceding two years.

(2) The authorization item of the license for the component maintenance personnel are classified in accordance with Annex Ⅷ of the Regulations: General Code Table for Aircraft Component Repair Authorization Items (F66 - 8).

(3) The authorization item list of the license for the component maintenance personnel shall be signed by the personnel authorized by CAAC Regions.

2.4.7 Rights of License Holders

The holders of the license for the component maintenance personnel shall, provided that the authorization items of the license are signed, be entitled to sign releases for the items authorized listed in the license but shall not sign any release for items outside the authorization item list.[6]

2.4.8 Liabilities of the License Holders

The license holders shall comply with the following requirements:

(1) Exercise the maintenance/repair work not exceed the authorized items listed in the authorization portion of the license;

(2) Ensuring the completeness and validity of the license in question;

(3) Not being permitted to exercise the power of release in the event of physical or psychological unfitness.[7]

2.4.9 Cancellations of the License

The license for the civil aircraft component maintenance personnel being waived, suspended, or revoked shall be returned to CAAC within 5 working days, otherwise they shall be cancelled by CAAC through notifications.

New Words/ Phrases/ Expression

1. CCAR:China Civil Aviation Regulations 中国民用航空规章
2. in accordance with 根据;依据
3. personnel [ˌpəːsəˈnel] *n.* 人员,员工
4. license [ˈlaisns] *n.* 执照;许可证;资格证
5. portion [ˈpɔːʃən] *n.* 部分
6. obtain [əbˈtein] *vt.* 获得,得到
7. authorization [ˌɔːθəraiˈzeiʃən] *n.* 授权,委任;认可;批准
8. annex [əˈneks] *n.*, *vt.* 附件;附加
9. applicant [ˈæplikənt] *n.* 申请人
10. comply with 遵守
11. diploma [diˈpləumə] *n.* 文凭;学位证书
12. engaged in 从事于;致力于
13. prior to 之前
14. accumulative [əˈkjuːmjulətiv] *adj.* 累积的
15. respectively [riˈspektivli] *adv.* 分别地;各自地
16. syllabus [ˈsiləbəs] *n.* 教学大纲,课程大纲
17. makeup examination 补考
18. cheat [tʃiːt] *vt.* 欺骗;作弊
19. unendorsed [ˈʌninˈdɔːst] *adj.* 未认可的
20. deprive of /deprivation [diˈpraiv] *v.*, *n.* 剥夺;免去;免职
21. commence [kəˈmens] *vt.* 开始;着手
22. qualification [ˌkwɔlifiˈkeiʃən] *n.* 资格;能力
23. conforms to 符合
24. stipulate [ˈstipjuleit] *v.* 规定,约定

25. submit [səb'mit] *v.* 提交;呈递
26. issuance ['iʃjuəns] *n.* 发行;发布
27. granted with 授予
28. notify/notification ['nəutifai]/[ˌnəutifi'keiʃn] *v./n.* 通知,告知;公布
29. expound [iks'paund] *vt.* 解释;详细叙述
30. fee [fiː] *n.* 费用
31. release [ri'liːs] *vt.* 放行
32. right/liability [ˌlaiə'biliti] *n.* 权利,义务
33. completeness [kəm'pliːtnis] *n.* 完整性
34. validity [væ'liditi] *n.* 有效性;合法性
35. physical ['fizikəl] *adj.* 身体的;物质的
36. psychological [ˌsaikə'lədʒikəl] *adj.* 心理的;精神的
37. waive [weiv] *vt.* 放弃
38. suspend [səs'pend] *vt.* 吊扣;悬挂
39. revoke [ri'vəuk] *vt.* 吊销

Notes

【1】The basic portion of the license in question may be issued without any authorization items. Applicants for the authorization items of the license in question shall obtain the basic portion first.

分析:注意两句之间的逻辑关系。

翻译:(部件修理人员执照)基础部分可以在没有项目签署的情况下颁发。申请项目签署部分的申请人应当首先取得部件修理人员执照基础部分。

【2】The authorization items of the license for the component maintenance personnel are classified in accordance with Annex Ⅷ of the Regulations: General Code Table for Aircraft Component Authorization Form (F66-8).

分析:航空规章通常附有附件或附表,附表的序号一般为罗马数字大写,Ⅷ为阿拉伯数字8。

翻译:航空器部件修理人员执照项目部分按规章附件八——航空器部件项目通用代码表(F66-8)划分。

【3】They shall have diplomas issued by technical secondary schools or educational institute of higher levels with the majors relevant to aviation technology, have the experience of being engaged independently in the aircraft component maintenance work consistent with the respective categories for which they apply for more than two years in total (including two years) and, in addition, and have been engaged in the aircraft component maintenance work consistent with the categories concerned during the one year prior to the date of application.

分析:这是一个典型的平行结构的英语长句,并且每一部分有较长的修饰语或从句,翻译时应注意其条理性。

翻译:他们应具有中专(含)以上航空技术相关专业学历,并且独立从事所申请专业的航空

器部件修理工作累计在 2 年(含)以上,并且在申请之日前 1 年应当持续从事所申请专业的民用航空器部件修理工作。

【4】The applicants shall score 70 or higher in such examinations so as to be rated as “qualified”.

分析:注意“so as to be”的翻译。

翻译:申请者在这些考试中的成绩以 70 分(含)以上为合格。

【5】CAAC shall notify the unqualified applicant in written form within 20 working days of the application decline, return their application documents, expound the reasons and apprise them of the lawful rights they are entitled to.

分析:“notify…in written”翻译为“书面通知……”;“be entitled to”是“有权”的意思。

翻译:对于不符合规定的申请,中国民用航空局应在 20 个工作日内做出不予颁发执照的书面通知,退回其申请材料,说明理由并告知申请人享有的法律权利。

【6】The holders of the license for the component maintenance personnel shall, provided that the authorization items of the license are signed, be entitled to sign releases for the items authorized listed in the license but shall not sign any release for items outside the authorization item list.

分析:注意本句中几个“sign”的意思有所不同,第一个“signed”为被动语态,是指执照的项目部分已获得签署,后两个“sign release”是指持照人员的签字放行。

翻译:部件修理人员执照项目部分获得签署后,可对执照签署项目类别范围内的修理项目具有签字放行权,但不得跨项目放行。

【7】Not being permitted to exercise the power of release in the event of physical or psychological unfitness.

分析:“in the event of…”翻译为“在……情况下”或“如果……”,这个短语经常出现在民航专业英语中;“exercise the power of release”翻译为“行使放行权”。

翻译:在部件修理人员的生理或者心理状况不适合行使放行权时,不得行使这种放行权。

Exercises

Ⅰ. Answer the following questions:

1. What is the right of the license holder for the component maintenance personnel?

2. What are the liabilities of the license holder for the component maintenance personnel?

Ⅱ. Translate the following sentences into Chinese:

1. Those who fail in the examination may take makeup examinations. The results of the examination are valid within 5 years.

2. Those who have cheated or conducted any other unendorsed dishonest acts shall be deprived of the right to take the examination going on and shall not be allowed to attend the examination within the two years commencing from the date of deprivation.

3. The basic portion of the license for the component maintenance personnel shall be signed by relevant personnel authorized by CAAC.

4. The license for the civil aircraft component maintenance personnel being waived, suspended, or revoked shall be returned to CAAC within 5 working days, otherwise they shall be cancelled by CAAC through notifications.

Ⅲ. Fill in the following blanks according to the text:

1. Inaccordance with CCAR 66, licenses and certificates of civil aircraft maintenance personnel include the following two types:

(1) ____;

(2) ____.

2. The basic portion of the license for the component maintenance personnel are classified in accordance with the following categories:

(1) ____________, English code: STR;

(2) ____________, English code: PWT;

(3) ____________, English code: LGR;

(4) ____________, English code: MEC;

(5) ____________, English code: AVC;

(6) ____________, English code: ELC.

3. The examination in basic portion shall include the ________ examination and examination on.

Chapter 3
Aircraft Mechanical Component Maintenance

Chapter 3 Aircraft Mechanical Component Maintenance

3.1 Introduction of Pneumatic Component

3.1.1 General

Pneumatic components are widely used in the engine starting, ice and rain protection, engine bleed air, air conditioning, pressurization, the auxiliary power unit (APU) and other systems, including pneumatic valve, air starter, air cycle machine (ACM), heat exchanger, etc.

3.1.2 Description of Air Bleed System (B737NG)

Bleed air comes from the 9th and 5th stages of the engine high stage compressors. At low engine speed, the pneumatic system uses 9th stage bleed air. 5th stage air is not sufficient for pneumatic system demands at low engine speeds.

At low engine speed the high stage regulators and high stage valves control the pressure of the engine bleed air, and the 5th stage check valves prevent reverse flow. At high engine speed the high stage valves close and the 5th stage check valves open to supply bleed air to the pressure regulating shutoff valves.

The air conditioning bleed air controls panel has engine bleed switches to control the pressure regulating shutoff valves. Also, there are BLEED TRIP OFF lights to show overpressure or overtemperature. The bleed air regulators and pressure regulator and shutoff valves control the flow of engine bleed air to the pneumatic manifold. The bleed air regulators have overpressure switches to prevent overpressure conditions and turn on the BLEED TRIPOFF lights.

The 232℃ (450℉) thermostats make the pressure regulating and shutoff valves move towards closed when the temperature gets to 232℃ (450℉). The air conditioning accessory unit (ACAU) is an interface between the air conditioning bleed air controls panel and the pressure regulating shutoff valves. The 254℃ (490℉) overheat switches turn on the BLEED TRIP OFF lights and close the pressure regulating shutoff valves. This prevents overheat damage to the pneumatic manifold and user systems (see Figure 3.1-1).

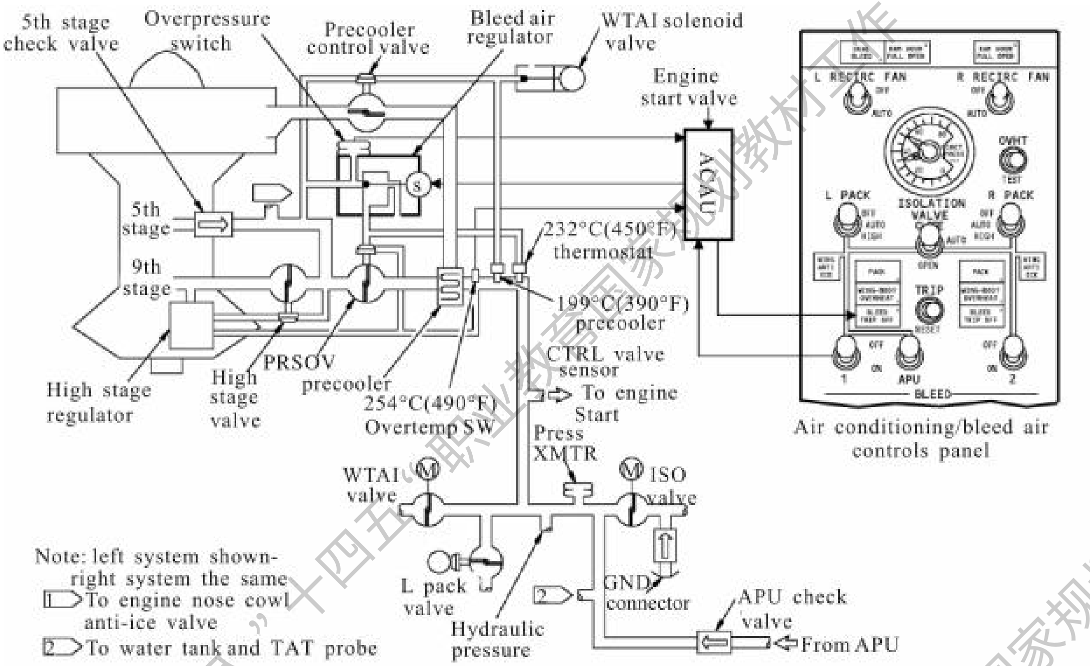


Figure 3.1-1 Air bleed system from the aircraft engine

3.1.3 Description of Air Conditioning System (B737-800)

1. General

The air conditioning system controls the interior environment of the airplane for flight crew, passengers, and equipment.

These are the air conditioning sub-systems:

- distribution;
- pressurization;
- equipment cooling;
- heating;
- cooling;
- temperature control.

2. Cooling System

The cooling system uses these components and systems to cool the bleed air (see Figure 3.1-2):

- air conditioning/bleed air controls panel;
- flow control and shutoff valve;
- heat exchangers;
- air cycle machine;

• reheater;
• condenser;
• ram air system;
• water extraction.

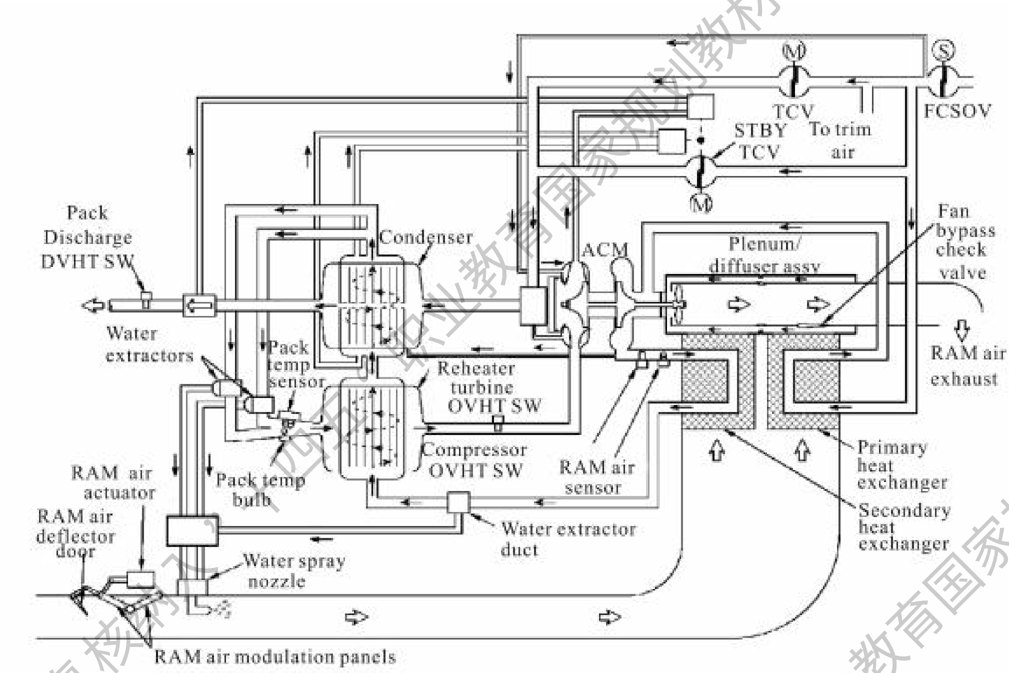


Figure 3.1-2 Air conditioning-cooling-functional description

The flow control and shutoff valve gets hot bleed air from the pneumatic manifold. The flow control and shutoff valve controls the flow of hot bleed air to the trim air system, primary heat exchanger and to the two temperature control valves. A hot air connection downstream of the FCSOV supplies hot bleed air to the turbine case. This prevents ice in the turbine case.

The ram air system controls the flow of ram air to the primary and secondary heat exchangers. When bleed air goes through the primary heat exchanger, ram air removes some of the heat. This partially cool bleed air goes to the compressor section of the air cycle machine.

The compressor section increases the pressure and temperature of the partially cool bleed air. This compressed air goes to the secondary heat exchanger.

When the compressed air goes through the secondary heat exchanger, ram air removes some of the heat. This bleed air goes through the water extractor duct and into the reheater.

Bleed air that leaves the secondary heat exchanger goes through the hot side of the reheater. Air that goes through the reheater the first time is cooled by colder air from the condenser. The temperature of the bleed air increases as it goes through the reheater a second time and into the turbine section of the air cycle machine.

Air that leaves the turbine goes through the cold side of the condenser. Air flow from the condenser divides into two paths; each path goes through a water extractor.

The water extractors remove moisture. This moisture goes to the water spray nozzle. The water spray nozzle sprays the water into the ram air duct.

Part of the cold air bypasses through the condenser core to prevent ice in the condenser. This supplies warm air through deicing passages in the core and by a mix of hot bleed air into the turbine muff at the cold air inlet.[1] The standby temperature control valve senses condenser ice conditions and sends hot bleed air to the turbine muff.

New Words/ Phrases/ Expression

1. pneumatic [njuːˈmætik] *adj*. 气动的
2. auxiliary [ɔːgˈziljəri] *adj*. 辅助的
3. check valve 单向活门
4. TRIP OFF 跳开
5. manifold [ˈmænifəuld] *n*. 多支管;歧管
6. thermostat [ˈθəːməstæt] *n*. 恒温器
7. interior [inˈtiəriə] *adj*. 内部的
8. ram air 冲压空气
9. duct [dʌkt] *n*. 管道
10. moisture [ˈmɔistʃə]*n*. 水气
11. spray nozzle 喷嘴
12. bypass [ˈbaiˌpaːs] *v*. 旁通
13. condenser core 冷凝器芯体

Notes

【1】Part of the cold air bypasses through the condenser core to prevent ice in the condenser. This supplies warm air through deicing passages in the core and by a mix of hot bleed air into the turbine muff at the cold air inlet.

分析:“this”应指代前句。

翻译:部分冷路空气通过冷凝器芯体旁通,以防止冷凝器结冰。这样一来,热的引气会在冷路空气入口的涡轮集气口混合,以提供暖空气流过芯体防冰通道。

Exercises

Ⅰ. Answer the following questions:

1. Where are pneumatic components mainly used in aircraft?
2. How does the air bleed system operate in B737－800 at high engine speed?
3. What role does the condenser play in the cooling system?

Ⅱ. Translate the following sentences into Chinese:

1. The air conditioning bleed air controls panel has engine bleed switches to control the pressure regulating shutoff valves. Also, there are BLEED TRIP OFF lights to show overpressure or overtemperature.

2. The temperature of the bleed air increases as it goes through the reheater a second time and into the turbine section of the air cycle machine.

Ⅲ. Fill in the following blanks according to the text:

1. There is one bleed air system for each ________. The engine bleed system controls bleed air ________ and ________.

2. The 5th stage bleed air check valve ________ 9th stage bleed air flow into the 5th stage bleed port.

3. After the bleed air goes through the flow control and shutoff valve it enters ________, and ________.

4. The condenser ________ the temperature of the air in the air conditioning pack to below the dew point. This causes the water vapor in the airstream to go into a ________ form.

5. The reheater ________ the temperature of the air in the air conditioning pack before it enters the turbine of the air cycle machine.

3.2 Bleed Valve

3.2.1 Description

The bleed valve of the butterfly type is installed in the bleed air portion of the air bleed system from the aircraft engine. The high pressure bleed valve consists of the high stage regulator and valve.

The high stage regulator and valve control the supply of high stage engine bleed air. The high stage regulator operates the high stage valve, and the high stage valve controls the flow of bleed air from the 9th stage bleed air manifold (see Figure 3.2-1).

The high stage regulator gets unregulated air from a tap on the 9th stage bleed air manifold. The unregulated air goes through the pneumatic shutoff mechanism to the reference pressure regulator.

The reference pressure regulator decreases the pressure to a constant control pressure. A relief valve prevents damage to the high stage valve if the reference pressure regulator fails. The control pressure from the high stage regulator goes to chamber A of the high stage valve. The actuator opens the valve against spring force and pressure in chamber B. The combination of forces that operate on the actuator cause the valve to regulate the downstream pressure to 32 psig (nominal)[1] (see Figure 3.2-2).

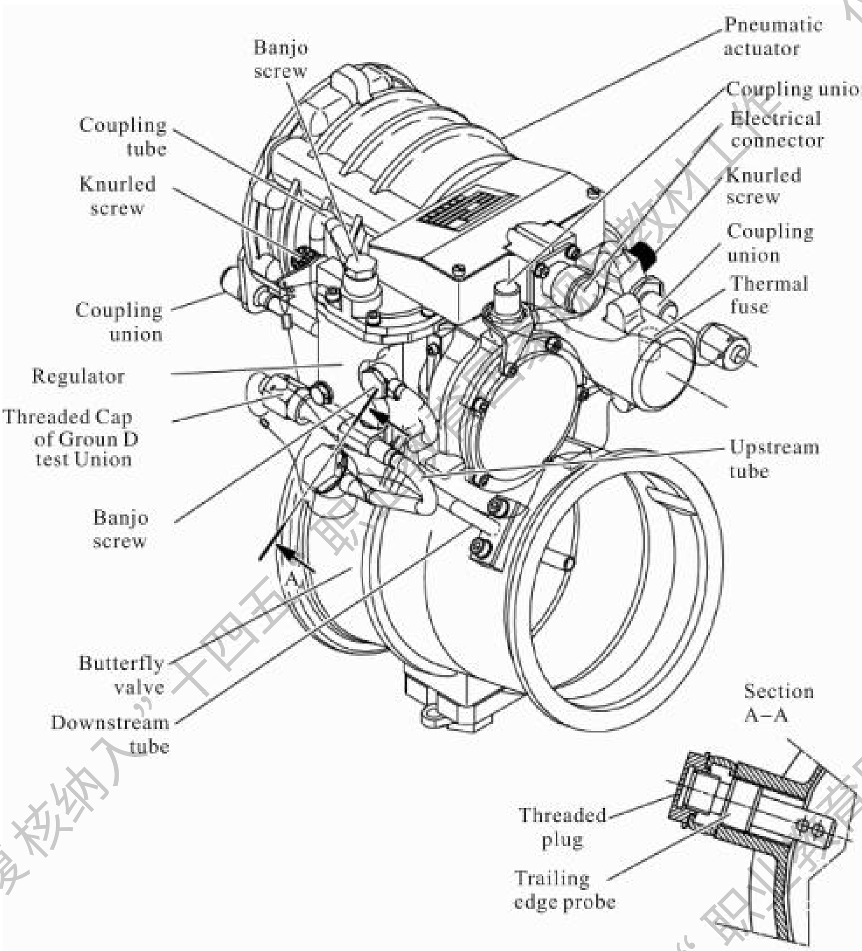


Figure 3.2-1 HP bleed valve-structural description

During normal operation, the high stage valve closes for these reasons:

- Downstream pressure is more than 9th stage pressure;
- The 5th stage pressure is greater than the high stage regulated pressure.

When downstream pressure is more than 9th stage pressure, the reverse flow mechanism in the high stage regulator opens and bleeds off the control pressure to the high stage valve. The high stage valve then closes.

When 5th stage manifold pressure is greater than the high stage regulated pressure (nominal 34 psig), the high stage valve closes because the force in chamber B, combined with the spring force, is greater than the force in chamber A. This causes the high stage valve to close.

The pneumatic shutoff mechanism increases the life of the high stage regulator. The shutoff operates after the shift to 5th stage engine supply occurs. High pressures (110 psig) in the supply port operate a shutoff mechanism. The shutoff mechanism closes the supply to the regulator inlet and vents the regulator. This reduces the duty cycle of the regulator and exposure to extreme pressures and temperatures during high engine power operation.

A relief valve in the high stage valve decreases downstream pressure in the interstage duct when the pressure regulator and shutoff valve (PRSOV) is closed.

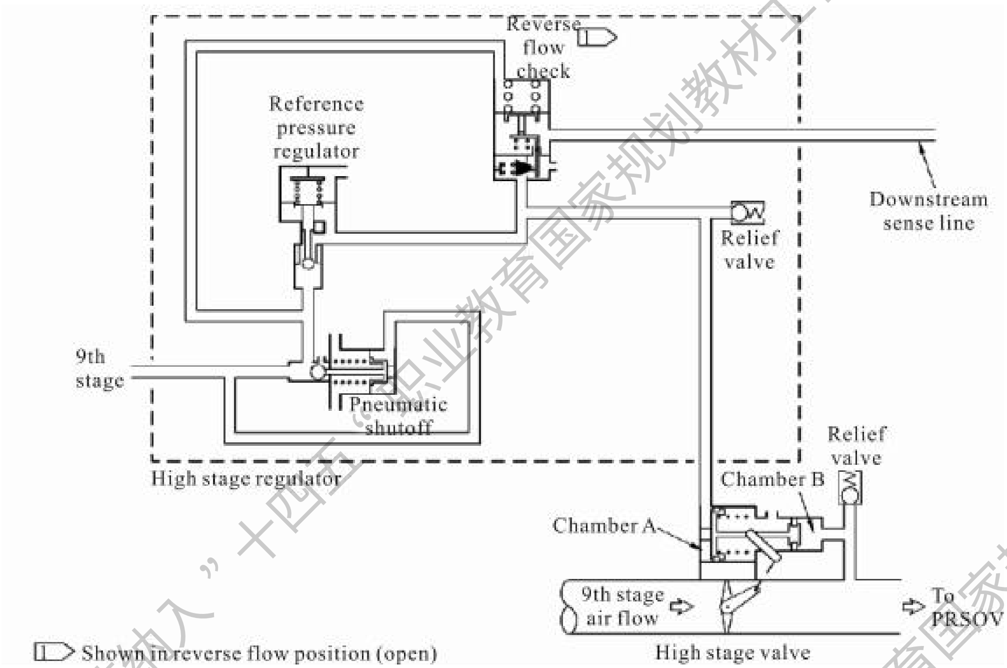


Figure 3.2 - 2 HP bleed valve-functional description

The operation of the high stage bleed system is automatic and self-regulating. There are no external controls.

3.2.2 Test and Fault Isolation

1. Preliminary Tests

(1) Visual check.

1) Make sure that the unit is complete and not damaged. Make sure that the details on the identification plate are correct.

2) Examine the unit for signs of impact damage, in particular at the location of the valve body, the pneumatic actuator body and the regulator body.[2]

3) With the butterfly valve in the fully closed position, make sure that the butterfly valve sealing rings are in contact with the periphery of the valve body bore.

4) With the butterfly valve in the open position, examine the bore of the valve body for signs of scratches, scouring.

(2) Electrical tests.

1) Insulation resistance test.

(a) Apply a 50 V DC voltage with the electrical cord (T40) between the connector contact pins connected together and one point of the valve body.

(b) Make sure that the insulation resistance is more than 100 MΩ.

Note: The modern megohmmeters give a test voltage of 50 V DC as opposed to the 45 V DC found with the earlier models.[3]

2) Continuity test.

(a) Measure the continuity between two points of the unit.

(b) Make sure that the continuity is less than or equal to 20 mΩ.

2. Hot-Air Functional Tests at (250±10)℃ (464 to 500°F) (see Figure 3.2-3)

(1) Preparation.

1) Make sure that the pneumatic coupling to the bleed valve is vented.

2) Let the upstream parameters that follow become stable for 10 to 15 minutes: $-T_1$ equal to (250±10)℃ (464 to 500℉), $-P_1$ equal to 39.16 to 47.86 psig ((3±0.3) bar rel.).

3) Then, increase and decrease at the rate of 0.362 to 0.725 psig/s (25 to 50 mbar/s) the (p_1) pressure between 43.50 to 130.53 psig (3 and 9 bar rel.).

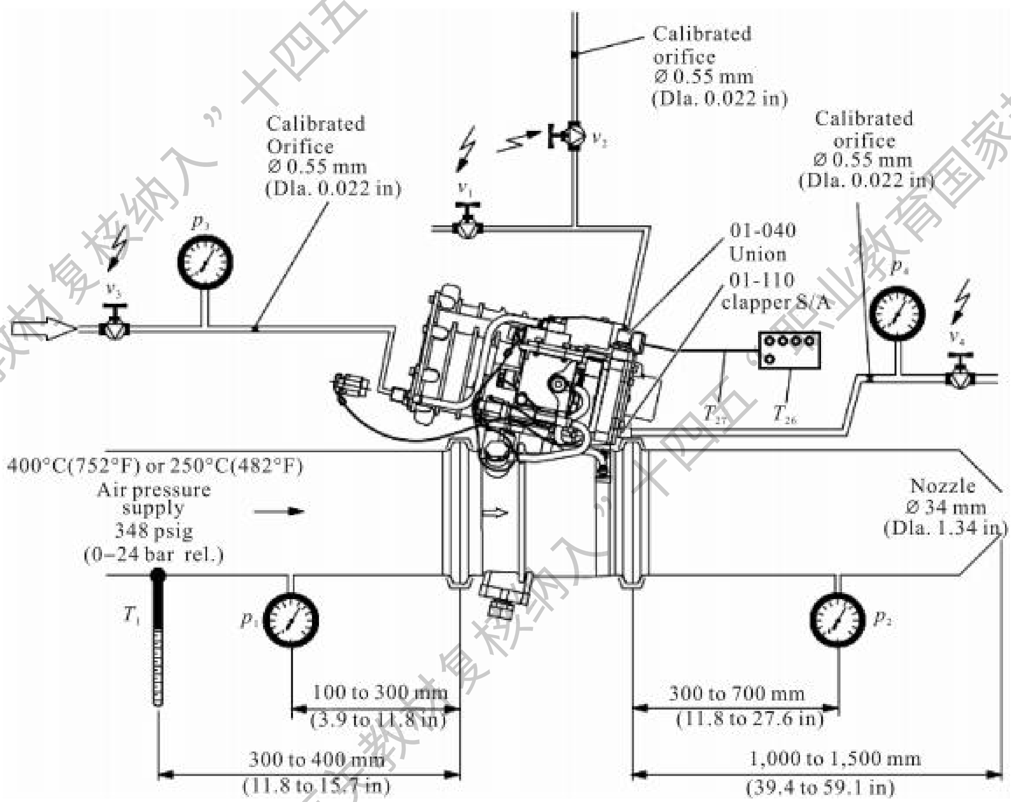


Figure 3.2-3　Hot test bench

(2) Closing/reopening tests.

1) Test at high pressure;

2) Test at low pressure.

(3) Pressure regulation tests.

1）Pressure regulation test；

2）Pressure limitation test.

（4）Screening rest procedure.

（5）Closure with no pressure.

3. Hot-Air Functional Tests at（400±20）℃（716 to 788°F）

4. Ambient-Air Functional Test at（25±20）℃（41 to 113°F）

5. Leakage Tests

6. Fault Isolation（see Table 3.2－1）

Table 3.2－1　Fault Isolation—Preliminary Tests

Defect	Possible Cause	Correction
1. Preliminary Tests（Ref. Task 36-11-06-700-801-A01）		
Visual Check（Ref. Subtask 36-11-06-210-001-A01）		
Visual Defect	The external component is loose（screw missing or loose）	Torque the attaching part（Ref. Task 36-11-06-820-802-A01）
	The coating protection of the parts are damaged	Do the corrosion protection（Ref. Repair No. 1 Task 36-11-06-380-801-A01）
	There is impact damage，crack	Change the defective parts
	The lockwire is broken or not installed	Do the safetying procedure（Ref. Subtask 36-11-06-440-018-A01）
Insulation Resistance Test（Ref. Subtask 36-11-06-750-001-A01）		
Insulation Resistance ＜100 MΩ	Wiring of electrical connector（03－120）or wiring of microswitch（03－110）stripped or unsoldered	Repair，re-crimp or replace the wiring as applicable： （a）Test of the wiring（Ref. Subtask 36-11-06-750-002-A01） （b）Replace the microswitch（03-110）if the wiring is damaged or unsoldered Removal（Ref. Subtask 36-11-06-040-009-A01）；Disassembly（Ref. Subtask 36-11-06-040-010-A01）；Assemble（Ref. Subtask 36-11-06-440-003-A01） （c）Replace the connector（03-120）if damaged：Removal（Ref. Subtask 36-11-06-040-009-A01）；Assemble（Ref. Subtask 36-11-06-440-004-A01）
Continuity Test（Ref. Subtask 36-11-06-750-001-A01）		
Continuity ＞20 mΩ	The electrical bonding is defective	• Find the defective electrical bonding point • Repair the bonding point as per bonding procedure（Ref. Repair No. 2 Task 36-11-06-300-801-A01）

New Words/ Phrases/ Expression

1. butterfly type 蝶形
2. portion [ˈpɔːʃən] *n.* 部分
3. unregulated [ʌnˈregjuleitid] *adj.* 未经调节的，紊乱的
4. tap [tæp] *n.* 龙头，阀门
5. mechanism [ˈmekənizəm] *n.* 机械装置
6. thermostat [ˈθəːməstæt] *n.* 恒温器
7. nominal [ˈnɔminəl] *adj.* 名义上的
8. vent [vent] *v.* 泄漏，排出
9. duty [ˈdjuːti] *n.* 负荷
10. preliminary [priˈliminəri] *adj.* 初步的
11. identification plate 指阀芯的碟片及关联部分
12. sign [sain] *n.* 征兆
13. sealing ring 密封圈
14. periphery [pəˈrifəri] *n.* 周围
15. bore [bɔː] *n.* 内镗
16. scratch [skrætʃ] *v.* 划伤
17. scouring [ˈskauəriŋz] *n.* 残屑
18. insulation resistance 绝缘电阻
19. electrical cord 绝缘电线
20. contact pin 触点引脚
21. continuity test 导通性测试
22. megohmmeter 兆欧级电阻表

Notes

【1】The combination of forces that operate on the actuator cause the valve to regulate the downstream pressure to 32 psig (nominal).

分析：“combination of forces”这里指“合力”。

翻译：作动机构所受合力使得活门调节下游气压为32psig(名义)。

【2】With the butterfly valve in the fully closed position, make sure that the butterfly valve sealing rings are in contact with the periphery of the valve body bore.

分析：“in contact with…”这里指“与……有接触”。

翻译：当蝶形阀在全关位时，确认其密封圈与阀体内镗周围处于接触状态。

【3】The modern megohmmeters give a test voltage of 50 V DC as opposed to the 45 V DC found with the earlier models.

分析：“as opposed to”这里指“与……相对比”。

翻译：现代兆欧级电阻表给出50V直流相当于以前型号的45 V直流。

Exercises

Ⅰ. Answer the following questions:

1. What does the HP bleed valve consist of?
2. How does actuator operate when the downstream pressure increases?
3. List the main test procedure.

Ⅱ. Translate the following sentences into Chinese:

1. The regulator has a light cast alloy body which includes the pneumatic connections. These connections duct the upstream and downstream pressure between the body of the valve and the pneumatic actuator.

2. Depending on the engine stages pressure level, the bleed pressure regulating valve is pneumatically supplied either by the IP stage or the HP stage.

3. If a temperature greater than 235℃ (455℉) is detected by the solenoid thermostat, it causes a variation of pressure in the chamber (B) because of an air leakage controlled by the solenoid thermostat. The movement of the diaphragm transmitted by the guide pin to the diaphragm and the clapper results in a decrease of the regulation level.

Ⅲ. Fill in the following blanks according to the text:

1. When the pressure bled from the IP stage is too low, the bleed valve is pneumatically supplied by the ________ valve downstream pressure.

2. Any variation in the downstream pressure brings about a change in the position of the butterfly to keep the downstream pressure ________.

3. In the ________ of air pressure on the upstream side of the butterfly valve, the butterfly is locked in the "CLOSED" position by the effect of the ________ load on the piston in the pneumatic actuator.

4. The operation of the high stage valve is automatic. Also there is a manual ________ to lock the valve in the closed position.

3.3 Cooling Turbine

3.3.1 General

The cooling turbine is used in an air conditioning system to cool pressurized bleed air to a temperature which will permit cooling of the aircraft cabin.[1]

3.3.2 Description

The cooling turbine is a bootstrap expansion type. The cooling turbine consists of an impeller and a turbine wheel mounted on opposite ends of a common shaft. The common shaft rotates within two spring-loaded annular ball bearings. The impeller wheel is enclosed by a compressor scroll assembly. The turbine wheel is enclosed by a turbine scroll assembly.

The common shaft and ball bearings are encased by the main housing (see Figure 3.3-1 and Figure 3.3-2).

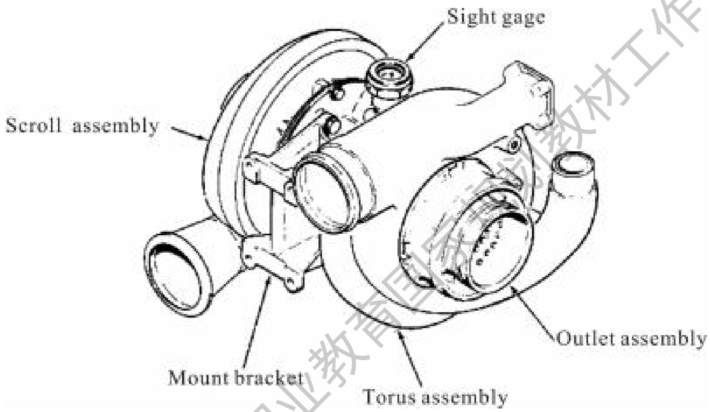


Figure 3.3-1 Cooling turbine

The bottom of the main housing is an oil reservoir. Oil is supplied to the bearings by wicks which are located in the main housing and run to the stationary bearing carrier assembly.

Oil slingers are located on the common shaft adjacent to the bearings. An air seal is located between the main housing and compressor section. Another air seal is located between the main housing and turbine section.

An oil plug and sight gage are located on either side of the main housing.

The compressor scroll assembly is composed of two welded halves which contain a vaned diffuser.

The impeller wheel is a 4.10 inch (104.14 mm) diameter aluminum radial outward flow wheel. The impeller wheel and compressor scroll together form the cooling turbine compressor section.

The turbine scroll assembly consists of two welded halves which cover the turbine nozzle.

The turbine wheel is a two piece 4.05 inch (102.87 mm) diameter aluminum, radial inward flow wheel. The turbine wheel rotates within the turbine nozzle. The turbine wheel, nozzle and turbine scroll assembly together form the turbine section of the cooling turbine.

3.3.3 Operation

The aircraft main engine bleed air is routed through the aircraft primary heat exchanger where the aircraft main engine bleed air is partially cooled by aircraft ram air (see Figure 3.3-2 and Figure 3.3-3).

The aircraft main engine bleed air leaves the primary heat exchanger and enters the cooling turbine compressor section. The aircraft main engine bleed air compression is increased by the compressor section, also causing an increase in air temperature.

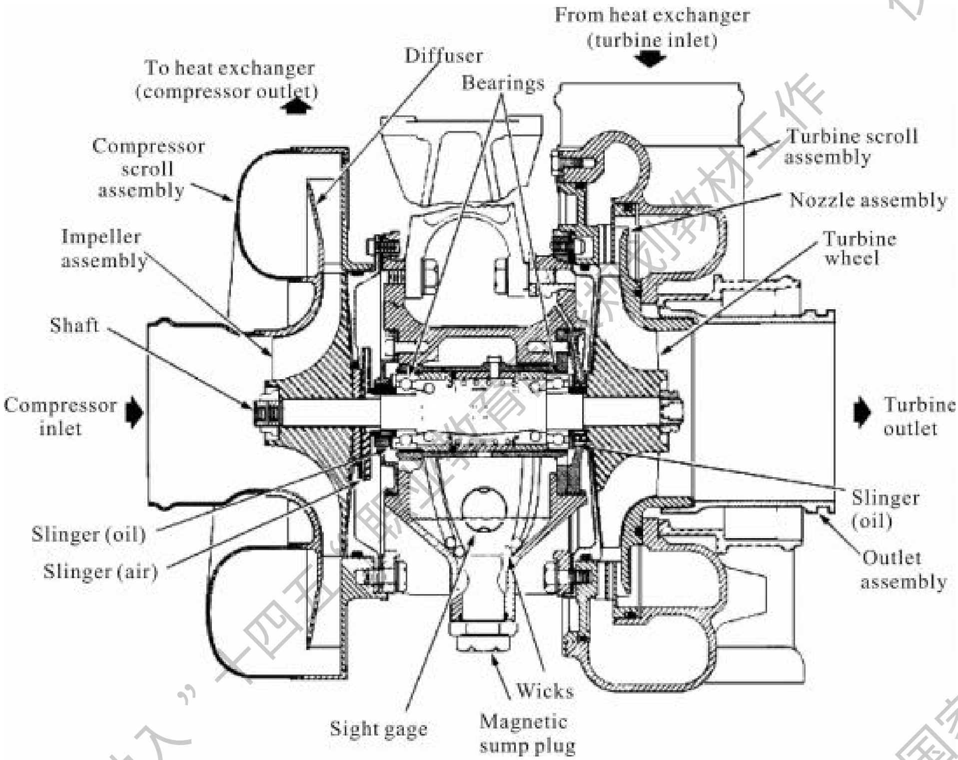


Figure 3.3－2　Cooling turbine schematic diagram

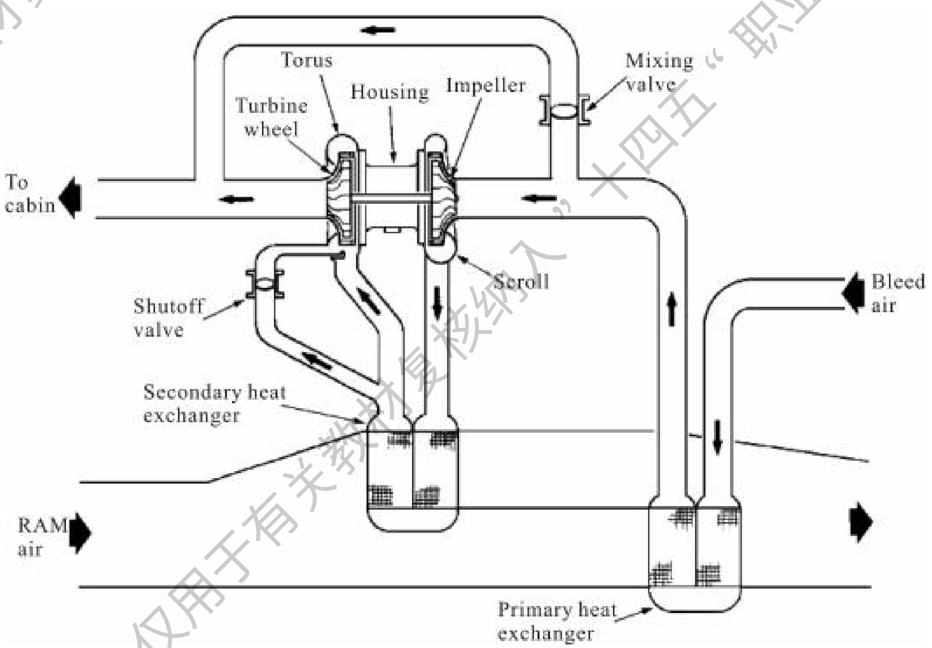


Figure 3.3－3　Schematic diagram

The bleed air then leaves the compressor section of the cooling turbine and enters the secondary heat exchanger to be additionally cooled by aircraft ram air.

The bleed air then exits the secondary heat exchanger and enters the turbine section of the cooling turbine. The bleed air is caused to rapidly expand in the turbine section, also causing a decrease in air temperature.

Dual turbine nozzles are used in conjunction with the turbine nozzle shutoff valve to control cooled compressed air for maximum cooling capabilities during ground/auxiliary power unit operation. During normal operation, the turbine nozzle shutoff valve remains open. Bleed air is ducted to the turbine scroll and rapidly expanded by both turbine nozzles. The air passes over the turbine wheel and is ducted from the turbine scroll to the aircraft cabin. During ground/auxiliary power unit operation, the turbine nozzle shutoff valve remains closed. Bleed air is ducted to the turbine scroll and rapidly expanded by the larger turbine nozzle. The air passes over the turbine wheel and is ducted from the turbine scroll to the aircraft cabin.

The rapidly expanded bleed air then leaves the turbine section of the cooling turbine and enters the cabin air conditioning control system.

The compressor section provides pneumatic energy for the air conditioning system and the cooling turbine operation. The bleed air compressed in the compressor section is transferred to rapidly expanded cooled air for the air conditioning system and mechanical energy for cooling turbine operation in the turbine section.【2】

The workload required of the turbine section to maintain efficient operation of the compressor section is controlled by the mixing valve. The mixing valve controls the speed of rotation of the cooling turbine within a range of compressor section and turbine section efficiency. Also the mixing valve is used to produce a reduction or increase in air temperature to maintain the temperature requirements of the aircraft cabin. Opening of the mixing valve causes an amount of aircraft main engine bleed air to bypass the cooling turbine and mix into the rapidly expanded bleed air leaving the turbine section of the cooling turbine. The action causes a reduction in the cooling turbine rotation and an increase in air temperature at the turbine section discharge. Closing of the mixing valve causes all aircraft main engine bleed air to enter the cooling turbine. The action causes an increase in cooling turbine rotation and a decrease in air temperature at turbine section discharge.

As rotation is established, oil is provided from the main housing reservoir to the bearings by wicks. Oil is forced through the wicks by a capillary action to the common shaft. Rotation of the common shaft causes the oil to be sprayed in a fine mist, onto the bearings. Oil is pulled through the bearing by centrifugal motion caused by rotation of the oil slingers mounted on the common shaft.

The oil slingers provide a passage for oil to return to the main housing reservoir. Air trapped in the bearings and oil system is pulled from the system by centrifugal motion caused by rotation of an air slinger mounted on the common shaft.【3】

Oil seals mounted on both ends of the common shaft provide a seal between the common shaft and main housing. The seal prevents oil migration from the oil system to the compressor section and the turbine section.

Air seals mounted on both ends of the common shaft provide a seal between the compressor section and the main housing, and the turbine section and the main housing. The seal allows an amount of air to escape from the compressor section and turbine section and form an air pocket formed around the oil seal aids in prevention of oil migration. This air pocket is contained between the air seal and main housing and is vented to ambient.

3.3.4 Leading Particulars

Leading particulars are listed in Table 3.3-1.

Table 3.3-1 Leading Particulars

Turbine Airflow	(332.64±16.6)kg/s [(44.0±2.2) lb/min]
Turbine Speed: (Part No. 204950-5-1 thru-5-5) (Part No. 204950-6-1 thru-7-2)	 49,000 to 53,500 r/min (approx.) 50,400 to 50,500 r/min (approx.)
Lubrication Provisions	Felt Wick and Sump
Lubrication Oil	MIL-PRF-7808 or MIL-PRF-23699
Lubrication Capacity	300 mL
Weight (dry): (Part No. 204950-5-1 thru -6-2) (Part No. 204950-7,-7-2)	 12.42 kg (27.4 lb) (approx.) 12.51 kg (27.6 lb) (approx.)

New Words/ Phrases/ Expression

1. bootstrap [ˈbuːtstræp] *n.* 自动持续作用;自举作用
2. bootstrap air-cycle machine 自持空气循环机
3. impeller [imˈpelə] *n.* (压缩机)叶轮
4. stem [stem] *n.* 芯柱,导杆
5. scroll [skrəul] *adj.* 涡旋式的
6. housing [ˈhausiŋ] *n.* 外壳,壳体
7. wick [wik] *n.* 油绳
8. oil slinger/slinger ring 甩油盘,离心喷油环
9. oil plug (放)油塞
10. sight gage 观察仪
11. vaned diffuser 叶片扩压器
12. radial outward flow 径向外流式
13. radial inward flow 径向内流式

14. route through 穿过,经过
15. leakage test 渗漏测试
16. primary heat exchanger 初级热交换器
17. secondary heat exchanger 次级热交换器
18. workload ['wəːkləud] *n.* 工作载荷;工作量
19. capillary action 毛细管作用
20. centrifugal [sen'trifjugəl] *adj.* 离心的
21. migration [mai'greiʃən] *n.* 渗漏

Notes

【1】The cooling turbine is used in an air conditioning system to cool pressurized bleed air to a temperature which will permit cooling of the aircraft cabin.

分析:"is used in"翻译为"用于,作用是";两个"to"的用法不同,第一个表示目的,第二个是介词,表示"到……"的意思。

翻译:冷却涡轮用于空调系统内,它的作用是冷却增压气源以达到冷却座舱所需要的温度。

【2】The bleed air compressed in the compressor section is transferred to rapidly expanded cooled air for the air conditioning system and mechanical energy for cooling turbine operation in the turbine section.

分析:两个"for"分别修饰不同的名词,第一个修饰的是"rapidly expanded cooled air",第二个修饰的是"mechanical energy"。

翻译:经过压气机增压的气源到达涡轮,转化为供往空调系统的冷却空气和提供给冷却涡轮工作的机械能。

【3】Air trapped in the bearings and oil system is pulled from the system by centrifugal motion caused by rotation of an air slinger mounted on the common shaft.

分析:整个句子是个被动句,被动句经常用于技术文件中。"trapped in the bearings and oil system"作为定语修饰"air";"by…"说明一种方式、方法。

翻译:安装在转轴上的旋流器的离心作用将滞留在轴承和滑油系统内的滞留空气抽吸出来。

Exercises

Ⅰ. Answer the following questions:

1. What are the features of the cooling turbine?
2. Where is the cooling turbine mounted in the cooling subsystem?
3. How does the air flow through the cooling subsystem?
4. How can the rotary section be lubricated?
5. How many kinds of seals are mounted on the cooling turbine?

Ⅱ. Translate the following sentences into Chinese:

1. Dual turbine nozzles are used in conjunction with the turbine nozzle shutoff valve to

control cooled compressed air for maximum cooling capabilities during ground/auxiliary power unit operation.

2. Opening of the mixing valve causes an amount of aircraft main engine bleed air to bypass the cooling turbine and mix into the rapidly expanded bleed air leaving the turbine section of the cooling turbine.

3. Air seals mounted on both ends of the common shaft provide a seal between the compressor section and the main housing, and between the turbine section and the main housing.

Ⅲ. Fill in the following blanks according to the text:

The ________ required of the turbine section to maintain efficient operation of the compressor section is controlled by the mixing valve. The mixing valve controls the speed of rotation of the cooling turbine within a range of compressor section and turbine section ________. Also the mixing valve is used to produce a ________ or ________ in air temperature to maintain the temperature requirements of the aircraft cabin. Opening of the ________ causes an amount of aircraft main engine bleed air to ________ the cooling turbine and mix into the rapidly expanded bleed air leaving the turbine section of the cooling turbine. The action causes a ________ in the cooling turbine rotation and an ________ in air temperature at the turbine section discharge. Closing of the mixing valve causes all aircraft main engine bleed air to enter the cooling turbine. The action causes an ________ in cooling turbine rotation and a ________ in air temperature at turbine section discharge.

3.4 Starter

3.4.1 Description (see Figure 3.4-1)

The air turbine engine starter changes compressed air pressure into mechanical force, sufficient to increase the speed of the aircraft engine to start speed.[1]

The air turbine starter has:

- an inlet assembly;
- a stator;
- a containment ring;
- a cutter ring;
- a diffuser assembly;
- a planet gear;
- a ring gear;
- a sprag clutch;
- a filter disc;
- a pump assembly;
- a sun gear;

- a turbine wheel;
- an intermediate housing;
- an output shaft with decoupler assembly.

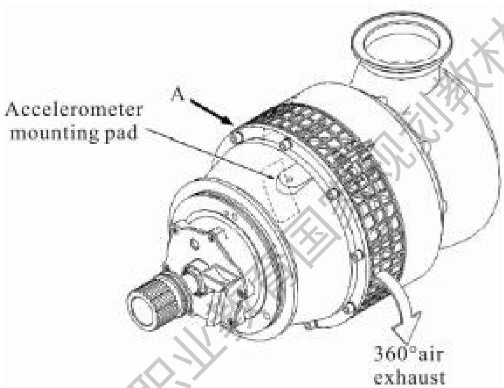


Figure 3.4-1 Engine air turbine starter

3.4.2 Operation (see Figure 3.4-2)

Compressed air flows through the inlet assembly through the stator to the turbine wheel to cause high speed and low rotational torque at the sun gear. Exhaust air is released to ambient through the diffuser assembly. The sun gear, planet gears and ring gear decrease the high speed to transmit a high torque to the output shaft.

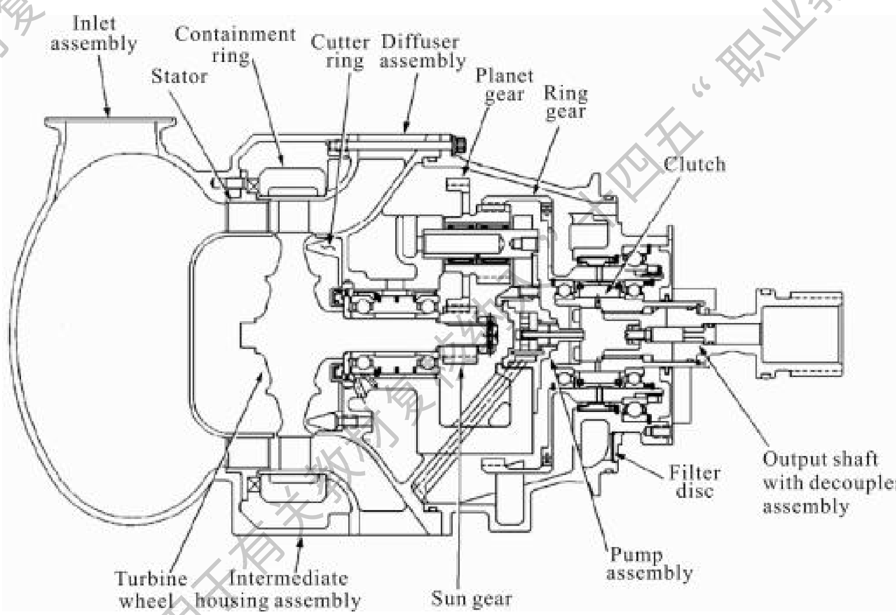


Figure 3.4-2 Engine air turbine starter cross sectional view

When the starter control valve closes and the aircraft engine speed is more than the starter speed, the sprag clutch disengages the output shaft from the clutch hub. The turbine wheel, sun gear, planet gear, ring gear and clutch hub will stop. The clutch shaft, the shaft on the pump assembly and the output shaft assembly continue to turn with the aircraft engine.

If the sprag clutch fails to disengage the turbine wheel from the output shaft assembly, the decoupler assembly has a tension bar that will disconnect the aircraft engine from the starter. The function of the pump assembly is to supply lubricant to the sprag clutch and the overrun bearings during engine operation after the starter has stopped.

If the turbine wheel moves axially during a thrust bearing failure, the cutter ring will cut the rim from the turbine wheel hub and the containment ring will contain the high-energy turbine wheel rim and blade pieces. A magnetic drain plug in the gear housing will collect metal particles in the lubricant. A filter disc is supplied at the lubricant leveling port to keep unwanted objects out of the engine.

3.4.3 General Assembly Procedures

Note: The assembly procedures are in the sequence of the illustration first and then the text on the same page or adjacent pages where possible. All necessary information is given so that the unit can be assembled without reference to a different part of the manual.

(1) Remove all corrosion preventive compound and contamination from the parts before assembly.

(2) All the nuts, bolts and screws must be tightened to a standard torque unless the torque is specified in the text. Refer to FAA Manual AC65 - 9A, Airframe and Powerplant Mechanics General Handbook, for the standard torque.

(3) Use lubricating compound for the assembly of all threaded parts as follows.

Caution: Use of too much lubricating compound can cause clogged vents and orifices.

1) Apply a small quantity of lubricating compound to the threads of all male threaded parts except where noted.

2) Remove all of the lubricating compound that is remaining after assembly of the threaded parts.

Warning: Use the correct personal protection. oil can have an additive called tricresyl phosphate in it. This chemical is an asphyxiant, it is poisonous and can be absorbed through the skin.

(4) Use lubricating oil (Mobil Jet Ⅱ, MIL-PRF-23699) to lubricate all packings before installation.

(5) Use lockwire on all hardware (bolts, screws, plumbing, electrical connectors) with lockwire holes. Install the lockwire as specified in SAE-AS567.

(6) When screws or bolts are too long or too short, a longer or shorter standard screw or bolt can be used if there is a minimum of one full thread more than the face of the threaded part or nut.

Note: There are no optional screw or bolt lengths permitted for blind hole applications.

New Words/ Phrases/ Expression

1. stator [ˈsteitə] *n.* 定子
2. torque [tɔːk] *n.* 扭矩
3. sprag clutch 斜撑离合
4. hub [hʌb] *n.* (轮)毂
5. axially [ˈæksiəli] *adj.* 轴向的
6. rim [rim] *n.* (尤指圆形物的)边
7. containment [kənˈteinmənt] *n.* 阻遏
8. contain [kənˈtein] *v.* 包含;控制
9. magnetic [mægˈnetik] *adj.* 有磁性的

Notes

【1】The air turbine engine starter changes compressed air pressure into mechanical force, sufficient to increase the speed of the aircraft engine to start speed.

分析:在"to"之前应使用"sufficient",而不是"sufficiently"。

翻译:空气涡轮发动机启动机把压缩空气的压力转化成机械力,充分提升飞机发动机的转速到启动速度。

Exercises

Ⅰ. Answer the following questions:

1. What is the purpose of the gears in the starter?

2. What happens if the sprag clutch fails to to disengage the turbine wheel from the output shaft assembly?

Ⅱ. Translate the following sentences into Chinese:

1. Compressed air flows through the inlet assembly through the stator to the turbine wheel to cause high speed and low rotational torque at the sun gear.

2. When the starter control valve closes and the aircraft engine speed is more than the starter speed, the sprag clutch disengages the output shaft from the clutch hub.

Ⅲ. Fill in the following blanks according to the text:

1. The sun gear, planet gears and ring gear ________ the high speed to transmit a high torque to the ________.

2. A ________ drain plug in the gear housing will collect ________ particles in the lubricant.

3.5 Variable Delivery Hydraulic Pump Maintenance

The aircraft engine operates the variable delivery hydraulic pump (see Figure 3.5-1) through a speed-reduction gearbox. The gearbox connects to the external drive shaft of the pump and decreases the rpm (revolutions per minute) of the engine to that necessary for pump operation. The pump uses phosphate ester type fluid and supplies hydraulic pressure for the hydraulic system.

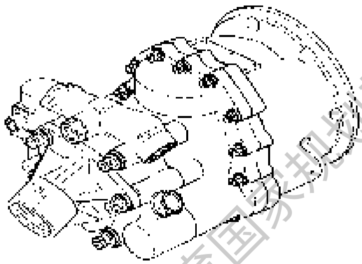


Figure 3.5 - 1　Variable delivery hydraulic pump

3.5.1　Testing and Fault Isolation

1. Testing

Before you do a test, examine the pump exterior for damage and defects. Look for cracks, loose bolts, housing damage and other conditions that make the pump operationally unsafe. Do not do a test on a pump that is damaged. Repair the pump first, and then do the tests.

After examination, do the performance evaluation tests to find the condition of a pump when you receive the pump with a malfunction tag. When knowing the repair done, or the status of the pump, according to the Table 3.5 - 1, we can find what tests are necessary. The details of each test refer to the manual. After a pump is repaired, do the specified acceptance tests.

Table 3.5 - 1　Repair-Test Matrix

Repairs Done (or Status)	Necessary Tests								
	Static Proof Pressure	Break in Run	Patch	Dynamic Shaft Seal Leakage	Calibration	Pressure Control	Blocking Valve Operation	Case Relief Valve	Case Drain Flow
Performance Evaluation				×	×	×	×	×	×
Small Repairs									
External Leakage				×	×	×	×	×	×
Pressure Control Fix				×	×	×	×	×	×
Solenold or Blocking Valve				×	×	×	×	×	×

Continued

Repairs Done (or Status)	Necessary Tests								
	Static Proof Pressure	Break in Run	Patch	Dynamic Shaft Seal Leakage	Calibration	Pressure Control	Blocking Valve Operation	Case Relief Valve	Case Drain Flow
Shaft Seal Leakage		×		×	×	×	×	×	×
Large Repairs (Replacement of Parts)									
Housing	×	×		×	×	×	×	×	×
Mounting Flange	×	×		×	×	×	×	×	×
Inlet Adapter	×	×	×	×	×	×	×	×	×
Port Cap Subassembly	×	×		×	×	×	×	×	×
A Rotating Group Part		×	×	×	×	×	×	×	×
Trunnion Bearings		×	×	×	×	×	×	×	×
Barrel or Shaft Bearing		×	×	×	×	×	×	×	×
Overhaul of Pump (Replacement of Parts)									
Mounting Flange Front Housing and/or Port Cap Subassembly	×	×	×	×	×	×	×	×	×
Bearing and Rotating Group		×	×	×	×	×	×	×	×

2. Fault Isolation

When a pump assembly test does not agree with a test specification, attach a tag to the pump to identify the test parameter and the probable cause as found by fault isolation. When more than one probable cause are given for a fault, narrow them down to the most likely one before you do a corrective action.[1]

3.5.2 Disassembly

1. External Drive Shaft Subassembly Disassembly (see Figure 3.5-2)

Pull the external drive shaft subassembly (5) from the pump assembly. Remove the retaining ring (20) and the spline adapter (10) from the external drive shaft (15). Remove the retaining ring (25) from the external drive shaft.

2. Port Adapter Removal (see Figure 3.5-2)

Remove machine bolts (35, 40) and the flat washers (45) that hold the port adapter (30) to the port cap and depressurizer subassembly. Remove the port adapter and discard the packing (50) from the base of the port adapter.

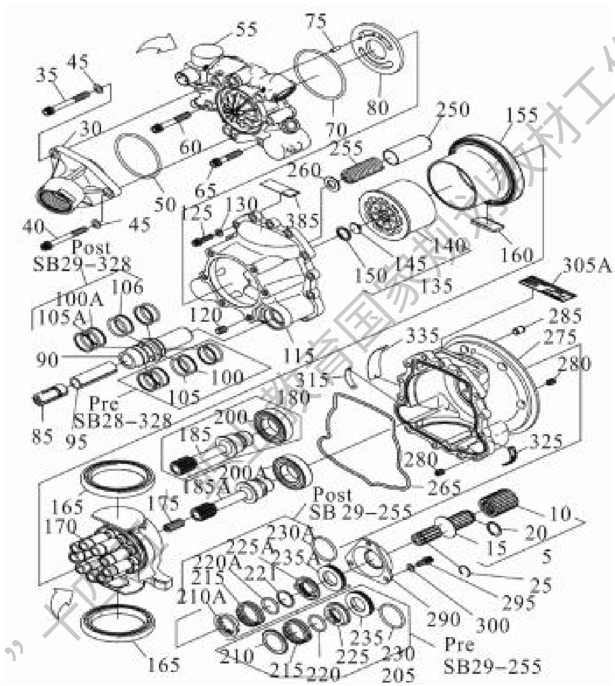


Figure 3.5 - 2　Variable delivery hydraulic pump—exploded view

3. Electrical Solenoid Removal and Disassembly (see Figure 3.5 - 3)

Remove two socket head cap screws (45) and the electrical solenoid (40) assembly. Remove and discard the packing (50) and two backup rings (55) from the base of the solenoid. Remove the spool and sleeve subassembly from the solenoid depressurizer bore of the port cap subassembly (5). Remove the solenoid spring (75) and the solenoid spool (65) from the solenoid sleeve (70).

4. Spool and Sleeve Subassembly Removal and Disassembly (see Figure 3.5 - 3)

Remove the compensator plug (80) from the compensator bore of the port cap subassembly (5). Remove and discard the packing (85) from the compensator plug. Loosen the lock nut (105) on the adjusting screw (110). Remove the adjusting screw from the port cap subassembly. Remove the compression spring (125) and the two spring guides (115, 130) from the bore. Remove the guides from the spring. Remove and discard the packing (120) from the spring guide (115). Remove the compensator spool and sleeve subassembly (90) from its bore in the port cap subassembly.

5. Blocking Piston Removal (see Figure 3.5 - 3)

Remove two machine bolts (150) and the blocking piston cap (135) from the port cap subassembly (5). Remove and discard the packing (140) and the backup ring (145) from the blocking piston cap. Remove the blocking piston spring (155) and the blocking piston (160) from the piston bore.

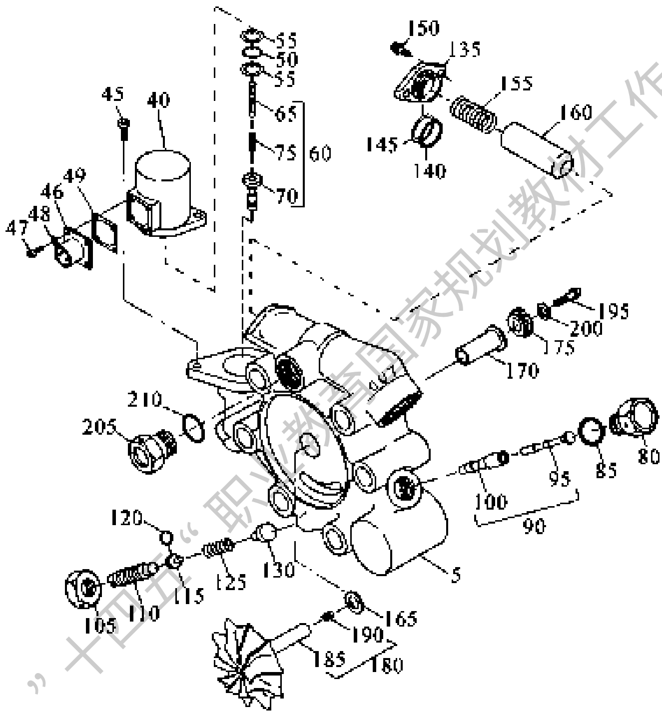


Figure 3.5 - 3 Port cap and depressurizer subassembly

6. Port Cap and Depressurizer Subassembly Removal (see Figure 3.5 - 2)

Remove the compensator plug (see Figure 3.5 - 3, Item 205) from the sensing hole in the port cap and depressurizer subassembly (55). Remove and discard the packing (see Figure 3.5 - 3, Item 210) from the compensator plug. Remove two machine bolts (60), one machine bolt (65) and the port cap and depressurizer subassembly from the front housing (115). Remove the port plate (80). Examine the straight headless pin (75) for damage. Remove the pin only if it is damaged. Remove and discard the packing (70) from the base of the port cap subassembly.

7. Impeller Subassembly Disassembly and Removal (see Figure 3.5 - 3)

Remove the wire that safeties the socket head cap screw (195) to the drive coupling (175). Write down where and how the wire is installed so that you can refer to it during the pump assembly. Remove the socket head cap screw and washer (200) from the impeller subassembly. Remove the drive coupling and the impeller subassembly. Remove the thrust washer (165) from the shaft of the impeller (185). Remove the sleeve bearing (170) from the port cap subassembly (5) only if the sleeve is damaged, using an arbor press as necessary.

8. Stroking Piston and Auxiliary Piston Removal (see Figure 3.5 - 2)

Remove the auxiliary piston (85) from the stroking piston sleeve in the bore of the front housing (115). Remove the stroking piston (95) and the stroking piston sleeve (90).

Remove and discard three packing (105) and four backup retainers (100) from the stroking piston sleeve.

9. Front Housing Subassembly Removal and Disassembly (see Figure 3.5-2, Figure 3.5-4)

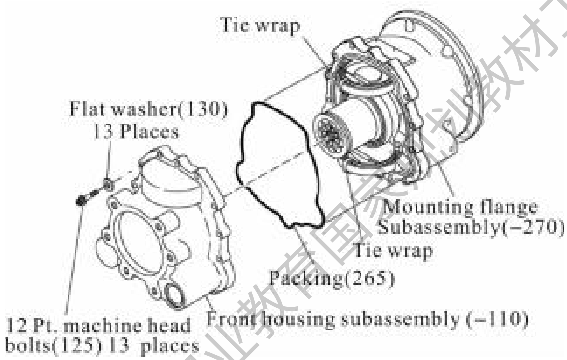


Figure 3.5-4 Front housing subassembly

Remove 13 bolts (125), 13 flat washers (130), and the front housing subassembly (−110) from the mounting flange subassembly (−270). Put your hand over the front housing opening so you do not get splashed with hydraulic fluid. Remove the rate piston (250), helical compression spring (255) and flat washer (260) from the front housing subassembly. Remove and discard the packing (265) from the groove in the mounting flange subassembly. Install a tie wrap around the inner and outer race of each trunnion bearing (165) before you remove the hanger and piston subassembly (170) from the mounting flange subassembly. Remove the hanger and piston subassembly, along with the barrel and washer subassembly (135), radial barrel bearing (155) and trunnion bearings, from the mounting flange subassembly.

10. Barrel and Washer Subassembly Disassembly (see Figure 3.5-2)

Carefully remove the two trunnion bearings (165) from the hanger and piston subassembly (170). Remove the barrel and washer subassembly (135) from the radial barrel bearing (155) and the hanger and piston subassembly. Remove the thrust clip (160) and the radial barrel bearing from the hanger and piston subassembly.

11. Hanger and Piston Subassembly Disassembly (see Figure 3.5-5)

Put the hanger and piston subassembly on the holding fixture. Put the holding fixture in a vise. Remove the retainer nut (5) from the plate and washer retainer (65). Remove these parts from the plate and washer retainer (65):

(1) Shoe retaining plate (10) with nine piston and shoe subassemblies (20);

(2) Hanger wear plate (15);

(3) Hanger subassembly (40);

(4) Needle bearing (35);

(5) Thrust washer (60).

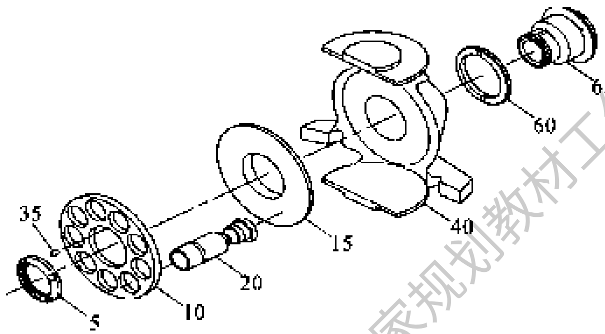


Figure 3.5 - 5 Hanger and piston subassembly

12. Shaft Seal Subassembly Removal and Disassembly (see Figure 3.5 - 2)

Remove three machine bolts (295), three flat washers (300) and the seal retainer (290) from the mounting flange (275). Remove the mating face seal subassembly (235). Remove and discard the packing (230) from the mating face seal subassembly. Remove the nose seal (225), compression spring (215) and spring seat (210) from the shaft and pin subassembly (185). Remove and discard the packing (220) from the nose seal.

13. Shaft and Bearing Assembly Removal and Disassembly (see Figure 3.5 - 2)

Remove the shaft and bearing subassembly (180) along with the compression spring (175) from inside the mounting flange subassembly. Put the shaft and bearing subassembly on the Holding Fixture. Remove the ball bearing (200) from the shaft and pin subassembly (185).

14. Mounting Flange Subassembly Disassembly (see Figure 3.5 - 2)

Remove the helical coil inserts (280) or straight headless pins (285) from the mounting flange (275) only if they are damaged. Remove these parts from the mounting flange (275) only if they are damaged or the information must be changed. Before you remove a plate, be sure to write down all the information on the plate. Use this information to stamp on the replacement plate, as necessary.

(1) Identification plate (305A);

(2) Rotation plate (315);

(3) Fluid identification plate (325);

(4) Modification plate (335).

3.5.3 Cleaning

We usually use the solvent to clean the components. The procedures of solvent cleaning are as follow.

First, remove loose unwanted matter from the part with compressed air and use a light spray of solvent on the part until it is clean, with nozzle pressure of not more than 30 psig. Clean all non-electrical parts in a non-filming solvent. Stubborn dirt can be removed with a nylon brush that is moist with solvent.

Then, dry all parts fully with a clean cloth that has no lint, or with dry, compressed, filtered air of not more than 30 psig.

After that, remove all stains and unwanted surface color from bare metal surfaces with polishing paper, or with a cloth soaked with liquid metal polish. Do not use harsh abrasives that might scratch, score, or mar the surfaces. If you use a metal polish, rub the part briskly, polish with a clean, dry cloth that has no lint, fully clean the parts after you use any abrasives. If you want to remove corrosion from ferrous metal surfaces, polish with a crocus abrasive cloth. If you want to remove corrosion from aluminum parts, you can do the steps as follows:

(1) Do the "first" step.

(2) Flush the part fully with water to remove any solvent.

(3) Apply the correct masking tape to the areas of any parts that are not aluminum or corroded.

(4) Apply the aluminum etchant to the corroded areas for 3 to 12 minutes.

(5) Flush the part fully with water.

(6) Examine the part, if not all the corrosion was removed, replace the part; if the corrosion was fully removed, treat the area with alodine.

After cleaning, cover the part to prevent dust and dirt contamination. Apply a thin layer of hydraulic fluid to all parts after cleaning.

3.5.4 Inspection and Check

(1) Examine the pump assembly housing. Look for signs that the pump operated very hot, such as melted cadmium plating, identification plates that have a burned or melted color, and an off color housing. Replace the full pump assembly if you see any of those signs.

(2) Use a bright light and a magnifier to examine all the metal parts for signs of:

• structural failure;

• nicks and burrs;

• scratches and cracks;

• corrosion.

(3) Examine all the packing and ring grooves for burrs, nicks or dents.

(4) Examine all the screw threads. Make sure they are not cross-threaded or stripped.

(5) Examine all bearings for smooth and free operation.

(6) Although a damaged part can possibly be repaired, the cause of the damage must be found and corrected to prevent future failures. These are some of the problems that can cause damage to the pump assembly parts:

• incorrect clearance between the parts—incorrect or no lubricant;

• unwanted movement of parts bolted or pressed together—too much load, heat and shock;

• contamination, such as grits, chips and chemicals—extension of small damage.

3.5.5 Typical Repair

In this subject, we will introduce the repairs of removing and installing these parts on the mounting flange subassembly (—270):

- helical coil insert (280);
- straight headless pin (285);
- name plates (305, 315, 325, 335, 380, 385).

1. Helical Coil Insert Replacement (see Figure 3.5－2, Figure 3.5－6)

First, remove the damaged insert with a helicoil extracting tool. Set the sharp blade end of the tool against the insert. Hit the tool head lightly so it holds the insert. Push down on the tool and turn it counterclockwise (CCW) to remove the insert. Discard the removed insert.

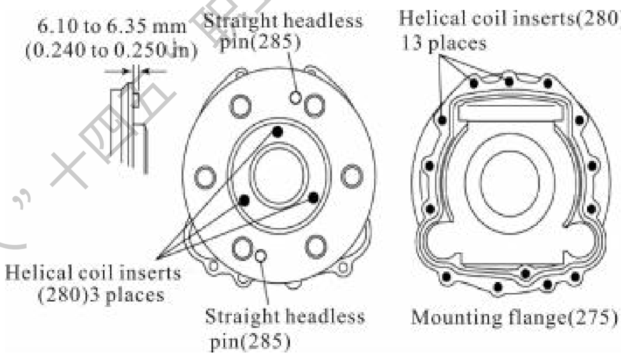


Figure 3.5－6 Helical coil insert and headless pin

Then, use mineral spirits to clean the insert bores. Examine the condition of the threads in the mounting flange (275). If they are damaged due to wear, corrosion, or too much torque, repair them with a helicoil thread repair kit, or equivalent.

After that, install the new insert with a helicoil installation tool, until the outer end is $\frac{1}{2}$ to $1\frac{1}{2}$ turns below the outer end of the bore. Use a small punch to break off the insert installation tang. Be sure to remove the tang from bore.

Finally, examine the insert installation. Make sure it is as specified in specification. If it is not, repair as necessary.

2. Straight Headless Pin Replacement

Remove a damaged pin with pliers or other pin extraction tool. Do not damage the mounting flange machined surfaces. Then install a new pin: Apply retaining compound to the pin. Use an arbor press to press the pin into the mounting flange hole.

3. Name Plate Replacement (see Figure 3.5－2)

Remove these parts from the mounting flange only if they are damaged or the information must be changed:

- Identification plate (305);

- rotation plate (315);
- fluid identification plate (325);
- modification plate (335);
- identification plate (385).

The steps of name plate replacement are as follow:

(1) Before you remove the plate, write down all the information that is on it;

(2) Remove the plate;

(3) Fully clean the area where the new plate will be installed;

(4) Stamp the necessary information on the replacement plate;

(5) Apply adhesive to the back of the replacement plate;

(6) Install the plate on the mounting flange subassembly in its correct place.

3.5.6 Assembly and Storage

Before assembly, make sure you have all the parts necessary to assemble the pump. Figures 3.5 - 2, 3.5 - 3 and 3.5 - 5 show how the pump parts are related. Use only new sealing devices to assemble the pump. Before installation, lubricate all sealing devices with hydraulic lubricant.

During assembly, prevent damage to the sealing surfaces of parts. Do not use tools with sharp corners, sharp edges, or rough surfaces to install sealing devices. Install preformed packing with the mold flash in one plane. Be sure to stretch the packing evenly around the seal groove. Clean parts before assembly. Safety the necessary external attaching parts with the lockwire or lock cable.

After you assemble the pump, refer to the Testing and Fault Isolation section and do the test procedures. If the pump fails any test, it must be repaired before it is returned to service.[2]

1. Shaft and Bearing Subassembly Assembly (see Figure 3.5 - 7, Figure 3.5 - 2)

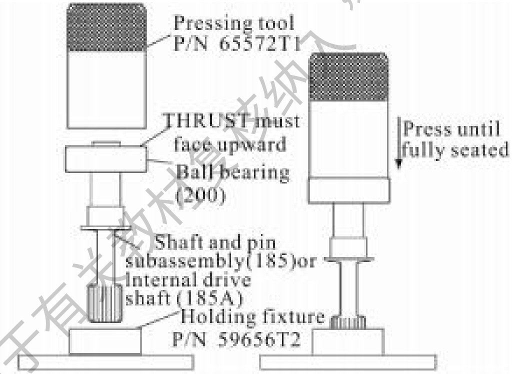


Figure 3.5 - 7　Shaft and bearing assembly

Put the ball bearing (200) on the shaft and pin subassembly (185). Make sure the word "THRUST" is up. Put the shaft and pin subassembly in the Holding Fixture. Use the pressing tool to install the ball bearing on the shaft and pin subassembly. Make sure the bearing is fully against its seat, it is flat and it turns freely. Remove the shaft and pin subassembly from the holding fixture. Install the shaft and bearing subassembly (180) into the mounting flange subassembly. Make sure the ball bearing fits correctly against its seat, it is flat and not at an angle.

2. Shaft Seal Subassembly Assembly (see Figure 3.5 - 2, Figure 3.5 - 4)

First, examine the faces of the nose seal (225) and mating face seal subassembly (235). Make sure the faces are clean and unmarred.

Then, lubricate the lapped faces of the nose seal and mating face seal with a small amount of hydraulic fluid as follows:

(1) On the repair bench, lay down a clean cloth that has no lint.

(2) In one area of the cloth, pour a small amount of alcohol. In another area of the cloth, pour a small amount of hydraulic fluid.

(3) Take each seal, one at a time, and put its lapped face down on the area soaked with alcohol. Turn the seal back and forth slightly. Then put the seal down on the area soaked with hydraulic fluid, and turn the seal back and forth slightly to lubricate it.

After that, install the packing (220) in the nose seal (225). Align the spring seat (210) and fully engage it with the pins on the shaft and pin subassembly (185). Assemble the compression spring (215) onto the nose seal. Install the compression spring and the nose seal onto the spring seat. Make sure the parts move freely in place after installation. Lubricate and install the packing (230) on the mating face seal subassembly (235). Push the mating face seal subassembly into the bore by hand until the packing is just inside the bore. Do not push the seal in so far that it is flush.

Finally, use the seal retainer (290) and push by hand to install the mating face seal subassembly into the bore. Use three machine bolts (295) and three flat washers (300) to attach the seal retainer (290) to the mounting flange subassembly (—270). Torque the bolts from 120 to 130 in • 1b①. Turn the pump shaft two to three times to make sure it turns freely. The nose seal must move freely on the shaft and be fully against the mating face seal.

3. Hanger and Piston Subassembly Assembly (see Figure 3.5 - 5, Figure 3.5 - 8)

First, put the thrust washer (60) on the plate and washer retainer (65). Install the plate and washer retainer with the thrust washer through the large bore of the hanger subassembly (40). Install the hanger wear plate (15) over the plate and washer retainer. Install nine pre-lapped piston and shoe subassemblies (20) in the shoe retaining plate (10). Install the shoe retaining plate, the piston and shoe subassemblies on the plate and washer retainer. Install the needle bearing (35) into the slot of the shoe retaining plate and the slot of the plate and washer retainer. Install the retainer nut (5) on the plate and washer retainer. Put the hanger and piston subassembly on the holding fixture. Use wrench and

① 1 in • 1b≈11.3 N • m。

torque the retainer nut from 590 to 600 in • lb.

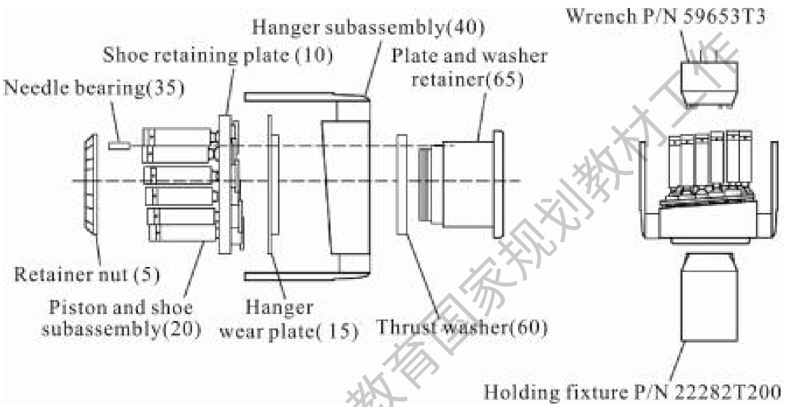


Figure 3. 5 – 8　Hanger and piston subassembly installation

Then, use non-metallic feeler gauges and measure two points at the same time, 180 degrees apart, for clearances between the piston shoes (—25) and hanger wear plate (15) (see Figure 3. 5 – 9). Clearances must be 0. 002 to 0. 003 in at both points.

(1) If the clearance is more than 0. 003 in, disassemble the hanger and piston subassembly, install a thicker thrust washer (60) to decrease the clearance, assemble the subassembly and check the clearance again.

(2) If the clearance is less than 0. 002 in, disassemble the hanger and piston subassembly, lap the thrust washer to the necessary thickness, assemble the subassembly and check the clearance again.

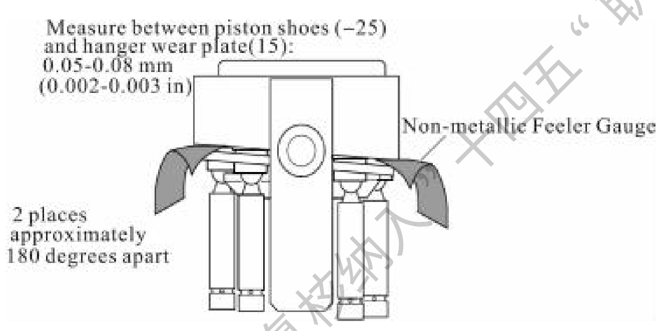


Figure 3. 5 – 9　Piston shoe clearance measurements

After that, install the hanger and piston subassembly onto the cold forming tool. Align the 90-degree forming angle over two of the machined slots on the retainer nut (5). Use 3, 500 lbf[①] maximum on an arbor press and swage the plate and washer retainer (65) into the indents of the retainer nut. Align the 110° forming angle of the Cold Forming Tool, over the same two slots of the retainer nut. Do not stake all four retainer grooves. Visually examine

① 1 lbf≈4. 45 N。

the two staked areas of the plate and washer retainer (65) to make sure the threads are sufficiently formed into the notches of the retainer nut (5). Visually examine the retainer nut for any indication of cracks. No cracks are permitted.

4. Barrel and Washer Subassembly-Assembly (see Figure 3.5 - 2)

Look for the Teflon ring (150) and cylinder barrel washer (145) in the cylinder barrel (140). Set the cylinder barrel and washer subassembly (135) face down on a safe, clean surface (see Figure 3. 5 - 10).

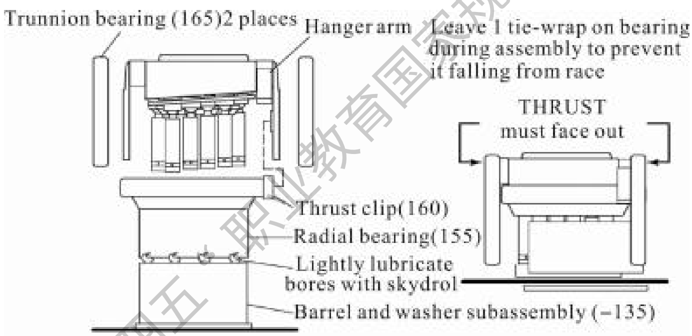


Figure 3. 5 - 10　Barrel and washer subassembly installation

Then, lightly lubricate all of the bores of the cylinder barrel (140). Install the radial barrel bearing (155). Install the thrust clip (160) on the outer race of the radial barrel bearing. Install the hanger and piston subassembly (170) on the barrel and washer subassembly (135). Make sure to install the thrust clip correctly in the milled groove of the hanger subassembly on the hanger arm side. Install the two trunnion bearings (165) on the hanger and piston subassembly (170). Make sure the bearing sides marked with the word "THRUST" are out, away from the subassembly. Install the compression spring (175) in the end of the shaft and pin subassembly (185). Install the assembled hanger and piston assembly into the mounting flange subassembly, over the shaft and bearing subassembly (180). Remove the tie wraps from the trunnion bearings (165).

5. Front Housing Subassembly Assembly (see Figure 3.5 - 2, Figure 3.5 - 4)

Install the flat washer (260) inside the rate piston bore of the front housing subassembly (—110). Install the helical compression spring (255) in the rate piston (250). Install the rate piston and compression spring into the rate piston bore, spring end first. Install the packing (265) into the groove on the end surface of the mounting flange subassembly (—270). Use hydraulic lubricant to hold the packing in place. Install the front housing subassembly over the mounting flange subassembly. Make sure the trunnion bearings (165) are in the bearing seats inside the mounting flange and front housing. Attach the front housing subassembly to the mounting flange subassembly. Use 13 flat washers (130) and the bolts (125). Tighten the bolts and torque from 120 to 130 in • lb.

6. Stroking Piston and Auxiliary Piston Assembly (see Figure 3.5 - 2)

Apply hydraulic lubricant to the three packing (105) and four backup retainers (100) and install on the stroking piston sleeve (90). Install the assembled stroking piston sleeve into the bore of the front housing subassembly. Install the stroking piston (95) into the stroking piston sleeve. Install the auxiliary piston (85) into the stroking piston sleeve. Apply hydraulic lubricant, to both pieces of the modified seal assembly (106).

Then, install the modified seal assembly onto the stroking piston sleeve (see Figure 3.5 -11).

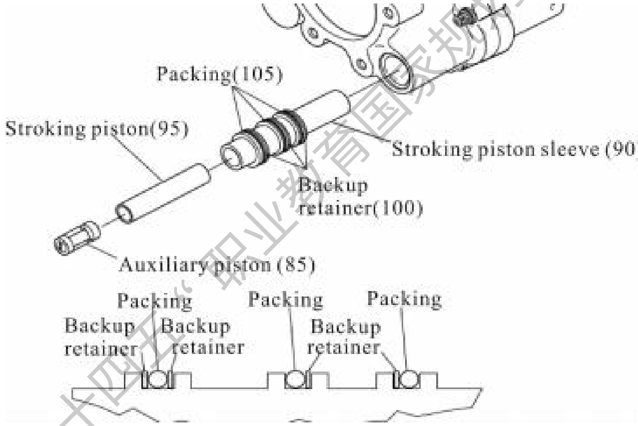


Figure 3.5 - 11 Auxiliary and stroking piston installation

(1) Install the backup retainer and packing of the modified seal assembly onto the stroking piston sleeve using the bullet of the seal assembly tool.

(2) Resize the backup retainer of the modified seal assembly, by placing the stroking piston sleeve with the resizing ring of the seal assembly tool, in the freezer for 10 to 15 minutes. Apply hydraulic lubricant to three backup retainers and install on the stroking piston sleeve. Install the assembled stroking piston sleeve, long end first, into the bore of the front housing subassembly. Install the stroking piston, closed end first, into the stroking piston sleeve. Install the auxiliary piston, open end first, into the stroking piston sleeve.

7. Port Cap and Depressurizer Subassembly Assembly (see Figure 3.5 - 3)

Install the blocking piston spring (155) into the blocking piston (160). Install the blocking piston with its spring into the blocking bore of the port cap subassembly (5). Install the backup ring (145) and the packing (140) on the blocking piston cap (135). Install two machine bolts (150) and torque from 60 to 80 in • lb.

8. Impeller Subassembly Assembly (see Figure 3.5 - 3)

Install a new helical coil insert (190), if it was removed from the end of the impeller shaft. Install the insert $\frac{3}{4}$ to $1\frac{1}{2}$ turns below the surface. Install the thrust washer (165) over the shaft of the impeller (185). Use an arbor press and install the sleeve bearing (170) in the bore on the bottom side of the port cap subassembly (5). Push in the sleeve until the sleeve lip is fully seated on the port cap surface. Install the impeller subassembly (180) through the sleeve bearing. Install the drive coupling (175) over the shaft of the impeller subassembly (180), with the beveled spline and the safety wire hole out away from the port cap subassembly.

Then, measure how far the shaft of the impeller subassembly (180) extends out of the drive coupling (175). The distance must be (0.003±0.001) inch (see Figure 3.5-12). Install the socket head cap screw (195) with the washer (200) into the drive coupling. Torque the screw from 10 to 20 in • lbs. Use a feeler gauge and measure the clearance between the drive coupling and sleeve bearing (170). The clearance must be 0.002 to 0.004 in. Use lockwire to safety the cap screw to the drive coupling.

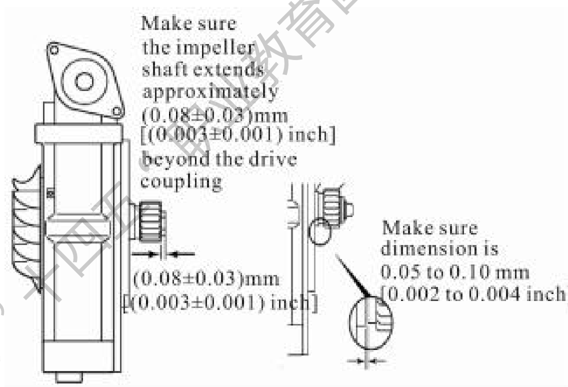


Figure 3.5-12 Impeller installation details

9. Port Cap and Depressurizer Subassembly to Front Housing Subassembly Assembly (see Figure 3.5-2)

First, install the packing (70) onto the port cap and depressurizer subassembly (55). Install the straight headless pin (75) into the port cap and depressurizer subassembly, if it was removed during disassembly. Apply a small quantity of hydraulic lubricant onto the port face surface of the port cap and depressurizer subassembly. Install the port plate (80) on the port cap and depressurizer subassembly. Make sure the straight headless pin (75) goes into its locating hole.

Then, apply hydraulic fluid to the surfaces of the barrel and washer subassembly (135). Fill the barrel and washer subassembly with hydraulic fluid. Put the assembled port cap and depressurizer subassembly (55) on the front housing (115). Make sure the stroking piston sleeve (95) aligns correctly with the port cap. Attach the port cap and depressurizer subassembly to the front housing with two machine bolts (60) and one machine bolt (65). Torque the bolts from 150 to 200 in • lb.

After that, install the packing (see Figure 3.5-3, Item 210) on the compensator plug (see Figure 3.5-3, Item 205). Install the compensator plug in the sensing hole on the outlet port side of the port cap and depressurize subassembly (55). Torque the plug from 250 to 275 in • lb.

10. Spool and Sleeve Subassembly to Port Cap Subassembly Assembly (see Figure 3.5 - 3)

Put the compensator spool (95) in the compensator sleeve (100). Install the assembled spool and sleeve subassembly (90) into the compensator bore of the port cap subassembly (5). Install the packing (85) on the compensator plug (80). Install the compensator plug into the port cap subassembly. Torque the plug from 250 to 275 in • lb.

Then, put the compression spring (125) on the spring guide (130). Install the spring guide with the compression spring into the compensator bore of the port cap subassembly (5). The bore is opposite the end of the compensator plug (80). Make sure the guide goes into the bore before the spring. Install the packing (120) on the spring guide (115). Put the assembled spring guide, nib end first, into the compensator bore of the port cap subassembly (5). Install the adjusting screw (110) into the compensator bore far enough to push the assembled spring guides (115, 130) against the compression spring (125). Install the lock nut (105) on the adjusting screw. Tighten the lock nut by hand. Make sure after the lock nut is tight that you can see four or more threads of the adjusting screw (110).

11. Electrical Solenoid Subassembly to Port Cap Subassembly Assembly (see Figure 3.5 - 3)

Install the solenoid spring (75) on the solenoid spool (65). Put the solenoid spring and spool into the solenoid sleeve (70). Install the solenoid sleeve assembly into the solenoid bore of the port cap assembly (5). Install the packing (50) and two backup rings (55) onto the base of the electric solenoid (40). Attach the solenoid to the solenoid flange of the port cap assembly (5) with two socket head cap screws (45). Torque the screws from 40 to 50 in • lb.

12. Port Adapter Assembly (see Figure 3.5 - 2)

Install the packing (50) on the base of the port adapter (30). Attach the port adapter to the assembled pump with two machine bolts (35), one machine bolt (40) and three flat washers (45). The machine bolt (40) has the safety wire hole. Torque the bolts from 150 to 200 in • lb.

13. External Drive Shaft Subassembly Assembly (see Figure 3.5 - 2)

Install the spline adapter (10) over the splines of the external drive shaft (15) to engage the drive gear of the engine. Install the retaining ring (20) to safety the spline adapter. Install the retaining ring (25) into the groove on the other end of the external drive shaft (15). Put the external drive shaft subassembly (5) into the end of the shaft and pin subassembly (185) at the rear of the pump.

Before you store a pump, do the related checks. Correct any fluid or leakage problems as necessary. The pump must be at least 90 percent full of clean, filtered, hydraulic fluid. All openings must be sealed and dry, without leakage. After check, pack the pump in a dust-proof container and store the pump in a clean, dry area. Before you put a unit on an aircraft, make sure that it has not been in storage for more than 48 months and do the applicable tests.

New Words/ Phrases/ Expression

1. hydraulic [haiˈdrɔːlik] *adj*. 液压的;水力的
2. revolution [ˌrevəˈluːʃən] *n*. 革命;旋转;转数
3. phosphate ester 磷酸酯
4. defect [ˈdiːfekt; ˌdiˈfekt] *n*. 缺点,缺陷,不足之处
5. crack [kræk] *vt*., *vi*., *n*. 使破裂;破裂,爆裂;裂缝
6. malfunction tag 故障标签
7. specified [ˈspesifaid] *adj*. 规定的;详细说明的
8. parameter [pəˈræmitə] *n*. 参数,系数,参量
9. narrow…down 收窄,使……变窄
10. spline [splain] *n*., *vt*. 花键,齿条;开键槽,用花键连接
11. socket head cap screw 内六角螺钉
12. spool [spuːl] *vt*., *n*. 缠绕,卷在线轴上;线轴;缠线框
13. sleeve [sliːv] *n*. 套筒,套管;袖子,袖套
14. adjusting screw 调节螺钉
15. thrust washer 止推垫片
16. auxiliary [ɔːgˈziljəri] *n*., *adj*. 助动词,辅助者;辅助的,副的,附加的
17. get splashed with 被……溅滴
18. needle bearing 滚针轴承
19. solvent [ˈsɔlvənt;ˈsɔːl-] *adj*., *n*. 有溶解力的;溶剂
20. spray [sprei] *n*., *vt*., *vi*. 喷雾,喷雾器;喷射;喷
21. nozzle [ˈnɔzl] *n*. 喷嘴;管口
22. nylon [ˈnailɔn] *n*. 尼龙,聚酰胺纤维
23. stain [stein] *vt*., *vi*., *n*. 沾污;给……着色;污染;污点,瑕疵;着色剂
24. polish [ˈpɔliʃ] *n*., *vi*., *vt*. 磨光,擦亮,擦亮剂;擦亮,变光滑;磨光
25. soaked with 用……浸湿
26. harsh [hɑːʃ] *adj*. 严厉的,粗糙的;刺目的
27. briskly [ˈbriskli] *adv*. 迅速地;活泼地
28. lint [lint] *n*. 软麻布,线头,棉绒
29. ferrous metal 铁金属
30. aluminum [əˈljuːminəm] *n*. 铝
31. magnifier [ˈmægnifaiə] *n*. 放大镜,放大器
32. nick [nik] *vt*., *n*., *vi*. 刻痕于,用刻痕记;刻痕,缺口;刻痕
33. scratch [skrætʃ] *n*., *vt*., *vi*. 擦伤,抓痕;抓,刮;抓,搔
34. contamination [kənˌtæmiˈneiʃən] *n*. 污染;玷污;污染物
35. counterclockwise[kəʊntəˈkiɔkwaiz] *adj*., *adv*. 逆时针
36. equivalent [iˈkwivələnt] *adj*., *n*. 相等的,同意义的;等价物,相等物
37. evenly [ˈiːvənli] *adv*. 均匀地,平衡地,平坦地,平等地

38. ball bearing 球轴承
39. back and forth 来回地
40. align [ə'lain] *vt.*，*vi.* 使结盟，使成一行，匹配；排列，排成一行
41. notch [nɔtʃ] *n.*，*vt.* 刻痕，凹口；在……上刻凹痕
42. teflon ['teflɔn] *n.* 聚四氟乙烯
43. groove [gruːv] *n.*，*vt.*，*vi.* 凹槽，槽；开槽于；形成沟槽
44. proof [pruːf] *adj.* 防……的，不能透入的，耐……的

Notes

【1】When more than one probable cause are given for a fault, narrow them down to the most likely one before you do a corrective action.

分析："narrow ... down"的意思是"收窄，使变狭窄"。

翻译：当一个故障可能由多个原因引起时，先缩小范围到最可能引起故障的那个原因，再进行排除。

【2】After you assemble the pump, refer to the Testing and Fault Isolation section and do the test procedures. If the pump fails any test, it must be repaired before it is returned to service.

分析："refer to"的意思是"参考，涉及，提到，查阅"。

翻译：组装完泵后，参考"测试与故障隔离"章节内容并完成测试。如果有任何故障，在投入使用前必须修理完好。

Exercises

Ⅰ. Answer the following questions:

1. What is the procedure of removing corrosion from aluminum parts?
2. What are the problems that can cause damage to the pump assembly parts?

Ⅱ. Translate the following sentences into Chinese:

1. Before you do a test, examine the pump exterior for damage and defects. Look for cracks, loose bolts, housing damage and other conditions that make the pump operationally unsafe. Do not do a test on a pump that is damaged. Repair the pump first, and then do the tests.

2. First, remove loose unwanted matter from the part with compressed air and use a light spray of solvent on the part until it is clean, with nozzle pressure of not more than 30 psig. Clean all non-electrical parts in a non-filming solvent. Stubborn dirt can be removed with a nylon brush that is moist with solvent.

3. First, remove the damaged insert with a helicoil extracting tool. Set the sharp blade end of the tool against the insert. Hit the tool head lightly so it holds the insert. Push down on the tool and turn it counterclockwise (CCW) to remove the insert. Discard the removed insert.

4. Before you store a pump, do the related checks. Correct any fluid or leakage problems

as necessary. The pump must be at least 90 percent full of clean, filtered, hydraulic fluid.

Ⅲ. Fill in the following blanks according to the text:

1. After that, remove all ________ and unwanted surface color from bare metal surfaces with ________, or with a cloth ________ liquid metal polish. Do not use ________ that might scratch, score, or mar the surfaces. If you use a metal polish, ________, polish with a clean, dry cloth that has no ________, fully clean the parts after you use any abrasives. If you want to remove corrosion from ________ surfaces, polish with a crocus abrasive cloth.

2. Then, lubricate the lapped faces of the nose seal and mating face seal with ________ hydraulic fluid as follows:

(1) On the repair bench, ____.

(2) In one area of the cloth, pour a small amount of alcohol. In another area of the cloth, ________ a small amount of hydraulic fluid.

(3) Take each seal, ________, and put its lapped face down on the area soaked with alcohol. Turn the seal ________ slightly. Then put the seal down on the area soaked with ________ fluid, and turn the seal back and forth slightly to ________ it.

3.6 Flexible Fuel Level Measuring Stick (Flexi-Stick Assembly)

3.6.1 Description

(1) Flexi-Stick™ Assemblies (thereafter referred to as fuel sticks) are installed in aircraft fuel tanks to measure fuel level during preflight checks. Each fuel stick consists of a base, a housing assembly with float assembly, and a flexible stick assembly. The stick assembly may be calibrated in one of six systems of units (see Figure 3.6-1):

1) Depth of fuel in inches;

2) Depth of fuel in centimeters;

3) Quantity of fuel in pounds (at nominal density);

4) Quantity of fuel in kilograms (at nominal density);

5) Quantity of fuel in liters (at nominal density);

6) Relative depth of fuel in linear markings (no specific units).

(2) The stick assembly is contained within the housing assembly. The float assembly is installed over the upper end of the housing assembly and is free to slide up or down with changes in the fuel level.[1] The housing assembly attaches to the base assembly or to the fitting provided for configurations noted in CMM in detail.

(3) The calibrated units, length and maximum weight for each fuel stick dash number are tabulated in CMM in detail.

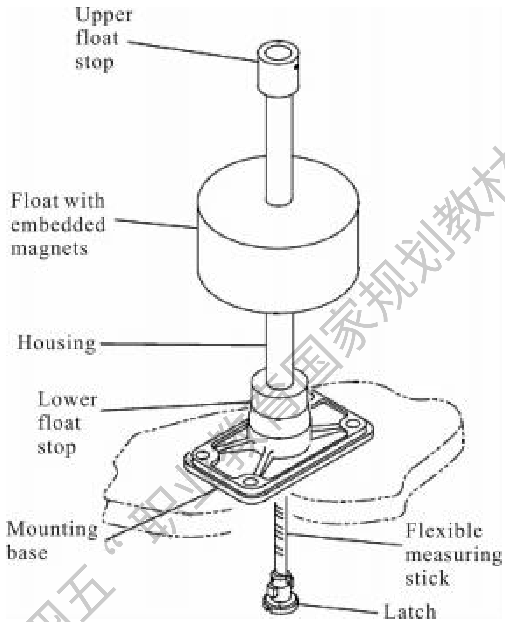


Figure 3.6-1　Flexible fuel level measuring stick (flexi-stick assembly)

3.6.2　Operation

(1) The fuel level in a tank is checked by depressing a slotted latch on the stick assembly and rotating the latch 90 degrees, allowing the stick assembly to fall freely from the housing.[2]

(2) The stick assembly will extend until a magnet in the float assembly locks onto a magnet at the top of the stick assembly.

(3) The fuel level is then read at the retainer (190) on the stick assembly.

3.6.3　Leading Particulars

The leading particulars of the Flexi-Stick™ Assembly are given in Table 3.6-1.

Table 3.6-1　Leading Particulars

Item		Specification
Manufacturer		Flexible Fuel Level Measuring Stick (Flexi-Stick Assembly)
Description		Rockwell Collins, Inc. (CAGE 4V297)
Part Number(s)	Rockwell Collins, Inc.	1140-0110-2 through −41, −211 through −250, −311 through −315, −321 through −325, −331 through −335
	Boeing	S345T001-2 through −41, −211 through −250, −311 through −315, −321 through −325, −331 through −335

Continued

Item		Specification
Functional Specifications	Calibrated Fuels	JP-4, JP-5, AMS5572, MIL-DTL-5624, MIL-PRF-680, MIL-PRF-7024, and ASTM-D1655
	Calibration Markings	Markings on inner stick are black on yellow background
Pressure Limits	Maximum Working	20 psig (138 kPa gage)
	Proof	−6 to 40 psig (−41.37 to 276 kPa gage)
	Burst	80 psig (552 kPa gage)
External Leakage		Zero at −6 to 40 psig (−41.37 to 276 kPa gage)
Temperature Limits	Ambient	−54℃ to 71℃ (−65 to 160℉)
	Normal Operation	−54℃ to 57℃ (−65 to 135℉)
Force Required to Break Coupling		1.4 N (5 ounces)

3.6.4 Testing and Trouble Shooting

3.6.4.1 General

Note: The warranty herein on Products corrected by other than Rockwell Collins shall remain in effect as if Rockwell Collin's Product were repaired and corrected by Rockwell Collins provided, however, Rockwell Collins shall not be liable for defects or failures attributable to misuse, negligence or improper correction.[3]

This section contains test procedures. Testing information is provided to determine the operational readiness of the Flexible Fuel Level Measuring Stick (Flexi-Stick Assembly).

The operational tests provide test setup instructions and test procedures for each Line Replaceable Unit (LRU) function. Do the tests before disassembly to identify the faulty component(s). Do the tests after repair to verify performance.

3.6.4.2 Test Tools, Fixtures, and Equipment

(1) Standard tools and materials that may be required are listed in the Rockwell Collins Avionics Standard Shop Practices manual 523-0768039. Equivalent items can be used (see Table 3.6-2).

Note: All test equipment must be in current calibration to ANSI/NCSL Z540-1 or an approved inhouse standard.

Table 3.6 – 2 Tools, Fixtures, and Test Equipment

Nomenclature	Part or Specification Number	Source (Cage)*
Adapter	T9-0551K	Rockwell Collins, Inc. (V86831)
Fixture, Torque	T5-0497K	Rockwell Collins, Inc. (V86831)
Pressure Gage	0 to 60 psig (0 to 408 kPa gage)	Commercially Available
Tank, Compressed Air	0 to 40 psig (0 to 276 kPa gage)	Commercially Available
Valve, Manual Shutoff (Qty. 2)	No Specific	Commercially Available

* Refer to the IPL for the address.

3.6.4.3 Test Materials

None Required.

3.6.4.4 Functional Tests

1. Pre-Test Examination

(1) Visually examine the UUT (unit under test) for workmanship and visible damage. Pay special attention to the item identification, cleanliness, condition of finishes. Refer to CHECK for more details.

(2) Examine UUT for any Foreign Object Debris (FOD).

(3) If the UUT fails a test, try the test a second time. After repair, do the full test procedure again to verify the UUT is functioning properly.

2. Test Setup (see Figure 3.6 – 2)

Install the UUT in the test setup shown in Figure 3.6 – 2.

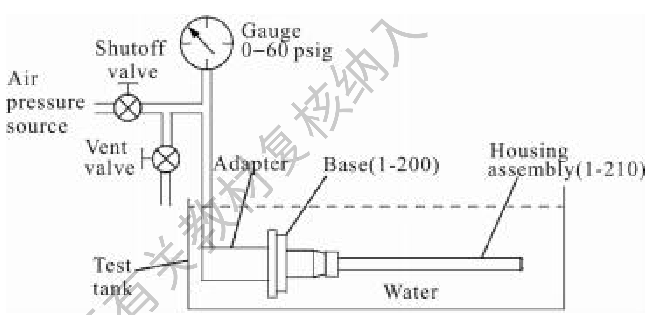


Figure 3.6 – 2 Test Setup

3. Test Procedures

(1) External leakage test (see Figure 3.6 – 2, Figure 3.6 – 3).

1) Using suitable adapter, apply 40 psig (272 kPa gage) air pressure to housing assembly

(210) and base (200). Submerge housing assembly in water. Maintain pressure for 1 minute while checking for external leakage.

Note: On fuel stick configurations with no base, a base (200) is required for testing.

2) There must be no external leakage.

3) If external leakage is noted, check O-Ring(s) (250 or 250A) on tube assembly (271), or housing assembly (210) as applicable for deterioration and corrosion.

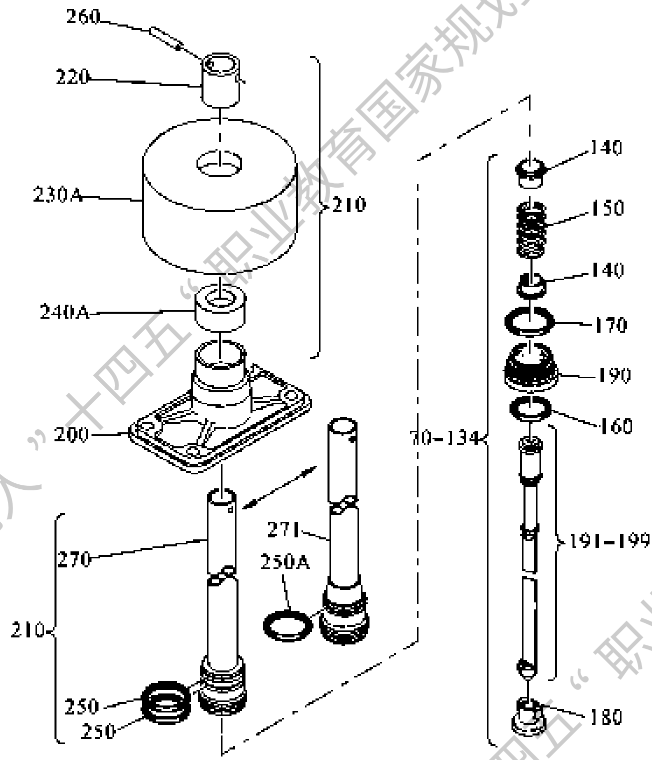


Figure 3.6-3 Flexi-Stick assembly

(2) Latch lock test.

1) With fuel stick assembled, depress latch (180) and rotate latch to locked position.

2) If excessive force is required to depress latch, replace spring (150). If excessive torque is required to turn latch, check O-Ring (160) for deterioration and retainer (190) and housing assembly (210) for binding or corrosion.

(3) Operational test.

1) Actuate stick assembly within housing assembly at least five times. The stick assembly shall move smoothly along the entire length of the housing assembly. If stick assembly malfunctions, examine stick assembly and housing assembly for distortion. Replace defective assembly.

2) With stick assembly removed, float assembly (230) shall move freely on housing assembly. If float assembly malfunctions, examine float assembly and housing assembly for

distortion. Replace defective assembly.

(4) Magnetic coupling test.

1)Magnetically couple float assembly and stick assembly. Actuate float assembly over housing assembly at least five times. The float assembly and stick assembly shall move simultaneously along entire length of outer tube assembly and shall simultaneously free fall under gravity when tilted 15 degrees from vertical.

Note: The float and stick will normally rise and fall in small jumps, rather than slide smoothly along the housing.

2)If float assembly and stick assembly will not couple, the probable cause is a defective magnet in the float assembly. Replace defective assembly.

New Words/ Phrases/ Expression

1. fuel stick 油尺
2. preflight checks 航前检查
3. calibrate [ˈkælibreit] *vt.* 校正;调整
4. slide [slaid] *n.* 滑动
5. tabulate [ˈtæbjʊleit] *vi.* 制成表格
6. slot [slɔt] *n.* 狭槽
7. latch [lætʃ] *n.* 门闩
8. burst [bəːst] *vi.* 爆发,突发
9. herein [hiərˈin] *adv.* 于此;在这方面
10. Line Replaceable Unit (LRU) 航线可更换件
11. Foreign Object Debris (FOD) 外来物损伤
12. submerge [səbˈməːdʒ] *vt.* 淹没;把……浸入
13. deterioration [diˌtiəriəˈreiʃən] *n.* 恶化;退化;堕落
14. distortion [diˈstɔːʃ(ə)n] *n.* 变形,扭曲
15. simultaneously [saiməlˈteiniəsli] *adv.* 同时地

Notes

【1】The float assembly is installed over the upper end of the housing assembly and is free to slide up or down with changes in the fuel level.

分析:“with”表“伴随”。

翻译:浮子组件安装在壳体组件的上端,它随着燃油液面的高度变化而上下滑动。

【2】The fuel level in a tank is checked by depressing a slotted latch on the stick assembly and rotating the latch 90 degrees, allowing the stick assembly to fall freely from the housing.

分析:“by”后面是三个并列的现在分词。

翻译:油尺的检查步骤是先压下油尺组件上开槽的锁闩,再旋转锁闩90°,则油尺会自动从壳体内滑下。

【3】The warranty herein on Products corrected by other than Rockwell Collins shall remain in effect as if Rockwell Collin's Product were repaired and corrected by Rockwell Collins provided, however, Rockwell Collins shall not be liable for defects or failures attributable to misuse, negligence or improper correction.

分析:此句是由"however"连接起来的表示转折的并列句;"other than"表"除了,不同于"。

翻译:此处的有关非 Rockwell Collins 公司产品的警告也应在 Rockwell Collins 公司对其自身公司产品的修理或改型时有效,但是,Rockwell Collins 公司对由于错误使用、忽视或不正确改型而造成的缺陷不负有责任。

Exercises

Ⅰ. Translate the following sentences into Chinese:

1. The stick assembly may be calibrated in one of six systems of units.

2. The stick assembly will extend until a magnet in the float assembly locks onto a magnet at the top of the stick assembly.

3. On fuel stick configurations with no base, a base (200) is required for testing. If excessive torque is required to turn latch, check O-Ring (160) for deterioration and retainer (190) and housing assembly (210) for binding or corrosion.

4. The float assembly and stick assembly shall move simultaneously along entire length of outer tube assembly and shall simultaneously free fall under gravity when tilted 15 degrees from vertical.

5. The float and stick will normally rise and fall in small jumps, rather than slide smoothly along the housing.

Ⅱ. Fill in the following blanks according to the text:

1. Flexi-Stick™ Assemblies (thereafter referred to as ________) are installed in aircraft fuel tanks to measure fuel level during ________.

2. Visually examine the UUT for ________ and ________. Pay special attention to the item ________, ________, ________.

3. If ________ is noted, check O-Ring(s) (250 or 250A) on tube assembly (271), or housing assembly (210) as applicable for ________ and ________.

4. If ________ and ________ will not couple, the probable cause is a defective ________ in the float assembly.

3.7　Surge Tank Pressure Relief Valve

3.7.1　Description & Operation

3.7.1.1　Description

The surge tank pressure relief valve assembly, hereinafter referred to as the valve, limits both the positive and negative active pressure inside the fuel surge tank.[1] The valve consists of a cover and upper housing that is connected to a lower housing. The valve is mounted inside the fuel tank by a mounting flange in the lower housing. The inside of the housings consists of a system of compressed springs, lock, and poppet actuated by an actuating stem attached to the diaphragm. At closed position, the valve is locked; the valve is actuated to open by the pressure inside the fuel tank. Valve requires manual reset after it is opened.

3.7.1.2 Operation

(1) At closed position, the poppet locks against the housing and seals the valve to prevent fuel leaking from fuel tank. In this position, the actuating spring is compressed by the lock and is locked into place by the actuating stem and three detent balls.

(2) When the pressure inside the fuel tank reaches a positive value from 2.50 to 2.75 psig (17.23 to 18.96 kPa gage), the diaphragm is pressed upward to lift the stem, which unlocks the lock. The compressed spring of the lock actuates the valve to open the poppet with a pressure differential of 10 psig (68.94 kPa gage) across the valve.

(3) If fuel tank pressure reaches a negative value of −1.00 to −1.25 psid (−6.89 to −8.61 kPa differential), the poppet is positioned by outside pressure to open the valve and relieve the fuel tank pressure.

3.7.1.3 Leading Particulars

Leading particulars for the Surge Tank Pressure Relief Valve Assembly are shown in Table 3.7-1.

Table 3.7-1 Leading Particulars

Service Fluids		JP-4 and JP-5 per MIL-T-5624, D1655 Type Jet A, A1 or B, PWA552F
Pressures	Operating	−1.25 to 10 psig (−8.61 to 68.94 kPa gage)
	Proof	20 psig (137.9 kPa gage)
Temperatures	Fuel	−54 to 57℃ (−65 to 135℉)
	Ambient	−54 to 71℃ (−65 to 160℉)
Leakage		Air and fuel tight between −1.0 and 2.5 psig (−6.89 to 17.24 kPa gage)
Weight		1.17 kg (2.65 pounds) maximum
Physical Dimensions		See Figure 3.7-1

3.7.2 Testing and Trouble Shooting

3.7.2.1 General Instructions

Note: Use Testing and Fault Isolation procedures to find the cause of any malfunction.

Where possible, repair malfunctions without complete disassembly.

(1) Recommended tools, equipment and standard repair shop tools are shown in Table 3.7－2 and in the Special Tools, Fixtures, and Equipment section.

(2) If the Surge Tank Pressure Relief Valve Assembly test is not completed, refer to Fault Isolation at the end of the test section, to isolate the cause of the malfunction and the necessary correction.

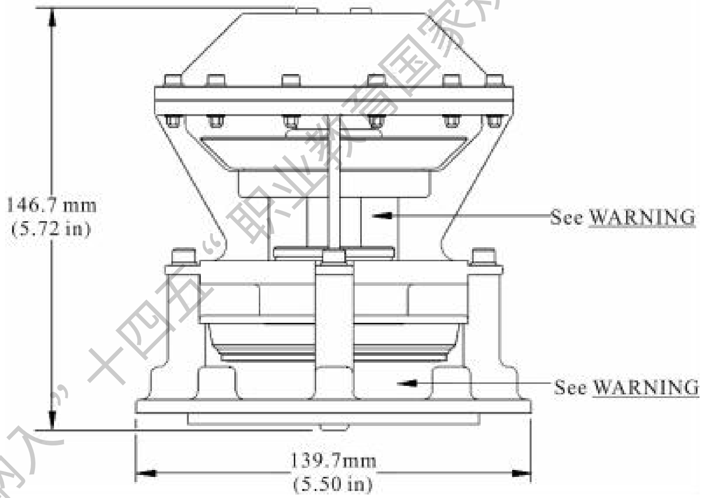


Figure 3.7－1　Physical dimensions

WARNING: Spring force is extremely strong. to avoid any serious injury, keep fingers away from these areas.

(3)If necessary, before the tests start, tighten all fasteners to the torque value shown in the Fits and Clearances section. Re-Torque fasteners as necessary after testing.

(4) It is recommended tests follow the order given in this procedure.

(5) Make sure fluid connections and mounting holes do not have thread damage. Make sure all connections are tight.

(6) Test Conditions:

1)Test Fluid: Air or gaseous nitrogen;

2)Temperature: 10℃ to 32℃ (50 to 90℉);

3)Pressure: Local atmosphere;

4)Humidity: Local atmosphere.

3.7.2.2　Test Tools and Equipment

Note: Item numbers refer to Figure 3.7－2 unless specified.

The tools and equipment shown in Table 3.7－2 are recommended for the test procedures in this section.

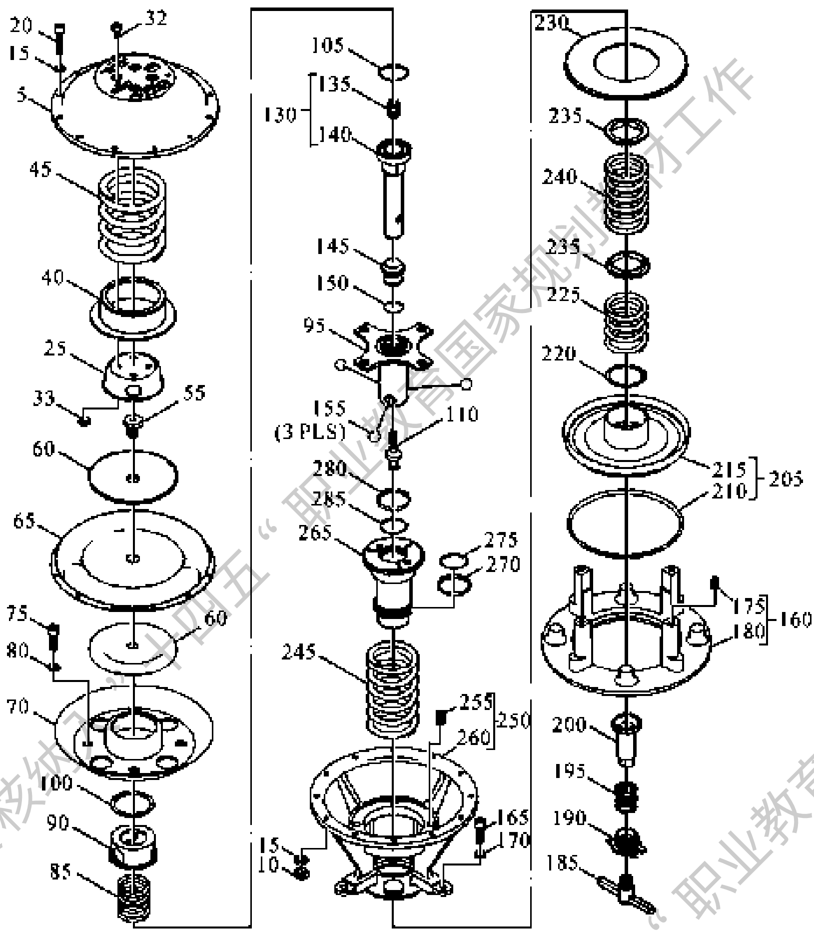


Figure 3.7－2　Surge tank pressure relief valve assembly

Table 3.7－2　Test Tools and Equipment

Nomenclature	Part NO. /Parameter	Use
Flowmeter	0 to 45 mL/minute	Used during leakage test
Hydraulic Test Stand	Optional	Used to supply test fluid
Multimeter	Optional	Used for electrical bonding test
Pressure Gage	－5 to 5 psig (－34.5 to 34.5 kPa gage)	Used throughout testing
Test Solvent	MIL-PRF-680 (or equivalent)	Used in hydraulic test stand
Test Tank	F65-0-4120	Holds test article during testing
Wrench	T-Handled, Allen	Used to adjust positive and negative test pressures

3.7.2.3 Functional Tests

Note: The following test results are based on using MIL-PRF-680 solvent. If a different test solvent is used, test results must be adjusted for the difference in specific gravity.

Note: Item numbers refer to Figure 3.7-2 unless specified.

Warning: Make sure the electrical power is off before electrical connections are connected or disconnected. Do not touch electrically energized components. Injury to personnel and/or damage to the equipment could occur.

Warning: Spring force is extremely strong. Keep fingers away from poppet area to avoid serious injury.

1. Bonding Test (see Figure 3.7-3)

(1) Place the valve in the closed position. With a multimeter and two sharp multimeter leads, measure the electrical resistance.

(2) Place one of the multimeter leads on the poppet assembly (205) (see Figure 3.7-2).

(3) Place the second multimeter lead on the lower housing mounting flange (160) (see Figure 3.7-3).

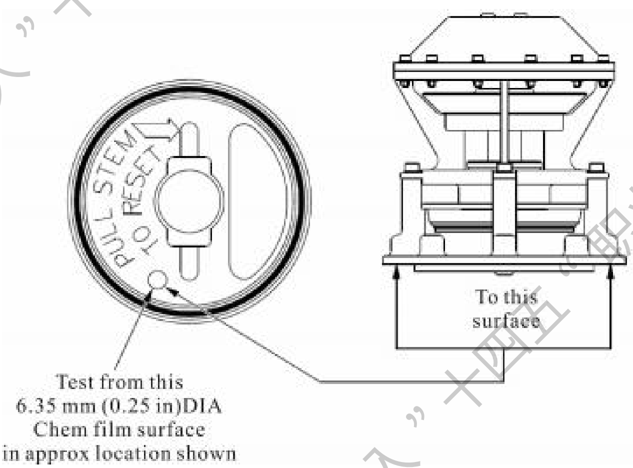


Figure 3.7-3 Bonding test setup

(4) Measure the resistance.

(5) The resistance must not exceed 1 Ω.

2. Negative Pressure Test (See Figure 3.7-4)

(1) Install the valve in a test setup as shown in Figure 3.7-4.

(2) Slowly apply a vacuum pressure greater than −1.0 psig (−6.89 kPa gage).

Note: The vacuum pressure of −1.0 psig (−6.89 kPa gage) is equivalent to −704 mm (−27.7 in) of water.[2]

(3) Record the vacuum pressure at which the valve opens.

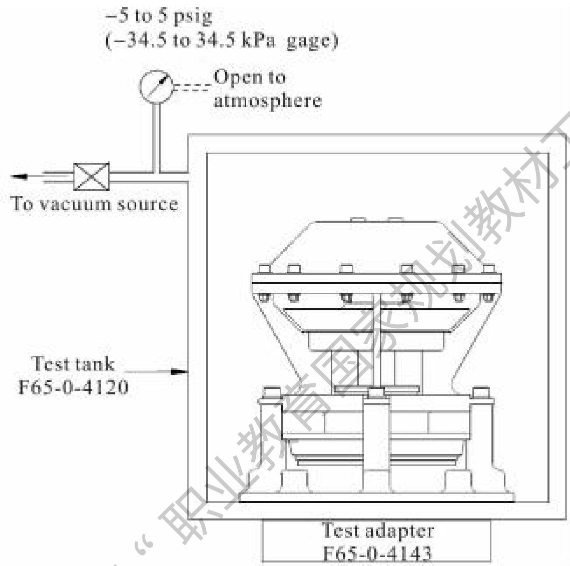


Figure 3.7－4　Negative pressure test setup

(4)The valve opening pressure must be between －1.0 and －1.25 psig (－6.89 and －8.62 kPa gage).

Note: The vacuum pressure of －1.0 to －1.25 psig (－6.89 to －8.62 kPa gage) is equivalent to －704 to －879 mm (－27.7 to －34.6 in) of water.

(5) Slowly decrease pressure to zero.

3. Positive Pressure Tests (see Figure 3.7－5)

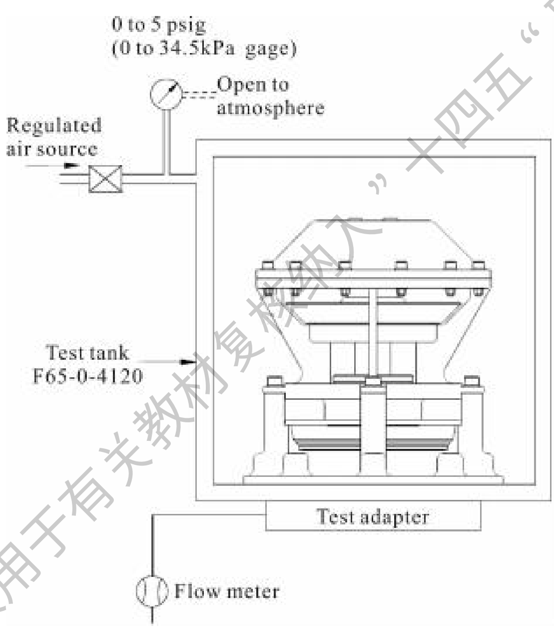


Figure 3.7－5　Positive pressure test setup

(1) Install valve in a test setup.

(2) Slowly apply a positive pressure of 2.45 to 2.50 psig (16.89 to 17.23 kPa gage) to test tank.

(3) Record the leakage to ambient.

(4) The leakage to ambient must not exceed 15 sccm.

(5) Remove test adapter and flowmeter from test setup as shown in Figure 3.7-4.

(6) Slowly apply a positive pressure greater than 2.50 psig (17.23 kPa gage).

(7) Record the pressure at which the valve opens.

(8) The valve opening pressure must be between 2.50 and 2.75 psig (17.23 and 18.96 kPa gage).

(9) Slowly decrease pressure to zero.

3.7.2.4 Fault Isolation

Note: Item numbers refer to Figure 3.7-2 unless specified.

Fault isolation procedures are shown in Table 3.7-3.

Table 3.7-3 Fault Isolation

Problem	Probable Cause	Corrective Action
Valve does not open at operating pressures	Balls (155) damaged, stem (140) bent, or cage (95) is cocked	Replace any damaged part
Positive leakage out of valve limits	Improper spring (45) force	Select proper spring from alternate sources
Valve positive opening pressure is too low or too high	Stem assembly (130) improperly adjusted	Adjust per of Testing and Fault Isolation section
	Improper spring (45) force	Replace spring (45) with proper variant
Valve negative opening pressure is too low or too high	Stem assembly (130) improperly adjusted	Adjust per of Testing and Fault Isolation section
	Improper spring (45) force	Replace spring (45) with proper variant
Excessive leakage when valve closed	Defective poppet seal (210) or housing seats (180)	Replace poppet and/or housing

3.7.3 Repair

3.7.3.1 Minor Rework

Note: Item numbers refer to IPL unless specified.

(1) Polish out small nicks and scratches from threaded areas with a fine buffing wheel, A-A-51175.

(2) Use abrasive paper, ANSI B74.18, for coarse cleanup or smoothing.

(3) Use aluminum oxide abrasive cloth on aluminum and aluminum alloy parts.

CAUTION: Do not use crocus cloth on aluminum or aluminum alloy parts. It contains iron oxide, which causes fast oxidation of aluminum.

(4) Use crocus cloth, ANSI B74.18, for fine polishing of steel parts.

3.7.3.2 Repair to Anodized or Alodined Surfaces

Note: Item numbers refer to IPL unless specified.

(1) Repair damage to anodized or alodined surfaces and touch up bare aluminum surfaces with aluminum oxide abrasive cloth.

Warning: Alodine, no. 1200, is toxic to skin, eyes, and respiratory tract. Skin and eye protection are necessary. Use in a well-ventilated area. Do not breathe fumes. Do not let alodine touch skin for a long time. Wash hands when complete.

(2) Use a cotton swab to apply brush alodine per MIL-C-5541, Class 1A, onto base metal area.[3] Keep surface wet for 3 to 5 minutes.

Note: A light color change will start during this time.

Caution: Do not apply heavy pressure to the fresh alodine chemical film. Damage to parts may result.

(3) Flush or dip in water to remove solution. If the solution is caught, use a swab with a lint-free cloth or a sponge soaked with water to remove all solution.

Warning: Compressed air can cause airborne particles that may go into eyes or skin. Do not use more than 25 psig (172 kPa gage) nozzle pressure when compressed air is used to dry parts. Wear eye protection. do not point air stream at yourself or other personnel.

(4) Dry with compressed air at 25 psig (172 kPa gage) maximum nozzle pressure, or oven dry to a maximum temperature of 54.44℃ (130℉).

3.7.3.3 Repair of Inserts

Note: Item numbers refer to IPL unless specified.

(1) Remove damaged inserts (135, 175, 255).

(2) Clean area around inserts (135, 175, 255).

(3) Refer to NASM33537 to replace inserts (135, 175, 255).

New Words/ Phrases/ Expression

1. surge tank(surge chamber) 通风油箱
2. hereinafter [hiərin'ɑːftə] *adv.* 以下,在下文中
3. poppet ['pɔpit] *n.* 菌状活门;提升阀(亦作 poppet valve)
4. stem [stem] *n.* 芯柱,导杆
5. actuating stem 作动杆
6. diaphragm ['daiəfræm] *n.* 膜片
7. detent [di'tent] *n.* 止动装置;棘爪

8. proof [pruːf] *n.* 证明;试验,校验
9. nitrogen ['naitrədʒ(ə)n] *n.* 氮
10. flowmeter ['fləʊmiːtə] *n.* 流量计
11. Hydraulic Test Stand 液压测试台
12. multimeter [mʌl'timitə] *n.* 万用表
13. pressure gage 压力表,表压
14. solvent ['sɔlv(ə)nt] *n.* 溶剂
15. leakage test 渗漏测试
16. electrical bonding test 电气接地测试
17. vacuum ['vækjʊəm] *n.* 真空;空间
18. sccm 标况毫升每分,是 standard-state cubic centimeter per minute 的缩写
19. fine buffing wheel 细砂轮
20. abrasive paper 砂纸
21. aluminum oxide abrasive cloth 氧化铝砂布
22. crocus cloth 细砂布
23. iron oxide 氧化铁
24. anodize ['ænədaiz] *vt.* 阳极电镀;作阳极化处理
25. alodine *n.* 阿洛丁(氧化法);铬酸阳极化
26. cotton swab 棉签;棉纱擦帚
27. lint-free cloth 不起毛的抹布
28. sponge [spʌn(d)ʒ] *n.* 海绵
29. oven ['ʌv(ə)n] *n.* 炉,灶;烤炉,烤箱
30. inserts [in'səːt] *n.*, *vt.* 衬垫;插入,嵌入

Notes

【1】The surge tank pressure relief valve assembly, hereinafter referred to as the valve, limits both the positive and negative active pressure inside the fuel surge tank.

分析:"hereinafter referred to as"意思是"下文称之为"。

翻译:通风油箱释压活门,下文简称为活门,同时限制通风油箱内的正、负作动压力。

【2】The vacuum pressure of －1.0 psig (－6.89 kPa gage) is equivalent to －704 mm (－27.7 in) of water.

分析:"be equivalent to"意思是"等同于",为常用比较句型。

翻译:－1.0 磅每英寸表压(－6.89 千帕表压)的真空压力相当于海平面－704 毫米(－27.7英寸)的压力。

【3】Use a cotton swab to apply brush alodine per MIL-C-5541, Class 1A, onto base metal area.

分析:注意几个介词的用法。"to"表示目的,常有结构"use sth. to do sth.";"per"表示方式,意思为"按照";"onto…"表示位置,即"在……之上"。

翻译:按照 MIL-C-5541,Class 1A 标准的要求,用蘸有阿洛丁的棉签涂抹在基座金属区域。

Exercises

Ⅰ. Translate the following sentences into Chinese:

1. At closed position, the poppet locks against the housing and seals the valve to prevent fuel leaking from fuel tank.

2. When the pressure inside the fuel tank reaches a positive value from 2.50 to 2.75 psig (17.23 to 18.96 kPa gage), the diaphragm is pressed upward to lift the stem, which unlocks the lock.

3. The valve opening pressure must be between −1.0 and −1.25 psig (−6,89 and −8,62 kPa gage).

4. Repair damage to anodized or alodined surfaces and touch up bare aluminum surfaces with aluminum oxide abrasive cloth.

5. If the solution is caught, use a swab with a lint-free cloth or a sponge soaked with water to remove all solution.

Ⅱ. Fill in the following blanks according to the text:

1. The valve consists of a ________ and ________ that is connected to a ________.

2. The inside of the housings consists of a system of ________, ________, and ________ actuated by an ________ attached to the ________.

3. In this position, the ________ is compressed by the ________ and is locked into place by the ________ and three detent balls.

4. Polish out small ________ and ________ from ________ areas with a ________, A-A-51175.

5. If the solution is caught, use a ________ with a ________ cloth or a ________ soaked with water to remove all solution.

Chapter 4
Aircraft Electrical Component Maintenance

Chapter 4 Aircraft Electrical Component Maintenance

4.1 Introduction of Aircraft Electrical System

With the development of civil aviation, the technology of the aircraft improves a lot, especially the aircraft electrical system, which playing more important role in the air travel, not only to the pilots but also to passengers.

The satisfactory performance of any modern aircraft depends to a very great degree on the continuing of electrical systems. The continued proper performance of electrical systems depends on the knowledge and technique of the mechanic who installs, inspects, and maintains the electrical system wires and cables.

The new aircrafts have extremely complex electrical system, such as Boeing or Airbus. These aircrafts use alternative current as the primary source. A typical electrical system consists of main source, secondary power conversion equipment, emergency power source, system control and protection devices, interconnection network, and power distribution system (The Boeing 737NG aircraft electrical system schematic is shown in Figure 4.1-1).

A primary source is the equipment that generates power from engine other than electrical device, and is independent of any other electrical source. When the engine not start, APU-driven generator can be used as an appendix power, a ground power source also can be connected to the aircraft when the plane is on ground for fuel saving and environment protection. A secondary source is the equipment that transforms and/or converts primary source power to supply electrical power to either AC or DC powered equipment, it is entirely depend upon the primary source and considered part of the load of the primary source. In the event of a primary power source failure, the emergency power comes from the battery on board or RAT emergency generator (The Airbus A380 aircraft electrical power sources are shown in Figure 4.1-2).

The electrical power can be used not only on the aircraft control system (such as engine control, lighting and signal, flight control, avionic device, life protection, anti-icing) but also the passenger service system (such as reading light, coffee maker, entertainment system).

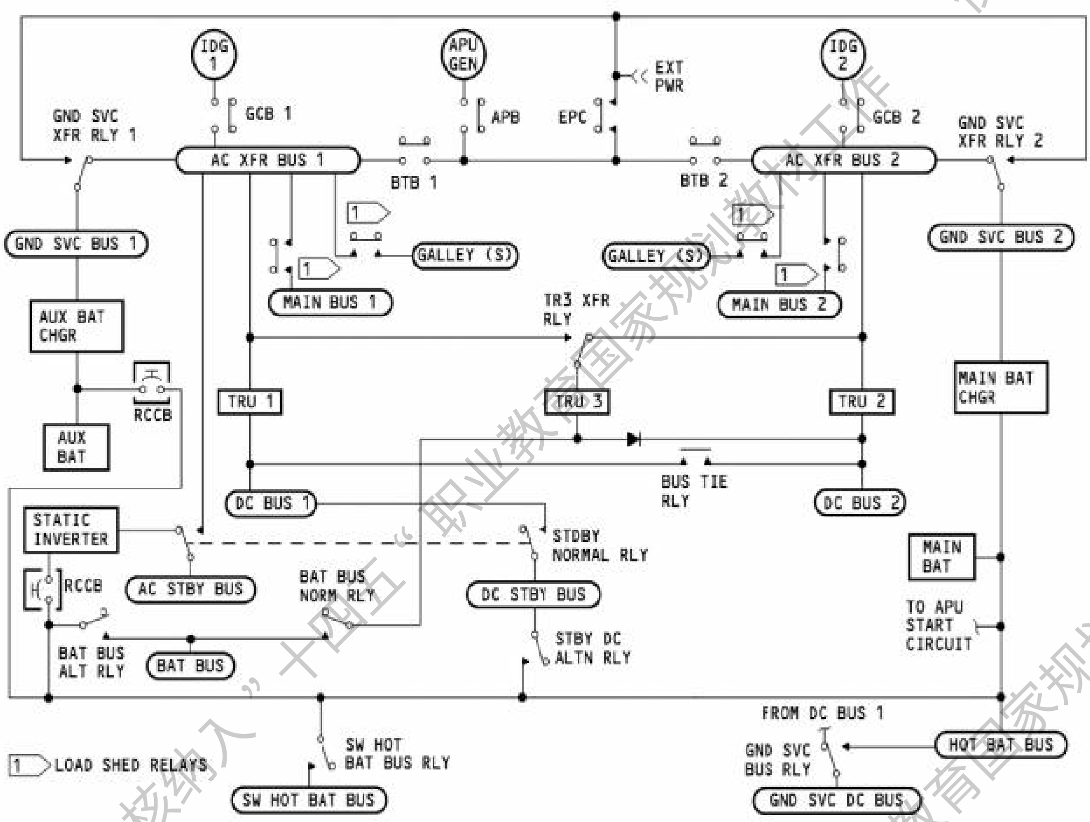


Figure 4.1-1 Boeing 737NG aircraft electrical system schematic

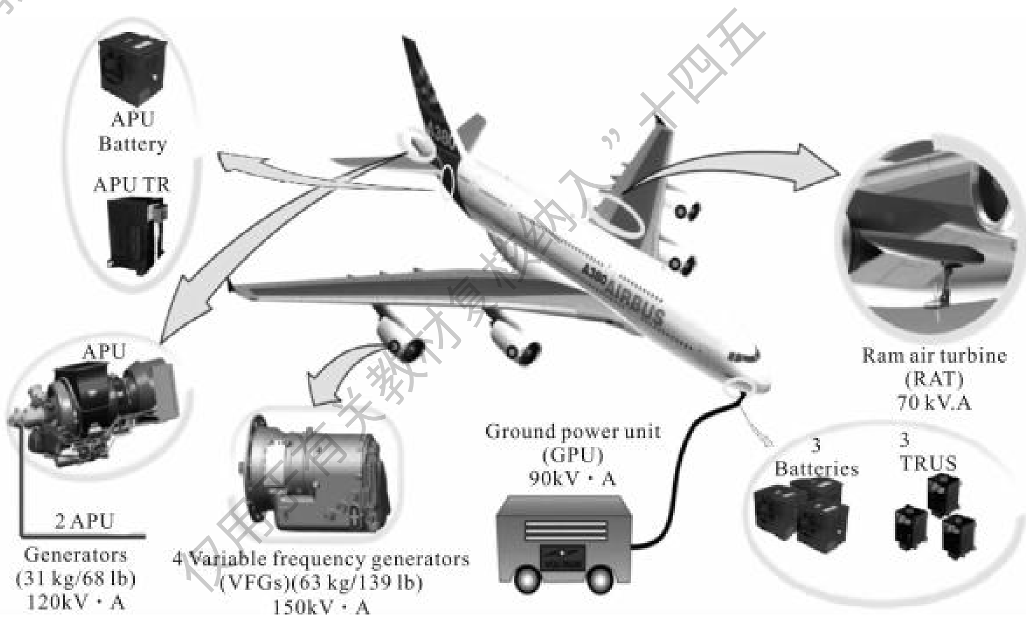


Figure 4.1-2 Airbus A380 aircraft electrical power sources

The electrical system should be reliable and sustainable, especially the safety-related system. It should ensure that all power facilities will work properly.

4.2 APU Generator for A380

4.2.1 General

This section gives the description and theory of operation for the auxiliary power unit (APU) generator for the Airbus Industrie A380 aircraft.

4.2.2 Description

The APU generator is a three-stage, brushless, oil-spray-cooled and lubricated, rotating rectifier machine.

The parts of the finished rotor assembly are a pilot exciter (PE) rotor assembly, a main exciter (ME) rotor assembly, a diode rectifier assembly and a main rotor assembly, all installed on or in the same shaft which is held by one split inner bearing at the drive end (DE) and one angular contact bearing at the non drive end (NDE).[1]

The main output stator assembly and the protection current transformers (CTs) are installed in the generator main housing assembly. The PE stator assembly and the ME stator assembly are installed in the generator end frame assembly.

The cooling and lubrication oil is supplied under pressure, scavenged from and conditioned by the APU. The oil is supplied and scavenged through holes in the generator drive interlace. An electrical resistance temperature bulb is installed in the generator to measure the outlet oil temperature.

A general view of the APU generator is shown in Figure 4.2-1.

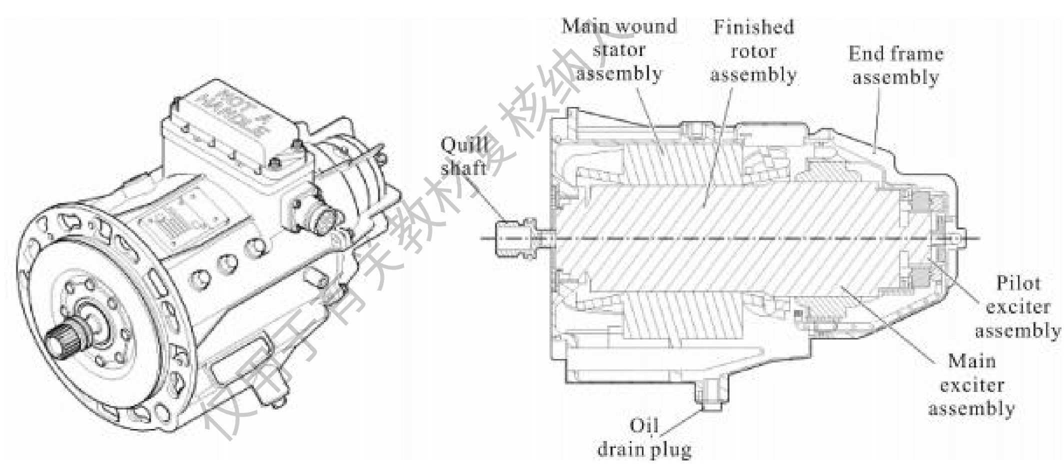


Figure 4.2-1 APU generator

4.2.3 Theory of Operation

4.2.3.1 Electrical System (see Figure 4.2 - 2)

The aircraft APU supplies the mechanical power to drive the APU generator. This power is transmitted from the APU output shaft serrations to the APU generator quill shaft. The APU rotates the APU generator finished rotor assembly at 24,000 revolutions per minute (rpm, r/min)(nominal).

The PE rotor rotates in the PE stator and causes an alternating current (AC) voltage in the three-phase windings of the PE stator. This power is then supplied to the generator control unit (GCU).

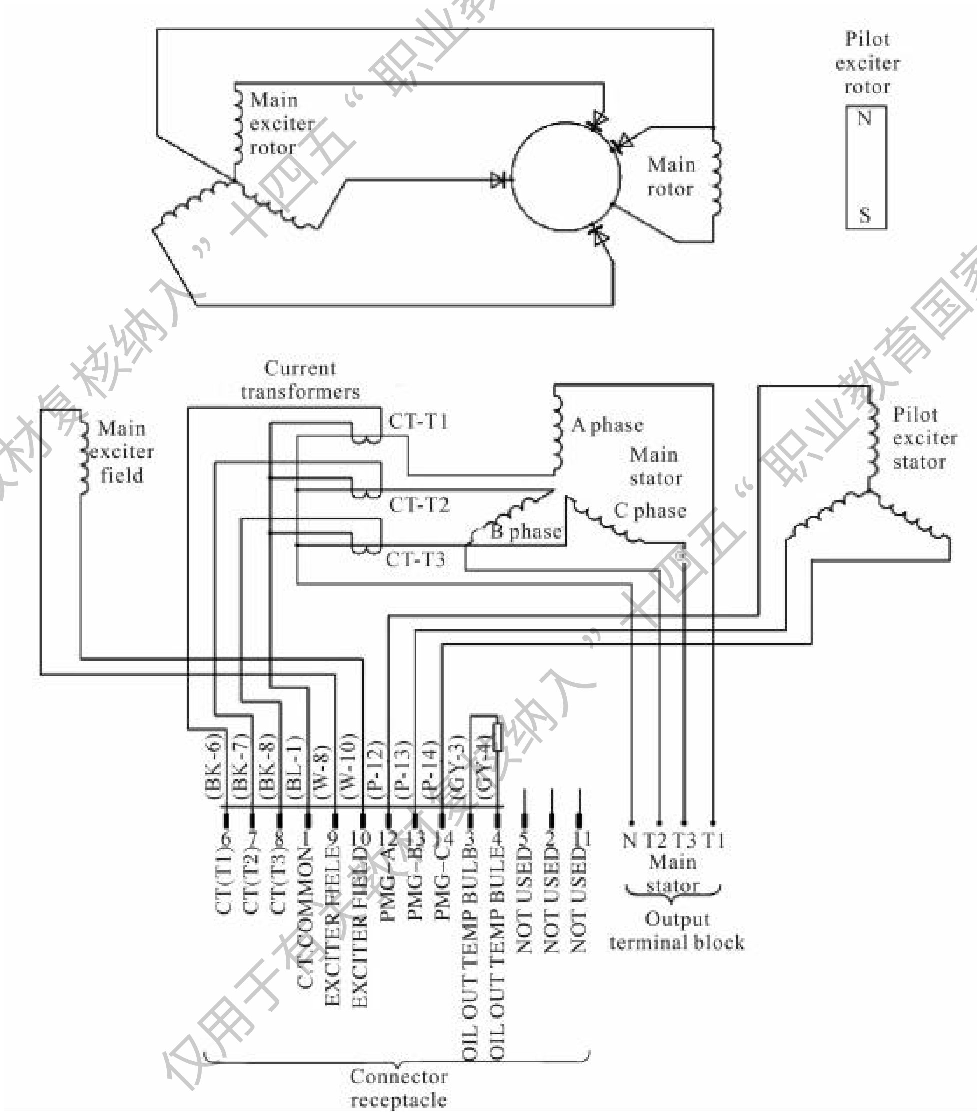


Figure 4.2 - 2 APU generator—electrical schematic

The GCU rectifies and conditions the PE AC voltage to supply excitation power to the ME stator. This power causes a magnetic field in the ME stator and the rotation of the rotor assembly causes an AC voltage in the ME rotor three-phase winding. The AC voltage in this winding is rectified by the diode rectifier assembly and the direct current (DC) caused by this is supplied to the main rotor winding to give a two-pole magnetic field.[2]

The combination of this magnetic field and the rotation of the rotor assembly causes an ac voltage in the three-phase main output stator.[3] The power from the main output stator is supplied to the terminals on the generator main housing for use by the aircraft electrical system.

The APU generator electrical schematic is shown in Figure 4.2-2.

4.2.3.2 System Oil Flow

Oil is supplied by the APU oil system at the necessary pressure and flows into the generator oil inlet and along a high pressure gallery into the generator main housing.[4]

The oil goes through a ferrule to the end frame assembly and through an oil transfer configuration to the finished rotor assembly.

In the finished rotor assembly there are a number of holes that are installed and dimensioned to cause the oil to flow to the bearings and the rotor windings. The oil then goes onto the PE stator, ME stator and the main output stator windings.

To prevent erosion of the winding insulation, the holes in the main rotor assembly that are installed to cool the main stator windings are "back-angled" to reduce the oil impact velocity.[5]

Oil also goes from the high pressure gallery in the main housing through a jet to a groove around the main output stator lamination core. As the generator gets hot, the oil flows between the stator core and the housing and cools the generator main stator core and the housing.

The cooling oil drains by gravity from the static windings to the bottom of the generator housing and is scavenged from the generator by the APU for conditioning and recirculation.[6]

4.2.4 Equipment Specifications

Equipment specifications are listed in Table 4.2-1.

Table 4.2-1 Equipment Specifications

APU generator type BA15400 series	
Input Speed Range	23,700 to 24,300 min
Frequency Range	395 to 405 Hz
Power Output at 24,000 r/min	
Phase Voltage at the Point of Regulation	115 V (nominal)

Continued

Number of Phases	3
Frequency	400 Hz
Power Factor	Unity to 0.75 lagging
Rating at Unity to 0.75 Lagging Power Factor at POR	120 kV·A (347 A per phase) continuously 135 kV·A (391 A per phase) for 5 minutes 180 kV·A (521 A per phase) for 5 seconds
Short Circuit Capacity at POR	1,000 A minimum for 5 seconds
Feeder Impedance	0.034,2+j0.031,42 Ω/phase at 400 Hz
Direction of Rotation (Look on the Drive End)	Counterclockwise
Cooling and Lubrication Oil	MIL-L-23699 MIL-L-7808
Cooling Oil Flow	17.5 L/min at 121℃(250 ℉) (nominal)
Oil Inlet Temperature (Maximum Continuous)	135℃ (275 ℉)
Oil Inlet Pressure	(4,140+ 690) mB (60 psig)(nominal)
Width (Drain Plug to Lifting Boss Maximum)	257 mm (10.12 in)
Length (Maximum)	419.94 mm (1,653 in)
Mass (Maximum)	31.4 kg (69.22 lb)
Terminations	
Main Terminals T1, T2, T3 and N	9.525 mm (0.375 in)-24 UNJF studs
Auxiliary Connector	Receptacle, flange mounted MIL 83723/88Y 18.14 N
Lifting Boss Thread	9.525 mm (0.375 in)-24 UNJF studs
Cable Clamp Boss Thread	10.32 UNF-8.0 mm (0.315 in) long

New Words/ Phrases/ Expression

1. auxiliary power unit (APU) 辅助动力装置
2. brush [brʌʃ] *n.* 电刷
3. pilot exciter (PE) 副励磁机
4. main exciter (ME) 主励磁机
5. diode rectifier 二极管整流器
6. drive end (DE) 驱动端
7. non drive end (NDE) 非驱动端
8. split inner bearing 对开内轴承;剖分内轴承

9. angular contact bearing 向心止推滚动轴承，角面接触滚动轴承
10. scavenge [ˈskævin(d)ʒ] *vi.* 抽吸，回收；清除污物
11. generator drive interface 发电机驱动接口
12. current transformers (CTs) 电流互感器，变流器
13. electrical resistance temperature bulb 电阻式感温包
14. serration [seˈreiʃn] *n.* 锯齿
15. revolutions per minute (rpm) 转数每分钟
16. generator control unit (GCU) 发电机控制器
17. magnetic field 磁场
18. gallery [ˈgæl(ə)ri] *n.* 通道；走廊
19. ferrule [ˈferuːl；ˈfer(ə)l] *n.* 套圈；金属箍
20. lamination core 积层铁芯
21. gravity [ˈgræviti] *n.* 重力，地心引力
22. recirculation [riːˌsəːkju-ˈleiʃən] *n.* 再循环
23. feeder impedance 支线阻抗

Notes

【1】The parts of the finished rotor assembly are a pilot exciter (PE) rotor assembly, a main exciter(ME) rotor assembly, a diode rectifier assembly and a main rotor assembly, all installed on or in the same shaft which is held by one split inner bearing at the drive end (DE) and one angular contact bearing at the non drive end (NDE).

分析：“finished”在此意思为“完整的，已装配完的”；“all installed …”作定语，其中的“which”引导定语从句。

翻译：完整的转子组件包括主、副励磁机，二极管整流器和一个主转子，这些全都装在同一个转轴上，这个转子由一个位于驱动端的对开内轴承和一个位于非驱动端的向心止推滚动轴承支撑。

【2】The AC voltage in this winding is rectified by the diode rectifier assembly and the direct current (DC) caused by this is supplied to the main rotor winding to give a two-pole magnetic field.

翻译：该绕组的交流电压经过二极管整流组件整流变成直流电给主转子线圈提供一个双极磁场。

【3】The combination of this magnetic field and the rotation of the rotor assembly causes an ac voltage in the three-phase main output stator.

翻译：这种磁场和转子绕组的旋转组合使三相主输出定子产生交流电压。

【4】Oil is supplied by the APU oil system at the necessary pressure and flows into the generator oil inlet and along a high pressure gallery into the generator main housing.

分析：此句注意几个介词的使用：“at”表示“在某个压力值”，“into”表示“进入”，“along”表示“沿着”。

翻译：APU 滑油系统提供一定压力的滑油，它流入发电机滑油进口，并沿着高压通道流入

发电机主壳体。

【5】To prevent erosion of the winding insulation, the holes in the main rotor assembly that are installed to cool the main stator windings are "back-angled" to reduce the oil impact velocity.

分析:前面的"to…"不定式表目的;"that"引导定语从句。

翻译:为了防止绝缘绕组腐蚀,用于冷却主转子绕组的主转子中的冷却孔是"反向角"设计,以降低滑油冲击速度。

【6】The cooling oil drains by gravity from the static windings to the bottom of the generator housing and is scavenged from the generator by the APU for conditioning and recirculation.

分析:"conditioning"在这里有"调节、改善状态"的意思,通过油滤实现。

翻译:APU 发电机的冷却滑油在重力作用下从静态绕组流到发电机外壳的底部,准备过滤清洁和再循环。

Exercises

Ⅰ. Answer the following questions:

1. What are the parts of a complete rotor assembly?
2. How does APU oil system work?
3. How is the hole in the main rotor assembly designed?

Ⅱ. Translate the following sentences into Chinese:

1. This power causes a magnetic field in the ME stator and the rotation of the rotor assembly causes an ac voltage in the ME rotor three-phase winding.
2. The AC voltage in this winding is rectified by the diode rectifier assembly and the direct current (DC) caused by this is supplied to the main rotor winding to give a two-pole magnetic field.
3. The power from the main output stator is supplied to the terminals on the generator main housing for use by the aircraft electrical system.
4. In the finished rotor assembly there are a number of holes that are installed and dimensioned to cause the oil to flow to the bearings and the rotor windings.
5. As the generator gets hot, the oil flows between the stator core and the housing and cools the generator main stator core and the housing.

Ⅲ. Fill in the following blanks according to the text:

1. The APU generator is a ________, ________, ________ and lubricated, rotating rectifier machine.
2. The ________ and ________ are installed in the generator main housing assembly.
3. This power is transmitted from ________ to ________.
4. The oil then goes onto the ________, ________ and the ________ windings.
5. Oil also goes from the ________ in the main housing through a ________ to a ________ around the main output stator lamination core.

4.3 Direct-Current Motor

4.3.1 Description and Operation

4.3.1.1 Description

The direct-current motor consists essentially of a rotor assembly and a stator assembly (see Figure 4.3 - 1).

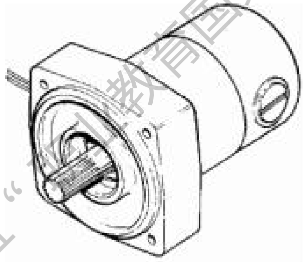


Figure 4.3 - 1 Direct-current motor

4.3.1.2 Operation

The motor operates the cabin pressure outflow valve actuator gearbox.

4.3.1.3 Leading Particulars

Leading particulars are shown in Table 4.3 - 1.

Table 4.3 - 1 Leading Particulars

Rated-Load Operation	
Horsepower	0.0054 hp①
Current	1.73 A
Speed	9,700 r/min
Voltage	24.9 V DC

4.3.2 Testing and Trouble Shooting

Unless otherwise stated in test descriptions, all tests must be performed at laboratory ambient conditions. Table 4.3 - 2 provides a list of necessary test equipment.

Table 4.3 - 2 Test Equipments

DC Voltmeter	Weston Model 931 or equivalent, 0.75 percent full-scale accuracy
DC Ammeter	Weston Model 931 or equivalent, 0.75 percent full-scale accuracy

① 1 hp≈745.7 W.

Continued

Torque Measuring Device	Capable of measuring 10.0 ounce-inches *
RPM Measurement	Strobe light or revolution counter ±1.0% full-scale accuracy

Note: Equivalent substitutes may be used for listed items.

(1) Conduct all tests at room temperature (see Figure 4.3－2 for wiring diagram). Perform all tests in both directions, using 28.0 V DC power source.

(2) Check that motor rotates clockwise when energized through green, black, and white terminals and counterclockwise when energized through red, blue, and white terminals; there must be no binding or unusual noise.[1]

(3) Operate motor at test voltage with no load. Check speed and current; speed must be 16,000 r/min minimum and current must not exceed 0.5 A.[2]

(4) Operate motor at test voltage and apply rated load of 0.42 ounce-inch. Speed must be at least 13,000 r/min and current must not exceed 1.0 A.

(5) Apply sufficient torque to stall motor. Check torque and current; torque must be 2.3 ounce-inch minimum and current must not exceed 3.0 A.

(6) Refer to Table 4.3－3 for trouble shooting information.

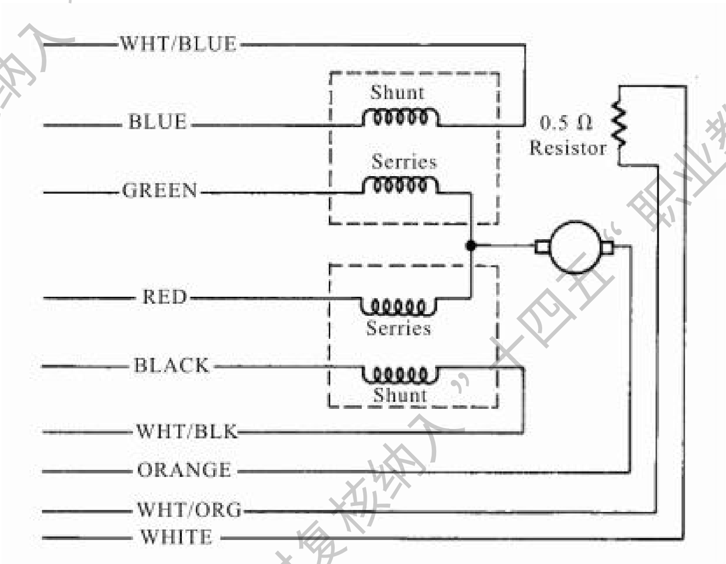


Figure 4.3－2　Wiring diagram

Table 4.3－3　Trouble Shooting Information

Trouble	Probable Cause	Remedy
Motor does not operate; no current flows	Power circuit defective	Repair power circuit

* 1 ounce-inch≈0.007 N·m.

Continued

Trouble	Probable Cause	Remedy
Motor does not operate, but stalled-motor current is approximately normal	Leads incorrectly connected	Connect leads correctly
	Interference between armature assembly and stator assembly	Check dimensions; Replace defective part
	Bearing defective	Replace defective part
Motor operates in one direction only	Stator assembly defective	Replace stator assembly
Motor operates at less than specified speed and current is excessive	Interference between armature assembly and stator assembly	Check dimensions; Replace defective part
	Bearing defective	Replace defective bearing
	Stator assembly windings shorted	Replace stator assembly

4.3.3 Disassembly

Note: Motor should be tested in accordance with Testing and Trouble Shooting procedures to determine extent of disassembly.

(1) Do not remove identification plate (10, -13) unless required after check;

(2) Remove retainer (15);

(3) Remove brush assembly (20);

(4) Remove two nuts (25) and washers (30);

(5) Remove end bell (35);

(6) Remove shim washers (45, 50, 55) and spring washer;

(7) Remove stator assembly (65, -66);

(8) Remove armature assembly (70);

(9) Remove bearings (60, 75) from armature assembly.

4.3.4 Cleaning

Refer to Table 4.3-4 for cleaning materials (see Figure 4.3-3).

Table 4.3-4 Cleaning Materials

Brush, Soft Bristle	Commercially Available
Solvent (Stoddard)	Commercially Available Federal Specification P-D-680

Note: Equivalent substitutes may be used for listed items.

(1) Clean armature assembly (70) and stator assembly (65, 66) with a soft bristle brush.

Warning: Use solvent in a well-ventilated area away from flame. Avoid breathing fumes. Failure to comply with this warning can result in death or injury to personnel.[3]

(2) Wash all nonelectrical parts, except bearings (60,75), with cleaning solvent. Dry

parts thoroughly.

(3) Wipe bearings (60,75) with clean cloth moistened in cleaning solvent.

4.3.5　Assembly

Assembly materials and reassemble motor are as required (see Figure 4.3-3).

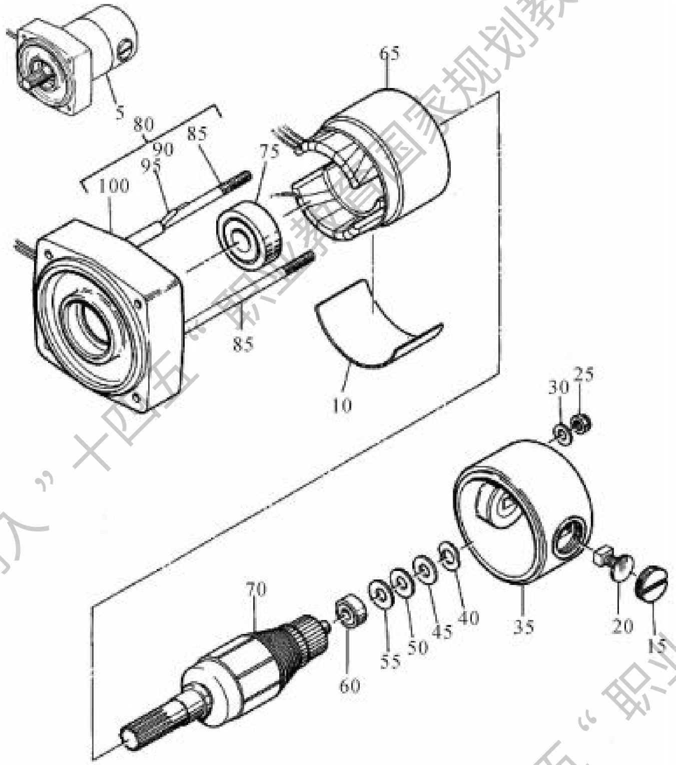


Figure 4.3-3　Direct-current motor

(1) Press bearings (60, 75) on armature assembly (70).

(2) Install end bell assembly (80) on stator assembly (65, —66).

(3) Install armature assembly (70) in stator assembly (65, —66).

(4) Temporarily install end bell (35) on stator assembly and secure with washers (30) and nuts (25).

(5) Check end play of armature assembly (70) to determine the amount of shim washers (45, 50, 55) required to provide 0.017 to 0.020 inch gap for spring washer(40).[4]

(6) Remove washers (30) and nuts (25) from end bell (35), and remove end bell. Install the required amount of shim washers (45, 50, 55) plus spring washer (40) in end bell (35). Install end bell and secure with washers (30) and nuts (25).

(7) Install brush assemblies (20) in end bell brush ports. Apply sealant compound to threads of retainers (15) and install retainers in end bell.

New Words/ Phrases/ Expression

1. outflow valve 外流活门
2. gearbox [ˈgiəbɒks] *n.* 变速箱;齿轮箱
3. rated-load 额定载荷
4. horsepower [ˈhɔːspaʊə] *n.* 马力(功率单位)
5. equivalent [iˈkwiv(ə)l(ə)nt] *adj.* 等价的,相等的
6. substitute [ˈsʌbstitjuːt] *n.* 代用品;代替者
7. binding [ˈbaindiŋ] *n.* 卡滞
8. clockwise [ˈklɔkwaiz] *adv.* 顺时针方向地
9. counterclockwise [kaʊntəˈklɔkwaiz] *adv.* 反时针方向地
10. leads [liːdz] *n.* 引线,接线
11. interference [intəˈfiər(ə)ns] *n.* 干扰
12. excessive [ikˈsesiv; ek-] *adj.* 过多的;极度的
13. armature [ˈɑːmətʃə; -tj(ʊ)ə] *n.* 电枢(电机的部件)
14. comply with 照做,遵守
15. ventilate [ˈventileit] *vt.* 使通风
16. sealant [ˈsiːlənt] *n.* 密封剂

Notes

【1】Check that motor rotates clockwise when energized through green, black, and white terminals and counterclockwise when energized through red, blue, and white terminals; there must be no binding or unusual noise.

分析:整句为并列句,其中"when"引导时间状语从句。

翻译:当给绿、黑、白三个接线柱通电时,检查发动机是否是顺时针转动;当给红、蓝、白三个接线柱通电时,检查发动机是否是逆时针转动;且转动不能有卡滞或不正常的噪声。

【2】Operate motor at test voltage with no load. Check speed and current; speed must be 16,000 r/min minimum and current must not exceed 0.5 A.

分析:"r/min"是"转/分钟"的意思。

翻译:在没有负载的情况下用测试电压运行电机。检查转速和电流:转速必须至少为16 000转/分钟,电流不得超过0.5安。

【3】Failure to comply with this warning can result in death or injury to personnel.

分析:"comply with"是"遵守"的意思;"result in"是"导致"的意思。

翻译:不遵守这些警告,可能会导致人员伤亡。

【4】Check end play of armature assembly (70) to determine the amount of shim washers (45, 50, 55) required to provide 0.017 to 0.020 inch gap for spring washer (40).

分析:"to"表目的;"require"的分词结构引导定语从句。

翻译:检查电枢组件(70)的末端间隙,以确定需要添加的垫片(45,50,55)的总数是多少,以使之有足够0.017~0.020英寸的间隙来安装弹簧垫片(40)。

Exercises

Ⅰ. Answer the following questions:

1. How to check the motor rotation?

2. What should pay attention to when clean armature assembly and stator assembly?

3. How to reassemble motor?

Ⅱ. Translate the following sentences into Chinese:

1. The direct-current motor consists essentially of a rotor assembly and a stator assembly.

2. Unless otherwise stated in test descriptions, all tests must be performed at laboratory ambient conditions.

3. Motor should be tested in accordance with Testing and Trouble Shooting procedures to determine extent of disassembly.

4. Temporarily install end bell (35) on stator assembly and secure with washers (30) and nuts (25).

Ⅲ. Fill in the following blanks according to the text:

1. The motor operates the cabin pressure ________ actuator ________.

2. The direct-current motor consists essentially of a ________ and a ________.

3. Operate motor at ________ and apply ________ of 0.42 ounce-inch. Speed must be at least 13,000 r/min and current must not exceed 1.0 A.

4. Wash all ________, except ________, with ________. Dry parts thoroughly.

5. Apply ________ to ________ of retainers (15) and install retainers in end bell.

4.4 Battery Maintenance

The battery (see Figure 4.4 - 1) is a part of the aircraft supply units, e.g. for emergency lighting. In case of a breakdown of the aircraft power supply the battery supplies electrical circuits with its stored energy for a defined time period.[1]

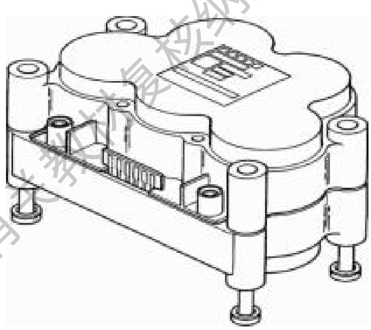


Figure 4.4 - 1 Battery

Each battery has these main components(see Figure 4.4-2).

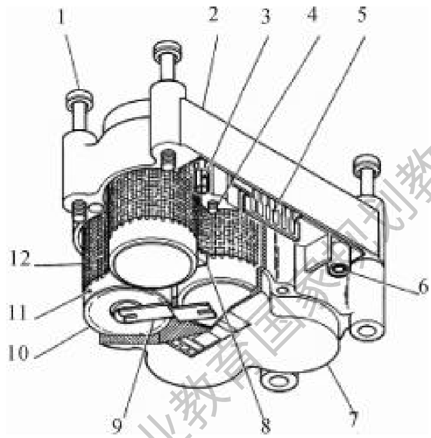


Figure 4.4-2 Battery—cutaway view

1—Captive screw; 2—Cover; 3—Battery contact (−); 4—Captive screw; 5—Connector; 6—Battery contact (+); 7—Case; 8—Insulator assy; 9—Welding lug; 10—Insulation disc; 11—NiCd cell; 12—Heating mat

Description (see Figure 4.4-2):

(1) The battery consists of 5 NiCd cells (11) connected in series. Welding lugs (9) are the connection between the individual cells. An insulating disk (10) around the positive pole of each cell is the protection against short circuits. The positive (+) terminal (6) and the negative (−) terminal (3) of the battery are high current female contacts.

(2) The battery block assembly consists of the five connected cells and the insulator assy (8) inside them.[2]

The elastic and heat-conductive material of the insulator assy helps to suppress vibrational movements of the cells.

(3) The battery block assembly is installed in a housing which consists of a case (7) and a cover (2). Three captive screws (4) connect both parts together.

Recesses in the case and in the cover hold the battery block assy in place.

(4) A heating mat (12) is glued into the case (7) and encloses the cells. A temperature sensor and a thermostat which is embedded in the insulator assembly monitor the temperature of the battery.[3]

4.4.1 Testing and Fault Isolation

We must prepare some equipments for the battery test procedure. For example, DC power supply, load resistor, digital multimeter, megohmmeter, etc. Then, we can do some preparation for tests. The necessary environmental conditions for the test procedure are: The ambient temperature is 10 to 30℃; the relative humidity is less than 80%; the atmospheric pressure is local standard.[4]

The procedure of the test is:

(1) Visual check. Examine the battery for mechanical damage. Make sure that the 3 screws which attach the cover to the case are tight and there are no leads squeezed between cover and case.

(2) Insulation resistance. Connect the negative terminal of the megohmmeter to the negative battery terminal (—) and the positive terminal to contact No. 1 of the connector. Set the test voltage to 500 V DC and make sure that the insulation resistance is equal to or more than 10 MΩ. Set the test voltage to 0 V and remove the battery from the megohmmeter.

(3) Functional test.

1) Discharge circuit. Set the DMM to measure the DC voltage. Refer to Figure 4.4 - 3 and connect the discharge circuitry to the battery as shown. Set the test equipment switch to ON. Discharge the battery into the load until the meter shows a voltage between 5 to 5.3 V. Set the test equipment switch to OFF and disconnect the discharge circuitry from the battery.

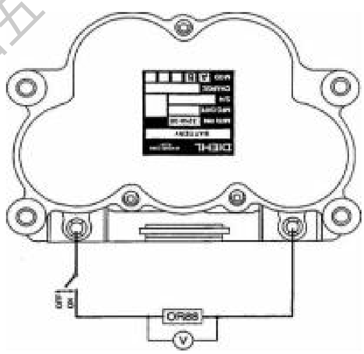


Figure 4.4 - 3 Discharge circuit

2) Charge circuit. Set the output voltage of the DC supply to (10±1) V and the short circuit limitation to a current of (450±20) mA. Obey the polarity and connect the DC supply to the battery terminals. Switch on the DC supply and charge the battery for abort 14 hours. Switch off the DC supply and remove it from the battery.

3) Test of several circuits (see Figure 4.4 - 4).

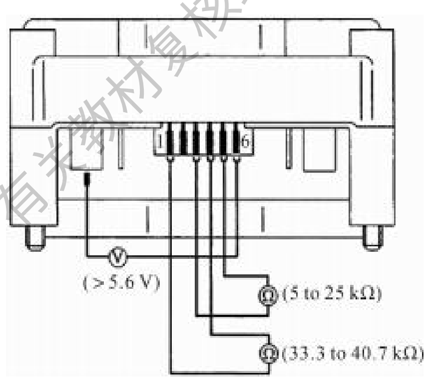


Figure 4.4 - 4 Test circuit

4)Test of the thermostat:

Step 1: Put the battery into the climatic chamber.

Step 2: Increase the temperature of the chamber to 60℃ (140℉) within 30 minutes an hold the temperature for a period of 90 minutes.

Step 3: Set the DMM to measure the resistance.

Step 4: Remove the battery from the climatic chamber and connect the DMM to the contacts No. 1 and No. 4.

Step 5: Make sure that the resistance is between 3.3 kΩ and 3.374 kΩ.

Step 6: Disconnect the DMM from the battery and store the battery at an ambient temperature of 15 to 20℃ (59 to 68℉) for at least 2 hours.

Step 7: Repeat step 2.

5)Capacity test. First, set the DMM to measure the DC voltage.[5] Refer to Figure 4.4-5 and connect the test circuitry to the battery as shown. Then, set the switch of the test circuitry to ON in order to start the discharge operation, and at the same time start the stop watch to measure the elapsed time. When 15 minutes have elapsed, measure the voltage of the battery and make sure that the shown value is not less than 5.6 V. The last thing is deleted and set the test circuitry switch to OFF when the battery voltage reaches 5.0 V.

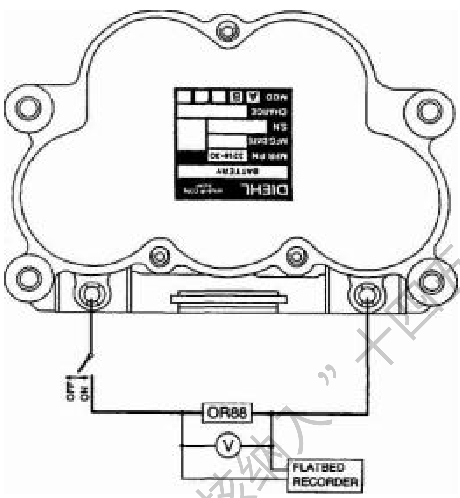


Figure 4.4-5　Test circuitry—capacity test

4.4.2　Disassembly

After finishing the testing, we must disassemble the battery. Some special tools will be required as follow.

The procedure of the disassembly is:

(1) Refer to "Testing and Fault Isolation", and connect the battery to the discharge circuitry.

(2) Discharge the battery into the load until the voltage is:

1) 5.1 V, in case you will keep the battery pack for re-usage;

2) less than 1 V, in case you will scrap the battery block.

(3) Remove the test circuitry from the battery.

(4) Removal of the cover: Unscrew the 3 captive screws and move apart the cover.

(5) Remove the cover.

(6) Remove the contacts, using the extraction tool (see Figure 4.4-6).

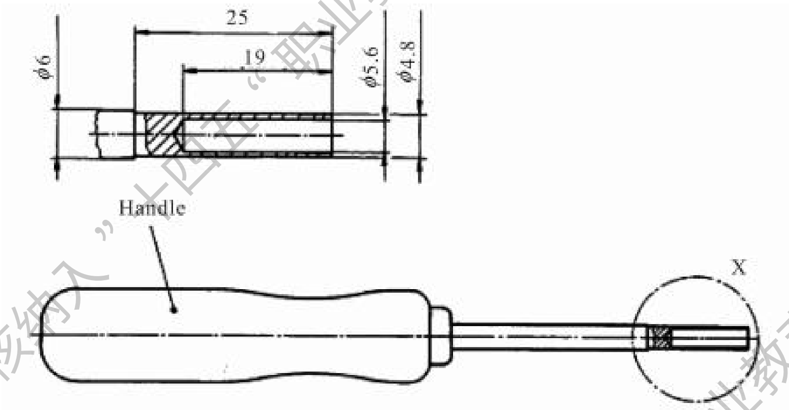
(7) Pull connector carefully out of the recess in the case.

(8) Remove the cable spot tie.

(9) Desolder the cable connections of the connector.

(10) Remove the connector and keep it.

(11) Pull the battery block out of the case.



Detail X scale 2:1

Figure 4.4-6 Extraction tool(mm)

4.4.3 Cleaning

Use the cleaning material to clean the battery and its parts.

4.4.4 Check

Check all parts for obvious defects in accordance with standard industry practices.

4.4.5 Repair

We must prepare some equipments for the battery repair procedure. For example, cleaning fluid, silicone, adhesive, lacing cord, protective varnish for PC boards, etc.

Here are two brief introductions of the repair process:

1. Replacement of the Heating Mat

(1) Refer to chapter "Disassembly" and dismantle the battery.

(2) Remove the heating mat from the inner side of the case.

(3) Remove still adherent residues on the side wall with mechanical means.

(4) Hand clean inner side wall with cleaning fluid and a lint-free cloth.

(5) Put silicone adhesive on the inner side wall of the case and attach the replacement heating mat carefully.

(6) Before installation of the battery block allow the adhesive to cure for at least 24 hours at room temperature.[6]

2. Replacement of the Battery Pack

(1) Refer to chapter "Disassembly" and dismantle the battery.

(2) Install the replacement battery pack (40) in the case (140).

(3) Push the contacts (110) into their bores in the case. Make sure that the contacts are locked.

(4) Refer to Figure 4.4-7. Install the end-fitted wires to the connector and solder them in position.

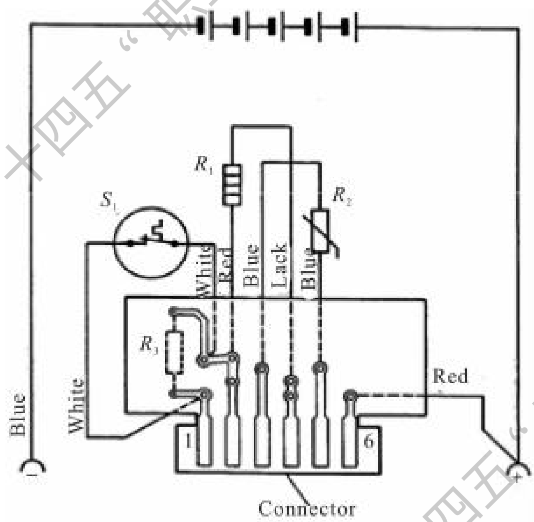


Figure 4.4-7 Wiring diagram

(5) Clean the soldering joints with cleaning fluid.

(6) Apply protective varnish on the soldering joints and allow varnish to dry for 4 hours.

(7) Secure the wire leads with a lacing spot tie near the connector.

4.4.6 Assembly

When all components are fixed and available, we must assemble the components together.

The procedure of the assemble is:

(1) Install the connector (160) in the recess of the case (140).

(2) Position the cable leads next to the cells in order to prevent squeezing between case and cover.

(3) Put the cover (10) on the assembly. Make sure that no leads are squeezed.

(4) Attach the cover with the 3 captive screws (20) and washers (30).

(5) Refer to Figure 4.4-8 and measure the protruding thread of each attaching screw (180). If necessary, adjust dimension A by inserting or removing the washer (190) and/or the washer.

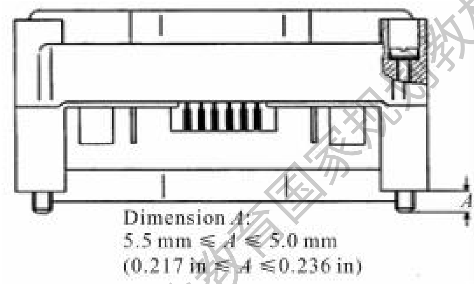


Figure 4.4-8 Attaching screws

The storage that immediate serviceability not required: Prepare and store the battery in accordance with the standard industry practices.

The storage that immediate serviceability is required:

(1) When the storage under trickle charge, the first is discharge and charge the battery in accordance with "Testing and Fault Isolation".[7] For the second, store the battery under workshop environmental conditions and connected to a constant current source with a charge current of 90 to 110 mA. The third one is remove the battery from the constant current source after 6 months and do a functional test in accordance with "Testing and Fault Isolation".

(2) When the storage without trickle charge, the first is discharge and charge the battery in accordance with "Testing and Fault Isolation". For the second, store the battery at a temperature of approx. 0℃ (+32℉) and the loss of capacity will be 10% to 15% within 2 months. The last one is after 12 months do a functional test in accordance with "Testing and Fault Isolation".

New Words/ Phrases/ Expression

1. captive screw 固定螺钉
2. assy ['esi] *n.* 组件;装配(assembly 的缩写)
3. recesses [ri'sesiz] *n.* 凹槽
4. nicd cell 镍镉电池
5. isolation [ˌaisə'leiʃən] *n.* 隔离
6. varnish ['vɑːniʃ] *n.* 清漆,亮漆
7. dimension [di'menʃən] *n.* 尺寸
8. vibrational [ˌvəi'breiʃənd] *adj.* 振动的,摇摆的
9. multimeter['mʌltimiːtə] *n.* 万用表
10. megohmmeter ['megəumiːtə] *n.* 兆欧级电阻表

11. dismantle [dis'mæntl] *v.* 拆开，拆卸
12. female contact 柔性连接
13. adhesive [əd'hi:siv] *n.* 黏合剂，胶
14. trickle ['trikl] *n.* 涓流，细流

Notes

【1】In case of a breakdown of the aircraft power supply the battery supplies electrical circuits with its stored energy for a defined time period.

翻译：在飞机失去正常电源的情况下，电池用其储存的电能继续给飞机供电，以保证飞机在规定时间内用电。

【2】The battery block assembly consists of the five connected cells and the insulator assy (8) inside them.

翻译：电池组件由5个串联的单元体和内部的绝缘体组件(8)组成。

【3】A temperature sensor and a thermostat which is embedded in the insulator assembly monitor the temperature of the battery.

翻译：温度传感器和嵌在绝缘体上的恒温器监测电池的温度。

【4】The necessary environmental conditions for the test procedure are: The ambient temperature is 10 to 30℃; the relative humidity is less than 80%; the atmospheric pressure is local standard.

翻译：试验程序的必要环境条件有：环境温度在10～30℃；相对湿度小于80%；气压为当地标准大气压。

【5】First, set the DMM to measure the DC voltage.

分析："DMM"指"Digital Multimeter"（数字式万用表）；"DC"指"Direct Current"（直流电）。

翻译：首先，设置数字式万用表到直流电压挡。

【6】Before installation of the battery block allow the adhesive to cure for at least 24 hours at room temperature.

翻译：在安装电池块之前，要让黏合剂在室温条件下固化至少24小时。

【7】When the storage under trickle charge, the first is discharge and charge the battery in accordance with "Testing and Fault Isolation".

翻译：当蓄电池在涓流充电情况下时，首先是根据测试和故障隔离的要求对电池进行充/放电。

Exercises

Ⅰ. Answer the following questions:

1. What are the important components of the battery?
2. What is the battery test procedure?
3. What are the steps taken to disassemble?

Ⅱ. Translate the following sentences into Chinese:

1. Examine the battery for mechanical damage. Make sure that the 3 screws which attach the cover to the case are tight and there are no leads squeezed between cover and case.

2. First, set the DMM to measure the DC voltage. Refer to Figure 4.4-5 and connect the test circuitry to the battery as shown.

3. Then, set the switch of the test circuitry to ON in order to start the discharge operation, and at the same time start the stop watch to measure the elapsed time. When 15 minutes have elapsed, measure the voltage of the battery and make sure that the shown value is not less than 5.6 V. The last thing is deleted and set the test circuitry switch to OFF when the battery voltage reaches 5.0 V.

4. We must prepare some equipments for the battery repair procedure. For example, cleaning fluid, silicone adhesive, lacing cord, protective varnish for PC boards, etc.

5. The storage that immediate serviceability not required: Prepare and store the battery in accordance with the standard industry practices.

6. For the second, store the battery under workshop environmental conditions and connected to a constant current source with a charge current of 90 to 110 mA. The third one is remove the battery from the constant current source after 6 months and do a functional test in accordance with "Testing and Fault Isolation".

Ⅲ. Fill in the following blanks according to the text:

1. From the battery- cutaway view, the components it includes is: ________.

2. The necessary environmental conditions for the test procedure of battery are: ______, ________, ________.

3. The procedure of the capacity test is: First, set the DMM to measure the DC voltage. Then, set the switch of the test circuitry to ________ in order to start the discharge operation, and at the same time start the stop watch to measure the elapsed time. When 15 minutes have elapsed, measure the voltage of the battery and make sure that the shown value is not less than. The last thing is deleted and set the test circuitry switch to ________ when the battery voltage reaches ________.

4. When all components are fixed and available, we must assemble the components together. The procedure of the assemble is: ________, ________, ________, ________.

4.5 Coffee Maker

The coffee maker is closed on the sides, back and top using black anodized plates attached by screws.[1] Attached to the top plate there is a recessed handle for transporting the coffee maker when not installed in the galley. On the back there is a reset button for the circuit breaker. On the lower part of the back there is the electrical and water interface (see Figure 4.5-1 to Figure 4.5-3).

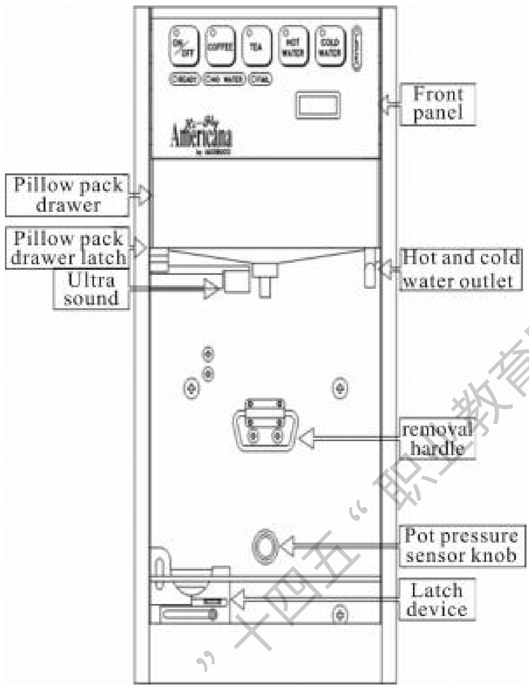


Figure 4.5－1　Front view

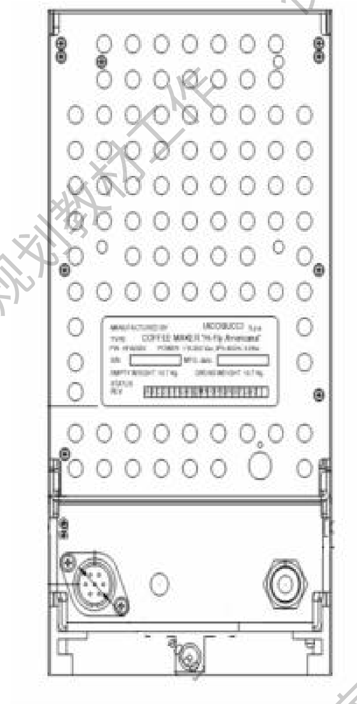


Figure 4.5－2　Back view

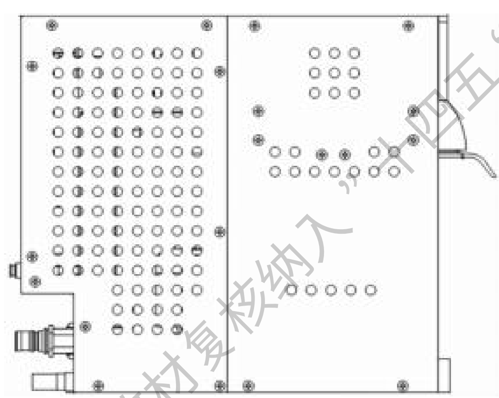


Figure 4.5－3　Side view

Coffee Maker Maintenance：

Schematic plumbing diagram is shown in Figure 4.5－4.

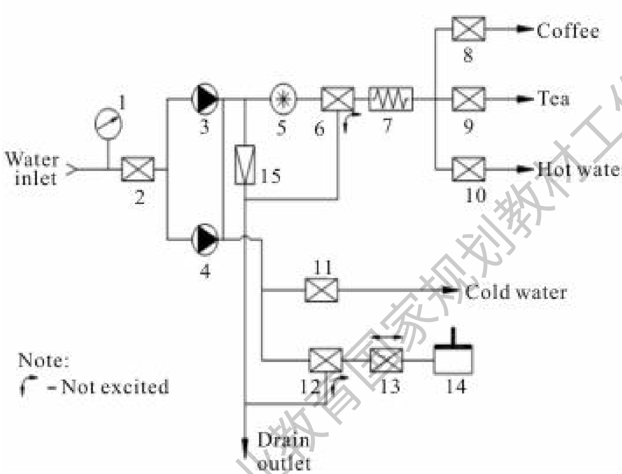


Figure 4.5-4 Schematic plumbing diagram

1—Pressure sensor; 2— 2-way solenoid valve; 3—Pump; 4—Pump; 5—Flowmeter; 6— 3-way solenoid valve; 7—Heater; 8— 2-way solenoid valve; 9— 2-way solenoid valve; 10— 2-way solenoid valve; 11— 2-way solenoid valve; 12— 3-way solenoid valve; 13— 3-way solenoid valve (normally open); 14— Hydraulic ram; 15— Relief valve

Front Panel Description (see Figure 4.5-5).

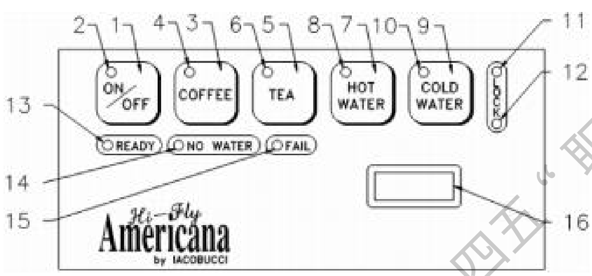


Figure 4.5-5 Front panel

The key to startup/shutdown the coffee maker, the four keys to activate the different functions (each one with a in-progress light indicator), the light indicators for the out of range line pressure, fail situation, ready to brew, and drawer locked/unlocked, and the run-time indicator are all positioned on the front panel (see Table 4.5-1).

Table 4.5-1 Front Panel Indicator

Item	Describe	Function	Color
1	Key	ON/OFF	
2	LED	ON State Indicator	RED
3	Key	Coffee	
4	LED	Coffee Brew in Progress Indicator	YELLOW

Continued

Item	Describe	Function	Color
5	Key	Tea	
6	LED	Tea Brew in Progress Indicator	YELLOW
7	Key	Hot Water	
8	LED	Hot Hater Supply in Progress Indicator	YELLOW
9	Key	Cold Water	
10	LED	Cold Water Supply in Progress Indicator	YELLOW
11	LED	Drawer Locked Indicator	YELLOW
12	LED	Drawer Unlocked Indicator	RED
13	LED	Ready Indicator	YELLOW
14	LED	No Water Indicator	RED
15	LED	Fail Indicator	RED
16	Counter	Run-Time Indicator	

4.5.1 Function Description

1. Coffee Function

The Coffee Function is admitted if all the following conditions are fulfilled: The "Coffee" key on the front panel has been pressed for at least 0.5 second; The line pressure read by the pressure sensor is between 0.3 and 3 bar① (the "No Water" LED is off); The temperature of the heater read by the temperature probe at the beginning of the cycle is at least 98℃ (the "Ready" LED is on); The pot has been inserted, its presence checked by the presence sensor; The drawer has been completely inserted, its presence checked by the drawer microswitch; The ram has completed the stroke in 2 seconds after the "Coffee" key has been pressed, closing the coffee drawer chamber tightly. The complete stroke is checked by the ram microswitch.

During the brewing cycle, if one of the above conditions is not fulfilled, the cycle will immediately stop.[2]

The completion of the cycle is checked by counting the number of impulses given by the flowmeter and by comparing with a preset value or the ultrasound will sense a liquid level that is to high.[3] If none of these values are reached in four minutes, the cycle will be stopped by a time-out condition.

① 1 bar≈0.1 MPa.

The operator can abort the cycle at any time by pressing the "Coffee" key a second time.

2. Tea Function

The Tea Function is admitted if all the following conditions are fulfilled: The "Tea" key on the front panel has been pressed for at least 0.5 second; The line pressure read by the pressure sensor is between 0.3 and 3 bar (the "No Water" LED is off); The temperature of the heater read by the temperature probe at the beginning of the cycle is at least 98℃ (the "Ready" LED is on); The pot has been inserted, its presence checked by the presence sensor.

During the brewing cycle, if one of the above conditions is not fulfilled, the cycle stops immediately.

The completion of the cycle is checked by counting the number of impulses given by the flowmeter and by comparing with a preset value or the ultrasound will sense a liquid level that to high. If none of these values are reached in four minutes, the cycle will be stopped by a time-out condition.

The operator can abort the cycle at any time by pressing the "Tea" key a second time.

3. Hot Water Function

The Hot Water Function is admitted if all the following conditions are fulfilled: The "Hot Water" key on the front panel has been pressed for at least 0.5 second; The line pressure read by the pressure sensor is between 0.3 and 3 bar (the "No Water" LED is off); The temperature of the heater read by the temperature probe at the beginning of the cycle is at least 98℃ (the "Ready" LED is on).

During the brewing cycle, if one of the above conditions is not fulfilled, the cycle stops immediately.

The cycle has a time-out limit of 20 seconds.

The operator can abort the cycle at any time by pressing the "Hot Water" key a second time.

4. Cold Water Function

The Cold Water Function is admitted if the following conditions are fulfilled: The "Cold Water" key on the front panel has been pressed for at least 0.5 second; The line pressure read by the pressure sensor is between 0.3 and 3 bar (the "No Water" LED is off).

During the cycle, if the last condition is not fulfilled, the cycle stops immediately.

The cycle has a time-out limit of 20 seconds.

The operator can abort the cycle at any time by pressing the "Cold Water" key a second time.

5. Making Coffee

Press the drawer latch down and pull out the drawer.

Gently pat or fluff the coffee pillow pack to loosen coffee grounds, then place it into the drawer.

Slide the drawer back into the coffee maker and press firmly until it snaps into place.

The "Drawer Unlocked" indicator shall turn off and the "Drawer Locked" indicator shall turn on (items 11 and 12 in Figure 4.5-5). If the coffee maker does not perform as stated above, see section "Testing and Fault Isolation" of this manual.

Place an empty pot into the coffee maker which will be blocked by the spring-loaded retention bar.

Press the "Coffee" key (items 3 in Figure 4.5-5) on the front panel. The "Coffee Brew in Progress" indicator (items 4 in Figure 4.5-5) will light, indicating that the brewing cycle has begun. If the coffee maker does not perform as stated above, see section "Testing and Fault Isolation" of this manual.

The brewing cycle will stop after 3 to 4 minutes, as defined earlier in section 3 "Performance". If the duration of the cycle is out of these limits, or the quantity of liquid is much different than quantity per cycle defined in section 3 "Performance", see section "Testing and Fault Isolation" of this manual.

To remove the pot, press the spring-loaded retention bar down.

Remove the pillow pack from the drawer and rinse eventual coffee grounds.

6. Making Tea

Place an empty pot into the coffee maker. It will be blocked by the spring-loaded retention bar.

Press the "Tea" key (item 5 in Figure 4.5-5) on the front panel. The "Tea Brew in Progress" indicator (item 6 in Figure 4.5-5) will light, indicating that the brewing cycle has begun. If the coffee maker does not perform as stated above, see section "Testing and Fault Isolation" of this manual.

The brewing cycle will stop after 3 to 4 minutes, as defined earlier in section 3 "Performance". If the duration of the cycle is out of these limits, or the quantity of liquid is much different than quantity per cycle defined in section 3 "Performance", see section "Testing and Fault Isolation" of this manual.

To extract the pot, press the spring-loaded retention bar down.

4.5.2 Testing and Fault Isolation

The procedure of the test is as follow.

1. Coffee Function

Check that the indication on the front panel pass from "Unlocked" to "Locked" when the pillow pack drawer is inserted.

Check that the absence of the pot blocks the function.

With the line pressure set at a value in the normal range, start the "Coffee Function" (section 5 "Making Coffee") and check that during the cycle.

With the line pressure set to the minimum value start the "Coffee Function" (section 5 "Making Coffee") and make sure that the unit doesn't fail or that the time per cycle and/or the temperature of the produced coffee is not out of limit.[4]

Repeat the operations defined in the previous paragraph for the maximum pressure.

2. Tea Function

Check that the absence of the pot blocks the function.

With the line pressure set at a value in the normal range, start the "Tea Function" (section 6 "Making Tea") an check that during the cycle.

With the line pressure set to the minimum value, start the "Tea Function" (section 6 "Making Tea") and make sure that the unit doesn't fail or that the time per cycle and/or the temperature of the produced hot water is not out of limit.

Repeat the operations defined in the previous paragraph for the maximum pressure.

3. Hot Water Function

With the line pressure set at a value in the normal range, start the "Hot Water Function" and check that during the cycle.

With the line pressure set to the minimum value, start the "Hot Water Function" and make sure that the unit doesn't fail or that the time per cycle and/or the temperature of the produced hot water is not out of limit.

Repeat the operations defined in the previous paragraph for the maximum pressure.

4. Cold Water Function

With the line pressure set at a value in the normal range, start the "Cold Water Function" and check that during the cycle:

(1) There is no leakage from the hydraulic components;

(2) The current absorption on each phase is below the limit.

With the line pressure set to the minimum value start the "Cold Water Function" and make sure that the unit doesn't fail or that the time per cycle and/or the temperature of the produced hot water is not out of limit.

Repeat the operations defined in the previous paragraph for the maximum pressure.

4.5.3 Disassembly/Assembly

The details of the procedure refers to the relevant CMM.

4.5.4 Cleaning

The procedure of the cleaning is as follows.

1. Cleaning the Casing

• Blow dust from the surfaces, holes and recesses using oil-free compressed air of max 2 bars (29 psig).[5]

• Wash coffee drawer and any contaminated surfaces with detergent. Rinse with clear water. Wipe dry with a clean, dry, lint-free cloth.

• Clean stained surfaces with a cleaning compound. Rinse with clear water.

• Scale build-up due to operation with hard water may be removed soaking the affected parts in a solution of 5% sulfamic acid. Rinse with clear water.

2. Cleaning of Electrical Parts

• Remove dust and dirt from the circuit boards with a small soft-bristled brush and isopropyl alcohol. Dry with oil-free compressed air of max 2 bars (29 psig).

• With minimum movement of the wiring, wipe dust and dirt from bodies, shells and cable clamps with lint-free cloth moistened with alcohol. Wipe dry with a clean, dry, lint-free cloth.

3. Cleaning the Tubing

Clean all internal tubes by running a non-metallic brush along them. Rinse with clear water. Dry with oil-free compressed air of max 2 bars (29 psig).

4. Onboard Cleaning

To make sure that the coffee maker stays clean all the time it should be cleaned after each flight. Using a damp sponge wipe clean the front face of the coffee maker, clean the drain plate and make sure that the drain hole is free from dirt.

4.5.5 Check

1. Ready Check

Start up the coffee maker, after it has performed its self-test, the heat exchanger is warming up and the "Ready" indicator is not yet lit, press the "Coffee" "Tea" and "Hot Water" keys, for each one a warning buzzer should sound, alerting that the heat exchanger has not yet reached its operating temperature. The "Cold Water" key if pressed should start the cold water in any case.

2. Drawer Absence Check

Without inserting the drawer try to start a coffee cycle by pressing the "Coffee" key, the warning buzzer should sound. The "Tea" "Hot Water" and "Cold Water" functions will work in any case.

3. Pot Absence Check

Without inserting the pot try to start a coffee cycle by pressing the "Coffee" key, the warning buzzer should sound. Perform the same test for the "Tea" function. The "Hot Water" and "Cold Water" functions will work in any case.

4. Cycle Interruption Check

Start a coffee brew cycle, after approximately 20 to 30 seconds interrupt the cycle by pressing the "Coffee" key a second time, the cycle should stop. Perform the same test for the "Tea" function. Perform the same test for the "Hot Water" and "Cold Water" functions, with the only difference that the function has to be interrupted after approximately 5 seconds.

5. Pot Removal Check

Start a coffee brew cycle, after approximately 20 to 30 seconds lower the pot retention bar and remove the pot, the brew cycle should stop.[6] Perform the same test for the "Tea" function. The "Hot Water" and "Cold Water" functions will work in any case.

4.5.6 Repair

If the coffee maker is malfunctioning or if it has gone into a fail mode, the faulty part could be located by following the steps in the sections "Testing and Fault Isolate" and/or "Inspection and Check".[7] Substitution of broken or damaged parts shall be performed according to the sections "Disassembly" and "Assembly" of this manual.

New Words/ Phrases/ Expression

1. anodized [ˈænəudaizd] *v.* 做阳极化处理
2. galley [ˈgæliː] *n.* (轮船、飞机上)厨房
3. panel [ˈpænəl] *n.* 面板
4. ultrasound [ˌʌltrəˈsaund] *n.* 超声波
5. flowmeter [ˈfləumiːtə] *n.* 流量计
6. microswitch [ˈmaikrəuˌswitʃ] *n.* 微动开关
7. probe [prəub] *n.* 探头,探针
8. detergent [diˈtəːdʒənt] *n.* 洗涤剂
9. sulfamic acid 氨基磺酸
10. moistened [ˈmɔisənd] *v.* (使)变得潮湿,变得湿润
11. buzzer [ˈbʌzə] *n.* 蜂鸣器
12. substitution [ˌsʌbstiˈtuːʃən] *n.* 代替,代用,替换
13. approximately [əprɔksiˈmətli] *adv.* 近似地,大约
14. malfunction [mælˈfʌŋkʃən] *n.* 故障,功能障碍,失灵
15. remove from 移除,清除
16. start up 启动

Notes

【1】The coffee maker is closed on the sides, back and top using black anodized plates attached by screws.

翻译:咖啡壶的两边是封闭的,背部和顶部使用黑色阳极化电镀板,用螺钉装在咖啡壶上。

【2】During the brewing cycle, if one of the above conditions is not fulfilled, the cycle will immediately stop.

翻译:在煮咖啡过程中,如果上述条件之一没有得到满足,将立即停止。

【3】The completion of the cycle is checked by counting the number of impulses given by the flowmeter and by comparing with a preset value or the ultrasound will sense a liquid level that is to high.

翻译:通过对流量计测得数值与预设值进行比较,或者超声波能感应到较高的液面水平,来判断程序的完成情况。

【4】With the line pressure set to the minimum value start the "Coffee Function" (section 5 "Making Coffee") and make sure that the unit doesn't fail or that the time per cycle and/or the temperature of the produced coffee is not out of limit.

翻译: 将线路压力设置为最小值开始"咖啡功能"(第5节"煮咖啡"),确保组件无故障,每个循环的时间和煮咖啡的温度都没有超出限制。

【5】Blow dust from the surfaces, holes and recesses using oil-free compressed air of max 2 bars (29 psig).

分析: oil-free:无油的;bar:巴,压强单位(1 bar=100 000 Pa); psig: (pounds per square inch, gauge)压强单位,定义为 1 lb/in^2。

翻译: 使用清洁的气压不超过 2 bar(29 psig)的压缩空气吹掉表面上、孔里以及凹槽里的灰尘。

【6】Start a coffee brew cycle, after approximately 20 to 30 seconds lower the pot retention bar and remove the pot, the brew cycle should stop.

翻译: 启动一个煮咖啡周期,在大约 20~30 秒后,按下咖啡壶的保持杆,并把壶移开,该周期停止。

【7】If the coffee maker is malfunctioning or if it has gone into a fail mode, the faulty part could be located by following the steps in the sections "Testing and Fault Isolation" and/or "Inspection and Check".

翻译: 如果咖啡壶出故障了或是进入一种故障模式,故障部位可以在"测试和故障隔离"和(或)"检验和检查"部分来进行定位。

Exercises

Ⅰ. Answer the following questions:

1. What is the function of the keys on coffee maker?
2. What are the procedures for testing these functions?
3. How to clean the coffee maker?

Ⅱ. Translate the following sentences into Chinese:

1. Attached to the top plate there is a recessed handle for transporting the coffee maker when not installed in the galley.
2. Within the opening there is a latch to keep the pillow pack drawer locked in position, an outlet for the coffee (on the bottom of the pillow pack drawer), an outlet for hot water for making tea.
3. The Coffee Function is admitted if all the following conditions are fulfilled: The "Coffee" key on the front panel has been pressed for at least 0.5 second.
4. Slide the drawer back into the coffee maker and press firmly until it snaps into place.
5. Scale build-up due to operation with hard water may be removed soaking the affected parts in a solution of 5% sulfamic acid. Rinse with clear water.
6. Remove dust and dirt from the circuit boards with a small soft-bristled brush and isopropyl alcohol. Dry with oil-free compressed air of max 2 bars.
7. Without inserting the pot try to start a coffee cycle by pressing the"Coffee" key, the warning buzzer should sound.

8. Perform the same test for the "Hot Water" and "Cold Water" functions, with the only difference that the function has to be interrupted after approximately 5 seconds.

9. Substitution of broken or damaged parts shall be performed according to the sections "Disassembly" and "Assembly" of this manual.

Ⅲ. Fill in the following blanks according to the text:

1. Within the opening there is a latch to keep the pillow pack drawer locked in position, an outlet for ________, an outlet for hot water for ________, an external outlet for ________, ________ to be used for the removal of the coffee maker from the galley compartment.

2. The Coffee Function is admitted if all the following conditions are fulfilled: The "Coffee" key on the front panel has been pressed for at least ________ seconds; The line pressure read by the Pressure Sensor is between ________ bar (the "No Water" LED is off); The temperature of the heater read by the temperature probe at the beginning of the cycle is at least ________ ℃.

3. Without inserting the pot try to start a coffee cycle by pressing the "Coffee" key, ________ the ________ should sound. Perform the same test for the "Tea" function. The "________" and "________" functions will work in any case.

4. If the coffee maker is ________ or if it has ________, the faulty part could be located by following the steps in the sections "Testing and Fault Isolation" and/or "Inspection and Check".

Chapter 5
Aircraft Avionics Component Maintenance

Chapter 5 Aircraft Avionics Component Maintenance

5.1 Introduction to Avionics System

Modern aviation uses many avionics systems. As aviation develops, newer avionics systems are coming on the scene, and their usage and application are more and more extensive.

We can roughly divide avionics systems into three main categories: the communication systems, the navigation systems, and the autoflight control system/flight management system.

5.1.1 Communication

Communications connect the flight deck to the ground and the flight deck to the passengers.

The VHF radio system provides short range communication capability. It works on the airband of 118 to 136.975 MHz. This system includes transceivers, control panels and antennas.

The HF radio system provides long range communication capability. It works on the airband of 2 to 30 MHz. This system includes transceivers, control panels, antenna couplers, and a common antenna.

5.1.2 Navigation

The navigation systems compute and display the airplane's movement with respect to the earth's surface. They sense from the environment, receive from ground stations and /or acquire from other systems the data used to provide these displays. The systems all provide one or more of the following functions:

- Acquire and transmit navigation data.
- Receive and process navigation data from other systems.
- Generate and display processed data.

Avionics can use satellite-based systems(such as GPS), ground-based systems (such as VOR or ILS), or any combination of them. Navigation systems calculate the position automatically and display it to the flight crew on moving map displays.

5.1.3 FMCS/AFCS System

The primary elements of the Flight Management Computer System (FMCS) are two Flight Management Computers (FMC) and two Control and Display Units (CDUs). The CDUs provide pilot interface with the flight management computer system. The flight management computers gather the necessary sensor data, perform computations and drive displays and other systems to navigate and guide the airplane.

The Auto Flight Control System (AFCS) automatically controls the airplane's surfaces and engine thrust as required. Two subsystems, the Autopilot Flight Director System (AFDS) and the Thrust Management System (TMS) provide the primary surface and throttle control respectively.

The AFDS has three Flight Control Computers (FCC) and an AFCS mode control panel. A single computer, the Thrust Management Computer (TMC) controls the throttles and calculates thrust limits. The TMS and AFDS use the AFCS mode control panel to provide an interface with the flight crew. The TMS also includes a thrust mode select panel for selecting the thrust limit mode.

The yaw damper system and an automatic stabilizer trim system provide dutch roll damping and pitch trim respectively.

The maintenance control and display panel (MCDP) provides a central location for storage and display of fault data for the FMCS, AFDS, and TMS via the flight management, flight control, and thrust management computers. It also provides ground test control and display for the autopilot flight director and thrust management systems.

New Words/ Phrases/ Expression

1. coupler [ˈkʌplə] *n.* 耦合器
2. thrust [θrʌst] *n.* 推力
3. damping [dæmpiŋ] *n.* 阻尼
4. yaw [jɔː] *n.* 偏航
5. VHF 甚高频通信系统(Very High Frequency 的缩写)
6. HF 高频通信系统(High Frequency 的缩写)
7. GPS 全球定位系统(Global Positioning System 的缩写)
8. VOR 甚高频全向定位信标(VHF Omnidirectional Range 的缩写)
9. ILS 仪表着陆系统(Instrument Landing System 的缩写)

Exercises

Ⅰ. Translate the following sentences into Chinese:

1. We can roughly divide avionics systems into three main categories: the communication systems, the navigation systems, and the autoflight control system/flight management

system.

2. The VHF radio system provides short range communication capability.

3. The HF radio system provides long range communication capability.

4. They sense from the environment, receive from ground stations and /or acquire from other systems the data used to provide these displays.

Ⅱ. Answer the following questions:

1. How many kinds of avionics systems are there?

2. Name some of the systems or devices employed in the communications system?

3. What type of communication is the VHF radio system suited to?

4. What is the purpose of the AFCS?

5. The FMCS comprises four primary component elements. What are they? Describe their functions briefly.

5.2 Flight Control Computer

5.2.1 Description

The purpose of the Digital Flight Control System(DFCS) is to provide automatic or pilot assisted functions for climb, cruise and approach control of the airplane.

The major components of the system are two Flight Control Computers (FCC) and a Mode Control Panel (MCP). The MCP provides inputs to both FCC's for engagement, mode selection, and pilot assisted controls of certain modes. Airplane sensor systems such as inertial reference units and VHF navigation systems provide inputs. The status of the system and the modes of operation are provided visually on the Flight Mode Annunciator(FMA). The outputs of the FCC's provide control signals to the ailerons, spoilers, elevators and stabilizer for pitch and roll attitude control.

5.2.1.1 Physical Description

The FCC is a line replaceable, dual channel, microprocessor-based digital computer (see Figure 5.2-1).

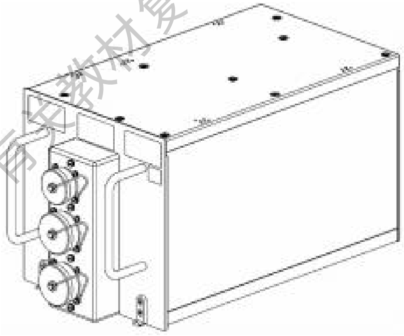


Figure 5.2-1 Flight Control Computer(FCC)

The FCC is packaged in a size 6, modular control unit (MCU) chassis that conforms with the dimensional, mounting, and cooling requirements of Aeronautical Radio, Inc. (ARINC) specification 600 - 7. The chassis holds seven plug-in circuit card assemblies (CCA), a plug-in power supply, and a hardwired motherboard, which are all shop replaceable. The CCAs and the power supply plug into mating connectors on the motherboard. Each plug-in CCA is supported by card guides. The power supply is fastened to the top of the chassis with mounting hardware. Single-sided access to all shop replaceable assemblies is obtained through removable top and bottom covers, which are all held in place with captive screws. The aluminum alloy chassis and covers are finished with Class Ⅲ Chromate Dip. This finish optimizes thermal and electrical performance providing protection against corrosion.

The front panel of the FCC contains the identification plates, built-in carrying handles, hold-down hooks, and three electrical test connectors (J2, J3, and J4). The rear of the chassis contains one ARINC 600, size 2, electrical connector with three cavities (J1A, J1B, and J1C). Cavities J1A and J1B each contain 150 size 22 contacts. Cavity J1C contains various sizes for power. Both the front and rear connectors are mechanically keyed. The J2 connector is for data loading only. J3 and J4 connectors are for testing. Connector J1, which is keyed, mates with the airplane avionics rack. The keying is shown in Figure 5.2 - 2.

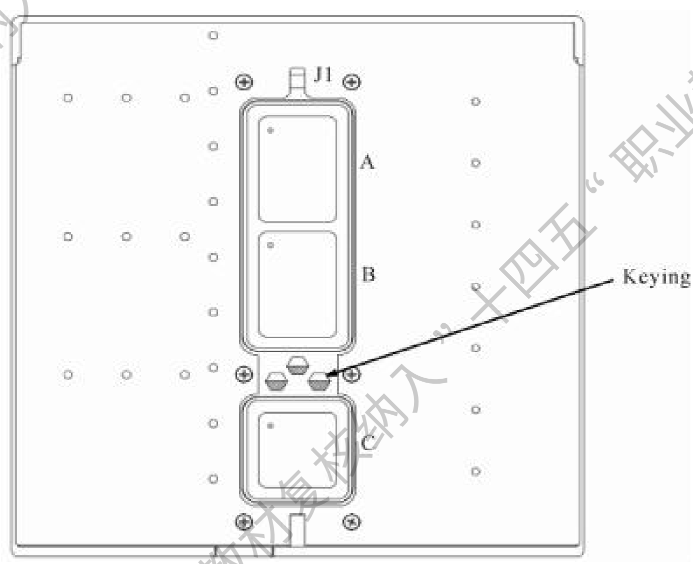


Figure 5.2 - 2　FCC keying arrangements

The FCC is mounted directly on the airplane avionics rack and does not require the use of vibration or shock attenuating mounts. National Aircraft Standards (NAS) 622 hold-down hooks provide front support to the FCC and the ARINC 600 style unit connector (J1) provides rear support.[1] Leading particulars of the FCC are shown in Figure 5.2 - 3.

Dimensions	
Height	7.6 inches (19.30 cm)
Width	7.5 inches (19.05 cm)
Depth	12.8 inches (32.51 cm)
Weight (approximate)	20.4 pounds (9.25 kg)
Power Requirements:	
AC Input Voltage	115 V ac, 400 Hz
DC Input Voltage	28 Volts dc nominal
Power Dissipation	70 watts (maximum)
Electrical Connectors	
J1 Mates With	Cannon Part No. BKAC-68134-108
J2 Mates With	Bendix Part No. JT06RE18-53P(SR)
J3 Mates With	Bendix Part No. JT06RE22-35PA(SR)
J4 Mates With	Bendix Part No. JT06RE22-35P(SR)

Figure 5.2 - 3　Leading particulars

1. FCC Partitioning

The CCAs are installed through the top of the FCC chassis and plugged into the motherboard. Apply Figure 5.2 - 4 for card slot assemblies. The motherboard in the FCC provides interconnect capability for up to 11 assemblies, however, only eight are used in the present FCC configuration (Card slots labeled A4, A9, and A10 are not used.). Card slots are physically divided into sections with a solid aluminum wall to separate the analog from the digital CCAs. Total possible electrical interconnects are approximately 2052 with approximately 600 made within the 14 - layer printed wiring motherboard.

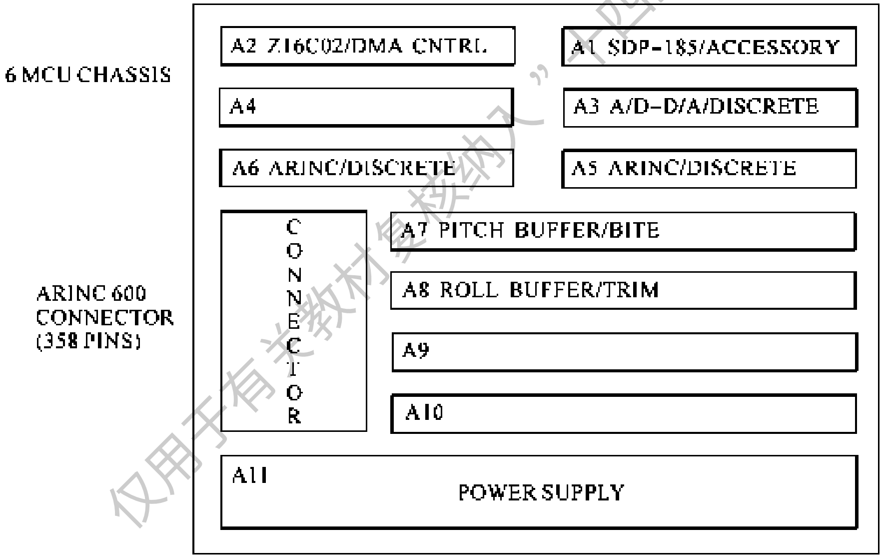


Figure 5.2 - 4　CCA locations

Refer to Figure 5.2－5 for a list of major subassemblies, cross-referenced by reference designators, that make up the modular design of the unit. The CCAs are labeled for ease of circuit function identification. CCAs that contain electrostatic discharge sensitive devices (ESDs) are clearly marked with the standard ESDs symbol.

Nomenclature	Ref Des	Part No. for 4082499-902	Part No. for 4082499-903
Electrical equipment rack	—	4082411-901	4082411-901
Motherboard (interconnect) CCA	—	4082420-2002	4082420-2002
SDP-185/Accessory	A1	4082421-1902	4082421-1903
Z16C02/IOC CCA	A2	4082422-1902	4082422-1903
Discrete/A/D-D/A CCA	A3	4082423-1901	4082423-1901
Discrete/ARINC CCA	A5	4082424-1902	4082424-1902
Discrete/ARINC CCA	A6	4082424-1901	4082424-1901
Pitch/BITE CCA	A7	4082425-1002	4082425-1003
Roll/Trim CCA	A8	4082426-1002	4082426-1003
Power Supply ECA	A11	4082427-901	4082427-902
FCC Unprogrammed	—	4082499-902	4082499-903

Figure 5.2－5　FCC subassemblies

2. Major Assemblies

The FCC contains five half-size (approximately 6 in×6 in) CCAs designated A1, A2, A3, A5, and A6 and two full-size (approximately 10 in×6 in) CCAs, A7 and A8. The FCC also Contains ECA A11, the shop replaceable unit power supply. Digital CCAs have a 4-row, 180-pin blade connector, a 70-pin top test connector, sliding extractor handles, and exposed ground planes on the edges. Analog CCAs have a 3-row 228-pin blade connector, sliding extractors, and an exposed ground plane on the edges. Power supply assembly A11 is a single (approximately 10 in×6 in) CCA with a 2-row 60-pin blade connector, sheet metal on the back plane, and two machined heat sinks.

The CCAs are constructed from an epoxy printed wiring board (PWB) with edge connectors, microcircuits, and discrete analog and digital components. The PWBs are made of nonconstrained fiberglass (FR4) and have acrylic conformal coating applied. The connectors, microcircuits, and discrete analog and digital components are mounted on both sides of the PWB. Card connectors are of the blade-and-tuning fork design, with each connector having an integral shroud that extends over the body of the connector to shield the pins from external damage. The card connectors also contain keying pins, which also serve as alignment pins. In order to prevent mislocation of a CCA, each connector is uniquely keyed to fit only those card slots designed for that card. All CCAs contain captive ejector handles to assist in extracting the CCAs from the chassis.

3. Wire Harness

The FCC motherboard uses PWB interconnect card to card and wire-wrap to rear connector and front test connectors. The rear aircraft connector uses an ARINC 600 size 2 connector with wire-wrap contacts. Front Data Loader/Test connectors use circular bayonet connectors with wire-wrap connections to the motherboard.

4. Electronics

FCC electronics consists of Advanced CMOS logic including Electronically Programmable Logic Devices (EPLD). All parts are Surface Mounted (SMT), plastic devices. Flash memory is used for program, Built-in Test Equipment (BITE), and maintenance data storage. Flash memory is a high density, truly nonvolatile, and high performance read-write memory characterized by low power consumption and high reliability.

5.2.1.2 Functional Description

The following paragraphs discuss how the FCC operates functionally to the subassembly level. Refer to Figure 5.2 - 6 when reading these paragraphs.

1. Processor CPU1 CCA (A1)

CCA A1 is the SDP - 185/Accessory CCA and contains the CPU1 processor, memory, maintenance memory, and control circuitry. The processor used for CPU1 is the SDP - 185 16-bit CMOS microprocessor. Also on the CCA are three flash memory devices (one each for program), BITE, and maintenance memory Static Random Access Memory (SRAM) devices for temporary data storage, an EPLD for control logic, a provisional ARINC 429 octal/receiver quad receiver device, and various buffers for data transfer. The SDP - 185 uses a 16-bit bidirectional bus and a 16-bit address bus to perform data transfer operations. The CPU1 processor uses programmable logic devices (PLD) for memory address decoding. Total program memory is 128 KB words and CPU1 RAM consists of 128 KB words. Processor timing is generated from a 32-MHz crystal oscillator on the CCA. CCA A1 also contains the CPU heartbeat monitors and hardware engage control logic.

2. Processor CPU2 CCA (A2)

The CPU2 circuitry is located on CCA A2. CPU2 circuitry consists of a Z16C12 processor (functionally equivalent to the Z8002 microprocessor), one FLASH memory device used for program storage, two SRAM devices used for temporary storage, an EPLD used for control logic, a provisional ARINC 429 Octal/Receiver Quad Transmitter device, and various buffers used for data transfers. Total onboard memory is 60 KB, 16-bit words and 128 KB×8-bit SRAM. The processor clock rate is 10 MHz.

The DMA controller circuitry is also contained on CCA A2. The primary function of the DMA controller is to interface all external I/O with CPU2. DMA RAM consists of two IDT 7024 dual port RAMs giving a total on-CCA memory of 8 KB words.

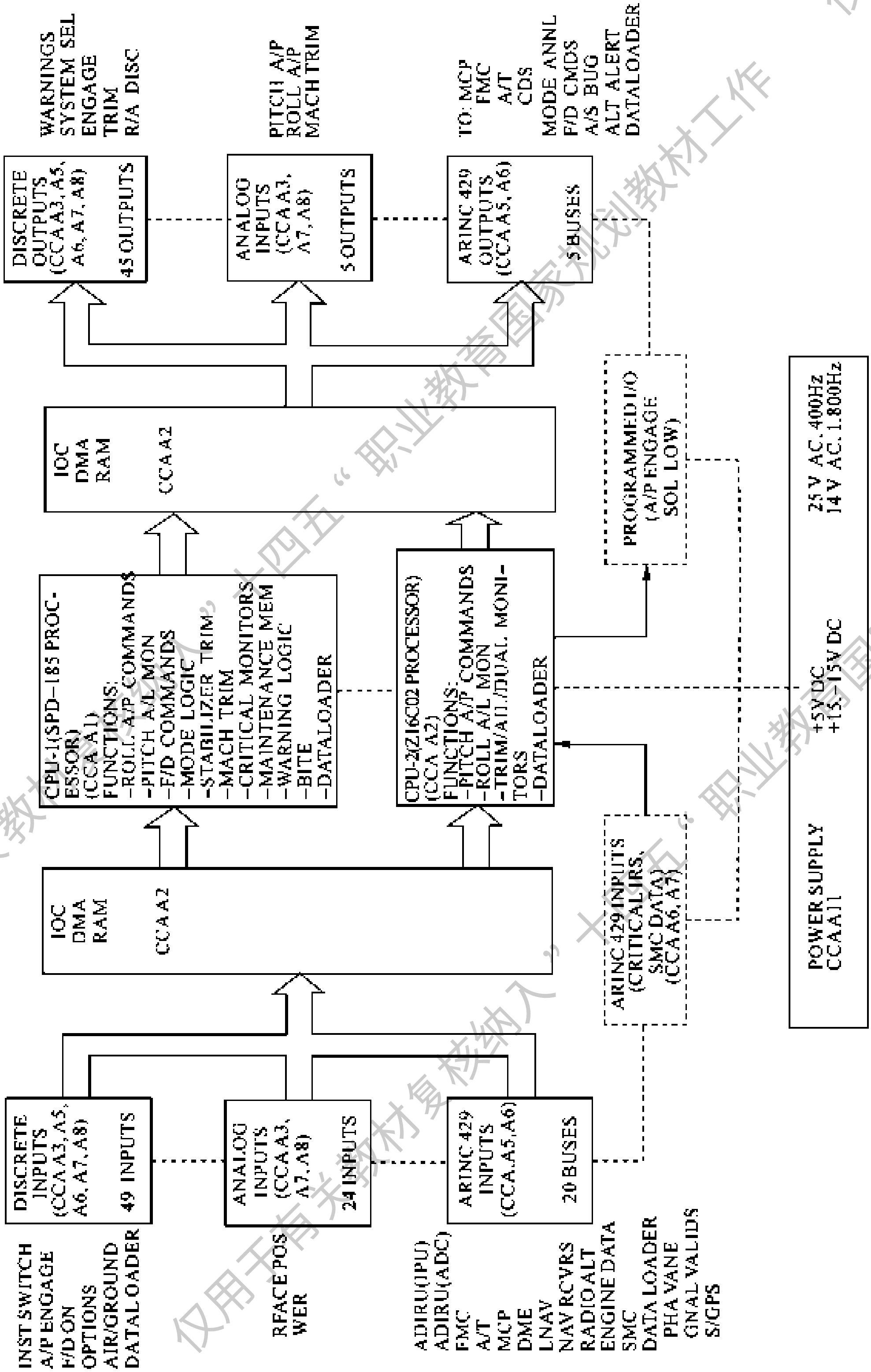


Figure 5.2-6 FCC Functional Block Diagram

3. A/D - D/A CCA (A3)

The analog-to-digital (A/D) and digital-to-analog (D/A) circuitry is contained on CCA A3.

The A/D - D/A circuitry consists of an A/D converter, a D/A converter, a memory map programmable read-only memory (PROM), and EPLD for control logic, an 8-bit and a 16-bit analog multiplexers, sample and hold circuitry, and various buffers for data transfers. The A/D circuitry is capable of converting up to 112 analog signals plus one on-card D/A wrap. The D/A has 15 possible sample and hold outputs plus a dedicated sample and hold used as a wrap back to the A/D converter for test purposes.

4. ARINC CCAs (A5/A6)

Discrete input/output (I/O) circuitry is contained on CCAs A3, A5, and A6. CCAs A5 and A6 share a common PWB. ARINC receivers and transmitters are also on CCAs A5 and A6. Part configuration, EPLD programs, and connector keying are the only difference between the two cards. CCA A3 also contains the A/D - D/A devices along with the discretes. The total number of discrete inputs for each CCA is 45, plus four stretched input discretes for each CCA. Each input is configured as +5 V/GND, +28 V/OPEN, or GND/OPEN.

ARINC circuitry is contained on CCAs A5 and A6. The ARINC section is made up of three parts: receivers, transmitters, and ARINC discrete out circuitry. Each CCA has 16 receivers and four transmitters available, with an LRU total of 32 receivers and eight transmitters.

5. Elevator CCA (A7)

CCA A7 processes the elevator command from the D/A converter on CCA A3 through a bandpass filter and summing amplifier before being applied to the Elevator Actuator Servo Loop. Elevator actuator position and elevator neutral shift are fed back to the servo loop. Elevator linear variable differential transformer (LVDT) and neutral shift sensors (NSS) are excited by an 1800-Hz pitch reference generated from the FCC. The demodulators of these signals use the same 1800-Hz reference. CCA A7 also contains the Mach Trim Coupler (MTC) servo drive circuitry from the D/A converter on CCA A3.

6. Aileron CCA (A8)

CCA A8 processes the aileron command output from the D/A converter on CCA A3. The signal is applied to the aileron servo actuator loop and output to the transfer value. Feedback is from the aileron actuator and spoiler position sensors. Aileron actuator LVDT and spoiler position sensors are excited by 1,800 Hz from the FCC, which also provides the internal demodulator reference.

7. Power Supply ECA (A11)

Electronics components assembly A11 contains the power supply. The power supply is made up of four main functional blocks: the FCC power converters, the power and temperature monitors, the LVDT oscillators, and the MTC motor supply drive.

The block diagram of the FCC power supply is shown in Figure 5. 2 - 7. The three inputs to the power supply are airplane +28 V DC, airplane 115 V AC, and airplane battery power. Normally, internal FCC +5V DC and +15/−15V DC are generated from the+28 V DC through power converters. A low-voltage detector determines when to activate the battery switchover circuit to switch to the battery bus. The +40 V AC for the MTC circuitry is transformed and rectified from the 115 V AC input. An LVDT oscillator/driver circuit provides a 14 V AC, 1,800 Hz excitation for the servo and surface position sensors which are input to the FCC. Pitch axis sensors include the A/P Actuator position LVDT, elevator position sensor, stabilizer position sensor, and neutral shift sensor. Sensors excited in the roll axis are the A/P actuator position LVDT, aileron position sensor, and spoiler position sensors.

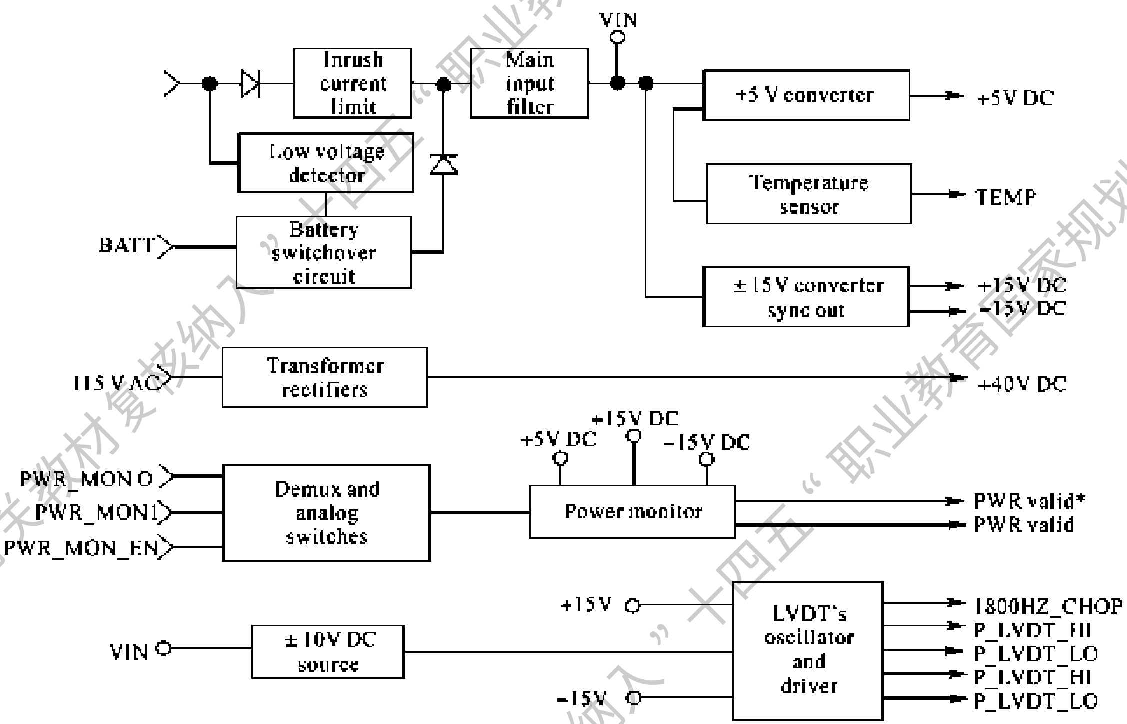


Figure 5. 2 - 7　Power supply block diagram

8. FCC Internal BITE Description

The FCC internal monitoring consists of in-line monitoring of the two processors, cross-channel monitoring between the two processors, and cross-processor monitoring in each channel.

In-line monitoring in the main processor (CPU1) includes continuous processor and memory monitoring, A/D - D/A monitoring, DMA monitoring, power monitoring, heartbeat monitoring, sensor validity monitoring, servo command/response monitoring, radio altimeter buffer monitoring, trim monitoring, elevator LVDT monitoring, and neutral shift monitoring.

In-line monitoring of CPU2 includes continuous processor and memory monitoring, pitch inner loop signal validity monitoring, elevator command wrap-around monitoring, trim warning, trim warning for excessive pitch actuator position, and +15V DC and −15V DC monitoring.

Cross-channel monitoring is implemented by comparing elevator and aileron actuator positions against surface position and is referred to as SPM. Cross-processor monitoring consists of CPU2 repeating or modeling the roll autoland and go-around computations performed in CPU1. Similarly, CPU1 models the pitch autoland and go-around computations performed in CPU2. Both CPUs monitor the tracking of the active elevator and aileron command wrap-around versus model computation during dual-channel operation.

Extensive tests are run, mainly during FCC power-up on the ground, to verify elements that are difficult or time consuming to test continuously. Tests performed at power-up are software monitor tests, heartbeat monitor tests, DMA RAM tests, power supply monitor test, memory tests, trim time delay test, CPU g-limit test and, long-versus short-term power interrupt tests.

5.2.2 Testing and Fault Isolation

The function of the test procedures is to find if there is a failure in the operation of the FCC. If corrective steps are necessary, you must make sure the product is in serviceable condition. Use the test procedures in Automatic Test Requirements (ATR) to make an analysis of the performance of the FCC. Fault isolation is included as part of the automatic test procedure.

5.2.3 Disassembly

To determine the extent of disassembly required, refer to "Testing and Fault Isolation" to make sure of the condition of the FCC. Testing will show the probable cause of its malfunction.

Refer to the Illustrated Parts List to find the location and part numbers for all replaceable parts. Disassembly of the FCC beyond the limits established by the parts list is not authorized.

Procedures required to disassemble the FCC into major subassemblies are provided below.

Disassemble the FCC only to the extent necessary to clean, check, fault isolate, or repair the unit. During disassembly, all desoldered connections should be tagged to aid in assembly of the FCC.

(1) Remove cover.

(2) Remove subassembly.

(3) Remove connector J1.

(4) Remove bracket assembly A13.

(5) Remove connectors J2, J3, and J4.

(6) Remove printed wiring board.

(7) Disassemble printed wiring board.

(8) Remove chassis handle.

(9) Remove chassis hook.

5.2.4 Cleaning

This subheading supplies cleaning instructions for the FCC. These cleaning instructions are for general, pre- or post-rework cleaning.

Use best-established shop procedures to clean the FCC. These shop procedures are sufficient to remove all contaminants.

1. External Cleaning

(1) Use compressed air or a clean, soft, natural-bristle brush (to prevent ESD damage) to remove light dirt and dust on the external surfaces of the FCC.

(2) Use lint-free cleaning swabs or cleaning tissues dampened with solvent to clean large amounts of oil or grease.

(3) Remove dirt and dust from around the connector pins with low-pressure ionized air.

2. Internal Cleaning

(1) Remove dirt and dust from around the connector pins with low-pressure ionized air.

(2) Use lint-free cleaning swabs or cleaning tissues dampened with solvent to clean difficult areas.

(3) Remove dirt and dust from around the connector pins with low-pressure ionized air.

5.2.5 Check

Checks of the FCC tell the condition of its physical, mechanical, and electrical properties. These properties are compared to established standards.

Visual checks make sure the parts of the FCC are serviceable and show no signs of wear, damage, or possible failure.

1. Exterior Checks

(1) Check the metal parts for corrosion, rust, or other structural damage.

(2) Check for bent or damaged connector pins.

(3) Check all painted surfaces for scratches or other damage.

(4) Make sure the FCC is clean and has no dirt, chips, solder splashes, or other unwanted materials such as excess grease or oil. The component leads must be free from grease, dirt, paint, mold flash, and other contaminants.

(5) Make sure all parts are installed or attached correctly. Check for damaged, loose, or missing parts.

2. Interior Checks

(1) Check that solder is properly applied and connections are secure. Solder joints must

be tight and free of scratches, roughness, sharp edges, dullness, bridging, or blistering. Solder joints must show evidence of wetting (molten solder adhering and flowing on a metallic surface to a smooth, even coating) and bonding where the solder blends to the soldered surface forming a small contact angle.

(2) Make sure the FCC is clean and has no dirt, chips, solder splashes, or other unwanted materials such as excess grease or oil. The component leads must be free from grease, dirt, paint, mold flash, and other contaminants.

(3) Make sure all parts are installed or attached correctly. Check for damaged, loose, or missing parts.

(4) Check threads on applicable parts for burrs or cross-threads (connectors, frames, and heat sink brackets, etc.).

(5) Check the electrical components for cracks, corrosion, discoloration, or burned, overheated areas.

(6) Check for broken or disconnected wires. Wires found in this condition must be replaced.

(7) Check leadwires for breaks or brittleness.

5.2.6 Repair

Repair of the FCC shows you how to repair defective wires, replace defective subassemblies and/or piece-parts, and do paint touchup as discovered during ATR. Parts replacement procedures are given in Assembly.

(1) Replacement of damaged equipment.

(2) Removal and rewrapping of wire-wrap connections.

5.2.7 Assembly

(1) Assembly of the printed wiring board.

(2) Installation of the printed wiring board.

(3) Installation of front connectors (J2, J3, and J4).

(4) Assembly and installation of bracket assembly A13.

(5) Installation of connector J1.

(6) Installation of assemblies A1, A2, A3, A5 thru A8, and power supply A11.

(7) Installation of the covers.

(8) Installation of the handle.

New Words/ Phrases/ Expression

1. dual channel 双通道
2. FCC 飞控计算机(Flight Control Computer 的缩写)
3. package [ˈpækidʒ] *vt.* 打包;将……包装
4. modular [ˈmɔdjʊlə] *adj.* 模块化的

5. MCU　模块控制单元(Modular Control Unit 的缩写)
6. chassis [ˈʃæsi] *n.* 底盘,底架;机架
7. Aeronautical Radio Inc. 航空无线电通信公司
8. plug-in [ˈplʌgoˈin] *n.* 插件
9. CCA　电路板组件(Circuit Card Assemblies 的缩写)
10. avionics rack 电子设备架
11. Card slots 卡插槽
12. analog [ˈænəlɔgʒ] *adj.* 模拟的
13. digital [ˈdidʒitl] *adj.* 数字的
14. FMA　飞行状态指示器(Flight Mode Annunciator 的缩写)
15. FMCS　飞行管理计算机系统(Flight Management Computer System 的缩写)
16. DFCS　数字飞控系统(Digital Flight Control System 的缩写)
17. MCP　模式控制面板(Mode Control Panel 的缩写)

Notes

【1】National Aircraft Standards (NAS) 622 hold-down hooks provide front support to the FCC and the ARINC 600 style unit connector (J1) provides rear support.

分析:ARINC 标准规范用于定义航空电子设备的物理包装和装配,数字通信标准和计算机高级语言。

Exercises

Ⅰ. Translate the following sentences into Chinese:

1. The major components of the system are two FCC and a Mode Control Panel (MCP). The MCP provides inputs to both FCC's for engagement, mode selection, and pilot assisted controls of certain modes.

2. The FCC is a line replaceable, dual channel, microprocessor-based digital computer (see Figure 5.1-1). The FCC is packaged in a size 6, modular control unit (MCU) chassis that conforms with the dimensional, mounting, and cooling requirements of Aeronautical Radio, Inc. (ARINC) specification 600-7.

3. The FCC is mounted directly on theairplane avionics rack and does not require the use of vibration or shock attenuating mounts.

4. The three inputs to the power supply are airplane +28 V DC, airplane 115 V AC, and airplane battery power. Normally, internal FCC +5V DC and +15/−15V DC are generated from the +28 V DC through power converters.

5. Checks of the FCC tell the condition of its physical, mechanical, and electrical properties. These properties are compared to established standards. Visual checks make sure the parts of the FCC are serviceable and show no signs of wear, damage, or possible failure.

Ⅱ. Fill in the following blanks according to the text:

1. The major components of the system DFCS are ________ and ________.

2. The chassis holds ________ plug-in circuit ________ , ________ supply, and ________ , which are all shop replaceable.

3. The front panel of the FCC contains ________ , ________ , ________ , and ________ .

4. In-line monitoring in the main processor (CPU1) includes ________ and ________ , ________ monitoring, ________ monitoring, ________ monitoring, ________ monitoring, monitoring, ________ monitoring, ________ monitoring, ________ monitoring, ________ monitoring, and ________ monitoring.

5. The major components of the system are ________ and ________ .

Ⅲ. Answer the following questions:

1. What is the primary function of the DFCS?

2. What is the primary function of the FCC?

5.3 Solid-State Flight Data Recorder

The primary purpose of the flight data recorder system (FDRS) is to monitor the airplane's functional parameters and to process and store the data in a crash protected module. The FDRS provides airlines and government agencies with a record of flight parameters. These parameters provide data to flight conditions and airplane systems operation, used for analyzing system performance during airplane maintenance or for tracing the cause of an airplane crash.

The flight data recorder system consists of a flight data recorder, a digital flight data acquisition unit (DFDAU), a three axis accelerometer, an aircraft I. D., shorting plug, and a flight recorder module.

Analog, discrete, and digital signals from various transducers and systems are applied to the DFDAU. The DFDAU processes digital, discrete, and analog signals and provides outputs to the flight recorder. The flight recorder has the capacity to store the last 25 hours of flight data.

The FDRS operates an engine start, while the engine is running, during a test or when the airplane is in the air.

There are three means of storing flight parameters: wire, magnetic tapes, and solid state memory. Wire used to be used on early airplanes, while solid-tapes, and solid-state memory is used on more recent airplanes.

5.3.1 Description

The SSFDR is a crash survivable flight data recorder. The unit eliminates moving parts and uses solid-state flash memory as the crash survivable memory unit (CSMU) recording medium. The unit stores up to 25 hours of aircraft parameters in the crash survivable memory module, which is painted orange with some letters. Once 25 hours of data has been stored, the system begins to overwrite the oldest memory locations, so that a continual 25 hour data stream is kept. It is possible to get a storage duration of greater than 25 hours if the correct combination of SSFDR capacity and data rate are employed.

The SSFDR has a variety of configurations to accommodate various customer demands. The options include input power source, form factor size underwater locator (ULB) installation, memory module size, and on-board maintenance system(OMS) interface. The CSMU capacity allows for the last 25 hours of flight data to be stored at an input data rate of 64 wps* or optionally at 128 wps or at 256 wps.

Refer to Figure 5.3-1 for the leading particulars.

Characteristic	Specification
Size	1/2 ATR long or short form factor
Length: · Short with beacon · Long with beacon	 358.1mm (14.10 inches)MAX 535.9mm (21.10 inches)MAX
Width	124.7mm (4.91 inches)MAX
Height	158.7mm (6.25 inches)MAX
Wight: · SN 4999 and below · SN 5000 and on	 8.2kg (18.00 pounds) MAX 6.8kg (15.00 pounds) MAX
Finish	International orange
Mounting	Standard ARINC 404 hard mount tray
Cooling	Ambient air
Power requirements	115 V AC,440Hz,single-phase power
Dissipation	15 W MAX
Mating aircraft connector	DPX2-37065-12,ITT Cannon mates with DPX2MA57S00S33-001

Figure 5.3-1 Leading particulars

Refer to Figure 5.3-2 for the SSFDR.

Refer to Figure 5.3-3 for the SSFDR block diagram.

The function of the SSFDR is to receive aircraft parameter data from a digital flight data acquisition unit (DFDAU) and store the data for future retrieval purposes (see Figure 5.3-4). Mandatory and non-mandatory aircraft parameters input to the DFDAU are serially transmitted to the SSFDR. The SSFDR processes the data and appropriately stores the information in the CSMU. When needed, access to the stored information can be accomplished with ground based equipment (GBE) utilizing the SSFDR's RS422 interface. Optionally, on units with an OMS interface, access to the stored data may be accomplished with a portable data loader(PDL) or airborne data loader(ADL). An internal BITE system is

* wps: word per second.

also provided with the SSFDR.

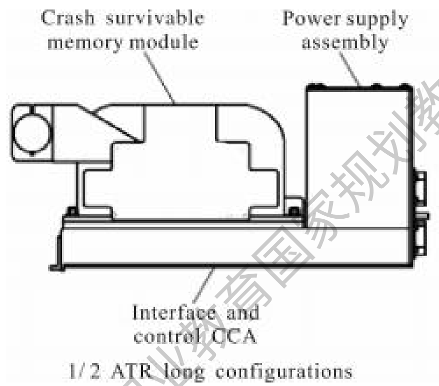


Figure 5.3－2　SSFDR

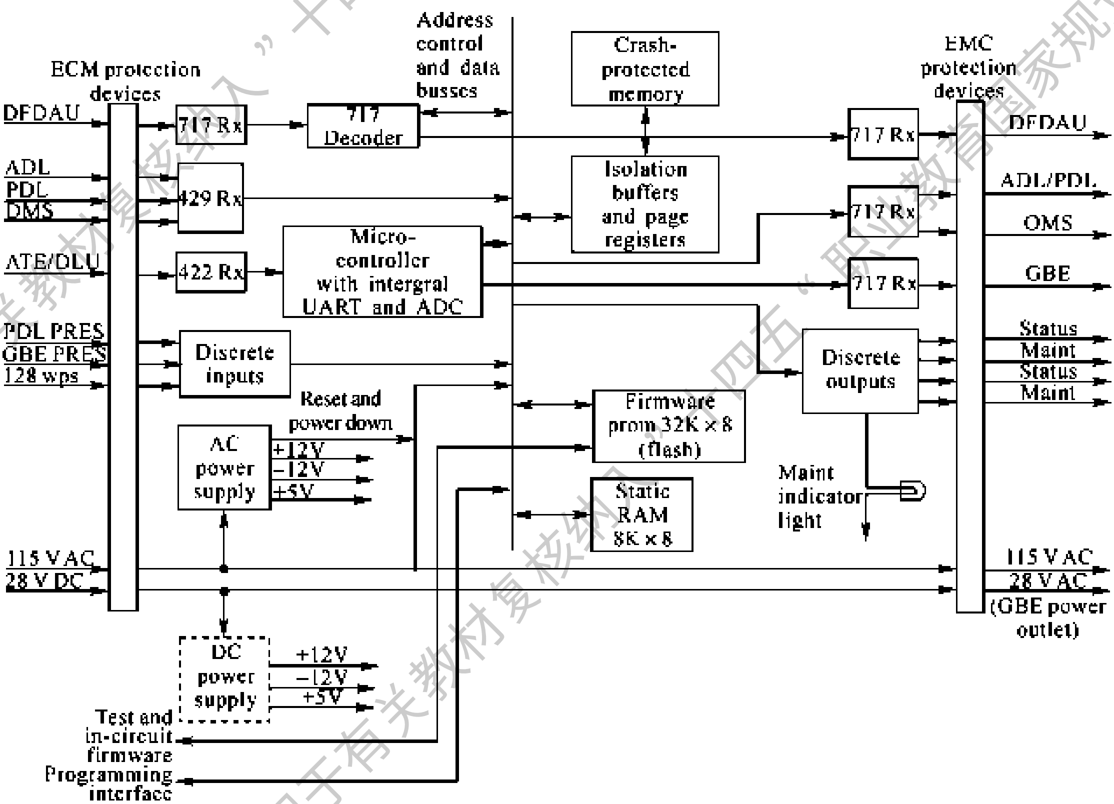


Figure 5.3－3　SSFDR block diagram

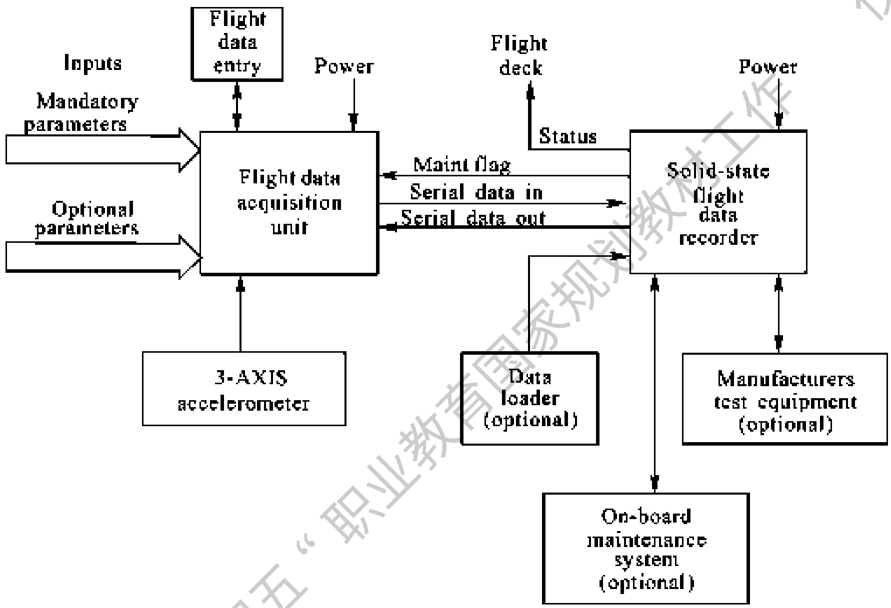


Figure 5.3 - 4 SSFDR/DFDAU interface diagram

The major components of the SSFDR are as follow:

- CCA;
- Controller A1;
- Power supply regulator A2;
- Power supply filter A3;
- Memory.

These CCAs are interfaced with each other or external devices through the J1 to J8 connectors. The interconnection schematic for the SSFDR illustrates connections between the CCAs and also the external box connections.

The PN 722 - 4005 device is the controller CCA. This CCA does the main control functions and has an 80C198 microcontroller. This CCA controls the reception and transmission of all aircraft parameter data. Data inputs flow through the controller CCA and then on to the CSMU.

The PN 722 - 4006 and PN 722 - 4021 functional blocks make up the power supply. This device takes the 115 - V AC input from the rear connector through the controller CCA, then filters and regulates the power to the needed voltages for other SSFDR circuitry. The power supply also has some supervisory circuitry to monitor the integrity of the input and output power parameters.

The memory module is comprised of solid state memory devices that use FLASH memory technology. A memory module that can store 25 hours of data at 64 wps is identified as a "1X" (one times) unit, at 128 wps as "2X" unit, and at 256 wps as "4X" unit. An alternate connector (header) is supplied on the memory card to access the stored data in the event that the primary connector is destroyed in a crash. Additional characteristics of the memory module are identified in the paragraphs below.

The SSFDR memory can store the latest 25 hours of FDAU data received at a rate of either a 64 wps, 128 wps, or 256 wps. Once 25 hours of data has been stored, the system begins to overwrite the oldest memory locations, so that a continual 25 hour data stream is kept. It is possible to get a storage duration of greater than 25 hours if the correct combination of SSFDR capacity and data rate are employed.

The J1 GBE connector is an SSFDR external connector. This connector projects through the front panel of the SSFDR. This connector is used to download data from the SSFDR to ground based equipment.

The connector can also be used to mate a DSDU to calibrate transducers on the aircraft. The J1 GBE input is checked during SSFDR testing to verify the connector integrity. In a test procedure, both connectors J8 and J1 are interfaced to the test equipment. During flight, the J1 front connector is not connected.

The J2 connector is normally not utilized. Its function was designed to permit programming of the U3 firmware PROM on the controller CCA. Currently, the firmware PROM is programmed before assembly on the controller CCA. If the PROM ever needed an update, the modification could be done through the J2 connector. This would not occur on aircraft but at production level. Opening the bottom of the box accesses this connector.

Another function of the J2 connector is to permit monitoring of SSFDR activity. The address bus, data bus, read/write control signals, and other signals are present to permit monitoring of SSFDR operations with any piece of test equipment such as a logic analyzer. Currently, there is no testing done through the J2 connector. The connector test functions were designed for future use.

The J3 connector is the memory CCA interface. Data storage and retrieval occur through this connector.

The J4 connector supplies a power supply interface. All SSFDR power is regulated through this connector.

Connector J5 interfaces with the J8 connector and has identical signal descriptions.

Connector J6 interfaces with the J4 connector and has identical signal descriptions.

The J8 connector is the rear aircraft interface ARINC connector. This is the only SSFDR connector mated when installed in the aircraft. This connector is comprised of 57 pins and is located on the rear of the SSFDR. Only the lower shell of the connector is used in this design.

System modes and states are as follow:

1. Power Off

The power off state is achieved when the input power has been removed from the SSFDR for more than 200 ms. No functions are available. This state can only be exited when the input power is applied.

2. Initialization Mode

(1) The initialization mode is achieved immediately upon application of primary power, or when actuated by command. The SSFDR initializes and does a BIT (built-in test) within 500 ms of the application of power. When initializing, the system detects unit configuration (memory size, rate of transfer, and address of next available memory location to be recorded).

(2) If the self-test fails, the external BITE light (located on SSFDR front panel) is illuminated, but the SSFDR still attempts to record data. If it is not possible to record data due to a critical failure (example: CSMU register failure), the recorder exits this mode of operation with a flag set that instructs the continuous monitor to inhibit recording.

3. Continuous Monitor Mode

The SSFDR does continuous background tests (non-destructive) on the system hardware to make sure that the recorder is can do the intended function. While in this mode the SSFDR continues to monitor the input ARINC 717 data stream. If the data is no longer present or the data rate has changed, an entry is made into the BIT table.

4. Data Communication States

The active communication state defaults to the record mode after the initialization and self-test mode (in 500 ms of application of power). The record mode is used to interface with the devices that follow:

- Download mode with HHDLU (RS-422);
- FDAU (through ARINC 717);
- RPGSE.

5. Monitor Mode (RS-422)

Monitor mode is supplied primarily for aircraft installation diagnostics and troubleshooting. In this mode, normal flight recording occurs in parallel with the RS-422 communications. The recorder only enters this mode when commanded by the GBE.

While in the monitor mode, the GBE either commands the SSFDR to output a data frame (once each second) that has the status of the recorder or to output the ARINC 717 data.

6. Test Mode (RS-422)

Test mode is primarily supplied for initial acceptance tests and subsequent return to service tests of the SSFDR. The recorder only enters this mode when commanded by the ATU or RPGSE.

7. Download Mode (RS-422)

The SSFDR enters this mode when the HHDLU or RPGSE initiates the commands to begin a download of the recorders memory contents. Both the commands to control the download and the actual transfer occur over the RS-422 interface.

8. Power Down Mode

The SSFDR power supply maintains internal voltages to continue normal operation in a power failure of less than 200 ms. For interruptions greater than 10 to 20 ms (approximate time for a power down interrupt from the power supply), the recorder enters the power down mode.

5.3.2 Operation

The system operations are managed by a local microprocessor (80C198). The microprocessor supplies the logical processing and data flow needed to do all system functions. For the data recording and download process, there is an undetected transmission error rate of less than one error in every 10^6 bits.

An ARINC 573/717 hardware interface is supplied to accept serial Harvard Bi-phase data at a rate of 64, 128, or 256, 12 bit words each second from the flight data acquisition unit. Pins 17 and 18 on the rear connector are used to select the data transfer rate. A continuous data stream is received, with each word immediately transmitted after its predecessor.

Flight data is received from the ARINC 717 transceiver one byte at a time, converted to a TTL level signal and stored in buffer. Eight times each second the buffered data is written to the CSMU. The SSFDR records the data as it is received, and does not attempt to synchronize to the input data stream. The time delay between data availability at the input port and storage of the data must not exceed 0.5 second.

If the ARINC 717 data stream is interrupted, recording is halted. The partial buffer, if any, is recorded at the normal 125 ms interval. The ARINC 717 data lines are then monitore for the return of data. If data does not resume in 5 seconds, a full frame (384 or 768 bytes, depending on installation configuration) of zeros is recorded to the CSMU as a marker. The status discrete is asserted. If the data stream returns, normal recording resumes. The status discrete is reset in 1 second of the return of data.

Memory chip failure in normal recording is tolerated (failed locations or blocks are identified and mapped out) until the total memory capacity falls below 25 hours of flight data. Both the maintenance and status flags are asserted when the 25 hour threshold is crossed. The SSFDR continues to record data until power is turned off.

The input data is recorded as it is received and is not aligned or processed in any way.

No data compression is needed to store the entire 25 hours of data in the CSMU. The input sync words are recorded, but are not detected or given any significance. The ground readout station must assemble the data into frames/subframes before display and analyzing the data.

5.3.3 Testing and Fault Isolation

Use the test procedures in this section to test and isolate faults. The function of the test procedures is to find if there is a failure in the operation of the SSFDR. Do not drop or hit the solid state flight data recorder during these procedures. The solid state flight data recorder contains an assembly that can be damaged from incorrect use. Do these procedures in a clean environment to prevent damage to mechanical components.

(1) Isolation/continuity checking;

(2) UUT preparation;

(3) PC initialization;

(4) Automated acceptance test procedure;

(5) Automated acceptance tests;

(6) Test results;

(7) Power-down and disconnect;

(8) Underwater locating device test.

Every ULD is operated in water under essentially free field conditions and a data sheet is issued by the vendor to show the serial number and pertinent data for each unit.

Due to lack of proper test facility and equipment for underwater testing, the following test is to be performed during incoming inspection, installation to the recorder, before shipment of ULD by itself and after changing the battery.

Results of the tests with the ULD operating in air will usually be in only approximate agreement with the values shown on the individual Dukane datasheet since the latter values were obtained with the ULD operating in water under conditions approaching free field operation. In air, the pulse duration will be longer and the pulse repetition rate slower than in water. If normal operation does not occur after installation of a new battery, ULD should be returned to vendor for examination.

To fault isolate a SSFDR, do the test procedure. If the test procedure can be completed from start to finish without failure, the SSFDR can be returned to service. During the test procedure, error messages (generated from test equipment software) or BITE faults (generated from internal SSFDR software) can appear on the CRT screen. Possible suspect components have been supplied for each of the BITE faults and test procedure error messages. Check and or replace the suspect components as necessary.

5.3.4　Disassembly

Use these procedures to remove parts from the SSFDR to do the cleaning, checks, and repair. only those procedures of disassembly that are necessary to remove the defective parts.

The item numbers shown in the DPL are the same as the item numbers on the exploded view illustration(s). To find a part number, find the part on the illustration and note the item number.

Find the item number in the parts list and read the correct part number.

Before disassembly, use Testing and Fault Isolation to examine the condition of the unit or to find the malfunction. Do this to prevent disassembly that is not necessary. If applicable, as an aid for assembly, tag the items that are disconnected to show where the connections were made. Include data for special conditions of a connection such as the polarity and the position of the items. If applicable, identify the tie points for the wire assembly to prevent damage to the wire insulation during assembly.

(1) Disassembly of the SSFDR chassis assembly;

(2) Disassembly of the power supply assembly;

(3) Disassembly of the power supply cable assembly W1;

(4) Disassembly of the controller CCA A1;

(5) Disassembly of the power supply cable assembly W2;

(6) Disassembly of the regulator power supply CCA A2;

(7) Disassembly of the capacitor power supply CCA A3;

(8) Disassembly of the AC/DC power supply CCA;

(9) Job close-up.

5.3.5 Cleaning

Use these procedures to remove dust, dirt, and unwanted oil and grease. Be careful not to cause damage to the parts when you do these procedures. Do the procedures in a clean location.

When you use pressurized air to clean assemblies and parts, do not use more air pressure than is necessary. After you clean the assemblies and parts, supply protection from moisture, dust, and other contamination until you do a visual check and assemble the component. Use the standard repair procedures and approved local shop procedures.

1. External Parts

(1) Remove dirt and dust with pressurized air or a soft-bristle brush.

(2) Remove oil and grease that has collected on the SSFDR. Use a clean cloth or cotton swab that is moist with isopropanol.

(3) Remove unwanted material on painted surfaces that show index marks, numerals, or letters. Use a clean cloth that is moist with a weak detergent.

(4) To clean an area in a recess, use a stiff-bristle brush that is moist with a weak detergent.

2. Electrical Parts

(1) Remove dirt and dust around the connector pins with ionized, pressurized air.

(2) Remove dirt and dust on the electrical parts with a soft-bristle brush or cotton swab that is moist with isopropanol.

3. Metal Mechanical Parts

(1) Remove corrosion from the metal parts with a 4/0 crocus cloth.

(2) Use isopropanol to clean the metal parts.

(3) Dry the part with pressurized air.

4. Miscellaneous Metal Parts

(1) Wash metal parts, such as mounting plates, mounting clamps, brackets, heat sinks, and attaching hardware in a suitable cleaning machine or in isopropanol to remove all accumulated dirt and dust.

(2) Dry the part with pressurized air.

5. Nonmetallic Parts (Excluding Static Sensitive Components)

(1) Clean all surfaces with a soft-bristle brush and pressurized air.

(2) Wipe clean with a lint-free cloth that is moist with a suitable solvent.

(3) Dry the part with pressurized air.

6. PWBs

(1) Make sure the PWB circuits are grounded.

(2) Remove dirt and dust with pressurized air.

Note: If wiring and cables are disturbed, restore them in their correct positions after cleaning.

(3) Use isopropanol to clean all of the solder joints.

7. Connectors

(1) Remove dirt and dust from the bodies, shells, and cable clamps with a cloth that is moist with isopropanol.

(2) Dry the part with a clean, dry, lint-free cloth.

(3) Clean inserts with a small, soft-bristle brush and pressurized air.

(4) Remove dirt and any traces of lubricant from inserts, insulation, and contacts with a small, soft-bristle brush that is moist with isopropanol.

(5) Dry the part with pressurized air.

8. Job Close-Up

Remove all tools, equipment, used parts, and materials from the work area.

5.3.6 Check

Use these procedures to find damage or worn parts and parts that show signs of near failure.

Repair or replace all damaged or worn parts. This prevents possible failures of the equipment.

1. General Inspection/Check Procedure of the SSFDR

(1) Visually check all parts for breaks, cracks, corrosion, foreign matter, nicks, scratches, and obvious wear. Use adequate light and moderate magnification.

(2) Check springs for distortion, fatigue, permanent set, position, and correct tension.

(3) Check decals, identification plates, and labels for legibility.

(4) Check cables and wires for broken strands, poor connections, and short circuits.

(5) Check flexible cables for exposed or cracked conductors.

(6) Check insulation/sleeving for broken, burned, and worn areas.

(7) Check connectors for bent, corroded, or loose pins, and loose conductive material

between pins.

(8) Check printed wiring boards for deterioration, overheating, physical damage, short circuits, and small cracks (opens) in circuit traces.

2. Detailed Inspection/Check Procedure of the SSFDR

(1) Remove 12 or 14 screws and bottom cover.

(2) Set the DMM to read ohms.

(3) Connect the DMM between A1J2－47 (controller CCA test and program connector) and J8－18(SSFDR rear connector).

(4) The resistance is 20 kΩ $\leqslant R \leqslant$ 25 kΩ.

3. Dimensional Inspection/Check Procedure of the SSFDR

4. Job Close-Up

Remove all tools, equipment, used parts, and materials from the work area.

5.3.7 Repair

Use these procedures for the SSFDR to replace defective parts and replace or repair defective subassemblies. Do only those procedures of DISASSEMBLY (PGBLK 31-30-40-3000) that are necessary to make repairs. When new parts are necessary, refer to the Illustrated Parts List for the correct part numbers and quantities.

New Words/ Phrases/ Expression

1. monitor ['mɔnitə] *vt.* 监控
2. FDRS　飞行数据记录系统(Flight Data Recorder System 的缩写)
3. module ['mɔdjuːl] *n.* [计] 模块;组件;模数
4. accelerometer [əkˌseləˈrɔmitə] *n.* 加速度计
5. CSMU　碰撞可存活存储单元(Crash Survivable Memory Unit 的缩写)
6. ULB　水下定位器(Underwater Locator Beacon 的缩写)
7. OMS　机载维护系统(On Board Maintenance System 的缩写)
8. GBE　地面设备(Ground Based Equipment 的缩写)
9. PDL　便携式数据加载器(Portable Data Loader 的缩写)
10. ADL　机载数据加载器(Airborne Data Loader 的缩写)
11. DFDAU　数字飞行数据收集单元(Digital Flight Data Acquisition Unit 的缩写)
12. acquisition [ˌækwiˈziʃən] *n.* 获得,采集
13. solid-state memory 固态存储器
14. magnetic tape 磁带

Exercises

Ⅰ. Translate the following sentences into Chinese:

1. The primary purpose of the flight data recorder system (FDRS) is to monitor the

airplane's functional parameters and to process and store the data in a crash protected module. The FDRS provides airlines and government agencies with a record of flight parameters. These parameters provide data to flight conditions and airplane systems operation, used for analyzing system performance during airplane maintenance or for tacing the cause of an airplane crash.

2. The flight data recorder system consists of a flight data recorder, a digital flight data acquisition unit(DFDAU), a three axis accelerometer, an aircraft I. D, shorting plug, and a flight recorder module.

Ⅱ. Fill in the following blanks according to the text:

1. The DFDAU processes ________, ________, and ________ and provides outputs to the ________. The flight recorder has the capacity to store ________ hours of flight data.

2. There are three means of storing flight parameters: __________, __________, and ________.

3. The SSFDR has a variety of configurations to accommodate various customer demands. The options ________, form factor size ________ installation, ________, and ________ interface. The CSMU capacity allows for the ________ of flight data to be stored at an input data rate of ________ or optionally at ________ or at ________.

5.4　HF Antenna Coupler

The high frequency communication system is used for long range air-to-ground and air-to-air voice communications in the high frequency band. The system is used primarily for air traffic control, but is going to be used as the high frequency data link for ACARS. In sparsely populated areas, and particularly, in transoceanic flights, the HF SSB radio will be the only available communications today.

The system uses direct (ground) waves for short distance, but relies on refraction in an ionized layer and the earth's surface to achieve long range "sky wave" transmission by single or multiple "bounces".

Therefore, successful operation may depend upon correct frequency selection for the time of day.

The high frequency communications system can be operated in amplitude modulation (AM) mode or single side band(SSB) mode, but in civil aviation, usually the upper side band (USB) is used.

An HF communications system consists of a control panel, a transceiver, an antenna coupler and an antenna.

1. Control Panel

The control panel provides remote control of the HF communications system. Power on/off, frequency and mode selection, and RF sensitivity are controlled from the control panel.

2. Transceiver

The HF transceiver is used to communicate in the high-frequency band on either SSB or AM mode of operation.

3. Antenna Coupler

Antenna couplers provide impedance matching between their respective transceivers and the antenna over the entire HF spectrum. The dual coupler configuration allows two transceivers to share a single antenna.

4. Antenna

The purpose of the antenna is to radiate RF signals from the transmitter and to intercept RF signals for the receiver.

The antenna is a shunt (slot) type, approximately 8 feet long. Its frequency range is approximately 2.8 to 24 MHz, and the radiation pattern is essentially omni-directional. The antenna is physically an integral part of the vertical stabilizer leading edge.

The antenna leading-edge section is joined to the vertical stabilizer by screws along the perimeter of the section. The couplers are mounted inside the vertical stabilizer aft of and adjacent to the auxiliary spar, with the rack antenna connectors protruding through the spar into the antenna section. Access to the couplers is through an aluminum honeycomb panel in the left side of the fin. normally held in place by 75 screws. The screws require standard torquing.

Connection between the couplers and the antenna is by a rigid, high-current tubing lead-in which is bolted to the coupler rack RF connectors. The branched lead-in is bolted to the flange antenna connection, which is accessible through a small screw held aluminum cover require standard torquing.

The RF coax cable and the power and control wiring are routed out of the coupler compartment, down to the base of the fin, forward through the pressure dome, and forward to the equipment center and the transceivers.

5.4.1 Description and Operation

The HF antenna coupler automatically matches the 50-ohm coaxial output impedance of the HF transceiver to an aircraft notch or shunt antenna from 2 to 30 MHz.

The coupler contains the necessary switching and interlocking circuitry for use in either a single or dual system installation. The mounts provide interface with the aircraft antenna. The CPL interfaces with ARINC 719 and ARINC 753 installations with no wiring changes required. The CPL provides significant system advantages such as fast tuning. In addition, quick tune allows the coupler to tune in fractions of a second to a previously tuned-to frequency, instead of several seconds. In the data mode, this helps to avoid interference to other aircraft and enhancing overall data link system performance.

Refer to Figure 5.4-1 for an overall view of the HF antenna coupler. The coupler mount provides interface between dual HF antenna couplers and the antenna (see Figure 5.4－2).

Figure 5.4－3 lists the CPL specifications.

The CPL consists of circuit cards and assemblies housed in a chassis A1 assembly. Control interconnect to the HF transceiver is through a MIL-C-26482 circular connector(J1) size 16, 26 pins mounted on the front panel. The contacts are soldered into input/output filter A1A1.

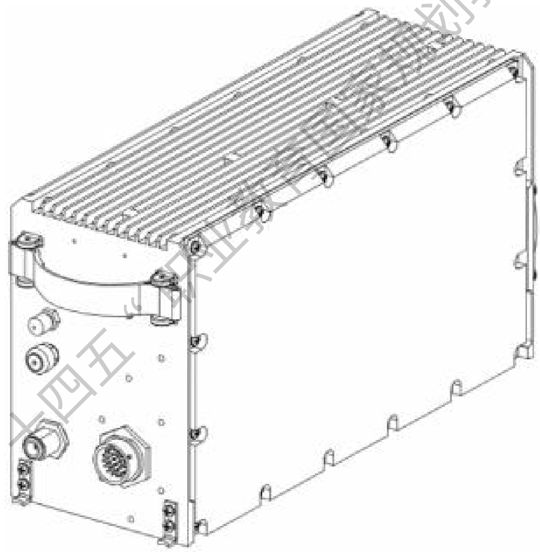


Figure 5.4－1 HF antenna coupler

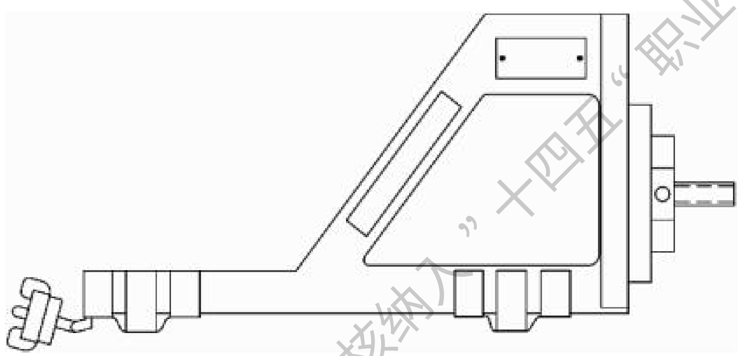


Figure 5.4－2 Dual antenna coupler mount

Input/output filter A1A1 provides interconnect for the distribution of power, digital bus, and discrete information to the input transformer and control circuit card A4. The input/output filter A1A1 contains HIRF/lightning protection for the unit. A removable right-side panel provides access to the A1, A6, A3, and A5 that are mounted in the chassis A1 cavity. Mounted on the right-side panel is the A4 card interconnected by two ribbon cables and two wire cables. Removal of the left-side panel provides access to the A2 assembly mounted within chassis A1 (see Figure 5.4－4).

The front panel also contains RF interconnect to the HF transceiver by J2 type-N connector. A pneumatic tank valve provides inert gas fill/empty capability and pressure relief is provided by a relief valve. Cooling is by normal convection airflow aided by cooling fins on the top surface of the coupler.

CHARACTERISTIC	SPECIFICATION
RF Duty Cycle (Maximum)	Continuous transmit at nominal RF input power (125 watts average)
RF Power Input (Maximum)	Operate: 125 watts average +1.0 dB (157 watts) and 400 watts PEP +1.0 dB (504 watts) Tune: 50 to 85 watts average
Tuning Time	Initial: 2 to 4 s typical, 7 s maximum Quick tune (ARINC 719): 1000 ms typical Quick tune (ARINC 753): 200 ms maximum Nonvolatile memory stores 100 previously tuned frequencies
ARINC 719 Interface	Upon being commanded to tune, the coupler measures and determines the transmitter RF frequency of operation. If the frequency matches a frequency that has previously been learned and stored in memory as a quick tune and quick tunes are enabled, the antenna coupler positions its tuning elements from the stored information for optimum impedance match to the antenna. The VSWR of the tune is then checked using a burst of RF from the transceiver. If the tune VSWR is within limits, the system will go into the operate mode. If the tune VSWR is greater than the limits, a complete tune cycle is initiated and the subsequent tuning element values are stored as quick tune information for that frequency.
ARINC 753 Interface	Once a specific frequency has been learned and stored in memory as a quick tune, the coupler will, upon being commanded to tune, position its tuning elements from the stored information for optimum impedance match to the antenna if quick tunes are enabled. Operating frequency information is supplied by the R/T via the serial bus connection. The VSWR of the tune is then checked using a burst of RF from the transceiver. If the tune VSWR is within the limits, the system will go into the operate mode. If the tune VSWR is greater than the limits, a complete tune cycle is initiated and the subsequent tuning element values are stored as quick tune information for that frequency.
Tuning Accuracy	1.3:1 VSWR maximum
Antenna Impedance (Tuning Range)	The coupler will tune the 172H-18 General Shunt Antenna Simulator (CPN 622-0180-001) across the 2-to 30-MHz frequency range.
	The coupler will tune a 50-ohm load across the 2-to 30-MHz frequency range.
Transition Times	
Receive-To-Transmit	75 ms maximum when operating with the ARINC 719 or ARINC 753 system interface. This time includes a PTT key closure debounce time of 10 ms.
Transmit-To-Receive	30 ms maximum when operating with the ARINC 719 or ARINC 753 system interface. This time includes a PTT key release debounce time of 10 ms.
System Operation	The antenna coupler operates in both single and dual applications where one or two HF systems are connected to one aircraft antenna. All required dual system antenna arbitration switching will be contained in the antenna coupler.

(a)

Figure 5.4-3 Equipment specifications

Dual System Operation	The antenna coupler contains interlocking circuitry designed to insure satisfactory automatic tune-up and transmission when two HF systems are connected to the same antenna. This interlock circuitry prevents one system from being tuned or operated while the other system is either tuning or keyed. A fault is generated in case of a malfunction of the interlock circuits. When one unit is physically removed from the system or its power removed, the interlock circuitry will not prevent normal operation of the remaining system. This is the default-operating mode of the coupler. This mode is selected upon initialization if there is not an electrical ground on pin J1-b, (RCV THRU TUNER). When a rechannel pulse is received or the operating frequency is changed (depending on the system interface used), the coupler detunes the RF tuning network and disables RF from the transceiver.
Receive	When commanded to enter receive, the coupler switches the RF signal to bypass the RF tuning network. When in receive, the other system uses the antenna for receive. The coupler will disconnect from the antenna within 55 ms when the other system requests the antenna.
Transmit	When commanded to enter transmit (keyed), the coupler arbitrates for the antenna and then either initiates a tune if the RF tuning network is currently not tuned, or switches the RF tuning network into the RF signal path if the network is currently tuned. The coupler will wait a minimum of 55 ms after requesting the antenna and before RF is enabled.
System Interface Connections	The antenna coupler is compatible with the 628T-2/2A, HFS-700, and HFS-900 transceivers using ARINC 719 parallel control lines and with the 628T-2D, HFS-700D, and HFS-900D transceivers using the system serial bus interface. The applicable interface is automatically detected using an interface determination circuit.
Single System Operation	This mode is not compatible with dual system operation. When this mode is active, the other system is prevented from using the antenna. This mode is selected upon initialization if there is an electrical ground on pin J1-b (RCV THRU TUNER). The dual system interlock circuits are monitored in this operating mode and a fault is generated in case of a malfunction of the interlock circuits. When a rechannel pulse is received or the frequency is changed (depending on the system interface used), the coupler detunes the RF tuning network and disables RF from the transceiver.
Receive	When commanded to enter receive, the coupler switches the RF signal to bypass the RF tuning network if the network is currently not tuned, or leaves the RF tuning network in the RF signal path if the network is currently tuned in single system only. The dual system never uses a tuned RF network for receive.
Transmit	When commanded to enter transmit (keyed), the coupler either initiates a tune operation if the RF tuning network is currently not tuned, or leaves the network in the RF signal path if the network is currently tuned.

(b)

Continued Figure 5.4-3 Equipment specifications

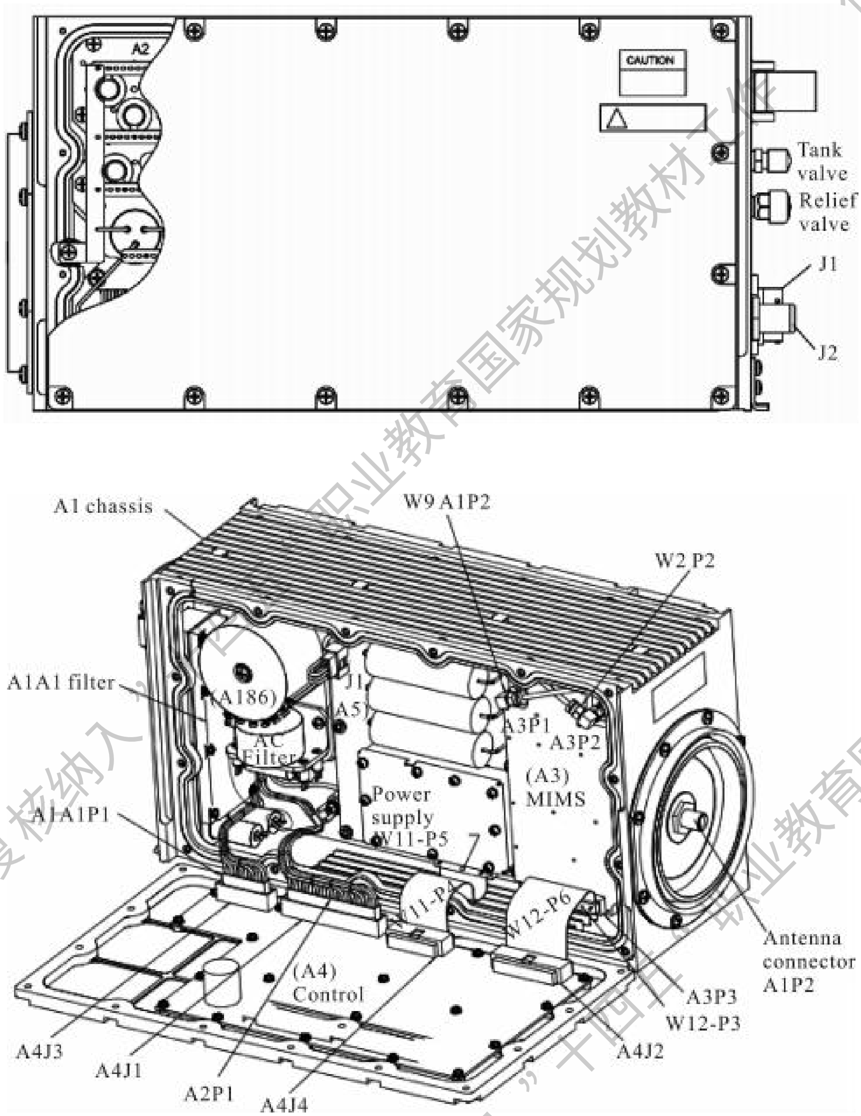


Figure 5.4 - 4 Location of major assemblies

Chassis A1 contains input/output filter A1A1 Radio Frequency Interference (RFI) filter on the front panel main input connector J1. The function of this module is to protect the internal electronics of the coupler from external noise and prevent internally generated noise from being conducted externally on the antenna coupler interface cable. Harmonic filter A1A6 provides filtering on the incoming power (115 V AC) and a step down transformer to reduce 115 to 28 V AC for use in power supply A5. Chassis A1 provides a sealed container to minimize high-voltage arcing. The front panel contains control interface connector J1 to the HF transceiver, RF input/output connector J2 to the HF transceiver, and the rear RF contact that interfaces with the antenna through the coupler mount.

The RF network A2 module contains the tuning elements (coils and capacitors) which are switched into the antenna circuit during transmit operation by RF vacuum relays in order to translate the antenna impedance to 50Ω. A 50Ω impedance match enables the power amplifier in the HF transceiver to accomplish maximum power transfer to the antenna. During receive, the antenna signal bypasses the tuning elements and feeds the signal directly to the HF transceiver by a switched relay. The RF network A2 contains a cable connection to control circuit card A4, a RF cable connection to MIMS/Sensor A3, and a rear RF contact that interfaces with the antenna through the coupler mount.

The MIMS/sensor circuit card A3 contains an impedance measuring system that provides resistance, phase and voltage standing-wave ratio (VSWR) information to the control circuit card A4 microprocessor. An analog-to-digital (A/D) converter provides information in a digital format to the microprocessor in order to make intelligent decisions and provide quick tuning solutions. The MIMS/sensor circuit card A3 contains ribbon connector interface to control circuit card A4 and RF connector interface to RF network A2 and front connector J2.

The control circuit card A4 contains a 386EX microcontroller that controls the CPL. The control circuit card A4 also contains RAM memory for temporary variable storage and interrupt vectors, EEPROM for nonvolatile memory, quick tune information, and coupler internal fault history. Flash memory is used for program memory storage and board level programming. It also provides serial communications for the coupler interface and frequency counter chips that facilitate the tuning algorithm. Parallel ports with associated buffer/drivers control the relays in the RF tuner. Control circuit card A4 connectors interface with MIMS/sensor circuit card A3, power supply A5, RF network A2, and input/output filter A1A1.

The power supply A5 operates on 115 V AC, 400 Hz from the HF transceiver. The 115 V AC is first filtered by harmonic filter A1A6. The chassis mounted A1A6 transformer converts 115 to 28 V AC. A5 then rectifies and filters the DC voltages. Voltage regulation is provided by the high efficiency switching power supply that provides +5 V DC, +15 V DC, −5 V DC, and −15 V DC to the other internal modules. Power supply A5 contains ribbon connector interface to control circuit card A4 and cable connection to harmonic filter A1A6.

The HF antenna coupler provides the proper impedance match between an aircraft shunt or notch antenna and the 50Ω impedance of the transmission line. The coupler operates for both transmit and receive with a VSWR of not more than 1.3∶1 throughout the specified frequency range. The coupler may be used in either a single or dual system.

The coupler dual system is capable of operation using a common antenna with two transceivers (see Figure 5.4 - 5). When both couplers are in a receive/untuned condition, neither one is tuned. In the system block diagram, system 2 series elements are shorted and the shunt elements are open so it is a direct connector from input to output. However, once a rechannel pulse is imposed both couplers become untuned.

In the case where system 1 wants to transmit, then system 1 clicks in the pretuned value for that frequency or it may be tuning, then system 2 series output relay opens and disconnects from the antenna. To achieve this, coupler 1 sends a disable signal to system 2. If either system is shut off, the normal state is for the series elements to be shorted, shunt elements open, and disconnected from the antenna. If primary power is lost or removed for any reason, the other side will operate normally as a single system.

If a single/simplex system is used, input line Rec Thru Tuner (J1－b) is grounded, and the coupler will receive tuned, if it is already tuned. Receiving through a tuned coupler is especially useful when weak or noisy signals are being received. The series and shunt elements actually are in the signal path in receive and transmit. If it is not tuned, for instance if a rechannel is received, then it would be in the bypass or not tuned mode.

Primary 115 V, 400 Hz power comes from the R/T along with parallel and serial control signals.

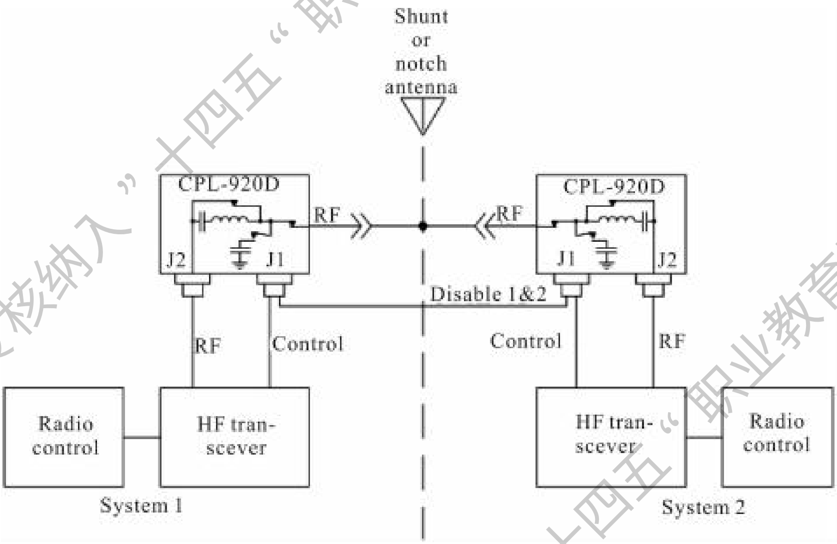


Figure 5.4－5　Typical dual system block diagram

5.4.2　Testing and Fault Isolation

The CPL requires 110 to 120 V AC, 390 to 410 Hz, single-phase power for test purposes. For testing purposes, power is provided by the test set.

You can use the UUT performance test as a customer acceptance test to find if the CPL operates correctly. Do the fault isolation test procedure to troubleshoot the UUT fully and to make sure that individual modules operate correctly.

You must do all of the test procedure/performance test to make sure that the UUT operates correctly. If the unit does not complete a test satisfactorily and there is a fault, refer to the troubleshooting procedures to find the defective circuit. If you must repair the unit, the technician must do the full test procedure/performance test (after the repair) to make sure that the unit operates correctly. The technician must know the test equipment used and know how to operate the equipment to get the correct inputs and results (indications). The technician must know how to operate the test equipment to do tests and do troubleshooting of the CPL.

5.4.3 Disassembly

Refer to the "Testing and Fault Isolation" section to find the condition or cause of malfunction. This can help to find the level of disassembly that is necessary.

(1) Right side cover removal.

(2) Left side cover removal.

(3) Control circuit card A4 removal.

(4) RF network assembly A2 removal.

(5) Power supply circuit card A5 removal.

(6) MIMS/sensor circuit card A3 removal.

(7) Chassis assembly A1 disassembly and filter assemblies removal.

5.4.4 Assembly

The order of assembly starts with the lowest subassembly or piece part (parts which require the most disassembly to reach) and proceeds to the complete module or equipment.

(1) Chassis assembly A1 assembly.

(2) RF network assembly A2 installation.

(3) Right side cover assembly and seal installation.

(4) Power supply circuit card A5 installation.

(5) MIMS/sensor circuit card A3 installation.

(6) Control circuit card A4 installation.

(7) Left side cover (with circuit card A4 mounted) and seal installation.

New Words/ Phrases/ Expression

1. coupler [ˈkʌplə] *n.* 耦合器

2. HF 高频(High Frequency 的缩写)

3. SSB 单边带(Single Side Band 的缩写)

4. ionized layer 电离层

5. refraction [riˈfrækʃən] *n.* 折射;折光

6. ACARS 飞机通信寻址与报告系统(Aircraft Communication Addressing and Reporting System 的缩写)

7. bounce [bauns] *v.* 反弹,跳,蹦

8. CPL 耦合器(coupler 的缩写)

Exercises

Ⅰ. Translate the following sentences into Chinese:

1. The system uses direct (ground) waves for short distance, but relies on refraction in an ionized layer and the earth's surface to achieve long range "sky wave" transmission by single or multiple "bounces".

2. Antenna couplers provide impedance matching between their respective transceivers and the antenna over the entire HF spectrum. The dual coupler configuration allows two transceivers to share a single antenna.

Ⅱ. Answer the following questions:

1. What is the high frequency communication system used for?
2. What kind of wave does this communication system use?
3. What is the purpose of antenna couplers?
4. What component parts does a HF communication system consist of?

5.5 VOR/ILS Navigation Receiver

In order to be able to land the airplane safely under poor visual conditions, we use the instrument landing system (ILS), which provides instrumentation to the pilot. By using this steering information, pilots will be able to make an accurate and safe descent and touchdown. Today the instrument landing system is always utilized in every landing process to make the pilot's job easier. For airplanes which have autolanding ability, the steering information by ILS is supplied to the AFCS(Auto Flight Control System) in order to guide the airplane to a safe descent and landing a long an ideal path.

Let's imagine that there are two planes within the airspace above the airport and its adjacent area. One is a localizer course plane, and the other is a glide path plane. The intersection of these two planes forms a line, which is the ideal descent path. Since the localizer course plane is perpendicular to the runway surface and contains the runway central line, landing along this path assures that the track of the landing airplane is aligned with the central line of the runway. In the same manner, this will keep the airplane at the predetermined glide slope angle, which is about three degrees.

In addition to heading information and a homing function, the landing systems must provide an indication of absolute altitude or control of the glide path of the aircraft. Altitude is controlled during relatively high-level flight with a sensitive altimeter, which provides altitude information through the process of atmospheric pressure measurement. Because the altimeter must be set with the sea-level atmospheric pressure to account for weather-related variations, and because of the basic design of the instrument, the accuracy of the sensitive aneroid altimeter is not sufficient to provide glide path control to very low altitudes. For poor visibility landings an instrument landing system consisting of both horizontal and vertical control is used. ILS consists of three basic components: a localizer for horizontal positioning, a glide slope for vertical glide path control, and beacons for homing and for position determination.

The localizer, which provides precision horizontal guidance for the approach, operates in the VHF spectrum on one of the 40 channels assigned to that service. A transmitter with about 100 W output power and with a horizontally polarized antenna radiates two beams having a combined beamwidth of about four degrees. One beam is amplitude-modulated with a 90 Hz sine wave, while the other beam is modulated with a 150 Hz sine wave. The antenna pattern is arranged so that when the aircraft is to the right of the approach centerline, mostly 150 Hz modulation is received. When the aircraft is to the left of the approach centerline, mostly 90 Hz modulation is received. When the aircraft is centered on the approach centerline, the amount of 90 and 150 Hz modulation received is equal.

The glide-slope system is the altitude-controlling part of the instrument landing system. The glide-slope transmitter is located to the side of the runway, about 1,000 ft from the touchdown end of the runway. The glide-slope system operates in the UHF portion of the radio spectrum on frequencies spanning from 329 to 335 MHz, using amplitude modulation. The operation of glide-slope is similar to the operation of the localizer: a directional antenna system transmits a signal with 90 Hz modulation above the desired glide path, and a signal with 150 Hz modulation is transmitted below the glide path.

The glide-slope frequencies are paired with the localizer frequencies. Thus, for an ILS system with a localizer, a DME, and a glide-slope system, there are three frequencies that form a group. The navigation receiver programs the glide-slope receiver and the DME can be separately programmed, there are no glide-slope receivers that can be individually programmed. Having a glide-slope receiver on one ILS frequency and a localizer on another ILS is very dangerous, and should be prevented.

5.5.1 Description and Operation

The 51RV is a solid-state, airborne navigation unit that combines the VOR, localizer, and glideslope functions. The dual-conversion 200-channel VOR/LOC (108 to 118 MHz with 50 kHz channel spacing) and 40-channel glideslope (329 to 335 MHz with 150 kHz channel spacing) receivers are remotely controlled by 2 out-of-5 binary control or by serial information transmitted in ternary broadcast form.

The 51RV has the capability of dual-instrumentation circuits with internal comparison and level monitoring; other options available are self-test functions, digital bearing output, added filtering of the basic bearing information, serial tuning, RMI servo amplifier, and heads up display driver capability. Refer to Figure 5.5 - 1 for an overall view.

The 51RV VOR/ILS navigation receiver receives VOR, localizer, and glideslope signals and provides outputs to operate deviation, flag, and to-from indicators, and to operate the VOR pointer of an RMI (radio magnetic indicator). The 51RV operating frequencies are

108.00 to 117.90 MHz for VOR/LOC and 329.15 to 335.00 MHz for glideslope.

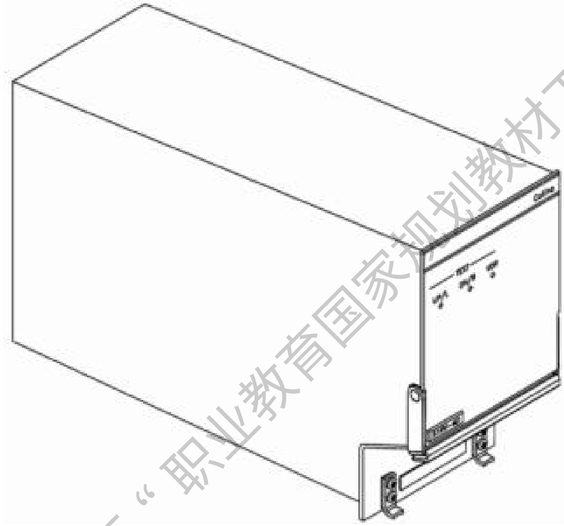


Figure 5.5-1　51RV VOR/ILS navigation receiver

When tuned to a VOR frequency, the 51RV operates with an external course indicator that provides a 400-Hz electrically zeroed course resolver. Outputs from the 51RV operate VOR deviation and to/from indicators, a VOR warning flag, a relative bearing indicator (RMI), and supply an aural output. The 51RV is capable of being tuned by 2 out-of-5 binary control or serial tune input. A digital VOR bearing word output provides for operations of digital instruments and systems.

When tuned to a localizer frequency, the corresponding glideslope frequency is automatically selected. The 51RV operates localizer and glideslope deviation indicators and ILS warning flags and also supplies an aural station identification output.

Figure 5.5-2 shows the equipment specifications for the 51RV VOR/ILS navigation receiver.

The 51RV is housed in an ARlNC 1/2-ATR short case with mounting facilities per ARINC 404 and 404A. Electrical connections are made through a dual DPX connector on the rear of the chassis. In addition, a 26-pin test connector is mounted on the rear of the chassis to provide access to additional outputs for testing and fault analysis. The mechanical construction of the 51RV is such that all electrical components are accessible with the dust cover removed. An aluminum wraparound chassis provides the mounting surfaces for the connectors, support for the two swing-out mounting frames, and a center mounting board. The center mounting board consists of a removable printed circuit board that supplies the mounting surface for the power supply, audio amplifier, and RMI driver circuits. The left swing-out mounting frame is a metal plate that supplies the support to mount the two receiver assemblies. The right swing-out mounting frame consists of a printed circuit interconnect board that supplies the interconnections between the boards mounted to it and the rest of the 51RV. An interconnect board, mounted parallel to the rear of the chassis, provides the interface between the DPX and test connector and the component mounting frames by means of ribbon cables and provides a mounting surface for a plug-on board. The unit is protected with a cover that has forced-air ARINC cooling holes.

CHARACTERISTIC	SPECIFICATION
Certification/Related documents	
ARINC characteristics, TSO	-547; C34c-Class D; C36c-Class D; C40a; DO-160 Environmental Category A2D2/A/JRN/XXXXXXAAAAA
RTCA papers	DO-69, DO-131, DO-132, DO-160, DO-195, DO-196
FCC rules and regulations	Part 15
Physical	
Size	ARINC 1/2-ATR short, with mounting per ARINC 404 or 404A
Height	199.11 mm (7.839 in) max
Width	128.27 mm (5.050 in) max
Length	415.24 mm (16.348 in) max including handle projection
Weight	51RV-4( ): 5.67 kg (12.5 lb) max 51RV-5( ): 5.81 kg (12.8 lb) max
Environmental characteristics	
Temperature	Storage: -55 to +85 °C (-67 to +185 °F) Continuous operation: -55 to +70 °C (-67 to +158 °F)
Humidity	DO-160 Category A
Altitude	-4572 to 15240 meters (-15000 to 50000 feet)
Vibration	
Shockmount	0.030 in da, 5 to 57 Hz; 5 g max, 57 to 350 Hz; 0.0008 in da, 350 to 500 Hz; 10 g max, 500 to 2000 Hz (Category R)
Rigid mount	0.10 in da, 5 to 17 Hz; 1.5 g max, 17 to 38 Hz; 0.20 in da, 38 to 54 Hz; 3 g max, 54 to 2000 Hz (combined Categories J and N)
Shock	6 g operating, 15 g crash safety (per DO-160)
Electrical Characteristics	
Power sources	+27.5 V dc +10%, -20%; 26 V ac +10%, -12.5%; 380 to 420 Hz

Figure 5.5 – 2 Equipment specifications

The 51RV provides omnibearing information (VOR) (electrical zeroed at 300 degrees) to the course indicator as well as SIN/COS omnibearing information to an RNAV computer and localizer and glideslope information for visual display and automatic flight control systems. The 51RV extracts the omnibearing and ILS information from the AM modulated received signals. The unit consists of digitally oriented VOR instrumentation and analog ILS instrumentation.

Functional circuits are separated by board construction allowing for fault isolation to a replaceable board. The type number and status of the 51RV are assigned by the complement of boards installed and the required settings of printed circuit board switches or, on units with SB 19, by use of jumper wires. The switch settings/jumper wires provide the logic controls to change the operating parameters of the 51RV.

There are three test push buttons on the front panel of the 51RV (see Figure 5.5-3).

CONTROL	DESCRIPTION
UP/L	Pushing the UP/L button performs a quick check of the ILS receiver system. The test causes the deviation bar to move to the left, the glideslope bar to move up, and both the VOR/LOC and GLIDESLOPE flags to go out of view.
DN/RT	Pushing the DN/RT button performs a quick check of the ILS receiver system. The test causes the deviation bar to move to the right, the glideslope bar to move down, and both the VOR/LOC and GLIDESLOPE flags to go out of view.
VOR	Pushing the VOR test button will perform a quick check of the VOR system if the NAV receiver is first tuned to a local VOR frequency. The OBS must also be set to 0 or 180 degree. The test will cause the deviation bar center and the RMI pointer to go to approximately 180 degrees. Depending on the status, the VOR/LOC flag on the course indicator may also come into view.

Figure 5.5-3　Front panel test indicators

51RV provides omnibearing information (VOR) (electrical zeroed at 300 degrees) to the course indicator as well as SIN/COS omnibearing information to an RNAV computer and localizer and glideslope information for visual display and automatic flight control systems. The 51RV extracts the omnibearing and ILS information from the AM modulated received signals. The unit consists of digitally oriented VOR instrumentation and analog ILS instrumentation.

5.5.2　Disassembly

Disassemble the 51RV only when necessary to do the repair on the 51RV. Do the test procedure in the Testing and Fault Isolation section of this manual to find the defective assembly. Disassemble the unit to get access to the defective assembly only. Usually, it is not necessary to disassemble all of the unit.

Use the standard tools listed in the subsequent paragraph to disassemble the unit. When necessary, refer to the special tools, fixtures, equipment, and consumables section for specifications of items used.

(1) Screwdrivers;

(2) Soldering iron.

All components of the 51RV mentioned in the disassembly procedure are identified by a figure and item number referenced to the IPL section. The applicable IPL figure and item numbers are shown in parenthesis following the component nomenclature. The figure number is given first, followed by a- and item number.

(1) Cover removal;

(2) Subassembly removal;

1) VOR/LOC receiver assembly A1 removal;

2) Glideslope receiver assembly A2 removal;

3) Circuit card removal;

4) RMI servo amplifier circuit card A12 or heads up display driver circuit card A26 removal;

5) Receiver interconnect circuit card A14 removal;

6) RMI/power supply/audio circuit card A3 removal.

5.5.3 Cleaning

No special instructions are necessary to clean this equipment.

5.5.4 Assembly

The following procedure provides instructions to assemble the subassemblies and circuit cards of the 51RV. Start the assembly process at the point where removal of subassemblies or circuit cards stopped. Assemble the necessary components to complete the unit.

1) VOR/LOC receiver assembly A1 assembly and replacement;

2) Glideslope receiver assembly A2 assembly and replacement;

3) Receiver interconnect circuit card A14 assembly and replacement;

4) RMI servo amplifier circuit card A12 or heads up display driver circuit card A26 card replacement;

5) RMI/power supply/audio circuit card A3 replacement;

6) Circuit card replacement;

7) Cover installation.

If storage is to be effected for long periods of time, encase the 51RV in a heavy plastic bag with sufficient desiccant to absorb any moisture, and seal with tape.

New Words/ Phrases/ Expression

1. ILS 仪表着陆系统(Instrument Landing System 的缩写)
2. AFCS 自动飞控系统(Auto Flight Control System 的缩写)
3. descent [di'sent] *v.* 下降
4. slope angle 倾斜角
5. Localizer(LOC) ['ləuklaizə] *n.* 航向信标
6. path [pa:θ] *n.* 航路,轨迹
7. glide slope(G/S) 下滑信标
8. beamwidth ['bi:mwidθ] *n.* 波束宽度
9. DME 测距设备(Eistance Measuring Equipment 的缩写)
10. RMI 相对方位角指示器(Relative Bearing Indicator 的缩写)
11. VOR 甚高频全方位范围(Very High Frequency Omnibearing Range 的缩写)

Exercises

Ⅰ. Translate the following sentences into Chinese:

1. ILS consists of three basic components: a localizer for horizontal positioning, a glide slope for vertical glide path control, and beacons for homing and for position determination.

2. The 51RV is a solid-state, airborne navigation unit that combines the VOR, localizer, and glideslope functions. The dual-conversion 200-channel VOR/LOC (108 to 118 MHz with 50 kHz channel spacing) and 40-channel glideslope (329 to 335 MHz with 150 kHz channel spacing) receivers are remotely controlled by 2 out-of-5 binary control or by serial information transmitted in ternary broadcast form.

Ⅱ. Answer the following questions:

1. What frequency range does the glide-slope operate?
2. What frequency band does the localizer operate in?
3. What is the function of the VOR?
4. What component parts does ILS consist of?

Chapter 6
Landing Gear

Chapter 6　Landing Gear

6.1　Introduction

For aircraft, the landing gear supports the aircraft when it is not flying, allowing it to take off, land, and taxi without damage (see Figure 6.1－1). It also serves as the primary means of absorbing the large amounts of energy developed in the transition from flight to ground roll during a landing approach.[1] Wheels are typically used but skids, skis, floats or a combination of these and other elements can be deployed depending both on the surface and on whether the aircraft only operates vertically (VTOL) or is able to taxi along the surface. The brakes, normally located in the main wheels, are used to retard the forward motion of the aircraft on the ground and may provide some control in the steering of the aircraft. In most modern aircraft the landing gear is designed to retract into the aircraft so that it is out of the airstream and drag is thus reduced.[2]

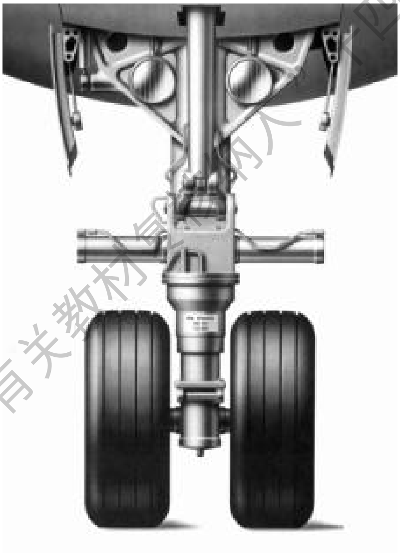


Figure 6.1－1　Landing gear

Aircraft landing gear usually includes wheels equipped with simple shock absorbers, or more advanced air/oil oleo struts, for runway and rough terrain landing. Some aircraft are equipped with skis for snow or floats for water, and/or skids or pontoons (helicopters).

It represents 2.5% to 5% of the MTOW (Maximum Take-Off Weight) and 1.5% to 1.75% of the aircraft cost but 20% of the airframe direct maintenance cost; each wheel can support up to 30 t (66,000 lb), reach over 300 km/h, roll up to 500,000 km (310,000 mi); it has a 20,000 hours time between overhaul and a 60,000 hours or 20 years life time.

Wheeled landing gears normally come in two types: conventional and tricycle (see Figure 6.1-2, Figure 6.1-3). Early aircraft and many small aircraft use a tail-wheel (or skid) in a conventional, or tail-dragger arrangement, in which the main landing gear is located ahead of or forward to the center of gravity of the aircraft.[3] The tail-dragger arrangement was common during the early propeller era, as it allows more room for propeller clearance. The popular arrangement on modern aircraft is a tricycle landing gear, with the main gear located behind of the center of gravity, and a nose gear located forward which carries about 20% of the static weight of the aircraft.

Figure 6.1-2　Conventional landing gear

Figure 6.1-3　Tricycle landing gear

As aircraft grow larger, they employ more wheels to cope with the increasing weights. Large aircraft, such as the wide-body commercial aircraft and military aircraft like the C-5A, employs multiple-wheeled bogies to support their huge weight and to provide soft terrain landing and takeoff capability (see Figure 6.1-4).

(a)

Figure 6.1-4　Multiple-wheeled bogies of C-5A

(b)

Continued Figure 6.1－4　Multiple-wheeled bogies of C－5A

The Boeing 747 has five sets of wheels: a nose-wheel assembly and four sets of four-wheel bogies (see Figure 6.1－5). A set is located under each wing, and two inner sets are located in the fuselage, a little rearward of the outer bogies, adding up to a total of eighteen wheels and tires. The Airbus A380 also has a four-wheel bogie under each wing with two sets of six-wheel bogies under the fuselage.

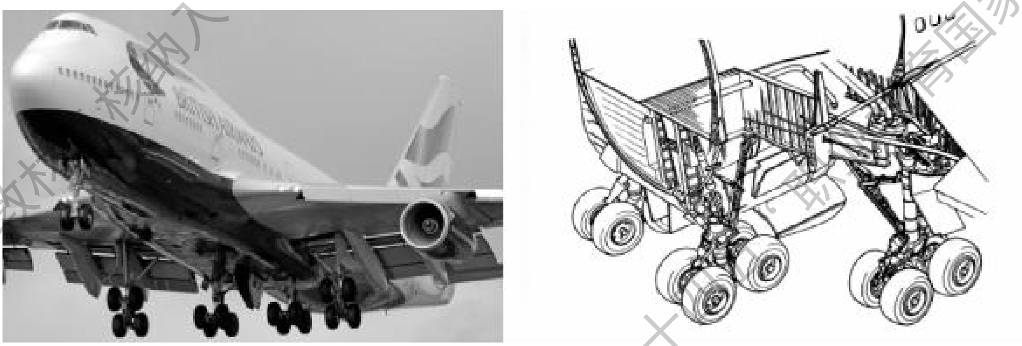


Figure 6.1－5　B747's landing gear

The Airbus A340-500/-600 has an additional four-wheel landing gear bogie on the fuselage centerline, much like the twin-wheel unit in the same general location, used on later DC-10 and MD-11 airliners (see Figure 6.1－6, Figure 6.1－7).

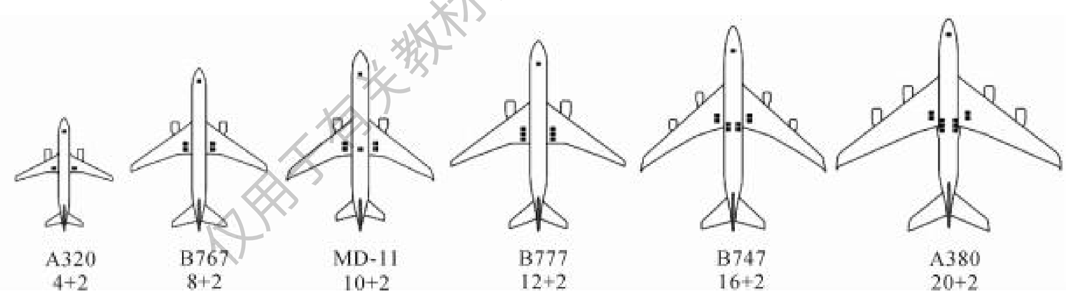


Figure 6.1－6　Typical airliner's tire arrangement

Figure 6.1 - 7 Additional bogie on the fuselage centerline

The world's largest jet cargo aircraft, the Ukrainian Antonov An-225 has 4 wheels on the twin-strut nose gear units (as its smaller "stablemate", the Antonov An-124 also uses), and 28 main gear wheel/tire units, adding up to a total of 32 wheels and tires (see Figure 6.1 - 8).

Figure 6.1 - 8 Seven dual wheels in tandem main gear with twin-strut nose gear, Antonov AN - 225

The landing gear of Boeing 737 consists of two main gear and one nose gear. Each main gear is located aft of the rear wing spar inboard of the engine nacelles. The nose gear is located below the aft bulkhead of the control cabin (see Figure 6.1 - 9).

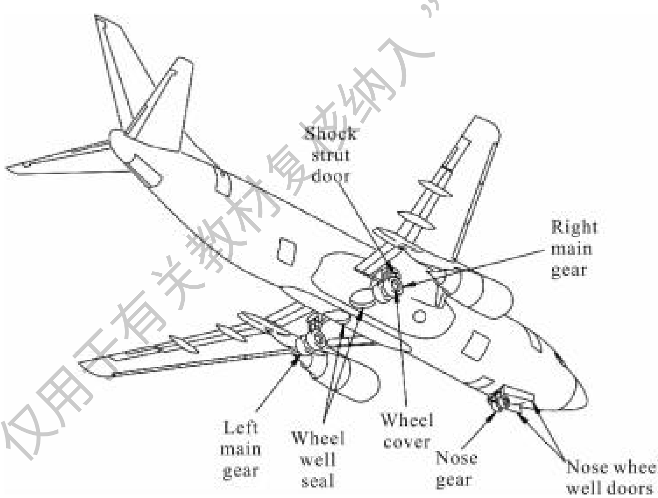


Figure 6.1 - 9 B737 landing gear location

New Words/ Phrases/Expression

1. landing gear 起落架
2. VTOL 垂直起降(Vertical Take-Off and Landing 的缩写)
3. airstream [ˈɛəstriːm] *n*. 气流(尤指与飞机前进方向相反的来流)
4. pontoon [pɔnˈtuːn] *n*. 浮筒
5. MTOW 最大起飞质量(Maximum Take-Off Weight 的缩写)
6. overhaul [ˈəʊvəhɔːl] *n*., *vt*. 翻修;彻底检查;大修
7. bogie[ˈbəʊgi] *n*. 转向架,轮架
8. nacelle[nəˈsel] *n*. 发动机舱

Notes

【1】It also serves as the primary means of absorbing the large amounts of energy developed in the transition from flight to ground roll during a landing approach.

分析:"serve" 意为"起作用"。

翻译:它(前指起落架)也在飞机从飞行到着陆的降落过程中,主要起到缓冲并吸收该过程中产生的巨大能量的作用。

【2】In most modern aircraft the landing gear is designed to retract into the aircraft so that it is out of the airstream and drag is thus reduced.

分析:"be out of"指"离开,脱离某种状态"。

翻译:绝大部分的现代飞机,起落架被设计成可以收入飞机内,这避免起落架暴露在气流中,从而大大减小了飞行的阻力。

【3】Early aircraft and many small aircraft use a tail-wheel (or skid) in a conventional, or tail-dragger arrangement, in which the main landing gear is located ahead of or forward to the center of gravity of the aircraft.

分析:"in which"是介词引导的先行词,等同于"where"。

翻译:早期的飞机和许多小型飞机使用传统的"尾轮(或尾橇)布局",该布局使得主起落架位于飞机重心之前。

Exercises

Ⅰ. Answer the following questions:

What are the functions of the landing gear?

Ⅱ. Translating the following sentences into Chinese:

1. It also serves as the primary means of absorbing the large amounts of energy developed in the transition from flight to ground roll during a landing approach.

2. The brakes, normally located in the main wheels, are used to retard the forward motion of the aircraft on the ground and may provide some control in the steering of the aircraft.

3. Some aircraft are equipped with skis for snow or floats for water (and/or skids or

pontoons helicopters).

4. The tail-dragger arrangement was common during the early propeller era, as it allows more room for propeller clearance.

5. The Boeing 747 has five sets of wheels: a nose-wheel assembly and four sets of four-wheel bogies. A set is located under each wing, and two inner sets are located in the fuselage, a little rearward of the outer bogies, adding up to a total of eighteen wheels and tires.

Ⅲ. Fill in the following blanks according to the text:

1. For aircraft, the landing gear supports the aircraft when it is not ________, allowing it to ________, ________, and ________ without damage.

2. The landing gear of Boeing 737 consists of ________ main gear and ________ nose gear. Each main gear is located aft of the rear ________ inboard of the engine nacelles. The nose gear is located below the aft ________ of the control cabin.

6.2 Main Gear Shock Strut Maintenance

The main and nose gear use air-oil type shock struts to absorb impact on landing and vibrations and shock from movement of the airplane on the ground. The basic components are an outer cylinder which contains the air-oil mixture and an inner piston that compresses the oil through an orifice. The flow of oil through the orifice is metered by a variable-diameter pin that passes through the orifice as the gear strokes. The flow of oil in effect varies the stiffness of the compression of the gear.

Each nose and main gear of Boeing 737 is equipped with two tire and wheel assemblies. Each main gear wheel is fitted with multiple disc type hydraulic brakes (see Figure 6.2-1).

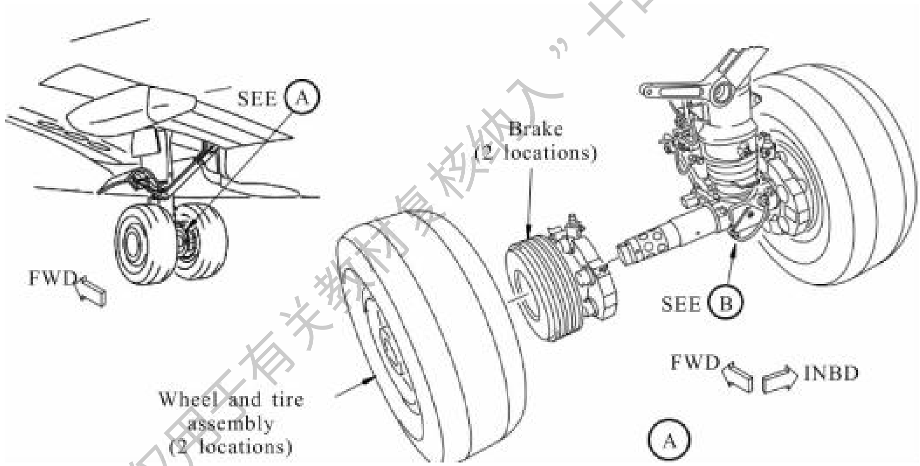


Figure 6.2-1 Wheels and brakes

6.2.1 General

Each main landing gear has these main components(see Figure 6.2-2):

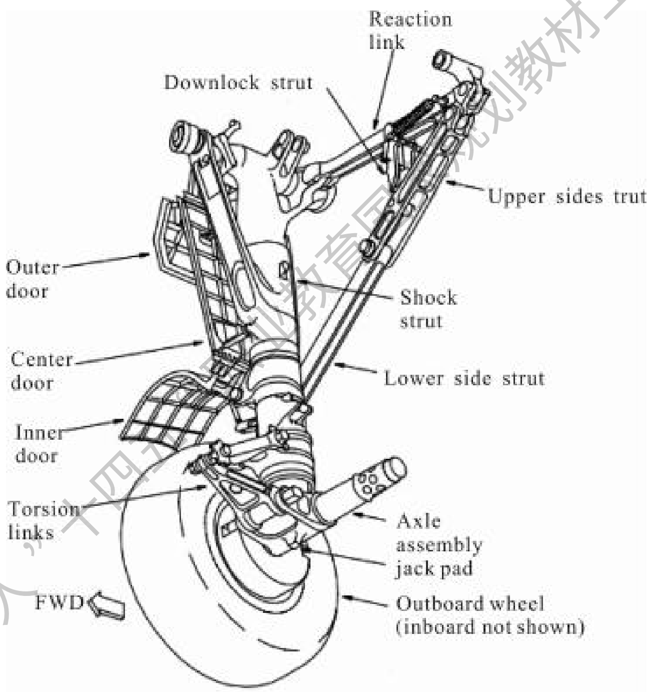


Figure 6.2-2 Components of right main gear

- Shock strut;
- Axle assembly;
- Torsion links;
- Side strut;
- Reaction link;
- Downlock strut.

The main gear shock strut assembly (see Figure 6.2-3) consists of inner and outer cylinders containing orifice support tube, metering pin, drain tube, packings, packing adapter, bearings, charging valve, and orifice plate.[1]

Some of the space between the inner and outer cylinder and part of the outer cylinder above the bulkhead is partially filled with hydraulic fluid and held under pneumatic pressure. The air cushion absorbs impact loads and taxi and landing shocks. The hydraulic fluid goes through an orifice plate and snubbing valve to slow down the motion of the inner cylinder.

Compressed nitrogen is in the upper part of the shock strut. BMS (Boeing Material Specification) 3-32 landing gear shock strut fluid is in the lower part of the shock strut.

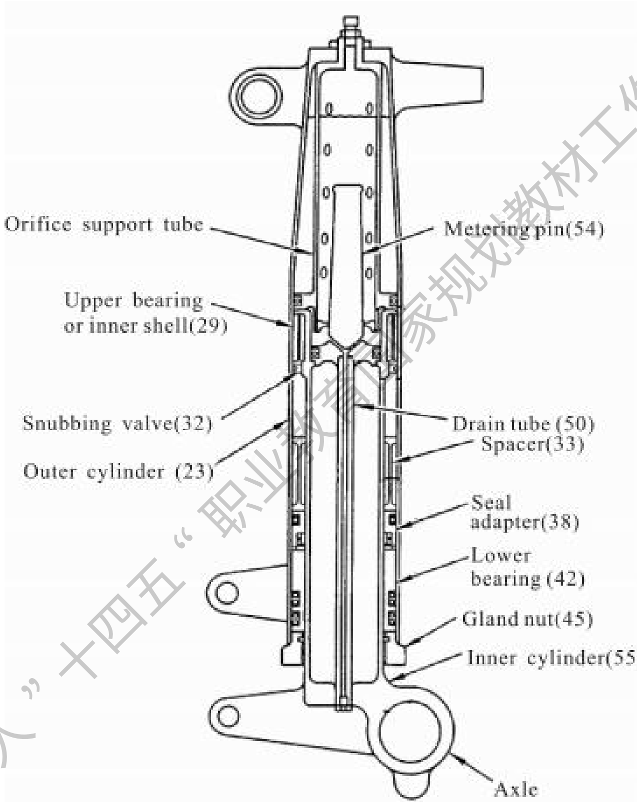


Figure 6.2－3　Main gear shock strut structure

6.2.2　Testing and Fault Isolation

The first step to the landing gear maintenance is to inspect the defects and faults. Before fixing the shock strut, we must prepare some equipments and consumable materials. For example, hydraulic pressure gauge, check valve, hydraulic fluid, gaseous nitrogen, etc. Then, we can do some preparation for tests.

First, put the shock strut in a vertical position, with the inner cylinder fully extended and the air valve open. Second, get the applicable hydraulic fluid; BMS 3－32 is preferred. Third, fill the shock strut with the hydraulic fluid until the fluid comes out at the air valve. And then extend and compress the inner cylinder until you are sure no air is caught inside the shock strut. The last, fully compress the shock strut and fill it with hydraulic fluid, if necessary.

Then, make a Standard Pressure Leakage Test. At the beginning, install air valve. Then, connect the air valve with the nitrogen. With the inner cylinder fully extended, inflate strut to 95 to100 psig. Let the system become stable for 30 minutes, then hold pressure for 1 hour minimum. There must be no sign of fluid or nitrogen leakage. A wet surface is acceptable if a drop of fluid does not occur. Once passing the test, release the nitrogen gas pressure from the shock strut. Be careful not to loosen the air valve body until the pressure is released from the strut, otherwise injury to personal and damage to equipment could occur.

If leaks occur during the standard pressure test, it is necessary to do a high pressure test. And the high pressure leakage test can find the source of a nitrogen leak.

When the air or fluid leaks occur, it is probably due to defective of the packing or seal, the trouble shooting solution is to replace a new packing.

6.2.3 Disassembly

After finishing the testing, we have to disassemble the shock strut (see Figure 6.2-4). Some special tools, like hook spanner wrench, main gear shock strut orifice plate wrench will be required.

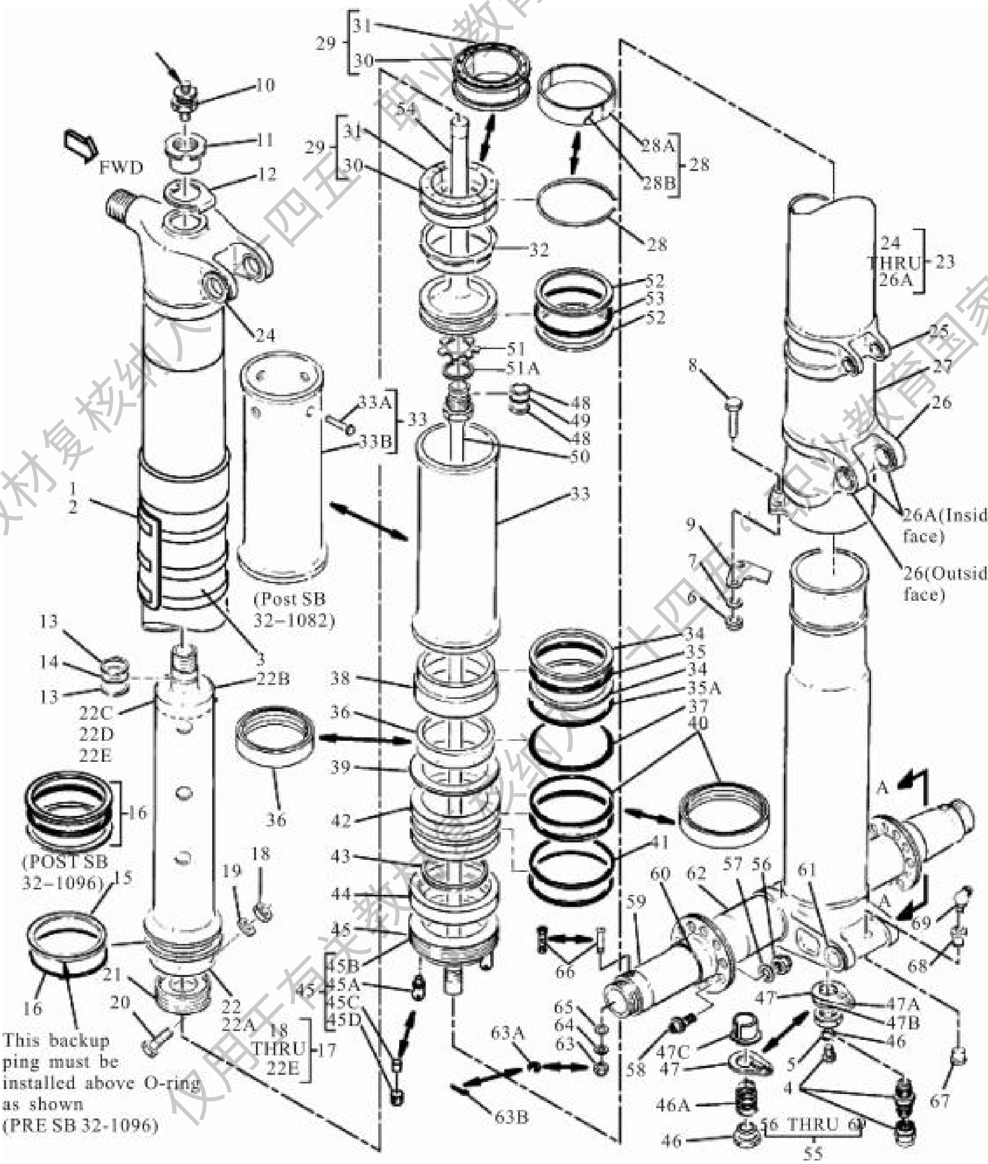


Figure 6.2-4 Main gear shock strut disassembly

The procedure of the disassembly is:

(1) Hang the shock strut in an upright position from a hoist in a commercial web belt sling. Carefully release the air pressure. After the pressure is released, remove all of the valve assembly.

(2) Remove all lock wiring. Remove parts (4, 5) (see Figure 6.2 - 5) and drain all hydraulic fluid through the bore of drain tube (50).

(3) Lower the shock strut, in a vertical position, into an assembly fixture.

(4) Remove parts (6 thru 9). Unscrew gland nut (45) with landing gear gland nut hook spanner. Pull off outer cylinder (23) from the inner cylinder with a hoist and a commercial web belt sling.

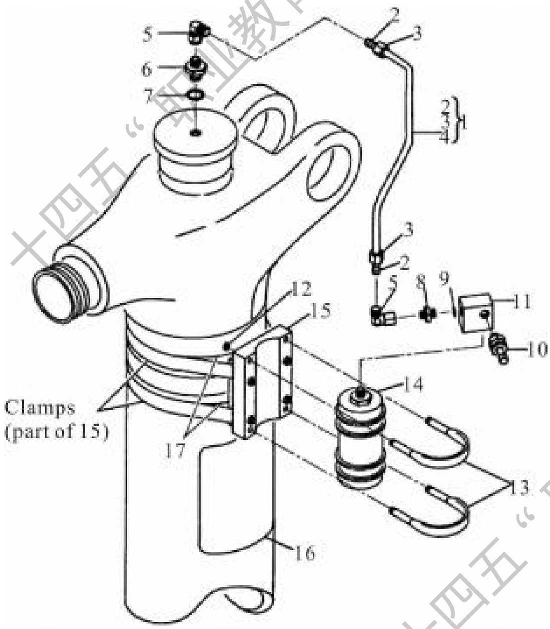


Figure 6.2 - 5　Components disassembly

(5) Unscrew retaining nut (11). Remove lock washer (12). Wrap the threads on orifice tube (21) with mylar tape, such as 3M No. 8412 tape or equivalent, to prevent thread damage when you remove the orifice tube from the outer cylinder.

(6) Push orifice tube support assembly (17) out of the outer cylinder. Disassemble parts (13 thru 22).

(7) Remove parts (28 thru 32) from the inner cylinder. Keep upper bearing halves (30, 31) together as a matched set. Be careful not to damage snubbing valve (32). You can keep ring (28) to use it again, but we recommend you discard it and assemble the unit without it.

(8) Remove parts (33 thru 45) from inner cylinder.

(9) Remove parts (46 thru 47C). Pull metering pin (54) with attached parts out of the inner cylinder.

(10) Unscrew drain tube (50) and remove washers (51, 51A) if used. Disassemble

parts (48, 49, 52, 53).

(11) Remove parts (56, 57, 58). Give protection to sleeves (59) and axle threads with axle and thread protector.

(12) Remove parts (1 thru 14 Figure 6.2-5).

6.2.4 Cleaning

Then clean all the parts as specified by standard industry practices and SOPM 20-30-03. SOPM is the abbreviation of "Standard Overhaul Practices Manual". It contains the detailed procedures of standard overhaul practices.

6.2.5 Check

Before repairing the components of the landing gear shock strut, defects in the parts of the main landing gear shock strut assembly must be inspected. The fundamental inspection methods includes: visual inspection, liquid penetrant inspection, magnetic particle inspection.

The procedure of the check is:

(1) Examine all parts for defects by standard industry practices. Refer to Fits and Clearances for design dimensions and wear limits and use the micrometer to examine.

(2) Examine the threads for the gland nut at the lower end of outer cylinder (27) for corrosion. After you chase or blend out defects, threads are acceptable if a minimum of 50% of thread bearing surface remains and the defects are not concentrated in any quarter segment across all threads.

(3) Examine the inner cylinder axle threads for nicks, burrs, defects and wear. Measure the thread pitch diameter and major diameter and compare them with the thread dimensions given in Fits and CLearances. Be sure to use the correct tool for the thread size.

(4) Use magnetic particle inspection method to inspect outer cylinder (27), Gland nut (45), Metering pin (54), Sleeve (59), Inner cylinder (62), etc.

(5) Use penetrant inspection method to inspect Orifice support tube (22), Lower tube segment (22A), bearings (42, 42A), adapter (44), tube (50), etc.

(6) Examine metering pin (54) for straightness. Examine the pin shaft for flat spots. Make sure the machined surface has a 32 microinch finish or smoother.

(7) Examine the brake attachment flange on inner cylinder (62) for signs of cracks. If there are cracks, they will start from the brake mounting holes and could go inwards (toward axle) or outward (toward outer edge of brake flange). No more than four holes can have cracks that go outward.

(8) Examine the lower quadrant of the main gear axle between the brake mounting flanges for cracks. If you find cracks, the main gear shock strut is unserviceable.

(9) Examine orifice support tube (22) for corrosion in the upper end threads.

(10) Make a check of the mating dimensions between upper bearing inner shell (29),

snubbing valve(32) and inner cylinder (62), to be sure these parts will stay in position after assembly.

6.2.6 Typical Repair

After disassembling and checking, the defects of the components would be exposed. Then we must repair the small defects by standard industry practices. Appropriate tools and equipments are required.

Among the large amount of the landing gear system components, the most typical defects in components maintenances are corrosion and wear. In components repair process, grinding is usually used to remove the defects. For severe corrosion and wear, after grinding, if the surface removal thickness exceeds the allowable limits, it must be discarded and use a new one to replace.

Here are three brief introductions of the repair process: outer cylinder lug faces and holes, metering pin, and support tube.

1. Outer Cylinder Lug Faces and Holes (see Figure 6.2-6)

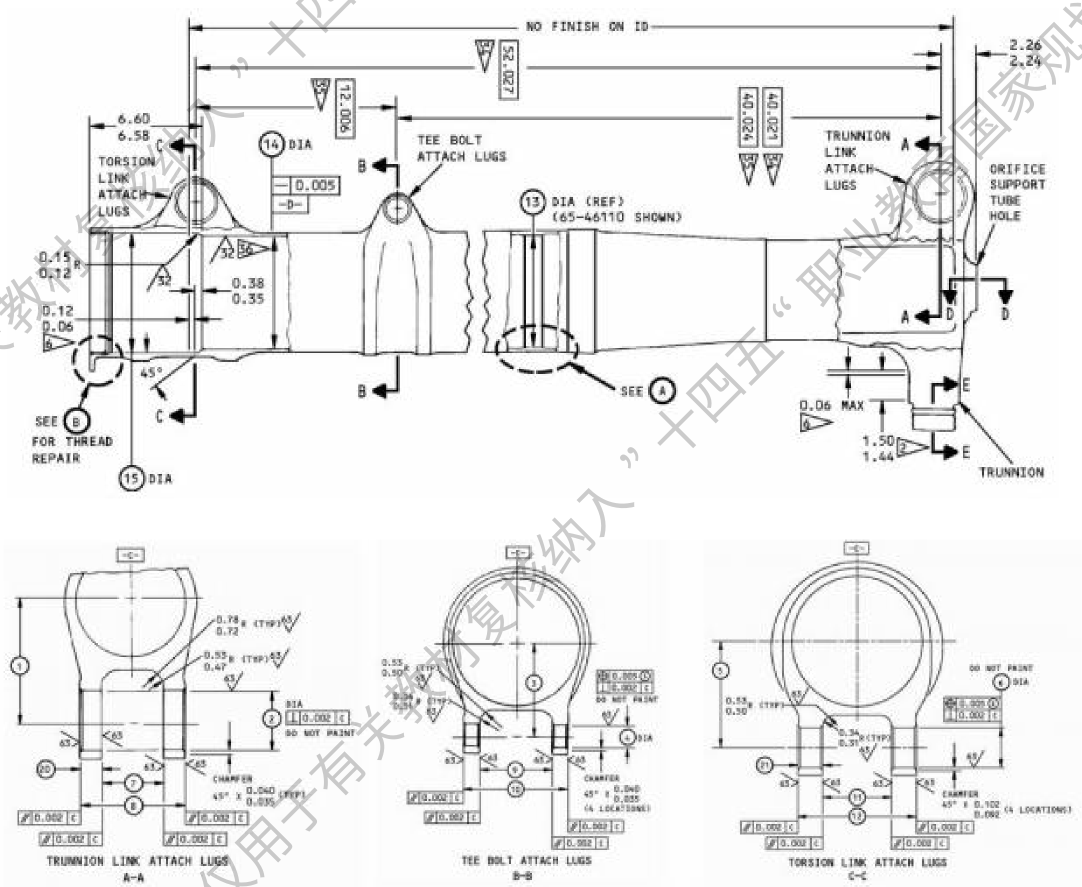


Figure 6.2-6 Outer cylinder repair and refinish

There are four methods to repair the outer cylinder lug faces and holes; the main task is to remove the defects.

Method 1—Installation of oversize bushings (see Figure 6.2－7). Machine the lug faces and holes as necessary, within repair limits, to remove defects. Typically, the grinding will reduce the structural strength of the surface, so we have to make a shot peen operation, and a cadmium titanium plate. Then apply primer. Make repair bushings with increased flange thickness as necessary to adjust for the material removed. Install the bushings.

Method 2 — Chrome plate or thermal spray buildup of lug faces. Machine it as necessary, within repair limits, to remove defects. Shot peen as indicated. Build up with chrome plate or thermal spray coating. Grind the chrome plate or thermal spray coating to design dimensions and finish. Install standard bushings.

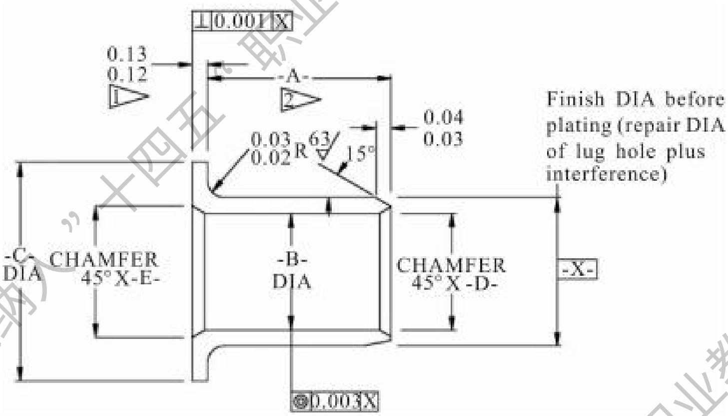


Figure 6.2－7 Installation of oversize bushings

Method 3—Installation of back-to-back bushings in the trunnion link attach lugs (see Figure 6.2－8). Remove material from all of the lug inner faces as necessary to permit flanged repair bushings to fit here. Do not remove more than 0.060 inch from the minimum design dimension. Blend into the radius as shown. As an alternative on the inner lug faces, you can make a spotface up to 0.060 inch deep. Chamfer the lug bores at the inner and outer faces. Shot peen as indicated. Chrome plate the inner lug faces 0.003 to 0.005 inch thick, with the chrome plate runout.

Apply primer to chamfers. Make repair bushings. It is recommended you wait until after installation to machine the bushing flange faces, not before, because the bushing flange is thin and could easily break. Fill all gaps with sealant, and then install the bushings with wet sealant by the shrink fit method. Machine the bushing flange faces as necessary. Fillet seal around bushing flanges and in the gap between the bushings with sealant.

Method 4—Installation of repair shim on the trunnion link attach lugs (see Figure 6.2－9). Machine lug inner faces, within repair limits, to remove defects. If you must remove more than 0.035 inch from the design dimension, use the Method 3 back-to-back bushing repair.

Shot peen the repaired surfaces as indicated. Chrome plate the inner lug faces 0.003 to 0.005 inch thick, with the chrome plate runout. Cadmium-titanium plate the other surfaces unless shown differently. Make a shim and install it with wet sealant. Line ream all bushings and shims to design dimensions and finish.

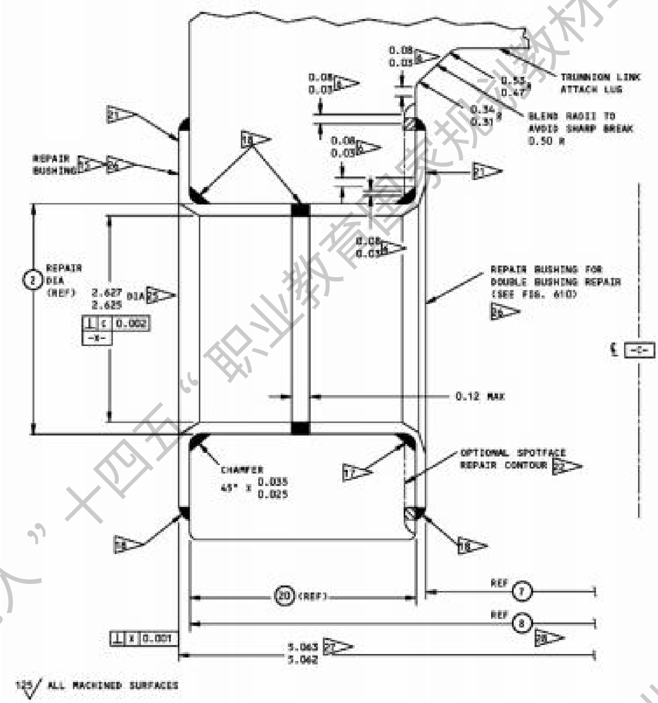


Figure 6.2 - 8　Installation of back-to-back bushings in the trunnion link attach lugs

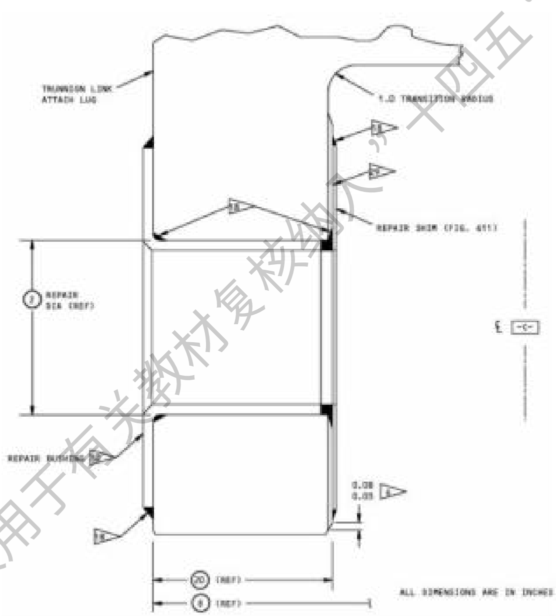
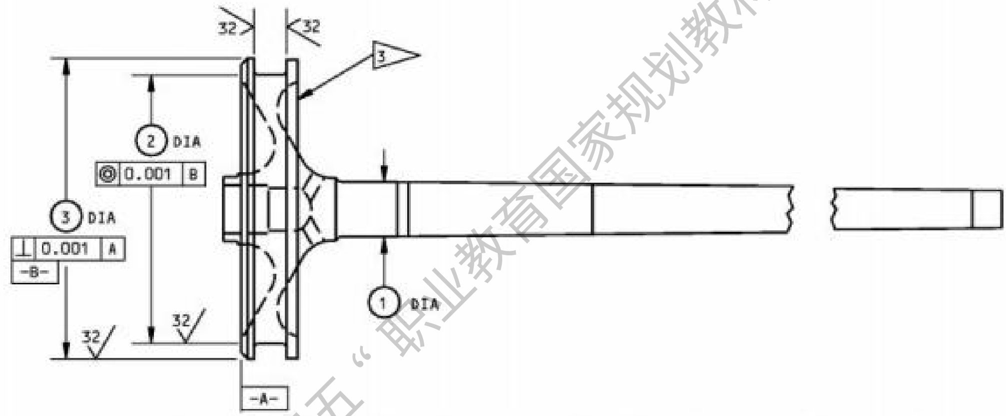


Figure 6.2 - 9　Installation of repair shim on the trunnion link attach lugs

2.Metering Pin (see Figure 6.2－10, Figure 6.2－11)

Step one, diameter 2 surface repair. If the O-ring groove surface is rougher than 32 microinches, remove the cadmium-titanium plate from the groove with a grit blast and polish the area to 32 microinches or smoother with abrasive paper, G50339.



	(1) [1]	(1) [2]	(1) [6]	(1) [7]	(2)	(3)
DESIGN DIM	1.072 1.068	1.040 1.036	1.072 1.068	1.039 1.037	4.872 4.869	5.348 5.345
REPAIR LIMIT	1.048 [4] 1.052 [9] 1.040 1.036 [10]	1.016 [4] [5] 1.020 [9]	1.048 [4] 1.052 [9]	—	4.850 [8] 4.852 [9]	—

Figure 6.2－10　Metering pin repair details and limits

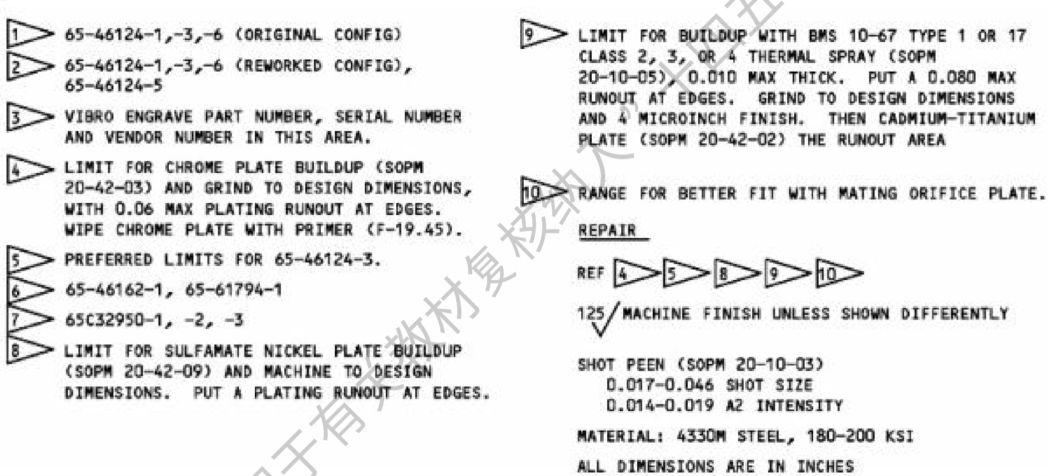


Figure 6.2－11　Metering pin repair details

Step two, diameters 1, 2 general repairs. Pay attention to the diameter 1 dimension on the 65-46124-1,-3 (P/N, represent two kinds of components) pins can be machined down to

1.036 to 1.040 inch to keep it away from the orifice plate (see Figure 6.2－10). Machine it as necessary, within repair limits, to remove defects. Shot peen as indicated. Build up with chrome plate or nickel plate or thermal spray, as applicable. Grind the chrome plate or thermal spray coating, or machine the nickel plate, to design dimensions and finish.

3. Support Tube (see Figure 6.2－12, Figure 6.2－13)

Step one, upper end O-ring groove repair. Machine it as necessary, within repair limits, to remove defects. Build up the machined area with thermal spray coating as shown. Machine it to design dimensions and finish.

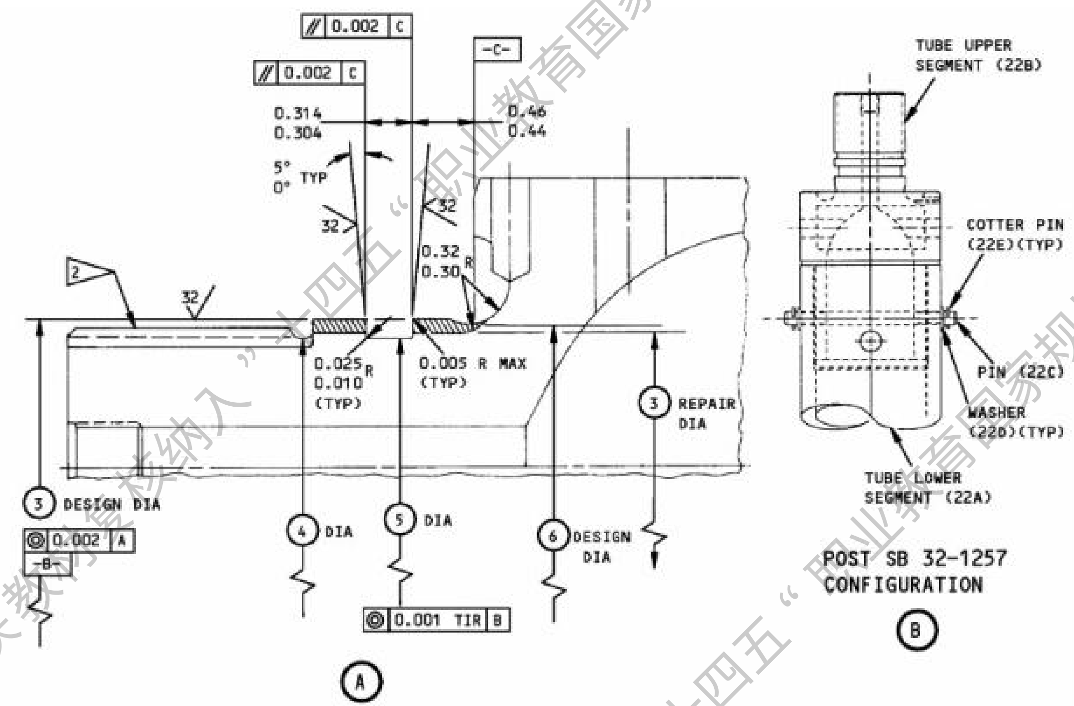


Figure 6.2－12　Support tube repair details

	①	②	③	④	⑤	⑥
DESIGN DIM	6.720 6.717	6.247 6.244	1.991 1.989	1.822 1.817	1.750 1.748	1.950 1.940
REPAIR LIMIT	6.657 ▷1	6.184 ▷1	1.929 ▷1	——	——	——

Figure 6.2－13　Support tube repair limits

Step two, upper end threads repair. Blend out defects if no more than 40% of the threads will be removed in any one quadrant. Do not remove more than 40% of any one thread from the circumference. If the defects on the threads make necessary the removal of more thread material than this, repair the support tube (22) as specified in SB 737-32-1257.

6.2.7 Assembly and Storage

When all components are fixed and available, we must assemble the components together.

First, put packings and backup rings in hydraulic fluid. Apply a thin film of grease on packings and backup rings as you put the parts together. Wipe with hydraulic fluid the shock strut surfaces which will rub against packings. Second, lubricate washers and the threads of bolts and nuts with grease before installation.

Install parts like bushings and packings on the shock strut, Assemble spare packings (41, 40) on lower bearing (42), and parts (37 thru 34) on seal adapter (38). See Figure 6.2-14 for correct installation of rings (36, 40).

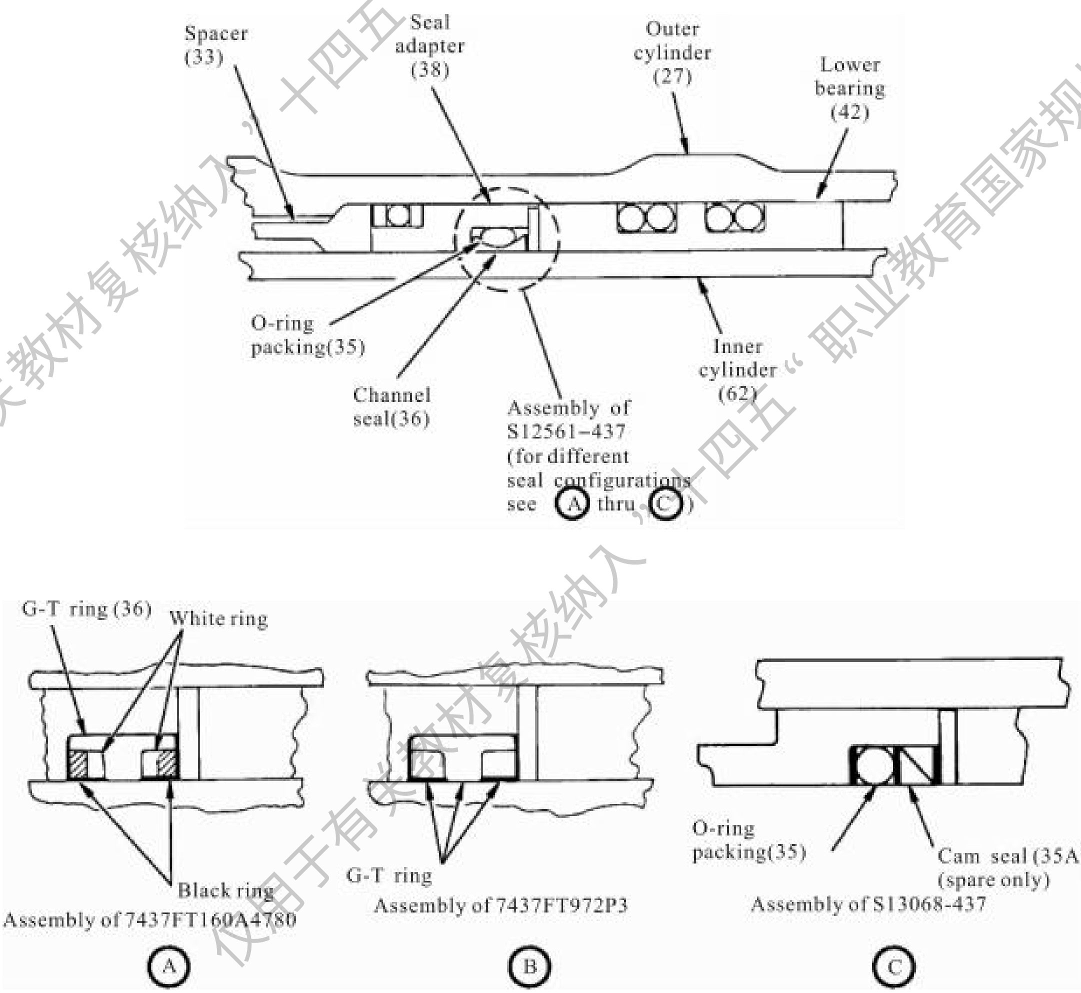


Figure 6.2-14 Sealing details

Then, install bearing or inner shell halves, orifice tube, inner cylinder into outer cylinder. Install gland nut, apply corrosion preventive compound, screw gland nut (45) into the outer cylinder with landing gear gland nut hook spanner. Tighten to 50 pound-feet. Manually compress, then extend the inner cylinder and measure the full stroke of the inner cylinder (see Figure 6.2-15). Compare your value with the values shown in Figure 6.2-16. If your value does not agree, disassemble the shock strut and look for missing or incorrectly-installed parts.

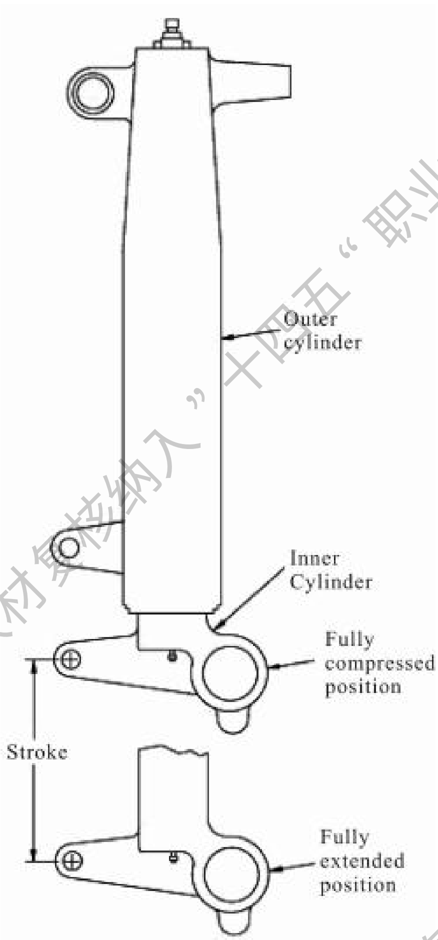


Figure 6.2-15 Shock strut assembly stroke check

Shock strut part number	Stroke inch
65-46100-5,-6, -9 THRU -31, -35 THRU -57, -60THRU-63, -65,-66,-68,-69, -72,-73,-74,-76 -77,-79	13.983 13.856
65-46100-58,-59 -64,-67,-70, -71,-75,-78	14.983 14.856

Figure 6.2-16 Standard value of the inner cylinder's full stroke

Install air valve, and install lockwire by the double-twist method at these locations: Lockwire retaining nut (11) to lockwasher (12); Lockwire plug (4), nut (46) and lockwasher (47) together or, if applicable, lockwire cap of valve (4) to valve and lockwire valve (4), nut (46) and lockwasher (47) together (see Figure 6.2-17).

Seal the split lines between nut (11), lockwasher (12) and orifice tube (17) with sealant and paint the sealant with enamel coating as shown in Figure 6.2-17.

Install nameplate (see Figure 6.2-18). Apply one wrap of 3M No. 5421 tape or 3M No. 8412 tape to the surface that will be under each strap (1). Make the ends of the tape overlap approximately 1 inch. Install nameplate (3) with sealant and straps (1) and seals as shown in Figure 6.2-18.

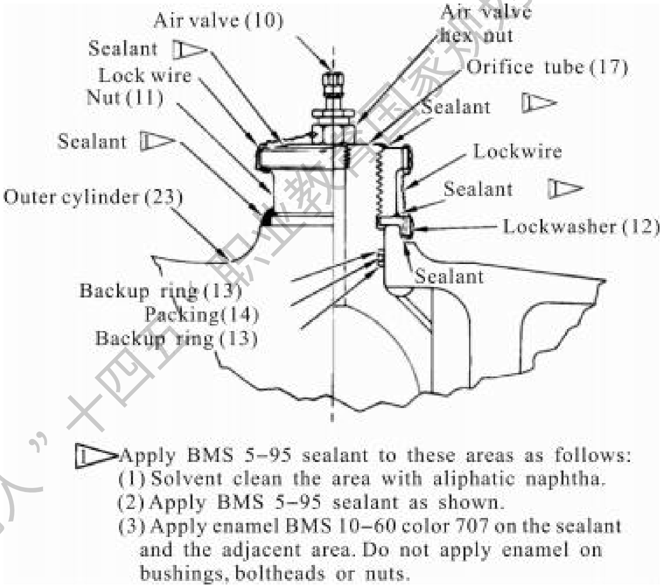


Figure 6.2-17 Sealing details

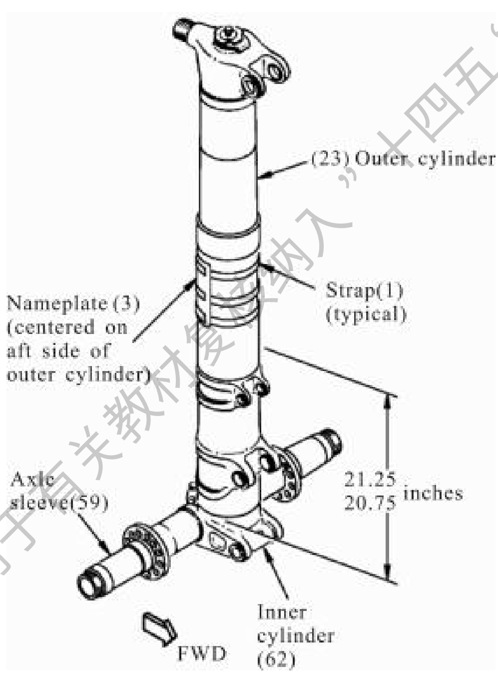


Figure 6.2-18 Nameplate installation

Lubricate the components and apply corrosion inhibiting compound to the bore of lower torsion link attach lug, but not on the bearing surfaces of the bushings.

If the repaired shock strut will not be installed to the airplane timely, it must be stored carefully. We must give protection to the shock strut and put it away by standard industry practices, do not inflate the unit with compressed air. Drain the unit and flush it with preservative hydraulic fluid. Do not drain. Tag it with the test date and a note that the unit contains preservative hydraulic fluid. Compress the unit and apply a layer of compound to the bare exposed portion of the inner cylinder. Always store the unit in the vertical position, to keep hydraulic fluid on the packings.

New Words/ Phrases/Expression

1. bulkhead [ˈbʌlkhed] *n.* 隔离壁,舱壁,防水壁
2. air-oil type shock struts 油气式减震支柱
3. orifice support tube 孔板支撑管
4. metering pin 计量油针
5. packing [ˈpækiŋ] *n.* (缝隙)填料,密封材料
6. bearing [ˈbɛəriŋ] *n.* 轴承
7. snubbing valve 防反跳活门
8. equivalent [iˈkwivələnt] *adj.* 同等的,相当的,等效的
9. discard [disˈkaːd] *vt.* 丢弃,报废
10. segment [ˈsegmənt] *n.* 部分,段
11. grind [graind] *vt.*, *vi.* 打磨,研磨
12. shot peen 喷丸强化
13. Cadmium [ˈkædmiəm] *n.* 镉
14. Titanium [taiˈteiniːəm] *n.* 钛
15. Chrome [krəʊm] *n.*, *vt.* 铬;铬合金;镀铬
16. thermal spray 热喷镀,热喷涂
17. shrink fit method 冷缩法
18. line ream 绞线
19. grit blast 喷砂
20. abrasive paper 砂纸
21. thin film 薄膜
22. wipe [waip] *vt.* 擦,涂上
23. lubricate [ˈluːbrikeit] *vt.* 润滑;使润滑
24. compound [ˈkɔmpaund] *n.* 腻子
25. hook spanner 勾头扳手
26. lockwire [ˈlɔkwaiə] *n.* 保险丝
27. preservative [priˈzɜːvətiv] *adj.* 防腐的,抑制腐蚀的
28. nameplate [ˈneimpleit] *n.* 铭牌,标识牌

Notes

【1】The main gear shock strut assembly consists of inner and outer cylinders containing orifice support tube, metering pin, drain tube, packings, packing adapter, bearings, charging valve, and orifice plate.

分析：“containing”的主语是“The main gear shock strut assembly”。

翻译：主起落架减震支柱是由内筒和外筒构成的，组成减震支柱的部件有孔板支撑管、计量油针、泄流管、密封填料、填料组件、轴承、灌充活门以及节流孔板。

Exercises

Ⅰ. Answer the following questions:

1. What is the procedure of the shock strut maintenance?

2. What kinds of fundamental inspection methods are in the shock strut maintenance?

Ⅱ. Translating the following sentences into Chinese:

1. Some of the space between the inner and outer cylinder and part of the outer cylinder above the bulkhead is partially filled with hydraulic fluid and held under pneumatic pressure. The air cushion absorbs impact loads and taxi and landing shocks. The hydraulic fluid goes through an orifice plate and snubbing valve to slow down the motion of the inner cylinder.

2. When the air or fluid leaks occur, it is probably due to defective of the packing or seal, the trouble shooting solution is to replace a new packing.

3. Among the large amount of the landing gear system components, the most typical defects in components maintenances are corrosion and wear. In components repair process, grinding is usually used to remove the defects. For severe corrosion and wear, after grinding, if the surface removal thickness exceeds the allowable limits, it must be discarded and use a new one to replace.

4. Grind the chrome plate or thermal spray coating, or machine the nickel plate, to design dimensions and finish.

5. First, put packings and backup rings in hydraulic fluid. Apply a thin film of grease on packings and backup rings as you put the parts together. Wipe with hydraulic fluid the shock strut surfaces which will rub against packings. Second, lubricate washers and the threads of bolts and nuts with grease before installation.

Ⅲ. Fill in the following blanks according to the text:

1. First, put the shock strut in a ________ position, with the ________ fully extended and the ________ open. Second, get the applicable hydraulic fluid; ________ is preferred. Third, fill the shock strut with the hydraulic fluid until _______. And then extend and compress the ________ until you are sure no ________ is caught inside the shock strut. The last, ________, if necessary.

2. Then, install ________ or inner shell halves, ________, inner cylinder into ________. Install gland nut, apply ________, screw ________ into the outer cylinder with landing gear gland nut hook spanner. Tighten to ________ pound-feet. Manually compress, then extend the inner cylinder and measure the ________ of the inner cylinder.

6.3 Landing Gear Extension and Retraction Systems

To decrease drag in flight, some landing gears retract into the wings and/or fuselage with wheels flush against the surface or concealed behind doors; this is called retractable gear (see Figure 6.3-1). Most extension and retraction systems are hydraulically operated (see Figure 6.3-2), though some are electrically operated or even manually operated.[1] This adds weight and complexity to the design.

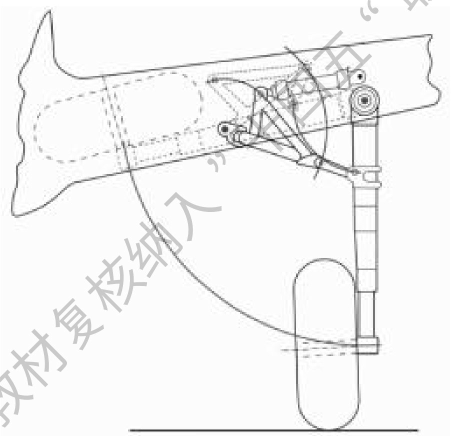


Figure 6.3-1 Retractable gear

Figure 6.3-2 Boeing 787's main landing gear

Multiple redundancies are usually provided to prevent a single failure from failing the entire landing gear extension process. Whether electrically or hydraulically operated, the landing gear can usually be powered from multiple sources. In case the power system fails, an emergency extension system is always available. This may take the form of a manually operated crank or pump, or a mechanical free-fall mechanism which disengages the uplocks and allows the landing gear to fall due to gravity.

The Boeing 737's landing gear extension and retraction system lower and lift the nose and main landing gears. There are several parts of the system, including landing gear control system, main landing gear extension and retraction system, nose landing gear extension and retraction system, main landing gear manual extension system, nose landing gear manual extension system (see Figure 6.3-3).

Figure 6.3－3　Manual extension system

6.3.1　Landing Gear Control System

The landing gear control system controls the extension and retraction of the main and nose landing gears (see Figure 6.3－4). It has these components: control lever assembly, control lever forward quadrant, selector valve, selector valve quadrant assembly, transfer valve, etc (see Figure 6.3－5).

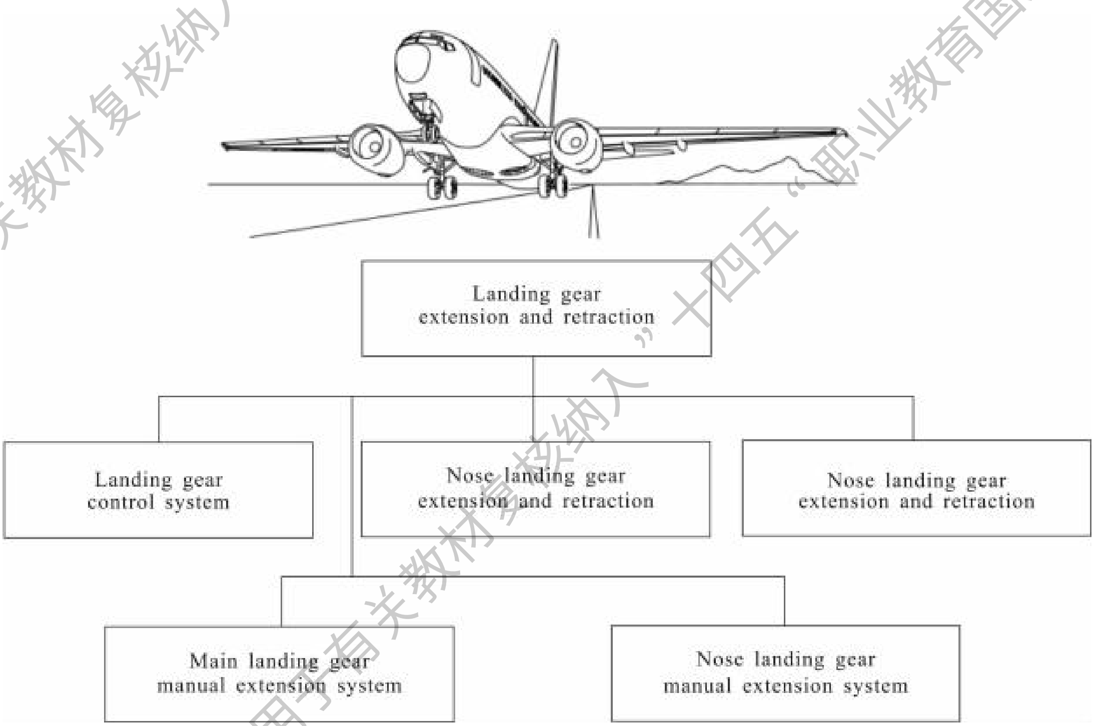


Figure 6.3－4　Landing gear extension and retraction system

Figure 6.3－5　Landing gear control lever

Hydraulic system A normally supplies pressure to the landing gear extension and retraction. Hydraulic system B supplies pressure for retraction only through the landing gear transfer valve. The landing gear transfer valve receives electrical signals from the proximity switch electronics unit (PSEU). Pilot move the landing gear control lever to control landing gear extension and retraction. The control lever moves the selector valve through cables. The selector valve also gets an electrical input from the manual extension system. This operates a bypass valve in the selector valve to connect the landing gear retraction to the hydraulic system return. This lets the manual extension system extend the landing gear (see Figure 6.3－6).

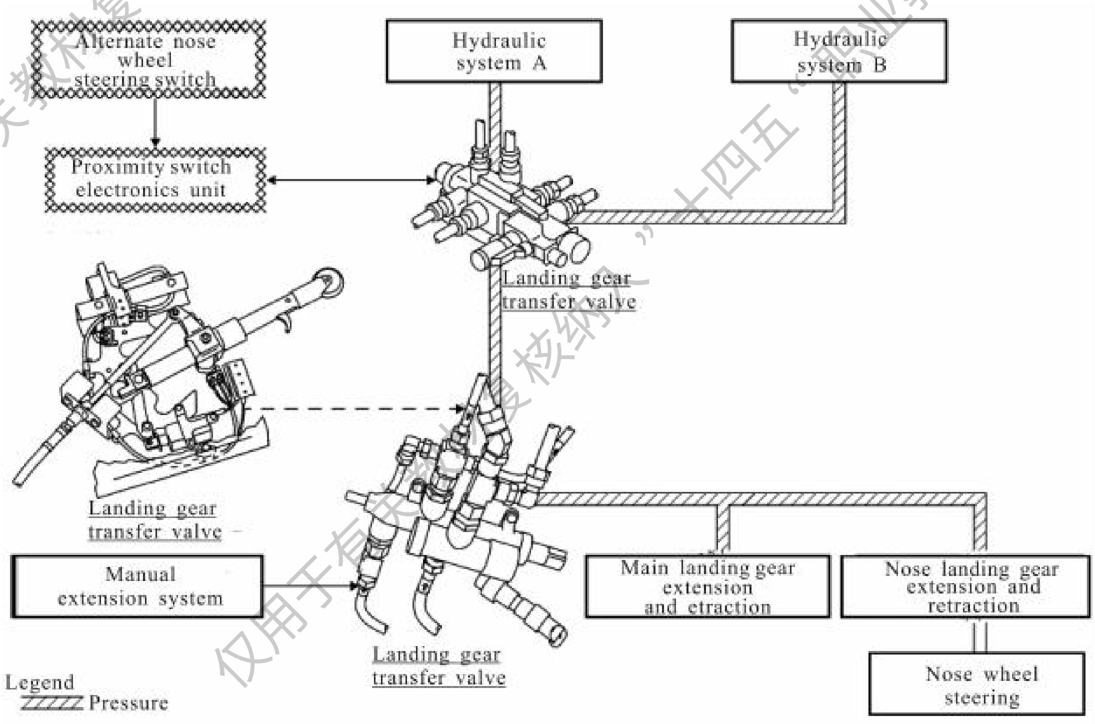


Figure 6.3－6　Landing gear control system

6.3.2 Landing Gear Extension and Retraction System

The main and nose landing gear extension and retraction systems extend and retract the main and nose landing gears.

The main gears are hydraulically actuated to retract inboard into the fuselage (see Figure 6.3-7). Each main gear is locked in the down position by a downlock strut and in the up position by an uplock hook and mechanism.[2] Shock strut doors close the opening in the wing for the main gear shock strut and drag strut. A wheel well seal closes against the main gear tire circumference when the airplane is in flight with gear retracted.

Figure 6.3-7 Main gear retracted(B737)

The nose gear is hydraulically actuated to retract forward into the fuselage. A lock strut assembly locks the nose gear in the up and down positions. Clamshell-type nose gear doors are closed and fair with the fuselage contour when the nose gear is retracted, and remain open when the nose gear is extended (see Figure 6.3-8, Figure 6.3-9).[3]

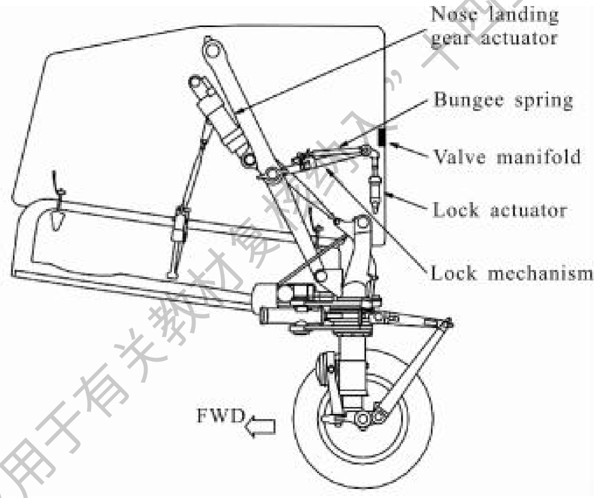


Figure 6.3-8 Nose landing gear extension and retraction system

Figure 6.3－9　Nose landing gear and doors of Boeing 737

There are many components in the main and nose landing gear extension and retraction systems, including landing gear actuators, uplock mechanisms and uplock actuators, downlock actuators, transfer cylinders, frangible fittings, fuses, etc.

The landing gear actuator moves the gear up and down. The downlock actuator locks the main landing gear during extension and unlocks the main landing gear during retraction. The uplock actuator unlocks the uplock mechanism during extension. The transfer cylinder gives a time delay to permit the landing gear to unlock before the gear actuator moves the gear. The frangible fitting removes up pressure from the main landing gear actuator when a damaged, spinning tire moves into the main landing gear wheel well. This prevents damage to components in the wheel well. The fuse prevents hydraulic system fluid loss when the frangible fitting operates (see Figure 6.3－10).

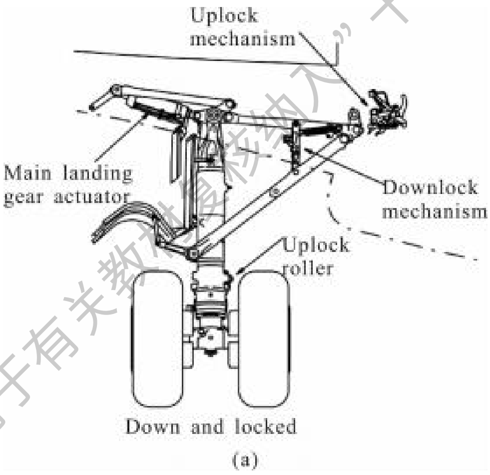
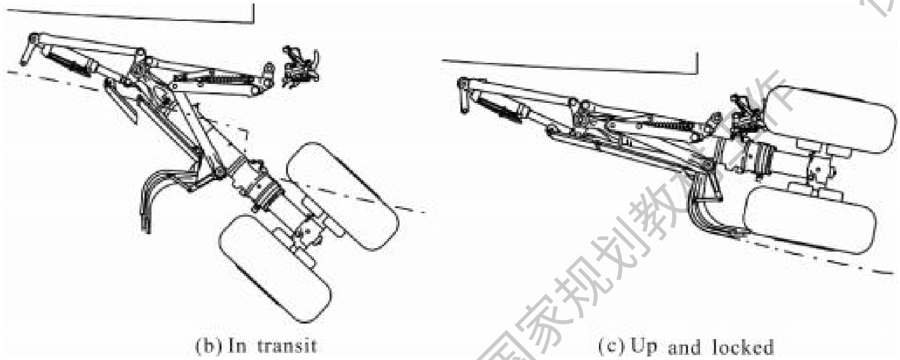


Figure 6.3－10　Main landing gear retraction



Continued Figure 6.3-10 Main landing gear retraction

6.3.3 Landing Gear Manual Extension System

The main and nose gear manual extension systems are operated to release each gear from the up and locked position and allow the gear to extend by airloads and its own weight to the down and locked position. Pilot use the manual extension system when hydraulic system pressure fails or if normal extension fails.

The repair process of extension and retraction system is very similar to the repair process of the shock strut, so it can refer to the shock strut parts repair process.

New Words/ Phrases/ Expression

1. retract [riˈtrækt] *vt.*, *vi.* 缩回，缩进
2. flush against the surface 与表面平齐
3. conceal [kənˈsil] *vt.* 隐藏
4. complexity [kəmˈplɛksiti] *n.* 复杂性
5. redundancy [riˈdʌndənsi] *n.* 余度
6. free-fall [ˈfriːfɔːl] *n.* 自由下落
7. take the form of 表现为……的形式
8. due to 由于
9. manual [ˈmænjuəl] *adj.*, *n.* 人工的；手册，指南
10. seal [sil] *n.* 密封，封盖
11. circumference [səˈkʌmfərəns] *n.* 周围，圆周
12. transfer cylinder 传压筒
13. frangible fitting 易断接头
14. fuse[fjuːz] *n.* 保险，保险活门
15. airload [eərˈloud] *n.* 飞行时的空气动力负荷

Notes

【1】Most extension and retraction systems are hydraulically operated, though some are electrically operated or even manually operated.

分析："though"表示"然而"。

翻译：大多数收放系统是液压驱动的，然而有些收放系统却是电动的，甚至是手动操作的。

【2】The main gears are hydraulically actuated to retract inboard into the fuselage. Each main gear is locked in the down position by a downlock strut and in the up position by an uplock hook and mechanism.

分析："inboard"表示"向内侧"。

翻译：主起落架通过液压作动，向内侧收入机身中。每一个主起落架都通过一个下位锁支柱将起落架锁定在放下位，通过一个上位锁机构将起落架锁定在收上位。

【3】Clamshell-type nose gear doors are closed and fair with the fuselage contour when the nose gear is retracted, and remain open when the nose gear is extended.

分析：此句"remain open"的主语是"clamshell-type nose gear doors"。

翻译：蛤壳式前起落架舱门在前起落架收上时保持关闭状态，并和机身轮廓保持平滑过渡，而在前起落架放下时，舱门保持在打开状态。

Exercises

Ⅰ. Answer the following questions:

1. What subsystems does the extension and retraction system contain?

2. Why the manual extension system is very important?

Ⅱ. Translate the following sentences into Chinese:

1. To decrease drag in flight, some landing gears retract into the wings and/or fuselage with wheels flush against the surface or concealed behind doors; this is called retractable gear.

2. In case the power system fails, an emergency extension system is always available. This may take the form of a manually operated crank or pump, or a mechanical free-fall mechanism which disengages the uplocks and allows the landing gear to fall due to gravity.

3. Shock strut doors close the opening in the wing for the main gear shock strut and drag strut. A wheel well seal closes against the main gear tire circumference when the airplane is in flight with gear retracted.

4. The transfer cylinder gives a time delay to permit the landing gear to unlock before the gear actuator moves the gear.

5. The frangible fitting removes up pressure from the main landing gear actuator when a damaged, spinning tire moves into the main landing gear wheel well. This prevents damage to components in the wheel well.

Ⅲ. Fill in the following blanks according to the text:

1. Hydraulic system A normally supplies pressure to the landing gear ______ and ______.

Hydraulic system B supplies pressure for ________ only through the landing gear ________ valve.

2. Pilot move the landing gear ________ to control landing gear extension and retraction. The control lever moves the ________ through cables. The ________ also gets an electrical input from the manual extension system. This operates a ________ in the selector valve to connect the landing gear retraction to the hydraulic system return.

3. The main and nose gear manual extension systems are operated to release each gear from the ________ and ________ position and allow the gear to extend by ________ and its own ________ to the down and ________ position. Pilot use the manual extension system when ________ fails or if ________ fails.

6.4 Aircraft Wheels

6.4.1 General

Modern aircraft wheels are one of the most highly stressed parts of an aircraft. Aircraft wheels are made from either forged aluminum or magnesium alloys.[1] These materials provide a strong, lightweight wheel that requires very little maintenance.

High tire pressures, cyclic loadings, corrosion, and physical damage contribute to failure of aircraft wheels. Complete failure of an aircraft wheel can be catastrophic. You must have the ability to identify potential safety hazards that you will encounter while working on aircraft tires and wheel assemblies. You must practice all the safety precautions related to wheel and tire maintenance procedures. Aircraft wheels are removed frequently for tire changes, inspections, and lubrication. Familiarity with various types of wheels and tires, and related components, will improve your ability to perform your duties.

6.4.2 Introduction of B737's Landing Gear Wheels

The B737 is supported during landing, takeoff, and ground operations on six wheel and tubeless tire assemblies. Four are on the main landing gear and two on the nose landing gear. Each main wheel is provided with a brake unit bolted to a flange on the axle.

The main landing gear wheels are manufactured by Honeywell (PN 2612301-2, Boeing Specification Number: 10-62237-11), which are made of inner and outer wheel halves. Tie bolts hold the two halves together. Brake rotor drive keys and heat shields are in the inner half of each wheel (see Figure 6.4-1).

Each main landing gear wheel has these main components (see Figure 6.4-1, Figure 6.4-2):

(1) Tire inflation valve: a tire inflation valve is in the inner wheel half.

(2) Over pressure relief valve: an over pressure relief valve is in the inner wheel half. The relief valve releases all of the pressure in the tire when the pressure increases more than

375 to 450 psig. The over pressure relief valve must be replaced if it releases pressure.

(3) Thermal fuse plugs: four thermal fuse plugs in the inner wheel half prevent tire explosion caused by hot brakes. The plugs melt to release tire pressure at approximately 177℃ (351℉). The fuse plug must be replaced if it melts.

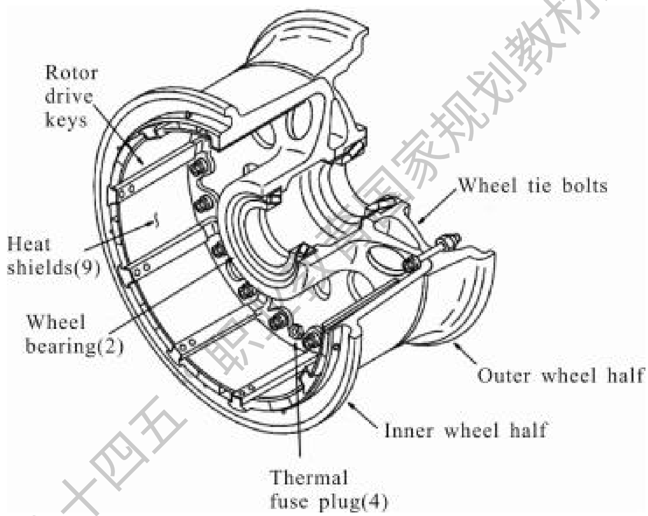


Figure 6.4-1 Main Landing Gear Wheel

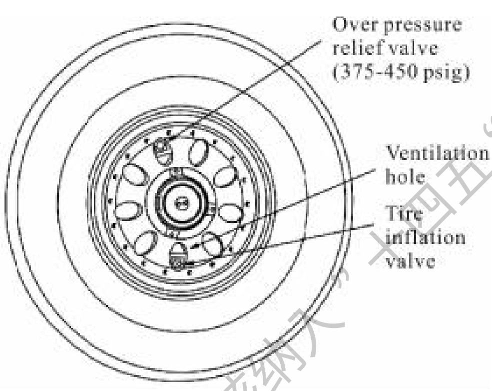


Figure 6.4-2 Wheel and tire

The nose wheel assemblies are also manufactured by Honeywell (PN 2607825-1 for the 737-300/400/500 aircraft and PN 2607825-2 for the 737-300/400/500/600/700 /800/900/ BBJ aircraft, Boeing Specification Number: 10-61063-22 and 10-62237-9), which are different from the main gear wheels in structure (see Figure 6.4-3). The nose wheels have no thermal fuse plugs and heat shields because no brakes installed in the nose gear. And the relief valve releases all of the pressure in the tire when the pressure is more than 375 to 450 psig.

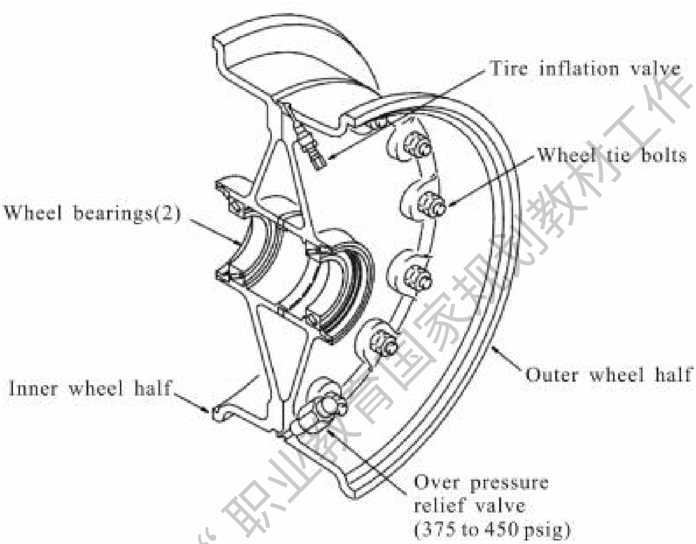


Figure 6.4-3 Nose landing gear wheel

6.4.3 Typical Maintenance Procedures

This section contains a description of a typical wheel's maintenance procedures. This wheel is manufactured by Messier- Bugatti, a subcompany of Safran group. Messier-Bugatti is one of the most influential companies specializing in aircraft landing and braking systems in the world. The part number of the wheel is C20195162, and widely used in the main landing gear of A320 airplanes.

This wheel is designed to be fitted with a tubeless tire. Melting point of the fusible plugs of the web is 183℃ (361.4℉) and melting point of the fusible plugs of the bead seat is 300℃ (572℉). The wheel is made up of half-wheels assembled together with bolts, washers and nuts, and a preformed packing ensures sealing efficiency between these half-wheels. A dust guard and two preformed packings provide for internal sealing. It is possible to install balance weights on each half-wheel to get the correct balancing (see Figure 6.4-4).

The inner half-wheel has: a taper roller bearing which is protected by a stop and seal assembly (see Figure 6.4-5); nine heat shields; nine undercut drive blocks which engage with the slots in the brake rotors; three fusible plugs installed on the web of the half-wheel and three installed on the outer bead seat at the end of the drive blocks.

The outer half-wheel has: a taper roller bearing; a high flow rate valve or optional low flow fill gage valve or optional low flow valve; 120° on either side of the inflation valve, the half-wheel is fitted with two tapped holes blanked by two plugs fitted with preformed packings. On an optional basis, one of the holes is for a pressure transducer (T.P.I.S.) (see Figure 6.4-6).

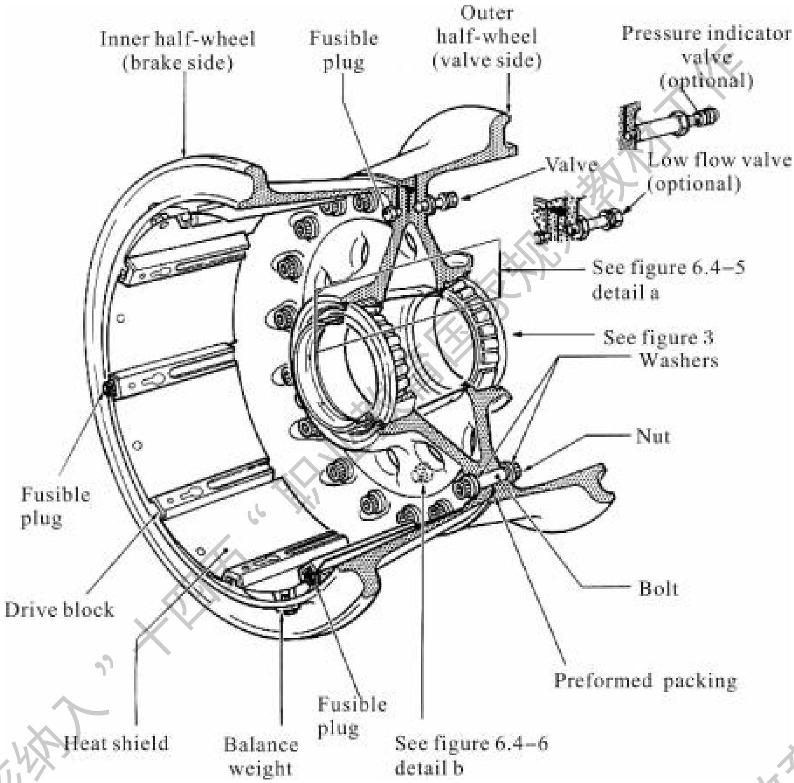


Figure 6.4 - 4 Wheel structure details

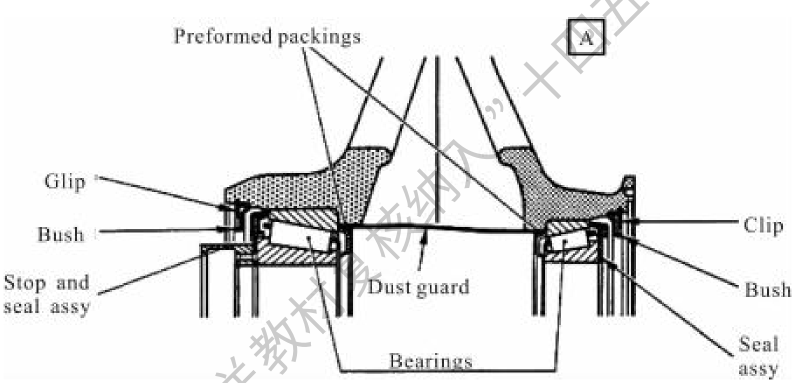


Figure 6.4 - 5 Taper roller bearing

The maintenance procedures of the wheels are very similar to the shock strut, it contains several major steps: testing, disassembly, check, repair, assembly and so on.[2]

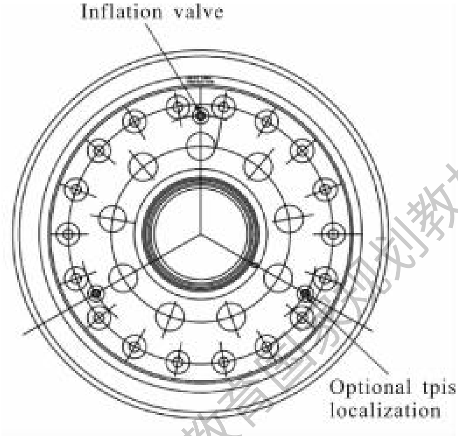


Figure 6.4 - 6 Installation holes location

6.4.4 Testing and Fault Isolation

In order to prevent the leakage of the tire during operation, we have to do a leakage test. This test is to check the leakage situation of the pressure indicator valves and the fusible plugs. The test procedure must be carried out after fitment of the tire.

First, check the pressure indicator valve. Connect a dry air or nitrogen supply to this end of the pressure indicator valve, supply the pressure indicator valve with a pressure of 5 to 7 psig, and then disconnect the air or nitrogen supply. Immerse the pressure indicator valve in water and examine it for external leakage through the absence of bubbles. A slight leakage at the valve core is permissible. It shall not exceed 3 bubbles per minute after the first minute of immersion. And then repeat the former operations with the pressure indicator valve supplied with a pressure of 200 psig.

Second, check the fusible plug. Apply silicone grease or vaseline grease to the preformed packings. Install the fusible plug on test tool. Tighten the fusible plugs with a correct torque loading. Supply the test tool with nitrogen at a pressure of 250 psig. After stabilization, adjust the pressure to maintain 250 psig. Check, after a 3-minute period, that there is no pressure drop, and then apply a soapy solution to the fusible plug to detect leaks. On completion of this check, release the pressure and rinse off the soapy solution with water.

If the leakage exceeds the allowed limits during the test, we must take a certain solution. If the leak is caused by the failure of the packing or seal, we must replace the packing or seal. If the leak is caused by the failure of the pressure indicator valve or fusible plug, we have to discard it and replace a new one.

6.4.5 Disassembly

Before disassembling the wheel, a very important step is to deflate the tire. Otherwise, injury to person or equipments could occur from sudden ejection of parts. When deflation is completed, remove basic components like fusible plugs, valves, bearing cones, clips and so on from the wheel. And then, disassemble the half-wheel assemblies.

Break the bond of the tire beads to the flange with a tire removal press. Release and loosen nuts in a criss-cross sequence. If a bolt is broken, discard it. Do an NDT inspection of the 17 remaining bolts before discarding the 2 bolts which are on each side of the broken bolt. If there is more than one broken bolt, discard all the bolts. Remove nuts, bolts and washers. And then remove a half-wheel assembly the tire.

Then, we could remove of the components of inner and outer half-wheel assembly, for example: drive blocks, heat shields from inner half-wheel, bearing cups and balance weights from both inner and outer half-wheel. Be careful that before removing the balance weights make a record of its location and its weight.

6.4.6 Cleaning

Before the cleaning of parts, remove all their preformed packings. Carefully clean the blending area between the bead seat and the rim to remove any remaining grease and rubber particles. Clean the surfaces on which there is MASTINOX with the chlorinated solvent trichloroethane or methyl ethyl ketone. clean all the parts with white spirit and then dry them with dry compressed air.

When cleaning the valve, do not immerse the valve in the cleaning mixture. Thoroughly clean the threads of wheel and inflation valve to remove contaminants. Uses LOCTITE chisel 790 (or equivalent) to remove old LOCTITE residue. Rinse with cold, clean water and permit to dry. Clean the external surface of the valve with a piece of cloth soaked in liquid.

6.4.7 Check

Do the general inspection procedures of the wheel shown in the "Recommended Inspection Procedure Schedule" (see Figure 6.4－7). The fundamental inspection methods include (see Figure 6.4－8): visual inspection, penetrant inspection, eddy current inspection, metallurgical inspection. Specific inspection methods have been introduced in the previous section.

Manufacturer recommends to do the general inspection of the wheel every 5/7 tire replacements. Do the same inspections at every 5/7 tire replacements on a wheel which had a tire that burst or deflate during landing and/or take-off roll. Discard half-wheels that show signs of a rolling touch with the runway.

PART	INSPECTION PROCEDURE	TIRE REPLACEMENTS					*
		1	2	3	4	5/7	
HALE -WHEEL	VISUAL INSPECTION:						
	–TIRE BEAD SEAT AREAS	×	×	×	×	×	×
	–RIM	×	×	×	×	×	
	–AIR VENT HOLES	×	×	×	×	×	
	–TIE BOLT HOLES AND SPOT FACING AREAS	×	×	×	×	×	
	–DRIVE BLOCKS	×	×	×	×		×
	–DRIVE KEY AREAS					×	×
	–TAPPED HOLES (FUSIBLE PLUGS, PLUGS AND VALVES OR PRESSURE INDICATOR VALVES)					×	×
	–BEARING CUPS	×	×	×	×		×
	–BEARING CUP HOUSINGS (IF REMOVED)					×	×
	–WORN AREAS PAINT	×	×	×	×	×	
	EDDY CURRENT INSPECTON:						
	–TIRE BEAD SEAT AREAS	×	×	×	×	×	×
	–DRIVE KEY AREAS					×	×
	–AIR VENT HOLES					×	×
	–TIE BOLT HOLES AND SPOT FACING AREAS					×	×
	DIMENSIONAL CHECK –BUCKLING AND OUT OF ROUNDNESS					×	×
	CONDUCTIVITY(IACS) AND HARDNESS TEST						×
	PENETRANT PROCEDURE (SECTION 38 OR 39 OF MANUAL 32-09-01)					×	×

*:SIGNS OF OVERHEATING (FUSIBLE PLUGS MELTED, DISCOLORATION OF WHEEL SURFACE) OR DOUBT.

Figure 6.4－7　Recommended inspection procedure schedule (excerpt part)

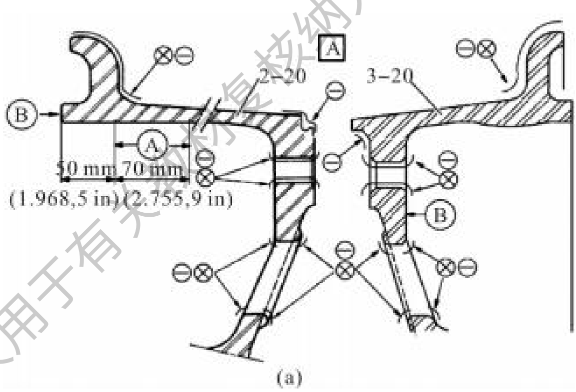
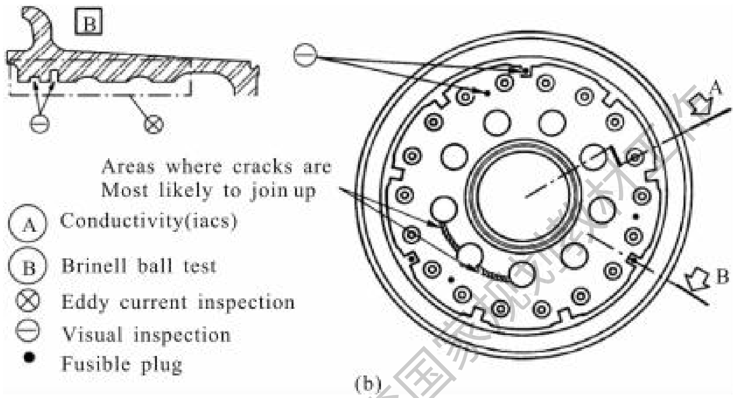


Figure 6.4－8　Areas of inspected



Continued Figure 6.4-8　Areas of inspected

6.4.8　Typical Repair

Corrosion removing is a very important task of wheel repairing. To remove deep corrosion, rub the damaged surfaces with an abrasive stone or a glassfiber brush. Be careful to keep the minimum or maximum dimensions (external or internal diameter) in the permitted limits, when this work is done on a mating part. Remove light signs of corrosion chemically. Make sure that the corrosion is not so large that it will cause a decrease in the strength of the part.[3]

Please pay attention to the application of an anti-corrosive protection to the parts before any permanent protection, machining or assembly. You can easily remove this protection with white spirit.

If some small defects are inspected in checking, we have to repair it. Remove the operation marks, scores, scratches, hit damage and peening marks without the aid of a machine tool (lapping, scraping, use of stones, files or abrasive cloth). Keep the minimum or maximum dimensions in the permitted limits. Make smooth all sharp corners.

For the important task of repair, we must use the adapted machine tool for the approved and important remachining tasks.

(1) Typical repair task one: Repair of half-wheels.

To remove light signs of corrosion or of hit damage, rework the surfaces where necessary. Be careful to keep the dimensions in the limits specified on Figure 6.4-9 and Figure 6.4-10. The maximum depth of rework on all the surface of the wheel is 0.5 mm, but you must keep the dimensions in the limits given on the figures.

We can remove corrosion by the use of a chemical procedure. Rub with a swab soaked in a mixture made up of DEOXIDINE and pumice powder, diluted to 50%, in water. Rinse in running water. Do the rework with a smooth file or a machine tool. Finish off with 400-grit aluminium oxide or silicon oxide abrasive cloth or paper. Make smooth any sharp edges of the reworked areas.

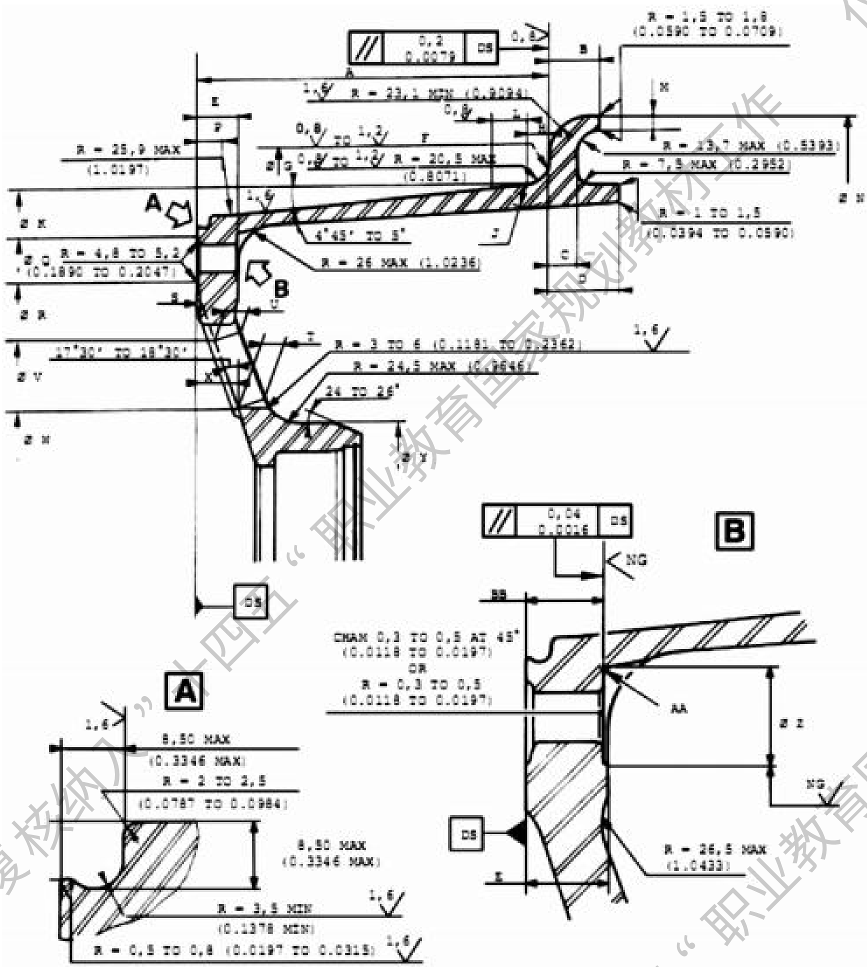


Figure 6.4－9　Repair of half wheel

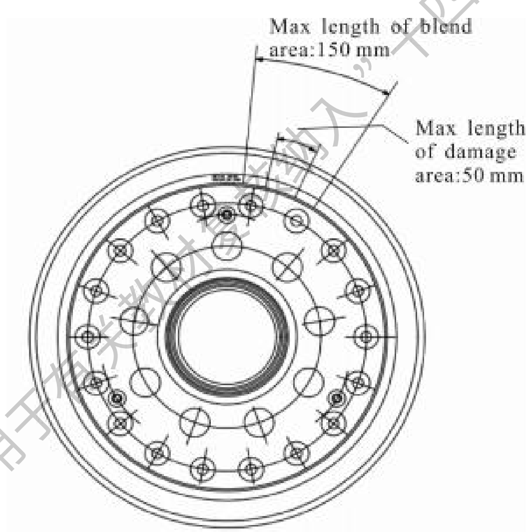


Figure 6.4－10　Repair of C flange，limit repair area

(2) Typical repair task two: Repair of the housings of fusible plugs in the inner half-wheel.

First, machine the hole to the dimensions shown on the figure. Then, apply the protective treatment. And last, install a union and a preformed packing (see Figure 6.4 - 11).

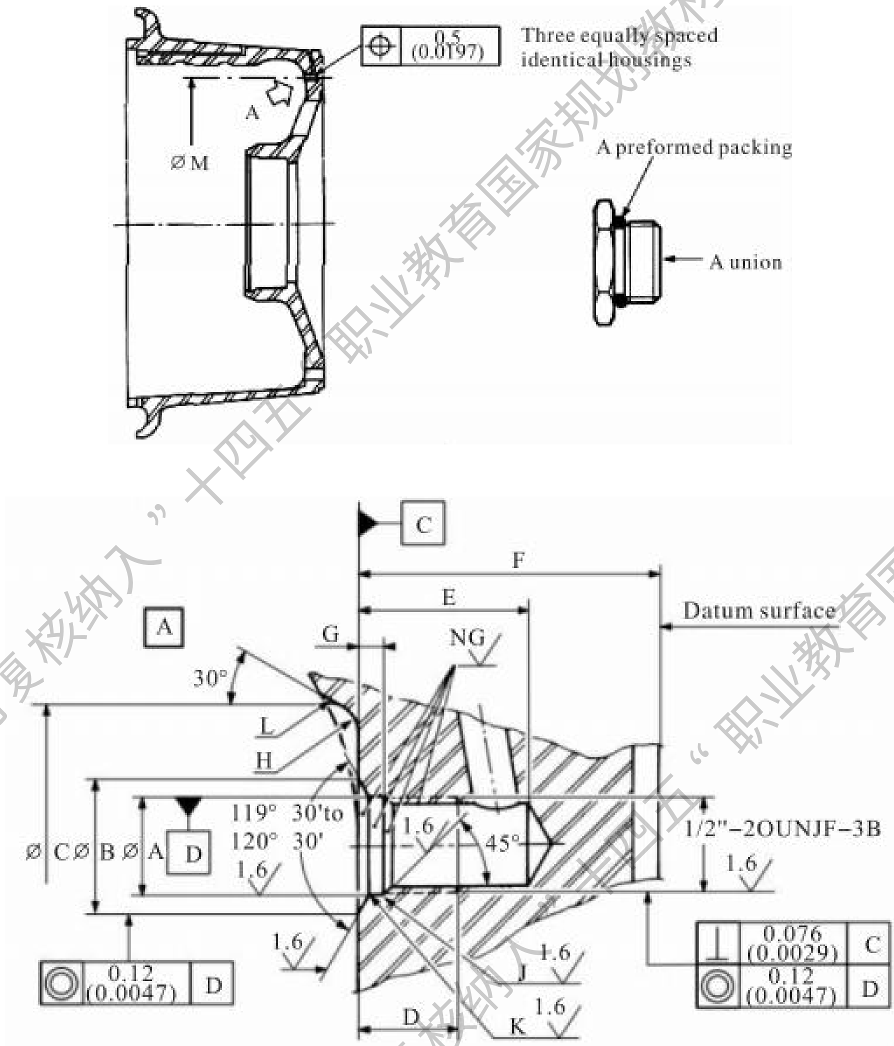


Figure 6.4 - 11　Repair of the housings of fusible plugs

6.4.9　Assembly

After checking and repairing, all the components should be assembled together. We must clean and dry the parts, lubricate the parts or apply to them the protective treatment.

Then assemble the components to the inner half-wheel, including bearing cup and fusible plugs. We must do the leakage test of the fusible plugs before installation on the half-wheel. Lubricate the parts as shown (see Figure 6.4 - 12).

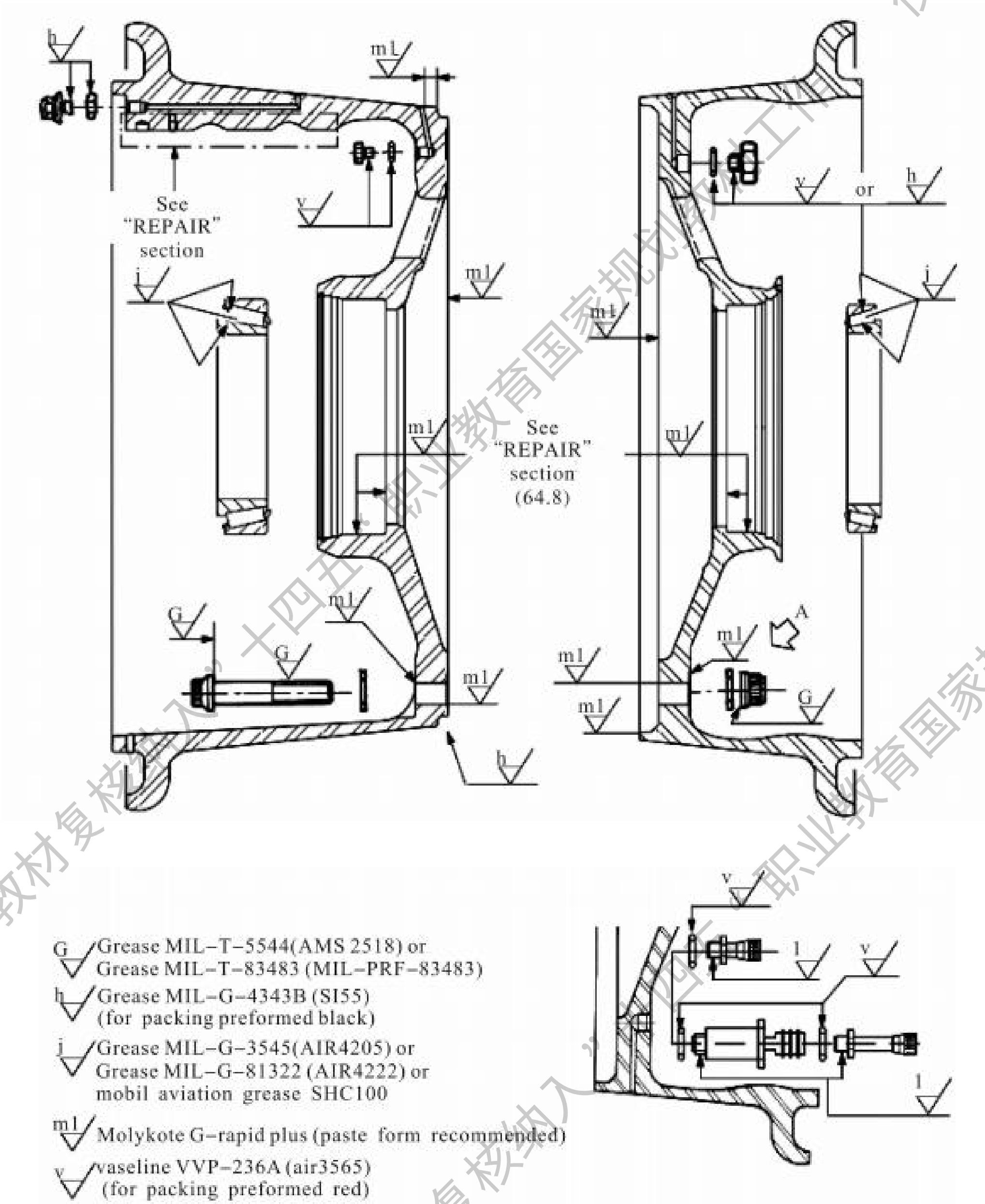


Figure 6.4 - 12 Protective treatment and lubrication

Install preformed packings on fusible plugs and put the fusible plugs in position. We must tighten the fusible plugs with a torque loading between 9 and 10 N·m (6.6 and 7.4 lbf·ft). Install the drive blocks, bearing cone and the stop and seal assembly.

Next, we assemble the components to the outer half-wheel, including bearing cup, plugs and valves.

After balancing the half-wheels, we should install the balance weights to the wheels (see Figure 6.4 - 13). Drill the hole for the attachment of the balance weight. Apply a protective coating with Alodine 1200 into the hole. Put in position the balance weights, install screws, washers and nuts in position. Mark the mass (in grams) of the balance weight where it is installed.

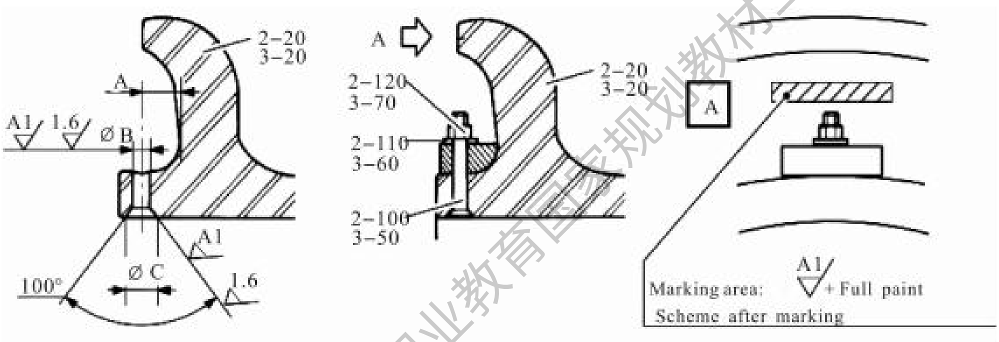


Figure 6.4 - 13 Installation of balance weights

Next install the heat shields. Put heat shields in position between drive blocks. Attach heat shields with threaded fasteners (see Figure 6.4 - 14).

The last, assemble outer and inner half-wheel together, with threaded fasteners. Then we have to do an inflation test, make sure that the aircraft wheels are available and no leakage occurs.

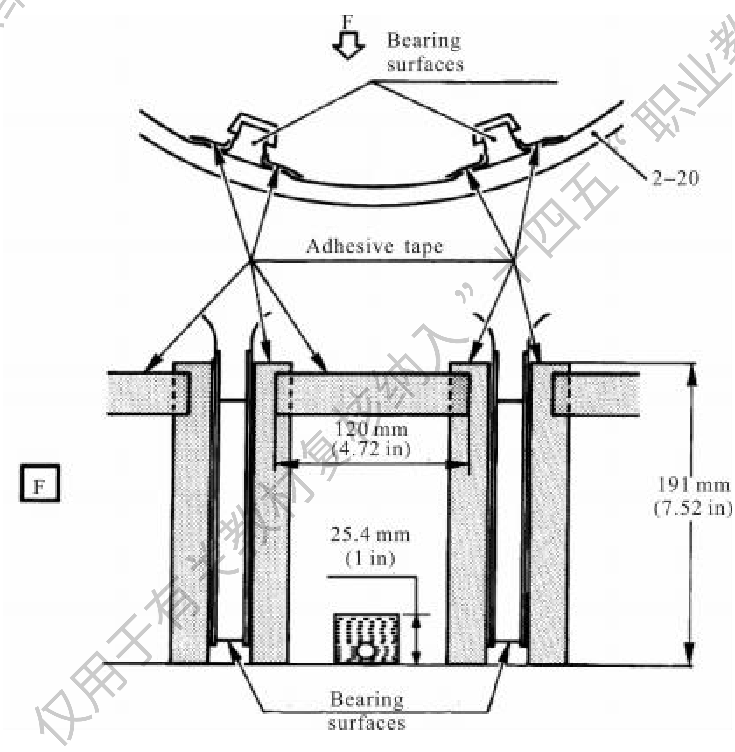


Figure 6.4 - 14 Install the heat shields

New Words/ Phrases/ Expression

1. forge[fɔːdʒ] *vi.*, *vt.* 锻制，锻造
2. cyclic ['saiklik; 'siklik] *adj.* 周期的，循环的
3. catastrophic [ˌkætə'strɔfik] *adj.* 灾难的，惨重的
4. drive key 驱动键
5. heat shield 隔热板，隔热片
6. thermal fuse plug 热熔塞
7. melt [melt] *vi.*, *vt.* 熔化，溶解；逐渐融合
8. tubeless [tjuːbles] *adj.* 无内胎的
9. drive block 驱动块，驱动键
10. immerse [i'məːs] *vt.* 浸没
11. permissible [pə'misəbl] *adj.* 可允许的；得到准许的
12. rinse [rins] *vt.* 漂洗，冲洗
13. tire bead 胎缘，胎底
14. sequence ['siːkwəns] *n.* 数列，序列；顺序
15. rim [rim] *n.* 边，缘，框；轮缘
16. contaminant [kən'tæmənənt] *n.* 污物，残留物
17. residue ['reziˌduː; -ˌdjuː] *n.* 残余，残渣
18. pumice powder 浮石粉
19. aluminium oxide 氧化铝
20. silicon oxide 二氧化硅

Notes

【1】Aircraft wheels are made from either forged aluminum or magnesium alloys.

分析："made from"和"made of"都表示"由……制造"，区别在于"made from"表示看不出原材料，"made of"则表示可以看出原材料。"either…or"表示"不是……就是……"，这个词组的否定表达为"neither…nor"，意为"既不……也不……"。

翻译：飞机机轮是由锻造铝合金或者镁合金制成。

【2】The maintenance procedures of the wheels are very similar to the shock strut, it contains several major steps: testing, disassembly, check, repair, assembly and so on.

分析："be similar to"表示"与……类似"。

翻译：机轮的修理流程与减震支柱的修理流程非常相似，它包含了几个主要步骤——测试、分解、清洗、检查、修理以及组装等。

【3】Make sure that the corrosion is not so large that it will cause a decrease in the strength of the part.

分析：此句"make sure that"后接的宾语从句中包含了一个"so…that"的句型。

翻译：确保腐蚀的范围不会大到足以降低此部件的强度。

Exercises

Ⅰ. Answer the following questions:

1. What's the affects of the aircraft wheels?
2. What factors led to the failure of the aircraft wheels?
3. What are procedures of the wheel repair?

Ⅱ. Translate the following sentences into Chinese:

1. Aircraft wheels are removed frequently for tire changes, inspections, and lubrication. Familiarity with various types of wheels and tires, and related components, will improve your ability to perform your duties.

2. In order to prevent the leakage of the tire during operation, we have to do a leakage test. This test is to check the leakage situation of the pressure indicator valves and the fusible plugs. The test procedure must be carried out after fitment of the tire.

Ⅲ. Fill in the following blanks according to the text:

1. The B737 is supported during landing, takeoff, and ground operations on ________ wheel and ________ tire assemblies. ________ are on the main landing gear and ________ on the nose landing gear. Each main wheel is provided with a ________ bolted to a flange on the axle.

2. Break the bond of the tire beads to the flange with a tire removal press. Release and loosen nuts in a ________ sequence. If a bolt is broken, ________ it. Do an ________ inspection of the ________ remaining bolts before discarding the ________ bolts which are on each side of the broken bolt. If there is more than ________ broken bolt, discard ________ bolts. Remove nuts, bolts and ________. And then remove a half-wheel assembly the tire.

6.5　Aircraft Brakes

6.5.1　General

Aircraft brakes are used to slow down the forward speed of the aircraft on the ground. The brakes are multiple disc type. Each brake is provided with pistons which actuate the brakes when hydraulic pressure is applied, causing the rotors and stators to compress and creating friction, thus stopping the aircraft. The brakes are also provided with combination return springs and automatic adjusters. The automatic adjusters compensate for brake wear.

6.5.2　Steel Brake Assembly of the Boeing 737

B737's brake assembly mainly uses two company's products, BENDIX brakes and GOODRICH brakes (see Figure 6.5-1, Figure 6.5-2). The two products are slightly different in details, but the braking principle are the same.

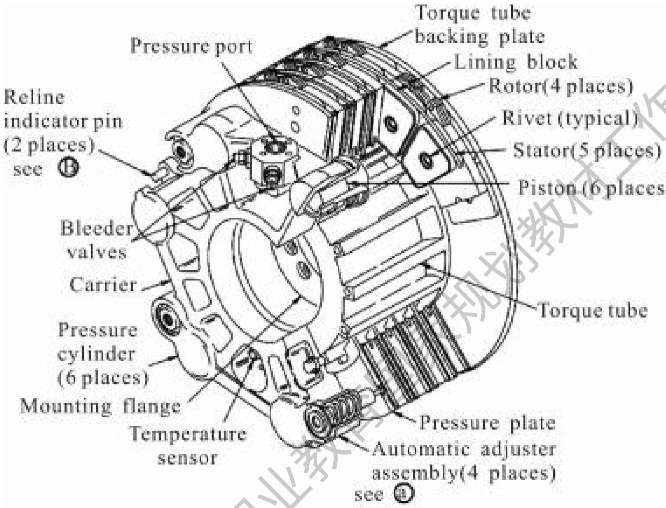


Figure 6.5-1 BENDIX brake

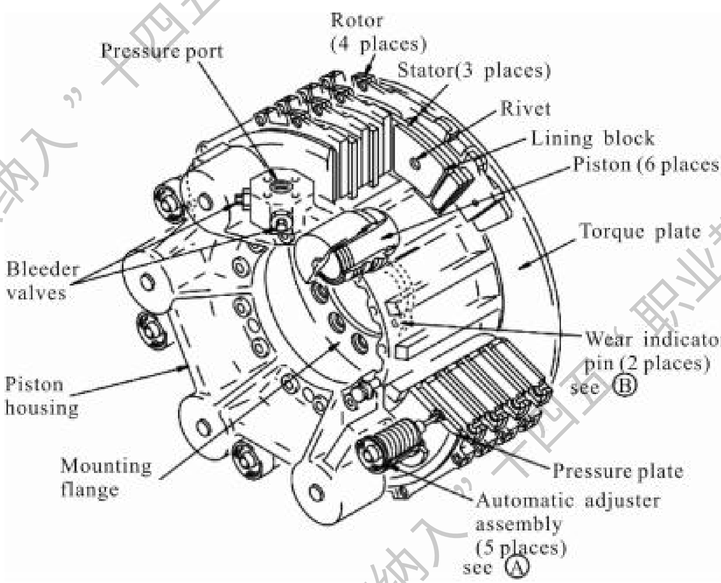


Figure 6.5-2 GOODRICH brake

The brake assembly is a rotor-stator unit that operates using hydraulic pressure. The assembly uses multiple steel discs as rotors and stators.

Tire to surface friction force for halting the aircraft is controlled through the application of hydraulic pressure to the multidisc brake. Rotors coupled to wheel/tire assemblies and stators attached to gear structure are pressed together by the action of hydraulic pistons causing the frictional force required to halt the aircraft. Automatic adjustment assemblies maintain correct brake element clearances. Wear indicators give visual warning of time to overhaul brakes. Hydraulic bleed ports are provided to assist in the overhaul.

Each main landing gear wheel brake has these components (see Figure 6.5-3):

- Stators;
- Rotors;
- Pressure plate;
- Piston;
- Adjusters;
- Axle bushings;
- Wear indicator pins;
- Brake hose connection;
- Hydraulic bleed port.

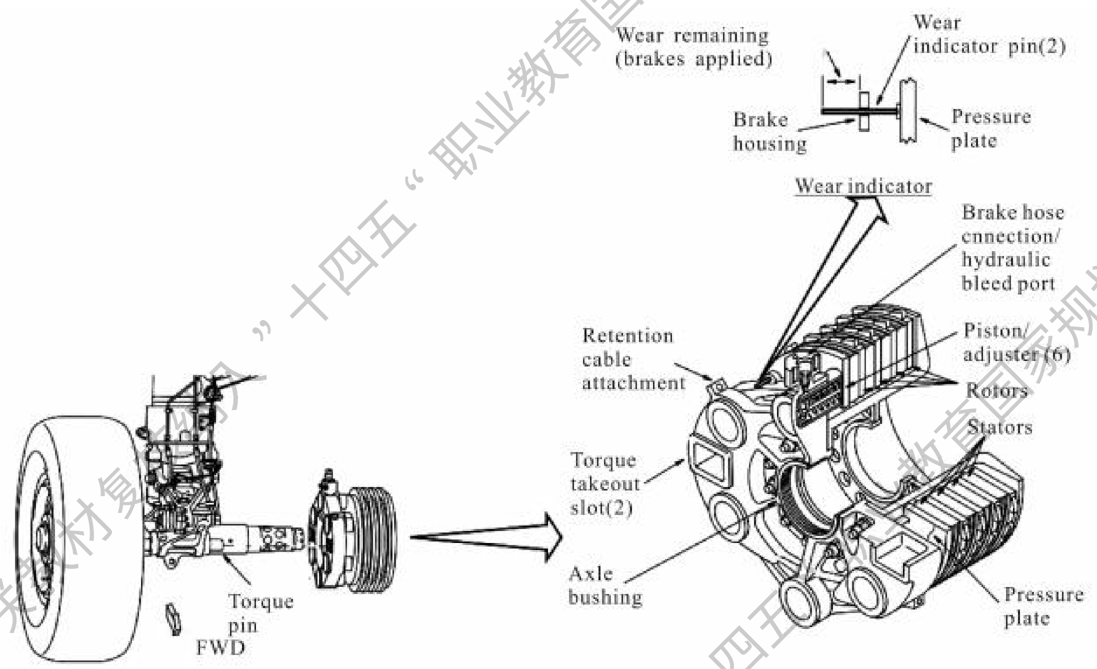


Figure 6.5-3

6.5.3 Typical Carbon Brake Introduction

The brake assembly installed on the A320 airplane is manufactured by Messier-Bugatti, it is a kind of carbon brake (see Figure 6.5-4). This brake assembly has two sets of independent operation system, called "NORMAL" and "EMERGENCY". This is to ensure safety, if the normal system fails, the standby (emergency) system can still work. Friction between the stator assemblies and rotor assemblies causes the carbon brake to operate.

The input of the hydraulic fluid pressure into a set of seven pistons compresses the stator assemblies and the rotor assemblies together and thus causes friction. The nine pins and three bolts installed in the torque tube transfers the braking torque to the landing gear. The thermocouple installed through the complete hydraulic crown and into a spline of the torque tube assembly, is the sensing element of the monitoring system for the carbon brake temperature.[1] The thermocouple supplies an electrical resistance which changes with the heat released on brake application.

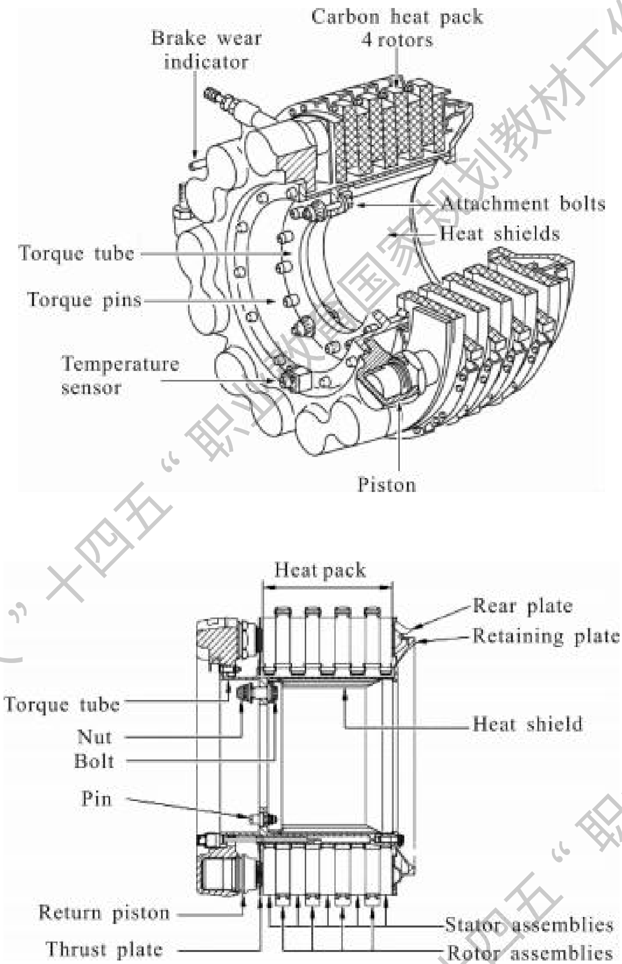


Figure 6.5 - 4 Carbon brake

The carbon brake has these components (see Figure 6.5 - 5):

- A complete hydraulic crown;
- A torque tube assembly;
- A thrust plate;
- A heat pack;
- A retaining plate.

The complete hydraulic crown has fourteen return pistons, two hydraulic fitting assemblies and two valves. It is made of forged aluminum alloy, has two systems which operate independently ("NORMAL" and "EMERGENCY" systems).[2] Each system has a hydraulic fitting assembly, a valve which is connected to seven piston cavities (see Figure 6.5 - 6).

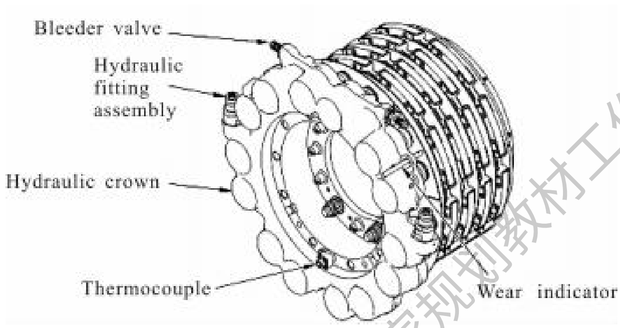


Figure 6.5 - 5 Carbon Brake Assembly

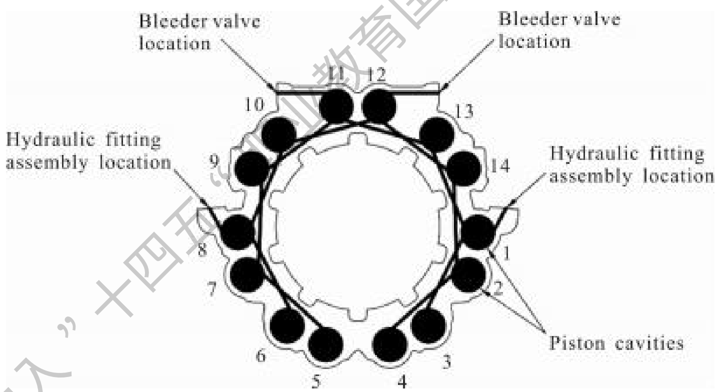


Figure 6.5 - 6 Dual system of the brake

The thrust plate, assembled with the insulating washers, transmits the force applied by the pistons to the heat pack. The retaining plate is installed at the end of the torque tube assembly. The retaining plate, together with the rear plate prevents translatory motion of the heat pack. The heat pack has four rotor assemblies, three central stator assemblies, and two lateral stator assemblies. The rotor clips on the rotors prevent damage to carbon when the drive keys in the wheel cause the rotor assemblies to turn. The stator clips installed on the stators prevent damage to carbon caused by the splines of the torque tube when you operate the carbon brake (see Figure 6.5 - 7).

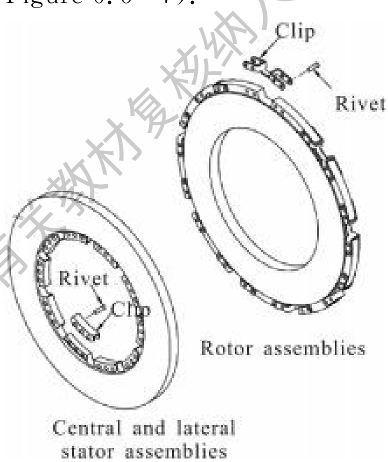


Figure 6.5 - 7 Heat pack parts

6.5.4 Typical Carbon Brake Repair Procedure

A carbon brake is possibly sent to the repair shop for the two causes that follow:

(1) Full wear of the heat pack with a life extension shim installed (the wear indicators are aligned "flush" with the complete hydraulic crown).

(2) Deterioration/Failure caused by:

- Hydraulic leakage;
- Overheating caused by a rejected take-off;
- Overheating caused by a dragging brake.

The first step of repair procedure is testing. Apply a pressure of 2,100 psig to one of the two circuit of the carbon brake. Measure the length of the wear indicators. If the end of the wear indicators are aligned "flush" with the complete hydraulic crown and that a life extension shim is installed, the heat pack is fully worn (see Figure 6.5-8). And then, do a low pressure leakage test and a high pressure leakage test, make sure that there is no external leakage and no pressure drop. If a set of new heat pack is replaced, we have to adjust the wear indicators.

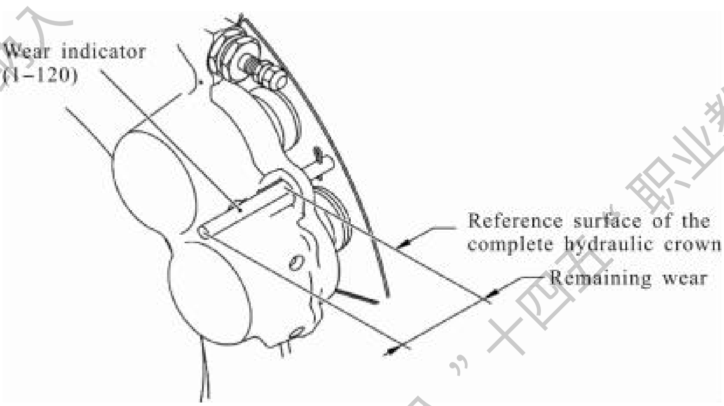


Figure 6.5-8 Measurement of the remaining length of the wear indicators

The second step is disassembly. After measuring the wear indicator, drain the brake assembly. Remove the thermocouple and the heat pack. Pay attention that removing the components one after another. Discard lockwire and cotter pins. If the heat pack is not fully worn, do not discard the wear indicators. Use them again with the same heat pack.

The third step is cleaning. Clean the heat pack parts, thermocouple, metal and non-metal parts refer to the SOPM. Then, remove paint from the hydraulic crown, from the torque tube and from the retaining plate.

The fourth step is inspection. After disassembling and cleaning the brake, we must do some inspection of the components (see Figure 6.5-9).

PART	INSPECTION PROCEDURE	CYCLES				*
		1	2	3	4	
Hydraulic crown (2-380)	Visual inspection	X	X	X	X	X
	Penetrant inspection				X	X
	Conductivity test (IACS)					X
	Hardness test					X
Torque tube (1-310) together with its pins (1-370)	Visual inspection	X	X	X	X	X
	Magnetic particle inspection				X	X
	Hardness test					X
Bolts (1-070)	Visual inspection	X	X	X	X	X
Retaining plate (1-060)	Visual inspection	X	X	X	X	X
	Magnetic particle inspection				X	X
	Hardness test					X
Return pistons (2-110)						
- Liner (2-320)	Visual inspection		X		X	X
- Piston (2-260)	Visual inspection		X		X	X
- Adjuster pin (2-180)	Visual inspection		X		X	X
	Magnetic particle inspection				X	X
- Guide (2-210)	Dimensional check		X		X	X
- Spring (2-220)	Compression check				X	X
Thrust plate (1-130)**	Visual inspection	X	X	X	X	X
	Dimensional check				X	X
	Penetrant inspection				X	X

Figure 6.5－9 Parts inspection procedure

One cycle represents full wear of the heat pack with a life extension shim installed. "*" represents signs of overheating (caused by a rejected take-off or a dragging brake) or after a rejected take-off. "* *" represents do a visual inspection before the installation of a life extension shim and at each cycle (see Figure 6.5－10).

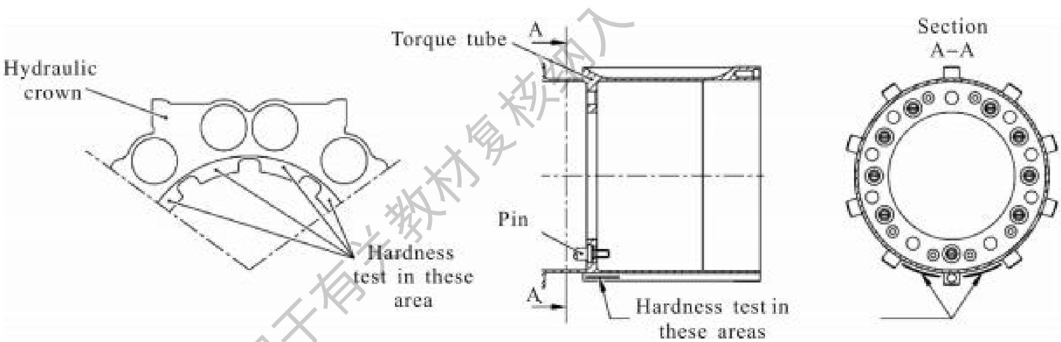


Figure 6.5－10 Hardness tests

The fifth step is repair. There are two typical repair procedures introduced as follow.

(1) Repair of the hydraulic crown. Remove corrosion from the piston cavities, from the

mounting holes, from the mounting faces of the hydraulic fitting assembly and the valve. The general procedure of the repair is: Mask the threaded holes and the surfaces that do not have corrosion. Remove corrosion [maximum depth of the repair: 0.5 mm (0.020 in)] from the mounting faces of the hydraulic fitting assembly and the valve with a large-grit abrasive paper (#400 or #600). Apply a chemical oxidizer to locally repair the protection. Restore the surface protection on the mounting faces of the hydraulic fitting assembly and the valve. Remove the mask material from the repaired area (see Figure 6.5-11).

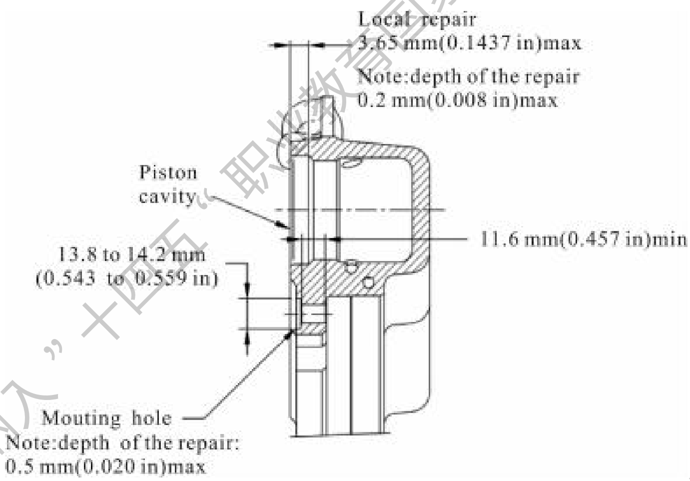


Figure 6.5-11　Repair of the hydraulic crown

(2) Repair of the thrust plate. Counter-drill the existing stress-relief hole from which the crack starts to a diameter of between 7 and 7.5 mm (0.27 and 0.295 in). If you do not remove the crack fully, drill a stop hole as shown (see Figure 6.5-12). Remove the burrs.

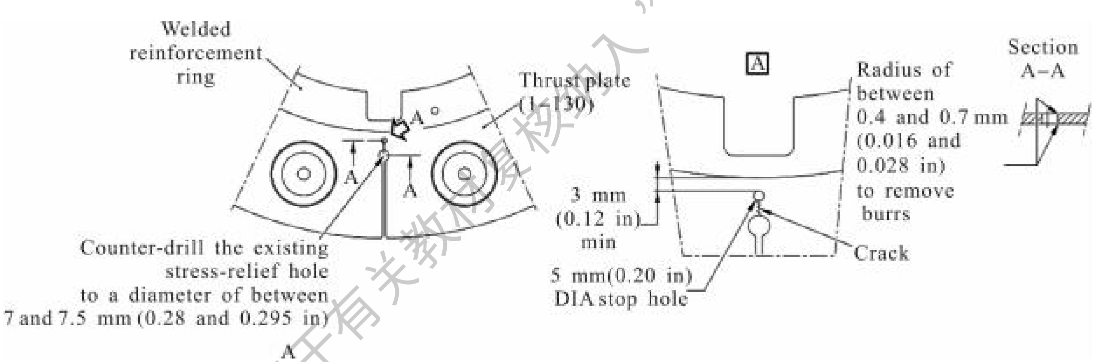


Figure 6.5-12　Repair of the thrust plate

The last step is assembly. Assemble all components in reverse order of the disassembly procedure (see Figure 6.5-13).[3]

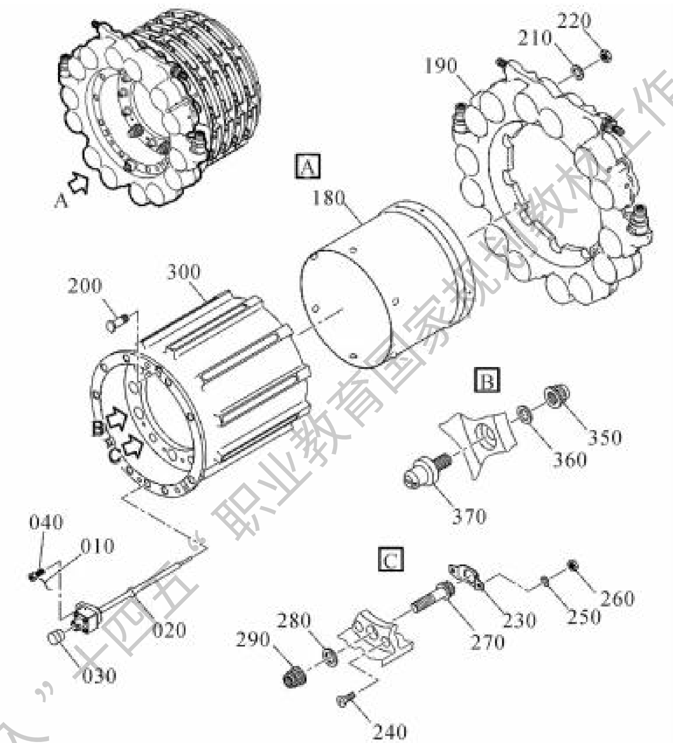


Figure 6.5 - 13 Assembly of the carbon brake

New Words/ Phrases/ Expression

1. stator ['steitə] *n.* 静盘
2. rotor['rəʊtə] *n.* 动盘
3. adjuster [ə'dʒʌstə] *n.* 调节器
4. wear indicator pin 磨损指示销
5. thermocouple['θəːməuˌkʌpl] *n.* 热电偶,温度传感器
6. spline [splain] *n.* 花键
7. thrust plate 推力盘
8. heat pack 热组件
9. translatory['trænslətəri] *adj.* 平移的,平动的
10. flush[flʌʃ] *adj.* 平齐的,等高的
11. counter drill 埋头钻

Notes

【1】The thermocouple installed through the complete hydraulic crown and into a spline of the torque tube assembly, is the sensing element of the monitoring system for the carbon brake temperature.

分析:第二个分句中“is”的主语是“the thermocouple”。

翻译:穿过刹车液压冠安装在扭力管组件中花键上的热电偶传感器是碳刹车温度监控系统的传感元件。

【2】It is made of forged aluminum alloy, has two systems which operate independently ("NORMAL" and "EMERGENCY" systems).

分析:此句中"has"的主语是前面的"it"。

翻译:由锻造铝合金加工而成的液压冠有两套相对独立工作的系统(正常系统和紧急系统)。

【3】Assemble all components in reverse order of the disassembly procedure (see Figure 6.5-13).

分析:"in reverse order"表示相反的顺序。

翻译:将所有部件按拆卸程序的相反顺序组装(见图 6.5-13)。

Exercises

Ⅰ. Answer the following questions:

1. What is the working principle of aircraft brakes?
2. What components does the brake system contain?
3. What are the differences between the typical steel brake and the carbon brake?

Ⅱ. Translate the following sentences into Chinese:

1. B737's brake assembly mainly uses two company's products, BENDIX brakes and GOODRICH brakes. The two products are slightly different in details, but the braking principle are the same.

2. This brake assembly has two sets of independent operation system, called "NORMAL" and "EMERGENCY". This is to ensure safety, if the normal system fails, the standby (emergency) system can still work. Friction between the stator assemblies and rotor assemblies causes the carbon brake to operate.

Ⅲ. Fill in the following blanks according to the text:

1. Aircraft brakes are used to slow down the ________ of the aircraft on the ground. The brakes are ________ type. Each brake is provided with pistons which actuate the brakes when ________ is applied, causing the ________ and ________ to compress and creating ________, thus stopping the aircraft. The brakes are also provided with combination ________ and automatic adjusters. The automatic adjusters compensate for ________.

2. The ________ step is disassembly. After measuring the wear indicator, drain the brake assembly. Remove the ________ and the ________. Pay attention that removing the components one after another. Discard ________ and ________. If the heat pack is not fully worn, ________ the wear indicators. ________ with the same heat pack.

Chapter 7
Aircraft Power Plant Maintenance

Chapter 7 Aircraft Power Plant Maintenance

7.1 Theory of Aircraft Engine

Aircraft power plant includes aircraft engines and systems and accessories necessary to ensure its operation, such as fuel system, oil system, ignition system, starting system, fire protection system and so on. The first powered flight in an airplane was made by the Wright brothers on December 17, 1903. From then on, aircraft engine as the power plant of aircraft, has developed more than 100 years.

7.1.1 Principles of Jet Propulsion

Newton's third law of motion states that for every action, there is an equal and opposite reaction. Jet propulsion applies this law by taking in a quantity of air and accelerating it through an orifice or nozzle.[1] The acceleration of the air is the action and forward movement is the reaction. In nature, a squid propels itself through the water using a form of jet propulsion. A squid takes sea water into its body and uses its muscles to add energy to the water, then expels the water in the form of a jet.[2] This action produces a reaction that propels the squid forward, as shown in Figure 7.1-1.

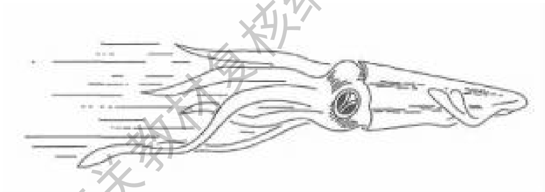


Figure 7.1-1 A squid

As early as 250 B.C., a writer and mathematician named Hero devised a toy that used the reaction principle. The toy, called the aeolipile, consisted of a covered kettle of water that was heated to produce steam. The steam was then routed through two vertical tubes and into a spherical container. Attached to the spherical container were several discharge tubes arranged radially around the container. As steam filled the container, it would escape through the discharge tubes and cause the sphere to rotate, as shown in Figure 7.1－2.

A more modern example of Newton's reaction principle is observed when the end of an inflated balloon is released. As the air in the balloon rushes out the opening, the balloon flies wildly around a room, as shown in Figure 7.1－3.

Figure 7.1－2 Hero's aeolipile

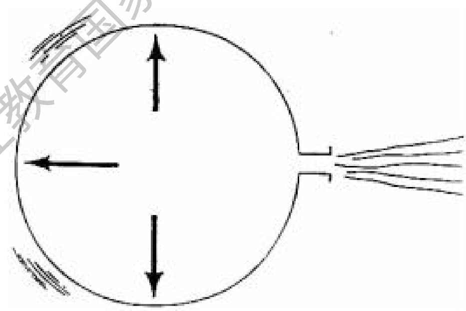


Figure 7.1－3 A released balloon

The acceleration and movement of a jet engine are caused by similar forces. In its simplest form, any jet engine draws in air, compress the air, heats it, and forces it out through a jet nozzle at a very high velocity.[3] As shown in Figure 7.1－4, the exhaust gases are forced out the nozzle (action), and those gases exert a force or thrust (reaction) on the engine and aircraft in a forward direction. It is a common misunderstanding that the escaping gases push on the air behind the engine to move the engine forward. The thrust does not come from the jet engine pushing against the air behind it, but from the forces exerted by the hot expanding gases produced within the engine.[4] The expanding gases push on the engine parts in sideways and forward directions, but since the back of the engine is just a large hole, no force can be exerted in a rearward direction. The engine moves in the direction of the unbalanced forces.

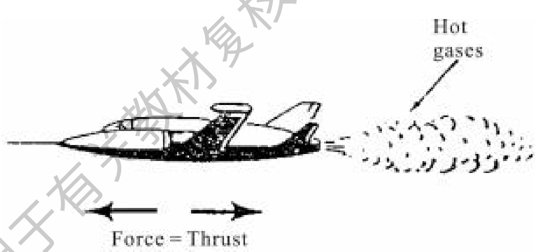


Figure 7.1－4 Newton's third law of motion

7.1.2 Types of Aircraft Engines

Aircraft engine is a heat engine that produces thrust (or pulling force) for aircraft. In the past more than 100 years, the main aircraft engines used by humans are basically classified as two types: piston engines and air jet engines, as shown in Figure 7.1－5. Piston engines and gas-turbine engines are most widely used in modern aircraft.

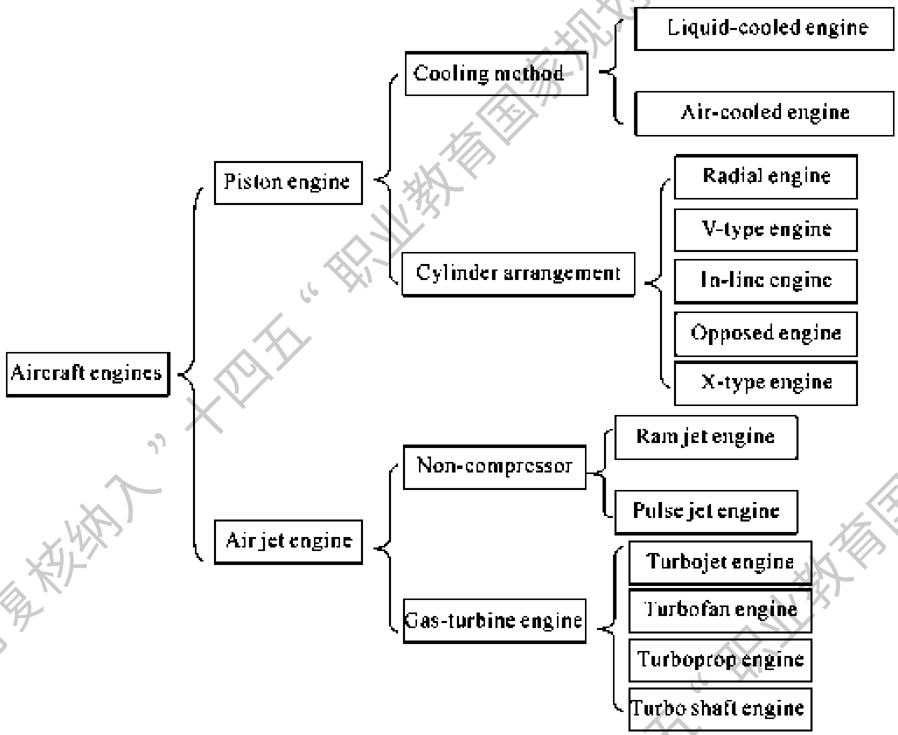


Figure 7.1－5　Classification of aircraft engines

7.1.2.1 Piston Engine

Piston engine is a form of heat engine that converts the chemical energy of fuel into mechanical energy by the reciprocating motion of the piston in the cylinder to complete the thermodynamic cycle.[5] The basic parts of a piston engine include the crankcase, cylinders, pistons, connecting rods, valves, valve-operating mechanism, and crankshaft, as shown in Figure 7.1－6.

The Otto-cycle piston engine is widely used as aircraft engines. Otto-cycle includes four strokes, they are: the intake stroke, the compression stroke, the power stroke, and the exhaust stroke. In a Otto-cycle engine, the crankshaft makes 2 revolutions for each complete cycle. During the intake stroke, the intake valve is open and the exhaust valve is closed, the piston moves from its top dead center(TDC) to bottom dead center(BDC), drawing the fuel-air mixture into the cylinder, and the intake valve closes; in the compression stroke, both valves are closed, the piston moves toward TDC, compressing the fuel-air mixture, and ignition takes place near the top of the stroke; in the power stroke, both valves are closed, the pressure of the expanding gases forces the piston toward BDC, and the exhaust valve opens well before the bottom of the stroke; during the exhaust stroke, the exhaust valve is open and the intake valve closed, the piston moves toward TDC, forcing the burned gases out through the open exhaust valve, and the intake valve opens near the top of the stroke and the cycle repeats. The four strokes of an Otto-cycle engine are illustrated in Figure 7.1-7.

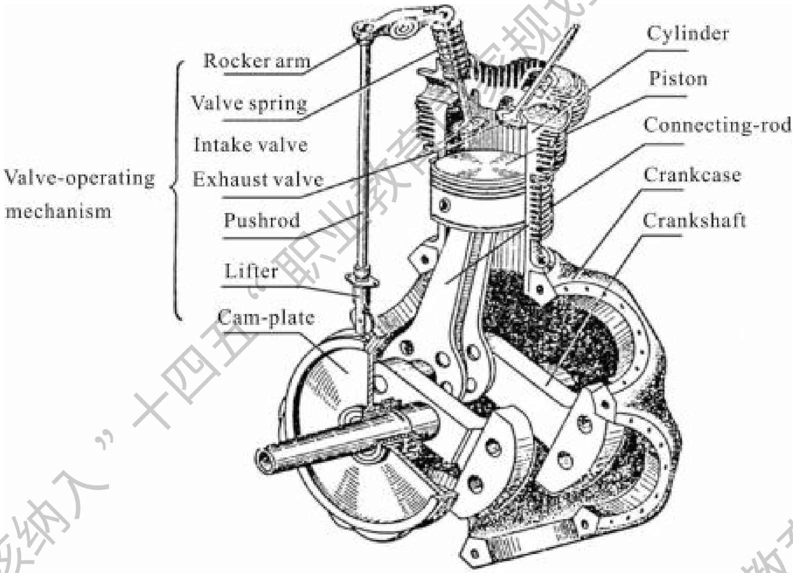


Figure 7.1-6 Basic parts of piston engine

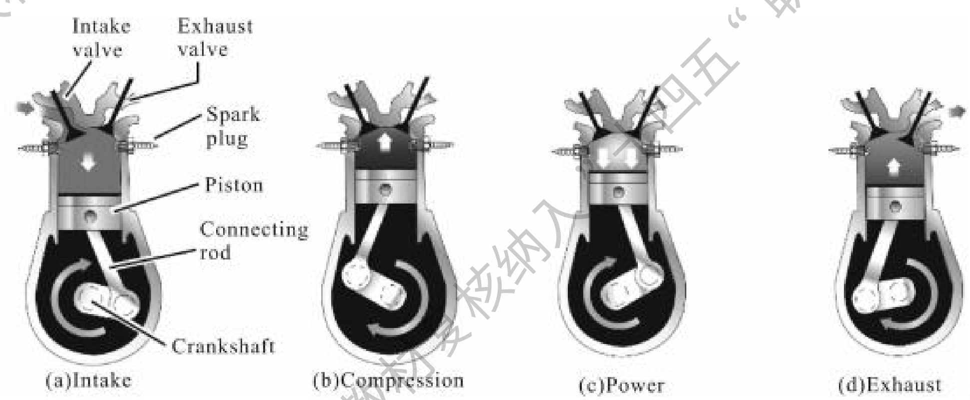


Figure 7.1-7 The four strokes of an Otto-cycle engine

7.1.2.2 Gas Turbine Engine

The basic operation of the gas turbine or turbojet engine is relatively simple. Air is brought into the front of the turbine engine and compressed, fuel is mixed with this air and burned, and the heated exhaust gases rush out the back of the engine. The parts of a turbojet engine work together to change fuel energy to energy of motion, to cause the greatest thrust for the fuel used. A basic turbine engine is illustrated in Figure 7.1-8.

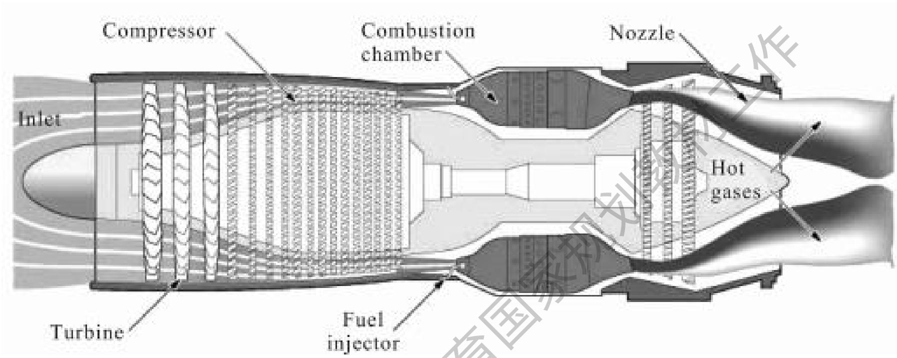


Figure 7.1-8 Major parts of a turbojet engine

A gas turbine engine has three major sections: an air compressor, a combustion section, and a turbine section. The engine may also be divided into the cold section and the hot section. The forward or front part of the engine contains the air compressor, which is the cold section. The combustion and turbine sections make up the hot section of the engine. The compressor packs several tons of air into the combustion chamber every minute and works somewhat like a series of fans. Then fuel is forced into the combustion chamber through nozzles, a spark provides ignition, and the mixture burns in a process similar to a blowtorch, creating hot exhaust gases. These gases expand and are ejected from the rear of the engine. As the gases leave, they drive a turbine which is located just behind the combustion chamber. By means of an interconnection shaft, the rotating turbine is connected to and turns the compressor, completing the cycle. After rushing by the turbine, the hot gases continue to expand and blast out through the exhaust nozzle at a high velocity, creating the force which propels a jet aircraft.[6]

The high-velocity jet from a turbojet engine may be considered a continuous recoil, imparting force against the aircraft in which it is installed, thereby producing thrust.[7] The formula for thrust can be derived from Newton's second law, which states that force is proportional to the product of mass and acceleration.

New Words/ Phrases/ Expression

1. power plant 动力装置
2. jet propulsion 喷气推进
3. orifice [ˈɔrifis] *n.* 孔；洞口
4. nozzle [ˈnɔzl] *n.* 喷管，喷嘴
5. squid [skwid] *n.* 乌贼，墨鱼
6. propel [prəˈpel] *vt.* 推进；推动
7. devise [diˈvaiz] *vt.* 设计；发明
8. aeolipile [iːˈɒləpail] *n.* 汽转球

9. kettle ['ketl] *n*. (烧水用的)壶；小汽锅
10. discharge [dis'tʃɑːdʒ] *vt*. 排出；放电
11. radially ['reidiəli] *adv*. 放射状地
12. inflate [in'fleit] *vt*.，*vi*. 使充气(于轮胎、气球等)
13. draw in 吸入
14. compress [kəm'pres] *vt*. 压缩
15. jet nozzle 尾喷管
16. thrust [θrʌst] *n*. 推力
17. ram jet engine 冲压式喷气发动机
18. pulse jet engine 脉冲式喷气发动机
19. piston engine 活塞发动机
20. gas turbine engine 燃气涡轮发动机
21. convert [kən'vɜːt] *vt*. 转化，转变
22. mechanical energy 机械能
23. reciprocate [ri'siprəkeit] *vi*. 往复运动
24. thermodynamic [ˌθɜːməʊdai'næmik] *adj*. 热力学的
25. crankcase ['kræŋkˌkeis] *n*. 曲轴箱
26. cylinder ['silində(r)] *n*. 气缸
27. piston ['pistən] *n*. 活塞
28. connecting rod 连杆
29. valve [vælv] *n*. 气门
30. valve operating mechanism 气门传动机构
31. crankshaft ['kræŋkʃɑːft] *n*. 曲轴
32. Otto-cycle ['ɔtəu'saik(ə)l] 奥托循环
33. stroke [strəʊk] *n*. 冲程；活塞行程
34. intake ['inteik] *n*. 进气
35. revolution [ˌrevə'luʃən] *n*. 圈，转
36. top dead center 上死点
37. bottom dead center 下死点
38. ignition [ig'niʃən] *n*. 点火；着火；燃烧
39. cold section 冷端
40. hot section 热端
41. compressor [kəm'presə(r)] *n*. 压气机
42. combustion chamber 燃烧室
43. turbine ['tɜːbain] *n*. 涡轮
44. fuel injector 燃油喷嘴
45. spark [spɑːk] *n*. 火花；电火花
46. mixture ['mikstʃə(r)] *n*. 混合气
47. blowtorch ['bləʊtɔːtʃ] *n*. 吹管，喷灯；喷气发动机

48. eject [i'dʒekt] *vt.* 喷出
49. interconnection [ˌintəkə'nekʃn] *n.* 相互连接
50. blast [blaːst] *vt.* 喷出
51. exhaust nozzle 排气喷管
52. recoil [ri'kɔil] *n.* 反作用;反冲力
53. formula ['fɔːmjələ] *n.* 公式
54. be proportional to 与……成正比
55. product ['prɔdʌkt] *n.* 乘积;产品;结果

Notes

【1】Jet propulsion applies this law by taking in a quantity of air and accelerating it through an orifice or nozzle.

翻译:喷气推进就是利用牛顿第三定律,吸入大量空气并让这些空气加速流过一个圆孔或喷管。

【2】A squid takes sea water into its body and uses its muscles to add energy to the water, then expels the water in the form of a jet.

翻译:乌贼将海水吸入体内,并利用肌肉给海水增加能量,然后将海水以喷射的方式排出体外。

【3】In its simplest form, any jet engine draws in air, compress the air, heats it, and forces it out through a jet nozzle at a very high velocity.

翻译:用最简单的方式,喷气式发动机吸入空气并将其压缩、加热,同时让空气流经喷管以高速向后喷出。

【4】The thrust does not come from the jet engine pushing against the air behind it, but from the forces exerted by the hot expanding gases produced within the engine.

翻译:推力并非由喷气式发动机推动其后部空气所产生,而是由发动机内部燃气的热膨胀所产生。

【5】Piston engine is a form of heat engine that converts the chemical energy of fuel into mechanical energy by the reciprocating motion of the piston in the cylinder to complete the thermodynamic cycle.

翻译:活塞发动机是热机的一种,通过气缸内活塞的往复运动,将燃油的化学能转化为机械能,从而完成热力循环。

【6】After rushing by the turbine, the hot gases continue to expand and blast out through the exhaust nozzle at a high velocity, creating the force which propels a jet aircraft.

翻译:流过涡轮后的高温燃气在尾喷管中继续膨胀并以高速向后排出,从而产生推动飞机的推力。

【7】The high-velocity jet from a turbojet engine may be considered a continuous recoil, imparting force against the aircraft in which it is installed, thereby producing thrust.

翻译:从涡喷发动机排出的高速喷射流可看作是一个连续的反作用力,给安装发动机的飞机一个力,这样就产生了推力。

Exercises

Ⅰ. Answer the following questions:

1. Which law does jet propulsion apply?
2. How does the jet engine produce thrust?
3. What are the four strokes of the Otto-cycle?
4. Which three major sections does a gas turbine engine have?
5. What is the compressor turned by?

Ⅱ. Translate the following sentences into Chinese:

1. Aircraft power plant includes aircraft engines and systems and accessories necessary to ensure its operation, such as fuel system, oil system, ignition system, starting system, fire protection system and so on.

2. A more modern example of Newton's reaction principle is observed when the end of an inflated balloon is released. As the air in the balloon rushes out the opening, the balloon flies wildly around a room.

3. The exhaust gases are forced out the nozzle (action), and those gases exert a force or thrust (reaction) on the engine and aircraft in a forward direction.

4. Then fuel is forced into the combustion chamber through nozzles, a spark provides ignition, and the mixture burns in a process similar to a blowtorch, creating hot exhaust gases. These gases expand and are ejected from the rear of the engine.

5. By means of an interconnection shaft, the rotating turbine is connected to and turns the compressor, completing the cycle.

Ⅲ. Fill in the following blanks according to the text:

1. Newton's third law of motion states that for every action, there is an ________ and reaction.

2. The expanding gases push on the engine parts in ________ and ________ directions, but since the ________ of the engine is just a large hole, no force can be exerted in a rearward direction.

3. The basic parts of a piston engine include the ______, ______, ______, ________, ________, and ________.

4. During the intake stroke, the intake valve is ______ and the exhaust valve is ______, the piston moves from its ________ to ______, drawing the fuel-air mixture into the ______, and the intake valve ________.

5. The engine may also be divided into the cold section and the hot section. The forward or front part of the engine contains the ________, which is the cold section. The ________ and sections make up the hot section of the engine.

7.2 Types of Gas Turbine Engines for Aircraft

Gas turbine engines come in various mechanical arrangements. Aircraft turbine engines can generally be classified into four types of engines: turbojet, turbofan, turboprop and turboshaft. The basic components of all these engines are essentially the same: a compressor, a combustion chamber, a turbine to drive the compressor, and an exhaust nozzle. The difference lies in the type and arrangements of these components. The mechanical arrangements of various types of gas-turbine engines are shown in Figure 7.2 - 1.

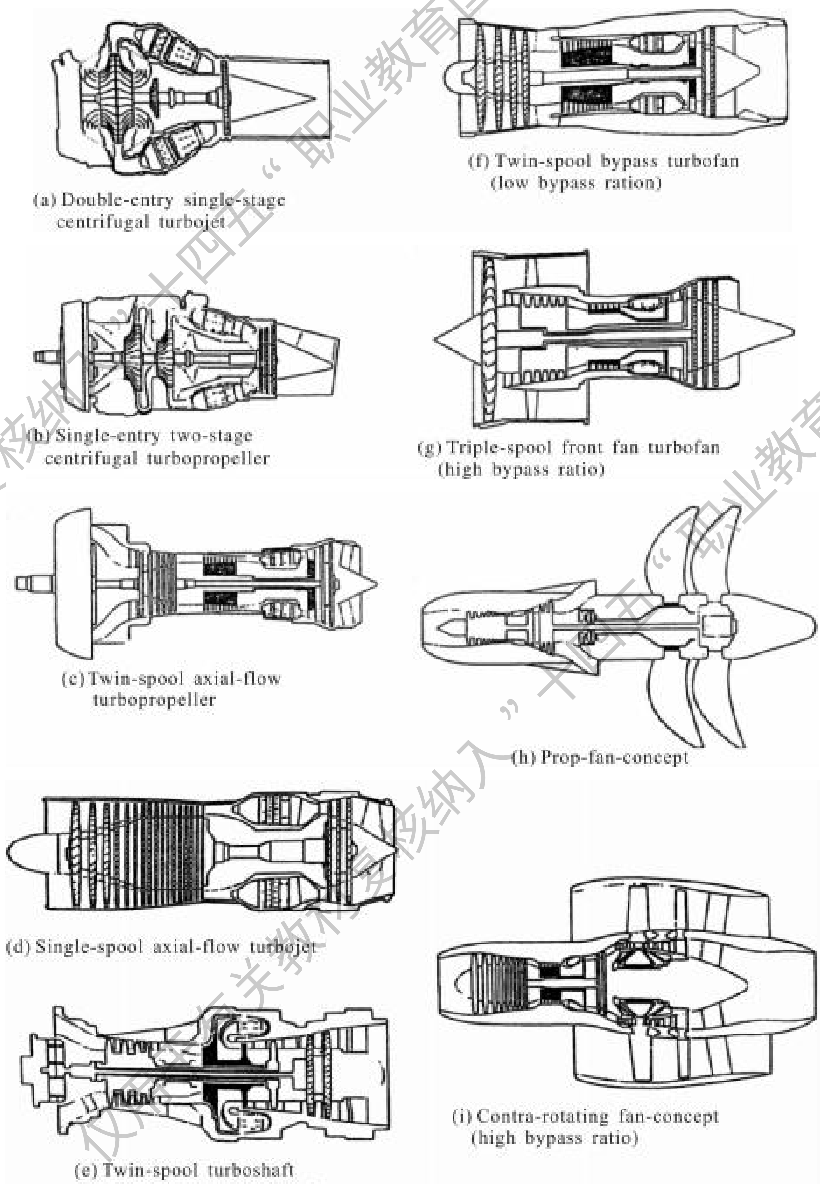


Figure 7.2 - 1 Mechanical arrangements of gas-turbine engines

7.2.1 Turbojet Engine

A turbojet engine is a type of gas-turbine engine which produces thrust through the hot gases exiting the exhaust section of the engine. Although this engine was the first real successful gas-turbine engine, it has been replaced in most aircraft by turbofan, because of its fuel efficiency. However, it is still used in some military applications.

There are two types of turbojet, the centrifugal flow compressor type (see Figure 7.2-2) and the axial flow compressor type. Either may have one or more compressors, and in some engines both a centrifugal compressor and an axial flow compressor are incorporated.

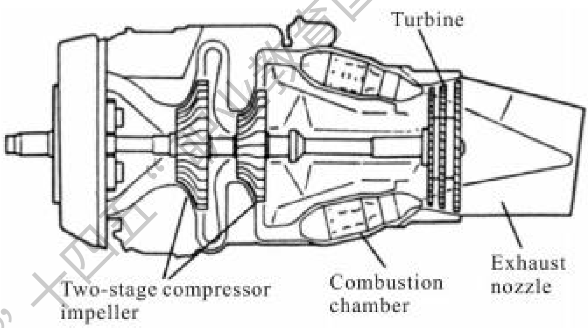


Figure 7.2-2 Centrifugal compressor turbojet engine

Centrifugal compressors operate by taking air into the engine near the compressor hub at the front of the engine. The air is then rotated at high speed by an impeller. Centrifugal force carries the air to the perimeter of the impeller and increases its total pressure. The air is then collected by a diffuser that converts the total pressure to static pressure. From the diffuser, the air is led to a manifold which feeds it to a series of individual combustion chambers.

Large, high performance turbojets and turbofans require the greater efficiency and higher compression ratios that can be obtained only with an axial flow compressor. Axial flow compressors have the added advantage of enabling an engine to have a small frontal area. Either a single compressor (see Figure 7.2-1(d)) or a dual compressor (see Figure 7.2-3) may be used. The latter type results in very high compressor efficiency, compression ratio, and thrust. In dual compressor engines, one or more turbine stages drive the low pressure compressor, while a separate, one-or two-stage turbine drives the high pressure compressor.[1] The two rotor systems operate independently of one another except for airflow. The turbine assembly for the low pressure compressor is the rear turbine unit. This set of turbines is connected to the forward, low pressure compressor by a shaft that passes through the hollow center of the high pressure compressor and turbine drive shaft.[2] The dual compressor configuration is often called a single rotor or single-spool engine.

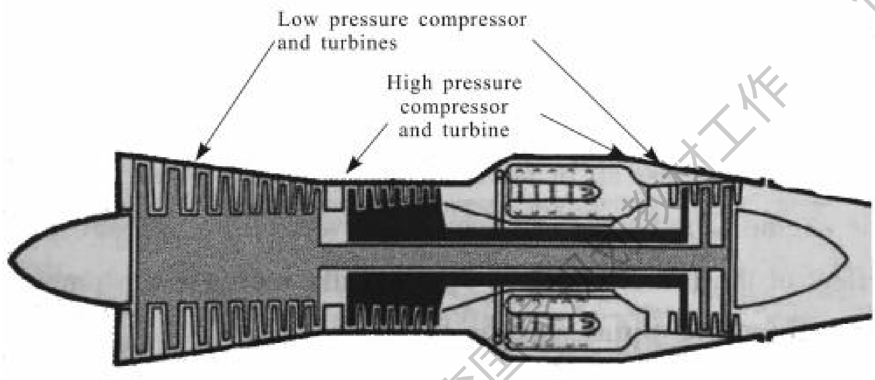


Figure 7.2-3　Dual axial flow compressor turbojet engine

7.2.2　Turbofan Engine

A turbofan engine may be considered a cross between a turbojet engine and a turboprop engine. The turboprop engine drives a conventional propeller through reduction gears to provide a speed suitable for the propeller. The propeller accelerates a large volume of air in addition to that which is being accelerated by the engine itself. The turbofan engine accelerates a smaller volume of air than the turboprop engine but a larger volume than the turbojet engine.

There are two principle configuration for a turbofan, each of which has its advantages. One configuration places the fan at the front of the engine, while, in the other, the fan is at the rear of the engine. The first, called a forward fan engine (see Figure 7.2-1(f) and (g)), is the type most commonly used today. In a dual compressor forward fan engine, the fan is an integral part of the low pressure compressor (see Figure 7.2-4). There is also a forward fan engine design which has three separate turbines and three separate drive shafts (see Figure 7.2-1g). The rear turbine drives only the fan while the intermediate and forward turbines drive a forward, low pressure compressor and a rear, high pressure compressor, respectively.[3] In the other turbofan configuration (called an aft fan engine), the fan is mounted at the rear of the engine (see Figure 7.2-1(h)).

On the engine shown in Figure 7.2-4, the fan's rotational speed is the same as the low-pressure compressor speed (N1). During operation, air from the fan section of the forward blades is carried outside to the rear of the engine, through ducting. The bypass engine has two gas streams: the cool bypass airflow and the hot turbine discharge gases which have passed through the core of the engine.[4] The bypass air or fan air is cool because it has not passed through the actual gas turbine engine. The fan air can account for around 80 percent of the engine's total thrust. The effect of the turbofan design is to greatly increase the power-weight ratio of the engine and to improve the thrust specific fuel consumption.

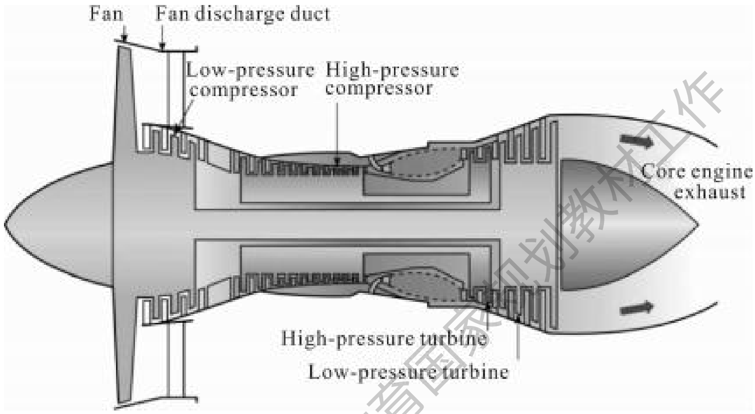


Figure 7.2－4　Arrangement of a dual compressor forward turbofan engine

Turbofan engine may be high-bypass or low-bypass engines. The ratio of the amount of air that bypasses (passes around) the core of the engine to the amount of the air that passes through the core is called the bypass ratio.[5] A low-bypass engine does not bypass as much air around the core as a high-bypass engine.

7.2.3　High Bypass Turbofan Engine

During recent years, the high-bypass turbofan engine has become one of the principal sources of power for large transport aircraft. Among such engines are the Pratt & Whitney PW4000, the General Electric GE90, and the Roll-Royce RB211. These engines are used, respectively, in Boeing 747, Boeing 777, and Airbus 330 aircraft.

A high-bypass engine utilizes the fan section of the compressor to bypass a large volume of air compares with the amount which passes through the engine. The bypass ratio for PW4000 and RB211 engine is approximately 5∶1. This means that the weight of the bypassed air is five times the weight of the air passed through the core of the engine. The bypass ratio for GE90 engine is approximately 8.4∶1; however, some models have a variable bypass ratio, and the amount of bypassed air may be more or less than stated above.

The principle advantages of the high-bypass engine are greater efficiency and reduced noise. The high-bypass engine has the advantages of the turboprop engine but does not have the problems of propeller control. The design is such that the fan can rotate at its most efficient speed, depending on the speed of the aircraft and the power demanded from the engine.

On some front fan engines, the bypass airstream is ducted overboard either directly behind the fan through short ducts (see Figure 7.2－1(g)) or at the rear of the engine through longer ducts, thus the term “ducted fan”.

The forward fan turbofan engine depicted in Figure 7.2－5 has what is called a nonmixed exhaust. That is, although the fan discharge air is carried to the rear of the engine, it is not mixed with the exhaust gases from the basic engine before being delivered to the outside air.

A long duct type forward fan engine with a mixed exhaust is shown in Figure 7.2-1(f). In this engine, the fan discharge is carried to the engine tail pipe where it mixes with the exhaust from the basic engine. The air from the fan and the engine exhaust gases are then discharged together through the engine jet nozzle.

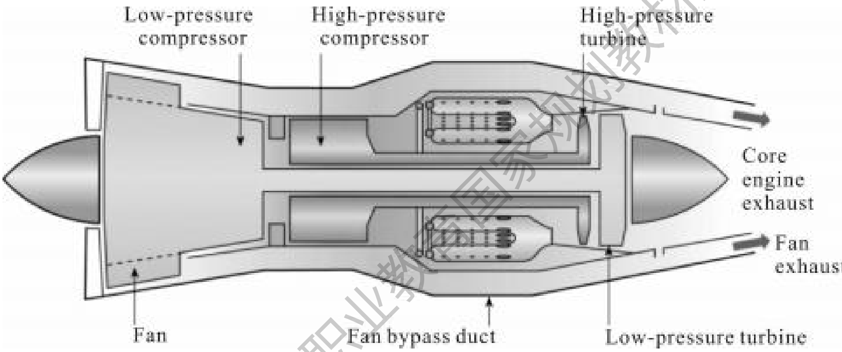


Figure 7.2-5 Forward fan engine with a nonmixed long duct

7.2.4 Turboprop Engine

A turboprop engine, such as that illustrated in Figure 7.2-6, is nothing more than a gas turbine or turbojet with a reduction gearbox mounted in the front or forward end to drive a standard airplane propeller. This engine uses almost all the exhaust-gas energy to drive the propeller and therefore provides very little thrust through the ejection of exhaust gases.[6] The exhaust gases represent only about 10% of the total amount of energy available. The other 90% of the energy is extracted by the turbines that drive the compressor and a second turbine that drives the propeller. The basic components of the turboprop engine are identical to those of the turbojet that is, compressor, combustor, and turbine. The only difference is the addition of the gear-reduction box to reduce the rotational speed to a value suitable for propeller use.

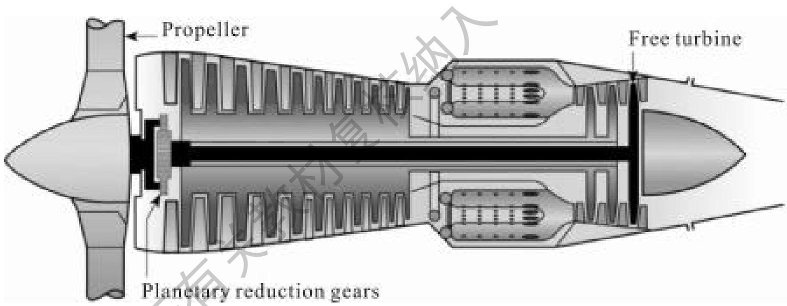


Figure 7.2-6 A turboprop engine

7.2.5 Turboshaft Engine

A turboshaft engine is a gas-turbine engine which delivers shaft horsepower through an output shaft (see Figure 7.2-7). This engine, like the turboprop, uses almost all the exhaust energy to drive the output shaft. This type of gas-turbine engine is used in aviation mainly on helicopters and for auxiliary power units on large transport aircraft.

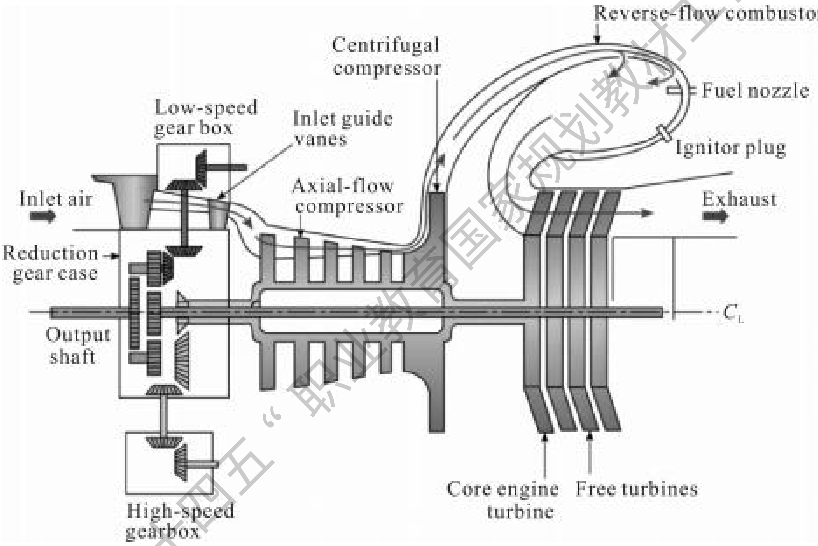


Figure 7.2-7 A turboshaft engine

New words/ Phrases/ Expression

1. turbojet [ˈtɜːbəʊdʒet] *n*. 涡轮喷气
2. turbofan [ˈtɜːbəʊfæn] *n*. 涡轮风扇
3. turboprop [ˈtɜːbəʊprɔp] *n*. 涡轮螺旋桨
4. turboshaft [ˈtɜːbəʊʃæft] *n*. 涡轮轴
5. centrifugal [ˌsentriˈfjuːgl] *adj*. 离心的
6. centrifugal compressor 离心式压气机
7. axial flow compressor 轴流式压气机
8. hub [hʌb] *n*. 轮轴；中心，焦点
9. impeller [imˈpelə] *n*. 叶轮
10. centrifugal force 离心力
11. perimeter [pəˈrimitə(r)] *n*. 边界
12. total pressure 总压
13. static pressure 静压
14. performance [pəˈfɔːməns] *n*. 性能
15. compression ratio 压缩比
16. frontal area 迎风面积
17. rotor [ˈrəʊtə(r)] *n*. 转子
18. spool [spuːl] *n*. 轴，转子
19. integral [ˈintigrəl] *adj*. 完整的，整体的

20. intermediate [ˌintəˈmiːdiət] *adj*. 中间的
21. respectively [riˈspektivli] *adj*. 各自地,分别地
22. rim [rim] *n*. 边缘,轮缘
23. free turbine 自由涡轮
24. bypass engine 有涵道的发动机
25. power-weight ratio 功率-重量比
26. thrust specific fuel consumption 单位推力燃油消耗量
27. high-bypass engine 高涵道比发动机
28. low-bypass engine 低涵道比发动机
29. bypass ratio 涵道比
30. duct [dʌkt] *n*. 涵道,管道
31. depict [diˈpikt] *v*. 描述
32. tail pipe 尾喷管
33. jet nozzle 排气喷管
34. prop-fan [prɔpˈfæn] *n*. 桨扇
35. theme [θiːm] *n*. 题目;主题
36. reduction gearbox 减速齿轮箱
37. energy available 可用能量
38. extract [iksˈtrækt] *v*. 吸收,吸取
39. deliver [diˈlivə] *v*. 传递,传送
40. helicopter [ˈhelikɔptə(r)] *n*. 直升机
41. auxiliary power unit 辅助动力装置

Notes

【1】In dual compressor engines, one or more turbine stages drive the low pressure compressor, while a separate, one-or two-stage turbine drives the high pressure compressor.

翻译:在双压气机发动机中,某一级或几级涡轮带动低压压气机转动,而另一个单级或两级的涡轮带动高压压气机转动。

【2】This set of turbines is connected to the forward, low pressure compressor by a shaft that passes through the hollow center of the high pressure compressor and turbine drive shaft.

翻译:这组涡轮通过一根轴与前面的低压压气机连接,该轴穿过空心的高压压气机和涡轮传动轴的中心。

【3】The rear turbine drives only the fan while the intermediate and forward turbines drive a forward, low pressure compressor and a rear, high pressure compressor, respectively.

翻译:后面的涡轮只驱动风扇,而中间的涡轮和前面的涡轮分别驱动前面的低压压气机和后面的高压压气机。

【4】The bypass engine has two gas streams: the cool bypass airflow and the hot turbine discharge gases which have passed through the core of the engine.

翻译:有涵道的发动机的气流分为两股:冷的涵道空气流和流过核心发动机经涡轮排出的高温燃气。

【5】The ratio of the amount of air that bypasses (passes around) the core of the engine to the amount of the air that passes through the core is called the bypass ratio.

翻译:从发动机核心机外部流过的空气量与流过发动机核心机的空气量之比称为涵道比。

【6】This engine uses almost all the exhaust-gas energy to drive the propeller and therefore provides very little thrust through the ejection of exhaust gases.

翻译:这种发动机利用几乎所有的排气能量来驱动螺旋桨,因此通过排气获得的推力很小。

Exercises

Ⅰ. Answer the following questions:

1. What types of aircraft gas turbine engines can be classified into?
2. What are the two types of turbojet engine?
3. What's the bypass ratio of turbofan engine?
4. What are the principle advantages of high-bypass turbofan engine?

Ⅱ. Translate the following sentences into Chinese:

1. Although this engine was the first real successful gas-turbine engine, it has been replaced in most aircraft by turbofan, because of its fuel efficiency.
2. The propeller accelerates a large volume of air in addition to that which is being accelerated by the engine itself.
3. The effect of the turbofan design is to greatly increase the power-weight ratio of the engine and to improve the thrust specific fuel consumption.
4. A high-bypass engine utilizes the fan section of the compressor to bypass a large volume of air compares with the amount which passes through the engine.
5. The other 90% of the energy is extracted by the turbines that drive the compressor and a second turbine that drives the propeller.

Ⅲ. Fill in the following blanks according to the text:

1. The basic components of all turbine engines are essentially the same, they are: ________, ________, ________, and ________.
2. Although this engine was the first real successful gas-turbine engine, it has been replaced in most aircraft by ________, because of its ________.
3. Centrifugal compressors operate by taking ______ into the engine near the compressor hub at the front of the engine. The air is then rotated at high speed by an ______. ________ carries the air to the perimeter of the impeller and increases its ________. The air is then collected by a ________ that converts the total pressure to ________.
4. The bypass engine has two gas streams: the cool ________ and the hot ________ which have passed through the core of the engine.

5. The basic components of the turboprop engine are identical to those of the turbojet that is, ________, ________, and ________. The only difference is the addition of the to reduce the rotational speed to a value suitable for propeller use.

7.3 Basic Components of Gas Turbine Engine

All gas turbine engines consist of the same basic components. However, the nomenclature used to describe each component does vary among manufacturers. Nomenclature differences are reflected in applicable maintenance manuals. The following discussion uses the terminology that is most commonly used in industry.

There are seven basic sections within every gas turbine engine. They are:

(1) Air inlet;

(2) Compressor section;

(3) Combustion section;

(4) Turbine section;

(5) Exhaust section;

(6) Accessory section;

(7) Systems necessary for starting, lubrication, fuel supply, and auxiliary purposes, such as antiicing, cooling, and pressurization.

Additional terms you often hear include hot section and cold section. A turbine engine's hot section includes the combustion, turbine, and exhaust sections. The cold section, on the other hand, includes the air inlet duct and the compressor section (see Figure 7.3-1).

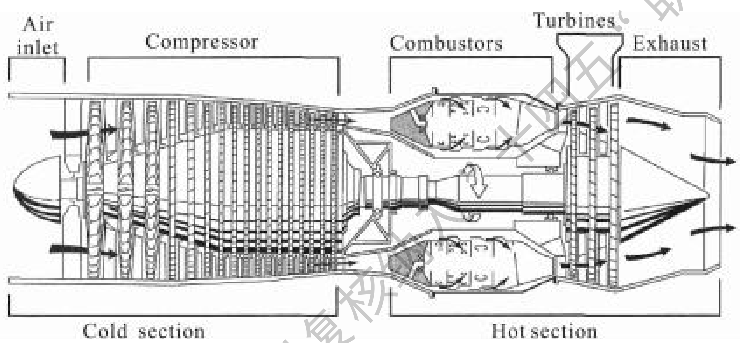


Figure 7.3-1 Basic components of a gas-turbine engine

7.3.1 Air Inlet

The air inlet of a turbojet engine is typically located at the front of the compressor. It is not really a section of the engine defined by any one particular part. The air inlet is formed by the structural support parts located forward of the compressor and has the purpose of admitting air to the forward end of the compressor.[1] The opening of the air inlet is usually of fixed size, but may be variable depending on the design of the compressor used in the particular engine. The air inlet must have a clean aerodnamic design to ensure a smooth, evenly distributed airflow into the engine.

The inlet area can be controlled by a set of vanes known as the inlet guide vanes. The guide vanes in the axial-flow turbojet engine provide a change in direction of airflow so that air is directed on the first stage of the compressor at the proper angle.[2] Controlling the amount of air flowing into the compressor in the axial-flow engine is necessary under some operating conditions, because at low engine speed the forward stages of the compressor could deliver more air than can be effectively handled by the rear stages of the compressor. When this condition exists, the engine may encounter compressor stall. To prevent this situation, the angles of the inlet guide vanes and some of the first stages of the stator vanes are varied to reduce the amount of air flowing through the engine. A less efficient way to reduce the amount of air reaching the rear stages is to bleed off some of the excess air partway through the compressor.

7.3.1.1 Subsonic Air Inlet

A typical subsonic air inlet consists of a fixed geometry duct whose diameter progressively increases from front to back. This divergent shape works like a venturi in that as the intake air spreads out, the velocity of the air decreases and the pressure increases.[3] This added pressure contributes significantly to engine efficiency once the aircraft reaches its design cruising speed. At this speed, the compressor reaches its optimum aerodynamic efficiency and produces the most compression for the best fuel economy. It is at this design cruise speed that the inlet, compressor, combustor, turbine, and exhaust duct are designed to match each other as a unit. If any section mismatches any other because of damage, contamination, or ambient conditions, engine performance suffers. In most cases, subsonic inlets are designed to diffuse the air in the front portion of the duct. This allows the air to progress at a fairly constant pressure before it enters the engine (see Figure 7.3-2).

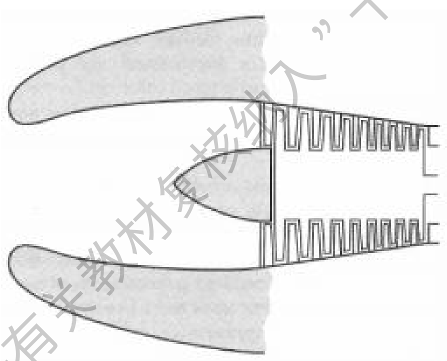
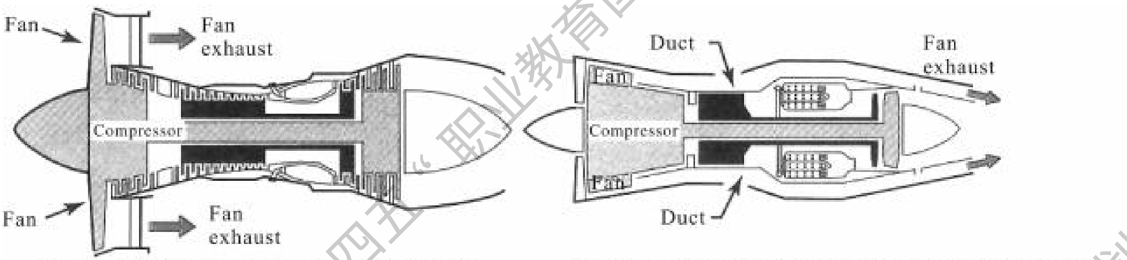


Figure 7.3-2 Subsonic turbine engine inlets

A turbofan inlet is similar in design to a turbojet inlet except that the inlet discharges only a portion of its air into the engine. The remainder of inlet air passing through the fan flows around, or bypasses the engine core to create thrust much in the same way a propeller does. In addition, the bypass air helps cool the engine and reduce noise.

A turbofan engine utilizes two types of inlet duct designs. One type is the short duct design that allows a large percentage of fan air to bypass the engine core and produce thrust. This type of duct is typically used on high bypass engines. The other duct design forms a shroud around the engine core and is used on low and medium bypass engines. Full fan ducts reduce aerodynamic drag and noise emissions. In addition, a full duct generally has a converging discharge nozzle that produces reactive thrust. Full ducts are not used on high bypass engines because the weight penalty caused by such a large diameter duct would offset the benefits (see Figure 7.3-3).



(a) Short duct that allows a large portion of the incoming air to bypass the engine

(b) Medium bypass engines use long inlet ducts that reduce surface drag of the fan discharge air and enhance thrust

Figure 7.3-3

7.3.1.2 Supersonic Air Inlet

Air entering the compressor on a turbine engine must flow slower than the speed of sound. Therefore, the inlet duct on a supersonic aircraft must decrease the speed of the inlet air before it reaches the compressor. To understand how a supersonic inlet does this, you must first understand how supersonic airflow reacts to converging and diverging openings.

Air flowing at subsonic speeds is considered to be incompressible while air flowing at supersonic speeds is compressible. Because of this, air flowing at supersonic speeds reacts differently when forced to flow through either a convergent or divergent opening. For example, when supersonic airflow is forced through a convergent duct, it compresses, or piles up, and its density increases. This causes a decrease in air velocity and a corresponding increase in pressure. On the other hand, when supersonic airflow passes through a divergent duct, it expands and its density decreases. As it expands, its velocity increases and its pressure decreases (see Figure 7.3-4).

7.3.2 Compressor

As discussed earlier, a gas turbine engine takes in a quantity of air, adds energy to it, then discharges the air to produce thrust. Based on this, the more air that is forced into an engine, the more thrust the engine can produce. The component that forces air into the engine is the compressor. To be effective, a modern compressor must increase the intake air pressure 20 to 30 times above the ambient air pressure and move the air at a velocity of 400 to

500ft/s* feet per second.[4] One way of measuring a compressor's effectiveness is to compare the static pressure of the compressor discharge with the static air pressure at the inlet. If the discharge air pressure is 30 times greater than the inlet air pressure, that compressor has a compressor pressure ratio of 30∶1.[5] There are two types of compressors with respect to airflow: the centrifugal type and the axial type.

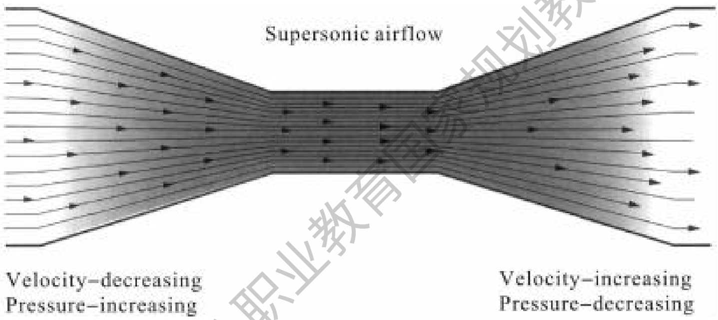


Figure 7.3-4 Convergent-divergent supersonic inlet

7.3.2.1 Centrifugal-Flow Compressor

The centrifugal compressor, sometimes called a radial outflow compressor, is one of the earliest compressor designs and is still used today in some smaller engines and auxiliary power units (APU). Centrifugal compressors consist of an impeller, a diffuser, and a manifold (see Figure 7.3-5). The term "centrifugal" means that the air is compressed by centrifugal force.

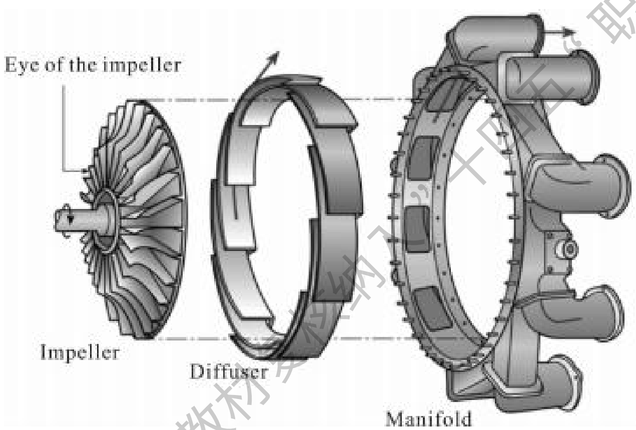


Figure 7.3-5 A typical single-entry centrifugal compressor

Centrifugal compressors operate by taking in outside air near the hub and rotating it by means of an impeller. The impeller, which is usually an aluminum-alloy forging, guides the air toward the outside of the compressor, building up the air velocity by means of the high

* 1 ft=12 in≈3.4.8 mm.

rotational speed of the impeller.[6] The air then enters the diffuser section. The diffuser converts the kinetic energy of the air leaving the compressor to potential energy (pressure) by exchanging velocity for pressure.[7] An advantage of the centrifugal-flow compressor is its high pressure rise per stage (see Figure 7.3－6).

A centrifugal compressor is either a double-entry type (see Figure 7.2－1(a)) or a single-entry type (see Figure 7.2－1(b)). In Figure 7.3－7, a double-entry type compressor (double sided) is shown, with air inlets on both sides, front and rear air reaches the rear inlet of the compressor by flowing between the compressor outlet adapters.

Although the centrifugal compressor is not as expensive to manufacture as the axial-flow compressor, its lower efficiency eliminates the advantages of lower cost, except for some small turboprop engines.

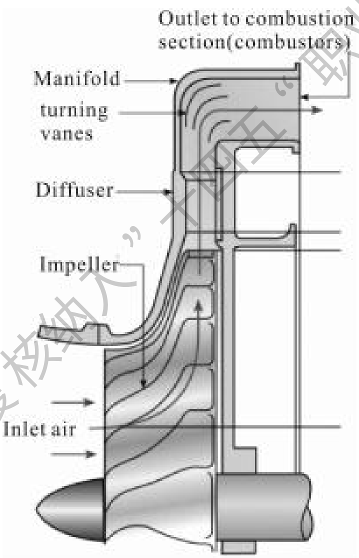


Figure 7.3－6　Airflow in centrifugal compressor

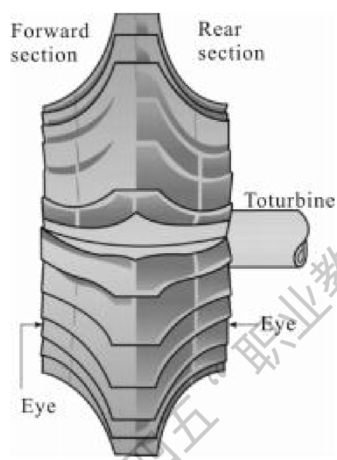


Figure 7.3－7　A double-entry centrifugal compressor

7.3.2.2　Axial-Flow Compressor

In an axial-flow jet engine, the air flows axially—that is in a relatively straight path in line with the axis of the engine. The axial-flow compressor consists of two elements: a rotating member called the rotor, and the stator, which consists of rows of stationary blades. The stator vanes are airfoil sections that are mounted in stationary casings. The compressor rotor and stator case for an axial-flow turbojet engine are shown in Figure 7.3－8 and Figure 7.3－9. The rotor comprises the rotating components and castings that support the rotor blades which are attached to the rotor. The rotor is attached to a shaft which is driven by the turbine or turbine stages that drive this compressor. The rotor blades are attached to the rotor and are of an airfoil shape which maintains an axial air flow throughout the compressor. Methods of blade attachment are shown in Figure 7.3－10.

Figure 7.3－8 Compressor rotor

Figure 7.3－9 Compressor stator

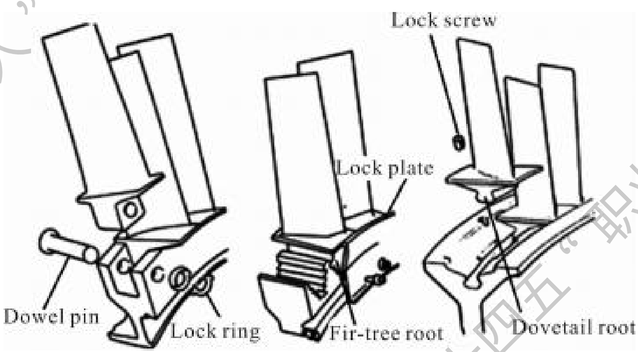


Figure 7.3－10 Methods of securing compressor blades to disk

The principle of operation of the axial-flow turbojet engine is the same as that of the centrifugal-flow engine; however, the axial-flow engine has a number of advantages:

(1) The air flows in an almost straight path through the engine, and therefore less energy is lost as a result of the air changing direction;

(2) The pressure ratio (ratio of compressor discharge pressure to compressor inlet pressure) is greater because the air can be compressed through as many stages as the designer wishes;

(3) The engine frontal area can be smaller for the same volume of air consumed;

(4) There is high peak efficiency.

The compressor blades, shaped like small airfoils, become smaller from stage to stage, moving from the front of the compressor to the rear.[8] The stator blades are also shaped like small airfoils, and they, too, become smaller toward the high-pressure end of the compressor. The purpose of the stator blades is to change the direction of the airflow as it leaves each stage of the compressor rotor and to give it proper direction for entry into the next stage.[9] Stator blades also eliminate the turbulence that would otherwise occur between the compressor blades. The ends of the stator blades are fitted with shrouds to prevent the loss of air from stage to stage and to the interior of the compressor rotor.

During the operation of the compressor, the air pressure increases as it passes each stage, and at the outlet into the diffuser it reaches a value several times that of the atmosphere, the actual pressure being over 482.65 kPa (70 psig).

Sometimes gas turbine engines use more than one axial-flow compressor; in fact, some engines use up to three separate compressors. The arrangement of a dual axial (twin-spool) compressor is shown in Figure 7.3－11. This compressor design makes it possible to obtain extremely high pressure ratios with reduced danger of compressor stall because the low pressure compressor is free to operate at its best speed and the high pressure compressor rotor is speed-regulated by the fuel control unit.

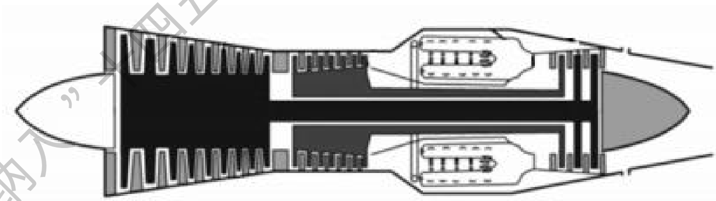


Figure 7.3－11　Twin-spool compressor

7.3.2.3　Multiple-Compressor Axial-Flow Engines

A dual-compressor jet engine utilizes two separate compressors, each with its own driving turbine. This type of engine is also called a "twin-spool" or "split-compressor" engine.

The construction of the dual-compressor engine is shown in Figure 7.2－1(f). The forward compressor section is called the low-pressure compressor (N1) and the rear section the high-pressure compressor (N2). The low-pressure compressor is driven by a two-stage turbine mounted on the rear end of the inner shaft, and the high-pressure compressor is driven by a single-stage turbine mounted on the outer coaxial shaft. The high-pressure rotor turns at a higher speed than the low-pressure rotor.

One of the principle advantage of the split-compressor arrangement is greater flexibility of operation. The low-pressure compressor can operate at the best speed for the accommodation of the low-pressure, low-temperature air at the forward part of the engine. During high-altitude operation where air density is low, the speed of the N2 compressor will increase as the compressor load decrease. This makes N1 in effect a supercharger for N2. The high-pressure compressor is speed-governed to operate at proper speeds for the most efficient performance in compressing the high-temperature, high-pressure air toward the rear of the compressor section.[10] The use of the dual compressor makes it possible to attain pressure ratios of more than 20∶1, whereas the single axial-flow compressor produces pressure ratios of only 6∶1 or 7∶1 unless variable stator vanes are employed.

On many turbofan engines, the compressor section is divided into three sections and is referred to as a triple-spool compressor. In this arrangement the fan is referred to as the low speed, or N1 compressor. The compressor next in line is called the intermediate, or N2 compressor, and the innermost compressor is the high pressure, or N3 compressor. The low speed compressor is typically driven by a multiple stage low pressure turbine, while the intermediate and high pressure compressors are driven by single stage turbines (see Figure 7.3-12).

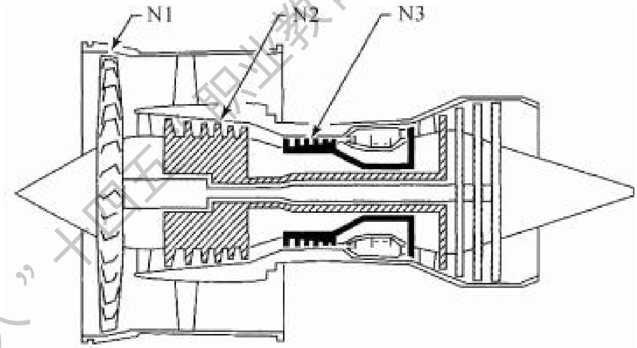


Figure 7.3-12 A triple-spool turbofan engine

7.3.2.4 Compressor Airflow and Stall Control

Where high-pressure ratios on a single shaft are required, it becomes necessary to introduce airflow control into the compressor design. This may take the form of variable inlet guide vanes for the first stage, plus a number of stages incorporating variable stator vanes, as illustrated in Figure 7.3-13. As the compressor speed is reduced from its design value, these stator vanes are progressively closed in order to maintain an acceptable air angle for the following rotor blades.

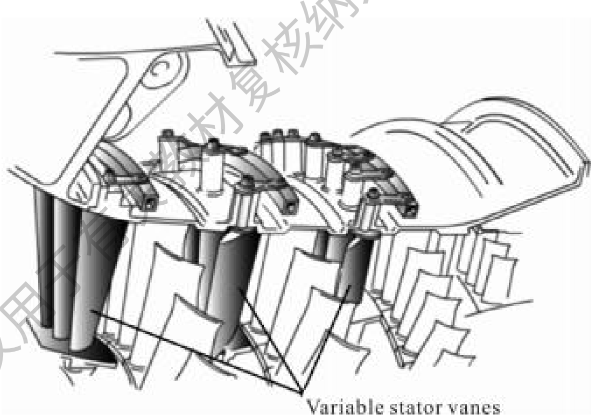


Figure 7.3-13 Typical variable stator vanes

The variable vanes are automatically regulated in pitch angle by means of the fuel control unit. The regulating factors are compressor inlet temperature and engine speed. The effect of the variable vanes is to provide a means for controlling the direction of compressor interstage airflow, thus ensuring a correct angle of attack for the compressor blades and reducing the possibility of compressor stall.[11]

7.3.2.5 The Diffuser

The diffuser for a typical gas-turbine engine is that portion of the air passage between the compressor and the combustion chamber or chambers. The purpose of the diffuser is to reduce the velocity of the air and prepare it for entry into the combustion area. As the velocity of the air decreases, its static pressure increases in accordance with Bernoulli's law. As the static pressure increases, the ram pressure decreases. The diffuser is the point of highest pressure within the engine.

7.3.3 Combustion Section

A combustion section is typically located directly between the compressor diffuser and turbine section. All combustion sections contain the same basic elements: one or more combustion chambers (combustors), a fuel injection system, an ignition source, and a fuel drainage system.

The combustion section of a turbojet engine may consist of individualcombustion chambers ("cans"), an annular chamber which surrounds the turbine shaft, or a combination consisting of individual cans within an annular chamber.[12] The latter type of combustor is called the can-annular type or simply the cannular type (see Figure 7.3-14).

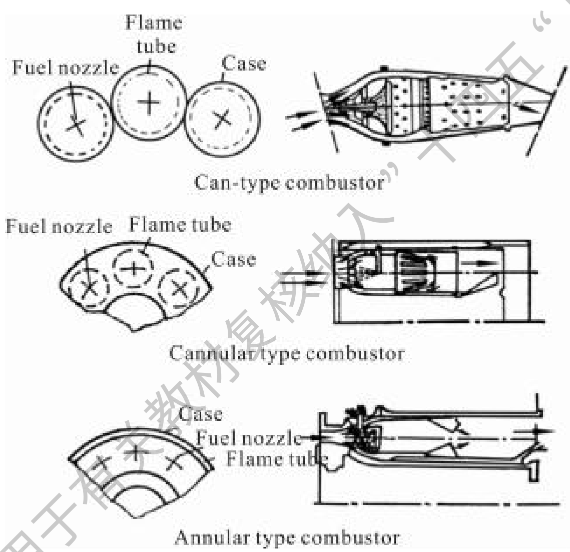


Figure 7.3-14 Three types of the combustion chamber

A typical can-type combustor, shown in Figure 7.3-14, consists of an outer shell and a removable liner with openings to permit compressor discharge air to enter from the outer chamber. Approximately 25% of the air that passes through the combustion section is actually used for combustion, the remaining air being used for cooling. Located at the front end of the combustion chamber is a fuel nozzle through which fuel is sprayed into the inner liner. The flame burns in the center of the inner liner and is prevented from burning the liner by a blanket of excess air which enters through holes in the liner and surrounds the flame as illustrated in Figure 7.3－15. All burning is completed before the gases leave the chamber.

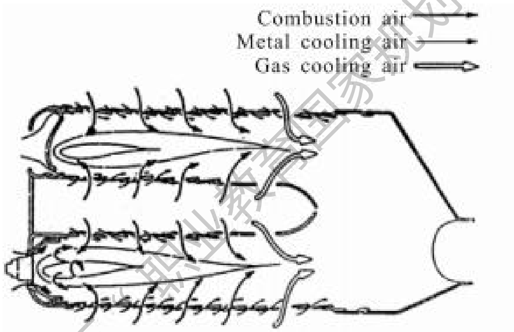


Figure 7.3－15　Airflow in a combustion liner

The high-bypass turbofan engines mentioned previously employ annular combustion chambers. These chambers have proven efficient and effective in producing smoke free exhaust. The general configuration of the combustion chamber for the Pratt & Whitney JT9D engine is shown in Figure 7.3－16. This is a two-piece assembly consisting of an inner and an outer liner. At the front are 20 fuel nozzle openings with swirl vanes to help vaporize the fuel. Two of the openings, on opposite sides of the combustion chamber are designed to hold the igniter plugs.

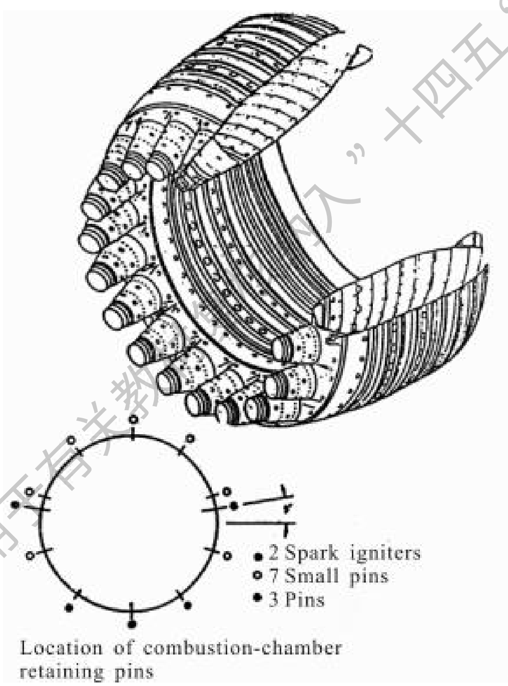


Figure 7.3－16　Combustion chamber for the JT9D turbofan engine

7.3.4 Turbines

A turbojet engine may have a single-stage turbine or a multistage arrangement. The function of the turbine is to extract kinetic energy from the high-velocity gases leaving the combustion section of the engine. The energy is converted to shaft horsepower for the purpose of driving the compressor. Approximately three-fourths of the energy available from the burning fuel is required for the compressor. If the engine is used for driving a propeller or a power shaft, up to 90 percent of the energy of the gases will be extracted by the turbine section.

Turbines come in three types: the impulse turbine, the reaction turbine, and a combination of the two called a reaction-impulse turbine. Turbojet engines normally employ the reaction-impulse type.

The difference between an impulse turbine and a reaction turbine is illustrated in Figure 7.3-17. The pressure and speed of the gases passing through the impulse turbine remain essentially the same, the only change being in the direction of flow. The turbine absorbs the energy required to change the direction of the high-speed gases. A reaction turbine changes the speed and pressure of the gases. As the gases pass between the turbine blades, the cross-sectional area of the passage decreases and causes an increase in gas velocity. This increase in velocity is accompanied by a decrease in pressure according to Bernoulli's law. In this case the turbine absorbs the energy required to change the velocity of the gases.

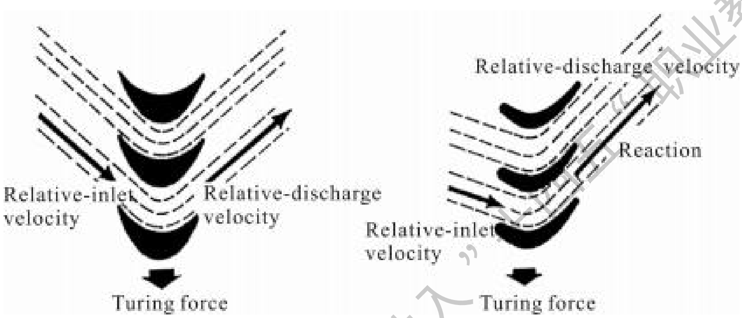


Figure 7.3-17 Comparison of impulse and reaction turbines

The turbine section of a turbojet engine is located downstream of the combustion section and consists of four basic elements: a case, a stator, a shroud, and a rotor (see Figure 7.3-18).

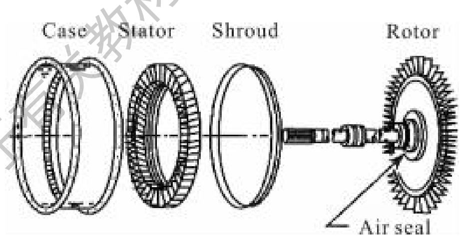


Figure 7.3-18 The four basic elements of a turbine assembly

7.3.4.1　Case

The turbine casing encloses the turbine rotor and stator assembly, giving either direct or indirect support to the stator elements. A typical case has flanges on both ends that provide a means of attaching the turbine section to the combustion section and the exhaust assembly.

7.3.4.2　Turbine Stator

A stator element is most commonly referred to as the turbine nozzle; however, you may also hear the stator elements referred to as the turbine guide vanes, or the nozzle diaphragm. The turbine nozzle is located directly after the combustion section and immediately forward of the turbine wheel. Because of its location, the turbine nozzle is typically exposed to the highest temperatures in a gas turbine engine.

The purpose of the turbine nozzle is to collect the high energy airflow from the combustors and direct the flow to strike the turbine rotor at the appropriate angle.[13] The vanes of a turbine nozzle are contoured and set at such an angle that they form a number of converging nozzles that convert some of the exhaust gases' pressure energy to velocity energy. In addition, the angle of the stator vanes is set in the direction of turbine wheel rotation. Since the gas flow from the nozzle must enter the turbine blade passageway while it is still rotating, it is essential to aim the gas in the general direction of turbine rotation. As a result, the velocity energy of the exhaust gases is more efficiently converted to mechanical energy by the rotor blades.

7.3.4.3　Shroud

The turbine nozzle assembly consists of an inner and outer shroud that retains and surrounds the nozzle vanes. The number of vanes employed varies with different types and sizes of engines. The vanes of a turbine nozzle are assembled between the outer and inner shrouds, or rings, in a variety of ways. Although the actual elements may vary slightly in their configuration and construction, there is one similarity among all turbine nozzles: the nozzle vanes must be constructed to allow for thermal expansion. If this is not done, the rapid temperature changes imposed by the engine would cause severe distortion or warping of the nozzle assembly (see Figure 7.3-19).

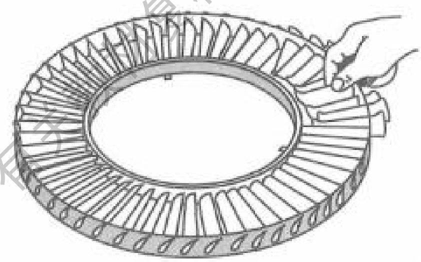


Figure 7.3-19　A loose fit between the vanes and shrouds

7.3.4.4 Turbine Rotor

The rotating elements of a turbine section consist of a shaft and a turbine rotor, or wheel. The turbine wheel is a dynamically balanced unit consisting of blades attached to a rotating disk. The turbine disk is the anchoring component for the turbine blades and is bolted or welded to the main shaft. The shaft rotates in bearings that are lubricated by oil between the outer race and the bearing housing. This reduces vibration and allows for a slight misalignment in the shaft.

As the high velocity gases pass through the turbine nozzle and impact the turbine blades, the turbine rotor rotates. In some engines, a single turbine rotor cannot absorb sufficient energy from the exhaust gas to drive the compressor and accessories. Therefore, many engines use multiple turbine stages, each stage consisting of a turbine nozzle and rotor.

The severe centrifugal loads imposed by the high rotational speeds, as well as the elevated operating temperatures exert extreme stress on the turbine blades. At times, these stresses can cause turbine blades to grow in length. If left unchecked, this growth or creep can result in the turbine blades rubbing against the engine's outer casing.

7.3.4.5 Turbine Blades

Turbine blades are airfoil shaped components designed to extract the maximum amount of energy from the flow of hot gases. Blades are either forged or cast, depending on their alloy composition. Early blades were manufactured from steel forgings; however, today most turbine blades consist of cast nickel-based alloys. In either case, once a blade is forged or cast, it must be finish-ground to the desired shape. As an alternative to metal turbine blades, the development of a blade manufactured from reinforced ceramic material holds promise. Because of ceramic's ability to withstand high temperatures, greater engine efficiency may be possible. Their initial application is likely to be in small, high speed turbines that operate at very high temperatures.

Turbine blades fit loosely into a turbine disk when an engine is cold, but expand to fit tightly at normal operating temperatures. The most commonly used method for attaching turbine blades is by fir tree slots cut into the turbine disk rim and matching bases cast or machined into the turbine blade base (see Figure 7.3－20).

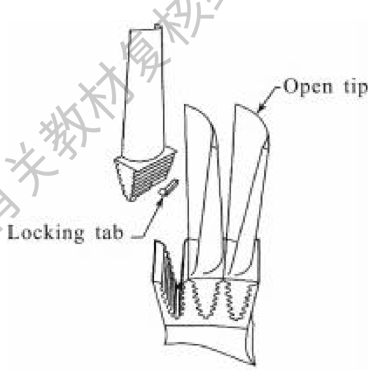


Figure 7.3－20 Turbine blades with fir tree base

Turbine blades can be open or shrouded at their ends. Open ended blades are used on high speed turbines, while shrouded blades are commonly used on turbines having slower rotational speeds. With shrouded blades, a shroud is attached to the tip of each blade. Once installed, the shrouds of the blades contact each other, thereby providing support. This added support reduces vibration substantially. The shrouds also prevent air from escaping over the blade tips, making the turbine more efficient. However, because of the added weight, shrouded turbine blades are more susceptible to blade growth (see Figure 7.3-21).

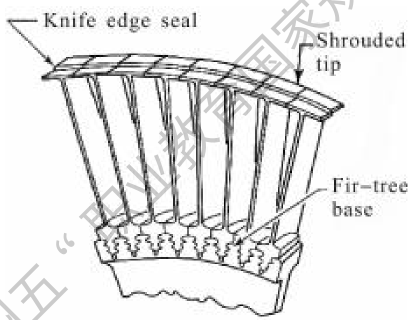


Figure 7.3-21 Shrouded blades

To further improve the airflow characteristics around shrouded turbine blades, a knife-edge seal is machined around the outside of the shroud that reduces air losses at the blade tip. The knife-edge seal fits with a close tolerance into a shrouded ring mounted in the outer turbine case.

7.3.4.6 Cooling

When a turbine section is designed, temperature is an important consideration. In fact, the most limiting factor in running a gas turbine engine is the temperature of the turbine section. However, the higher an engine raises the temperature of the incoming air, the more power, or thrust an engine can produce. Therefore, the effectiveness of a turbine engine's cooling system plays a big role in engine performance. In fact, many cooling systems allow the turbine vane and blade components to operate in a thermal environment 315.6 to 426.7℃ (600 to 800℉) above the temperature limits of their metal alloys.

One of the most common ways of cooling the components in the turbine section is to use engine bleed air. For example, turbine disks absorb heat from hot gases passing near their rim and from the blades through conduction. Because of this, disk rim temperatures are normally well above the temperature of the disk portion nearest the shaft. To limit the effect of these temperature variations, cooling air is directed over each side of the disk.

To sufficiently cool turbine nozzle vanes and turbine blades, compressor bleed air is typically directed in through the hollow blades and out through holes in the tip, leading edge, and trailing edge. This type of cooling is known as convection cooling or film cooling (see Figure 7.3-22).

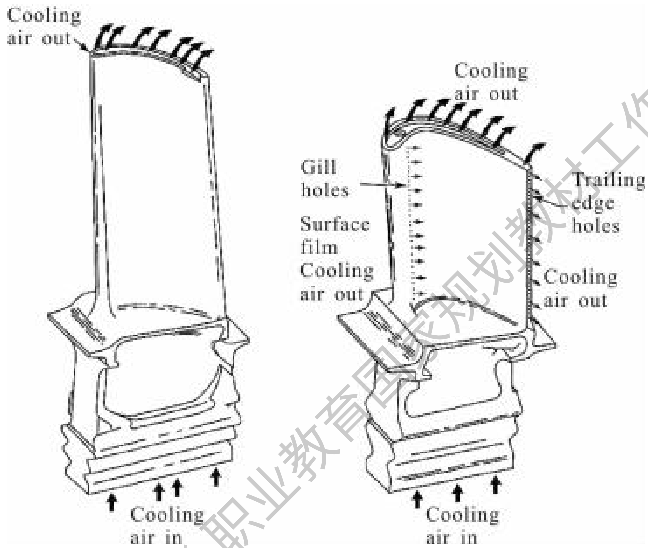


Figure 7.3 - 22 An internally cooled blade

In addition to drilling holes in a turbine vane or blade, some nozzle vanes are constructed of a porous, high-temperature material. In this case, bleed air is ducted into the vanes and exits through the porous material. This type of cooling is known as transpiration cooling and is only used on stationary nozzle vanes.

Modern enginedesigns incorporate many combinations of air cooling methods that use low and high pressure air for both internal and surface cooling of turbine vanes and blades. However, to provide additional cooling, the turbine vane shrouds may also be perforated with cooling holes.

7.3.5 Exhaust Section

A typical exhaust section extends from the rear of the turbine section to the point where the exhaust gases leave the engine. An exhaust section is comprised of several components including the exhaust cone, exhaust duct or tailpipe, and exhaust nozzle (see Figure 7.3 - 23).

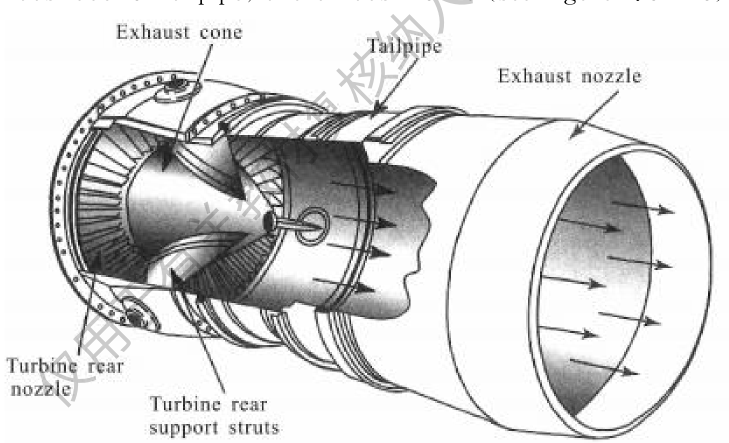


Figure 7.3 - 23 A typical exhaust section

7.3.5.1 Exhaust Cone

A typical exhaust cone assembly consists of an outer duct, or shell, an inner cone, or tail cone, three or more radial hollow struts, and a group of tie rods that assist the struts in centering the inner cone within the outer duct. The outer duct is usually made of stainless steel and attaches to the rear flange of the turbine case (see Figure 7.3-24).

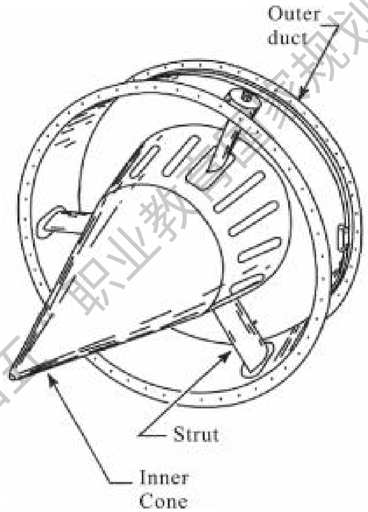


Figure 7.3-24 The exhaust cone

The purpose of an exhaust cone assembly is to channel and collect turbine discharge gases into a single jet. Due to the diverging passage between the outer duct and inner cone, gas velocity within the exhaust cone decreases slightly while gas pressure rises.[14] Radial struts between the outer shell and inner cone support the inner cone, and help straighten the swirling exhaust gases that would otherwise exit the turbine at an approximate angle of 45 degrees.

7.3.5.2 Tailpipe

A tailpipe is an extension of the exhaust section that directs exhaust gases safely from the exhaust cone to the exhaust, or jet nozzle. The use of a tailpipe imposes a penalty on an engine's operating efficiency due to heat and duct friction losses. These losses cause a drop in the exhaust gas velocity and, hence, the thrust. Tailpipes are used almost exclusively with engines that are installed within an aircraft's fuselage to protect the surrounding airframe. Engines installed in a nacelle or pod, however, often require no tailpipe, in which case the exhaust nozzle is mounted directly to the exhaust cone assembly.

7.3.5.3 Exhaust Nozzle

An exhaust, or jet nozzle, provides the exhaust gases with a final boost in velocity. An exhaust nozzle mounts to the rear of a tailpipe, if a tailpipe is required, or to the rear flange of the exhaust duct if no tailpipe is necessary.

Two types of exhaust nozzle designs used on aircraft are the converging design, and the converging-diverging design. On a converging exhaust nozzle, the nozzle diameter decreases from front to back. This convergent shape produces a venturi that accelerates the exhaust gases and increases engine thrust.

The diameter of a converging-diverging duct decreases, then increases from front to back. The converging portion of the exhaust nozzle accelerates the turbine exhaust gases to supersonic speed at the narrowest part of the duct. Once the gases are moving at the speed of sound they are accelerated further in the nozzle's divergent portion, so the exhaust gases exit the nozzle well above the speed of sound.

On fan or bypass type engines, there are two gas streams venting to the atmosphere. High temperature gases are discharged by the turbine, while a cool air mass is moved rearward by the fan section. In a low by-pass engine, the flow of cool and hot air are combined in a mixer unit that ensures mixing of the two streams prior to exiting the engine. High bypass engines, on the other hand, usually exhaust the two streams separately through two sets of nozzles arranged coaxially around the exhaust nozzle.[15] However, on some high bypass engines, a common or integrated nozzle is sometimes used to partially mix the hot and cold gases prior to their ejection (see Figure 7.3-25).

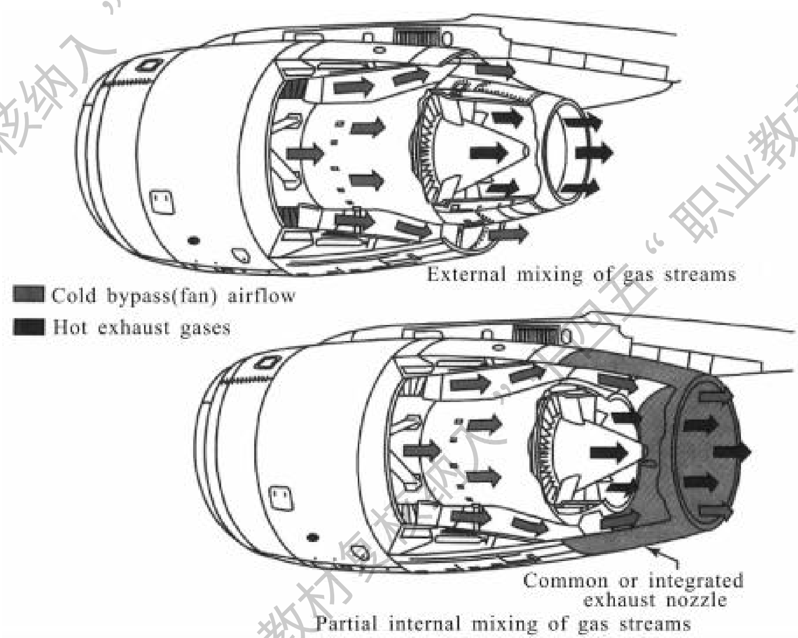


Figure 7.3-25 Two exhaust methods of high bypass engines

An exhaust nozzle opening can have either a fixed or variable area. A variable geometry nozzle is sometimes necessary on engines that utilize an afterburner. Variable nozzles are typically operated with pneumatic, hydraulic, or electric controls.

7.3.5.4 Thrust Reversers

Airliners powered by turbojets and turbofans, most commuter aircraft, and an increasing number of business jets are equipped with thrust reversers to:

(1) Aid in braking and directional control during normal landing, and reduce brake maintenance.

(2) Provide braking and directional control during emergency landings and balked takeoffs.

(3) Back an aircraft out of a parking spot in a "power back" operation.

While some thrust reversers are electrically powered, most large transport-category aircraft use hydraulically actuated reversers powered by main system hydraulic power, or by pneumatic actuators powered by engine bleed air (see Figure 7.3-26).

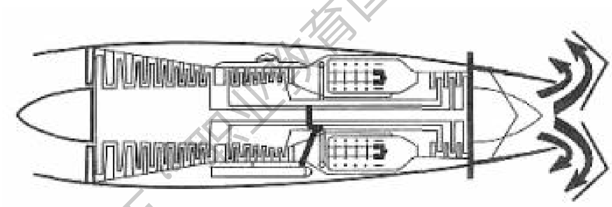


Figure 7.3-26 Thrust reverser

Thrust reversers provide approximately 20% of the braking force under normal conditions. Reversers must be capable of producing 50% of rated thrust in the reverse direction. However, exhaust gas exits a typical reverser at an angle to the engine's thrust axis. Because of this, maximum reverse thrust capability is always less than forward thrust capability. Operating in reverse at low ground speeds can cause re-ingestion of hot gases and compressor stalls. It can also cause ingestion of fine sand and other runway debris. The most frequently encountered thrust reversers can be divided into two categories: the mechanical-blockage type and the aerodynamic-blockage type.

Mechanical blockage is accomplished by placing a movable obstruction in the exhaust gas stream either before or after the exhaust exits the duct. The engine exhaust gases are mechanically blocked and diverted to a forward direction by an inverted cone, half-sphere, or other device. The mechanical blockage system is also known as the "clamshell" thrust reverser because of its shape (see Figure 7.3-27).

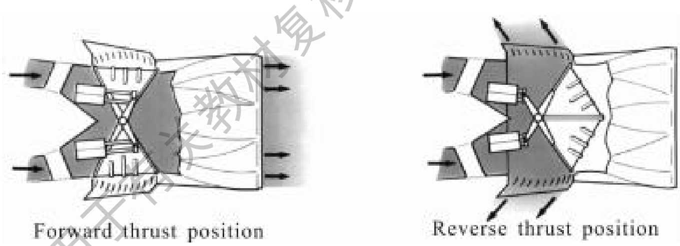


Figure 7.3-27 Clamshell thrust reverser

The aerodynamic-blockage type of thrust reverser uses thin airfoils or obstructions placed in the gas stream. These vanes are often referred to as "cascades" and turn the escaping exhaust gases to a forward direction, which in turn causes a rearward thrust. Some aircraft may use a combination of the aerodynamic-blockage and the mechanical-blockage type reversers.

Mixed exhaust turbofans are configured with one reverser, while unmixed or bypass exhaust turbofans often have both cold stream and hot stream reversers. Some high bypass turbofans will have only cold stream reversing because most of the thrust is present in the fan discharge and a hot stream reverser would be of minimum value and become a weight penalty[16] (see Figure 7.3 - 28).

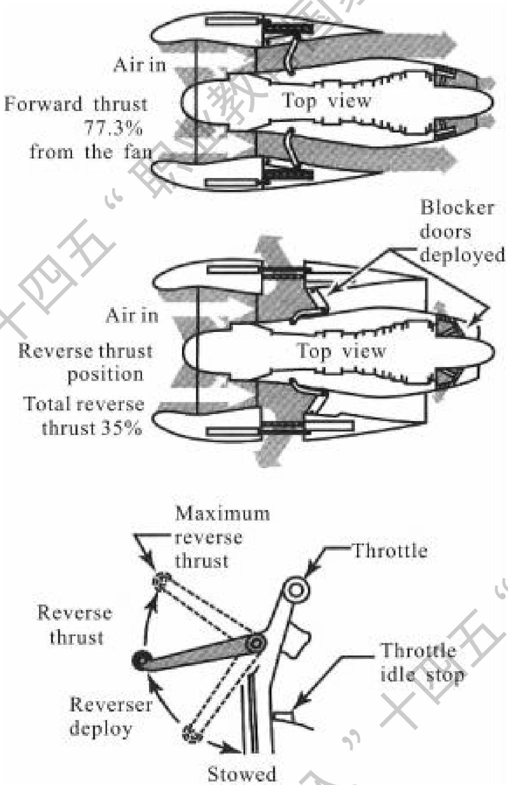


Figure 7.3 - 28　Aerodynamic-blockage type

7.3.5.5　Noise Suppressors

Noise is best defined as unwanted sound that is both irritating and harmful. Since most major airports are located near large cities, the need to minimize turbine exhaust noise is apparent. The aircraft industry has reacted to the need for less offensive operations by continually improving noise reduction techniques on every new generation of engine and aircraft.

Older turbojet engines produce a combination of noise frequencies at very high levels. Although a turbojet compressor produces a great deal of high frequency sound, this noise decreases rapidly as the distance from the source increases. On the other hand, turbojet exhaust produces noise at a wide range of frequencies and at very high energy levels.[17] This noise is audible over great distances and is more damaging to human hearing. One solution to turbojet exhaust noise is the use of a corrugated perimeter noise suppressor that helps break up the exhaust flow and raise its noise frequency (see Figure 7.3-29).

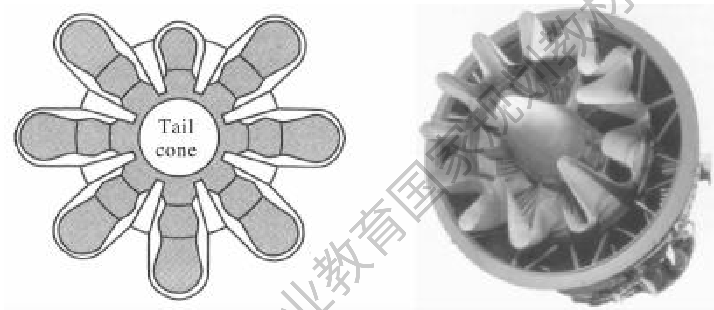


Figure 7.3-29 A Corrugated-perimeter noise suppressor

Newer engines employ a variety of techniques to reduce harmful noise. For example, some turbofan engines blend fan discharge air with the exhaust gases to reduce sound emission. On these engines, the sound from the inlet is likely to be louder than from the tail pipe. In addition, the inlet and exhaust ducts on turbofan engines are lined with sound attenuating materials that greatly reduce noise levels (see Figure 7.3-30).

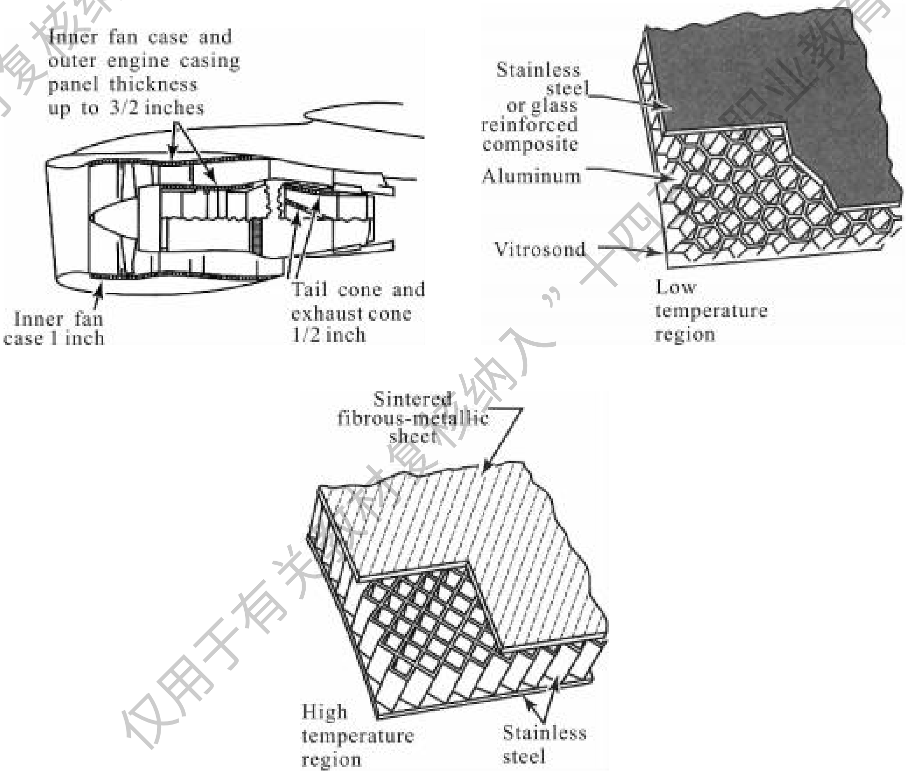


Figure 7.3-30 Turbofan engine with sound attenuating materials

Because of the characteristic of low frequency noise to linger at a relative high volume, noise reduction is often accomplished by increasing the frequency of the sound. Frequency change is accomplished by increasing the perimeter of the exhaust stream. This reduces the tendency of hot and cold air molecules to shear against each other and also to break up the large turbulence in the jet wake.

New Words/ Phrases/ Expression

1. component [kəm'pəʊnənt] *n.* 部件；组成
2. nomenclature [nə'menklətʃə(r)] *n.* （某一学科的）术语；专门名称
3. reflect [ri'flekt] *vt.* 表达，显示
4. applicable [ə'plikəbl] *adj.* 适当的，可应用的
5. terminology [ˌtɜːmi'nɔlədʒi] *n.* 专门名词；术语，术语学；用辞
6. air inlet 进气道
7. accessory [ək'sesəri] *n.* 附件
8. lubrication [ˌluːbri'keiʃn] *n.* 润滑
9. auxiliary [ɔːg'ziliəri] *adj.* 辅助的
10. anti-icing ['æti'aisiŋ] *adj.* 防冰
11. pressurization [ˌpreʃərai'zeiʃn] *n.* 增压
12. aerodynamic [ˌeərəʊdai'næmik] *adj.* 空气动力(学)的
13. distributed [dis'tribjuːtid] *adj.* 分配的
14. inlet guide vanes 进口导向叶片
15. encounter [in'kaʊntə(r)] *vt.* 遭遇
16. stall [stɔːl] *n.* 喘振
17. stator vanes 静子叶片
18. bleed off 放掉
19. excess [ik'ses] *adj.* 超重的，过量的，额外的
20. partway ['paːt'wei] *v.* 到中途，到达一半
21. subsonic [ˌsʌb'sɔnik] *adj.* 亚声速的
22. geometry [dʒi'ɔmətri] *n.* 几何学；几何形状；几何图形
23. diameter [dai'æmitə(r)] *n.* 直径
24. progressively [prə'gresivli] *adv.* 逐步地
25. divergent [dai'vɜːdʒənt] *adj.* 扩散的
26. venturi [ven'tʊəri] *n.* 文氏管（一种流体流量测定装置）
27. spread out 分散；伸展，延长
28. velocity [və'lɔsəti] *n.* 速率，速度
29. cruising speed 巡航速度
30. optimum ['ɔptiməm] *adj.* 最适宜的
31. mismatch ['mismætʃ] *vt.* 使配合不当

32. contamination [kənˌtæmiˈneiʃən] *n.* 污染，弄脏
33. ambient [ˈæmbiənt] *adj.* 周围的，包围着的
34. suffer [ˈsʌfə(r)] *vi.* 变糟，变差
35. diffuse [diˈfjuːs] *vt.* 扩散，发散
36. discharge [disˈtʃɑːdʒ] *vt.*，*vi.* 放出；流出；排出
37. remainder [riˈmeində(r)] *n.* 剩余物
38. shroud [ʃraʊd] *n.* 护罩
39. converging [kənˈvɜːdʒiŋ] *adj.* 收敛(缩)的
40. penalty [ˈpenəlti] *n.* 害处
41. offset [ˈɔfset] *vt.* 抵消，补偿
42. benefit [ˈbenifit] *n.* 利益，好处
43. supersonic [ˌsuːpəˈsɔnik] *adj.* 超声速的
44 incompressible [ˌinkəmˈpresəbl] *adj.* 不可压缩的
45. pile up 堆积，积聚
46. corresponding [ˌkɔrəˈspandiŋ] *adj.* 相当的，对应的；一致的
47. static pressure 静压
48. compressor pressure ratio 压气机增压比
49. axial [ˈæksiəl] *adj.* 轴向的
50. radial [ˈreidiəl] *adj.* 径向的；星形的
51. impeller [imˈpelə] *n.* 叶轮
52. diffuser [diˈfjuːzə(r)] *n.* 扩散器
53. manifold [ˈmænifəʊld] *n.* 总管；歧管
54. hub [hʌb] *n.* 轮毂
55. rotational [rəʊˈteiʃənl] *adj.* 转动的
56. kinetic energy 动能
57. potential energy 势能
58. double-entry [ˈdʌblˈentri] *adj.* 双面进气
59. single-entry [ˈsiŋg(ə)lˈentri] *adj.* 单面进气
60. eliminate [iˈlimineit] *vt.* 排除，消除
61. rotor [ˈrəʊtə(r)] *n.* 转子
62. stator [ˈsteitə] *n.* 静子
63. blade [bleid] *n.* 叶片
64. airfoil [ˈeəfɔil] *n.* 翼型
65. casing [ˈkeisiŋ] *n.* 机匣；壳体；外罩
66. comprise [kəmˈpraiz] *vt.* 包含，包括；由……组成；由……构成
67. dowel pin 定位销
68. lock ring 卡环
69. lock plate 锁片
70. fir-tree root 枞树形榫头

71. lock screw 锁紧螺钉
72. dovetail root 燕尾形榫头
73. frontal area 迎风面积
74. turbulence [ˈtəːbjələns] *n.* 紊流，湍流
75. interior [inˈtiəriə(r)] *adj.* 内部的
76. twin-spool [ˈtwinspuːl] *adj.* 双转子，双轴
77. flexibility [ˌfleksəˈbiləti] *n.* 机动性，灵活性
78. accommodation [əˌkɒməˈdeiʃn] *n.* 适应
79. supercharger [ˈsjuːpətʃaːdʒə] *n.* 增压器
80. triple-spool [ˈtriplspuːl] *adj.* 三转子，三轴
81. intermediate [ˌintəˈmiːdiət] *n.* 中压压气机
82. innermost [ˈinəməʊst] *adj.* 最里面的，最深处的
83. variable stator vanes 可变静子叶片
84. interstage [intə(ː)ˈsteidʒ] *adj.* 级间的
85. drainage [ˈdreinidʒ] *n.* 排放
86. annular chamber 环形燃烧室
87. cannular chamber 环管燃烧室
88. fuel nozzle 燃油喷嘴
89. spray [sprei] *vt.* 喷射
90. configuration [kənˌfigəˈreiʃn] *n.* 布局，构造
91. swirl vanes 旋流器叶片
92. vaporize [ˈveipəraiz] *vt.* 蒸发，汽化
93. flame tube 火焰筒
94. can-type combustor 罐式燃烧室，筒形燃烧室
95. curvature [ˈkəːvətʃə(r)] *n.* 弯曲；弯曲部分；曲率；曲度
96. warpage [ˈwɔːpeidʒ] *n.* 翘曲，扭曲；热变形
97. circumferentially [səˌkʌmfəˈrenʃəli] *adv.* 圆周地
98. impulse turbine 冲击式涡轮
99. reaction turbine 反应式涡轮
100. reaction-impulse turbine 冲击-反力式涡轮
101. flange [flændʒ] *n.* 法兰
102. turbine nozzle 涡轮喷嘴
103. distortion [diˈstɔːʃn] *n.* 扭曲，变形
104. loose fit 间隙配合
105. anchor [ˈæŋkə(r)] *vt.* (使)固定
106. vibration [vaiˈbreiʃn] *n.* 摆动；震动
107. misalignment [ˌmisəˈlainmənt] *n.* 未对准；角误差
108. exert [igˈzəːt] *vt.* 发挥；运用；使受(影响等)
109. creep [kriːp] *n.* 蠕变

110. forge [fɔːdʒ] *vt.* 锻造
111. cast [kaːst] *vt.* 铸造
112. nickel-based alloys 镍基高温合金
113. ceramic [sə'ræmik] *adj.*，*n.* 陶器的；陶瓷制品
114. shrouded blade 带有叶冠的转子叶片
115. knife-edge seal 刀边封严
116. exhaust cone 排气尾锥
117. tailpipe ['teilpaip] *n.* 尾喷管
118. exhaust nozzle 喷口
119. strut [strʌt] *n.* 支柱
120. fuselage ['fjuːzəlaːʒ] *n.* （飞机的）机身；火箭的外壳
121. nacelle [nə'sel] *n.* 发动机短舱
122. accelerate [ək'seləreit] *vt.* （使）加快，（使）增速；加速
123. air mass 气团
124. mixer ['miksə(r)] *n.* 排气混合器
125. coaxially [kəʊ'æksiəli] *adv.* 同轴地
126. pneumatic [njuː'mætik] *adj.* 气动的
127. hydraulic [hai'drɔːlik] *adj.* 液压的
128. thrust reverser 反推
129. category ['kætəgəri] *n.* 类型，种类
130. actuator ['æktʃʊeitə] *n.* 作动器
131. re-ingestion [riˌin'dʒestʃən] *n.* 再次吸入；倒吸
132. debris ['debriː] *n.* 碎片，残渣
133. obstruction [əb'strʌkʃn] *n.* 障碍物
134. clamshell ['klæmʃel] *n.* 蛤壳
135. noise suppressor 消声器
136. audible ['ɔːdəbl] *adj.* 听得见的
137. corrugated ['kɒrəgeitid] *adj.* 波纹状的
138. perimeter [pə'rimitə(r)] *n.* 边界
139. blend [blend] *vt.* 混合
140. lined with 布满
141. sound attenuating material 消声材料
142. molecule ['mɔlikjuːl] *n.* 分子；微小颗粒
143. jet wake 排气尾流

Notes

【1】The air inlet is formed by the structural support parts located forward of the compressor and has the purpose of admitting air to the forward end of the compressor.

翻译：进气道由位于压气机前端的结构支撑部件构成，其目的是将空气吸入压气机的

前端。

【2】The guide vanes in the axial-flow turbojet engine provide a change in direction of airflow so that air is directed on the first stage of the compressor at the proper angle.

翻译:轴流式涡喷发动机的进口导向叶片改变了气流的方向,使空气以适当的角度流向压气机的第一级。

【3】This divergent shape works like a venturi in that as the intake air spreads out, the velocity of the air decreases and the pressure increases.

翻译:这种扩散形的管道,其工作原理类似于文丘里管。随着空气的流动扩散,空气速度降低,压力增大。

【4】To be effective, a modern compressor must increase the intake air pressure 20 to 30 times above the ambient air pressure and move the air at a velocity of 400 to 500 feet per second.

翻译:为了提高效率,现在的压气机必须将流入的空气压力提高到外界大气压力的20～30倍,并让空气以400～500英尺每秒的速度流动。

【5】If the discharge air pressure is 30 times greater than the inlet air pressure, that compressor has a compressor pressure ratio of 30∶1.

翻译:如果出口压力是进口压力的30倍,则压气机的增压比为30∶1。

【6】The impeller, which is usually an aluminum-alloy forging, guides the air toward the outside of the compressor, building up the air velocity by means of the high rotational speed of the impeller.

翻译:叶轮一般由铝合金锻造而成,用来引导气流流向压气机外部,叶轮通过高速转动来提高空气的速度。

【7】The diffuser converts the kinetic energy of the air leaving the compressor to potential energy (pressure) by exchanging velocity for pressure.

翻译:扩散器通过用速度换取压力的方式,在空气流出压气机时将空气的动能转化为压力势能。

【8】The compressor blades, shaped like small airfoils, become smaller from stage to stage, moving from the front of the compressor to the rear.

翻译:压气机叶片的形状类似于机翼的翼型,其尺寸由前向后逐级减小。

【9】The purpose of the stator blades is to change the direction of the airflow as it leaves each stage of the compressor rotor and to give it proper direction for entry into the next stage.

翻译:静子叶片的作用是在气流离开压气机的每一级转子时改变其流动方向,从而保证气流以恰当的方向进入下一级转子。

【10】The high-pressure compressor is speed-governed to operate at proper speeds for the most efficient performance in compressing the high-temperature, high-pressure air toward the rear of the compressor section.

翻译:高压压气机是经过调速的,以适当的速度工作,从而获得最高效的性能去压缩高温高压的空气,使其流向压气机后部。

【11】The effect of the variable vanes is to provide a means for controlling the direction of compressor interstage airflow, thus ensuring a correct angle of attack for the compressor blades and reducing the possibility of compressor stall.

翻译:可调静子叶片的作用是控制压气机级间的气流方向,从而保证转子叶片的攻角正确并且降低压气机喘振的可能。

【12】The combustion section of a turbojet engine may consist of individual combustion chambers ("cans"), an annular chamber which surrounds the turbine shaft, or a combination consisting of individual cans within an annular chamber.

翻译:涡喷发动机的燃烧室由若干个单独的燃烧室(单管)组成,它们围绕发动机转轴排列成环形;或者由若干个单独的火焰筒共用一个环形的机匣而构成。

【13】The purpose of the turbine nozzle is to collect the high energy airflow from the combustors and direct the flow to strike the turbine rotor at the appropriate angle.

翻译:涡轮导向器的作用是收集来自燃烧室的高能量燃气并引导燃气以适当的角度推动涡轮转子转动。

【14】Due to the diverging passage between the outer duct and inner cone, gas velocity within the exhaust cone decreases slightly while gas pressure rises.

翻译:由于排气管外壳与排气尾锥之间形成了扩散形的通道,流过尾锥的燃气速度稍有减小同时压力升高。

【15】High bypass engines, on the other hand, usually exhaust the two streams separately through two sets of nozzles arranged coaxially around the exhaust nozzle.

翻译:另一方面,高涵道比发动机通常采用两个同轴分布的排气管将两股气流分开排出。

【16】Some high bypass turbofans will have only cold stream reversing because most of the thrust is present in the fan discharge and a hot stream reverser would be of minimum value and become a weight penalty.

翻译:一些高涵道比的涡扇发动机只采用冷气流反推,因为涡扇发动机大部分的推力由风扇排气产生,而热气流反推产生的效果甚微并且会增加发动机重量。

【17】On the other hand, turbojet exhaust produces noise at a wide range of frequencies and at very high energy levels.

翻译:另一方面,涡喷发动机排气产生的噪声具有较宽的频率范围,并且带有较高的能量。

Exercises

Ⅰ. Answer the following questions:

1. What are the seven basic sections of gas turbine engine?
2. Which type of the air inlet is utilized in the high bypass turbofan engine?
3. What is the definition of compressor pressure ratio?
4. What the centrifugal compressor consists of?
5. What the axial-flow compressor consists of?
6. What's the advantages of axial-flow compressor?
7. In a twin-spool engine, what drives the low-pressure compressor?

8. What are the three types of combustion chamber?

9. What's the function of the turbine?

10. What are the three types of the turbine? Which type is normally employed in the turbojet engine?

11. What are the four basic elements of the turbine section?

12. What the exhaust section is comprised of?

Ⅱ. Translate the following sentences into Chinese:

1. A typical subsonic air inlet consists of a fixed geometry duct whose diameter progressively increases from front to back.

2. For example, when supersonic airflow is forced through a convergent duct, it compresses, or piles up, and its density increases.

3. The rotor is attached to a shaft which is driven by the turbine or turbine stages that drive this compressor. The rotor blades are attached to the rotor and are of an airfoil shape which maintains an axial air flow throughout the compressor.

4. The low-pressure compressor is driven by a two-stage turbine mounted on the rear end of the inner shaft, and the high-pressure compressor is driven by a single-stage turbine mounted or the outer coaxial shaft.

5. The use of the dual compressor makes it possible to attain pressure ratios of more than 20:1, whereas the single axial-flow compressor produces pressure ratios of only 6:1 or 7:1 unless variable stator vanes are employed.

6. In this arrangement the fan is referred to as the low speed, or N1 compressor. The compressor next in line is called the intermediate, or N2 compressor, and the innermost compressor is the high pressure, or N3 compressor.

7. All combustion sections contain the same basic elements: one or more combustion chambers (combustors), a fuel injection system, an ignition source, and a fuel drainage system.

8. A reaction turbine changes the speed and pressure of the gases. As the gases pass between the turbine blades, the cross-sectional area of the passage decreases and causes an increase in gas velocity.

9. As the high velocity gases pass through the turbine nozzle and impact the turbine blades, the turbine rotor rotates.

10. Modern engine designs incorporate many combinations of air cooling methods that use low and high pressure air for both internal and surface cooling of turbine vanes and blades.

Ⅲ. Fill in the following blanks according to the text:

1. A turbine engine's hot section includes the _________, _________, and _________ sections.

2. The cold section, on the other hand, includes the ________ and the ________.

3. The air inlet of a turbojet engine is typically located at the front of the ________.

4. Therefore, the inlet duct on a supersonic aircraft must ________ the speed of the inlet air before it reaches the compressor.

5. Centrifugal compressors operate by taking in outside air near the hub and rotating it by means of an ________.

6. The diffuser converts the ______ energy of the air leaving the compressor to ______ energy (pressure) by exchanging velocity for pressure

7. A centrifugal compressor is either a ________ type or a ________ type.

8. The effect of the variable vanes is to provide a means for controlling the ________ of compressor interstage airflow, thus ensuring a correct ________ for the compressor blades and reducing the possibility of compressor ________.

9. A combustion section is typically located directly between the ________ and ________.

10. The purpose of the turbine nozzle is to collect the ________ airflow from the combustors and direct the flow to strike the ________ at the appropriate angle.

11. The most commonly used method for attaching turbine blades is by ________ slots cut into the turbine disk rim and matching bases cast or machined into the turbine blade base.

12. To sufficiently cool turbine nozzle vanes and turbine blades, ________ is typically directed in through the hollow blades and out through holes in the tip, leading edge, and trailing edge.

13. Some high bypass turbofans will have only ________ reversing because most of the thrust is present in the fan discharge.

7.4　Typical Components Maintenance of Gas Turbine Engine

7.4.1　Airworthy Manuals for Engine Maintenance

(1) Engine Maintenance Manual (EMM).

(2) Engine Cleaning, Inspection and Repairing Manual (CIR).

(3) Engine Illustrated Parts Catalog (IPC).

(4) Power Plant Buildup Manual (PPBM).

(5) Standard Processes Manual (SPM).

(6) Aircraft Maintenance Manual (AMM).

(7) Component Maintenance Manual (CMM).

(8) Overhaul Processes Manual (OPM).

(9) Time Limits Manual (TLM).

(10) Service Bulletin (SB).

(11) Airworthiness Directives (AD).

(12) Engineering Order (EO).

7.4.2 Main Procedures of Engine Maintenance (see Figure 7.4-1)

(1) Engine disassembly and assembly.
(2) Module disassembly and assembly.
(3) Cleaning of engine components.
(4) Inspection of engine components.
(5) Maintenance of engine components.
(6) Engine testing.
(7) Engine installation.

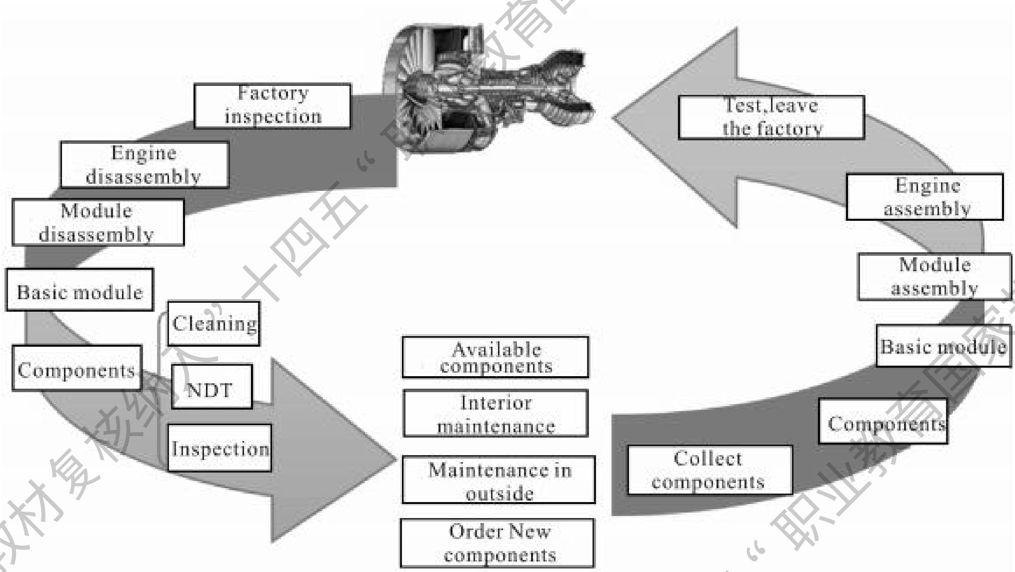


Figure 7.4-1 Engine shop-maintenance flow diagram

7.4.2.1 Disassembly

Turbine engines are disassembled either vertically or horizontally. When the vertical method is used, the forward part of the engine is usually mounted in a fixture facing downward. A small engine may be mounted on a fixture with castors so it can be rolled from one work area to another. On the other hand, large engines are often mounted vertically on a stationary fixture which is surrounded by scaffolding.[1] Another vertical mounting method for large engines involves securing the engine to an elevator which can be lowered into the shop floor. Scaffolds or elevators permit access to any point along the engine's length. When disassembled horizontally, an engine is typically mounted in a stand designed to allow the engine to be turned over for access to all external engine areas.

Once mounted on a disassembly stand, the engine is dismantled into modules, or main subassemblies. Each module is then mounted on a separate stand and moved to an area where it is further disassembled for cleaning, inspection, and overhaul. Large or heavy modules such as the compressor section and turbine section are lifted from the mounted engine by cranes or hoists.

7.4.2.2 Cleaning

Once disassembled, each engine component is cleaned so flaws and defects can be more easily detected. In addition, cleaning is required so that oxide deposits and dirt can be removed from a serviceable part to prepare it for special applications such as plating, anodizing, or painting before it is placed back in service.

All engine components are cleaned using approved cleaning methods and agents to prevent unintentional damage. For example, some cleaning solutions may strip plating from a part or cause a reaction with a base metal. As another example, you should refrain from cleaning titanium components with trichlorethylene. The reason for this is that entrapped traces of trichlorethylene can cause corrosion. Some commonly used cleaning methods include washing with organic solvents, vapor degreasing, steam cleaning, and tumbling in a grit solution. An effective cleaning method for hot section components consists of a series of controlled acid or alkali baths and water rinses.[2] Grit blasting may also be useful on either cold or hot section components.

7.4.2.3 Visual Inspection

Heavy maintenance inspections performed during overhaul start with a thorough visual examination after the engine parts have been cleaned. Typically, an inspection light and magnifying glass are used for close visual inspections.

Before conducting an actual inspection, it is advisable to review an engine's operation logs for entries made since the last inspection. Entries of hot starts, hung starts, oil and fuel pressure fluctuations, and overspeed or overtemperature incidents provide clues to what type of defects may be found.

1. Compressor Section

A turbine engine's fan blades or first stage compressor blades are vulnerable to damage caused by ingestion of foreign objects and erosion. Therefore, compressor blades and vanes must be visually examined to detect cracks, dents, gouges, and other defects caused by FOD.[3] It is very important that you be able to detect and correct critical blade defects because a single blade failure can lead to total engine failure (see Figure 7.4-2).

Light or minor foreign object damage can typically be repaired by blending the affected area away and then contouring to a final shape. On the other hand, severe damage or any damage in a blade's root requires blade replacement.

Blade and vane erosion results from ingestion of sand, dirt, dust, and other fine airborne contaminants. The abrasive effect of repeated ingestion can wear through a blade's surface coating and into the base metal. Slipstreams around the engine core of modern high bypass engines reduce blade erosion by directing some of the contaminants around, rather than through a compressor.[4] However, wing mounted turbofan engines often have little ground clearance, making them vulnerable to blade erosion during ground operations (see Figure 7.4-3).

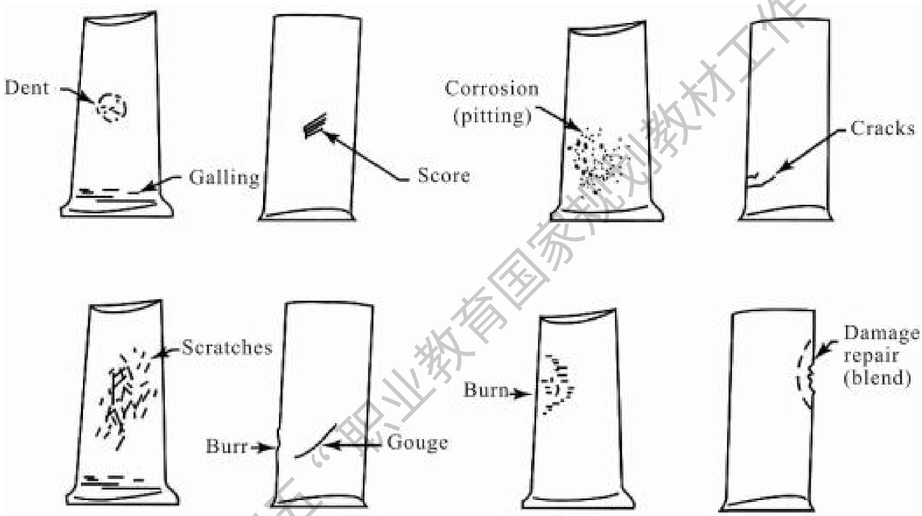


Figure 7.4-2　Compressor blades are subject to stress, metal fatigue, and FOD related defects ranging from light scratches and small dents to dangerous defects such as cracks and deep gouges

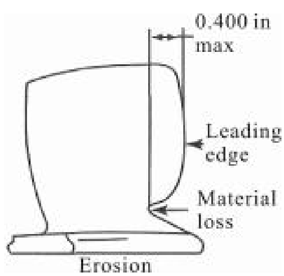


Figure 7.4-3　Blade erosion is accumulative and occurs over many hours of operation. Erosion shows up as a loss of material on a blade's leading edge and near a blade's root

2. Combustion Section

The types of defects that are acceptable for a given combustion section vary among engine models. Therefore, when inspecting a combustion chamber, you must follow the manufacturer's instructions. Typically, a combustion section is examined for the same types of damage in both line maintenance and heavy maintenance inspections. However, the method of inspection often differs. For example, when inspecting a combustion chamber during line maintenance, a borescope is required. However, during an overhaul, the entire combustion section is disassembled allowing a detailed inspection without a borescope.

Some of the more common defects found during an inspection include cracks, burner can shift, hot spots or scorched areas, warpage, and erosion. Combustion liners should also be checked for excess weld material or slag around all welded seams. If the welded material is not thoroughly fused into the base metal, the weld should be removed and reapplied. If this is not done, pieces of excess weld could break loose and damage turbine components downstream. By the same token, a liner having two or more converging cracks that are progressing from a free edge must be repaired or replaced to prevent a piece of metal from breaking free and causing damage elsewhere. Minor cracks in the baffling around a fuel nozzle support seat should be repaired if a single crack connects more than two air holes. In addition, minor cracks in a liner and around igniter boss pads should also be repaired. However, cracks in a cone or swirl vane are cause for rejection of the combustion liner.

A malfunctioning fuel nozzle can seriously damage a combustion liner. Typically, hot spots or scorched areas on a combustion liner result from flame contact due to a malfunctioning or misaligned fuel nozzle. For example, a partially clogged fuel nozzle often causes damage known as hot streaking in a combustion section. Hot streaking typically consists of burn marks along the length of a combustion section that result from unatomized fuel contacting the combustion liner and then burning. Severe hot streaking can result in a flame passing through the entire turbine section to the tailpipe.

3. Turbine Section

As you know, the turbine section of an engine is subjected to a great deal of heat and stress. Therefore, it is common to find damage in the form of cracking, warping, erosion, and burning. Cracking is probably the most common type of damage found in a turbine engine, followed by erosion which is caused by the flow of gases and the impingement of impurities in the gases on internal components. To aid in the inspection of a complete turbine section, it is best to inspect the turbine nozzle vanes, turbine disk, and turbine blades separately.

(1) Turbine nozzle vanes.

The hottest gases in a turbine engine pass through the first set of turbine nozzle vanes. Because of this, small cracks are frequently found. Depending on the size and orientation of the cracks, a small amount of cracking may be acceptable. Since stress is initially relieved by the development of small cracks, the small amount of crack progression in non-moving parts is usually negligible. However, anytime a set of cracks appear to be converging, the cracked component must be replaced to prevent major engine damage from occurring.

In addition to cracking, many operational hours of intense thermal stress and high-speed gases impacting a set of vanes can cause bowing and warping. The amount a given vane is bowed is measured on the trailing edge of each vane using a flat plate fixture and thickness gauge. Vanes which are bowed more than the allowable limits are either replaced or repaired in accordance with overhaul instructions. Typically, bowing is greater on the trailing edge than the leading edge. Therefore, if the trailing edge is within serviceable limits, the leading edge will more than likely be within limits as well (see Figure 7.4-4).

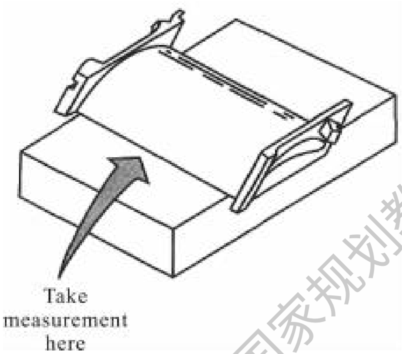


Figure 7.4-4 Checking a vane for bowing is accomplished by placing the vane on a flat plate fixture and inserting a thickness gauge under the leading and trailing edge

(2)Turbine disk.

A turbine disk is typically inspected visually using a strong inspection light and magnifying glass. Because of the centrifugal forces a turbine wheel is subjected to, any cracks found on a turbine disk are caused for rejection and replacement. However, some manufacturers do allow continued use of a turbine disk if slight pitting exists as long as the pitting can be blended by stoning and polishing.

(3) Turbine blades.

Turbine blades routinely incur damage because of the extreme environment in which they operate. Because of the potential for catastrophic engine failure should a turbine blade fail, cracking is not permitted in a turbine blade. Of particular concern during visual inspections are stress rupture cracks on turbine blade leading and trailing edges. Stress rupture cracks are perceptible as fine hairline cracks that appear at right angles to the blade length. Typical causes of stress rupture cracks include excessive temperatures or centrifugal loading.

Turbine blades are more prone to blade creep than compressor blades due to the high temperatures and centrifugal loads imposed during each engine cycle. A turbine engine cycle consists of engine start, operation for a period of time, and shutdown. Each engine cycle subjects turbine blades to high heat and high rotational speeds. As a result, every turbine blade becomes slightly longer with each engine cycle. Although the additional length may be only millionths of an inch, the accumulative effect produced by numerous engine cycles can eventually eliminate blade-to-case clearances.

Loads imposed by the flow of gases across turbine blades and vanes can cause them to untwist. When turbine blades and vanes begin untwisting, the efficiency of the turbine system decreases resulting in the deterioration of total engine performance. In order to check blades and vanes for untwist, they must be removed during engine tear down. Once removed, they can be measured in special shop fixtures. When a blade is removed for inspection, it must be reinstalled in the exact slot from which it came. This is necessary to maintain turbine wheel balance.

Curling of blade tips is usually acceptable if no sharp bends exist and the curling is within prescribed limits. Leading edge limits are typically a one-half square inch area at the tip while trailing edge limits are much less. Cracking or breaking of a blade tip commonly results from sharp bends at the tip and are cause for blade replacement.

4. Exhaust Section

The exhaust section of a turbine engine is subjected to the same high stresses and corrosive environment as the turbine section. Therefore, warping, buckling, and cracking are common defects found during inspections. A malfunctioning fuel nozzle or combustion chamber can produce hot spots, or hot streaking on the exhaust cone and tailpipe. If you recall, a fuel nozzle spraying a solid stream of fuel can produce a flame long enough to burn the exhaust cone. By the same token, if secondary airflow does not properly control the flame zone, the combustion flame may be allowed to contact the exhaust cone or tailpipe. Warping in an exhaust duct liner generally indicates the occurrence of a severe overtemperature event.

7.4.2.4 Structural Inspection

Structural inspections are conducted using nondestructive testing methods such as magnetic particle, fluorescent or dye penetrant, radiography, eddy current, and ultrasonic. The purpose of a structural inspection is to detect hidden flaws that are undetectable through visual inspection. For example, a hairline crack in a hot section component may only be visible with a fluorescent or dye penetrant. As another example any defects that exist below the surface of a component are detectable only through magnetic particle, radiography, eddy current, or ultrasonic testing.

As you know, magnetic particle testing can only be used on ferrous materials. The particles may be applied in either a dry form or wet in a solvent solution. The dry form works best on cast or forged parts with rough surfaces. A wet solution with fluorescent particles and an ultraviolet lamp best detects fine cracks in smooth surfaces.

Dye penetrant test kits are available with red dye or green dye. Red dye is convenient for daylight use because the developer may be sprayed from a can on the tested part. The developer causes penetrant trapped in a surface defect to turn red. The red mark or line on the part's surface is then clearly visible. Green dye kits work best on parts which can be removed and placed in a drip tray. After cleaning, a green fluorescent penetrating fluid is sprayed on the part and allowed to dry. An ultraviolet lamp is then used in a darkened room to illuminate defects, which show up as bright yellow-green lines.

Radiography is a testing method which uses X-rays or Gamma rays to penetrate a part and reveal hidden flaws. This testing method requires special training and licensing because it presents a hazard to personnel and requires certain safety precautions. Defects missed by visual and dye-penetrant methods are typically detected by radiography. This method may occasionally be utilized to verify suspected defects in an area which is not easily accessible.[5] However, several inherent limitations of this method limit its usefulness in engine overhaul applications.

Eddy current inspection locates both surface and subsurface discontinuities in metal parts. The specialized test equipment supplies alternating current at a specified frequency to a test coil which is held on the part to be tested. The magnetic field produced by the test coil induces a secondary magnetic field in the part being tested. The secondary magnetic field causes eddy current flow in the part which is measured and analyzed electronically. Discontinuities in a component disrupt the induced magnetic field and produce an anomaly which is detected by the test equipment and analyzed.[6]

Ultrasonic testing introduces high frequency sound waves through a part to detect discontinuities. There are two types of ultrasonic test equipment available: the immersion type and the contact type. Immersion equipment is heavy and stationary while contact equipment is small and portable. Both types beam sound waves through a part and display the response on a CRT for analysis. Examination of the variations found in a standard response pattern provides indications of discontinuities and flaws in a part.

7.4.2.5 Dimensional Inspection

Close tolerances and fits make dimensional inspections of turbine engine parts very important in determining their serviceability. For example, correct clearances between compressor and turbine blades and the engine housing is crucial to engine efficiency. Blade tip clearances are usually measured with a thickness gauge. Additional components that must be dimensionally checked during an overhaul are listed by manufacturers for each engine model in the overhaul manual. When specified, special tools provided by the engine manufacturer must be used to obtain accurate readings (see Figure 7.4-5).

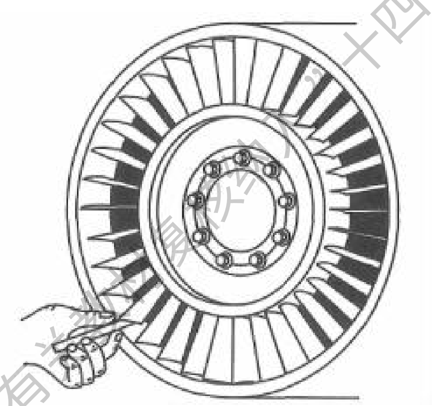


Figure 7.4-5　A thickness gauge is typically used to check clearances between turbine blades and the shroud unless a special tool is required by the manufacturer

7.4.2.6 Repairs

The decision to repair or replace a turbine engine component is based on many factors.

For example, mandatory replacement may be specified for certain parts in the overhaul manual instructions. On the other hand, some parts may be inspected for serviceability and repaired or replaced as necessary. If repairs can restore serviceability to a defective part, the remaining service life projections must be considered. Furthermore, repairs that must be built up or welded to serviceable limits typically require specialized equipment and facilities.

One popular technique used to build up a component and restore it to its original dimensions is plasma coating. The plasma coating process has proven to be a valuable means of extending the service life of blades and vanes and reducing overhaul costs. Plasma coating involves spraying an atomized metallic material onto the base metal of a part at a high velocity and at a high heat.[7] For example, to build up a compressor blade, the blade is sprayed with ionized argon gas heated to 27,760℃ (50,000℉), traveling at speeds over 2, 200 feet per second. Metallic powder is then introduced into the gas stream, causing a coat of molten metallic particles to bond to the airfoil. The process is controlled to produce multiple coatings as thin as 0.000, 25 inch each. Each coating becomes thoroughly fused to the base metal to provide excellent adhesion characteristics. Once the coating process is complete, the blade or vane airfoil can be ground to new part dimensions.

Another application of this process is referred to as ceramic coating and is used to coat compressor parts for corrosion protection. In addition, the ceramic coating produces a smooth surface that reduces air friction and surface drag, improving a compressor's performance. Some experimental processes are now used to apply ceramic materials on many of an engine's hot section components including combustors, turbine nozzle diaphragms, turbine disks, turbine blades, and vanes.[8]

In addition to the various types of coating processes used to build up engine components to serviceable limits, there are several welding methods that are used to make engine repairs. One such type of welding is called electron beam welding. Electron beam welding is a relatively new technique that is used to make repairs to compressor airfoils constructed from titanium alloys. When done properly, electron beam welding is as strong or stronger than a new blade or vane, making it possible to rework some compressor airfoils that would otherwise be rejected.

The primary difference between electron beam welding and other conventional welding techniques is that electron beam welding produces a narrower bead. This is possible because the welding process is done in a vacuum chamber which allows better control over the oxygen level. Heat is concentrated in a smaller area using this method, which subsequently reduces the stress on the base metal at the weld. As a result, this method of repair can often be used when damage to an airfoil exceeds blending or contouring repair limits. An insert of new material can be welded into place and then ground to the airfoil's original shape. As with most welding procedures, heat-treatment procedures are normally used to relieve stress in the area of the weld.

1. Compressor Section

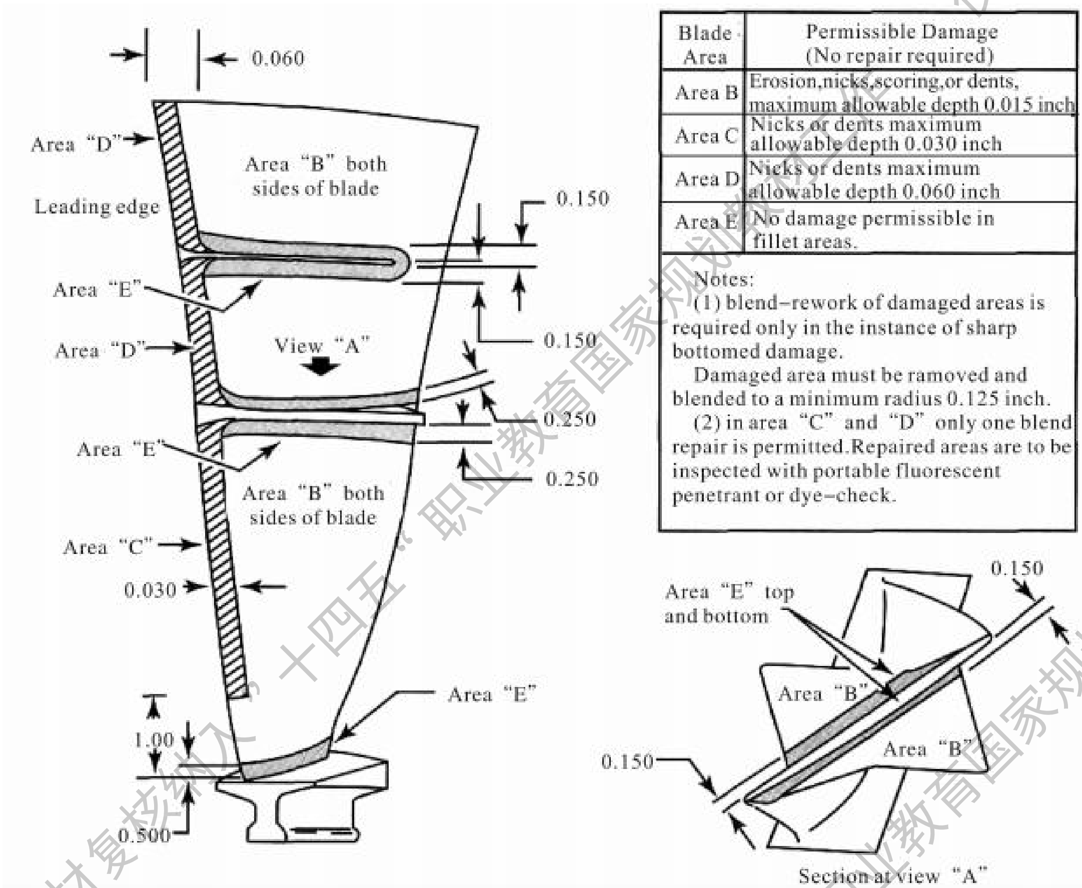
One of the most common repairs made to a compressor section is the removal of foreign object damage from blades and vanes by blending. Blending, as you recall, is a method of repairing damaged blades and vanes by removing metal with hand tools to smooth out all rough edges and restore an aerodynamic shape. Blending should be performed parallel to the length of a blade using smooth contours to minimize stress points. Common files, emery or crocus cloth, and carborundum stones are commonly used in blend repairs. Use of power tools is not permitted when blending because of the increased possibility of creating a heat stress buildup or inflicting accidental damage to adjacent areas.

A typical blend repair has a length to depth ratio of approximately 4 to 1 and is completed in several steps. First, the damaged area is scalloped by filing enough material away to create a saddle or dished out shape. Next, a stone or finish file is used to smooth out score marks and radius the edges of the repair. Last, the repair is polished with emery or crocus cloth to restore the original finish. Usually, repaired blades must be inspected by magnetic particle or dye penetrant methods to verify that all damage has been removed. Repaired areas are often marked with a felt tip dye marker to help maintenance personnel identify reworked areas during future inspections.

The amount of damage that is permissible on engine fan blades, inlet guide vanes, and compressor blades typically varies from engine to engine. Therefore, it is important that the manufacturer's repair instructions be referred to before any repair is made. As a general rule, nicks, dents, erosion, and scoring on the face of a fan blade require no repair as long as the damage does not exceed 0.030 inch.[9] The area where the deepest damage is permitted is on a fan blade's leading edge above a mid-span shroud. Damage in this area can typically extend into a blade up to 0.060 inch. The areas where no damage is permitted include the fillet areas at a blade's base and where a shroud meets the blade face (see Figure 7.4-6).

The amount of damage that is permissible on hollow inlet guide vanes is typically much less than the damage allowed on compressor fan blades. The reason for this is that inlet guide vanes are typically hollow and the vane walls are constructed of thin material. Based on this, blending out damage may result in inadvertently penetrating a vane wall if too much material is removed. Furthermore, attempting to repair an inlet guide vane by straightening, brazing, welding, or soldering is usually not permitted.

As a general rule, any sharp, V-shaped dent or any cracking and tearing of a guide vane requires vane replacement. However, small, shallow dents can typically be left unrepaired if they are rounded, have a gradual contour, and fall within the manufacturer's specifications. In addition, trailing edge damage of an inlet guide vane may be blended if one-third of the weld seam remains after a repair is made. Guide vanes that are rubber filled can usually be reused if some cracking exists as long as the cracks extend inward from the outer airfoil and do not appear to be converging. In addition, there can be no indication of pieces breaking away (see Figure 7.4-7).



Blade Area	Permissible Damage (No repair required)
Area B	Erosion, nicks, scoring, or dents, maximum allowable depth 0.015 inch
Area C	Nicks or dents maximum allowable depth 0.030 inch
Area D	Nicks or dents maximum allowable depth 0.060 inch
Area E	No damage permissible in fillet areas.

Notes:
(1) blend-rework of damaged areas is required only in the instance of sharp bottomed damage.
Damaged area must be ramoved and blended to a minimum radius 0.125 inch.
(2) in area "C" and "D" only one blend repair is permitted. Repaired areas are to be inspected with portable fluorescent penetrant or dye-check.

Figure 7.4 - 6 Light damage on a fan blade which falls within permissible damage limits can be left unrepaired. On the other hand, no damage is permitted in fillet areas and cracks require replacement of a fan blade (inch)

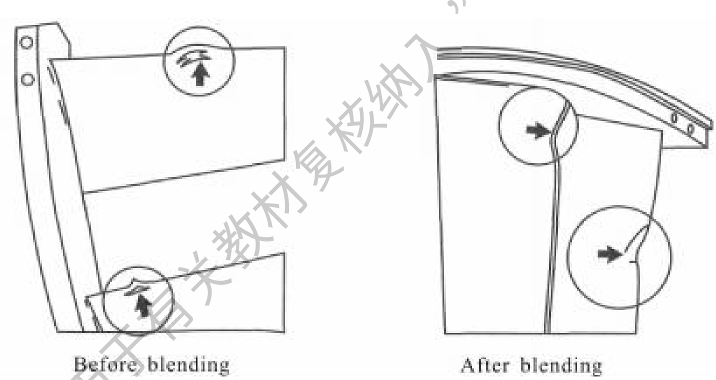


Figure 7.4 - 7 If an inlet guide vane becomes damaged and the damage does not penetrate the outer shell of the vane, the damage can be blended and contoured

Typically, minor damage on the outer half of an axial-flow compressor blade is repairable if the repaired area can be kept within the manufacturer's limits. However, some manufacturers may allow damage to be left unrepaired if the damage meets certain criteria. For example, if light damage to the leading or trailing edge of a compressor blade is visible from either side of a blade, confined to the outer half of the blade, well-rounded, and within acceptable limits, the damage may be left unrepaired.[10] On the other hand, damage on the inner half of a blade is critical. Minor damage must be repaired or the blade must be replaced, depending on the severity of the damage and the manufacturer's requirements. Cracks of any size on compressor blades are unacceptable and require replacement of the blade (see Figure 7.4-8).

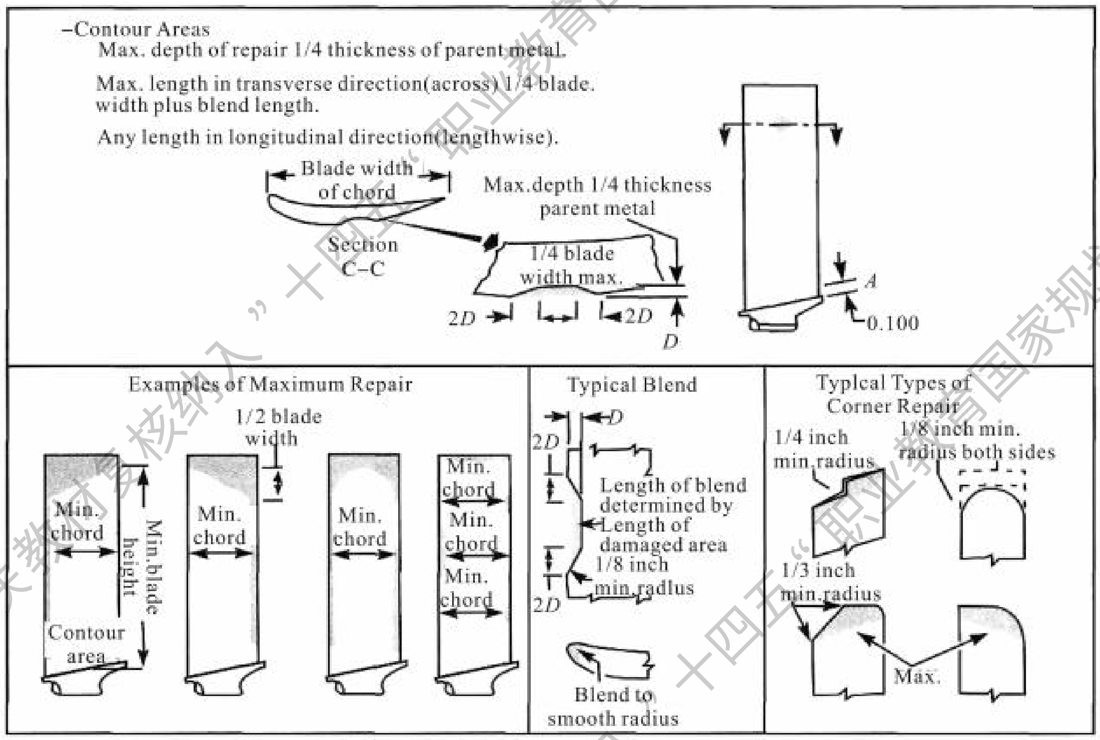


Figure 7.4-8 Compressor blade repairable limits and blended repairs are based on blade width, length, and chord dimensions. Typically, most leading and trailing edge damage as well as tip damage may be repaired provided that, after the damage is removed, the minimum chord and height are maintained (inch)

2. Combustion Section

Various methods are used to restore combustion section components. For example, cracked components can typically be welded while some worn components can be restored using a ceramic coating process that builds up component thickness. However, most of the repair processes used on combustion components require the use of specialized equipment that is generally found only at certified repair stations.

Welding is the most widely used method for repairing cracks in combustion liners that are outside of acceptable limits but within repairable limits. The exact type of welding process used on a particular liner depends on the material used to build the liner. Typically, combustion liners are constructed of stainless steel and can be repaired using either inert gas or electron beam welding. However, once a component has been welded, it must be heat-treated to relieve any stress buildup caused by the welding process.

3. Turbine Section

The amount of damage that is permitted in a turbine section varies from one manufacturer to another. Therefore, it is imperative that you refer to the manufacture's instructions when tying to determine if a specific type of damage is acceptable. As a general guideline, a maximum of three nicks, dents, or pits are permitted on the front and rear face of a turbine blade. However, only one nick, dent, or pit is permitted within a quarter inch of a fillet. Other areas where some minor damage may be permissible include the leading and trailing edges. However, the amount of damage that is serviceable is typically limited (see Figure 7.4-9).

Inspection	Maximum serviceable	Maximum repairable	Correction action
Blade Shift	Protrusion of any blade root must be equal within 0.015 inch either side of disk	Not repairable	Return blade disk assembly to an overhaul facility
Area A Nicks(3 maximum)	0.015 inch long by 0.005 inch deep	0.015 inch long by 0.010 inch deep	Blend out damaged
Dents and pits(3 maximum)	0.010 inch	0.015 inch long by 0.010 inchdeep	Blend out damaged
Area B Nicks,dents,and pits	One 0.020 inch deep	Not repairable	Replace blade
Leading and Trailing Edges Nicks,dents,and pits	One 0.020 inch deep	Two 1/8 inch deep	Blend out damaged area/ Replace blade

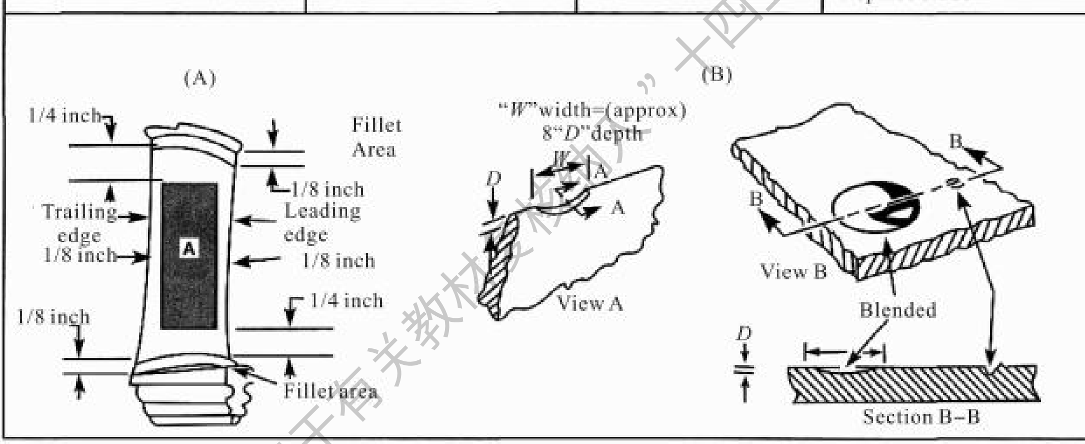


Figure 7.4-9　Repair turbine blade

Another type of damage that is common to turbine blades is erosion. One method used to repair erosion is to weld a new piece of blade into place using electron beam welding techniques. Once a new piece is welded, the blade is ground to the appropriate shape and heat treated to relieve any stress concentrations produced during the welding process. Another technique used to repair erosion is plasma coating. With this process, atomized metallic material is sprayed onto the eroded section of a turbine blade in multiple coats. Once the coating process is complete, a blade is ground to its original shape.

Additional turbine components that often require repair during an overhaul are the turbine nozzle vanes. Typical damage that can be repaired on turbine nozzle vanes include nicks, dents, scratches, bowing, and cracking.[11] Most nicks, dents, and scratches are repaired using simple blending and contouring techniques that help relieve stress concentrations and maintain a smooth airflow. If a turbine nozzle vane is bowed, it can usually be repaired by straightening. However, the material used to build some nozzle vanes cannot withstand the straightening process. In situations where straightening is not a permissible repair, the bowed area can be cut away and a new piece of blade material can be welded in place. Once welded in place, the vane is ground to the proper shape and heat-treated for stress relief (see Figure 7.4-10).

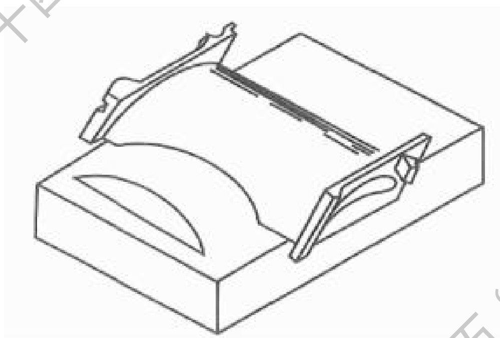


Figure 7.4-10 To repair a badly damaged turbine nozzle vane, the damaged area is removed and a new piece of material is welded in its place

Since turbine nozzle vanes do not rotate, they are not subject to the extreme stresses turbine blades must withstand. Therefore, minor cracking is permissible in most nozzle vanes. However, there are several factors that determine whether a crack or multiple cracks are permissible. To determine the exact criteria for permissible cracking, you must refer to the specific manufacturers overhaul manual (see Figure 7.4-11).

4. Exhaust Section

Damage in an exhaust section that can typically be repaired includes minor warping, buckling, and cracking. Warping and buckling are generally repaired by straightening whereas cracks are typically welded. Additional repairs that can be accomplished by welding include filling small holes with weld metal and replacing larger areas of damage by welding a new piece of metal in position. Typically gas or electron beam welding techniques are used to repair engine exhaust sections constructed of stainless steel.

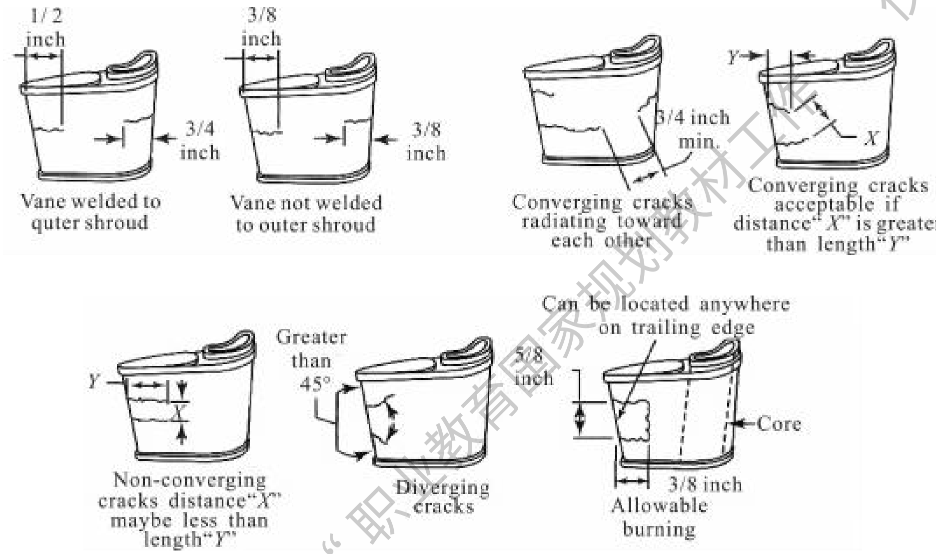


Figure 7.4-11 Some basic criteria for determining whether a crack or multiple cracks are acceptable in a turbine nozzle vane

5. Balancing

Approved repair procedures to a turbine engine are designed to maintain the strength and balance with which an engine was originally engineered. This is crucial because of the high rotational speeds at which turbine engines operate. If the main rotating assembly of a turbine engine is not balanced, severe vibration can occur. To help ensure that proper balance is maintained, both compressor and turbine blade replacement must be done in a specific way. For example, typically an engine manufacturer places restrictions on the number of blades that can be replaced in a given stage and on a single rotor before the rotor must be re-balanced.

A single blade replacement is generally accomplished by installing a new blade with an equal moment-weight. To determine the moment-weight of a single blade, each compressor or turbine blade is marked with a code indicating the blade's moment-weight in inch-ounces or inch-grams. If a new blade with the same moment-weight as the damaged blade is not available, multiple blades must be replaced. For example, on a compressor or turbine wheel with an even number of blades, the damaged blade and the blade opposite, or 180 degrees away, are replaced with blades having an equal moment-weight. If a damaged blade exists on a compressor or turbine wheel with an odd number of blades, three blades with equal moment-weights must be replaced; the damaged blade and the blades 120 degrees to the right and left (see Figure 7.4-12).

Most engines are limited to a maximum rpm that is less than the lowest rpm at which a rotating assembly begins to vibrate. However, if repairs are not done properly, the rpm at which vibration begins can be lowered into an engine's operational rpm range. Furthermore, if vibrations occur in one assembly they can induce vibrations in other assemblies having the same natural frequency. If allowed to continue, severe vibrations can eventually lead to complete engine destruction. Because of this, a turbine engine is normally checked for both static and dynamic balance during the repair process. As you recall, static balancing procedures ensure that an engine's main rotating assembly is balanced in the rotational plane. On the other hand, dynamic balancing ensures that the main rotating assembly is balanced both in the rotational plane and along the rotor's axis.

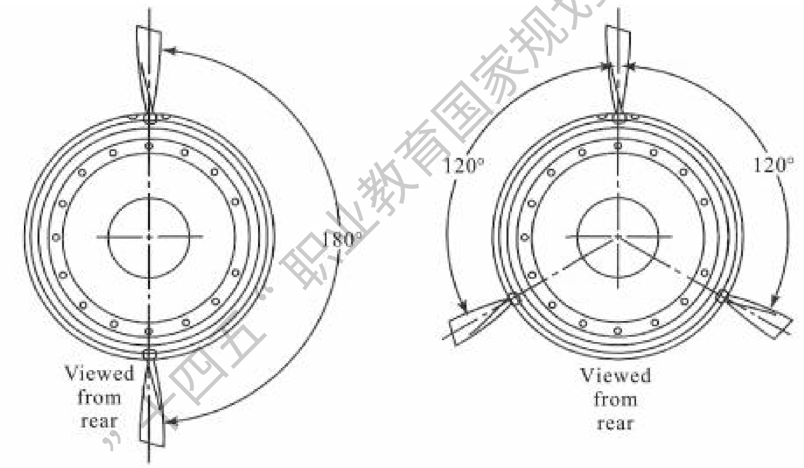


Figure 7.4－12 If a blade having the exact same moment-weight is not available to replace a damaged blade, blade replacement on a compressor or turbine wheel having an even number of blades is accomplished by replacing two blades with equal moment-weight. However, if the compressor or turbine wheel has an odd number of blades, replacement is done by replacing the damaged blade and each blade 120 degrees to the left and right of the damaged blade

6. Reassembly

As a general rule, the same fixtures and tooling used to disassemble a gas turbine engine are used to reassemble an engine after heavy maintenance or overhaul. In addition, torque wrenches and other torque measuring tools are needed to ensure components are properly torqued to manufacturer specifications.【12】 Closely machined mating surfaces and tight clearances typical of turbine engine construction demand the utmost care during reassembly.

Turbine engines may be reassembled vertically or horizontally. Reassembly procedures are basically the reverse process of disassembly, however, more time is needed to ensure proper fit and tightening of hardware. In addition, it is absolutely crucial that the specified hardware tightening sequences are observed during reassembly to prevent incorrect torque settings. A turbine engine has many circular bolt-ring sets and special torquing procedures are often stipulated by the engine manufacturer. In addition, all modules, or sections, must be checked for airworthiness certification and appropriate paperwork prior to reassembly.

A typical overhaul manual specifies parts which must be replaced regardless of condition when reassembling an engine. Some examples of parts which are ordinarily replaced during an overhaul include all bearings, seals, gaskets, O-rings, lock-wire, lock washers, tablocks, and cotter pins.

7. Engine Testing

The final step in the overhaul process is to test the engine. Engine performance is evaluated in a test cell during block testing by specialized test equipment and standard engine instruments. Operational test procedures vary with individual engines, however, the failure of any internal part during an engine run-in requires return of the engine for tear-down and repair. If failure of an engine accessory occurs, a new accessory is installed and the block test continues. Following successful completion of block test requirements, engines not slated for immediate installation and operation on an aircraft should receive a corrosion prevention treatment and be placed in storage.

7.4.2.7 Engine Installation

After an engine has been repaired, overhauled, or replaced, it must be prepared for installation. With a repaired or overhauled engine, preparation typically entails returning the engine to the configuration it was in immediately after it was removed. However, if the engine being installed is shipped new from the factory, additional assembly is typically required. For example, if an engine was preserved in storage, de-preservation procedures are usually outlined in the overhaul manual provided by the engine manufacturer.

New words/ Phrases/ Expression

1. dismantle [dis'mæntl] *vt.* 拆开，拆卸
2. crane [krein] *n.* 吊车
3. hoist [hɔist] *n.* 升降机
4. flaw [flɔː] *n.* 裂缝，裂纹
5. defect ['diːfekt] *n.* 缺陷，瑕疵
6. oxide deposit 氧化物沉淀
7. plating ['pleitiŋ] *n.* 电镀
8. anodizing ['anəˌdaiziŋ] *v.* 阳极电镀；作阳极化处理
9. painting ['peintiŋ] *v.* 喷涂
10. unintentional [ˌʌnin'tenʃənl] *adj.* 无意的，无心的
11. refrain [ri'frein] *vt.* 抑制
12. titanium [ti'teiniəm] *n.* [化]钛
13. trichlorethylene [traiklɔː'reθiliːn] *n.* [化]三氯乙烯
14. solvent ['sɔlvənt] *n.* [化]溶剂
15. degrease [ˌdiː'griːs] *vt.* 脱脂，除油污
16. grit blasting 沙砾溶液
17. alkali ['ælkəlai] *n.* 碱
18. rinse [rins] *vt.* 漂洗；冲洗
19. grit blasting 喷砂

20. magnifying glass 放大镜
21. fluctuation [ˌflʌktʃʊ'eiʃn] *n*. 波动,涨落,起伏
22. crack [kræk] *n*. 裂纹
23. dent [dent] *n*. 凹痕
24. gouge [gaʊdʒ] *n*. 沟槽
25. erosion [i'rəʊʒn] *n*. 腐蚀
26. borescope [bɔː(r)skəʊp] *n*. 孔探;光学孔径仪
27. welded seam 焊缝
28. malfunctioning [mæl'fʌŋkʃəniŋ] *n*. 出故障
29. scorch [skɔːtʃ] *vt*., *vi*. 烧焦,烤焦
30. negligible ['neglidʒəbl] *adj*. 可以忽略的;微不足道的
31. bowing ['bəʊiŋ] *n*. 卷边
32. trailing edge 后缘
33. leading edge 前缘
34. pitting ['pitiŋ] *n*. 点蚀
35. stoning ['stəʊniŋ] *n*. 打磨
36. polishing ['pɔliʃiŋ] *n*. 抛光
37. catastrophic [ˌkætə'strɔfik] *adj*. 灾难的;惨重的
38. accumulative [ə'kjuːmjələtiv] *adj*. 积聚的,累积的
39. untwist ['ʌn'twist] *v*. 拆开,解开
40. deterioration [diˌtiəriə'reiʃn] *n*. 恶化,变坏
41. tear down 拆卸
42. reinstall [ˌriːin'stɔːl] *vt*. 重新设置
43. buckling ['bʌkliŋ] *n*. 弯曲
44. magnetic particle 磁粉
45. fluorescent [ˌflɔː'resnt] *n*. 荧光
46. dye penetrant 着色渗透
47. radiography [ˌreidi'ɔgrəfi] *n*. X 光,放射线
48. eddy current 涡流
49. ultrasonic [ˌʌltrə'sɔnik] *n*. 超声波
50. ultraviolet lamp 紫光灯
51. developer [di'veləpə(r)] *n*. 显影剂,显像剂
52. discontinuity [ˌdisˌkɒnti'njuːəti] *n*. 不连续,中断
53. plasma coating 等离子喷涂
54. molten ['məʊltən] *adj*. 熔化的
55. electron beam welding 电子束焊
56. scoring ['skɔːriŋ] *n*. 擦痕
57. brazing [breiziŋ] *n*. 铜焊
58. soldering ['sɔldəriŋ] *n*. 锡焊

59. heat-treated ['hiːt'triːt'] *adj.* 热处理的

60. cotter pin 开口销

Notes

【1】On the other hand, large engines are often mounted vertically on a stationary fixture which is surrounded by scaffolding.

翻译:另一方面,大型发动机通常被垂直安装在固定的夹具上,周围是一些支架。

【2】An effective cleaning method for hot section components consists of a series of controlled acid or alkali baths and water rinses.

翻译:发动机热端部件的有效清洗方法是由一系列的控制酸碱浴和水冲洗完成的。

【3】Therefore, compressor blades and vanes must be visually examined to detect cracks, dents, gouges, and other defects caused by FOD.

翻译:因此,必须对压气机转子和静子叶片进行目视检查,以发现裂纹、凹痕、裂缝和其他由外物损伤引起的缺陷。

【4】Slipstreams around the engine core of modern high bypass engines reduce blade erosion by directing some of the contaminants around, rather than through a compressor.

翻译:现代高涵道比发动机中,核心机周围的气流会引导一部分污染物绕过压气机流动,而并非流经压气机,这样可以减少对压气机叶片的侵蚀。

【5】This method may occasionally be utilized to verify suspected defects in an area which is not easily accessible.

翻译:这种方法有时被用来验证一个不易接近区域中的可疑缺陷。

【6】Discontinuities in a component disrupt the induced magnetic field and produce an anomaly which is detected by the test equipment and analyzed.

翻译:被测部件中的不连续性破坏了感应磁场,产生异常,这些都可以由测试设备检测和分析出来。

【7】Plasma coating involves spraying an atomized metallic material onto the base metal of a part at a high velocity and at a high heat.

翻译:等离子喷涂包括以高速和高温将雾化后的金属材料喷涂到零件的金属基体上。

【8】Some experimental processes are now used to apply ceramic materials on many of an engine's hot section components including combustors, turbine nozzle diaphragms, turbine disks, turbine blades, and vanes.

翻译:现在某些实验过程主要研究将陶瓷材料应用在发动机的许多热端部件中,包括燃烧室、涡轮导向器隔板、涡轮盘、涡轮转子叶片和静子叶片。

【9】As a general rule, nicks, dents, erosion, and scoring on the face of a fan blade require no repair as long as the damage does not exceed 0.030 inch.

翻译:一般情况下,只要损伤不超过0.030英寸,风扇叶片表面的缺口、凹痕、腐蚀和划痕就不需要修复。

【10】For example, if light damage to the leading or trailing edge of a compressor blade is visible from either side of a blade, confined to the outer half of the blade, well-rounded, and within acceptable limits, the damage may be left unrepaired.

翻译:例如,如果压气机叶片前缘或后缘的轻微损伤从叶片的任何一侧都可见,仅限于叶片的外半部,且在可接受的范围内,则损伤可能无法修复。

【11】Typical damage that can be repaired on turbine nozzle vanes include nicks, dents, scratches, bowing, and cracking.

翻译:涡轮导向器叶片可以修复的典型损伤包括缺口、凹痕、划痕、卷边和裂纹。

【12】In addition, torque wrenches and other torque measuring tools are needed to ensure components are properly torqued to manufacturer specifications.

翻译:此外,需要用到力矩扳手或其他力矩测量工具,以保证部件的安装力矩符合制造商的要求。

Exercises

Ⅰ. Answer the following questions:

1. What are the main procedures of engine maintenance?
2. What's the purpose of cleaning the engine components?
3. What are the main defects of compressor blades and vanes?
4. What are the more common defects found during an inspection of combustor?

Ⅱ. Translate the following sentences into Chinese:

1. Light or minor foreign object damage can typically be repaired by blending the affected area away and then contouring to a final shape.

2. Cracking is probably the most common type of damage found in a turbine engine, followed by erosion which is caused by the flow of gases and the impingement of impurities in the gases on internal components.

3. Turbine blades are more prone to blade creep than compressor blades due to the high temperatures and centrifugal loads imposed during each engine cycle.

4. Electron beam welding is a relatively new technique that is used to make repairs to compressor airfoils constructed from titanium alloys.

Ⅲ. Fill in the following blanks according to the text:

1. Once mounted on a disassembly stand, the engine is dismantled into ________, or main ________.

3. Structural inspections are conducted using nondestructive testing methods such as ________, ________, and ________.

3. Blade tip clearances are usually measured with a ________.

4. ________ is the most widely used method for repairing cracks in combustion liners that are outside of acceptable limits but within repairable limits.

Vocabulary

A

abrasive paper	砂纸	3.7/6.2
abuse	滥用	1.4
ACARS	飞机通信寻址和报告系统(Aircraft Communications Addressing and Reporting System 的缩写)	5.4
accelerate	(使)加快,(使)增速;加速	7.3
accelerometer	加速度计	5.3
accessory	附件;附加的,附属的	2.1/7.3
accommodate	容纳	1.4
accommodation	适应	7.3
accordingly	因此;依据,照着,相应地	2.2
accumulative	累积的,积聚的	2.4/7.4
accuracy	精确性,准确性	1.4
accurate	精确的	1.4
acquisition	获得,采集	5.3
acronym	首字母缩略词	1.3
actuating stem	作动杆	3.7
actuator	作动器	7.3
adhesive	黏合剂,胶	4.4
adjuster	调节器	6.5
adjusting screw	调节螺钉	3.5
ADL	机载数据装载器(Airborne Data Loader 的缩写)	5.3

administration	管理；实行；(法律的)施行	2.1
aeolipile	汽转球	7.1
aerodnamic	空气动力(学)的	7.3
aeronautical material	航空材料	1.2
Aeronautical Radio Inc.	航空无线电通信公司	5.2
AFCS	自动飞行控制系统(Auto Flight Control System 的缩写)	5.5
aforementioned	上述的；前述的	2.3
aging	时效	1.2
air inlet	进气道	7.3
air mass	气团	7.3
airfoil	翼型	7.3
airframe material	飞机框架(骨架)材料	1.2
airload	飞行时的空气动力负荷	6.3
air-oil type shock struts	油气式减震支柱	6.2
airstream	气流(尤指与飞机前进方向相反的来流)	6.2
airworthiness	适航性,适航	2.1
align	使结盟,使成一行,匹配；排列,排成一行	3.5
alkali	碱	7.4
Allen screw	内六角螺钉	1.4
Allen wrench	内六角扳手	1.4
allocate	分配,分派；划拨	2.1
alodine	阿洛丁(氧化法)；铬酸阳极化	3.7
alteration	变化,改变；变更	2.1
alternating stress	交变应力	1.2
Alumina	Al_2O_3(三氧化二铝)	1.2
aluminium oxide	氧化铝	6.4
aluminum	铝	1.2/3.5
aluminum oxide abrasive cloth	氧化铝砂布	3.7
ambient	周围的,包围着的	7.3

amendment	(法律、文件的)改动；修改	2.3
amplify	放大，增强	1.4
analog	模拟的	1.4/5.2
analyze	分析；解释	2.2
anchor	(使)固定	7.3
anchor nut	托板螺母	1.3
angular contact bearing	向心止推滚动轴承，角面接触滚动轴承	4.2
annealing	退火	1.2
annex	附件、附加	2.4
annular chamber	环形燃烧室	7.3
anodic film	阳极化膜	1.5
anodize	阳极电镀；作阳极化处理	3.7
anodized	做阳极化处理	4.5
anodizing	阳极化，阳极电镀，作阳极化处理	1.2/7.4
anticipate	预期；预料；预计	2.1
anti-icing	防冰	7.3
appliance	工具，器械，装置	2.1
applicable	适当的；可应用的	2.1/7.3
applicant	申请人	2.4
application	适用，应用，运用；申请，请求	1.3/2.2
approve	赞成，批准	2.1
approximately	近似地，大约	4.5
arbitrarily set	主观设定	1.1
armature	电枢(电机的部件)	4.3
ASSY	assembly 的缩写	4.4
asterisk	星号	1.3
audible	听得见的	7.3
audit	审计，审核	2.2
authorization	授权，委任，认可，批准	2.4
authorized	权威认可的，审定的，经授权的	2.1

auxiliary	助动词，辅助者；辅助的，副的，附加的	3.1/3.5/7.2/7.3
auxiliary power unit (APU)	辅助动力装置	4.2/7.2
available	可用的；有空的	2.2
avionics rack	电子设备架	5.2
avoid	避免，预防	2.1
awkward	别扭的，难操纵的	1.4
axial	轴向的	7.3
axial flow compressor	轴流式压气机	7.2
axially	轴向的	3.4

B

back and forth	来回地	3.5
ball bearing	球轴承	3.5
be proportional to…	与……成正比	7.1
beamwidth	波束宽度	5.5
bearing	轴承	6.2
benefit	利益，好处	7.3
bias	倾向；斜线	2.2
binding	卡滞	4.3
biweekly	两周一次地，双周地	2.3
blade	叶片	7.3
blast	喷出	7.1
bleed off	放掉	7.3
blend	混合	7.3
blind rivet	盲铆钉	1.3
blowtorch	吹管，喷灯；喷气发动机	7.1
blunt	钝的	1.4
bogie	转向架，轮架	6.2
bol	螺栓	1.3
bootstrap	自动持续作用，自举作用	3.3

bootstrap air-cycle machine	自持空气循环机	3.3
bore	内镗	3.2
borescope	内窥镜，孔探	1.5/7.4
bottom dead center	下死点	7.1
bounce	反弹，跳，蹦	5.4
bound	给……划界，限制；有义务的	2.1
bowing	卷边	7.4
box-end wrench	梅花扳手	1.4
brazing	铜焊	7.4
break down	分解	1.3
briskly	迅速地；活泼地	3.5
brush	电刷	4.2
buckling	弯曲	7.4
built-in light source	内置光源	1.5
bulkhead	舱壁，隔板，隔墙	1.2/6.1
burst	爆发，突发	3.6
butterfly type	蝶形	3.2
buzzer	蜂鸣器	4.5
bypass	旁通	3.1
bypass engine	有涵道的发动机	7.2
bypass ratio	涵道比	7.2

C

cadmium	镉	6.2
calibrate	校准，校正；调整	1.4/3.6
caliper	（常用复数）卡钳；卡尺	1.4
cannular chamber	环管燃烧室	7.3
can-type combustor	罐式燃烧室，筒形燃烧室	7.3
capability	才能，能力；容量；性能	2.1
capillary	毛细管	1.5
capillary action	毛细作用	3.3

captive screw	固定螺钉	4.5
carbon monoxide	一氧化碳	1.2
card slots	卡插槽	5.2
cargo	(船或飞机装载的)货物	2.2
casing	机匣;壳体;外罩	7.3
cast	铸造	7.3
castellation	堞形	1.3
casting alloy	铸造合金	1.2
catalog	目录;登记	2.3
catastrophic	灾难的; 惨重的,悲惨结局的	2.1/6.4/7.4
category	类别, 种类	2.1/7.3
cathode-ray oscilloscope	阴极射线示波器	1.5
CCA	电路板组件(Circuit Card Assemblies 的缩写)	5.2
CCAR:China Civil Aviation Regulations	中国民用航空规章	2.4
centrifugal	离心的	3.3/7.2
centrifugal compressor	离心式压气机	7.2
centrifugal force	离心力	7.2
ceramic	陶器的;陶瓷制品	1.2/7.3
certification	证明,证实,证书	2.1
chassis	底盘,底架,机架	5.2
cheat	欺骗、作弊	2.4
check valve	单向活门	3.1
chisel	凿子	1.4
Chrome	铬,铬合金; 镀铬	6.2
Chromium	铬	1.2
circular	通知,通告;圆形的; 环行的	2.3
circumference	周围,圆周	6.3
circumferentially	圆周地	7.3
circumstance	情况,环境,条件	1.4

clamp	夹紧，夹钳	1.4
clamshell	蛤壳	7.3
classification	分等，分类；类别，等级	2.1
clearance	空隙，间隙	2.3
clockwise	顺时针方向地	4.3
close tolerance bolt	高精度螺栓	1.3
coaxially	同轴地	7.3
cold section	冷端	7.1
combustion chamber	燃烧室	7.1
combustor	燃烧室，燃烧器，火焰筒	1.2
commence	开始，着手	2.4
compensation	补偿，赔偿；修正	2.1
completeness	完整性	2.4
complexity	复杂性；复杂的事物	2.2/6.3
compliance	服从，听从；承诺	2.3
compliant	顺从的，应允的	2.1
comply with	照做，遵守	2.4/4.3
component	（机器，设备等）构成要素，零件，成分	1.1/2.1
component	部件；组成	7.3
composite	复合材料	1.2
compound	腻子	6.2
compress	压缩	7.1
compression ratio	压缩比	7.2
compressor	压气机	7.1
compressor blade	压缩机叶片	1.2
compressor pressure ratio	压气机增压比	7.3
comprise	包含，包括；由……组成；由……构成	7.3
conceal	隐藏	6.3
concentricity	中心度，同轴度（同心度）	1.4

condenser core	冷凝器芯体	3.1
configuration	布局，构造	7.3
conforms to	符合	2.4
connecting rod	连杆	7.1
consumable	消耗性的	2.3
contact pin	触点引脚	3.2
contain	包含，遏制	3.4
containment	阻遏	3.4
contaminant	污物，残留物	6.4
contamination	污染；玷污；污染物	3.5/7.3
continued	连续不断的；继续不变的	2.1
continuity test	导通性测试	3.2
continuous	连续的；延伸的	2.3
convenience	方便，便利	2.3
conventional	常规的，传统的	1.3
converging	收敛(缩)的	7.3
convert	转化，转变	7.1
Copper	铜	1.2
corrective	矫正的；修正的	2.1
corresponding	相当的，对应的	2.2/7.3
corrosion fatigue	腐蚀疲劳	1.2
corrosion resistance	耐腐蚀性	1.2
corrugated	波纹状的	7.3
cotter pin	开口销	1.3/7.4
cotton swab	棉签；棉纱擦帚	3.7
counterclockwise	反时针方向，逆时针	3.5/4.2
counter-drill	埋头钻	6.5
countersunk head	沉头	1.3
coupler	耦合器	5.1/5.4
CPL	coupler 的缩写	5.4

crack	使破裂;破裂,爆裂;裂缝	3.5/7.4
crane	吊车	7.4
crankcase	曲轴箱	7.1
crankshaft	曲轴	7.1
creep	蠕变	7.3
crevice corrosion	缝隙腐蚀	1.2
criteria	(批评、判断等的)标准,准则	2.1
crocus cloth	细砂布	3.7
cross point screw driver	十字螺丝刀	1.4
cruising speed	巡航速度	7.3
CSMU	抗撞击存储器组件(Crash Survivable Memory Unit 的缩写)	5.3
current	电流	1.4/2.2
current transformers (CT's)	电流互感器,变流器	4.2
curvature	弯曲; 弯曲部分;曲率;曲度	7.3
cutting tool	切割工具	1.4
cyclic	周期的,循环的	6.4
cylinder	气缸	7.1

D

damping	阻尼	5.1
debris	碎片;残渣	7.3
defect	缺点,缺陷,不足之处	3.5/7.4
deficiency	缺乏,不足; 缺点,缺陷	2.1
degrease	脱脂,除油污	7.4
delamination	分层	1.2
deliver	递送;投递;运送	2.2/7.2
demagnetization	退磁	1.5
demonstrate	证明; 论证; 表明; 说明	2.1
dent	凹痕	7.4
depict	描述	7.2
deprive of /deprivation	剥夺,免去;免职	2.4

descent	下降	5.5
designation	牌号	1.2
desire	渴望	1.4
detent	止动装置;[机] 棘爪	3.7
detergent	洗涤剂	4.5
deterioration	恶化,退化;堕落	3.6/7.4
developer	显影剂,显像剂	1.5/7.4
deviation	偏差	1.4
devise	设计;发明	7.1
DFCS	数字飞行控制系统(Digital Flight Control System 的缩写)	5.2
DFDAU	数字式飞行数据采集组件(Digital Flight Data Acquisition Unit 的缩写)	5.3
diagonal	对角线的,斜的	1.4
diagram	图表	1.1
dial	(仪器等的)刻度盘,示数盘	1.4
dial indicator	百分表	1.4
diameter	直径	1.3/7.3
diaphragm	膜片	3.7
diffuse	扩散,发散	7.3
diffuser	扩散器	7.3
digital	数字的,数字显示的	1.4/5.2
dimension	尺寸	4.4
diode rectifier	二极管整流器	4.2
diploma	文凭、学位证书	2.4
disassemble	分解	1.3
discard	丢弃,报废	6.2
discharge	放出,流出,排出	7.1/7.3
discontinuity	不连续,中断	7.4
discrepancy	不一致之处	1.1
dismantle	拆开,拆卸	4.4/7.4

dispose	处理,处置;安排	2.2
distortion	变形,扭曲	3.6/7.3
distribute	分配,散布;散发,分发	2.3
distributed	分配的	7.3
divergent	扩散的	7.3
DME	测距机(Distance Measuring Equipment 的缩写)	5.5
documentation	文件	1.1
domestic	家庭的,家的;国内的	2.1
double-entry	双面进气	7.3
dovetail root	燕尾形榫头	7.3
dowel pin	定位销	7.3
drainage	排放	7.3
draw in	吸入	7.1
drawing	拉(件),拉拔	1.2
drive block	驱动块,驱动键	6.4
drive end (DE)	驱动端	4.2
drive key	驱动键	6.4
dual channel	双通道	5.2
Duckbill pliers	鸭嘴钳	1.4
duct	涵道,管道	3.1/7.2
due to	由于	6.3
duty	负荷	3.2
dye	染色	1.5
dye penetrant	着色渗透	7.4

E

eddy current	涡流	7.4
eddy current inspection	涡流(探伤)检查	1.5
effective	有效的;起作用的	2.3
eject	喷出	7.1
electrical bonding test	电气接地测试	3.7

electrical conductivity	导电性能	1.2
electrical cord	绝缘电线	3.2
electrical resistance temperature bulb	电阻式感温包	4.2
electron beam welding	电子束焊	7.4
element	成分,组成部分	2.3
elevator	升降舵	1.2
eliminate	排除,消除	7.3
elimination	排除;除去	2.1
emergency	紧急状态	2.1
encompass	包含	1.4/2.1
encounter	遭遇	7.3
endow	捐赠,资助;赋予,赐予	2.1
energy available	可用能量	7.2
engage	啮合,配合	1.3
engaged in	从事于,致力于	2.4
engine material	发动机材料	1.2
equivalency	相等,等价	2.2
equivalent	相等的,同意义的;等价物,相等物	3.5/4.2/6.2
erosion	腐蚀	7.4
estimation	估计;评价;判断	2.2
evaluate	评价,评估	2.2
evenly	均匀地,平衡地,平坦地,平等地	3.5
excess	超重的,过量的,额外的	7.3
excessive	过多的,极度的	4.3
exert	发挥;运用;使受(影响等)	7.3
exfoliation	剥离	1.2
exhaust cone	排气尾锥	7.3
exhaust nozzle	排气喷管	7.1/7.3

expose	使(胶片,胶卷)曝光	1.5
expound	解释,详细叙述	2.4
extinguish	熄灭(火)	2.3
extract	吸收,吸取	7.2
extruded section	挤压成型	1.2

F

fabricate	制造;装配	2.2
failure	失败,不及格;缺乏,不足	2.1
fastener	紧固件	1.2/1.3
fatigue	疲劳	1.5
fatigue performance	抗疲劳性能	1.2
FCC	飞行控制计算机(Flight Control Computer 的缩写)	5.2
FDRS	飞行数据记录器系统(Flight Data Recorder System 的缩写)	5.3
fee	费用	2.4
feedback	反馈;回复;自动调节	2.1
feeder impedance	支线阻抗	4.2
feeler gauge	塞尺,厚薄规,间隙片	1.4
female contact	柔性连接	4.4
ferrous metal	铁金属	3.5
ferrule	套圈;金属箍	4.2
fine buffing wheel	细砂轮	3.7
fir-tree root	枞树形榫头	7.3
fixed	固定的,不变的	2.3
fixture	装置,定设施	2.2
flame tube	火焰筒	7.3
flange	法兰	7.3
flaw	裂缝,裂纹	7.4
flexibility	机动性,灵活性	7.3
flowmeter	流量计	4.5/3.7
fluctuation	波动,涨落,起伏	7.4

fluorescent	(发)荧光的	1.5/7.4
flush	平齐的,等高的	6.5
flush against the surface	与表面平齐	6.3
FMA	飞行模式指示器(Flight Mode Annunciator 的缩写)	5.2
FMCS	飞行管理计算机系统(Flight Management Computer System 的缩写)	5.2
foreign object debris (FOD)	外来物损伤	3.6
forge	锻制,锻造	6.4/7.3
forging	锻造,锻件	1.2
formula	公式	7.1
formulate	构想出,规划;阐述;用公式表示	2.1
frangible fitting	易断接头	6.3
free turbine	自由涡轮	7.2
free-fall	自由下落	6.3
frequency	频繁性;[数][物]频率	2.2
frontal area	迎风面积	7.2/7.3
fuel injector	燃油喷嘴	7.1
fuel nozzle	燃油喷嘴	7.3
fuel stick	油尺	3.6
fulfill	履行;执行;达到;使结束	2.1/2.3
fungi	(fungus 的复数)真菌;霉菌	1.2
fuse	保险,保险活门	6.3
fuselage	(飞机的)机身;火箭的外壳	7.3

G

gallery	流道;走廊	4.2/4.5
galvanic corrosion	电偶腐蚀,接触腐蚀,电化腐蚀	1.2
gap	缺口,空隙,间隙,缝隙	1.4
gas turbine engine	燃气涡轮发动机	7.1
gauge	测量仪器;规,表,计	1.4
GBE	地面设备(Ground Based Equipment 的缩写)	5.3
gearbox	变速箱;齿轮箱	4.3

generator control unit (GCU)	发电机控制器	4.2
generator drive interface	发电机驱动接口	4.2
geometry	几何学;几何形状;几何图形	7.3
get splashed with	被……溅滴	3.5
glide slope(G/S)	下滑信标	5.5
gouge	沟槽	7.4
govern	控制,支配	1.3
GPS	全球定位系统(Global Positioning System 的缩写)	5.1
graduation	分级 刻度	1.4
grant	承认;同意;准许;授予	2.1/2.3
granted with	授予	2.4
gravity	重力,地心引力	4.2
grind	打磨,研磨	6.2
grip	夹紧	1.3
grit blast	喷砂	6.2
grit blasting	喷砂	7.4
groove	凹槽,槽;开槽于;形成沟槽	3.5
guidance	指导,引导	2.3

H

halide	卤化物(的)	1.2
hardcopy	硬拷贝	2.3
harsh	严厉的;粗糙的;刺目的	3.5
heat pack	热组件	6.5
heat shield	隔热板,隔热片	6.4
heat-treatable alloy	可热处理合金	1.2
heat-treated	热处理的	7.4
helicopter	直升机	7.2
herein	于此;在这方面	3.6
hereinafter	以下,在下文中	3.7
HF	高频通信系统(High Frequency 的缩写)	5.1/5.4

high-bypass engine	高涵道比发动机	7.2
hoist	升降机	7.4
holding tool	夹持工具	1.4
hook spanner	勾头扳手	6.2
horsepower	马力(功率单位)	4.3
hot section	热端	7.1
housing	外壳,壳体	3.3
hub	(轮)毂;轮轴;中心,焦点	3.4/7.2/7.3
hydraulic	液压的;水力的	3.5/7.3
Hydraulic Test Stand	液压测试台	3.7
hydrogen	[化]氢	1.2

I

identification plate	指阀芯的碟片及关联部分	3.2
identify	识别,认出;确定	2.2
ignite	点火,点燃	1.2
ignition	点火;着火;燃烧	7.1
illumination	照明	1.5
illustrated	(用图等)说明的,图解的	2.3
ILS	仪表着陆系统(Instrument Landing System 的缩写)	5.1/5.5
immerse	浸没	6.4
impeller	(压缩机)叶轮	3.3/7.2/7.3
imperial	英制的	1.4
implement	使(某事物)生效;履行;实施	2.1
impose	强制,实行;强加	2.1
impulse turbine	冲击式涡轮	7.3
in accordance with	根据、依据	2.4
incompressible	不能压缩的	7.3
inflate	使充气(于轮胎、气球等)	7.1

initial	最初的，初步的	2.1
inlet guide vanes	进口导向叶片	7.3
innermost	最里面的；最深处的	7.3
inserts	衬垫；插入，嵌入	3.7
inspector	检查员，检察官	2.2
install	安装，安置	2.1
insulation resistance	绝缘电阻	3.2
intake	进气	7.1
integral	完整的，整体的	7.2
interchange	互换	1.4
interconnection	相互连接	7.1
interference	干扰	4.3
intergranular	晶粒间的，粒间的	1.2
interior	内部的	3.1/7.3
interlocking joint pliers	内锁支点钳	1.4
intermediate	中间的	7.2
intermediate	中压压气机	7.3
interstage	级间的	7.3
interval	间隔时间	1.4
investment	投资，投入	2.2
ionized layer	电离层	5.4
iron oxide	氧化铁	3.7
isolation	隔离	4.3
issuance	发行、发布	2.4
issue	发行；签发	2.2

J

jaw	颚，钳口	1.4
jet nozzle	尾喷管；排气喷管	7.1/7.2
jet propulsion	喷气推进	7.1
jet wake	排气尾流	7.3

kettle	(烧水用的)壶；小汽锅	7.1

K

kinetic energy	动能	7.3
knife-edge seal	刀边封严	7.3

L

lamination core	积层铁心	4.2
landing gear	起落架	6.2
lap	搭接	1.5
latch	门闩	3.6
leading edge	前缘	7.4
leads	引线,接线	4.3
leakage test	渗漏测试	3.3/3.7
lens	镜头、镜片	1.5
leverage	杠杆作用,杠杆效率	1.4
license	许可证,执照；特许	2.1/2.4
line maintenance	航线维修	1.4
line ream	线绞	6.2
Line Replaceable Unit (LRU)	航线可更换件	3.6
lined with	布满	7.3
lint	软麻布,线头,棉绒	3.5
lint-free cloth	不起毛的抹布	3.7
liquid penetrant inspection	液体渗透检查	1.5
Lithium	锂	1.2
Localizer(LOC)	航向信标	5.5
lock plate	锁片	7.3
lock ring	卡环	7.3
lock screw	锁紧螺钉	7.3
lockwire	保险丝	6.2

longeron	（飞机机体的）纵梁	1.2
loose fit	间隙配合	7.3
low-bypass engine	低涵道比发动机	7.2
lubricate	润滑；使润滑	6.2
lubrication	润滑	7.3

M

Magnesium	镁	1.2
magnetic	有磁性的	3.4/7.4
magnetic field	磁场	4.2
magnetic particle inspection	磁粉检查	1.5
magnetic tape	磁带	5.3
magnifier	放大镜，放大器	3.5
magnifying glass	放大镜	7.4
main exciter (ME)	主励磁机	4.2
maintenance	维修	1.1
makeup examination	补考	2.4
malfunction	故障，功能障碍，失灵	4.5
malfunction tag	故障标签	3.5
malfunctioning	出故障	7.4
mandatory	法定的，强制的	2.1/2.3
Manganese	锰	1.2
manifold	多支管；歧管	3.1/7.3
manual	人工的；手册，指南	1.1/6.3
manufactured head	（铆钉）制造头	1.3
manufacturer	制造商，制造厂；厂主，厂商	2.1
maraging steel	马氏体时效不锈钢	1.2
marked	显著的	1.5
matrix material	基体材料	1.2
MCP	方式控制面板（Mode Control Panel 的缩写）	5.2

MCU	模块式控制组件(Modular Control Unit 的缩写)	5.2
mechanical energy	机械能	7.1
mechanism	机械装置	3.2
megohmmeter	兆欧表	3.2/4.3
melt	熔化,溶解;逐渐融合	6.4
metabolism	新陈代谢;代谢作用	1.2
metering pin	计量油针	6.1
microbial	微生物的;由细菌引起的	1.2
micrometer	千分尺;测微计	1.4
micro-organism corrosion	微生物腐蚀	1.2
microswitch	微动开关	4.5
migration	渗漏	3.3
misalignment	未对准;角误差	7.3
mismatch	使配合不当	7.3
mixer	排气混合器	7.3
mixture	混合气	7.1
modify	修改;变更;改进	2.1
modular	模块化的	5.2
module	[计] 模块;组件;模数	5.3
moistened	(使)变得潮湿,变得湿润	4.4/4.5
moisture	水气	3.1
molecule	分子;微小颗粒	7.3
molten	熔化的	7.4
monitor	监控;监视;监督	2.1/5.3
MTOW	最大起飞重量(Maximum Take-Off Weight 的缩写)	6.2
multimeter	万用表	1.4/3.7/4.4

N

nacelle	发动机短舱	6.2/7.3
nameplate	铭牌,标识牌	6.2

narrow … down	收窄,使……变窄	3.5
needle bearing	滚针轴承	3.5
needle nose pliers	尖嘴钳	1.4
negligible	可以忽略的;微不足道的	7.4
nicd cell	镍镉电池	4.4
nick	刻痕于,用刻痕记;刻痕,缺口;刻痕	1.4/3.5
nickel-based alloys	镍基高温合金	7.3
nitrogen	氮	3.7
noise suppressor	消声器	7.3
nomenclature	(某一学科的)术语;专门名称	7.3
nominal	名义上的	3.2
non drive end (NDE)	非驱动端	4.2
not heat-treatable alloy	不可热处理合金	1.2
notch	刻痕,凹口;在……上刻凹痕	3.5
notify/ notification	通知,告知,公布	2.4
nozzle	喷嘴;喷管,管口	3.5/7.1
nut	螺母	1.3
nylon	尼龙,聚酰胺纤维	3.5

O

obstruction	障碍物	7.3
obtain	获得,得到	2.4
occasion	机会;场合;理由;需要	2.3
offset	偏置;抵消;补偿	1.4/7.3
oil plug	(放)油塞	3.3
oil slinger/slingerring	甩油盘,离心喷油环	3.3
OMS	机载维护系统(Onboard Maintenance System 的缩写)	5.3
open-end wrench	开口扳手	1.4
optimum	最适宜的	7.3
orifice	孔;洞口	7.1
orifice support tube	孔板支撑管	6.2

original	原始的,最初的;原文,原件	2.2
Otto-cycle	奥托循环	7.1
outflow valve	外流活门	4.3
oval	椭圆形的	1.3
oven	炉,灶;烤炉,烤箱	3.7
overhaul	翻修;彻底检查,大修	1.1/2.1/6.2
oxide deposit	氧化物沉淀	7.4

P

package	打包;将……包装	5.2
packing	(缝隙)填料,密封材料	6.2
painting	喷涂	7.4
panel	面板	4.5
parallel	平行的,平行线	1.4
parameter	参数,系数,参量	3.5
partway	到中途,到达一半	7.3
path	航路,轨迹	5.5
payload	载重量,载重	1.2
PDL	便携数据装载器(Portable Data Loader 的缩写)	5.3
penalty	害处	7.3
performance	性能	7.2
perimeter	边界	7.2/7.3
periphery	周围	3.2
permanent	永久(性)的,永恒的	2.3
permissible	可允许的;得到准许的	6.4
perpendicular	垂直的,呈直角的	1.5
personnel	人员、员工	2.4
pertain	与……相关;属于;适用(于)	2.2
phosphate ester	磷酸酯	3.5
physical	身体的;物质的	2.4

pile up	堆积;积聚	7.3
pilot exciter (PE)	副励磁机	4.2
pin	销钉,销子	1.3
piston	活塞	7.1
piston engine	活塞发动机	7.1
pitting	点蚀	7.4
pitting corrosion	麻点腐蚀,点蚀	1.2
plasma coating	等离子喷涂	7.4
plating	电镀	7.4
pliers	钳子	1.4
plug-in	插件	5.2
pneumatic	气动的	3.1/7.3
pneumatic tool	气源工具	1.3
polish	磨光,擦亮,擦亮剂;擦亮,变光滑;磨光	3.5
polishing	抛光	7.4
pontoon	浮筒	6.2
poppet	菌状活门;提升阀(亦作 poppet valve)	3.7
porosity	多孔性	1.5
portion	一部分	2.1/2.4/3.2
potential energy	势能	7.3
pounding tool	敲击工具	1.4
pour	倒,倾注	1.5
power plant	动力装置	7.1
power-weight ratio	功率-重量比	7.2
precision	精确,精密度,精度	1.4
preflight checks	航前检查	3.6
preliminary	初步的	3.2
preservative	防腐的,抑制腐蚀的	6.2
pressure gage	压力表	3.7

pressurization	增压	7.3
primary heat exchanger	初级热交换器	3.3
primer	底漆	1.5
prior	在前，居先	2.2
prior to	之前	2.4
probe	探头，探针	4.5
procedure	程序，手续；工序，过程，步骤	2.2
product	乘积；产品；结果；作品	7.1
progressively	逐步	7.3
prohibit	禁止，阻止，防止；不准许	2.2
proof	防……的，不能透入的，耐……的；证明；试验，校验	3.5/3.7
propel	推进；推动	7.1
propeller	推进器，螺旋桨	2.1
Prop-Fan	桨扇	7.2
provision	规定，条项，条款	2.3
pry bar	撬杆	1.4
psychological	心理的，精神的	2.4
pulse jet engine	脉冲式喷气发动机	7.1
pulse-echo	脉冲-回波	1.5
pumice powder	浮石粉	6.4
punch	冲子	1.4
pursuant	追踪的，依照的	2.1/2.3

Q

qualification	资格，能力	2.4
quenching	淬火	1.2
quote	引用；报价	2.3

R

radial	径向的；星形的	7.3
radial inward flow	径向内流式	3.3
radial outward flow	径向外流式	3.3

radially	放射状地	7.1
radiation	辐射,放射线	1.5
radiographic inspections	放射照相检查	1.5
radiography	X光,放射线	7.4
ram air	冲压空气	3.1
ram jet engine	冲压式喷气发动机	7.1
ratchet	棘轮,棘齿	1.4
rated-load	额定载荷	4.3
rating	等级;评估,评价	2.1
reaction turbine	反应式涡轮	7.3
reaction-impulse turbine	冲击-反力式涡轮	7.3
recesses	凹槽	4.4
reciprocate	往复运动	7.1
recirculation	再循环	4.2
recoil	反作用;反冲力	7.1
rectification	矫正,纠正	2.1
reduction gearbox	减速齿轮箱	7.2
redundancy	余度	6.3
reflect	表达;显示	7.3
refraction	越洋的,跨洋的	5.4
refrain	抑制	7.4
regulation	规章,条例,规则,规定	2.1
reinforcing material	增强材料	1.2
re-ingestion	再次吸入,倒吸	7.3
reinstall	重新设置	7.4
reissue	(使)重新发行	1.1
release	释放,放行	2.1/2.4
remainder	剩余物	7.3
Remove from	移除,清除	4.5
requirement	要求,必需品	2.1

residue	残余,残渣	6.4
resistance	抵抗,反抗,电阻(值)	1.4
resonance	共振,谐振	1.5
respective	各自的,分别的	2.1
respectively	分别地,各自地	2.4/7.2
restoration	修复,整修;(规章制度等的)恢复;复原	2.1
retract	缩回,缩进	6.2
revision	修订,修改	2.3
revoke	吊销	2.4
revolution	革命;旋转;转数;圈,转	3.5/7.1
revolutions per minute (rpm)	转每分钟	4.1/4.2
right/liability	权利/义务	2.4
rim	(尤指圆形物的)边,边,缘,框;轮缘	3.4/6.4/7.2
rinse	漂洗;冲洗	6.4/7.4
rivet	铆钉,包头钉	1.2
RMI	无线电磁指示器(Radio Magnetic Indicator 的缩写)	5.5
rolling	扎(件),轧制,滚压	1.2
rotational	转动的	7.3
rotor	动盘,转子	6.5/7.2/7.3
route through	穿过,经过	3.3
rudder	方向舵	1.2

S

scale	刻度;尺度;刻度尺	1.4
scavenge	抽吸,回收;清除污物	4.2
sccm	标况毫升每分(Standard-state Cubic Centimeter per Minute 的缩写)	3.7
scheme	策划;计划;体系	2.2
scope	(处理、研究事务的)范围;审视	2.1

scorch	烧焦,烤焦	7.4
scoring	擦痕	7.4
scouring	残屑	3.2
scratch	划伤;擦伤,抓痕;抓,刮; 抓,搔	3.2/3.5
screw	螺钉,螺丝;螺钉,螺旋状物,螺旋形	1.3/1.4
screw driver	螺丝刀	1.4
scroll	涡旋式的	3.3
seal	密封,封盖	6.3
sealant	密封剂	4.3
sealing ring	密封圈	3.2
seam	缝;接缝,缝合处	1.5
secondary heat exchanger	次级热交换器	3.3
segment	部分,段	6.2
self-locking	自锁	1.3
separated	分开的	2.3
sequence	数列,序列; 顺序	2.3/6.4
serration	锯齿	1.4/4.1
serviceable	有用的,可供使用的	2.1
shank	杆,柄	1.3
sheet metal	钣金工	1.4
shim	薄垫片,用垫片填	1.3
shipment	装运;运输	2.2
shop	车间	1.4
shop head	(铆钉)墩头	1.3
shortage	不足,缺点; 缺少	2.2
shot peen	喷丸强化	6.2
shrink fit method	冷缩法	6.2
shroud	护罩	7.3
shrouded blade	带有叶冠的转子叶片	7.3
sight gage	观察仪	3.3

sign	征兆	3.2
significant	重要的；有意义的	2.1
Silicon	硅	1.2
silicon oxide	二氧化硅	6.4
simultaneously	同时地	3.6
single-entry	单面进气	7.3
sleeve	套筒，套管；袖子，袖套	3.5
slide	滑动	3.6
slip joint pliers	鱼口钳	1.4
slope angle	倾斜角	5.5
slot	狭槽	3.6
slotted screw	带槽螺钉（一字螺钉）	1.4
snubbing valve	防反跳活门	6.2
soaked with	用……浸湿	3.5
socket head cap screw	内六角螺钉	3.5
socket wrench	套筒扳手	1.4
solder	焊接，锡焊	1.4
soldering	锡焊	7.4
solely	唯一地；仅仅	2.1
solid shank rivet	实心铆钉	1.3
solid wrench	呆扳手（开口扳手的别称）	1.4
solid-statememory	固态存储器	5.3
solution heat treatment	固溶处理	1.2
solvent	有溶解力的；[化]溶剂	3.5/3.7/7.4
sound attenuating material	消声材料	7.3
spark	火花；电火花	7.1
specification	规范，规格	2.3
specified	规定的；详细说明的	3.5

specimen	样本，标本	1.5
speed handle	快速摇把	1.4
spike	尖峰脉冲	1.5
spline	花键，齿条；开键槽，用花键连接	3.5
spline	花键	6.5
split inner bearing	对开内轴承；剖分内轴承	4.2
sponge	海绵	3.7
spool	缠绕，卷在线轴上；线轴，缠线框，轴，转子	3.5/7.2
sprag clutch	斜撑离合	3.4
spray	喷雾，喷雾器；喷射；喷	3.5/7.3
spray nozzle	喷嘴	3.1
spread out	分散；伸展，延长	7.3
squeeze	挤压	1.3
squid	乌贼，墨鱼	7.1
SSB	单边带（Single Side Band 的缩写）	5.4
stain	沾污，给……着色；污染；污点，瑕疵，着色剂	3.5
stall	喘振	7.3
standardize	使标准化；用标准校检	2.3
Start up	启动	4.5
static pressure	静压	7.2/7.3
stator	定子，静盘，静子	3.4/6.5/7.3
stator vanes	静子叶片	7.3
steel	钢	1.2
stem	芯柱，导杆	3.3/3.7
stiffness	刚度	1.2
stipulate	规定，约定	2.4
stoning	打磨	7.4
stress corrosion cracking	应力腐蚀开裂	1.2
stringer	纵梁，纵桁，长桁	1.2

strip	剥除，褪除	1.5
stroke	冲程；活塞行程	7.1
strut	支柱	7.3
subject to	遭受	1.3
submerge	淹没；把……浸入	3.6
submit	提交，呈递	2.4
subsonic	亚声速的	7.3
substantially	本质上，实质上	1.3
substantiation	证实，证明	2.2
substitute	代用品；代替者	4.3
substitution	代替，代用，替换	4.5
subsystem	子系统，分系统	2.3
subtlety	精细，细微的差别	1.4
suffer	变糟，变差	7.3
sufficient	足够的，充足的	1.5/2.1
sulfamic acid	氨基磺酸	4.5
super alloy	超合金	1.2
supercharger	增压器	7.3
superficial	表面的，表面的，肤浅的	1.2
supersonic	超声速的	7.3
supervision	监督，管理；监督的行为或过程	2.1
surface corrosion	表面腐蚀	1.2
surge tank(surge chamber)	通风油箱	3.7
suspend	吊扣，悬挂	2.4
sustenance	食物，营养，养料	1.2
swirl vanes	旋流器叶片	7.3
syllabus	教学大纲、课程大纲	2.4

T

tabulate	制成表格	3.6

tag	标签,标牌	2.2
tail pipe	尾喷管	7.2/7.3
take the form of	表现为……的形式	6.3
tap	龙头,阀门	3.2
taper	锥度	1.4
tear down	拆卸	7.4
technician	技师	1.3
technique	技巧;方法;工艺	2.3
teflon	聚四氟乙烯	3.5
temporary	临时的,暂时的	2.3
terminology	专门名词;术语,术语学;用词	7.3
theme	题目,主题	7.2
thermal conductivity	导热性能	1.2
thermal fuse plug	热熔塞	6.4
thermal spray	热喷镀,热喷涂	6.2
thermocouple	热电偶,温度传感器	6.5
thermodynamic	热力学的	7.1
thermostat	恒温器	3.1/3.2
thin film	薄膜	6.2
thread	螺纹	1.3
thread pitch gauge	螺距规,螺纹规	1.4
thrust	推力	5.1/7.1
thrust plate	推力盘	6.5
thrust reverser	反推	7.3
thrust specific fuel consumption	单位推力燃油消耗量	7.2
thrust washer	止推垫片	3.5
tire bead	胎缘,胎底	6.4
Titanium	钛	1.2/6.2/7.4

toggle	开关，触发器	1.4
tolerance	公差	1.3
top dead center	上死点	7.1
torque	扭矩	3.4
torque value	力矩值	1.4
torsion bar torque wrench	扭力杆式力矩扳手	1.4
total pressure	总压	7.2
traceability	可描绘，可描写，可追溯	2.1
trailing edge	后缘	7.4
transfer cylinder	传压筒	6.3
translatory	平移的，平动的	6.5
triangle	三角形	1.3
trichlorethylene	三氯乙烯	7.4
trickle	涓流，细流	4.4
trim	修整，配平	1.4
trip off	跳开	3.1
triple-spool	三转子，三轴	7.3
tubeless	无内胎的	6.4
turbine	涡轮	7.1
turbine nozzle	涡轮喷嘴	7.3
turbofan	涡轮风扇	7.2
turbojet	涡轮喷气	7.2
turboprop	涡轮螺旋桨	7.2
turboshaft	涡轮轴	7.2
turbulence	紊流；湍流	7.3
turning tool	拧动工具	1.4
tweaking	校正，调整	1.1
twin-spool	双转子；双轴	7.3

U

ULB	水下定位信标（Underwater Locator Beacon 的缩写）	5.3
ultrasonic	超声波	7.4

ultrasonic inspection	超声波检查	1.5
ultrasound	超声波	4.5
ultraviolet	紫外线	1.5
ultraviolet lamp	紫光灯	7.4
unendorsed	未认可的	2.4
unintentional	无意的，无心的	7.4
universal head	通用头	1.3
unregulated	未经调节的，紊乱的	3.2
untwist	拆开，解开	7.4
upgrade	改良；更新；升级	2.3
urgent	急迫的；紧急的	2.2
utilization	利用，使用，效用	2.1

V

vacuum	真空；空间	3.7
validation	确认	2.2
validity	有效性，合法性	2.4
valve	气门	7.1
valve operating mechanism	气门传动机构	7.1
vaned diffuser	叶片扩压器	3.3
vaporize	蒸发，汽化	7.3
variable stator vanes	可变静子叶片	7.3
varnish	清漆，亮漆	4.4
velocity	速率，速度	7.3
vendor	供应商，厂家	1.1/2.2
vent	泄漏，排出	3.2
ventilate	使通风	4.3
venturi	文氏管(一种流体流量测定装置)	7.3
verification	证实，核对(某事物)；检查	2.1
vernier caliper	游标卡尺	1.4

versatile	万向的;万能的	1.4
VHF	甚高频通信系统(Very High Frequency 的缩写)	5.1
vibrate	振动	1.3
vibration	摆动;震动	7.3
vibrational	振动的,摇摆的	4.4
viscosity	黏度,黏性	1.5
vise grip	大力钳	1.4
visual	目视的,视力的	1.4
visual inspection	目视检查	1.5
void	空隙,缩孔	1.5
voltage	电压,伏特数	1.4
volume	卷,册	2.3
VOR	甚高频全向定位信标(VHF Omnidirectional Range 的缩写)	5.1/5.5
VTOL	垂直起降(Vertical Take-Off and Landing 的缩写)	6.2

W

waive	放弃	2.4
warpage	翘曲,扭曲,热变形	7.3
warranty	保证,担保	2.1
washer	垫片	1.3
wear indicator pin	磨损指示销	6.5
welded seam	焊缝	7.4
welding	焊接性	1.2
wick	油绳	3.3
wing box	翼盒	1.2
wipe	擦,涂上	6.2
workload	工作载荷;工作量	3.3
wrap	卷,裹	1.4
wrench	扳手	1.4
wrought alloy	变形铝合金	1.2

Y

yaw	偏航	5.1

Z

Zinc	锌	1.2

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