PFN NUMBER 011-9762
SEPTEMBER 2004

STUDENT GUIDE

FOR

UH-60 POWERPLANT

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SEPTEMBER 2004

UH-60 POWERPLANT

TABLE OF CONTENTS

SECTION I. -INTRODUCTION

TERMINAL LEARNING OBJECTIVE:

At the completion of this lesson you will:

ACTION: Identify the characteristics of the UH-60 Powerplant System

CONDITIONS: As a UH-60 maintenance test pilot

STANDARD: In accordance with (IAW) TM 1-2840-248-23

SAFETY REQUIREMENTS: Remove all watches, rings and other jewelry before operating, or maintaining electronic equipment.

RISK ASSESSMENT LEVEL: Low

ENVIRONMENTAL CONSIDERATIONS: There are no environmental concerns for this lesson.

SECTION II. - PRESENTATION

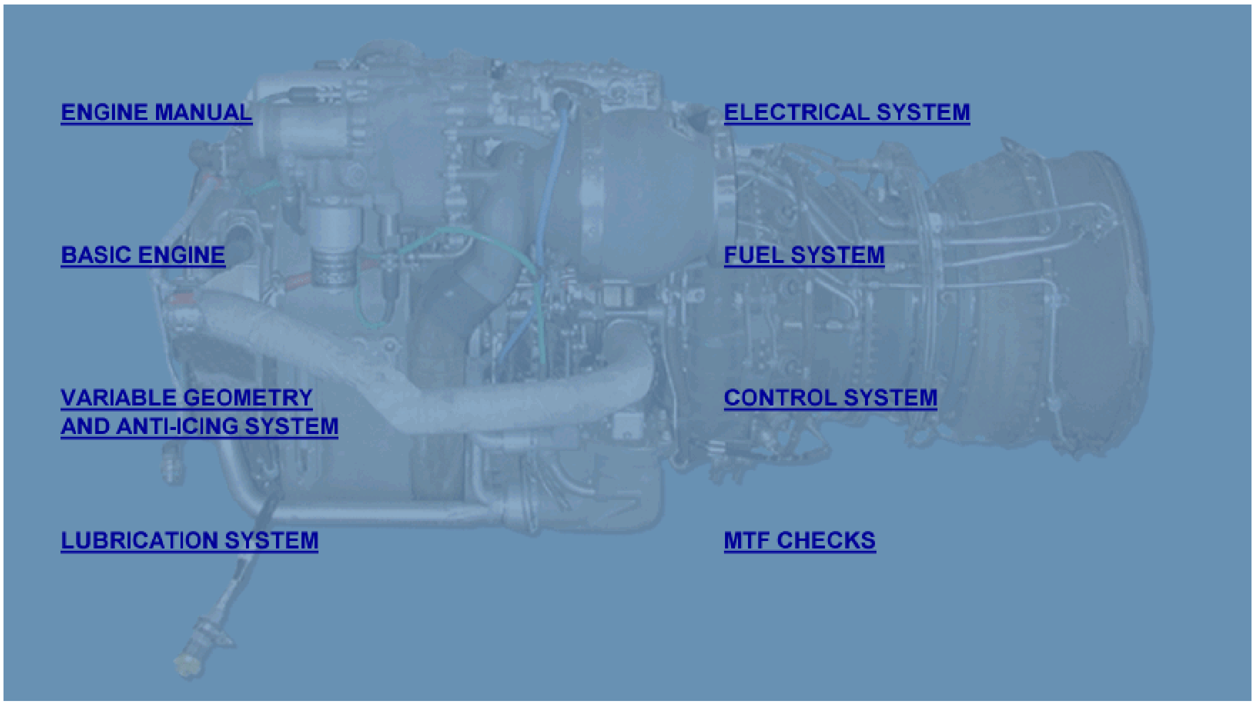
A. ENABLING LEARNING OBJECTIVE No. 1

ACTION: Use TM 1-2840-248-23 to locate and identify power plant engine components and systems.

CONDITIONS: Using TM 1-2840-248-23

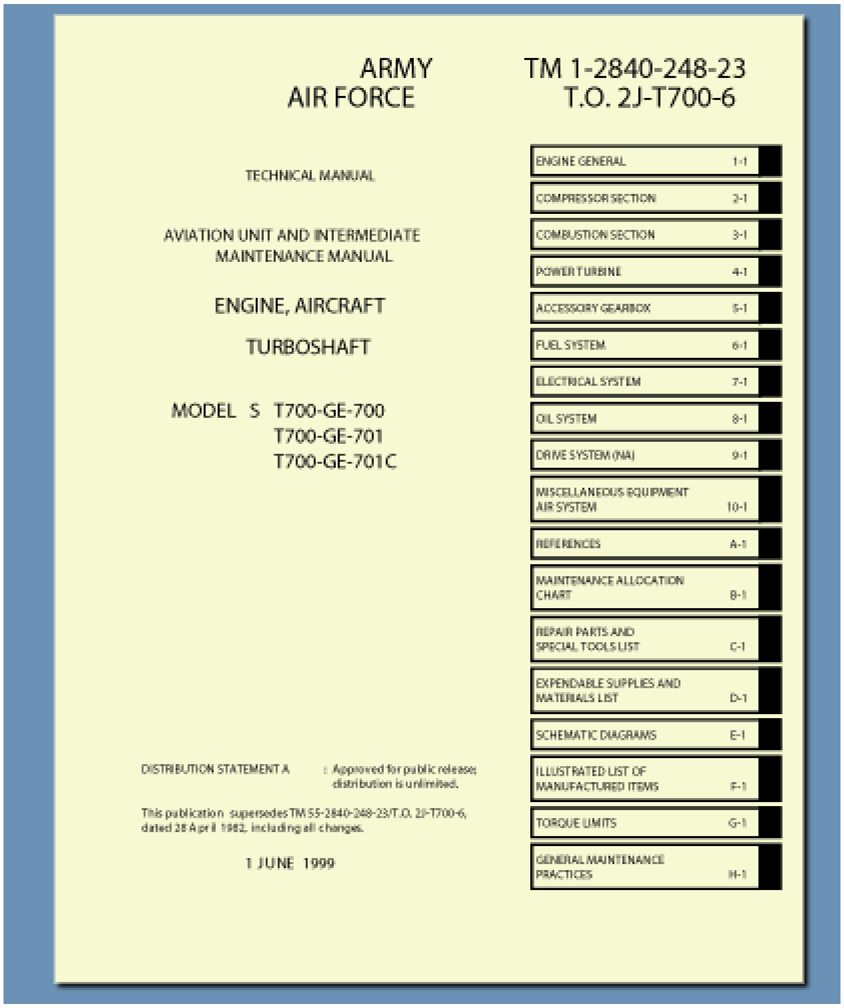
STANDARD: IAW TM 1-2840-248-23

Frame # 0015 (MENU)



a. Engine Manual

Frame # 0025 (Engine Manual)



ARMY
AIR FORCE

TM 1-2840-248-23
T.O. 2J-T700-6

TECHNICAL MANUAL

AVIATION UNIT AND INTERMEDIATE
MAINTENANCE MANUAL

ENGINE, AIRCRAFT

TURBOSHAFT

MODEL S T700-GE-700
T700-GE-701
T700-GE-701C

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DISTRIBUTION STATEMENT A : Approved for public release; distribution is unlimited.

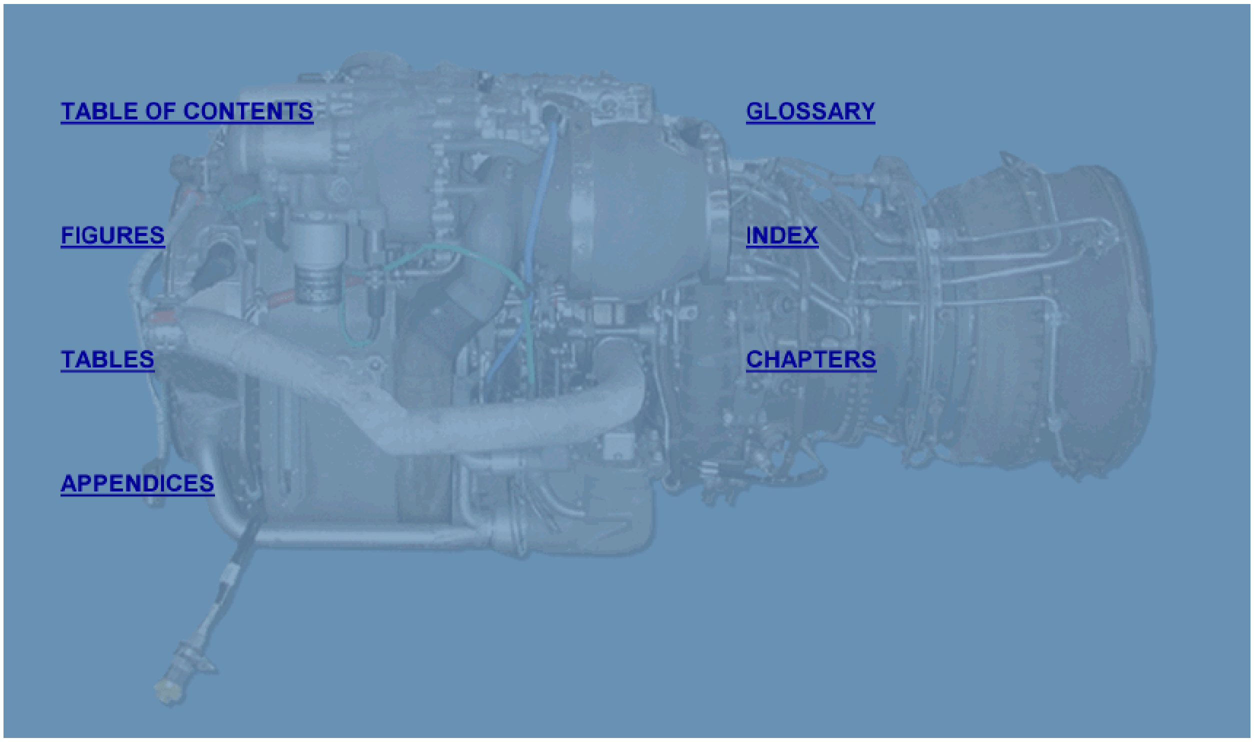
This publication supersedes TM 55-2840-248-23/T.O. 2J-T700-6, dated 28 April 1982, including all changes.

1 JUNE 1999

(1) As a maintenance test pilot, you must become familiar with the engine manual (TM 1-2840-248-23).

(2) You must know how to locate and use the areas related to engine components and systems.

Frame # 0030 (Engine Manual MENU)



(3) The information contained in the engine manual can be broken down into seven major categories: the table of contents, figures, tables, appendices, glossary, index, and chapters.

(4) Each category addresses pertinent information related to the engine.

(a) Table of Contents

Frame # 0035 (TABLE OF CONTENTS)

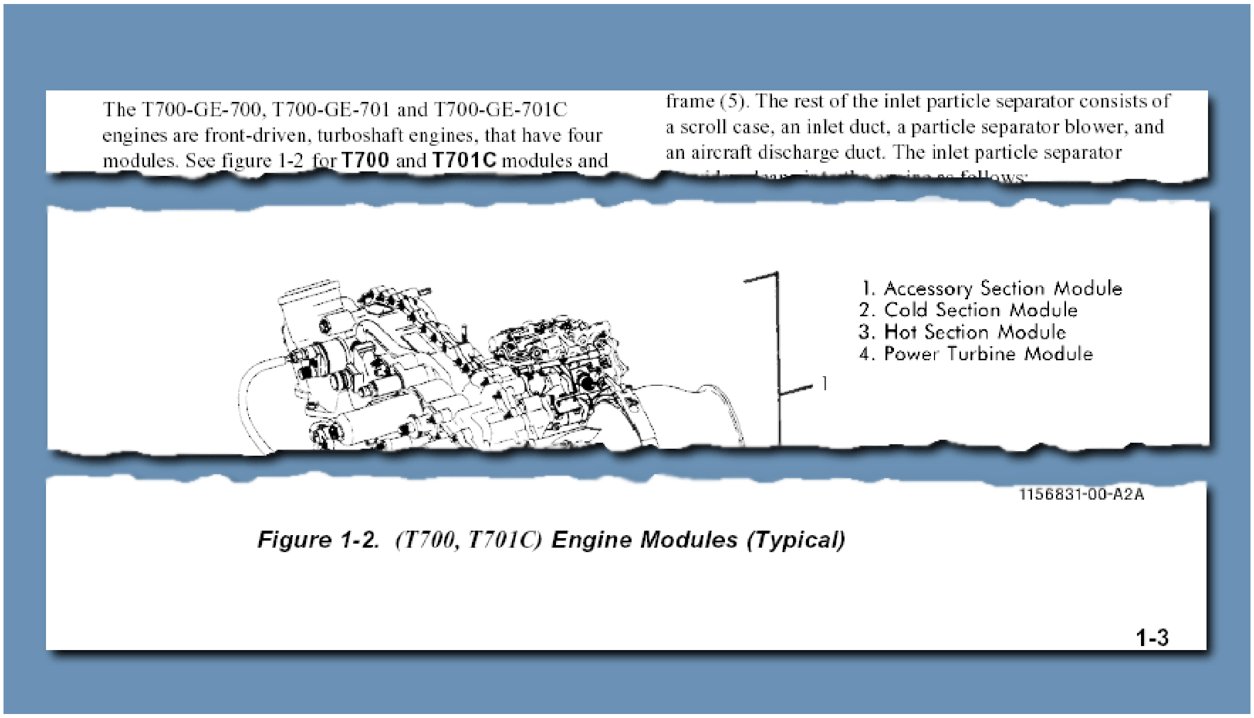
TABLE OF CONTENTS

1) The table of contents will provide a list of subjects, items, and/or topics contained in this manual.

2) The listings will include page references with the associated contents.

(b) Figures

Frame # 0040 (FIGURES)


The T700-GE-700, T700-GE-701 and T700-GE-701C engines are front-driven, turboshaft engines, that have four modules. See figure 1-2 for **T700** and **T701C** modules and

frame (5). The rest of the inlet particle separator consists of a scroll case, an inlet duct, a particle separator blower, and an aircraft discharge duct. The inlet particle separator

Figure 1-2.** (T700, T701C) **Engine Modules (Typical)

1-3

1) The figures are illustrations used throughout the manual to better identify a subject or item found in the text.

(c) Tables

Frame # 0045 (TABLES)

circuit closes a solid-state switch when Np reaches 25,000 ±250 rpm. Both switches must be closed before the solenoid in the ODV is energized.

engine is operating at flight idle and above. If a failure has occurred on a signal, the failed component or related circuit will be identified by a pre-selected fault code (table 1-2). It

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Table 1-2. Digital Electronic Control (DEC) Signal Validation-Fault Codes

Signal Failed	Engine Torque Indicator (± 3% Tolerance)
DEC	15%
Np Demand Channel	25%
Load Share Channel	35%
TGT Channel	45%

1) The tables are illustrations or listed information used throughout the manual to better identify or explain a subject or item found in the text.

(d) Appendices

Frame # 0050 (APPENDICES)

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APPENDIX A

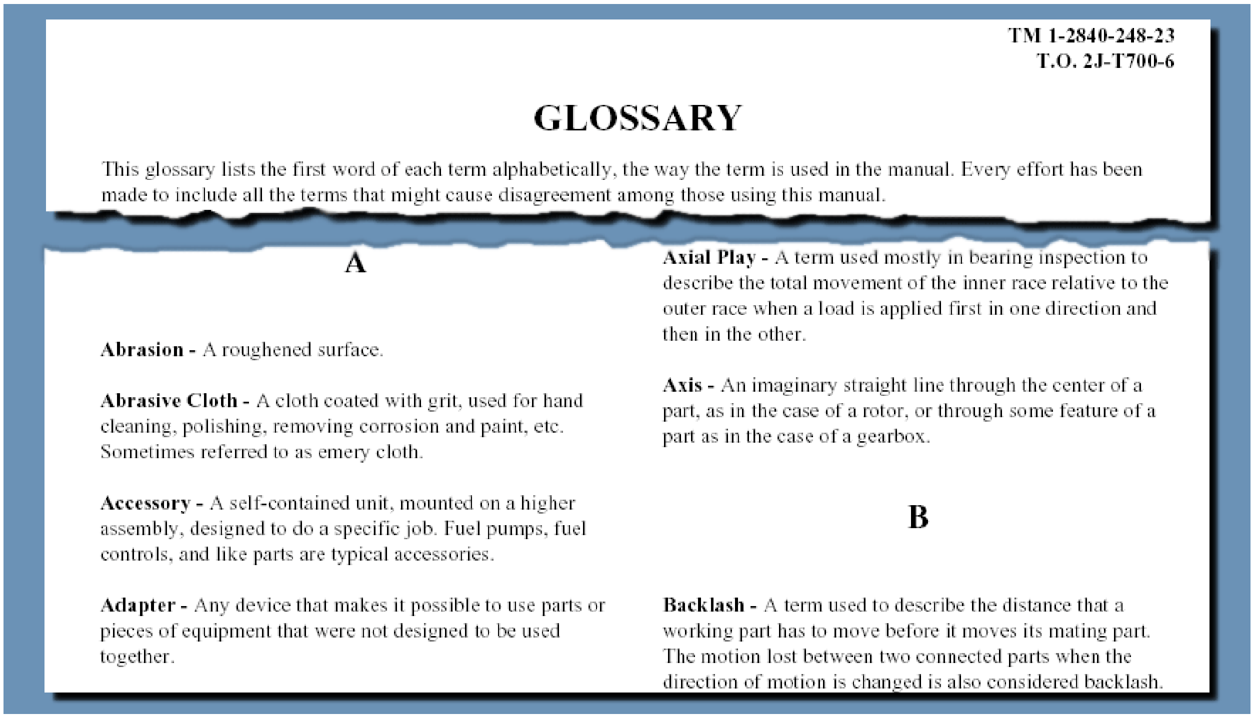
REFERENCES

AR 95-1	Army Aviation General Provisions and Flight Regulations
AR 750-1	Army Material Maintenance Concepts and Policies
DA Form 2028	Recommended Changes to Publications and Blank Forms
DA Form 2028-2	Recommended Changes to Publications and Blank Forms
DA PAM 738-751	Functional User's Manual for the Army Maintenance Management System - Aviation (TAMMS-A)
FM 21-11	First Aid Data
FM 3-04.500	Army Aviation Maintenance

1) Appendices are located near the back of the TM and provide lists of references, maintenance allocation charts, schematic drawings, illustrations, and other associated topics.

(e) Glossary

Frame # 0055 (GLOSSARY)



TM 1-2840-248-23
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GLOSSARY

This glossary lists the first word of each term alphabetically, the way the term is used in the manual. Every effort has been made to include all the terms that might cause disagreement among those using this manual.

A

Abrasion - A roughened surface.

Abrasive Cloth - A cloth coated with grit, used for hand cleaning, polishing, removing corrosion and paint, etc. Sometimes referred to as emery cloth.

Accessory - A self-contained unit, mounted on a higher assembly, designed to do a specific job. Fuel pumps, fuel controls, and like parts are typical accessories.

Adapter - Any device that makes it possible to use parts or pieces of equipment that were not designed to be used together.

Axial Play - A term used mostly in bearing inspection to describe the total movement of the inner race relative to the outer race when a load is applied first in one direction and then in the other.

Axis - An imaginary straight line through the center of a part, as in the case of a rotor, or through some feature of a part as in the case of a gearbox.

B

Backlash - A term used to describe the distance that a working part has to move before it moves its mating part. The motion lost between two connected parts when the direction of motion is changed is also considered backlash.

1) The glossary follows the appendices in the TM and contains definitions of words or terms used in this manual listed in alphabetical order.

(f) Index

Frame # 0060 (INDEX)

TM 1-2840-248-23
T.O. 2J-T700-6

ALPHABETICAL INDEX

1) Following the glossary, the index is a list of subjects, in alphabetical order, with the paragraph, figure, table, or page reference listed.

(g) Chapters

Frame # 0065 (CHAPTERS)

Change 5 i

1) The chapters, located throughout the TM, cover the major topics discussed in the manual.

2) Some of the chapters are broken down farther into sections.

a) Chapter 1

Frame # 0070 (Sections MENU)

1 Chapter 1 consists of several sections.

2 Section I discusses general information about the engine.

3 Section II discusses equipment description and data.

4 Section III discusses repair parts; special; test, measurement, and test equipment; and support equipment.

5 Section IV discusses service upon receipt.

6 Section V discusses preventative maintenance checks and services.

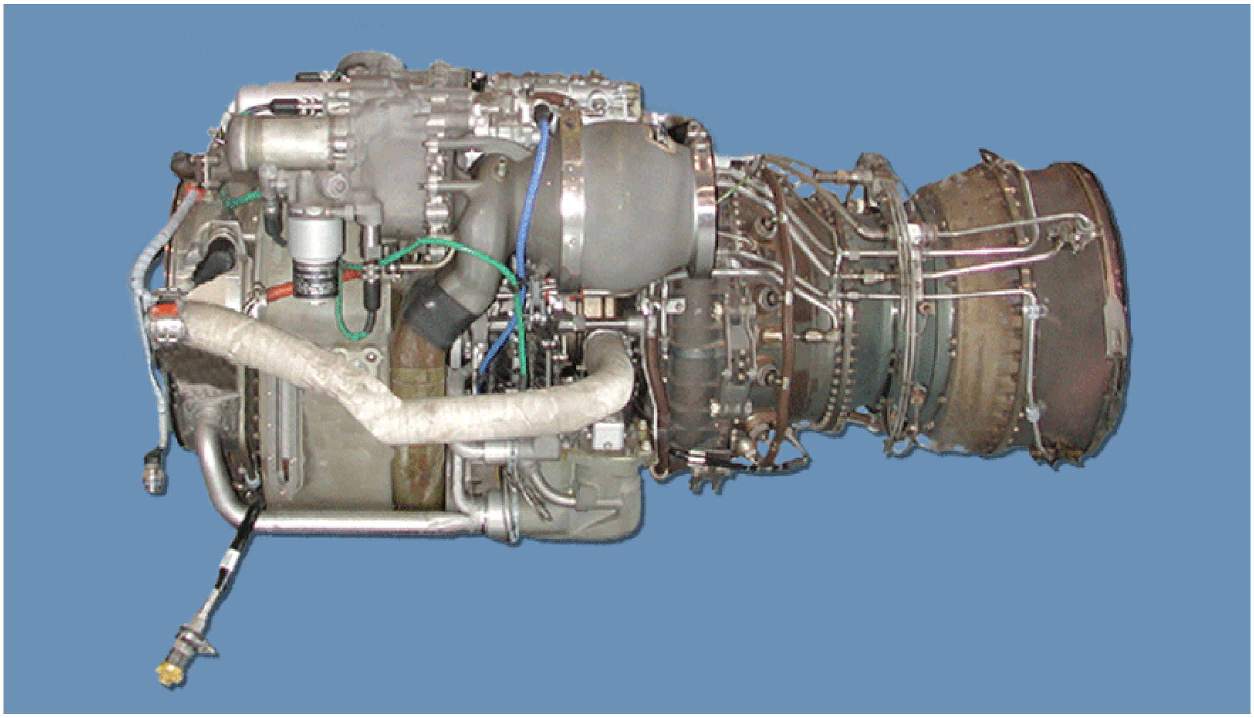
7 Section VI discusses Troubleshooting (Engine installed in aircraft).

8 Section VII discusses general maintenance procedures.

9 Section VIII discusses engine test in mobile or fixed facilities.

<u>a</u> Section I

Frame # 0075 (SECTION I)

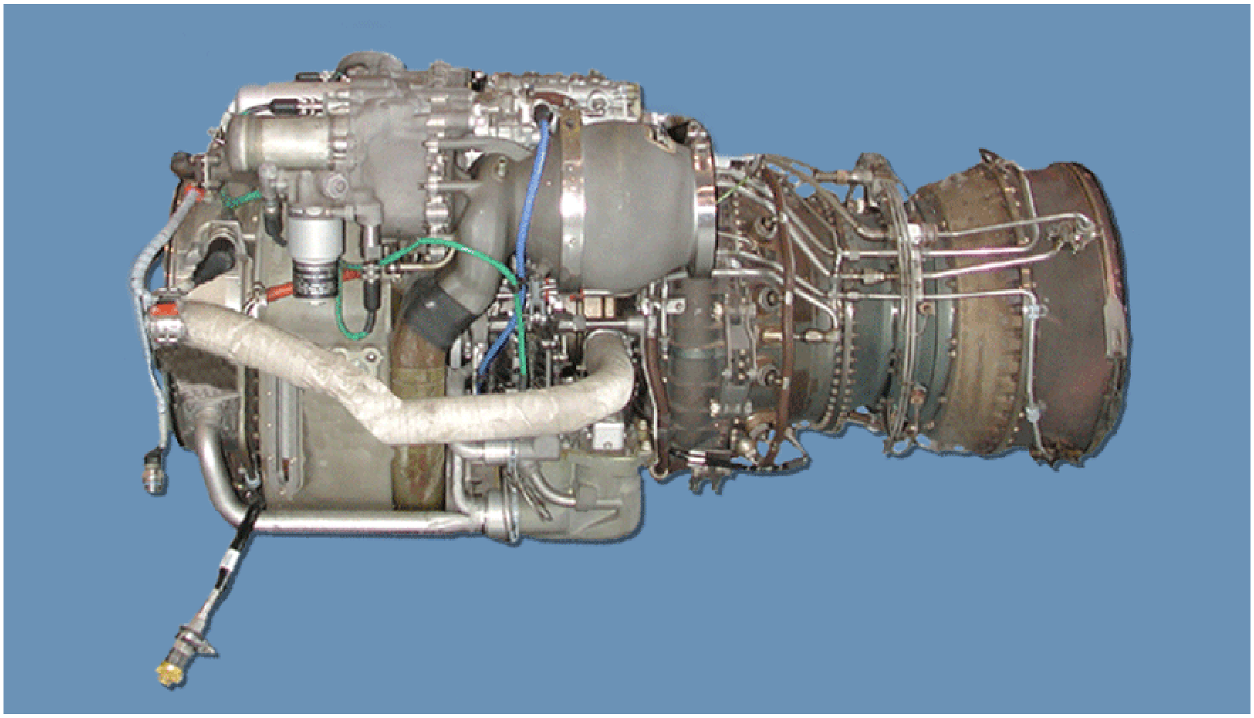


i) Section I provides general information about the engine, references for forms and records, maintenance concepts, Line Replaceable Units (LRU), asbestos warning, and a listing of Flight Safety Critical Aircraft Parts (FSCAP).

ii) FSCAP is defined as any part, assembly, or installation whose failure, malfunction, or absence could cause an uncommon engine shutdown, and/or catastrophic engine failure resulting in loss or serious damage to an aircraft and/or serious injury or death to the crew.

b Section II

Frame # 0080 (SECTION II)



i) Section II provides information about the engine system operation.

ii) Also included in this section are tables for the Digital Electronic Control (DEC) codes, anti-icing bleed and start valves, and equipment data.

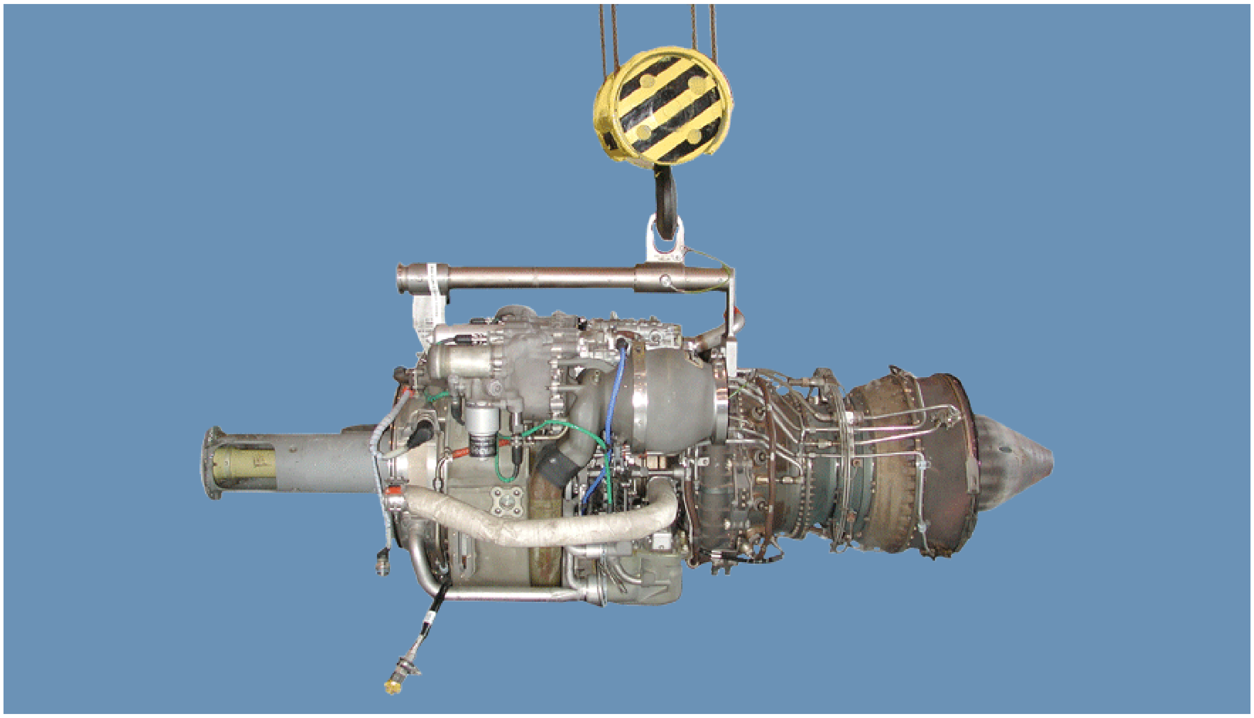
<u>c</u> Section III

Frame # 0085 (Select SECTION III)

i) Section III contains two tables; special tools and support equipment, and Test, Measurement, and Diagnostic Equipment (TMDE).

d Section IV

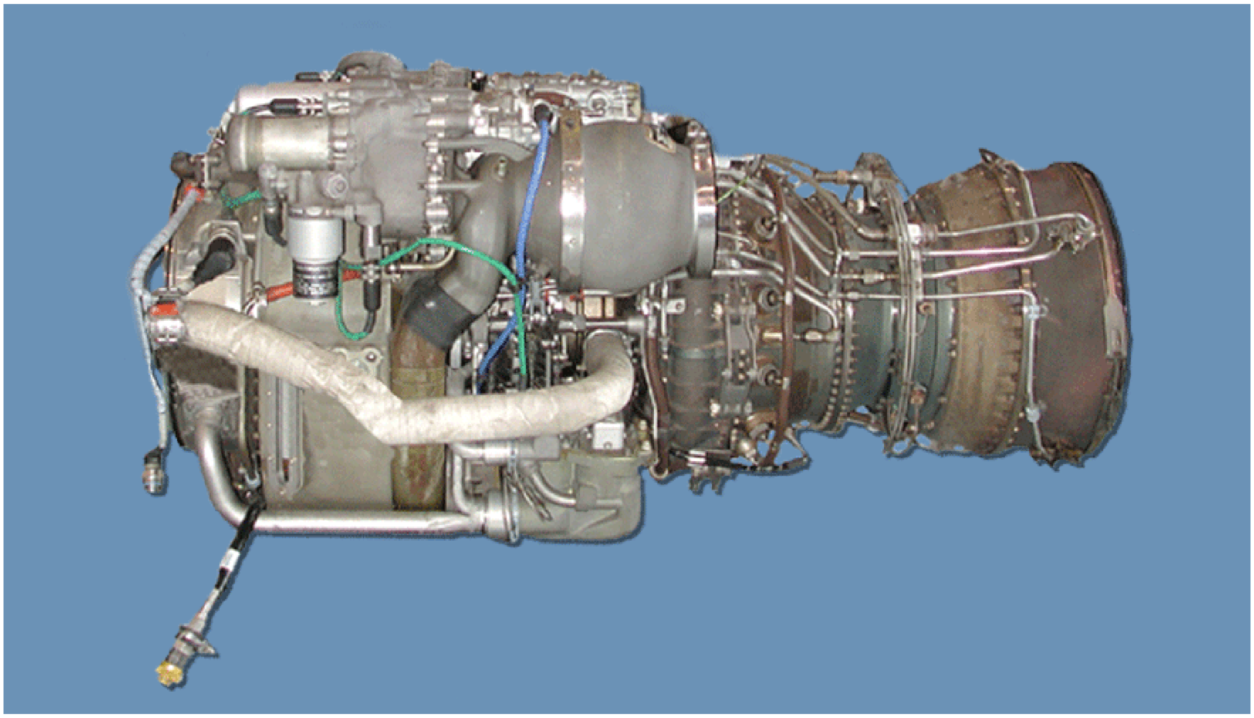
Frame # 0090 (SECTION IV)



i) Section IV provides instruction to remove an engine from the shipping container or maintenance stand, and how to install an engine in a shipping container or a maintenance stand using the engine sling.

e Section V

Frame # 0095 (SECTION V)



i) Section V discusses the 10 Hour/14 Day Inspection Requirements, Periodic Inspection Requirements (250/500 Flight Hour Inspection), retirement intervals for life-limited parts (FSCAP), and the correction of History Recorder or History Counter readings.

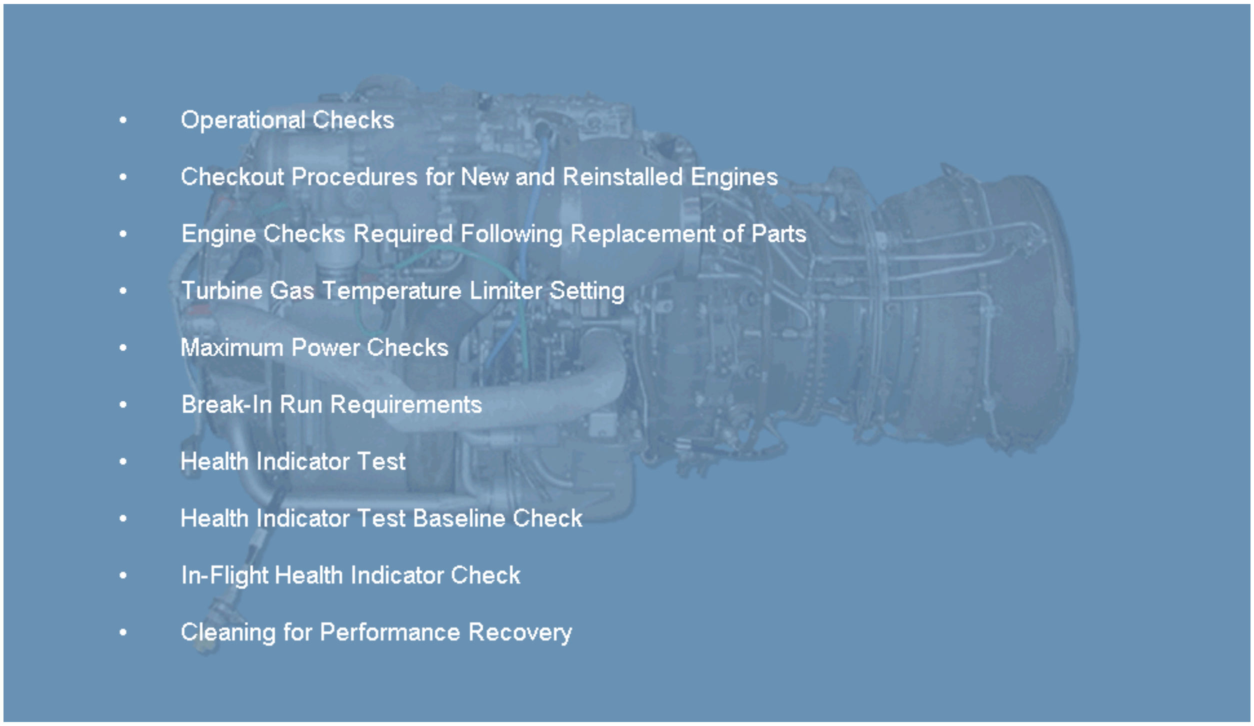
f Section VI

Frame # 0100 (SECTION VI)

NOTE: Two basic things have been assumed in these procedures: The correct operating procedures have been followed. The fault is caused by a single failure.

i) Section VI provides an outline of procedures to follow when troubleshooting, a symptom index, low engine performance and Turbine Gas Temperature (TGT) margins out-of limits procedures.

Frame # 0105 (SECTION VII)



i) In this section, general maintenance procedures for the engine are discussed.

ii) Operational Checks

iii) Checkout Procedures for New and Reinstalled Engines

iv) Engine Checks Required Following Replacement of Parts

v) Turbine Gas Temperature Limiter Setting

vi) Maximum Power Checks

vii) Break-In Run Requirements

viii) Health Indicator Test

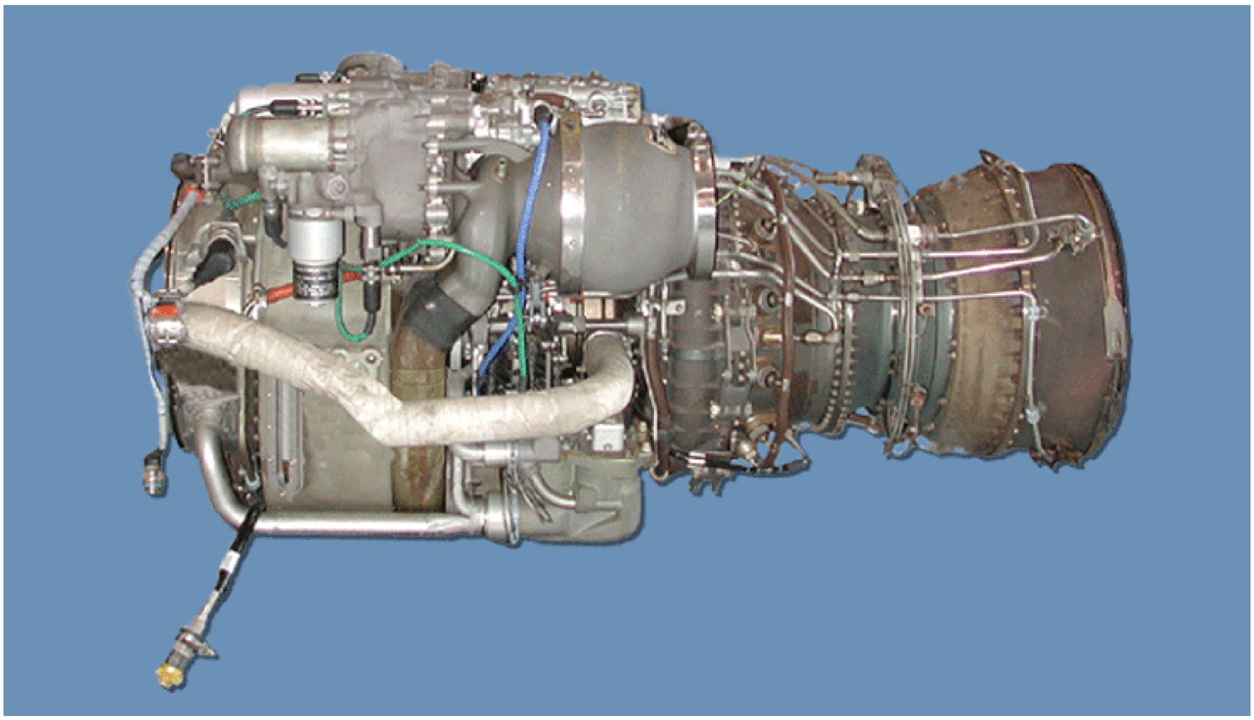
ix) Health Indicator Test Baseline Check

x) In-Flight Health Indicator Check

xi) Cleaning for Performance Recovery

h Section VIII

Frame # 0110 (SECTION VIII)



xii) Section VIII covers testing of the engine in a mobile or fixed facility.

xiii) The testing of an engine in these facilities is the preferred method, although the testing of an engine in the aircraft is an authorized alternate method.

CHECK ON LEARNING

1. Where would you find a list of the references used in the development of this TM?

2. In which section of this TM are the Periodic Inspection Requirements located?

3. Which Section and Table lists a part number for a T700 Borescope Kit?

SECTION III. -SUMMARY

1. REVIEW/SUMMARIZE:

You have completed the Engine Manual topic.
The key points to remember are:

- The TM 1-2840-248-23 is separated into seven major areas: Table of Contents, Figures, Tables, Appendices, Glossary, Index, and Chapters.
- The Table of Contents
- Figures provide a list of illustrations used throughout the manual that will help make a component or assembly clear.
- Tables provide listed information and illustrations to better identify or explain a subject or item.
- References, Maintenance Allocation Charts, Schematics, and Illustrations are listed in the Appendices.
- The Glossary provides Definitions of Words and Terms, listed in alphabetical order, used throughout the TM.
- A list of all subjects covered in this TM, in alphabetical order, is found in the Index. Provided with the subjects are the paragraph, figure, table, or page number.
- The Chapters cover all of the major topics.
- Listed under some Chapters are Sections. Sections provide an additional subtopic breakdown found in the Chapter.
- General information concerning the engine is found in Section I.
- In Section II, an equipment description and data about the engine are found.
- The RPSTL is listed in Section III.
- Section IV addresses the process required for accepting an engine, Service Upon Receipt.
- Scheduled inspections, 10 hour/14 day, 250 hour, and 500 hour, are addressed in Section V.
- A Symptom Index, Low Engine Performance, and TGT Limits are covered in Section VI, Troubleshooting.
- Section VII, General Maintenance, provides information and procedures for the HIT Check, HIT Baseline, and Maximum Power Check.
- The steps required for the engine setup and testing in a Mobile or Fixed Facility are addressed in Section VIII.

B. ENABLING LEARNING OBJECTIVE No. 2

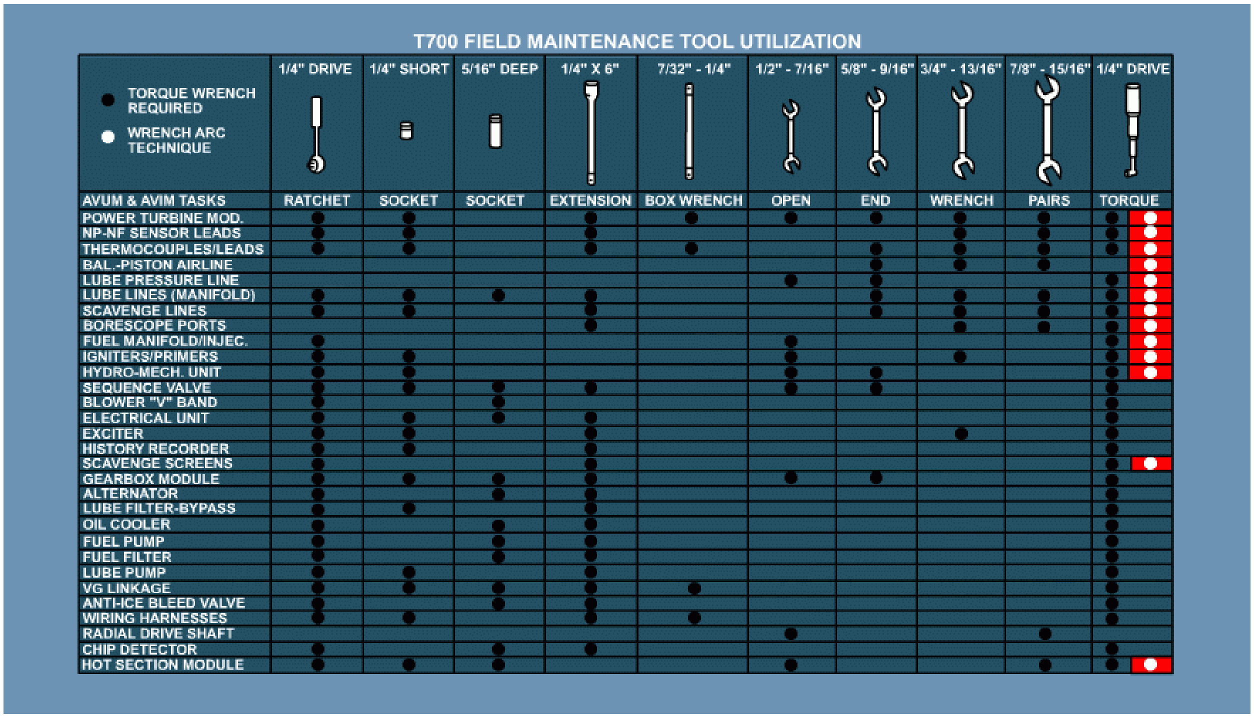
ACTION: Identify the function of the major components of the powerplant system.

CONDITION: Using TM 1-2840-248-23

STANDARD: IAW TM 1-2840-248-23

a. T700 Field Maintenance Tool Utilization

Frame # 0136 (T700 Field Maintenance Tool Utilization)

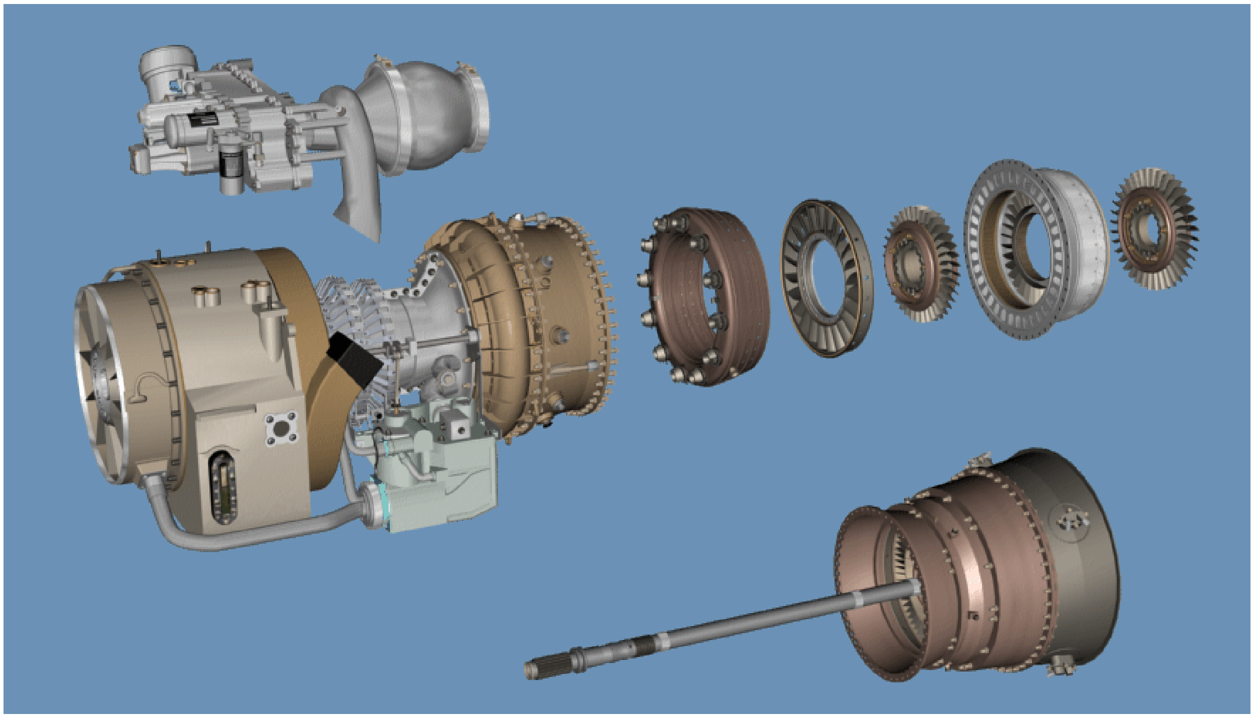


AVUM & AVIM TASKS	1/4" DRIVE RATCHET	1/4" SHORT SOCKET	5/16" DEEP SOCKET	1/4" X 6" EXTENSION	7/32" - 1/4" BOX WRENCH	1/2" - 7/16" OPEN	5/8" - 9/16" END	3/4" - 13/16" WRENCH	7/8" - 15/16" PAIRS	1/4" DRIVE TORQUE
POWER TURBINE MOD.	●	●		●	●	●	●	●	●	● ○
NP-NF SENSOR LEADS	●	●		●				●	●	● ○
THERMOCOUPLES/LEADS	●	●		●	●		●	●	●	● ○
BAL.-PISTON AIRLINE							●	●	●	○
LUBE PRESSURE LINE						●	●			● ○
LUBE LINES (MANIFOLD)	●	●	●	●			●	●	●	● ○
SCAVENGE LINES	●	●		●			●	●	●	● ○
BORESCOPE PORTS				●				●	●	● ○
FUEL MANIFOLD/INJEC.	●					●				● ○
IGNITERS/PRIMERS	●	●				●		●		● ○
HYDRO-MECH. UNIT	●	●				●	●			● ○
SEQUENCE VALVE	●	●	●	●		●	●			●
BLOWER "V" BAND	●		●							●
ELECTRICAL UNIT	●	●	●	●						●
EXCITER	●	●		●				●		●
HISTORY RECORDER	●	●		●						●
SCAVENGE SCREENS	●			●						● ○
GEARBOX MODULE	●	●	●	●		●	●			●
ALTERNATOR	●		●	●						●
LUBE FILTER-BYPASS	●	●		●						●
OIL COOLER	●		●	●						●
FUEL PUMP	●		●	●						●
FUEL FILTER	●		●	●						●
LUBE PUMP	●	●		●						●
VG LINKAGE	●	●	●	●	●					●
ANTI-ICE BLEED VALVE	●		●	●						●
WIRING HARNESSES	●	●		●	●					●
RADIAL DRIVE SHAFT						●			●	
CHIP DETECTOR	●		●	●						●
HOT SECTION MODULE	●	●	●			●			●	● ○

(1) The T700 Field Maintenance Tool Utilization chart shows the common hand tools required to perform the associated maintenance listed on the left hand side of the chart.

b. Engine Modules

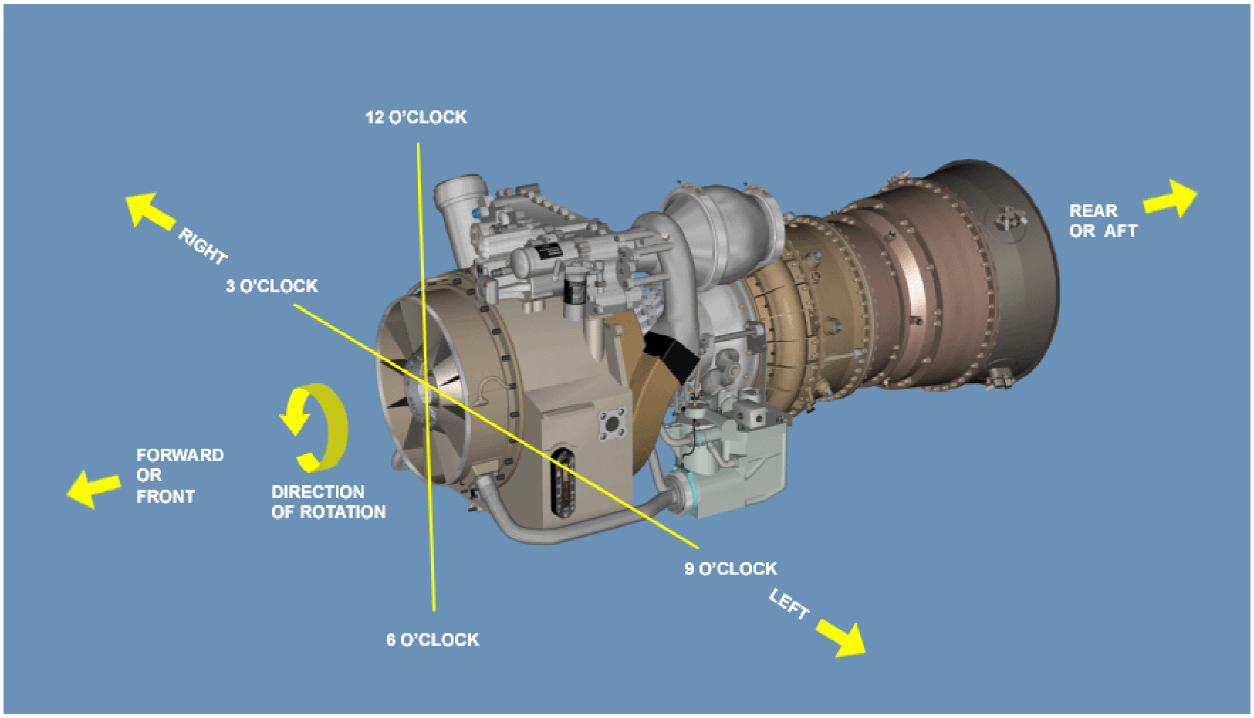
Frame # 0140 (Engine Modules)



(1) The engine is comprised of four modules: the accessory section module, cold section module, hot section module, and the power turbine module.

c. Engine orientation

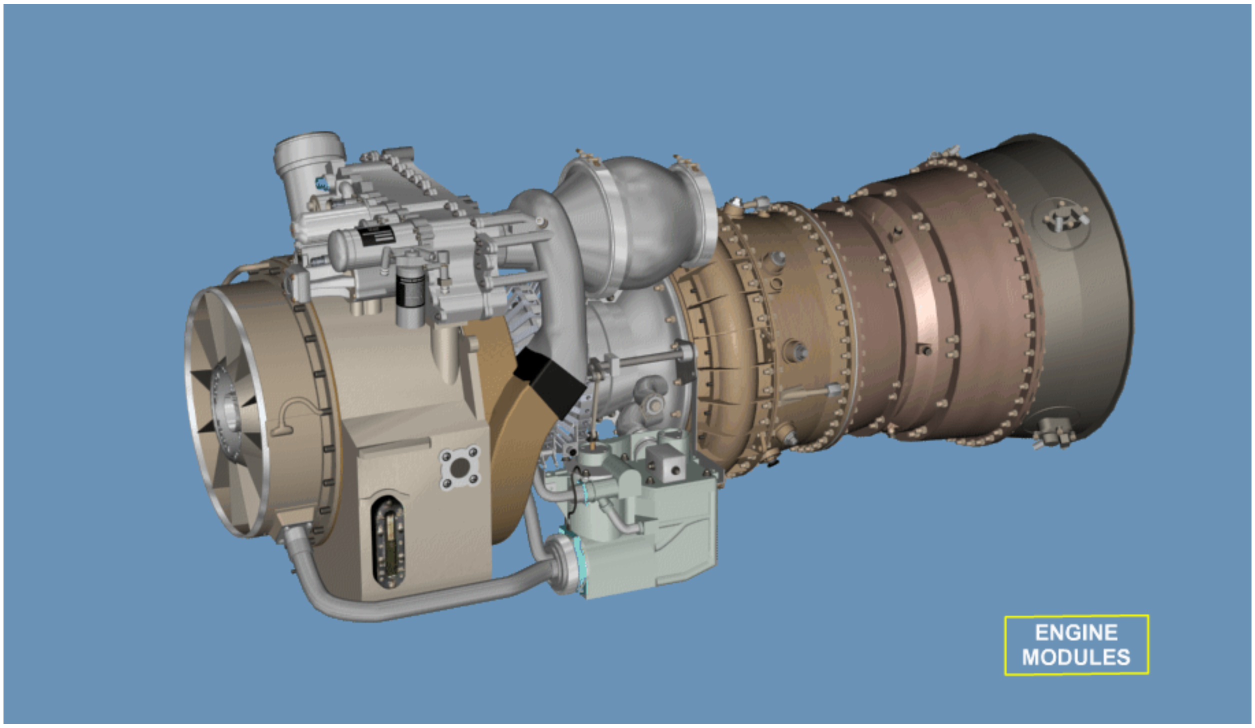
Frame # 0145 (Engine Orientation)



(1) The engine is referenced from the rear (aft) looking towards the front (forward).

d. Major Engine Components

Frame # 0150 (Major Engine Components FLASH)



(1) Under the modular maintenance concept, the T700 series turboshaft engines are divided into four modules:

(a) Accessory Section Module (Accessory Gearbox)

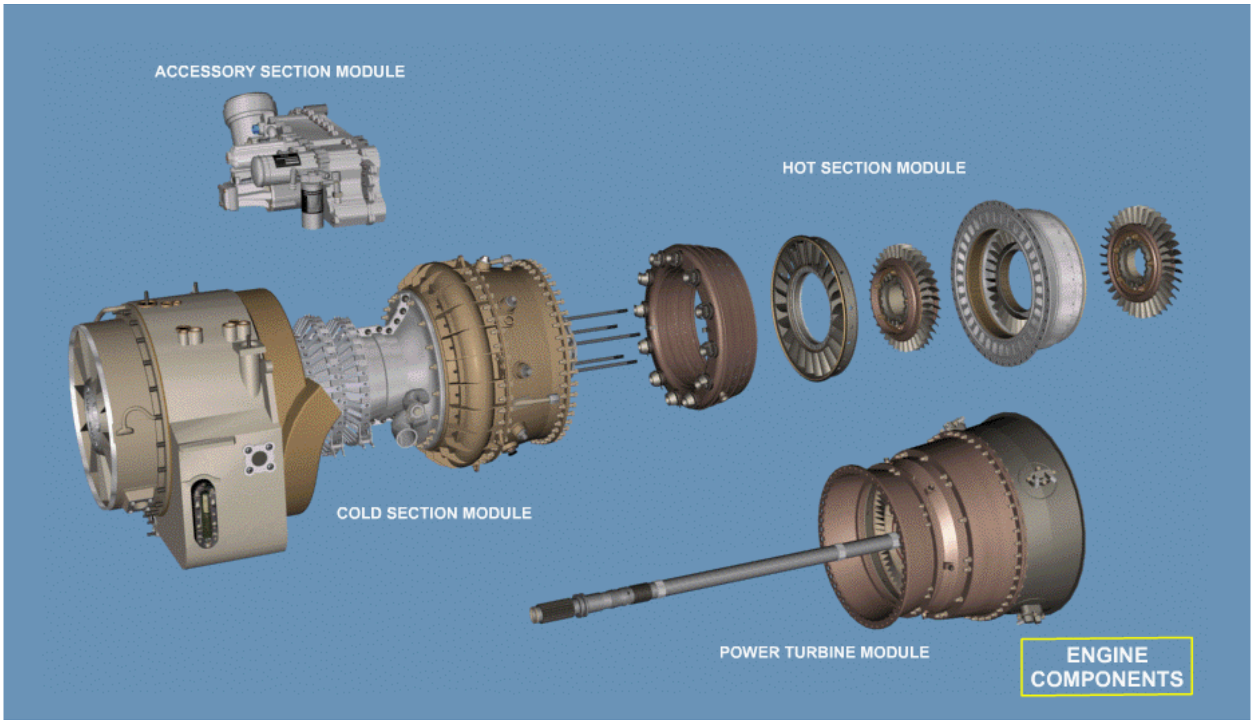
(b) Cold Section Module (Compressor Section)

(c) Hot Section Module (Combustion Section)

(d) Power Turbine Module (Power Turbine)

(2) The engine can be disassembled into the four modules.

Frame # 0150 (Major Engine Components FLASH)



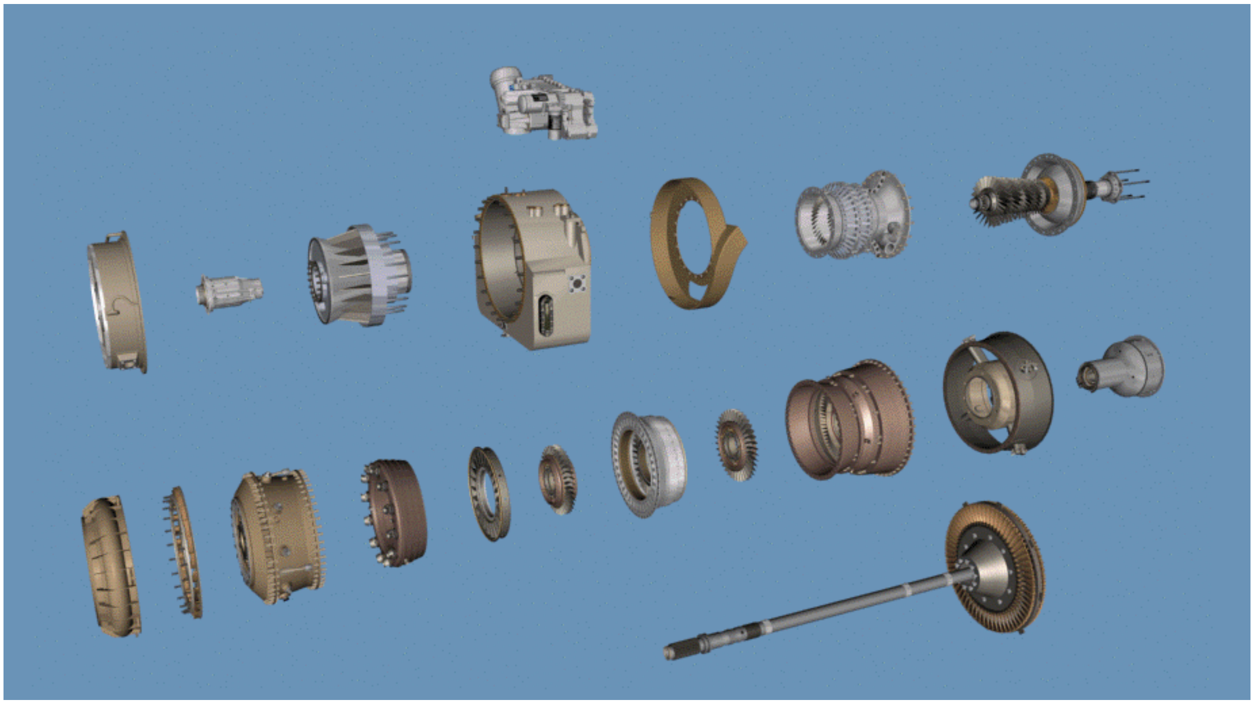
(3) The four modules consist of several major components.

(4) The T700 engine major components consists of the swirl frame, front frame, main frame and scroll case which comprise the inlet section of the engine; a vertically split compressor stator casing which provides a housing for the variable and fixed stator vanes, a 6-stage (5 stages axial, 1 centrifugal) compressor rotor; the diffuser case, diffuser and mainframe.

(5) The components are part of the cold section module.

(6) The accessory gearbox is top mounted to the main frame and, together with the various accessories mounted on the forward and aft casings, is the accessory section module.

Frame # 0150 (Major Engine Components)



(7) The combustion liner and stage one turbine nozzle is housed in the midframe, which also provides a mounting provision for the gas generator turbine stator.

(8) The combustion liner, stage one turbine nozzle, gas generator turbine stator, and rotor comprise the hot section module.

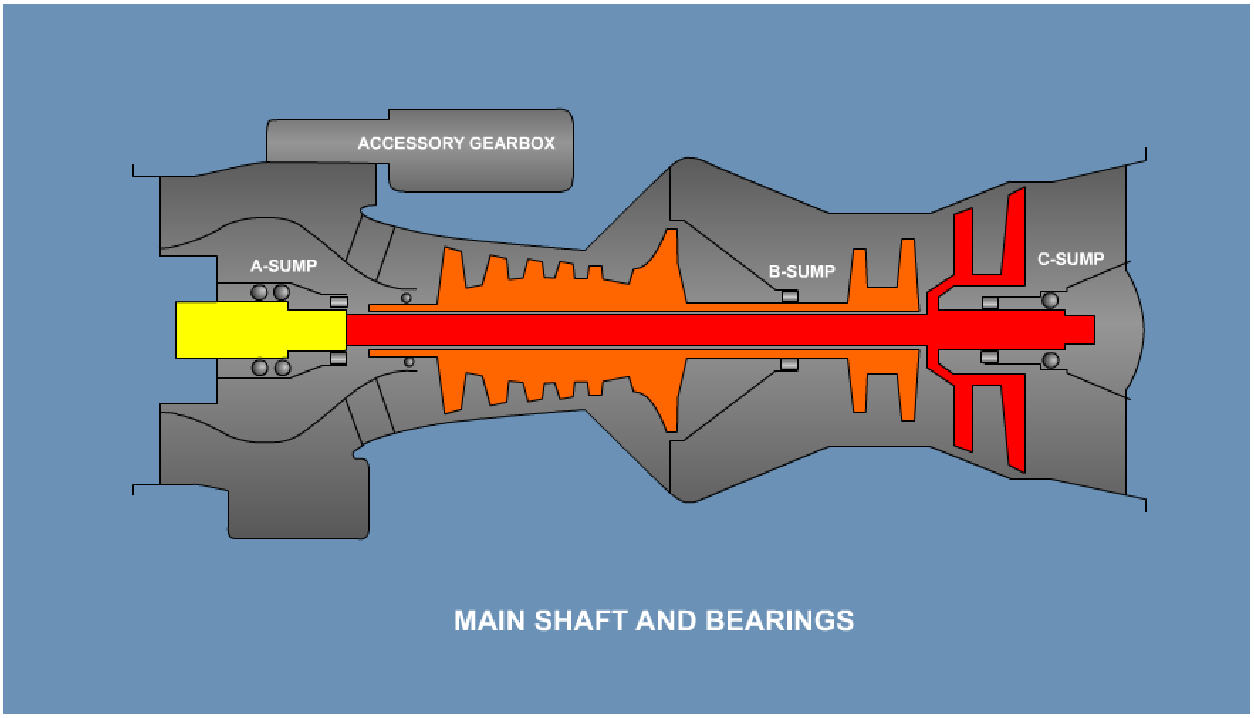
(9) A two-stage power turbine rotor is housed in the power turbine casing, which also contains the No. 3 and No. 4 power turbine nozzles.

(10) The exhaust frame is bolted to the power turbine casing.

(11) The power turbine rotor, casing and exhaust frame comprise the power turbine module.

(a) Main Bearings and Shafts

Frame #0155 (Main Bearings and Shafts)



1) The engine rotor systems are supported by six main bearings located in three bearing sumps, A, B, and C.

2) All roller bearings contain spring cage roller supports which aid in keeping the bearing centered and also dampens vibration.

3) The No. 1 and No. 2 bearings support the output shaft.

4) The No. 3 bearing is located on the forward end of the compressor, and together with the No. 4 bearing, located between the compressor and turbine, support the gas generator rotor.

5) The No. 5 and No. 6 bearings provide support for the power turbine rotor.

6) A spline is provided in the output shaft, which supports the forward end of the power turbine drive shaft.

7) The bearing sumps are identified from front to aft of the engine and contain the following bearings:

a) A-sump - No. 1, 2, and 3 bearings

b) B-sump - No. 4 bearing

c) C-sump - No. 5 and 6 bearings.

1 No. 1, Ball (duplex) thrust (5-piece), Absorbs radial and axial loads – output shaft.

2 No. 2, Roller (2-piece), Absorbs radial loads – output shaft.

3 No. 3, Ball (4-piece) thrust, Absorbs radial and axial loads – gas generator rotor.

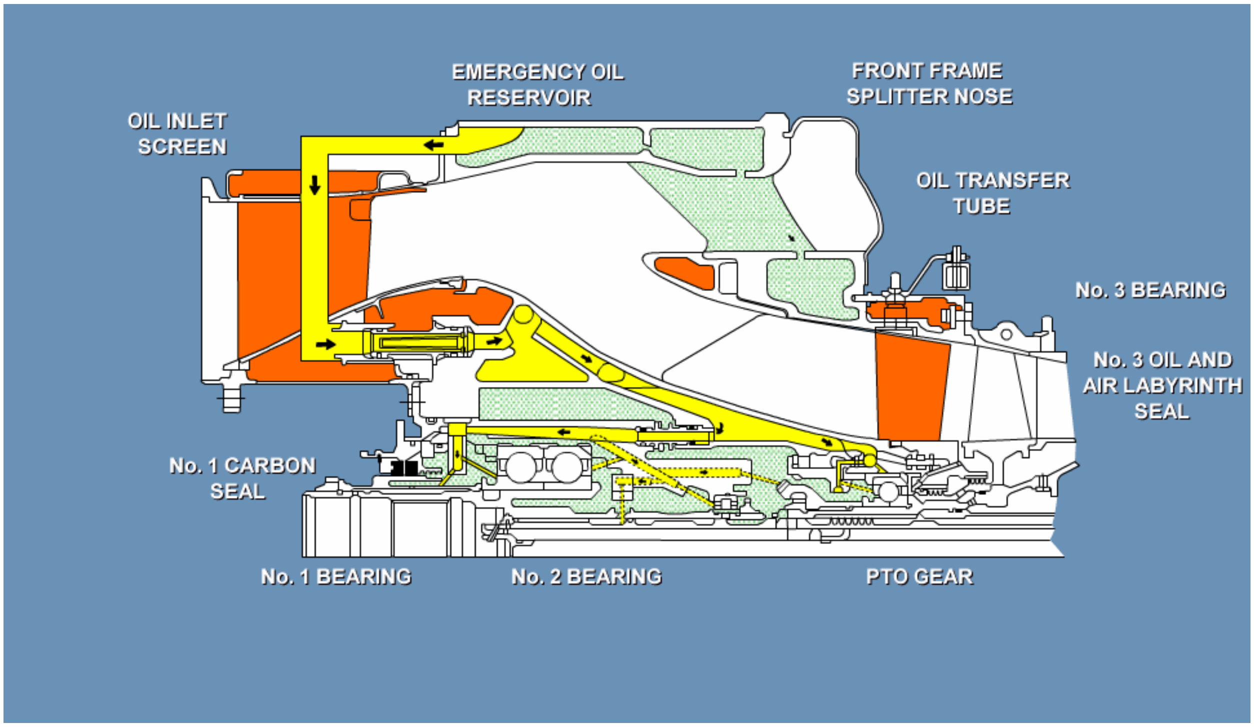
4 No. 4, Roller (2-piece), Absorbs radial loads – gas generator rotor.

5 No. 5, Roller (2-piece), Absorbs radial loads – power turbine rotor.

6 No. 6, Ball (4-piece) thrust, Absorbs radial and axial loads – power turbine rotor.

8) Carbon and Labyrinth Seals

Frame #0156 (CARBON AND LABYRINTH SEALS)



a) Seal pressurization limits oil loss from the sumps by controlling the airflow into them.

b) Pressurization also keeps hot gases, dust, and moisture out of the sumps by providing a high-pressure air barrier to the inward airflow.

c) Air for pressurizing the A and B sump seals is bled from Stage 4 on the compressor rotor.

d) Bleed air enters the rotor through curvic coupling teeth aft of the Stage 4 rotor blades.

e) Once inside the rotor, the flow divides, flowing both forward and aft.

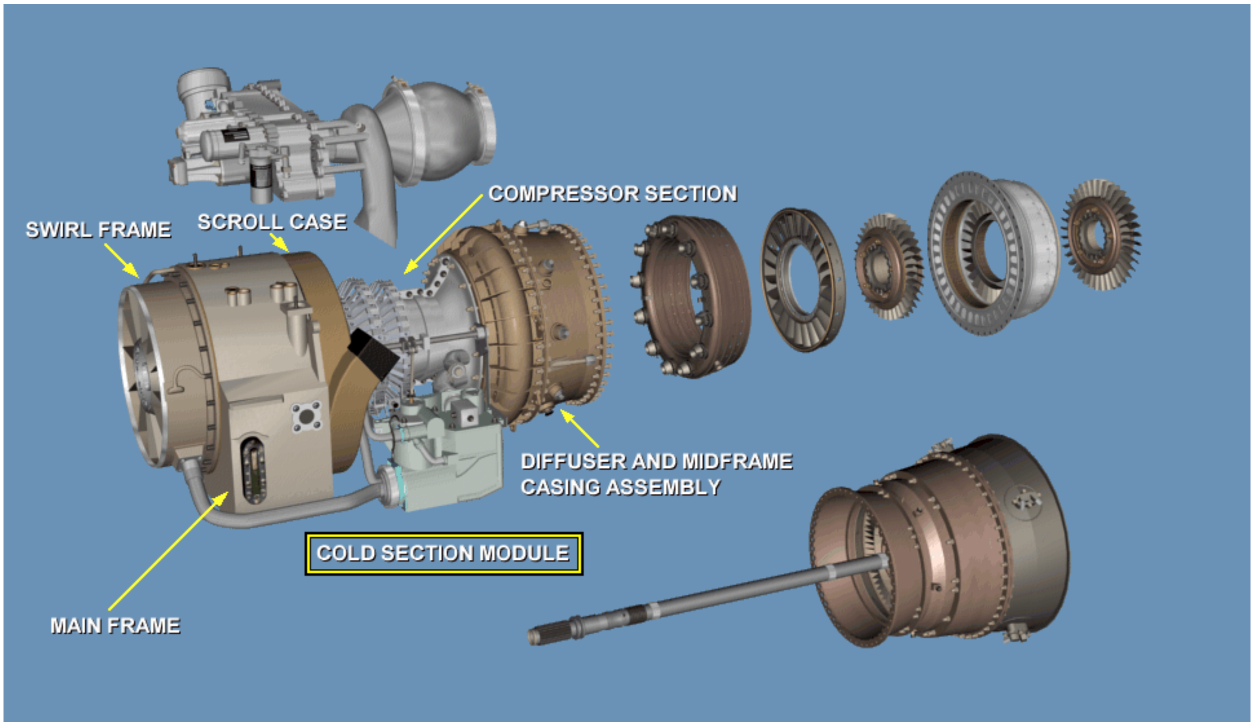
f) Air flows forward in the compressor rotor to the A sump aft labyrinth seals and enters the space between the seals through holes in the Stage 1 blade-disk.

g) A small amount of air from this space pressurizes the No. 1 carbon seal and the oil mist nozzle.

h) Some air enters the A sump through the No. 1 carbon seal, and some returns to the compressor inlet through the No. 3 labyrinth seal.

(b) Cold Section Module

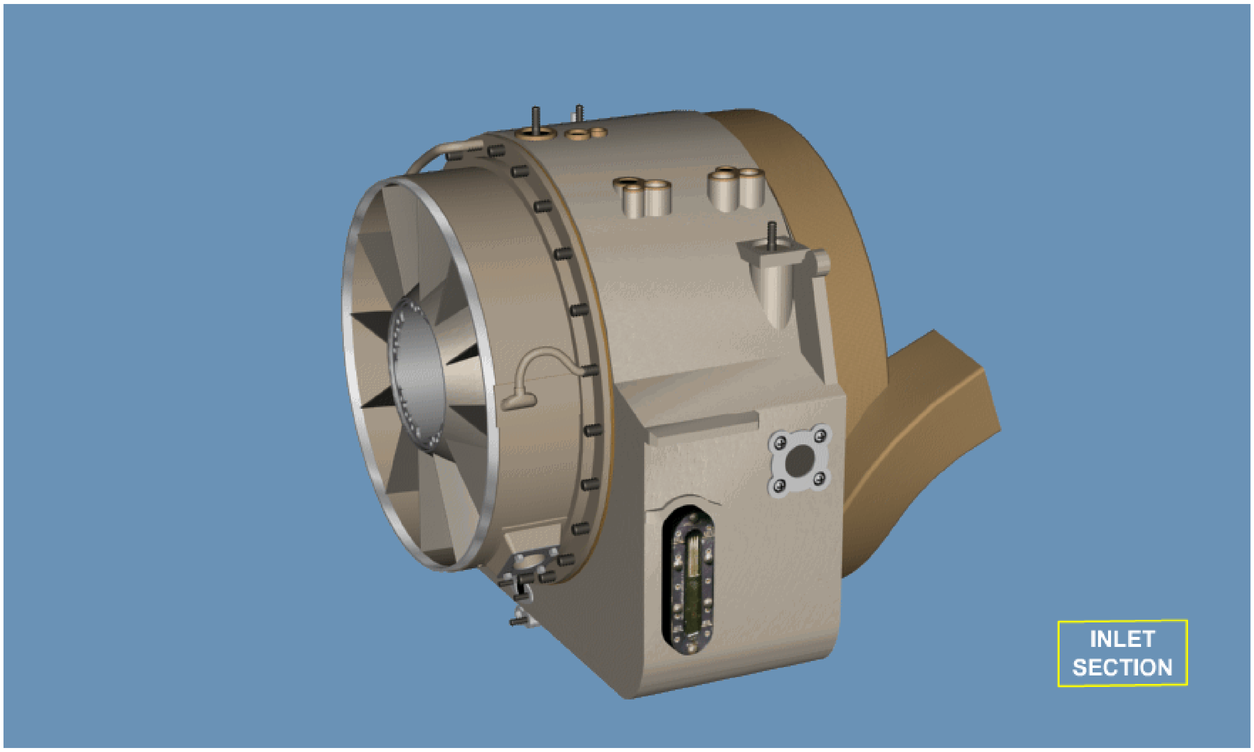
Frame # 0160 (Cold Section Module)



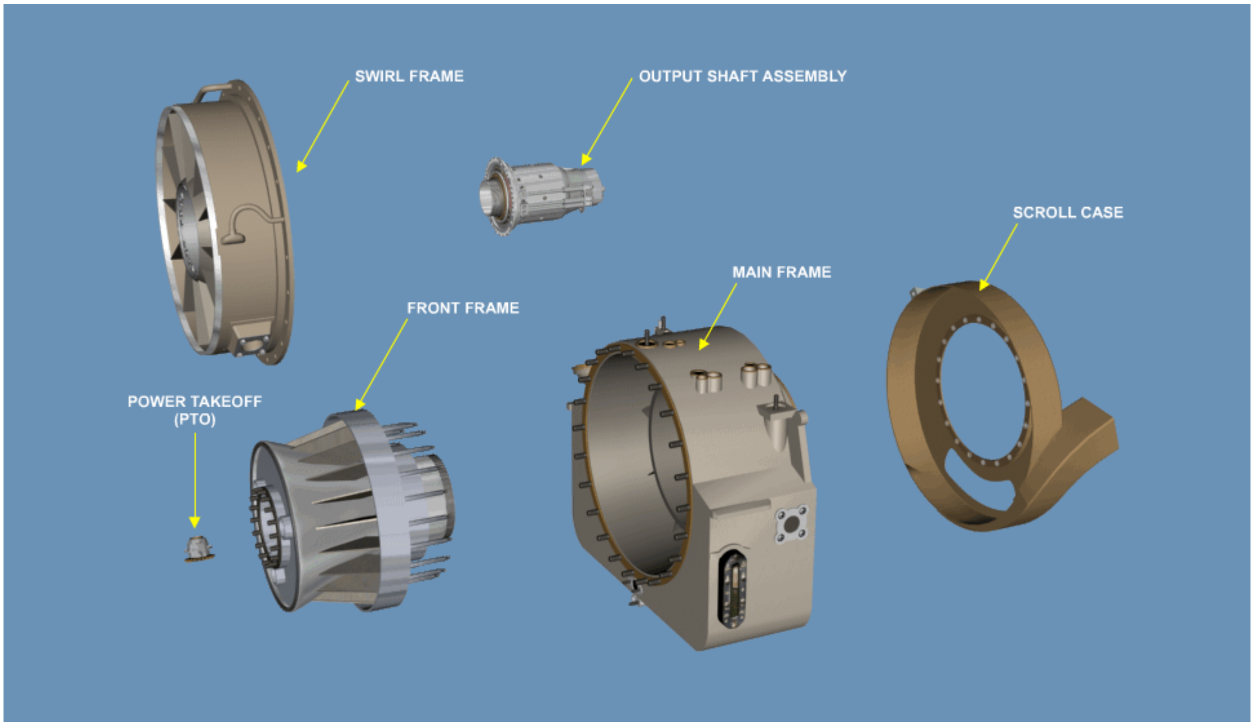
1) The cold section module includes the inlet section, comprised of the swirl frame, main frame, output shaft (internal), front frame (internal), and scroll case, as well as the compressor section and the diffuser and midframe casing assembly.

a) Inlet Section

Frame # 0165 (Inlet Section FLASH)



Frame # 0165 (Inlet Section FLASH)



1 The inlet section includes the components forward of the compressor.

2 The components are the swirl frame, main frame, output shaft, front frame, and scroll case.

3 These, together with the inlet duct and blower, make up the engine inlet particle separator.

4 Air enters the separator through the swirl frame.

5 Swirl vanes direct the air into a rotating or swirling pattern to separate sand, dust and other foreign objects by centrifugal action.

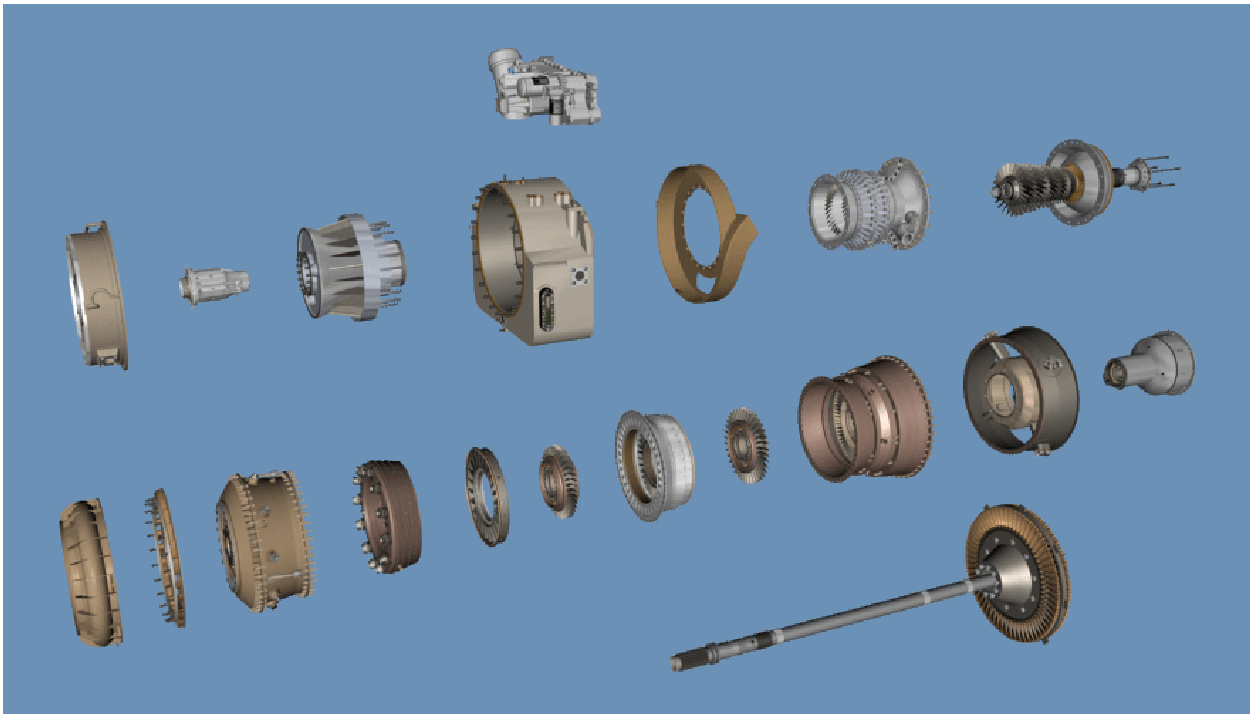
6 These particles are carried to the outer section of the main frame, through a series of scroll vanes and into the scroll case.

7 The particles are sucked from the scroll case by the blower and are blown out through an airframe supplied overboard duct.

8 Air that remains after particle separation is carried to the front frame deswirl vanes, straightened and directed to the compressor inlet.

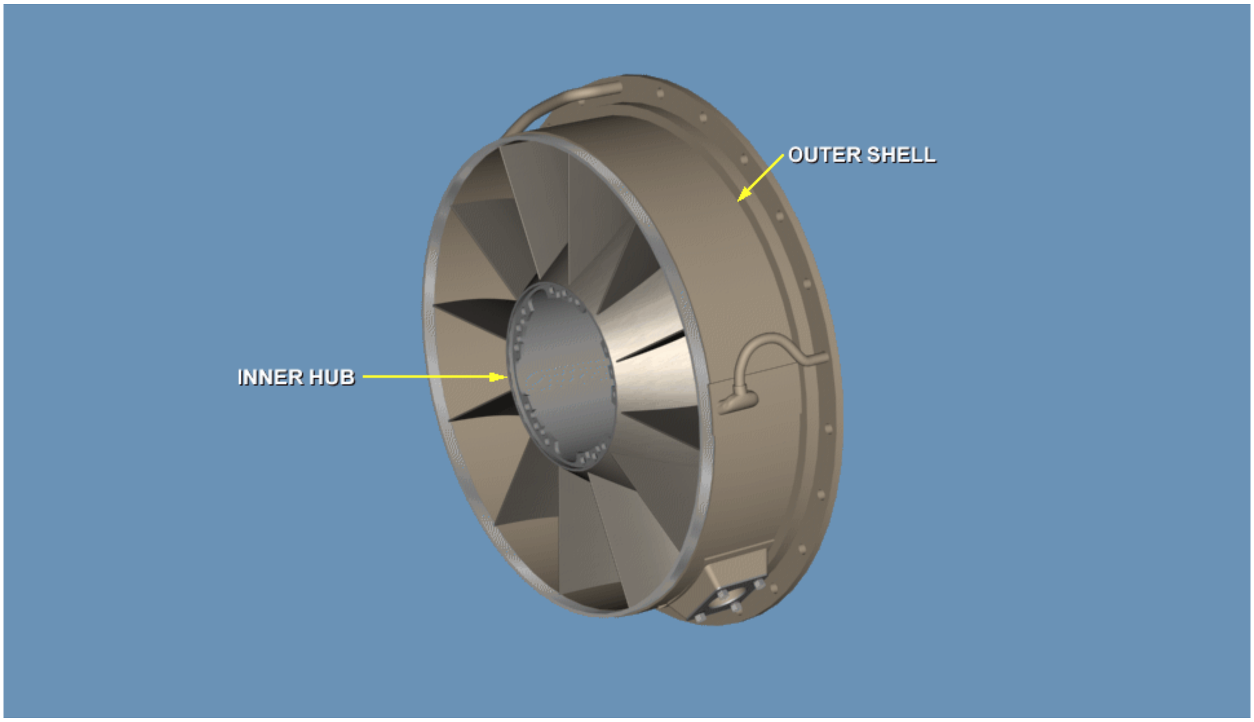
a Swirl Frame

Frame # 0170 (Swirl Frame)



i) The swirl frame is a stainless-steel fabricated structure which is bolted to the forward face of the main frame.

Frame # 0170 (Swirl Frame)



ii) The swirl frame has 12 fixed swirl vanes which impart rotation to the airflow to effect particle separation.

iii) The swirl vanes are hollow to permit passage of hot air for anti-icing purposes.

iv) The engine wash manifold (internal) is an integral part of the swirl frame. It has a series of jets aimed at the compressor inlet area.

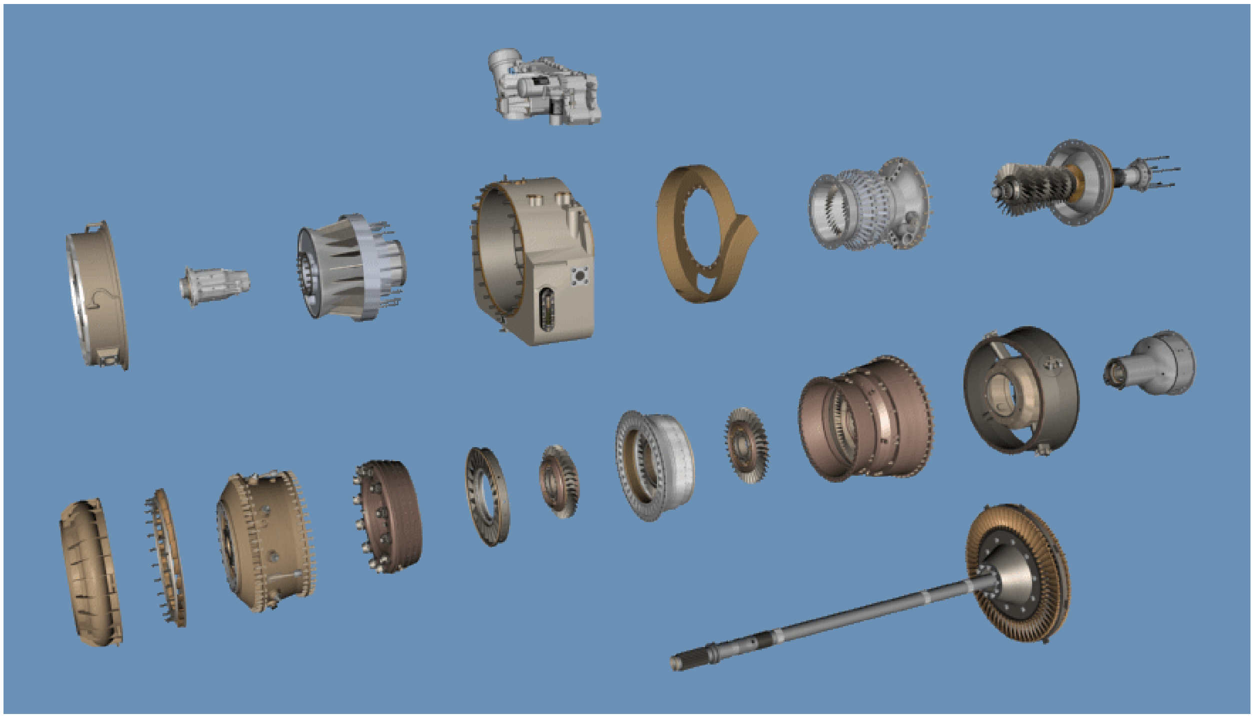
v) The wash manifold fitting is located at the 7 o'clock position on the swirl frame.

vi) The inner hub of the swirl frame supports the output shaft assembly and contains a bolt circle for engine/airframe interface.

vii) The outer shell contains integral tubing that facilitates oil supply and oil scavenge for the A-sump area as well as a drain located at the 6 o'clock position.

b Main Frame

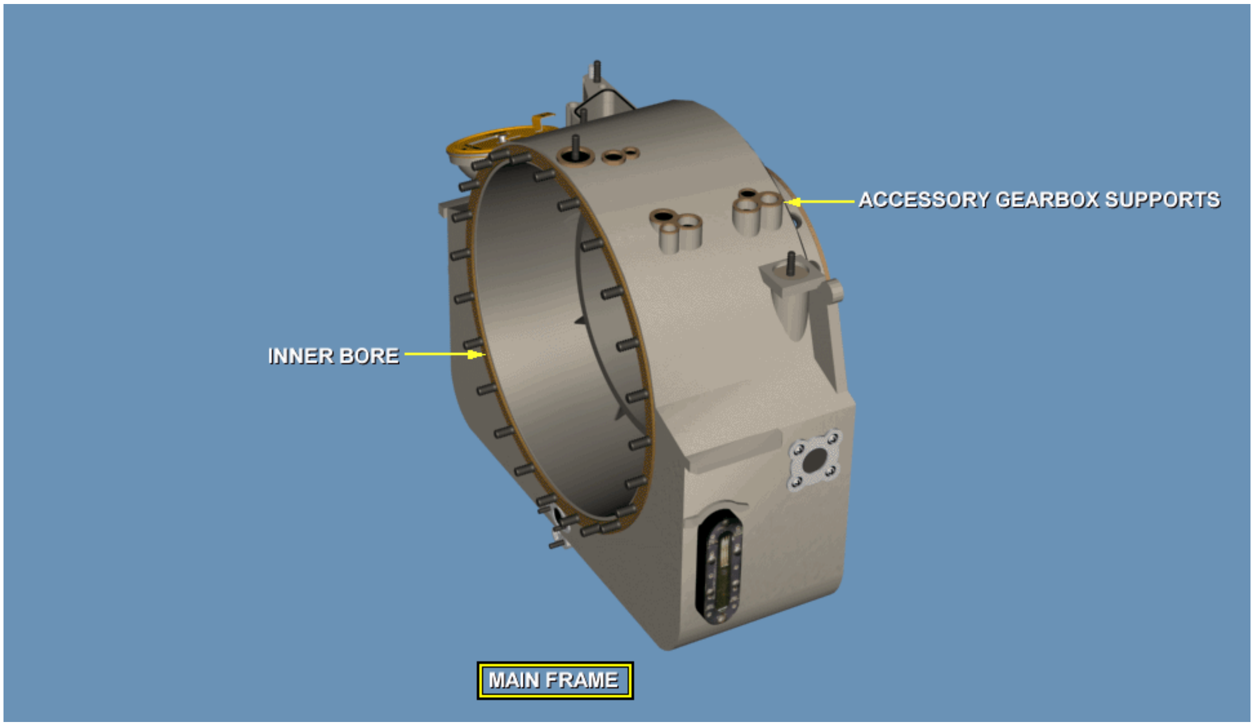
Frame # 0175 (Main Frame)



i) The main frame is a one piece, aluminum casting, with seven integrally cast scroll vanes.

ii) Internally cored passages within the main frame provide for the flow of oil to and from the A-sump area and the accessory gearbox.

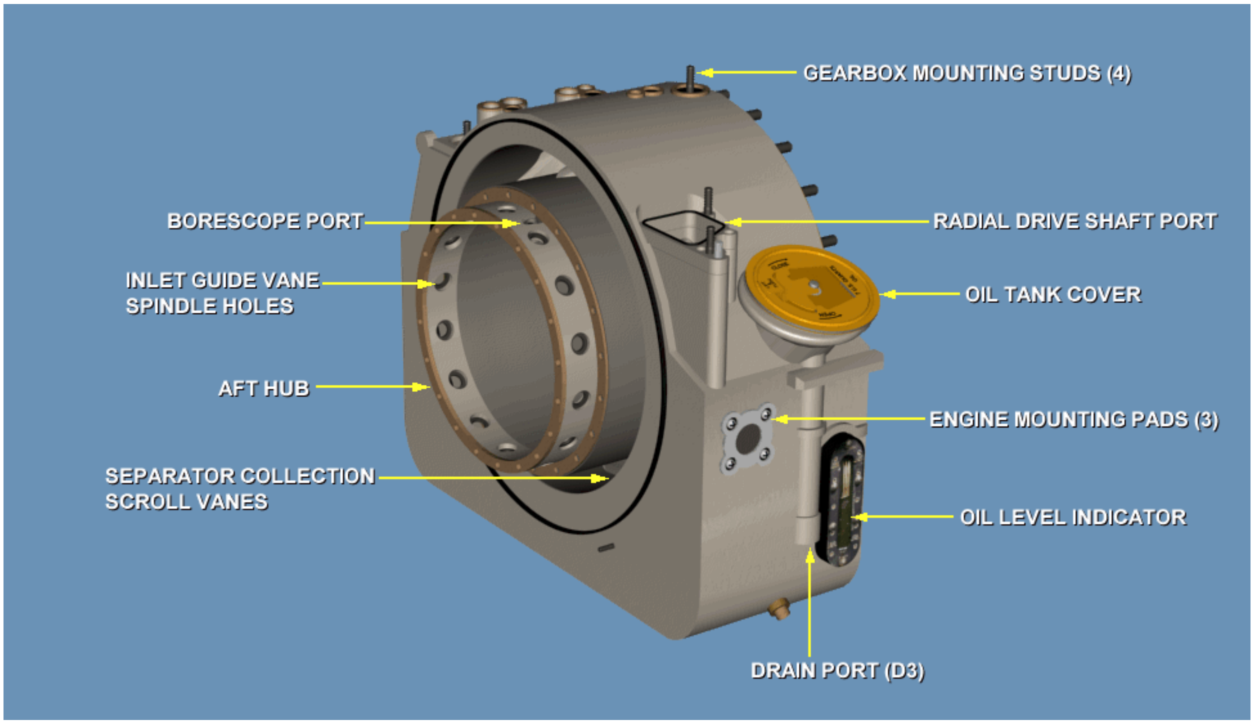
Frame # 0175 (Main Frame)



iii) The inner bore of the main frame houses the front frame and forms the outer surface of the compressor inlet flow path.

iv) The accessory gearbox supports are located on the main frame.

Frame # 0175 (MAIN FRAME)



v) The aft hub of the main frame is used to mount and support 18 Inlet Guide Vanes (IGVs).

vi) Lever arms are fitted to the IGV spindles and to an actuating ring.

vii) The inlet guide vanes are anti-iced by compressor bleed air.

viii) The main frame houses the oil tank and oil level indicators, and provides three mounting pads which can be utilized as engine mounting points or to facilitate ground handling equipment.

ix) A port, located at the 1:30 o'clock position, accommodates the radial drive shaft utilized to drive the accessory drive gearbox, which mounts to the top of the main frame.

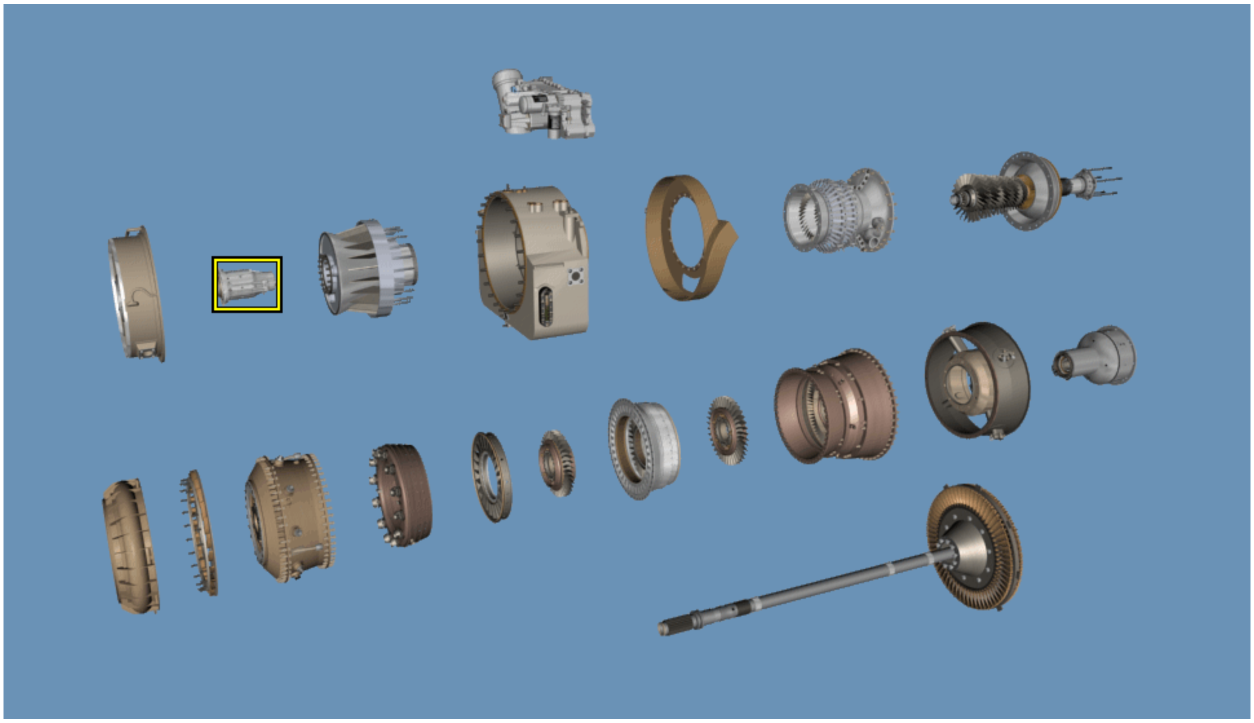
x) Hot oil from the bearing sump areas, provides for the anti-icing of the main frame by its flow through each of the hollow scroll vanes prior to its entry into the oil tank.

xi) The scroll vanes also act as an air/oil cooler to supplement the engine fuel/oil cooler mounted on the accessory drive gearbox.

xii) A borescope port permits inspection of the stage 1 compressor rotor blades.

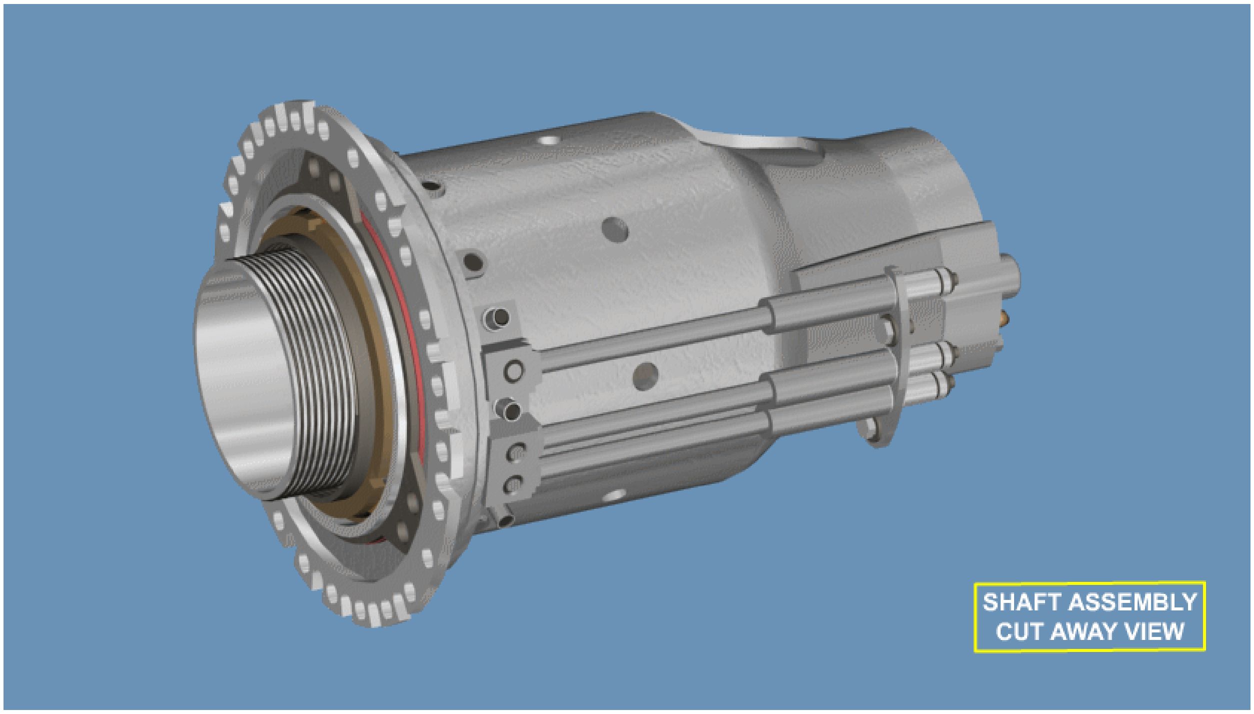
c Output Shaft

Frame # 0180 (Output Shaft)



i) The output shaft assembly is housed in the front frame.

Frame # 0181 (Output Shaft FLASH)



ii) The output shaft assembly provides a mounting surface for the No. 1 and No. 2 main bearing and supplies power through shafting to the helicopter transmission.

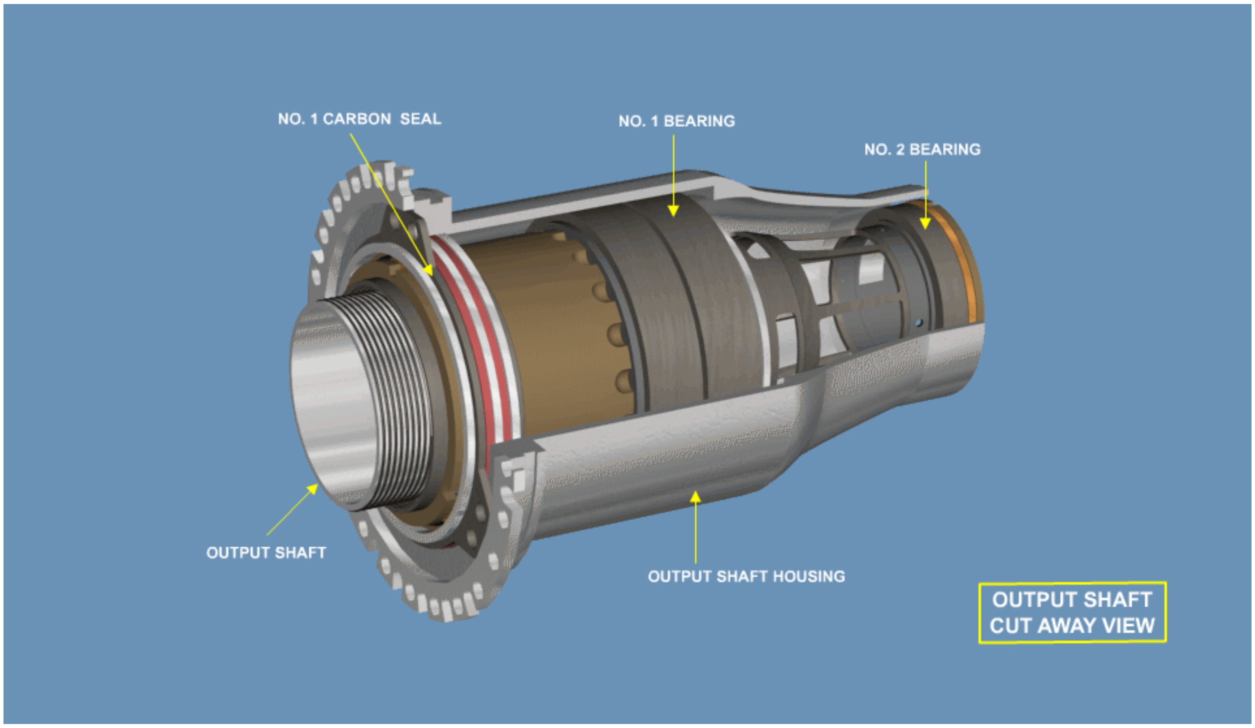
iii) The output shaft connects to the power turbine drive assembly by a working splined joint.

iv) Removal of the output shaft is not necessary to facilitate removal of the power turbine module.

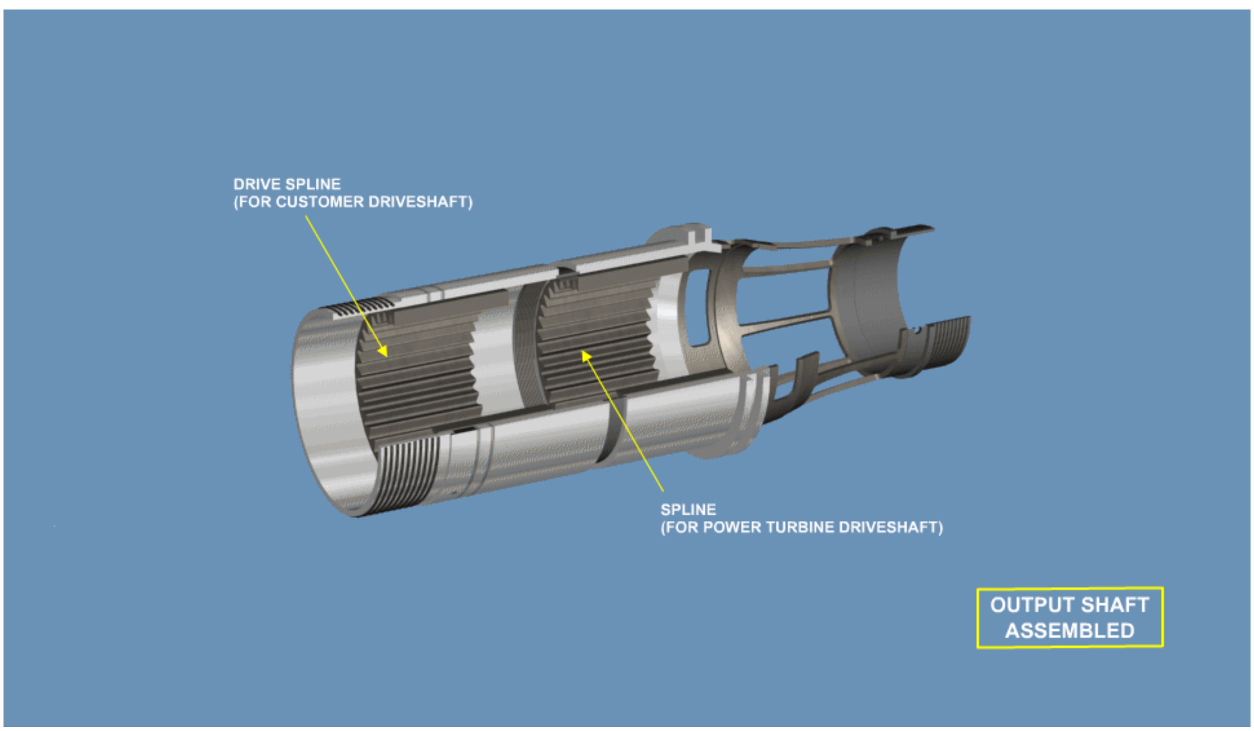
v) A pressurized, tandem-type carbon seal is attached on the bearing housing.

vi) It provides the forward seal to the "A" sump.

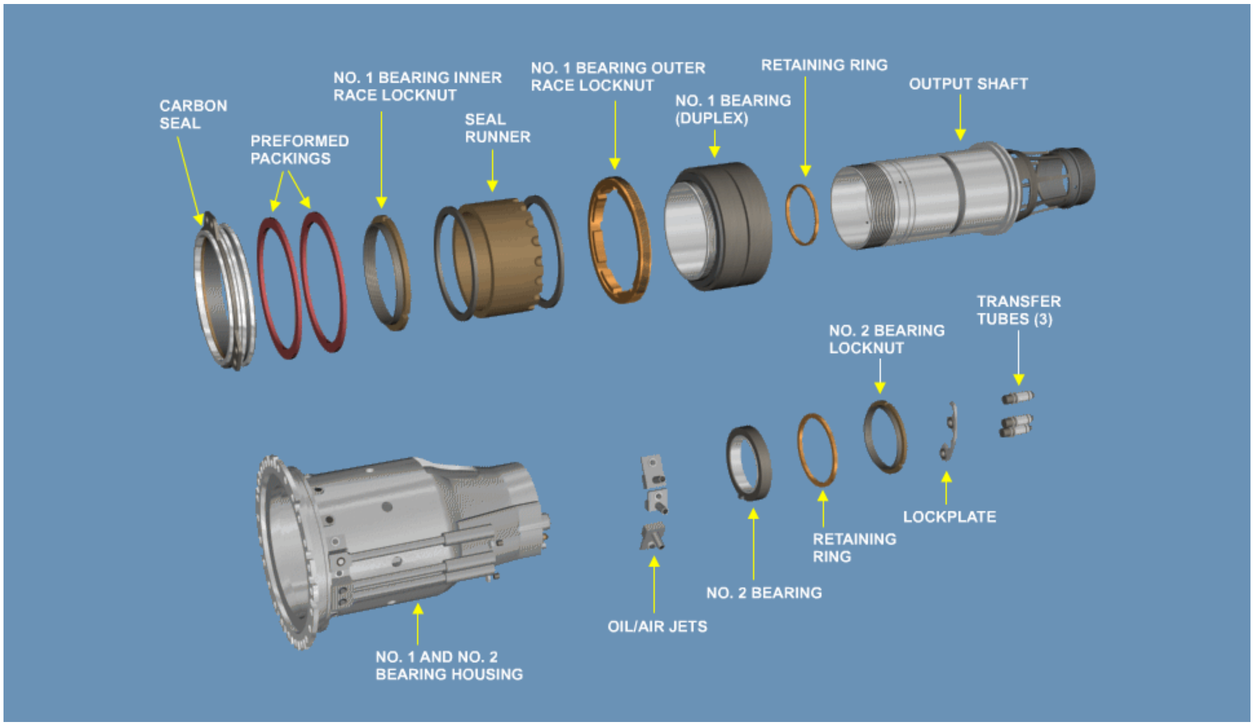
Frame # 0181 (Output Shaft FLASH



Frame # 0181 (Output Shaft FLASH

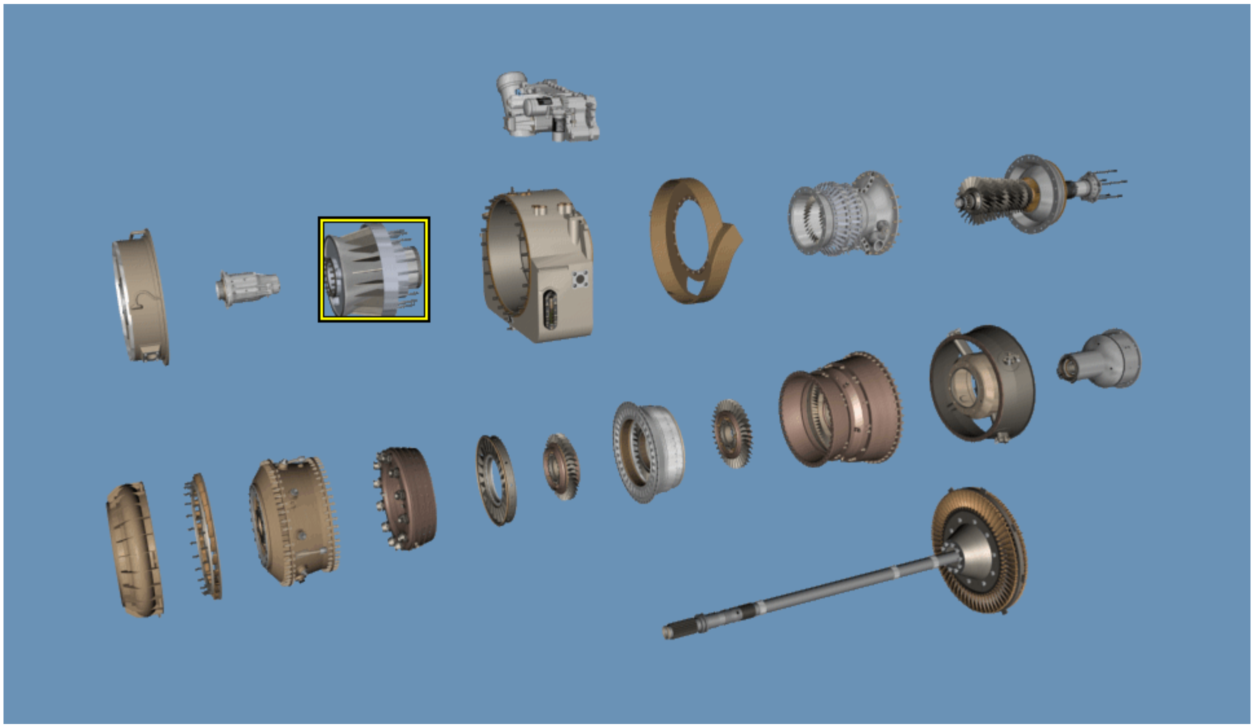


Frame # 0181 (Output Shaft FLASH



d Front Frame

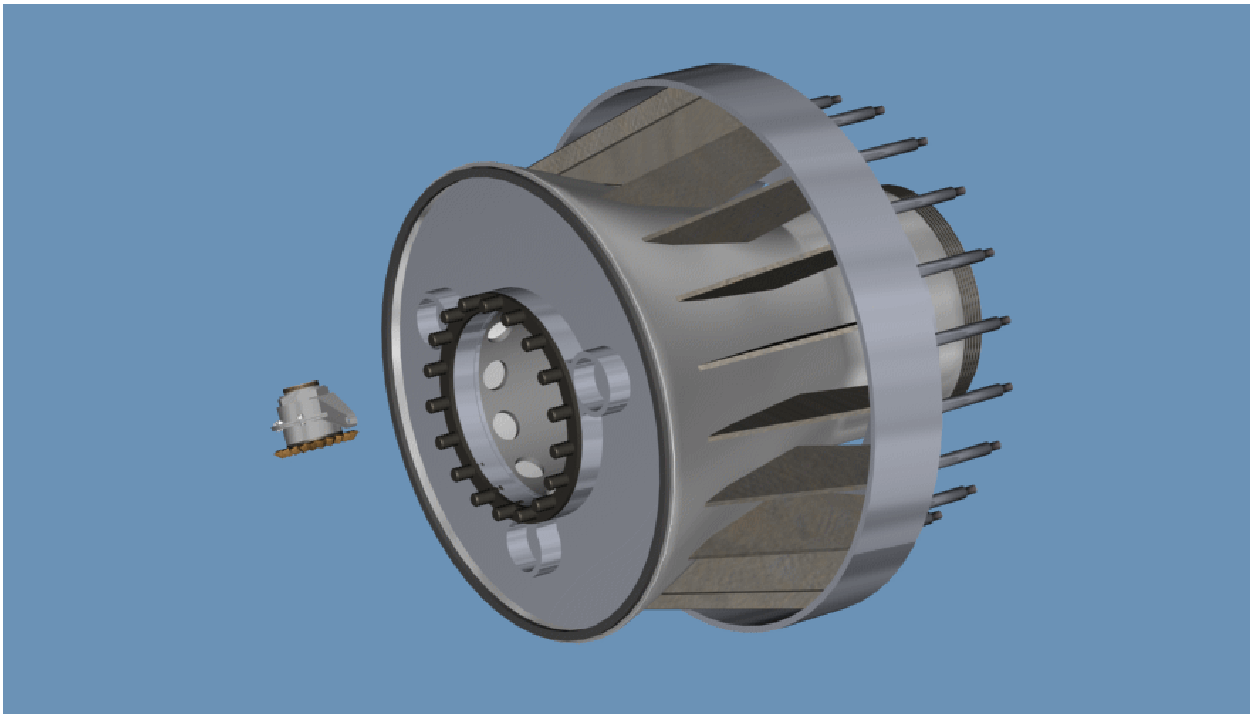
Frame # 0185 (Front Frame)



i) The front frame is enclosed within the main frame.

ii) It is an aluminum casting, incorporating the 18 deswirl vanes of the particle separator.

Frame # 0185 (Front Frame)



iii) The front frame inner bore houses the output shaft assembly (internal).

iv) The aft inner bore of the front frame houses the bearing support (internal) for the number three bearing.

v) The Power Takeoff (PTO) is mounted inside the front frame at the 1:30 o'clock point.

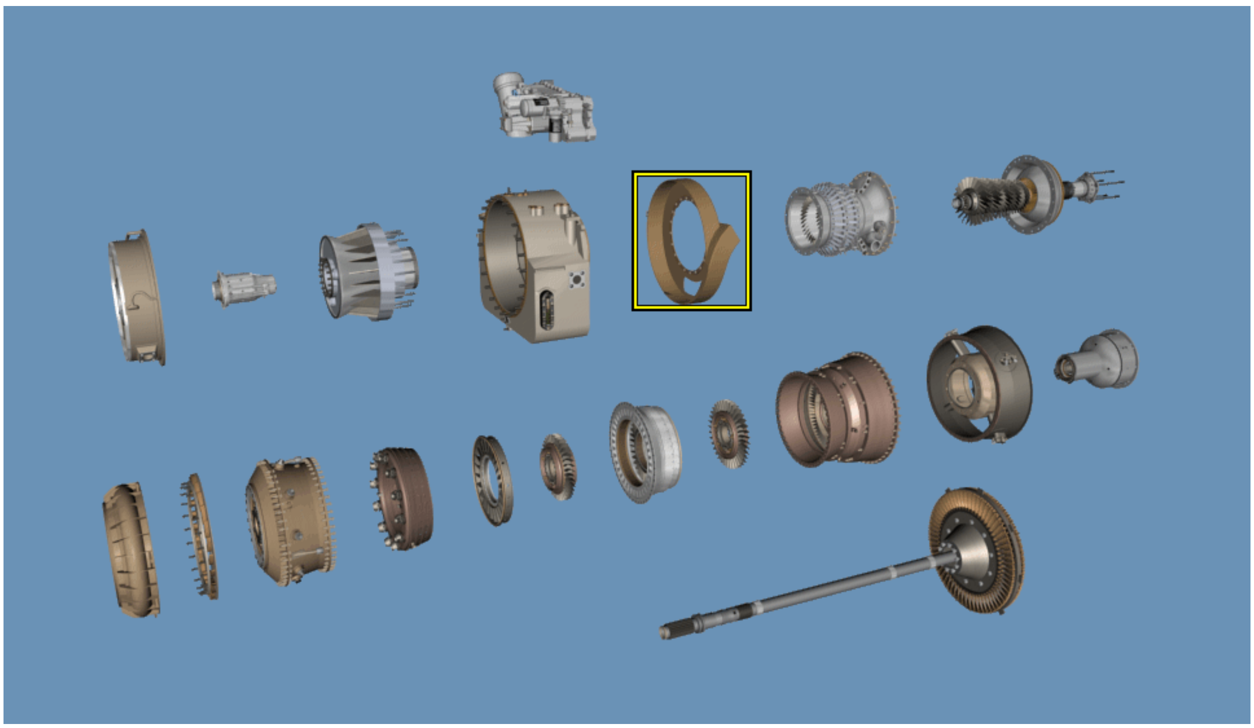
vi) It consists of a bevel gear with a duplex ball bearing. The PTO drives the accessory module through a radial drive shaft, which extends through the front frame and main frame 1:30 o'clock vanes.

vii) The outer flange of the front frame is rabbeted to facilitate assembly of the swirl frame (forward) and the main frame (rear).

viii) Transfer tubes between the front frame and swirl frame allow oil to be supplied to and scavenged from the A-sump bearings and gears.

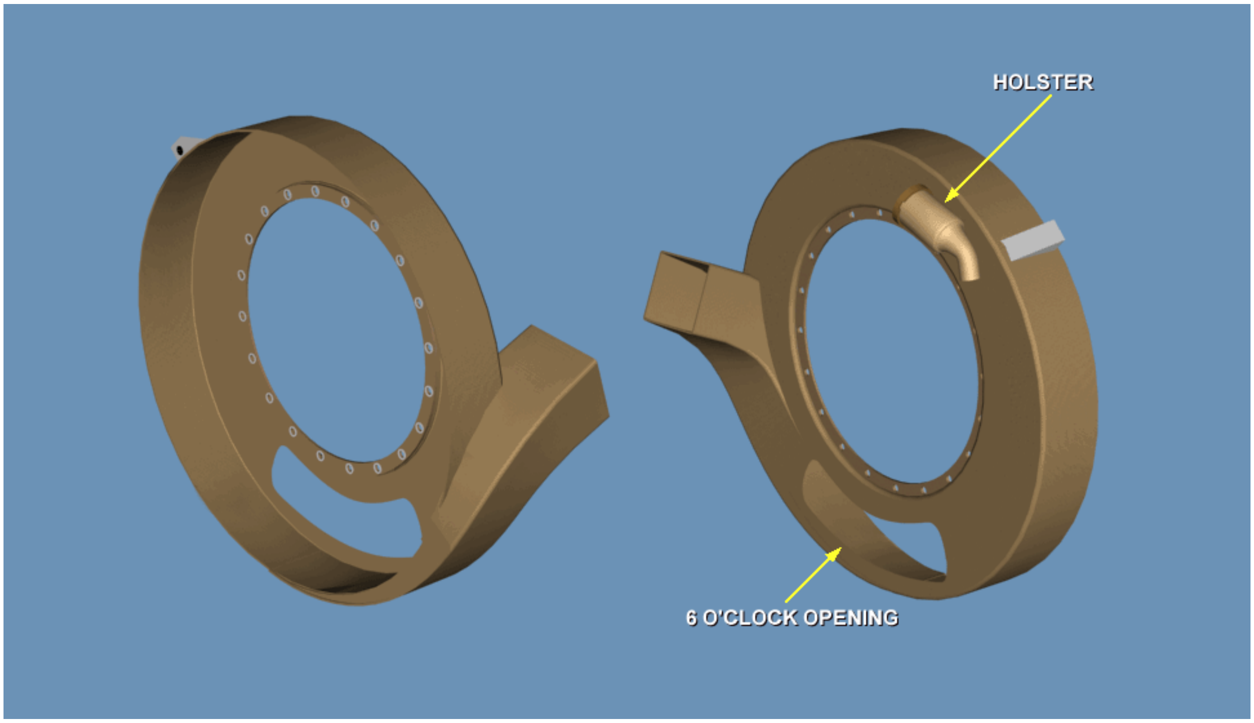
e Scroll Case

Frame # 0190 (Scroll Case)



i) The collection scroll case, which is a fiberglass shell, attaches to the aft flanges of the main frame.

Frame # 0190 (Scroll Case)



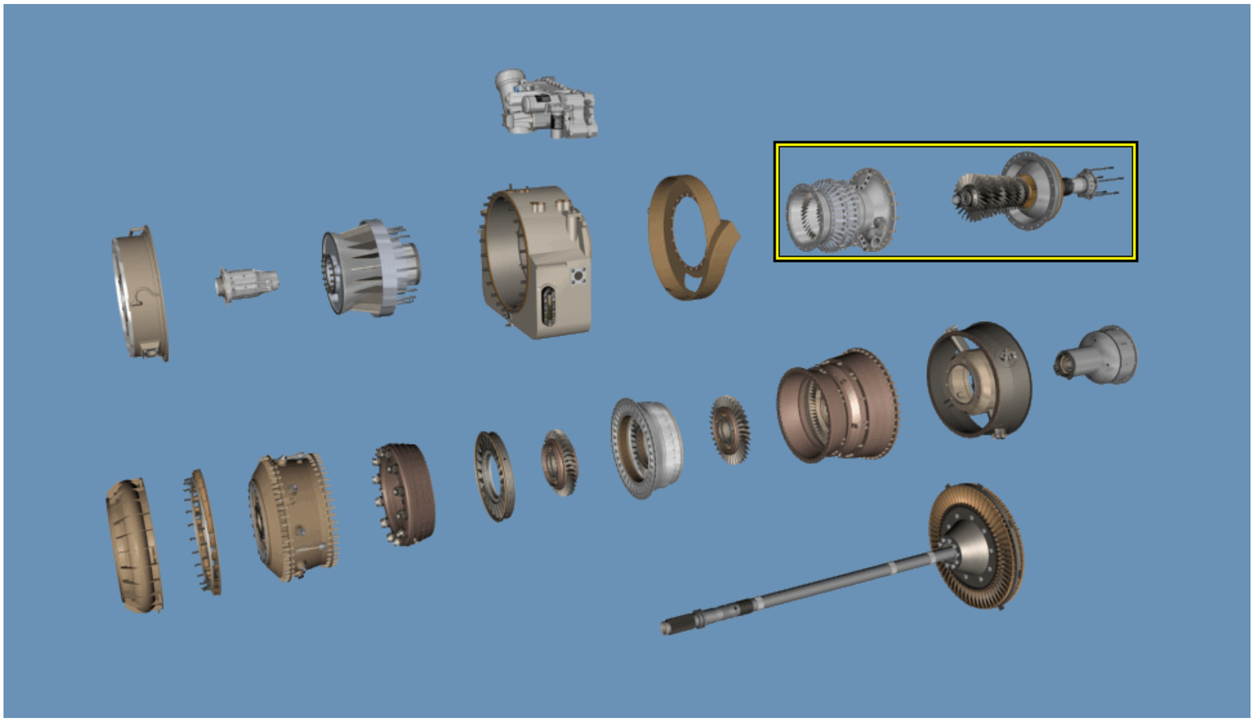
ii) The scroll case provides the flow path for scavenging of foreign particles via the engine-driven blower of the accessory module.

iii) An opening at 6 o'clock provides cooling for the electrical control unit.

iv) The scroll case also contains a holster, which accommodates the T2 sensor of the hydromechanical unit.

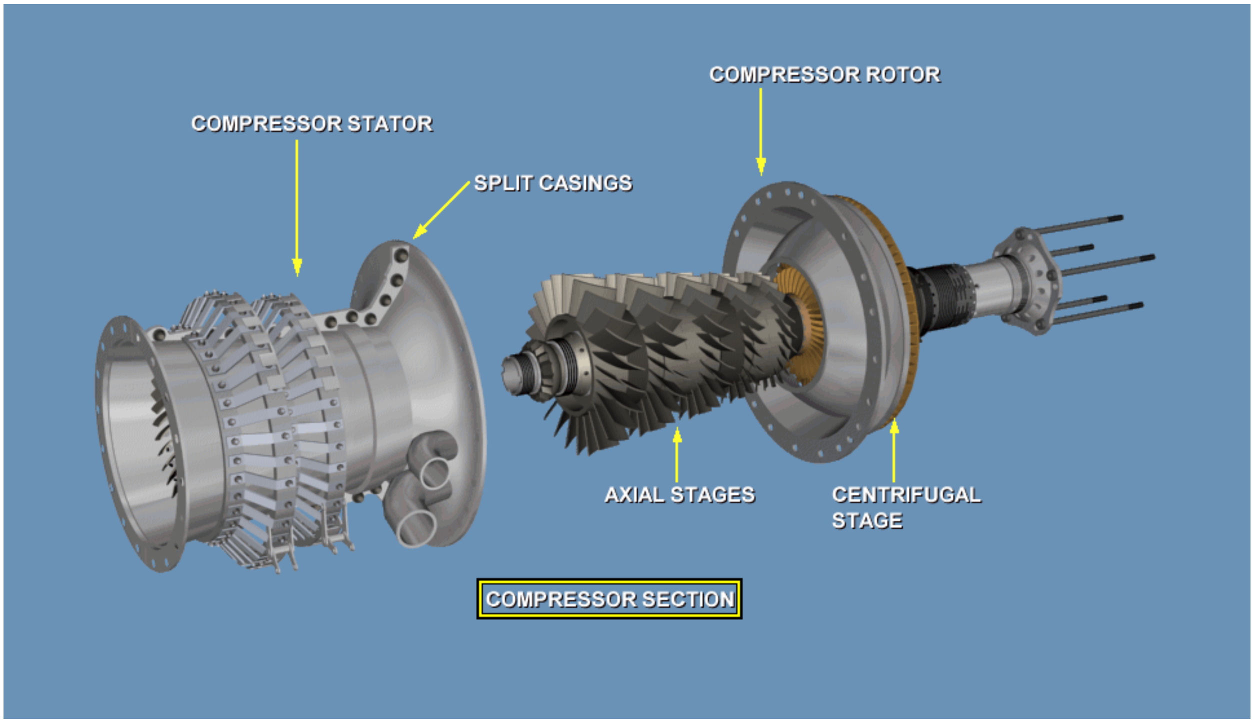
f Compressor Section

Frame # 0191 (Compressor Section)



i) The compressor section consists of two assemblies: the compressor rotor and the compressor stator

Frame # 0205 (Compressor Section)



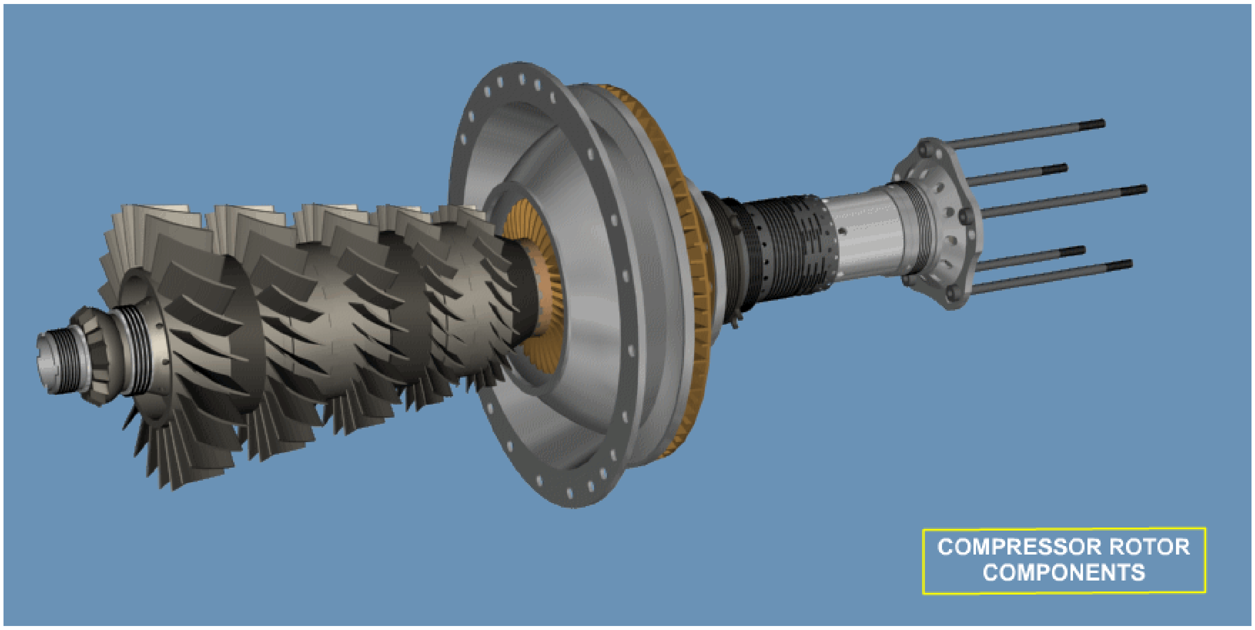
ii) The compressor rotor is comprised of five axial stages and one centrifugal stage.

iii) The compressor stator contains split casings, two stages of variable vanes, and three stages of fixed vanes (internal).

iv) The diffuser case, which is bolted to the aft flange of the stator case, provides a housing for the centrifugal stage of the compressor.

v) The maximum steady-state speed of the compressor is 44,700 rpm.

Frame # 0210 (Compressor Rotor Assembly FLASH)



vi) The rotor assembly is composed of four forged and machined blade disks (combined disk and airfoils), a centrifugal impeller, a spacer ring, a bleed air vortex spoiler, and the compressor tie rod.

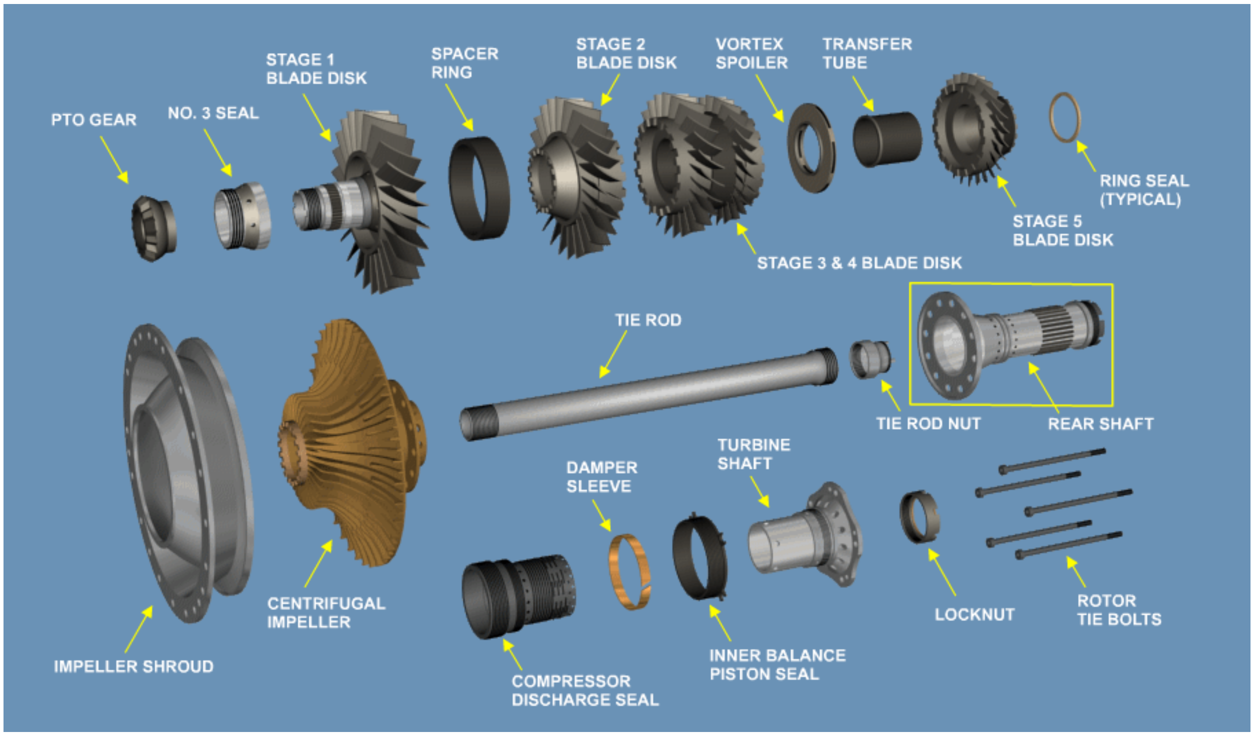
vii) Curvic coupling teeth are combined into mating parts, and are sealed at the assembly with polyamide rings.

viii) The front shaft and the stage one blade disk are machined as one piece.

ix) A bearing journal on the shaft mounts the number three bearing inner race, No. 3 labyrinth seal, and accessory drive bevel gear, all secured on the shaft by a locknut.

x) The number three bearing is a ball bearing, which absorbs the axial load of the rotor.

Frame # 0210 (Compressor Rotor Assembly FLASH)



xi) A spacer is rabbetted between the flange diameters of the stage one and two blade disks.

xii) The vortex spoiler located at stage four, bleeds seal pressurizing air into the rotor interior.

xiii) The tie rod is used as a drawbar to stack and unite the rotor assembly; the front end threads into the stage one blade disk, and a nut on the aft end clamps against the centrifugal impeller.

xiv) The rear shaft is bolted to the centrifugal impeller.

xv) This shaft carries the compressor discharge (rotating) seal, and is splined to accept the gas generator turbine forward shaft, which mounts the number four bearing.

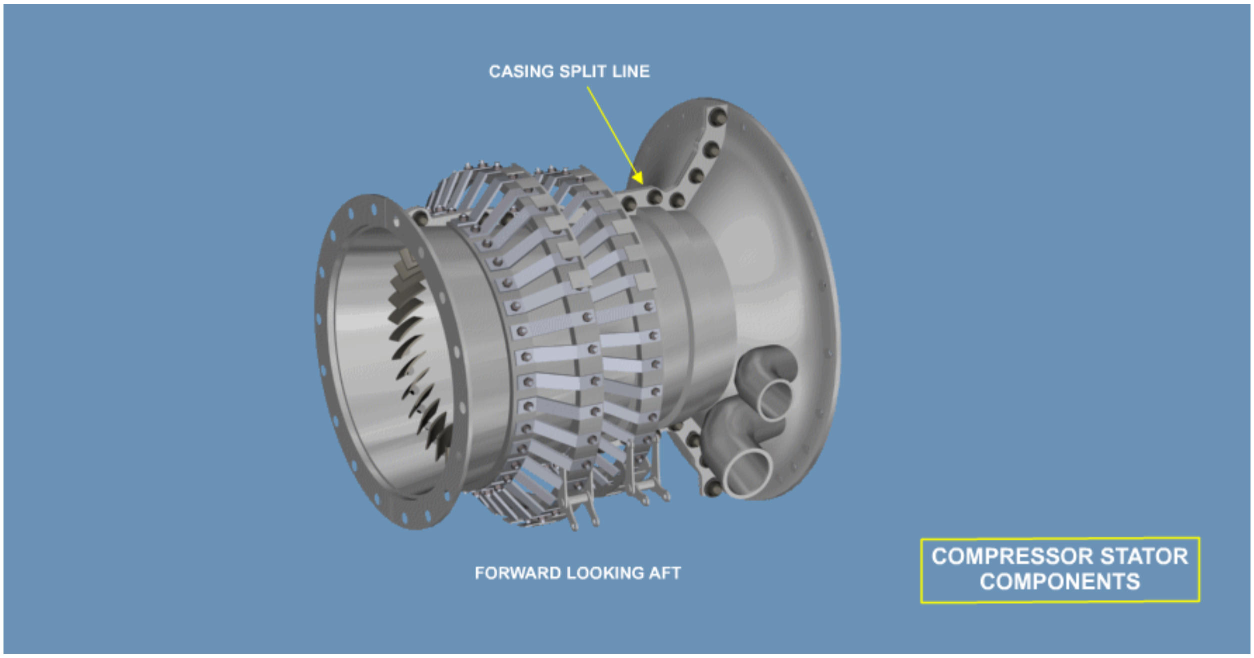
xvi) The number four bearing is a roller bearing carrying only radial load.

xvii) It supports the aft end of the compressor rotor, and the gas generator turbine.

xviii) The impeller shroud, part of the stator assembly, is assembled to the rotor during rotor buildup.

xix) It becomes trapped between the impeller and the blade disks.

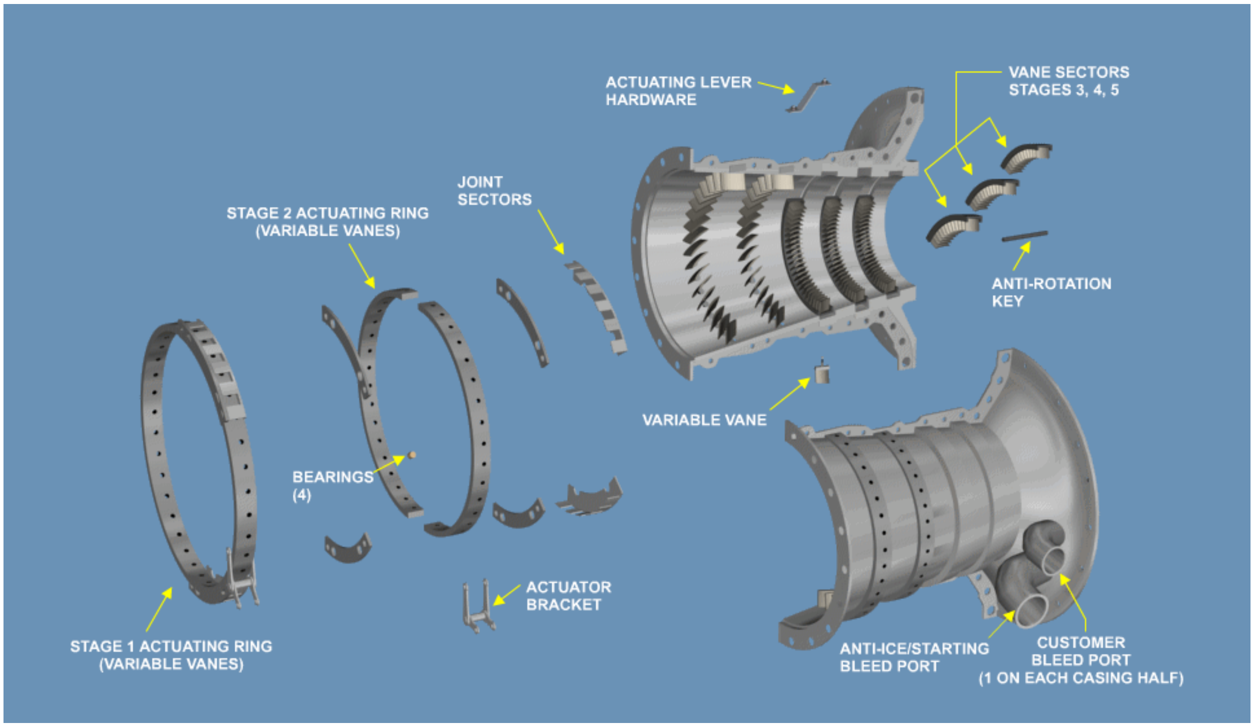
Frame # 0215 (Compressor Stator Assembly FLASH)



xx) The compressor casing, containing the stator vanes, is split and flanged along a vertical plane through the engine axis.

xxi) The casing is titanium

Frame # 0215 (Compressor Stator Assembly FLASH)



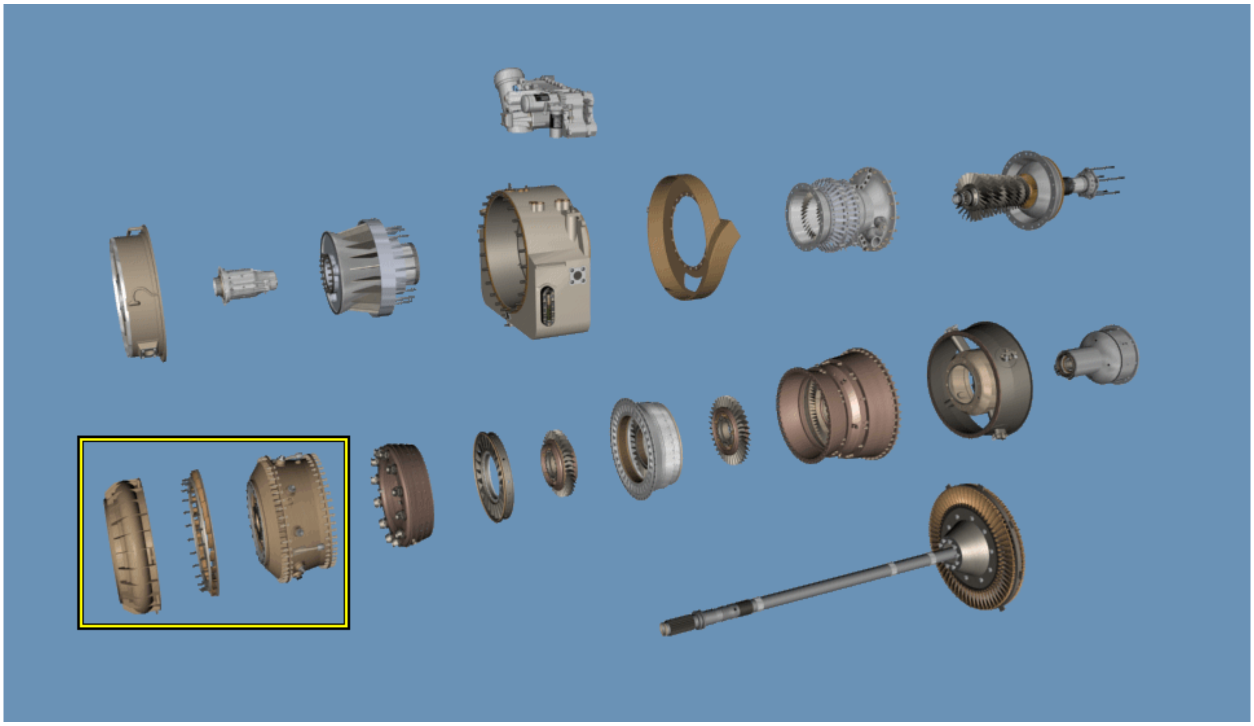
xxii) The first and second stages are variable stator vanes similar to the inlet guide vanes

xxiii) Stages 3, 4, and 5 are fixed vanes, made up of airfoils mounted in ring or band segments.

xxiv) The 90-degree vane segments are assembled into T-slots in the casing, and secured against rotation by keys in the casing split lines.

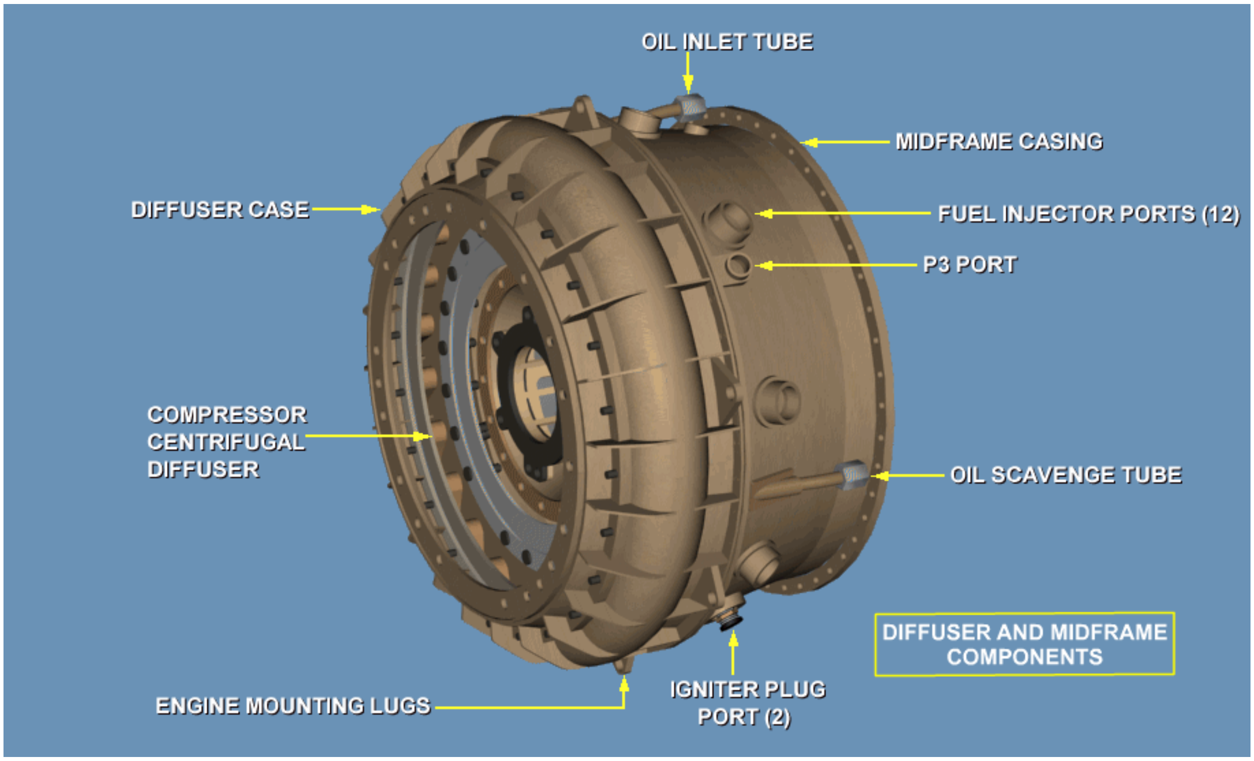
g Diffuser and Midframe Assembly

Frame # 0216 (Diffuser and Midframe Assembly)



i) The diffuser and midframe casing assembly is a matched assembly that includes the diffuser, diffuser case, and midframe assembly.

Frame # 0220 (Diffuser and Midframe Assembly FLASH)



ii) The diffuser reduces the speed of the centrifugal impeller airflow, causing the air pressure to increase.

iii) The pressurized air is directed to the diffuser case.

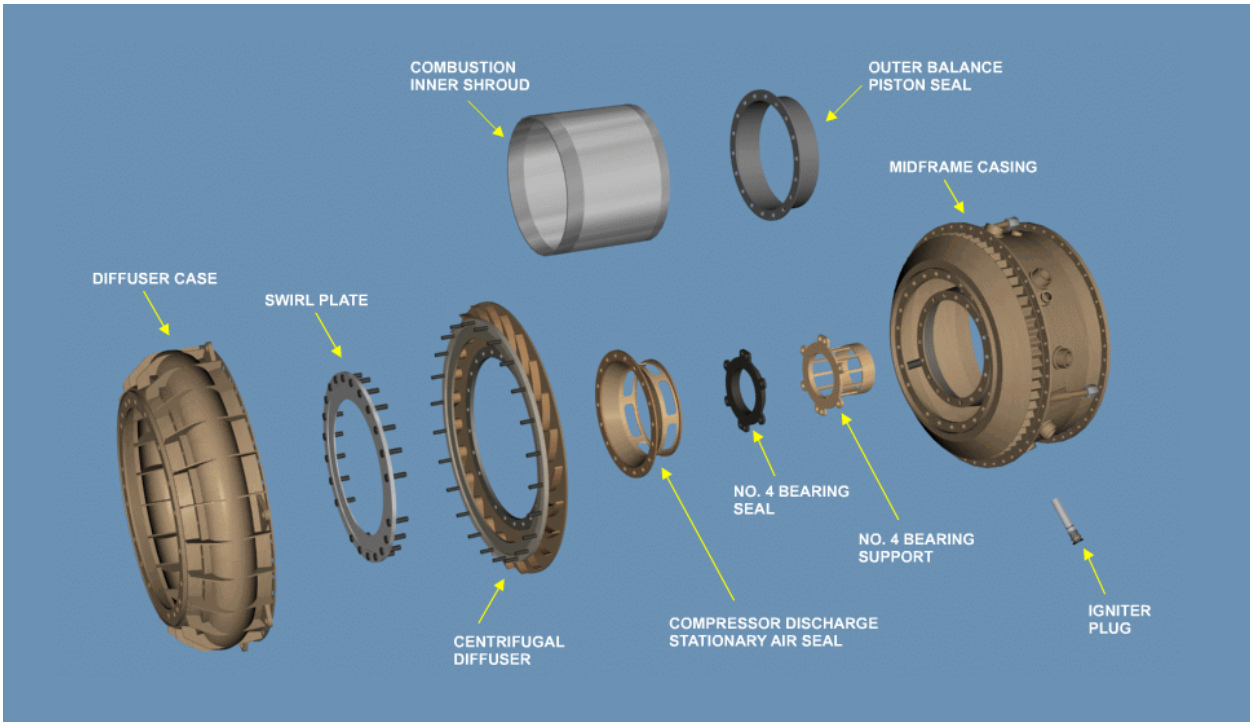
iv) The diffuser case mounts on the rear flange of the compressor casing.

v) It directs air to the combustion chamber.

vi) A port at the 6 o'clock position on the diffuser case serves as a drain for the combustion chamber.

vii) The midframe assembly houses the combustion liner and contains the B sump (No. 4 bearing).

Frame # 0220 (Diffuser and Midframe Assembly FLASH)



viii) Ports are provided for attaching twelve fuel injectors, two igniter plugs, and four service tubes.

ix) Access is obtained for borescoping the combustion liner, fuel injectors and stage one nozzle assembly, through igniter plug ports at the 4 and 8 o'clock positions.

x) The B-sump is supported by three struts (internal), and a fitting at the 1 o'clock position (oil inlet tube) that admits oil to the B-sump via the 1 o'clock strut.

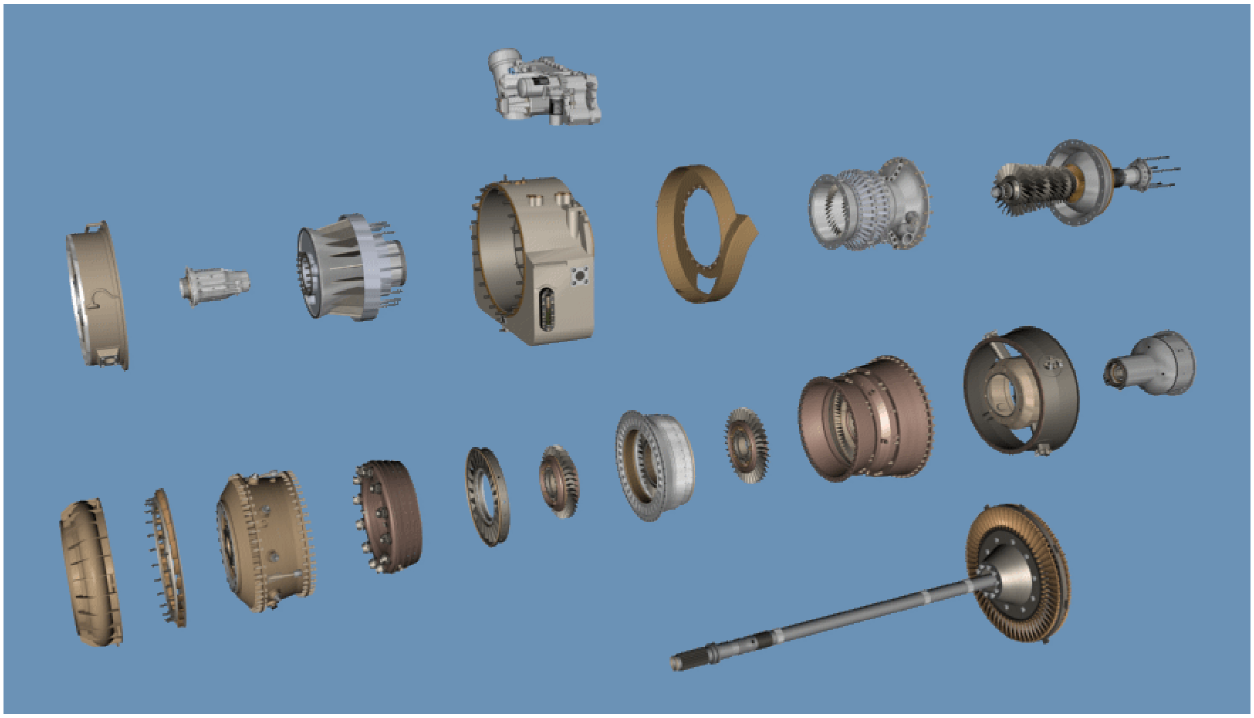
xi) The 5 o'clock strut (internal) contains the B-sump seal drain, and Compressor Discharge Leakage Pressure (CDLP) air, which is ducted to the turbine case for shroud cooling.

xii) The strut at 9 o'clock contains a tube (internal) for scavenging oil out of the B-sump.

xiii) A port at the 11 o'clock position provides compressor discharge air (P3) to the Hydromechanical Unit HMU.

(c) Hot Section Module

Frame # 0221 (Hot Section Module)



1) The hot section module consists of the following components:

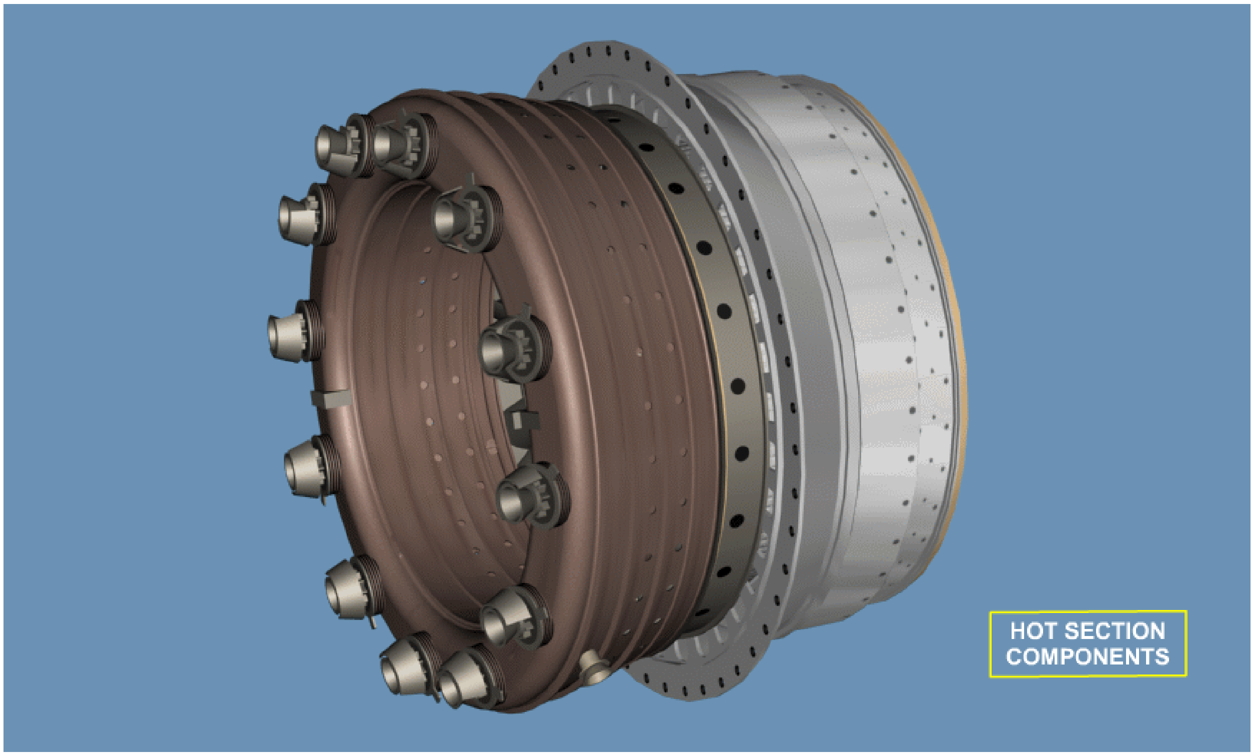
a) The combustion liner

b) The stage one nozzle assembly

c) The stages one and two gas generator turbine rotor

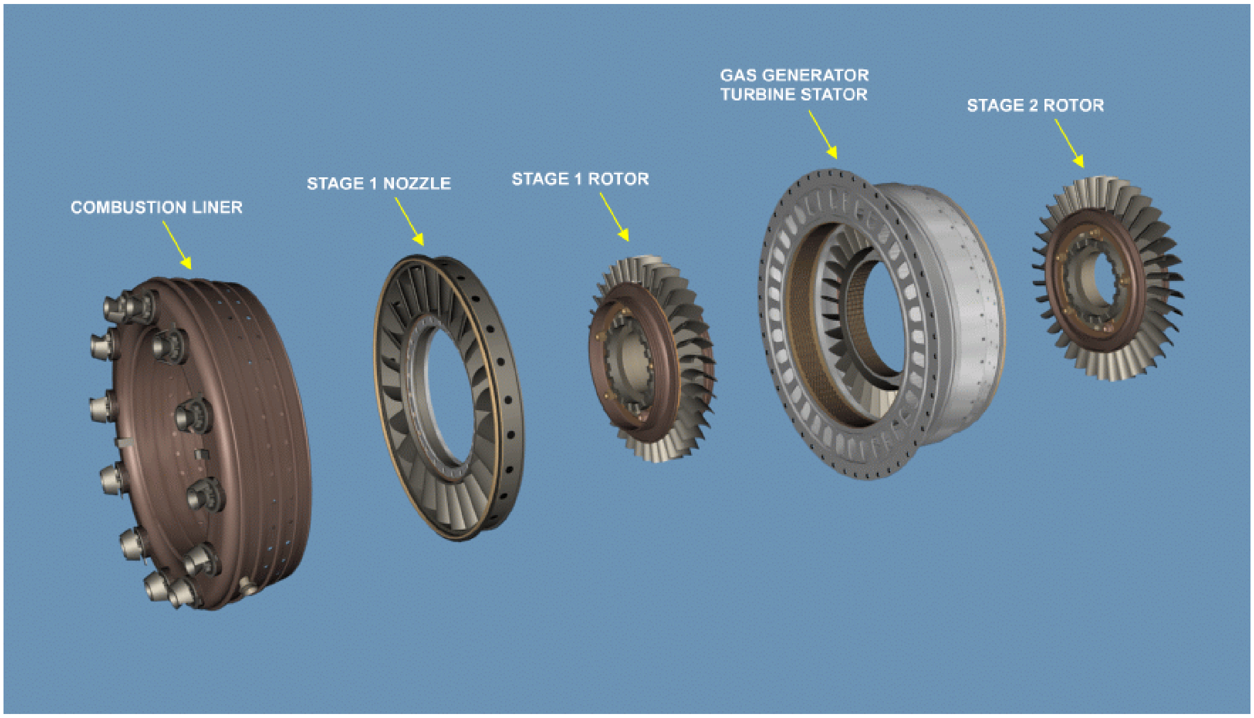
d) The gas generator stator

Frame # 0225 (Hot Section Module FLASH)



e) This is the hot section module assembly.

Frame # 0225 (Hot Section Module FLASH)



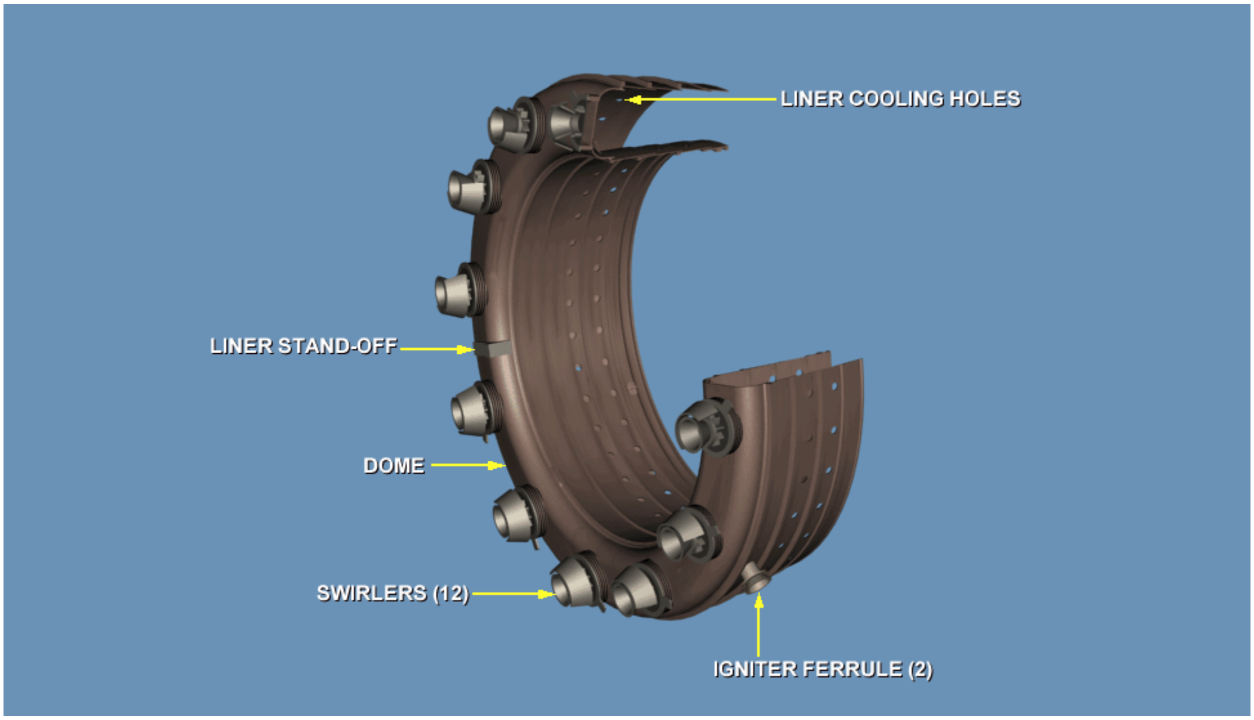
f) The gas generator turbine consists of the gas generator stator assembly and a two-stage air cooled turbine rotor assembly.

g) The combustion liner is a ring type combustor cooled with secondary airflow from the diffuser case.

h) The stage one nozzle contains 12 air cooled nozzle segments and directs gas flow to the gas generator turbine.

1 Combustion Liner

Frame # 0231 (Combustion Liner)



a The combustion liner is an annular, machined and welded ring liner, that uses a low pressure fuel injection system with vortex air swirlers to mix fuel and compressor discharge air prior to combustion.

b The 12 fuel injectors are mounted in the midframe.

c Each one preswirls the fuel before it is introduced to the combustion liner.

d Each fuel injector inserts into the center of an air swirler in the dome of the liner.

e Fuel leaving the injectors is surrounded by a concentric air vortex pattern, and thus fuel particles are broken down to extremely small size prior to reaching the combustion zone.

f This excellent fuel-air mixing ensures a low smoke level in the exhaust.

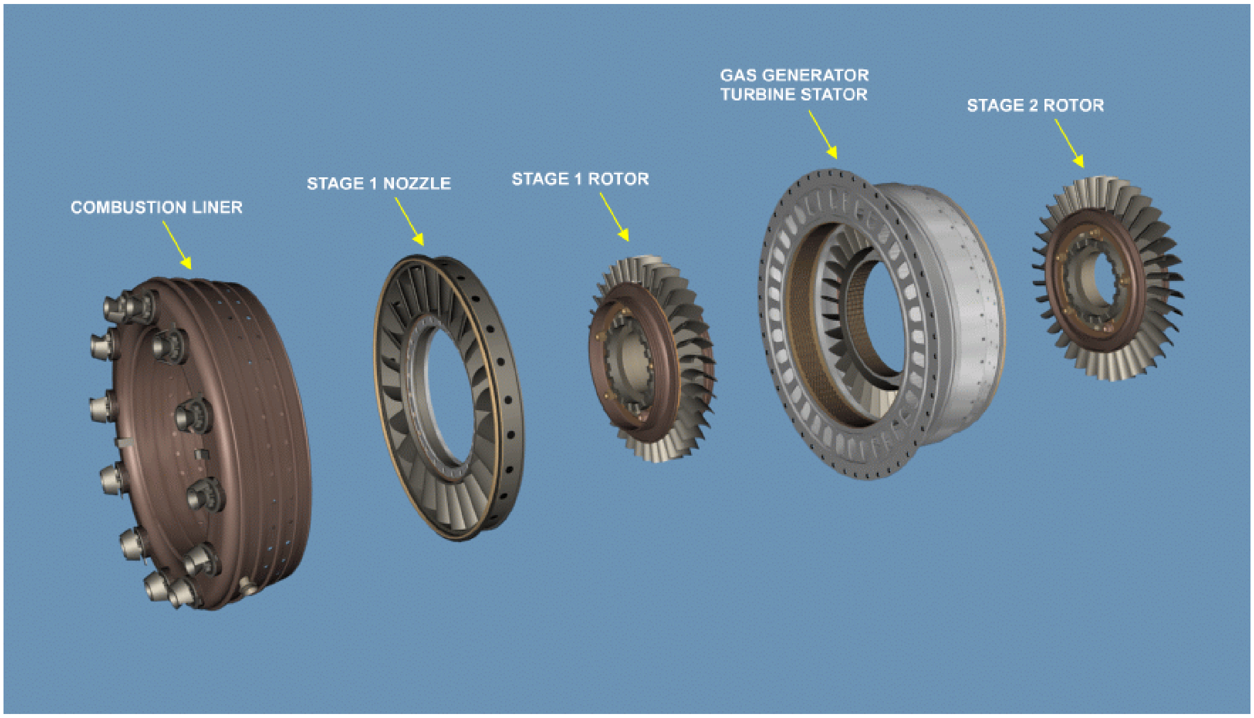
g For engine starting, two spark igniters are incorporated.

h The igniters are energized by the electrical system and are controlled by an airframe supplied switch.

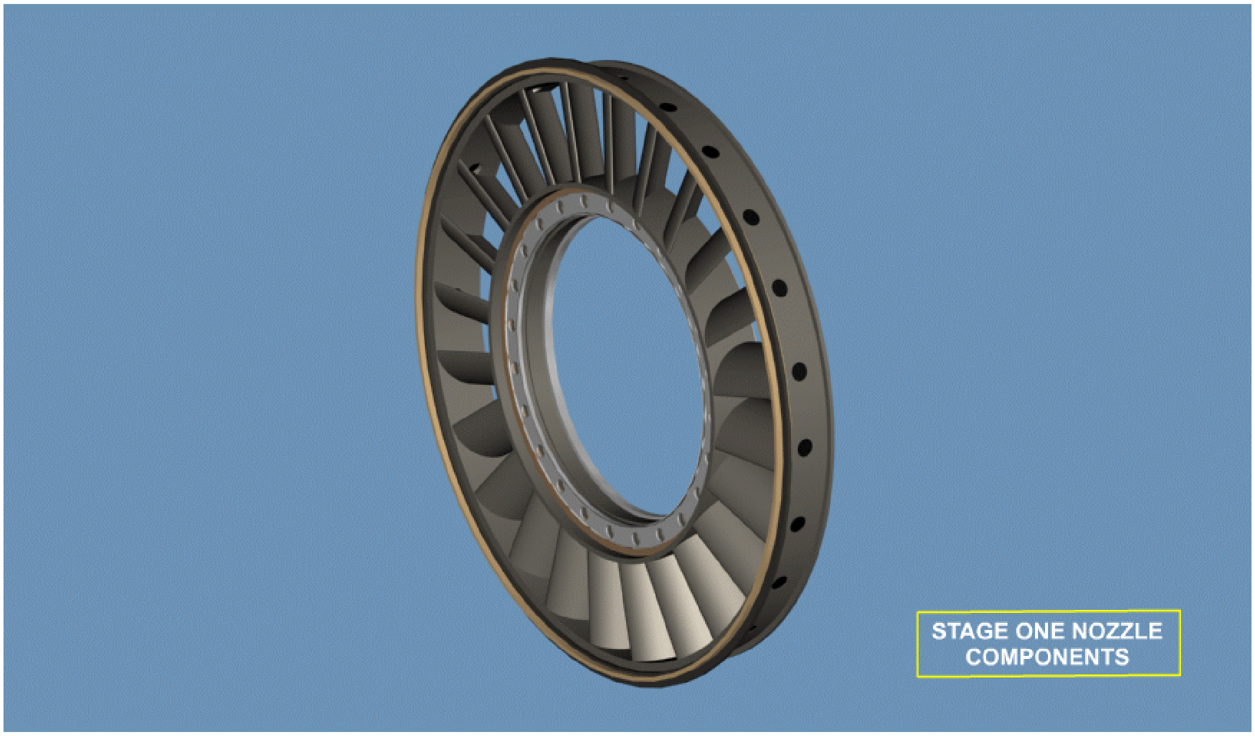
i The combustor may be removed for repair or replacement, along with the rest of the hot section module, without removal of the fuel injectors.

2 Stage 1 Turbine Nozzle

Frame # 0235 (Stage 1 Turbine Nozzle)

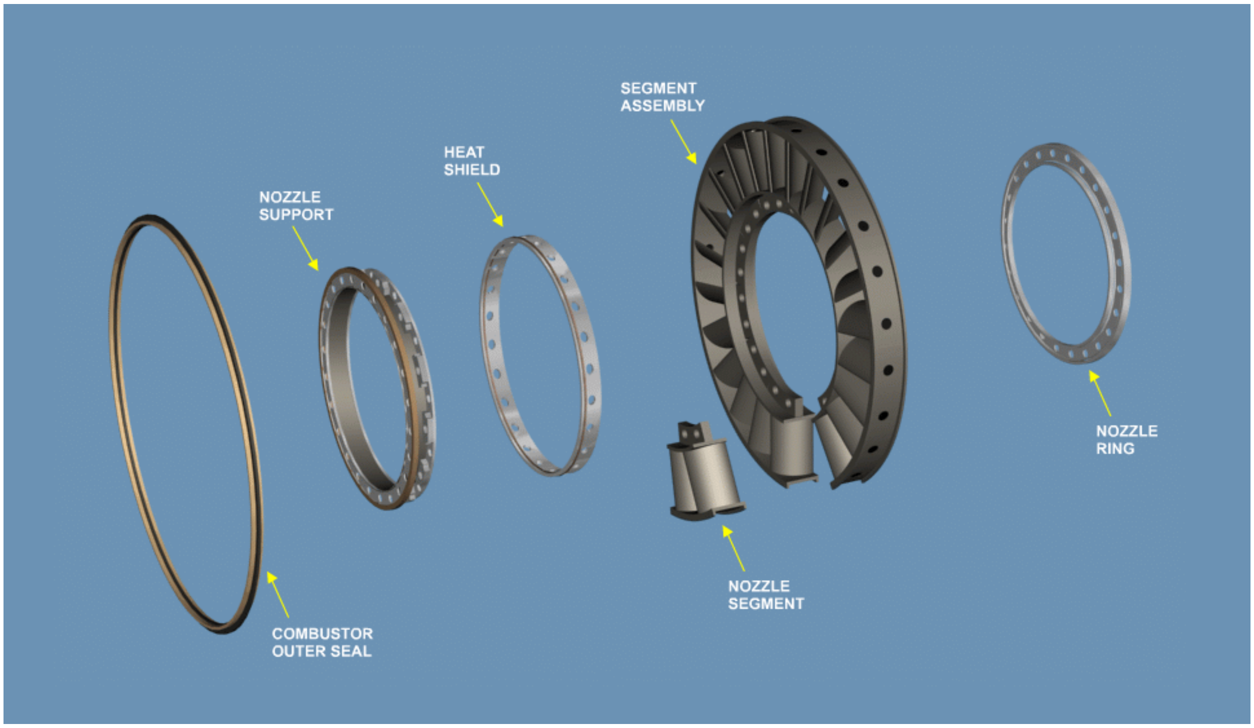


Frame # 0236 (Stage 1 Nozzle Components FLASH)



a The stage one nozzle directs gas flow from the combustor discharge to the stage one and two gas generator turbine rotor and gas generator stator.

Frame # 0236 (Stage 1 Nozzle Components FLASH)



b The stage one nozzle consists of 24 air-cooled vanes cast in pairs (segments).

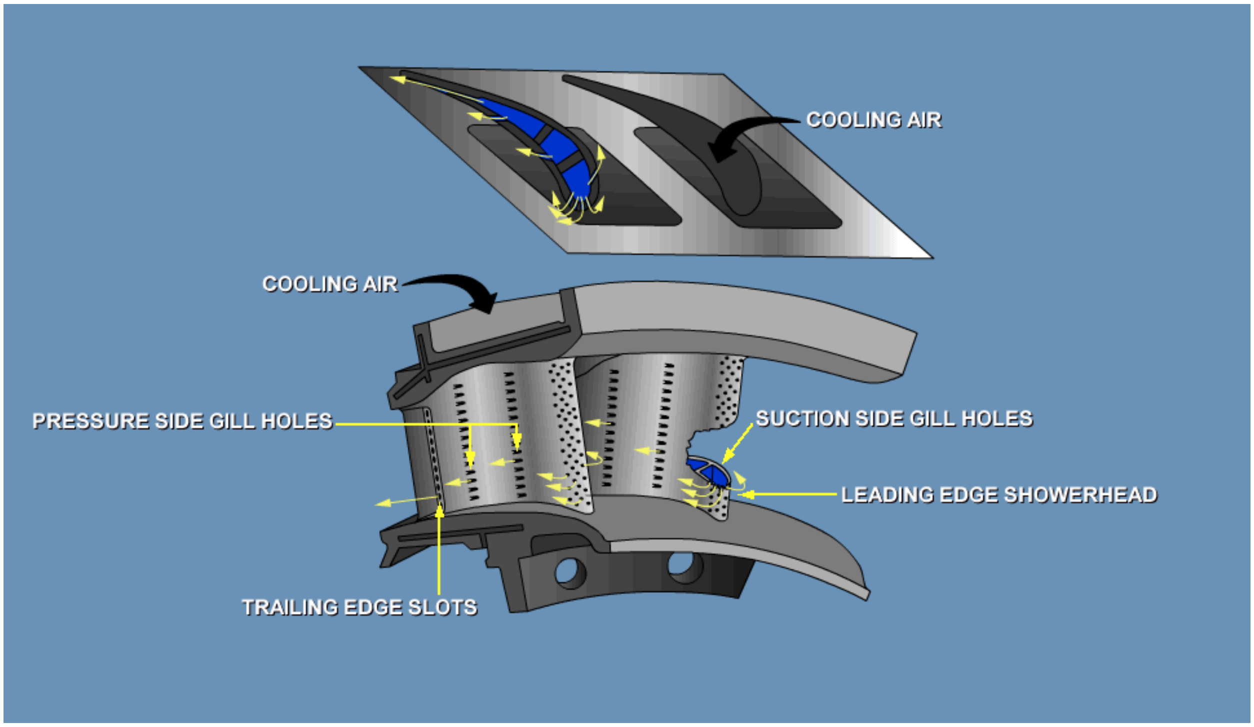
c These 12 segments are assembled to the inner support.

d The segmented design also permits individual replacement of nozzle segments for overhaul.

e The nozzle also contains the combustor outer seal, nozzle support, heat shield, and the nozzle ring.

f This nozzle can be removed as a complete assembly, to give unobstructed access to the combustion liner for routine maintenance.

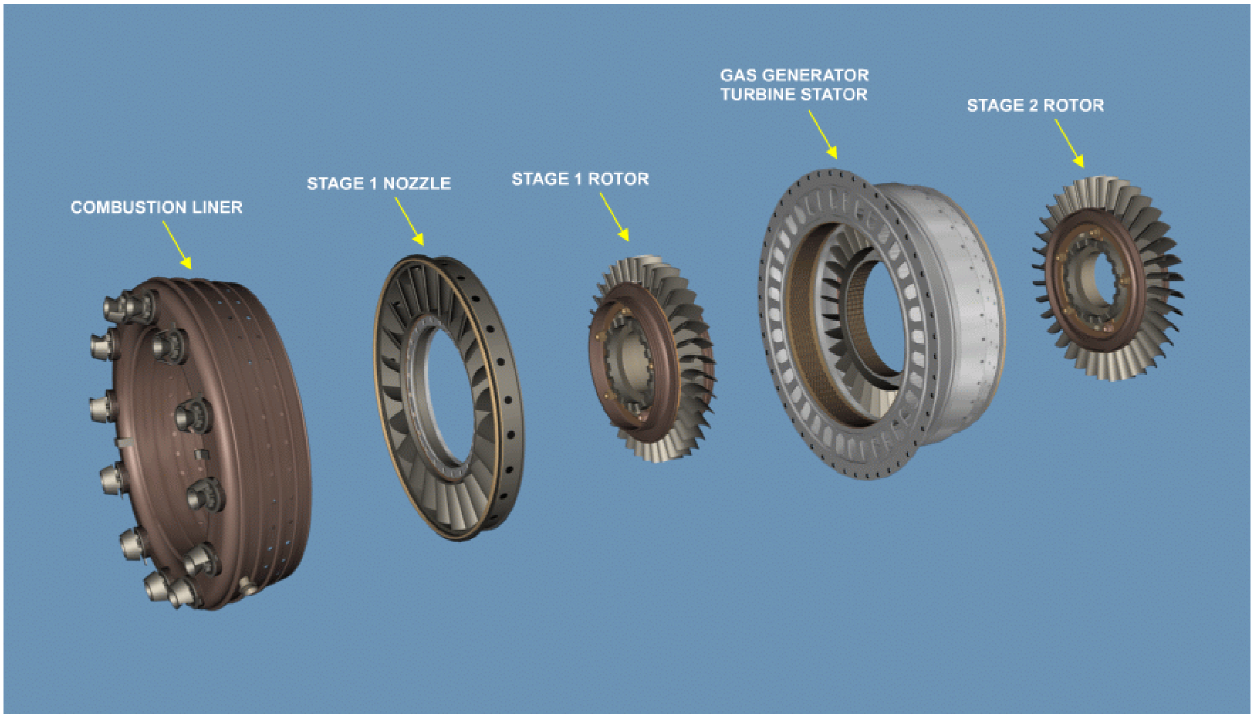
Frame # 0238 (Stage 1 Turbine Nozzle Cooling)



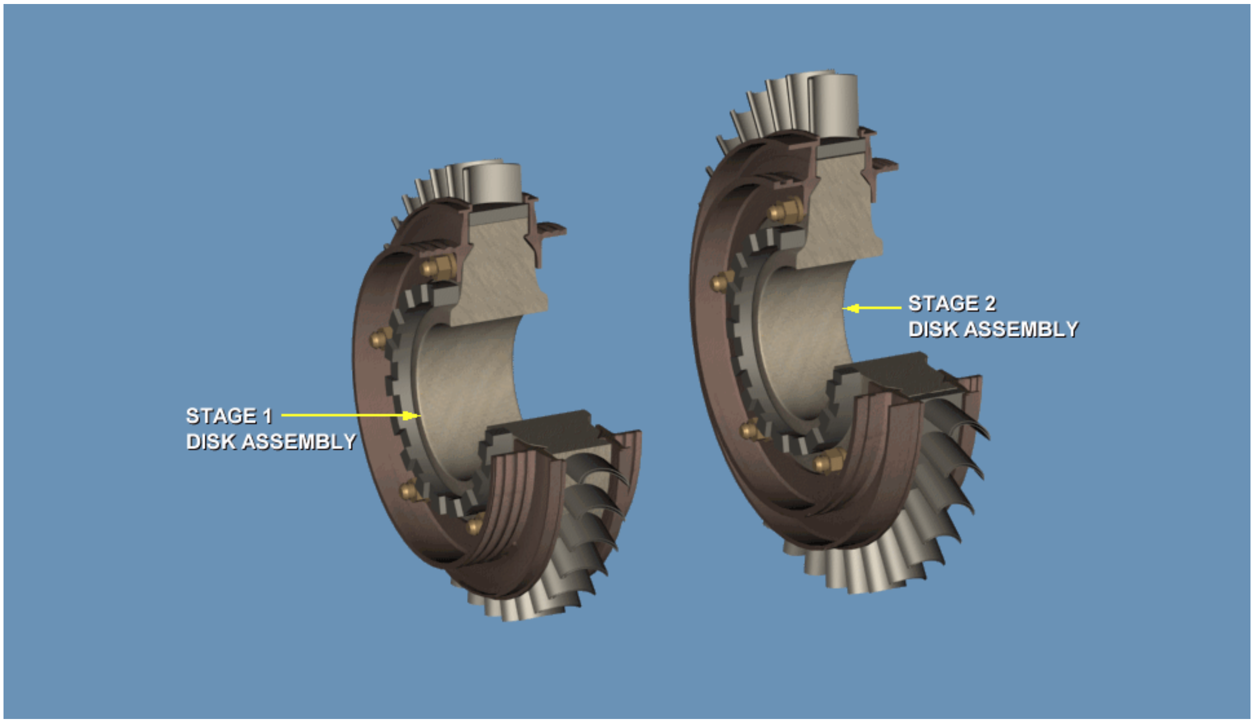
g As the stage one turbine nozzle rotates, air enters the nozzle segments and is forced over and around the airfoil through the leading edge showerhead, suction side gill holes, pressure side gill holes, and the trailing edge slots.

3 Stage 1 and Stage 2 Turbine Rotors

Frame # 0240 (Stage 1 and Stage 2 Turbine Rotors)



Frame # 0241 (Stage 1 and Stage 2 Turbine Rotors)



a The gas generator turbine drives the compressor and AGB.

b It is a two-stage air cooled, high performance axial design of simple, rugged construction.

c Stage 1 and stage 2 turbine rotors are assembled to the gas generator turbine shaft (part of the cold section module) by means of five long tiebolts which are captive in the shaft.

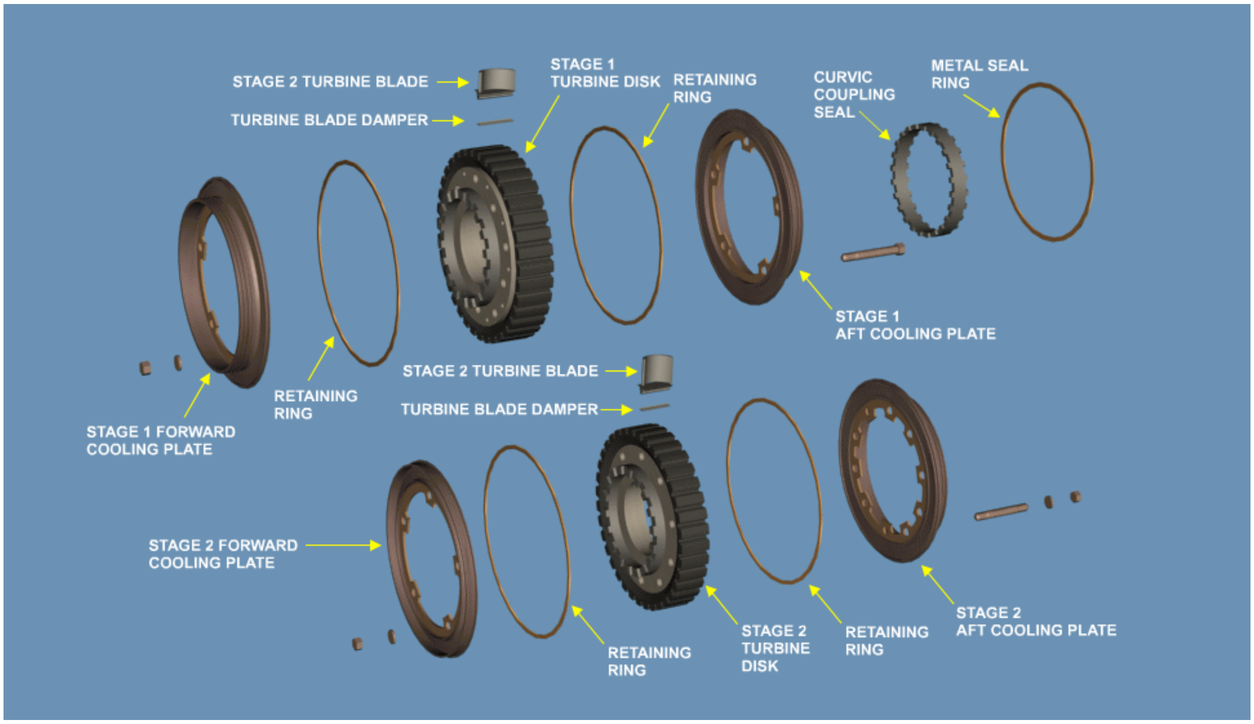
d Concentricity is achieved by precision curvic coupling teeth on the shaft and each disk assembly.

4 Gas Generator Turbine Rotor Components

Frame # 0243 (Gas Generator Turbine Rotor Components FLASH)

a Stages one and two of the gas generator turbine rotor are both air-cooled.

Frame # 0243 (Gas Generator Turbine Rotor Components FLASH)



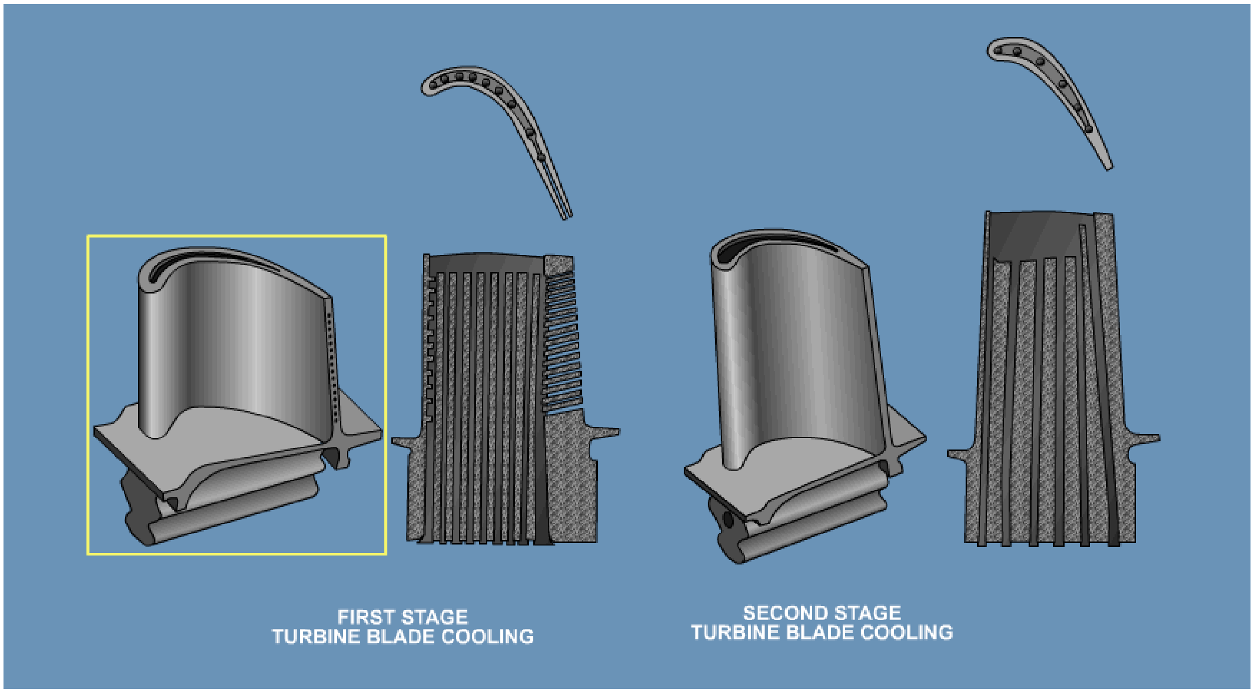
b The first stage of the gas generator turbine rotor consists of a turbine disk, 34 cast air-cooled blades and dampers, forward and aft cooling plates, and retaining rings for the stage one disk.

c There is a curvic coupling seal and a seal ring between the stages.

d The second-stage consists of a turbine disk, 38 cast air-cooled blades and dampers, forward and aft cooling plates, and retaining rings for the stage two disk.

5 T700 Turbine Blade Cooling

Frame # 0245 (T700 Turbine Blade Cooling FLASH)



a The stage one nozzle leading edge is convection and film cooled with the air exiting through a shower head series of holes in the leading edge.

b Aft of the leading edge, film cooling air exits through convex and concave side gill holes and trailing edge slots.

c The stage one blades also use trailing edge holes for cooling.

d Cooling air for the stage two nozzle is bled from the centrifugal impeller exit and piped back through the midframe to enter the stage two nozzle.

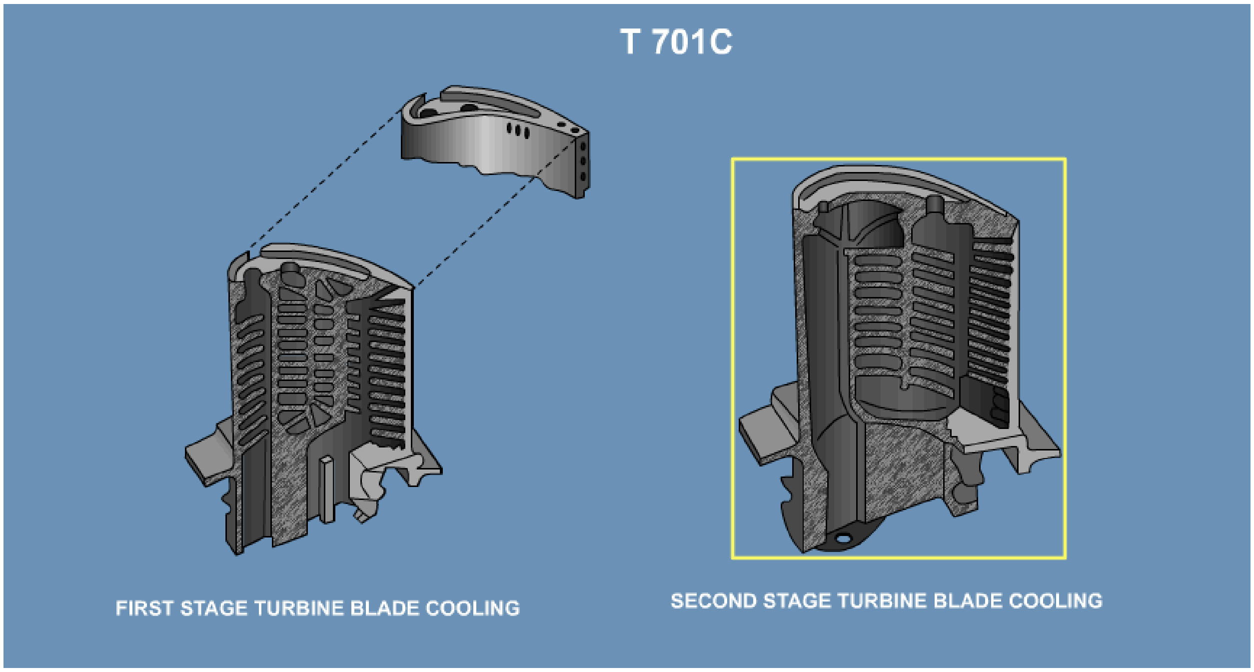
e It cools by internal convection, exiting both by trailing edge holes and by inner band holes, where it cools the interstage seal.

f The turbine blades are convection cooled through radial holes in the dovetail.

g Air exits through tip holes.

6 T701 Turbine Blade Cooling

Frame # 0250 (T701C Turbine Blade Cooling FLASH)



a All first and second stage airfoils are internally cooled by means of compressor discharge air.

b The first stage blades are convection cooled through radial holes in the dovetail.

c Air passes through these radial holes and exits out the tip of the blade.

d The first radial hole contains the turbulators, which increase the efficiency of cooling airflow.

e These turbulators are a series of ribbed fins, which are manufactured within the first stage blades and are placed perpendicular to the leading edge.

f They provide an increase in surface area and turbulate the airflow for a better heat transfer.

g The aft circuit feeds cooling air directly to the trailing edge holes.

h A portion of this air flows forward through a turbulated serpentine passage.

i It is joined by additional cooling air at the bottom turnaround and then exits at the blade tip.

j The second stage turbine blade has a single circuit, turbulated, three-pass serpentine cooling arrangement.

k Most of the cooling air exits through pressure side trailing edge film cooling holes.

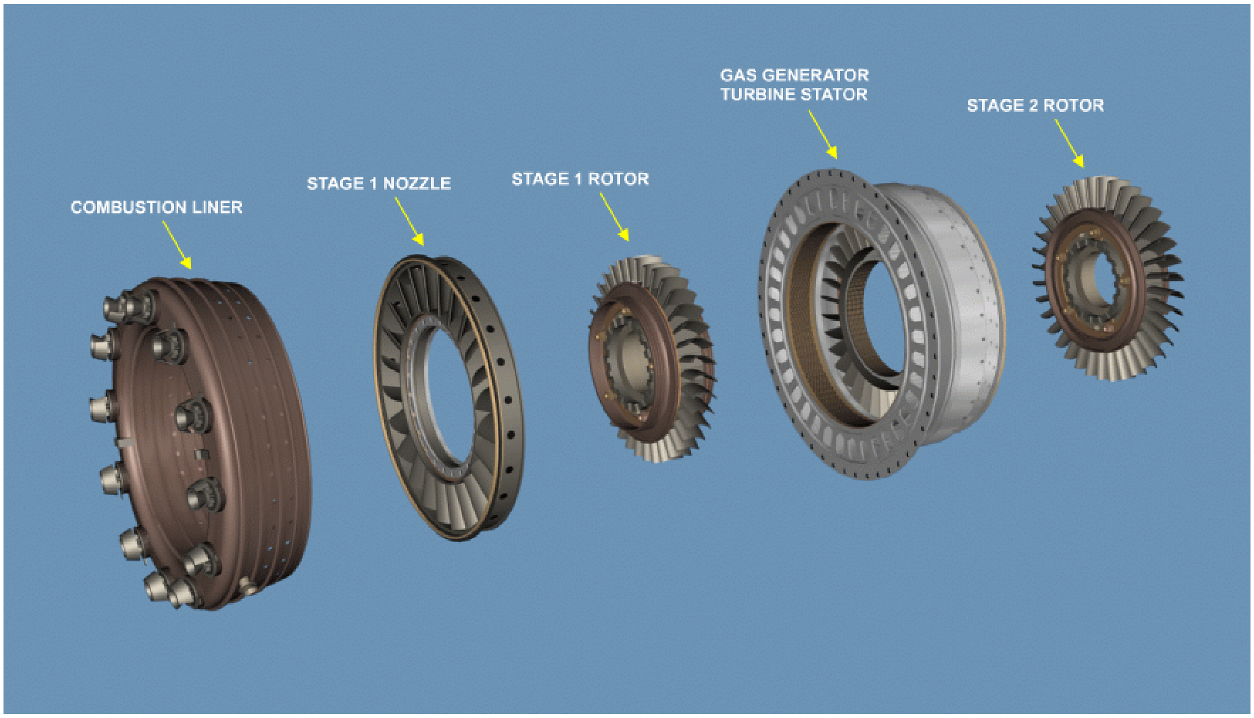
l The remainder exits through the tip plenum holes; one at the top of the first upward pass of the serpentine and the other at the top of the third pass (upward).

m These holes provide cooling to the plenum walls.

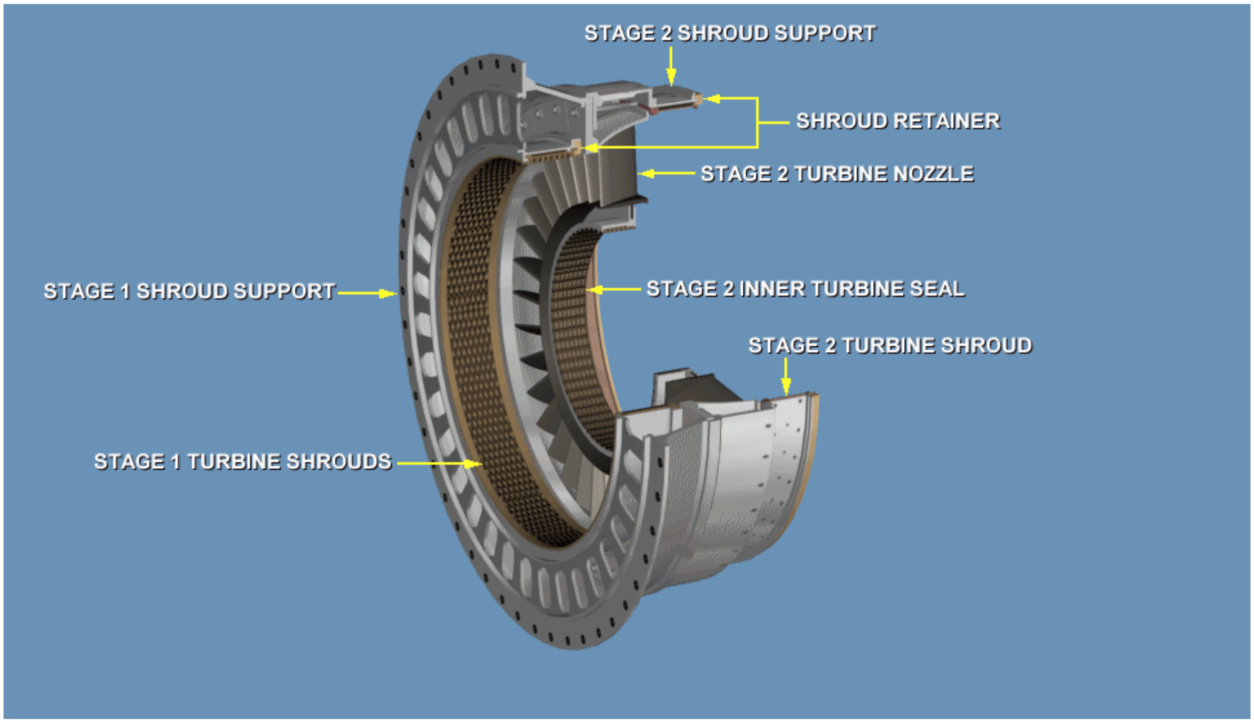
n This more efficient cooling allows for higher engine operating temperatures.

7 Gas Generator Turbine Stator

Frame # 0253 (Gas Generator Turbine Stator)



Frame # 0256 (Gas Generator Turbine Stator)



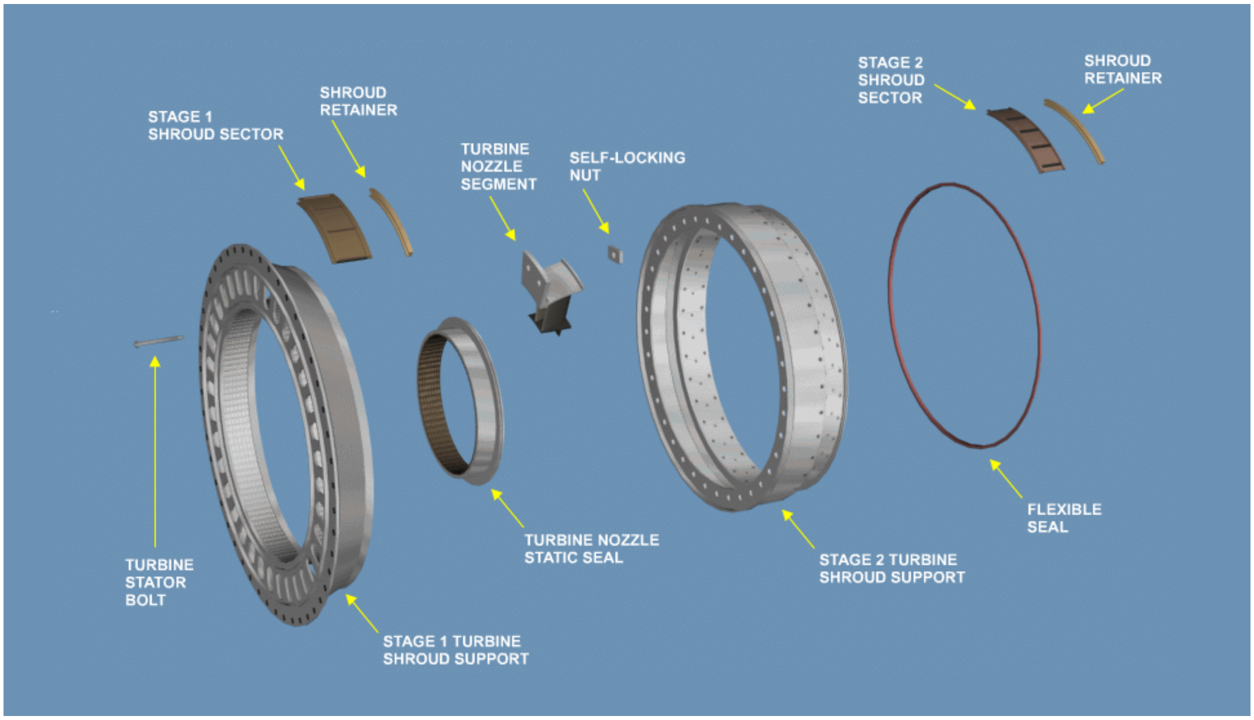
a The stator assembly includes 13 air cooled stage 2 turbine nozzle segments of two vanes each, stage 1 and 2 shrouds, and the stage 2 inner turbine seal.

b These are all housed by the stator support, which is in turn supported by the engine outer casings.

Frame # 0258 (Gas Generator Stator Components FLASH)

c The gas generator stator houses the stages one and two gas generator turbine rotor and the stage two turbine nozzle segments.

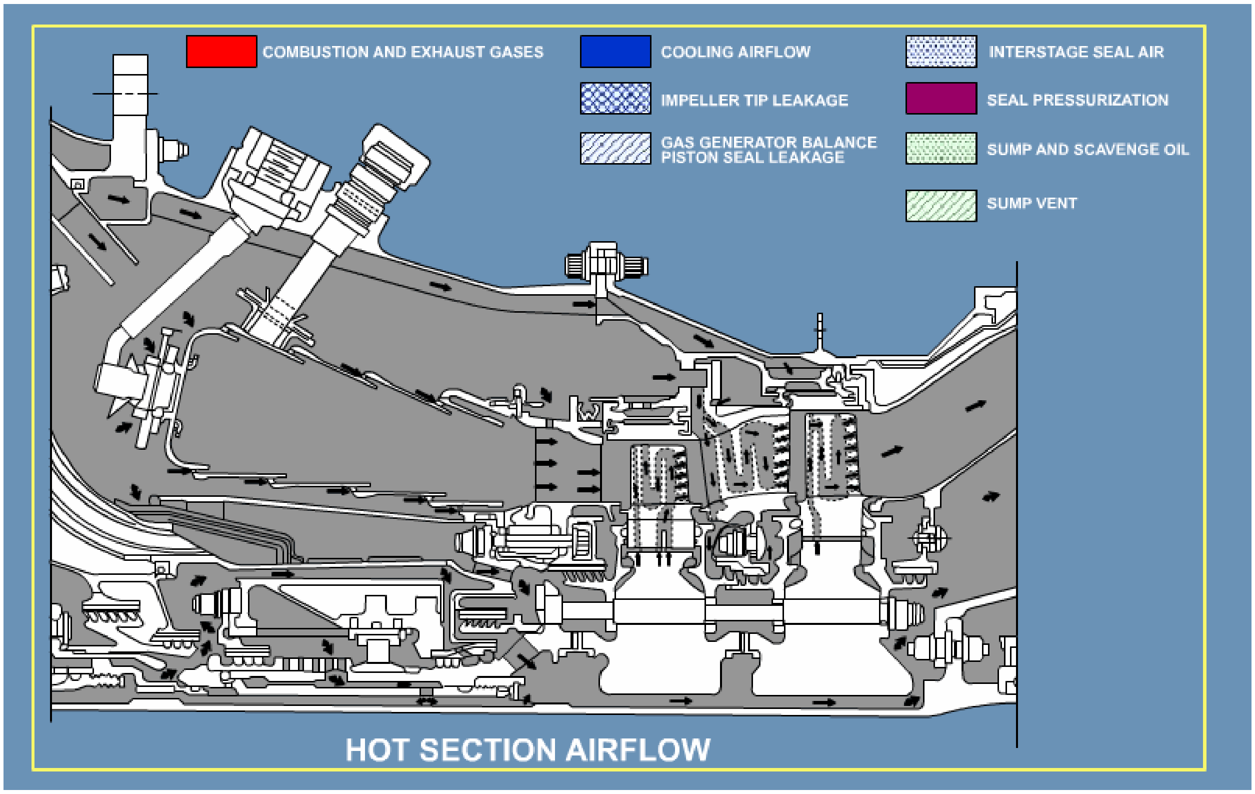
Frame # 0258 (Gas Generator Stator Components FLASH)



d The gas generator stator consists of the stage 1 and stage 2 turbine shroud supports, turbine nozzle static seal, a flexible seal, stage 1 and stage 2 shroud sectors, shroud retainers, and the nozzle segments.

8 Hot Section Airflow

Frame # 0260 (Hot Section Airflow FLASH)



a Seal pressurization limits oil loss from the sumps by controlling the airflow into them.

b Pressurization also keeps hot gases, dust, and moisture out of the sumps by providing a high-pressure air barrier that keeps external air from flowing into the sumps.

c Clean air for pressurizing the A- and B- sump seals is bled from stage 4 on the compressor rotor.

d Bleed air enters the rotor through curves coupling teeth aft of the stage 4 rotor blades.

e As the air enters the rotor the flow divides.

f Some air flows forward through the rotor and some flows aft through the rotor.

g The air that goes forward goes to the A-sump aft labyrinth seals.

h The air enters the space between the seals through holes in the stage 1 blade disk.

i A small amount of air from this space pressurizes the No. 1 carbon seal and oil mist nozzle.

j The air enters the forward space between the seals through holes in the compressor rear shaft.

k The air then flows to the aft space between the seals through an internal passage.

l A small amount of air flows into the B-sump to prevent oil loss.

m The remaining air cools the sump and keeps hot air from entering it.

n Air leaks out of the forward space between the seals to join compressor discharge air seal leakage air.

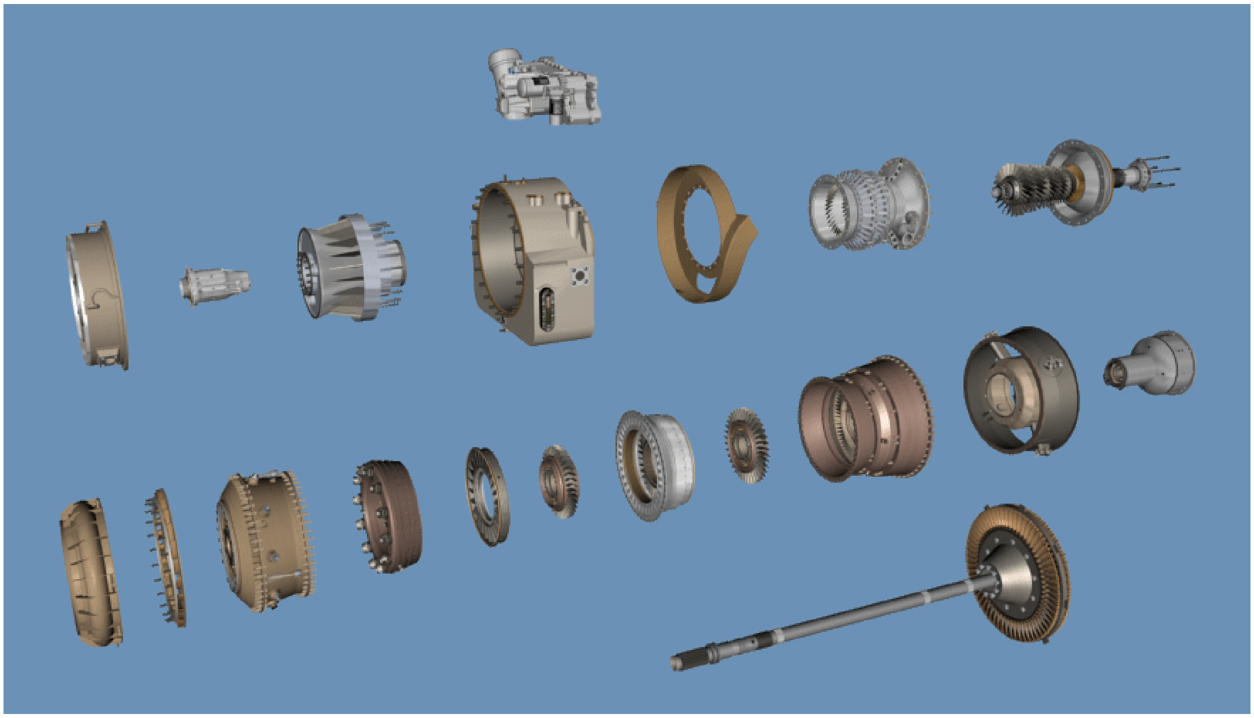
o This air flows out through the strut at the 5'clock position on the midframe and then aft to the turbine case and cools the stage 4 shrouds.

p Stage 4 bleed air also pressurizes the No. 5 carbon seal and the power turbine balance piston seal in the C-sump.

q It is piped externally from the 5 o'clock position on the compressor stator to the 4:30 position on the exhaust frame.

(d) Power Turbine Module

Frame # 0261 (Power Turbine Module)



1) The power turbine module includes the following components:

   a) Turbine case

   b) Power turbine rotor assembly

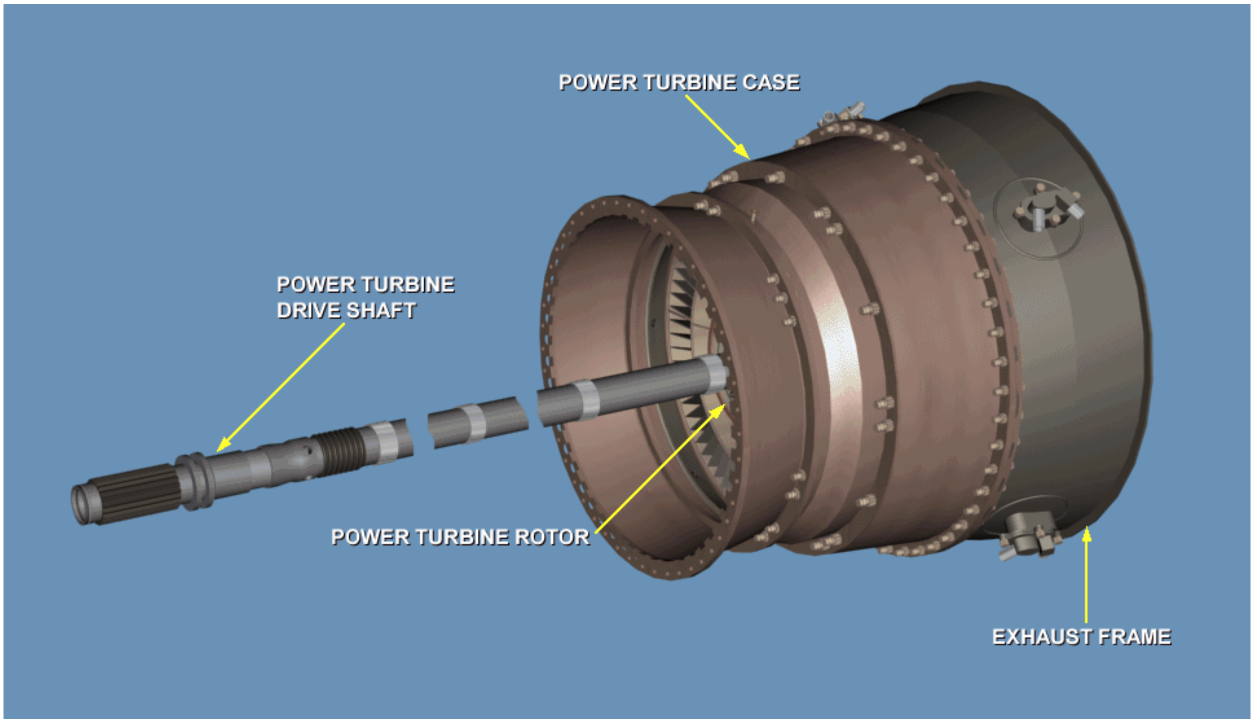
   c) Power turbine drive shaft assembly

   d) Exhaust frame

   e) C-sump housing.

1 Power Turbine Rotor

Frame # 0265 (Power Turbine Module)

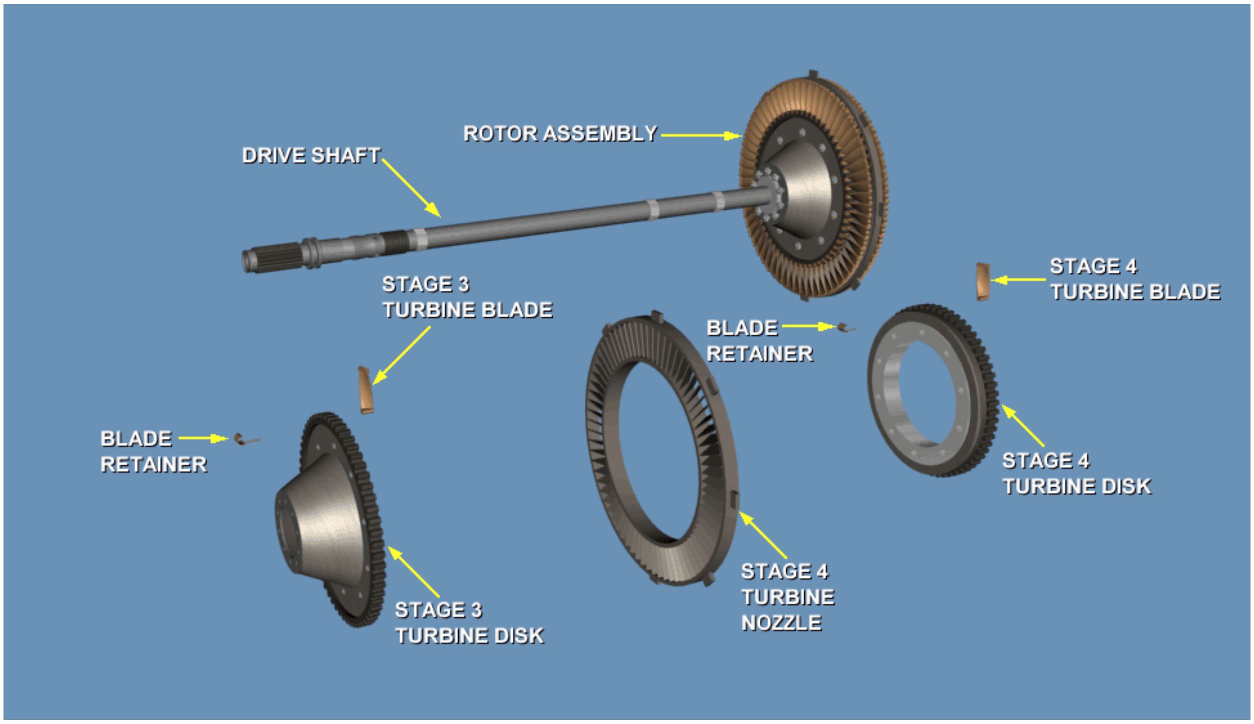


a The power turbine module is comprised of the power turbine rotor, power turbine drive shaft, power turbine case, which contains the No. 3 and No. 4 nozzles, and the exhaust frame.

b It is a self-contained, two-stage, uncoiled, tip shrouded design.

2 Power Turbine Rotor and Drive Shaft Components.

Frame # 0270 (Power Turbine Rotor and Drive Shaft Components)



a The power turbine rotor assembly consists of the third and fourth stage disks, mounted on a drive shaft system, that is supported by the number 5 and 6 bearings at the rear, and by the output shaft assembly at the forward end.

b Each disk incorporates shaft and seal features as an integral part of the disk, thus reducing the number of parts to a minimum and simplifying rotor assembly and maintainability.

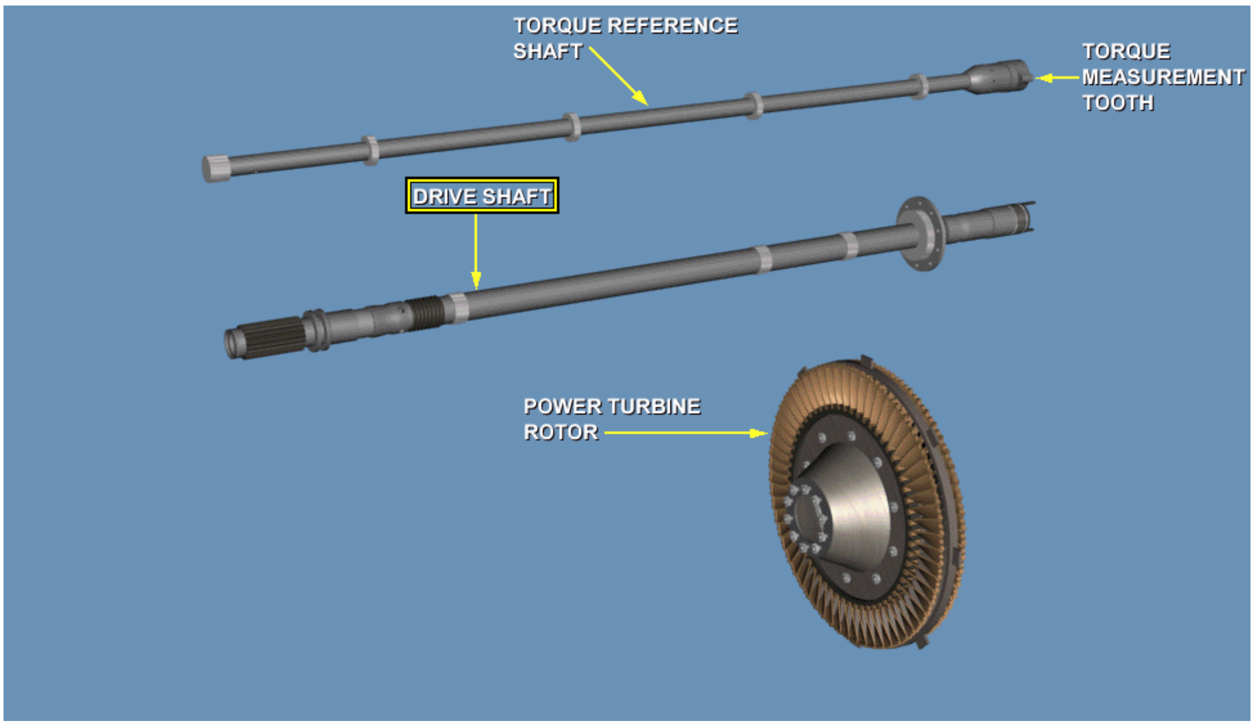
c The disks are secured to the drive shaft by a single rabbetted flange.

d The stage 3 and 4 disks have tip-shrouded blades attached to the disk through conventional dovetails and retained axially by blade retainers (locking strips) inserted under the blade dovetail and bent against the disks.

e A stator ring is utilized to increase containment margin over the stage 4 rotor.

3 Drive Shaft Assembly

Frame # 0275 (Drive Shaft Assembly)



a The power turbine drive shaft is a hollow unit, splined at the forward end to couple with the output shaft, and flanged close to the rear to accept the power turbine rotor disks.

b Assembled within the drive shaft and pinned at the forward end, is the torque reference shaft.

c Machined on the aft end of both shafts are torque measurement teeth, two on each shaft and under a no-load condition, are approximately 90 degrees from one another.

d Torque loading on the drive shaft causes the drive shaft to twist.

e The reference shaft, since its only connection to the drive shaft is a pin at the forward end, will not twist.

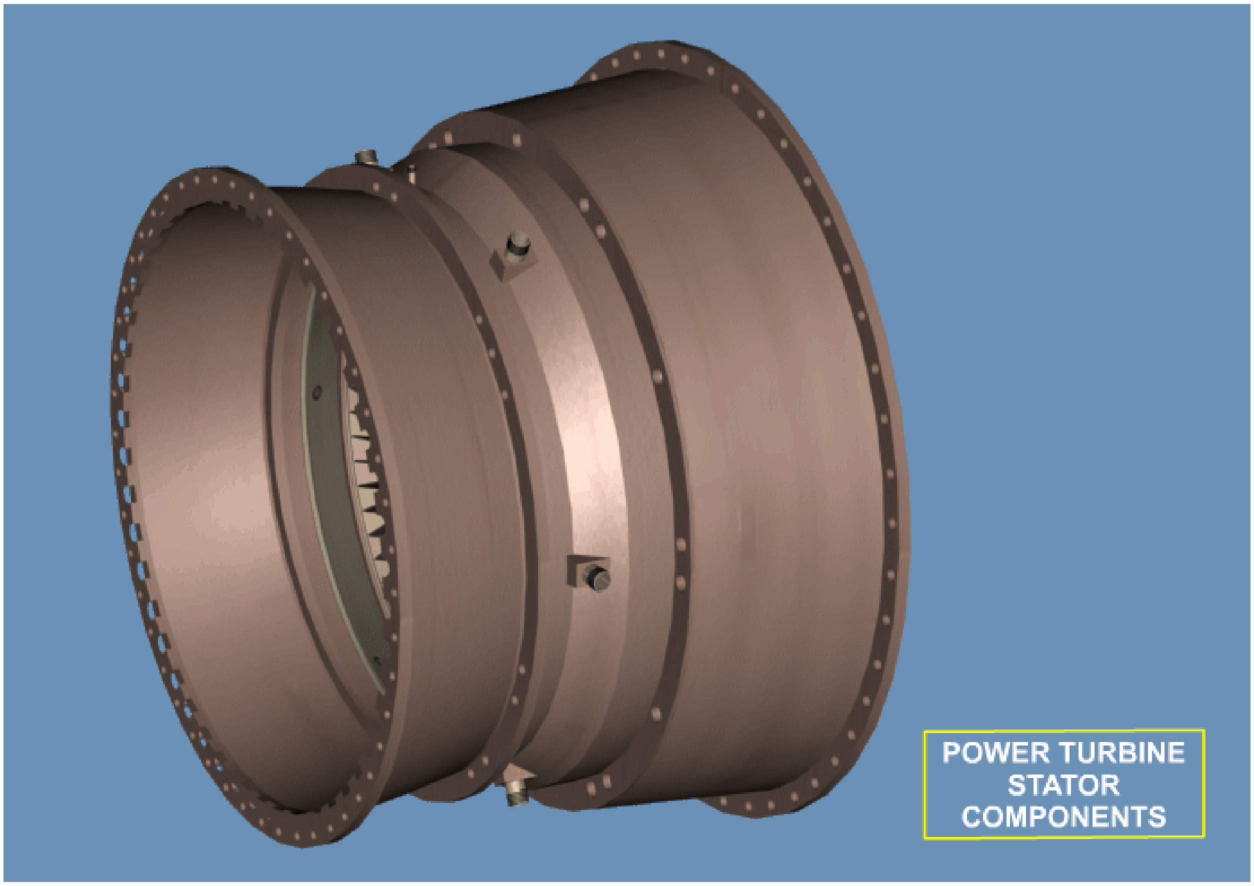
f As torque loading increases, the teeth on the drive shaft will, in two planes, draw closer to the teeth on the reference shaft, thus creating a basis to measure engine torque.

g Sensors, installed in the exhaust frame, contain a magnet and wire coil, which will produce an electrical pulse each time a drive shaft or reference shaft tooth passes by.

h The sensors transmit the pulses to the Electronic Control Unit (ECU) or Digital Electronic Control Unit (DECU).

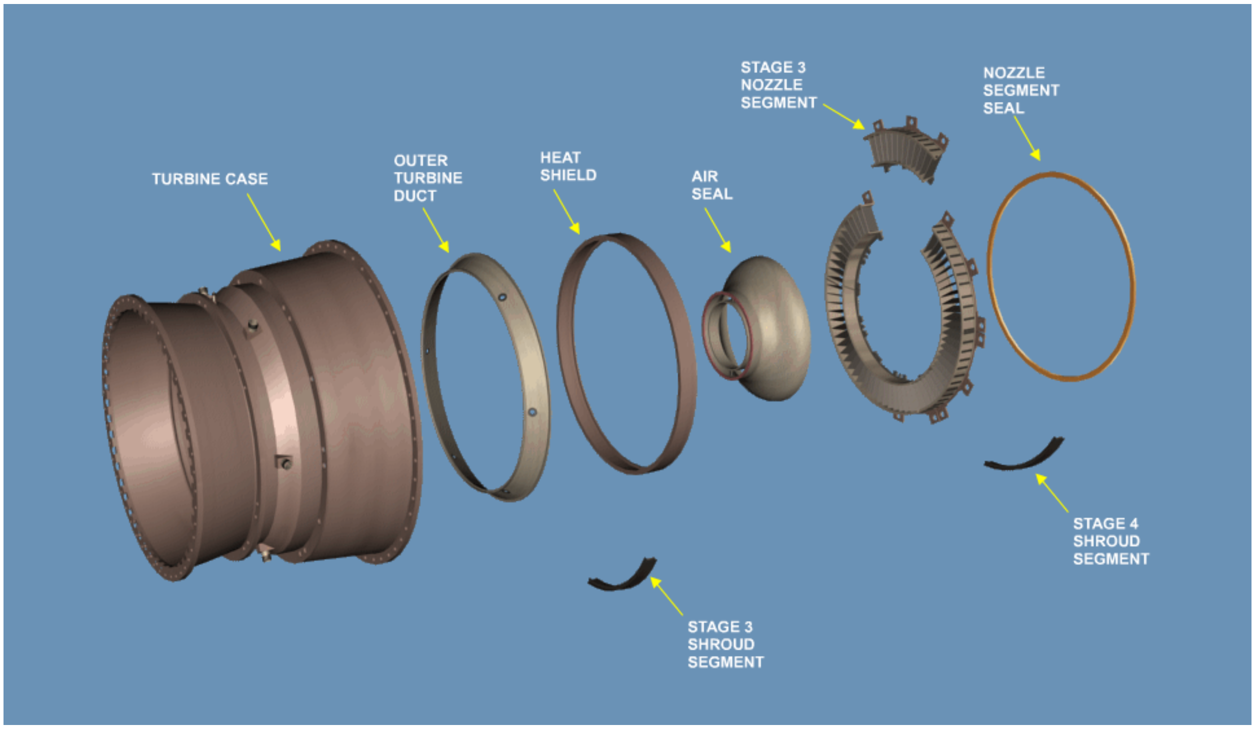
4 Power Turbine Stator Components

Frame # 0280 (Power Turbine Stator Components FLASH)



a The one-piece cast power turbine case provides a housing for the power turbine rotor and the stage 3 and 4 nozzle assemblies.

Frame # 0280 (Power Turbine Stator Components FLASH)



<u>b</u> The stage 3 nozzle is a one-piece nozzle/duct assembly.

<u>c</u> The stage 4 nozzle is a one-piece casting sandwiched between the rotor stages.

<u>d</u> The blade tip shrouds are also housed in the casing, four 90 degree sectors per stage.

<u>e</u> The shrouds are of open honeycomb construction.

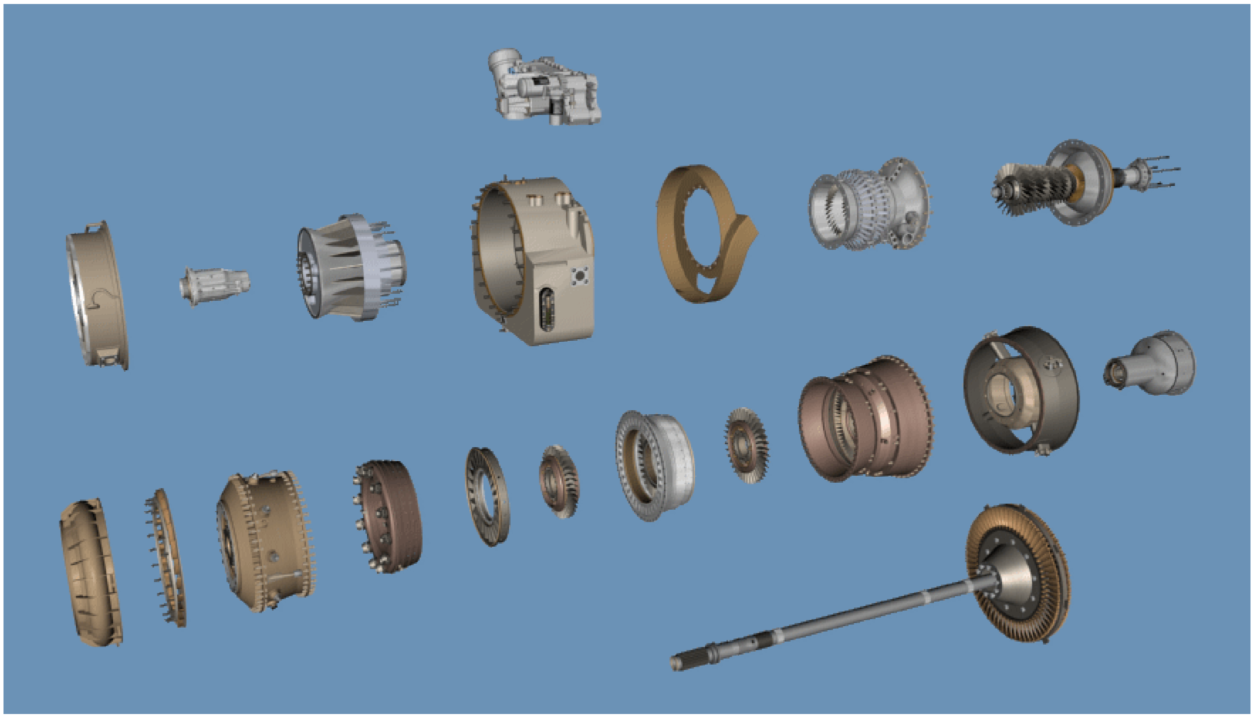
<u>f</u> The one-piece cast casing also supports the thermocouple assembly.

<u>g</u> A two-piece cooling shroud is bolted external to the cast casing, which cools the casing skin using nacelle air, which is ejected into the main gas stream.

<u>h</u> Radiation shields and insulation provide for cooler casing operation.

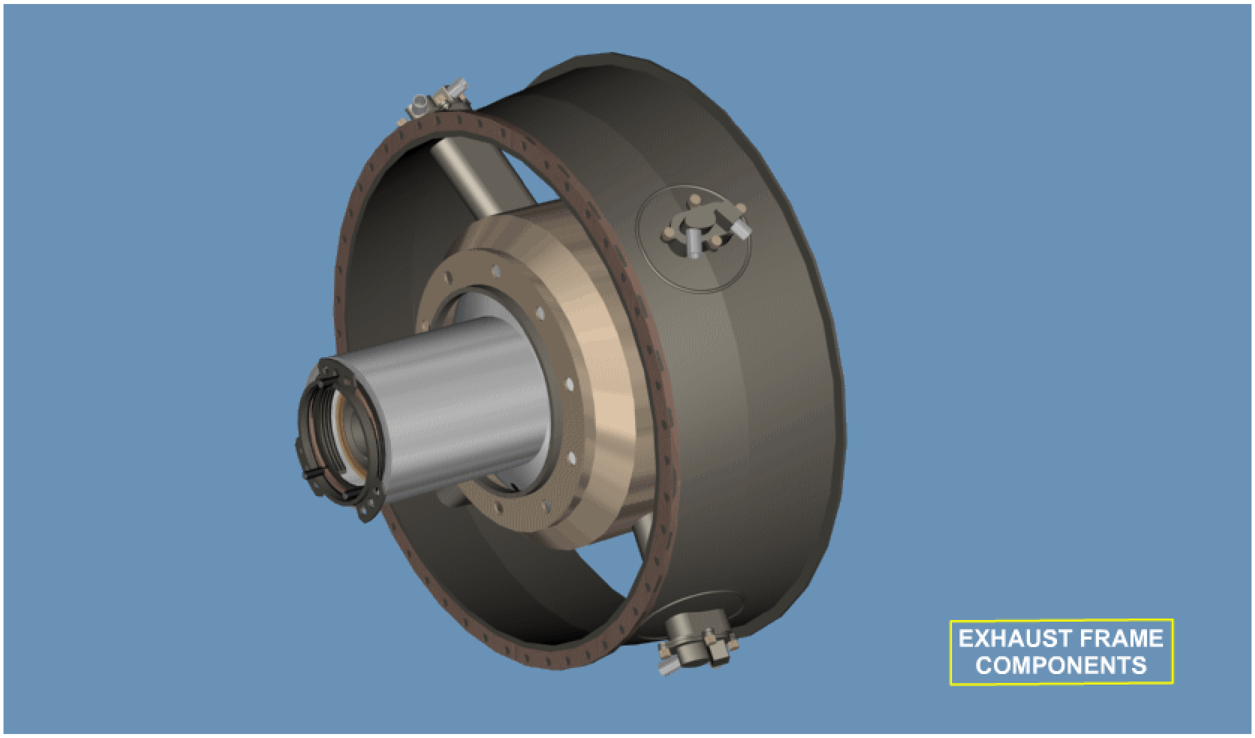
5 Exhaust Frame Components

Frame # 0281 (Exhaust Frame Components)



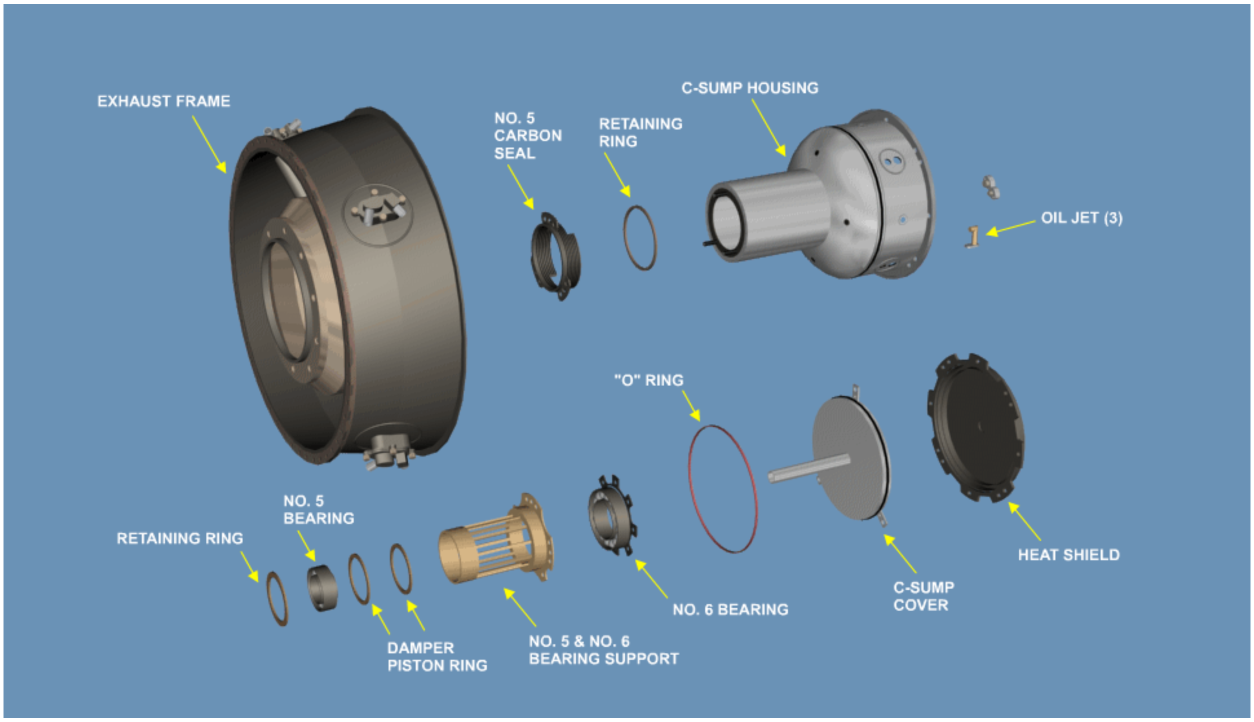
a The exhaust frame supports the C-sump housing.

Frame # 0285 (Exhaust Frame Components FLASH)



b The cast exhaust frame contains the C-sump and bolts to the aft flange of the power turbine case.

Frame # 0285 (Exhaust Frame Components FLASH)



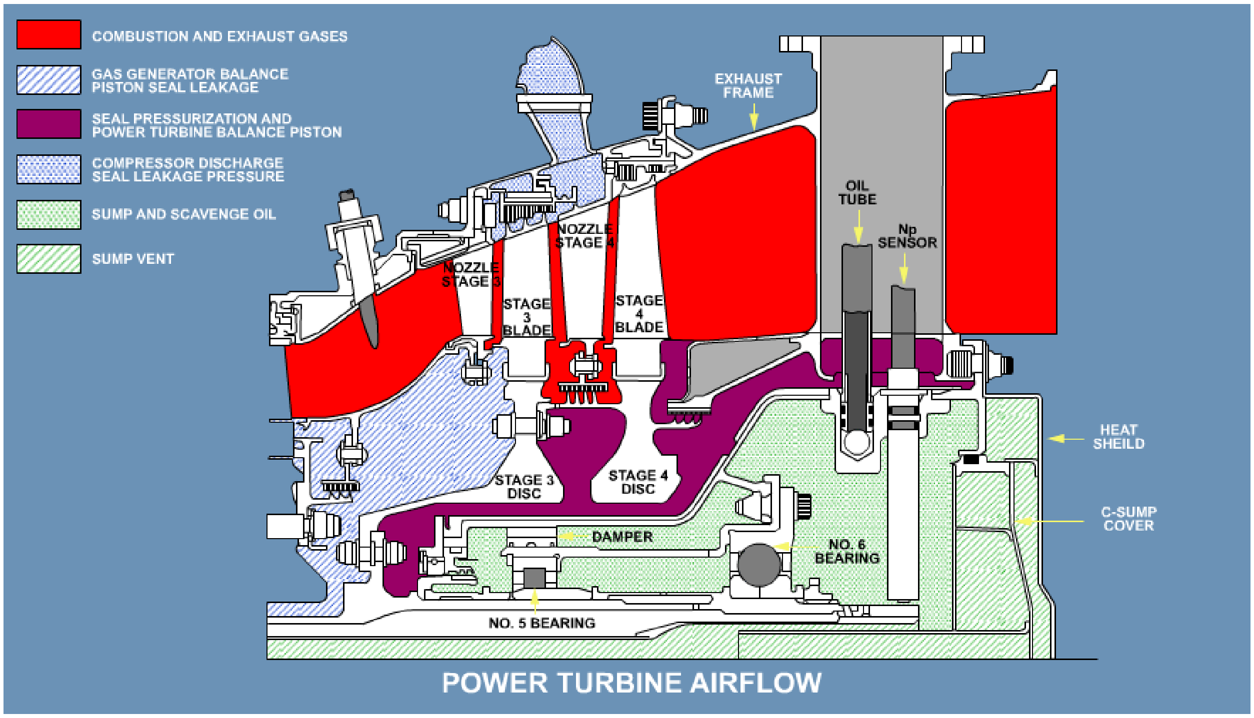
c Four struts support the C-sump and provide housings for oil and scavenge lines, and the torque and overspeed sensors.

d The exhaust frame also houses the No. 5 carbon seal.

e The C-sump contains the oil jets, retaining ring, No. 5 bearing, damper piston rings, the bearing support, No. 6 bearing, C-sump cover, and the heat shield.

6 Power Turbine Airflow

Frame # 0290 (Power Turbine Airflow)



a Diffuser discharge air cools the stage 1 nozzle and shrouds.

b Stage 2 nozzle and segments are cooled with compressor impeller tip bleed air, routed through three internal tubes in the midframe casing.

c Cooling plates on the gas generator turbine rotor assembly direct cooling air through the rotor blades.

d Inner balance piston leakage air flows under the turbine disks.

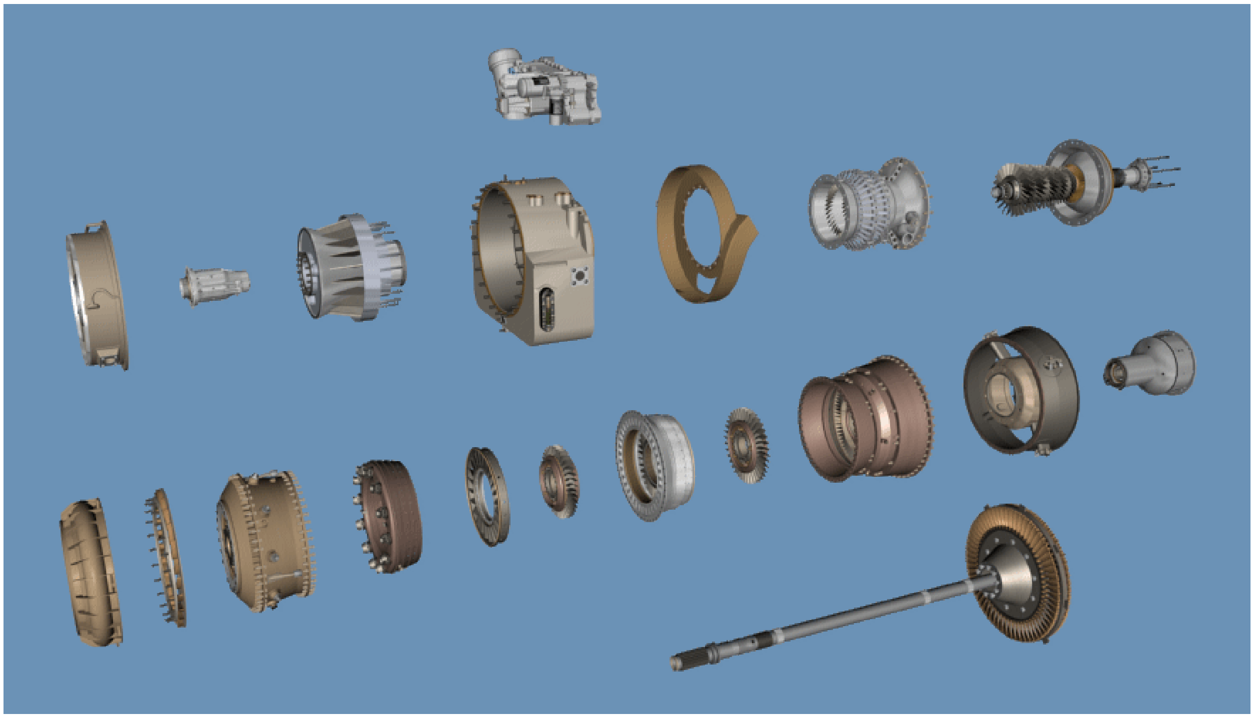
e This air cools and dilutes hot gas from the turbine flow path.

f The air re-enters the flow path through the baffle seal at the stage three turbine inlet.

g Stage four shrouds are cooled by compressor discharge seal leakage air piped externally from the midframe.

(e) Accessory Section Module

Frame # 0291 (Accessory Section Module)



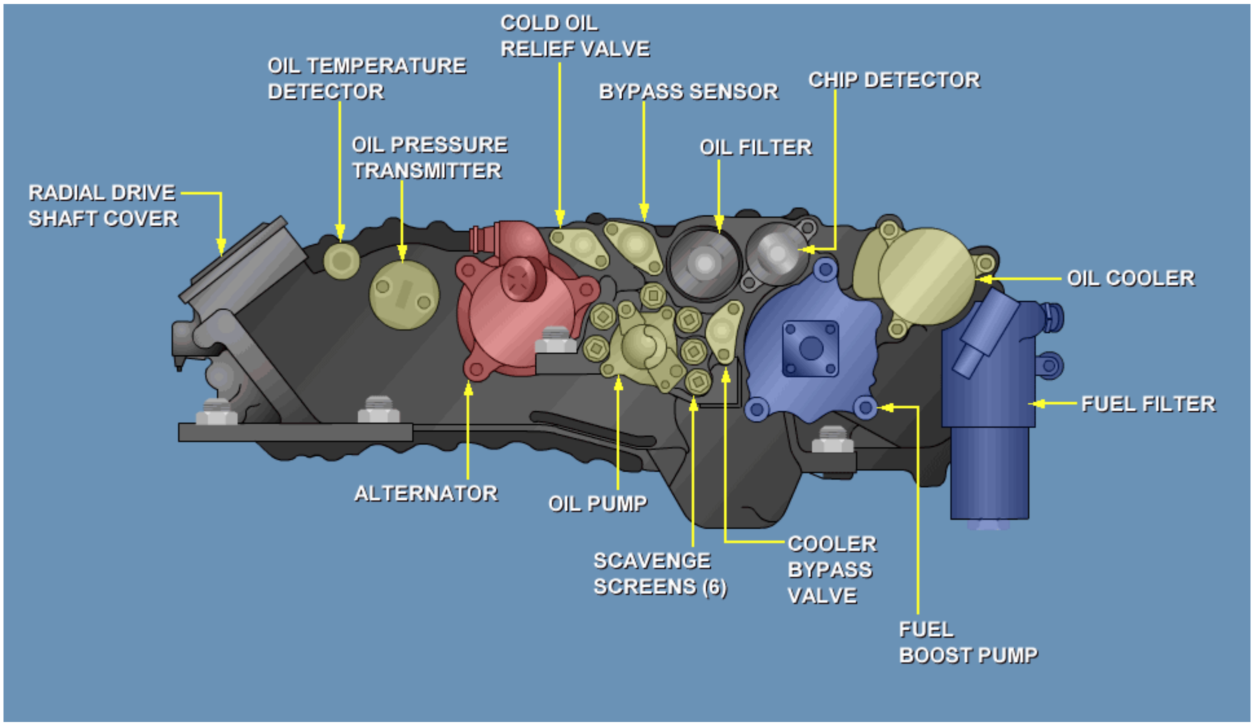
1) The accessory module mounts on the cold section module at the 12 o'clock position of the main frame.

2) It includes the Accessory Gearbox (AGB) that is driven by a bevel gear system from the compressor rotor via a radial drive shaft.

3) Several accessories are contained in or mounted on the front and rear of the AGB.

a) Accessory Section Module (Front)

Frame # 0295 (Accessory Section Module Front)



1 On the front face are pads for the alternator and fuel boost pump.

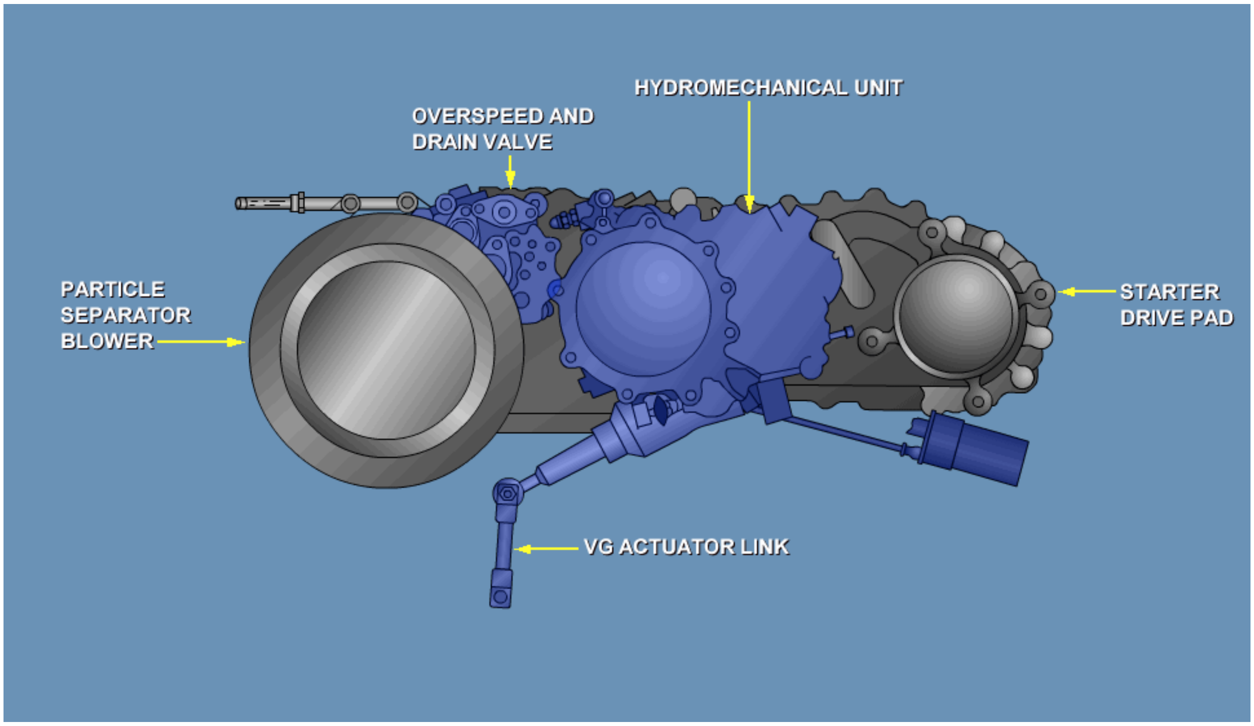
2 A cavity is provided for the lube and scavenge pump, and chip detector.

3 Pads are supplied for the oil cooler, and fuel and lube filters.

4 Cored passages in the AGB housing convey fuel and oil between components.

b) Accessory Section Module (Rear)

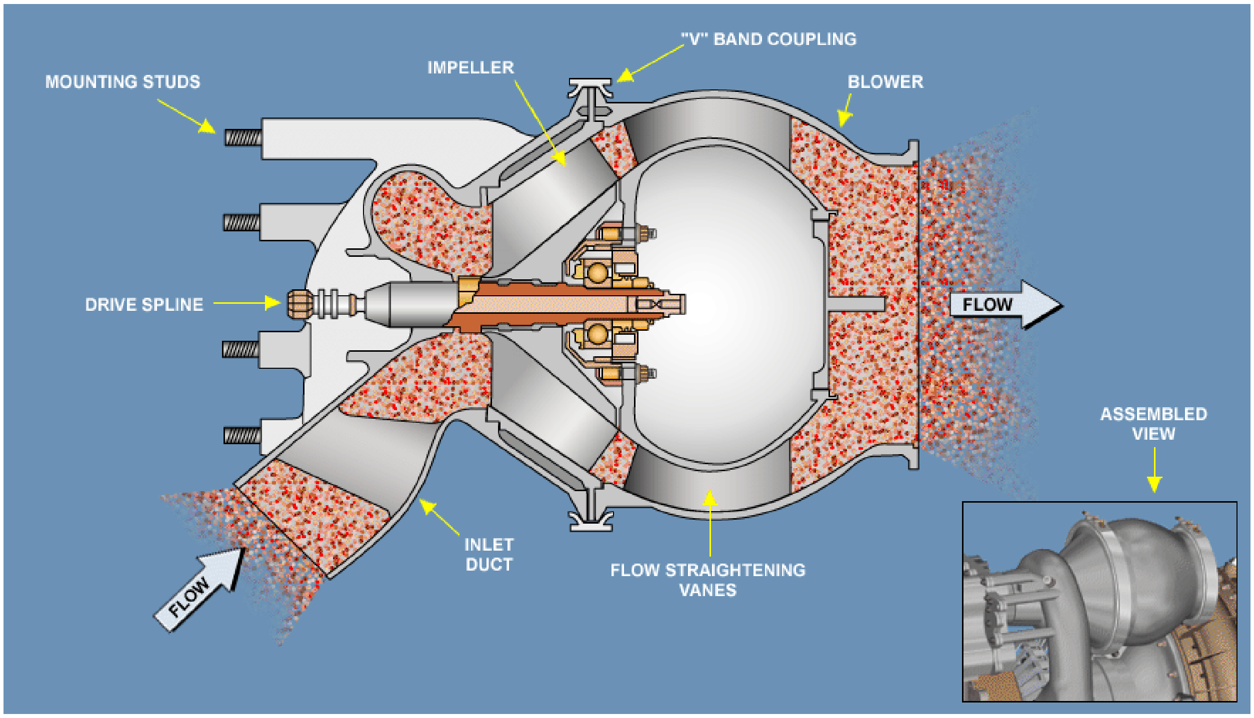
Frame # 0300 (Accessory Section Module Rear)



1 The rear face provides drive pads for the engine starter, hydromechanical unit, inlet particle separator blower and a face ported pad for the overspeed and drain valve.

a Particle Separator Blower

Frame # 0305 (Particle Separator Blower)



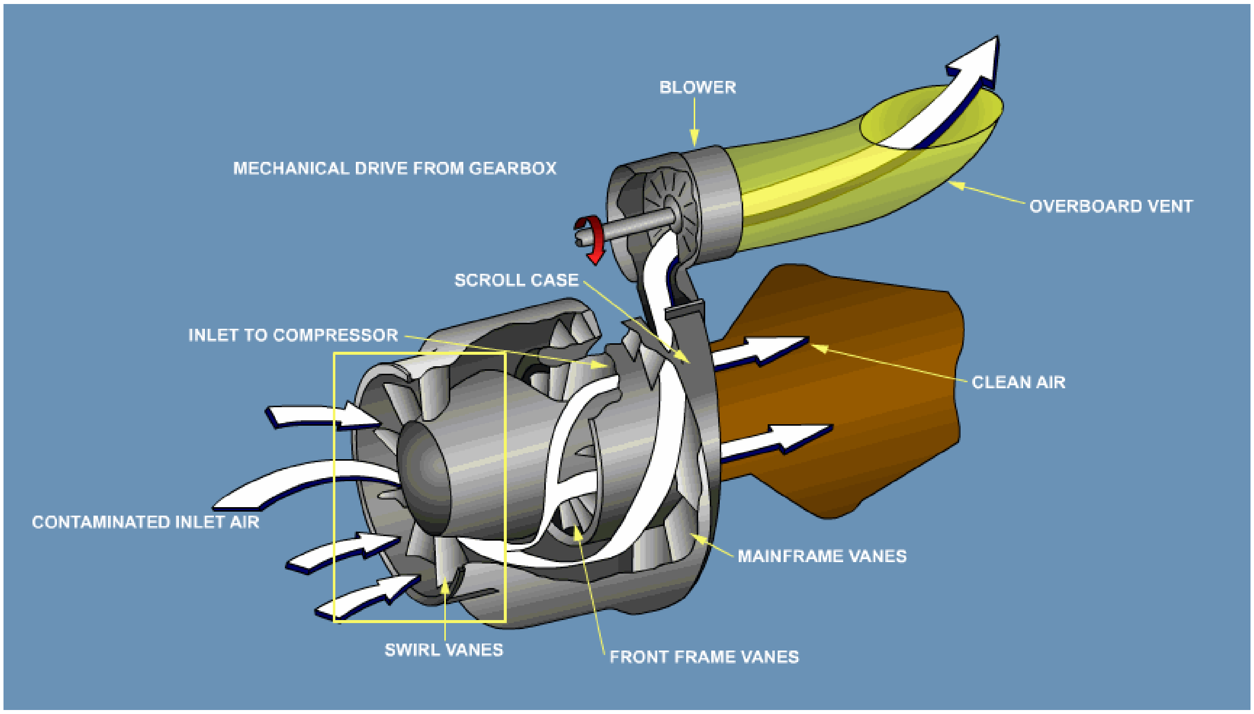
i) The particle separator blower removes sand, dust, and other foreign material from the engine inlet air.

ii) Engine inlet air passes through the swirl vanes, spinning the air and throwing dirt out by inertial action into the collector scroll.

iii) The foreign material is drawn into the blower and discharged overboard around the engine exhaust duct.

b Inlet Particle Separator Airflow

Frame # 0301 (Inlet Particle Separator Airflow FLASH)



i) The inlet particle separator removes particles from the inlet air flow.

ii) The inlet air is drawn into the swirl frame and the swirl vanes direct the air into a swirling pattern.

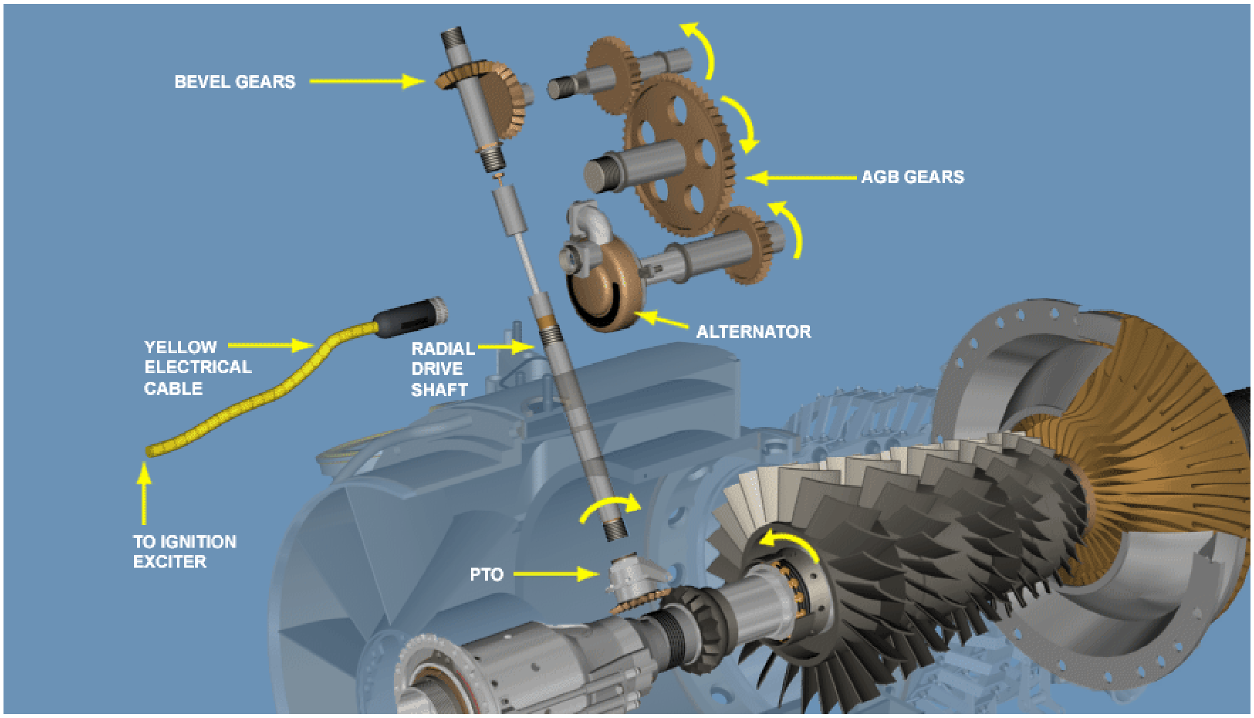
iii) Centrifugal action then removes dust, sand, and foreign objects.

iv) The foreign objects are carried to the outer section of the main frame and collected in the scroll case.

v) The inlet particle separator blower draws the objects from the scroll case and discharges them overboard.

c Starter Drive Train

Frame # 0302 (Starter Drive Train)

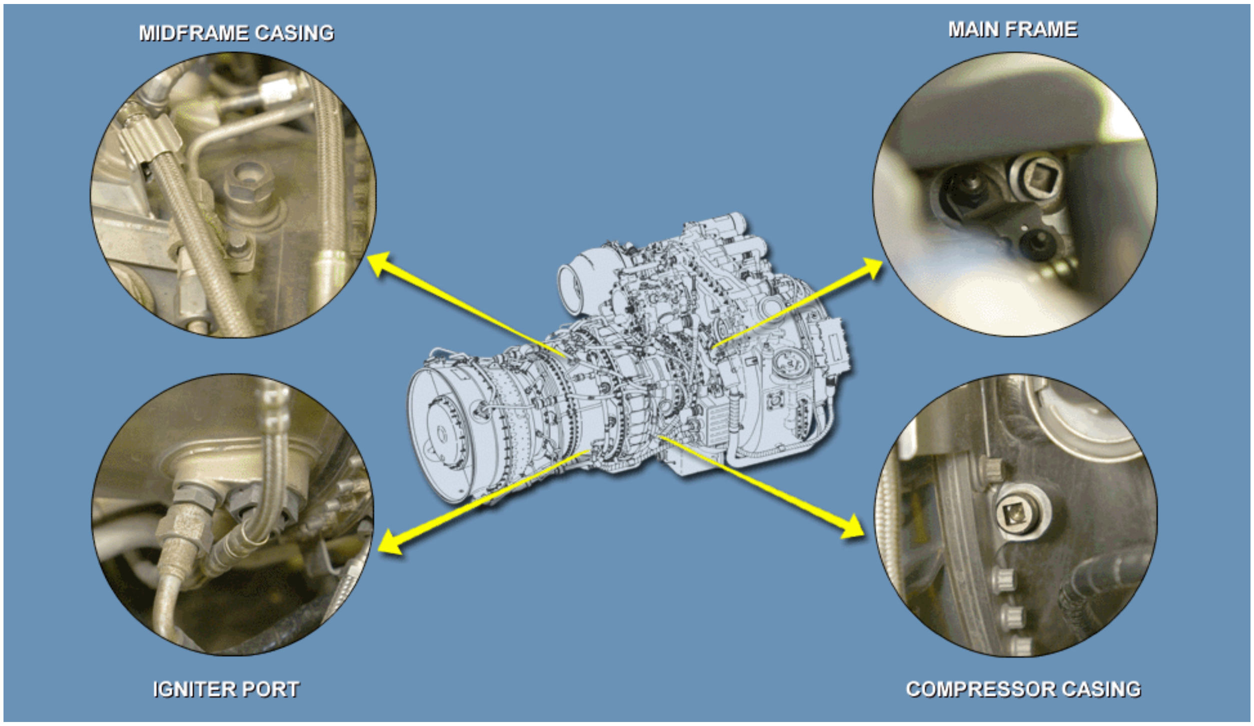


i) The PTO assembly drives the radial drive shaft, which through drive train gearing, drives the accessory gearbox.

ii) The starter assembly is mounted to the accessory gearbox.

e. Borescope Inspections (Right Side View)

Frame # 0310 (Borescope Inspections (Right Side View)



(1) Several borescope ports have been provided for borescope probe access so engine parts may be inspected for damage or condition without disassembly of the engine, or removal of the engine from the aircraft.

(2) Port locations on the right side of the engine are as follows:

(a) Midframe casing, 12:30 o'clock position (combustion section)

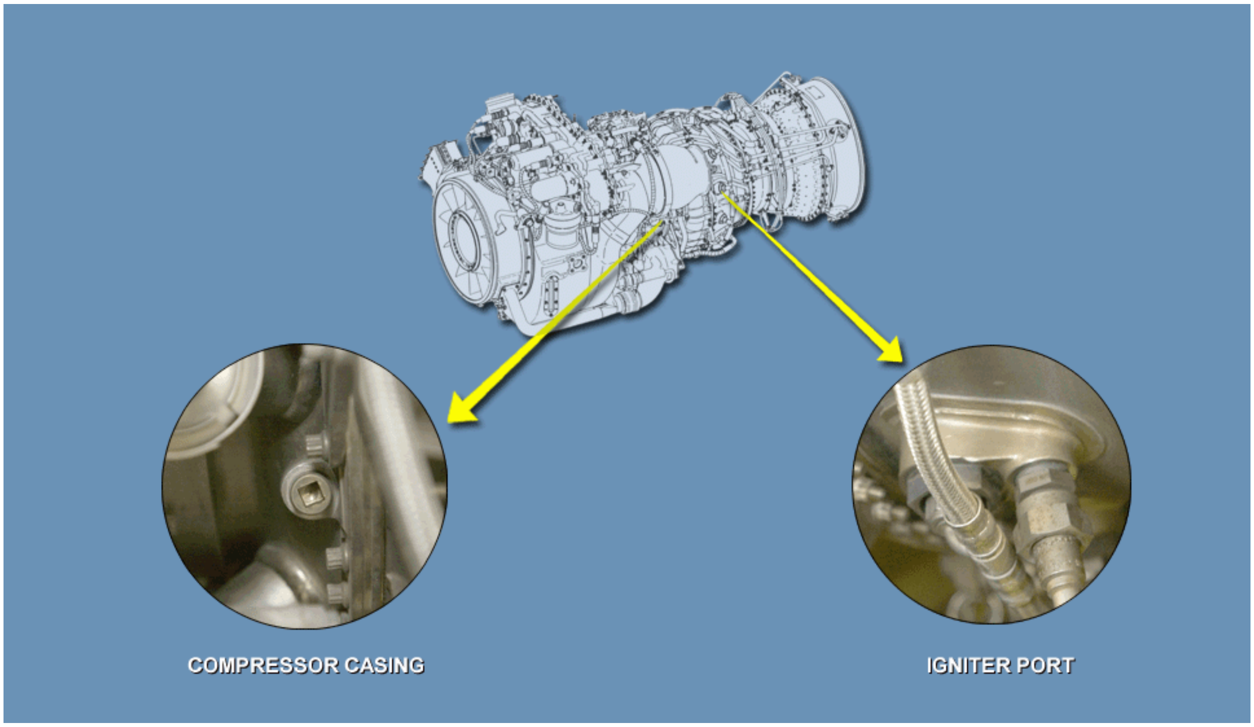
(b) Main frame, 1 o'clock position (compressor forward)

(c) Compressor casing, 4 o'clock position (compressor aft)

(d) Igniter port, 4 o'clock position (combustion section)

1) Borescope Inspection (Left Side)

Frame # 0315 (Borescope Inspection (Left Side View)



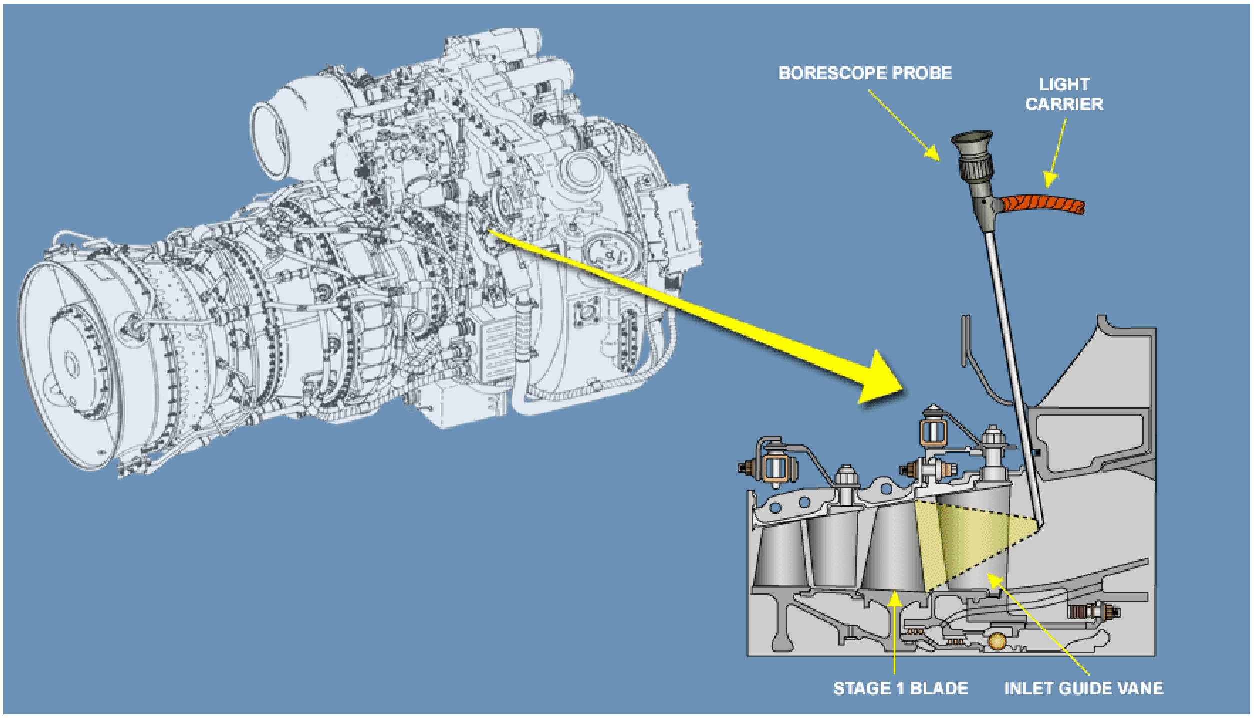
a) Port locations on the left side of the engine are as follows:

1 Igniter port, 8 o'clock position (combustion section)

2 Compressor casing, and 8 o'clock position (compressor aft).

2) Borescope Inspection Compressor Forward

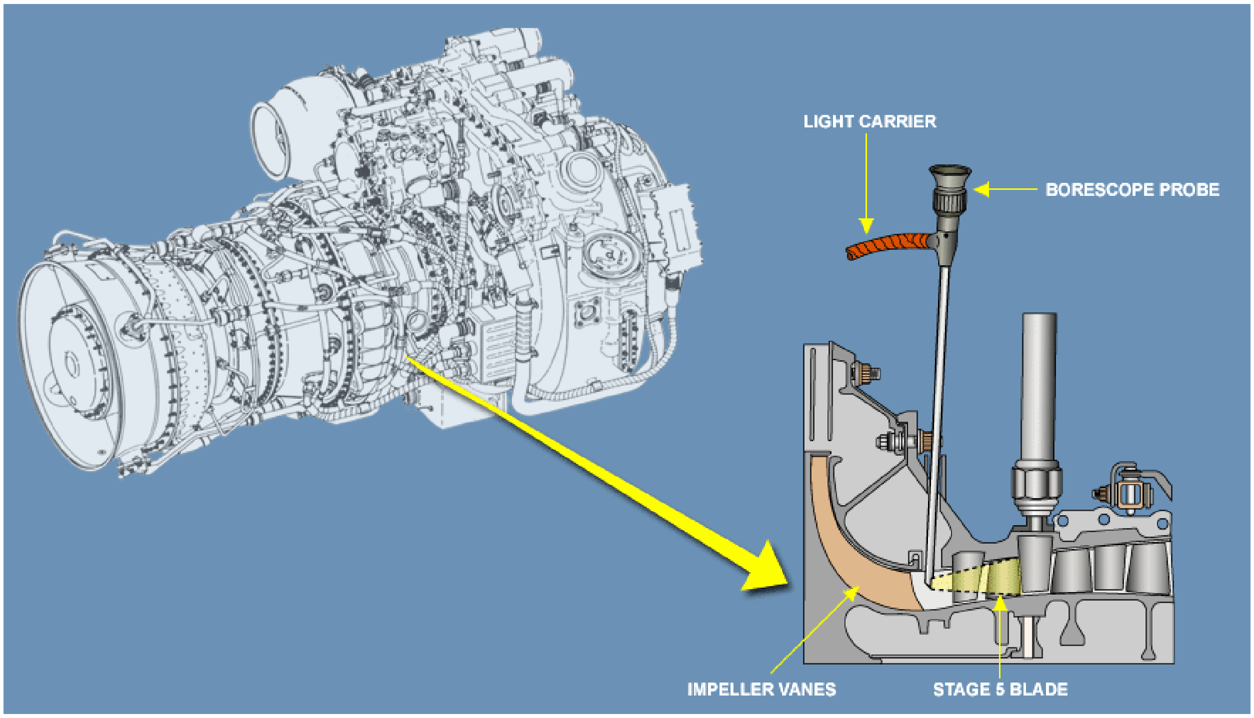
Frame # 0320 (Borescope Inspection Compressor Forward)



a) This view illustrates the borescope inserted into the mainframe borescope port at the 1 o'clock position, inspecting the forward side of the compressor.

3) Borescope Inspection Compressor AFT

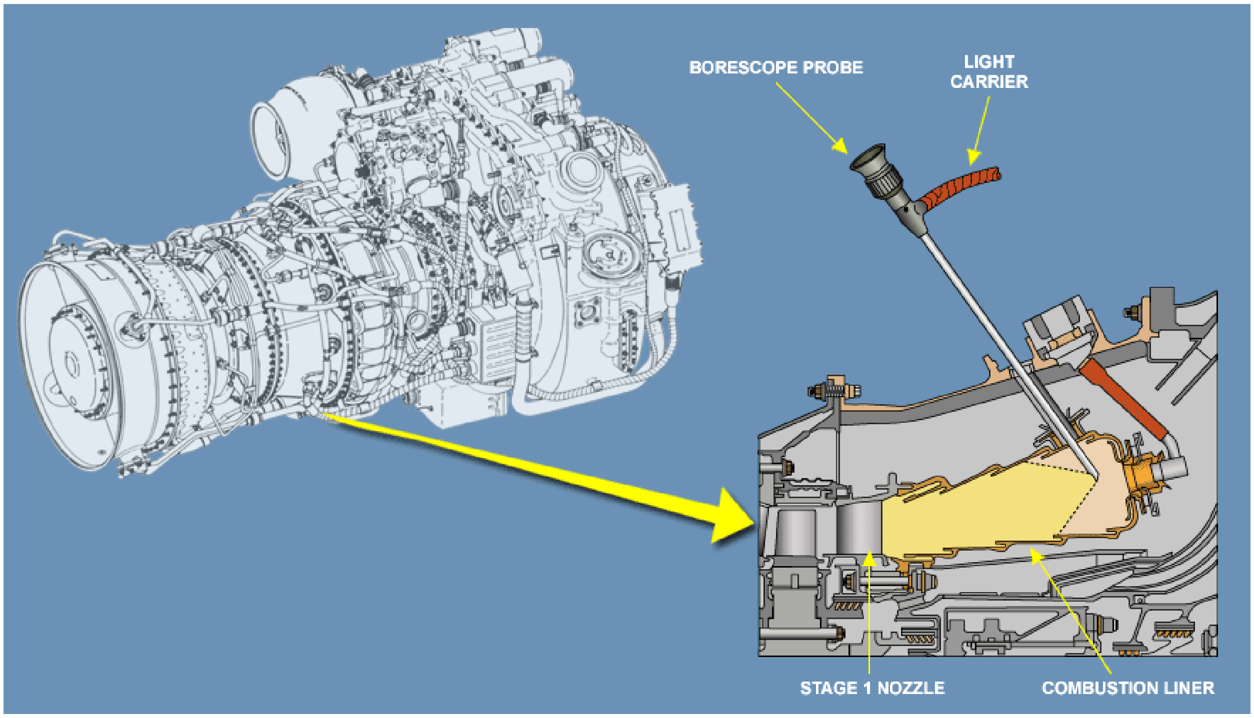
Frame # 0325 (Borescope Inspection Compressor AFT)



a) This view illustrates the borescope inserted into the compressor casing borescope port at the 4 o'clock position, inspecting the aft side of the compressor.

4) Borescope Inspection Combustor

Frame # 0330 (Borescope Inspection Combustor)



a) This view illustrates the borescope inserted into the igniter borescope port at the 4 o'clock position, inspecting the combustion section.

CHECK ON LEARNING

1. The T701C engine consists of what four modules?

2. Where is the output shaft assembly housed?

3. The number three bearing is a ball bearing, which absorbs the ________ load of the rotor.

4. The cast exhaust frame contains the ________ and bolts to the aft flange of the power turbine case.

5. There are ________ stages of axial compression in the T701C engine.

SECTION IV. -SUMMARY

1. REVIEW/SUMMARIZE:

You have completed the UH-60 Powerplant major components topic.
The key points to remember are:

- Basic Engine - the T700 engine design has been directed at minimizing required inspections and maintenance without sacrificing mechanical integrity and performance.
- The maintenance tasks of the LRU removal/installation can be accomplished using only 10 common tools.
- The T700 engine consists of four modules:
    - Cold section module
    - Hot section module
    - Power turbine module
    - Accessory section module
- Engine orientation - the engine is referenced from the rear (aft) looking towards the front (forward).
- Major engine components - the engine can be disassembled into four modules and the four modules consist of several major engine components.
- Main bearings and shafts - the engine rotor systems are supported by six main bearings located in three bearing sumps.
- Accessory section module is mounted at the 12:00 o'clock position on the mainframe and includes the Accessory Gearbox (AGB) and several accessories that are contained in or mounted on the front and rear casings of the AGB.
- Cold section module includes the inlet section, compressor section, and diffuser and midframe casing assembly.
    - The inlet section consists of the: swirl frame, main frame, output shaft, front frame, and scroll case.
    - The compressor section consists of the: compressor rotor assembly and compressor stator assembly.
    - The diffuser and midframe casing assembly consists of the: diffuser, diffuser case, and midframe assembly.
- Hot section module includes the gas generator turbine, stage one nozzle assembly, and combustion liner.
    - The gas generator turbine consists of the: gas generator stator assembly and a two-stage turbine rotor assembly.
    - The stage one nozzle assembly consists of: 12 segments, combustor outer seal, nozzle support, heat shield, and nozzle ring.
    - As the stage one nozzle rotates, air enters the nozzle segments and is forced over and around the airfoil through the leading edge showerhead, suction side gills, pressure side gill holes, and the trailing edge slots.
    - The combustion liner is an annular, machined and welded ring liner, using a low pressure fuel injection system with vortex air swirlers to mix fuel and compressor discharge air prior to combustion.

- Power Turbine Module includes the power turbine rotor, power turbine drive shaft, power turbine case and exhaust frame.
  - The power turbine rotor consists of the third and fourth stage disks, mounted on a drive shaft system, supported by the number 5 and 6 bearings at the rear, and by the output shaft assembly at the forward end.
  - The power turbine shaft is a hollow unit, splined at the forward end to couple with the output shaft, and flanged close to the rear to accept the power turbine rotor disks.
  - The one-piece cast power turbine case provides a housing for the power turbine rotor and stage three and four nozzle assemblies.
  - The cast exhaust frame contains the C-sump and bolts to the aft flange of the power turbine case.
- The particle separator blower removes sand, dust, and other foreign material from the engine inlet air.
- The Power Takeoff (PTO) assembly drives the radial drive shaft, which through drive train gearing, drives the accessory gearbox.
- Several boroscope ports have been provided for borescope probe access so engine parts may be inspected for damage or condition without disassembly of the engine, or removal of the engine from the aircraft.

C. ENABLING LEARNING OBJECTIVE No. 3

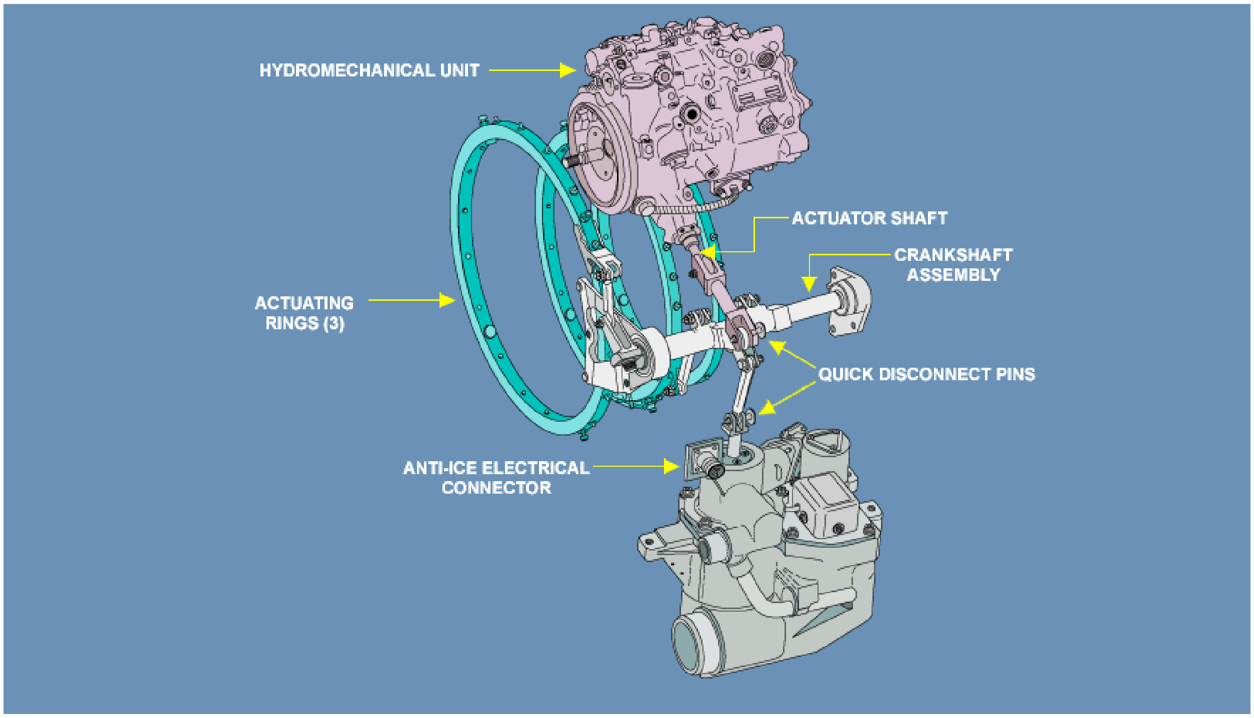
ACTION: Identify the characteristics off the variable geometry and anti-icing system.

CONDITION: Using TM 1-2840-248-23

STANDARD: IAW TM 1-2840-248-23

a. Actuation System

Frame # 0380 (Compressor Variable Geometry Actuation System)



(1) The variable geometry actuation system of the T700 high performance compressor permits optimum performance over a wide range of operating conditions.

(2) Use of variable stator vane angles facilitates rapid stall-free accelerations and optimizes fuel consumption at partial power conditions.

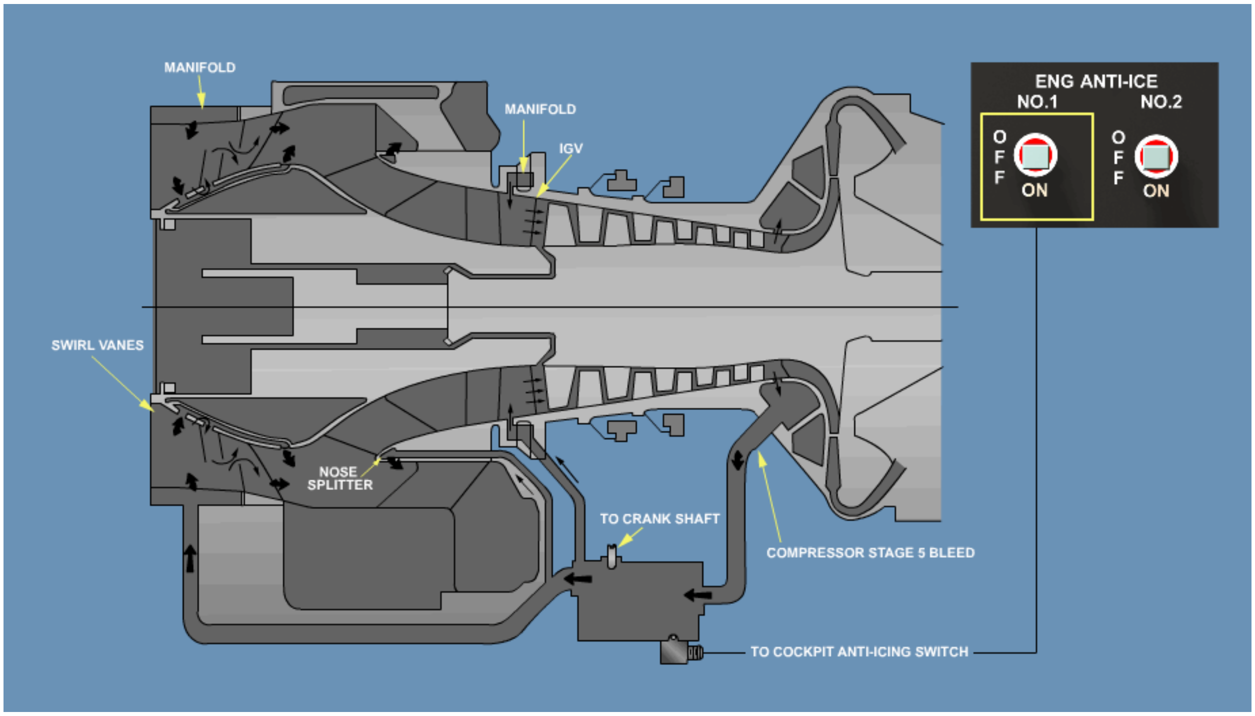
(3) The variable geometry components include the stage 1 and stage 2 variable vanes of the compressor casing, inlet guide vanes (IGV's) in the main frame, lever arms attached to the individual vanes, and three actuating rings (one for each stage).

(4) The three actuating rings, levers, and vanes are actuated and synchronized by the crankshaft assembly, which is positioned by an actuator within the hydromechanical unit (HMU).

(5) This actuator is in turn, positioned by a servo system with feedback, which responds to compressor or gas generator speed (Ng), compressor inlet temperature (T2) and physical position of the variable geometry actuator.

(a) Anti-Icing Airflow

Frame # 0385 (Anti-icing Airflow FLASH)



1) Axial compressor discharge air (stage 5) is tapped from the compressor casing at the 7 o'clock position, routed through the anti-icing/start bleed valve, and delivered to the front frame, main frame, and swirl frame via ducting.

2) Within the swirl frame, hot air is ducted around the casing to each swirl vane.

3) The air is circulated within each vane by a series of baffles, then exits from two areas.

4) Approximately 90% of this air exits at the swirl vane outer trailing edges, and the other 10% exits through a series of holes in the swirl frame hub at the aft edge.

5) This arrangement acts as a "rain step" to reduce the amount of water adhering to the hub and flowing into the compressor.

6) Front frame anti-icing flows through a cored passage in the main frame to the front frame splitter nose, then exits to the main frame scroll and is discharged with inlet particle separator air.

7) Another branch of the anti-icing air duct is utilized to heat the IGVs.

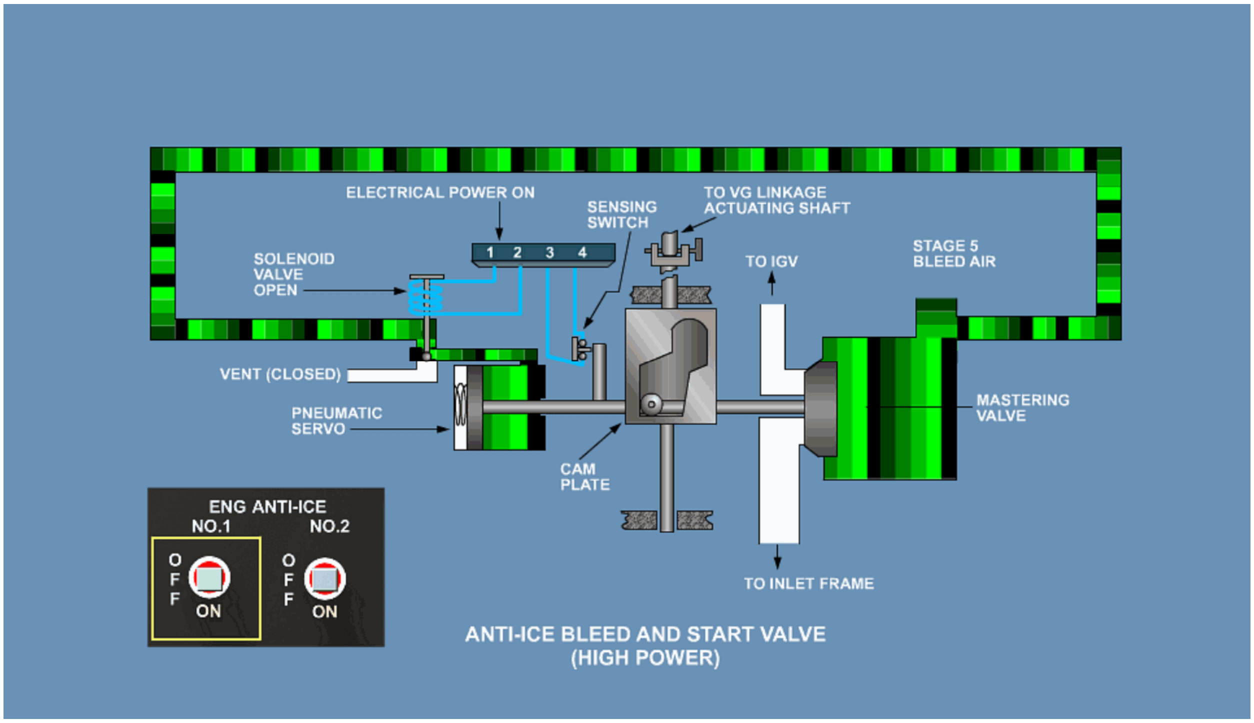
8) A manifold surrounds the aft flange of the main frame to distribute hot air to the hollow IGVs.

9) Slots in the trailing edge of the IGVs discharge this flow into the compressor inlet.

10) Hot scavenge oil passing within the scroll vanes in the main frame precludes ice build-up on scroll vanes.

(b) Anti-Ice and Start Bleed Valve

Frame # 0389 (Anti-ice and Start Bleed Valve High Power FLASH)

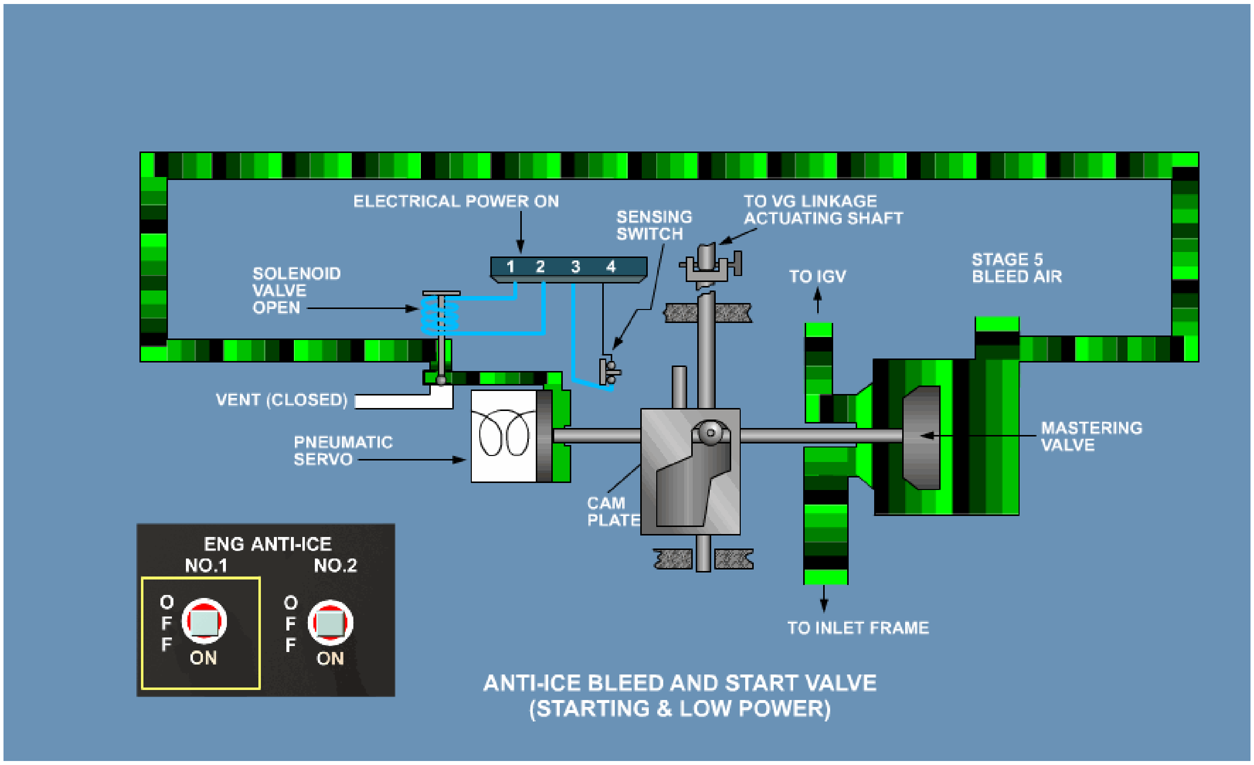


1) The anti-ice bleed and start valve is controlled by a solenoid operated air valve.

2) At higher power settings, the anti-ice bleed and start valve functions when the ENG ANTI-ICE switch is ON.

3) During the HIT procedure, cycling of the ENG ANTI-ICE switch more than once will cause the valve to steal bleed air from the engine compressor, and create an incorrect fuel to air mixture for the engine.

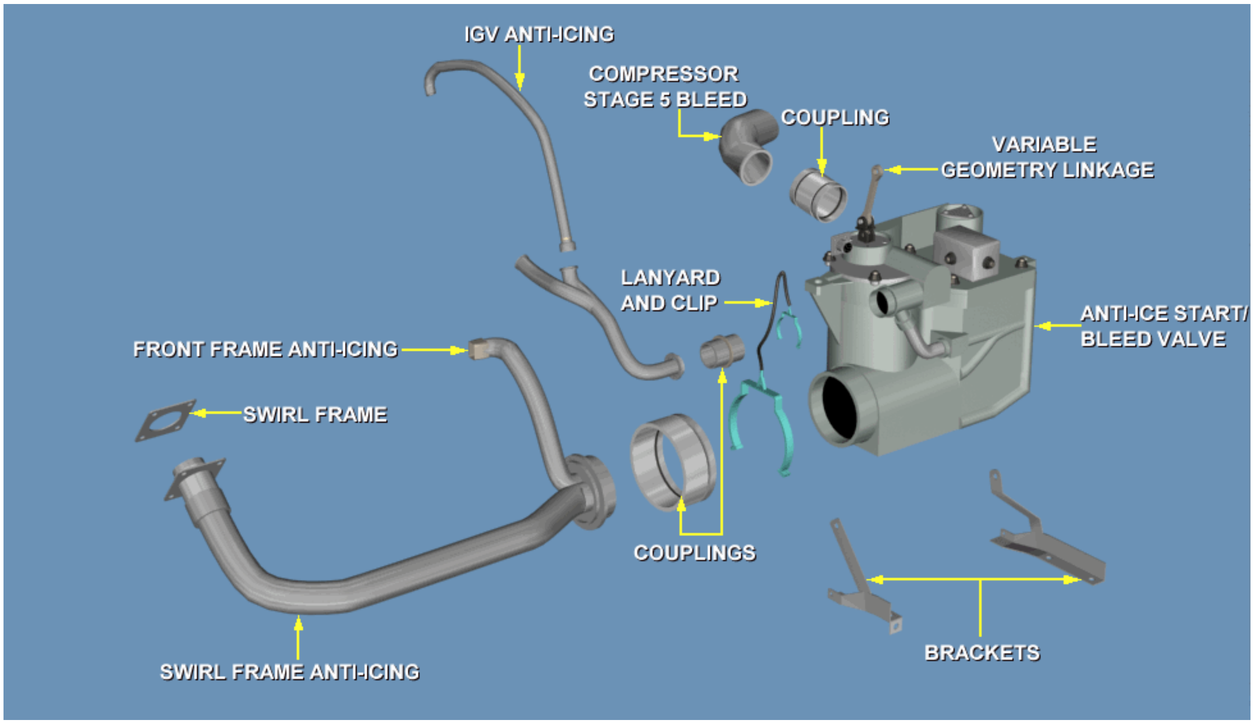
Frame # 0391 (Anti-ice and Start Bleed Valve Starting and Low Power FLASH)



4) The engine anti-ice bleed and start valve opens during starting and will remain open at low power settings until the engine reaches 88 - 92% NG, depending on the outside air temperature, with the anti-ice OFF.

(c) Anti-Icing Valve and Manifolds

Frame # 0395 (Anti-icing Valve and Manifolds)



1) Anti-icing air is discharged through two ports in the anti-ice start bleed valve.

2) Air is ducted via external piping and internal passages to heat the swirl frame vanes and front frame splitter nose.

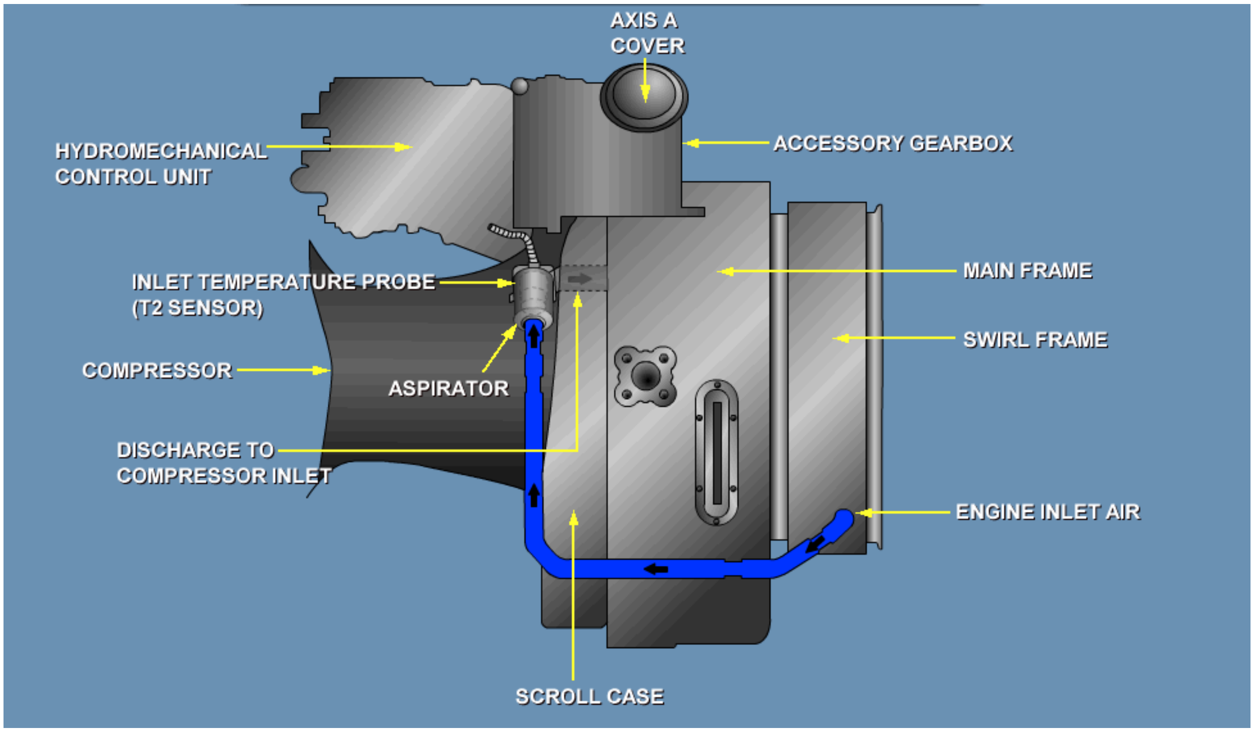
3) The air discharges from the splitter nose and vanes to rejoin engine airflow.

4) Air is also piped to a manifold, formed by the mainframe assembly, where it enters each IGV through holes provided in the vane spindles.

5) The air flows through the hollow IGVs and discharges into the engine airflow via trailing edge vane slots.

(d) T2 Sensor Airflow

Frame # 0400 (T2 Sensor Airflow)



1) Engine inlet air from the swirl frame flows through a tube to the T2 sensor.

2) From the sensor, air flows back into the engine at the compressor inlet.

CHECK ON LEARNING

1. The three actuating rings, levers and vanes are actuated and ________ by the crankshaft assembly.

2. Axial compressor discharge air is tapped from the compressor casing at ________ and routed through the anti-icing/start bleed valve.

3. The manifold surrounding the aft flange of the main frame distributes ________ to the hollow IGVs.

SECTION V. -SUMMARY

1. REVIEW/SUMMARIZE:

You have completed the UH-60 Variable Geometry and Anti-icing System topic. The key points to remember are:

- The variable geometry system of the T700 high performance compressor permits optimum performance over a wide range of operating conditions.
- The variable geometry components include the stage 1 and stage 2 variable vanes of the compressor casing, inlet guide vanes (IGVs) in the main frame, lever arms attached to the individual vanes, and three actuating rings (one for each stage).
- Axial compressor discharge air (stage 5) is tapped from the compressor casing at the 7 o'clock position, routed through the anti-icing/start bleed valve, and delivered to the front frame, main frame, and swirl frame via ducting.
- Front frame anti-icing air flows through a cored passage in the main frame to the front frame.
- Anti-icing air is also utilized to heat the inlet guide vanes (IGVs).
- Hot scavenge oil provides anti-icing for the scroll vanes.
- The anti-icing/start bleed valve is controlled by a solenoid operated air valve. The engine anti-icing/start bleed valve opens during starting and will remain open at low power settings until the engine reaches 88 - 92% NG, depending on the outside air temperature, with the anti-ice OFF. At higher power settings, the anti-ice bleed and start valve functions when the ENG ANTI-ICE switch is ON.
- Anti-icing air is discharged through two ports in the anti-icing/start bleed valve. Air is ducted via external piping and internal passages to heat the swirl frame vanes and front frame splitter nose.
- Engine inlet air from the swirl frame flows through a tube to the T2 sensor. From the sensor, air flows back into the engine at the compressor inlet.

D. ENABLING LEARNING OBJECTIVE No. 4

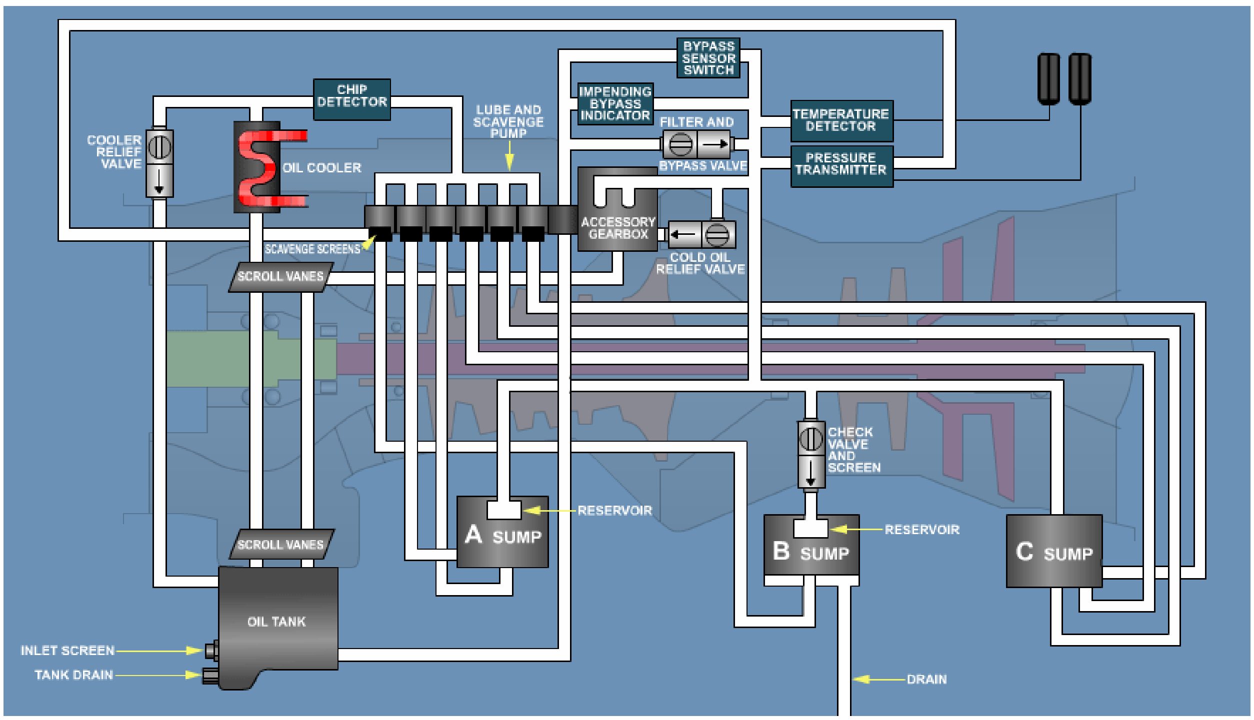
ACTION: Identify the characteristics of the lubrication and sump sealing system.

CONDITION: Using TM 1-2840-248-23

STANDARD: IAW TM 1-2840-248-23

a. Lubrication System

Frame # 0427 (Lubrication System)

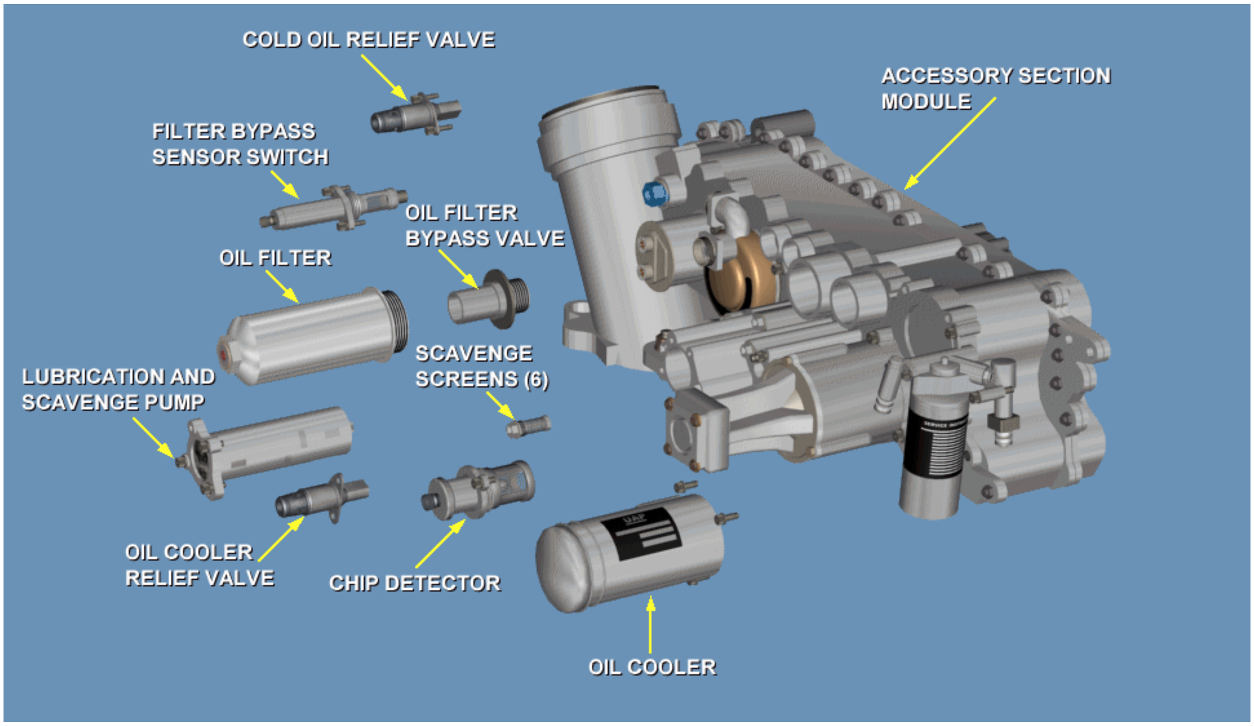


(1) The lubrication system in the T700-GE-701C engine distributes oil to all lubricated parts, and in emergencies, supplies an air-oil mist to the main shaft bearings in the A and B sumps.

(2) The system is a self-contained, recirculating dry sump system.

(a) Lubrication System Components

Frame # 0430 (Lubrication System Components)



1) The lubrication system consists of the following components:

a) Lubrication and scavenge pump

b) Scavenge screens

c) Oil cooler

d) Cold oil relief valve

e) Oil cooler relief valve

f) Chip detector

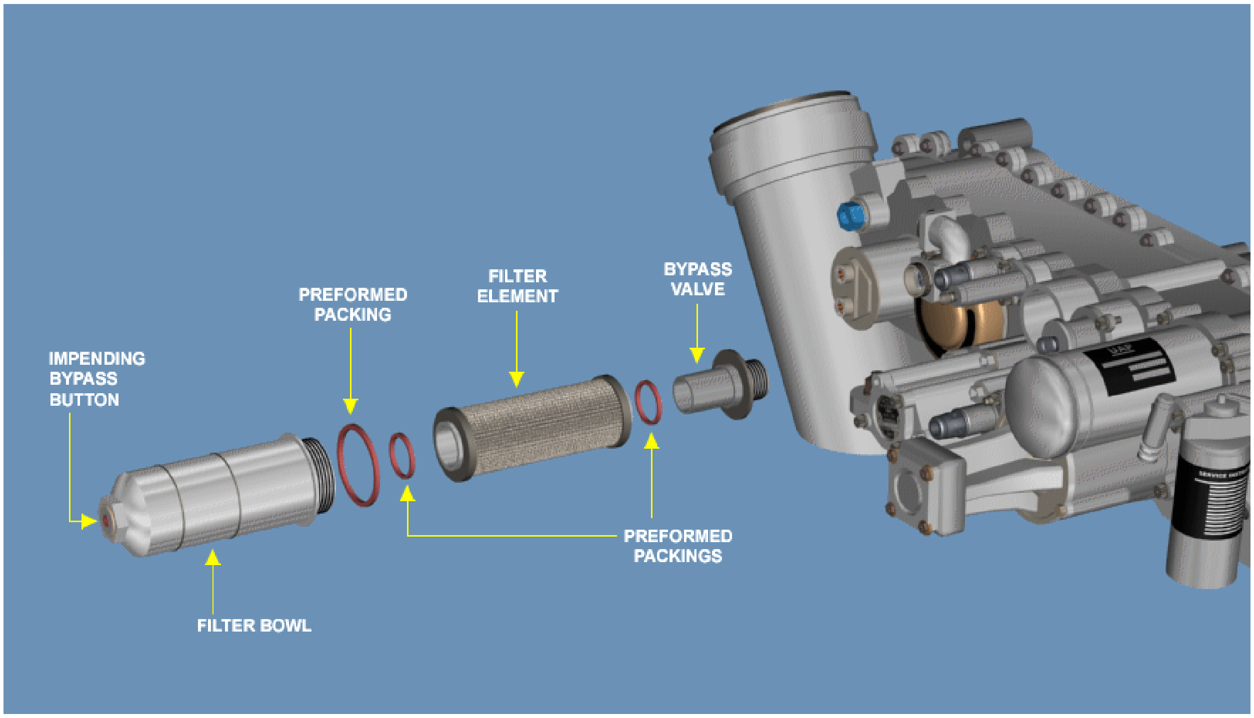
g) Filter bypass sensor switch

h) Oil filter

i) Oil filter bypass valve

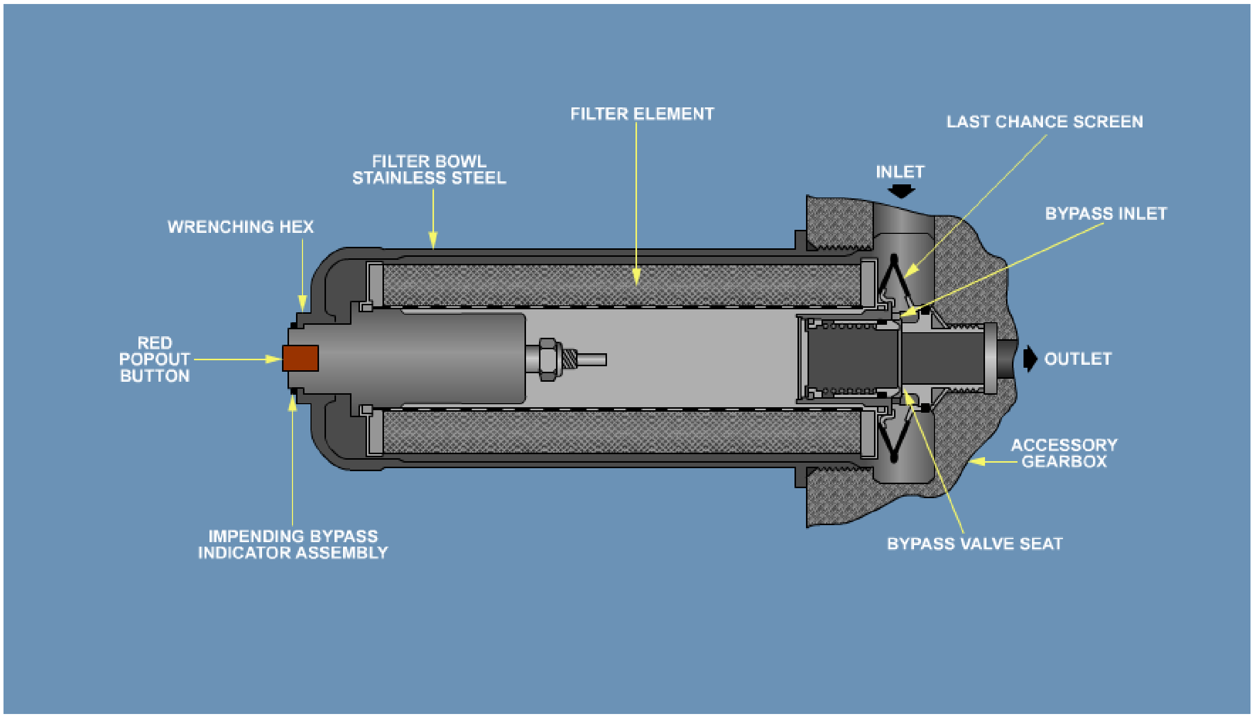
1 Oil Filter

Frame # 0435 (Oil Filter)



a The oil filter consists of three subassemblies; the filter element, filter bowl and impending bypass indicator (button), and the bypass valve and inlet screen (internal).

Frame # 0440 (Oil Filter (Cross Section)



b The oil filter consists of a stainless steel bowl with an impending bypass indicator, a throw away filter element, and a bypass valve assembly.

c The bowl threads into the forward side of the accessory gearbox.

d The bypass valve assembly threads into the accessory gearbox and supports the aft end of the filter element.

e If the impending bypass indicator button pops, it means that the filter element is dirty and that it needs to be replaced.

f Once the button has popped, it cannot be reset until the bowl and the filter element has been removed.

g The oil filter bypass sensor switch (located next to the filter) will send a signal to the cockpit and illuminate the #1 or #2 OIL FLTR BYPASS indicator to let the pilot know the filter is in a bypass condition.

h If the oil is cold during engine starting, the pressure will be high, which will cause the oil to be bypassed.

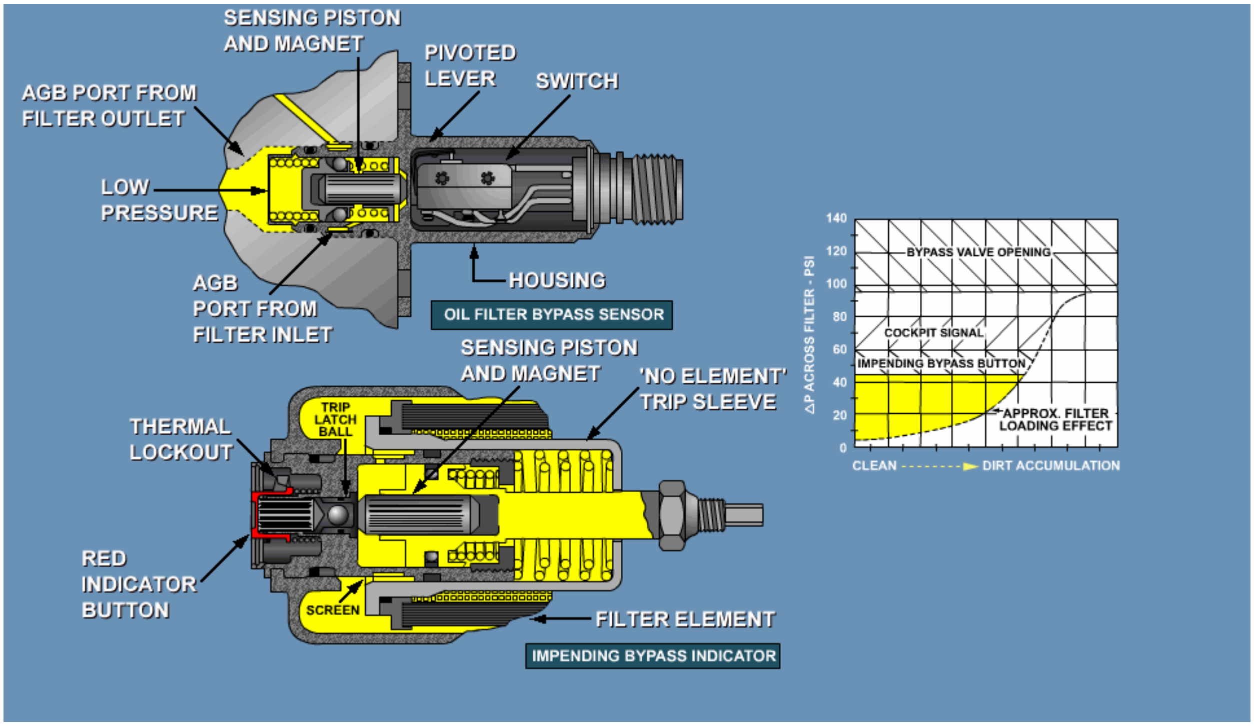
i A thermal lockout prevents the button from popping when the oil temperature is below 100 ºF (38 ºC).

j The bypass valve assembly opens when the oil pressure is too high.

k This means the filter element is dirty or the oil is still cold.

l The bypass valve will close when the oil temperature warms up to operating temperature and pressure decreases.

Frame # 0445 (Oil Filter Bypass Indicator System (Normal Position)



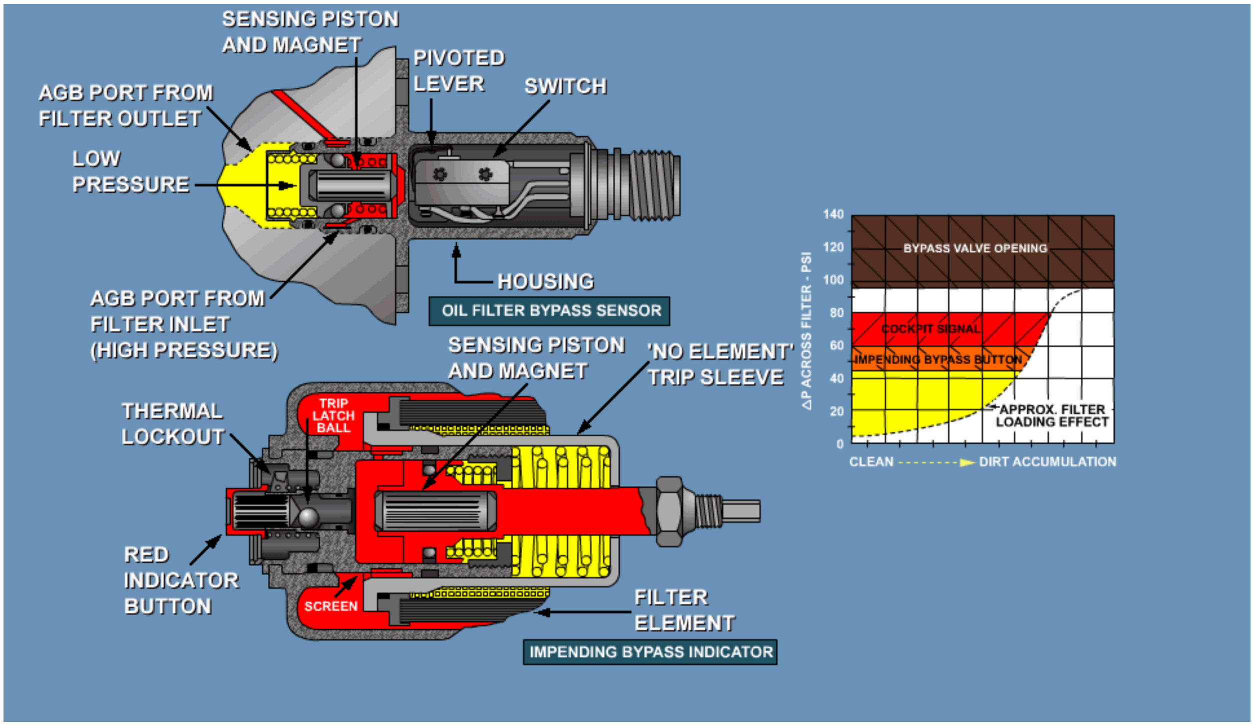
m Differential pressure between filter inlet and outlet act to move a piston against a spring at 44 to 60 psi.

n The piston contains a magnet, which normally attracts a red button assembly and holds it seated against its spring.

o When the piston moves, the button is released and it extends 3/16 inch to visually indicate an impending bypass condition.

p The button is physically restrained from tripping by a cold lockout bimetallic latch if temperature is less than 100 to 130'F to prevent a false trip during cold starts.

Frame # 0450 (Oil Filter Bypass Indicator Systems (Tripped Position)



q As the button is released, a small ball also moves out of position to latch the button and block reset.

r The internal piston assembly automatically resets on shutdown; however, the indicator remains latched out.

s When the bowl is removed from the gearbox and the filter element is removed, a spring-loaded sleeve around the indicator moves aft and pulls the piston assembly to a tripped position.

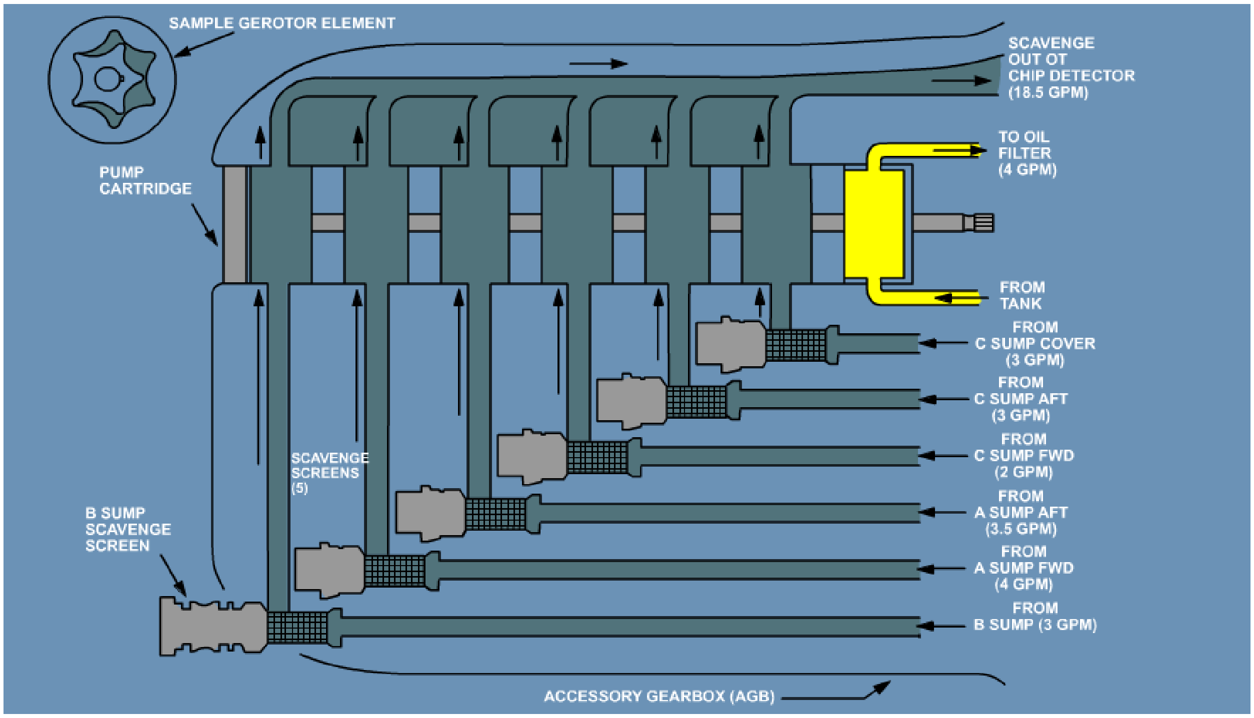
t This makes the button trip if operation is attempted with no filter in the bowl.

u To reset the indicator, the bowl is held vertical so that the button latch ball can roll out of the latched position.

v The button is then manually reset.

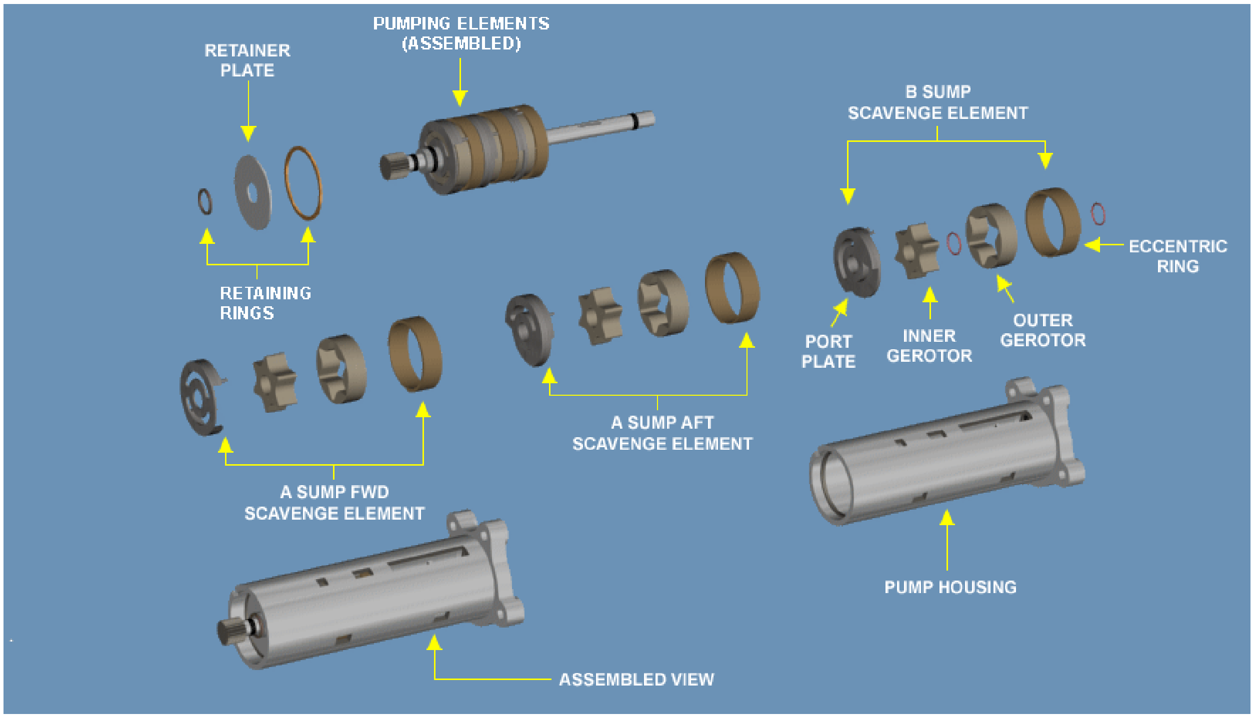
2 Lubrication and Scavenge Pump

Frame # 0455 (Lubrication and Scavenge Pump)



a There are seven different elements in the pump from the spline end forward, which are: the lube supply element, the C sump cover, C sump aft, C sump forward, A sump forward, A sump aft, and B sump scavenge elements.

Frame # 0460 (Lubrication and Scavenge Pump Breakdown)



b The lubrication and scavenge pump is a seven-element gerotor-type pump of cartridge design, and is located on the forward side of the accessory gearbox.

c The gerotor-type pump was chosen because of its good wear resistance and efficiency.

d Gerotor elements are similar to a male gear inside a female (internal) gear with one less tooth on the inner member.

e The inner gerotors are keyed to the drive shaft, and the outer gerotors are pocketed in individual eccentric rings.

f As the assembly rotates, oil is drawn into an expanding cavity between teeth on one side, and expelled when the cavity contracts approximately 180 degrees away.

g Inlet and discharge ports are cast into the port plates and are shaped and positioned to fill and empty at proper timing for maximum volumetric efficiency and resistance to inlet cavitation.

h The port plates, eccentric rings, and gerotors are assembled into a surrounding concentric aluminum tubular housing that maintains all elements in proper alignment.

i The oil suction and discharge passages from the gerotors are brought radically through the housing to match the appropriate locations of the mating passages in the engine gearbox casting.

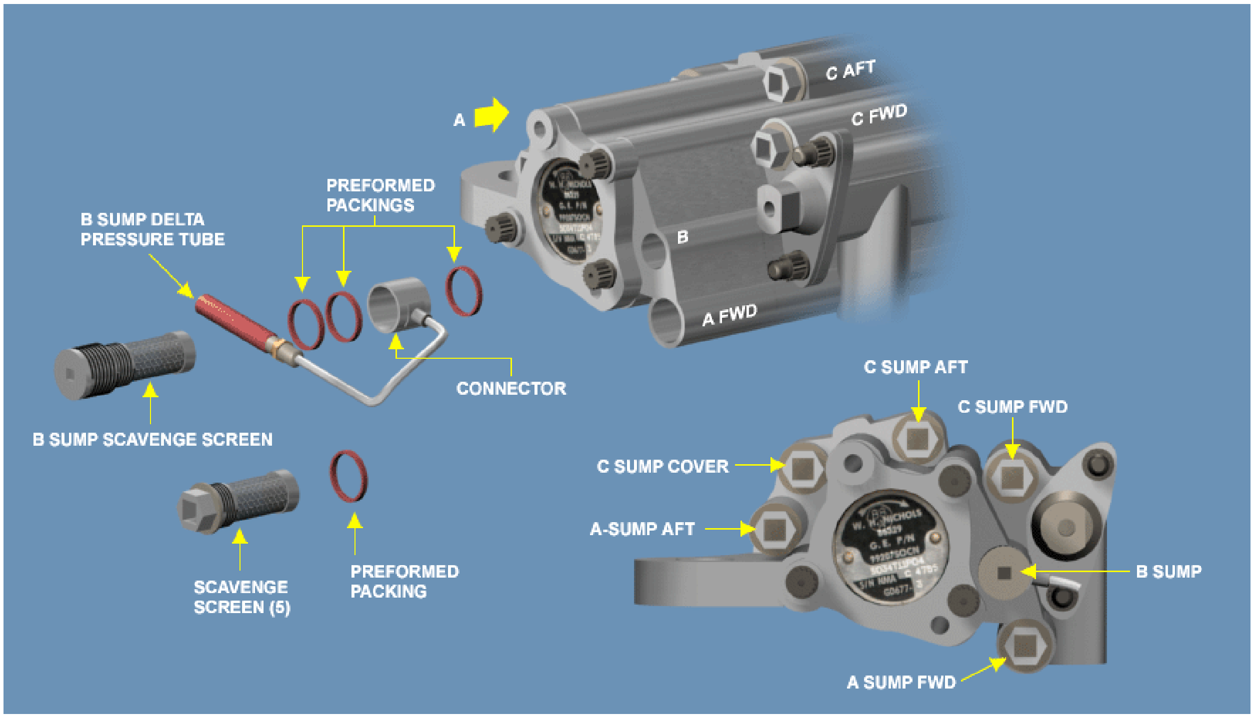
j The entire stack of port plates is retained in the housing with retaining rings at the spline end.

k The outermost end of the housing has an integrally cast cover.

l The cover boltholes are so arranged as to properly orient the pump assembly in the gearbox housing during installation.

3 Scavenge Screens

Frame # 0465 (Scavenge Screens)



a Six scavenge screens are located on the front of the accessory gearbox.

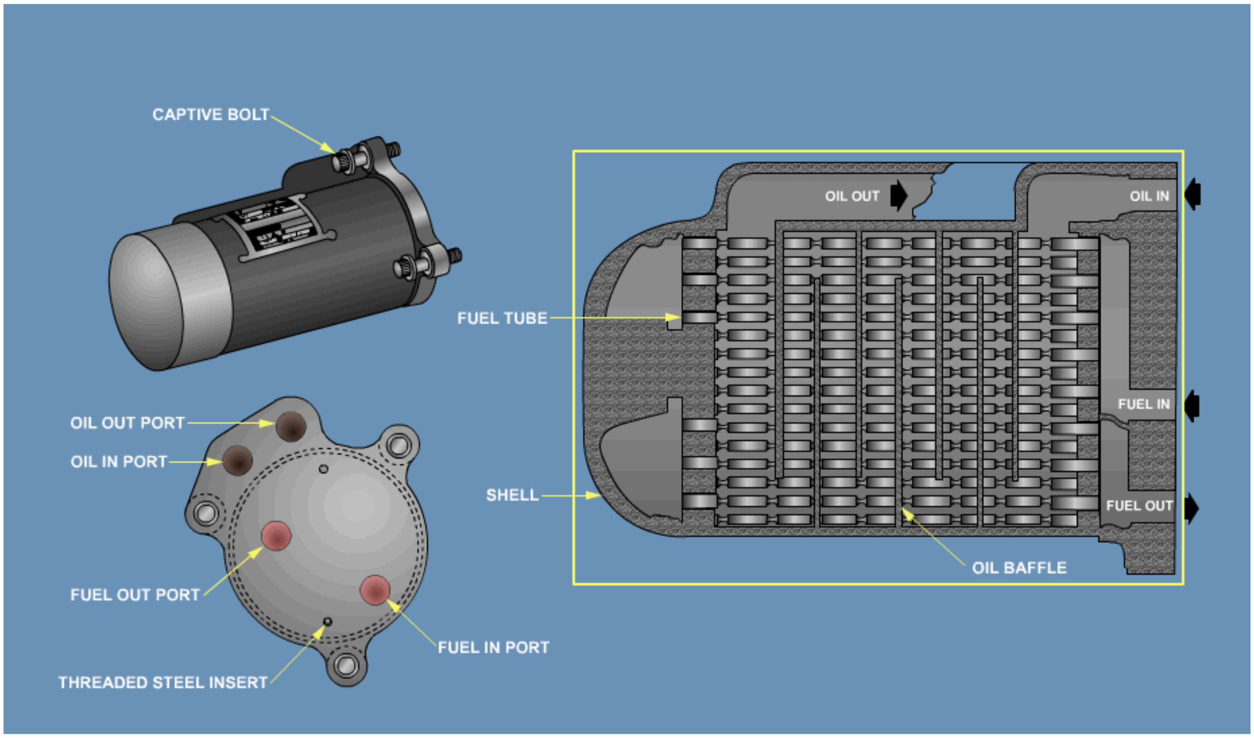
b The screens collect particles before they enter the scavenge sections of the lubrication and scavenge pump.

c These screens prevent damage to the pump.

d The six screens are individually labeled to show which sump the particles came from.

<u>4</u> Oil Cooler

Frame # 0470 (Oil Cooler FLASH)



<u>a</u> The fuel-oil cooler is a tube and shell design which cools the combined output of the scavenge discharge oil that is ported through gearbox cored passages to the cooler.

<u>b</u> The cooler is mounted adjacent to the fuel boost pump on the forward side of the gearbox.

<u>c</u> Fuel is used as the coolant and is provided to the cooler via the boost pump, fuel filter, and hydromechanical control unit.

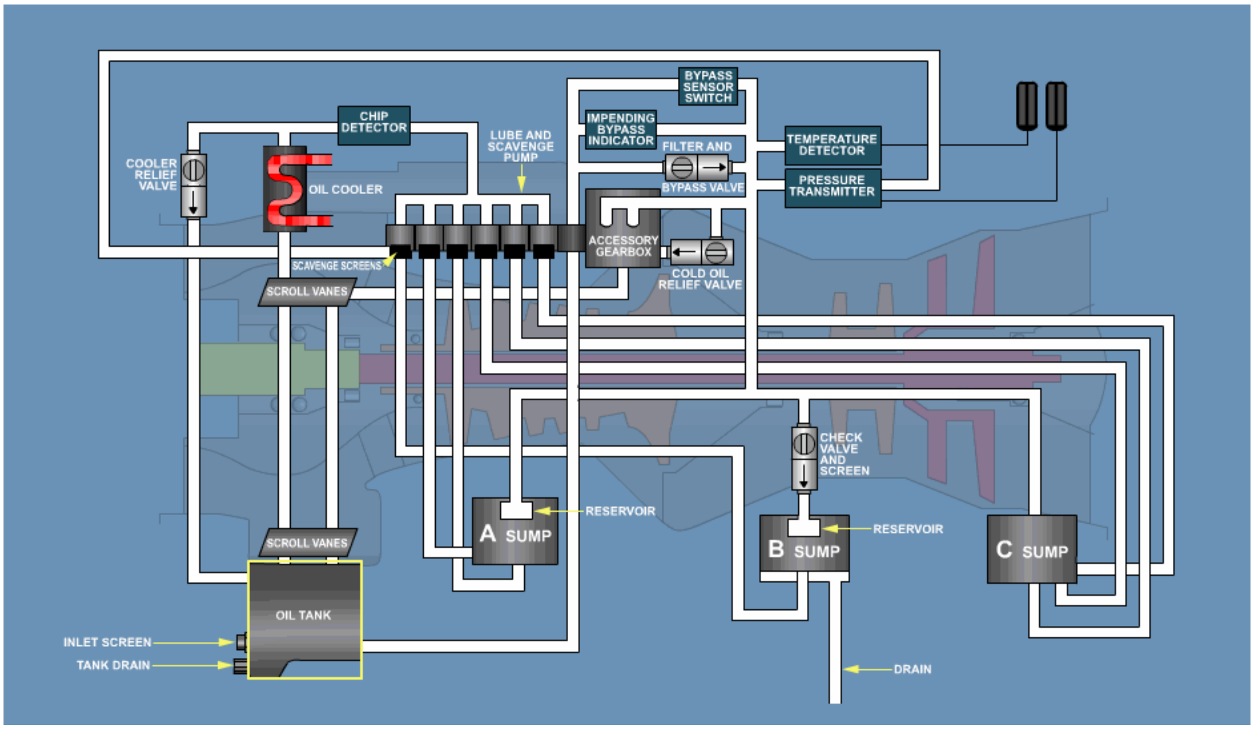
<u>d</u> A counter parallel flow multi-pass cooler design is used in order to minimize pressure drop while obtaining maximum cooler effectiveness.

<u>e</u> Fuel flows through the tubes, while the oil flows over the tubes resulting in the counter-parallel flow arrangement.

f If the oil cooler pressure becomes too high, the oil cooler relief valve will open to dump scavenge oil directly into the oil tank.

5 Lubrication System Schematic

Frame # 0475 (Lubrication System Schematic Flash)



a Oil flow is drawn from the oil tank by the lubrication and scavenge pump.

b From the pump, pressurized oil flows through the oil filter and into the cored passages in the accessory gearbox.

c Inside of the gearbox the oil divides and flows to the A, B, and C sumps and to the gearbox.

d Scavenge oil from the lubrication and scavenge pump then flows through the electrical chip detector.

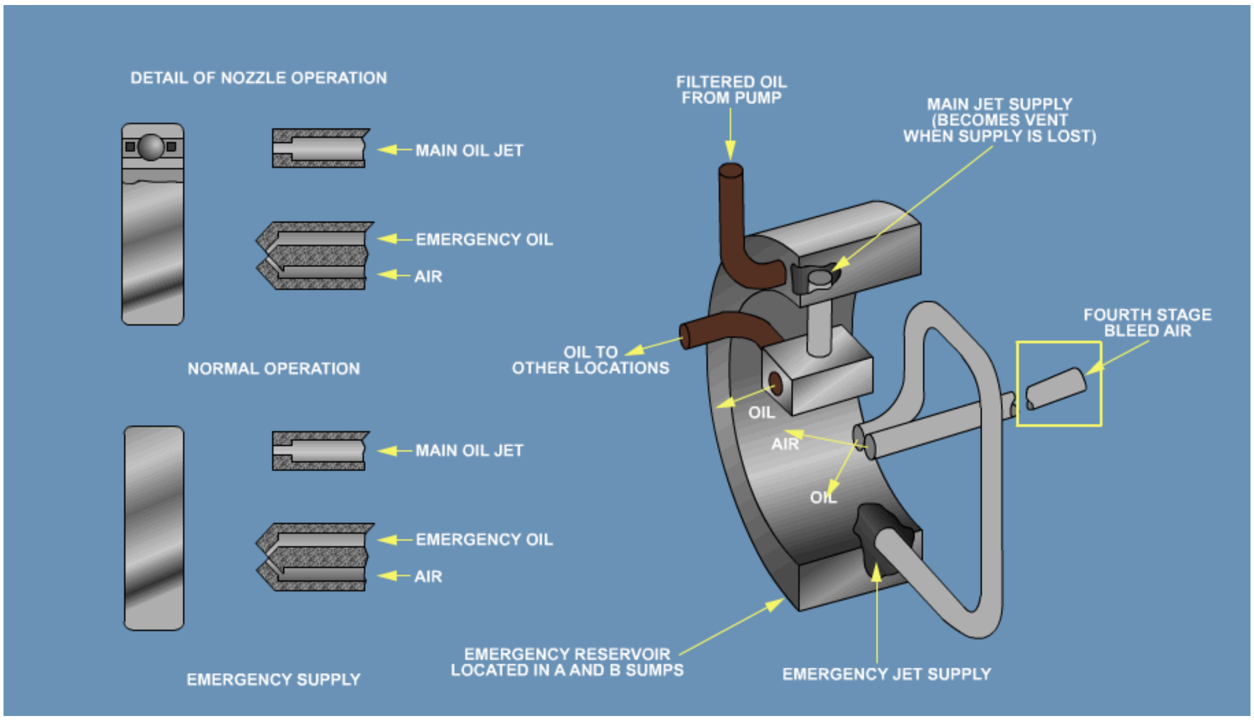
e From there the oil flows through the oil cooler and into the main frame.

f Scavenge oil enters a manifold at the top of the main frame.

g The oil then flows through the scroll vanes and back to the oil tank.

6 Normal and Emergency Sump Oil Distribution

Frame # 0480 (Normal and Emergency Sump Oil Distribution FLASH)



a In the event of oil system failure, the bearings will be lubricated by an oil mist from the emergency oil system.

b A small reservoir, curved to fit the A- and B-sumps, retains a sufficient amount of oil to provide air-oil mist when normal lubrication is interrupted.

c Oil from these reservoirs passes through the primary oil nozzles and the oil mist nozzle to lubricate the bearings.

d When oil pressure is lost, the oil mist nozzles continue to supply oil from the reservoirs to the A and B-sump bearings.

e The emergency oil system is intended to maximize the time an engine can operate at reduced power conditions with partial loss of oil.

f The total sump oil supply is fed into the reservoir at the top.

g Top feed prevents reservoir drainage if the supply line is damaged.

h Primary oil jets squeeze film damper, and uncritical lube jets are connected to a standpipe at the top of the tank.

i Secondary or emergency jets are similarly connected to the lowest point in the tank.

j Secondary jets are located only at points where lubrication is vital for short duration emergency operation.

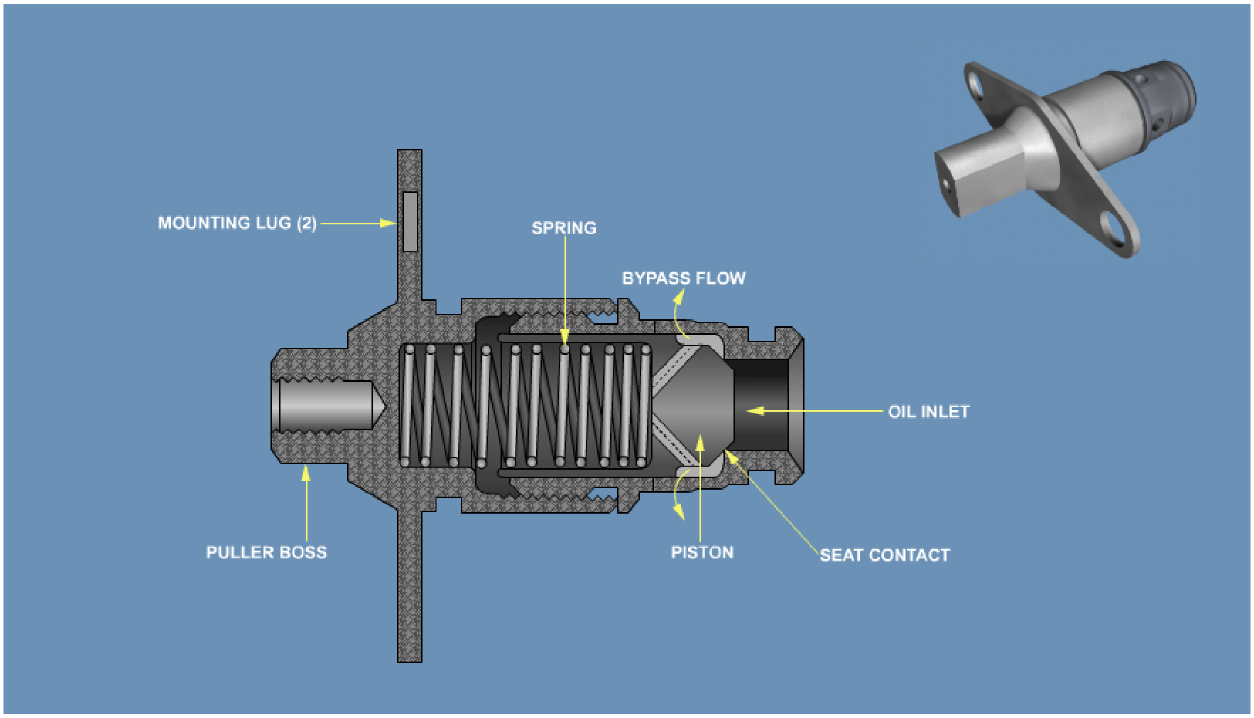
k Each secondary oil jet has a companion air jet or air source, which flows over the end of the oil jet and impinges on the lubricated part.

l The air jets aspirate oil mist when normal oil supply pressure is lost.

m They are pressurized from the seal pressurization cavities and operate continuously with no valving required.

7 Cold Oil Relief Valve

Frame # 0485 (Cold Oil Relief Valve)



a The cold-oil relief valve mounts on the front of the accessory gearbox downstream of the oil filter.

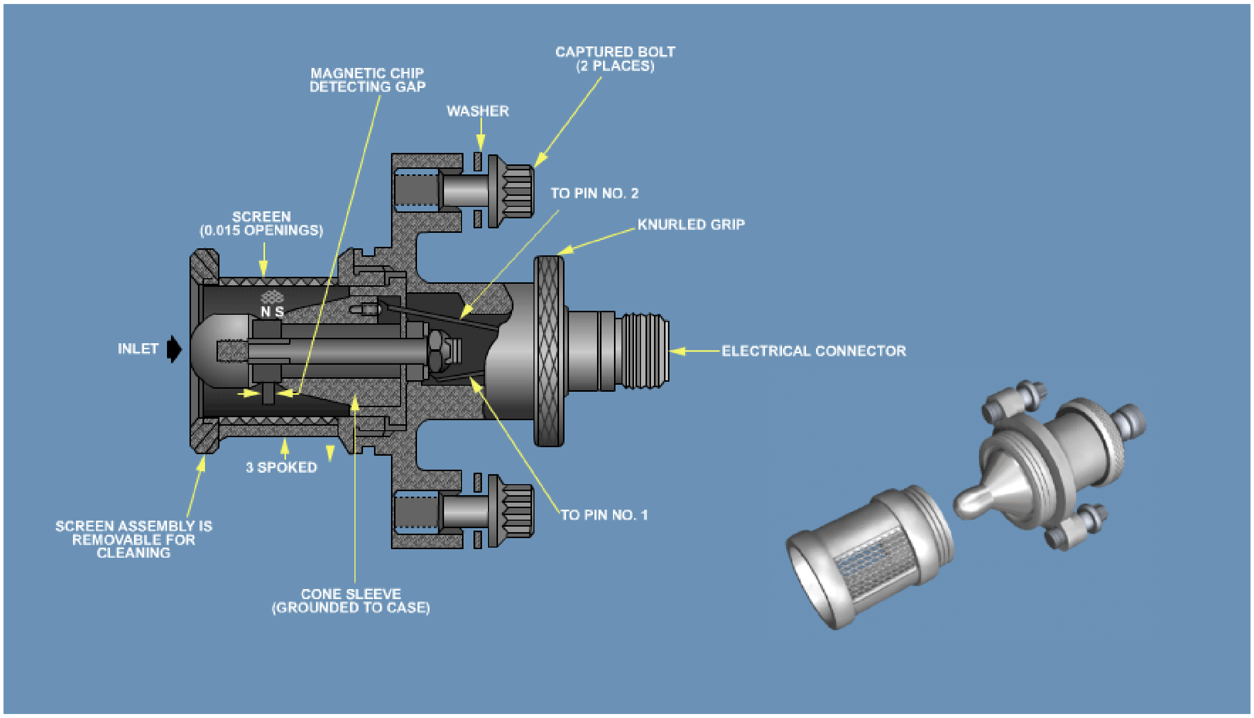
b The valve protects the oil supply system from excessive pressure.

c During cold starts, the valve opens and discharges excess oil to the gearbox.

d The oil discharged to the gearbox is churned in the gears to assist in reducing warm-up time.

8 Chip Detector

Frame # 0490 (Chip Detector)



a The engine diagnostic device most likely to provide first warning of impending part failure is the chip detector in the common scavenge line from all sumps.

b The chip detector mounts on the front of the accessory gearbox.

c The chip detector has an outer shell with an internal magnet, an electrical connector, and a removable screen.

d The magnet attracts magnetic particles to the detector.

e When these particles bridge the gap between the magnet and the outer shell, a circuit is completed which illuminates the CHIP #1 ENGINE or CHIP #2 ENGINE chip detector caution light in the cockpit.

f Non-conductive particles are trapped inside the screen, for visual examination, if greater than a 0.015-inch minimum dimension.

g Smaller particles will be found either in the lube tank or in the lube supply filter.

h The detector housing pushes into the accessory gearbox and is retained by two captive bolts used in common with other accessories.

i Self-locking inserts in the gearbox ensure retention of these bolts if assembly torque is improperly low.

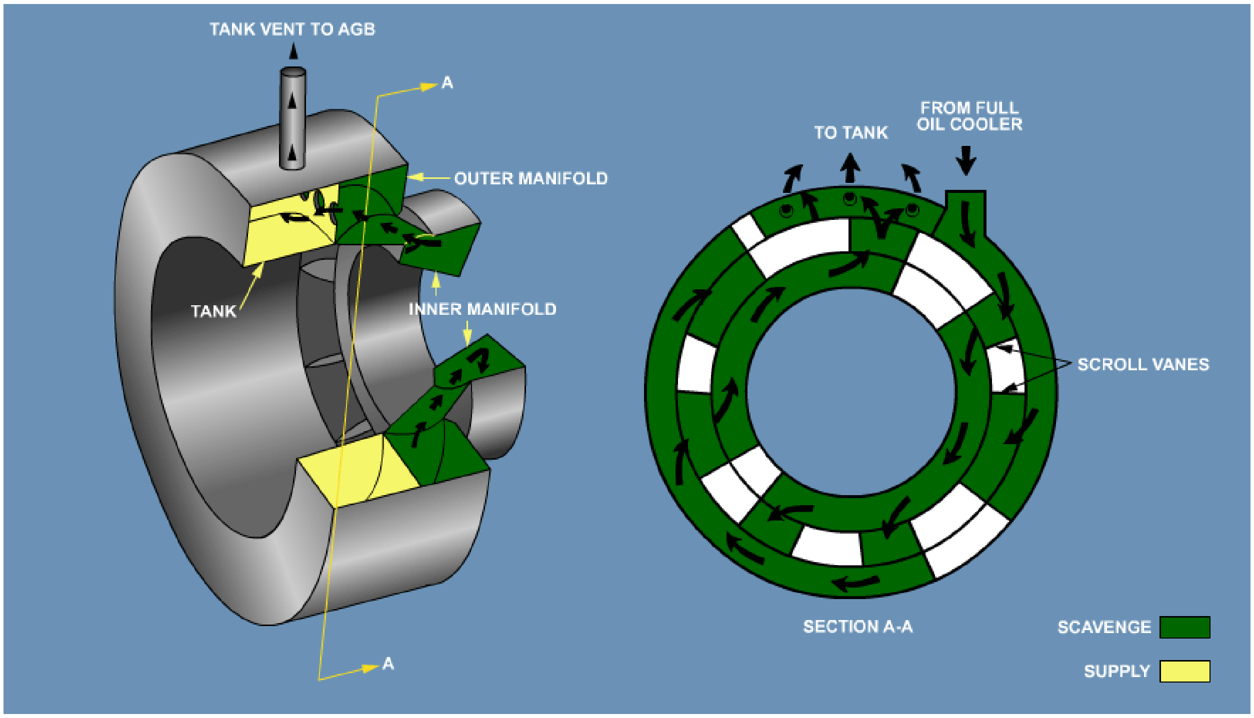
j Removal of the unit from the AGB housing bore is manual following release of the two bolts.

k A knurled grip is provided to facilitate removal.

l The external body diameter fits a 15/16-inch open-end wrench so that this tool can be used as a handle, if necessary, for a two-hand grip.

9 Mainframe Oil Flow

Frame # 0495 (Mainframe Oil Flow)



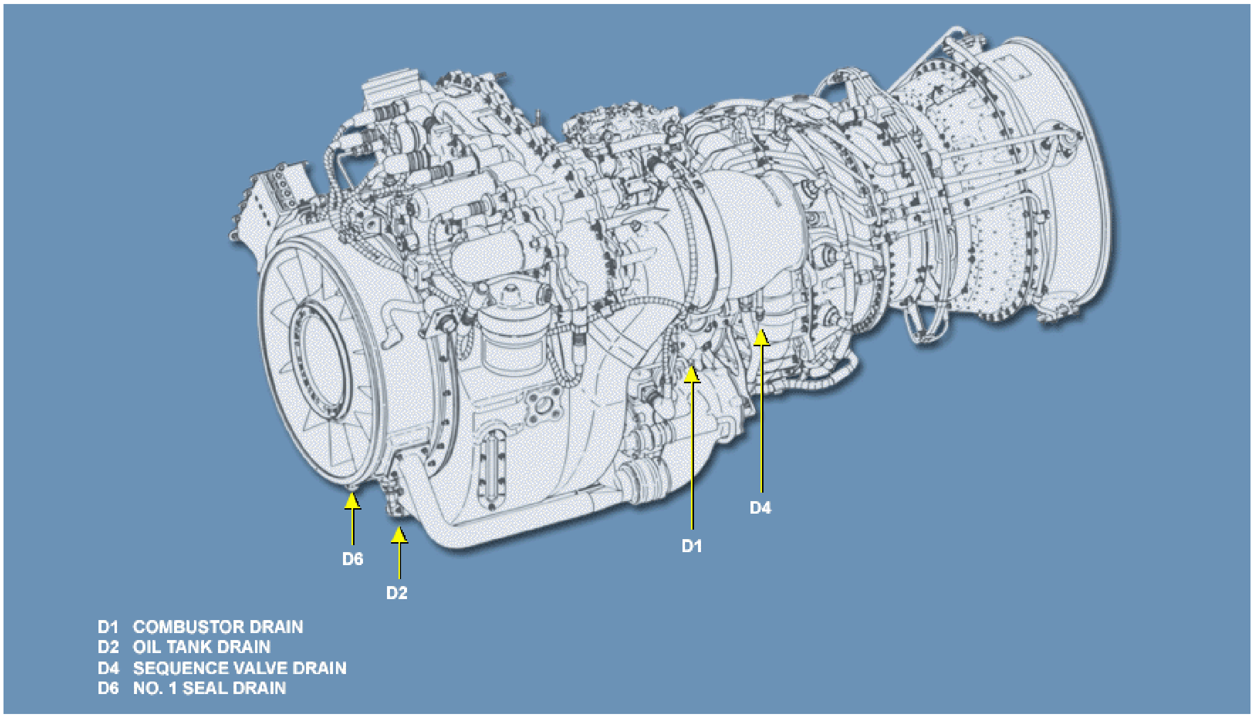
a The mainframe includes the oil tank.

b Cored passages within the mainframe provide for the flow of oil to and from the A-sump area and the accessory gearbox.

c Hot oil from the bearing sump areas provide for the anti-icing of the mainframe by flowing through each of the hollow scroll vanes prior to returning to the oil tank.

10 Drain System-Left Side

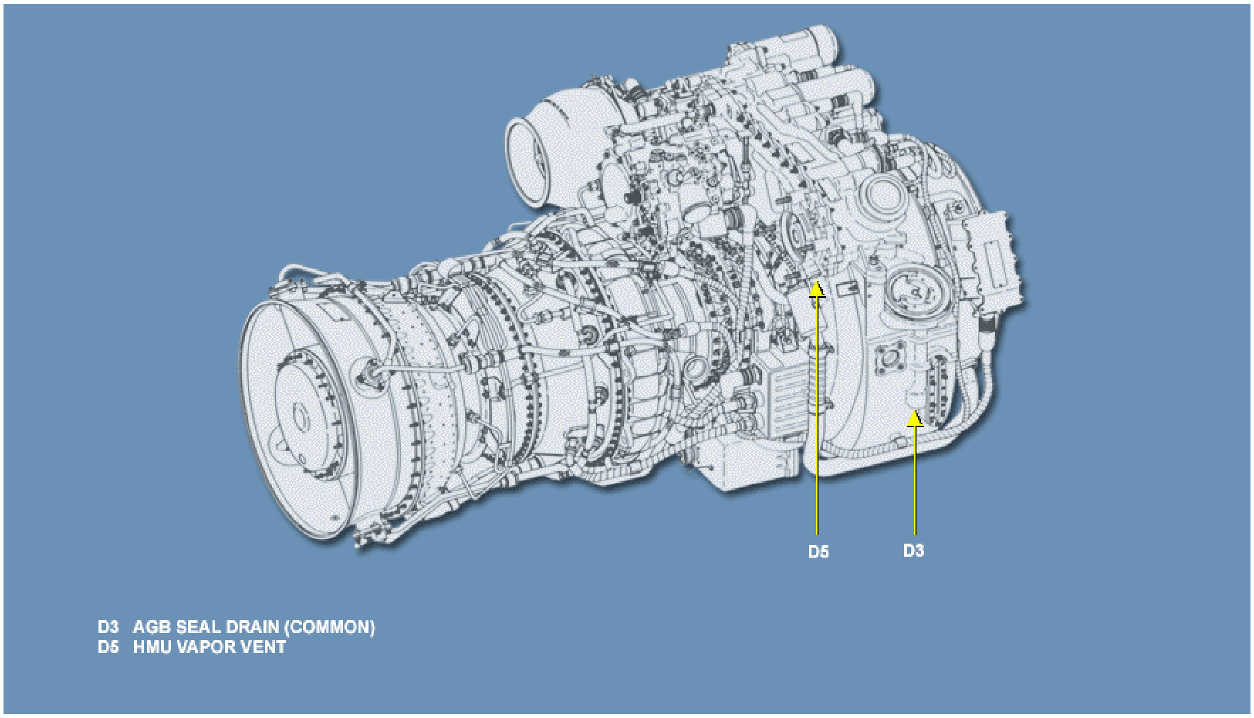
Frame # 0500 (Drain System Left Side)



a D1 (Combustor drain) drains residual fuel from the combustion section, D2 (Oil tank drain) used to drain oil from the oil tank, D4 (Sequence valve drain) drains the Overspeed and Drain Valve, D6 (No. 1 seal drain) drains the No. 1 carbon seal area.

11 Drain System Right-Side

Frame # 0501 (Drain System Right Side)

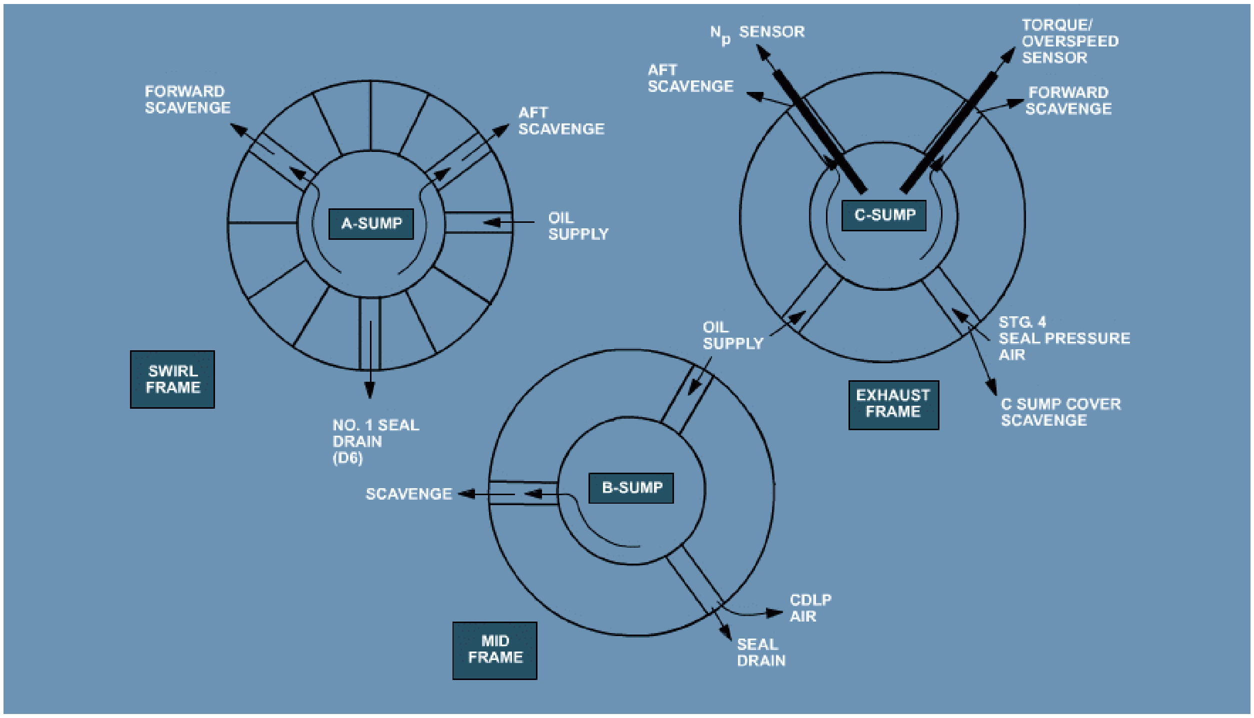


b D3 (AGB common seal drain) drive pad seals for the starter, HMU, and fuel boost pump, all drain into a common cored passage in the AGB housing, and drain to an external port on the right-hand side of the main frame.

c D5 (HMU vapor vent) vents HMU vapors overboard.

12 Frame Strut Usage

Frame # 0505 (Frame Strut Usage)



a Oil enters the A-sump through the strut at the 3 o'clock position on the swirl frame.

b The A-sump forward and aft scavenge lines are housed in the struts at the 10 o'clock and 2 o'clock positions on the swirl frame.

c Oil is supplied to and scavenged from the A-sump entirely through these internal lines.

d Oil enters the B-sump through a tube in the strut at the 1 o'clock position on the midframe.

e Oil is scavenged from the B-sump through a tube in the strut at the 9 o' clock position on the midframe.

f Oil flows to the C-sump through a supply tube at the 7:30 o'clock position on the exhaust frame.

g Oil is scavenged from the C-sump through the C-sump forward scavenge tube at the 2 o'clock position, the aft scavenge tube at the 10 o'clock position, and through the seal pressure and scavenge tube assembly at the 4:30 o'clock position on the exhaust frame.

CHECK ON LEARNING

1. What are the three subassemblies that make up the oil filter?

2. The scavenge screens collect particles before they enter the ________.

3. Where does the scavenge oil flow to after it goes through the scroll vanes?

SECTION VI. -SUMMARY

1. REVIEW/SUMMARIZE:

You have completed the UH-60 Lubrication System topic.
The key points to remember are:

- The lubrication system in the T700 engine distributes oil to all lubricated parts, and in emergencies, supplies an air-oil mist to the main shaft bearings in the A- and B-sumps. The system is a self-contained, recirculating dry sump system.
- The lubrication system consists of the following components: lubrication and scavenge pump, scavenge screens, oil cooler, cold oil relief valve, oil cooler relief valve, chip detector, filter bypass sensor switch, oil filter, and the oil filter bypass valve.
- The oil filter consists of three subassemblies; the filter element, bowl and impending bypass indicator, and the bypass valve and inlet screen.
- The oil filter consists of a stainless steel bowl with an impending bypass indicator, a throw away filter element, and a bypass valve assembly.
- Differential pressure between the oil filter inlet and the outlet act to move a piston against a spring at 44 to 60 psi. The impending bypass indicator button is released when the piston moves and extends 3/16 inch for a visual indication. When the button is released, a small ball moves out of position to latch the button and block reset.
- The lubrication and scavenge pump is a gerotor-type pump of cartridge design and is located on the forward side of the accessory gearbox.
- There are six scavenge screens located on the front of the accessory gearbox. The screens collect particles before they enter the scavenge sections of the lubrication and scavenge pump.
- The fuel-oil cooler is located on the forward side of the accessory gearbox. The fuel-oil cooler transfers heat from the oil to the fuel.
- Oil is drawn from the oil tank by the lubrication and scavenge pump and delivered to all lubricated parts of the lubrication system.
- In the event of a system failure, the bearings will be lubricated by an oil mist from the emergency oil system.
- The cold-oil relief valve mounts on the front of the accessory gearbox downstream of the oil filter. The valve protects the oil supply system from excessive pressure.
- The engine diagnostic device most likely to provide first warning of impending part failure is the chip detector. The chip detector mounts on the front of the accessory gearbox.
- The mainframe includes the oil tank. Cored passages within the mainframe provide for the flow of oil to and from the A-sump area and the accessory gearbox. Anti-icing for the mainframe is provided by flowing hot oil through the hollow scroll vanes.
- The T700 drain system consists of the following drains: D1-Combustor drain, D2-Oil tank drain, D3-AGB seal drain (common), D4-Sequence valve drain, D5-HMU vapor vent, D6-No. 1seal drain.

E. ENABLING LEARNING OBJECTIVE No. 5

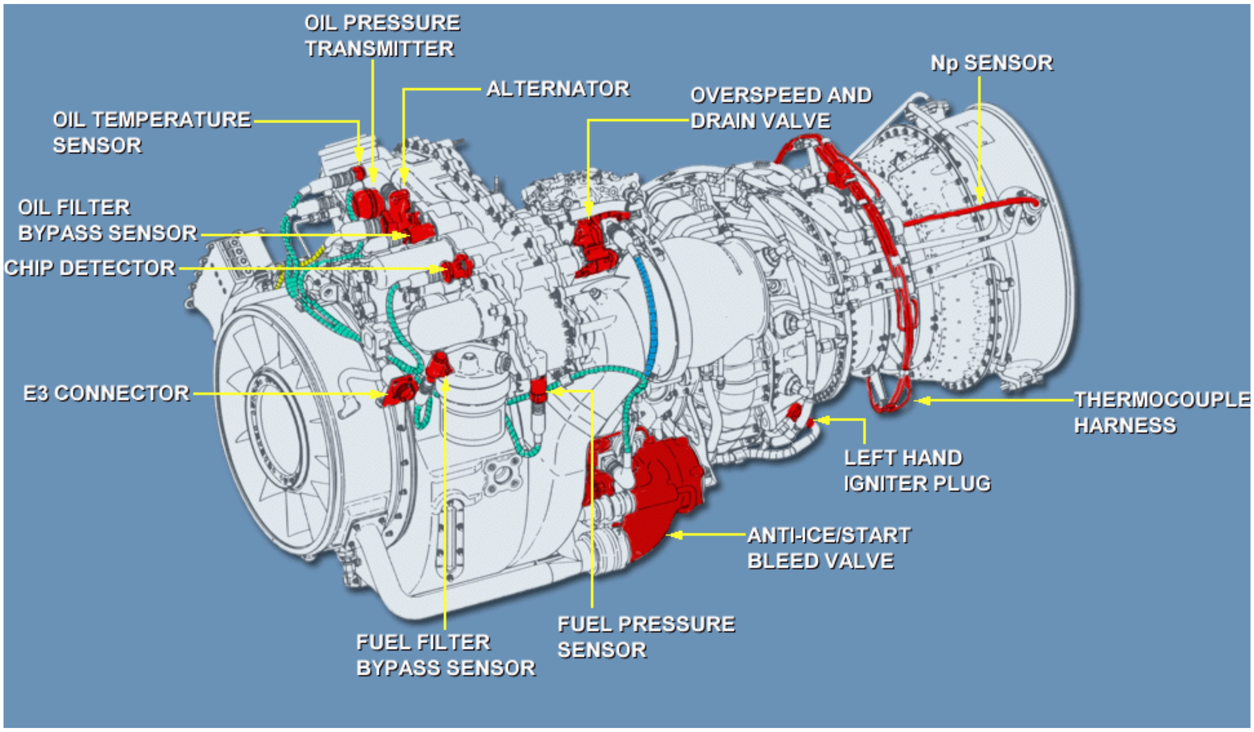
ACTION: Identify the characteristics of the electrical system.

CONDITION: Using TM 1-2840-248-23

STANDARD: IAW TM 1-2840-248-23

a. T700 Electrical System

Frame # 0529 (Electrical System Components Left Side)



(1) The T700-GE-701C engine uses electrically operated accessories to control anti-icing airflow, ignite the fuel-air mixture in the combustor, and control the engine power level.

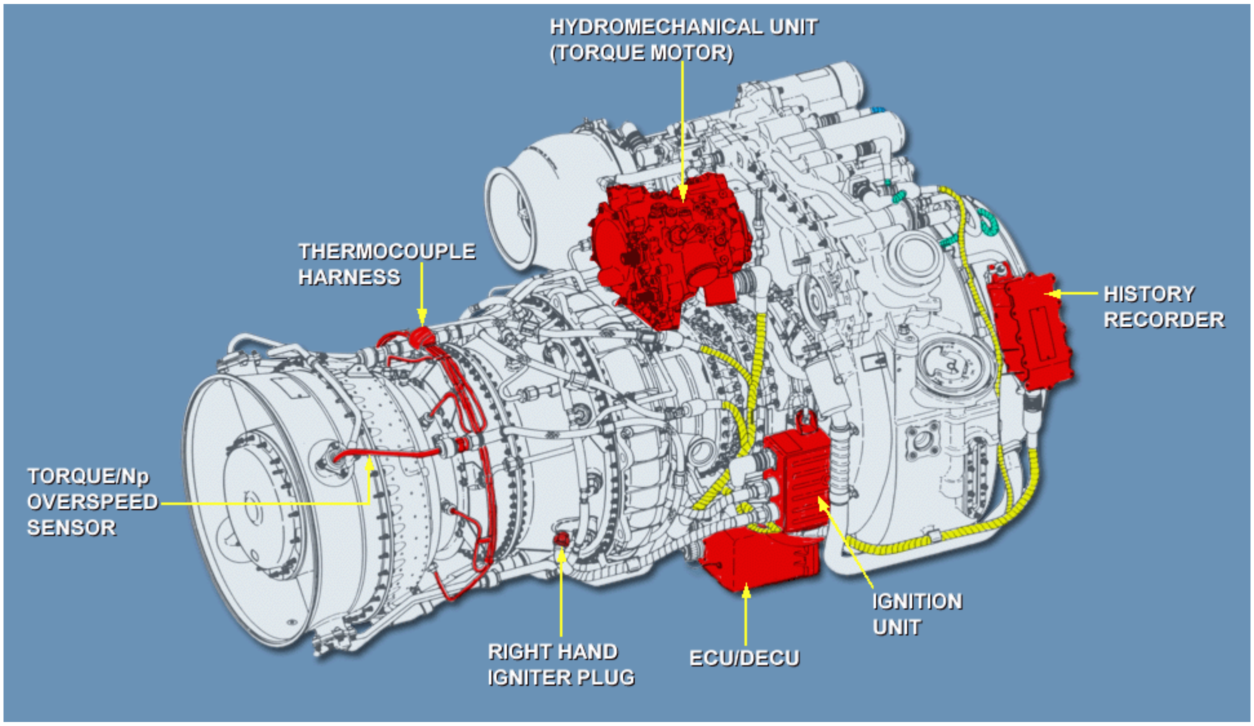
(2) In addition, electrical indication and warning devices assist the pilot in engine operation.

(3) The electrical system provides: all electrical power required for engine ignition and all electrical control requirements throughout the operating range of the engine without the use of airframe power; interconnecting harnesses between engine electrical and diagnostic components; an accurate and stable trimming signal to the HMU to isochronously govern power turbine speed, limit maximum TGT, and share the load between engines; and an Np overspeed limiting system.

(4) This overspeed limiting system provides that no single failure of the overspeed system can cause fuel flow to be reduced.

(5) Ground checking capability for the Np overspeed system is also provided.

Frame # 0529a (Electrical System Components Right Side)

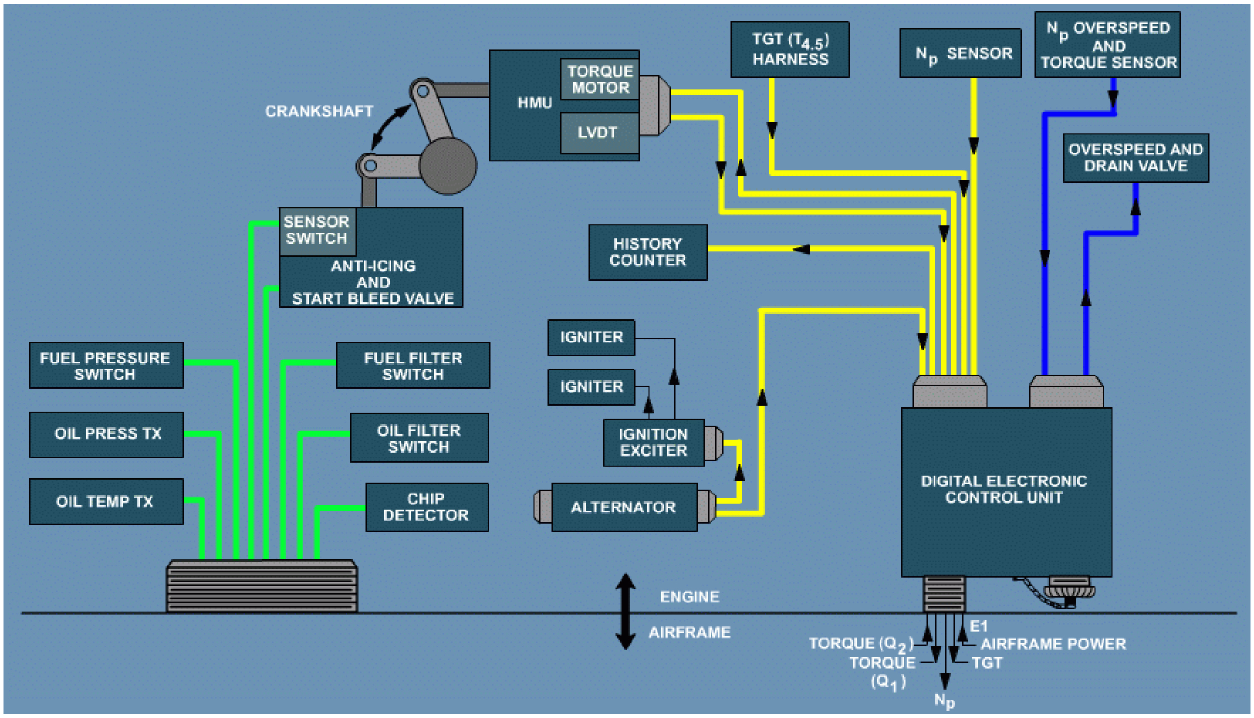


(6) The electrical system also provides: engine ignition during starting; cockpit signals of gas generator speed (Ng), power turbine speed (Np), engine shaft torque (Q), power turbine inlet temperature (TGT), fuel and oil pressure, and oil temperature.

(7) Cockpit display of failure codes is provided on the aircraft torque meter at engine shutdown.

(8) Also provided are: history counter signals of Ng (for LCF1 and LCF2) and T4.5 (for time-temperature counting); and an engine shaft torque signal for use in the load-sharing circuit and hot start prevention.

Frame # 0530 (Electrical Connection Diagram)



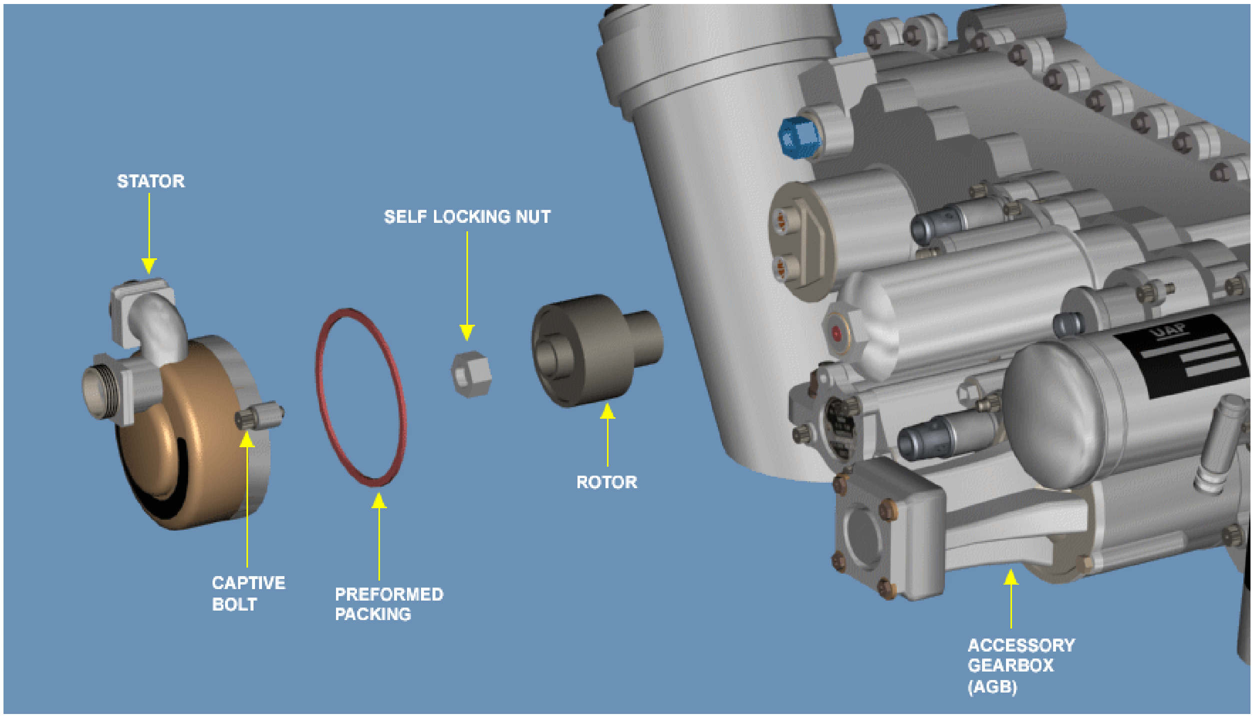
(9) Interconnecting wiring harnesses are color-coded to aid the mechanic.

(10) The yellow harness supplies power and control system trim signals.

(11) The blue harness transmits all overspeed and torque signals, and the green harness conducts engine diagnostic signals.

(a) Alternator

Frame # 0535 (Alternator)



1) The engine-supplied electrical alternator is mounted on the forward face of the Accessory Gearbox (AGB), on the right-hand side.

2) It supplies AC power to the ignition exciter and Digital Electronic Control (DEC) unit or Electrical Control Unit (ECU)..

3) It also supplies an Ng speed signal to the cockpit tachometer.

4) All essential engine functions are powered by the alternator.

5) The alternator rotor is mounted on a cantilevered shaft extending from the gearbox.

6) The rotor contains a set of permanent 12 magnets.

7) The stator housing encloses the rotor and is bolted to the gearbox case.

8) It contains three separate sets of windings for its three functions:

a) Ignition power

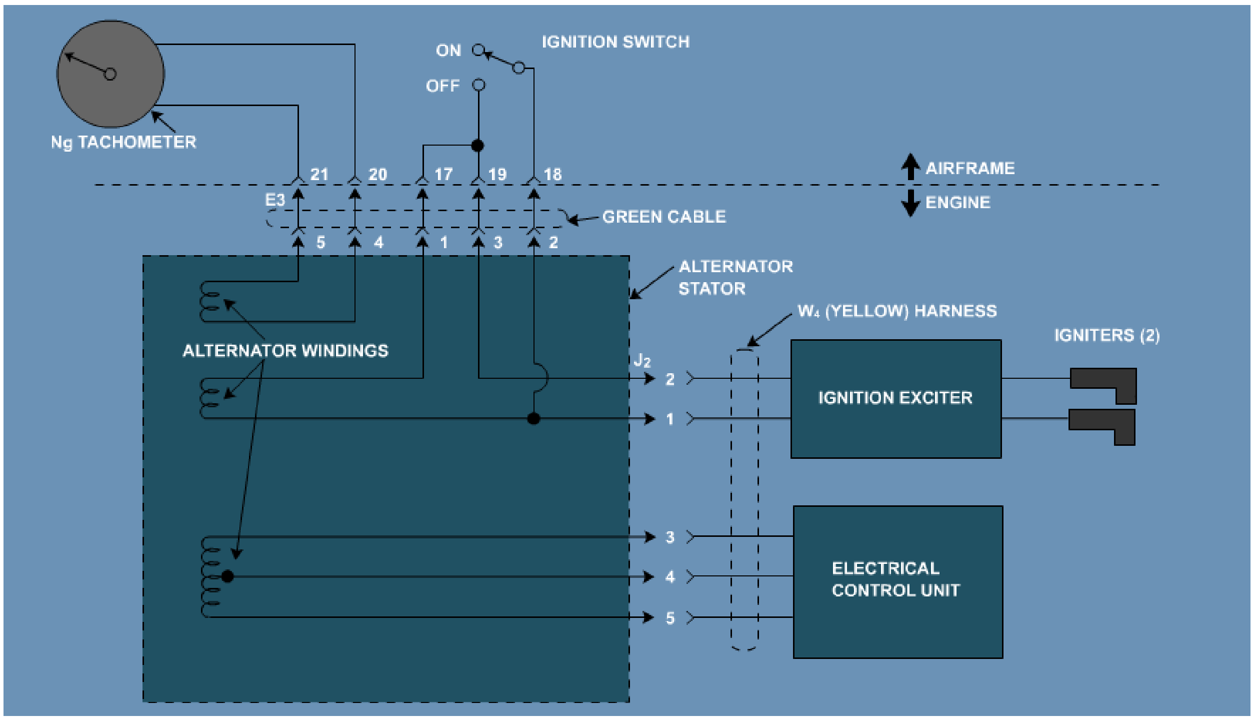
b) DECU/ECU power

c) Ng signal.

9) The mounting bolts are captive in the stator housing to simplify maintenance.

10) Alternator Schematic Diagram

Frame # 0540 (Alternator Schematic Diagram)



a) The upper left electrical connector of the alternator conducts power to the airframe Ng tachometer and ignition switch.

b) The forward connector of the alternator conducts power to the digital electronic control unit and the ignition exciter.

c) The upper left outlet is connected to the "E3" (interface) connector, conducting power to the airframe cockpit for Ng tachometer indication and ignition switch power.

d) The first winding, the Ng signal, is a constant amplitude frequency wave form furnished for engine rpm.

e) The second winding supplies power to the ignition exciter by way of the yellow harness.

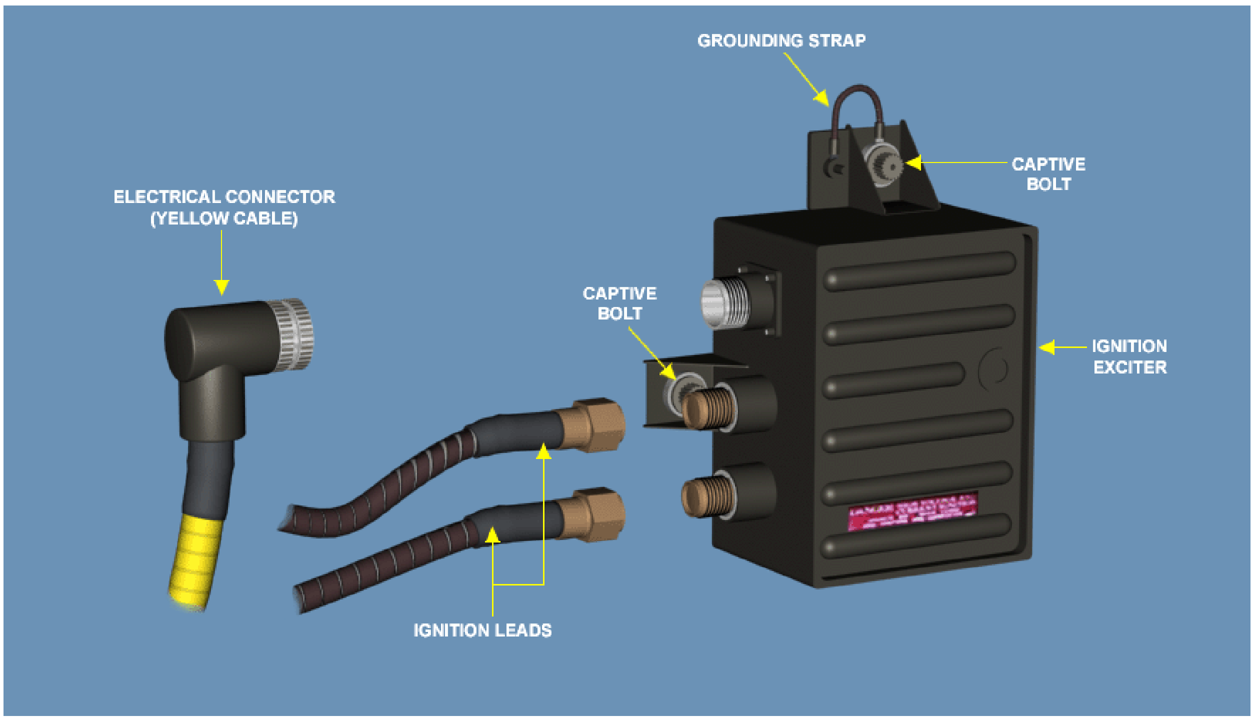
f) One of the leads from this winding passes through the cockpit ignition switch (shown in the "on" position).

g) The pilot controls this circuit to the "off" position by shorting out the ignition winding.

h) The third winding supplies power to the DEC/ECU also by way of the yellow harness.

(b) Ignition System

Frame # 0545 (Ignition System)



1) The ignition system is an AC-powered capacitor discharge, low-voltage system.

2) It includes a dual exciter unit mounted on the right hand side, and two igniter plugs.

3) The spark rate of each ignition circuit is two sparks per second minimum.

4) Energy at the igniter plugs is at least 0.45 joules per spark.

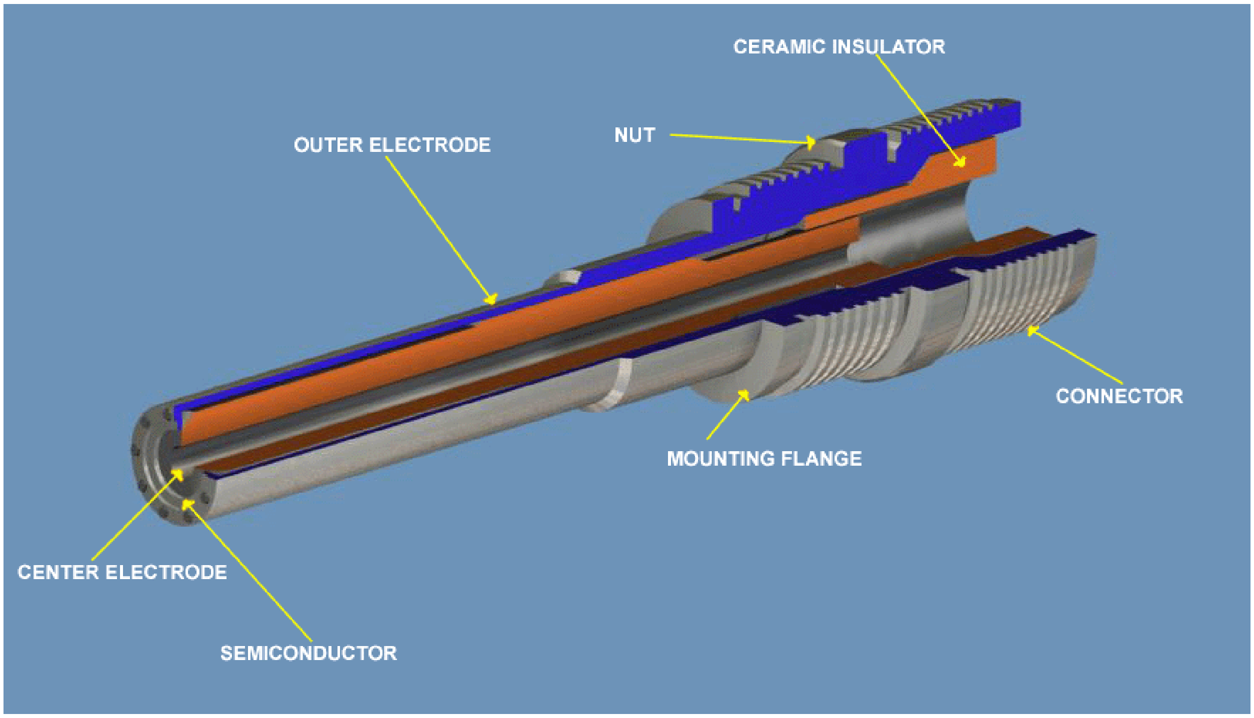
5) The exciter is powered by one winding of the engine alternator, and is connected to it by the yellow harness.

6) The ignition system must be turned off after starting by shorting the alternator output.

7) For normal starting, the aircraft ignition circuit is tied in with the aircraft starting system to de-energize the ignition system at the starter/dropout speed.

a) Igniter Plug

Frame # 0550 (Igniter Plug)



1 The igniter plug is a homogeneous semiconductor, surface-gap-type spark plug utilizing air-cooling of the firing tip.

2 It provides a projected electrical discharge for light off of the combustor.

3 The engine utilizes two igniters located at the 4 and 8 o'clock position.

4 They are mounted in the mid frame using a drop-in boss retaining nut and extend inward through the outer panel of the combustion liner.

5 The ignition system operates with a maximum output of 7000 volts.

6 To create a spark across the electrode gap with this voltage, the gap surface is a semiconductor material in the form of a homogeneous button extending into the tip of the plug.

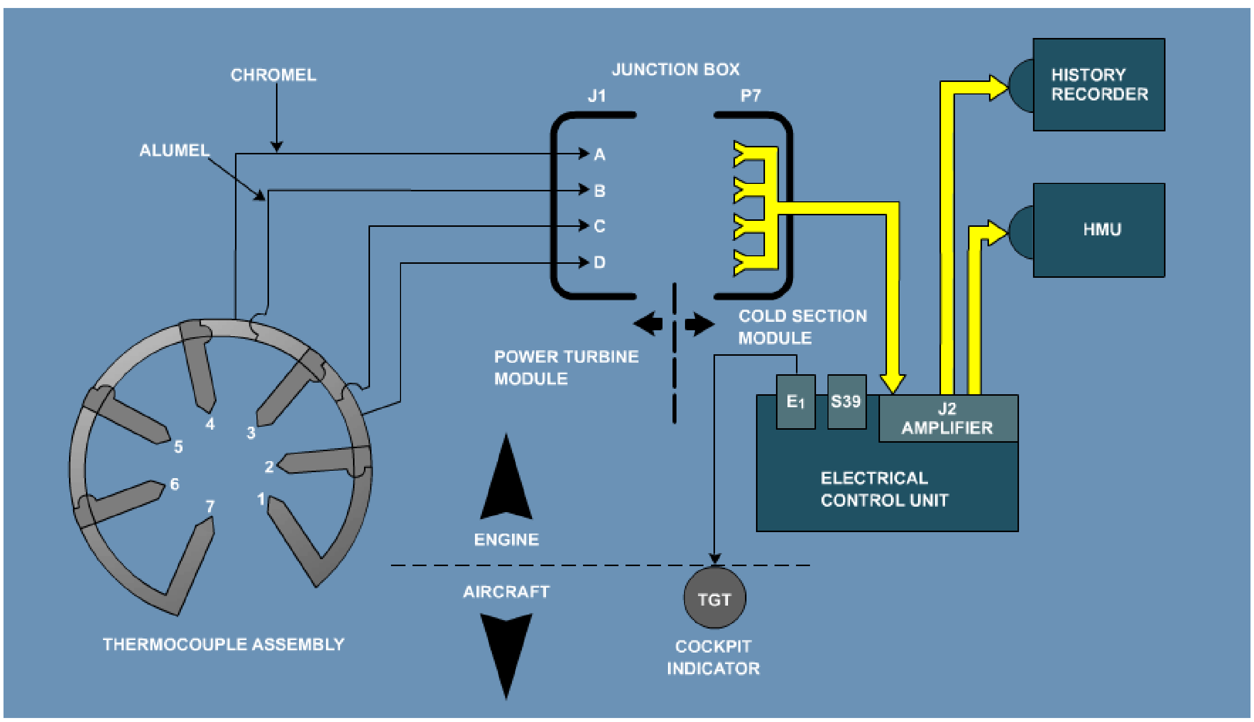
7 It is capable of coping with erosion over a long period of operating time.

8 The center electrode is pure tungsten and the outer electrode is tungsten alloy.

9 These electrodes are nickel-plated to prevent oxidation, a problem further minimized through six holes around the tip body and exits through twelve holes at the tip end.

(c) Temperature Control and Indication System

Frame # 0555 (Temperature Control and Indication System)



1) The thermocouple harness is a one piece assembly consisting of seven single immersion, equally spaced thermocouples for measuring power turbine inlet gas temperature (TGT).

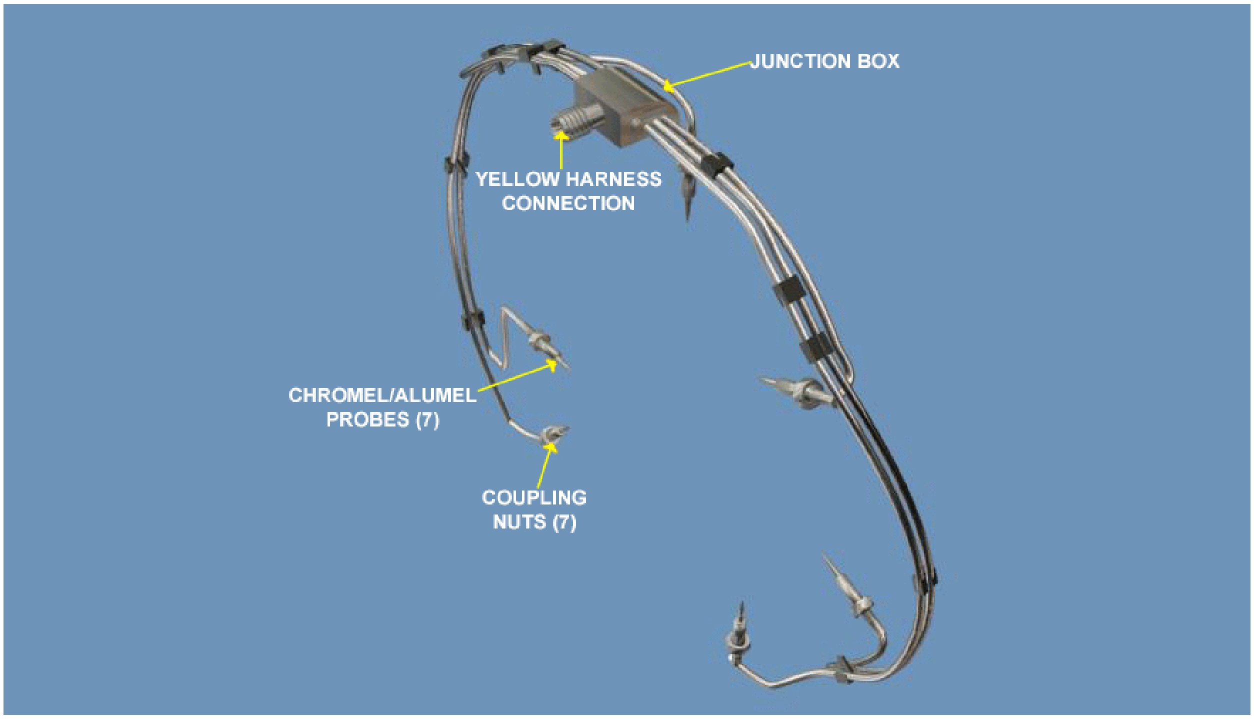
2) The thermo elements are made from special tolerance, oxidation resistant, chromel-alumel wire.

3) Each thermocouple junction is sealed with a Hastelloy X sheath.

4) The thermo element for the junction of each probe is continuous, without joints or splices, from the junction to the harness output connector junction box where all output are paralleled.

5) The harness output connector is hermetically sealed and has two alumel contacts and two chromel contacts.

Frame # 0555 (Temperature Control and Indication System)

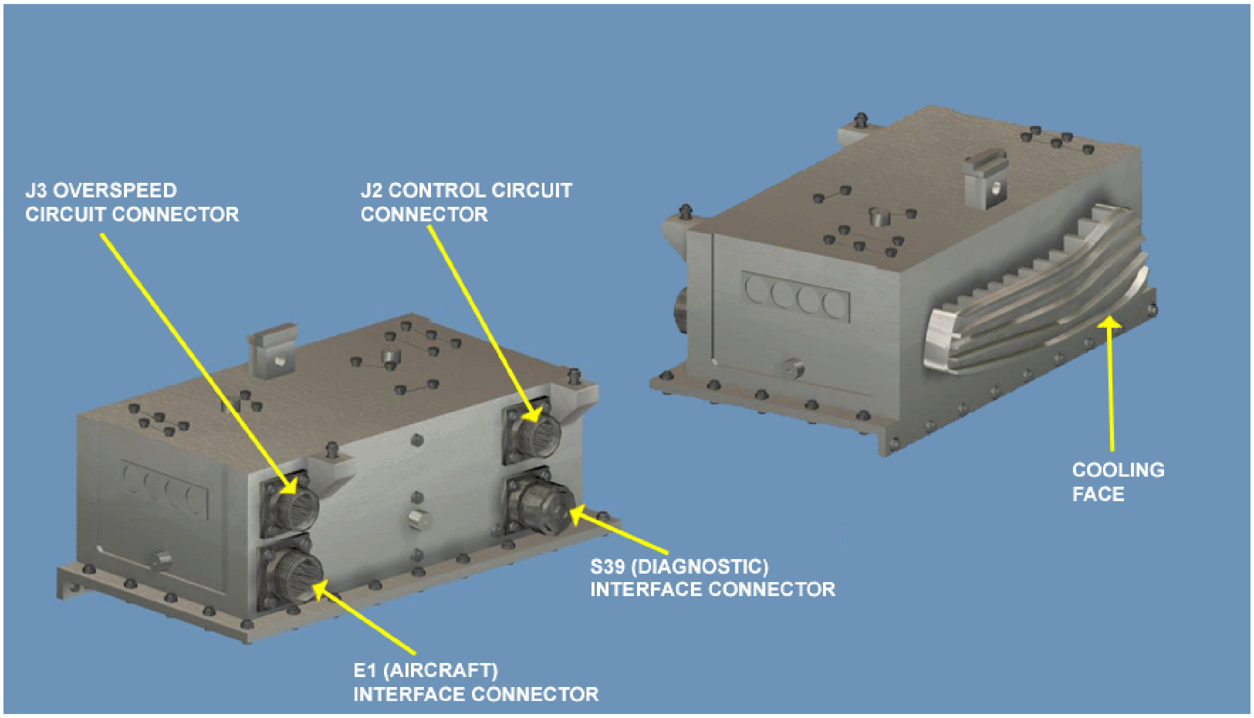


6) The average output of the seven probes provides the temperature signal to the DEC/ECU via the yellow cable.

7) From the DEC/ECU, this signal is relayed to the cockpit TGT indicator, and to the history counter.

(d) Electrical Control Unit

Frame # 0565 (Electrical Control Unit)



1) The Electrical Control Unit (ECU) operates with the history recorder, and the DEC operates with the history counter.

2) Both installed engines must have the same combination of components.

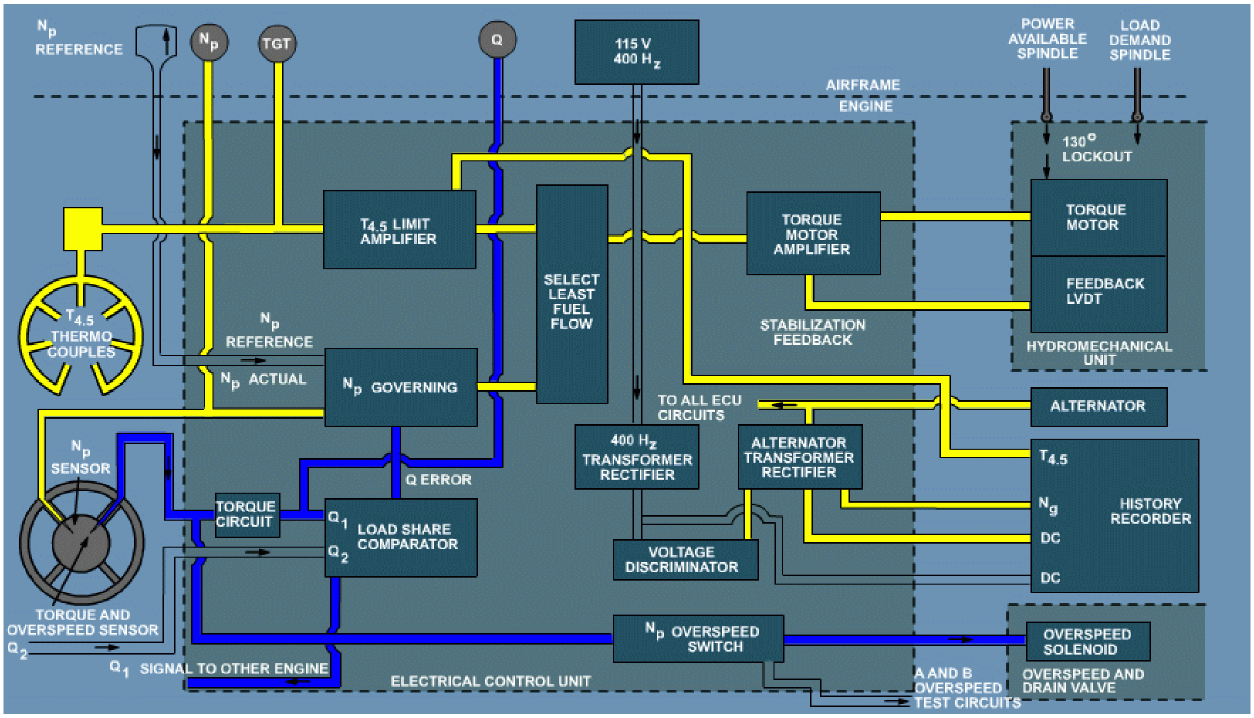
3) The Digital Electronic Control Unit (DEC) is a solid-state device mounted below the compressor casing and is cooled entirely by airflow through the scroll case.

4) Connector designations are S39, E1, J2, and J3.

5) The functions of the four connectors and the DEC are as follows: Connector S39 - this connector is used for troubleshooting the engine or electrical control system while the aircraft is on the ground.

6) The aircraft cable attaches to Connector E1; Connector J2 is for the yellow cable and the cable carries signals between the DEC, speed sensor, HMU, thermocouple assembly, history counter, and alternator; Connector J3 is for the blue cable and the cable carries signals between the torque and overspeed sensor, the DEC, and the ODV.

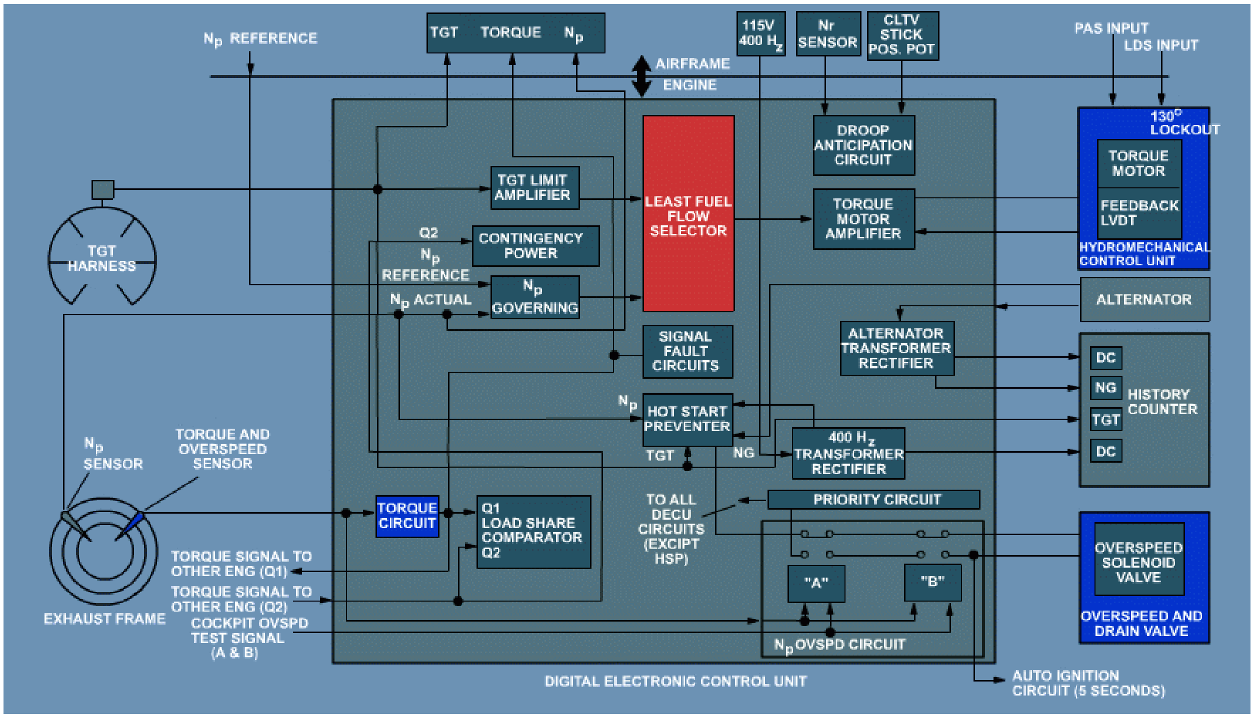
Frame # 0570 (Electrical Control Unit Schematic)



7) The ECU is located on the bottom aft side of the scroll case.

8) The ECU provides Np governing, TGT limiting, Np overspeed protection, and load-sharing between the engines.

Frame # 0575 (DECU Block Diagram)



9) The Digital Electronic Control Unit (DECU) provides additional features such as: contingency power, hot start prevention, and fault indication.

10) The DEC contains signal validation for selected input signals within the electrical control system.

11) Signals are continuously validated when the engine is operating at flight idle and above.

12) If a failure has occurred on a signal, the failed component or related circuit will be identified by a pre-selected fault code.

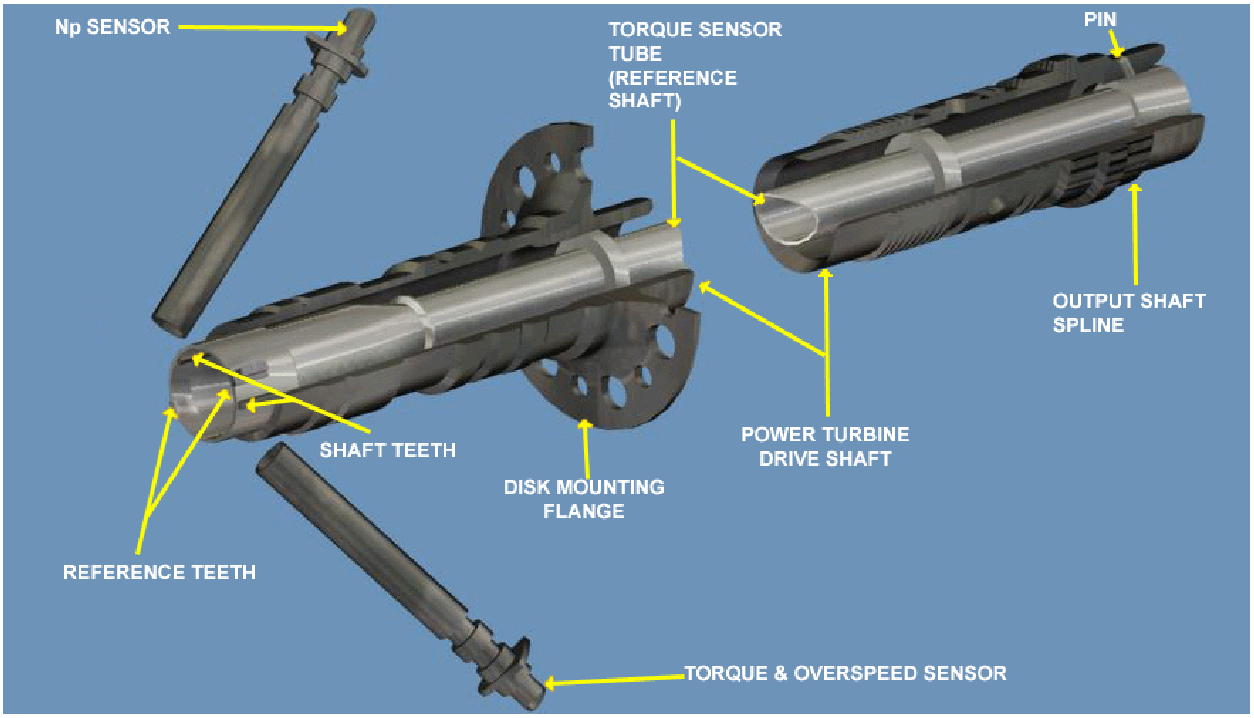
13) It is possible to have more than one fault detected.

14) Each code should be treated as an individual fault.

15) It should be noted that the signal validation does not recognize aircraft instrument failure.

(e) Power Turbine (Np) Sensors

Frame # 0580 (Power Turbine (Np) Sensors)



1) Two Np Sensors are located in the exhaust frame; one extends through the 1:30 o'clock strut, and the other through the 10:30 o'clock strut.

2) The power turbine shaft is equipped with two pairs of teeth, which induce electrical pulses in the Np sensors.

3) These teeth permit measurement of the torsion or twist of the shaft, which is proportional to output torque.

4) The sensors are identical and interchangeable, but serve different functions.

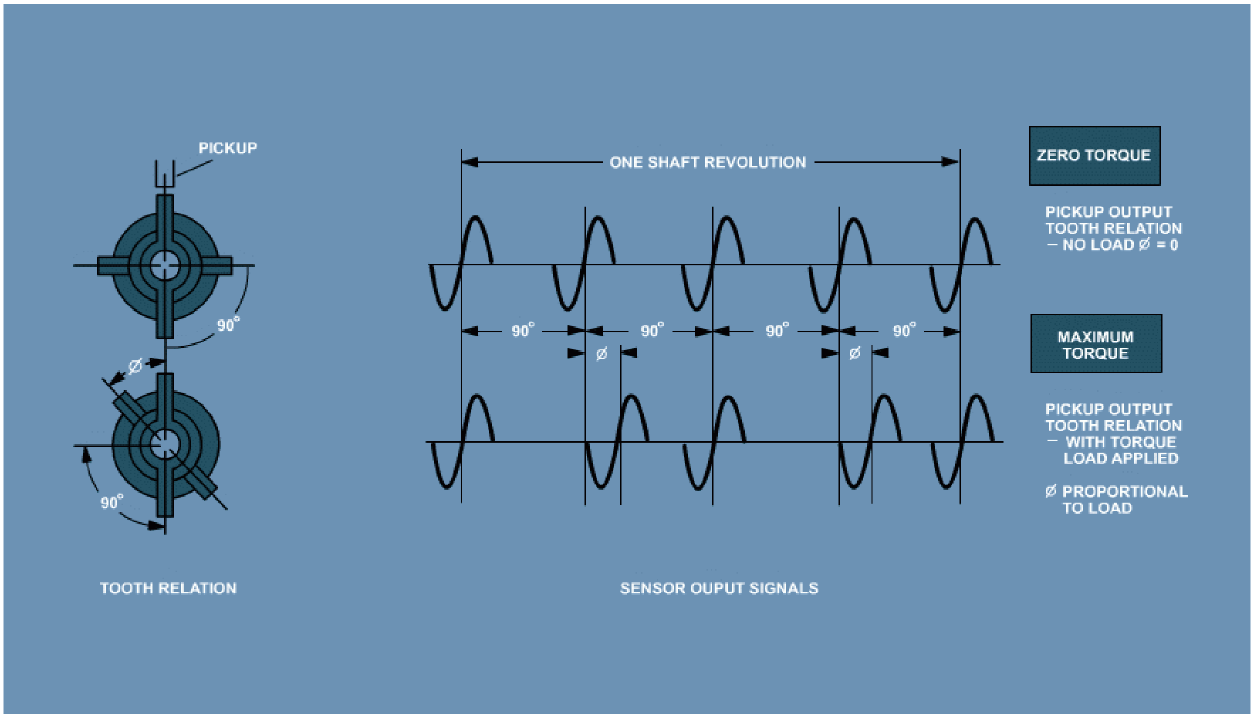
5) The left-hand (10:30 o'clock) sensor provides a Np signal to the DEC to be utilized in the Np governing circuitry and for generation of a cockpit tachometer signal.

6) The right-hand (1:30 o'clock) sensor feeds the torque computation circuit of the DEC and the Np overspeed protection system.

7) The sensors contain a permanent magnet and wire coil, and produce a pulse of current each time a shaft or reference tooth passes.

(f) Torque Sensor Operation

Frame # 0585 (Torque Sensor Operation)



1) The torque system matches torque between engines, and provides cockpit readout.

2) Torque sensing (or measurement) is accomplished by a reference shaft that is pinned to the front end of the drive shaft and extends to the aft end, where it is free to rotate relative to the drive shaft.

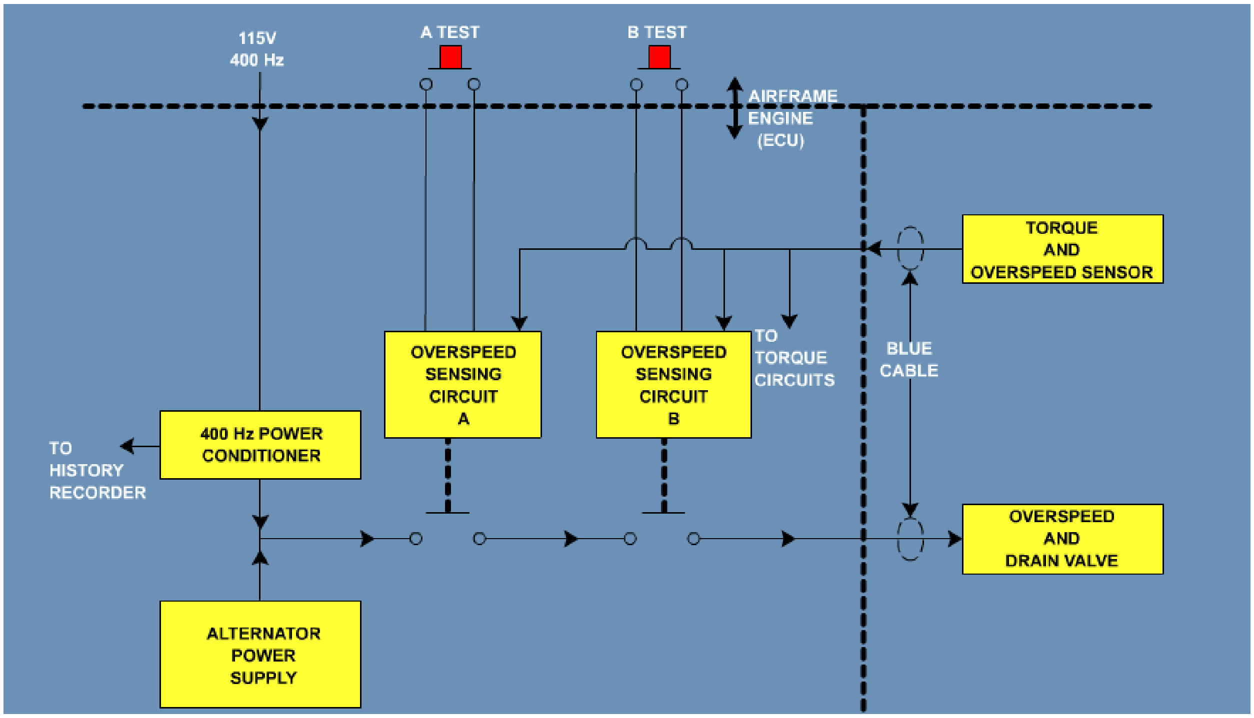
3) The relative rotation (or twist of the driveshaft) is due to output torque, and the resultant phase angle shift between the drive shaft teeth and reference teeth is electrically sensed by a pickup sensing the two teeth on the drive shaft plus the two reference teeth.

4) The electrical signal is conditioned in the electrical control unit, which provides a DC voltage proportional to torque.

5) At Intermediate power, the twist of the shaft is 7.4 degrees.

(g) Np Overspeed System

Frame # 0590 (Np Overspeed System)



1) The power turbine rotor is protected from destructive overspeed by an overspeed system.

2) This system is completely independent of the normal Np governing system.

3) The overspeed system consists of: the Np torque and overspeed sensor at the 1:30 o'clock position on the exhaust frame, an overspeed switch circuit contained in the DEC, an overspeed solenoid in the overspeed and drain valve which reduces fuel flow to the engine to zero, a separate wiring harness (blue) which interconnects these components.

4) The overspeed switch circuit obtains operating power from either of two independent sources; first, from the engine-driven alternator, and second, from a backup airframe 400 Hz (115V) circuit.

5) Either power source is sufficient to operate the overspeed system.

6) The overspeed system will cause the engine to cycle in test mode and flame out in actual flight overspeed.

7) The overspeed switch system includes two overspeed-sensing circuits (A and B).

8) Each circuit is calibrated to close a solid-state switch when an Np of 25,000 rpm (119.6%(+ -)) is reached.

9) Both solid-state switches must be closed before the overspeed solenoid can be energized.

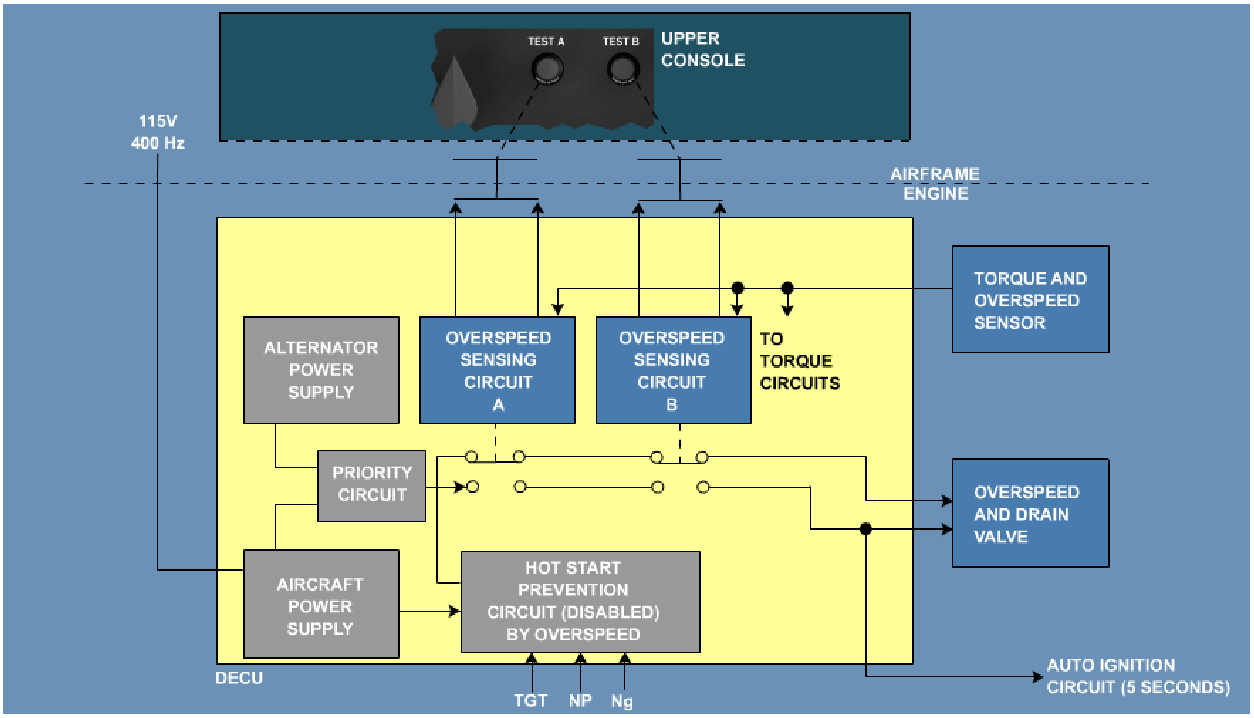
10) Test switches are provided for both the A and B circuits.

11) The test switches change the overspeed cut-in point from 119.6% to 95.6% Np.

12) Both test switches must be closed for the system to cycle.

13) During overspeed tests, an airframe circuit turns ignition on so that the engine will relight following overspeed trip, and prevent engine shut down.

Frame # 0595 (Engine Overspeed System Block Diagram)



14) The overspeed switch circuit obtains operating power from either of two independent sources; first, from the engine-driven alternator, and second, from a backup airframe 400 Hz (115V) circuit.

15) Either power source is sufficient to operate the overspeed system; thus it is completely independent of the normal Np governing system.

16) The overspeed system will cause the engine to cycle in test mode and flame out in actual flight overspeed.

17) The overspeed switch system includes two overspeed - sensing circuits (A and B).

18) Each circuit is calibrated to close a solid-state switch when an Np of 25,000 rpm (119.6%(+ -) is reached.

19) Both solid-state switches must be closed before the overspeed solenoid can be energized.

20) Test switches are provided for both the A and B circuits.

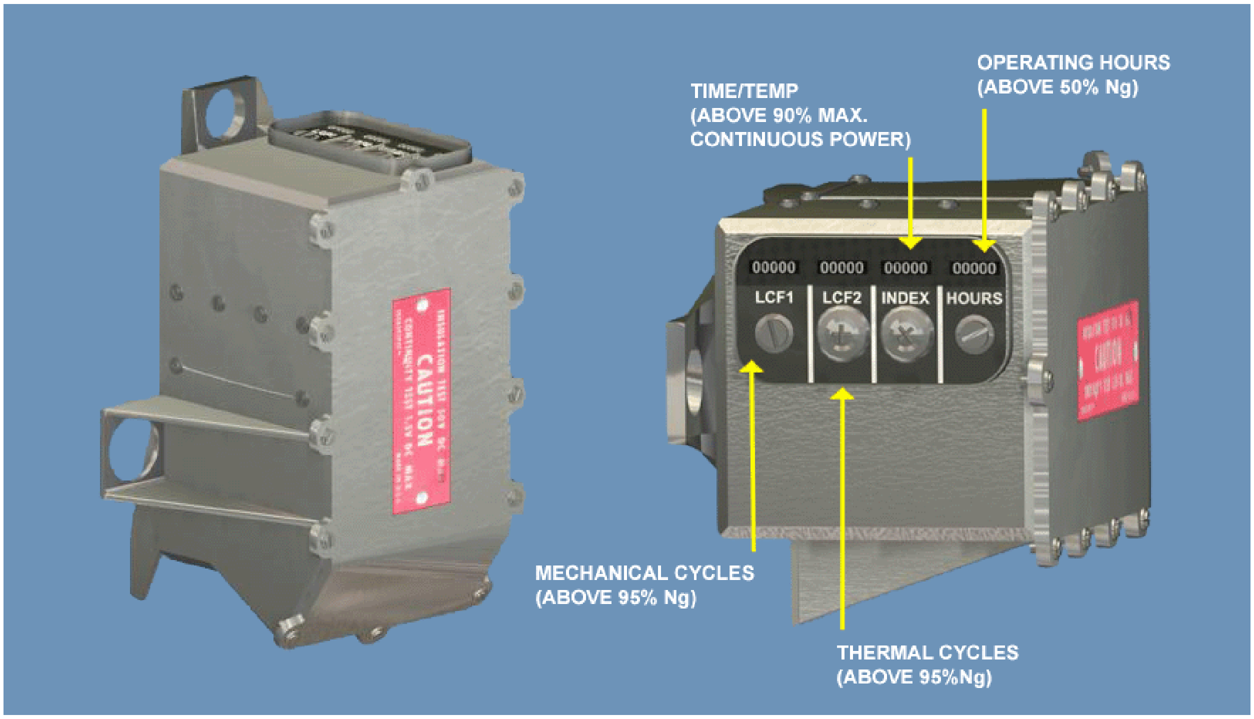
21) The test switches change the overspeed cut-in point from 119.6% to 95.6% Np.

22) Both test switches must be closed for the system to cycle.

23) During overspeed tests, an airframe circuit turns ignition on so that the engine will relight following overspeed trip and prevent engine shut down.

(h) History Counter

Frame # 0600 (History Counter)



1) The T700-GE-701C history counter replaces the history recorder used on previous T700 models and must be used with the digital electronic control unit in order to function.

2) Signals are sent to the history counter by the DEC.

3) Counter displays are similar to those on the previous history recorder.

4) In addition to the four history counts displayed by the history counter, the DEC internally tracks several other key indicators on engine history.

5) These can be accessed by the S39 test connector and include: cumulative time at temperature, four cycle counts for more precise measure of LCF, HPT bucket stress rupture life (two), number of starts, max T4.5, Ng, Np per flight and Time speed above exceedence value of T4.5 per flight.

a) LCF 1 (Low Cycle Fatigue 1 Indicator).

1 This indicator displays actual number of times engine parts experience mechanical stress associated with Ng from shutdown to above 95% and from 95% to shutdown.

2 It can display numbers up to 99.999 times. When engine exceeds 95% Ng, a count is made on the indicator.

3 The indicator will not make an additional count until Ng drops below 40% and then increases to exceed 95%.

b) LCF 2 (Low Cycle Fatigue 2 Indicator).

1 This indicator displays actual number of times engine parts experience a reduced level of mechanical stress associated with a narrower Ng range.

2 It can display up to 99,999 high-temperature stress events.

3 When Ng exceeds 95%, a count is made on the indicator.

4 The indicator will not make an additional count until Ng drops below 86% and the increases to exceed 95%.

c) Time-temperature Index Indicator.

1 This indicator displays numbers up to 99,999.

2 The index number advances when T4.5 reaches approximately 90% of the maximum continuous power value (775 degrees C).

3 The number of index is a function of time and temperature.

4 It advances faster as temperature increases.

d) Hours Indicator.

1 This indicator displays actual running time up to 99,999 hours.

2 Running time is not accumulated until Ng exceeds 60%.

3 The counter stops when Ng drops below 55% (below ground idle).

CHECK ON LEARNING

1. The engine mounted electrical alternator supplies AC power to the ignition exciter and the ________.

2. The ignition system is an AC-powered capacitor discharge ________ type system.

3. What type of special tolerance, oxidation resistant wire, is the thermo elements of the thermocouple harness made from?

4. The blue electrical cable carries signals between the torque and overspeed sensor, DEC and the ________.

SECTION VII. -SUMMARY

1. REVIEW/SUMMARIZE:

You have completed the UH-60 Electrical System topic.
The key points to remember are:

- The T700 engine uses electrically operated accessories to control anti-icing airflow, ignite the fuel-air mixture in the combustor, and control the engine power level.
- Electrical indication and warning devices assist the pilot in engine operation.
- The engine electrical system provides all electrical power required for engine ignition and all electrical control requirements throughout the operating range of the engine without the use of airframe power.
- Interconnecting wiring harnesses are color coded to aid the mechanic.
- The engine-supplied electrical alternator is mounted on the AGB, on the right-hand side. The alternator supplies AC power to the ignition exciter and DECU. It also supplies an Ng speed signal to the cockpit tachometer. All essential engine functions are powered by the alternator.
- The ignition system is an AC-powered capacitor discharge, low-voltage system.
- The igniter plug is a homogenous semiconductor, surface-gap-type spark plug, utilizing air-cooling of the firing tip. It provides a projected electrical discharge for light off of the combustor. The engine utilizes two igniters located at the 4 o'clock and 8 o'clock position.
- The thermocouple harness is a one piece assembly consisting of seven single immersion, equally spaced thermocouples for measuring power turbine inlet gas temperature (TGT).
- The ECU operates with the history recorder, and the DECU operates with the history counter. Both installed engines must have the same combination of components.
- The ECU is located on the bottom aft side of the scroll case. The ECU fine-trims the engine for changes in, power turbine speed (Np), Torque (Q), Turbine Gas Temperature (TGT), and load sharing between the engines.
- The DECU provides additional features such as: Np governing, TGT limiting, Np overspeed protection, load-sharing, contingency power, hot start prevention and fault indication.
- Two Np sensors are located in the exhaust frame; one extends through the 1:30 o'clock strut, and the other through the 10:30 o'clock strut.
- The torque matches torque between the engines, and provides a cockpit readout.
- The power turbine rotor is protected from destructive overspeed by an overspeed system. The system is completely independent of the normal Np governing system.
- The T700-GE-701C history counter replaces the history recorder used on previous T700 models and must be used with the DECU in order to function.

F. ENABLING LEARNING OBJECTIVE No. 6

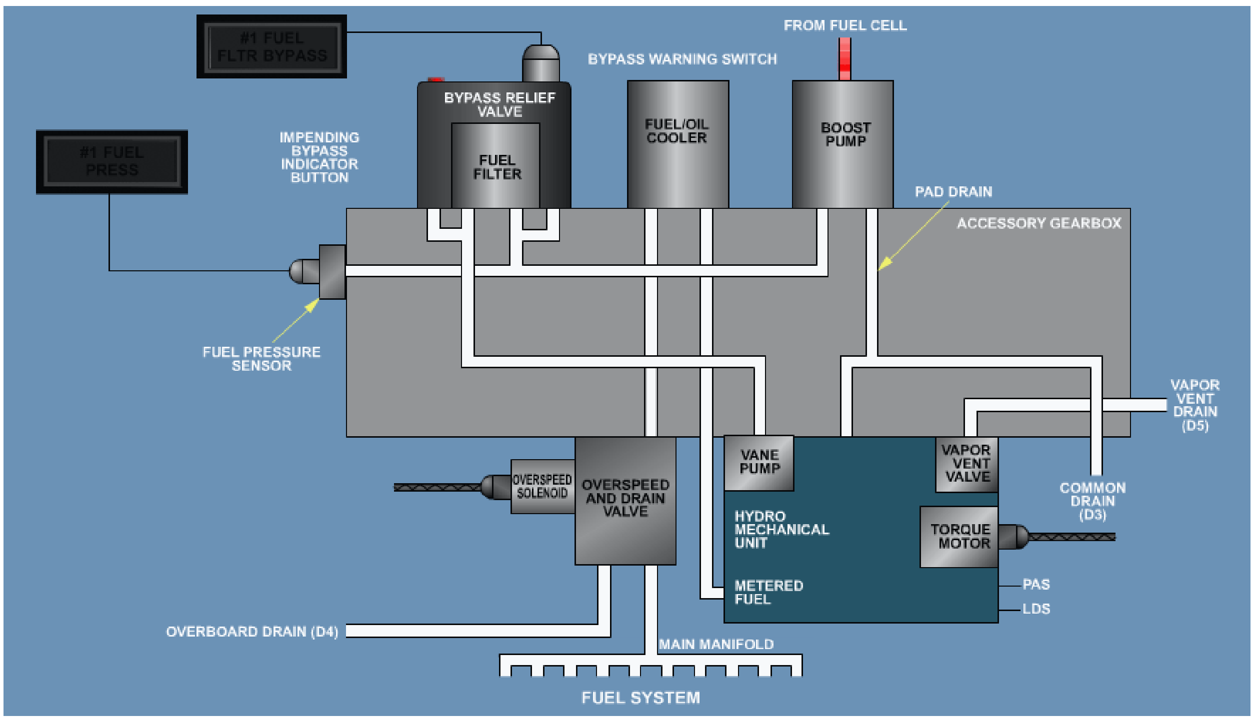
ACTION: identify the characteristics of the fuel system.

CONDITION: Using TM 1-2840-248-23

STANDARD: IAW TM 1-2840-248-23

a. T770 Fuel System

Frame # 0640 (T770 Fuel System)



(1) The primary requirements of the fuel system are to control accurate and stable engine speed for all steady state operations, and to provide transient control to achieve rapid power changes.

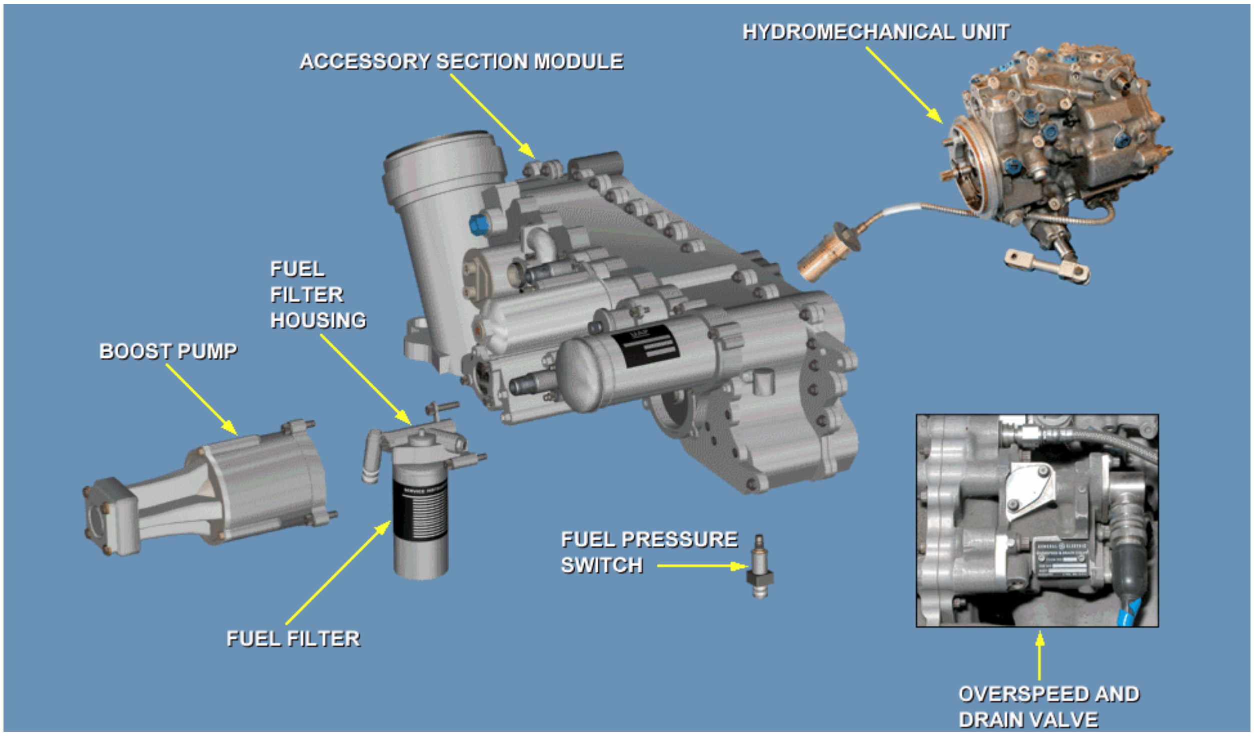
(2) This system pumps, filters, and meters fuel in response to Power Available Spindle (PAS) position, Load Demand Spindle (LDS) position, sensed engine variables, and torque motor input from the electrical control unit.

(3) The fuel system also positions the compressor variable stator vanes throughout the engine operating range to achieve the required compressor performance with respect to airflow and stall margin, and provides a schedule for starting bleed.

(4) The fuel system provides automatic start schedules from sea level to 20,000 feet altitude, and protects the engine against destructive gas generator and power turbine overspeed.

(5) These requirements must be met over the full engine operating parameters.

Frame # 0645 (Fuel System Components)



(6) The fuel system consists of:

(a) The fuel boost pump

(b) Fuel filter

(c) Hydromechanical Unit (HMU)

(d) Overspeed and drain valve.

1) Integral within the HMU are the high-pressure vane pump, variable geometry (VG) actuator, and compressor inlet temperature (T2) sensor.

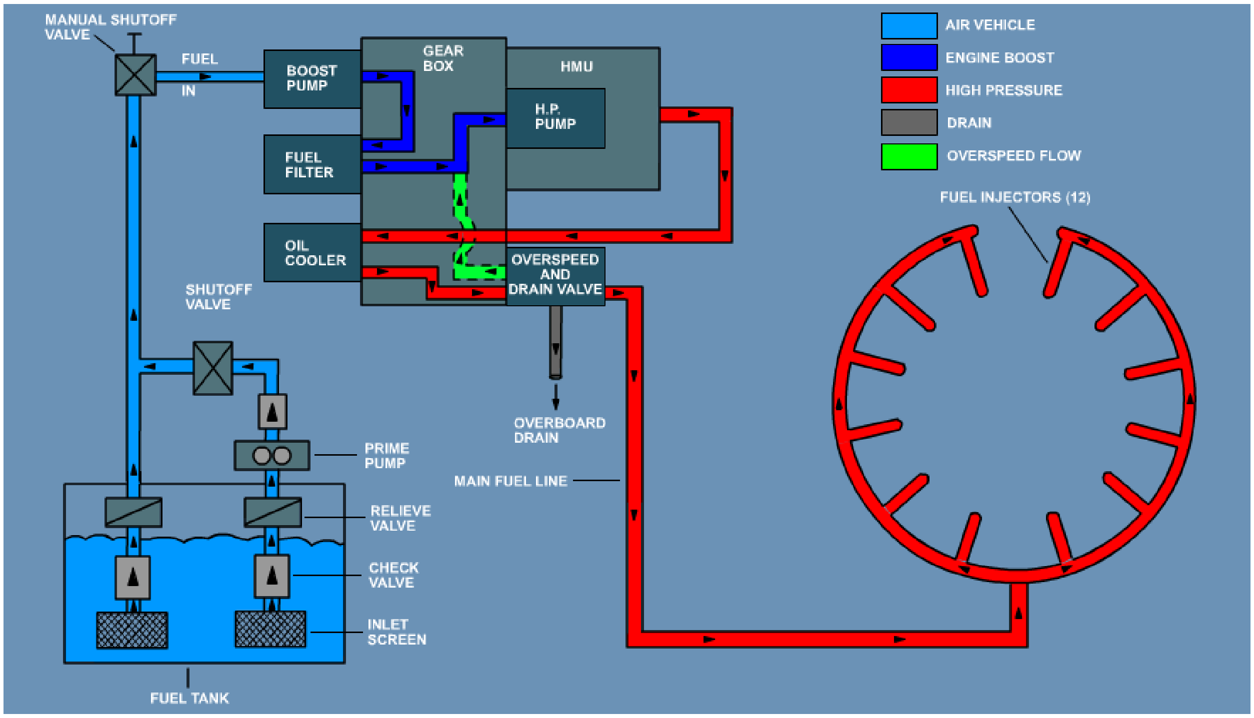
2) The hydromechanical unit, and overspeed and drain valve are mounted on the aft side of the accessory section module.

3) The boost pump, fuel filter, and fuel pressure switch are mounted on the front side of the accessory section module.

4) The fuel filter housing contains the fuel filter bypass valve and the fuel filter bypass sensor.

b. Fuel Supply System

Frame # 0650 (Fuel Supply System)



(1) Fuel is supplied from the fuel tank to the boost pump.

(2) From the boost pump, fuel goes to the fuel filter.

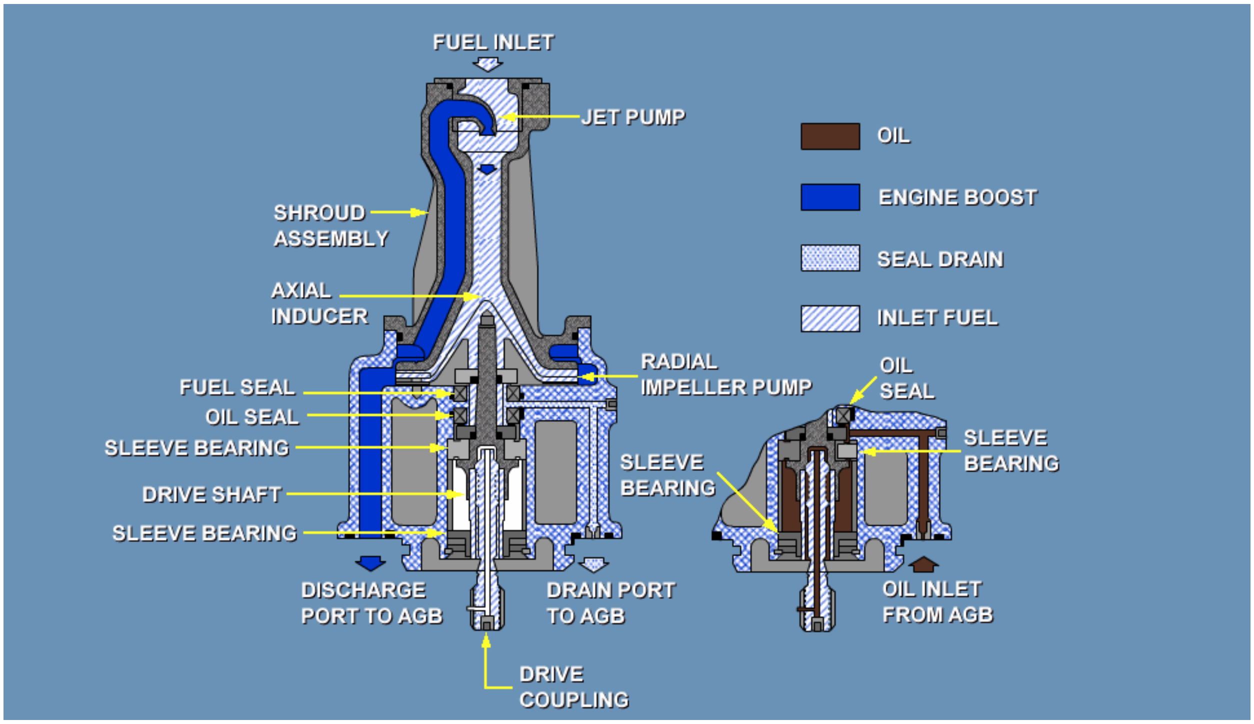
(3) From the filter, fuel is drawn to the high pressure vane pump in the HMU.

(4) The fuel leaving the HMU is metered fuel and is routed through the oil cooler, and then goes to the overspeed and drain valve.

(5) From the overspeed and drain valve, fuel is delivered to the twelve fuel injectors.

(a) Fuel Boost Pump Cross-Section

Frame # 0655 (Fuel Boost Pump Cross-Section)



1) The pump inlet is the engine-airframe fuel interface.

2) The pump is mechanically designed as a cantilevered pumping element on a rigid shaft, running in two oil lubricated sleeve bearings.

3) Oil is supplied from the engine oil system through a face port mating with the gearbox for bearing lubrication.

4) Oil and fuel are separated by two dynamic carbon seals with a center vent to the engine overboard drain manifold.

5) Shaft splines are lubricated by oil mist, which is pumped through the splines by radial pumping holes in the pump quill shaft and the mating engine gearbox shaft.

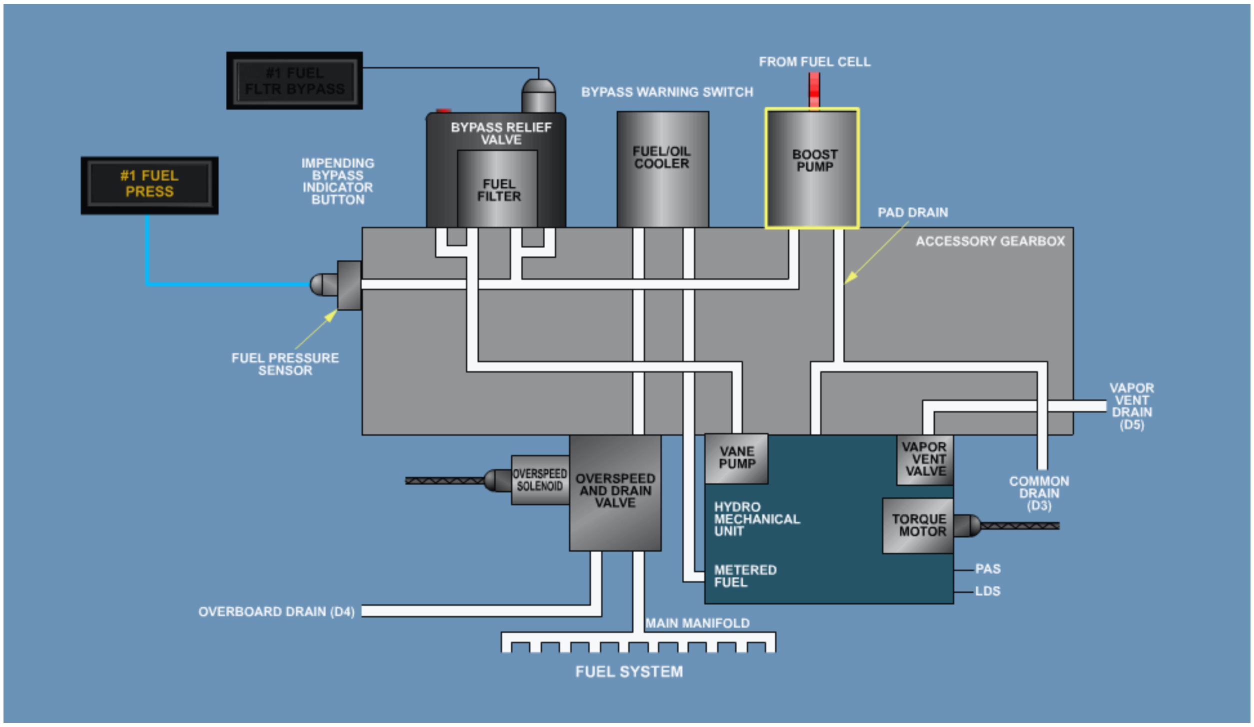
6) The pumping elements are an ejector pump or jet pump.

7) A mixed flow centrifugally induced, and a radial flow from the impeller discharge, provides ejector pump motive flow.

8) This bypass flow is approximately equal to twice-maximum engine flow at pump rated speed.

(b) Fuel System

Frame # 0660 (Fuel System FLASH)



1) The fuel boost pump draws fuel from the unpressurized fuel cells to the engine.

2) The fuel then flows through passages in the AGB to the fuel filter.

3) Filtered fuel flows through a cored passage in the AGB to the HMU vane pump (high pressure).

4) The HMU meters fuel in response to the following control inputs; T2, P3, ECU or DEC trim signal, LDS, PAS and Ng.

5) Metered fuel is routed to the oil cooler by an external hose, and then to the ODV.

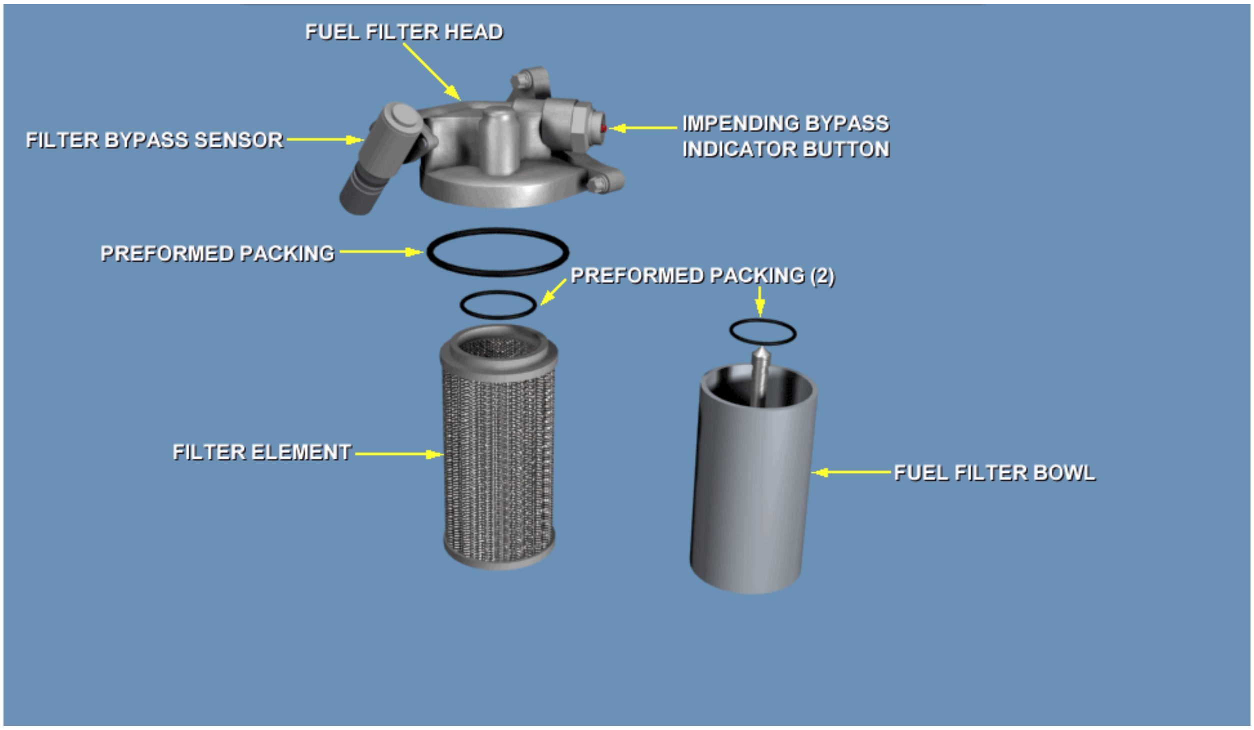
6) The ODV provides main fuel flow to the 12 fuel injectors during start and normal operation.

7) If the fuel filter becomes clogged, it is bypassed and the indicator button will pop.

8) The #1 FUEL FLTR BYPASS indicator in the cockpit will illuminate.

a) Fuel Filter

Frame # 0665 (Fuel Filter)



1 The fuel filter consists of:

a The fuel filter head

b Fuel filter bowl

c Disposable filter element

d Impending bypass indicator button

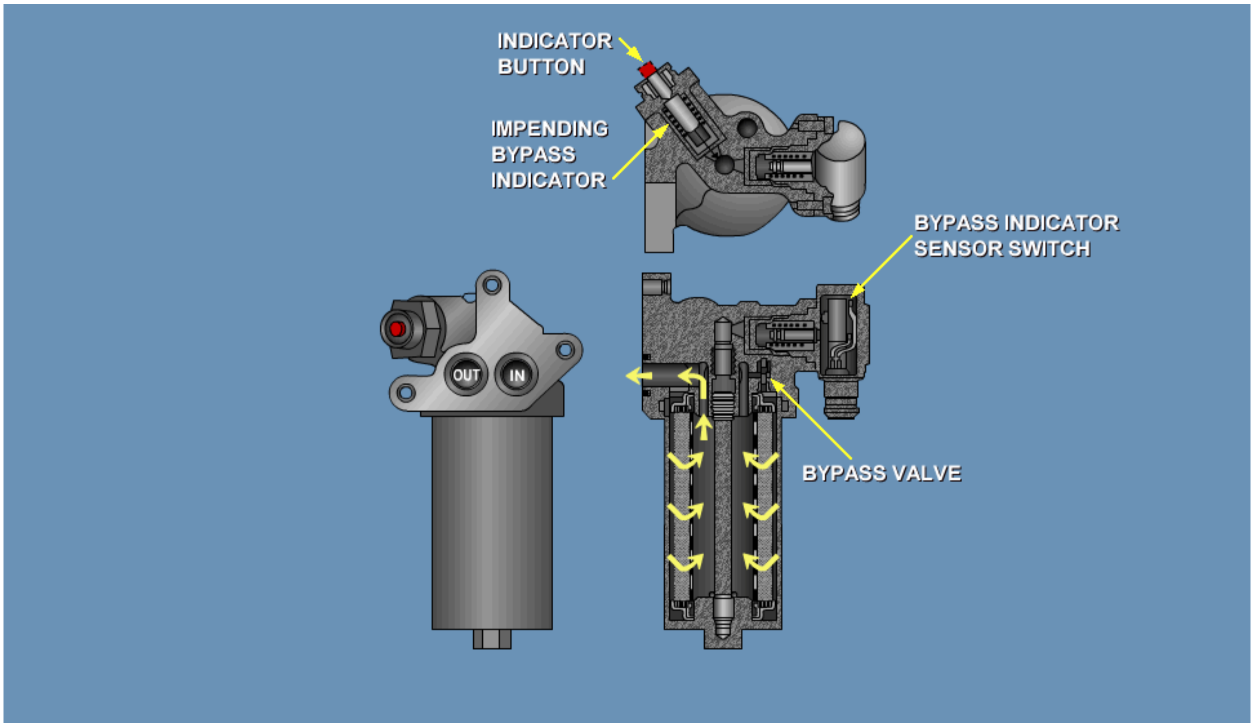
e Bypass relief valve

f Filter bypass sensor.

2 The fuel filter provides 30 micron absolute filtration for engine fuel prior to entering the high pressure vane pump in the hydromechanical control unit.

a Fuel Filter Cross Section

Frame # 0670 (Fuel Filter Cross Section)



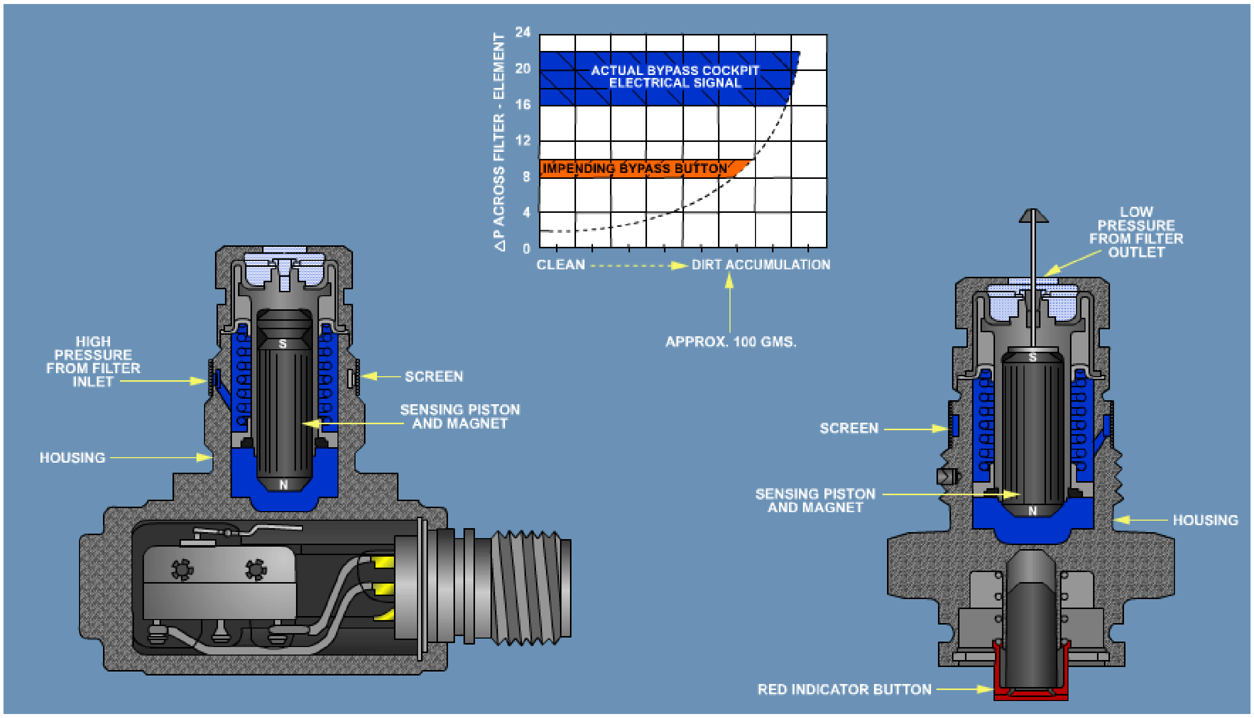
i) Engine fuel flow enters the filter through its inlet port from the engine boost pump discharge after passing through a core in the accessory gearbox.

ii) The flow then is directed across the 30 micron pleated barrier type filter element (outside to inside direction), then out the discharge port through another gearbox core to the HMU vane pump inlet.

iii) The filter element is disposable when loaded.

b Fuel Filter Bypass Indicator Systems (Tripped Position)

Frame # 0675 (Fuel Filter Bypass Indicator System (Tripped Position)



i) The fuel differential pressure across the element is sensed across a magnetic piston assembly on both the impending and actual bypass indicators.

ii) At 8-10 psi of pressure differential, the impending button piston assembly moves, carrying the magnet with it.

iii) As the magnet of the impending indicator moves away from the button, the magnetic field holding the red button in the inward position is reduced, allowing the button to pop out aided by a spring.

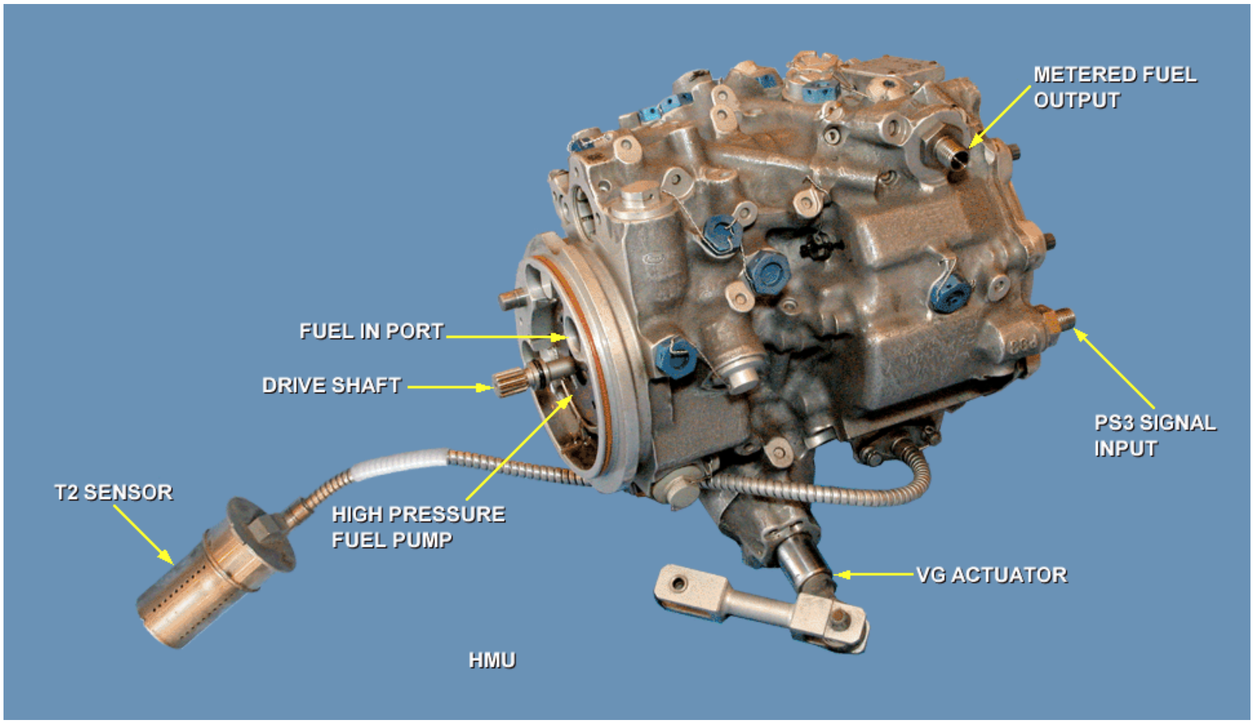
iv) The electrical filter bypass sensor (or actual bypass indicator) is activated by a pressure signal as the bypass valve opens at 18-22 psi differential pressure.

v) However, in this case, the reduced magnetic field allows the button return spring inside the micro switch to actuate the switch button through the action of the pivoted switch lever arm.

vi) This action provides a cockpit indication of filter bypass.

b) Hydromechanical Unit

Frame # 0680 (Hydromechanical Unit)



1 The HMU, mounted on the aft center of the AGB, provides fuel pumping, fuel metering, fuel flow computation, fuel pressurization, and fuel shutoff.

2 It provides gas generator speed control, compressor variable geometry scheduling and actuation, and anti-icing and starting bleed valve actuation.

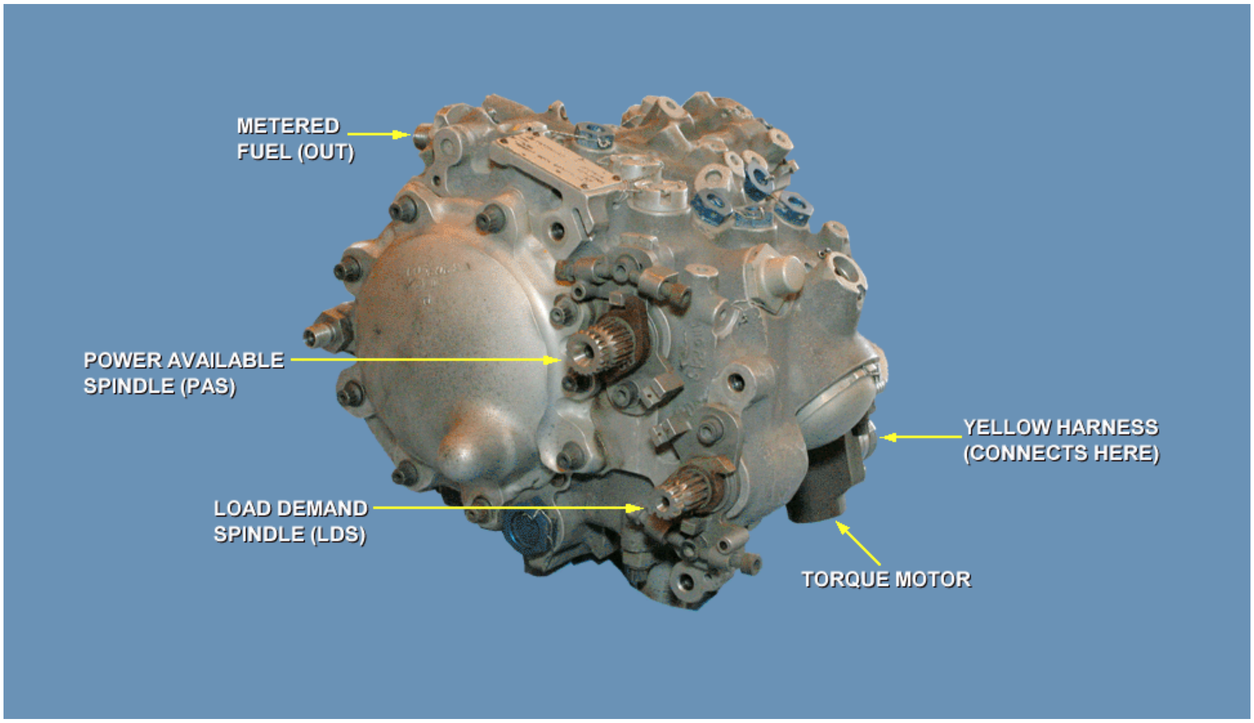
3 The unit responds to Power Available Spindle (PAS) input for fuel shutoff, start, ground idle, to set permissible gas generator speed up to maximum, vapor venting, and to provide for a Digital Electronic Control unit (DEC) override capability.

4 The HMU also responds to an externally supplied load demand input via the Load Demand Spindle (LDS), which is proportional to power absorber load.

5 This initially and directly coordinates gas generator speed and power to closely approximate the power required by the rotor or shaft power absorber.

a Hydromechanical Unit Aft Side

Frame # 0685 (Hydromechanical Unit Aft Side)



i) The HMU then responds to input from the DEC via the HMU torque motor, to precisely trim gas generator speed as directed for both power turbine speed control and turbine temperature limiting for more exact load share control.

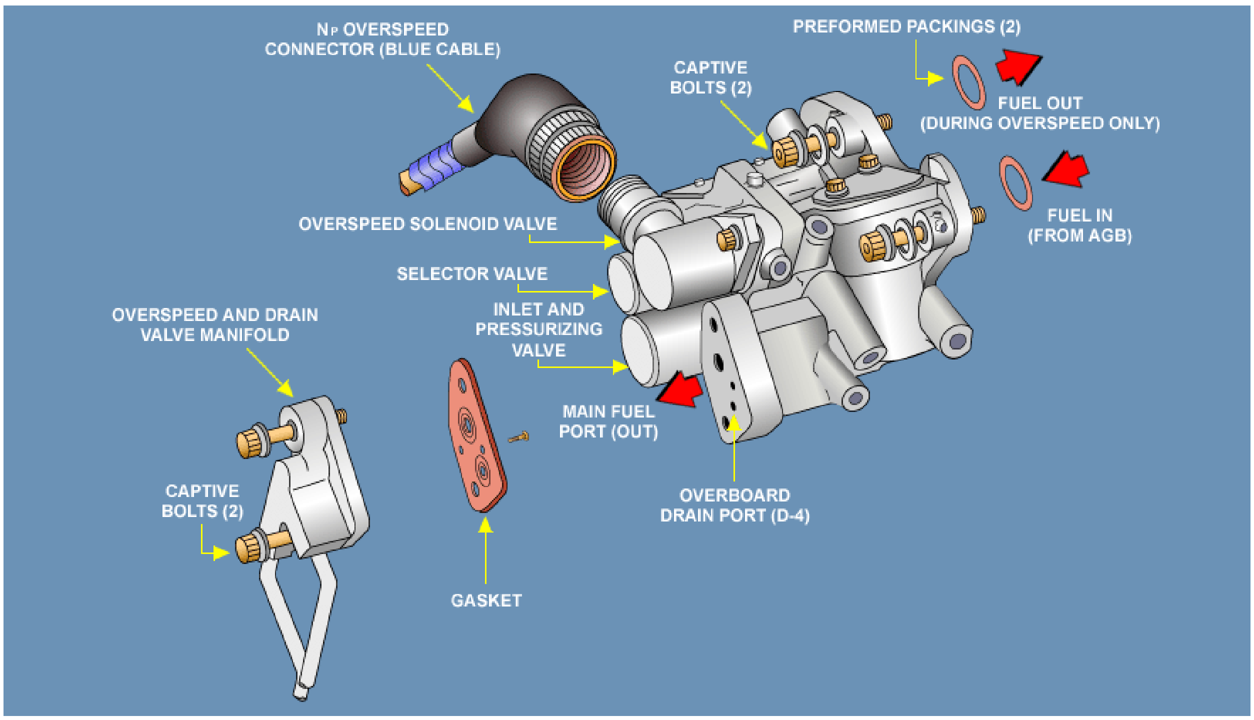
ii) The HMU also has the capability to mechanically deactivate the DEC in the event of a DEC failure, and vent the unit case to the overboard drain in the event of excessive air or vapor at the inlet, by use of over travel in the PAS.

iii) The HMU responds to sensed engine parameters (T2, P3 and Ng), which influence fuel flow and variable geometry position.

iv) The HMU provides three major engine functions; fuel pumping, fuel metering, and variable geometry positioning.

c) Overspeed and Drain Valve

Frame # 0690 (Overspeed and Drain Valve)



1 The metered fuel from the HMU is delivered to the oil cooler and then to the overspeed and drain valve.

2 The overspeed and drain valve has three functions: First, it provides main fuel flow to the 12 fuel injectors during engine starting and operation.

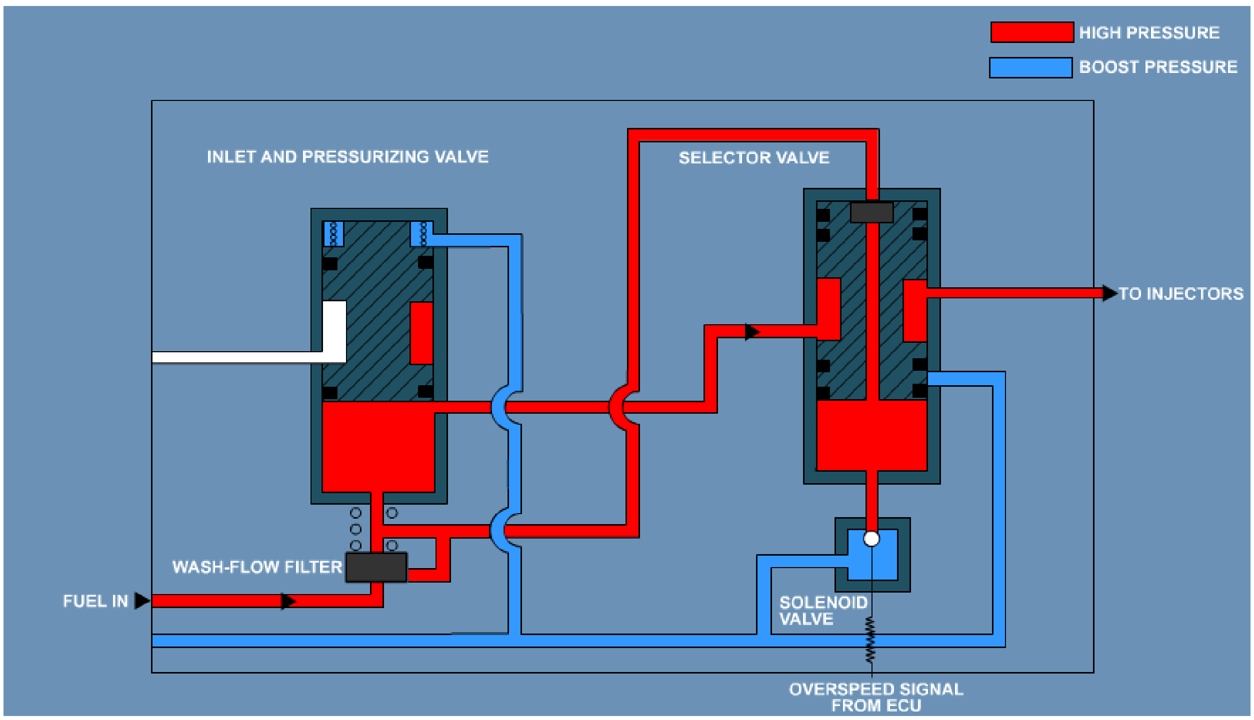
3 Second, upon shutdown, it purges the main manifold of fuel and directs it out the overboard drain to prevent coking of the fuel injectors.

4 Third, it traps fuel upstream, which keeps the liquid-to-liquid heat exchanger full so that system priming is not necessary prior to the next start.

5 During overspeed it diverts the fuel back to the HMU inlet.

b Overspeed and Drain Valve (Normal Operating Mode)

Frame # 0695 (Overspeed and Drain Valve (Normal Operating Mode)(0695)



i) With the engine shutdown, the pressure in the overspeed and drain valve is equal to ambient pressure and the inlet and pressurizing valve is spring-loaded closed.

ii) When the engine is cranked over and the PAS is advanced to open the stopcock in the HMU, the HMU delivers metered flow to the overspeed and drain valve inlet.

iii) This metered flow passes through a wash-flow filter and line pressure builds up until the inlet and pressurizing valve opens.

iv) Fuel boost pressure is directed to the top of a selector valve while higher pressure (Wf) passes through the open selector valve and flows to the 12 fuel injectors for engine light off and normal operation.

v) The power turbine overspeed function is designed to divert fuel flow from the combustor and flame the engine out to protect against destructive Np overspeed.

vi) When Np reaches 25.000 rpm (119.6%), the solenoid valve in the ODV is energized and opens a ball valve.

vii) This causes a bleed off of equalizing fuel pressure on the bottom part of the selector valve.

viii) The high pressure Wf causes the selector valve to move down causing all Wf to bypass back to the HMU inlet.

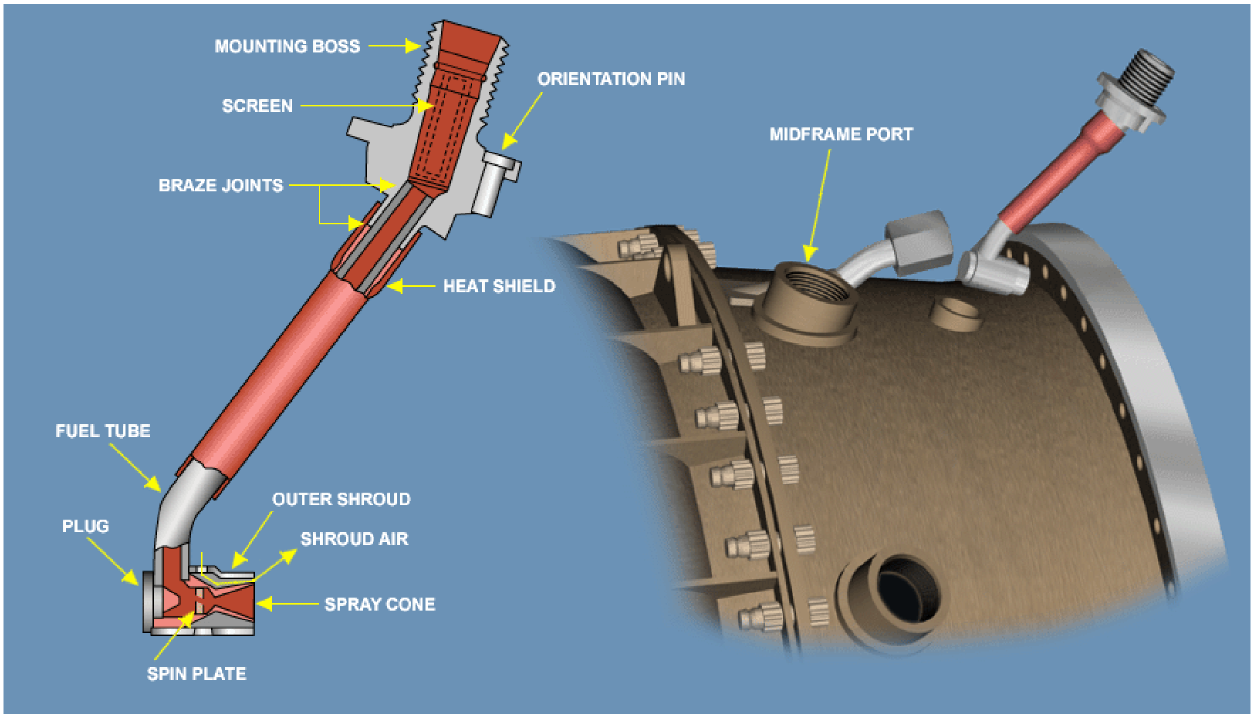
ix) This instantaneous loss of Wf to the combustor causes the engine to flameout.

x) When the PAS is moved to the OFF position, the HMU is stop cocked, fuel flow to the overspeed and drain valve is stopped, and the inlet and pressurizing valve is forced down by spring action.

xi) This opens the main fuel line in the overspeed and drain valve to the fuel in the injectors and main manifold, back through the overspeed and drain valve, and out the overboard drain line.

d) Fuel Injector

Frame # 0700 (Fuel Injector)



1 Twelve fuel injectors, installed in the midframe, receive fuel from the main fuel manifold and supply it to the combustion liner swirl cup (swirler) subassemblies.

2 The injector is a simplex nozzle with a single spin chamber fed by two spin holes.

3 The swirled fuel from the spin holes exits through orifice and discharges onto a 30 degrees primary cone.

4 This cone flares outwards at the exit.

5 The contoured exit provides a good quality fuel spray at a very low fuel pressures in the starting regime.

6 The injector has a last-chance screen with 0.009 inch diameter mesh to protect the orifice spin slot.

7 Correct orientation of the injector within the midframe casing is assured through use of two locating pins in the mounting flange.

8 It is not necessary to remove the injectors to facilitate combustion liner removal and replacement.

CHECK ON LEARNING.

1. Metered fuel leaving the HMU is routed through the oil cooler and then to the ________.

2. The 30 micron fuel filter provides absolute filtration for engine fuel prior to entering the ________.

3. What are the parameters that influence fuel flow and variable geometry positioning?

SECTION VIII. -SUMMARY

1. REVIEW/SUMMARIZE:

You have completed the UH-60 Fuel System topic.
The key points to remember are:

- The T700 fuel system consists of the fuel boost pump, fuel filter, Hydromechanical Unit (HMU), and the overspeed and drain valve. Integral within the HMU are the high-pressure vane pump, Variable Geometry (VG) actuator, and compressor inlet temperature (T2) sensor.
- The HMU and overspeed and drain valve are mounted on the aft side of the accessory section module. The boost pump, fuel filter, and fuel pressure switch are mounted on the front side of the accessory section module.
- The fuel supply system supplies fuel from the fuel tank to the boost pump, fuel filter, HMU high-pressure vane pump, oil cooler, overspeed and drain valve, and the twelve fuel injectors.
- The fuel boost pump inlet is the engine-airframe fuel interface.
- The fuel boost pump draws fuel from the unpressurized fuel cells to the engines.
- The HMU meters fuel in response to control inputs from T2, P3, ECU/DEC trim signal, LDS, PAS, and Ng.
- If the fuel filter becomes clogged, it is bypassed and the indicator button will pop and the #1 FUEL FLTR BYPASS indicator in the cockpit will illuminate.
- The fuel filter provides 30 micron absolute filtration for engine fuel prior to entering the high pressure vane pump in the HMU.
- The fuel differential pressure across the fuel filter element is sensed across a magnetic piston assembly on both the impending and actual bypass indicators. At 8-10 psi of pressure differential, the impending button piston assembly moves carrying the magnet with it. As the magnet of the impending indicator moves away from the button, the magnetic field holding the red button in the inward position is reduced, allowing the button to pop out aided by a spring.
- Locking of the impending bypass indicator mechanism is accomplished when the wire and half ball element moves with the magnet piston assembly towards the center of the filter until the half ball drops down and catches on the edge of the ramp. This latching prevents the magnet piston assembly from returning to its original position.
- The HMU, mounted on the aft center of the AGB, provides fuel pumping, fuel metering, fuel flow computation, fuel pressurization, and fuel shutoff. It provides gas generator speed control, compressor variable geometry scheduling and actuation, and anti-icing and starting bleed valve actuation.
- The overspeed and drain valve provides main fuel flow to the 12 fuel injectors during engine start and operation. It also purges the main fuel manifold on shutdown, and traps fuel upstream, which keeps the liquid-to-liquid heat exchanger full, making it unnecessary to prime the engines for the next start.

- With the engine shutdown, the pressure in the overspeed and drain valve is equal to ambient pressure and the inlet and pressurizing valve is spring-loaded closed. When the engine is cranked over and the PAS is advanced to open the stopcock in the HMU, the HMU delivers metered flow to the overspeed and drain valve inlet.
- Twelve fuel injectors, installed in the midframe receive fuel from the main fuel manifold and supply it to the combustion liner swirl cup (swirler) subassemblies.

G. ENABLING LEARNING OBJECTIVE No. 7

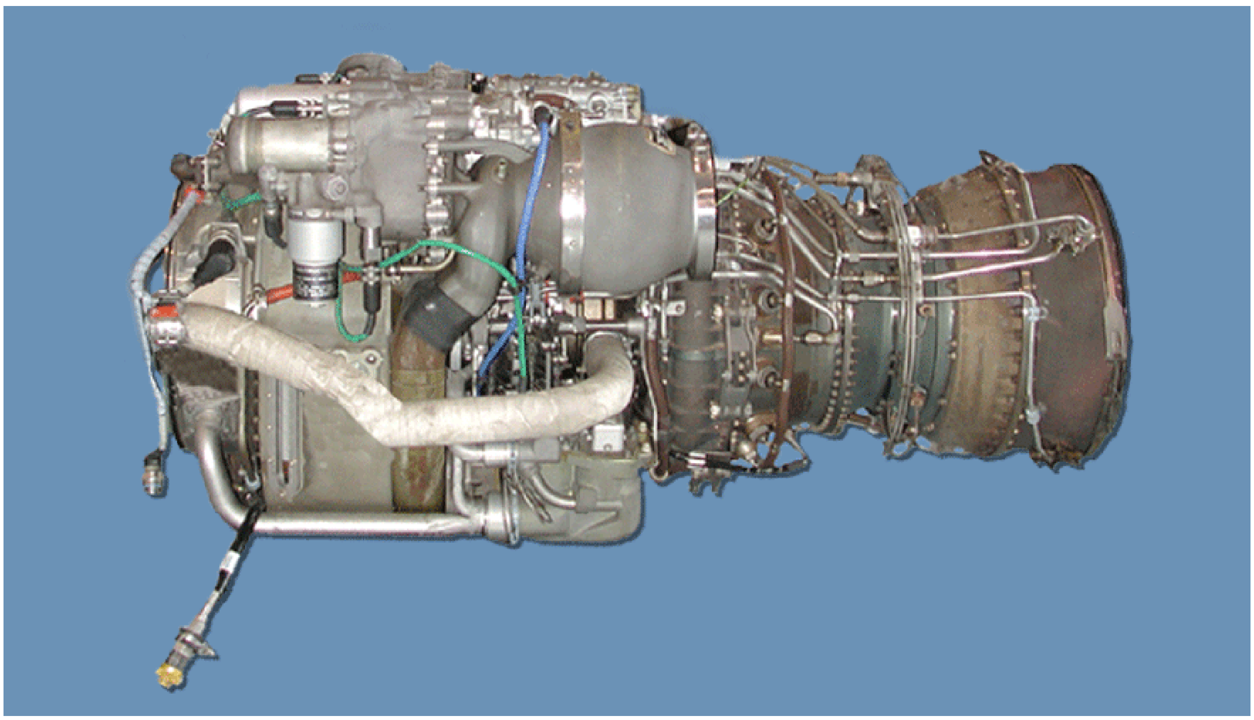
ACTION: Identify the characteristics of the control system.

CONDITION: Using TM 1-2840-248-23

STANDARD: IAW TM 1-2840-248-23

a. T700 Engine Control System

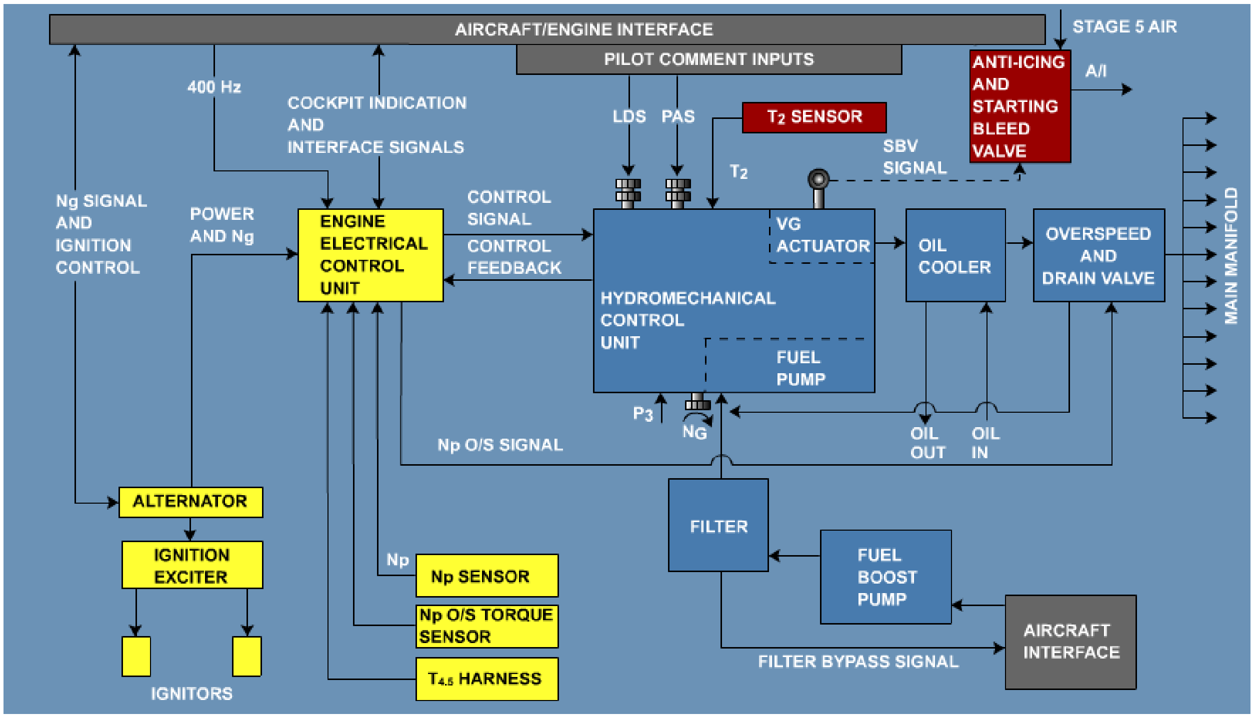
Frame # 0724 (T700 Engine Control System)



(1) The T700 engine control system incorporates all the functions necessary for the proper and complete control of the engine.

(a) Engine and Control System Schematic

Frame # 0725 (Engine and Control System Schematic)



1) The engine control system provides for fuel handling, computation, compressor bleed and variable geometry control, speed control, overspeed protection, and over temperature protection.

2) The system also incorporates control features for torque matching of multiple engine installations.

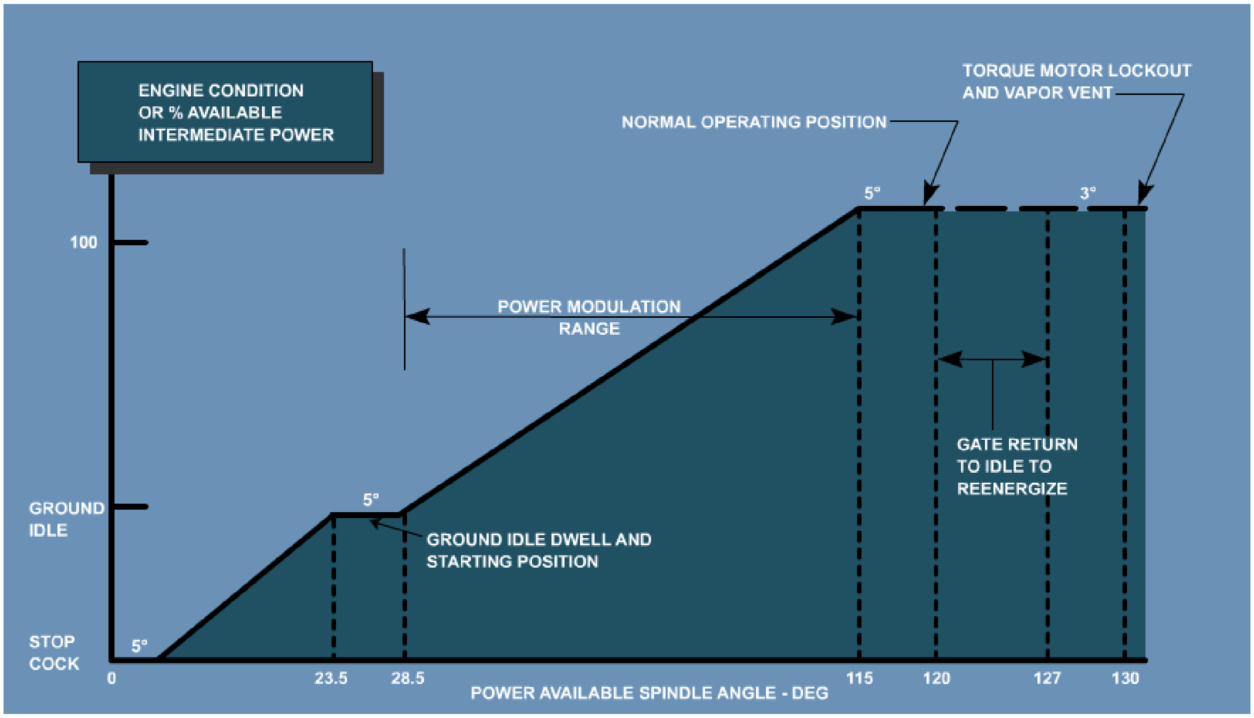
3) Shaft power absorber coordination is provided initially by a mechanical input signal to the control system, proportional to helicopter rotor collective pitch setting, and a final automatic trim of the power setting to precisely equal the rotor needs is provided electrically.

4) The engine control system is self-contained and does not require external electrical power for any controlling functions.

5) Design of the engine control system allows removal of major components from the engine separately from any input components and replacement without calibration or matching.

(b) Power Available Spindle Angle

Frame # 0730 (Power Available Spindle Angle)



1) The PAS sets a maximum available gas generator speed.

2) This will usually be set at 120 degrees.

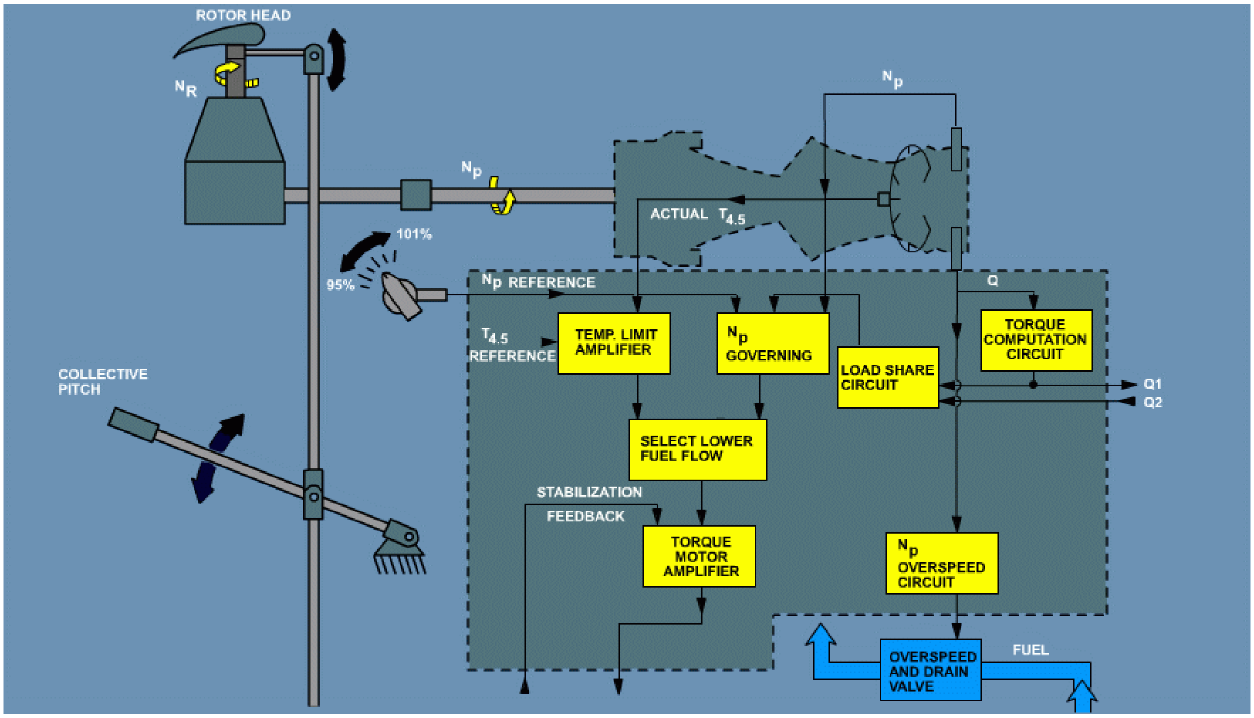
3) The load demand signal is then provided through the Load Demand Spindle (LDS).

4) As the LDS is reduced from its maximum setting with a reduction of aircraft rotor collective pitch, the desired gas generator speed is reset down from the prevailing PAS schedule to provide immediate and accurate gas generator response.

5) This reset is then trimmed by the ECU/DEC to satisfy the Np and load control function established by the ECU/DEC.

(c) ECU Schematic Diagram

Frame # 0735 (ECU Schematic Diagram)



1) The turbine rotor speed (Np) governing system compares the signal sent from the Np sensor with the Np selected by the pilot.

2) It varies fuel flow by actuating the torque motor in the HMU.

3) Constant Np is governed to within +/- 1% of required Np.

4) The TGT limiting system overrides the Np governing system and the load-sharing system when TGT reaches 866 degrees C.

5) It limits fuel flow to hold a maximum TGT by actuating the torque motor in the HMU.

6) TGT limiting system is accurate to within c/- 5 degrees C.

7) The Np overspeed protection system receives a power turbine speed signal from the torque and overspeed sensor.

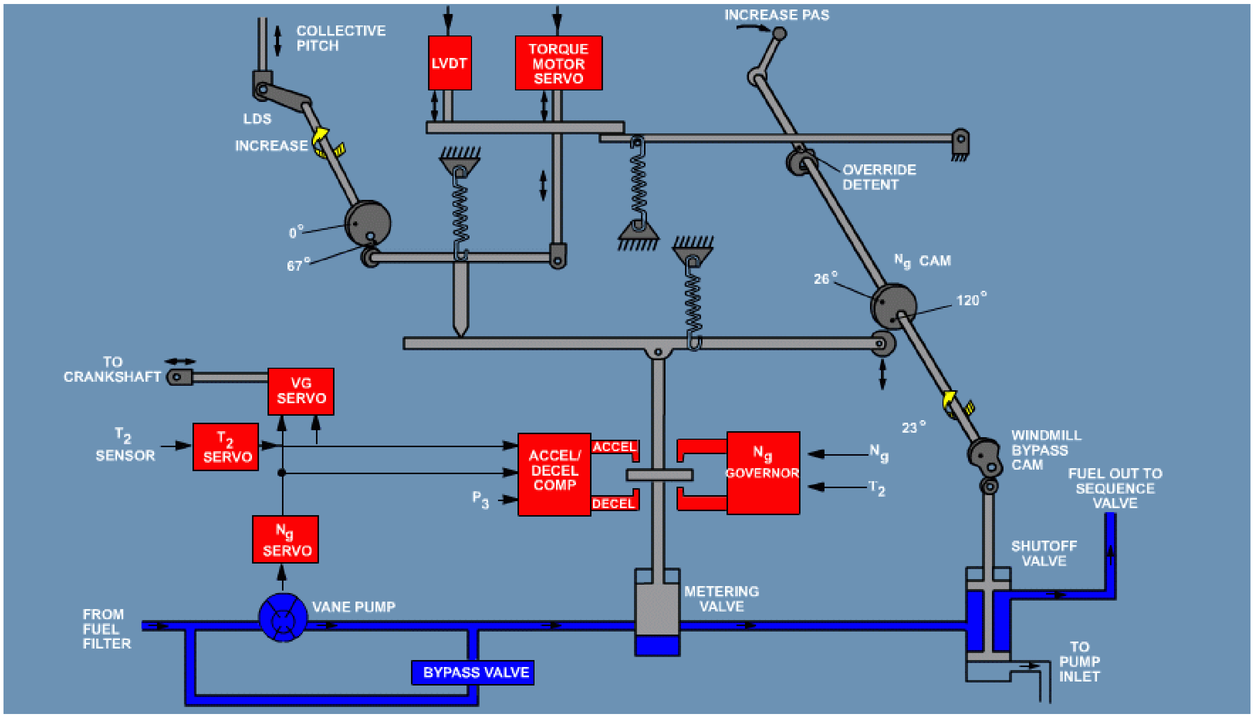
8) When Np exceeds 25,000 +/- 250 rpm, output from the protection system activates a solenoid in the ODV.

9) This shuts off fuel flow, causing the engine to shut down.

10) The DECs compare torque signals for automatic load sharing.

(d) HMU Schematic Diagram

Frame # 0740 (HME Schematic Diagram)



1) The HMU operates as a conventional gas generator power control when there is no input to the torque motor and with the LDS set for maximum load.

2) Engine schedules, such as acceleration fuel flow and compressor variable geometry position, are controlled by a 3-D cam in the HMU which is positioned by Ng and T2.

3) The acceleration (or stall) limit is imposed by a maximum cam schedule of Wf/P3 versus Ng and T2.

4) A minimum flow schedule controls engine deceleration.

5) Maximum and minimum metering valve stops provide absolute fuel flow limits.

6) An intermediate topping line controls maximum Ng speed.

7) The topping line also limits excessive T4.5 in the event of an electrical T4.5 control system failure.

8) Since these features are incorporated in the HMU, any PAS motion will result in safe engine operation and will not cause engine damage.

9) Except for intentional stopcocking of the control, no inadvertant shutdowns will occur from PAS motion.

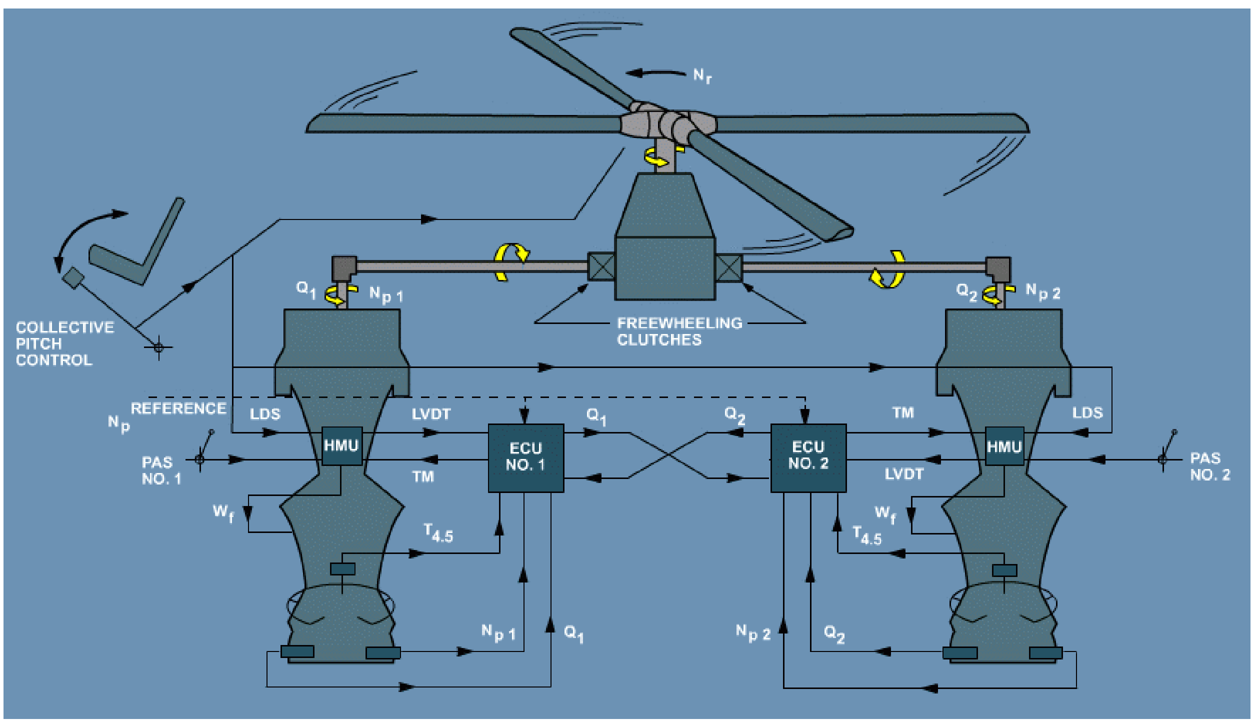
10) A load demand signal is introduced to the HMU through the LDS.

11) When the LDS is reduced from its maximum setting with a reduction of aircraft rotor collective pitch setting, the desired Ng is reset down from the prevailing PAS setting to provide immediate and accurate gas generator response.

12) This new setting is trimmed by the DECU or ECU to satisfy the Np and load control functions established by the DECU or ECU.

(2) T700 Twin Engine Helicopter Installation

Frame # 0745 (T700 Twin Engine Helicopter Installation)



(a) The ECU or DECU accepts inputs from the alternator, thermocouple harness, Np (% RPM 1 and 2) sensor, torque and overspeed sensors, torque signal from the opposite engine for load-sharing, feedback signals from the HMU for system stabilization, and a demand speed from the engine speed trim button.

(b) The torque matching/load sharing system increases power on the lower-torque engine to keep engine torques approximately equal.

(c) The system does not allow an engine to reduce power to match a lower power engine.

CHECK ON LEARNING

1. The engine control system is ________ and does not require external electrical power for any controlling functions.

2. The Np governing system compares the signal sent from the Np sensor with the selected Np and varies fuel flow by actuating the ________ in the HMU.

3. The HMU responds to an input from the ECU/DECU to reduce fuel flow for limiting the ________.

SECTION IX. -SUMMARY

1. REVIEW/SUMMARIZE:

You have completed the UH-60 Control System topic.
The key points to remember are:

- The T700 control system incorporates all the functions necessary for the proper and complete control of the engine.
- The system provides for fuel handling, computation, compressor bleed and variable geometry control, speed control, overspeed protection, and over temperature protection.
- The control system also incorporates control features for torque matching of multiple engine installations.
- The PAS sets a maximum available gas generator speed. This will usually be set at 120 degrees.
- The load demand signals are provided through the Load Demand Spindle (LDS).
- The turbine rotor speed (Np) governing system compares the signal sent from the Np sensor to the Np selected by the pilot and varies fuel flow by actuating the torque motor in the HMU.
- The TGT limiting system overrides the Np governing system and load-sharing system when TGT reaches 866 degrees C.
- The HMU provides fuel pumping, fuel metering, compressor variable geometry scheduling and actuation, and acceleration bleed control.
- The HMU responds to PAS inputs from the aircraft for fuel shutoff, for start and ground idle speed, to set permissible gas generator speeds up to the maximum limit, and to provide an ECU/DECU override capability and fuel vapor venting to aid fuel system priming.
- The HMU responds to an input from the ECU/DECU to reduce fuel flow for limiting the turbine temperature.
- The ECU accepts inputs from the alternator, thermocouple harness, Np (% RPM 1 and 2) sensor, torque and overspeed sensors, torque signal from the opposite engine for load-sharing, feedback signals from the HMU for system stabilization, and a demand speed from the engine speed trim button.

H. ENABLING LEARNING OBJECTIVE No. 8

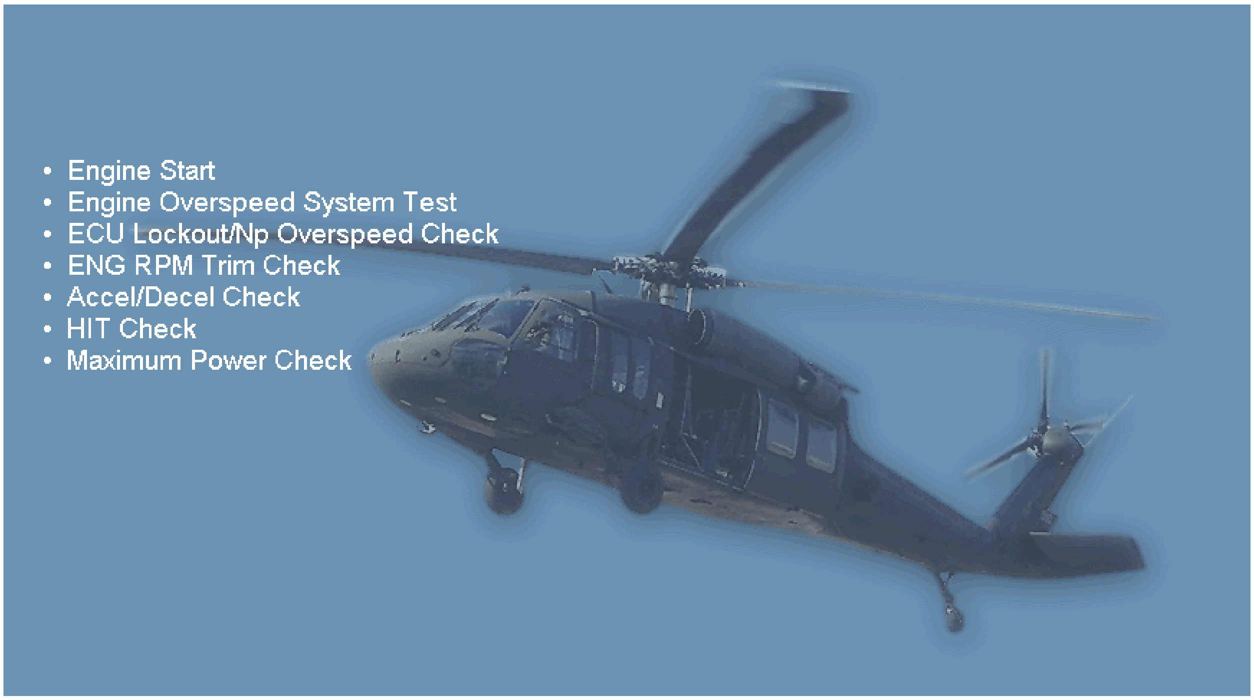
ACTION: Identify the Maintenance Test Flight (MTF) checks.

CONDITION: Using TM 1-1520-237-MTF

STANDARD: IAW TM 1-1520-237-MTF

a. Powerplant System MTF Checks

Frame # 0775 (Powerplant System MTF Checks)



(1) Engine Start

(2) Engine Overspeed System Test

(3) ECU Lockout/Np Overspeed Check

(4) ENG RPM Trim Check

(5) Accel/Decel Check

(6) HIT Check

(7) Maximum Power Check

(a) The above is a simplified list of Maintenance Test Flight (MTF) checks for the powerplant system.

APPENDIX A

ILLUSTRATION LISTING

APPENDIX B

TEST AND TEST SOLUTIONS

1. This appendix is only used when the test and solutions are internal to the POI file.

2. When the test and solutions are internal to the POI file, then the POI file becomes a FOR OFFICIAL USE ONLY document.