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VOL I

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GASTURBINE
LM 500 (GEK 99441)
OPERATION AND MAINTENANCE MANUAL

SØVÆRNETS MATERIELKOMMANDO ST.
JAN 1997

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GE Marine Engines

GEK 99441 VOL I

OPERATION AND MAINTENANCE FOR GE LM500 MARINE AND INDUSTRIAL GAS TURBINE

GE Marine Engines
Cincinnati, Ohio 45215-6301, USA

GE Marine Engines

GEK 99441 VOL I

TECHNICAL MANUAL

GE LM500 MARINE AND INDUSTRIAL GAS TURBINE

OPERATION AND MAINTENANCE

NOTE: THIS REVISION REPLACES GEK 99441 VOL I, DATED 1 MAY 1992.

GE Marine Engines
Cincinnati, Ohio 45215-6301, USA

31 May 2002

NUMERICAL INDEX OF EFFECTIVE WORK PACKAGES

List of Current Changes

Dates of issue for Original and Changed pages are listed in the List of Effective Pages.

Original . . . . 0 . . . . 31 May 2002

Interim Change Notices (ICN) GEK 99441-01 through GEK 99441-05 are incorporated in this revision.

Only those work packages assigned to the manual are listed in this index.

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SERVICE BULLETIN LIST

SERVICE BULLETIN NUMBER	DATE INCORPORATED	SERVICE BULLETIN NUMBER	DATE INCORPORATED

LM500 GAS TURBINE

OPERATING INSTRUCTIONS AND ON-SITE MAINTENANCE

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	ADDENDUM
A	Critical Parts Life Management

Warnings Applicable to Hazardous Materials

Warnings in this manual alert personnel to hazards associated with the use of hazardous materials. Consult your local safety and health staff concerning any questions regarding hazardous materials, Material Safety Data Sheets (MSDS), personal protective equipment requirements, appropriate handling and emergency procedures, and disposal guidance.

Under the heading "HAZARDOUS MATERIALS WARNINGS," complete warnings, including related icon(s) and numeric identifier, are provided for hazardous materials used in this manual.

In the text of the manual, the caption "WARNING" is not used for hazardous material warnings. Hazards are cited with appropriate icon(s), the nomenclature of the hazardous material, and the numeric identifier that relates to the complete warnings. Users of hazardous materials shall refer to the complete warnings.

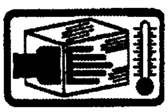
EXPLANATION OF HAZARDOUS MATERIALS WARNING ICONS

Biological

The abstract symbol bug shows that a material may contain bacteria or viruses that present a danger to life or health.

Chemical

The symbol of a liquid dripping onto a hand shows that the material will cause burns or irritation to human skin or tissue.

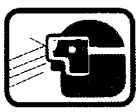


Cryogenic

The symbol of a hand in a block of ice shows that the material is extremely cold and can injure human skin or tissue.

Explosion

This rapidly expanding symbol shows that the material may explode if subjected to high temperature, sources of ignition, or high pressure.



Eye Protection

The symbol of a person wearing goggles shows that the material will injure the eyes.

EXPLANATION OF HAZARDOUS MATERIALS WARNING ICONS (Cont)

Fire

The symbol of a fire shows that the material may ignite and cause burns.

Poison

The symbol of a skull and crossbones shows that the material is poisonous or is a danger to life.

Radiation

The symbol of three circular wedges shows that a material emits radioactive energy and can injure human tissue or organs.

Vapor

The symbol of a human figure in a cloud shows that material vapors present a danger to life or health.

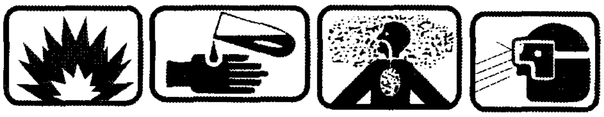
HAZARDOUS MATERIALS WARNINGS

Acetone, O-A-51 **1**

- Flammable - do not use near open flames, near welding areas, or on hot surfaces.
- Do not smoke while using it, and do not use it where others are smoking.
- Prolonged inhalation of vapor can irritate eyes and mucous membranes and can cause dizziness and headache. If vapors cause drowsiness, go to fresh air.
- If any liquid contacts skin or eyes, immediately flush affected area thoroughly with water. Immediately remove solvent-saturated clothing.
- When handling large quantities of liquid (more than a gallon), use at air-exhausted workbench. Wear approved gloves.
- Store solvent and dispose of liquid-soaked rags in approved metal safety container.
- Metal containers of solvent must be grounded to maintain electrical continuity.

Nitric Acid, O-N-350 **4**

- Highly reactive - do not mix with combustible organics or other oxidizable materials such as wood, paper, and cloth. When heated, toxic gases are released.
- When mixing solutions, add acid to water, not water to acid.
- Contact of skin with liquid or inhalation of mist can cause severe burns, respiratory tract irritation, and chronic bronchitis.
- If any solution, liquid, or mist contacts skin or eyes, flush affected area throughly with water. Immediately change any contaminated clothing. If mist is inhaled, go to fresh air. Immediately get medical help.
- If handling solution or concentrated liquid in air-exhausted covered tank, wear approved gloves and apron, and wear goggles or face shield.
- When handling solution or concentrated liquid in open tank, wear approved respirator, full-body clothing, gloves, and goggles.



Phosphoric Acid, O-O-670 **5**

- Contact with metals releases flammable hydrogen gas.
- When mixing solutions, add acid to water, not water to acid.
- Do not have any contact with liquid, it is very corrosive. Contact with liquid will burn any exposed tissue. Inhalation of mist can irriate nose and throat.
- If any liquid contacts skin or eyes, immediately flush affected area thoroughly with water. Get medical attention immediately. Immediately remove acid-saturated clothing.
- When handling concentrated or diluted liquid in air-exhausted tank, wear approved gloves, and wear goggles or face shield.
- When handling concentrated or diluted liquid in open unexhausted tank, wear approved respirator, gloves, and goggles.

Isopropyl Alcohol, TT-I-735 **11**

- Flammable - do not use near open flames, near welding areas, or on hot surfaces.
- Do not smoke when using it, and do not use it where others are smoking.
- Inhalation of vapors can cause drowsiness, dizziness, and headache. Contact of liquid with skin may cause dermatitis and irritation.
- If any liquid contacts skin or eyes, immediately flush affected area thoroughly with water. Remove solvent-saturated clothing. If vapors cause drowsiness, go to fresh air.
- When handling large quantities (greater than one gallon), work at air-exhausted workbench or covered tank.
- Store solvent and dispose of liquid-soaked clothes in approved metal safety container.
- Metal containers of liquid must be grounded to maintain electrical continuity.

B&B 3100 Cleaner-Water Solution 18

- B&B 3100 cleaner shall be mixed with water (or water antifreeze solution) only in the proportions specified.
- For engines installed in aircraft, close off appropriate air bleed ducts to cockpit/cabin to prevent entrance of cleaning solution or gases during washing and drying cycles.
- For engines installed in aircraft, make sure that compressor is rinsed and dried for the periods specified so that cleaning solution is not trapped in passages, crevices, and other areas of the engine.
- Solution irritates eyes. Wear splashproof goggles or face shield when using solution.
- Use protective gloves and clothing. Repeated or prolonged contact will dry the skin and will cause irritation and dermatitis.
- If clothing becomes contaminated with cleaning solution, remove affected clothing. Wash affected skin areas with plenty of water.
- Use solution with adequate ventilation. Repeated or prolonged breathing of vapors may irritate mucous membranes and may cause headaches and dizziness.
- Persons with known respiratory irritation should get medical advice before using cleaning solution.
- Avoid open flames, heat, smoking, or other ignition sources in the areas of storage and use.
- Spills should be immediately cleaned up (using squeegee or absorbent material) to prevent evaporation of vapors and slippery floors. Dispose of spillage according to local safety regulations.

Calibrating Fluid, MIL-C-7024 **21**

- Combustible near sparks, open flames, welding areas, hot surfaces, other sources of ignition, or while smoking.
- Inhalation may cause irritation or burning of respiratory system.
- Contact with eyes/face/skin may cause severe irritation or burning.
- Ingestion may cause irritation or burning of digestive system.
- Personal protective equipment required when handling or using this material.
- Thermal decomposition may release toxic by-products.

Dry Cleaning Solvent **32**
(Stoddard Solvent), P-D-680

- Combustible - do not use near open flames, near welding areas, or on hot surfaces.
- Prolonged contact of skin with liquid can cause dermatitis. Repeated inhalation of vapor can irritate nose and throat and can cause dizziness.
- If any liquid contacts skin or eyes, immediately flush affected area thoroughly with water. Remove solvent-saturated clothing. If vapors cause dizziness, go to fresh air.
- When handling liquid or when applying it in an air-exhausted, partially covered tank, wear approved gloves and goggles.
- When handling liquid or when applying it at unexhausted, uncovered tank or workbench, wear approved respirator, gloves, and goggles.

General Purpose Detergents, MIL-D-16791
40

- Do not take internally.
- Do not get in eyes.
- Wear goggles or face shield when handling.

Lubricating Oil **66**

- If oil is decomposed by heat, toxic gases are released.
- Prolonged contact with liquid or mist may cause dermatitis and irritation.
- If there is any prolonged contact with skin, wash area with soap and water. If solution contacts eyes, flush eyes with water immediately. Remove saturated clothing.
- If oil is swallowed, do not try to vomit. Get immediate medical attention.
- When handling liquid, wear rubber gloves. If prolonged contact with mist is likely, wear approved respirator.

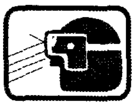
Corrosion Preventive Compound, Petrolatum, Hot Application, MIL-C-11796
69

- If solution is decomposed by heat, toxic gases are released.
- Prolonged contact with solution or mist can cause dermatitis and irritation.
- If there is any prolonged contact with skin, wash contacted area with soap and water. If solution contacts eyes, flush eyes with water immediately. Remove saturated clothing.
- If solution is swallowed, do not try to vomit. Get immediate medical help.
- When handling solution, wear rubber gloves. If prolonged contact with mist is likely, wear approved respirator.

Hydraulic Fluid **71**

- Inhalation may cause irritation or burning of repsiratory system.
- Contact with eyes/face/skin may cause irritation or burning.
- Ingestion may cause irritation or burning of digestive system.
- Personal protective equipment required when handling or using this material.
- Thermal decomposition releases toxic by-products.

Methanol, O-M-232 **83**



- Flammable - do not use near open flames, near welding areas, or on hot surfaces.
- Do not smoke when using it, and do not use it where others are smoking.
- Prolonged or repeated inhalation of vapor can cause eye irritation, drowsiness, and headache. Ingestion may be fatal or may cause eye damage.
- If vapor contacts eyes, immediately flush eyes with large amounts of water. Immediately remove solvent-saturated clothing. If vapors cause drowsiness, go to fresh air.
- When handling or applying liquid at air-exhausted workbench, wear approved goggles.
- When handling or applying liquid at unexhausted workbench, wear approved respirator and goggles.
- Solution of 40% methanol and 60% water is combustible.

Miller-Stephenson Solvent MS-160 (Or Freon, TP-35) **85**

- Vapors are harmful; do not use solvent near open flames or on hot surfaces. Use it only with adequate ventilation.
- Do not use it near welding areas, a source of concentrated ultraviolet rays. Intense ultraviolet rays can cause the formation of toxic gas.
- Do not smoke when using it.
- Do not take it internally.
- Prolonged or repeated contact can cause skin irritation. Wear approved gloves and goggles (or face shield) when handling, and wash hands thoroughly after handling.
- Store it in approved metal safety containers.

Naphtha **88**

- Combustible - do not use it near welding areas, near open flames, or on hot surfaces.
- Avoid prolonged or repeated contact with liquid.
- Contact of skin with liquid can cause irritation and dermatitis. Inhalation of vapors can cause irritation, giddiness, and drowsiness.
- If liquid contacts eyes, flush eyes thoroughly with water. If there is any prolonged skin contact, wash contacted area with soap and water. If vapors cause drowsiness, go to fresh air. Remove solvent-saturated clothing. If liquid is swallowed, do not try to vomit. Get medical attention.
- When handling liquid in an air-exhausted, partially covered tank, wear approved gloves.
- When handling liquid in an open, unexhausted container, wear rubber gloves and goggles. If contact with vapor is likely, wear an approved respirator. Dispose of liquid-soaked rags in approved metal container.
- Metal containers of liquid must be grounded to maintain electrical continuity.

RTV Silicone Rubber Adhesive/Sealant, MIL-A-46106 or MIL-A-46106A **95**
RTV-60 Silicone Rubber Potting Compound, MIL-I-46838B

- Vapor released during curing is combustible. Do not use near open flames, near welding areas, or on hot surfaces.
- Vapor is corrosive. Contact of vapor with skin or eyes will cause burns. Inhalation of vapor may cause severe nose and throat irritation; repeated inhalation may result in chronic bronchitis.
- If any vapor contacts skin or eyes, immediately flush affected area thoroughly with water. If vapors cause irritation, go to fresh air. Get medical attention.
- When mixing uncured rubber, and during curing of rubber wear approved respirator, gloves, and goggles or face shield.

Tetrachloroethylene (Perchloroethylene), O-T-236 **99**

- Repeated or prolonged contact with liquid or inhalation of vapor can cause skin and eye irritation, dermatitis, narcotic effects, and liver and kidney damage.
- After prolonged skin contact, wash contacted area with soap and water. Remove contaminated clothing. If vapors cause irritation, go to fresh air. For prolonged over-exposure, get medical help.
- When handling liquid in vapor-degreasing tank with hinged cover and air exhaust, or at air-exhausted workbench, wear approved gloves and goggles to prevent contact with liquid.
- When handling liquid at open, unexhausted workbench, wear approved respirator, gloves, and goggles.
- Dispose of liquid-soaked rags in approved metal container.

Trichloroethane, O-T-620 122

- Do not use near open flames, welding areas, or on very hot surfaces. Do not smoke when using it. Heat and flames can cause the formation of phosgene gas which is injurious to the lungs.
- Repeated or prolonged contact with liquid or inhalation of vapor can cause skin and eye irritation, dermatitis, narcotic effects, and heart damage.
- After prolonged skin contact, wash contacted area with soap and water. Remove contaminated clothing. If vapors cause irritation, go to fresh air. Get medical attention for overexposure of skin and eyes.
- When handling liquid in vapor-degreasing tank with hinged cover and air exhaust, or at air-exhausted workbench, wear approved gloves and goggles.
- When handling liquid at open, unexhausted workbench, wear approved respirator, gloves, and goggles.
- Dispose of liquid-soaked rags in approved metal container.

Trichlorotrifluoroethane, MIL-C-81302 124

- Repeated or prolonged contact with liquid or inhalation of vapor can cause skin and eye irritation, dermatitis, drowsiness, and heart damage.
- After prolonged skin contact, wash contacted area with soap and water. Remove contaminated clothing. If vapors cause irritation, go to fresh air; get medical attention.
- When handling liquid in vapor-degreasing tank with hinged cover and air-exhaust, or at air-exhausted workbench, wear approved gloves and goggles.
- When handling liquid at open, unexhausted workbench, wear approved respirator, gloves, and goggles.
- Dispose of liquid-soaked rags in approved metal container.

Penetrating Oil **234**

- Do not use near open flames or other heat source including smoking.
- Do not have any contact with liquid or vapor. Contact of eyes with vapor or liquid can cause severe irritation. Prolonged inhalation of vapor may cause headache, dizziness, and nausea.
- If liquid contacts eyes, flush them throughly with water. After prolonged skin contact, wash contacted area with soap and water. If vapors cause dizziness, go to fresh air.
- When handling or applying liquid, wear goggles or face shield. If prolonged exposure to vapor is likely, wear approved respirator.

Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys, MIL-C-81706 **281**

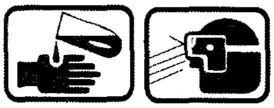
- Highly reactive - do not mix with oxidizable materials such as cloth, paper, and wood.
- When mixing solutions, add acid to water, not water to acid.
- Contact with powder or vapors can cause severe skin and eye irritation, and skin ulcers. Repeated or prolonged inhalation or ingestion can result in nasal and kidney damage.
- If any liquid or powder contacts skin or eyes, immediately flush affected area thoroughly with water. Immediately change any contaminated clothing. If skin disorders appear, get medical attention.
- When handling powder or liquid at air-exhausted workbench or tank, wear approved gloves and apron.
- When handling powder or liquid at unexhausted workbench, wear approved respirator, gloves, and apron.
- Do not eat, smoke, or carry smoking materials in areas where powder is handled.
- Contains chromates. Follow approved toxic waste disposal procedures.

Aviation Turbine Fuel (Jet Fuel) 292

- Flammable near sparks, open flames, hot surfaces, other sources of ignition, or while smoking.
- Inhalation may cause irritation or burning of respiratory system.
- Contact with eyes/face/skin may cause irritation or burning.
- Ingestion may cause irritation or burning of the digestive system.
- Material contains chemicals known to be carcinogenic.
- Personal protective equipment required when handling or using this material.
- Thermal decomposition may release toxic by-products

R-MC or Rivenaes R-MC Cleaner/Mixture 403

- Do not use the Rivenaes R-MC cleaner/mixture near flames or heat.
- The cleaner/mixture, when mixed with isopropyl alcohol or methanol, is a flammable mixture.
- Do not breathe the fumes released from this cleaner/ mixture. Make sure you have a good flow of air. The fumes can make you sick.
- Do not let the cleaner/mixture stay on your skin because the cleaner/mixture can dry your skin or can cause injury to your eyes.



Antiseize Compound
Braycote 655
416

- Contact with these materials can cause irritation to skin and eyes.
- After any prolonged skin contact, wash contacted area with soap and water. If material contacts eyes, flush them thoroughly with water.

Natural Gas **4018**

- Provide adequate ventilation to avoid concentration of potentially explosive fumes or vapor.
- Enclosed areas should be monitored for oxygen content and explosive vapors. If oxygen content falls below 19.5 percent, self-contained breathing equipment is required. Cartridge or canister respirators must not be used.
- Never use open flame to detect leaks, use a soap and water solution.

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

ALPHABETICAL INDEX

Effectivity:	L32119G01/-G03/-G04/	
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Alphabetical Index

Subject Page No.

Alphabetical Index 2

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Removal	I	WP 029 00
Replacement	I	WP 029 00

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Subject	Volume	Work Package
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Vibrations (Abnormal Running Condition) (Industrial)	I	WP 005 00
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W

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Removal	I	WP 022 00
Water Wash Hoses and Spray Nozzles		
Installation	I	WP 022 00
Removal	I	WP 022 00
Water Wash Spray Nozzles		
Installation	I	WP 022 00
Removal	I	WP 022 00
White-Light Inspection	I	WP 007 00
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Work Package Page Numbers	I	WP 002 00
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Wrench, Offset Extension (Crowfoot)	I	WP 007 00
Wrench Sizes, Torque	I	WP 007 00

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

INTRODUCTION

GENERAL INFORMATION, SAFETY PRECAUTIONS, AND ABBREVIATIONS

Effectivity: L32119G01/-G03/-G04/
-G05/-G06 MARINE GAS TURBINE
L32119G02 INDUSTRIAL GAS TURBINE

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1. GENERAL INFORMATION.

a. Purpose and Scope of Technical Manual.

(1) This manual provides instructions for organizational level maintenance (installation and removal, operation, troubleshooting, and preventive maintenance) for the LM500 Gas Turbine models L32119G02 (Industrial) and L32119G01/-G03/-G04/-G05/-G06 (Marine).

(2) These gas turbines were designed by GE Aircraft Engines, Marine and Industrial Engine Projects Department, Cincinnati, Ohio 45215 USA. These gas turbines are manufactured by GE Aircraft Engines, Military Engine Projects Division, 1000 Western Avenue, Lynn, Massachusetts 01910 USA.

b. Levels of Maintenance.

(1) Level 1 maintenance tasks consist of all work done on the exterior of an installed gas turbine: scheduled inspections, compressor cleaning (water wash), and replacement of the gas turbine. Level 1 maintenance tasks are provided in WP 003 00 through WP 020 00.

(2) Level 2 maintenance tasks consist of removal, cleaning, inspection, repair, test, and installation of one or more major gas turbine components. Level 2 maintenance tasks are provided in WP 021 00 through WP 032 00.

c. Arrangement of Technical Manual.

(1) This manual is arranged in Work Package format.

(2) Pages, paragraphs, tables, and figures have been assigned successive Arabic numerals, starting from 1, in each work package.

(3) Subparagraphs have been assigned lower-case letters (a., b., c., etc.), and are further subdivided by Arabic numerals in parentheses: (1), (2), (3), etc.

(4) Further subdivisions are in lower-case letters in parentheses: (a), (b), (c), etc.

d. Warnings, Cautions, and Notes.

Warnings, Cautions, and Notes will be found throughout this manual. It is important that the significance of each is thoroughly understood by personnel using this manual. Their definitions are:

(1) WARNING: indicates a procedure or practice which, if not followed correctly, could result in personal hazard or injury.

(2) CAUTION: indicates a procedure or practice which, if not strictly observed, could result in damage or destruction of equipment.

(3) NOTE: highlights an essential procedure to assure correct maintenance.

e. Changes to Technical Manual.

(1) Change Symbol. Changes (including addition of new technical data to text, tables, and illustrations) are indicated by the use of vertical line (see figure 1). Previous change symbols will be deleted when a page is subsequently changed, so that the new change symbols show the latest technical change.

(2) Changes to Text. Changes are indicated by a vertical line at the margin of the page, along the changed text (see figure 1). When paragraphs, steps, or tables are deleted, the word "Deleted" will appear next to the paragraph/step/table number.

(3) Changes to Illustrations, Diagrams, and Schematics. Changes to illustrations, diagrams, and schematics are also indicated by a vertical line (see figure 1). When index numbers are deleted, the word "Deleted" will appear next to the index number. (Illustrations represent the gas turbine configuration at the time of inclusion in this technical manual. They may not be changed to represent all and/or the latest gas turbine configurations. They are to be used as an aid in doing maintenance tasks in accordance with the procedures in this manual.)

(4) Page Changes. Insert the latest changed pages and discard the superseded pages. Pages that have changed are designated by the change number and date at the top of each affected page. Refer to the List of Effective Pages in the front of each Work Package to determine the latest changed pages including added and/or deleted pages.

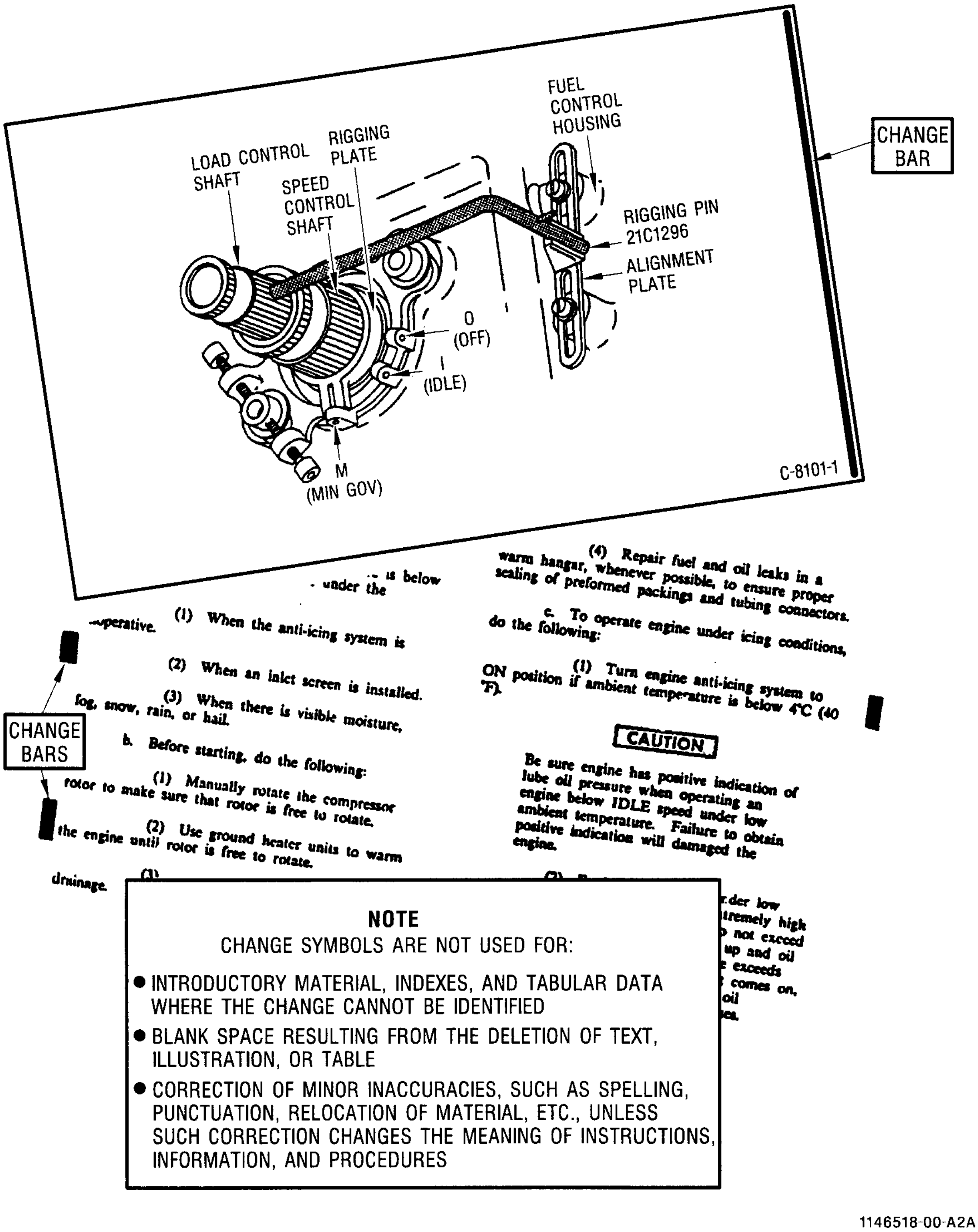

Figure 1. Change Symbols

f. Work Package Page Numbers. The page count at the top of each work package title page indicates the total number of pages in the work package, including A and B pages. Therefore, the page number on the last page may not agree with the page count on the title page. For example, if the pages in WP 001 00 are numbered 1, 2, 2A, 2B, 3, 4, 5/6, the title page will read "Page 1 of 8".

g. Work Package Change/Revised Numbers.

(1) Revised Work Packages (WP) have the issue date only in the upper left-hand corner of Title Page and each page within the WP. At the time of subsequent Changes, the Change Date and Change Number are placed in the upper left-hand corner of Title Page and on each Change Page in the WP, while the Original or Revised pages remain the same, having Change Bars and Revision Date. The backup page to a Change Page also continues to carry its Change/Revised Date or Original Date and Change Bars if applicable.

(2) The status of each page can be verified by the "0" or Change Number listed in the Change No. column in the List of Effective Work Package Pages on the WP Title Page. Revised pages are identified by the "0". Change Pages are identified by the Change Number and Change Date appearing in the upper left-hand corner of the Change Page. This number is also the same as the Change Number on the Title Page of the manual at the time the Change Page is issued.

h. Gas Turbine Points of Reference and Orientation. Unless otherwise specified, all references to left, right, forward, aft, and clock positions apply when viewing the gas turbine from the aft end (exhaust end) looking towards the forward end (see figure 2).

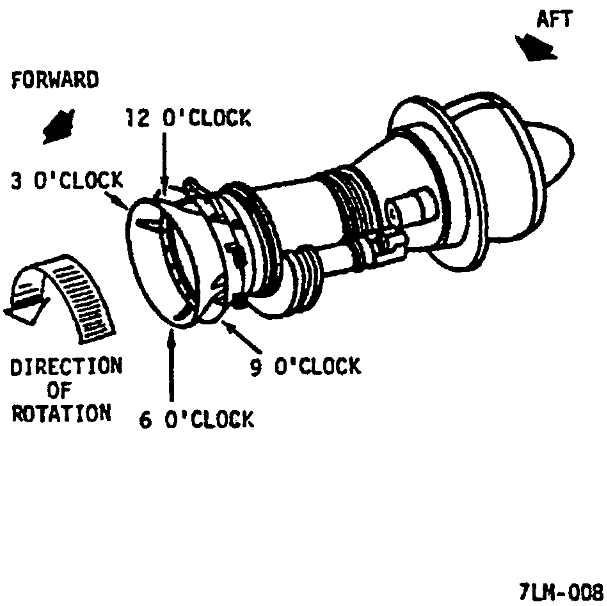

Figure 2. Gas Turbine Points of Reference and Orientation

i. Support Equipment, Consumable Materials, and Expendables. At the beginning of each work package there may be a table that lists the support equipment and the consumable materials that are required to do the maintenance tasks in the work package. The support equipment and the consumable materials are defined as follows:

(1) Support Equipment: special tools that are needed to remove, clean, inspect, repair, assemble, install, or test gas turbine components to make them operational.

(2) Consumable Materials: items that are not listed in the Illustrated Parts Breakdown (GEK 99441, Volume II), or that cannot be reused, are considered consumable materials. Included are items such as lockwire, greases, and solvents.

(3) Expendables: some items that are listed in the Illustrated Parts Breakdown (GEK 99441, Volume II) are not reusable. These items include preformed packings, tabwashers, and cotter pins.

2. SAFETY PRECAUTIONS.

a. General. The intent of this technical manual is to provide procedures and processes for accomplishing the safe operation and maintenance tasks of the gas turbine. Therefore, it is important that the Warnings and Cautions be thoroughly understood and observed by the users of the manual. Any changes, additions, or suggestions that are deemed necessary for the proper operation, maintenance, and safety improvements of the gas turbine should be submitted using the Publication Change Request Form (see figure 3) to:

Manager, Customer Service and Product Support
Marine and Industrial Engine Projects Department
GE Aircraft Engines
Mail Drop S156
Cincinnati, OH 45215
USA

PUBLICATION CHANGE REQUEST
GE Marine Engines

PCR No. ______

Mail to: GE Marine Engines
Marine Service and Factory Technical Support
Mail Drop S-156
One Neumann Way
PO Box 156301
Cincinnati, Ohio 45215-6301, USA

ATTN: Documentation Programs

☐ LM6000 ☐ LM5000 ☐ LM2500 ☐ LM1600 ☐ LM500
☐ Industrial ☐ International Marine ☐ Shipyard

REQUEST FOR ☐ Manual
☐ Other ______

Originator ______

Date ______

Address ______

Document I.D. No. ______

Page No. ______ Para. ______

Fig No. ______ Table No. ______

Phone No. ______

Subject of Change ______

Specific Instructions ______

Reference Documents ______

FOR GE USE:

GE Manual Specialist ______ Send To ______

Closed Date ______ Closed By ______

Response ______

CC:

1172535-00-A2A

Figure 3. Publication Change Request Form

b. Hazards and General Safety Precautions. The following are general safety precautions that are not related to any specific procedures; therefore, they do not appear elsewhere in this manual. Personnel must understand and apply these precautions during any phase of operation and maintenance of the gas turbine.

(1) Health Hazards:

WARNING

- Use all cleaning solvents, fuels, oils, adhesives and epoxys, and catalysts in a well-ventilated area. Avoid frequent and prolonged inhalation of fumes. Concentrations of fumes of many cleaners, adhesives, and esters are toxic and will cause serious damage to the body's nervous system and possible death, if breathed frequently.
- Avoid frequent or prolonged exposure to the skin. Wash thoroughly with soap and warm water as soon as possible after using these materials.
- Take special precautions to avoid getting materials in the eyes. If exposed, rinse the eyes in an eye bath fountain immediately and report to a physician.
- Avoid spilling Freon or similar solvents on the skin. Extremely rapid evaporation of these solvents has a refrigerating effect and may cause serious frostbite.
- Do not allow adhesives to contact the skin. Rapid bonding of certain adhesives will cause instant adhesion to body members or objects. Do not attempt to forcefully separate body members if bonded together. Consult the area supervisor or a physician for separation procedures.

(2) Fire Hazards:

WARNING

- Keep all cleaning solvents, oils, esters and adhesives away from open flame space heaters, exposed element electric heaters, sparks, or flame. Do not smoke when using, or when in the vicinity of flammable materials, or in areas where flammables are stored.
- Provide adequate ventilation to avoid concentrations of potentially explosive fumes or vapors.
- Provide approved containers for bulk storage of flammable materials, and for dispensers in the working areas. Keep all containers tightly closed when not in use.

(3) Procedural Hazards:

WARNING

- Observe all specified and logical safety practices when doing maintenance on the gas turbine.
- Wear safety glasses or other appropriate eye protection at all times.
- Do not allow lockwire or lockwire clippings to fly from the cutter during removal or installation of lockwire.
- Do not use fingers as guides when installing parts or when checking alignment of holes.
- Use only the correct tools and fixtures, and use them as recommended.
- Avoid shortcuts, such as using fewer, shorter, or the incorrect quantity of attaching bolts.
- Read all warnings contained in this manual to avoid injury to personnel or damage to gas turbine parts.

(4) Tooling Hazards:

WARNING

- Improperly maintained tools and support equipment can be dangerous to personnel and can damage gas turbine parts. Observe the recommended inspections and maintenance schedules of tools.
- Use tools only for the purpose for which they were designed, and avoid abuse. Be constantly alert for damaged or unauthorized tools and support equipment, and initiate appropriate corrective action for repair immediately.

WARNING

When using equipment provided or associated with high frequency power generators, be sure that all components are adequately isolated from noninvolved personnel, and be sure they are insulated to prevent serious injury to the operator. Be sure the generator power is off when connecting or positioning connectors and cables, and when adjusting the heater elements.

CAUTION

All gas turbine components have been manufactured using the U.S. (English) measurement units. Use of substitute metric-size components is not recommended, and will void warranty for interfacing parts. Metric tools should be used with suitable adapters to interface with English-size tools. Limits, fits, and clearance measurements may be converted to either the English or the metric units.

(5) Operating Hazards:

WARNING

- The external surfaces of the gas turbine are not insulated. Adequate precautions should be taken to prevent operating personnel from inadvertent contact with the hot surfaces.
- The gas turbine is a source of considerable noise. It will be necessary for personnel working in the gas turbine compartment to wear ear protection when the gas turbine is operating.
- The gas generator is a high-speed machine. In the remote event of parts failure, the casing of the gas generator would contain the compressor blades and turbine blades, but might not contain major failures of compressor or turbine disks. Operating personnel should not be permanently stationed in, or near, the plane of the rotating parts.
- The rotating parts of the starter operate at very high speeds. In the remote event of parts failure, personnel should not be stationed in the plane of the starter during the starting cycle.
- The low pressure and the high velocity created by the gas generator compressor can draw objects and personnel into the inlet of the gas generator. The use of an inlet screen and other protective devices is recommended.
- Fire protection equipment must be available at all times.

WARNING

When opening the gas turbine enclosure for inspection, or maintenance, the following safety precautions must be observed:

- The gas turbine must be shut down, or limited to idle speed.
- The fire extinguishing system must be made inactive. Halon can cause suffocation, if accidentally discharged.
- Avoid contact with hot parts; wear thermally insulated gloves as necessary.
- Ear protection must be worn if gas turbine is operating.
- When doing maintenance on electrical components, avoid shocks and burns by turning off electrical power to those components, except when necessary to take voltage measurements.
- Tag electrical switches OUT-OF-SERVICE to prevent activation. Tag the operating controls of the gas turbine DO NOT OPERATE to prevent starting during a shutdown condition.

c. The maintenance of the gas turbine requires that inspection checks be made periodically. The inspection requirements and limits throughout this manual are based on operation within specified limits. In addition to the regular inspections, there are those necessary when the gas turbine has been operated outside of the specified limits, for example, off-schedule variable geometry operation, overspeed, or overtemperature. There are also specific inspections necessary for gas turbines exposed to abnormal conditions. These may include, for example, failures with significant damage and other abnormal exposure such as installation fire or mishap during transportation, handling, or storage. This manual includes routine inspection requirements to be accomplished for preventative maintenance and for troubleshooting. It also includes criteria for determining if special instructions are necessary because of exposure to abnormal conditions.

3. **ABBREVIATIONS.** The abbreviations that are used throughout this manual to describe limits, settings, and commonly used terms are listed in table 1.

TABLE 1. ABBREVIATIONS

Abbreviation	Definition	Abbreviation	Definition
ac	Alternating Current	LPT	Low Pressure Turbine
AGB	Accessory Gearbox	M	Meter
Btu/lb	British Thermal Units per Pound	mm	Millimeter
cc	Cubic Centimeter	N1	Compressor Gas Generator Rotor Speed (rpm) (Industrial Only)
CIT	Compressor Inlet Temperature	N2	Power Turbine Shaft Speed (rpm) (Industrial Only)
cm	Centimeter	N•m	Newton Meters
Cont	Continued	OAT	Outside Air Temperature
Dia	Diameter	OD	Outside Diameter
FOD	Foreign Object Damage	Δ P	Differential Pressure
GG	Gas Generator	P4.8	Power Turbine Inlet Total Pressure
gpm	Gallons per Minute	pph	Pounds per Hour
HMWS	Hazardous Material Warning Section	ppm	Parts per Million
hp	Horsepower	PS or PS3	Compressor Discharge Static Pressure
HPT	High-Pressure Turbine or Gas Generator Turbine	psi	Pounds per Square Inch
Hz	Cycles per Second (Hertz)	psia	Pounds per Square Inch Absolute
ID	Inside Diameter	psid	Pounds per Square Inch Differential
IGV	Inlet Guide Vane	psig	Pounds per Square Inch Gage
kg	Kilogram	PT	Power Turbine
kg/hr	Kilograms per Hour	PT4.8	Power Turbine Inlet Pressure
kPa	Kilopascals	PTO	Power Takeoff
lb	Pounds	Qty	Quantity
lb/hr	Pounds per Hour	rpm	Revolutions per Minute
lb ft	Pound Feet		
lb in.	Pound Inches		
LHV	Low Heating Value		
lpm	Liters per Minute		

TABLE 1. ABBREVIATIONS (Cont)

Abbreviation	Definition	Abbreviation	Definition
SI	System Internationale	VSV	Variable Stator Vanes
SOAP	Spectrometric Oil Analysis Program	Wf	Fuel Flow
T1.5	Compressor Inlet Temperature	WP	Work Package
T4.8	Power Turbine Inlet Total Temperature	XN2	Compressor Gas Generator Rotor Speed (rpm) (Marine Only)
V	Volt	XN2R	Gas Generator Corrected Rotor Spec (rpm) (Marine Only)
VA	Volt-Ampere	XNSD	Power Turbine Shaft Speed (rpm) (Marine Only)
V ac	Alternating-Current Volts		
V dc	Direct-Current Volts		
VG	Variable Geometry		

4. **UNIT CONVERSION.** This technical manual utilizes U.S. (English) units of measurement as the primary values. The metric, or SI (Systems Internationale) units are expressed in parentheses following the English units. In most cases the SI units are direct mathematical conversions and may be rounded off at the user's discretion. Examples where the SI units may not be rounded off are those used for dimensional checks, rigging adjustments, runouts, etc. Tables 2, 3, and lists the conversion factors.

TABLE 2. CONVERSION FACTORS

To convert from	to	Multiply by
LENGTH		
centimeters	inches	0.3937
inches	centimeters	2.540
inches	feet	0.08333
inches	meters	0.02540
inches	microns	25,400
inches	millimeters	25.400
inches	yards	0.02778
meters	feet	3.2809
meters	yards	1.0936
microns	inches	0.0000394
microns	meters	0.000001
PRESSURE		
kg/cm^2	$lb/in.^2$ (psi)	14.223
kg/cm^2	pascals	98,066.5
kg/m^2	pascals	9.8066
kg/m^2	lb/ft^2	0.2048
$lb/in.^2$ (psi)	kg/cm^2	0.0703
$lb/in.^2$(psi)	kilopascals (kPa)	6.8948
DENSITY		
grams per cm^3	ounces per $in.^3$	0.5780
ounces per $in.^3$	grams per cm^3	1.730
kilograms per m^3	pounds per ft^3	0.06243
pounds per ft^3	kilograms per m^3	16.019

TABLE 2. CONVERSION FACTORS (Cont)

To convert from	to	Multiply by
VOLUME		
cubic centimeters	cubic inches	0.06102
cubic inches	cubic centimeters	16.39
cubic inches	cubic feet	0.0005787
cubic inches	cubic meters	0.00001639
cubic inches	liters	0.0164
cubic inches	gallons	0.004329
cubic inches	quarts	0.01732
gallons	cubic inches	231.0
gallons	cubic meters	0.003785
gallons	liters	3.785
gallons	quarts	4.0
pints	liters	0.4732
pints	quarts	0.50
ounces	milliliters (cc)	29.57353
quarts	liters	0.9464
quarts	pints	2.0
WEIGHT		
grams	kilograms	0.001
grams	ounces	0.03527
grams	pounds	0.002205
kilograms	ounces	55.274
kilograms	pounds	2.2046
ounces	grams	28.35
ounces	kilograms	0.02835
pounds	grams	453.6
pounds	kilograms	0.4536
pounds	ounces	16.0
TORQUE		
pound foot (lb ft)	newton-meter (N•m)	1.356
pound inch (lb in.)	newton-meter (N•m)	0.113

TABLE 3. Temperature Conversion Chart

To convert indicated temperature between Fahrenheit and Celsius, find indicated temperature (either Celsius or Fahrenheit) in middle column and read Fahrenheit equivalent in the right column or the Celsius equivalent in the left column. For example, a temperature of 32°F, when selected from the center column, shows a corresponding temperature of 0°C in the left column. A temperature of 0°C, when selected from the center column, shows a corresponding temperature of 32°F in the right column.

Temperature Conversion Formulas

Temperature (°C) = (Temperature °F - 32) ÷1.8 Temperature (°F) = (1.8 x Temperature °C) + 32

-60 to 60			61 to 350			360 to 1050			1060 to 1750			1760 to 2450			2460 to 3000		
°C		°F	°C		°F	°C		°F	°C		°F	°C		°F	°C		°F
-51	-60	-76	16.1	61	141.8	182	360	680	571	1060	1940	960	1760	3200	1349	2460	4460
-46	-50	-58	16.7	62	143.6	188	370	698	577	1070	1958	966	1770	3218	1354	2470	4478
-40	-40	-40	17.2	83	145.4	193	380	716	582	1080	1976	971	1780	3236	1360	2480	4496
-34	-30	-22	17.8	64	147.2	199	390	734	588	1090	1994	977	1790	3254	1366	2490	4514
-29	-20	-4	18.3	65	149.0	204	400	752	593	1100	2012	982	1800	3272	1371	2500	4532
-23	-10	14	18.9	66	150.8	210	410	770	599	1110	2030	988	1810	3290	1377	2510	4550
-17.8	0	32	19.4	67	152.6	216	420	788	604	1120	2048	993	1820	3308	1382	2520	4568
-17.2	1	33.8	20.0	68	154.4	221	430	806	610	1130	2066	999	1830	3326	1388	2530	4586
-16.7	2	35.6	20.6	69	156.2	227	440	824	616	1140	2084	1004	1840	3344	1393	2540	4604
-16.1	3	37.4	21.1	70	158.0	232	450	842	621	1150	2102	1010	1850	3362	1399	2550	4622
-15.6	4	39.2	21.7	71	159.8	238	460	860	627	1160	2120	1016	1860	3380	1404	2560	4640
-15.0	5	41.0	22.2	72	161.6	243	470	878	632	1170	2138	1021	1870	3398	1410	2570	4658
-14.4	6	42.8	22.8	73	163.4	249	480	896	638	1180	2156	1027	1880	3416	1416	2580	4676
-13.9	7	44.6	23.3	74	165.2	254	490	914	643	1190	2174	1032	1890	3434	1421	2590	4694
-13.3	8	46.4	23.9	75	167.0	260	500	932	649	1200	2192	1038	1900	3452	1427	2600	4712
-12.8	9	48.2	24.4	76	168.8	266	510	950	654	1210	2210	1043	1910	3470	1432	2610	4730
-12.2	10	50.0	25.0	77	170.6	271	520	968	660	1220	2228	1049	1920	3488	1438	2620	4748
-11.7	11	51.8	25.6	78	172.4	277	530	986	666	1230	2246	1054	1930	3506	1443	2630	4766
-11.1	12	53.6	26.1	79	174.2	282	540	1004	671	1240	2264	1060	1940	3524	1449	2640	4784
-10.6	13	55.4	26.7	80	176.0	288	550	1022	677	1250	2282	1066	1950	3542	1454	2650	4802
-10.0	14	57.2	27.2	81	177.8	293	560	1040	682	1260	2300	1071	1960	3560	1460	2660	4820
- 9.4	15	59.0	27.8	82	179.6	299	570	1058	688	1270	2318	1077	1970	3578	1466	2670	4838
- 8.9	16	60.8	28.3	83	181.4	304	580	1076	693	1280	2336	1082	1980	3596	1471	2680	4856
- 8.3	17	62.6	28.9	84	183.2	310	590	1094	699	1290	2354	1088	1990	3614	1477	2690	4874
- 7.8	18	64.4	29.4	85	185.0	316	600	1112	704	1300	2372	1093	2000	3632	1482	2700	4892
- 7.2	19	66.2	30.0	86	186.8	321	610	1130	710	1310	2390	1099	2010	3650	1488	2710	4910
- 6.7	20	68.0	30.6	87	188.6	327	620	1148	716	1320	2408	1104	2020	3668	1493	2720	4928
- 6.1	21	69.8	31.1	88	190.4	332	630	1166	721	1330	2426	1110	2030	3686	1499	2730	4946
- 5.6	22	71.6	31.7	89	192.2	338	640	1184	727	1340	2444	1116	2040	3704	1504	2740	4964
- 5.0	23	73.4	32.2	90	194.0	343	650	1202	732	1350	2462	1121	2050	3722	1510	2750	4982
- 4.4	24	75.2	32.8	91	195.8	349	660	1220	738	1360	2480	1127	2060	3740	1516	2760	5000
- 3.9	25	77.0	33.3	92	197.6	354	670	1238	743	1370	2498	1132	2070	3758	1521	2770	5018
- 3.3	26	78.8	33.9	93	199.4	360	680	1256	749	1380	2516	1138	2080	3776	1527	2780	5036
- 2.8	27	80.6	34.4	94	201.2	366	690	1274	754	1390	2534	1143	2090	3794	1532	2790	5054
- 2.2	28	82.4	35.0	95	203.0	371	700	1292	760	1400	2552	1149	2100	3812	1538	2800	5072
- 1.7	29	84.2	35.6	96	204.8	377	710	1310	766	1410	2570	1154	2110	3830	1543	2810	5090
- 1.1	30	86.0	36.1	97	206.6	382	720	1328	771	1420	2588	1160	2120	3848	1549	2820	5108
- 0.6	31	87.8	36.7	98	208.4	388	730	1346	777	1430	2606	1166	2130	3866	1554	2830	5126
0.0	32	89.6	37.2	99	210.2	393	740	1364	782	1440	2624	1171	2140	3884	1560	2840	5144
0.6	33	91.4	37.8	100	212.0	399	750	1382	788	1450	2642	1177	2150	3902	1566	2850	5162
1.1	34	93.2	43	110	230	404	760	1400	793	1460	2660	1182	2160	3920	1571	2860	5180
1.7	35	95.0	49	120	248	410	770	1418	799	1470	2678	1188	2170	3938	1577	2870	5198
2.2	36	96.8	54	130	266	416	780	1436	804	1480	2696	1193	2180	3956	1582	2880	5216
2.8	37	98.6	60	140	284	421	790	1454	810	1490	2714	1199	2190	3974	1588	2890	5234
3.3	38	100.4	66	150	302	427	800	1472	816	1500	2732	1204	2200	3992	1593	2900	5252
3.9	39	102.2	71	160	320	432	810	1490	821	1510	2750	1210	2210	4010	1599	2910	5270
4.4	40	104.0	77	170	338	438	820	1508	827	1520	2768	1216	2220	4028	1604	2920	5288
5.0	41	105.8	82	180	356	443	830	1526	832	1530	2786	1221	2230	4046	1610	2930	5306
5.6	42	107.6	88	190	374	449	840	1544	838	1540	2804	1227	2240	4064	1616	2940	5324
6.1	43	109.4	93	200	392	454	850	1562	843	1550	2822	1232	2250	4082	1621	2950	5342
6.7	44	111.2	99	210	410	460	860	1580	849	1560	2840	1238	2260	4100	1627	2960	5360
7.2	45	113.0	104	220	428	466	870	1598	854	1570	2858	1243	2270	4118	1632	2970	5378
7.8	46	114.8	110	230	446	471	880	1616	860	1580	2876	1249	2280	4136	1638	2980	5396
8.3	47	116.6	116	240	464	477	890	1634	866	1590	2894	1254	2290	4154	1643	2990	5414
8.9	48	118.4	121	250	482	482	900	1652	871	1600	2912	1260	2300	4172	1649	3000	5432
9.4	49	120.2	127	260	500	488	910	1670	877	1610	2930	1266	2310	4190			
10.0	50	122.0	132	270	518	493	920	1688	882	1620	2948	1271	2320	4208			
10.6	51	123.8	138	280	536	499	930	1706	888	1630	2966	1277	2330	4226			
11.1	52	125.6	143	290	554	504	940	1724	893	1640	2984	1282	2340	4244			
11.7	53	127.4	149	300	572	510	950	1742	899	1650	3002	1288	2350	4262			
12.2	54	129.2	154	310	590	516	960	1760	904	1660	3020	1293	2360	4280			
12.8	55	131.0	160	320	608	521	970	1778	910	1670	3038	1299	2370	4298			
13.3	56	132.8	166	330	626	527	980	1796	916	1680	3056	1304	2380	4316			
13.9	57	134.6	171	340	644	532	990	1814	921	1690	3074	1310	2390	4334			
14.4	58	136.4	177	350	662	538	1000	1832	927	1700	3092	1316	2400	4352			
15.0	59	138.2				543	1010	1850	932	1710	3110	1321	2410	4370			
15.6	60	140.0				549	1020	1868	938	1720	3128	1327	2420	4388			
						554	1030	1886	943	1730	3146	1332	2430	4406			
						560	1040	1904	949	1740	3164	1338	2440	4424			
						566	1050	1922	954	1750	3182	1343	2450	4442			

TABLE 4. Conversion Table - Fractions to Decimals

Fraction	Decimal	Fraction	Decimal	Fraction	Decimal
1/64	0.0156	23/64	0.3594	45/64	0.7031
1/32	0.0312	3/8	0.3750	23/32	0.7188
3/64	0.0469	25/64	0.3906	47/64	0.7344
1/16	0.0625	13/32	0.4063	3/4	0.7500
5/64	0.0781	27/64	0.4219	49/64	0.7656
3/32	0.0938	7/16	0.4375	25/32	0.7813
7/64	0.1094	29/64	0.4531	51/64	0.7969
1/8	0.1250	15/32	0.4688	13/16	0.8125
9/64	0.1406	31/64	0.4844	53/64	0.8281
5/32	0.1563	1/2	0.5000	27/32	0.8438
11/64	0.1719	33/64	0.5156	55/64	0.8594
3/16	0.1875	17/32	0.5313	7/8	0.8750
13/64	0.2031	35/64	0.5469	57/64	0.8906
7/32	0.2188	9/16	0.5625	29/32	0.9063
15/64	0.2344	37/64	0.5781	59/64	0.9219
1/4	0.2500	19/32	0.5938	15/16	0.9375
17/64	0.2656	39/64	0.6094	61/64	0.9531
9/32	0.2813	5/8	0.6250	31/32	0.9688
19/64	0.2969	41/64	0.6406	63/64	0.9844
5/16	0.3125	21/32	0.6563	1	1.0000
21/64	0.3281	43/64	0.6719		
11/32	0.3438	11/16	0.6875		

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

DESCRIPTION AND SPECIFICATIONS

Effectivity:	L32119G01/-G03/ -G04/-G05/-G06	MARINE GAS TURBINE
	L32119G02	INDUSTRIAL GAS TURBINE

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1. INTRODUCTION. This work package provides general information for the LM500 gas turbine. Included in this work package is a description of the gas turbine and its related systems, and the principles of operation.

2. SUPPORT EQUIPMENT.

None

3. CONSUMABLE MATERIALS.

None

4. GAS TURBINE CHARACTERISTICS.

a. The LM500 is a dual-rotor gas turbine with a single-rotor gas generator and an annular combustor. The gas generator (core engine) high-pressure turbine has two air-cooled axial-flow stages. The power turbine has four axial-flow stages. The power turbine drives an output shaft that passes concentrically forward inside the core engine rotor. The power turbine output shaft rotates counterclockwise as viewed from the output shaft flange at the front of the gas turbine (forward looking aft). The gas turbine-mounted accessory drive gearbox assembly is supported by the front frame, and incorporates pads for the mounting of controls and accessories. The basic gas turbine (see figure 1) consists of the following:

- Front frame
- Accessory drive gearbox assembly
- Compressor section
- Combustion section
- High-pressure turbine section
- Power turbine section.

b. The LM500 gas turbine is designed to separate into major sections and structural units. Sectionalized construction is specifically oriented to provide maximum flexibility for maintenance tasks. This capability provides for sectionalized repair or sectionalized replacement.

c. The LM500 gas turbine is constructed with a high degree of accessibility. Detail features are specifically aimed at individual component replacements. They are as follows:

- Stator casing is split on horizontal line for easy access
- All compressor blades, vane sectors, and vanes are individually replaceable
- Fuel tubes and injectors are individually replaceable
- High-pressure turbine (HPT) nozzle segments are individually replaceable
- A limited number of HPT blades are replaceable without rotor balancing, or the HPT may be replaced as a matched, prebalanced assembly
- Power turbine rotor blades are individually replaceable
- Power turbine is replaceable as an assembly
- Compressor water-wash capability is provided
- Mounted accessories and variable geometry system are provided.

d. The gas turbine has incorporated a number of ports, specifically located to provide access to the gas turbine's interior to facilitate borescope inspection. Using the borescope procedure, inspection of the gas turbine's gas path can be accomplished with the gas turbine installed.

e. Design characteristics for the marine gas turbine are listed in table 1.

f. Design characteristics for the industrial gas turbine are listed in table 2.

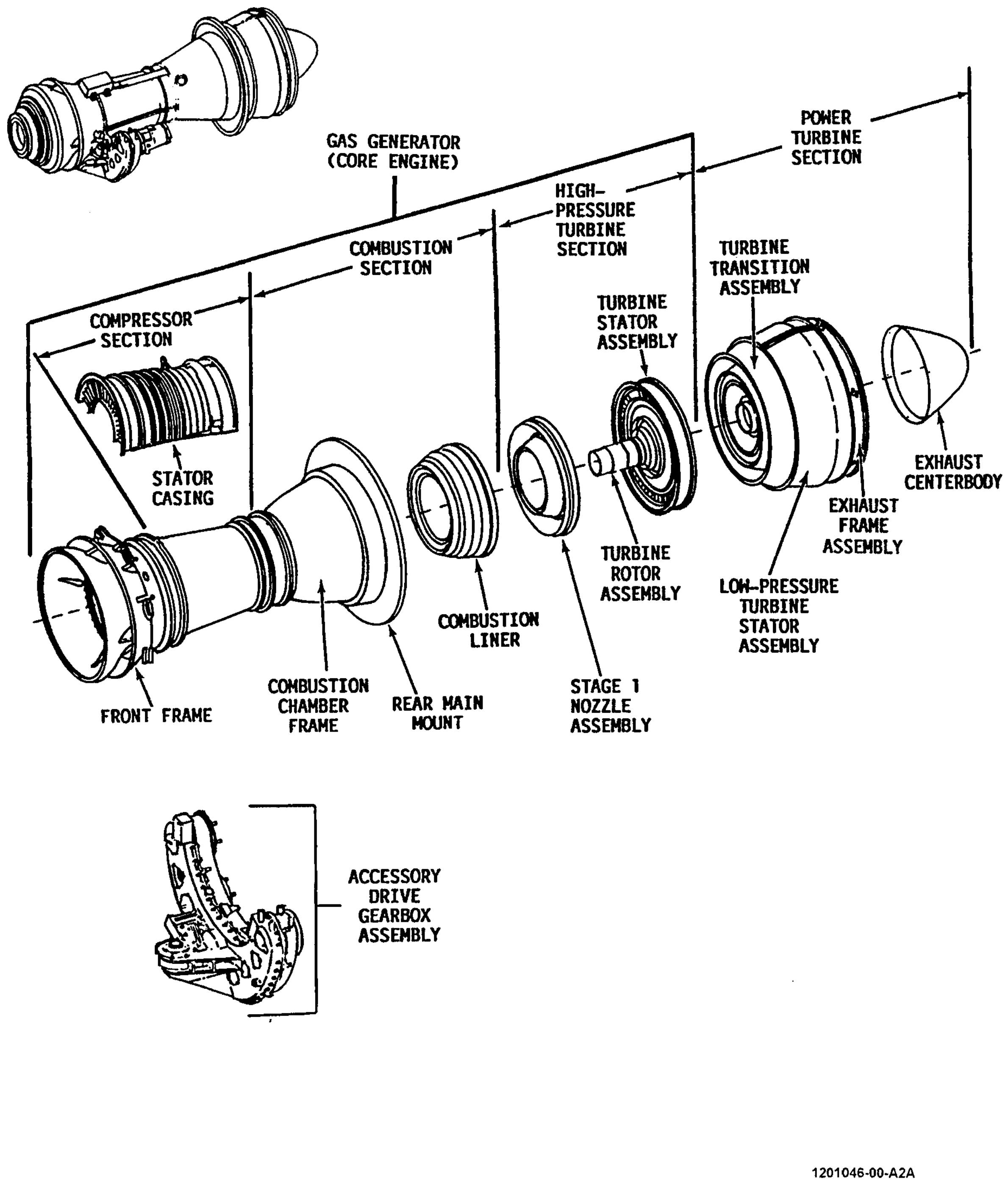


Figure 1. LM500 Gas Turbine Major Components

TABLE 1. DESIGN CHARACTERISTICS (MARINE ONLY)

General	
Type of Engine	Gas Turbine
Type of Compressor	Axial Flow
Number of Compressor Stages	14
Variable Compressor Stators	Inlet guide vanes, stator vane stages 1 through 5
Type of Combustion Chamber	Single, annular, through-flow
High-Pressure Turbine Stages	2
Gas Generator Rotor Speed	0-17,000 rpm (Normal)/17,600 (Max)
Power Turbine Speed	0-7,000 rpm (Normal)/7,700 rpm (Max)
Power Turbine Stages	4
Direction of Rotation	Clockwise (aft looking forward)
Basic Gas Turbine Length	86.14 inches (2.2 meters)
Gas Turbine Weight (dry)	1,300 pounds (590 kg)
Gas Turbine Length with Inlet and Exhaust Duct	130.3 inches (3.3 meters)
Residual Fluids	Negligible
Center of Gravity	At Station 184.12
Ambient Temperature	-65°F to 125°F (-54°C to 52°C)
Fuel System	
Fuel Specification	NATO-F-75 (Liquid fuel: MIL-F-1688A) GE Spec: MIL-TD-0000-2
Manifold Inlet Pressure Required	270 psig (1862 kPa)
Manifold Inlet Temperature	-65°F to 150°F (-54° to 66°C)
Flow Range: Standard Sea Level Conditions Fuel LHV 18,400 Btu/lb	
Idle	400 lb/hr (182 kg/hr)
Maximum Power	2,800 lb/hr (1,270 kg/hr)
Flow	290-3,400 lb/hr (132-1,543 kg/hr)
Specific Gravity (Nominal)	0.835 at 59°F (15°C)
Ignition System	
Ignition Exciter Input:	
Voltage	115 V ac
Amperage	1.3 Amps
Frequency	50/60 Hz
Power	150 VA
Rating	Intermittent (60 seconds between starts)
Duty Cycle (Max)	2 minutes ON, 3 minutes OFF 2 minutes ON, 23 minutes OFF

TABLE 1. DESIGN CHARACTERISTICS (MARINE ONLY) (Cont)

Gas Turbine Lube and Hydraulic System	
Oil Specification	MIL-L-23699
Startup Oil Temp	+ 40°F (4.4°C) minimum
Lube Pressure to Gas Turbine (Minimum)	30 psig (207 kPa) above sump pressure
Hydraulic Oil Pressure to VG Control	30-100 psig (207-690 kPa)
Lube Temperature (to bearings)	140°-170°F (60°-77°C) (248°F (120°C) max)
Lube Scavenge Temperature (B-sump)	176°-310°F (80°-155°C)
Lube Pressure Normal Operation (to bearings)	30-70 psig (207-483 kPa) above B-sump scavenge pressure
Lube Flow	9.9 gpm max (37.5 lpm)
Hydraulic Oil Flow	9.0 gpm max (34.1 lpm)
Filter Efficiency - Lube and Hydraulic System	10 microns

TABLE 2. DESIGN CHARACTERISTICS (INDUSTRIAL ONLY)

General	
Type of Engine	Gas Turbine
Type of Compressor	Axial Flow
Number of Compressor Stages	14
Variable Compressor Stators	Inlet guide vanes, stator vane stages 1 through 5
Type of Combustion Chamber	Single, annular, through-flow
High-Pressure Turbine Stages	2
Gas Generator Rotor Speed	0-17,150 rpm (Normal)/17,360 (Max)
Power Turbine Speed	0-7,000 rpm (Normal)/7,050 rpm (Max)
Power Turbine Stages	4
Direction of Rotation	Clockwise (aft looking forward)
Basic Gas Turbine Length	130.2 inches (3.3 meters)
Gas Turbine Weight (dry)	1,066 pounds (484 kg)
Residual Fluids	Negligible
Center of Gravity	At Station 186.34: 16 inches (406 mm) forward of rear main mount
Fuel System	
Fuel Specification	MID-S-00000-1 (natural gas fuel)
Manifold Inlet Pressure Required	270 psig (1,862 kPa)
Manifold Inlet Temperature	-65° to 150°F (-54° to 66°C)
Flow Range: Standard Sea Level Conditions Fuel LHV 19,000 Btu/lb	
Idle	420 lb/hr (191 kg/hr)
Maximum Power	2,630 lb/hr (1,190 kg/hr)
Specific Gravity (Nominal)	0.568 at 100°F (38°C)

TABLE 2. DESIGN CHARACTERISTICS (INDUSTRIAL ONLY) (Cont)

Ignition System	
Ignition Exciter Input:	
Voltage	115 V ac
Amperage	1.3 Amps
Frequency	60 Hz
Power	150 VA
Rating	Intermittent (60 seconds between starts)
Duty Cycle (Max)	2 minutes ON, 3 minutes OFF 2 minutes ON, 23 minutes OFF
Gas Turbine Lube and Hydraulic System	
Oil Specification	MIL-L-23699 or MIL-L-7807
Startup Oil Temperature:	
MIL-L-23699	+40°F (4.4°C) minimum
MIL-L-7807	0°F (-18°C) minimum
Lube Pressure to Gas Turbine (Minimum)	30 psig (207 kPa) above sump pressure
Hydraulic Oil Pressure to VG Control	30-100 psig (207-690 kPa)
Lube Temperature (to bearings)	140°-170°F (60°-77°C)
Lube Scavenge Temperature (B-sump)	100°-150°F (38°-66°C) above inlet temperature
Lube Pressure Normal Operation (to bearings)	30-60 psig (207-415 kPa) above B-sump scavenge pressure
Lube Flow	9.9 gpm max (37.5 lpm)
Hydraulic Oil Flow	9.0 gpm max (34.1 lpm)
Filter Efficiency - Lube and Hydraulic System	10 microns

5. GAS TURBINE COMPONENTS DESCRIPTION.

a. Front Frame. The front frame (see figure 2) is used to channel the air into the compressor rotor. Mating with the inlet duct and housing, the front frame supports the A-sump No. 1 and No. 2 bearings, power turbine balance piston seal, and stator casings. A reinforcing cone is bolted to the front frame to transfer mounting loads to the front frame struts. The compressor rotor is supported on its forward shaft by the No. 3 thrust bearing, also housed in the front frame. The accessory drive gearbox assembly is also supported by the front frame by designated mounting pads cast into the frame. The front frame also houses the nozzles for waterwashing the compressor rotor.

b. Compressor Section.

(1) Compressor Stator Casings. The steel compressor stator casings (see figure 3) are split on a horizontal plane for access to the compressor rotor. The casings contain three integral air manifolds: two at stage 7 for sump pressurization and one at stage 10 for customer bleed air. The inlet guide vanes, as well as stator vanes, stages 1 through 5, are forged steel alloy variable vanes. The inlet guide vanes and vanes in stages 1 and 2 are shrouded at the ID. The shrouds are split on a horizontal plane to match the casings splitline. An extension of this half-ring acts as the interstage labyrinth seal seat on stages 1 and 2. The sealing surface is pre-grooved to improve its capability to withstand seal rubs. Vanes in stages 1 through 5 are individually replaceable. Vanes in stages 6 through 13 and the guide vanes are nickel base alloy. All are replaceable as sectors. Stages 6 through 13 sectors are inserted into the casing by means of circumferential grooves.

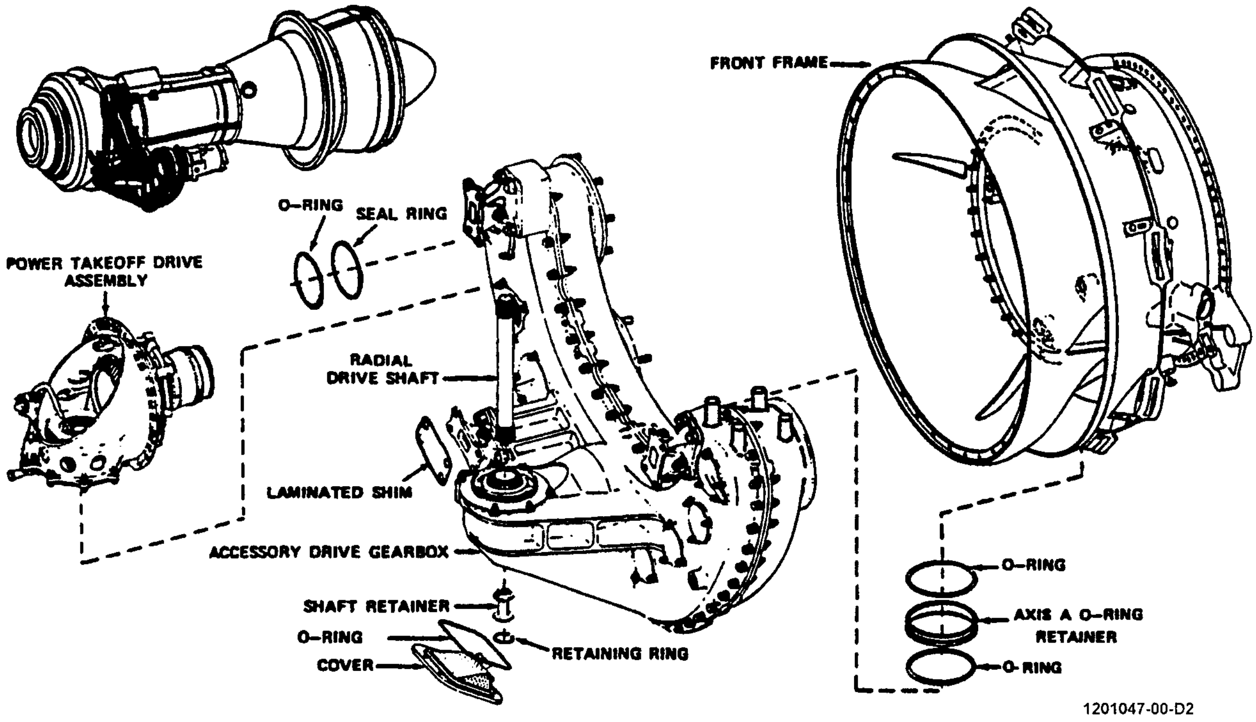
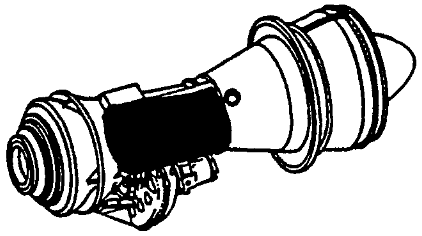


Figure 2. Front Frame and Accessory Drive System

(2) Compressor Rotor. The 14-stage axial-flow compressor rotor assembly produces a pressure ratio of approximately 14 to 1. The compressor rotor (see figure 4) is a rigid drum, consisting of nickel alloy stage 1 disk, titanium alloy stage 2 disk and front spool, and a nickel alloy stage 9 disk and rear spool. These are supported by tight tolerance bolts on steel alloy forward and nickel alloy rear shafts, resulting in a rugged drum containing only two flange joints. The first two stages have axially-oriented blade retention slots. The compressor spools and stage 9 disk contain circumferential grooves for blade retention. These features allow blades to be removed easily. Stage 1 blades are made of steel alloy. Stages 2 through 9 blades are made of titanium alloy. Stages 10 through 14 blades are made of nickel alloy. A stepped seal is mounted on the rear shaft which mates with the static seal in the combustion section.

c. Combustion Section.

(1) The combustion section (see figure 5) has a ring-type, or annular configuration combustion liner. The system provides high reliability for long turbine life and low smoke emission. The combustion chamber frame and the inner casing support the B-sump and the No. 4 and No. 5 roller bearings. The outer casing of the frame has pads for 18 removable fuel injectors, P3 and T3 taps, igniters, and borescope inspection ports. The annular combustion liner is fabricated from shells machined of Hastelloy X. The dome, which joins the inner and outer shells to form the liner assembly, has 18 fuel/air swirlers. The compressor discharge static seal is made of Hastelloy X. The static seal is centered and bolted to the same flange that supports the forward end of the B-sump.



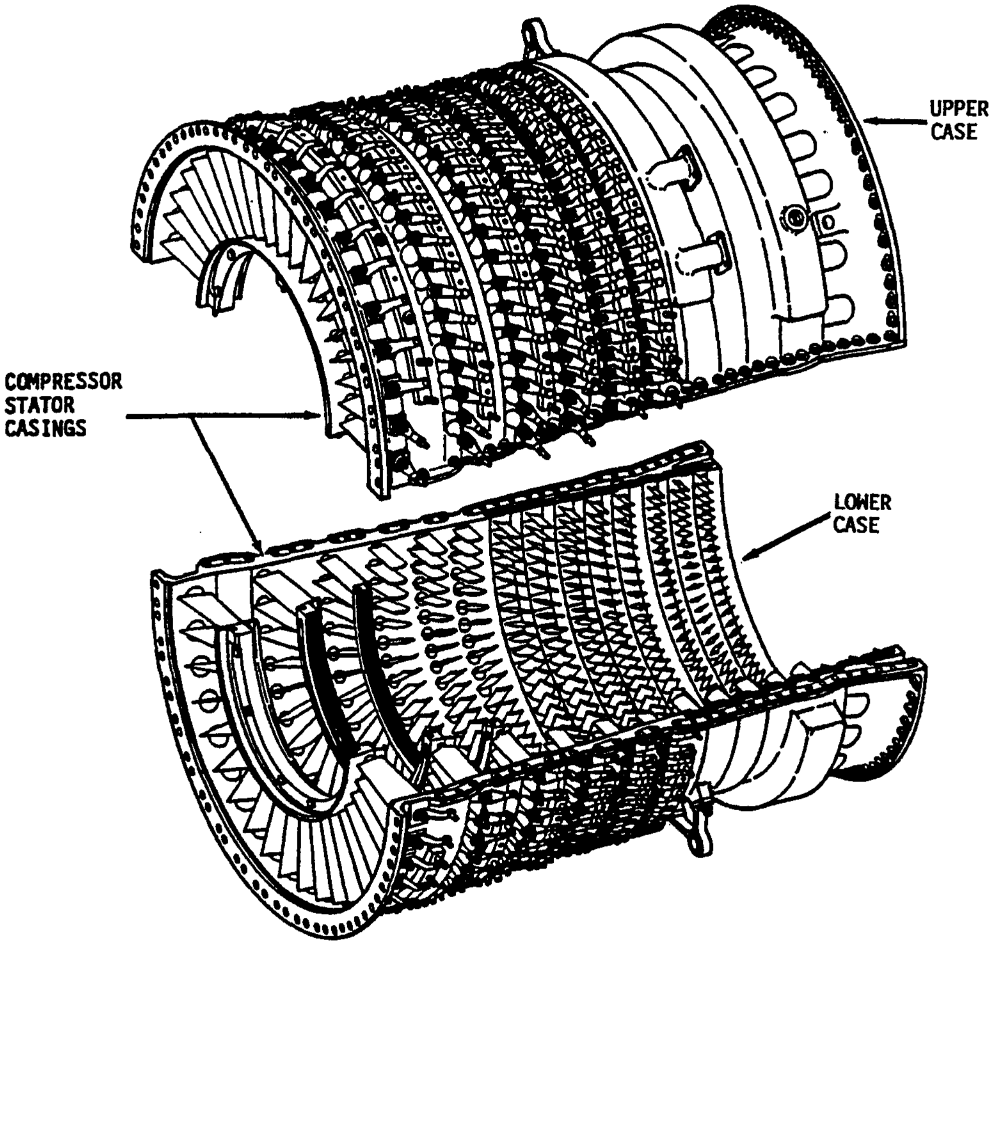


Figure 3. Compressor Stator Casings

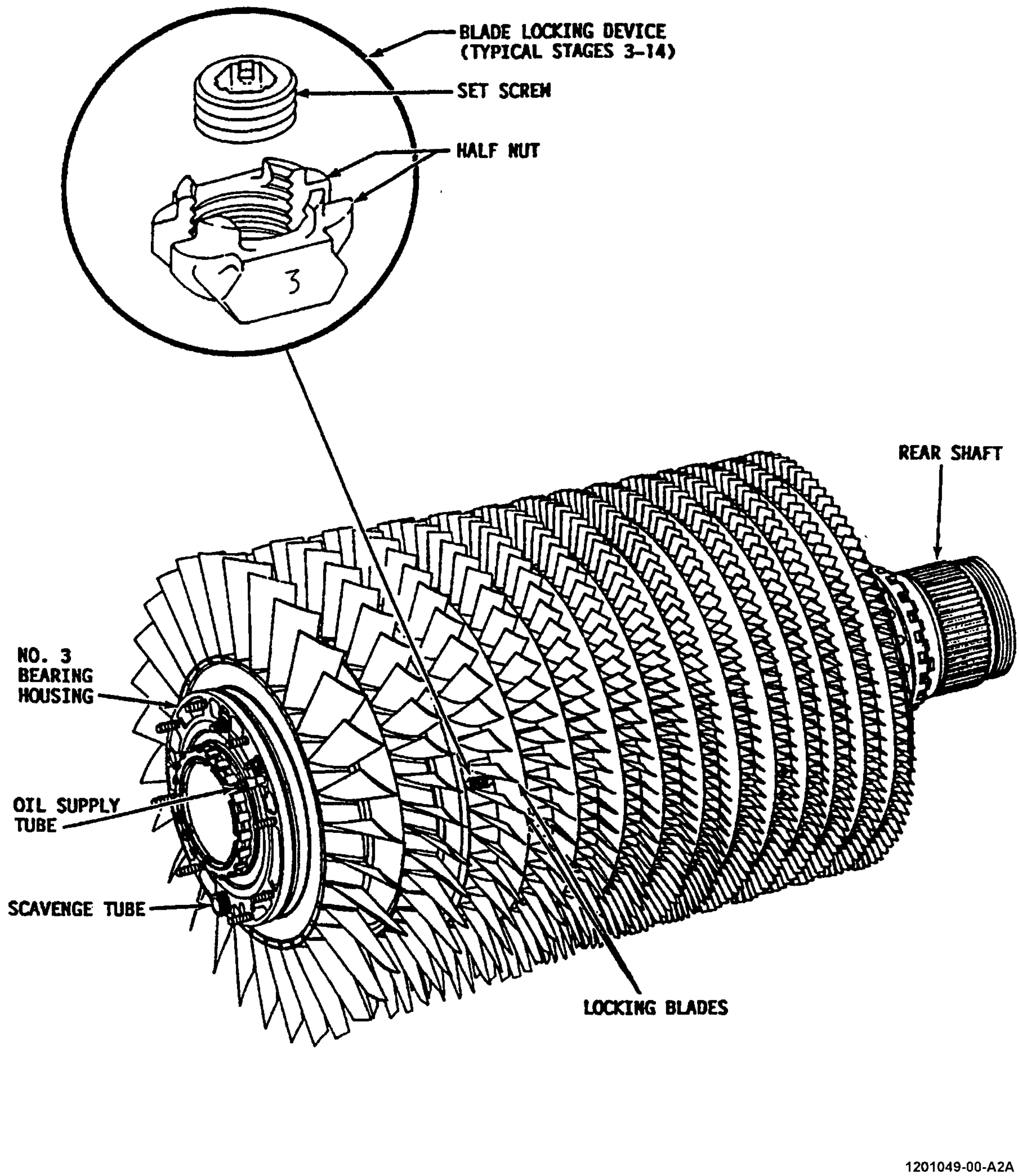


Figure 4. Compressor Rotor Assembly

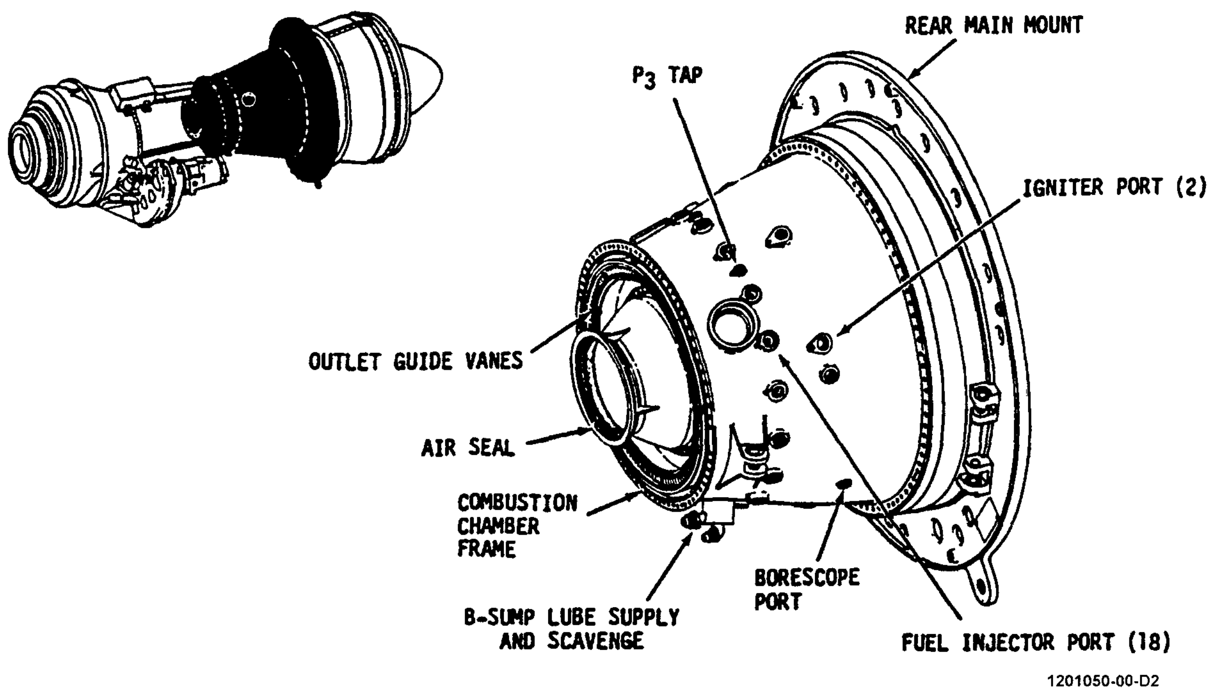


Figure 5. Combustion Section

(2) Air leaving the compressor is diffused to approximately 60% of compressor discharge velocity in the prediffuser, and divides into three approximately equal streams at the dome entrance. Inner and outer cowls, supported from the dome, capture compressor discharge air for metering air flow to the dome. Most of this air flow passes through the swirlers and into the reaction zone where it serves as primary combustion air. The remainder of the air flow is used for cooling the dome. Air passing into the inner and outer passages formed between the combustion liner shells and the combustion chamber serves as primary air (to complete combustion), as dilution air (to reduce turbine inlet temperature), and as cooling air for combustion liner shell and other gas turbine hot parts. Primary air and dilution air is injected through the shells in radial and axial holes, which meter the required amount of air to achieve the required depth of penetration. Shell cooling air is metered through rows of small circular holes and is injected along the inner surface of the shells through annular slots along the combustor.

(3) (Marine Only). Liquid fuel is metered, distributed, and introduced into the combustion chamber through 18 fuel injector hose assemblies which project into the swirlers of the combustion liner. The fuel manifold consists of 18 fuel injectors permanently connected to the fuel tubes, connecting the manifold to the fuel distributor block assembly. The hot combustion products exiting the primary zone are reduced to the required turbine inlet temperature by two rows of air jets in both the outer and inner shells.

(4) (Industrial Only). Natural gas is distributed and introduced into the combustion chamber through 18 fuel injectors which project into the swirlers of the combustion liner. The fuel manifold assembly consists of an annular tube of right and left sections. Natural gas is fed to the fuel injectors through 18 fuel feed tubes connecting the manifold assembly to the fuel injectors. The hot combustion products exiting the primary zone are reduced to the required turbine inlet temperature by two rows of air jets in both the outer and the inner shells.

(5) The swirler is a fuel/air mixing device in which fuel atomization and aeration is accomplished by high-energy air. This mixture is introduced into the combustor reaction zone in a wide cone angle, thus avoiding over-rich (high fuel/air ratio) combustion and producing low smoke emissions. Ignition is accomplished by two igniter plugs. At ignition, fuel is injected into the swirlers and the igniters are activated. After ignition, the igniters are deactivated by a control system switch.

d. High-Pressure Turbine Section.

(1) The high-pressure turbine section (see figure 1) consists of the turbine stator assembly, stage 1 nozzle assembly, and turbine rotor assembly.

(2) The high-pressure turbine stator assembly (see figure 6) is located between the aft flange of the combustion chamber frame and the forward flange of the turbine transition assembly.

(a) The stage 1 shroud segments, stage 2 turbine nozzle assembly, stage 2 turbine shroud segments and support, stages 1 and 2 shroud retainers, and air baffle are all assembled inside a cylindrical air-cooled inner casing which is bolted through a flange to the outer casing.

(b) There are 20 individually replaceable stage 1 shroud segments supported by ten shroud retainers and a cylindrical groove in the inner casing. The 27 stage 2 nozzle segments also fit in similar inner casing grooves. The stage 2 shrouds cut in ten segments, are assembled in the stage 2 shroud support. The interstage seal consists of nine segments containing open-faced honeycomb. These segments are pinned to the inner radius of the stage 2 nozzle segments.

(c) The stage 2 turbine nozzle assembly, the outer and inner casings, and the air baffle have borescope ports for inspection purposes.

(3) The high-pressure stage 1 turbine nozzle assembly (see figure 7) is located at the aft end inside the combustion chamber frame and forward of the turbine rotor assembly.

(a) The nozzle assembly consists of a nozzle inner support, nozzle segments, combustor outer seal, and an air nozzle guide.

(b) The 24 nozzle segments are cast with two vanes on each segment. The segments are installed on the circular outer flange of the nozzle inner support. The nozzle inner support locates the segments and prevents leakage. The nozzle vanes are cooled by compressor discharge air by means of film cooling for the leading edge portions, and convection and film cooling for the trailing edge portions. Inner and outer bands are cooled by convection and film cooling.

(4) For all models except L32119G06, the high-pressure turbine rotor assembly (see figure 8, sheet 1) consists of stage 1 and stage 2 turbine rotor disks bolted together by a torque coupling and contains internally-cooled stage 1 rotor blades. Stage 2 rotor blades are not internally cooled. The rotor blades are held in position axially on each disk by a pair of cooling plates, which are held by axial bolts through the disks. These plates also serve to seal against leakage of blade cooling air. The cooling plates, which provide support for the outer torque coupling seal, seal the rotor cooling air. The plates have baffles to reduce hot gas inflow to the rotor-to-stator cavities. The stage 1 rotor blades are cooled by air which flows through holes in the dovetails and out the tip and trailing edge. The torque coupling has the rotating interstage seal teeth. A one-piece conical shaft and air balance piston seal are bolted on the forward side of the stage 1 turbine disk with the same body-bound bolts that hold the torque coupling to the rear of the stage 1 turbine disk. The shaft drives the compressor rotor by means of a piloted spline coupling. The stage 2 turbine disk is coupled to the rear side of the torque coupling with the same type body-bound bolts.

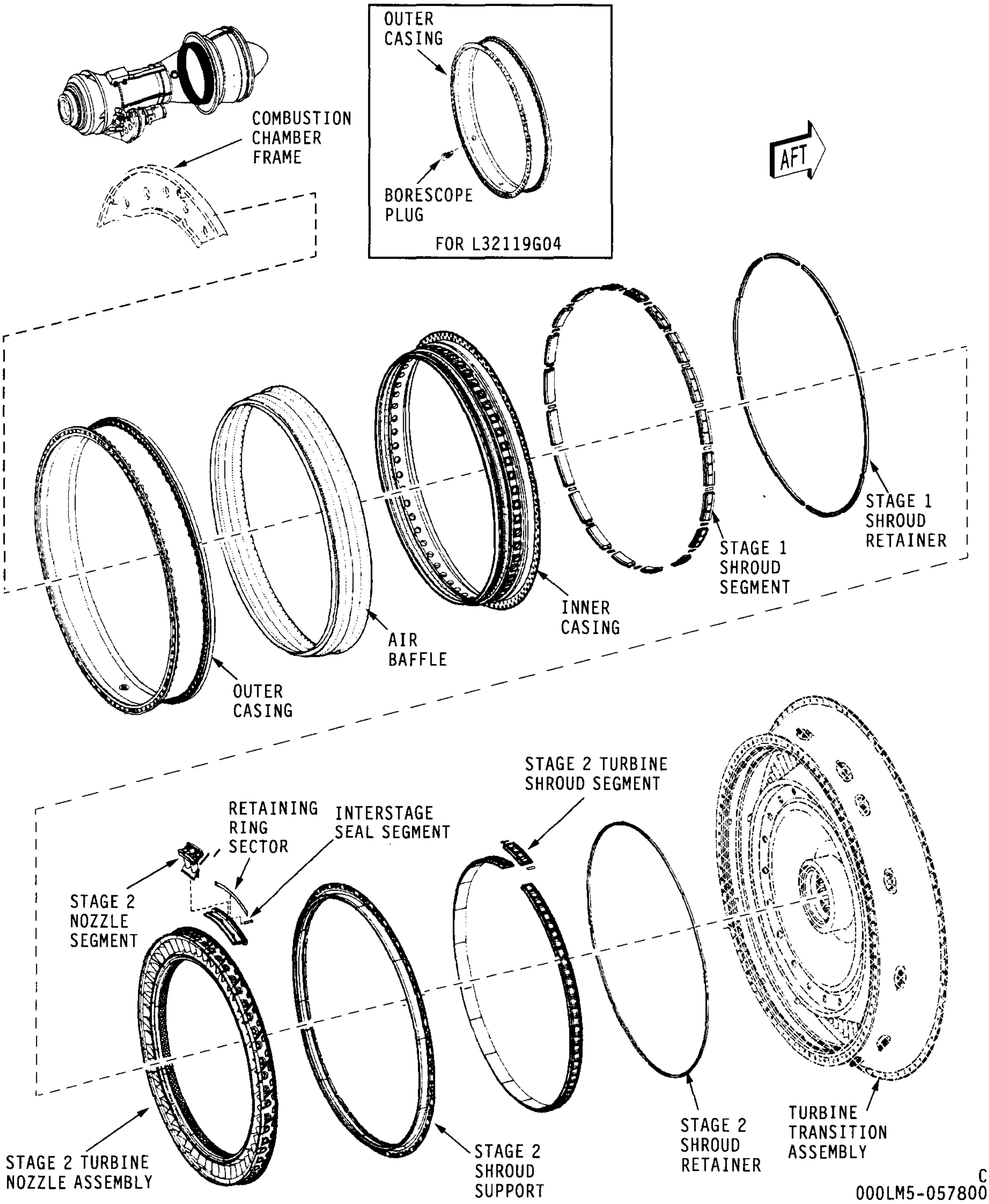


Figure 6. High-Pressure Turbine Stator Assembly

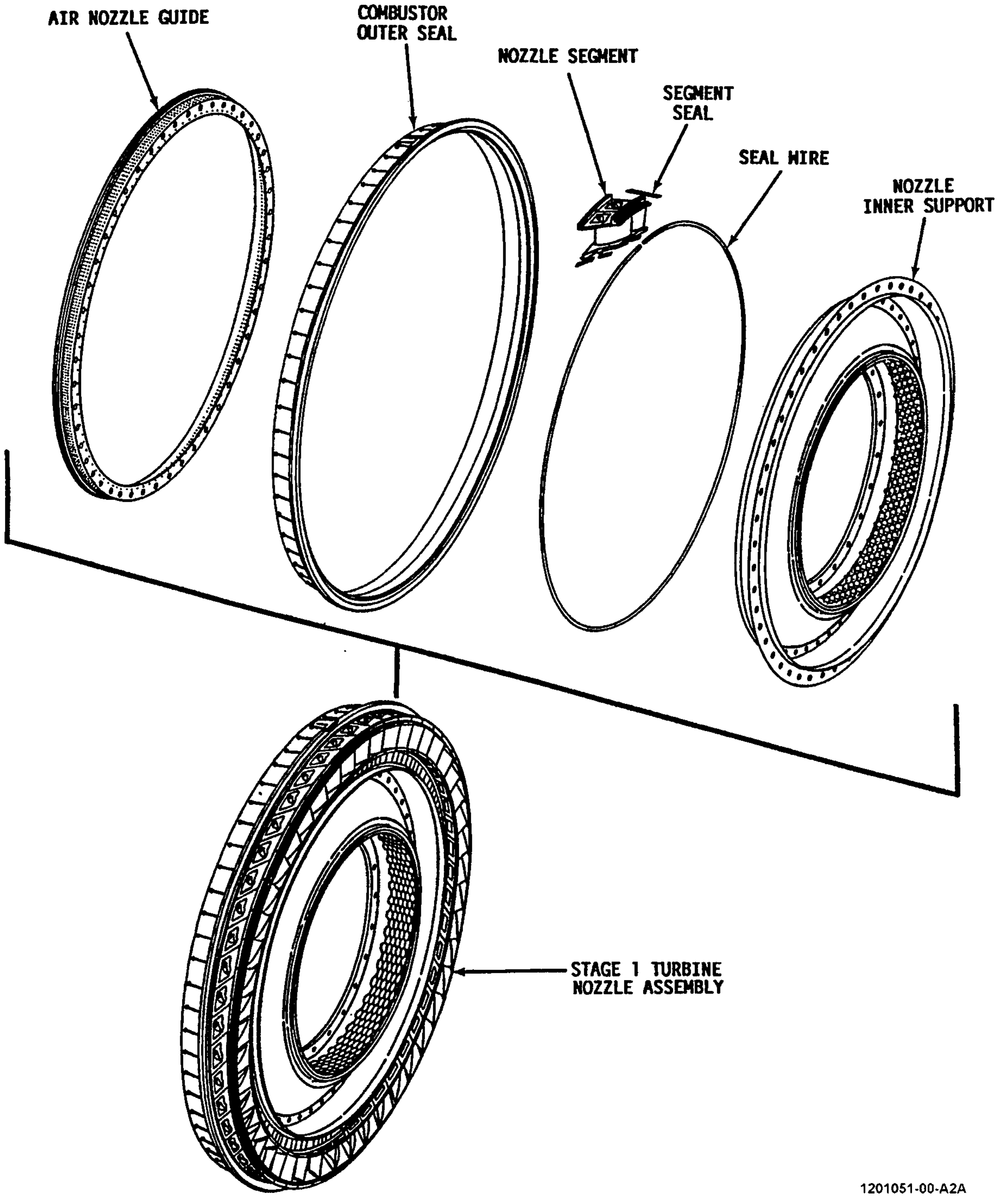


Figure 7. High-Pressure Stage 1 Turbine Nozzle Assembly

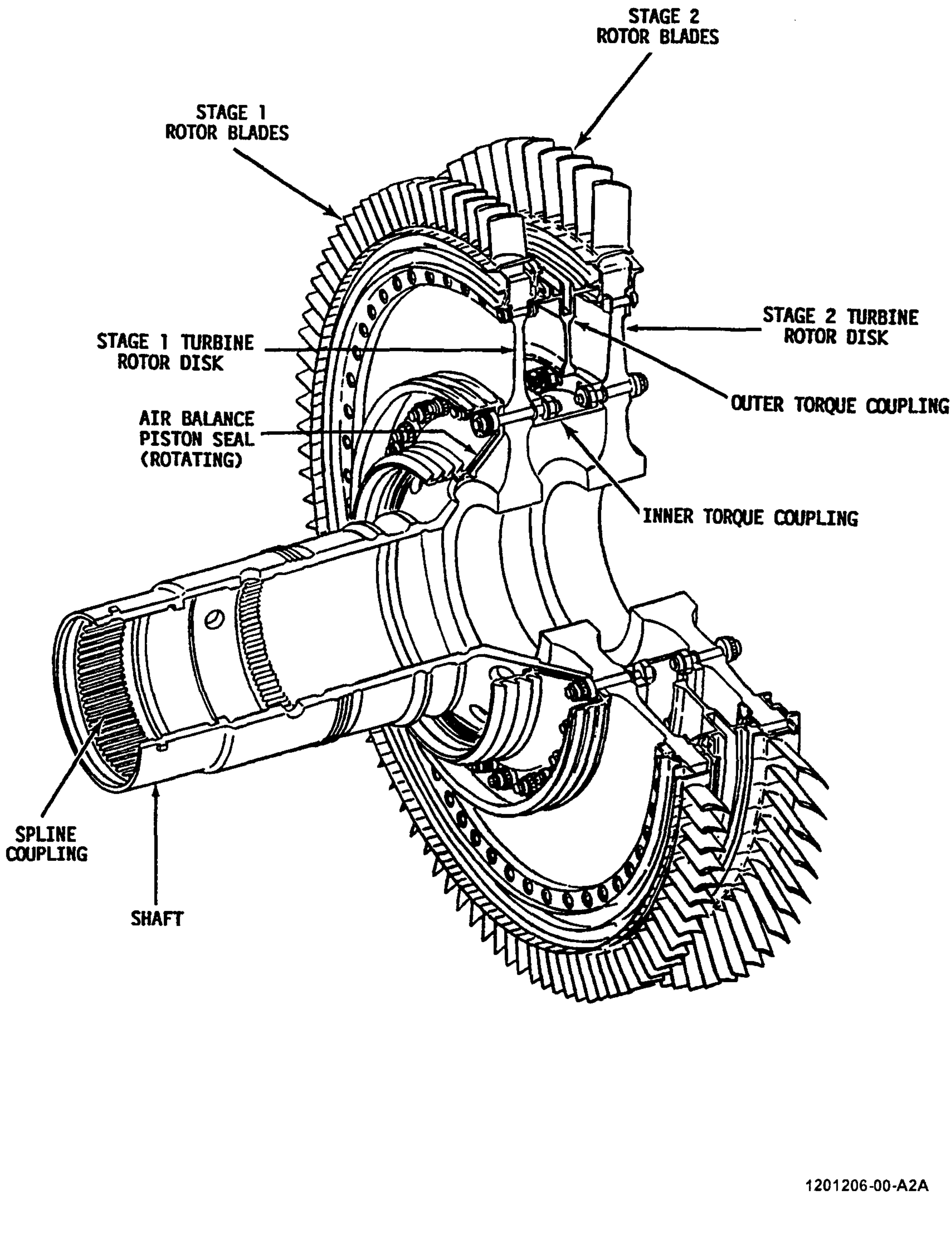
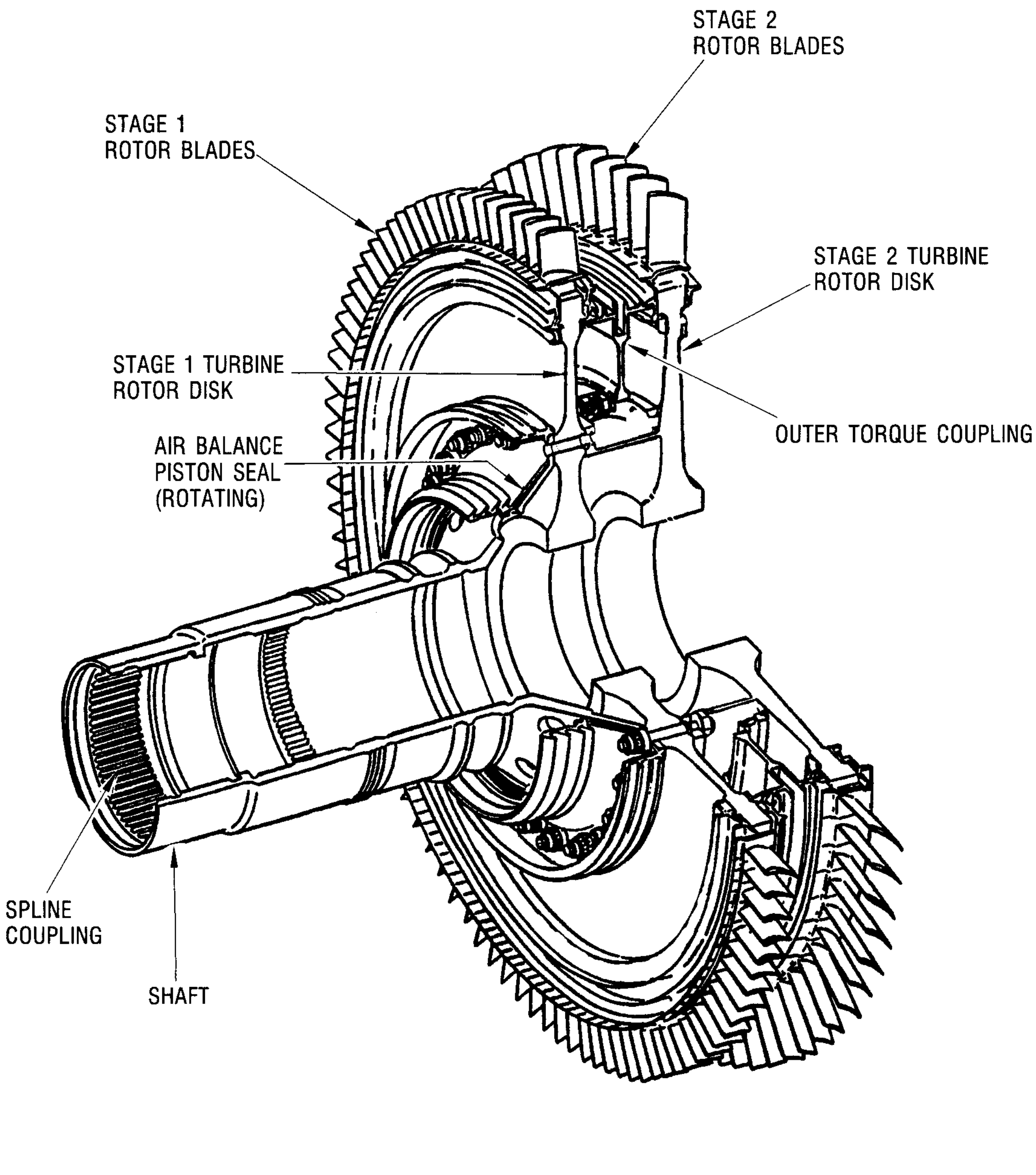


Figure 8. High-Pressure Turbine Rotor Assembly (Sheet 1 of 2)



MODEL L32119G06 ONLY

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Figure 8. High-Pressure Turbine Rotor Assembly (Sheet 2 of 2)

(5) For model L32119G06, the stages 1 and 2 turbine rotors consist of two turbine disks. The forward flange of the stage 2 disk is bolted by body-bound type bolts to the aft end of the stage 1 disk (see figure 8, sheet 2). The stage 1 rotor blades are internally-cooled serpentine blades. The stage 1 blades are cooled by air which flows through the holes in the dovetails and out the tip and trailing edge. The stage 2 rotor blades are not internally cooled. Both stages 1 and 2 blades are retained to the disks by fir-tree type dovetails. The blades are held in position axially on each disk by two cooling plates.

(a) The cooling plates are held in position onto the disks by retaining rings. The cooling plates serve to seal against any leakage of blade cooling air, provide support for the outer torque coupling, and seal the rotor cooling air. Also, the plates contain projections which act as baffles to reduce the hot gas in-flow into the rotor-to-stator cavities. The outer torque coupling carries the rotating interstage seal teeth.

(b) A single conical rotor shaft and a balance piston seal are bolted on the forward side of the stage 1 disk with the same body-bound bolts that attach the flange of the stage 2 disk to the aft side of the stage 1 disk. The rotor shaft drives the compressor by means of a piloted spline coupling.

e. Power Turbine Section.

(1) The power turbine section consists of the turbine transition assembly, low-pressure turbine stator assembly, power turbine rotor assembly, and the exhaust frame assembly.

(2) The turbine transition assembly (see figure 9) is the duct for the hot gases leaving the high pressure turbine rotor. The transition assembly funnels the hot gases into the larger diameter power turbine rotor. Inside the transition casing is the stage 3 nozzle, the liner forward seal, and the outer transition liner. The stage 3 nozzle consists of 11 nozzle segments and is interlocked into the interturbine seal and liner. A thermocouple harness is mounted on the transition casing to detect power turbine inlet temperature (T4.8) for control and indicating purposes.

(3) The low-pressure turbine stator assembly (see figure 10) consists of two stator casings which are split at the 6 and 12 o'clock positions. The stator casings can be removed without disassembling the gas turbine. The casings contain segmented turbine nozzle vanes (for stages 4, 5, and 6) and turbine shrouds (for stages 3 through 6). Codep coating is applied to the first stage power turbine rotor blades and vanes. The shrouds have four segments per stage and open-faced honeycomb surfaces. The stator casings have two borescope ports for inspecting stages 4 and 5 nozzle segments and stages 3 and 5 power turbine blades.

(4) The power turbine rotor assembly (see figure 11) consists of stages 3 through 6 turbine disks and blades. The four disks and the interstage seals are bolted together with close tolerance bolts. Blades are held in the disks by the blade retainers and the blades can be replaced without disassembling the rotor. The shrouded blade tips have an interlock feature that keeps them rigid. The rear shaft is bolted between stages 4 and 5 and is splined to the drive shaft. The No. 6 and No. 7 roller bearings support the rear shaft. The drive shaft is supported at the forward end by the No. 1 bearing in the A-sump. The stages 3 and 5 turbine blades can be borescope inspected using the two borescope ports located on the turbine stator casings.

(5) The exhaust frame assembly (see figure 12) serves as the main structural support for the power turbine section. The outer and inner casings are joined together by six struts. The struts support the inner hub, which supports the C-sump and the No. 6 and No. 7 bearings. The C-sump oil supply tube, C-sump aft scavenge, and C-sump forward scavenge are routed through the struts. The frame also houses two power turbine speed sensors that are routed through the struts. The aft scavenge tube is surrounded by the oil supply tube within the 6 o'clock strut to minimize any "coking" in the supply tube due to high "soakback" temperature in this area following gas turbine shutdown.

f. Accessory Drive Section.

(1) The accessory drive section (see figure 13) consists of the power takeoff (PTO) drive assembly (1), radial drive shaft (5), and accessory drive gearbox assembly (6).

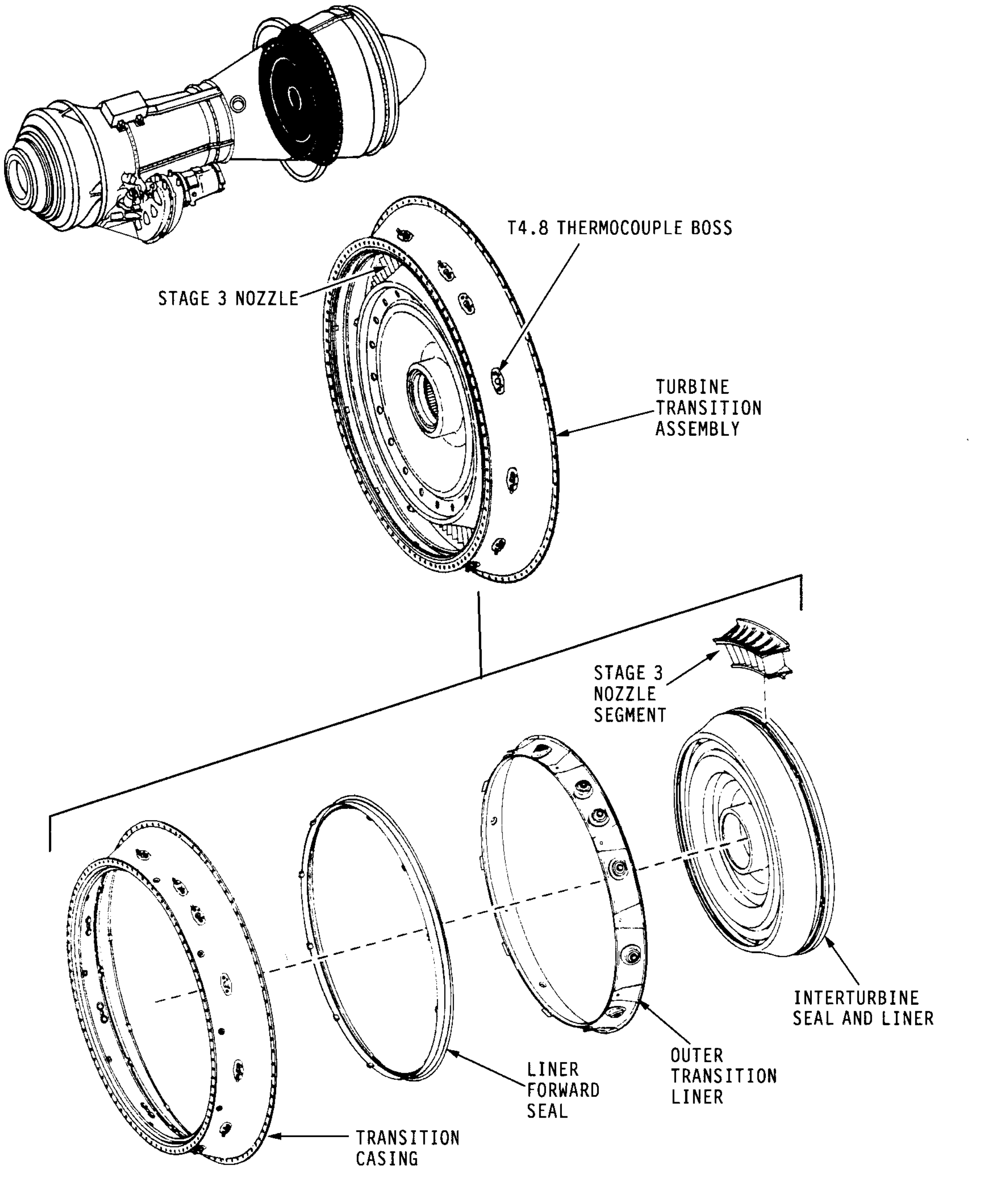

Figure 9. Turbine Transition Assembly

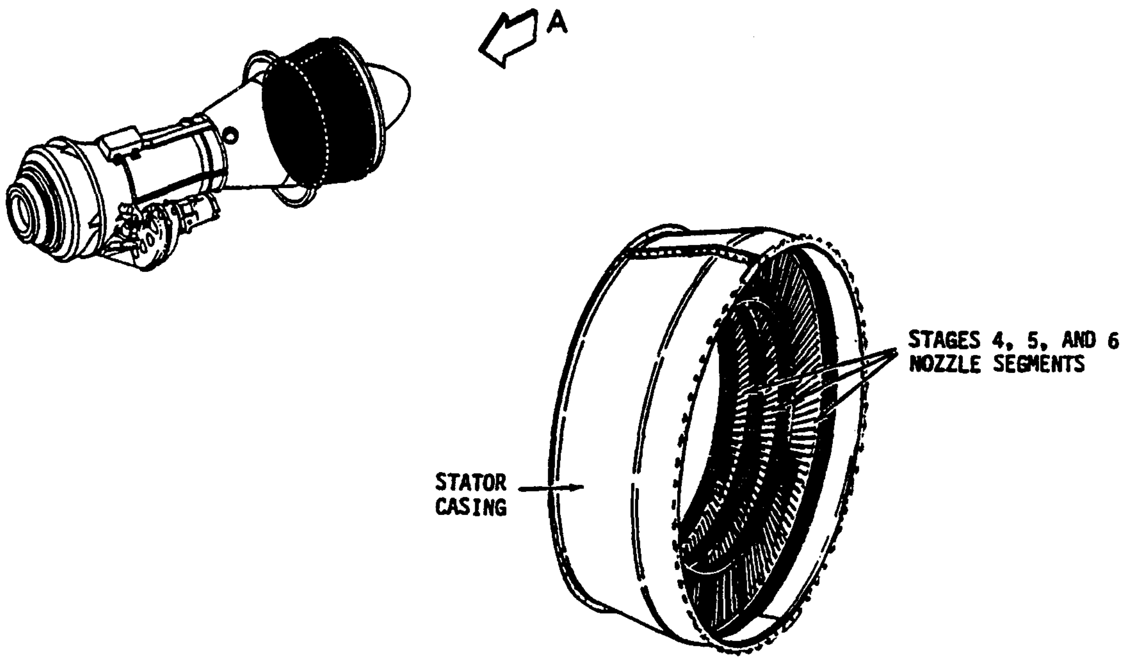

Figure 10. Low-Pressure Turbine Stator Assembly

(2) The PTO assembly (1) is located in the compressor front frame (7) as part of the A-sump. The PTO assembly consists of a PTO bevel gear (3) and a nozzle tube assembly (2) for lubrication to the No. 3 bearing, splines, and bevel gear.

(3) The radial drive shaft (5) transmits power to the gearbox assembly (6) through the bevel gear (3).

(4) The gearbox assembly (6) is supported by the front frame (7). An external spline on the lower end of the radial drive shaft (5) engages with an internal spline in the gearshaft in the gearbox assembly thus engaging a train of spur gears within the gearbox assembly. The spur gears provide the mechanical drives for the gas turbine and customer's accessories. The gearbox assembly (6) also provides a cranking pad, the mounting support, and drivepads for the variable geometry control, gas generator speed sensors, gas turbine lube and scavenge pump, fuel pump (Marine Only), and starter.

6. <u>GAS TURBINE SYSTEMS DESCRIPTION</u>. The gas turbine systems include the pressurization air, and portions of the electrical, fuel, lubrication, and variable geometry systems. The engine portions of these systems are described in this section.

a. Air System. Air enters the gas turbine through the front frame to the compressor rotor, where the air is compressed at a ratio of approximately 14 to 1. About one-fourth of the compressor discharge air is used for combustion. The remaining air is used for diluting combustion gases to ensure safe operating turbine inlet temperatures, hot section cooling, seat pressurizing, high-pressure rotor thrust balance, and the power turbine balance piston. Seal and balance piston pressurization air is bled from the seventh stage of the compressor rotor. Air to the balance piston and B-sump cavities is unregulated. Seal pressurization air to the A- and C-sumps is controlled to 15 psig (103 kPa) by a pressure regulating valve mounted on the outside of the compressor casing. Only the airflow to the A-sump passes through a water trap/separator to remove any waterwash solution or water in the compressor airstream and prevent corrosion within the sump. The B- and C-sumps operate at higher temperature to vaporize and expel any water in the pressurizing airstream.

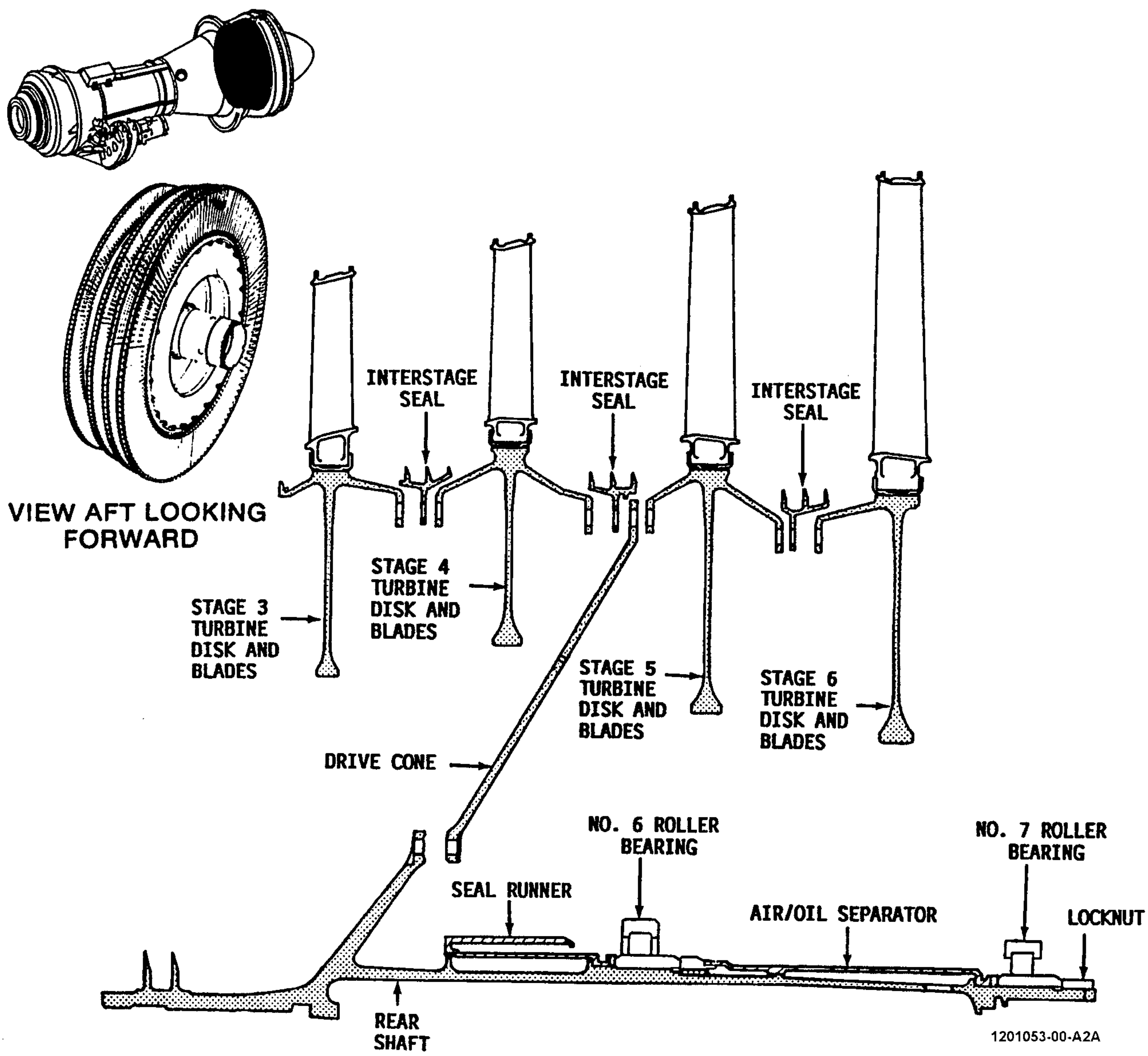

Figure 11. Power Turbine Rotor Assembly

b. Electrical System.

(1) Ignition System.

(a) The ignition system on the LM500 gas turbine consists of an ignition exciter and two integral igniter plug lead assemblies. The exciter is an intermittent duty, dual output, capacitor discharge unit requiring a 115 V, 60 Hz electrical power input. Two separate and independent circuits are contained in the exciter, each including a filter network, a stepup transformer, a rectifier circuit, a storage capacitor, an ionization tube, and a bleed resistor.

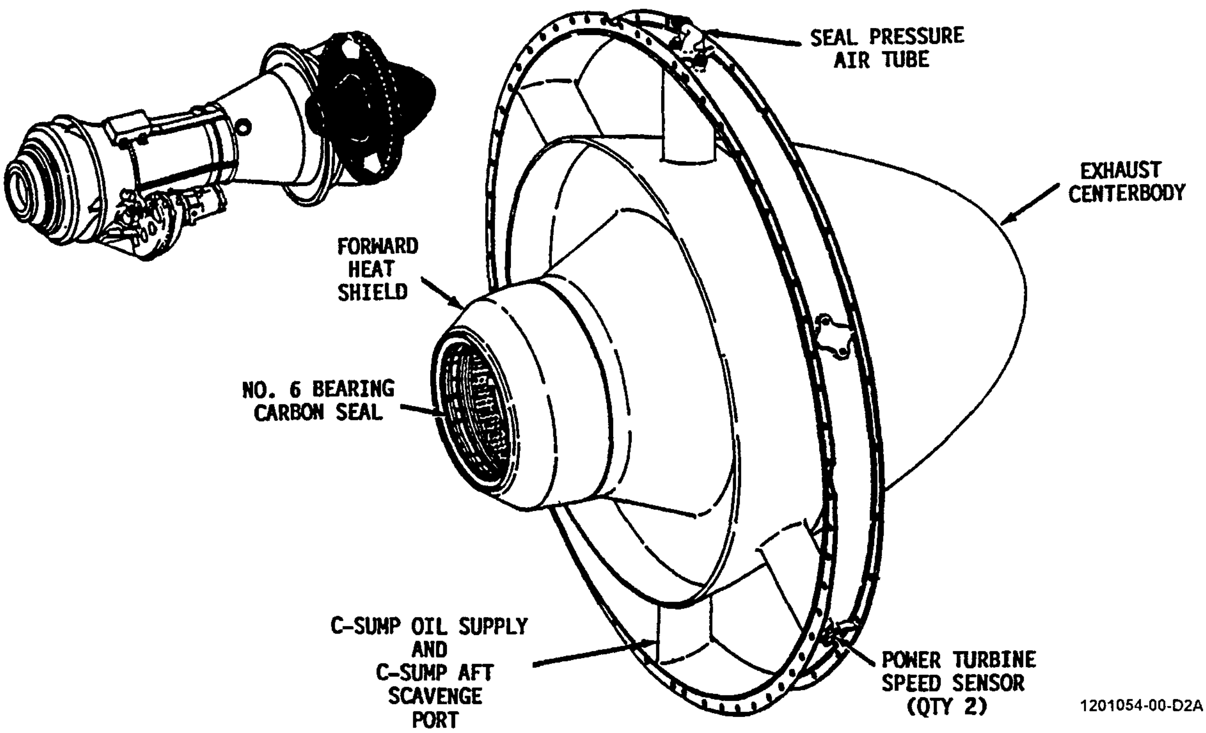

Figure 12. Exhaust Frame Assembly

(b) The two igniter plugs are connected to the ignition exciter by two separate igniter leads. The plugs are located in bosses in the combustion chamber frame at the 2 and 10 o'clock positions. They consist of a center and an outer electrode, with a semiconductor surface coating at the tip between the two electrodes. The semiconductor material is used as a shunt to aid in ionizing the air gap between the two electrodes so that the plugs will fire. An air shroud covers the end of the plug immersed in the air stream. Cooling holes under the flange area of the plug admit outer combustor flowpath air which discharges across the plug tip for cooling purposes.

(c) The ignition system is not required for gas turbine operation after starting, and is secured to prolong service life.

(2) Thermocouple Harness. Actual power turbine inlet temperature is sensed by a rigid, two-piece thermocouple harness consisting of a total of ten probes with alternating immersion depths located in the turbine transition assembly. There are two separate circuits in the harness with each probe containing two chromel-alumel thermocouple junctions. The junctions for each circuit are connected in parallel to provide a signal of average power turbine inlet temperature.

(3) Power Turbine Speed Sensors and Vibration Transducers. There are two power turbine speed sensors on the LM500 gas turbine. Each sensor is an electromagnetic device consisting of a coil-wound permanent magnet. The sensor is located over the rotating No. 7 bearing inner race locknut. The wrenching splines on this locknut intermittently bends the magnetic field set up by the permanent magnet in the inner tip of the sensor and induces a pulsating voltage in the internal coil. The frequency of this voltage signal is an indication of power turbine speed. Also, included on the gas turbine are mounting pads for two accelerometer-type vibration transducers (Industrial Only) located at 3 o'clock position on the compressor front frame and at 12 o'clock position on the exhaust frame. The vibration transducers are used to monitor radial movement as a result of gas turbine vibration.

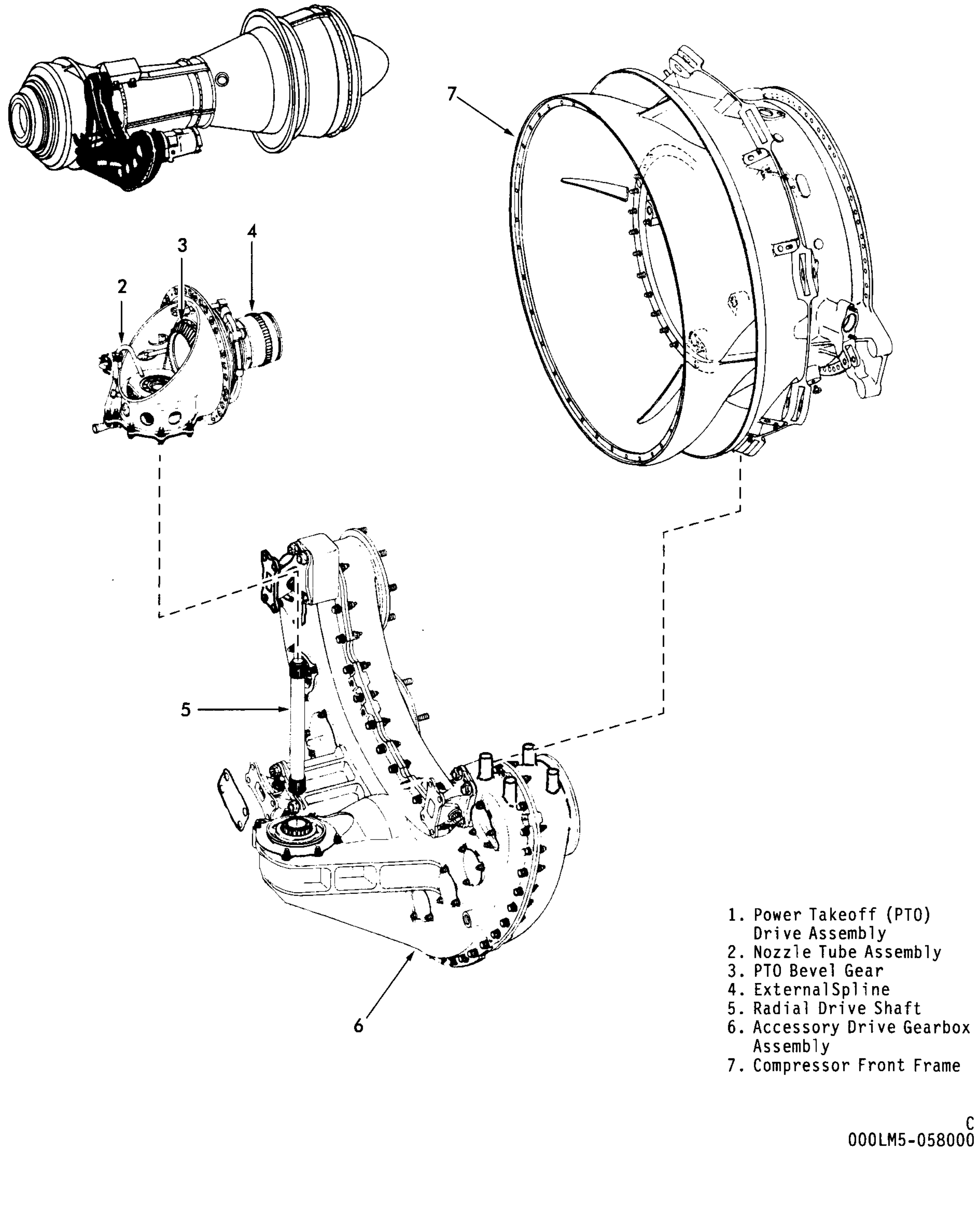

Figure 13. Accessory Drive Section

(4) Chip Detectors.

(a) Continuity-type magnetic chip detectors are used in the gas turbine lubrication system. During normal gas turbine operation, some accumulation of fuzz-like magnetic particles will be found on chip detectors when they are removed and inspected. Other materials, such as non-metallic sludge, small silver or non-magnetic flakes, bronze powder or machining chips of aluminum (the latter especially on new gas turbines), may accumulate on the tip.

(b) Periodically, chip detectors should be checked for continuity, from center post to body. Continuity is an indication of contamination. A significant increase in amount of change in makeup of accumulated material should be further evaluated by spectrometric oil analysis (WP 015 00).

c. Fuel System.

(1) (Marine Only). The fuel system distributes liquid fuel to the combustor. The gas turbine mounted components include a fuel filter with impending bypass indicator, fuel pump, fuel injector hose assemblies, and fuel distributor block assembly. The fuel injector system consists of each fuel injector permanently connected to the fuel tubes.

(2) (Industrial Only). The fuel system distributes natural gas to the combustor. The on-engine fuel system components include a manifold assembly, fuel feed tubes, and fuel injectors. The customer-provided fuel control and supply system are not part of the gas turbine. Natural gas enters the two-piece manifold assembly. The fuel feed tubes direct the natural gas from the manifold assembly to the 18 fuel injectors which are inserted into the fuel swirlers of the combustion liner. Compressor discharge air flows radially inward through the primary swirler in the combustion liner, which causes the air to rotate circumferentially and mix with the natural gas. Air entering radially inward through the secondary swirler is caused to rotate in the opposite direction. As the two counter rotating mixtures join, the natural gas mixes completely with the air. This process also promotes more complete mixing of the natural gas and air and, therefore, more complete burning of the mixture resulting in less smoke emission and a more uniform temperature distribution within the combustor.

(3) Ignition is accomplished by two igniter plugs. At ignition, fuel is injected into the swirlers and the igniters are activated. After ignition, the igniters are deactivated by a customer-provided switch.

d. Lubrication System. The lubrication system provides oil for lubricating and cooling the gas turbine main bearings, supplies hydraulic fluid for variable geometry actuation system and fuel metering valve actuator, and cools the air delivered to the power turbine balance piston. System pressure is provided by a positive displacement supply and scavenge pump. On-engine components include the main lube and scavenge pump, A-sump scavenge pump (all models except L32119G06), oil filter, oil supply resistance temperature detector (RTD), oil scavenge RTD, magnetic chip detectors, and related piping.

e. Starting System. The starter is mounted on the aft face of the accessory drive gearbox assembly, on the right side, aft looking forward. The starter drives the gas generator through the gearbox to a speed at which the gas turbine can sustain itself. In addition, the starter can be used for gas turbine waterwashing and other preventive maintenance. The starter is a hydraulic, variable displacement-type motor with pressure compensating control. The starter is equipped with an over running clutch to prevent the starter from being driven by the gas turbine when the hydraulic pressure and flow reach zero. The starter weighs approximately 50 pounds (23 kg). The starter is capable of operation at 0-100% salt air atmosphere.

f. Variable Geometry (VG) System. The variable geometry system positions the compressor rotor variable-controlled stator vanes (VSV). This system is supplied with an on-engine compressor variable geometry control, which is self-contained and is mounted on the accessory drive gearbox assembly. The VG control positions the compressor variable stators as a function of gas generator rotor speed and compressor inlet temperature. The output of the control is regulated hydraulic oil pressure supplied to the head and to the rod ends of two VG actuators. These VG actuators position two actuator linkage assembly shafts on both sides of the compressor stator casings, which act through mechanical linkage to rotate the inlet guide vanes (IGV's) and VSV's in stages 1 through 5. A feedback position linkage, mounted to one VG actuator shaft on the gas turbine and to the feedback position lever on the VG control, nulls out the control output pressure when the vanes have reached their correct position for that corrected gas turbine speed.

7. PRINCIPLES OF OPERATION.

a. Basic Gas Turbine Operation. The LM500 is a gas turbine consisting of a gas generator, or core engine, and an aerodynamically coupled power turbine. The core engine is started and assisted to idle speed by an external power source driven through an accessory drive gearbox assembly, and an electrical ignition system. Once the gas turbine reaches idle speed it is self-sustaining, requiring only a supply of air and fuel. The compressor draws inlet air that is compressed and discharged through a diffuser into a combustion chamber frame. There, fuel is injected and mixed with the airflow for combustion. The high-temperature combustion gases pass through an impulse-reaction high-pressure turbine (HPT). The HPT is mechanically coupled to the compressor rotor, which is directly connected to a 90-degree power takeoff (PTO) gearbox at the compressor inlet. The PTO drives an accessory drive gearbox through a drive shaft extending radially outward from the gas turbine centerline. About two-thirds of the energy in the combustion gas is required to maintain the core gas turbine cycle. The remaining energy in the gas flow is utilized to drive a free low-pressure power turbine. The power turbine rotor is directly connected to an output shaft at the front of the gas turbine by a shaft passing through the core engine. The LM500 gas turbine may therefore be categorized as a cold-end drive gas turbine engine.

b. Gas Turbine Control System Operation.

(1) Variable Geometry Control System:

(a) The variable geometry (VG) control system uses the following input parameters:

- Gas generator speed, by means of a centrifugal flyweight assembly.
- Compressor inlet temperature, by means of an integral, remotely mounted sensor on the inlet.
- Variable stator vane position by means of a mechanical feedback input to the control from the VSV linkage.

(b) The variable geometry control positions the gas generator variable stator vanes, as a non-linear function of gas generator speed and inlet temperature. The output of the control is regulated hydraulic oil pressure which is supplied to two VG actuators at the 4 and 10 o'clock positions (forward looking aft) on the front frame.

(c) The VG control includes an integral hydraulic pump that has enough capacity to satisfy the demands of the VG actuator system, and provide the steady-state internal cooling flow to the VG actuators.

(2) Speed (RPM) Sensing:

(a) The gas generator speed sensors are located and driven through the accessory drive gearbox assembly, and provide electrical signals that are proportional to gas generator high-pressure turbine rotor speed.

(b) The power turbine speed signals are generated by two (redundant) speed sensor assemblies, mounted in the power turbine exhaust frame. These sensor assemblies provide electrical signals in direct proportion to power turbine speed. The pickups generate a magnetic field, encompassing a multitooth gear or locknut rotating in close proximity to the transducer head. The resulting variations in magnetic flux generate an ac signal voltage.

(3) Temperature Sensing:

(a) A two-piece (right- and left-hand) thermocouple harness is mounted on the turbine transition assembly, with probes sensing the high-pressure turbine discharge power turbine inlet temperature (T4.8). The probes have redundant junctions and leads to provide separate circuits for gas turbine control and operator indication.

(b) The respective right- and left-hand circuits must be connected in parallel to provide an average of the temperature profile.

(4) Pressure Ratio Sensing:

(a) Taps are provided on the gas generator for compressor discharge static pressure (PS3) and high-pressure turbine discharge pressure.

(b) A probe is available to sense HPT total pressure (PT4.8) for control or condition monitoring.

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

INSTALLATION AND REMOVAL OF GAS TURBINE INTO/FROM SHIPPING CONTAINER

(LEVEL 1 MAINTENANCE)

Effectivity:	L32119G01/-G03/-G04/	
	G05/G06	MARINE GAS TURBINE
	L32119G02	INDUSTRIAL GAS TURBINE

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1. INTRODUCTION. This work package provides a description of the gas turbine shipping container, a procedure for maintaining the protective environment within the container during extended storage periods, instructions for gas turbine removal and installation from/into shipping container, and inspection and minor repair of shipping container prior to use.

2. SUPPORT EQUIPMENT.

Support Equipment

Part No.	Nomenclature
1C7300G01	Fixture, Lift
1C7301G02	Stand, Support and Maintenance
106C7556	Container, Shipping

3. CONSUMABLE MATERIALS.

NOTE

Equivalent materials approved by GE Aircraft Engines may be substituted for items listed.

Consumable Materials

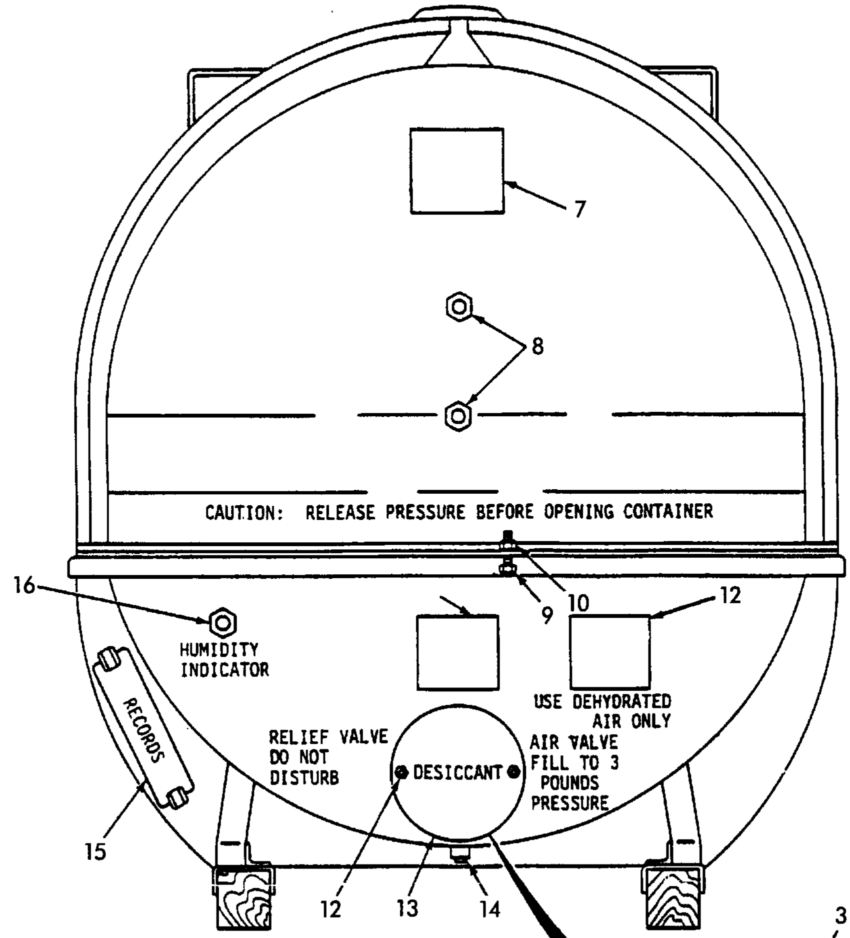
Description	Manufacturer
Brush, Wire	Local Purchase
Desiccant, Type I, (MIL-D-3464)	Davidson Chemical Co. Baltimore, MD USA
Enamel, Paint (MIL-E-529)	Local Purchase
Gasket Material, Class II, Grade 60 (MIL-R-6855)	Local Purchase
Ink, Stencil	Local Purchase
Primer, Zinc Chromate, Type II (MIL-P-23377 or MIL-P-8585)	Kop-Coat, Inc. 480 Frelinghuyser Ave. Newark, NJ 07114 USA

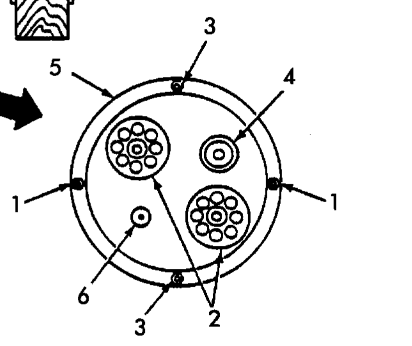
4. DESCRIPTION OF SHIPPING CONTAINER 106C7556.

CAUTION

- When lifting shipping container with gas turbine inside, the hoisting device must have a 2-1/2 ton (2500 kg) capacity.
- When lifting an empty shipping container or the gas turbine alone, the hoisting device must have a minimum capacity of 1-1/2 ton (1500 kg).

a. The 106C7556 shipping container is designed specifically for the LM500 gas turbine. The physical dimensions are approximately 61 inches (155 cm) high by 52 inches (132 cm) wide by 125 inches (318 cm) long. Empty container weight is 2000 pounds (907 kg). Weight with gas turbine and accessory drive gearbox assembly is 3300 pounds (1497 kg). Shipping container has side compartment record storage, enclosed pressure/vacuum relief valves, and uses ordinary capscrews around the cover flange. Figures 1 and 2 illustrate this container.





1. Stud
2. Automatic Pressure Relief Valve
3. Capscrew
4. Automatic Vacuum Relief Valve
5. Valve Mount and Desiccant Access Cup
6. Pressurizing Valve
7. Nameplate
8. Viewing Ports
9. Capscrew (Typical)
10. Locknut (Typical)
11. Data Plate
12. Locknut
13. Service Cover
14. Drainplug
15. Record Storage Container
16. Humidity Indicator
17. Nameplate

SERVICE VALVES AND DESICCANT ACCESS
(DESICCANT COVER REMOVED)

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Figure 1. Shipping Container 106C7556 Service Fittings

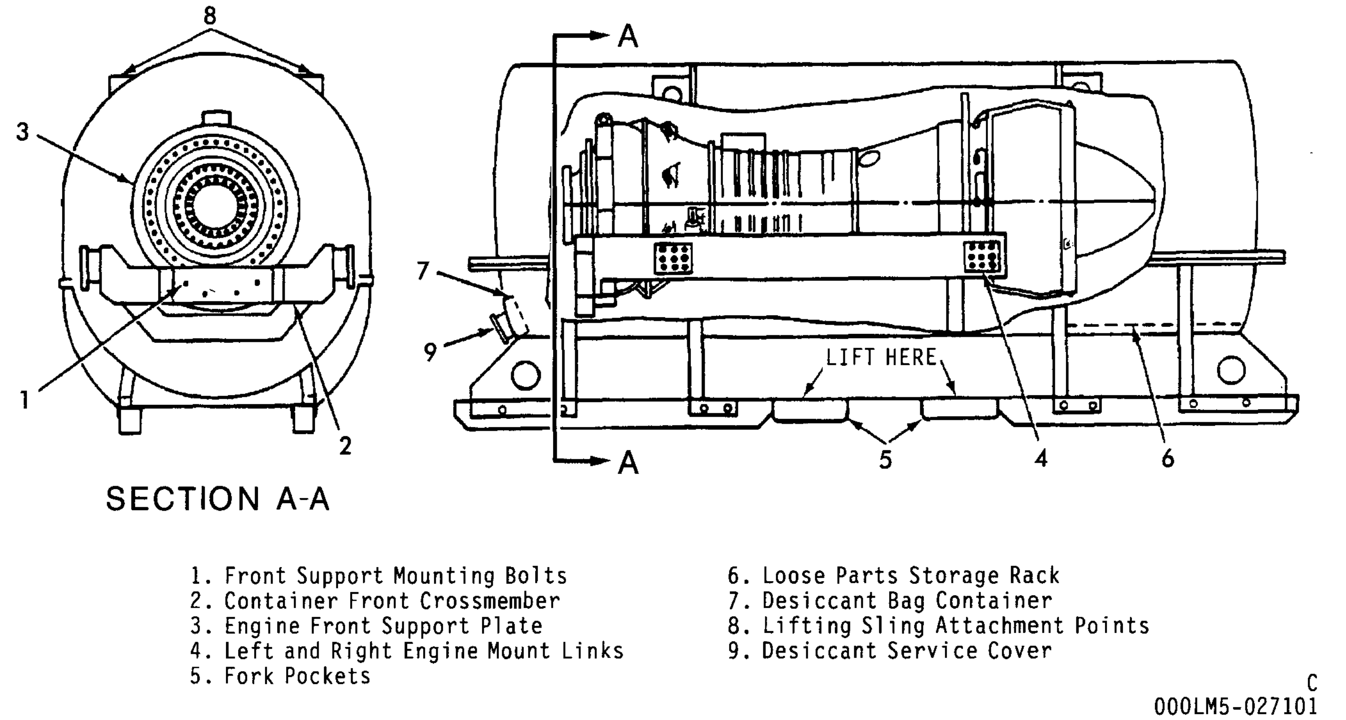


Figure 2. Gas Turbine in Shipping Container 106C7556

b. Gas Turbine Protection Capability.

(1) Environmental protection of the gas turbine from corrosive elements or particles in the atmosphere is provided by the shipping container for an indefinite period, if the seals remain intact and internal pressure is maintained.

(2) When transporting the gas turbine, the shipping container provides protection from static and dynamic loads. Static loads are limited to stacking a maximum of two containers. Dynamic loads of 3 g's vertically and axially, and 1.5 g's transversely, will be absorbed without damage to the gas turbine. The low frequency (2.5 to 7.5 Hz) vibration loads that may occur during transportation are also absorbed.

(3) Handling provisions include four lifting sling attachment points (8, figure 2), fork pockets (5), and surface skids.

5. STORAGE AND MAINTENANCE OF GAS TURBINE WHILE IN SHIPPING CONTAINER 106C7556.

NOTE

As received, the gas turbine installed into the shipping container has been preserved, packed for shipment, and hermetically sealed with humidity control and humidity indicator. The following instructions verify that a safe environment is maintained during long-term storage in the shipping container.

a. The following terms are used to describe the environment:

- Normal Environment:

Temperature	25°F to 85°F (-4°C to 29°C)
Relative humidity	25% to 65%

- Extreme Environments:

Temperature	-45°F to 24°F (-43°C to 4°C)
Relative humidity	10% to 24%

and

Temperature	86°F to 120°F (30°C to 49°C)
Relative humidity	66% to 100%

b. Store containers in area protected from direct sunlight, and, if possible, within limits of normal environment.

c. Do the following maintenance checks of container every 60 days or as noted:

(1) Using pressure gage at pressurizing valve (6, figure 1), check container internal pressure and inspect humidity indicator (16) as follows:

(a) Pressure must be 1-3 psig (7-21 kPa).

(b) Humidity indicator (16) must show a blue color (indicating low humidity).

(2) If pressure is less than 1 psig (7 kPa) and the humidity indicator is blue, do the following:

(a) Using an air chuck fitting, repressurize container to 2-4 psig (14-28 kPa) with dry, filtered dehydrated air.

(b) Recheck container at 30-day intervals following procedure in step (1).

(c) If the container internal pressure is found low during several inspection periods or in any two consecutive inspection periods, repressurize container and inspect all ports and flanges for leaks using soap-water solution.

WARNING

Removing Shipping Container Cover

To prevent personal injury, do not loosen nuts and bolts that secure cover until shipping container has been depressurized.

(d) If leaks are found, release container pressure. Repair leaks or replace leaking seals, valves, and/or gaskets as required. Replace desiccant as described in paragraph e.

(e) If pressure is less than 1 psig (7 kPa) and the humidity indicator has turned pink (indicating high humidity), do the following:

1 Replace desiccant (para e).

2 Return gas turbine (in shipping container) to an overhaul facility for inspection of bearings for corrosion and representation. Tag container for overhaul and expedite return.

d. Desiccant Time Replacement.

(1) The frequency of desiccant replacement with favorable periodic inspection is as follows:

(a) Five years for normal environments.

(b) Five years for extremely cold or hot and dry (relative humidity of less than 40%) environments.

(c) Three years for extremely hot and humid (relative humidity of over 40%) environments.

(2) Replace desiccant (para e).

e. Desiccant Replacement Method.

NOTE

Containers are equipped with a service cover (13, figure 1) for replacing desiccant without removing the container cover.

(1) Release container pressure as follows:

(a) Depress pressurizing valve (6) on service cover (13).

(b) Manually depress relief valve poppets in center of automatic pressure relief valve (2).

(c) Remove drainplug (14).

WARNING

Removing Shipping Container Cover

To prevent personal injury, do not loosen nuts and bolts that secure cover until shipping container has been depressurized.

(2) Remove valve mount and desiccant access cup (5) by removing service cover (13), two studs (1), and two capscrews (3).

(3) Remove and discard the existing desiccant bags from container. Place 16 new units of desiccant bags MIL-D-3464, Type I.

(4) Inspect gasket on access cup (5). Replace any gasket that might cause the container to leak.

(5) Replace access cup (5). Tighten two studs (1) and two capscrews (3) to 40-60 lb in. (4.5-6.8 N·m).

(6) Using an air chuck fitting, pressurize the container to 2-4 psig (14-28 kPa) with dry, filtered dehydrated air.

6. HANDLING EQUIPMENT FOR GAS TURBINE.

CAUTION

Use of slings or fixtures other than those recommended by GE Aircraft Engines may result in external or internal damage to the gas turbine during handling or maintenance.

a. Lift Fixture 1C7300G01. This fixture (1, figure 3) is designed as a close-coupled lifting device for removing or installing the gas turbine into shipping container 106C7556 or onto maintenance stand 1C7301G02. Use the following procedures to attach lift fixture 1C7300G01 to the gas turbine:

(1) Place lift fixture (1) on top of gas turbine, with rear yoke (9) over rear main mount and forward support block (10) resting on flange above compressor front frame.

(2) Secure rear yoke (9) with ball lockpin (4) through top rear ground handling hole (3).

(3) Secure right and left links (5) on chains to gas turbine forward handling mounts (6) as follows:

(a) Insert pins (7) from beneath bosses at 10 and 2 o'clock positions through bosses and links. Work around water-wash manifold as necessary.

(b) Secure pins with cotter clips (8).

(4) Position hoist (2) in proper position for configuration of gas turbine being handled as follows:

(a) For bare gas turbine, position saddle pin in fourth hole back in hole grouping under ENG C/G stencil mark (view B). Secure saddle pin with clevis pin.

(b) For gas turbine with accessory drive gearbox assembly installed, position saddle pin under ENG W/GB C/G stencil mark. Secure saddle pin with clevis pin.

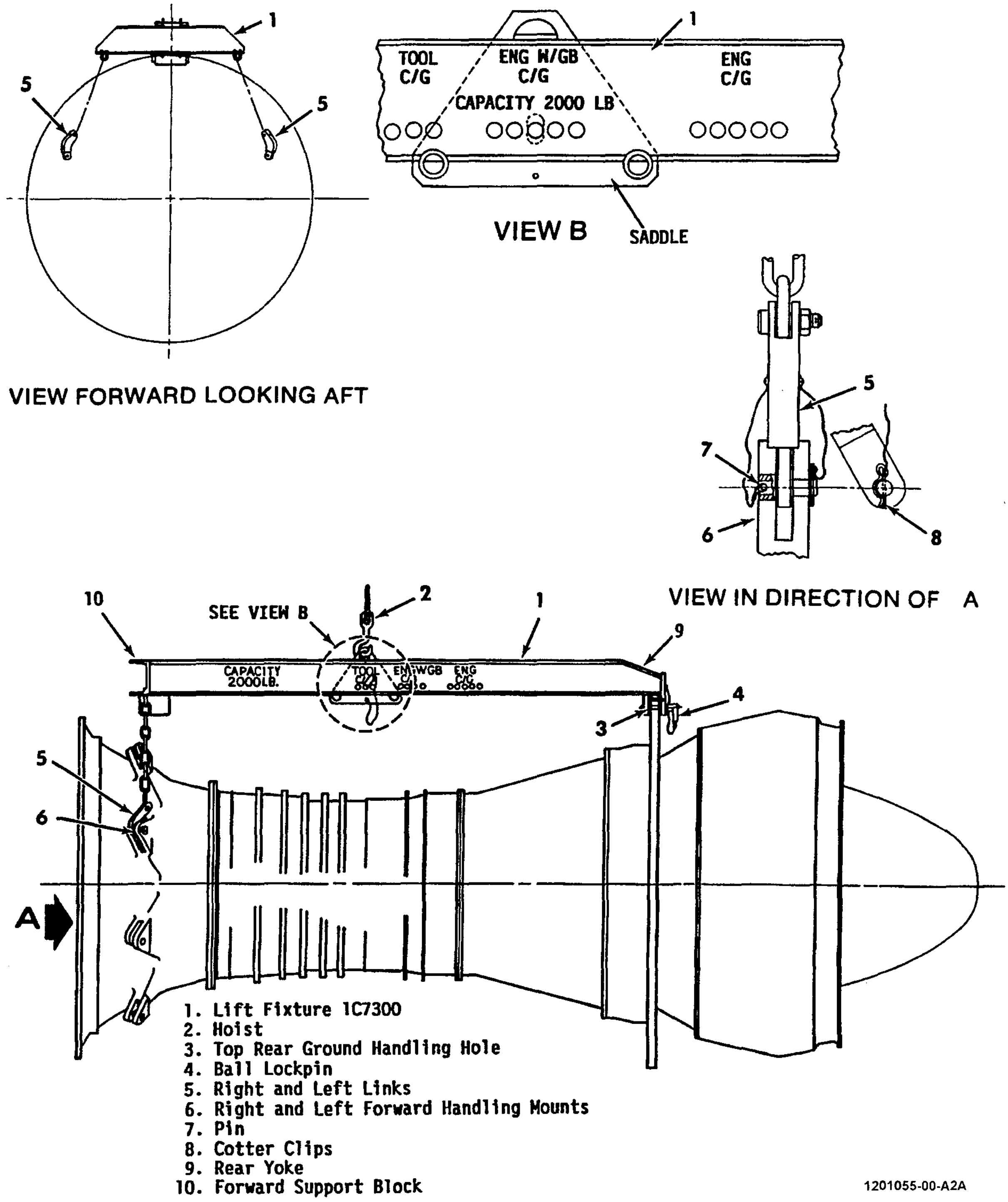


Figure 3. Lift Fixture 1C7300G01 Attachments to Gas Turbine

WARNING

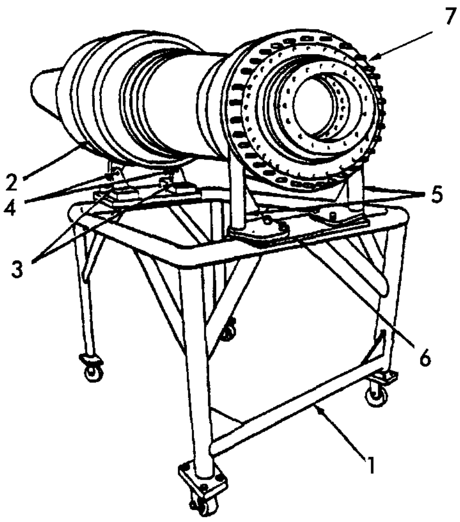
Using Hoisting Devices

- Hoisting shall only be done by designated personnel.
- Do not exceed load capacity rating marked on hoist.
- Inspection and testing for cracks or defects in hoisting system shall be performed on a regular basis.
- Use only pins, links, and hooks recommended for hoisting specific components.
- Before hoisting, balance the load.
- Do not stand under load while it is being moved from one area to another on a hoist. Do not stand under load to do maintenance work.
- Hoisting devices made of nylon, polyester, polypropylene, or aluminum shall not be used in areas where caustics are handled.

(5) Attach hoist hook or cable at top of saddle and lift gas turbine slightly. If gas turbine is not being lifted horizontally and evenly, lower the gas turbine and reposition saddle, as necessary.

b. Support and Maintenance Stand 1C7301G02.

(1) This stand (see figure 4) is designed to support the gas turbine at safe structural loading points. Also, this stand is intended to support the gas turbine during the installation and removal of the accessory drive gearbox assembly and gas turbine-mounted accessories.



1. Work Stand
2. Rear Flange
3. Clevis (Two)
4. Clevis Pins (Two)
5. Front Support (Two)
6. Front Mount Support Plate
7. Front Frame

C
000LM5-058100

Figure 4. Gas Turbine onto Support and Maintenance Stand 1C7301G02

(2) Install gas turbine onto stand as follows:

WARNING

Using Hoisting Devices

- Hoisting shall only be done by designated personnel.
- Do not exceed load capacity rating marked on hoist.
- Inspection and testing for cracks or defects in hoisting system shall be performed on a regular basis.
- Use only pins, links, and hooks recommended for hoisting specific components.
- Before hoisting, balance the load.
- Do not stand under load while it is being moved from one area to another on a hoist. Do not stand under load to do maintenance work.
- Hoisting devices made of nylon, polyester, polypropylene, or aluminum shall not be used in areas where caustics are handled.

CAUTION

The maintenance stand has casters for easy positioning, but it is not designed as a transportation dolly and must not be used as such.

NOTE

The maintenance stand supports the gas turbine under two angled bosses, behind the air intake flange, at 4 and 8 o'clock positions.

(a) Using lift fixture 1C7300G01, position gas turbine above stand 1C7301G02.

(b) Lower the forward end of gas turbine slightly and move it down and forward guiding front frame (7) onto front supports (5) and rear ball mounts within clevises (3).

(c) Insert clevis pins (4) through clevises (3) and ball mounts.

7. REMOVAL OF GAS TURBINE FROM SHIPPING CONTAINER 106C7556.

a. Release pressure on shipping container (see figure 1) as follows:

(1) Depress pressurizing valve (6) on service cover (13), or remove core of pressurizing valve.

(2) Manually depress relief valve poppets in center of automatic pressure relief valve (2).

(3) Remove drainplug (14).

(4) Reinstall drainplug (14) and core of pressurizing valve (6) (if removed) when airflow stops.

WARNING

Removing Shipping Container Cover

To prevent personal injury, do not loosen nuts and bolts that secure cover until shipping container has been depressurized.

b. Remove all capscrews (9) and locknuts (10) from cover flange.

WARNING

Using Hoisting Devices

- Hoisting shall only be done by designated personnel.
- Do not exceed load capacity rating marked on hoist.
- Inspection and testing for cracks or defects in hoisting system shall be performed on a regular basis.
- Use only pins, links, and hooks recommended for hoisting specific components.
- Before hoisting, balance the load.
- Do not stand under load while it is being moved from one area to another on a hoist. Do not stand under load to do maintenance work.
- Hoisting devices made of nylon, polyester, polypropylene, or aluminum shall not be used in areas where caustics are handled.

CAUTION

Cover must be lifted straight up to avoid damage to gas turbine or cover, using standard four-leg sling.

c. Attach lifting sling at lifting sling attachment points (8, figure 2).

d. Remove cover and place it onto wooden blocks to protect the sealing flange.

e. Remove four front support mounting bolts (1) securing engine front support plate (3) to container front crossmember (2).

f. Using lift fixture 1C7300G01 and instructions in paragraph 6.a., prepare gas turbine for removal from shipping container.

g. Raise gas turbine slightly to relieve weight on left and right engine mount links (4, figure 2). Remove ball-lock link pins through engine rear mounts.

h. Using instructions in paragraph 6.b., install gas turbine onto support and maintenance stand 1C7301G02.

i. Detach engine front support plate (3, figure 2) from front frame mounting study by removing 36 nuts that secure plate to mount core.

j. If container is not to be reused immediately, install front engine support plate (3) to container front crossmember (2).

k. Reinstall ball-lock link pins.

l. Reinstall container cover. Secure cover with locknuts (10, figure 1) and capscrews (9). Torque capscrews to 30-50 lb ft (40.7-67.8 N·m).

m. If container is to be stored outdoors, pressurize container to 3 psig (21 kPa) so that weathertight seal can be checked at 60-day intervals (refer to paragraph 5).

8. INSPECTION AND MINOR REPAIR OF SHIPPING CONTAINER 106C7556 PRIOR TO USE.

CAUTION

- Reusable shipping containers for current gas turbines must not be used for purposes other than storage and shipment of the gas turbine.
- Reusable shipping containers are high-cost items procured and used for storage and shipment of gas turbines. These containers are procured in limited quantities, and strict inventory control is maintained to ensure their availability for all serviceable gas turbines placed in the supply system. The use of shipping containers is mandatory for all gas turbines subject to indefinite storage and shipment.

a. Containers must be inspected in accordance with the following criteria, prior to repair or reuse for the protection of serviceable gas turbines:

(1) Inspect bolts, nuts, and container mating surfaces for cracks, burrs, elongation, misalignment, defective threads, and other mechanical defects that would affect serviceability.

NOTE

Pay particular attention to gas turbine suspension system bolts during this inspection.

(2) Inspect braces, lifting rings, eyes, or lugs, roller rings, relief valves, desiccant holders, access plate gaskets, record receptacles, and assembly guides for cracks, ruptures, deterioration, misalignment, and other defects.

(3) Inspect the closure flanges for cracks, dents, misalignment, and other defects which would affect sealing of the container. Check for flushness of the repaired area using suitable gages. Ordinarily, scattered pits not exceeding 1/16 inch (1.6 mm) in depth will not require fill welding but will require loose rust removal.

(4) Inspect the closure flange gasket for permanent deformation, cuts, abrasions, or other surface defects which would affect sealing of the container.

(5) Inspect the container top and bottom shell for dents, cracks, gouges, corrosion damage, holes, or ruptures in the surface that would affect serviceability. Scratches or gouges not more than 1/16 inch (1.6 mm) deep and dents not more than 1/2 inch (12.7 mm) deep are acceptable without repair.

(6) Inspect skids for broken ends, splits, dry rot, and other defects that would affect serviceability. Splits not exceeding 2 feet (61 cm) in length and 1/2 inch (12.7 mm) wide are acceptable without replacement.

(7) Inspect shock mounts for cracks, tears, bond separation, splits, and other defects that would affect serviceability.

(8) Check the automatic pressure relief valve (2, figure 1) for proper release pressure and for leakage. Relief valve should release at 2.5-3.5 psig (17-24 kPa) and be bubble-tight at 2.5 psig (17 kPa).

(9) If the container has been reconditioned and was not used, pressurize and check for leaks. Containers reconditioned for use must be checked for overall leakage simultaneously with final pressurization at the time the gas turbine is preserved. The container leakage check, required on all containers after reconditioning or when used to protect a serviceable gas turbine, may be accomplished by the following method:

(a) Install top half cover of container. Install and tighten flange bolts to 30-50 lb ft (40.7-67.8 kPa), and pressurize to 2-4 psig (14-28 kPa).

(b) Using a soap solution, check the container for leaks at mating flanges and areas where weld repairs were accomplished. If no leaks are detected in these areas, allow the container to stay pressurized for 24 hours and recheck the pressure with an accurate pressure gage. If noticeable pressure drop has not occurred, container can be considered free from leaks.

(10) To assure proper preservation maintenance of the gas turbine, all containers that contain serviceable or repairable gas turbines must have the following minimum markings:

- Preservation type
- Date of preservation
- Name of preserving activity
- Status of gas turbine (serviceable or repairable)
- Gas turbine type
- Gas turbine serial number
- A minimum of six spaces for inspection records labeled and titled as follows:

INSPECTION DATA

Activity	Date
----------	------

(11) A second area or part of a continuous area labeled "SHIPPING DATA" with a minimum of 5 square feet (4645 cm^2) must be reserved for indicating shipping data, as necessary. A contrasting background must be provided for easy reading. The following minimum information must be indicated:

SHIPPING DATA

- Destination
- Shipping activity
- Number of units
- Invoice number
- Weight
- Cube
- Dimensions
- Bill of lading.

b. Containers needing minor repairs or overhaul must be reconditioned only as necessary to restore the container to a serviceable condition. The following procedures must be considered as applicable for minor repair:

(1) Clean container interior to remove fuel, oil, rags, bolts, nuts, desiccant bags, and other debris.

(2) Using a wire brush, remove all loose rust from the container's internal and external surfaces including mounting rails, desiccant baskets, attaching hardware, and closure flange gasket surfaces. Bolts, mounts, and other fasteners which are badly corroded should be removed for replacement or chemical cleaning.

(3) Complete refinishing is unnecessary unless areas bare of paint exceed 25 percent of total surface area. Wherever practicable, touchup of surfaces must be accomplished using the same general paint tones as originally applied. Matching of colors is not necessary. When completely refinishing any painted surface, use enamel (MIL-E-529) in any available color or any spare or excess finishes which may be available. The use of special purpose colors such as red or yellow must be avoided. Interior touchup must consist of a mist coat of zinc chromate primer (MIL-P-23377 or MIL-P-8585) followed by a wet coat of the same material.

(4) Replace any flange gaskets that have cuts, abrasions, or other surface defects that would affect sealing of the container. Replacement gaskets may be fabricated locally using gasket material conforming to Specification MIL-R-6855, Class II, Grade 60. All joints must be vulcanized to form a continuous gasket.

9. INSTALLATION OF GAS TURBINE INTO SHIPPING CONTAINER 106C7556.

a. Inspect shipping container (para 8).

CAUTION

Prior to installation of the gas turbine into shipping container, all slave test equipment must be removed and all blank-off plates must be installed. All openings must be plugged or capped as necessary. A final inspection should be made to ensure all parts are installed or removed as appropriate.

b. Using lift fixture 1C7300G01 and instructions in paragraph 6.a., prepare gas turbine for installation into shipping container.

c. Attach engine front support plate (3, figure 2) to front frame mounting studs so that the support plate is indexed to position front mount pads horizontally on either side of gas turbine vertical centerline.

d. Secure support plate (3) with 36 nuts. Tighten nuts.

WARNING

Using Hoisting Devices

- Hoisting shall only be done by designated personnel.
- Do not exceed load capacity rating marked on hoist.
- Inspection and testing for cracks or defects in hoisting system shall be performed on a regular basis.
- Use only pins, links, and hooks recommended for hoisting specific components.
- Before hoisting, balance the load.
- Do not stand under load while it is being moved from one area to another on a hoist. Do not stand under load to do maintenance work.
- Hoisting devices made of nylon, polyester, polypropylene, or aluminum shall not be used in areas where caustics are handled.

e. Lift gas turbine with lift fixture.

f. Lower the gas turbine into container so that the support plate (3) rests on container front crossmember (2).

g. Attach gas turbine rear mount-to-container yoke links to left and right rear mounts.

h. Install four front support mounting bolts (1) to secure support plate (3) to container front crossmember (2).

i. Relieve weight on lift fixture and remove fixture from gas turbine.

j. Torque bolts (1) to 30-50 lb ft (40.7-67.8 N·m).

k. Replace desiccant bags in shipping container receptacle with fresh 16 unit desiccant bags (MIL-D-3464).

l. Install container cover as follows:

(1) Attach four standard four-leg lifting slings at lifting sling attachment points (8).

WARNING

Using Hoisting Devices

Observe warning preceding step e.

CAUTION

Cover must be installed straight down to avoid damage to gas turbine or to cover.

(2) Lift the cover and lower it onto gas turbine and onto bottom half of container cover.

(3) Install capscrews (9, figure 1) and locknuts (10). Torque locknuts to 30-50 lb ft (40.7-67.8 N·m).

m. Using an air chuck fitting, pressurize container to 2-4 psig (14-28 kPa) with dry (dehydrated), filtered air. Verify seal around cover flange and all container fill, vent, and drain ports for leakage with soap solution.

n. Put gas turbine log book in container records compartment.

o. Stencil gas turbine shipping container per the requirements of paragraph 8, steps a.(10) and a.(11).

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

OPERATION

OPERATING PROCEDURES AND LIMITS

Effectivity: L32119G02 INDUSTRIAL GAS TURBINE

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1. INTRODUCTION. This work package provides operating instructions and limits for the LM500 Industrial gas turbine. Also, this work package provides prestart checks, starting, and shutdown procedures.

a. The instructions cover operation. They apply to routine and emergency conditions. When a fault exists, refer to WP 006 00, TROUBLESHOOTING.

b. These instructions may not provide for every possible variation in equipment or situation to be met when operating the gas turbine. If additional information is needed, contact:

Manager, Customer Service and Product Support
Marine and Industrial Engine Projects Department
GE Aircraft Engines
Mail Drop S155
Cincinnati, Ohio 45215
USA

2. SUPPORT EQUIPMENT.

None

3. CONSUMABLE MATERIALS.

None

4. NORMAL OPERATING RANGES AND LIMITS.

a. General. If a questionable condition exists, do not operate the gas turbine until a thorough investigation has been made. Do not attempt a restart after a hot start, compressor stall, or other recognized problem without prior thorough investigation. Failure to do so can result in undue stress being imposed on gas turbine components, with immediate or subsequent destructive failure of the gas turbine.

b. Refer to table 1 for normal operating ranges and limits.

TABLE 1. NORMAL OPERATING RANGES AND LIMITS

Item	Value	Remarks
a. General.		
(1) Physical speeds:		
(a) Gas generator rotor (N1):		
• Idle	11,000-11,500 rpm 11,200 rpm	Typical speed range Nominal speed
• Operating Limit	17,150 rpm	Maximum rated
• Shutdown Limit	17,300 rpm	Overspeed trip setpoint
• Overspeed Limit	17,800 rpm	Gas generator inspection required
(b) Power turbine shaft (N2):		
• Operating Limit	7,050 rpm	Maximum rated
• Shutdown Limit	7,300 rpm	Alarm set point
• Overspeed Limit	7,700 rpm	Overspeed trip setpoint. Any observed/suspected rpm in excess of this limit requires a power turbine inspection.
(c) Locked rotor	Maximum 14 minutes at idle	

TABLE 1. NORMAL OPERATING RANGES AND LIMITS (Cont)

Item	Value	Remarks
(2) Power turbine inlet total temperature (T4.8):		
• Operating Limit	1,370°F (745°C)	Max allowable during starts
• Maximum Rated	1,380°F (750°C)	Alarm limit
• Shutdown Limit	1,400°F (760°C)	Troubleshoot (WP 006 00).
• Overtemperature Limit	1,555°F (850°C)	Power turbine inspection required
(3) Ambient temperature	-65° to 125°F (-54° to 52°C)	Do not operate gas turbine outside this range.
b. Fuel system (natural gas).		
(1) Fuel flow (Wf)	420 lb/hr (191 kg/hr) nominal at idle. 2,360 lb/hr (1,194 kg/hr) max at base load	Limits with fuel LHV of 19,000 BTU/lb nominal
(2) Specific gravity (nominal)	0.568 at 100°F (38°C)	
(3) Fuel manifold pressure	270 psig (1,862 kPa) minimum at rated load	
(4) Leakage	No detectable vapor allowed.	
c. Lubrication.		
(1) Flow (to gas turbine)	0 to 9.9 gpm (0 to 38 lpm)	Proportional to gas generator rotor (N1) speed
(2) Temperature at startup (minimum)	MIL-L-23699: 40°F (4°C) MIL-L-7808: 0°F (-18°C)	
(3) Lube supply temperature	140°-170°F (60°-77°C)	
(4) Scavenge temperature	176°-310°F (80°-155°C)	Normal range
	325°F (163°C) for 15 minutes	Transients (alarm)
	350°F (177°C)	Maximum (gas turbine cut-back)

TABLE 1. NORMAL OPERATING RANGES AND LIMITS (Cont)

Item	Value	Remarks
(5) Gas turbine oil pressure at 200°F (93°C) oil temperature:		Measured as differential pressure between filter discharge (pump connection) and the B-sump aft scavenge pressure
(a) Starting	Oil pressure should show a positive value during start and may peak at 100 psi (689 kPa) for a maximum of 2.5 minutes when operating in cold weather. Oil pressure should start to decrease after 2.5 minutes.	If limits are exceeded, shut down gas turbine and troubleshoot (WP 006 00).
(b) Idle	34 to 54 psid (234-372 kPa)	
(c) Above idle	60 to 87 psid (414-600 kPa)	
(d) Transients	Oil pressure transients that exceed the normal limits may occur for a maximum of 6 minutes, if during the 6-minute period, a steady decrease in pressure is occurring to return the gas turbine toward normal steady-state pressure.	
(6) Oil consumption	0.07 gph (0.27 lph)	
(7) Sumps pressure:		
(a) A-sump and accessory gearbox	Ambient to 4 psig (28 kPa)	
(b) B-sump	55 psig (379 kPa) maximum	
(c) C-sump	Ambient to 4 psig (28 kPa)	
(8) Oil leakage (during operation):		
(a) VG actuators	0.1 cc or 2 drops per minute maximum	Isolate faulty actuator and replace.
(b) A-sump drain	1 cc or 20 drops/minute maximum	Check for high sump pressure, low pressurizing air regulation, improper AGB scavenging, or flooded sump.
(c) Accessory gearbox seal cavities	3 cc/hr or 60 drops/minute minimum	
(d) Gas turbine fittings or strut tubes	No observed leakage allowed	
(9) Filter efficiency	10 microns maximum (lube and hydraulic oil)	

TABLE 1. NORMAL OPERATING RANGES AND LIMITS (Cont)

Item	Value	Remarks
(10) Change interval	As indicated by SOAP	Refer to WP 015 00.

d. Vibration.

NOTE

Vibration limits are displayed at a one-per-revolution value of the indicated rotor. For example, selecting "gas generator rotor vibration" for display will indicate only gas generator (compressor) vibration on the front frame transducer; the power turbine contribution to the total velocity seen by that transducer will be filtered out. Gas generator vibration will likewise be displayed from the turbine frame transducer and power turbine vibrations will be filtered out.

(1) Vibration Monitoring:

Pickup Location	Frequency (cycles/second)	Steady State (mils-double amplitude)	Transient (mils-double amplitude)	Direction and Clock Position
Compressor casing forward flange	25 to 130	3.5	4.5	1 horizontal
	130 to 310	2.5	3.5	
Exhaust frame flange	25 to 130	5	6	1 horizontal
	130 to 310	3	4	

(2) Corrective Action:

(a) Alarm: Temporary operation is allowed between alarm and shutdown setpoints for transient conditions or troubleshooting purposes. Throttle setting should be reduced, as necessary, to avoid steady-state operation in an alarm condition.

(b) Shutdown: Operation above this vibration level is not allowed.

Item	Value	Remarks
e. Starting.		Do not attempt restart until gas generator rotor has stopped.
(1) Time from starter initiation to idle	45 seconds maximum	
(2) Time to lightoff, from starter initiation	20 seconds maximum	
(3) Starter seal drainage	5 cc/hr	

5. GAS TURBINE INSPECTION AND PRESTART CHECKS.

a. General. If a questionable condition exists, do not operate the gas turbine until a thorough investigation has been made. Do not attempt a restart after a hot start, compressor stall, or other recognized problem without prior thorough investigation. Failure to do so can result in undue stress being imposed on gas turbine components, with immediate or subsequent destructive failure of the gas turbine.

b. Initial Operation Inspection. The initial operational period is that period of operation immediately following gas turbine installation or replacement, or following major maintenance on the system. Do the following:

(1) Verify that oil tank contains sufficient oil.

(2) Using table 2, do a prestart system check.

(3) Take oil sample (WP 015 00) for lab analysis prior to first motoring, unless oil has been changed as part of gas turbine maintenance.

c. Prestart Motoring (No Fuel).

(1) Never allow fuel (natural gas) to enter the gas turbine during prestart motoring. If fuel flows into the gas turbine, purge the fuel by motoring the gas turbine for a minimum of 15 seconds with no fuel flow.

(2) Deactivate ignition circuit at unit circuit breaker.

(3) Motor gas turbine to achieve max motoring speed on starter.

(4) Check for:

(a) Zero fuel flow (zero fuel manifold pressure).

(b) Unusual rubbing or scraping noises.

TABLE 2. PRESTART SYSTEM CHECKS

Item	Requirement
Maintenance requirements and discrepancies	Cleared
Fire and gas detection system	ON
Fuel valves	Closed
Ignition	OFF
Ventilation inlet air (secondary cooling air)	ON
Oil tank level	Full
Lube oil supply valves	Open
Lube oil temperature (in tank):	
● MIL-L-23699	40°F (4°C) minimum
● MIL-L-7808	0°F (-18°C) minimum
Water wash supply	Closed
Instrument gas valves	Open

(c) Positive oil pressure indication within 30 seconds. Stop motoring if no oil pressure is indicated.

(d) Lube leaks.

(5) Record:

- Gas generator rotor speed (N1)
- Power turbine output shaft speed (N2) (may be zero at cranking speed)
- Lube supply pressure
- VG indication (should close)
- Fuel flow (should be 0)
- Fuel manifold pressure (should be 0).

(6) After 2 minutes (maximum), de-energize starter.

6. STARTING AND SHUTDOWN PROCEDURES.

a. Before attempting to start gas turbine, observe the following precautions:

(1) Before making an initial start, do gas turbine inspection and prestart checks (para 5).

(2) Shut down gas turbine if any fuel or oil leaks are detected, or if there is no oil pressure indication within 30 seconds.

b. Follow the operating limits and performance ratings given in table 1.

7. SHUTDOWN.

a. Stabilize gas turbine at idle (minimum speed) for 5 minutes.

b. Close fuel valves.

c. Monitor coastdown.

d. Check for post shutdown fire by monitoring T4.8 for 3 minutes. If T4.8 does not decrease steadily after coast-down, close manual fuel valves and motor gas turbine until positive fuel shutoff is verified and fire is put out.

8. EMERGENCY SHUTDOWN.

a. An immediate shutdown from any power level may be made by de-energizing (closing) the fuel shutoff valves.

b. Do not attempt a restart until the cause of the shutdown has been verified and corrected.

c. Do a Prestart Motoring (para 5. c.) before attempting a restart.

d. A tripout due to overspeed, fuel flow interruption, or other control system safety feature is considered an emergency shutdown, if the tripout shuts the gas turbine down.

9. ABNORMAL RUNNING CONDITIONS.

a. General.

(1) If an abnormal gas turbine condition occurs, such as compressor stall, flameout, or overtemperature, shut down gas turbine. Record duration and degree of any abnormal condition. (Refer to table 1 for limits.)

(2) In most cases, continued operation of the gas turbine is permitted if the operator has been able to restore the gas turbine parameters within limits from an alarm or abnormal condition. Troubleshooting must be conducted at the earliest opportunity to find the cause of the problem, so as to preclude its reoccurrence during later operation. Causes of abnormal operation may involve complex control logic and/or interactions between several systems. Ensure that adequate corrective action has been taken prior to further operation.

b. Hot Start.

(1) If during a start T4.8 increases abnormally, shut the gas turbine down immediately and record highest observed T4.8. (Refer to table 1 to determine if operating limits have been exceeded.)

(2) If operating limits have been exceeded, troubleshoot (WP 006 00).

c. Overtemperature.

CAUTION

Do not operate gas turbine until cause of overtemperature has been determined. An overtemperature inspection may be necessary.

(1) An overtemperature condition exists and requires an overtemperature inspection if:

(a) During starting, T4.8 increases rapidly above 1,700°F (927°C) immediately after lightoff.

(b) After gas generator rotor reaches 8,900 rpm and T4.8 exceeds limits given in table 1.

(2) If an overtemperature condition exists, troubleshoot (WP 006 00).

d. Flameout.

(1) Shut down gas turbine (para 7).

(2) If operating limits have been exceeded, troubleshoot (WP 006 00).

e. Overspeed.

CAUTION

Do not operate gas turbine until cause of overspeed has been determined and corrective action taken; otherwise, gas turbine damage may occur.

(1) If gas generator speed or power turbine output shaft speed exceeds the limits given in table 1, or an overspeed trip occurs, shut down gas turbine.

(2) If operating limits have been exceeded, troubleshoot (WP 006 00).

f. Abnormal Oil Pressure.

(1) Do not operate gas turbine if stabilized oil pressure is outside the limits given in table 1.

(2) If limits are exceeded, troubleshoot (WP 006 00).

g. Abnormal Fuel Flow.

(1) Fuel flow is abnormal if it does not meet the operating limits given in table 1.

(2) If operating limits have been exceeded, troubleshoot (WP 006 00).

h. Abnormal Vibrations.

(1) High vibrations can be caused by rotor imbalance and by loose gas turbine mounts or other external connections. If operating limits have been exceeded, troubleshoot (WP 006 00).

(2) Occasionally, it may be noted that vibrations increase as much as 3 mils after a shutdown of 1 to 2 hours. The most probable cause is a temporary thermal rotor bow due to uneven cooling of the power turbine or gas generator rotors. If the shutdown is brief (less than 10 minutes) or long (more than 6 hours), thermal rotor bow is controlled because the rotors cool either very little or to a uniform temperature.

(3) A thermal rotor bow can be identified by noting that the increased vibration levels gradually decrease to previous levels during approximately 10 minutes of gas turbine operation. As long as vibrations are decreasing with time, gas turbine operation may be continued even if some limits are temporarily exceeded.

i. Compressor Stall.

(1) A compressor stall is caused by an aerodynamic disturbance of the smooth airflow pattern through the compressor. A rapid increase of T4.8 and usually a speed hangup (although some stalls are accompanied by a rapid decrease in speed) are indications of a stall. A change in gas turbine noise level may also be noted.

(2) If a stall occurs, do the following:

(a) Shut gas turbine down immediately.

CAUTION

Do not attempt a restart after a stall until cause has been investigated.

(b) If operating limits have been exceeded, troubleshoot (WP 006 00).

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

OPERATION

OPERATING PROCEDURES AND LIMITS

Effectivity: L32119G01/-G03/-G04/-G05/-G06 MARINE GAS TURBINE

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1. INTRODUCTION. This work package provides operating instructions and limits for the LM500 Marine gas turbine. Also, this work package provides prestart checks, starting, and shutdown procedures.

a. The instructions cover operation. They apply to routine and emergency conditions. When a fault exists, refer to WP 006 10, TROUBLESHOOTING.

b. These instructions may not provide for every possible variation in equipment or situation to be met when operating the gas turbine. If additional information is needed, contact:

Manager, Customer Service and Product Support
Marine and Industrial Engine Projects Department
GE Aircraft Engines
Mail Drop S156
Cincinnati, Ohio 45215
USA

2. SUPPORT EQUIPMENT.

None

3. CONSUMABLE MATERIALS.

None

4. NORMAL OPERATING RANGES AND LIMITS.

a. General. If a questionable condition exists, do not operate the gas turbine until a thorough investigation has been made. Do not attempt a restart after a hot start, compressor stall, or other recognized problem without prior thorough investigation. Failure to do so can result in undue stress being imposed on gas turbine components, with immediate or subsequent destructive failure of the gas turbine.

CAUTION

- Bypassing/disabling engine sensors or operating engine with monitoring systems inoperative can result in engine damage.
- Overriding engine control permissives can result in engine operational problems and engine damage.

b. Refer to table 1 for normal operating ranges and limits.

TABLE 1. NORMAL OPERATING RANGES AND LIMITS

Item	Value	Remarks
a. General.		
(1) Physical speeds:		

NOTE

XN2R = Corrected gas generator speed
XN2 = Physical gas generator speed

Item	Value	Remarks
(a) Gas generator rotor:		
• Idle (XN2)	11,000-11,500 rpm	Typical speed range
(XN2R)	11,200 rpm	Nominal speed
• Operating Limit		Maximum rated
(XN2)	17,600 rpm	
(XN2R)	17,200 rpm	
• Shutdown Limit (XN2R)	17,700-17,900 rpm	Overspeed trip setpoint
• Overspeed Limit (XN2)	18,150 rpm	Gas generator inspection required

TABLE 1. NORMAL OPERATING RANGES AND LIMITS (Cont)

Item	Value	Remarks
(b) Power turbine shaft (XNSD):		
• Operating Limit	7,050 rpm	Maximum rated
• Alarm Limit	7,300 rpm	Alarm setpoint
• Overspeed Limit	7,650-7,750 rpm	Overspeed trip setpoint
	7,826 rpm	Any observed/suspected rpm in excess of this limit requires a power turbine inspection.
(c) Locked rotor	Maximum 14 minutes at idle	
(2) Power turbine inlet total temperature (T4.8):		
• Operating Limit	1,395° to 1405°F (757° to 763°C)	Max allowable during starts
• Maximum Rated	1,549° to 1,560°F (843° to 849°C)	Alarm limit
• Shutdown Limit	1,580° to 1,591°F (860° to 866°C)	Troubleshoot (WP 006 10).
• Overtemperature Limit	1,625°F (885°C)	Power turbine inspection required
(3) Ambient temperature	-65° to 125°F (-54° to 52°C)	Do not operate gas turbine outside this range.
b. Fuel system (liquid fuel).		
(1) Fuel flow (Wf)	290 lb/hr (132 kg/hr) to 3,400 lb/hr (1,543 kg/hr) maximum	Fuel type NATO-F-76, MIL-F-1688A
(2) Fuel manifold pressure	0 to 270 psi (0 to 1,862 kPa)	
(3) Leakage	5 cc/minute max from all drains when running	
c. Lubrication.		
(1) Flow (to gas turbine)	0 to 9.9 gpm (0 to 38 lpm)	Proportional to gas generator rotor (XN2) speed
(2) Temperature at startup (minimum)	MIL-L-23699: 40°F (4°C)	Preheat lube oil, if required, prior to start.
(3) Lube supply temperature	248°F (120°C)	

TABLE 1. NORMAL OPERATING RANGES AND LIMITS (Cont)

Item	Value	Remarks
(4) Scavenge temperature	176°-310°F (80°-155°C)	Normal range
	329°-350°F (165°-177°C) for 15 minutes	Transients (alarm)
	Above 350°F (177°C)	Maximum (gas turbine cut-back)
(5) Gas turbine oil pressure at 200°F (93°C) oil temperature:		Measured as differential pressure between filter discharge (pump connection) and the B-sump aft scavenge pressure
(a) Starting	Oil pressure should show a positive value during start and may peak at 100 psi (689 kPa) for a maximum of 2.5 minutes when operating in cold weather. Oil pressure should start to decrease after 2.5 minutes.	If limits are exceeded, shut down gas turbine and troubleshoot (WP 006 10).
(b) Idle	35 to 55 psid (241-379 kPa)	
(c) Above idle	40 to 70 psid (276-483 kPa)	
(d) Transients	Oil pressure transients that exceed the normal limits may occur for a maximum of 6 minutes, if during the 6-minute period, a steady decrease in pressure is occurring to return the gas turbine toward normal steady-state pressure.	
(6) Oil consumption	0.07 gph (0.27 lph)	
(7) Sumps pressure:		
(a) A-sump and accessory gearbox	Ambient to 4 psig (28 kPa)	
(b) B-sump	55 psig (379 kPa) maximum	
(c) C-sump	Ambient to 4 psig (28 kPa)	

TABLE 1. NORMAL OPERATING RANGES AND LIMITS (Cont)

Item	Value	Remarks
(8) Oil leakage (during operation):		
(a) VG actuators	0.1 cc or 2 drops per minute maximum	Isolate faulty actuator and replace.
(b) A-sump drain (may not be applicable to some models)	1 cc or 20 drops/minute maximum	Check for high sump pressure, low pressurizing air regulation, improper AGB scavenge, or flooded sump.
(c) Accessory gearbox seal cavities	3 cc/hr or 60 drops/minute maximum	
(d) Gas turbine fittings or strut tubes	No observed leakage allowed	
(9) Filter efficiency	10 microns maximum (lube and hydraulic oil)	
(10) Change interval	As indicated by SOAP	Refer to WP 015 00.

d. Vibration.

NOTE

Vibration limits are displayed at a one-per-revolution value of the indicated rotor. For example, selecting "gas generator rotor vibration" for display will indicate only gas generator (compressor) vibration on the front frame transducer; the power turbine contribution to the total velocity seen by that transducer will be filtered out. Gas generator vibration will likewise be displayed from the turbine frame transducer and power turbine vibrations will be filtered out.

(1) Vibration Monitoring (all engines except as noted):

Transducer Location	Vibration Source (Symbol)	Alarm Setpoint (Mils DA)	Shutdown Setpoint (Mils DA)
Forward	GG	2.5	3.5
	PT	3.5	4.5
Aft	GG	3	4
	PT	5	6

(2) Vibration Monitoring - Danish Navy:

Transducer Location	Vibration Source (Symbol)	Alarm Setpoint (Mils DA)	Shutdown Setpoint (Mils DA)
Forward	GG	1.5	2.0
	PT	2.0	2.7
Aft	GG	1.5	2.0
	PT	2.0	2.7

TABLE 1. NORMAL OPERATING RANGES AND LIMITS (Cont)

Item	Value	Remarks
(3) Vibration Monitoring - FoilCat/11 PG:		

Transducer Location	Vibration Source (Symbol)	Alarm Setpoint (Mils DA)	Shutdown Setpoint (Mils DA)
Forward	GG	2.5	3.5
	PT	3.5	4.5
Aft	GG	2.5	3.5
	PT	3.5	4.5

(4) Corrective Action

(a) Alarm: Temporary operation is allowed between alarm and shutdown setpoints for transient conditions or troubleshooting purposes. Throttle setting should be reduced, as necessary, to avoid steady-state operation in an alarm condition.

(b) Shutdown: Operation above this vibration level is not allowed.

Item	Value	Remarks
e. Starting.		Do not attempt restart until gas generator rotor has stopped.
(1) Time from starter initiation to idle	90 seconds maximum	
(2) Time to lightoff, from starter initiation	20 seconds maximum	
(3) Starter seal drainage	5cc/hr	

5. GAS TURBINE OPERATION.

a. General. If a questionable condition exists, do not operate the gas turbine until a thorough investigation has been made. Do not attempt a restart after a hot start, compressor stall, or other recognized problem without prior thorough investigation. Failure to do so can result in undue stress being imposed on gas turbine components, with immediate or subsequent destructive failure of the gas turbine.

b. Motoring. During motoring, the fuel supply system must provide pressurized fuel to the fuel pump to prevent pump damage.

c. Starting. Shut down the gas turbine if any fuel or oil leaks are detected, or if there is no oil pressure indication within 30 seconds.

d. Fire Extinguishing. If Halon fire extinguishing agent is used in the gas turbine compartment, the gas turbine exterior must be cleaned per WP 017 00 prior to further operation.

6. PRESTART CHECKS.

a. General. The prestart system checks listed in table 2 should be performed prior to each gas turbine start. If major maintenance has been performed, ensure that the affected systems and components have been restored for operation and tested or aligned per the applicable work packages.

TABLE 2. PRESTART SYSTEM CHECKS

Item	Requirement
Maintenance requirements and discrepancies	Cleared
Fire detection system	ON
Hydraulic starter supply system	Ready
Fuel supply valves	Open
Fuel supply pump	ON
Gas turbine fuel shutoff valves	Closed
Ignition	OFF
Ventilation inlet air (secondary cooling air)	
• Fan	ON
• Fan damper	Open
• Fan bypass damper	Closed
Oil tank level	Full
Lube oil supply temperature	40°F (4°C) minimum
Water wash supply	Closed

7. MOTORING PROCEDURE.

a. Dry (No fuel).

(1) Complete prestart checks listed in table 2.

(2) Do not allow fuel to enter the gas turbine during dry motoring. If fuel flows into the gas turbine, purge fuel by motoring the gas turbine for 60 seconds with no fuel flow (gas turbine shutoff valves shut). Be sure that during motoring the fuel supply system is in operation to prevent the gas turbine fuel pump from running dry.

(3) Motor gas turbine with starter to achieve maximum motoring speed.

(4) Record:

- Gas generator rotor speed (XN2)
- Starter hydraulic supply pressure
- Lube supply pressure.

(5) Check for:

- Fluid leaks
- Unusual rubbing or scraping noises.

(6) After motoring is complete, disengage starter and record gas generator (XN2) coastdown time. Check for unusual noises.

b. Wet.

(1) Complete prestart checks listed in table 2.

CAUTION

Ensure that the ignition circuit remains deactivated during this procedure.

(2) Motor gas turbine with starter to achieve maximum motoring speed.

(3) When speed has stabilized, open gas turbine fuel shutoff valves.

(4) When fuel manifold pressure stabilizes, record:

- Fuel manifold pressure
- Gas generator rotor speed (XN2)
- Starter hydraulic supply pressure
- Lube supply pressure
- Fuel supply temperature.

(5) Close gas turbine fuel shutoff valves.

(6) Check for:

- Fluid leaks
- Unusual rubbing or scraping noises.

(7) Continue motoring for 60 seconds to purge fuel.

(8) Disengage starter and record gas generator (XN2) coastdown time. Check for unusual noises.

8. STARTING PROCEDURE.

a. Perform prestart checks listed in table 2.

b. The following constraints are imposed during the start to protect the gas turbine. If any of these constraints are violated, abort the start sequence immediately:

(1) Gas generator rotor (XN2) must reach 1,200 rpm within 5 seconds after energizing the starter.

(2) Power turbine inlet temperature (T4.8) must reach 392°F (200°C) within 40 seconds after opening the fuel shutoff valves.

(3) Gas generator rotor (XN2) must reach 9,500 rpm within 45 seconds after energizing starter.

c. For normal startup, the following sequence of events must be adhered to:

(1) Reset alarms and switches.

(2) Energize starter.

(3) At gas generator rotor speed (XN2) of 1,200 rpm do the following:

(a) Energize ignition system.

(b) Open fuel shutoff valves.

(4) At gas generator rotor speed (XN2) of 9,500 rpm do the following:

(a) De-energize ignition system.

(b) De-energize starter.

(5) When gas turbine is at idle, set control system for normal operation.

(6) Prior to accelerating above idle, ensure that all gas turbine parameters are in the normal operating range and no out-of-limit conditions exist.

9. NORMAL OPERATION.

a. Adhere to normal operating ranges and limits of table 1.

b. Ventilation inlet air (secondary cooling) to the gas turbine compartment must be aligned based on gas turbine operating condition, as follows:

Operating Condition	Fan	Fan Damper	Eductor Damper
Power Turbine Rotor Speed (XNSD) 5,500 rpm	ON	Open	Closed
Power Turbine Rotor Speed (XNSD) 5,500 rpm	OFF	Open	Open
Fire/Emergency Shutdown	OFF	Closed	Closed

10. ABNORMAL RUNNING CONDITIONS.

a. General.

(1) If an abnormal gas turbine condition occurs, such as compressor stall, flameout, or overtemperature, shut down gas turbine. Record duration and degree of any abnormal condition. (Refer to table 1 for limits.)

(2) In most cases, continued operation of the gas turbine is permitted if the operator has been able to restore the gas turbine parameters within limits from an alarm or abnormal condition. Troubleshooting must be conducted at the earliest opportunity to find the cause of the problem, so as to preclude its reoccurrence during later operation. Causes of abnormal operation may involve complex control logic and/or interactions between several systems. Ensure that adequate corrective action has been taken prior to further operation.

b. Overtemperature.

CAUTION

Do not operate gas turbine until cause of overtemperature has been determined. An overtemperature inspection may be necessary.

(1) An overtemperature condition exists and requires an overtemperature inspection if:

(a) During starting, T4.8 increases rapidly above 1,600°F (871°C) immediately after lightoff.

(b) After gas generator rotor reaches 8,900 rpm and T4.8 exceeds limits given in table 1.

(2) If an overtemperature condition exists, troubleshoot (WP 006 10).

c. Overspeed.

CAUTION

Do not operate gas turbine until cause of overspeed has been determined and corrective action taken; otherwise, gas turbine damage may occur.

(1) If gas generator speed or power turbine output shaft speed exceeds the limits given in table 1, or an overspeed trip occurs, shut down gas turbine.

(2) If operating limits have been exceeded, troubleshoot (WP 006 10).

d. Abnormal Vibrations.

(1) High vibrations can be caused by rotor imbalance and by loose gas turbine mounts or other external connections. If operating limits have been exceeded, troubleshoot (WP 006 10).

(2) Occasionally, it may be noted that vibrations increase as much as 3 mils after a shutdown of 1 to 2 hours. The most probable cause is a temporary thermal rotor bow due to uneven cooling of the power turbine or gas generator rotors. If the shutdown is brief (less than 10 minutes) or long (more than 6 hours), thermal rotor bow is controlled because the rotors cool either very little or to a uniform temperature.

(3) A thermal rotor bow can be identified by noting that the increased vibration levels gradually decrease to previous levels during approximately 10 minutes of gas turbine operation. As long as vibrations are decreasing with time, gas turbine operation may be continued even if some limits are temporarily exceeded.

e. Compressor Stall.

(1) A compressor stall is caused by an aerodynamic disturbance of the smooth airflow pattern through the compressor. A rapid increase of T4.8 and usually a speed hangup (although some stalls are accompanied by a rapid decrease in speed) are indications of a stall. A change in gas turbine noise level may also be noted.

(2) If a stall occurs, do the following:

(a) Shut gas turbine down immediately.

CAUTION

Do not attempt a restart after a stall until cause has been investigated.

(b) If operating limits have been exceeded, troubleshoot (WP 006 10).

f. Hot Start.

(1) If during a start T4.8 increases abnormally, shut the gas turbine down immediately and record highest observed T4.8. (Refer to table 1 to determine if operating limits have been exceeded.)

(2) If operating limits have been exceeded, troubleshoot (WP 006 10).

g. Flameout.

(1) Shut down gas turbine (para 12).

(2) If operating limits have been exceeded, troubleshoot (WP 006 10).

h. Abnormal Oil Pressure.

(1) Do not operate gas turbine if stabilized oil pressure is outside the limits given in table 1.

(2) If limits are exceeded, troubleshoot (WP 006 10).

i. Abnormal Fuel Flow.

(1) Fuel flow is abnormal if it does not meet the operating limits given in table 1.

(2) If operating limits have been exceeded, troubleshoot (WP 006 10).

11. NORMAL SHUTDOWN PROCEDURE.

a. The normal shutdown procedure must be used for all gas turbine shutdowns, except for those requiring instant shutdown to prevent significant damage.

b. For normal shutdown, the following sequence of events must be adhered to:

(1) Set throttle to idle.

(2) Run gas turbine at idle for 5 minutes.

(3) After 5 minutes at idle, de-energize fuel shutoff valves.

(4) If T4.8 does not decrease below 392°F (200°C) within 90 seconds, investigate for failure to stop. If T4.8 exceeds 1,000°F (538°C), take action for post-shutdown fire as follows:

(a) Ensure fuel shutoff valves are de-energized (closed).

(b) Motor gas turbine with starter until T4.8 decreases to 600°F (316°C) or less.

(5) Shut down gas turbine support systems as required.

12. EMERGENCY SHUTDOWN PROCEDURE. An emergency shutdown occurs when the control system shutdown trip is experienced or when the fuel shutoff valves are de-energized prior to a 5-minute idle period. The following procedures must be followed after an emergency shutdown:

a. Observe instrumentation for cause of shutdown.

b. Shut off ventilation fan to prevent irregular exterior cooling.

c. If rotor coastdown appeared normal, motor gas turbine for 2 minutes and check for abnormalities.

d. Troubleshoot (WP 006 10) and determine cause of shutdown.

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TROUBLESHOOTING

(LEVEL 1 MAINTENANCE)

Effectivity: L32119G02 INDUSTRIAL GAS TURBINE

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1. INTRODUCTION.

a. The troubleshooting work package consists of tables that list symptoms, possible cause, troubleshooting, and corrective action for each type of problem. Gas turbine operating limits and remarks are given in WP 005 00.

b. The following symbols are used in the troubleshooting section:

AGB	Accessory Gearbox
CIT	Compressor Inlet Temperature (T1.5)
FOD	Foreign Object Damage
HPT	High-Pressure Turbine or Gas Generator Turbine
N1	Compressor Gas Generator Rotor Speed (rpm)
N2	Power Turbine Shaft Speed (rpm)
PS or PS3	Compressor Discharge Static Pressure
PTO	Power Takeoff (inlet gearbox)
SOAP	Spectrometric Oil Analysis Program
T4.8	Power Turbine Inlet Total Temperature
VG	Variable Geometry
VSV	Variable Stator Vanes
Wf	Fuel Flow Delivery from the Fuel Valve

2. **SUPPORT EQUIPMENT.**

Support Equipment

Part No.	NomenclatureNomenclature
2C9111G01	Borescope Kit

3. **CONSUMABLE MATERIALS.**

. None

4. **INSTRUMENTATION REQUIREMENTS.**

Compressor Inlet Temperature (T1.5)	-40° to 150°F (-40° to 66°C)
Compressor Discharge Static Pressure (PS3)	0 to 300 psi (0 to 2,068 kPa)
Fuel Supply Pressure	0 to 400 psi (0 to 2,758 kPa)
Fuel Supply Temperature	-65° to 150°F (-54° to 66°C)
Fuel Manifold Pressure	0 to 300 psi (0 to 2,068 kPa)
Variable Stator Vane Angle	19 to 67 degrees
Oil Tank Temperature	0° to 300°F (-18° to 150°C)
Lube and VG Control Oil Inlet Temperature	0° to 300°F (-18° to 150°C)
Power Turbine Inlet Pressure (PT4.8)	0 to 75 psi (0 to 517 kPa)
Power Turbine Inlet Temperature (T4.8)	0° to 1,800°F (-18° to 1,000°C)

5. TROUBLESHOOTING INSTRUCTIONS.

a. If the gas turbine does not operate properly, refer to table 1 and locate the category which applies to the phase of operation during which the trouble occurred (for example, NO START - WITH N1 INDICATION). If the gas turbine is operating outside its limits, refer to the appropriate category (for example, LUBRICATION SYSTEM PROBLEMS).

b. Follow the sequence of checks outlined in the referenced paragraph.

c. If the checks indicate that a component is defective, replace the component. Test the gas turbine based on which component has been replaced.

d. Certain conditions may cause gas turbine damage. Refer to WP 016 00, paragraph entitled Special Inspections of Gas Turbine, in addition to the procedures in this work package.

e. Operation of the gas generator with variable stator vanes significantly out of limits can damage the gas turbine. When troubleshooting for abnormal speed, compressor stall, low power, or abnormal acceleration problems, ensure that precautions contained in WP 012 00 are observed.

TABLE 1. TROUBLESHOOTING INDEX

Symptom	Paragraph No.
NO START (WITH N1 INDICATION)	6
A. RPM and fuel flow OK	
B. RPM and ignition OK but no or low fuel manifold pressure	
C. N1 rises rapidly to starter cutout speed (58%)	
NO START (NO N1 INDICATION)	7
A. No N1 indication (with oil pressure indication)	
B. No N1 indication (without oil pressure indication)	
HOT START (STARTING STALL)	8
Gas turbine stalls during start. Slow increase in T4.8 plus N1 speed hangup or dropoff	
GAS TURBINE DOES NOT REACH IDLE OR SLOW ACCELERATION TO IDLE	9
No or slow acceleration to idle speed accompanied by low fuel flow and low T4.8	
IDLE SPEED PROBLEMS	10
A. No N1 indication (with oil pressure)	
B. No N1 indication and no oil pressure indication	
C. Idle speed low	
D. Idle speed high	
E. Instability	
F. Power turbine rotation without display indication	
G. No power turbine rotation	

TABLE 1. TROUBLESHOOTING INDEX (Cont)

Symptom	Paragraph No.
ABNORMAL ACCELERATION TO MAX POWER	11
A. No acceleration	
B. Slow acceleration with low T4.8	
C. Slow acceleration with high T4.8	
D. Compressor stall	
E. N1 or T4.8 overshoot at base load	
ABNORMAL DECELERATION FROM HIGH POWER	12
A. Flameout or low N1	
B. Compressor stall	
HIGH POWER (STEADY STATE) PROBLEMS	13
A. Low N2 in AUTO mode	
B. RPM fluctuation or T4.8 fluctuation in AUTO control mode	
C. Higher or lower T4.8 than previous reading at max	
D. Stall during steady-state operation	
FLAMEOUT	14
Low or no fuel manifold inlet pressure indication	
LUBRICATION SYSTEM PROBLEMS	15
A. Gas turbine oil tank contamination	
B. No oil pressure	
C. Low oil pressure	
D. High oil pressure	
E. Fluctuating oil pressure (greater than 5 psi (34 kPa))	
F. Overfull oil tank	
G. High oil temperature (oil appears as though it has been overheated)	
H. Fluctuating oil temperature	
I. High oil consumption	
J. Exhaust fire and smoke	
HIGH VIBRATIONS	16
A. Gas generator rotor vibration	
B. Power turbine rotor vibration	
POST-SHUTDOWN FIRE	17
After shutdown, T4.8 indicates 1,000°F (537°C) or higher	

TABLE 1. TROUBLESHOOTING INDEX (Cont)

Symptom	Paragraph No.
OVERSPEED/OVERTEMPERATURE A. N1 or T4.8 overshoot at max B. Different N1 than previous readings under same operating conditions C. Higher T4.8 than previous reading at 100% power under same operating conditions	18

6. NO START (WITH N1 INDICATION).

WARNING

Disconnecting Ignition Leads

- High voltage may be present. Contact with center conductor of electrical cable or center electrode of igniter plug will cause electric shock if the bleed resistors inside ignition unit have failed.
- Before removing igniter plug, be sure that discharge connector is grounded.

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. RPM and fuel flow OK.	1. Faulty igniter circuit.	a. Disconnect ignition leads at ignition exciter, check resistance of ignition leads, plug adapters and igniter plugs. Resistance to ground should be 100,000 ohms or more. If resistance is low, check individual components.	Replace faulty components (WP 023 00).
		b. Disconnect power connector at ignition exciter. Check resistance from pins A to C: 94 to 106 ohms required. Check resistance from pins A to B: 47 to 53 ohms required. Check resistance from pins B to C: 47 to 53 ohms required.	Replace faulty ignition exciter (WP 023 00).

6. **NO START (WITH N1 INDICATION).** (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
		c. Check for 115V, 50 to 60 Hz at power lead connection.	Restore power.
		d. Disconnect output connection at ignition exciter. Check resistance of outputs to ground. Resistance must be 590 to 610 ohms.	Replace ignition exciter (WP 023 00).
	2. Eroded igniter plugs (usually caused by leaving ignition switch ON for extended periods of time).	With ignition switch turned ON, listen for igniter plug clicking.	Replace igniter plugs (WP 023 00).
B. RPM and ignition OK but no or low fuel manifold pressure.	1. No fuel flow supply.	Check shutoff valve positions.	Open the fuel inlet valve(s).
	2. Air, water, or solids in fuel lines.	Disconnect fuel supply lines, and check for presence of air or contaminant.	a. Bleed the air from supply lines. b. Blow air in supply lines to flush liquid or solid contaminant.
	3. Failure of fuel shutoff valves.	Check that shutoff valves are energized.	Troubleshoot as required.
C. N1 rises rapidly to starter cutout speed (58%).	Sheared radial drive shaft, PTO gear, or AGB input gearing.	Crank gas turbine from pad on AGB. Check for compressor or HPT rotation using borescope 2C9111G01 through compressor or combustor port.	Isolate and replace defective drive component (WP 032 00).

7. NO START (NO N1 INDICATION).

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. No N1 indication (with oil pressure indication).	N1 indication failure.	Check GG speed sensors, indicator, and electrical leads. Check AGB to verify rotation of crank pad.	Replace speed sensors, indicator, electrical leads, or sensor wheel as required (WP 026 00).

CAUTION

Do not operate gas turbine for more than 30 seconds without oil pressure or damage to gas turbine could result.

Symptom	Possible Cause	Troubleshooting	Corrective Action
B. No N1 indication (without oil pressure indication).	1. Starter pressure below limits	Check starter supply pressure (refer to WP 005 00 for limits).	Increase pressure to proper limit, or replace starter if pressure is OK.
	2. Faulty start selector switch or open circuit breaker(s).	Check start selector switch and circuit breaker(s).	Replace switch and/or reset circuit breakers.
	3. Starter inoperative.	Check starter.	Replace starter if it does not rotate, if it cuts out early, or if drive clutch or shaft is faulty.
	4. Gas generator seizure.	a. Allow hot gas turbine to cool for 30 minutes, and check gas generator rotation with starter or with ratchet wrench on AGB crank pad.	Attempt another start after cooling period and rotation check.
		b. Check cold gas turbine rotation with ratchet wrench on AGB crank pad.	(1) Replace gas turbine if wrench cannot rotate gas turbine.
			(2) Replace radial drive shaft, power takeoff, or accessory gearbox (WP 032 00) if wrench turns but gas turbine does not rotate.
		c. Borescope-inspect (WP 10 00) gas turbine at compressor inlet and stage 10 port for FOD.	Remove gas turbine for repair of FOD if noted.

7. NO START (NO N1 INDICATION). (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	5. Accessory gearbox failure.	Rotate gas generator using AGB crack pad.	Replace gearbox (WP 032 00). Flush scavenge drain system and lube oil tank as necessary to remove contaminants.

8. HOT START (STARTING STALL).

Symptom	Possible Cause	Troubleshooting	Corrective Action
Gas turbine stalls during start. Slow increase in T4.8 plus N1 speed hangup or dropoff.	1. Variable stator vanes position is incorrect.	Check variable stator vanes position while motoring gas turbine (should be 62-64 degrees).	a. Check VG feedback cable for binding and interference. b. Re-rig VG feedback cable (WP 012 00).
	2. Fuel pressure irregular.	Check PS3 sensor and line (customer equipment) for leaks.	Repair or replace defective component.

9. GAS TURBINE DOES NOT REACH IDLE OR SLOW ACCELERATION TO IDLE.

Symptom	Possible Cause	Troubleshooting	Corrective Action
		CAUTION Do not exceed starter duty cycle.	
No or slow acceleration to idle speed accompanied by low fuel flow and low T4.8.	1. Low starter pressure.	Check starter hydraulic oil pressure. It should be 3,000 psig (20,684 kPa) and gas turbine should rotate at 28-34% N1 minimum.	Increase pressure to proper limit.
	2. Starter cutout speed too low.	Check rpm at which starter cuts out. It should cut out at 58% N1.	Troubleshoot starter, control valves, and starter drive clutch.
	3. Fuel contamination.	Check for filter bypass indication.	Blow down fuel system. Clean or replace all fuel filters. Reset bypass indicator.

9. GAS TURBINE DOES NOT REACH IDLE OR SLOW ACCELERATION TO IDLE. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	4. Variable stator vanes position is incorrect.	a. Check variable stator vanes position while motoring gas turbine (should be 62-64 degrees).	(1) Re-rig VG feedback cable (WP 012 00). (2) Check for binding and interferences using pull check. Pull check should be 10 pounds (4.5 kg) with cable connected, 4 pounds (1.8 kg) with cable disconnected, maximum.
		b. Check for excessively worn VSV linkage or improper stage-to-stage rigging.	Correct rigging of VSV linkage assembly (WP 012 00).
	5. P3 tube leakage or defective transducer.	Check for loose, damaged, or blocked tube, and loss of electrical signal to control.	Tighten or replace tube, replace transducer, or electrical lead.
	6. Compressor/high pressure turbine rotor rubbing excessively.	Borescope-inspect (WP 010 00) gas turbine. Look for rolled material on blade tip. This indicates heavy rub.	Replace gas turbine.

10. IDLE SPEED PROBLEMS.

Symptom	Possible Cause	Troubleshooting	Corrective Action

CAUTION

Do not operate gas turbine for more than 30 seconds without oil pressure or damage to gas turbine could result.

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. No N1 indication (with oil pressure indication).	Indicator or harness failure.	Check harness and indicator.	Replace faulty component.

10. IDLE SPEED PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
B. No N1 indication and no oil pressure indication.	Loss of signal.	Immediately shut gas turbine down. Check pump, transducer, indicator, piping and cabling.	Repair or replace faulty component.
C. Idle speed low.	1. VG control CIT sensor failure.	Check stator vanes position at idle.	Replace VG control assembly (WP 028 00).
	2. P3 tube leakage, blockage, or defective transducer.	Check for loose, damaged, or blocked tube.	Tighten or replace tube or replace transducer
	3. Faulty speed indication.	a. Check indicator for accuracy.	Replace indicator.
		b. Check gas generator speed sensor(s).	Replace sensor (WP 026 00).
D. Idle speed high.	1. VG control drive shaft failure.	a. N1 rises to 70 to 85%, depending on accessory loads.	Replace VG control assembly (WP 028 00).
		b. N2 low.	
		c. Stator vanes fully closed.	
	2. Faulty speed indication.	Check indicator for accuracy.	Recalibrate or replace indicator.
	3. P3 tube leakage.	Inspect fittings for looseness.	Tighten fittings.
E. Instability.	1. Air in gas system.	Advance power and return to idle.	Recheck for stability at idle.
	2. VG control CIT sensor failure.	Check CIT sensor bulb and capillary tube for damage.	Replace VG control assembly (WP 028 00).
	3. VG feedback cable is binding.	Disconnect VG feedback cable and do a pull check. Pull check should be 10 pounds (4.5 kg) when connected, 4 pounds (1.8 kg) when disconnected.	Replace VG feedback cable (WP 028 00).
	4. Intermittent N1 output.	Check gas generator speed sensors and output leads.	Replace defective component (WP 026 00).

10. IDLE SPEED PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
F. Power turbine rotation without display indication.	1. Faulty rpm indication.	a. Visually check power turbine rotation by observing shaft rotation through coupling guard access cover.	Verify rotation.
		b. Check indicator, power turbine speed sensors, and harnesses.	Replace faulty component (WP 027 00).
G. No power turbine rotation.	1. Failure of, or foreign object lodged in, gas compressor connected to gas turbine.	Visually inspect gas compressor through inlet or discharge flanges.	Repair or replace faulty component.
	2. Power turbine blade/ shroud or interstage seal seizure.	Allow gas turbine to cool for 2 hours and then attempt to rotate.	Repair or replace gas turbine.

CAUTION

Do not exceed IDLE power or damage to gas turbine may occur.

Symptom	Possible Cause	Troubleshooting	Corrective Action
	3. Wear-in of new shrouds and seals on initial startup. (Probable cause if turbine is free to rotate when cold.	Operate gas turbine at idle speed for 5 minutes. Shut gas turbine down if power turbine does not rotate.	Allow gas turbine to cool down until power turbine is free, and repeat start.

11. ABNORMAL ACCELERATION TO MAX POWER.

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. No acceleration.	Compressor discharge pressure system leak, blockage, or transducer failure.	Check for loose, damaged, or blocked lines.	Tighten or replace lines, or replace PS3 transducer.
B. Slow acceleration with low T4.8.	1. Low fuel inlet pressure.	Check inlet pressure.	Troubleshoot per paragraph 14 (Flameout).

11. ABNORMAL ACCELERATION TO MAX POWER. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	2. Compressor discharge pressure system leak, blockage, or transducer failure.	Check for loose, damaged, or blocked lines, and PS3 output.	Tighten or replace lines, or replace sensor.
C. Slow acceleration with high T4.8.	1. Foreign object damaged.	Borescope-inspect gas turbine (WP 010 00).	Replace gas turbine if FOD exceeds limits.
	2. Variable stator vanes schedule failure.	Check variable stator vanes schedule (WP 012 00). Check for binding VSV actuator or linkage assembly.	a. Re-rig VG feedback cable (WP 012 00). b. Replace VG control assembly (WP 028 00). c. Repair linkage assembly (WP 029 00).
	3. Dirty compressor.	Borescope-inspect (WP 010 00) gas turbine or check gas generator pressure ratio.	Water-wash compressor (WP 017 00).
D. Compressor stall.	1. VG feedback cable is binding.	Disconnect VG feedback cable and do a pull check. Pull check should be 10 pounds (4.5 kg) when connected, 4 pounds (1.8 kg) when disconnected.	Replace VG feedback cable (WP 028 00).
	2. Variable stator vanes schedule failure.	Check variable stator vanes schedule (WP 012 00).	Re-rig VG feedback cable (WP 012 00).
	3. VG control CIT sensor failure.	Check sensor.	Clean sensor (WP 009 00) or replace VG control assembly (WP 028 00).
	4. Stator vane lever arm broken or disconnected.	Check to see that all vane lever arms are engaged in holes of actuator rings.	If any lever arms are broken or disconnected, contact GE for assistance.
	5. Foreign object damage.	Borescope-inspect gas turbine (WP 010 00).	Replace gas turbine if FOD exceeds limits.
	6. VG control assembly defective.	Inspect VG control assembly (WP 028 00).	Replace VG control assembly (WP 028 00).

11. ABNORMAL ACCELERATION TO MAX POWER. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
E. N1 or T4.8 overshoot at base load.	1. Variable stator vanes are not fully open.	N1 reaches 99-100% but T4.8 and N2 remain low.	a. Check for free travel of stator system.
			b. Check rigging of VG feedback cable (WP 012 00).
			c. If problem persists, replace VG control assembly (WP 028 00).
	2. Faulty N1/T4.8 indications.	Check indicator systems.	Repair or recalibrate indicators.

12. ABNORMAL DECELERATION FROM HIGH POWER.

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. Flameout or low N1.	Leaking P3 tube to PS3 sensor connection.	Slow starts and slow acceleration with low T4.8.	Repair or replace P3 tube or PS3 sensor.
B. Compressor stall.	1. VG feedback cable is binding.	Disconnect both ends of VG feedback cable and check for free travel. Pull check should be 4 pounds (1.8 kg) maximum.	Replace VG feedback cable (WP 028 00).
	2. VG control feedback lever defective.	Check for free travel of lever.	Replace VG control assembly (WP 028 00).

13. HIGH POWER (STEADY-STATE) PROBLEMS.

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. Low N2 in AUTO mode.	1. Excessive output shaft torque (T4.8 limiting).	a. Check torque.	Reduce.
		b. Check for possible compressor discharge air leak at capped stage 10 or stage 14 bleed ports, or leak in sump pressurization air lines.	Eliminate leakage.

13. HIGH POWER (STEADY-STATE) PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	2. Dirty compressor.	Check performance (gas turbine pressure ratio) or borescope-inspect (WP 010 00).	Water-wash gas turbine (WP 017 00).
	3. Low fuel flow.	a. Check P3 tube and transducer.	Replace tube or transducer.
		b. Check VG schedule (WP 012 00).	Replace VG control assembly (WP 028 00).
B. RPM fluctuation or T4.8 fluctuation in AUTO control mode.			

NOTE

Fluctuation of a single instrument, without similar fluctuation of related instruments, indicates instrument malfunction.

Symptom	Possible Cause	Troubleshooting	Corrective Action
	1. Faulty N1/Wf/T4.8 indicators.	Check indicators for accuracy.	Replace faulty indicator.
	2. VG feedback cable is binding.	Disconnect VG feedback cable and check for free travel.	Replace VG feedback cable (WP 028 00).
	3. Fuel supply system defective.	a. Check fuel header pressure.	Correct as required.
		b. Check emergency shutoff valve for full open position.	Reposition or replace valve.
	4. Oxidized electrical connectors.	Check T4.8 harness electrical connectors for contamination/ oxidation.	Clean electrical connectors or replace harness.
	5. Compressor discharge pressure system leak.	Check for loose or damaged compressor bleed blankoff plates or leakage in sump pressurization lines.	Correct as required.

13. HIGH POWER (STEADY-STATE) PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
C. Higher or lower T4.8 than previous reading at max.	1. If all other readings are the same as those previously taken at rated load:		
	a. Faulty indicator.	Check T4.8 input and indicator for accuracy.	Replace indicator.
	b. Faulty T4.8 harness.	Measure harness pin-to-pin and pin-to-ground resistance.	Replace faulty harness.
	2. If all other readings changed with T4.8:		
	a. Dirty compressor blades.	Borescope-inspect compressor (WP 010 00).	Water-wash gas turbine (WP 017 00).
	b. CIT sensor failure.	Check CIT sensor.	Replace CIT sensor (WP 009 00).
	c. Foreign object damaged.	Borescope-inspect gas turbine (WP 010 00).	Replace gas turbine if FOD exceeds limits.
	d. VG control assembly is defective.	Inspect VG control assembly (WP 028 00).	Replace VG control assembly (WP 028 00).
D. Stall during steady-state operation.	1. Disengaged or broken vane lever arms.	Check that all vane lever arms are properly engaged in actuator rings.	If any lever arms are broken or disconnected, contact GE for assistance.
	2. Inlet screen is restricted by:		
	a. Ice.	(1) Melt ice with portable heater. Borescope-inspect (WP 010 00) gas turbine for FOD caused by ice formation on IGV's.	Replace gas turbine if FOD exceeds limits.
	b. Foreign objects (except ice).	(2) Remove objects restricting inlet screen. Borescope gas turbine if any deterioration in screen integrity is found or there is possibility that objects passed through screen into compressor.	Replace gas turbine if FOD exceeds limits.

13. HIGH POWER (STEADY-STATE) PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	3. Incorrect variable stator vanes position.	Check variable stator vanes schedule (WP 012 00).	Re-rig VG feedback cable (WP 012 00).
	4. Foreign object damage.	Borescope-inspect gas turbine (WP 010 00).	Replace gas turbine if FOD exceeds limits.

14. FLAMEOUT.

Symptom	Possible Cause	Troubleshooting	Corrective Action
Low or no fuel manifold pressure indication.	1. Contamination.		Blow air in gas supply lines to remove contaminants.
	2. Incorrect variable stator vanes position if flameout happened during compressor stall.	Check variable stator vanes schedule (WP 012 00).	a. Re-rig VG feedback cable (WP 012 00). b. Replace VG control assembly (WP 028 00).
	3. P3 sensing line transducer is leaking.	a. Inspect line for leaks or looseness.	Tighten or replace line.
		b. Check operation and calibration of transducer.	Recalibrate or replace transducer.

15. LUBRICATION SYSTEM PROBLEMS.

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. Oil tank is contaminated.	Maintenance error/ abnormal SOAP sample.	If gas turbine operated for 200 hours or more with MIL-L-23699 oil containing more than 5% mineral oil, remove C-sump cover and inspect for excessive coking and deposits.	Service lube system (WP 019 00).
B. No oil pressure.	1. Sheared pump shaft.	Check for N1 indication while motoring gas turbine. Verify lube supply to pump.	Replace pump (WP 031 00) if there is no oil pressure with an N1 indication and normal oil supply to pump.

15. LUBRICATION SYSTEM PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	2. Low oil level in tank.	Check for source of abnormal oil loss such as a loose connection, a crack in line or in a tank weld, a failed pump seal, an open SOAP sampling cock, or a loose drain fitting. Check for oil carryover to gas turbine through tank vent line to compressor front frame.	Correct the problem.
	3. Faulty oil pressure indication.	Check indicating system for faulty circuits.	Replace faulty component.
	4. Faulty transmitter or pressure line.	Check transmitter for open circuit or for loose or broken pressure line.	Replace faulty component.
	5. Obstruction in oil supply line to pump.	a. Disconnect supply line at pump, and check for presence of oil.	Correct the problem.
		b. Check oil supply hose for deterioration (collapsed.)	Replace oil supply hose (WP 031 00).
		c. Check for obstruction in pump inlet.	Remove obstruction from pump and clean oil tank.
		d. Check for improperly connected lines or reversed check valve.	Correct the problem.
	6. Inlet screen in tank (for pump supply line) obstructed.	Remove inlet screen and check for obstructions.	Remove obstruction and clean oil screen and tank.
C. Low oil pressure.			

NOTE

A decrease of 10 psig (69 kPa) from the normal pressure is cause for investigation. Do not operate gas turbine if pressure is more than 15 psi (103 kPa) below minimum.

Symptom	Possible Cause	Troubleshooting	Corrective Action
1. With fluctuation.	a. Low oil level in tank.	Check oil level.	Refill oil tank to correct level.
	b. External oil leak.	Inspect all external lines and components for leaks.	Replace leaking component. Torque loose fittings (WP 031 00).

15. LUBRICATION SYSTEM PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	c. Faulty oil pressure indication.	Check indicating system for accuracy.	Replace faulty component.
	d. Tank pressure fluctuation.	(1) Check for worn scavenge pump allowing too much air in oil tank.	Replace pump (WP 031 00).
		(2) Check for carryover and static lead of oil in tank vent line.	Correct the problem.
	e. Oil/water contamination.	Check oil sample for milky appearance or for dilution with water. Pressure leak-check oil tank if water is found in oil.	(a) Repair source of water entry into tank. (b) Service lube system (WP 019 00).
	f. Failure of pressure relief valve in lube and scavenge pump.		Replace lube and scavenge pump (WP 031 00).
	g. Obstructed or collapsed oil supply hose to pump.	(1) Disconnect supply hose at pump and check for flow.	Replace supply hose (WP 031 00).
		(2) Check oil-in hose for deterioration.	Replace oil-in hose (WP 031 00).
		(3) Check for obstruction in pump inlet.	Remove obstruction from pump.
2. Without fluctuation.	a. External oil leak.	Inspect for leaks.	Repair leak.
	b. Internal gas turbine leak (possible damaged oil seals).	Check for high oil consumption.	Repair or replace gas turbine.
	c. Faulty pressure transmitter or cable.	Install another transmitter to verify original pressure readings. Check transmitter for short circuit.	Replace transmitter or cable.
D. High oil pressure.			

15. LUBRICATION SYSTEM PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action

CAUTION

Do not operate gas turbine if oil pressure exceeds 30 psig (207 kPa) above normal pressure, after gas turbine reaches stabilized temperature; otherwise, damage to gas turbine may occur.

NOTE

- An increase in oil pressure of 10 psig (69 kPa) over normal pressure is cause for investigation. Do not replace the oil pump because it cannot be the cause of high oil pressure.
- Oil pressure during initial start (cold oil) should return to normal after 5 minutes at IDLE speed, but may take considerably longer under severe freezing conditions. Higher power settings are required for more rapid warm-up.

Symptom	Possible Cause	Troubleshooting	Corrective Action
	1. Low oil temperature after warm-up.		Operate gas turbine to allow pressure to decrease after warm-up.
	2. Faulty oil pressure indication.	Check indicating system for accuracy.	Replace faulty component.
	3. Plugged oil filter.	Remove and inspect oil filter (WP 019 00).	Service oil filter (WP 019 00).
	4. Check valve, in oil filter, is stuck.		Replace oil filter (WP 019 00).
	5. Blocked or kinked oil tanks.	Inspect tubes for kinks or blockage (WP 031 00).	Clean or replace faulty tube (WP 031 00).
	6. Clogged oil tubes and oil jets. (This is often indicated by tendency of pressure to creep up.)	If oil filter was plugged but the replacement oil filter did not reduce the pressure to within limits, remove and inspect chip detectors (WP 013 00) and record the location where metal chips and sludge were found.	Replace gas turbine.
	7. Restriction or blockage in oil tank vent line to gas turbine.	Check for restriction.	Clean or replace faulty component.

15. LUBRICATION SYSTEM PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
E. Fluctuating oil pressure (greater than 5 psi (34 kPa)).			

NOTE

Fluctuating oil pressure during transient conditions is considered normal; however, these fluctuations should stop 1 minute after returning to steady-state conditions.

Symptom	Possible Cause	Troubleshooting	Corrective Action
	1. Low oil level in tank.	Check oil level.	Refill oil tank to correct level.
	2. Oil/water contamination.	Check oil sample for milky appearance or for dilution with water. Pressure-check oil tank if water is found in oil.	a. Repair source of water entry into tank. b. Service lube system (WP 019 00).
	3. Plugged oil filter.	Remove and inspect oil filter (WP 019 00).	Service oil filter (WP 019 00).
	4. Faulty oil pressure transmitter.	Check transmitter for accuracy.	Replace transmitter.
	5. Blocked or damaged lube and scavenge pump inlet hose.	a. Disconnect inlet hose and check for blockage or damage.	Clean or replace hose (WP 031 00).
		b. Inspect oil tank screen for blockage.	Clean tank and screen.
	6. Failure of pressure relief valve in lube and scavenge pump.		Replace lube and scavenge pump (WP 031 00).
	7. Defective oil tank vent.	Remove cover and inspect deaerator for cracks.	Repair or replace oil tank.
	8. Defective oil pump-to-AGB drive pad seal.	Check seal for oil leakage or oil wetting.	Replace pump (WP 031 00).
F. Overfull oil tank.	1. Water in tank.	Check oil sample (WP 015 00) for water.	a. Determine and repair source of water entry. b. Service lube system (WP 019 00).

15. LUBRICATION SYSTEM PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	2. Incorrect servicing procedure.	Added too much oil.	Drain excess oil.
G. High oil temperature (oil appears as through it has been overheated).			

NOTE

Indication of overheated oil is apparent by extremely dark oil in oil tank, by a pungent burned odor, by sludge and varnish deposits on oil filter, or sludge on chip detectors.

Symptom	Possible Cause	Troubleshooting	Corrective Action
	1. Low oil level in tank.	Check oil level.	Refill oil tank to correct level.
	2. Low oil flow in B- and/or C-sump, resulting in high scavenge temperature.	a. Replace B- and C-sump chip detectors (WP 013 00) and thermocouple harness (WP 025 00).	Record the sump area that exceeded the limits, and replace gas turbine.
		b. Operate gas turbine and record B- and C-sump scavenge oil temperature and temperature at oil cooler output. Max allowable temperature at ail/oil cooler oil output is 350°F (177°C).	
		c. Subtract the temperature at the air/oil cooler from each of the B- and C-sump scavenge temperatures. The resulting differential temperature should be below the following limits: B-sump: 160°F (71°C) C-sump: 130°F (54°C)	
		d. Check for high or low oil pressure.	

15. LUBRICATION SYSTEM PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
H. Fluctuating oil temperature.	Faulty oil temperature indicating system.	Check indicating system for accuracy.	Replace faulty component.
I. High oil consumption.			

CAUTION

Do not operate gas turbine with fluctuating or below limits oil pressure. A sudden increase in oil consumption or a gradual increase over a period of time indicates deterioration of the oil system and is cause for investigation.

Symptom	Possible Cause	Troubleshooting	Corrective Action
	1. Records in error.	Verify records.	Correct records.
	2. Oil leaks in:		
	a. External hoses and tubes.	Check all hoses, tubes, and fittings for leaks.	Replace hose, tube, or fitting (WP 031 00).
	b. Accessory gearbox.	1. Check each gearbox pad flange for leakage: 5 cc/minute normal leakage during operation.	Replace defective parts.
		2. Check packings and seals for damage.	Replace defective parts.
	c. Oil pump.	Check oil pump seal drain: 5 cc/minute normal leakage during operation.	Replace oil pump (WP 031 00).
	3. Plugged A-sump seal drain tube (oil wetted areas in coupling guard).	Attach a tube to A-sump drain tube and blow through gently. Tube must have no restrictions.	Clean (WP 031 00) drain tube and orifice (from 6 o'clock front frame pad).
	4. Plugged seal pressure tube to C-sump.	Attach a tube to C-sump tube and blow through gently. Tube must have no restrictions.	Clean (WP 031 00) tube (from pressure regulating valve to 12 o'clock strut on exhaust frame).
	5. Internal gas turbine damage.	Check oil filters, chip detectors, and SOAP reports.	Replace gas turbine.
J. Exhaust fire and smoke.	Restricted or damaged C-sump scavenge hose.	Fire or excessive smoke observed in tailpipe.	Replace damaged C-sump scavenge hose (WP 031 00).

16. HIGH VIBRATIONS.

NOTE

- Occasionally it may be noted that vibrations increase as much as 3 mils after a shutdown of 1 to 2 hours. The most probable cause is a temporary thermal rotor bow due to uneven cooling of the power turbine or gas generator rotors. If the shutdown is brief (less than 10 minutes) or long (more than 6 hours), thermal rotor bow cannot occur because the rotors cool either very little or to a uniform temperature.
- A thermal rotor bow can be identified by noting that the increased vibration levels gradually decay back to previous levels during approximately 10 minutes of gas turbine operation. As long as vibrations are decreasing with time, gas turbine operation may be continued even if some limits are temporarily exceeded.

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. Gas generator rotor vibration.	1. Faulty vibration indicating system.	Check all connections and vibration transducers for looseness. Check leads for chafing. Check indicators for accuracy.	Replace faulty component (WP 024 00).
	2. Loose gas turbine mounts.	Check gas turbine mounts for security and alignment.	Realign and tighten mounts.
	3. Foreign object damage.	Borescope-inspect gas turbine (WP 010 00).	Replace gas turbine.
	4. Defective bearings.	a. Refer to paragraph 15, items B and C.	
		b. Inspect oil filter (WP 019 00) and chip detectors (WP 013 00) for debris.	Replace gas turbine.
		c. Check SOAP reports for signs of impending bearing failure.	Replace gas turbine.
	5. Dirty compressor.		Water-wash compressor (WP 017 00).
B. Power turbine rotor vibration.	1. Faulty vibration indicating system.	Check all connections and vibration transducers for looseness. Check leads for chafing. Check indicators for accuracy.	Replace faulty component (WP 024 00).

16. HIGH VIBRATIONS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	2. Loose gas turbine mounts.	Check gas turbine mounts for security and alignment.	Realign and tighten mounts.
	3. Foreign object damage.	Borescope-inspect gas turbine (WP 010 00).	Replace gas turbine.

17. POST-SHUTDOWN FIRE.

Symptom	Possible Cause	Troubleshooting	Corrective Action
After shutdown, T4.8 indicates 1,000°F (537°C) or higher.	1. High ambient temperatures.	With ambient temperature at 100°F (38°C) or above, a T4.8 of 1,000°F (537°C) or slightly higher can be normal.	Motor gas turbine with starter, ignition off, until T4.8 indicates 600°F (316°C) or less.
	2. Shutoff valves open.	Motor gas turbine and check for fuel flow indication and vapors. If present, check shutoff valves.	Replace shutoff valves.

18. OVERSPEED/OVERTEMPERATURE.

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. N1 or T4.8 overshoot at max.	1. Variable stator vanes are not fully open. N1 reaches 99-100% but T4.8 and N2 remain low.	a. Check for free travel of variable stator system. b. Check rigging of VG feedback cable (WP 012 00).	If problem persists, replace VG control assembly (WP 028 00).
	2. Faulty N1/T4.8 indications.	Check indicator systems.	Repair or recalibrate indicators.
	3. Thermocouple harness (open, short circuit).	Inspect thermocouple harness (WP 025 00).	Replace thermocouple harness (WP 025 00).
B. Different N1 than previous readings under same operating conditions.	1. If all other readings are the same as those previously taken, indicator may be faulty.	Check indicator output.	Replace faulty component.

18. OVERSPEED/OVERTEMPERATURE. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	2. If N1 and N2 are both low:		
	a. Dirty compressor rotor.	Borescope-inspect gas turbine (WP 010 00).	Water-wash gas turbine (WP 017 00).
	b. Foreign object damage.	Borescope-inspect gas turbine (WP 010 00).	Replace gas turbine.
	c. Compressor air leak.	Check sump pressurizing and balance piston lines and port blankoffs.	Eliminate leakage.
	d. Excessive power extraction (AGB).	Check for binding or abnormal torque on AGB mounted components or for failure within AGB.	Replace defective components (WP 032 00).
	3. If N1 increases and N2 decreases, variable vanes are misrigged (closed).	Check variable vane schedule (WP 012 00).	Re-rig VG feedback cable (WP 012 00).
	4. If N1 and N2 increase, the thermocouple harness has failed.	Inspect thermocouple harness (WP 025 00).	Replace thermocouple harness (WP 025 00).
C. Higher T4.8 than previous reading at 100% power under same operating conditions.	1. If all other readings are the same as those previously taken, indicator may be faulty.	Check indicator output.	Replace faulty indicator.
	2. If all other readings changed with T4.8:		
	a. Variable stator vanes off schedule.	Check VG feedback cable for looseness (WP 012 00).	Adjust VG feedback cable (WP 012 00).
	b. CIT sensor failure.	Check CIT sensor.	Clean sensor (WP 009 00) or replace VG control assembly (WP 028 00).

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TROUBLESHOOTING

(LEVEL 1 MAINTENANCE)

Effectivity: L32119G01/-G03/-G04/
G05/-G06 MARINE GAS TURBINE

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1. INTRODUCTION.

a. The troubleshooting work package consists of tables that list symptoms, possible cause, troubleshooting, and corrective action for each type of problem. Gas turbine operating limits and remarks are given in WP 005 10.

b. The following symbols are used in the troubleshooting section:

AGB	Accessory Gearbox	PS or PS3	Compressor Discharge Static Pressure
CIT	Compressor Inlet Temperature (T1.5)	PTO	Power Takeoff (inlet gearbox)
FOD	Foreign Object Damage	SOAP	Spectrometric Oil Analysis Program
HPT	High-Pressure Turbine or Gas Generator Turbine	T4.8	Power Turbine Inlet Total Temperature
XN2	Compressor Gas Generator Rotor Speed (rpm)	VG	Variable Geometry
		VSV	Variable Stator Vanes
XNSD	Power Turbine Shaft Speed (rpm)	Wf	Fuel Flow Delivery from the Fuel Valve

2. SUPPORT EQUIPMENT.

Support Equipment

Part No.	Nomenclature
2C91111G01	Borescope Kit

3. CONSUMABLE MATERIALS.

None

4. INSTRUMENTATION REQUIREMENTS.

Compressor Inlet Temperature (T1.5)	-40° to 150°F (-40° to 66°C)
Compressor Discharge Static Pressure (PS3)	0 to 300 psi (0 to 2,068 kPa)
Fuel Supply Pressure	5 to 55 psi (34 to 379 kPa)
Fuel Supply Temperature	-65° to 150°F (-54° to 66°C)
Fuel Manifold Pressure	0 to 300 psi (0 to 2,068 kPa)
Variable Stator Vane Angle	19 to 67 degrees
Oil Tank Temperature	0° to 310°F (-18° to 155°C)
Lube and VG Control Oil Inlet Temperature	0° to 219°F (-18° to 104°C)
Power Turbine Inlet Pressure (PT4.8)	0 to 75 psi (0 to 517 kPa)
Power Turbine Inlet Temperature (T4.8)	0° to 1800°F (-18° to 1000°C)
Gas Turbine Scavenge Oil Temperature	0° to 350°F (-18° to 177°C)

5. TROUBLESHOOTING INSTRUCTIONS.

a. If the gas turbine does not operate properly, refer to table 1 and locate the category which applies to the phase of operation during which the trouble occurred (for example, NO START - WITH XN2 INDICATION). If the gas turbine is operating outside its limits, refer to the appropriate category (for example, LUBRICATION SYSTEM PROBLEMS).

b. Follow the sequence of checks outlined in the referenced paragraph.

c. If the checks indicate that a component is defective, replace the component. Test the gas turbine, based on which component has been replaced.

d. Certain conditions may cause gas turbine damage. Refer to WP 016 00, paragraph entitled Special Inspections of Gas Turbine, in addition to the procedures in this work package.

e. Operation of the gas generator with variable stator vanes significantly out of limits can damage the gas turbine. When troubleshooting for abnormal speed, compressor stall, low power, or abnormal acceleration problems, ensure that precautions contained in WP 012 00 are observed.

TABLE 1. TROUBLESHOOTING INDEX

Symptom	Paragraph No.
NO START (WITH XN2 INDICATION)	6
A. RPM and fuel flow OK B. RPM and ignition OK but no or low fuel manifold pressure C. XN2 rises rapidly to starter cutout speed (58%)	
NO START (NO XN2 INDICATION)	7
A. No XN2 indication (with oil pressure indication) B. No XN2 indication (without oil pressure indication)	
HOT START (STARTING STALL)	8
Gas turbine stalls during start. Slow increase in T4.8 plus XN2 speed hangup or dropoff	
GAS TURBINE DOES NOT REACH IDLE OR SLOW ACCELERATION TO IDLE	9
No or slow acceleration to idle speed accompanied by low fuel flow and low T4.8	
IDLE SPEED PROBLEMS	10
A. No XN2 indication (with oil pressure) B. No XN2 indication and no oil pressure indication C. Idle speed low D. Idle speed high E. Instability F. Power turbine rotation without display indication G. No power turbine rotation	

TABLE 1. TROUBLESHOOTING INDEX (Cont)

Symptom	Paragraph No.
ABNORMAL ACCELERATION TO MAX POWER	11
A. No acceleration B. Slow acceleration with low T4.8 C. Slow acceleration with high T4.8 D. Compressor stall E. XN2 or T4.8 overshoot at base load	
ABNORMAL DECELERATION FROM HIGH POWER	12
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A. Low XNSD in AUTO mode B. RPM fluctuation or T4.8 fluctuation in AUTO control mode C. Higher or lower T4.8 than previous reading at max D. Stall during steady-state operation	
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Low or no fuel manifold inlet pressure indication	
LUBRICATION SYSTEM PROBLEMS	15
A. Gas turbine oil tank contamination B. No oil pressure C. Low oil pressure D. High oil pressure E. Fluctuating oil pressure (greater than 5 psi (34 kPa)) F. Overfull oil tank G. High oil temperature (oil appears as though it has been overheated) H. Fluctuating oil temperature I. High oil consumption J. Exhaust fire and smoke	
HIGH VIBRATIONS	16
A. Gas generator rotor vibration B. Power turbine rotor vibration	
POST-SHUTDOWN FIRE	17
After shutdown, T4.8 indicates 527°F (275°C) or higher	

TABLE 1. TROUBLESHOOTING INDEX (Cont)

Symptom	Paragraph No.
OVERSPEED/OVERTEMPERATURE A. XN2 or T4.8 overshoot at max B. Different XN2 than previous readings under same operating conditions C. Higher T4.8 than previous reading at 100% power under same operating conditions	18

6. NO START (WITH XN2 INDICATION).

Symptom	Possible Cause	Troubleshooting	Corrective Action

WARNING

Disconnecting Ignition Leads

- High voltage may be present. Contact with center conductor of electrical cable or center electrode of igniter plug will cause electric shock if the bleed resistors inside ignition unit have failed.
- Before removing igniter plug, be sure that discharge connector is grounded.

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. RPM and fuel flow OK.	1. Faulty igniter circuit.	a. Disconnect ignition leads at ignition exciter, check resistance of ignition leads, plug adapters and igniter plugs. Resistance to ground should be 100,000 ohms or more. If resistance is low, check individual components.	Replace faulty components (WP 023 00).
		b. Disconnect power connector at ignition exciter. Check resistance from pins A to C: 94 to 106 ohms required. Check resistance from pins A to B: 47 to 53 ohms required. Check resistance from pins B to C: 47 to 53 ohms required.	Replace faulty ignition exciter (WP 023 00).
		c. Check for 115V, 50 to 60 Hz at power lead connection.	Restore power.

6. NO START (WITH XN2 INDICATION). (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
		d. Disconnect output connection at ignition exciter. Check resistance of outputs to ground. Resistance must be 590 to 610 ohms.	Replace ignition exciter (WP 023 00).
	2. Eroded igniter plugs (usually caused by leaving ignition switch ON for extended periods of time).	With ignition switch turned ON, listen for igniter plug clicking.	Replace igniter plugs (WP 023 00).
B. RPM and ignition OK but no or low fuel manifold pressure.	1. No fuel flow supply.	Check shutoff valve positions.	Open the fuel inlet valve(s).
	2. Air, water, or solids in fuel lines.	Disconnect fuel supply lines, and check for presence of air or contaminant.	a. Bleed the air from supply lines. b. Blow air in supply lines to flush liquid or solid contaminant. c. Clean fuel strainers.
	3. Failure of fuel shutoff valves.	Check that shutoff valves are energized.	Troubleshoot as required.
C. XN2 rises rapidly to starter cutout speed (58%).	Sheared radial drive shaft, PTO gear, or AGB input gearing.	Crack gas turbine from pad on AGB. Check for compressor or HPT rotation using borescope 2C91111G01 through compressor or combustor port.	Isolate and replace defective drive component (WP 032 00).

7. NO START (NO XN2 INDICATION).

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. No XN2 indication (with oil pressure indication).	XN2 indication failure.	Check gas generator speed sensors, indicator, and electrical leads. Check AGB to verify rotation of crank pad.	Replace gas generator speed sensors, indicator, electrical leads, or sensor wheel as required (WP 026 00).

CAUTION

Do not operate gas turbine for more than 30 seconds without oil pressure or damage to gas turbine could result.

Symptom	Possible Cause	Troubleshooting	Corrective Action
B. No XN2 indication (without oil pressure indication).	1. Starter pressure below limits.	Check starter supply pressure (refer to WP 005 10 for limits).	Increase pressure to proper limit, or replace starter if pressure is OK (WP 033 00).
	2. Faulty start selector switch or open circuit breaker(s).	Check start selector switch and circuit breaker(s).	Replace switch and/or reset circuit breakers.
	3. Starter inoperative.	Check starter.	Replace starter if it does not rotate, if it cuts out early, or if drive clutch or shaft is faulty (WP 033 00).
	4. Gas generator seizure.	a. Allow hot gas turbine to cool for 30 minutes, and check gas generator rotation with starter or with ratchet wrench on AGB crank pad.	Attempt another start after cooling period and rotation check.
		b. Check cold gas turbine rotation with ratchet wrench on AGB crank pad.	(1) Replace gas turbine if wrench cannot rotate gas turbine.
			(2) Replace radial drive shaft, power takeoff, or accessory gearbox (WP 032 00) if wrench turns but gas turbine does not rotate.

7. NO START (NO XN2 INDICATION). (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
		c. Borescope-inspect (WP 010 00) gas turbine at compressor inlet and stage 10 port for FOD.	Remove gas turbine for repair of FOD if noted.
	5. Accessory gearbox failure.	Rotate gas generator using AGB crank pad.	Replace gearbox (WP 032 00). Flush scavenge drain system and lube oil tank as necessary to remove contaminants.

8. HOT START (STARTING STALL).

Symptom	Possible Cause	Troubleshooting	Corrective Action
Gas turbine stalls during start. Slow increase in T4.8 plus XN2 speed hangup or dropoff.	1. Variable stator vanes position is incorrect.	Check variable stator vanes position while motoring gas turbine (should be 62-64 degrees).	a. Check VG feedback cable for binding and interference. b. Re-rig VG feedback cable (WP 012 00).
	2. Fuel pressure irregular.	Check PS3 sensor and line (customer equipment) for leaks.	Repair or replace defective component.

9. GAS TURBINE DOES NOT REACH IDLE OR SLOW ACCELERATION TO IDLE.

Symptom	Possible Cause	Troubleshooting	Corrective Action
		CAUTION Do not exceed starter duty cycle.	
No or slow acceleration to idle speed accompanied by low fuel flow and low T4.8.	1. Low starter pressure.	Check starter hydraulic oil pressure. It should be 3,000 psig (20,684 kPa) and gas turbine should rotate at 5,000 rpm minimum.	Increase pressure to proper limit.
	2. Starter cutout speed too low.	Check rpm at which starter cuts out. It should cut out at 9,500 rpm XN2.	Troubleshoot starter, control valves, and starter drive clutch.
	3. Fuel contamination.	Check for filter bypass indication.	Blow down fuel system. Clean or replace all fuel filters. Reset bypass indicator.

9. GAS TURBINE DOES NOT REACH IDLE OR SLOW ACCELERATION TO IDLE. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	4. Variable stator vanes position is incorrect.	a. Check variable stator vanes position while motoring gas turbine (should be 62-64 degrees.	(1) Re-rig VG feedback cable (WP 012 00). (2) Check for binding and interferences using pull check. Pull check should be 10 pounds (4.5 kg) with cable connected, 4 pounds (1.8 kg) with cable disconnected, maximum.
		b. Check for excessively worn VSV linkage or improper stage-to-stage rigging.	Correct rigging of VSV linkage assembly (WP 012 00).
	5. P3 tube leakage or defective transducer.	Check for loose, damaged, or blocked tube, and loss of electrical signal to control.	Tighten or replace tube, replace transducer, or electrical lead.
	6. Compressor/high pressure turbine rotor rubbing excessively.	Borescope-inspect (WP 010 00) gas turbine. Look for rolled material on blade tip. This indicates heavy rub.	Replace gas turbine.
	7. Rich/lean shift in acceleration fuel schedule.	Check fuel metering valve output.	Replace or recalibrate fuel metering valve.

10. IDLE SPEED PROBLEMS.

CAUTION

Do not operate gas turbine for more than 30 seconds without oil pressure or damage to gas turbine could result.

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. No XN2 indication (with oil pressure indication).	Indicator or harness failure.	Check harness and indicator.	Replace faulty component.
B. No XN2 indication and no oil pressure indication.	Loss of signal.	Immediately shut gas turbine down. Check pump, transducer, indicator, piping and cabling.	Repair or replace faulty component.
C. Idle speed low.	1. VG control CIT sensor failure.	Check stator vanes position at idle.	Replace VG control assembly (WP 028 00).
	2. P3 tube leakage, blockage, or defective transducer.	Check for loose, damaged, or blocked tube.	Tighten or replace tube or replace transducer.
	3. Faulty speed indication.	a. Check indicator for accuracy.	Replace indicator.
		b. Check gas generator speed sensor(s).	Replace sensor (WP 026 00).
	4. Fuel metering valve failure.	Check valve position.	Replace valve.
D. Idle speed high.	1. VG control drive shaft failure.	a. XN2 rises to 70 to 85%, depending on accessory loads.	Replace VG control assembly (WP 028 00).
		b. XNSD low.	
		c. Stator vanes fully closed.	
	2. Faulty speed indication.	Check indicator for accuracy.	Recalibrate or replace indicator.
	3. P3 tube leakage.	Inspect fittings for looseness.	Tighten fittings.
E. Instability.	1. Water in fuel.		Clean fuel system due to water contamination (WP 020 00).
	2. Air in fuel system.	Advance power and return to idle.	Recheck for stability at idle.
	3. VG control CIT sensor failure.	Check CIT sensor bulb and capillary tube for damage.	Replace VG control assembly (WP 028 00).

10. IDLE SPEED PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	4. VG feedback cable is binding.	Disconnect feedback cable and do a pull check. Pull check should be 10 pounds (4.5 kg) when connected, 4 pounds (1.8 kg) when disconnected.	Replace VG feedback cable (WP 028 00).
	5. Intermittent XN2 output.	Check gas generator speed sensors and output leads.	Replace defective component (WP 026 00).
F. Power turbine rotation without display indication.	1. Faulty rpm indication.	a. Visually check power turbine rotation by observing ship's gearbox input shaft.	Verify rotation.
		b. Check indicator, power turbine speed sensors, and harnesses.	Replace faulty component (WP 027 00).
G. No power turbine rotation.	1. Failure of, or foreign object lodged in, unit connected to gas turbine.	Visually inspect ship's gearbox system.	Repair or replace faulty component.
	2. Power turbine blade/ shroud or interstage seal seizure.	Allow gas turbine to cool for 2 hours and then attempt to rotate.	Repair or replace gas turbine.

CAUTION

Do not exceed IDLE power or damage to gas turbine may occur.

Symptom	Possible Cause	Troubleshooting	Corrective Action
	3. Wear-in of new shrouds and seals on initial startup. (Probable cause if turbine is free to rotate when cold.	Operate gas turbine at idle speed for 5 minutes. Shut gas turbine down if power turbine does not rotate.	Allow gas turbine to cool down until power turbine is free, and repeat start.

11. ABNORMAL ACCELERATION TO MAX POWER.

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. No acceleration.	1. Fuel metering valve failure.	Check valve position.	Replace fuel metering valve.
	2. Compressor discharge pressure system leak, blockage, or transducer failure.	Check for loose, damaged, or blocked lines.	Tighten or replace lines, or replace PS3 transducer.
B. Slow acceleration with low T4.8.	1. Low fuel inlet pressure.	Check inlet pressure.	Troubleshoot per paragraph 14 (Flameout).
	2. Fuel filter blocked.	Bypass indication.	Service fuel filter (WP 020 00).
	3. Compressor discharge pressure system leak, blockage, or transducer failure.	Check for loose, damaged, or blocked lines, and PS3 output.	Tighten or replace lines, or replace sensor.
C. Slow acceleration with high T4.8.	1. Foreign object damage.	Borescope-inspect gas turbine (WP 010 00).	Replace gas turbine if FOD exceeds limits.
	2. Variable stator vanes schedule failure.	Check variable stator vanes schedule (WP 012 00). Check for binding VSV actuator or linkage assembly.	a. Re-rig VG feedback cable (WP 012 00). b. Replace VG control assembly (WP 028 00). c. Repair linkage assembly (WP 029 00).
	3. Dirty compressor.	Borescope-inspect gas turbine (WP 010 00) or check gas generator pressure ratio.	Water-wash compressor (WP 017 00).
D. Compressor stall.	1. VG feedback cable is binding.	Disconnect VG feedback cable and do a pull check. Pull check should be 10 pounds (4.5 kg) when connected, 4 pounds (1.8 kg) when disconnected.	Replace VG feedback cable (WP 028 00).
	2. Variable stator vanes schedule failure.	Check variable stator vanes schedule (WP 012 00).	Re-rig VG feedback cable (WP 012 00).
	3. VG control CIT sensor failure.	Check sensor.	Clean sensor (WP 009 00) or replace VG control assembly (WP 028 00).

11. ABNORMAL ACCELERATION TO MAX POWER. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	4. Stator vane lever arm broken or disconnected.	Check to see that all vane lever arms are engaged in holes of actuator rings.	If any lever arms are broken or disconnected, contact GE for assistance.
	5. Foreign object damage.	Borescope-inspect gas turbine (WP 010 00).	Replace gas turbine if FOD exceeds limits.
	6. VG control assembly defective.	Inspect VG control assembly (WP 028 00).	Replace VG control assembly (WP 028 00).
E. XN2 or T4.8 overshoot at base load.	1. Variable stator vanes are not fully open.	XN2 reaches 17,600 rpm but T4.8 and XNSD remain low.	a. Check for free travel of stator system.
			b. Check rigging of VG feedback cable (WP 012 00).
			c. If problem persists, replace VG control assembly (WP 028 00).
	2. Faulty XN2/T4.8 indications.	Check indicator systems.	Repair or recalibrate indicators.

12. ABNORMAL DECELERATION FROM HIGH POWER.

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. Flameout or low XN2.	Leaking P3 tube to PS3 sensor connection.	Slow starts and slow acceleration with low T4.8.	Repair or replace P3 tube or PS3 sensor.
B. Compressor stall.	1. VG feedback cable is binding.	Disconnect both ends of VG feedback cable and check for free travel. Pull check should be 4 pounds (1.8 kg) maximum.	Replace VG feedback cable (WP 028 00).
	2. VG control feedback lever defective.	Check for free travel of lever.	Replace VG control.

13. HIGH POWER (STEADY-STATE) PROBLEMS.

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. Low XNSD in AUTO mode.	1. Excessive output shaft torque (T4.8 limiting).	a. Check torque.	Reduce torque.
		b. Check for possible compressor discharge air leak at capped stage 10 or stage 14 bleed ports, or leak in sump pressurization air lines.	Eliminate leakage.
	2. Dirty compressor.	Check performance (gas turbine pressure ratio) or borescope-inspect (WP 010 00) compressor.	Water-wash gas turbine (WP 017 00).
	3. Low fuel flow.	a. Check P3 tube and transducer.	Replace tube or transducer.
		b. Check VG schedule (WP 012 00).	Replace VG control assembly (WP 028 00).
B. RPM fluctuation or T4.8 fluctuation in AUTO control mode.			

NOTE

Fluctuation of a single instrument, without similar fluctuation of related instruments, indicates instrument malfunction.

Symptom	Possible Cause	Troubleshooting	Corrective Action
	1. Faulty XN2/Wf/T4.8 indicators.	Check indicators for accuracy.	Replace faulty indicator.
	2. VG feedback cable is binding.	Disconnect VG feedback cable and check for free travel.	Replace VG feedback cable (WP 028 00).
	3. Fuel supply system defective.	a. Check fuel header pressure.	Correct as required.
		b. Check emergency shutoff valve for full open position.	Reposition or replace valve.
	4. Clogged fuel filter.	Check bypass indicator button.	Service fuel filter (WP 020 00).
	5. Worn or unstable fuel metering valve.	Check fuel metering valve operation.	Replace fuel metering valve.

13. HIGH POWER (STEADY-STATE) PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	6. Oxidized electrical connectors.	Check T4.8 harness electrical connectors for contamination/ oxidation.	Clean electrical connectors or replace harness.
	7. Compressor discharge pressure system leak.	Check for loose or damaged compressor bleed blankoff plates or leakage in sump pressurization lines.	Correct as required.
C. Higher or lower T4.8 than previous reading at max.	1. If all other readings are the same as those previously taken at rated load:		
	a. Faulty indicator.	Check T4.8 input and indicator for accuracy.	Replace indicator.
	b. Faulty T4.8 harness.	Measure harness pin-to-pin and pin-to-ground resistance.	Replace faulty harness.
	2. If all other readings changed with T4.8:		
	a. Dirty compressor blades.	Borescope-inspect compressor (WP 010 00).	Water-wash gas turbine (WP 017 00).
	b. CIT sensor failure.	Check CIT sensor.	Replace CIT sensor (WP 009 00).
	c. Foreign object damage.	Borescope-inspect gas turbine (WP 010 00).	Replace gas turbine if FOD exceeds limits.
	d. VG control assembly is defective.	Inspect VG control assembly (WP 028 00).	Replace VG control assembly (WP 028 00).
D. Stall during steady-state operation.	1. Disengaged or broken vane lever arms.	Check that all vane lever arms are properly engaged in actuator rings.	If any lever arms are broken or disconnected, contact GE for assistance.
	2. Inlet screen restricted by:		
	a. Ice.	(1) Melt ice with portable heater. Borescope-inspect (WP 010 00) gas turbine for FOD caused by ice formation on IGV's.	Replace gas turbine if FOD exceeds limits.

13. HIGH POWER (STEADY-STATE) PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	b. Foreign objects (except ice).	(2) Remove objects restricting inlet screen. Borescope gas turbine if any deterioration in screen integrity is found or there is possibility that objects passed through screen into compressor.	Replace gas turbine if FOD exceeds limits.
	3. Incorrect variable stator vanes position.	Check variable stator vanes schedule (WP 012 00).	Re-rig VG feedback cable (WP 012 00).
	4. Foreign object damage.	Borescope-inspect gas turbine (WP 010 00).	Replace gas turbine if FOD exceeds limits.

14. FLAMEOUT.

Symptom	Possible Cause	Troubleshooting	Corrective Action
Low or no fuel manifold pressure indication.	1. Fuel supply system defective.	Check fuel supply pressure to gas turbine fuel pump (5 to 55 psig (34-379 kPa)).	Correct per ship's manual.
	2. Fuel contamination.		Service fuel system (WP 020 00).
	3. Incorrect variable stator vanes position if flame-out happened during compressor stall.	Check variable stator vanes schedule (WP 012 00).	a. Re-rig VG feedback cable (WP 012 00).
			b. Replace VG control assembly (WP 028 00).
	4. P3 sensing line transducer is leaking.	a. Inspect line for leaks or looseness.	Tighten or replace line.
		b. Check operation and calibration of transducer.	Recalibrate or replace transducer.

15. LUBRICATION SYSTEM PROBLEMS.

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. Oil tank is contaminated.	Maintenance error/abnormal SOAP sample.	If gas turbine operated for 200 hours or more with MIL-L-23699 oil containing more than 5% mineral oil, remove C-sump cover and inspect for excessive coking and deposits.	Service lube system (WP 019 00).
B. No oil pressure.	1. Sheared pump shaft.	Check for XN2 indication while motoring gas turbine. Verify lube supply to pump.	Replace pump (WP 031 00) if there is no oil pressure with an XN2 indication and normal oil supply to pump.
	2. Low oil level in tank.	Check for source of abnormal oil loss such as a loose connection, a crack in line or in a tank weld, a failed pump seal, an open SOAP sampling cock, or a loose drain fitting. Check for oil carryover to gas turbine through tank vent line to compressor front frame.	Correct the problem.
	3. Faulty oil pressure indication.	Check indicating system for faulty circuits.	Replace faulty component.
	4. Faulty transmitter or pressure line.	Check transmitter for open circuit or for a loose or broken pressure line.	Replace faulty component.
	5. Obstruction in oil supply hose-to-pump.	a. Disconnect supply hose at pump, and check for presence of oil.	Correct the problem.
		b. Check oil supply hose for deterioration (collapsed).	Replace oil supply hose (WP 031 00).
		c. Check for obstruction in pump inlet.	Remove obstruction from pump and clean oil tank.
		d. Check for improperly connected lines or reversed check valve.	Correct the problem.
	6. Inlet screen in tank (for pump supply line) obstructed.	Remove inlet screen and check for obstructions.	Remove obstruction and clean oil screen and tank.

15. LUBRICATION SYSTEM PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
C. Low oil pressure.			

NOTE

A decrease of 10 psig (69 kPa) from the normal pressure is cause for investigation. Do not operate gas turbine if pressure is more than 15 psi (103 kPa) below minimum.

Symptom	Possible Cause	Troubleshooting	Corrective Action
1. With fluctuation.	a. Low oil level in tank.	Check oil level.	Refill oil tank to correct level.
	b. External oil leak.	Inspect all external lines and components for leaks.	Replace leaking component. Torque loose fittings (WP 031 00).
	c. Faulty oil pressure indication.	Check indicating system for accuracy.	Replace faulty component.
	d. Failure of pressure relief valve in lube and scavenge pump.		Replace lube and scavenge pump (WP 031 00).
	e. Obstructed or collapsed oil supply hose-to-pump.	(1) Disconnect supply hose at pump and check for flow.	Replace supply hose (WP 031 00).
		(2) Check oil-in hose for deterioration.	Replace oil-in hose (WP 031 00).
		(3) Check for obstruction in pump inlet.	Remove obstruction from pump.
2. Without fluctuation.	a. External oil leak.	Inspect for leaks.	Repair leak.
	b. Internal gas turbine leak (possible damaged oil seals).	Check for high oil consumption.	Repair or replace gas turbine.
	c. Faulty pressure transmitter or cable.	Install another transmitter to verify original pressure readings. Check transmitter for short circuit.	Replace transmitter or cable.
	d. Oil/fuel contamination.	Check oil sample for fuel dilution. Pressure leak-check oil tank if fuel is found in oil.	(1) Repair source of fuel entry into oil. (2) Service lube system (WP 019 00).

15. LUBRICATION SYSTEM PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
D. High oil pressure.			

CAUTION

Do not operate gas turbine if oil pressure exceeds 30 psig (207 kPa) above normal pressure, after gas turbine reaches stabilized temperature; otherwise, damage to gas turbine may occur.

NOTE

- An increase in oil pressure of 10 psig (69 kPa) over normal pressure is cause for investigation. Do not replace the oil pump because it cannot be the cause of high oil pressure.
- Oil pressure during initial start (cold oil) should return to normal after 5 minutes at IDLE speed, but may take considerably longer under severe freezing conditions. Higher power settings are required for more rapid warm-up.

Symptom	Possible Cause	Troubleshooting	Corrective Action
	1. Low oil temperature after warm-up.		Operate gas turbine to allow pressure to decrease after warm-up.
	2. Faulty oil pressure indication.	Check indicating system for accuracy.	Replace faulty component.
	3. Plugged oil filter.	Remove and inspect oil filter (WP 019 00).	Service oil filter (WP 019 00).
	4. Check valve, in oil filter, is stuck.		Replace oil filter (WP 019 00).
	5. Blocked or kinked oil tubes.	Check tubes for kinks or blockage (WP 031 00).	Clean or replace faulty tube (WP 031 00).
	6. Clogged oil tubes and oil jets. (This is often indicated by tendency of pressure to creep up.)	If oil filter was plugged but the replacement oil filter did not reduce pressure to within limits, remove and inspect chip detectors (WP 013 00) and record location where metal chips and sludge were found.	Replace gas turbine.
	7. Restriction or blockage in oil tank vent line to gas turbine.	Check for restriction.	Clean or replace faulty component.

15. LUBRICATION SYSTEM PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
E. Fluctuating oil pressure (greater than 5 psi (34 kPa)).			

NOTE

Fluctuating oil pressure during transient conditions is considered normal; however, these fluctuations should stop 1 minute after returning to steady-state conditions.

Symptom	Possible Cause	Troubleshooting	Corrective Action
	1. Low oil level in tank.	Check oil level.	Refill oil tank to correct level.
	2. Oil/water contamination.	Check oil sample for milky appearance or for dilution with water. Pressure-check oil tank if water is found in oil.	a. Repair source of water entry into tank. b. Service lube system (WP 019 00).
	3. Plugged oil filter.	Remove and inspect oil filter (WP 019 00).	Service oil filter (WP 019 00).
	4. Faulty oil pressure transmitter.	Check transmitter for accuracy.	Replace transmitter.
	5. Blocked or defective lube and scavenge pump inlet hose.	a. Disconnect inlet hose and check for blockage or damage.	Clean or replace hose (WP 031 00).
		b. Inspect oil tank for blocked screen.	Clean the tank and screen.
	6. Failure of pressure relief valve in lube and scavenge pump.		Replace lube and scavenge pump (WP 031 00).
	7. Defective oil tank vent.	Remove cover and inspect deaerator for cracks.	Repair or replace oil tank.
	8. Defective oil pump-to-AGB drive pad seal.	Check seal for oil leakage or oil wetting.	Replace pump (WP 031 00).
F. Overfull oil tank.	1. Fuel in tank.	Check oil sample (WP 015 00) for fuel.	a. Determine and repair source of fuel entry. b. Service lube system (WP 019 00).

15. LUBRICATION SYSTEM PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	2. Incorrect servicing procedure.	Added too much oil.	Drain excess oil.
G. High oil temperature (oil appears as though it has been overheated).			

NOTE

Indication of overheated oil is apparent by extremely dark oil in oil tank, by a pungent burned odor, by sludge and varnish deposits on oil filter, or sludge on chip detectors.

Symptom	Possible Cause	Troubleshooting	Corrective Action
	1. Low oil level in tank.	Check oil level.	Refill oil tank to correct level.
	2. Low oil flow in B- and/or C-sump, resulting in high scavenge temperature.	a. Replace B- and C-sump chip detectors (WP 013 00) and thermocouple harness (WP 025 00).	Record the sump area that exceeded the limits, and replace gas turbine.
		b. Operate gas turbine and record B- and C-sump scavenge oil temperature and temperature at oil cooler output. Max allowable temperature at air/oil cooler oil output is 350°F (177°C).	
		c. Subtract the temperature at the air/oil cooler from each of the B- and C-sump scavenge temperatures. The resulting differential temperature should be below the following limits: B-sump: 160°F (71°C) C-sump: 130°F (54°C)	
		d. Check for high or low oil pressure.	
H. Fluctuating oil temperature.	Faulty oil temperature indicating system.	Check indicating system for accuracy.	Replace faulty component.

15. LUBRICATION SYSTEM PROBLEMS. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
I. High oil consumption.			

CAUTION

Do not operate gas turbine with fluctuating or below limits oil pressure. A sudden increase in oil consumption or a gradual increase over a period of time indicates deterioration of the oil system and is cause for investigation.

Symptom	Possible Cause	Troubleshooting	Corrective Action
	1. Records in error.	Verify records.	Correct records.
	2. Oil leaks in:		
	a. External hoses and tubes.	Inspect hoses, tubes, and fittings for leaks.	Replace hose, tube, or fitting (WP 031 00).
	b. Accessory gearbox.	1. Check each gearbox pad flange for leakage: 5 cc/minute normal leakage during operation.	Replace defective parts.
		2. Check packings and seals for damage.	Replace defective parts.
	c. Oil pump.	Check oil pump seal drain: 5 cc/minute normal leakage during operation.	Replace oil pump (WP 031 00).
	3. Plugged A-sump seal drain tube (oil wetted areas in coupling guard).	Attach a tube to A-sump drain tube and blow through gently. Tube must have no restrictions.	Clean (WP 031 00) drain tube and orifice (from 6 o'clock front frame pad).
	4. Plugged seal pressure tube to C-sump.	Attach a tube to C-sump tube and blow through gently. Tube must have no restrictions.	Clean (WP 031 00) tube (from pressure regulating valve to 12 o'clock strut on exhaust frame).
	5. Internal gas turbine damage.	Check oil filters, chip detectors, and SOAP reports.	Replace gas turbine.
J. Exhaust fire and smoke.	Restricted or damaged C-sump scavenge hose.	Fire or excessive smoke observed in tailpipe.	Replace damaged C-sump scavenge hose (WP 031 00).

16. HIGH VIBRATIONS.

Symptom	Possible Cause	Troubleshooting	Corrective Action

NOTE

- Occasionally it may be noted that vibrations increase as much as 3 mils after a shutdown of 1 to 2 hours. The most probable cause is a temporary thermal rotor bow due to uneven cooling of the power turbine or gas generator rotors. If the shutdown is brief (less than 10 minutes) or long (more than 6 hours), thermal rotor bow cannot occur because the rotors cool either very little or to a uniform temperature.
- A thermal rotor bow can be identified by noting that the increased vibration levels gradually decay back to previous levels during approximately 10 minutes of gas turbine operation. As long as vibrations are decreasing with time, gas turbine operation may be continued even if some limits are temporarily exceeded.

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. Gas generator rotor vibration.	1. Faulty vibration indicating system.	Check all connections and pickups for looseness. Check leads for chafing. Check indicators for accuracy.	Replace faulty component.
	2. Loose gas turbine mounts.	Check gas turbine mounts for security and alignment.	Realign and tighten mounts.
	3. Foreign object damage.	Borescope-inspect gas turbine (WP 010 00).	Replace gas turbine.
	4. Defective bearings.	a. Refer to paragraph 15, items B and C.	
		b. Check oil filter and chip detectors for debris.	Replace gas turbine.
		c. Check SOAP reports for signs of impending bearing failure.	Replace gas turbine.
	5. Dirty compressor.		Water-wash gas turbine (WP 017 00).
B. Power turbine rotor vibration.	1. Faulty vibration indicating system.	Check all connections and pickups for looseness. Check leads for chafing. Check indicators for accuracy.	Replace faulty component.
	2. Loose gas turbine mounts.	Check gas turbine mounts for security and alignment.	Realign and tighten mounts.
	3. Foreign object damage.	Borescope-inspect gas turbine (WP 010 00).	Replace gas turbine.

17. POST-SHUTDOWN FIRE.

Symptom	Possible Cause	Troubleshooting	Corrective Action
After shutdown, T4.8 indicates 527°F (275°C) or higher.	1. High ambient temperatures.	With ambient temperature at 100°F (38°C) or above, a T4.8 of 527°F (275°C) or slightly higher can be normal.	Motor gas turbine with starter, ignition off, until T4.8 indicates 392°F (200°C) or less.
	2. Shutoff valves open.	Motor gas turbine and check for fuel flow indication and vapors. If present, check shutoff valves.	Replace shutoff valves.

18. OVERSPEED/OVERTEMPERATURE.

Symptom	Possible Cause	Troubleshooting	Corrective Action
A. XN2 or T4.8 overshoot at max.	1. Variable stator vanes are not fully open. XN2 reaches 17,600 rpm but T4.8 and XNSD remain low.	a. Check for free travel of variable stator system.	If problem persists, replace VG control assembly (WP 028 00).
		b. Check rigging of VG feedback cable (WP 012 00).	
	2. Faulty XN2/T4.8 indications.	Check indicator systems.	Repair or recalibrate indicators.
	3. Thermocouple harness (open, short circuit).	Inspect thermocouple harness (WP 025 00).	Replace thermocouple harness (WP 025 00).
	4. Fuel metering valve failure.	Check for worn valve.	Replace fuel metering valve.
B. Different XN2 than previous readings under same operating conditions.	1. If all other readings are the same as those previously taken, indicator may be faulty.	Check indicator output.	Replace faulty component.
	2. If XN2 and XNSD are both low:		
	a. Dirty compressor rotor.	Borescope-inspect gas turbine (WP 010 00).	Water-wash gas turbine (WP 017 00).
	b. Foreign object damage.	Borescope-inspect gas turbine (WP 010 00).	Replace gas turbine.

18. OVERSPEED/OVERTEMPERATURE. (Cont)

Symptom	Possible Cause	Troubleshooting	Corrective Action
	c. Compressor air leak.	Check sump pressurizing and balance piston lines and port blankoffs.	Eliminate leakage.
	d. Excessive power extraction (AGB).	Check for binding or abnormal torque on AGB mounted components or for failure within AGB.	Replace defective components (WP 032 00).
	3. If XN2 increases and XNSD decreases, variable vanes are misrigged (closed).	Check variable vane schedule (WP 012 00).	Re-rig VG feedback cable (WP 012 00).
	4. If XN2 and XNSD increase, thermocouple harness has failed.	Inspect thermocouple harness (WP 025 00).	Replace thermocouple harness (WP 025 00).
C. Higher T4.8 than previous reading at 100% power under same operating conditions.	1. If all other readings are the same as those previously taken, indicator may be faulty.	Check indicator output.	Replace faulty indicator.
	2. If all other readings changed with T4.8:		
	a. Variable stator vanes off schedule.	Check VG feedback cable for looseness (WP 012 00).	Adjust VG feedback cable (WP 012 00).
	b. CIT sensor failure.	Check CIT sensor.	Clean sensor (WP 009 00) or replace VG control assembly (WP 028 00).

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

GENERAL MAINTENANCE PRACTICES AND INSPECTION INSTRUCTIONS

(LEVEL 1 MAINTENANCE)

Effectivity:	L32119G01/-G03/-G04/ -G05/-G06	MARINE GAS TURBINE
	L32112G02	INDUSTRIAL GAS TURBINE

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1. INTRODUCTION. This work package provides instructions for general maintenance practices and techniques, and inspection methods for the LM500 gas turbine.

2. SUPPORT EQUIPMENT.

Support Equipment

Part No.	Nomenclature
---	White Light, 150-Watt

3. CONSUMABLE MATERIALS.

NOTE

Equivalent materials approved by GE Aircraft Engines may be substituted for items listed.

Consumable Materials

Description	Manufacturer
Acid, Nitric (O-N-350)	Local Purchase
Acid, Phosphoric (O-O-670)	Local Purchase
Alcohol, Isopropyl (TT-I-735)	Local Purchase
Alodine No. 1200	Parker & Amchem 32102 Stephenson Hwy. Madison Heights, MI 48071 USA
Bags, Polyethylene	Local Purchase
Bits, Grinding	Local Purchase
Brush, Soft-Bristle	Local Purchase
Brush, Rotary	Local Purchase
Brush, Stainless Steel Wire	Local Purchase
Burr, Carbide Rotary	Local Purchase
Caps, Protective	Protective Closures Co., Inc. 2166 Elmwood Avenue Buffalo, NY 14207 USA
Cloth, Abrasive (120-180 Grit) (150-240 Grit) (250-300 Grit) (400-500 Grit)	Local Purchase
Cloth, Crocus (500-600 Grade)	Local Purchase

Consumable Materials (Cont)

Description	Manufacturer
Cloth, Emery (150-600 Grit)	Local Purchase
Cloth, Lint-Free	Local Purchase
Compound, Antiseize (Braycote 655)	Bray Oil Co. Inc. 2698 White Rd. Irvine, CA 92714 USA
File, Rotary	Local Purchase
Gloves, Rubber or Polyethylene	Local Purchase
Marker, Blue Dykem (M-1)	Dykem Co. 8501 Delport Dr. St. Louis, MO 63114 USA
Material, Water- Vapor-proof Barrier (MIL-B-131)	Local Purchase
Oil, Lubricating (MIL-L-7808 or MIL-L-23699)	Local Purchase
Petrolatum	Local Purchase
Plugs, Protective	Protective Closures Co., Inc. 2166 Elmwood Avenue Buffalo, NY 14207 USA
Solvent, Tetrachloroethylene (Perchloroethylene) (O-T-236)	Local Purchase
Solvent, Trichloroethane (O-T-620)	Local Purchase
Solvent, Trichlorotrifluoroethane (MIL-C-81302)	Local Purchase

4. GENERAL MAINTENANCE PRACTICES. Maintenance personnel must familiarize themselves with the following general practices before attempting to do any maintenance on the gas turbine or its components.

a. The purpose of this work package is to guide and enhance the judgment and experience of qualified personnel.

b. Record on the appropriate forms the critical measurements taken during disassembly as follows:

(1) Specify both the name of the part that is measured and the area of measurement on the part.

(2) During disassembly, inspect all parts for serviceability.

(3) Look for indications of work performed incorrectly during previous maintenance or overhaul. Report any such indications in accordance with current practices.

c. Discard unserviceable parts in accordance with current regulations. Discard all preformed packings, gaskets, and tab washers that are removed during disassembly.

CAUTION

- Do not use cadmium-plated tools/fixtures for maintenance or repair of parts. Cadmium-plated tools/fixtures will embrittle many metals, including titanium, if they are exposed to temperatures of 500°F (260°C) and above.
- Do not use brass or lead tools when installing or disassembling hot section parts. Brass and lead contaminants can ultimately lead to part failure.
- Use of tools which appear physically similar to those authorized can result in gas turbine damage. Where special tools are identified, use of these tools by tool number is the only correct practice to follow unless an alternate tool is given for the task.
- To prevent possible stress corrosion, do not use adhesive paper or tape containing chlorine compounds on titanium parts.

d. The special tools identified in this manual are designed specifically for use on this gas turbine. Avoid the use of makeshift tools. Refer to table 1 for a list of recommended hand tools.

e. Before using tools, be sure that the tools are clean and free from nicks, dents, or burrs that could damage gas turbine parts. Lubricate tool threads and sliding surfaces.

f. Do not use hammers with metal heads on any part of the gas turbine. Use hammers with plastic, nylon, or rawhide heads. Do not use screwdrivers or sharp metal rods to separate gas turbine parts. If parts are bound or seized, use wooden wedges to separate them.

g. Where lockwire is used, remove it before dismantling parts.

h. Most locknuts are elliptical in shape by design intent: do not discard as unserviceable for this reason.

i. Always use two wrenches when disconnecting or tightening hoses and tubes: use one wrench to hold the fitting and another wrench to loosen or tighten the coupling nut.

j. Before disconnecting tubes and hoses, remove the locknuts and bolts from the cushioned clamps. This prevents damage to the fittings. If the same tubes and hoses are to be reinstalled, installation will be easier if the clamps are not removed from tubes and hoses.

k. When disconnecting tubes and flexible hoses, be careful to prevent damage and twisting action on the tubes and flexible hoses. As tubes and flexible hoses are disconnected, cap or cover openings to prevent entrance of foreign material.

CAUTION

- Do not use pliers on electrical connectors. Ferrules should be hand-tightened; otherwise, connectors will be damaged.
- Do not allow water, fuel, or oil to contact exposed electrical connectors. Moisture can cause short circuits.
- Do not cover electrical connectors with plastic bags or aluminum foil. Moisture can accumulate due to water vapor condensation. Aluminum foil particles and moisture could cause shorts circuits.

TABLE 1. RECOMMENDED HAND TOOLS

Nomenclature/Size	Quantity
Adapter, Socket, Square, Drive	-
1/4 inch Female - 3/8 inch Male	1
3/8 inch Female - 1/4 inch Male	1
Adapter, Torque Wrench, 1/4 inch Square, Drive	-
1/4 inch Opening (2 inch offset box end)	1
5/16 inch Opening (2 inch offset box end)	1
Adapter, Torque Wrench, 3/8 inch Square, Drive	-
3/8 inch Opening (2 inch offset box end)	1
7/16 inch Opening (2 inch offset box end)	1
Crowfoot Attachment, Open End, 3/8 inch Square, Drive	-
9/16 inch Opening	1
5/8 inch Opening	1
11/16 inch Opening	1
3/4 inch Opening	1
13/16 inch Opening	1
7/8 inch Opening	1
1 inch Opening	1
1-1/16 inch Opening	1
1-1/8 inch Opening	1
Extension, Socket Wrench, 1/4 inch Square, Drive	-
2 inch Nominal Length	1
6 inch Nominal Length	1
Extension, Socket Wrench, 3/8 inch Square, Drive	-
3 inch Nominal Length	1
6 inch Nominal Length	1
8 inch Nominal Length	1
12 inch Nominal Length	1
Extractor, Cotter Pin	1
Finger, Mechanical, Flexible	1
Flashlight	1
Gage, Thickness 0.0015-0.035 inch (0.04-0.90 mm)	1
Hammer, Plastic, 4 ounces (113 grams)	1
Hammer, Ball Peen, 8 ounces (227 grams)	1

TABLE 1. RECOMMENDED HAND TOOLS (Cont)

Nomenclature/Size	Quantity
Handle, Hinge	-
1/4 inch Square Drive	1
3/8 inch Square Drive	1
Handle, Ratchet, Reversible	-
1/4 inch Square Drive	1
3/8 inch Square Drive	1
3/4 inch Square Drive	1
Handle, Speed	-
1/4 inch Square Drive	1
3/8 inch Square Drive	1
Mirror, Inspection	-
1-1/8 inch (28.6 mm) Diameter, 6-3/4 inch (172 mm) long	1
1 inch x 2 inches, (25 x 51 mm), 8-1/2 inches (216 mm) long	1
Pliers	-
Conduit	1
Diagonal	1
Duckbill	1
Electrical Connector	1
Long Nose	1
Snap Ring	1
Vise Grip	1
Wire Twister	1
Punch Drive Pin, Straight	-
1/8 inch Point	1
3/16 inch Point	1
1/4 inch Point	1
Punch, Drive Pin, Tapered, 3/16 inch point Diameter	1
Retrieving Tool, Magnetic 17-27 inches (43-69 cm) Length	1
Rule, Steel, 6 inch (15 cm)	1
Screwdriver Set, Common	1
Screwdriver Set, Phillips	1
Socket, 1/4 inch Square Drive, Flexible, 12 Lobes	-
1/4 inch Size Opening	1
5/16 inch Size Opening	1
3/8 inch Size Opening	1
7/16 inch Size Opening	1
1/2 inch Size Opening	1
Socket, 1/4 inch Square Drive, Long, Thin Wall, 12 Lobes	-
7/32 inch Size Opening	1
1/4 inch Size Opening	1
5/16 inch Size Opening	1
3/8 inch Size Opening	1
7/16 inch Size Opening	1
1/2 inch Size Opening	1

TABLE 1. RECOMMENDED HAND TOOLS (Cont)

Nomenclature/Size	Quantity
Socket, 1/4 inch Square Drive, Regular Length, 12 Lobes	-
7/32 inch Size Opening	1
1/4 inch Size Opening	1
5/16 inch Size Opening	1
3/8 inch Size Opening	1
7/16 inch Size Opening	1
1/2 inch Size Opening	1
Socket, 1/4 inch Square Drive, Short, Thin Wall, 12 Lobes	-
7/32 inch Size Opening	1
1/4 inch Size Opening	1
5/16 inch Size Opening	1
3/8 inch Size Opening	1
7/16 inch Size Opening	1
1/2 inch Size Opening	1
Socket, 3/8 inch Square Drive, Deep Length, 12 Lobes	-
3/8 inch Size Opening	1
7/16 inch Size Opening	1
1/2 inch Size Opening	1
9/16 inch Size Opening	1
5/8 inch Size Opening	1
Socket, 3/8 inch Square Drive, Flexible, 12 Lobes	-
3/8 inch Size Opening	1
7/16 inch Size Opening	1
1/2 inch Size Opening	1
9/16 inch Size Opening	1
5/8 inch Size Opening	1
Socket, 3/8 inch Square Drive, Regular Length, 12 Lobes	-
3/8 inch Size Opening	1
7/16 inch Size Opening	1
1/2 inch Size Opening	1
9/16 inch Size Opening	1
5/8 inch Size Opening	1
Universal Joint	-
1/4 inch Square Drive	1
3/8 inch Square Drive	1
Wrench, Box End, 12 Lobes	-
7/32 inch x 1/4 inch Openings	1
1/4 inch x 5/16 inch Openings	1
5/16 inch x 5/8 inch Openings	1
7/16 inch x 1/2 inch Openings	1
Wrench, Box End, Ratcheting, 12 Point	-
1/4 inch Opening	1
5/16 inch Opening	1
3/8 inch Opening	1
7/16 inch Opening	1

TABLE 1. RECOMMENDED HAND TOOLS (Cont)

Nomenclature/Size	Quantity
Wrench, Combination, Box (12 Lobes) and Open End	-
1/4 inch Opening	1
5/16 inch Opening	1
3/8 inch Opening	1
7/16 inch Opening	1
1/2 inch Opening	1
9/16 inch Opening	1
5/8 inch Opening	1
11/16 inch Opening	1
3/4 inch Opening	1
13/16 inch Opening	1
7/8 inch Opening	1
1 inch Opening	1

l. Use extreme care when disconnecting electrical leads. Do the following:

(1) Remove and discard preformed packings from electrical connectors.

(2) Cap all ends to prevent entrance of dirt, oil, and moisture using only recommended protective caps or plugs.

m. To aid in assembly, mark bolts with the number of the flange bolt circle hole they were removed from. Observe the following:

(1) Do not mix bolts and locknuts from one part of the gas turbine with those from another.

(2) During assembly, be careful not to drop nuts, washers, pieces of lockwire, or other objects into the subassembly. If an object is dropped, do not proceed further until it is removed.

n. Do not place tools on any part of the gas turbine during assembly. Return each tool to its proper place immediately after use.

o. When installing body-bound bolts, align the bolts properly and drive them straight through with a plastic hammer. Do not rotate these bolts; rotation of bolts tends to loosen them, impairing alignment.

p. Use care when assembling bolts to shanktype locknuts. Align the bolts and engage the first few threads manually to avoid a shock that could dislodge the locknut from its seat.

q. All used locknuts must be tried for self-locking capabilities before being used. Do the following:

(1) Manually thread used locknut onto bolt or stud.

(2) Any locknut is serviceable if end of bolt or stud does not extend beyond end of locknut.

r. Be sure to use the correct bolt and nut at assembly. The bolt, when assembled and properly torqued, should protrude two to three threads beyond the nut.

Isopropyl Alcohol, TT-I-735 **11**

s. Condensation can form on all parts that have been chilled with dry ice (solidified carbon dioxide) to facilitate assembly. Remove this condensation by wiping the part with a lint-free cloth saturated with isopropyl alcohol and then with a dry lint-free cloth.

t. Lift all heavy parts with the proper lifting device to prevent damage to the part or injury to personnel.

u. Always use thermally insulated gloves when handling hot or chilled gas turbine parts.

v. Do not use excessive force to assemble mating parts. If excessive force appears necessary, inspect mating surfaces for burrs or metal pickup. Remove any such defects and repair or replace defective parts.

w. Carbon seals must be assembled in a clean work area. Prior to assembly on the gas turbine, they are to be kept clean, dry, and protected at all times. No lubricant is to be used on carbon seals.

CAUTION

- Never mark gas turbine parts with a lead pencil. The deposits left by the pencil can cause corrosion and burnout of parts.
- Do not mark rotating gas turbine parts using either the electrolytic-etch or electric-arc-scribe method to avoid initiation of corrosion conditions.

x. Use a blue Dykem marker or equivalent, to temporarily mark gas turbine parts. To permanently mark gas turbine parts, use the vibropeen or electric-arc-scribe method on stationary parts, and vapor- or dry-blast method on rotating parts.

y. Pins and bolts must be installed with heads up, forward, or inboard where possible.

z. Safety Requirements and Cleanliness.

(1) This manual is intended to provide safe procedures and processes for accomplishing the maintenance herein described. It is, therefore, important that the Warnings of possible personnel injury, and the Cautions and Notes, be thoroughly understood and observed by the users of this manual.

(2) Keep dirt and other foreign material out of the gas turbine. Use the recommended covers, caps, and plugs to seal all openings.

(3) Place each part on a clean surface as it is removed from the gas turbine.

(4) Wrap small parts in greaseproof paper, seal with tape, and tag (or otherwise identify) the package with the gas turbine serial number, part nomenclature, and part number.

(5) Keep related parts grouped together.

(6) Do not remove wrappings, caps, plugs, or covers until the part is ready to be installed.

5. MAINTENANCE TECHNIQUES.

a. Bearing Handling Practices. Removal of bearings from the gas turbine or its components, or both, must be accomplished with proper tools that are clean and in good condition. During removal, observe the following:

CAUTION

- Ball and roller bearings require special care to prevent corrosion.
- Bearings must not be handled with bare hands or with any device which might cause contamination.
- Clean rubber gloves or a protective cream must be used at all times when handling bearings.

(1) Examine assemblies requiring bearing removal carefully to determine the best way to remove the bearing and to prevent damage to bearing housing or shaft journal.

(2) Remove bearings at earliest possible stage of disassembly to prevent inadvertent damage and contamination. Carefully wipe off loose contamination from face of bearing to prevent it from entering bearing during removal.

(3) When bearing is to be pressed off shaft, apply pressure to the inner ring.

(4) When bearing is to be pressed out of housing recess, apply pressure to outer ring.

(5) Apply steady pressure during removal of bearing. Apply pressure evenly around the entire bearing face, when possible.

(6) Be careful to keep bearing removal tool straight to avoid damage from cocking. Do not let the bearing strike the floor or other objects when suddenly released from shaft or housing.

(7) In cases where gears or other removable parts do not allow the puller to contact the bearing directly, let the puller jaws contact the gear (or removable part) and remove bearing from shaft.

(8) All antifriction bearings are part of a matched bearing assembly. Observe the following:

(a) Keep components of same matched bearing assembly together at all times when they are removed from the gas turbine.

(b) If a component of a matched bearing assembly is damaged or lost, replace the complete bearing assembly.

CAUTION

Do not rotate or spin bearings prior to cleaning; otherwise, bearings may be damaged.

(c) Immediately after bearings have been removed, identify them by part number, serial number, and gas turbine serial number. Place bearings in plastic bags or wrap them in waterproof barrier material.

(9) Protect bearing journals and housing surfaces as follows:

(a) Apply preservative coating immediately after bearings are removed.

(b) Protect journals and housings from handling damage.

(10) Handle bearings carefully to avoid unnecessary movement of races and rolling elements as follows:

(a) Bearings are extremely susceptible to damage; handle bearings with care at all times.

(b) Use same care in handling as that intended on packages marked "FRAGILE". This includes methods of transporting bearings between areas.

(c) The timeliness of getting bearings to the cleaning and inspection area is also important. Avoid any unnecessary handling, including axial loading of balls or rollers between the inner and outer races.

b. Bearing Installation Practices.

(1) Use extreme care during installation of antifriction bearings in a gas turbine, because any damage that occurs at this time may go undetected until the gas turbine is in operation.

(2) During installation, to prevent damage and promote longer bearing life, observe the following:

(a) Assure that bearings are clean, undamaged, and lubricated, and that all parts are properly mated and marked.

CAUTION

Do not rotate or spin bearings unnecessarily; otherwise, bearings may be damaged.

(b) When installing bearings, use proper tools; tools must be clean and in good condition.

(c) Do not attempt to install a bearing on a shaft that has not been properly cleaned and given a light coat of oil. Dirt or chips on a shaft or in a housing can prevent accurate bearing alignment and result in improper operation.

(d) Using aluminum foil, wrap bearings that need to be heated for installation before placing them in an oven. If a hot oil bath is used to heat bearings, be sure the oil bath is kept clean by constant filtering through a 10-micron filter, or frequent changing. Be sure that hot bearing is handled in a manner to prevent contamination and damage.

(e) Do not heat bearings above 250°F (121°C) unless otherwise specified.

(f) Using aluminum foil, wrap bearings that need to be chilled for their installation.

(g) Push bearings into their assembled positions. Do not tap them into position; the series of shocks that result from tapping can cause permanent damage to the bearings. Dry chilled bearings or races with an air heat gun to prevent accumulation of moisture, which could cause corrosion.

(h) Assemble the split races of a split race bearing so that the matchmarks are aligned.

(i) When installing a bearing on a shaft, apply pressure to the inner ring. When installing a bearing in a housing recess, apply pressure to outer ring.

(j) Whenever bearings have been installed, always cover them with clean, lint-free cloth or paper to prevent dust or dirt contamination. Abrasive dust is not easy to see, and enough can collect on a bearing in a short period of time to eventually cause wear.

c. Lock-Wiring Practices. Lock-wiring is the securing together of two or more parts with a wire so that any tendency for a part to loosen will be counteracted by an additional tightening of the wire. Observe the following lock-wiring procedures:

(1) The common method of installing lockwire (see figure 1, sheet 1) is two strands of wire twisted together (called double-strand method), where one twist is produced by twisting the wires through an arc of 180 degrees and is equivalent to half of a complete turn. Use the single strand method of lock-wiring when so specified, such as in closely spaced, closed geometrical pattern (triangle, square, rectangle, circle, etc.), on parts in electrical systems, and in other places that would make the single-strand method more advisable. In such cases, the single strand wire must be limited to the pattern or group of similar parts.

(2) The maximum span of lockwire between points must be 6 inches (152 mm) unless otherwise specified.

(3) Where multiple groups are lock-wired by either the double-strand or the single-strand method, determine the maximum number in a series by the number of units that can be lock-wired with a 24-inch (61 cm) length of wire. When using the double-strand method to lock-wire widely spaced units in a group, not more than three units must be lock-wired in series (views A and B).

(4) Pull the wire taut while twisting.

(5) During the twisting operation be sure to keep the wire tight without overstressing it and to prevent it from becoming nicked, kinked, or otherwise mutilated (except that abrasions normally caused by commercially available wire twister pliers are acceptable).

(6) Do not lock-wire so as to cause the wire to be subjected to chafing, fatigue through vibration, or additional tension other than the tension imposed on the wire to prevent loosening.

(7) Wiring must be done through the holes provided. If no wire hole is provided, wiring should be to a convenient neighboring part in a manner not to interfere with the function of the parts (see views A, D, and E, sheet 2).

(8) Always use new lockwire for each application.

(9) Various examples of lock-wiring are shown in sheets 1 and 2. Although every possible combination is not shown, any combination used must adhere to the basic rules outlined in this procedure. View K (sheet 1) shows the single-strand method, while the other views show the two-strand or double-twist method.

(10) For use up to 700°F (371°C) use stainless steel or equivalent for lockwire material. For use up to 1,800°F (981°C), use a corrosion and heat resistant alloy or equivalent. Lockwire of 0.020 inch (0.51 mm) thick and 0.032 inch (0.81 mm) thick may be used, with choice determined by the size of the hole in the part being lock-wired. Where a choice is possible, use 0.032 inch (0.81 mm) thick lockwire.

(11) Check the parts to be lock-wired to make sure that they have been correctly torqued. Undertorquing or overtorquing to obtain proper alignment of the holes is not permitted. If it is not possible to obtain a proper alignment within the specified torque limits, loosen the part and try again, or select another neighboring part.

(12) In adjacent units, it is undesirable that the holes be in approximately the same relationship to each other. The proper relationship is shown in views A, B, C, D (sheet 1) for right-hand threads. Install lockwire so that the strand through the hole will have a tendency to pull the unit clockwise. Reverse for left-hand threads.

(13) Insert the lockwire through the first unit and bend the upper end either over or around the head of the unit. If bent around it, the direction of wrap and twist of the strands must be such that the loop around the unit comes under the strand protruding from the hole so that the loop will stay down and not tend to slip up and leave a slack loop (view A, sheet 1).

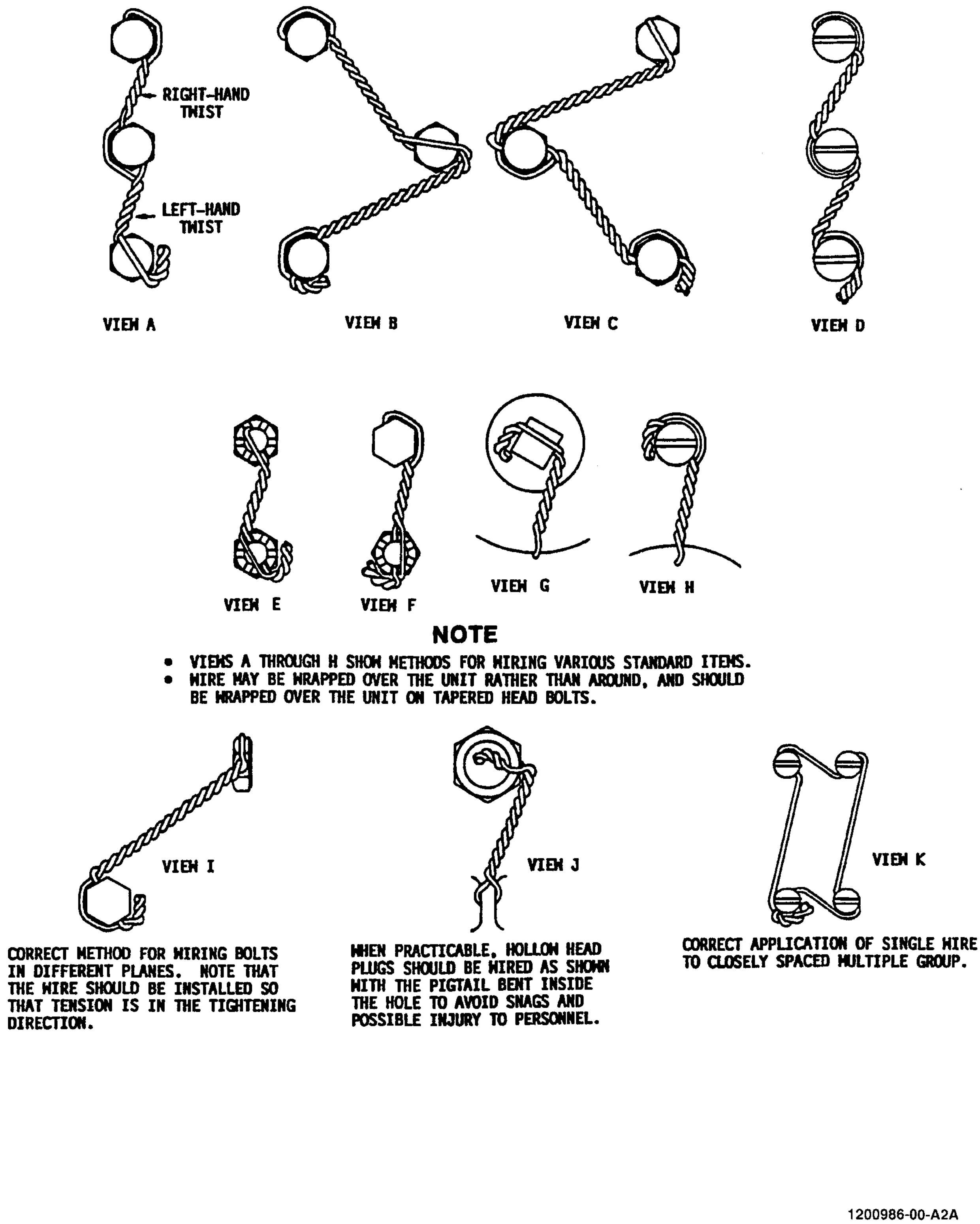

Figure 1. Lock-Wiring Practices (Sheet 1 of 2)

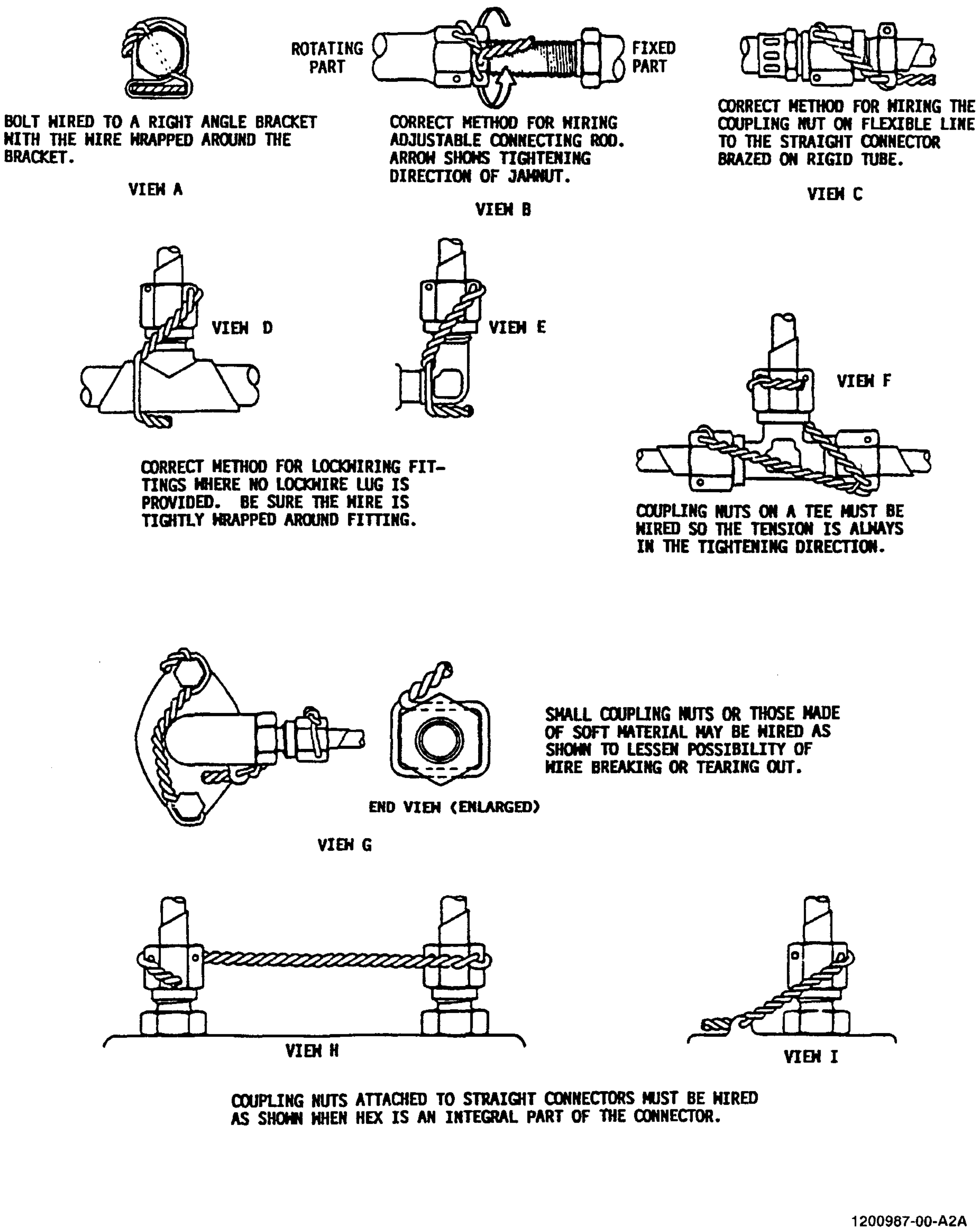

Figure 1. Lock-Wiring Practices (Sheet 2 of 2)

(14) Pull the wire to keep it taut and twist the strands until the twisted part is just short of a hole in the next unit. The twisted portion should be within 1/8 inch (3.2 mm) from the hole in either unit. There should be 9-12 twists per inch (25.4 mm) for the 0.020 inch (0.51 mm) thick lockwire and 7-10 twists per inch (25.4 mm) for the 0.032 inch (0.81 mm) thick lockwire.

(15) If the free strand is to be bent around the head of the second unit, insert the uppermost strand through the hole in this unit, and follow the procedures in step (13). (Refer to center unit of view A, sheet 1). If the free strand is to be bent over the unit, the direction of twist is unimportant. If there are more than two units in the series, repeat the above procedure.

(16) After lock-wiring the last unit, continue twisting the wires to form a pigtail of three to five twists 1/4-1/2 inch (6.4-12.7 mm) long and cut the excess wire. Bend the pigtail toward the part to prevent it from becoming a snag.

(17) When lockwire holes are drilled across comers, use method illustrated in view G (sheet 2) in preference to other methods.

d. Cotter Pin Practices. (See figure 2).

(1) Cotter pins are used to restrain motion between two parts by inserting the cotter pin through a hole in the part and spreading the exposed ends.

(2) Cotter pins are not reusable and must be replaced after removal.

(3) Refer to view A for the proper method of installing cotter pin into clevis pin.

(4) Refer to view B for the preferred method of installing cotter pin into locking nut. Use the alternative method (view C) only if there is lack of clearance.

e. Positioning and Non-Positioning Type Fittings Installation Practices. Positioning-type fittings (see figure 3, views A and B) are bulkhead tees, elbows, and similar fittings. Non-positioning-type fittings (view C) are nipples, plugs, reducers, bushings, etc. The following procedures provide instructions for installing positioning and non-positioning type fittings:

(1) Tighten plugs and tube fittings. Assembly techniques vary, depending upon the specific type of plug or tube fitting being used. These types include non-positioning plugs and unions, using packings, or other compressible packings for seals; positioning fittings, with or without backup washers; and universal bulkhead fittings, held in position by locknuts.

(2) Do not use lubricant on plugs and tube fittings unless specified. Do the following:

(a) If lubrication is needed, use same fluid that the system uses; for air hoses or tubes, use petrolatum or pneumatic system grease.

(b) When lubrication is specified, apply a thin coating to male threads only.

(3) When installing non-positioning fittings (view C), lubricate the packing lightly to prevent cutting by sharp threads. Do the following:

(a) Assemble fitting and packing so that the packing is seated evenly in groove of fitting.

(b) Thread the fitting into boss and tighten to the appropriate torque value.

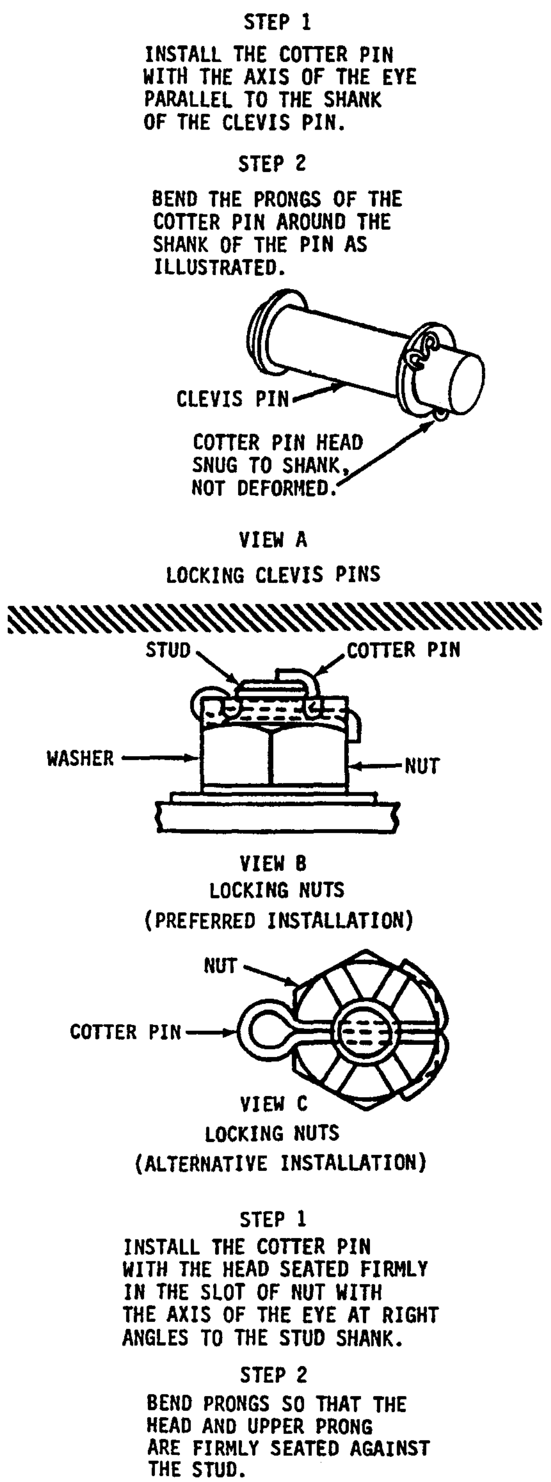

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Figure 2. Cotter Pin Practices

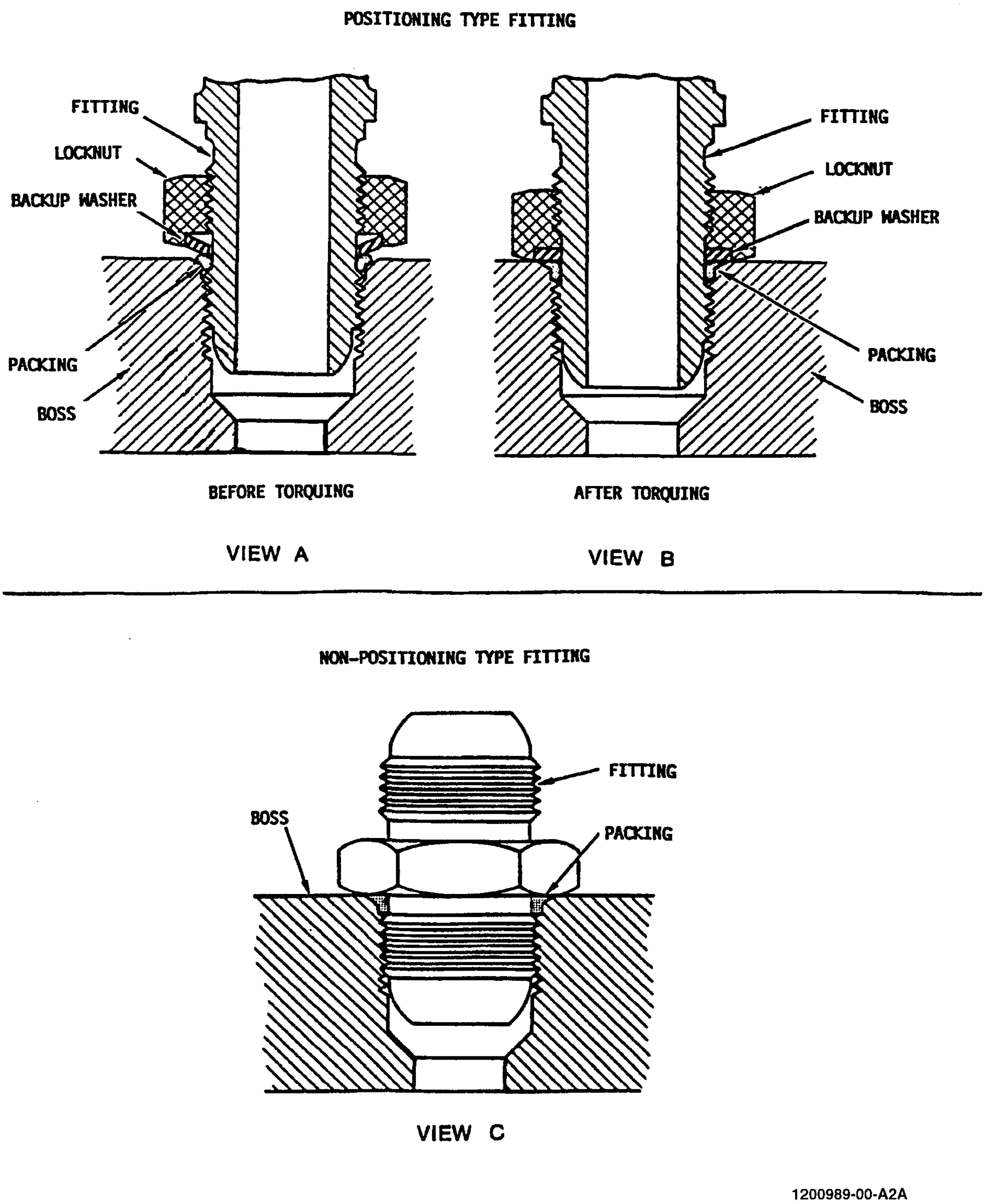


Figure 3. Installation of Positioning and Non-Positioning Type Fittings

(4) When installing positioning fittings (no backup washers) (view A), thread the locknut completely over the first section of threads on the fitting, past the packing groove, and onto the second section of threads as follows:

(a) Lubricate packing. Carefully install packing over first section of threads and into the packing groove so that the packing is seated evenly against the second section of threads.

(b) Tighten locknut until it touches the packing.

(c) Install fitting in boss so that packing touches the countersunk surface.

(d) Turn fitting to desired position by backing out not more than one turn.

(e) Hold fitting in position and tighten locknut to the appropriate torque value (view B).

(5) When installing positioning fittings (with backup washer) (view A), thread the locknut completely over the first section of threads on the fitting, and onto the second section of threads so that the backup washer recess faces the packing groove as follows:

(a) Grip the backup washer firmly by its outside edge, and thread the fitting into the cupped washer.

(b) Do not use any lubricant.

(c) Continue threading the washer onto the fitting until the washer is free on the packing groove.

(d) Pick up any slivers of plastic material cut from the washer.

(e) Press the edges of the washer into the recess in the locknut until evenly seated, making sure that threads of fitting do not interfere with seating of washer.

(f) Lubricate and install packing as directed in step (3).

f. Preformed Packings Installation Practices.

Lubricating Oil **66**

CAUTION

Do not lubricate preformed packings used in electrical connectors. Oil will damage connectors.

(1) Apply a light coating of lubricating oil or petrolatum to all packings unless some other lubricant is specified. Do not lubricate packings that are installed in electrical connectors. Oil will damage connectors.

(2) Before installing packings and parts containing packings, lubricate all grooves, lead-in chamfers, bores, and surfaces with lubricating oil. Wipe off excess oil before assembling parts.

(3) Do not reuse packings or gaskets that were exposed or removed during disassembly. Use new packings and gaskets at final assembly unless reuse is specifically specified.

g. Lubricants.

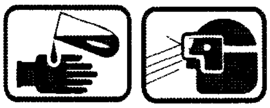
CAUTION

Molykote, graphite-type compounds or any other antiseize compound must not be used to lubricate a surface that will come in contact with lubricating oil or contamination may result.

(1) Be sure all surfaces requiring lubrication are clean and free of moisture, solvents, and other contaminants before applying the lubricant.

(2) Do not apply a lubricant over a corroded surface. During handling, do not contaminate highly-finished surfaces with body moisture or other agents prior to lubricating: such contamination could cause corrosion after lubricant is applied.

(3) Lubricating oil MIL-L-23699 or MIL-L-7808 is the type of oil meant wherever the term "light coat of oil" or the word "oil" is used in assembly procedures.



Antiseize Compound
Braycote 655
416

(4) Unless otherwise noted, lubricate threads of bolts, screws, studs, coupling nuts and fasteners used in the assembly of parts with a light coat of antiseize compound (Braycote 655). Failure to do this may cause bolts to be improperly torqued or cause shank nuts to become loosened during assembly, and may cause bolt seizure or failure or both during removal.

h. Spectrometric Oil Analysis Program (SOAP). A method used to monitor and evaluate the condition of the oil-lubricated parts of the gas turbine. This is done by making a spectrometric analysis of oil samples taken from the gas turbine at regular intervals. The extent of wear is determined by the amount and type of wear metals found in the oil (refer to WP 015 00 for procedure).

i. Torque-Tightening Practices. Torque is expressed in pound-inches (lb in.) or in pound-feet (lb ft). One pound-foot is the twisting force of one pound applied to a lever one foot long; torque values are equal to the pounds of force times the length of the lever (wrench) in feet or inches. The specified twisting force (torque) is applied to threaded fasteners, such as nuts or bolts, to obtain optimum security of the part within the tensile limits of the material or within the shear limits of the threads or the fastener. Unless otherwise specified, lubricate all fastener threads and washer faces with a light coat of antiseize compound (Braycote 655). Tighten fasteners to a specified torque value as follows:

CAUTION

When gas turbine parts have been chilled or heated during assembly, do not torque locknuts or retaining bolts until part returns to room temperature. If part has been heated, fastener may loosen as part cools. If part has been chilled, fastener may be overstressed as part expands.

(1) Tighten at a uniformly increasing rate until desired torque is obtained. In some cases, where gaskets or other parts cause a slow permanent set, be sure to hold torque at desired value until material is seated. For example:

Required torque = 135 lb in.
Effective length of torque wrench (L) = 10.0 inches
Effective length of crow foot (E) = 1.5 inches

Then: (Required torque) x (L) = 135 x 10 = 1350
L+ E = 11.5 inches

$$\frac{1350}{11.5} = 117.4 \text{ lb in.}$$

Thus: A gage reading of 117.4 lb in. indicates a required torque of 135 lb in.

(2) It is not desirable to tighten to the final torque value during the first drawdown; uneven tension can cause distortion or overstressing of parts.

(a) Seat and torque mating parts by tightening bolts or nuts gradually until parts are firmly seated.

(b) Loosen each bolt or nut separately and apply final torque. Tightening in a diametrically opposite (staggered) sequence is desirable in most cases.

(c) Do not exceed listed maximum torque values given in this manual.

NOTE

This procedure also applies to gas turbine parts which are bolted similar to the circumferential flanges (for example, the exhaust frame centerbody).

(3) When applying torque to a series of bolts, select a medium value. If some bolts in a series are torqued to a minimum value and others to a maximum, force is concentrated on the tighter bolts and is not distributed evenly. Such unequal distribution of force may cause bolt failure. Torque flange bolts as follows:

(a) Torque two bolts (each mounting flange) 180° apart.

(b) Torque two bolts (each mounting flange) 90° from the first bolts that were torqued.

(c) Torque remaining bolts.

(4) When installing keywashers, torque locknut to minimum value and then try keywasher in all possible positions. If slots and tabs on keywasher will not align, increase torque on locknut, not to exceed maximum torque.

j. Torque Wrench Sizes. The torque wrenches listed below are recommended for use within the indicated limits. Larger wrenches have a wider tolerance, and their use can result in serious inaccuracies.

Torque Wrench Size	Torque Limits		Tolerance
30 lb in. (3 N·m)	0-25 lb in.	(0-2.8 N·m)	± 1 lb in. (0.1 N·m)
150 lb in. (17 N·m)	25-140 lb in.	(2.8-15.8 N·m)	± 5 lb in. (0.6 N·m)
600 lb in. (68 N·m)	140-550 lb in.	(15.8-62.1 N·m)	±20 lb in. (2.3 N·m)
150 lb ft (200 N·m)	30-140 lb ft	(40.7-189.8 N·m)	± 5 lb ft (6.8 N·m)
250 lb ft (340 N·m)	140-240 lb ft	(189.8-325.4 N·m)	±10 lb ft (13.6 N·m)
1000 lb ft (1360 N·m)	240-1000 lb ft	(325.4-1355.8 N·m)	±20 lb ft (27.1 N·m)

k. Offset Extension (Crowfoot) Wrench. When a crowfoot extension is used with a torque wrench, the effective length of the torque may be changed. The torque wrench is so calibrated that when an extension wrench is used, the indicated torque (the value that appears on the scale or dial of the torque wrench) may be different from the actual torque that is applied to the nut or bolt. Therefore, when a crowfoot extension is used, the torque wrench must be preset to compensate for the increase or decrease in actual torque as compared to indicated torque.

l. Offset Extension (Crowfoot) Wrench Computations. (See figure 4.) The addition or subtraction of the effective length of the crowfoot extension (E) is determined by its position on the torque wrench (L). When the extension wrench is pointed in the same direction as the torque wrench, add the effective length of the extension to the effective length of the torque wrench (L + E). When the extension is pointed back toward the handle of the torque wrench, subtract the effective length of the extension from the effective length of the torque wrench (L - E). When the extension is pointed at right angles to the torque wrench, the effective length does not change. The effective length of the torque wrench is a variable, and a different figure must be used for each type of torque wrench. The effective length of the crowfoot extension is determined by measuring from the center of the drive opening to the center of the wrench opening. Multiply the required torque by the effective length of the torque wrench (L). Divide this product (L + E) or (L - E) as determined from figure 4. The quotient is the gage or scale reading required to obtain the desired torque.

6. GENERAL INSPECTION INSTRUCTIONS.

a. Shop Practices. Parts or assemblies designated as matched sets will be maintained as a matched set. Set numbers, part numbers, and serial numbers will be protected during cleaning or repair to prevent removal. When identification is removed or is no longer legible, re-mark the part.

b. Evaluation of Gas Turbine Part Serviceability Using the Borescope. Where no comparative dimensions are given, evaluation must be accomplished using good judgment and acquired knowledge/experience with the equipment. Borescope views of some parts are limited due to the physical configuration of the hardware. In these instances judge the condition of the remaining parts/areas on the condition of the visible parts. Information on the operation and use of the borescope as applied to the gas generator/power turbine, and when and what to inspect with the borescope is given in Work Package 010 00. Inspection limits of compressor blades and vanes, combustion liner, and high-pressure turbine blades are also given in WP 010 00.

c. Extent and Methods of Inspection. Damage can be evaluated only by thorough inspection. Inspection for defects should be visual, without the aid of magnification or the use of special processes such as fluorescent penetrant or magnetic-particle.

d. Definitions of Inspection Terms. Definitions of inspection terms used in this manual are listed in table 2. The first column lists terms generally used to describe deviations from normal conditions in gas turbine parts. The second column lists definitions which, although not technically identical, are related since the damage they describe is similar in origin or in appearance. The third column lists probable causes.

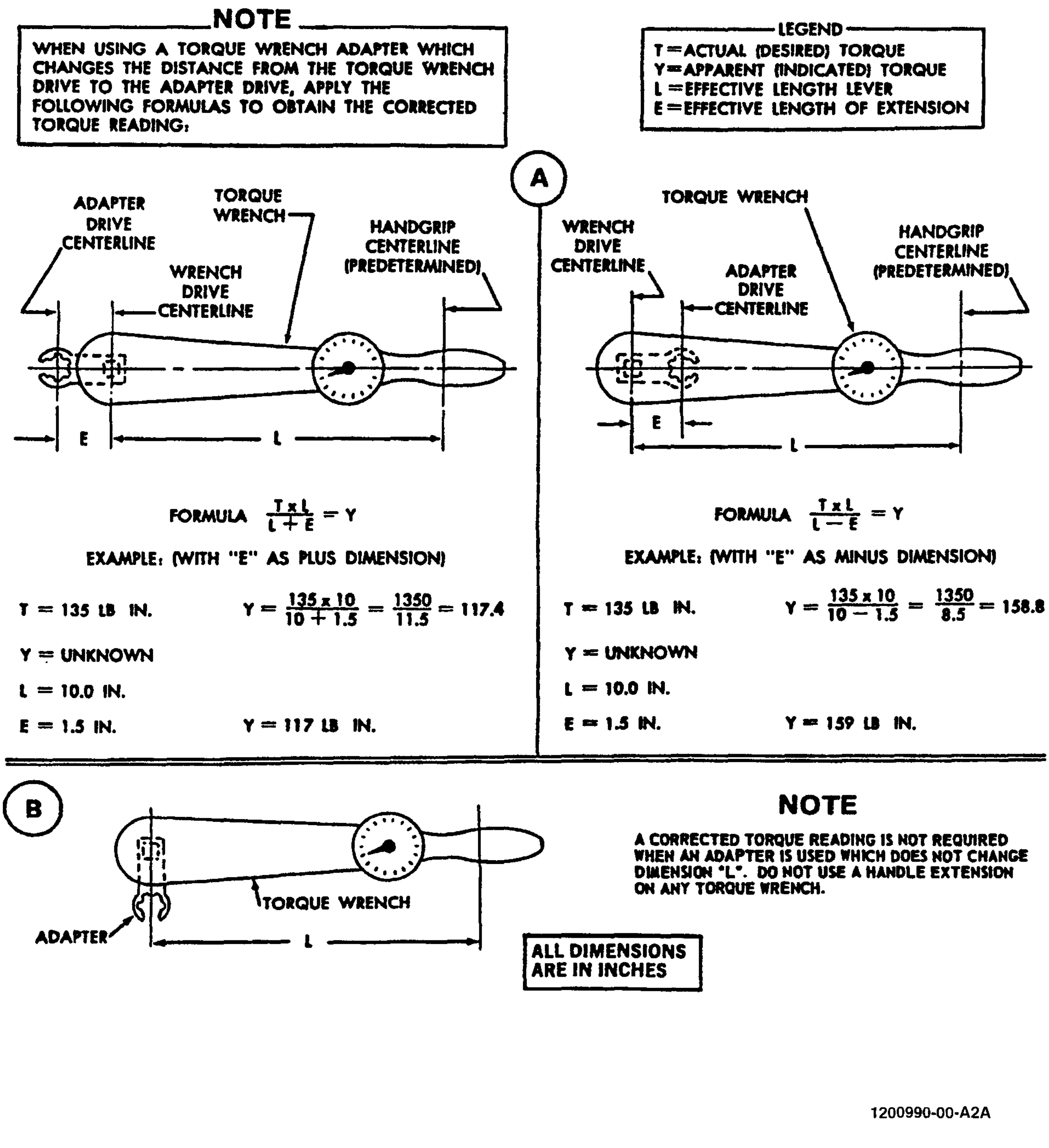


Figure 4. Offset Extension Wrench (Crowfoot) Computations

TABLE 2. DEFINITIONS OF INSPECTION TERMS

Term	Definition	Probable Causes
Abrasion	Roughened surface. May vary from light to severe.	Foreign material between moving parts.
Bend	Distortion in a part. Curvature out of proper contour.	Severe application of heat or excessive force.
Blister	Raised portion of a surface, usually where the surface has separated from the base. Generally found on surface-treated parts (plated or painted surfaces).	Poor original bond with base. Possible aggravation by heat or pressure.
Break	Separation of part.	Severe force, pressure, or overload.
Brinelling	Indentation of the surface, usually found on ball or roller bearings.	Incorrect assembly or disassembly procedure used on bearings, or application of excessive force on bearing.
Brittleness	Loss of resiliency is parent metal.	Severe application of heat, cold, or possible chemical action.
Buckling	Large deformation of the original contour; a bulge in a surface.	Severe pressure, impact of a foreign object, or heat distortion.
Bulge	A raised portion or outward swelling on surface.	Internal pressure.
Bum	A rapid, destructive, oxidizing action. Change in color and appearance often indicates this condition.	Part subjected to higher temperatures than the parent material can withstand structurally.
Burnishing	Smoothing of a metal surface by mechanical action, but without a loss of material; generally found on plain bearing surfaces. Surface discoloration is sometimes present around the outer edges. Normal burnishing from operational service is not detrimental if coverage approximates the carrying load and if there is no evidence of burns.	Operation of mechanical parts.
Burr	Rough edge or sharp projection.	Excessive wear or poor machining.
Chafing	A worn or rubbed area caused by friction.	Wear produced by fuel, lube, and air tubes rubbing against other parts.
Chatter Mark	Surface irregularity.	Machining process.
Chipping	Breaking away of small metallic particles.	Heavy impact of foreign object.

TABLE 2. DEFINITIONS OF INSPECTION TERMS (Cont)

Term	Definition	Probable Causes
Coking	Buildup of carbon deposits.	Deterioration of lubricants or incomplete combustion.
Cold-work	The rework of metal parts at room temperature, using hand tools. The removal of dents in sheet metal parts.	--
Corrosion	Formation of many small pits which cumulatively create a wide cavity (usually shallow) in surface of part.	Oxidation of particles.
Crack	Parting of parent material or of metal in a welded zone, with or without deformation of adjacent areas.	Severe stress from overloading or shock; possible extension of a scratch. Also caused by thermal expansion, vibration, and material fatigue.
Crazing	A mesh of minute hairlike cracks found in glazed or baked-on coated surfaces which do not penetrate into parent metal.	Temperature changes or deformation of parent metal.
Dent	Smooth surface depression. Material is displaced, but not separated.	Careless handling or striking the part; operational wear with foreign-object interference.
Deviation	A condition which causes a part to differ from the manufacturer's drawing.	Wear, rework, etc.
Erosion	The gradual wearing away of material.	Sand or corroding gas or liquids.
Fatigue Failure	Progressive yielding to repeated stress of one or more local areas, aggravated by the cumulative effect of scratches, sharp indentations, cracks, tool marks and inclusions. As the stress is repeated, cracks develop, then spread, usually from the surface (or near the surface) of the particular section. Finally, so little material remains that the normal stress on the part exceeds the strength of the remaining material. This results in separation. It is not caused by metal crystallization and can easily be determined by visual inspection of the part. There will be evidence of several more or less concentric lines. The center (or focus) of the lines indicates the origin of the failure.	High alternating stress. Cracks, tool marks, sharp comers, nicks, galling, inclusions, corrosion, and insufficient tightening of studs or bolts increases the possibility of fatigue failure.
Flaking	Pieces of a plated or painted surface breaking away.	Imperfect bond or severe load.
Fracture	Separation of part.	Severe force, pressure, or overload.
Fretting	Loss of fine particles of metal.	Rubbing action between parts.

TABLE 2. DEFINITIONS OF INSPECTION TERMS (Cont)

Term	Definition	Probable Causes
Galling	Accumulation of foreign material deposited on surfaces.	Movement of two surfaces in contact with one another under severe pressure.
Glazing	Covering of hard, glossy surface on plain bearing areas (sometimes a desirable condition).	Pressure, oil, and heat in combination.
Gouging	Wide, rough scratch or group of scratches, usually accompanied by one or more sharply impressed corners, and sometimes by deformation or removal of material.	Presence of a rather large foreign body between parts in motion.
Grooving	Long, narrow, continuous channels having no sharp edges.	Concentrated wear due to abnormal relative motion of parts.
High Metal	Displaced surface metal.	Nicks, scratches, gouges or dents.
Hot Gas Corrosion (Sulfidation)	The corrosion of unprotected metal (with no coating) that has been exposed to hot gases. When first exposed, the surface becomes rough and appears to be pitted and pockmarked. Also, there is a noticeable difference in the colors of the exposed and unexposed surfaces. Further exposure of surface to hot gases causes it to blister and, in time, to flake off in layers.	This kind of corrosion differs from that normally found on surfaces attacked only by salt in the atmosphere. In hot gas corrosion, the hot gases convert sulphur oxides to sulfates in the presence of salt. The metal is attacked by the resulting deposits.
Hot Spot	Heat blueing of metal on the external surfaces of combustion chamber frame or combustion liner.	A defective fuel nozzle (poor spray pattern) causing uneven burning of fuel in combustion chamber.
Imbalance	The state of being out-of-balance. An unequal distribution of weight about an axis of rotation.	Improper assembly of parts, shifting, damage, etc.
Inclusion	Foreign material impressed into a surface generally indicated by dark spots or lines.	Inherent porous condition in the material.
Looseness	Abnormal movement of a part.	Wear, improper assembly, etc.
Misaligned	A mismatching or malformation of any parts which either prevents perfect assembly or results in faulty operation or ultimate part failure, or both.	Wear, damage, using wrong parts, etc.
Missing Piece	Removal or loss of a portion of parent material due to a combination of defects or damage.	Breaking away of material, burnout, wear, rust, shearing.
Nick	Sharp indentation. The parent material is displaced but usually not separated.	Negligent handling of parts or foreign-object damage during gas turbine operation.

TABLE 2. DEFINITIONS OF INSPECTION TERMS (Cont)

Term	Definition	Probable Causes
No Apparent Depth	Term used to describe surface defects that can be seen visually with a white light, but can not be felt with fingernail or with a scriber.	---
Noisy	An abnormal sound condition of moving parts, usually an increase in volume or change in pitch.	Damaged working parts, misalignment of parts, etc.
Obstruction	Prevention of free flow of air or a fluid (oil, fuel, water) through the flow path.	Foreign material in the flow path, malformation in the flow member.
Oxidation	A surface deterioration that forms as red rust in iron and low-alloy steels at ambient temperatures. The oxides which form on super alloys are complex and can be green or black depending on material composition and temperature at which it is formed.	The chemical reaction between oxygen in the air and the metal surface.
Parent Metal	The basic metal of a part, sometimes referred to as base metal; the term is used particularly in connection with welding, where the parent metal is that being welded rather than that used in the welding rod.	---
Peening	Surface deformation.	Foreign object damage.
Pickup	Transfer of one material into or upon the surface of another.	Insufficient lubrication, unbroken edges of press-fitted parts. Seizure of rotating parts during operation. Improper manufacture.
Pinched	Distortion of one or more surfaces of the parent metal.	External pressure on part.
Pitting	Minute depression or cavities, without sharp, high-stress corners.	Chemical action, oxidation of surface, electrolytic action.
Rub	A surface cavity or impression.	Two surfaces moving against each other.
Scoring	Deep, multiple scratches or elongated gouging.	Presence of metal chips between loaded surfaces that have relative motion.
Scratch	Long, narrow, sharp-cornered impression.	Two surfaces moving against each other.
Scuff	A series of small superficial or shallow scratches.	Wear.
Seizure	A binding of two surfaces which prevent further movement.	Parts failure, shifting of parts, foreign objects.
Sheet Metal Dent	A large, smooth depression in the parent metal.	---

TABLE 2. DEFINITIONS OF INSPECTION TERMS (Cont)

Term	Definition	Probable Causes
Spalling	Sharply roughened area characteristic of progressive chipping or peeling of surface material.	Surface cracks, inclusions, or similar surface damage that causes a progressive breaking away of the parent material.
Spot-Welding	A resistance-welding process in which parts are held together under pressure by electrodes. When the current is turned on, the resistance-to-flow set up by the part creates enough heat to fuse the parts together. Size and shape of spot welds are determined by the size and shape of the electrodes.	---
Tack Weld	A weld made to hold parts in proper alignment until final welding is done. The weld or tacks are made small enough to allow parts to be broken apart if desired.	---
Varnish Film	A hard surface-film on metal; straw-color to dark brown.	Exposure to dry chemicals or fluids (commonly oil) while the part is heated above the breakdown point of the chemical or fluid.
Warped	Not true in plane or in line; out of true shape.	Overstressed, damaged.
Wear	Relatively slow removal of parent material from any cause; frequently not visible to the naked eye.	Chafing, chattering, erosion, oxidation, rubbing, scraping or scuffing.

e. Organization of Inspection Data.

(1) Inspection data for individual parts consists of procedures listed in table format, and related illustrations of the parts.

(2) Inspection tables are arranged as follows:

(a) Inspect Column - Each part listed in this column must be inspected for specific defects. For example, if wear is listed, the applicable limit refers only to wear. Other defects, even though related to wear (galling, pickup, fretting, etc.), are listed separately. Unless otherwise indicated, inspect defects visually.

(b) Usable Limits Column - This column lists the allowable limits for specific defects. If a defect is within these limits, the part does not require corrective action. If the limit is exceeded and if the defect cannot be repaired, replace the part.

(c) Max Repairable Limits Column - This column, which appears in all inspection tables except those with borescope data, lists the limit that is allowable if the defect is to be repaired according to the instructions in Corrective Action column. This limit is always greater than the limit listed in the Usable Limits column.

(d) Corrective Action Column - This column specifies the action to be taken if the maximum repairable limit is exceeded.

f. Crack Description. The following terms are generally used to describe cracks:

NOTE

The heat-affected zone in a welded area is the area in which the micro-structure of the material and/or its physical characteristics are affected by the heat of the welding. Cracks in the heat-affected zone will be considered weld cracks. Cracks outside the heat-affected zone will be considered parent metal cracks.

- Axial: General direction parallel to the centerline of the gas turbine
- Radial: General direction perpendicular to the centerline of the gas turbine
- Transverse: General direction perpendicular to the length of the weld
- Longitudinal: General direction parallel to the length of the weld.

7. STANDARD MAINTENANCE PRACTICES.

a. Cold-Working. Cold-working is a practice in which materials are reworked to original contour (as removal of dents). This procedure is used to repair parts (mostly sheet metal) which have been damaged or changed from their original contour. No heat is applied to the material.

(1) Inspect the part to be repaired.

(2) Using plastic or other soft-faced mallets, pliers and similar hand tools, return the part to its original contour within usable limits specified in manual.

(3) After cold-working, inspect the reworked area for cracks, observing limits in manual.

(4) Compare the repair part with a similar undamaged part.

b. Blending Procedures.

(1) Blending (see figure 5) is a repair procedure that is used to remove stress concentrations caused by nicks, scratches, or other sharp-edged damage marks on parts. Removal of the material surrounding the stress concentration, so that the sharp edges are blended into smooth contour, relieves the stress concentration and permits further use of the part by lessening the danger of cracking.

(2) Blending is also used to remove sharp edges resulting from machining, drilling, etc., and to restore the original contour and/or surface finish to parts that have been repaired by welding, brazing, etc.

(3) Defects more than 0.25 inch (6.4 mm) apart must be blended separately. Those less than 0.25 inch (6.4 mm) apart must be blended together.

(4) The finish on the blended area must be as close as practical to the original finish of the part.

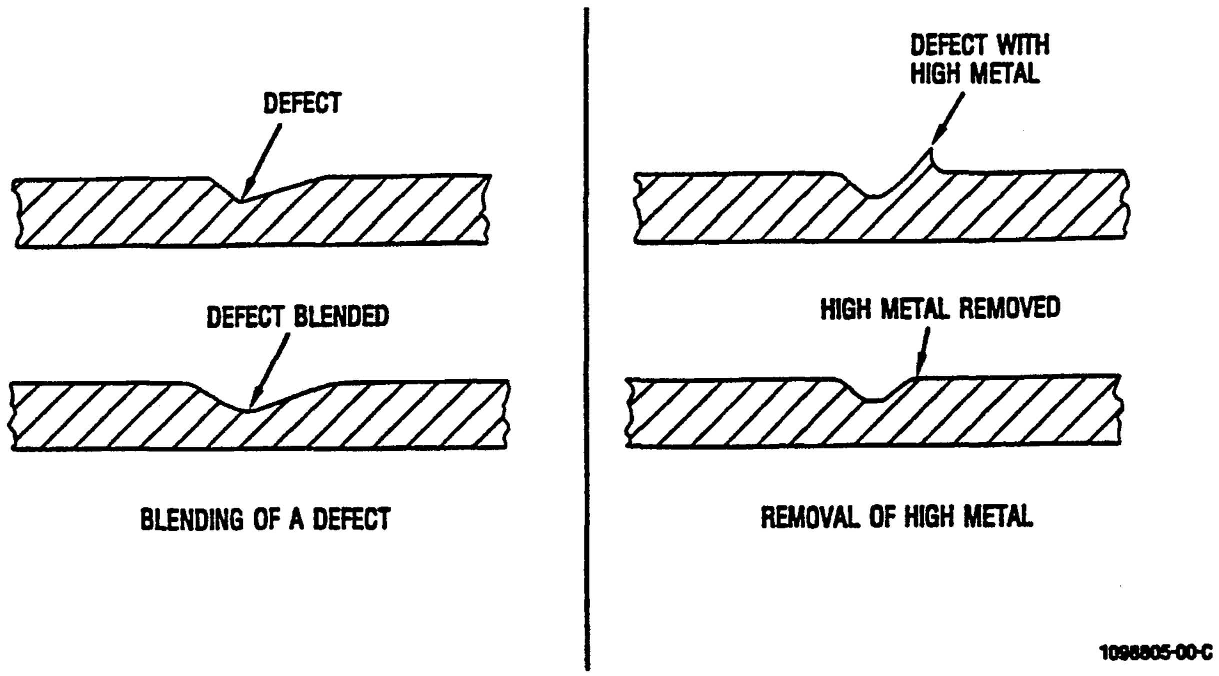


Figure 5. Blending and High Metal Removal

(5) Hand Blending.

(a) Sharp edges can be blended out, using abrasive stones or papers, files, or crocus cloth. Coarse grades of abrasives or files may be used for fast metal removal, but the parts must then be given a smooth surface finish with fine grades of abrasives or crocus cloth.

(b) When blending compressor rotor blades, stator vanes, turbine blades, and similar parts, blend in a radial direction in relation to the gas turbine. Avoid removing metal from leading and trailing edges or airfoil sections in such a way that the edges become thin or sharp; blend so as to maintain approximately the original contour.

(c) When blending a cylindrical part, blend in a circumferential direction, not along the axis of the part.

(6) Power Blending.

(a) Blending on most parts may be done by using a power-driven polishing wheel or rubber-bonded abrasive points. Any special instructions for the individual part must be followed.

WARNING

Power Grinding

- Avoid prolonged or repeated contact with dust. Inhalation of dust may cause temporary coughing and wheezing, respiratory tract irritation, and permanent lung problems. If coughing or wheezing persists, get medical help.
- If dust contacts eyes, flush them thoroughly with water.
- When using an air-exhausted grinding wheel, wear approved respirator, goggles, or face shield.
- If grinder is not equipped with local exhaust ventilation, wear an appropriate respirator and goggles or face shield.

CAUTION

When doing power blending, be sure to avoid building up excessive heat to avoid thermal stresses in the part.

(b) Rough out defects using coarse grades of resilient flexible abrasive impregnated wheels, brushes, or points. Use fine or extra fine grades to finish the blend areas.

(c) After power blending of a titanium part is completed, hand blend the same area approximately 0.002 inch (0.05 mm) deeper to remove any residual stresses in the surface material.

(7) Blending Minor Indications in Tubing.

(a) Use a fine abrasive stone, a small file, emery cloth or crocus cloth for blending.

(b) Blend around the circumference of the tubing. The finished blend must be as close as practical to the original finish of the part.

(8) Removing High Metal. High metal is caused by the displacement of metal above a surface. It is found around defects such as nicks and scratches. Remove high metal as follows:

(a) Use a fine abrasive stone, a small file, emery cloth, or crocus cloth to remove high metal (see figure 5).

(b) Remove only the material that is projecting above the original surface contour.

c. White-Light Inspection.

(1) This method of inspection is to be used on parts that have many sheared openings, such as a combustion liner, because it is difficult to determine the difference between shear marks and cracks using fluorescent penetrant inspection method.

(2) Operational cracking of parts having sheared openings is caused by thermal fatigue. This type of crack is easily seen using white light inspection method. The white light inspection is also used to inspect parts for defects that are visible to the naked eye or with 5X to 10X magnification.

(3) White-light-inspect parts as follows:

(a) Inspect the part for cracks under a bright white light (150-watt standard spotlight or equivalent). Hold light within 4 feet (1.2 meters) of the surface being inspected.

(b) Inspect each area where cracks are suspected (using 5X to 10X magnification) to verify that there is a defect and to determine its course and length.

(c) Mark each unacceptable defect along its entire length (in the crack), using a blue Dykem marker.

d. Alodine 1200 Touchup.

NOTE

The Alodine No. 1200 process is used to touch up and protect reworked and corroded aluminum surfaces. It can be used in place of anodizing and is either brushed or sprayed onto the part. Alodine No. 1200 solution is a thin, golden and iridescent coating. The color may vary with different aluminum alloys.

Phosphoric Acid, O-O-670 **5**

(1) Clean part using phosphoric acid. Keep part wet with phosphoric acid 1 to 5 minutes.

(2) Rinse part thoroughly with clean water.

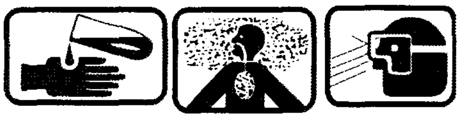
(3) Mix Alodine solution as follows:

Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys, MIL-C-81706 **281**

CAUTION

- Do not use lead or glass containers for mixing or storing the solution.
- Be sure Alodine solution does not come in contact with steel parts.

(a) Add 3 ounces (85 grams) of Alodine No. 1200 powder to each gallon (3.8 liters) of water. Stir mixture until powder is dissolved.



Nitric Acid, O-N-350 **4**

(b) Add 1/2 fluid ounce (15 cc) of concentrated (70 percent) nitric acid per gallon (3.8 liters) of solution, and stir thoroughly. Do not add wetting agents or any other material to this solution.

NOTE

A small amount of material may settle out of the solution; however, it can be disregarded.

(c) Let the solution stand for a minimum of 1 hour before use. Store surplus solution in polyethylene bottles or stainless steel containers.

(4) Brush or spray the Alodine No. 1200 solution on the surfaces of the part and allow solution to set for 3 to 5 minutes.

(5) Remove the excess Alodine with a wet cloth or sponge and rinse the part thoroughly in water.

(6) Allow Alodine coating to air-dry.

(7) Inspect the refinished area. The finish must appear adherent and free from dust.

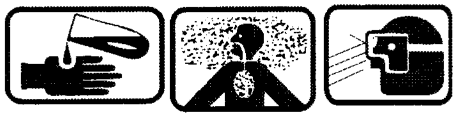
e. Vapor Degreasing.

CAUTION

Do not vapor-degrease titanium or titanium parts, bearings, rubber or plastic parts which can be attacked by organic solvents.

(1) General Information. Vapor degreasing is a cleaning method designed to remove oil, grease and preservative compounds from metal by solvent vapor. Part is immersed in vapor so that when vapor condenses on metal, grease, oil and preservative compounds are carried away. When part reaches temperature of vapor, cleaning action ceases. If further degreasing is necessary, part must be cool before returning to vapor degreaser.

Trichloroethane, O-T-620 **122**



Trichlorotrifluoroethane, MIL-C-81302 **124**

Tetrachloroethylene (Perchloroethylene), O-T-236 **99**

(2) Materials and Equipment.

(a) Solvents recommended for vapor degreasing, in order of preference, are: trichloroethane O-T- 620, trichlorotrifluorethane MIL-L-81302, and tetrachloroethylene (perchloroethylene) O-T-236. These solvents are used to clean metal by the vapor method. Their high vapor density makes it possible to use these solvents with only a small vapor loss.

(b) A flat bottom tank with heating coils installed at bottom, and cooling coils installed internally midway around tank to prevent escape of vapors. A tank cover should also be provided to prevent escape of vapors when tank is not in use. The level of the solvent in tank should be kept 2-4 inches (51-102 mm) above heating coils at all times.

(3) Procedure.

(a) Suspend part to be cleaned into vapor area below cooling coils on tank.

(b) Allow parts to be heated to the same temperature of the vapor. The heated vapor condenses on part to be degreased because the part is relatively cool, thus dissolving oil and grease and carrying it away. When the part is heated to the same temperature of the vapor, the cleaning action ceases.

(c) If further cleaning of the part is required, the part must be removed from tank and allowed to cool before immersion again into vapor.

8. SPECIAL INSPECTION REQUIREMENTS.

The maintenance of the gas turbine requires that inspection checks be made periodically. The inspection requirements and limits throughout this manual are based on operation within specified limits. In addition to the regular inspections, there are special inspections necessary when the gas turbine has operated outside of the specified limits, for example, off-schedule variable geometry operation, overspeed, or overtemperature. There may also be special inspections necessary if the gas turbine has been exposed to abnormal conditions. These events include failures with significant damage and other abnormal exposure such as an installation fire or mishap during transportation, handling, or storage. Some of the conditions to which an engine may be exposed are:

a. Shock loading, collision impact, exposure to explosion, handling or transportation mishap.

b. Structural overstress, mounting system overload to gas turbine interface (e.g., earthquake, installation error).

c. Any equipment failure where parts are not contained within the gas turbine or where a major rotating component separates.

d. Sudden seizure or stoppage of the gas turbine rotor(s) or driven equipment rotors.

e. Excess G-loading during operation in excess of packager manual limits.

f. Significant inlet ingestion events (e.g., foreign objects causing significant flowpath damage, ice ingestion, inlet system failure).

g. Exposure to external fire, involving inlet system, exhaust system, base, enclosure, and equivalent.

h. Exposure to external fire in storage or transport.

i. Internal fire.

j. Thermal quench by water or other agent, local overheating by fuel or steam system failure.

k. Exposure to corrosive chemicals, fire-fighting agents, salt water, or sewage.

These events are highly variable and the exposure and associated damage which a gas turbine experiences is unpredictable. This prevents establishing a single, all-inclusive inspection and repair procedure. Depending upon the circumstances of the event, instances of localized, limited damage can often be dispositioned by normal channels.

For abnormal events such as the events listed above, execution of a special inspection workscope is necessary for proper restoration of serviceability. In some extreme cases, repair may not be possible or economical, and therefore, further repair effort may not be advisable. Before proceeding with inspection or repair action to restore serviceability after a mishap, contact the following for guidance:

GE Aircraft Engines
Marine & Industrial Customer service
Mail Drop S-155
1 Neumann Way
Cincinnati, Ohio 45215-1988 USA

Assurance of a part's serviceability is derived from control of material processing and manufacturing, operation within defined limits, and maintenance within defined limits and processes, as well as by inspection. Parts exposed to abnormal conditions may appear to be serviceable when in fact the actual state of the material cannot be ascertained even by the most advanced non-destructive testing and inspection methods. Parts which have been involved in an abnormal event must be formally reviewed for severity of operation beyond the normal working environment and dispostioned as to the necessity for a special inspection workscope. The operator has the responsibility for the continued safe operating condition of the gas turbine. Since used replacement parts may be available which have operated in abnormal events, the operator should verify that the service histories of these parts are known and that, when applicable, the required special inspections and part disposition following exposure to abnormal conditions have been completed and that the part is serviceable.

Similarly, many components or assemblies from aircraft engines which have experienced previous flight service are not usable in LM engines. In addition, gas turbine components which have experienced an extremely high number of start/stop cycles, or partial cycles, such as in commercial marine service, may not be usable. Specifically, use of used-serviceable flight or high-cycle engine parts in the following categories should be evaluated prior to use:

1. Rotating components.
2. Stator cases and stator vanes.
3. Frame assemblies.
4. Main shaft bearings.

Prior to use of other components, contact Marine and Industrial Engines Customer Service about usability.

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

PREVENTIVE MAINTENANCE

PERIODIC INSPECTIONS AND MAINTENANCE

(LEVEL 1 MAINTENANCE)

Effectivity:	L32119G01/-G03/-G04/ -G05/-G06	MARINE GAS TURBINE
	L32119G02	INDUSTRIAL GAS TURBINE

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Periodic Inspections and Maintenance (Industrial Only)	3
Periodic Inspections and Maintenance (Marine Only)	2
Support Equipment	1

1. **INTRODUCTION**. This work package provides instructions for periodic inspections and maintenance tasks to be done on a regular schedule, based on calendar time. Preventive maintenance consists of scheduled inspections, compressor cleaning (water wash), servicing, calibration, troubleshooting, and adjustment of an installed gas turbine. The detailed procedures are contained in reference work packages given in table 1 for the Marine gas turbine and table 2 for the Industrial gas turbine.

2. **SUPPORT EQUIPMENT**.

None

3. **CONSUMABLE MATERIALS**.

None

4. **PERIODIC INSPECTIONS AND MAINTENANCE (MARINE ONLY)**. Refer to table 1 for periodic inspections and maintenance frequency.

TABLE 1. PERIODIC INSPECTIONS AND MAINTENANCE (MARINE ONLY)

Maintenance Item	Monthly	Engine Change	100 Operating Hours	6 Months Interval	12 Month Interval	Reference Work Package
Gas Turbine Inlet Inspection				X		009 00
Borescope Inspection				X		010 00
Gas Turbine Exhaust Inspection				X		011 00
Variable Stator Vanes (VSV) System Inspection and Rigging				X		012 00
Chip Detectors and Drain Plug Inspection	X					013 00
Preservation of Installed Gas Turbines (As Required)						014 00
Spectrometric Oil Analysis Program (SOAP)	X					015 00
Gas Turbine External Inspection	X					016 00
Compressor Cleaning (Water Wash) (As Required)						017 00
Ignition System Test				X		018 00
Lubrication System Servicing				X		019 00
Fuel System Servicing (As Required)						020 00
Velocity Pickup Calibration		X	X		X	Note 1
Accelerometer Calibration					X	Note 1

Note 1 - Send pickups to laboratory for shake test to verify output accuracy.

5. **PERIODIC INSPECTIONS AND MAINTENANCE (INDUSTRIAL ONLY)**. Refer to table 2 for periodic inspections and maintenance frequency.

TABLE 2. PERIODIC INSPECTIONS AND MAINTENANCE (INDUSTRIAL ONLY)

Maintenance Item	Three Months Interval	Six Months Interval	Reference Work Package
Gas Turbine Inlet Inspection		X	009 00
Borescope Inspection		X	010 00
Gas Turbine Exhaust Inspection		X	011 00
Variable Stator Vanes (VSV) System Inspection and Rigging		X	012 00
Chip Detectors and Drain Plug Inspection	X		013 00
Preservation of Installed Gas Turbines (As Required)			014 00
Spectrometric Oil Analysis Program (SOAP)		X	015 00
Gas Turbine External Inspection	X		016 00
Compressor Cleaning (Water Wash) (As Required)			017 00
Ignition System Test		X	018 00
Lubrication System Servicing		X	019 00

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

GAS TURBINE INLET INSPECTION

(LEVEL 1 MAINTENANCE)

Effectivity:	L32119G01/-G03/-G04/ -G05/-G06	MARINE GAS TURBINE
	L32119G02	INDUSTRIAL GAS TURBINE

Alphabetical Index

Subject	Page No.
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Inspection of Gas Turbine Inlet	2
Introduction	1
Support Equipment	1

1. **INTRODUCTION**. This work package provides instructions for inspecting the gas turbine inlet area. Only those checks critical to gas turbine operation are denoted in this work package.

2. **SUPPORT EQUIPMENT**.

Support Equipment

Part No.	Nomenclature
2C91111G01	Borescope Kit
---	Bright Light
---	Mirror, Inspection

3. **CONSUMABLE MATERIALS**.

NOTE

Equivalent materials approved by GE Aircraft Engines may be substituted for items listed.

Consumable Materials

Description	Manufacturer
Brush, Soft-Bristle	Local Purchase
Gloves, Thermally Insulated	Local Purchase
Lockwire, 0.032 inch (0.81 mm) diameter	Local Purchase
Solvent, Dry Cleaning (Stoddard Solvent) P-D-680	Local Purchase

4. INSPECTION OF GAS TURBINE INLET.

a. Before entering the gas turbine area to inspect the gas turbine inlet (see figure 1), do the following:

(1) Shut down the gas turbine.

(2) Deactivate the fire extinguishing system.

WARNING

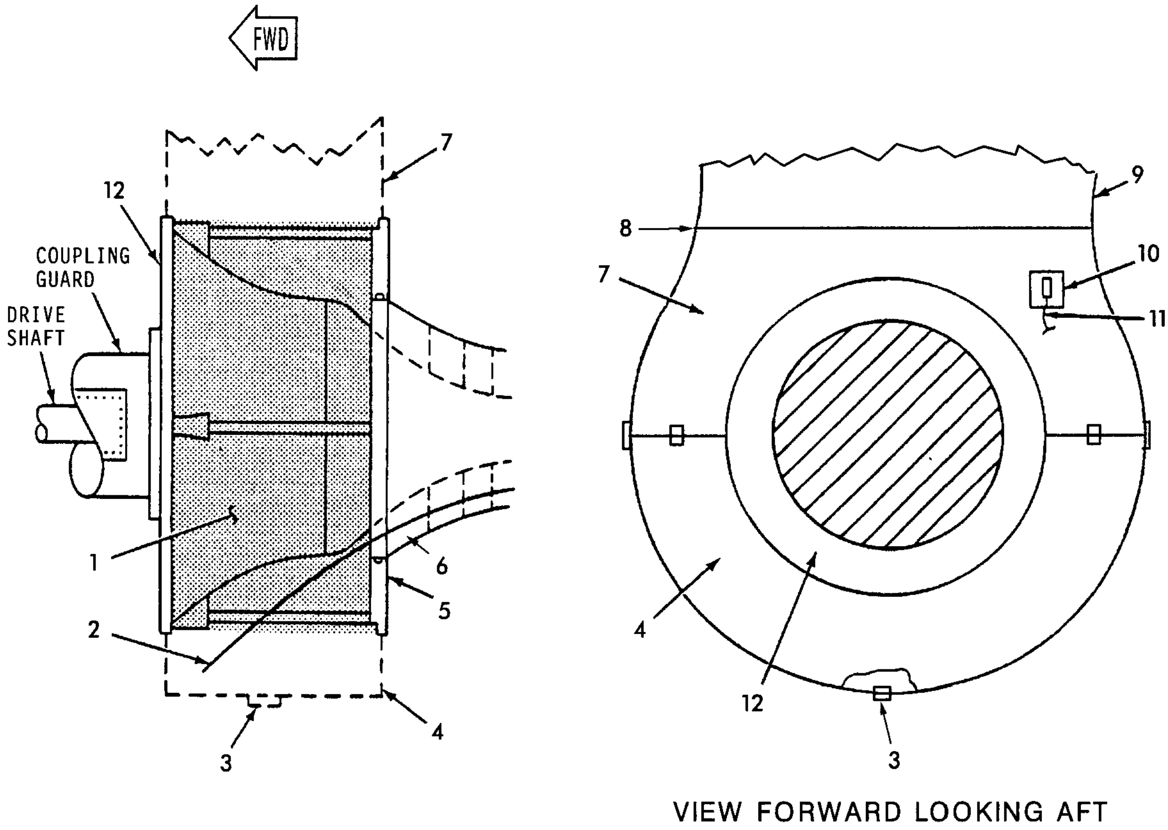
Handling Hot Parts

- When handling hot parts, wear approved gloves.
- Handling of hot parts with bare hands may cause reddening and blistering of skin, or third-degree bums.
- If skin is burned, immerse contacted area in cold water for 10 minutes. If pain or blistering persists, immediately get medical attention.

(3) Allow the gas generator to cool to room temperature. (Avoid contact with hot parts: wear thermally insulated gloves, if necessary.)

(4) Tag electrical switches "Out-Of-Service" to preclude inadvertent activation. Tag the gas turbine operating controls "Do Not Operate" to prevent starting during a desired shutdown condition.

b. Unlatch and lower, or remove, the lower half of inlet plenum (4). Verify that the inlet plenum drain port (3) is unobstructed and open.



1. Inlet Screen
2. Borescope Path
3. Inlet Plenum Drain Port
4. Inlet Plenum (Lower Half)
5. Inlet Housing-to-Gas Turbine Seal
6. Compressor Inlet
7. Inlet Plenum (Upper Half)
8. Inlet Duct-to-Plenum Seal
9. Inlet Duct
10. CIT Sensor
11. Shielded Capillary Tube
12. Inlet Housing

C
000LM5-058200

Figure 1. Gas Turbine Inlet

CAUTION

- The CIT sensor (10) is connected to the VG control assembly by a shielded capillary tube (11). The sensor, tube, and brazed connections are fragile and may be damaged or destroyed by mishandling.
- Care must be taken when removing the sensor to avoid bending or puncturing the sensor or tube resulting in loss of critical control functions.

c. Remove the sensor (10) from the upper half inlet plenum (7) as follows:

(1) Unfasten any clamps between the tube (11) and the sensor (10) to allow free movement of the tube.

(2) Remove lockwire and bolts securing sensor (10) to inlet plenum (7). Carefully remove sensor.

(3) Inspect sensor (10) for evidence of impact damage or cracking.

Dry Cleaning Solvent (Stoddard Solvent), P-D-680 **32**

(4) Using a soft-bristle brush soaked with dry cleaning solvent, clean the sensor (10) to remove any dirt or contaminants.

(5) Inspect seal or gasket between sensor mounting plate and inlet plenum flange. Replace if damaged.

d. Raise and latch the inlet duct (9).

e. Remove the upper half of the inlet plenum (7) and do the following:

(1) Inspect the upper and lower halves of the inlet plenums (7, 4) and the inlet screen (1) for cleanliness, corrosion, loose or missing fasteners, cracked welds or damage. Use a bright light and inspection mirror, as necessary, to inspect inlet screen (1).

(2) Verify that the inlet duct-to-plenum seal (8) and the inlet housing-to-gas turbine seal (5) are in place and intact.

f. If any damage, looseness, or penetration of the inlet screen (1) is noted, do the following:

(1) Remove four bolts and remove inlet screen (1).

(2) Using instructions in WP 010 00, borescope-inspect compressor inlet (6) through inlet housing (12). (Note borescope path (2).)

(3) Reinstall inlet screen (1). Using four bolts, secure inlet screen.

g. Reinstall the lower half of the inlet plenum (4) and, if disconnected, reconnect the drain tube to drain port (3).

h. Reinstall the upper half of the inlet plenum (7) by placing inlet plenum in position on seal.

i. Unlatch and lower the inlet duct (9) onto the upper half of the inlet plenum (7). Install and tighten flange bolts.

j. Reinstall the sensor (10), tube (11), and clamps as follows:

CAUTION

- The sensor (10) is connected to the VG control assembly by tube (11). The sensor, tube, and brazed connections are fragile and may be damaged or destroyed by mishandling.
- Care must be taken when installing the sensor to avoid bending or puncturing the sensor or tube resulting in loss of critical control functions.

(1) Using bolts, secure sensor (10) to the upper half of the inlet plenum (7).

(2) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire the bolts that secure sensor (10), using the double-strand method (WP 007 00).

(3) Fasten clamps between the tube (11) and the sensor (10).

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

BORESCOPE INSPECTION

(LEVEL 1 MAINTENANCE)

Effectivity:	L32119G01/-G03/-G04/-G05/-G06	MARINE GAS TURBINE
	L32119G02	INDUSTRIAL GAS TURBINE

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1. **INTRODUCTION**. This work package provides instructions to borescope-inspect internal areas of the assembled gas turbine.

2. **SUPPORT EQUIPMENT**.

Support Equipment

Part No.	Nomenclature
2C91071G01	Adapter, Igniter Port Borescope
2C91111G01	Borescope Kit

3. CONSUMABLE MATERIALS.

NOTE

Equivalent materials approved by GE Aircraft Engines may be substituted for items listed.

Consumable Materials

Description	Manufacturer
Alcohol, Isopropyl (TT-I-735)	Local Purchase
Beeswax	Local Purchase
Cloth, Lint-Free	Local Purchase
Compound, Magnesium Hydroxide (Unflavored Milk of Magnesia)	Local Purchase
Gloves, Thermally Insulated	Local Purchase
Oil, Penetrating (VV-P-216)	Local Purchase
Lockwire, 0.032 inch (0.81 mm) diameter	Local Purchase

4. GENERAL INSTRUCTIONS.

a. Only approved personnel is allowed to borescope-inspect the gas turbine. Incorrect inspection can cause gas turbine removal that is not necessary.

b. Borescope inspection procedures are provided to determine the conditions that can decrease the life of a part or cause the gas turbine performance to become unsatisfactory. These borescope inspection procedures allow the operator to inspect specified internal parts of an assembled gas turbine.

c. The most important functions of borescope inspections are to:

- Monitor the compressor for foreign object damage (FOD)
- Monitor the hot-section parts for uneven temperature distribution
- Look for possible indications of high temperature stress
- Monitor sensitive areas of the gas turbine.

d. Borescope inspection can help to decrease the number of times that:

- The gas turbine is removed
- Maintenance is done that was not scheduled
- Teardown inspections are done.

NOTE

Borescope inspections are not as complete as periodic tear-down inspections.

e. To be sure that the complete stage (all blades) has been visually inspected, use the locking screw as a reference mark. This will make sure that a full 360° turn of the compressor rotor has been inspected. (Refer to figure 1 for a typical view of the stages 3 through 14 locking screw.) The cranking pad found between the fuel pump pad and the lube pump pad on the accessory drive gearbox assembly can be used to rotate the compressor rotor 360°.

f. The borescope ports that are available on the gas turbine for the borescope inspections have different dimensions.

g. The length of the borescope probe must be a minimum of 10.5 inches (267 mm).

h. There are a number of borescope ports located on the gas turbine (see figure 2) which can be used to inspect the internal parts of the gas turbine. Also, refer to table 1 for details of what can be viewed from designated borescope ports.

TABLE 1. BORESCOPE PORT LOCATIONS

Port Designation (Refer to Figure 2)	Position (Aft Looking Forward)	Location	View
S17	1 o'clock	Combustion Chamber Frame	Fuel Injector
S18	2 o'clock	Igniter Port	Stage 1 Turbine Nozzle, Stage 1 HPT Blades, and Stage 1 HPT Shrouds
S18	2 o'clock	Igniter Port	Stage 1 Turbine Nozzle, and Combustion Liner Inner and Outer Shells
S18	2 o'clock	Igniter Port	Combustion Liner Swirler
S20	5 o'clock	Combustion Chamber Frame	Fuel Injector
S22	8 o'clock	Combustion Chamber Frame	Fuel Injector
S23	10 o'clock	Igniter Port	Combustion Liner Swirler and Fuel Injector
S23	10 o'clock	Igniter Port	Stage 1 Turbine Nozzle
S23	10 o'clock	Igniter Port	Stage 1 HPT Blade Tip and Stage 1 HPT Shrouds
S23	10 o'clock	Igniter Port	Stage 1 Turbine Nozzle Trailing Edge and Stage 1 HPT Blades
S33	2 o'clock	Compressor Casing (IGV)	IGV Trailing Edge and Stage 1 Blade Leading Edge

TABLE 1. BORESCOPE PORT LOCATIONS (Cont)

Port Designation (Refer to Figure 2)	Position (Aft Looking Forward)	Location	View
S33	2 o'clock	Compressor Casing (IGV)	Stage 1 Blade Leading Edge and Stage 1 Vanes
S33	2 o'clock	Compressor Casing (IGV)	IGV Trailing Edge and Stage 1 Blade Leading Edge
S34	2 o'clock	Compressor Casing (Stage 2)	Stage 2 Vane Leading Edge and Stage 2 Blade Trailing Edge
S34	2 o'clock	Compressor Casing (Stage 2)	Stage 2 Vane Trailing Edge and Stage 3 Blade Leading Edge
S34	2 o'clock	Compressor Casing (Stage 2)	Stage 1 Vane Trailing Edge, Stage 2 Blade Leading Edge, and Stage 2 Blade Trailing Edge
S34	2 o'clock	Compressor Casing (Stage 2)	Stage 2 Vane Leading Edge and Stage 2 Blade Trailing Edge
S35	2 o'clock	Compressor Casing (Stage 6)	Stage 6 Vane Leading Edge and Stage 6 Blade Trailing Edge
S35	2 o'clock	Compressor Casing (Stage 6)	Stage 7 Vane Leading Edge, Stage 7 Blade Leading Edge, and Stage 7 Blade Trailing Edge
S36	12 o'clock	Compressor Casing (Stage 12)	Not accessible through heat shield
S37	2 o'clock	Compressor Casing (Stage 8)	Stage 8 Blade Trailing Edge and Stage 8 Vane Leading Edge
S37	2 o'clock	Compressor Casing (Stage 8)	Stage 9 Blade Leading Edge
S38	11 o'clock	Compressor Casing (Stage 2)	Stage 1 Vanes and Stage 2 Blades
S38	11 o'clock	Compressor Casing (Stage 2)	Stage 2 Vanes
S38	11 o'clock	Compressor Casing (Stage 2)	Stage 2 Blades, Stage 2 Vanes, and Stage 3 Blades
S39	11 o'clock	Compressor Casing (IGV)	Stage 1 Blade Leading Edge and IGV Trailing Edge
S39	11 o'clock	Compressor Casing (IGV)	Stage 1 Blades and Stage 1 Vanes

TABLE 1. BORESCOPE PORT LOCATIONS (Cont)

Port Designation (Refer to Figure 2)	Position (Aft Looking Forward)	Location	View
S40	10 o'clock	Compressor Casing (Stage 12)	Stage 12 Blades
S40	10 o'clock	Compressor Casing (Stage 12)	Stage 12 Vanes, Stage 13 Blades, and Stage 13 Vanes
S40	10 o'clock	Compressor Casing (Stage 12)	Stage 13 Vanes, Stage 13 Blades, and Stage 14 Blades
S41	10 o'clock	Compressor Casing (Stage 10)	Stage 10 Vanes and Stage 11 Blades
S41	10 o'clock	Compressor Casing (Stage 10)	Stage 11 Vanes and Stage 11 Blades
S45	2:30 o'clock	Compressor Casing (Stage 3)	Stage 3 Blade Trailing Edge and Stage 4 Blade Leading Edge
S47	9:30 o'clock	Compressor Casing (Stage 7)	Stage 7 Blade Trailing Edge and Stage 8 Blade Leading Edge
S48	1:30 o'clock	Compressor Casing (Stage 9)	Stage 9 Blade Trailing Edge and Stage 10 Blade Leading Edge
S49	4:30 o'clock	HPT Casing (Stage 2)	Stage 1 Blade Trailing Edge and Stage 2 Blade Leading Edge
S50	4:30 o'clock	LPT Casing (Stage 4)	Stage 3 Blade Trailing Edge and Stage 4 Blade Leading Edge
S51	4:30 o'clock	LPT Casing (Stage 5)	Stage 4 Blade Trailing Edge and Stage 5 Blade Leading Edge

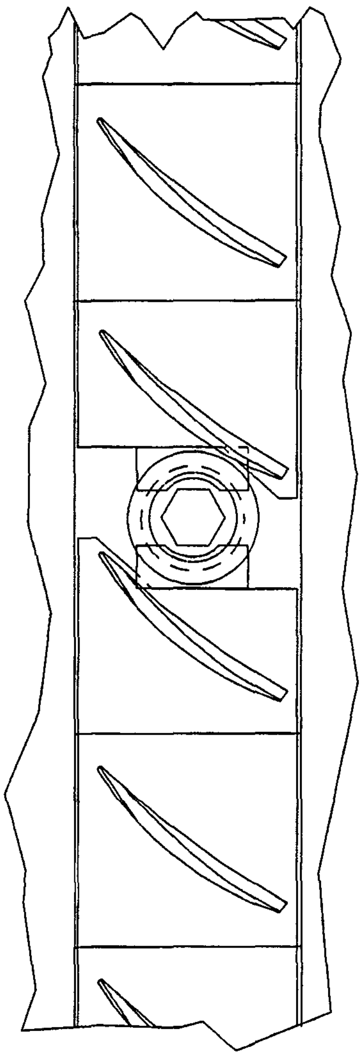

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Figure 1. View of Locking Screw on Stages 3 Through 14 (Typical)

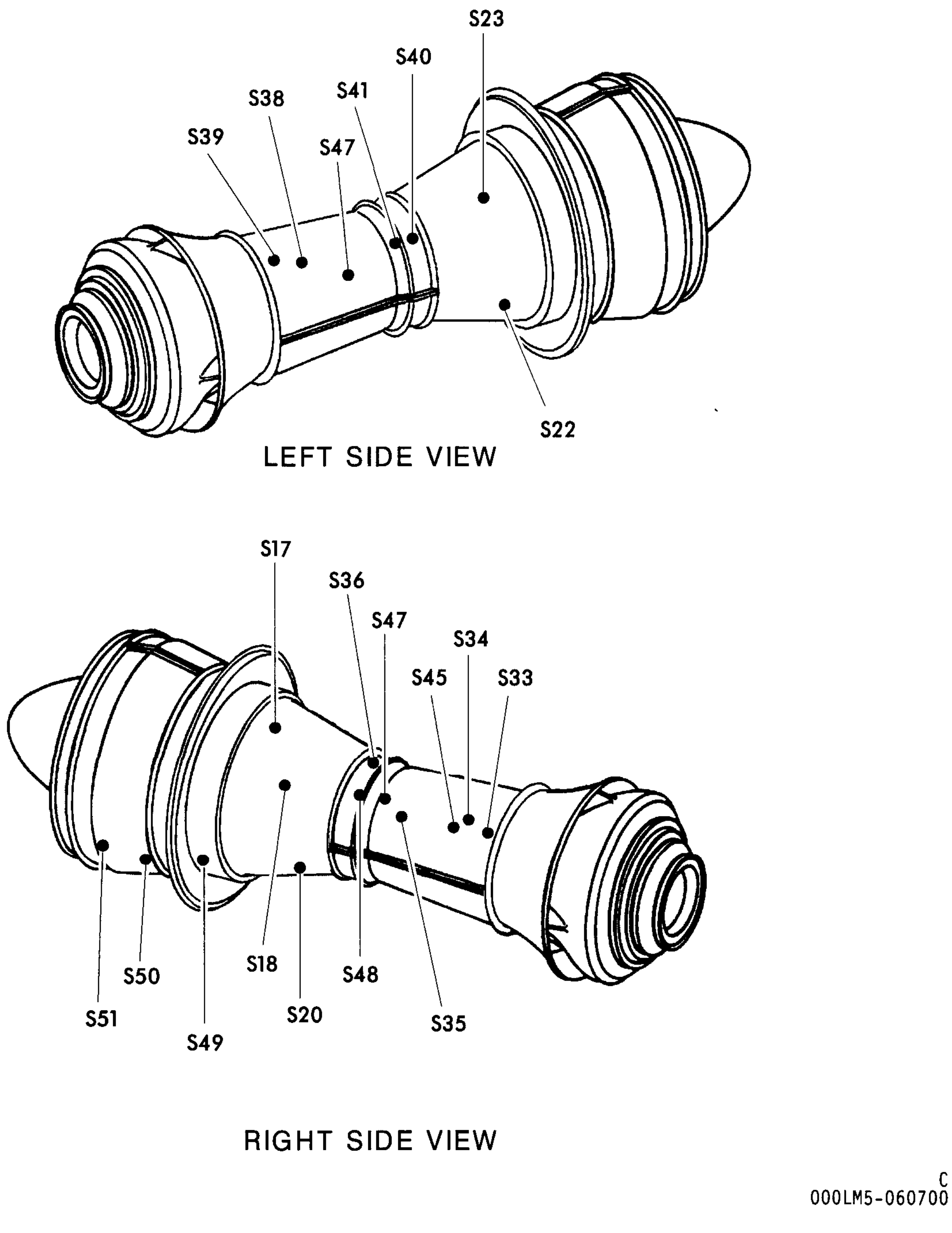


Figure 2. Location of Borescope Ports (Sheet 1 of 2)

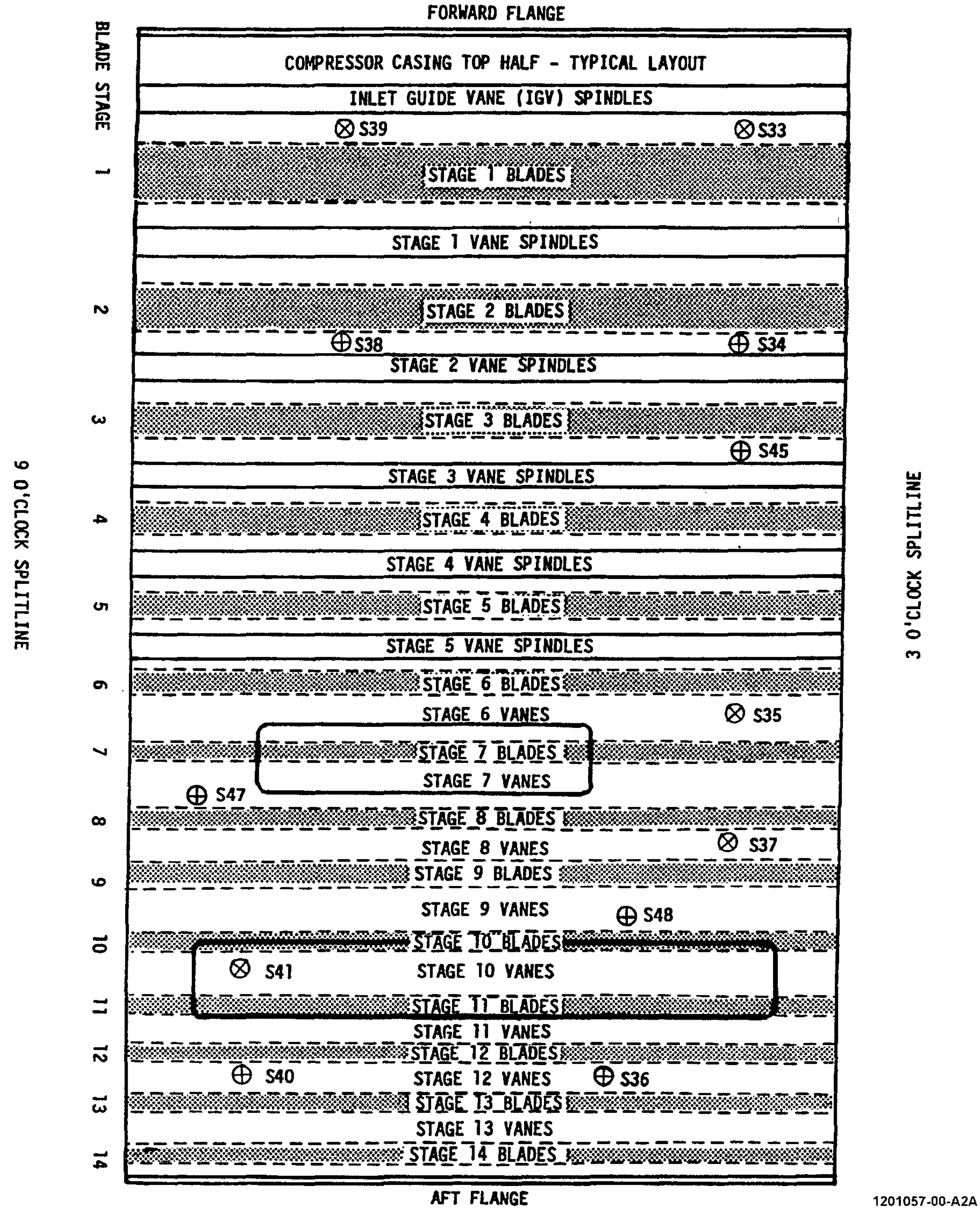


Figure 2. Location of Borescope Ports (Sheet 2 of 2)

i. A complete inspection using the borescope kit allows the operator to inspect the following:

(1) The compressor inlet guide vanes (IGV's) and the stage 1 compressor rotor blades and vanes through borescope ports S33 and S39 (on compressor casing).

(2) The stages 2 through 10 compressor rotor blades and vanes through borescope ports S34, S35, S37, S38, S41, S45, S47, and S48 (on compressor casing).

(3) The stage 11 compressor rotor blades and vanes with visible portions of stage 10 vanes through borescope port S41 (on compressor casing).

(4) The stages 12, 13, and 14 compressor rotor blades and stages 12 and 13 vanes through borescope ports S36 and S40 (on compressor casing).

NOTE

During normal hot section-parts inspection, if a piece of a part (not clearly visible) is damaged, inspection ports S17, S18, S20, S22, or S23 on the combustion chamber frame can be used to do a more complete inspection of the part.

(5) The combustion liner dome, inner shell, outer shell, fuel injectors, and swirlers through borescope ports S18 and S23 (on the combustion chamber frame through the igniter port).

(6) The stage 1 turbine nozzle partitions and the stage 1 turbine rotor blades through borescope ports S18 and S23 (on the combustion chamber frame through the igniter port).

(7) The stage 1 and stage 2 HPT rotor blades through borescope port S49 (on the HPT casing).

(8) The stages 3 through 5 LPT rotor blades through borescope ports S50 and S51 (on the LPT casing).

5. SETUP OF BORESCOPE KIT 2C91111G01.

a. Remove the protective cover from the light source set (see figure 3).

b. Turn the light source ON/OFF switch to the OFF position and turn the brightness switch to L (low).

c. Connect the light source to a 115 volt, 60 Hz power source.

Isopropyl Alcohol, TT-I-735 11

CAUTION

Borescopes are delicate instruments. Handle all parts carefully and return them to their case when not in use.

d. Using a lint-free cloth soaked with isopropyl alcohol, clean the eyepiece, the lens, and each of the two ends of the flexible fiber optic cable.

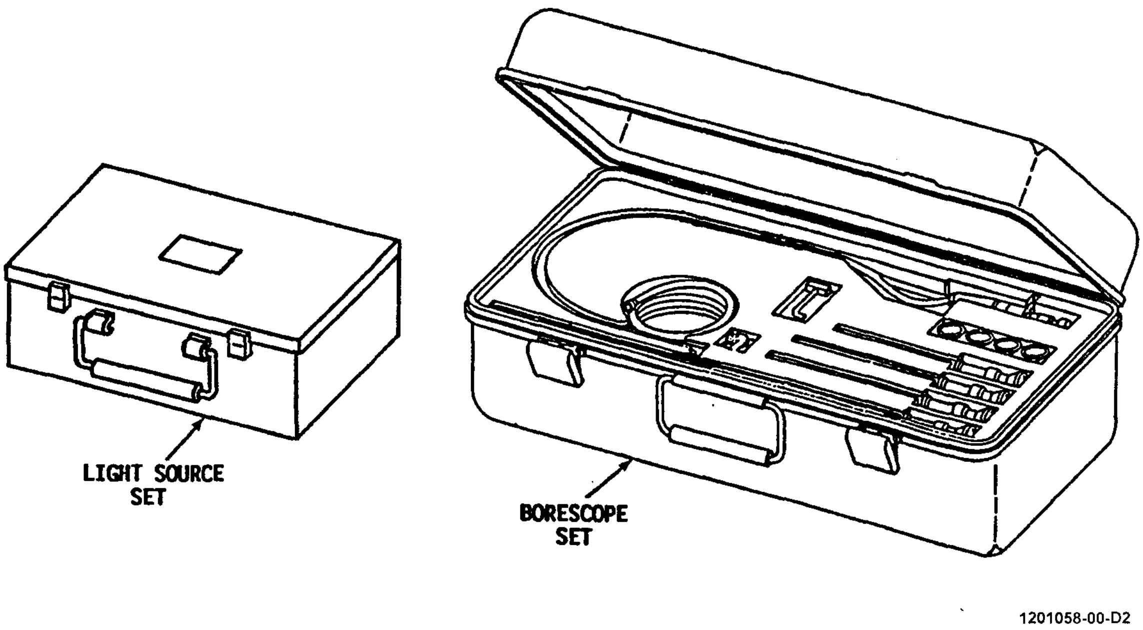


Figure 3. Borescope Kit 2C91111G01

NOTE

- Inspection of combustion section with rigid borescope is accomplished in the same way at each inspection port.
- The flexible borescope is used for inspection through igniter plug ports and inspection of gas turbine inlet.

e. Connect one end of the flexible fiber optic cable to the light source and connect the other end to the applicable borescope probe.

f. Before entering the gas turbine area to borescope-inspect the gas turbine, do the following:

(1) Shut down the gas turbine.

(2) Deactivate the fire extinguishing system.

WARNING

Handling Hot Parts

- When handling hot parts, wear approved gloves.
- Handling of hot parts with bare hands may cause reddening and blistering of skin, or third-degree bums.
- If skin is burned, immerse contacted area in cold water for 10 minutes. If pain or blistering persists, immediately get medical attention.

(3) Allow the gas generator to cool to room temperature. (Avoid contact with hot parts: wear thermally insulated gloves, if necessary.)

(4) Tag electrical switches "Out-Of-Service" to preclude inadvertent activation. Tag the gas turbine operating controls "Do Not Operate" to prevent starting during a desired shutdown condition.

(5) Remove customer equipment that prevents access to borescope inspection ports.

6. BORESCOPE INSPECTION OF COMPRESSOR CASING, INLET GUIDE VANES, COMPRESSOR ROTOR BLADES, VARIABLE VANES, AND STATIONARY VANES.

CAUTION

Be careful and do not let unwanted objects or material go into the opening in the accessory drive gearbox (AGB). Damage to the AGB can occur.

a. Remove the snapring and the cranking pad cover (found between the fuel control and the lube and scavenge pump) on the aft side of the accessory drive gearbox.

b. Connect a 3/8-inch drive extension to a ratchet wrench, then put the extension into the 3/8-inch square hole in the gearshaft.

c. Slowly turn the ratchet wrench in a clockwise or a counterclockwise direction to turn the rotor.

d. Borescope-inspect the right side and the left side of compressor as follows:

NOTE

The procedure that follows is applicable to the right side and the left side of the compressor. The differences between the two are specified.

(1) For the right side of the compressor, remove the borescope port plugs S33, S34, S35, S37, S45, and S48 that are found on the compressor casing (see figure 2).

(2) For the left side of the compressor, remove the borescope port plugs S38, S39, S40, S41, and S47 that are found on the compressor casing.

CAUTION

- Only approved personnel is allowed to borescope-inspect the gas turbine. Incorrect inspection can cause gas turbine removal that is not necessary.
- Be sure the inlet turbine temperature is less than 122°F (50°C) before you start the borescope procedure. Damage to the borescope can occur if the temperature is more than 122°F (50°C).

NOTE

It will be easier to see the components to be inspected if you use a rigid borescope that is 0.236 inch (6.0 mm) or less diameter, and will view at a right angle.

(3) Turn the light source ON/OFF switch to the ON position and turn the brightness switch from the L to the H position.

CAUTION

Be very careful and do not let the borescope probe touch the rotor or the rotor blades when you put probe into the gas turbine. Damage to the rotor and the rotor blades can easily occur.

(4) Insert the borescope probe approximately 0.750 inch (19.05 mm) into the borescope port on the compressor casing.

(5) Adjust the depth of the borescope probe and rotate probe until you can see the compressor blade.

CAUTION

- Before you turn the rotor, be sure the borescope probe will not touch the internal parts of the gas turbine. Damage to the internal parts of the gas turbine and to the borescope probe can occur.
- Count the rotor blades as you look at them when you inspect the stages 1 and 2 compressor rotor blades. Stage 1 has 30 blades and stage 2 has 38 blades. These stages do not have locking screws and an incorrect inspection can cause gas turbine removal that is not necessary.

NOTE

- The leading edge and the trailing edge of the rotor blade can be seen from the same angle.
- The fuel pump will make a loud ratcheting noise when you turn the ratchet wrench.
- One complete turn of the cranking pad equals 2-1/2 complete turns of the compressor rotor.

(6) Slowly turn the ratchet wrench in a clockwise or a counterclockwise direction to turn the cranking pad, and inspect the compressor casing, the inlet guide vanes, the rotor spools, the rotor blades, the variable vanes, and the stationary vanes. Refer to table 2 for inspection limits and corrective action.

(7) Turn the brightness switch on the light source from the H to the L position and put the ON/OFF switch to the OFF position.

(8) Carefully remove the borescope probe from the borescope port.

(9) Using procedures in steps (1) through (8), do a borescope inspection through other borescope ports.

NOTE

A thin coat of beeswax can be applied to the borescope plug sealing washer to help hold the washer in the correct position during installation.

(10) Lubricate the external threads of the removed borescope plugs with magnesium hydroxide compound (unflavored milk of magnesia). Let compound dry before installing plugs.

(11) For the right side of the compressor, install the borescope port plugs S34, S37, S45, and S48. Torque the plugs to 70-80 lb in. (7.9-9.0 N·m).

(12) For the right side of the compressor, install the borescope port plugs S33 and S35. Torque the plugs to 90-100 lb in. (10.2-11.3 N·m).

(13) For the left side of the compressor, install the borescope port plugs S38, S40, and S47. Torque the plugs to 70-80 lb in. (7.9-9.0 N·m).

(14) For the left side of the compressor, install the borescope port plugs S39 and S41. Torque the plugs to 90-100 lb in. (10.2-11.3 N·m).

(15) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire borescope plugs using the double-strand method (WP 007 00).

TABLE 2. BORESCOPE INSPECTION OF COMPRESSOR CASING, INLET GUIDE VANES, COMPRESSOR ROTOR BLADES, VARIABLE VANES, AND STATIONARY VANES

Inspect	Usable Limits	Corrective Action
a. Visible areas of the compressor casing for:		
(1) Abradable coating that has come off.	Permitted if the gas turbine performance and vibration levels are satisfactory, and there is no unserviceable FOD.	If there is unserviceable FOD, replace gas turbine.
(2) Rub marks because the blades have rubbed the compressor casing.	Permitted if: (a) There is no high metal. (b) The external area of the compressor casing is not discolored because of heat. (c) The gas turbine performance and vibration levels are satisfactory. (d) There is no unserviceable FOD.	If the defect is more than the usable limits, replace gas turbine.
b. Inlet guide vanes (see figure 4) for:		
(1) Cracks in the parent metal.	None permitted.	Replace gas turbine.
(2) Nicks, dents, and scratches in the trailing edge.	Permitted if: (a) The depth of each defect is less than 0.060 inch (1.52 mm). (b) There is no high metal. (c) The gas turbine performance is satisfactory.	If the defect is more than the usable limit, replace gas turbine.
(3) Surface areas that are rough.	Permitted if the gas turbine performance is satisfactory.	No action necessary.

TABLE 2. BORESCOPE INSPECTION OF COMPRESSOR CASING, INLET GUIDE VANES, COMPRESSOR ROTOR BLADES, VARIABLE VANES, AND STATIONARY VANES (Cont)

Inspect	Usable Limits	Corrective Action
c. Visible areas of the rotor spools for:		
(1) Abradable coating that is loose or has come off because of rubs, erosion, or FOD.	Permitted if the gas turbine performance and vibration levels are satisfactory, and there is no unserviceable FOD.	If there is unserviceable FOD, replace gas turbine.
(2) Adbradable coating that is loose or has come off because of delamination.	Permitted if the gas turbine performance and vibration levels are satisfactory, and there is no unserviceable FOD.	If there is unserviceable FOD, replace gas turbine.
(3) Contamination and discoloration (apparent oil or dirt).	Permitted if the gas turbine performance is satisfactory.	If the rotor spools are frequently dirty, increase the number of times the gas turbine is water washed.
d. Rotor blades (see figure 5) for:		
(1) Cracks or torn metal.	None permitted.	Replace gas turbine.

NOTE

- Critical areas are defined as the inner 1/3 of the blade, from the platform outward. Also, the fillet at the root of the blade.
- Noncritical areas are defined as the visible remaining area of the blade.

Inspect	Usable Limits	Corrective Action
(2) Critical areas for nicks, dents, and bends.	None permitted.	Replace gas turbine.
(3) Noncritical areas for nicks, dents, and bends.	Permitted if the depth of each defect is less than 0.010 inch (0.25 mm), and the gas turbine performance is satisfactory.	If the defect is more than the usable limit, replace gas turbine.
(4) Platform for nicks, pits, and scratches.	Permitted if: (a) The depth of each defect is less than 0.015 inch (0.38 mm). (b) There is no high metal. (c) The gas turbine performance is satisfactory.	If the defect is more than the usable limit, replace gas turbine.
(5) Corners of the locking blades for damage.	Not permitted.	Replace gas turbine.

TABLE 2. BORESCOPE INSPECTION OF COMPRESSOR CASING, INLET GUIDE VANES, COMPRESSOR ROTOR BLADES, VARIABLE VANES, AND STATIONARY VANES (Cont)

Inspect	Usable Limits	Corrective Action
(6) Platform edges for nicks and dents.	Permitted if: (a) The depth of each defect is less than 0.063 inch (1.60 mm). (b) 75 percent of each edge is not damaged. (c) There is no high metal. (d) The gas turbine performance is satisfactory.	If the defect is more than the usable limit, replace gas turbine.
(7) Surface areas that are rough because of erosion.	Permitted if the gas turbine performance is satisfactory.	If the gas turbine performance is not satisfactory, replace gas turbine.
(8) Jagged trailing edge tip because of erosion.	Permitted if the gas turbine performance is satisfactory.	If the gas turbine performance is not satisfactory, replace gas turbine.
(9) Blade tips for:		
(a) Burrs because of rubs.	Permitted if the gas turbine performance is satisfactory.	If the gas turbine performance is not satisfactory, replace gas turbine.
(b) Curling.	Permitted if: 1 Defects are less than 0.020 inch (0.51 mm) from the original contour on all blades. 2 Defects are less than 0.063 inch (1.60 mm) from the original contour on a maximum of 10 percent of the blades in a stage. 3 The gas turbine performance is satisfactory.	If the defect is more than the usable limit, replace gas turbine.
e. Variable vanes for:		
(1) Cracks or torn metal.	None permitted.	Replace gas turbine.

TABLE 2. BORESCOPE INSPECTION OF COMPRESSOR CASING, INLET GUIDE VANES, COMPRESSOR ROTOR BLADES, VARIABLE VANES, AND STATIONARY VANES (Cont)

Inspect	Usable Limits	Corrective Action
NOTE • Critical areas are defined as the inner 1/3 of the vane, from the platform outward. Also, the fillet at the root of the vane airfoil. • Noncritical areas are defined as the visible remaining area of the vane.		
(2) Critical areas for nicks, dents, pits, and scratches.	Permitted if: (a) The depth of each defect is less than 0.010 inch (0.25 mm) for stages 1 and 2. (b) The depth of each defect is less than 0.005 inch (0.13 mm) for stages 3, 4, and 5. (c) The gas turbine performance is satisfactory.	If the defect is more than the usable limit, replace gas turbine.
(3) Noncritical areas for:		
(a) Nicks.	Permitted if: 1 The depth of each defect is less than 0.031 inch (0.79 mm). 2 There is no high metal. 3 The gas turbine performance is satisfactory.	If the defect is more than the usable limit, replace gas turbine.
(b) Dents and bends in the leading and trailing edges.	Permitted if the depth of each defect is less than 0.031 inch (0.79 mm), and the gas turbine performance is satisfactory.	If the defect is more than the usable limit, replace gas turbine.
(4) Airfoil section for:		
(a) Surface areas that are rough because of erosion.	Permitted if the gas turbine performance is satisfactory.	If the gas turbine performance is not satisfactory, replace gas turbine.
(b) Jagged trailing edges because of erosion.	Permitted if there is no curled material and the gas turbine performance is satisfactory.	If there is curled material, replace gas turbine.

TABLE 2. BORESCOPE INSPECTION OF COMPRESSOR CASING, INLET GUIDE VANES, COMPRESSOR ROTOR BLADES, VARIABLE VANES, AND STATIONARY VANES (Cont)

Inspect	Usable Limits	Corrective Action
(5) Leading edge of the platform for under cut because of erosion.	Permitted if: (a) The depth of each defect is less than 0.040 inch (1.02 mm) for stages 1 and 2. (b) The depth of each defect is less than 0.020 inch (0.51 mm) for stages 3, 4, and 5. (c) The gas turbine performance is satisfactory.	If the defect is more than the usable limit, replace gas turbine.
f. Stationary vanes for:		
(1) Cracks or torn metal.	None permitted.	Replace gas turbine.

NOTE

- Critical areas are defined as the inner 1/3 of the vane, from the platform outward. Also, the fillet at the root of the vane airfoil.
- Noncritical areas are defined as the visible remaining area of the vane.

Inspect	Usable Limits	Corrective Action
(2) Critical areas for nicks, pits, dents, and scratches.	Permitted if the depth of each defect is less than 0.005 inch (0.13 mm), and the gas turbine performance is satisfactory.	If the defect is more than the usable limit, replace gas turbine.
(3) Noncritical areas for nicks, pits, dents, and scratches.	Permitted if: (a) The depth of each defect is less than 0.031 inch (0.79 mm). (b) There is no high metal. (c) The gas turbine performance is satisfactory.	If the defect is more than the usable limit, replace gas turbine.
(4) Vane platform for nicks, pits, dents, and scratches.	Permitted if: (a) The depth of each defect is less than 0.031 inch (0.79 mm). (b) There is no high metal. (c) The gas turbine performance is satisfactory.	If the defect is more than the usable limit, replace gas turbine.

TABLE 2. BORESCOPE INSPECTION OF COMPRESSOR CASING, INLET GUIDE VANES, COMPRESSOR ROTOR BLADES, VARIABLE VANES, AND STATIONARY VANES (Cont)

Inspect	Usable Limits	Corrective Action
(5) Vane tips for:		
(a) Burrs because of rubs.	Permitted if the gas turbine performance is satisfactory.	Replace gas turbine.
(b) Curling.	Permitted if:	If the defect is more than the usable limit, replace gas turbine.
	1 Defects are less than 0.031 inch (0.79 mm) from the original contour on all vanes.	
	2 Defects are less than 0.050 inch (1.27 mm) from the original contour on a maximum of 10 percent of the vanes in a stage.	
	3 The gas turbine performance is satisfactory.	
(6) Airfoil section for:		
(a) Surface areas that are rough because of erosion.	Permitted if the gas turbine performance is satisfactory.	Replace gas turbine.
(b) Jagged edges because of erosion.	Permitted if there is no curled material and the gas turbine performance is satisfactory.	If there is no curled material, replace gas turbine.

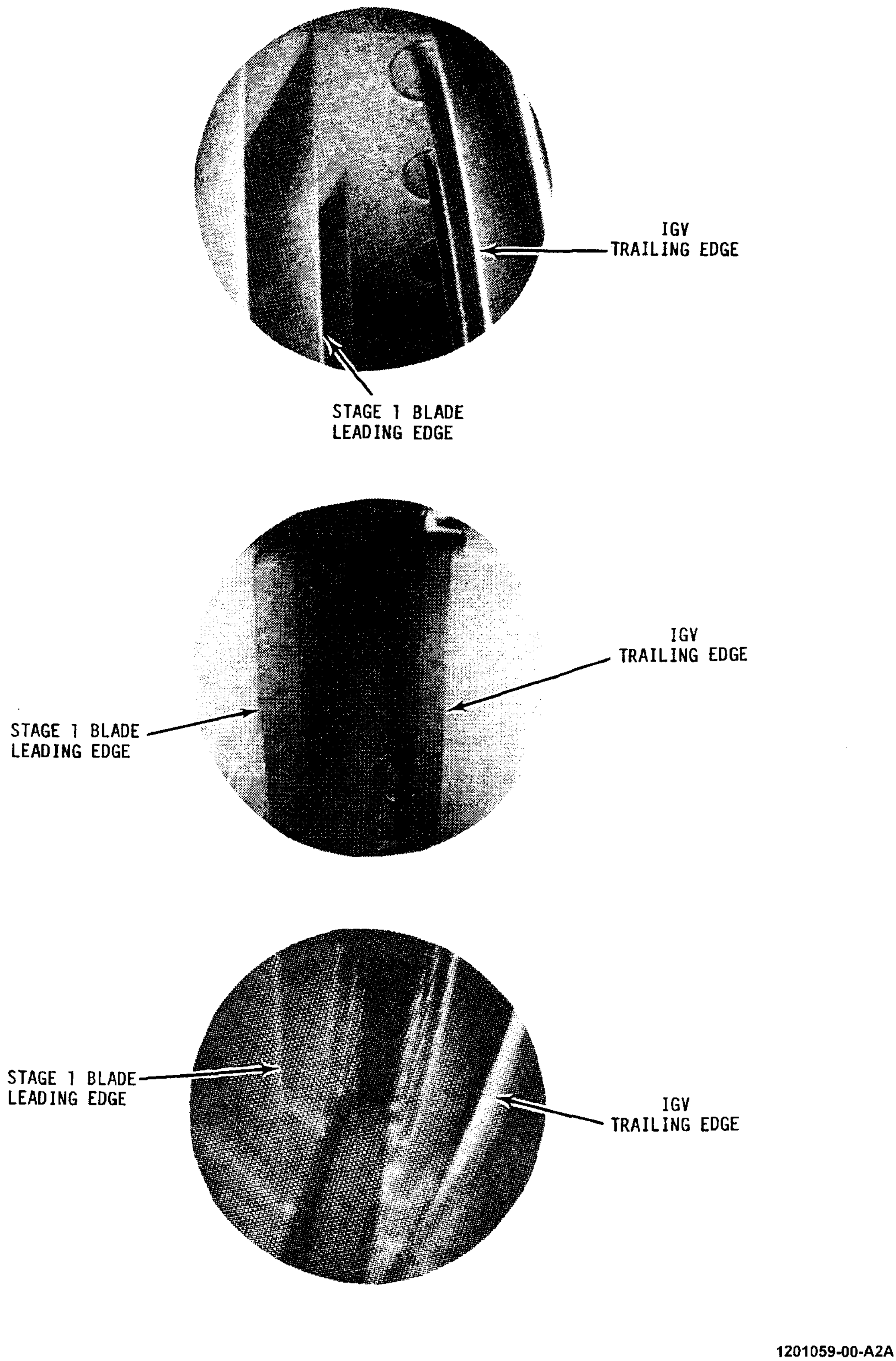


Figure 4. Views of Inlet Guide Vanes

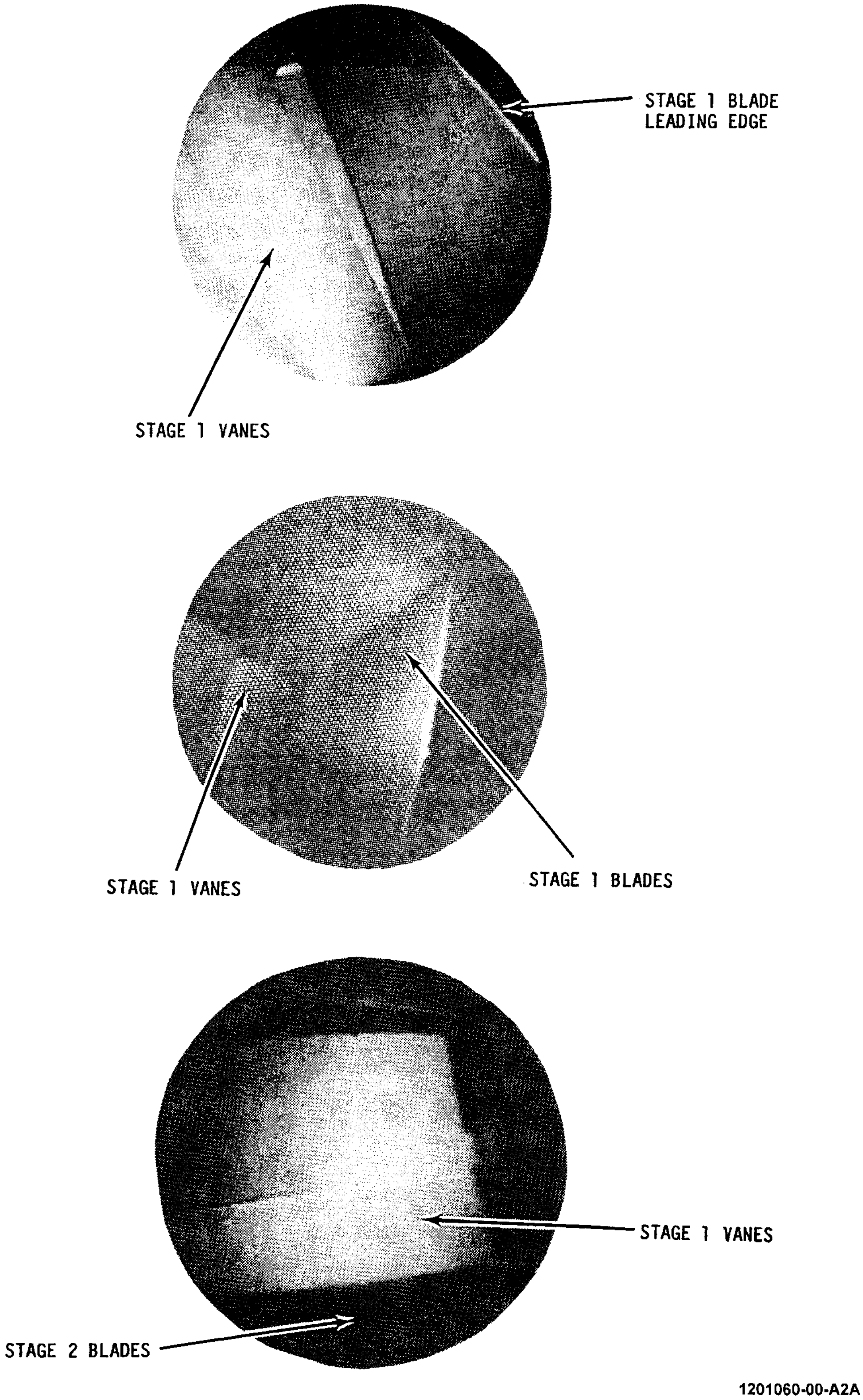


Figure 5. View of Compressor Rotor Blades and Vanes (Sheet 1 of 6)

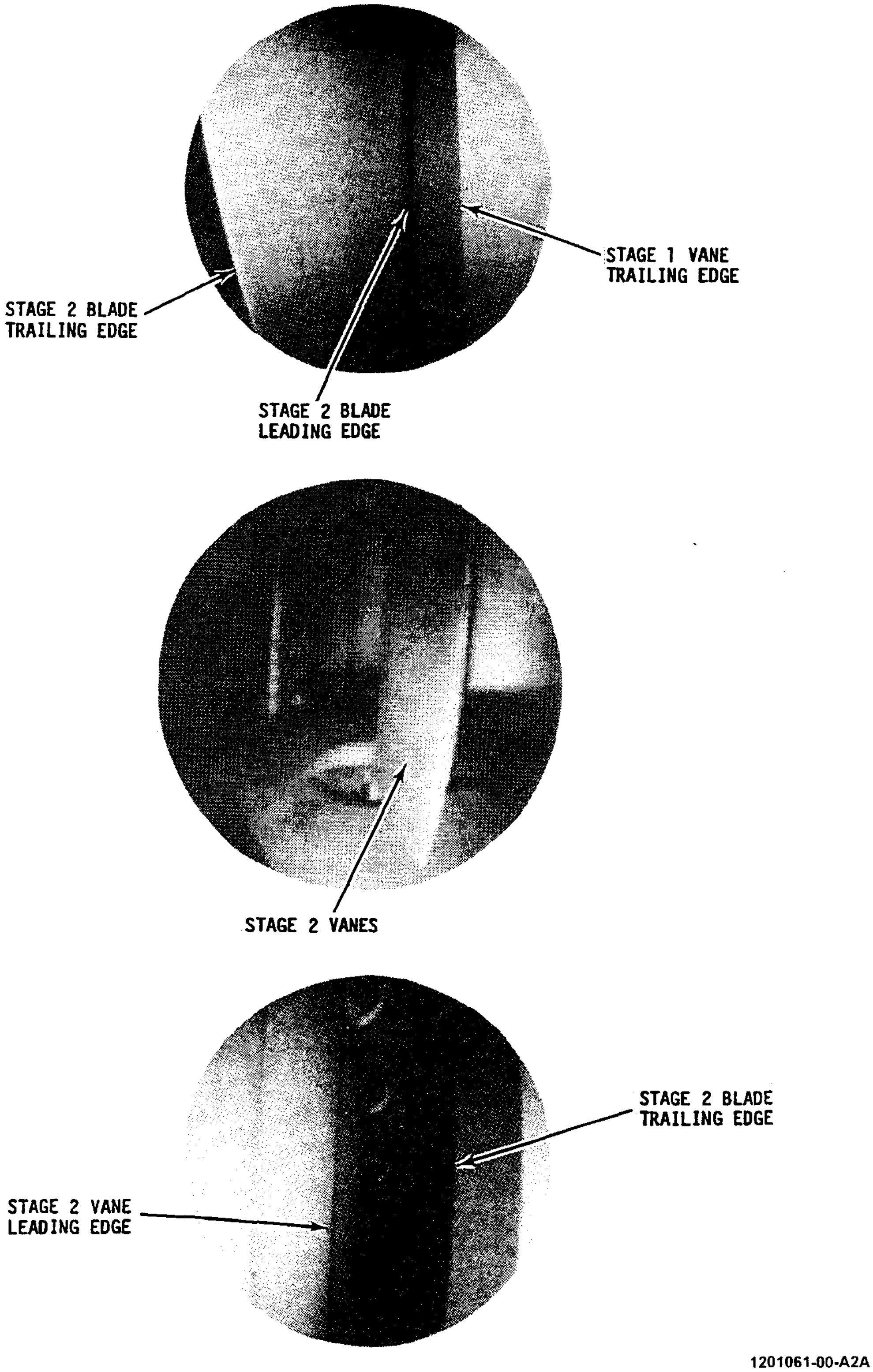


Figure 5. View of Compressor Rotor Blades and Vanes (Sheet 2 of 6)

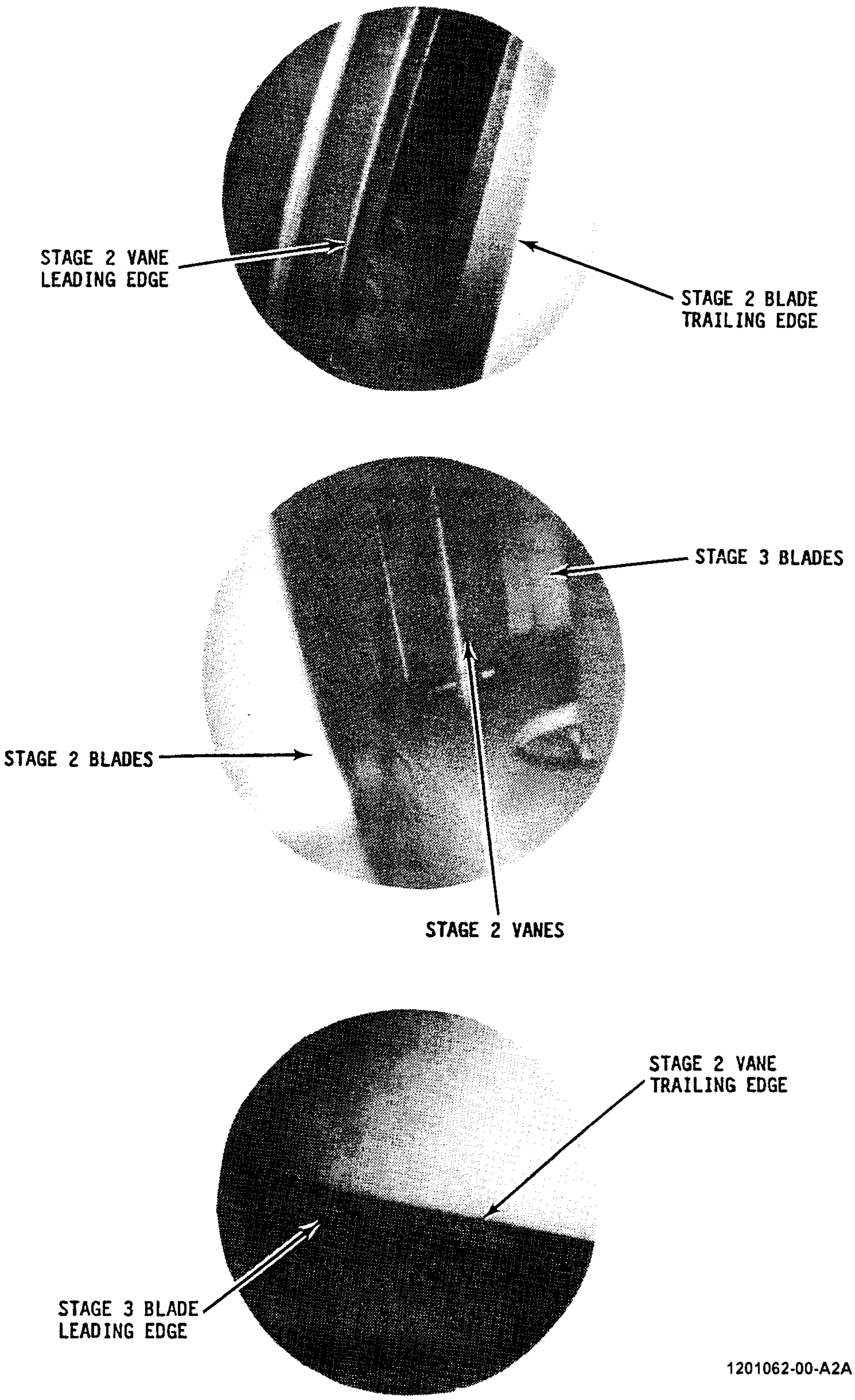


Figure 5. View of Compressor Rotor Blades and Vanes (Sheet 3 of 6)

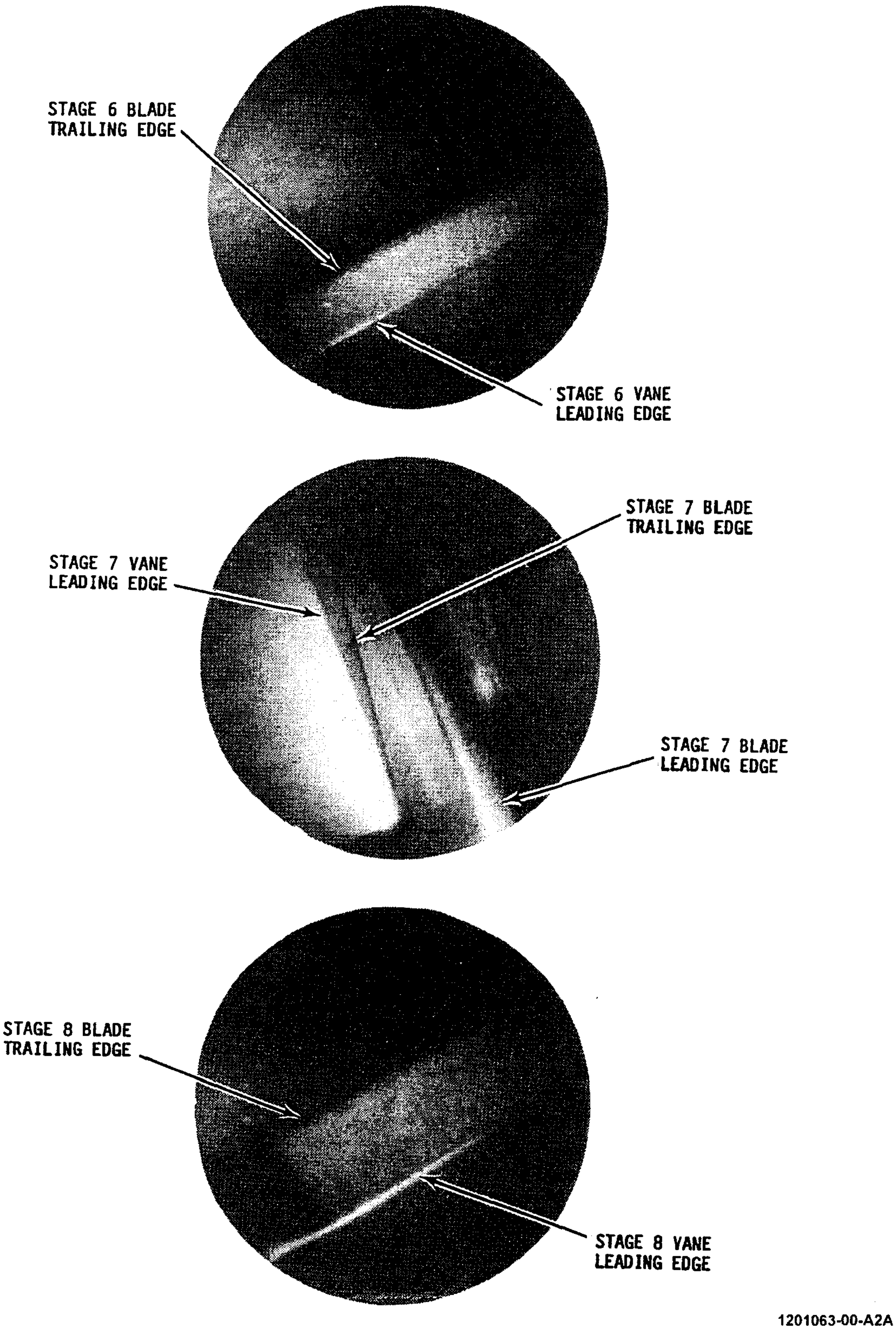


Figure 5. View of Compressor Rotor Blades and Vanes (Sheet 4 of 6)

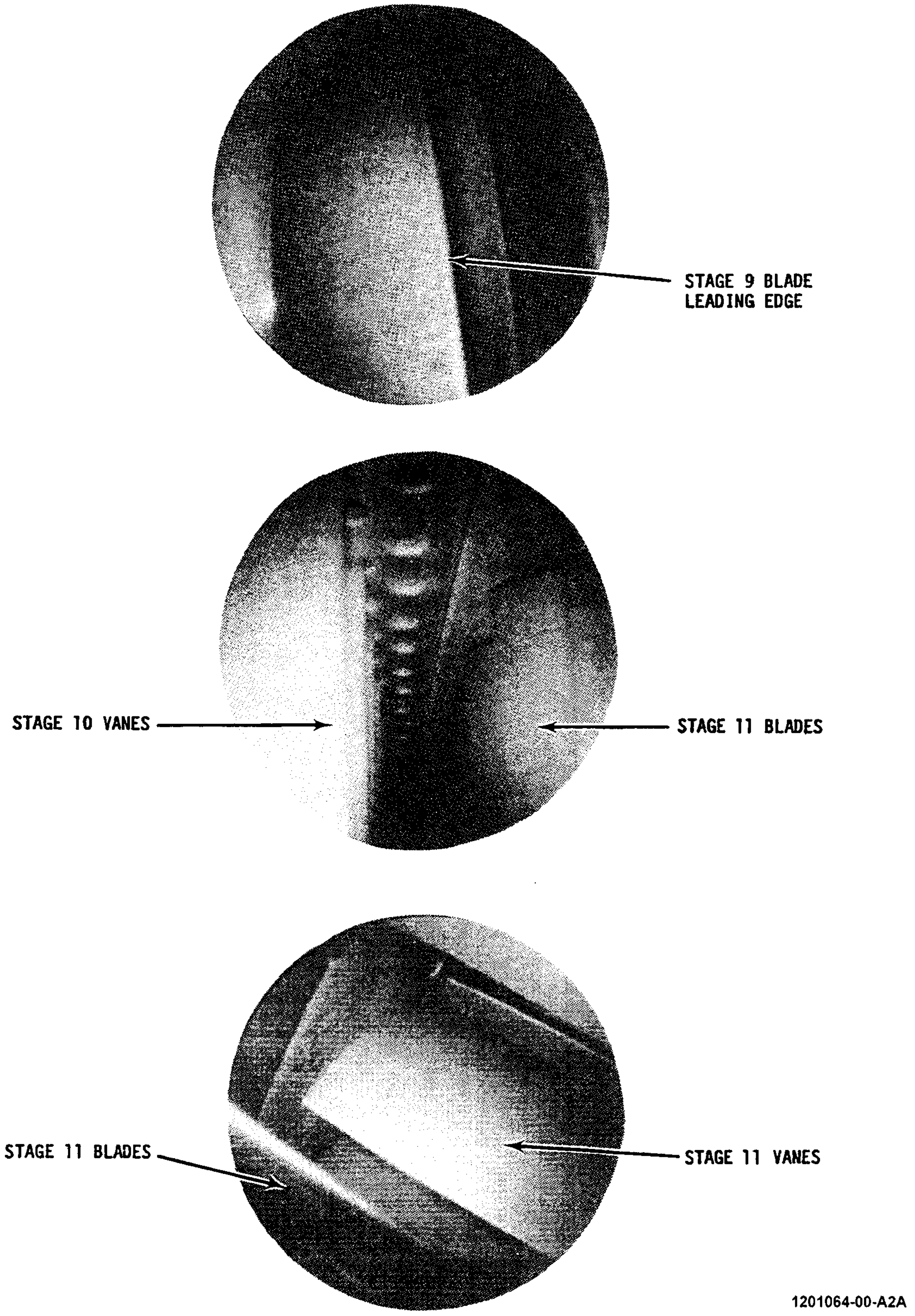


Figure 5. View of Compressor Rotor Blades and Vanes (Sheet 5 of 6)

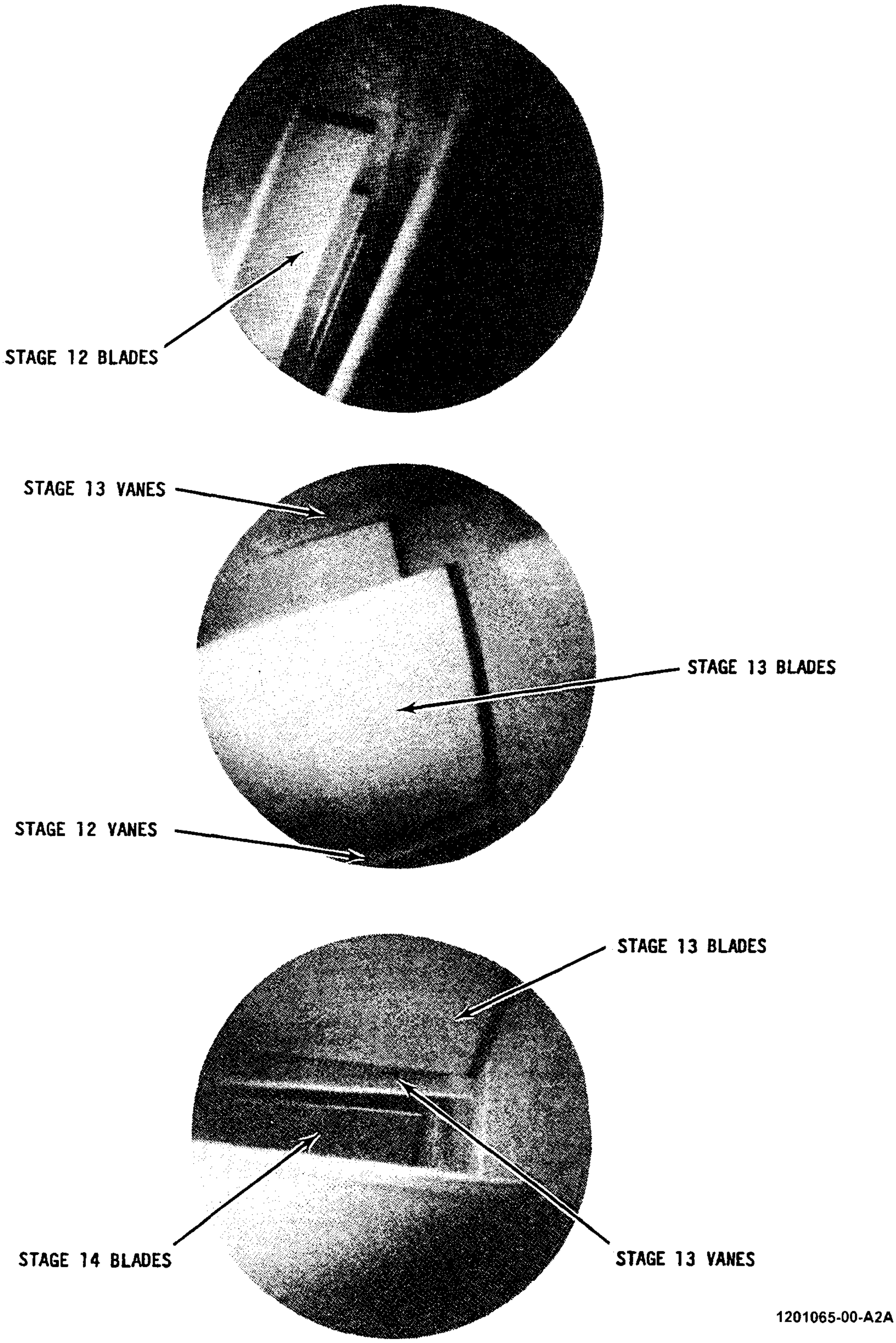


Figure 5. View of Compressor Rotor Blades and Vanes (Sheet 6 of 6)

7. BORESCOPE INSPECTION OF COMBUSTION LINER, FUEL INJECTORS, AND STAGE 1 TURBINE NOZZLE.

a. Remove (WP 023 00) two igniter plugs from the 2 and 10 o'clock positions (S18 and S23) on combustion chamber frame.

CAUTION

- Only approved personnel is allowed to borescope-inspect the gas turbine. Incorrect inspection can cause gas turbine removal that is not necessary.
- Be sure the inlet turbine temperature is less than 122°F (50°C) before you start the borescope procedure. Damage to the borescope can occur if the temperature is more than 122°F and (50°C).

NOTE

It will be easier to see the components to be inspected if you use a rigid borescope 0.315 inch (8.00 mm) or 0.394 inch (10.00 mm) diameter, and will view at a right angle. Different views can be seen, and a more complete inspection of any area can be done if you use a flexible borescope 0.236 inch (6.0 mm) or less diameter.

b. Turn the light source ON/OFF switch to the ON position and turn the brightness switch from the L position to the H position.

CAUTION

Be very careful and do not let the borescope probe touch the internal parts of the gas turbine when you put probe into the igniter port. Damage to the internal parts can occur.

NOTE

- The compressor rotor and the high-pressure turbine (HPT) rotor are not turned when you inspect the combustion liner and the stage 1 turbine nozzle.
- If you think that a piece of a part (not clearly visible) is damaged, inspection can be done through borescope port plugs S17, S20, and S22 to do a more complete inspection of the part.

c. Insert the borescope probe approximately 2 inches (51 mm) into the igniter port at the 2 o'clock position (S18). Turn the borescope probe until you can see a view that is forward. Adjust the depth and turn the borescope probe until you can see the combustion liner swirlers as shown in figure 6.

d. Turn the borescope probe clockwise and inspect all of the swirlers that you can see to make sure the end of the fuel injector is in the center of the swirler.

e. Turn the borescope probe counterclockwise and inspect all of the swirlers that you can see to make sure the end of the fuel injector is in the center of the swirler.

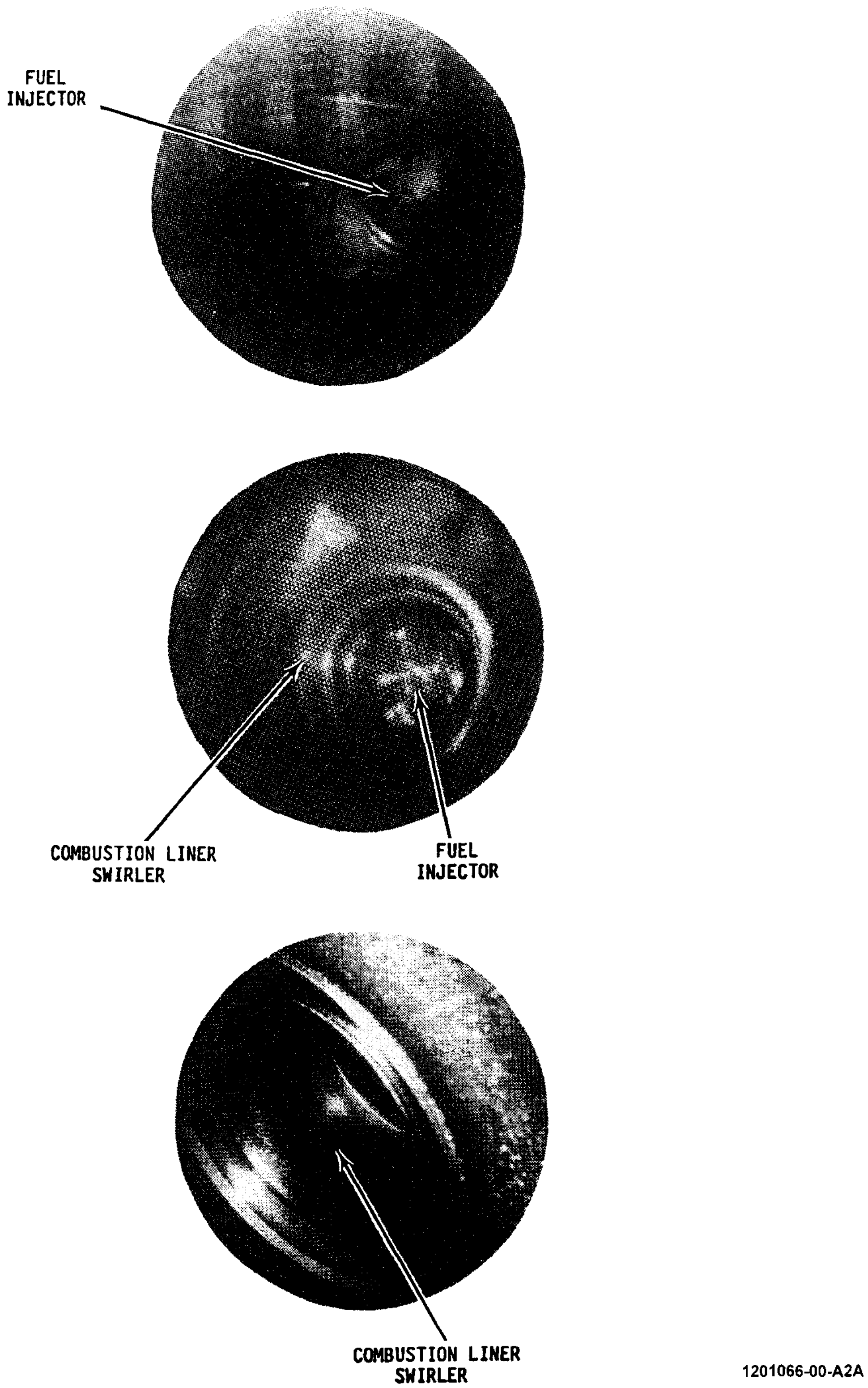


Figure 6. View of Combustion Liner Swirler and Fuel Injector

f. Adjust the depth and turn the borescope probe until you can see the outer shell as shown in figure 7.

g. Inspect all visible areas of the outer shell as follows:

(1) Start at the swirler and turn the borescope probe (inspect the outer shell as you turn probe) until the stage 1 turbine nozzle can be seen.

(2) Adjust the depth of the borescope probe after each pass, until all of the areas have been completely inspected. Refer to table 3 for inspection limits and corrective action.

h. Adjust the depth of probe and slowly turn the borescope probe clockwise until you can see the inner shell as shown in figure 7.

i. Inspect all visible areas of the inner shell as follows:

(1) Start at the swirler and turn the borescope probe (inspect the inner shell as you turn probe) until the stage 1 turbine nozzle can be seen.

(2) Adjust the depth of the borescope probe after each pass, until all of the areas of the inner shell have been completely inspected. Refer to table 3 for inspection limits and corrective action.

NOTE

The stage 1 turbine blade tips can be seen through the stage 1 turbine nozzle.

j. Slowly turn the borescope probe until you can see the stage 1 turbine nozzle as shown in figure 7. Refer to table 4 for inspection limits and corrective action. Also, see figure 8 to view the turbine nozzle from different directions.

k. Slowly turn the borescope probe in a counterclockwise direction (inspect the nozzle vanes as you turn probe) until the outer shell can be seen.

l. Slowly turn the borescope probe in a clockwise direction (inspect the nozzle vanes as you turn probe) until the outer shell comes into view.

m. Turn the brightness switch on the light source from the H to the L position and turn the ON/OFF switch to the OFF position.

n. Carefully remove the borescope probe from the igniter port.

o. Follow procedures in steps c through n for the igniter port at the 10 o'clock position (S23).

p. If borescope port plugs S17, S20, and S22 were removed, reinstall them as follows:

(1) Install plugs in applicable borescope port. Torque plug to 180-200 lb in. (20.3-22.6 N·m).

(2) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire borescope plugs using the double-strand method (WP 007 00).

q. Do not install the igniter plugs until the stage 1 HPT rotor blades have been inspected as specified in paragraph 8.

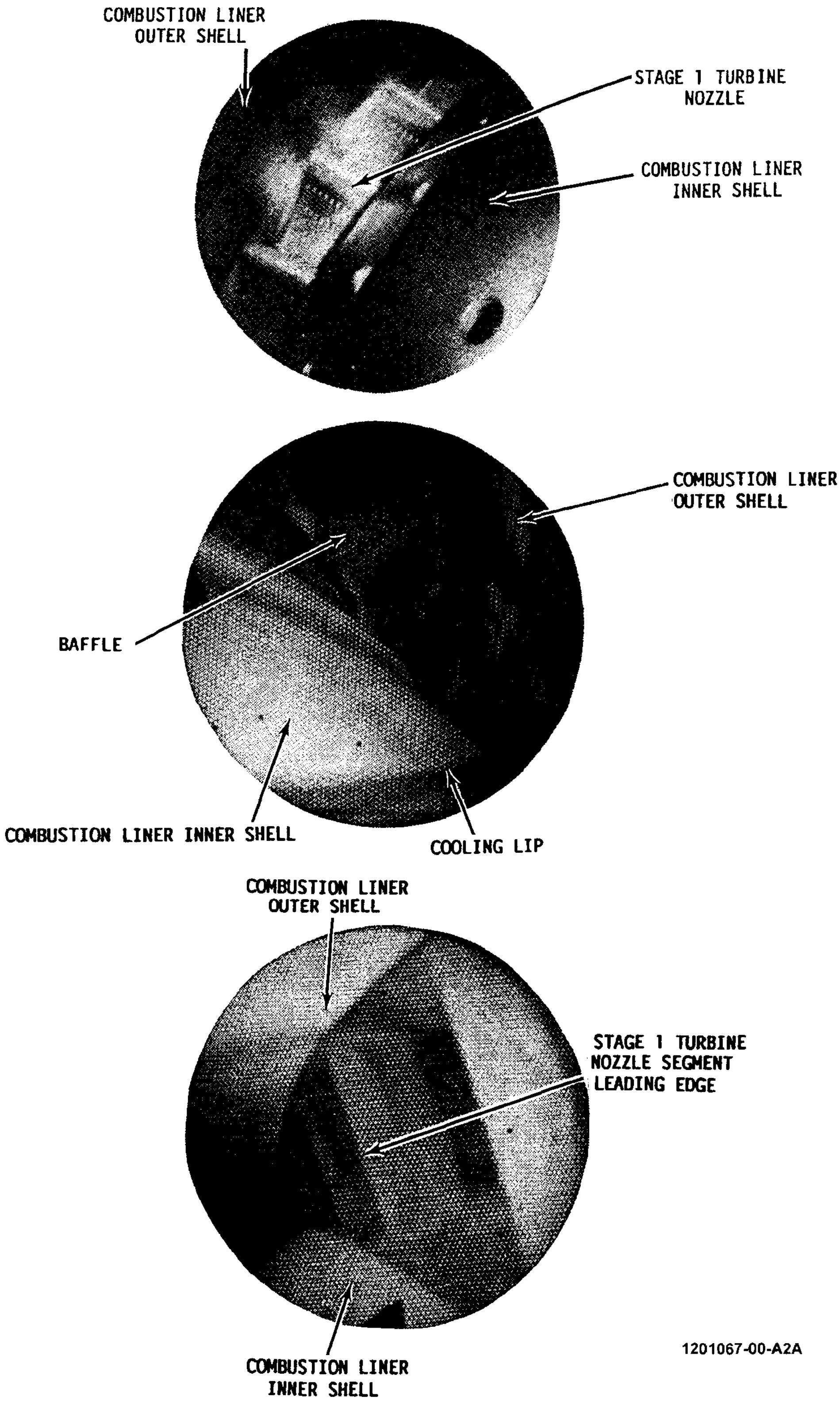


Figure 7. View of Combustion Liner Outer and Inner Shells, and Leading Edge of Stage 1 Nozzle Segments

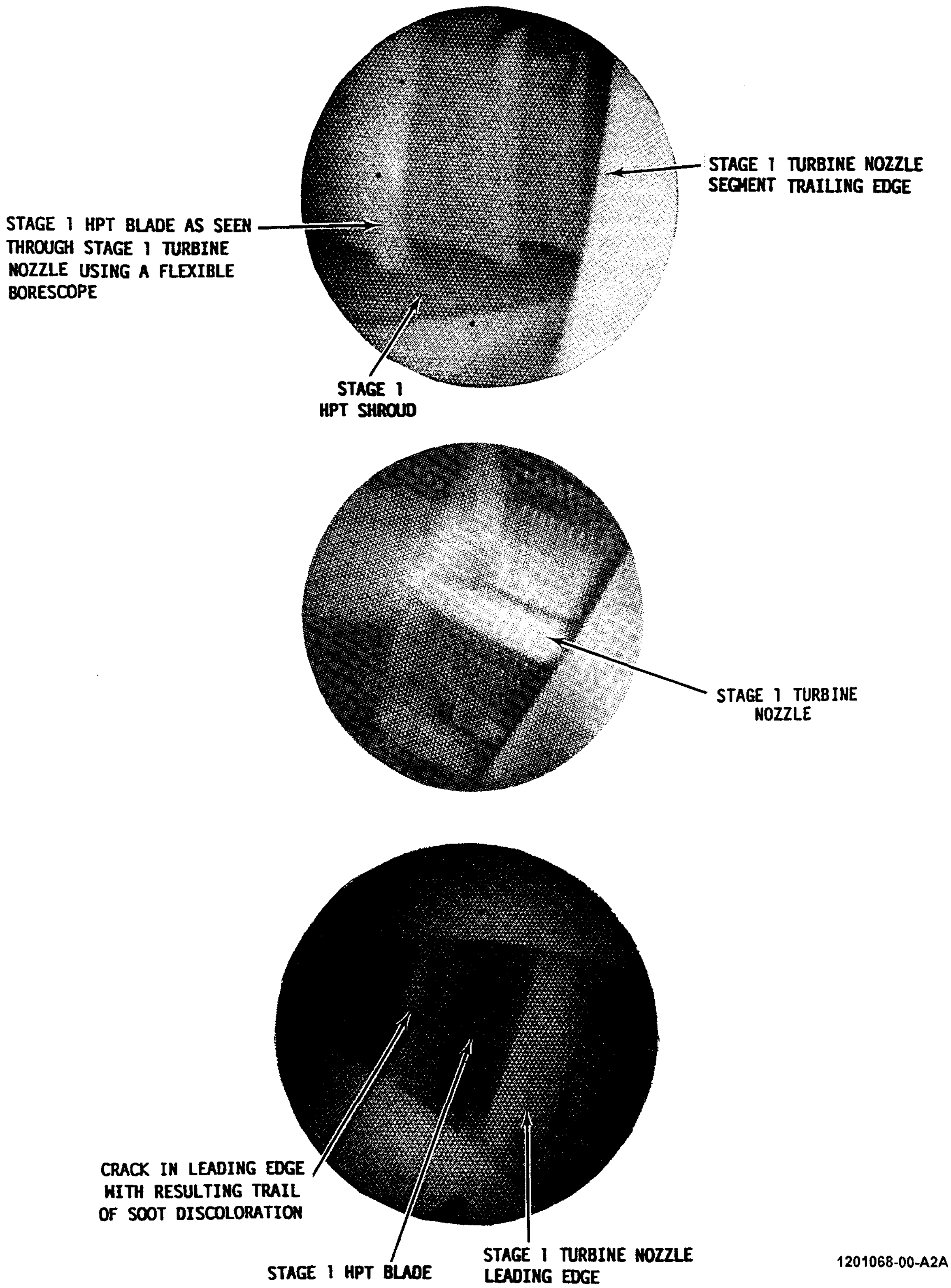
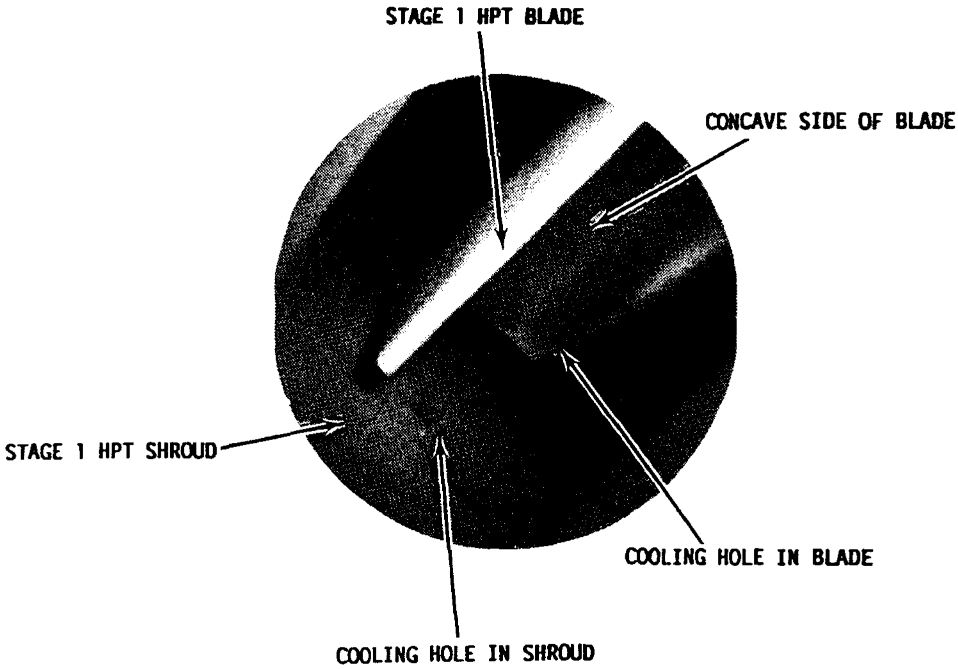


Figure 8. View of Stage 1 Turbine Nozzle, Stage 1 HPT Rotor Blade, and Stage 1 HPT Shrouds (Sheet 1 of 3)



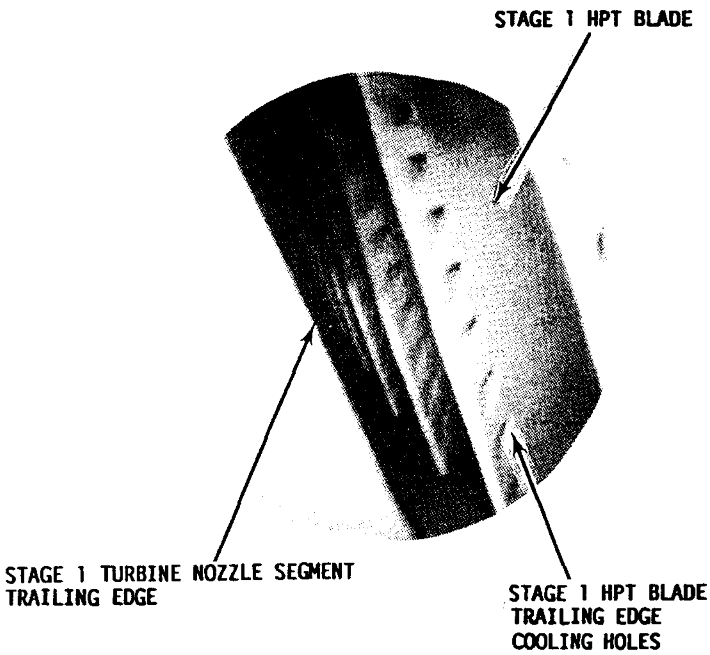


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Figure 8. View of Stage 1 Turbine Nozzle, Stage 1 HPT Rotor Blade, and Stage 1 HPT Shrouds (Sheet 2 of 3)

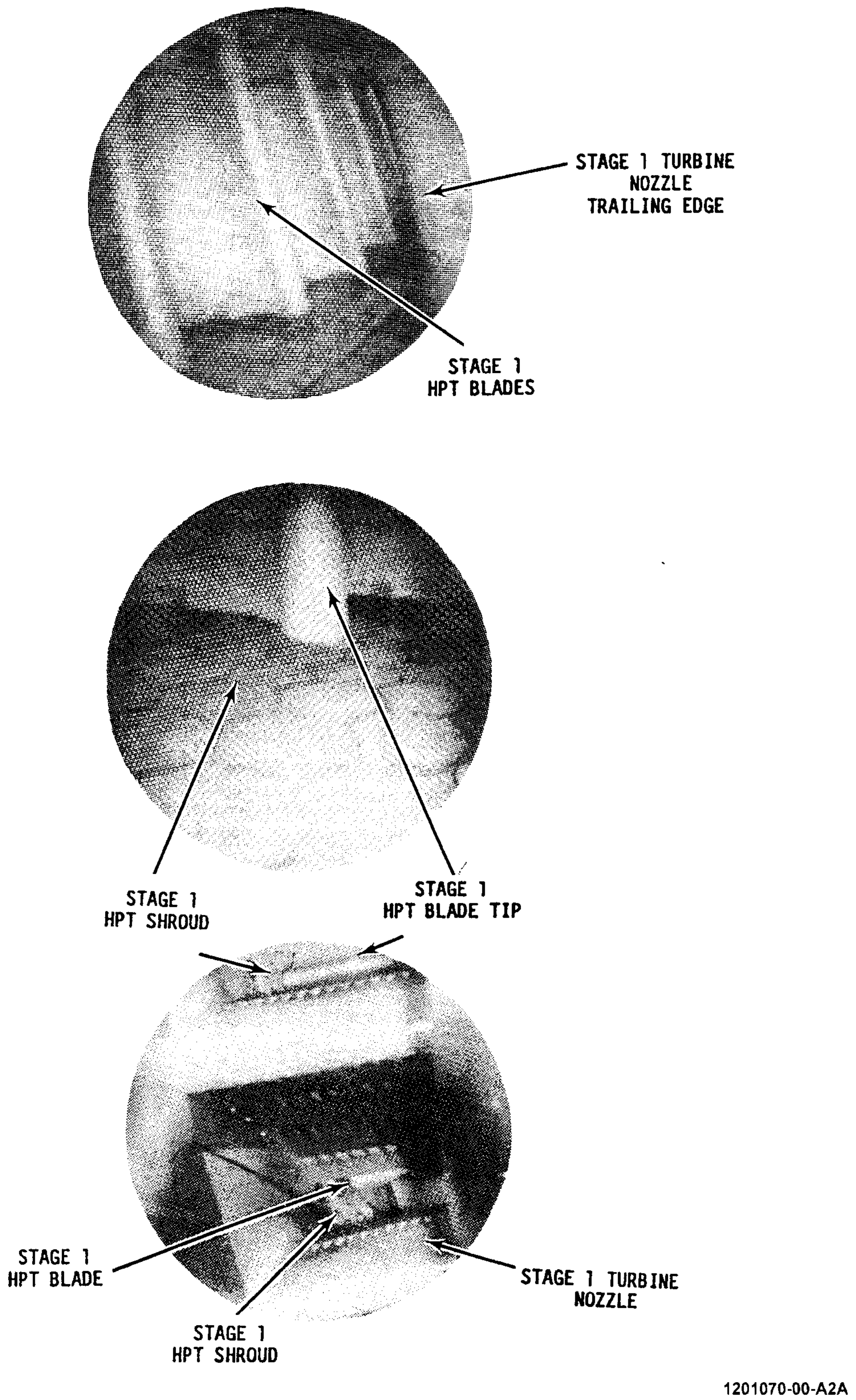


Figure 8. View of Stage 1 Turbine Nozzle, Stage 1 HPT Rotor Blade, and Stage 1 HPT Shrouds (Sheet 3 of 3)

TABLE 3. BORESCOPE INSPECTION OF COMBUSTION LINER

Inspect	Usable Limits	Corrective Action
a. Combustion liner outer and inner shells (2, 3, figure 9) for:		
(1) Cracks in shell bands (1), not including cooling lips (4):		
(a) Which run circumferentially around the shell.	Total circumferential length of a crack not to exceed 3 inches (76 mm). Two adjacent dilution holes (26) may be connected by a crack if no other crack has started from either connected hole towards a third hole. Cumulative length of all cracks in a shell band must not exceed 12 inches (305 mm) if no pattern is formed by any of the cracks where a piece is in danger of falling out.	Replace gas turbine.
(b) Other than circumferential (may be connected with cooling lip cracks).	Any number, 1.5 inches (38 mm) long if cracks are 0.375 inch (9.53 mm) apart and no piece is in danger of falling out.	Replace gas turbine.
(2) Cracks in welds.	Any number, 0.031 inch (0.79 mm) long and no closer than 1/2 inch (13 mm).	Replace gas turbine.

NOTE

The hot sides of the combustion liner are the ID of the outer shell (2) and the OD of the inner shell (3).

Inspect	Usable Limits	Corrective Action
(3) Distortion of cooling lips (4). (Annular slots aft of each band of aspirator holes on hot side of shell.)	Gap between lip and the shell to be as follows:	Replace gas turbine.
	(a) Aft gap on the inner shell (3) no less than 0.078 inch (1.98 mm).	
	(b) Aft gap on the outer shell (2) no less than 0.094 inch (2.39 mm).	Replace gas turbine.
	(c) All other gaps no less than 0.094 inch (2.39 mm).	Replace gas turbine.
(4) Dents.	Contour of defective area distorted no more than 0.062 inch (1.57 mm) above or below adjacent undistorted section.	Replace gas turbine.
(5) Local distortion due to high temperature.	Contour of defective area to be more than 0.188 inch (4.78 mm) above or below adjacent undistorted contour.	Replace gas turbine.

TABLE 3. BORESCOPE INSPECTION OF COMBUSTION LINER (Cont)

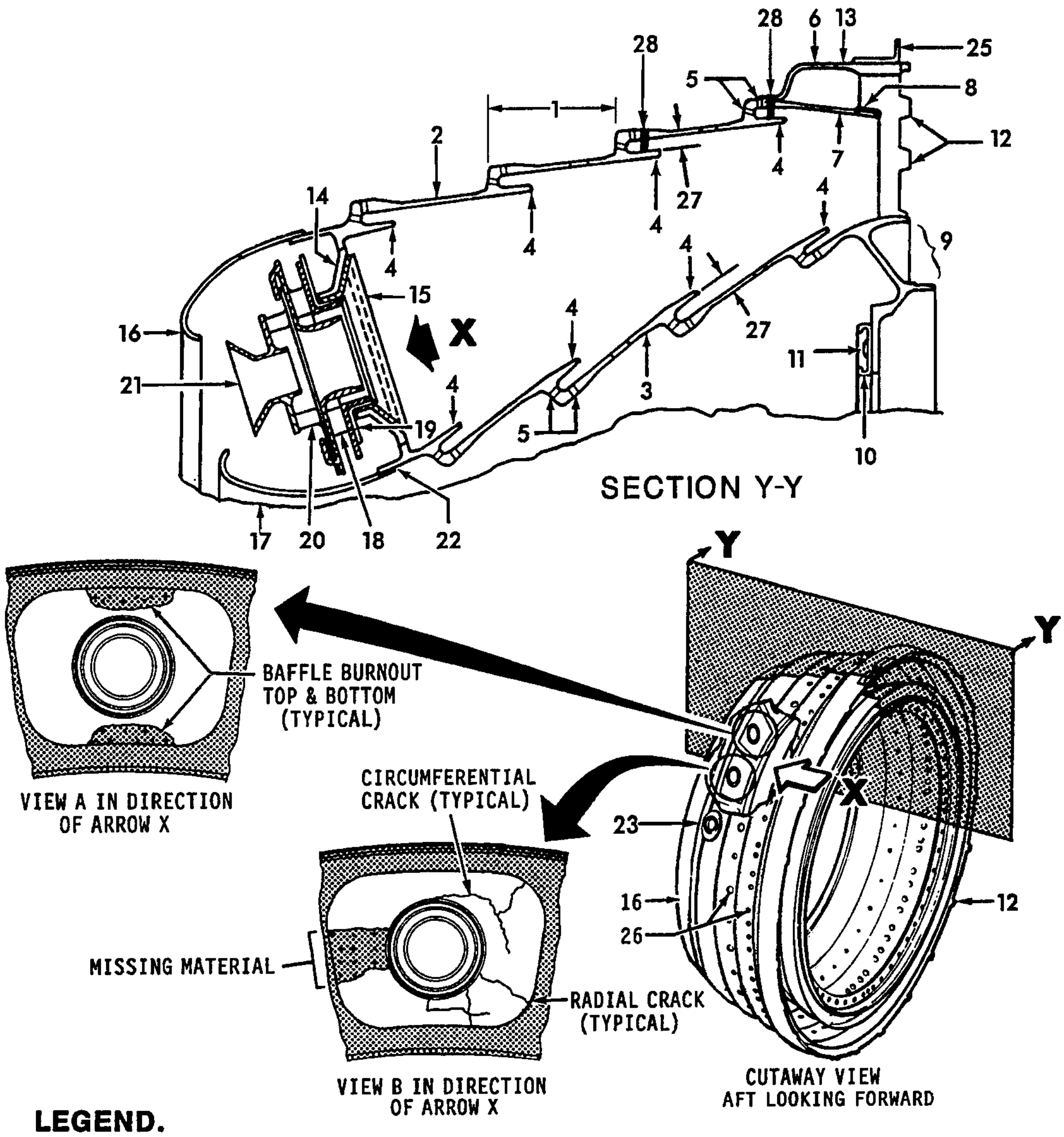
Inspect	Usable Limits	Corrective Action
(6) Burn holes in inner and outer shells.	Ten per shell band, if hole diameter does not exceed 0.250 inch (6.35 mm) and cracks extending from the defect have been previously repair-welded.	Replace gas turbine.
(7) Burnout or erosion of cooling lips (4).	Ten areas per lip if defect is no deeper than 0.188 inch (4.78 mm) from the original contour.	Replace gas turbine.
(8) Cracks in the cooling lips (4). (May be connected with shell cracks.)	Any number, if no piece is in danger of falling out.	Replace gas turbine.
b. Outer band (7) for burnout.	Any amount, if defect does not extend forward from band trailing edge more than 0.375 inch (9.53 mm) and the edges of the defect are smooth and in the normal contour of the band.	Replace gas turbine.
c. Baffles (15) for:		
(1) Cracks:		
(a) Radial.	Any number, any length.	No action necessary.
(b) Circumferential.	Any number, 0.750 inch (19.05 mm) maximum length if cumulative length per baffle does not exceed 1.5 inches (38 mm).	Replace gas turbine.
(c) Connecting circumferential and radial cracks.	(1) A circumferential crack may connect two radial cracks if radial cracks do not extend across entire baffle from outer edge (see view B).	Replace gas turbine.
	(2) A circumferential crack may extend 1/2 the distance between two radial cracks that extend across the entire baffle from outer edge to inner edge (see view B).	Replace gas turbine.
(2) Missing baffle material due to cracking or fragmentation (see view B).	None permitted.	Replace gas turbine.
(3) Burnout.	Permitted at corners and along edges, if no more than 16 cooling holes in dome (14) are visible: eight on top and eight on bottom side of the baffle (see view A).	Replace gas turbine.

TABLE 3. BORESCOPE INSPECTION OF COMBUSTION LINER (Cont)

Inspect	Usable Limits	Corrective Action
(4) Buckling.	Any amount, if baffle-to-dome gap is not less than 0.031 inch (0.79 mm).	Replace gas turbine.
(5) Carbon buildup.	Any amount, with no fuel injector obstruction.	No action necessary.
d. Igniter ferrules (23) for:		
(1) Cracks.	None permitted.	Replace gas turbine.

Penetrating Oil **234**

Inspect	Usable Limits	Corrective Action
(2) Seizure.	Ferrule must slide freely between retainer and pad.	Try to move the ferrule until it is released. Use penetrating oil to help release seized parts. Otherwise, replace gas turbine.



LEGEND.

1. Shell Band
2. Outer Shell
3. Inner Shell
4. Cooling Lip
5. Shell Cooling Hole
6. Outer Seal Support
7. Outer Band
8. Rub Strip (72 total)
9. Inner Flange
10. Gang Channel Nut Assembly
11. Gang Channel Rivet
12. Aft Stop (24 total)
13. Outer Ring
14. Dome
15. Baffle
16. Outer Cowl
17. Inner Cowl
18. Secondary Vanes
19. Bushing
20. Primary Vanes
21. Swirler Assembly
22. Cowl-to-Dome Weld
23. Igniter Ferrule (2 total)
24. Fuel Primer Ferrule (2 total)
25. Locating Bracket
26. Dilution Hole
27. Cooling Gap (typical)
28. Stand-Off Pins (108 total)

1201071-00-A2A

Figure 9. Inspection of Combustion Liner

TABLE 4. BORESCOPE INSPECTION OF STAGE 1 TURBINE NOZZLE

Inspect	Usable Limits	Corrective Action
Vanes (see figure 8) for:		
(1) Cracks in:		
(a) Leading edge.	Any number, any length, extending from the forward row of cooling holes or between the leading edge cooling holes to the concave side. Each crack must not exceed 0.016 inch (0.41 mm) in width and may connect up to six leading edge cooling holes if there are a minimum of two uncracked areas preventing material from coming loose. A 0.016 inch (0.41 mm) maximum width of complete penetration through vane surface is permitted.	Replace gas turbine.
(b) Trailing edge.	Maximum crack length 1 inch (25 mm). Cumulative length of all cracks not to exceed 1.5 inch (38 mm). Disregard cracks of 0.125 inch (3.18 mm) long or less, if no piece is in danger of falling out.	Replace gas turbine.
(c) Concave surface (mid-chord).	Maximum crack length 1.250 inches (31.75 mm). Cumulative length of all cracks not to exceed 3.5 inches (89 mm). Disregard cracks of 0.125 inch (3.18 mm) long or less, if no piece is in danger of falling out.	Replace gas turbine.
(2) Holes or burnouts.	0.016 inch (0.41 mm) maximum width of complete penetration through vane surface is permitted.	Replace gas turbine.
(3) Nicks, pits, and scratches.	Any number, 0.016 inch (0.41 mm) deep.	No action necessary.
(4) Plugged cooling air holes.	None permitted.	Replace gas turbine.
(5) Bent trailing edges.	Any amount, if gas turbine performance is satisfactory.	No action necessary.
(6) Hot gas corrosion (sulfidation).	Any amount of discoloration or surface roughness, if there is no blistering, splitting, or separation (delamination) of the airfoil surface.	No action necessary.
(7) Metal splatter.	Any amount, if cooling holes are not plugged.	Replace gas turbine.

8. BORESCOPE INSPECTION OF STAGE 1 HIGH-PRESSURE TURBINE (HPT) ROTOR BLADES, USING THE IGNITER PORTS S18 AND S23.

a. If not previously removed, remove (WP 023 00) two igniter plugs from the 2 and 10 o'clock positions (S18 and S23) on combustion chamber frame.

CAUTION

- Only approved personnel is allowed to borescope-inspect the gas turbine. Incorrect inspection can cause gas turbine removal that is not necessary.
- Be sure the inlet turbine temperature is less than 122°F (50°C) before you start the borescope procedure. Damage to the borescope can occur if the temperature is more than 122°F (50°C).

NOTE

It will be easier to see the components to be inspected if you use guide tube PN 17A1664 (part of 2C91111G01) with a flexible borescope 0.236 inch (6.0 mm) diameter or less. The length of the flexible borescope probe should be 40 inches (102 cm) minimum.

b. Turn the light source ON/OFF switch to the ON position and turn the brightness switch from the L position to the H position.

NOTE

- The igniter port borescope adapter 2C91071G01 (see figure 10) is used to support and secure the borescope probe in igniter plug boss during the inspection of the stage 1 HPT rotor blades.
- The use of adapter 2C91071G01 is optional.

c. Thread holder (1, figure 10) into the 2 o'clock igniter port (S18) by hand.

d. Install stop (2) onto borescope probe. Do not tighten knurled screw (3).

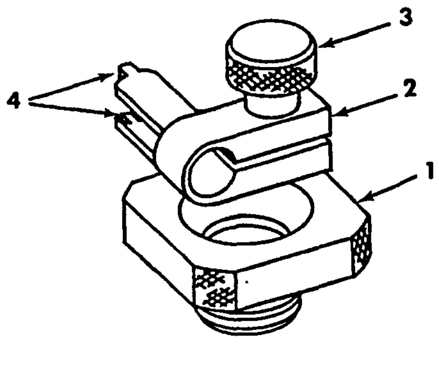


Figure 10. Removal and Installation of Igniter Port Borescope Adapter 2C91071G01

CAUTION

- Be sure the tabs (4) on stop (2) engage the antirotation slots in holder (1). Damage to the borescope probe can occur if the stop rotates during the inspection.
- Be very careful and do not let the borescope probe touch the rotor or the rotor blades when turning the rotor. Damage to gas turbine components and to borescope can occur.

e. Put the borescope probe into the stop (2) and turn the borescope probe until you can see the aft view of gas turbine components. Adjust the depth and turn the borescope probe until the stage 1 HPT rotor blade tips can be seen between the two nozzle vanes (see figure 8).

f. Hand-tighten the knurled screw (3, figure 10) to hold the borescope probe in the desired position.

NOTE

One complete turn of the cranking pad equals 2-1/2 complete turns of the HPT rotor.

g. Slowly turn the ratchet wrench in a clockwise or a counterclockwise direction to turn the cranking pad, and inspect the HPT rotor blade tips. Refer to table 5 for inspection limits and corrective action.

TABLE 5. BORESCOPE INSPECTION OF STAGE 1 HPT ROTOR BLADES

Inspect	Usable Limits	Corrective Action
a. Stage 1 rotor blades for cracks, nicks, dents, and scratches in coating or for other damage that exposes parent metal.	No leading edge cracks permitted. Trailing edge cracks permitted on upper 1/4 of blade, up to 0.090 inch (2.29 mm) long. Nicks, dents, and scratches permitted in coating but not into parent metal.	Replace gas turbine.
b. Leading edge of rotor blades for erosion.	0.010 inch (0.25 mm) maximum erosion, if gas turbine performance is satisfactory.	Replace gas turbine.
c. Blade tips for rub grooves.	Any number, any width, if none exceed 0.020 inch (0.51 mm) depth, without high metal.	Replace gas turbine.
d. Plugged cooling holes.	Not permitted.	Replace gas turbine.
e. Curled blade tip.	0.062 inch (1.57 mm) maximum on leading and trailing edges.	Replace gas turbine.
f. Hot gas corrosion (sulfidation).	Any amount of discoloration or surface roughness, if there is no blistering, splitting, or separation (delamination) of the airfoil surface.	Replace gas turbine.
g. Airfoil for buildup of metal splatter.	Any amount, if gas turbine performance is satisfactory.	Replace gas turbine.
h. Blade tip for burrs.	Any amount, if gas turbine performance is satisfactory.	Replace gas turbine.

h. Adjust the depth of the borescope probe and turn the probe end up until the stage 1 blade leading edge can be seen through the stage 1 nozzle (see figure 10).

i. Slowly turn the ratchet wrench and turn the rotor so that all the HPT blade leading edges can be inspected. Refer to table 5 for inspection limits and corrective action.

j. Turn the brightness switch on the light source from the H position to the L position and turn the ON/OFF switch to the OFF position.

k. Carefully remove the borescope probe from the igniter port.

l. Remove adapter 2C91071G01 from igniter port.

m. Follow procedures in steps b through l for the igniter port at the 10 o'clock position (S23).

n. Reinstall (WP 023 00) the two igniter plugs.

9. BORESCOPE INSPECTION OF STAGES 1 AND 2 HIGH-PRESSURE TURBINE (HPT) ROTOR BLADES, USING HPT CASING PORT S49.

There are two types of borescope plug S49, the screwdriver slot bayonet type and the threaded type. Remove the bayonet type per step a. and the threaded type per step b.

a. Remove the bayonet type borescope plug S49 (figure 11, sheet 1, detail A) as follows:

(1) Insert a wide flat-blade screwdriver into the borescope plug.

CAUTION

Be sure to press the borescope plug inward far enough so that plug turns easily. If the plug is turned before pressing plug inward sufficiently, damage to the plug or casing can occur.

(2) Press the borescope plug inward approximately 0.10 inch (2.5 mm) until plug can be turned easily in the counterclockwise direction.

(3) Push radially inward on the borescope plug approximately 0.20 inch (5.1 mm) and turn plug counterclockwise approximately 45 degree until slot in plug is approximately aligned with the unlocked position on the rear main mount. See view B.

(4) Release pressure on the plug.

(5) Remove the plug.

b. Remove the threaded type borescope plug S49 (figure 10, sheet 2, detail D) as follows:

(1) Insert a 1/4-inch drive into the borescope plug socket.

CAUTION

Do not use excessive force when removing the borescope plug or damage to the borescope plug and casing can occur.

(2) Turn the plug counterclockwise until plug turns easily.

(3) Remove the 1/4-inch drive from plug socket.

(4) Remove the plug.

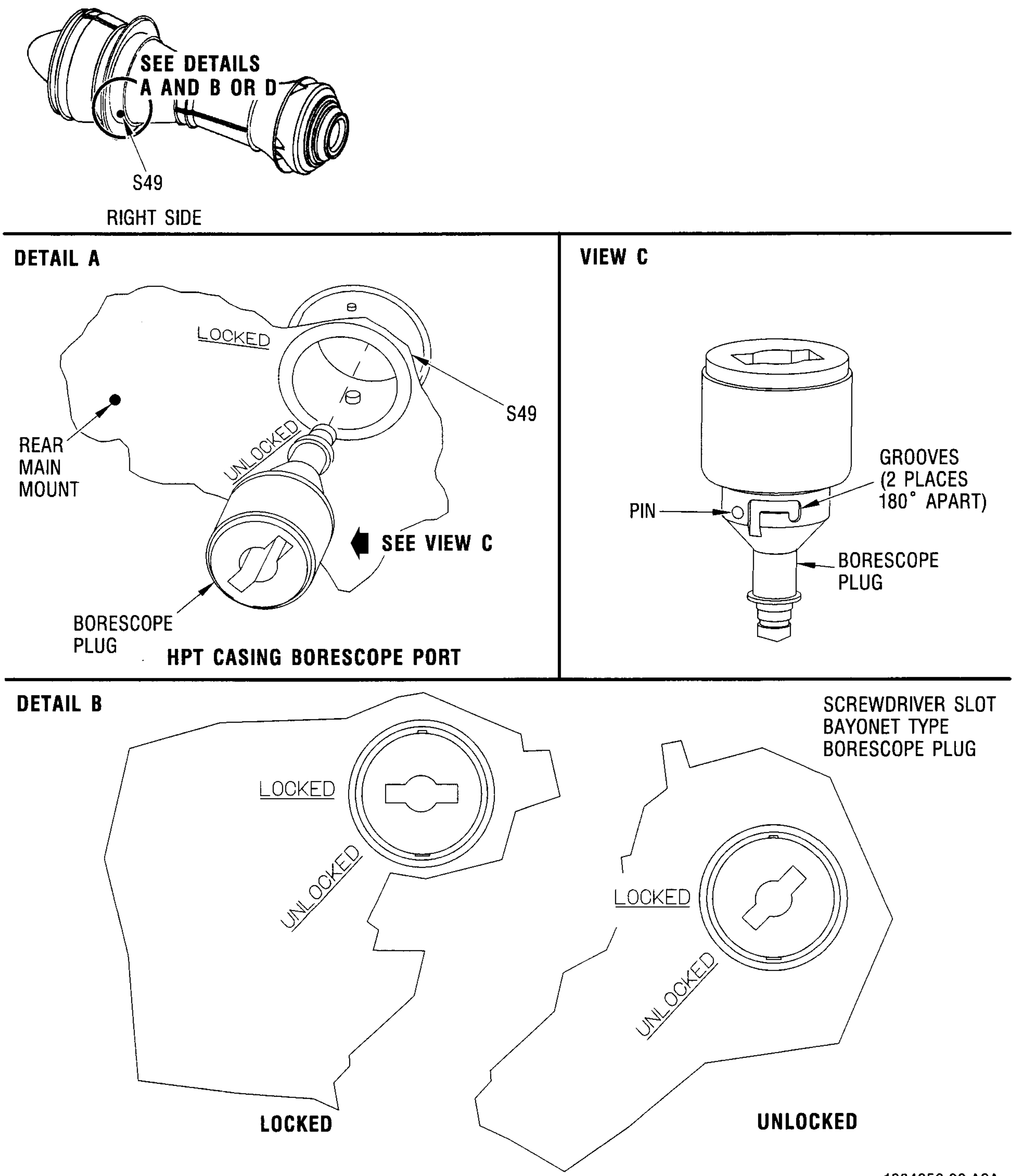


Figure 11. HPT Borescope Plug Removal and Installation (Sheet 1 of 2)

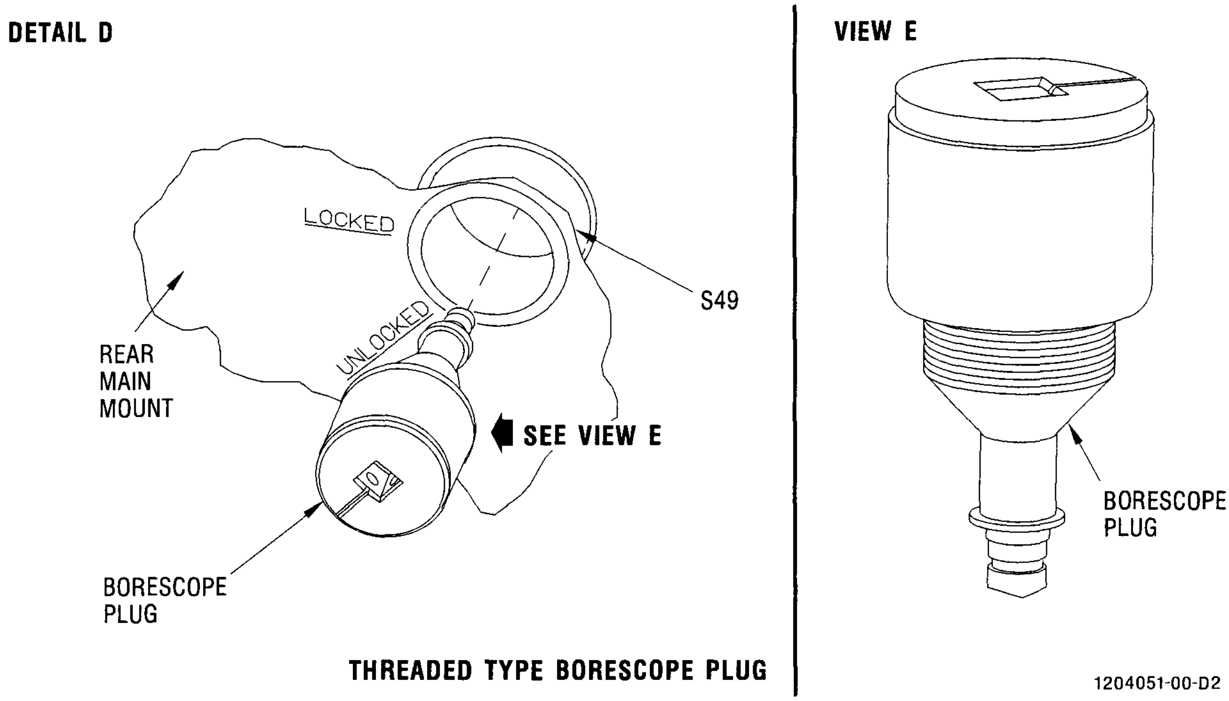


Figure 11. HPT Borescope Plug Removal and Installation (Sheet 2 of 2)

CAUTION

- Only approved personnel is allowed to borescope-inspect the gas turbine. Incorrect inspection can cause gas turbine removal that is not necessary.
- Be sure the inlet turbine temperature is less than 122°F (50°C) before you start the borescope procedure. Damage to the borescope can occur if the temperature is more than 122°F (50°C).

NOTE

It will be easier to see the components to be inspected if you use a rigid borescope 0.236 inch (6.0 mm) or less diameter, and will view at a right angle.

c. Turn the light source ON/OFF switch to the ON position and turn the brightness switch from the L position to the H position.

CAUTION

Be very careful and do not let the borescope probe touch the rotor or the rotor blades when turning the rotor. Damage to the gas turbine components and to borescope can occur.

d. Insert the borescope probe through the borescope port on the HPT casing.

e. Adjust the depth of borescope probe and turn the borescope probe until you can see the rotor blades.

NOTE

- The leading edge and the trailing edge of the rotor blade can be seen from the same angle.
- One complete turn of the cranking pad equals 2-1/2 complete turns of the HPT rotor.

f. Slowly turn the ratchet wrench in a clockwise or a counterclockwise direction to turn the HPT rotor, and inspect the rotor blades. Refer to table 6 for inspection limits and corrective action.

g. Turn the brightness switch on the light source from the H position to the L position and turn the ON/OFF switch to OFF.

TABLE 6. BORESCOPE INSPECTION OF STAGES 1 AND 2 HPT ROTOR BLADES

Inspect	Usable Limits	Corrective Action
a. Stages 1 and 2 rotor blades for cracks, nicks, dents, and scratches in coating or for other damage that exposes parent metal.	No leading edge cracks permitted. Trailing edge cracks permitted on upper 1/4 of blade, up to 0.090 inch (2.29 mm) long. Nicks, dents, and scratches permitted in coating but not into parent metal.	Replace gas turbine.
b. Leading edge of rotor blades for erosion.	0.010 inch (0.25 mm) maximum erosion, if gas turbine performance is satisfactory.	Replace gas turbine.
c. Blade tips for rub grooves.	Any number, any width, if none exceed 0.020 inch (0.51 mm) depth, without high metal.	Replace gas turbine.
d. Plugged cooling holes (stage 1 only).	Not permitted.	Replace gas turbine.
e. Curled blade tip.	0.062 inch (1.57 mm) maximum on leading and trailing edges.	Replace gas turbine.
f. Hot gas corrosion (sulfidation).	Any amount of discoloration or surface roughness, if there is no blistering, splitting, or separation (delamination) of the airfoil surface.	Replace gas turbine.
g. Airfoil for buildup of metal splatter.	Any amount, if gas turbine performance is satisfactory.	Replace gas turbine.
h. Blade tip for burrs.	Any amount, if gas turbine performance is satisfactory.	Replace gas turbine.

CAUTION

Do not use excessive force when installing the borescope plug or damage to the borescope plug and casing can occur

(2) Thread the plug into the borescope port. See view D.

(3) Torque the plug to 90-100 lb in. (10.2-11.3 N-m)

j. Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire borescope plug using the double-strand method (WP 007 00).

k. Follow procedures in steps a. through j for the borescope plug S51 at the 4:30 o'clock position on stage 5 LPT casing.

11. POST BORESCOPE INSPECTION PROCEDURES.

a. Disconnect the light source from the 115 volt, 60 Hz power source.

b. Disconnect the borescope probe from the light source.

c. Install the protective cover on the light source.

d. Put the light source and all borescope equipment in their cases (see figure 3).

e. Remove the ratchet wrench and the 3/8-inch drive extension from the cranking pad on the aft side of the accessory drive gearbox.

f. Install the cranking pad cover and the snapring.

g. Reinstall customer equipment that was removed to gain access to AGB cranking pad and to borescope plug ports.

Turbine Operating Hours 5000-10000

Elements of Turbine Blade Coat	Level
Chromium	80%
Natrium	60%
Carbondioxcide	70%

h. Carefully remove the borescope probe from the borescope port.

NOTE

There are two types of borescope plugs S49, the screwdriver slot bayonet type and the threaded type. Install the bayonet type per step i. and the threaded type per step j.

i. Install the bayonet type borescope plug S49 (figure 11, sheet 1, detail A) as follow:

(1) Align the borescope plug grooves with the pins in the borescope port and insert the plug into port. The screwdriver slot in the plug must be approximately aligned with the UNLOCKED position on the rear main mount. See detail B.

(2) Insert a wide flat blade screwdriver in the slot of the plug.

CAUTION

Do not use excessive force when installing the borescope plug or damage to the borescope plug and casing can occur.

(3) Push radially inward on the borescope plug approximately 0.20 inch (5.1 mm) and turn plug clockwise approximately 45 degrees. Do not turn the plug once an increase in resistance is felt.

(4) Release pressure from the plug. The plug must move radially outward approximately 0.10 inch (2.5 mm) and be correctly installed in the HPT casing as pressure is released. The slot in the plug must be aligned with the LOCKED position on the rear main mount. See detail B.

j. Install the threaded type borescope plug S49 (figure 11, sheet 2, detail D) as follows:

(1) Lubricate the external threads of the plug with magnesium hydroxide compound (unflavored milk of magnesia). See view E. Let the compound dry before installing the plug.

CAUTION

Do not use excessive force when installing the borescope plug or damage to the borescope plug and casing can occur.

(2) Thread the plug into the HPT casing boss. See detail D.

(3) Torque the plug to 50-60 lb in. (5.6-6.8 N·m).

(4) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire borescope plug using the double-strand method (WP 007 00).

10. BORESCOPE INSPECTION OF STAGES 3 THROUGH 5 LOW-PRESSURE TURBINE (LPT) ROTOR BLADES.

NOTE

There are two types of borescope plug S50, the bayonet type and the threaded type. Remove the bayonet type per step a. and the threaded type per step b.

a. Remove the bayonet type borescope plug S50 (figure 12, sheet 1, detail A) as follows:

(1) Insert a 3/8-inch drive into the borescope plug socket.

CAUTION

Do not use excessive force when removing the borescope plug or damage to the borescope plug and casing can occur

(2) Press the borescope plug inward and rotate plug counterclockwise.

(3) Remove the plug.

b. Remove the threaded type borescope plug S50 (figure 12, sheet 2, detail D) as follows:

CAUTION

Do not use excessive force when removing the borescope plug or damage to the borescope plug and casing can occur.

(1) Using a 3/8-inch drive or a 7/16-inch socket turn the plug counterclockwise until plug turns easily.

(2) Remove the 3/8-inch drive or 7/16-inch socket from the plug.

(3) Remove the plug.

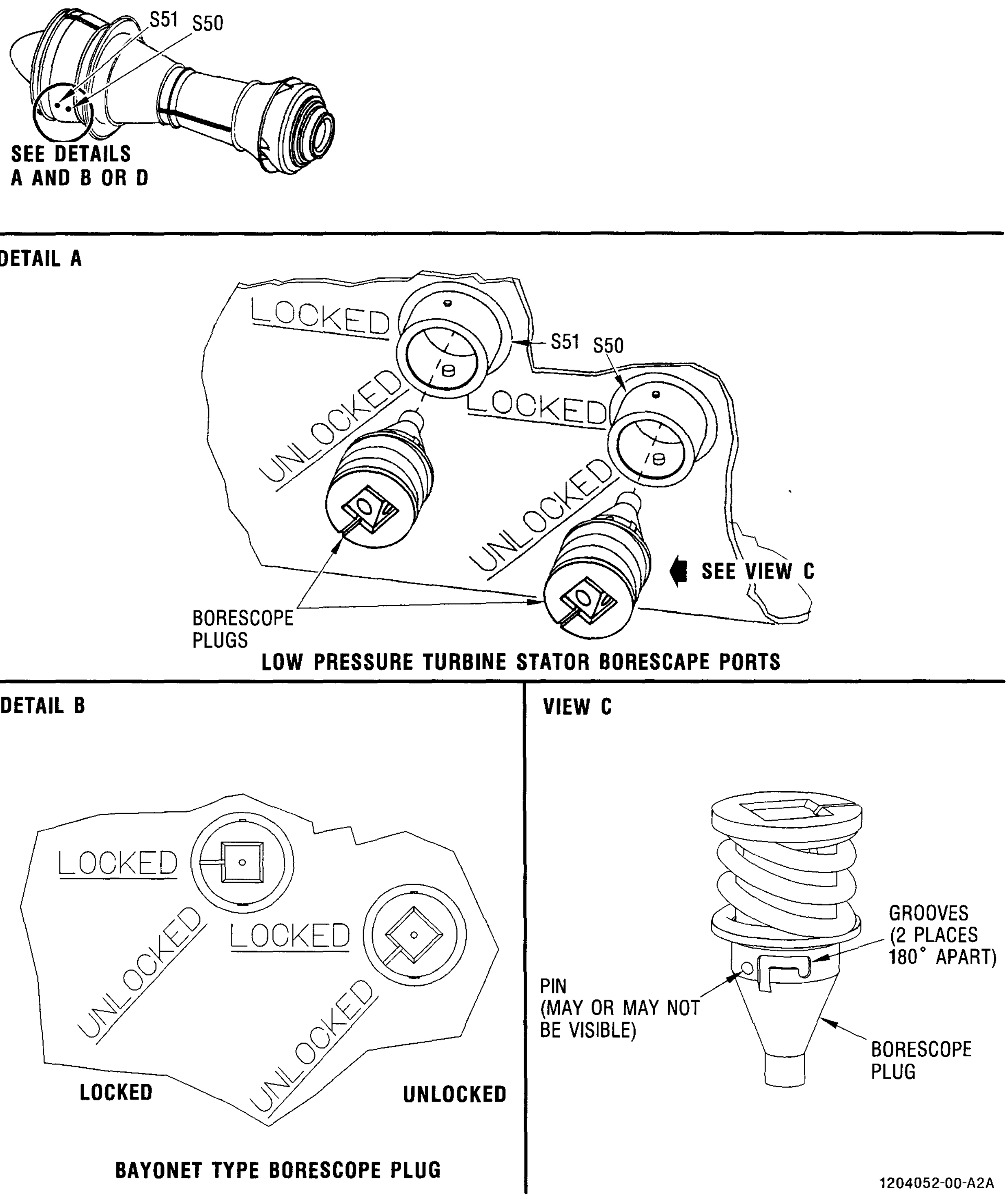


Figure 12. LPT borescope Plugs Removal and Installation (Sheet 1 of 2)

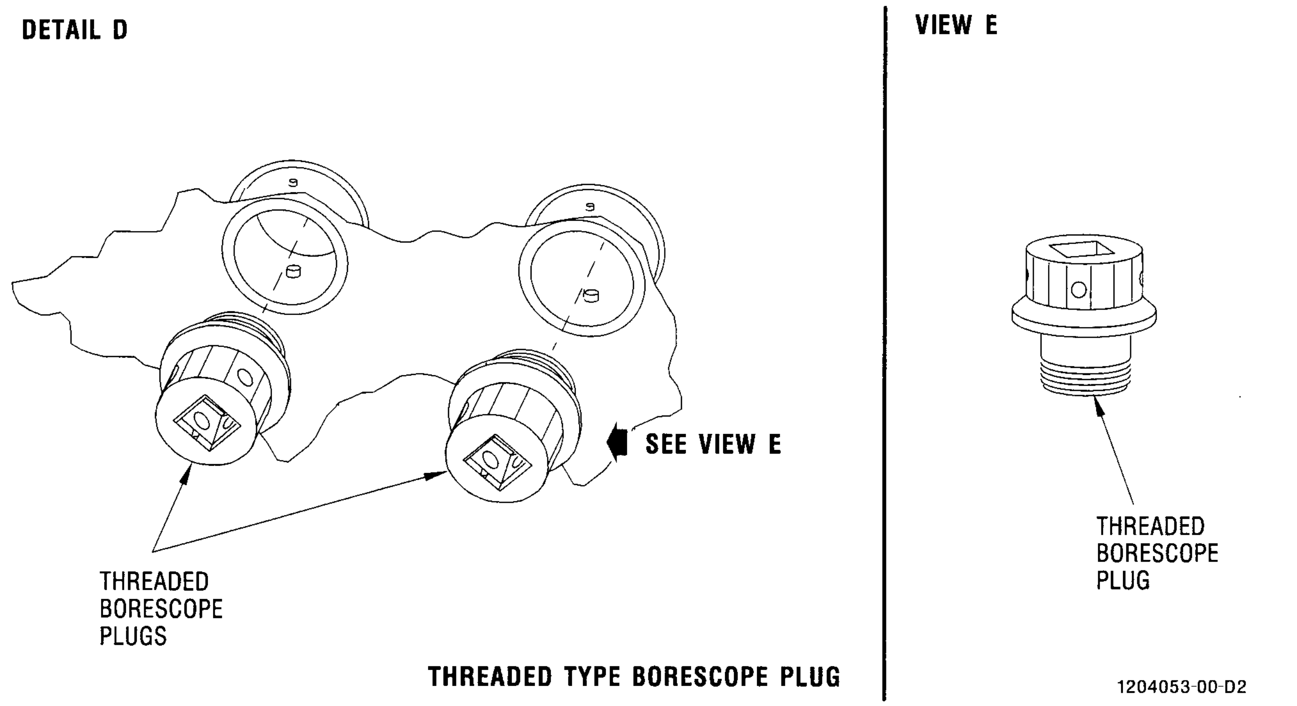


Figure 12. LPT borescope Plugs Removal and Installation (Sheet 2 of 2)

CAUTION

- Only approved personnel is allowed to borescope-inspect the gas turbine. Incorrect inspection can cause gas turbine removal that is not necessary.
- Be sure the inlet turbine temperature is less than 122°F (50°C) before you start the borescope procedure. Damage to the borescope can occur if the temperature is more than 122°F (50°C).

NOTE

It will be easier to see the components to be inspected if you use a rigid borescope 0.236 inch (6.0 mm) or less diameter, and will view at a right angle.

c. Turn the light source ON/OFF switch to the ON position and turn the brightness switch from the L position to the H position.

CAUTION

Be very careful and do not let the borescope probe touch the internal parts of the gas turbine when you put probe into the LPT casing port. Damage to the internal parts can occur.

NOTE

The compressor rotor and the high-pressure turbine (HPT) rotor are not turned when you inspect the stages 3 through 5 low-pressure turbine (LPT) rotor blades.

d. Carefully insert the borescope probe through the borescope port.

NOTE

The leading edge and the trailing edge of the rotor blades can be seen from the same angle.

e. Adjust the depth of the borescope probe and turn the borescope probe until you can see the LPT rotor blades (see figure 13). Inspect all LPT rotor blades. Refer to table 7 for inspection limits and corrective action.

f. Turn the brightness switch on light source from the H position to the L position and turn the ON/OFF switch to the OFF position.

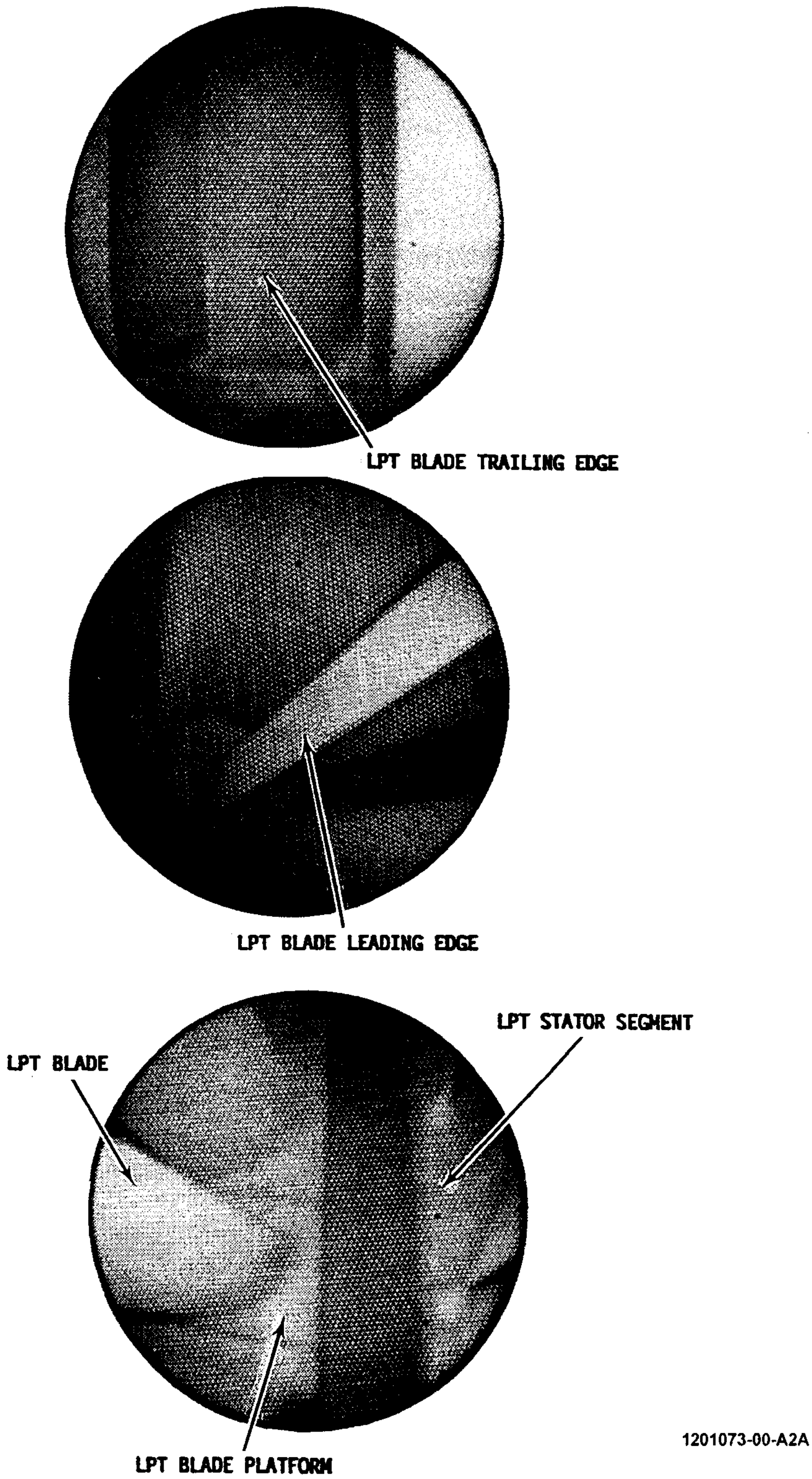


Figure 13. View of the LPT Rotor Blade Leading and Trailing Edges, the LPT Rotor Blade Platform, and the LPT Stator Segment

TABLE 7. BORESCOPE INSPECTION OF STAGES 3 THROUGH 5 LPT ROTOR BLADES

Inspect	Usable Limits	Corrective Action
a. Stages 3 through 5 rotor blades for:		
(1) Cracks.	None permitted.	Replace gas turbine.
(2) Erosion at leading edge.	0.010 inch (0.25 mm) maximum erosion, if gas turbine performance is satisfactory.	Replace gas turbine.
(3) Nicks, pits, scratches, and dents.	Any number, 0.005 inch (0.13 mm) deep without high metal.	Replace gas turbine.
(4) Hot gas corrosion.	Any amount of distortion with no surface roughness, blistering, or separation of airfoil surface.	Replace gas turbine.
b. Trailing edge for bending and twisting.	0.031 inch (0.79 mm) deviation from straight line.	Replace gas turbine.

g. Carefully remove the borescope probe from the borescope port.

NOTE

There are two types of borescope plug S50, the bayonet type and the threaded type. Install the bayonet type borescope plug S50 (figure 12, sheet 1, detail A) as follows:

h. Install the bayonet type borescope plug S50 (figure 12, sheet 1, detail A) as follows:

(1) Align the borescope plug grooves with the pins in the borescope port and insert the plug into the port

CAUTION

Do not use excessive force when installing the borescope plug or damage to the borescope plug and casing can occur

(2) Push inward on the borescope plug and turn plug counterclockwise until plug is engaged. Ensure the plug and the turbine stator matchmarks are aligned in the LOCKED position. See detail B.

i. Install the threaded type borescope plug S50 (figure 12, sheet 2, detail D) as follows:

(1) Lubricate the external threads of the plug with magnesium hydroxide compound (unflavored milk of magnesia). See view E. Let the compound dry before installing the plug.

CAUTION

Do not use excessive force when installing the borescope plug or damage to the borescope plug and casing can occur

(2) Thread the plug into the borescope port. See view D.

(3) Torque the plug to 90-100 lb in. (10.2-11.3 N-m)

j. Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire borescope plug using the double-strand method (WP 007 00).

k. Follow procedures in steps a. through j for the borescope plug S51 at the 4:30 o'clock position on stage 5 LPT casing.

11. POST BORESCOPE INSPECTION PROCEDURES.

a. Disconnect the light source from the 115 volt, 60 Hz power source.

b. Disconnect the borescope probe from the light source.

c. Install the protective cover on the light source.

d. Put the light source and all borescope equipment in their cases (see figure 3).

e. Remove the ratchet wrench and the 3/8-inch drive extension from the cranking pad on the aft side of the accessory drive gearbox.

f. Install the cranking pad cover and the snapring.

g. Reinstall customer equipment that was removed to gain access to AGB cranking pad and to borescope plug ports.

Level Elements	0-5000 operating hrs	5001-10 000 operating hrs	10001 - 25 000
Chromium	90-100%	70-90%	50-70%
Oxygen	90-100%	70-90%	50-70%
Natrium	90-100%	70-90%	50-70%
Carbondioxcide	90-100%	70-90%	50-70%

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

GAS TURBINE EXHAUST AREA AND EXHAUST CENTERBODY
INSPECTION, INSTALLATION, AND REMOVAL

(LEVEL 1 MAINTENANCE)

Effectivity:	L32119G01/-G03/-G04/ -G05/-G06	MARINE GAS TURBINE
	L32119G02	INDUSTRIAL GAS TURBINE

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1. INTRODUCTION. This work package provides instructions for inspecting (visually) the gas turbine exhaust area. Also, this work package provides instructions for removing and installing the exhaust centerbody to allow the inspection of the centervent tube for oil leakage.

2. SUPPORT EQUIPMENT.

Support Equipment

Part No.	Nomenclature
---	Bright Light
---	Grinder, Hand-Held Rotary

3. CONSUMABLE MATERIALS.

NOTE

Equivalent materials approved by GE Aircraft Engines may be substituted for items listed.

Consumable Materials

Description	Manufacturer
Cloth, Abrasive	Local Purchase
Gloves, Thermally Insulated	Local Purchase
Oil, Lubricating (MIL-L-7808 or MIL-L-23699)	Local Purchase

4. INSPECTION OF GAS TURBINE EXHAUST AREA.

a. Before inspecting the gas turbine exhaust area, do the following:

(1) Shut down the gas turbine.

(2) Deactivate the fire extinguishing system.

WARNING

Handling Hot Parts

- When handling hot parts, wear approved gloves.
- Handling of hot parts with bare hands may cause reddening and blistering of skin, or third-degree burns.
- If skin is burned, immerse contacted area in cold water for 10 minutes. If pain or blistering persists, immediately get medical attention.

(3) Allow the gas generator to cool to room temperature. (Avoid contact with hot parts: wear thermally insulated gloves, if necessary.)

(4) Tag electrical switches "Out-Of-Service" to preclude inadvertent activation. Tag the gas turbine operating controls "Do Not Operate" to prevent starting during a desired shutdown condition.

b. Remove customer equipment as follows:

(1) Remove the insulation on aft exhaust duct.

CAUTION

While removing the V-band clamp, be careful not to allow the aft exhaust duct to drop down and hit the inner exhaust cone.

(2) Remove the V-band clamp from forward and aft exhaust duct section.

(3) Push the aft exhaust duct into the exhaust collector as far as possible.

c. Inspect gas turbine exhaust area (table 1).

TABLE 1. INSPECTION OF GAS TURBINE EXHAUST AREA

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Inner casing (6, figure 1) for:			
(1) Cracks.	Any number, 1/4 inch (6.4 mm) long, a minimum of 1 inch (25 mm) apart.	Not repairable.	Replace exhaust frame.
(2) Dents.	Any number, 1/4 inch (6.4 mm) deep, a minimum of 1 inch (25 mm) from flange where exhaust centerbody (4) is attached.	Any number, any depth, a minimum of 1 inch (25 mm) from flange where exhaust centerbody (4) is attached.	Cold-work dent (WP 007 00) to usable limit. White-light inspect (WP 007 00) for cracks.
b. Flanges (7) for nicks, dents, and scratches.	Any number, 1/32 inch (0.8 mm) deep, without high metal, if 25 percent of original width of sealing surface is intact.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).
c. Outer casing (8) for:			
(1) Cracks in parent metal and welds.	None allowed.	Not repairable.	Replace exhaust frame.
(2) Dents.	Any number, 1/8 inch (3.2 mm) deep.	Any number, any depth.	Cold-work dent (WP 007 00) to usable limit. White-light inspect (WP 007 00) for cracks.
d. Struts (5) for cracks.	None allowed.	Not repairable.	Replace exhaust frame.
e. Exhaust centerbody (4) for:			
(1) Cracks.	Any number, 3/16 inch (4.8 mm) long.	Not repairable.	Replace centerbody (para 5).

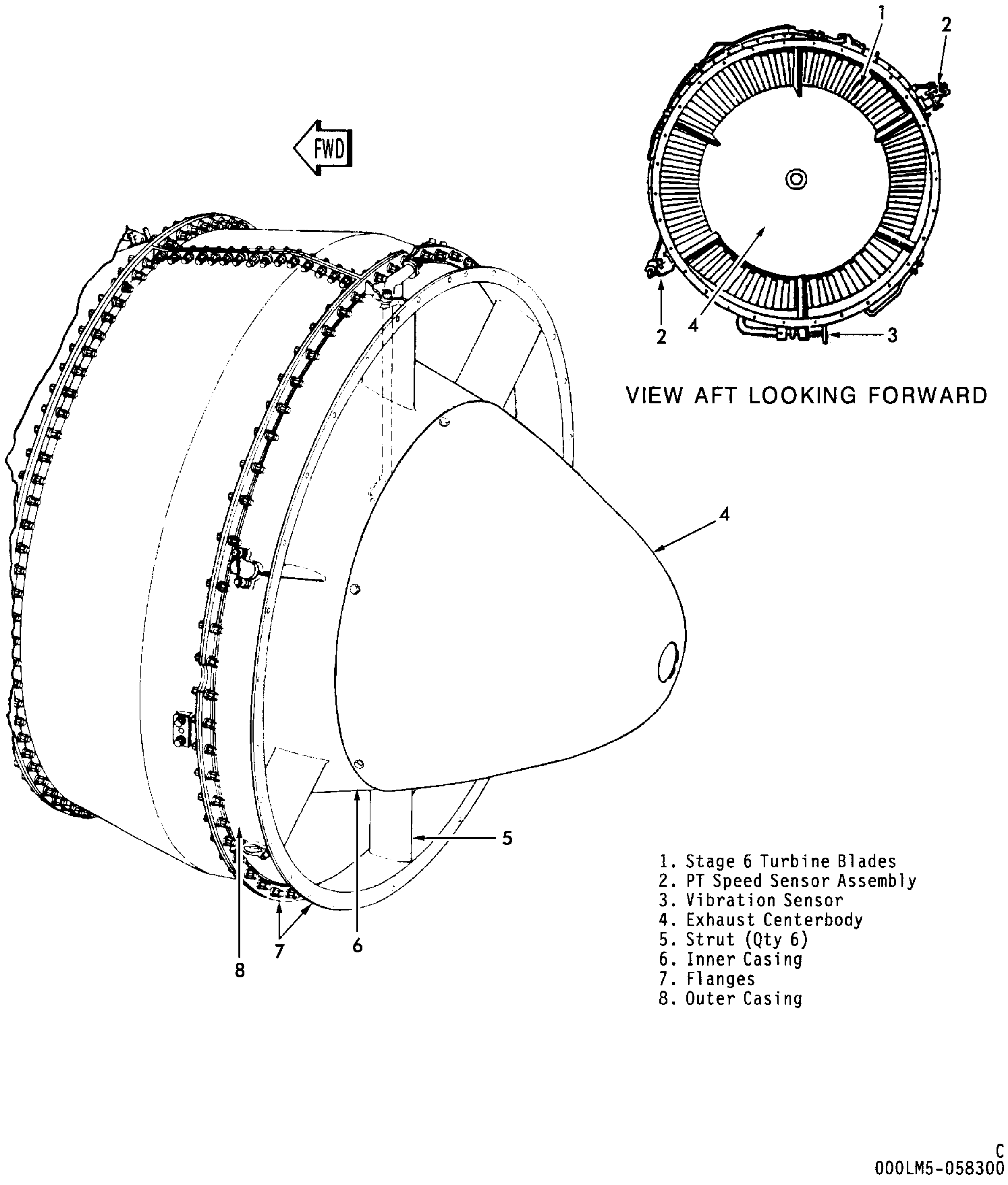


Figure 1. Inspection of Gas Turbine Exhaust Area

d. Reinstall customer equipment as follows:

(1) Pull the aft exhaust duct from the exhaust collector.

(2) Align the aft exhaust duct with the forward exhaust duct.

(3) Using V-band clamp, secure the forward and aft exhaust ducts. Torque V-band clamp to 35 lb in. (4.0 N·m). Be sure that the V-band clamp is seated onto flange of exhaust ducts equally.

(4) Using a plastic mallet, tap the V-band clamp lightly around its circumference while increasing the torque to 75 lb in. (8.5 N·m). After 75 lb in. (8.5 N·m) torque value is reached, tap around the clamp again and check that the torque remained at 75 lb in. (8.5 N·m).

(5) Reinstall insulation on aft exhaust duct.

5. REMOVAL AND INSTALLATION OF EXHAUST CENTERBODY.

a. Remove exhaust centerbody (2, figure 2) as follows:

(1) Remove six bolts (1) that secure centerbody (2) to exhaust frame (5).

(2) Remove centerbody (2) by pulling it straight aft.

b. Go to table 2 for inspection of centerbody and centervent tube (3).

c. Install exhaust centerbody (2, figure 2) as follows:

(1) Align TOP mark on centerbody (2) with the 12 o'clock position on exhaust frame (5). Install centerbody onto exhaust frame.

Lubricating Oil 66

(2) Using lubricating oil MIL-L-23699 or MIL-L-7808, lightly lubricate the threads of six bolts (1).

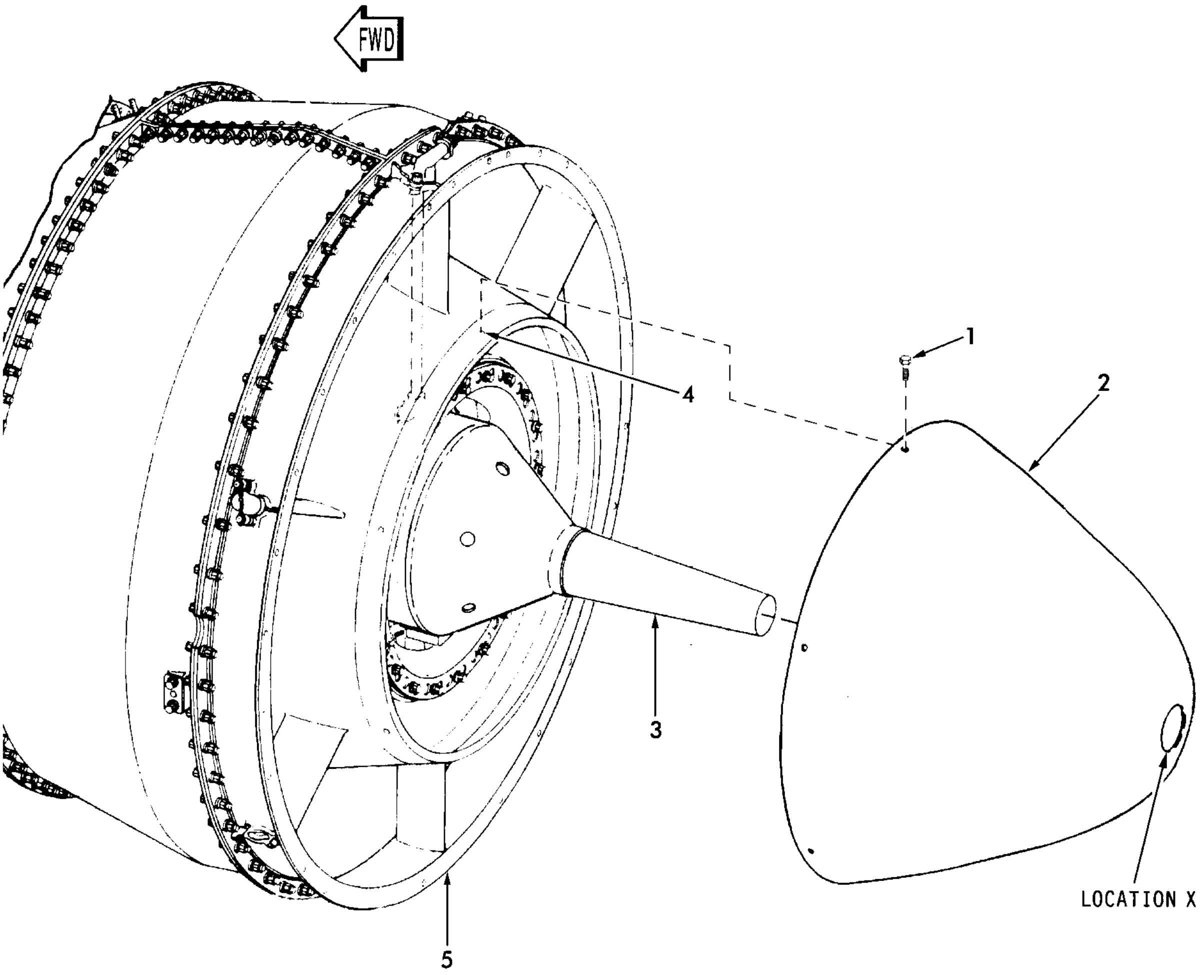
(3) Using six bolts (1), secure centerbody (2) to exhaust frame (5).

(4) Cross-torque bolts (1) to 38-42 lb in. (4.3-4.7 N·m).

(5) Insert a 0.050 inch (1.27 mm) thickness gage at location X, between centerbody (2) and centervent tube (3). Gage must enter at any point 360 degrees. If gage does not enter, loosen bolts (1) and reposition centerbody as necessary.

6. INSPECTION OF EXHAUST CENTERBODY AND CENTERVENT TUBE.

Go to table 2.



1. Bolt (Qty 6)
2. Exhaust Centerbody
3. Centervent Tube
   (part of C-Sump Rear Cover)
4. Anchor Nut (Qty 6)
5. Exhaust Frame

C
000LM5-058400

Figure 2. Removal, Inspection, and Installation of Exhaust Centerbody, and Inspection of Centervent Tube

TABLE 2. INSPECTION OF EXHAUST CENTERBODY AND CENTERVENT TUBE

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Exhaust centerbody (2, figure 2) for:			
(1) Cracks in:			
(a) Shell/cone.	Any number, 3/16 inch (4.8 mm) long.	Not repairable.	Replace centerbody (para 5).
(b) Stiffener.	Any number, 1/8 inch (3.2 mm) long.	Not repairable.	Replace centerbody (para 5).
(2) Dents.	Any number, 1/8 inch (3.2 mm) deep.	Any number.	Cold-work dent (WP 007 00) to original contour.
(3) Nicks and scratches.	Any number, 1/64 inch (0.4 mm) deep, without high metal.	Same as usable limits, with high metal.	Blend high metal (WP 007 00).
b. Anchor nuts (4) for:			
(1) Locking action.	Usable if bolt (1) cannot be threaded through entire nut by hand.	Not repairable.	Replace nut (para 7).
(2) Damaged threads.	Up to one thread cumulative, if bolt (1) can be threaded into nut.	Not repairable.	Replace nut (para 7).
c. Centervent tube (3) for:			
(1) Cracks.	None allowed.	Not repairable.	Replace exhaust frame.
(2) Evidence of oil leakage or coked oil.	Not allowed.	Not repairable.	Replace exhaust frame.
(3) Nicks and scratches.	Any number, 0.010 inch (0.25 mm) deep, without high metal.	Same as usable limits, with high metal.	Blend high metal (WP 007 00).

7. REPLACEMENT OF ANCHOR NUTS.

WARNING

Power Grinding

- Avoid prolonged or repeated contact with dust. Inhalation of dust may cause temporary coughing and wheezing, respiratory tract irritation, and permanent lung problems. If coughing or wheezing persists, get medical help.
- If dust contacts eyes, flush them thoroughly with water.
- When using an air-exhausted grinding wheel, wear approved respirator, goggles, or face shield.
- If grinder is not equipped with local exhaust ventilation, wear an appropriate respirator and goggles or face shield.

a. Using a hand-held rotary grinder, carefully grind off the damaged anchor nut. Do not grind into parent metal of exhaust frame.

b. Blend the area (WP 007 00) with abrasive cloth to remove all traces of nut retainer.

c. Using weld data (table 3), tackweld a new anchor nut at two locations 180 degrees apart.

TABLE 3. WELD DATA

Material to be Welded	Welding Rod Specification or Designation	Size (Dia)	Torch Gas Flow	Backup Gas Flow	Current (Amperes)	Weld Contour
AMS 5735	Hastelloy W (AMS 5786)	0.030-0.062 inch (0.76-1.57 mm)	Argon 8-14 CFH (0.23-0.40 m^3/hr)	Argon or Helium as required	25-30	Tack Weld

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

VARIABLE STATOR VANES (VSV) SYSTEM
INSPECTION AND RIGGING

(LEVEL 1 MAINTENANCE)

Effectivity:	L32119G01/-G03/-G04/ -G05/-G06	MARINE GAS TURBINE
	L32119G02	INDUSTRIAL GAS TURBINE

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1. INTRODUCTION. This work package provides instructions for inspecting and rigging the Variable Stator Vanes (VSV) system.

2. SUPPORT EQUIPMENT.

Support Equipment

Part No.	Nomenclature
1C7304G01	Set, VG Actuation Control
1C7307G01	Indicator, VSV Position
8600A-01	Voltmeter, Digital

3. CONSUMABLE MATERIALS.

NOTE

Equivalent materials approved by GE Aircraft Engines may be substituted for items listed.

Consumable Materials

Description	Manufacturer
Adhesive, RTV 106 Silicone Rubber (MIL-A-46106 or MIL-A-46106A)	GE Silicone Products Division 260 Hudson River Road Waterford, NY 12188-1910 USA or GE Silicones 5 Mail Joliot Curie 95-ST Ouen L'Aumone 95004 Cergy France
Caps, Protective	Protective Closures Co., Inc. 2166 Elmwood Avenue Buffalo, NY 14207 USA
Lockwire, 0.032 inch (0.81 mm) diameter	Local Purchase
Plugs, Protective	Protective Closures Co., Inc. 2166 Elmwood Avenue Buffalo, NY 14207 USA

4. INSPECTION OF VSV SYSTEM.

a. Inspect the following components of the VSV system (see figure 1) for evidence of leakage, looseness, damage, or binding:

- Actuator hose assembly (1)
- Actuator rings (2)
- Actuator shaft (3)
- VG actuator (4)
- Feedback arm (5)
- Feedback cable (6).

b. If any components listed in step a. show evidence of damage, refer to WP 028 00 or WP 029 00 for further inspection and, if necessary, replacement of components.

c. Inspect CIT sensor for damage. Replace CIT sensor (WP 009 00) if necessary.

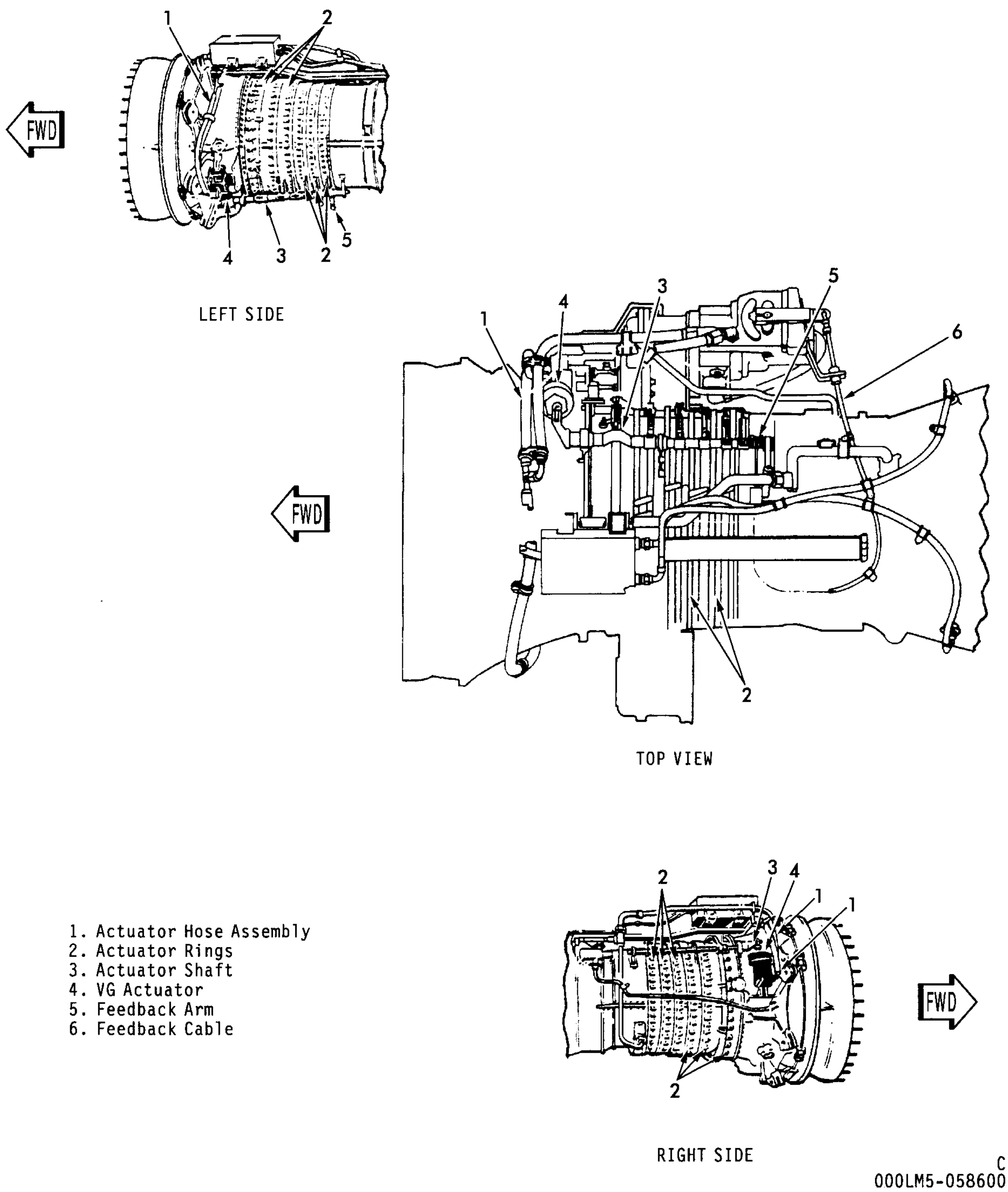


Figure 1. Inspection of Variable Stator Vanes (VSV) System Components

5. RIGGING OF VSV SYSTEM (STATIC CONDITION).

Hydraulic Fluid 71

NOTE

Have a 5-gallon (19 liters) container at hand to catch hydraulic fluid from VG actuator head hose (9, figure 2, view A) and rod hose (11).

a. Disconnect VG actuator head hose (9, figure 2, view A) from head end manifold tee (5). Install protective plug at end of head hose.

b. Disconnect VG actuator rod hose (11) from rod end manifold tee (8). Install protective plug at end of rod hose.

c. Connect head hose (3), of VG actuation control set 1C7304G01 (1), to head end manifold tee (5).

d. Connect rod hose (7), of VG actuation control set 1C7304G01 (1), to rod end manifold tee (8).

e. Position selector valve (15) to the NEUTRAL position.

f. Connect a source of compressed air to the quick-disconnect fitting (2). Adjust pressure regulator to maintain 30-35 psig (207-241 kPa). If a source of compressed air is not available, use a high-pressure nitrogen bottle with regulator (regulator must be preset to 200 psi (1379 kPa) maximum before connecting to control set (1)).

g. Move selector valve (15) to the OPEN position so that actuator rings on gas turbine move counterclockwise and actuator rods on VG actuators (4, 6) are fully extended (vanes are in the fully-open position).

h. Move selector valve (15) to the CLOSED position so that actuator rings on gas turbine move clockwise and actuator rods on VG actuators (4, 6) are fully retracted (vanes are in the fully-closed position).

i. If vanes are at or near the fully-closed position, repeat steps g and h to cycle the actuator rings to be sure that the vanes at the fully-closed position.

j. Check the rig position of the feedback lever arm (10, view A) by checking the alignment of the pointer on lever arm with the rig mark on the VG control indicator plate (12). If marks are not aligned, do the following:

(1) Remove lockwire and loosen jamnuts on either side of the feedback cable (13). Rotate turnbuckle until the pointer on lever arm (10) is aligned with the rig mark on indicator plate (12).

(2) Torque jamnuts to 135-150 lb in. (15.3-16.9 N·m). Do not lock-wire jamnuts at this time.

(3) Cycle the actuator rings and check that the feedback cable (13) is not bottomed out internally at either end of the actuator stroke.

k. Position selector valve (15) to the NEUTRAL position. Remove source of compressed air from quick-disconnect fitting (2).

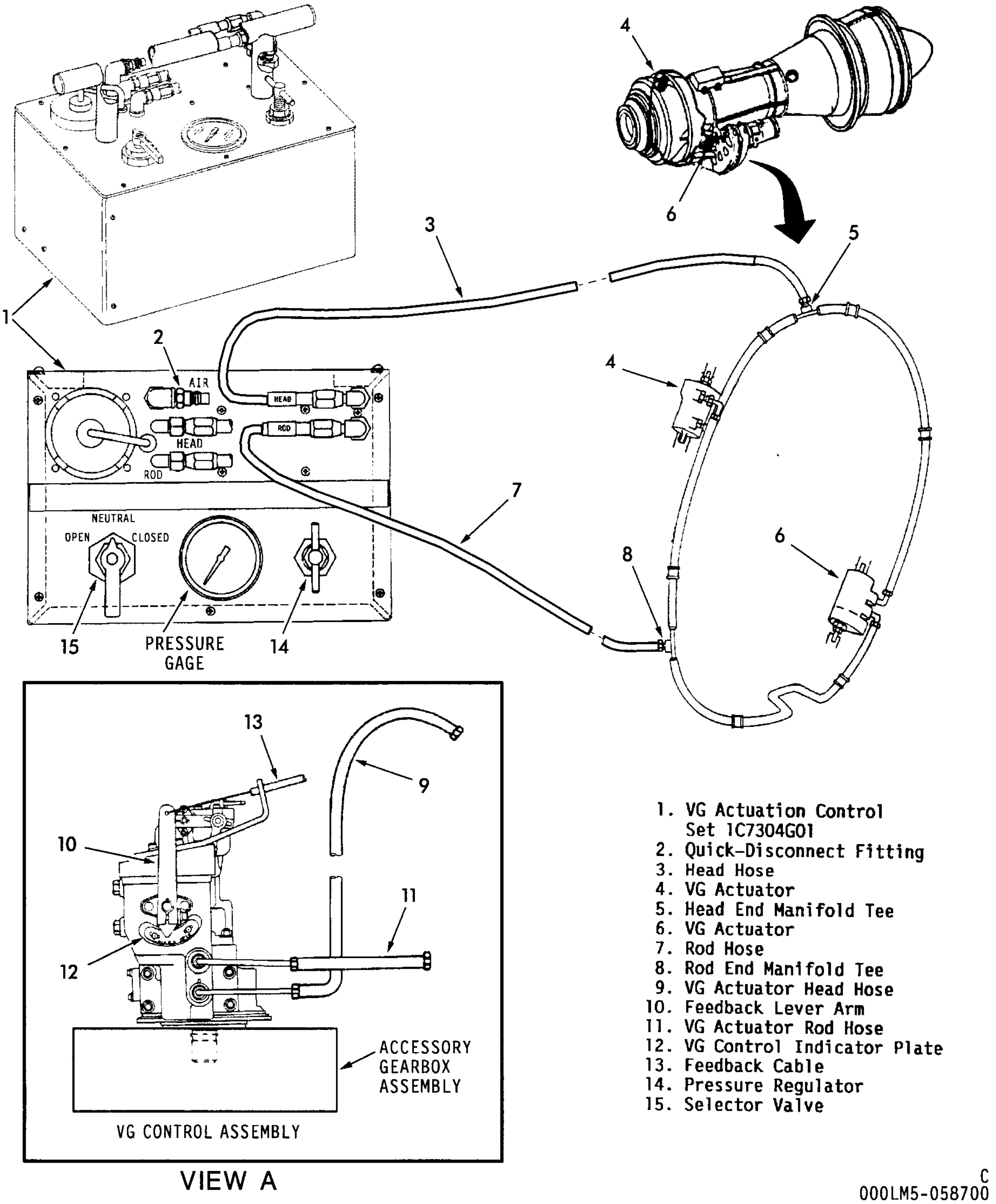


Figure 2. Rigging of VSV System (Static Condition), Using VG Actuation Control Set 1C7304G01

l. Disconnect rod hose (7) from rod end manifold tee (8).

m. Disconnect head hose (3) from head end manifold tee (5).

n. Connect VG actuator rod hose (11) to rod end manifold tee (8). Torque hose connection to 135-150 lb in. (15.3-16.9 N·m).

o. Connect VG actuator head hose (9) to head end manifold tee (5). Torque hose connection to 180-200 lb in. (20.3-22.6 N·m).

CAUTION

Gas turbine must be operated at IDLE speed for 5 minutes following the first start after rigging the VSV system. This is necessary to purge entrapped air from VG actuators and supply hoses before accelerating to operating speed; otherwise, gas turbine could stall.

p. Do an idle speed check and operate gas turbine for 5 minutes; shut down gas turbine. Do a VSV rig check (para 6).

6. RIG CHECK OF VSV SYSTEM (OPERATING CONDITION).

a. Preliminary Instructions.

(1) The VSV system rig check must be done during the first operation of a new or overhauled gas turbine. The VSV system should be checked at several points during operation between IDLE and 17,000 rpm (corrected).

(2) The VSV system rig check must be done periodically to check the VSV linkage for wear or if the VG schedule has shifted.

(3) The VSV system rig check must also be done after the adjustment, repair, or replacement of the VG control assembly, feedback cable, or any VG components.

b. Setup of VSV System Rig Check.

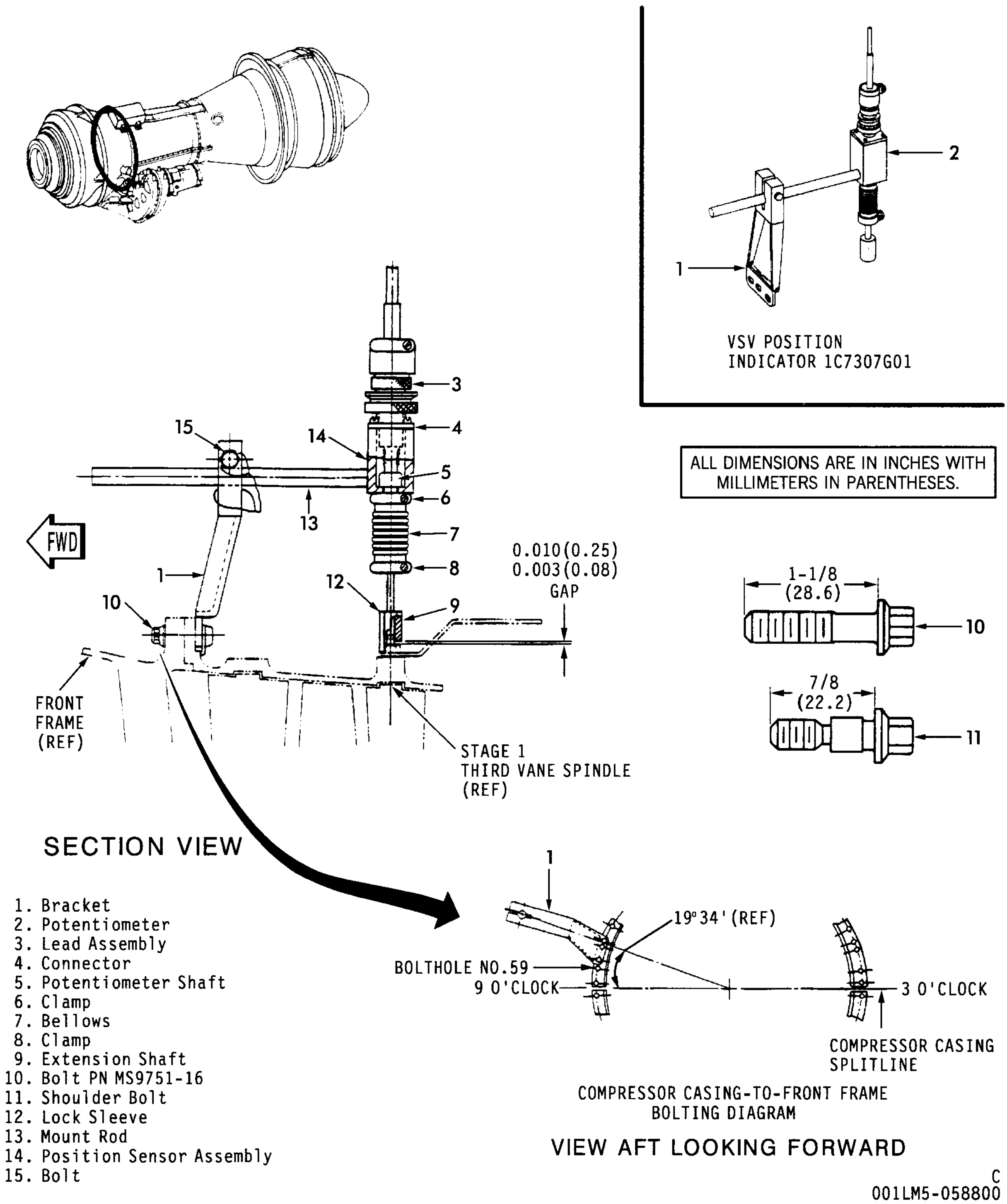
(1) Install VSV position indicator 1C7307G01 (see figure 3, sheet 1) as follows:

(a) Remove three locknuts and three 7/8 inch (22.2 mm) long shoulder bolts (11) from compressor casing-to-front frame flange at boltholes No. 60, 61, and 62.

(b) Position bracket (1) (part of indicator 1C7307G01) onto boltholes No. 60, 61, and 62.

(c) Using three 1-1/8 inches (28.6 min) long bolts PN MS9751-16 (10) and locknuts, secure bracket (1) to compressor casing flange. Torque locknuts to 105-115 lb in. (11.9-13.0 N·m).

(d) Position extension shaft (9) onto the third vane spindle of stage 1 so that the hex flat on shaft aligns with hex flat of vane lever locknut. Be sure there is a 0.003-0.010 inch (0.08-0.25 mm) gap as shown.



1. Bracket
2. Potentiometer
3. Lead Assembly
4. Connector
5. Potentiometer Shaft
6. Clamp
7. Bellows
8. Clamp
9. Extension Shaft
10. Bolt PN MS9751-16
11. Shoulder Bolt
12. Lock Sleeve
13. Mount Rod
14. Position Sensor Assembly
15. Bolt

Figure 3. Rig Check of VSV System (Operating Condition), Using VSV Position Indicator 1C7307G01 (Sheet 1 of 2)

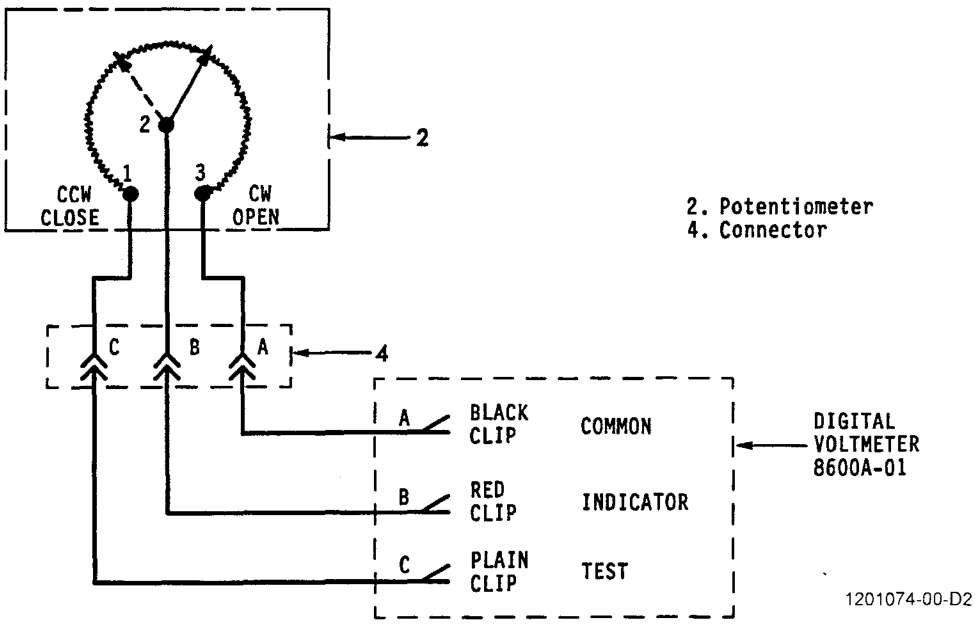


Figure 3. Rig Check of VSV System (Operating Condition), Using VSV Position Indicator 1C7307G01 (Sheet 2 of 2)

RTV Silicone Rubber Adhesive/Sealant, MIL-A-46106 or MIL-A-46106A **95**
RTV-60 Silicone Rubber Potting Compound, MIL-I-46838B

(e) Slide lock sleeve (12) over extension shaft (9) to prevent loosening during gas turbine operation. Secure lock sleeve with a small amount of RTV 106 silicone rubber adhesive (MIL-A-46106 or MIL-A-46106A).

(f) Assemble clamps (6, 8) and bellows (7) onto extension shaft (9).

(g) Insert mount rod (13) of position sensor assembly (14) in bracket (1).

(h) Align potentiometer shaft (5) with extension shaft (9).

(i) Slide bellows (7) up into potentiometer shaft (5).

(j) Tighten bolt (15) and clamp (6). Do not tighten clamp (8).

(2) Adjust bellows (7) and potentiometer (2) as follows:

(a) Using digital voltmeter 8600A-01, verify that there are 4,500-5,500 ohms between pins A and C (sheet 2) on potentiometer (2).

(b) Connect leads of voltmeter to connector (4) as shown in schematic (sheet 2). Zero the voltmeter.

(c) With the variable stator vanes in the fully-closed position (gas turbine is shutdown), rotate bellows (7) so that potentiometer reading on voltmeter is 2,760-2,800 ohms. Tighten clamp (8, sheet 1).

(3) Connect lead assembly (3) to connector (4). Route the other end of lead to outside area of gas turbine. Connect lead to digital voltmeter.

c. Performing Running Rig Check.

(1) Start gas turbine and stabilize at idle speed. Gas generator (GG) rotor speed should reach approximately 11,200 rpm and power turbine (PT) shaft speed should reach approximately 5,000 rpm with no load.

(2) Observe the resistance reading on digital voltmeter.

(3) Record the following data in applicable blocks in figure 4:

- Resistance reading
- GG rotor speed
- PT shaft speed.

(4) Enter the recorded resistance reading on the graph in figure 4 and obtain the VSV position beta angle. Record the obtained beta angle in applicable block.

(5) Determine the VSV system schedule as follows:

(a) Enter the recorded VSV position beta angle in figure 5 and figure 6.

(b) Observe and record gas turbine air inlet temperature in figure 5.

NOTE

- Figure 5 provides VSV system schedule limits without the correction to standard temperature.
- Figure 6 provides VSV system schedule limits corrected to standard temperature.
- For initial running rig check, it is preferred to use limits in figure 6.

(c) Using either figure 5 or 6, determine VSV position schedule (vanes open or closed) for a given beta angle, GG rotor speed, and air inlet temperature.

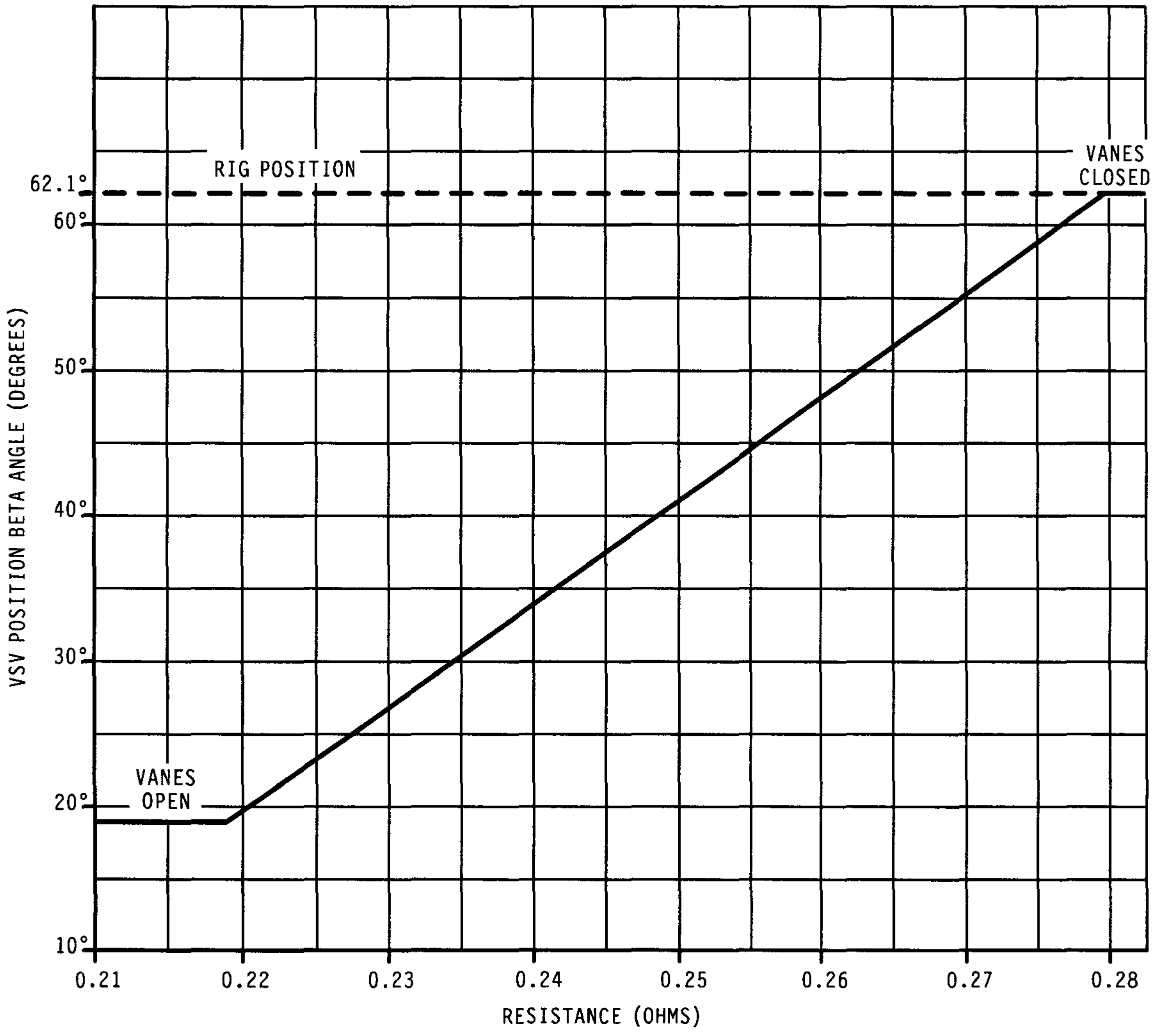
(6) If VSV position schedule is out of limits, do the following:

(a) Shut down gas turbine.

NOTE

Lengthening the feedback cable (13, figure 2) will close the vanes.

(b) Loosen jamnuts on either side of feedback cable (13). Rotate turnbuckle as required to achieve nominal position as shown in figure 6.



OHMS	RESISTANCE READING
RPM	GG ROTOR SPEED
RPM	PT SHAFT SPEED
DEGREES	VSV POSITION BETA ANGLE

C
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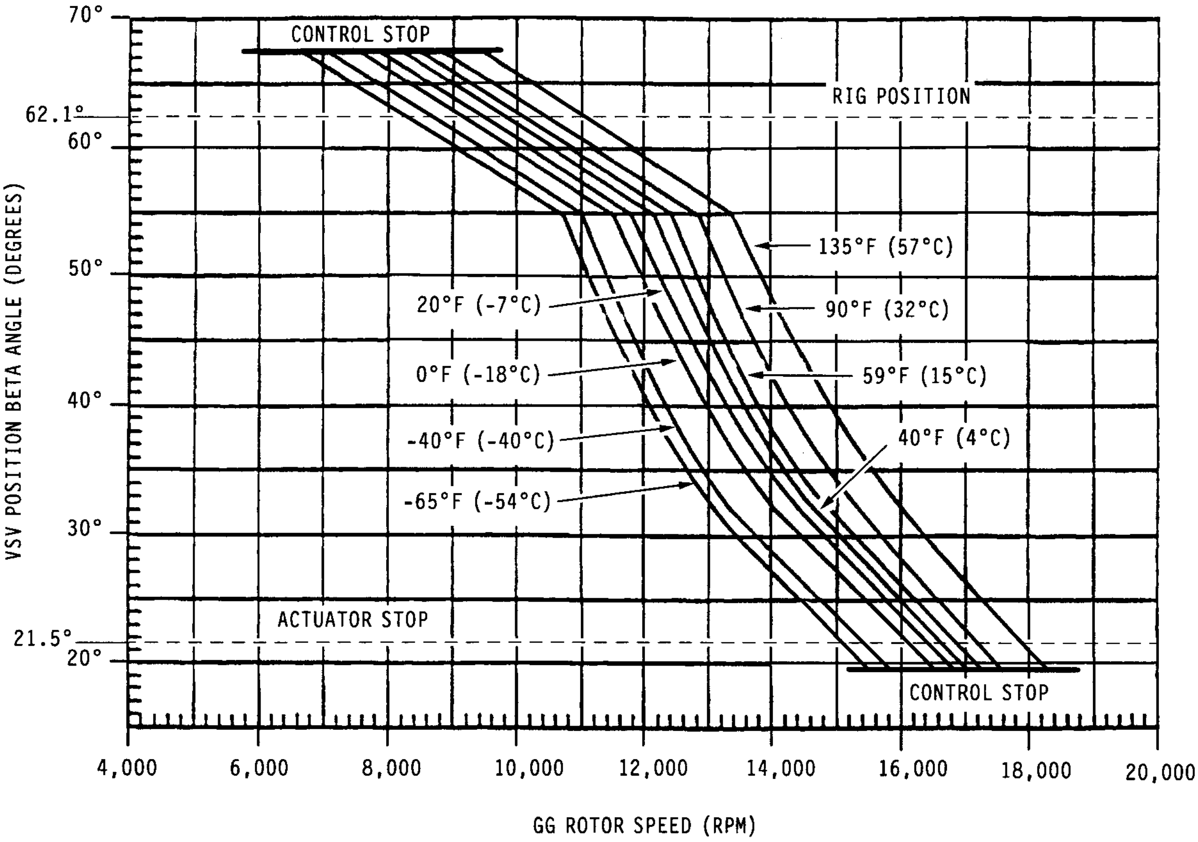
Figure 4. Determining VSV Position Beta Angle



$$\frac{\Delta \text{ GG ROTOR SPEED}}{\Delta \text{ AIR INLET TEMPERATURE}} = 13.939 \text{ RPM/DEGREE}$$

°F (°C)	AIR INLET TEMPERATURE

NOTE

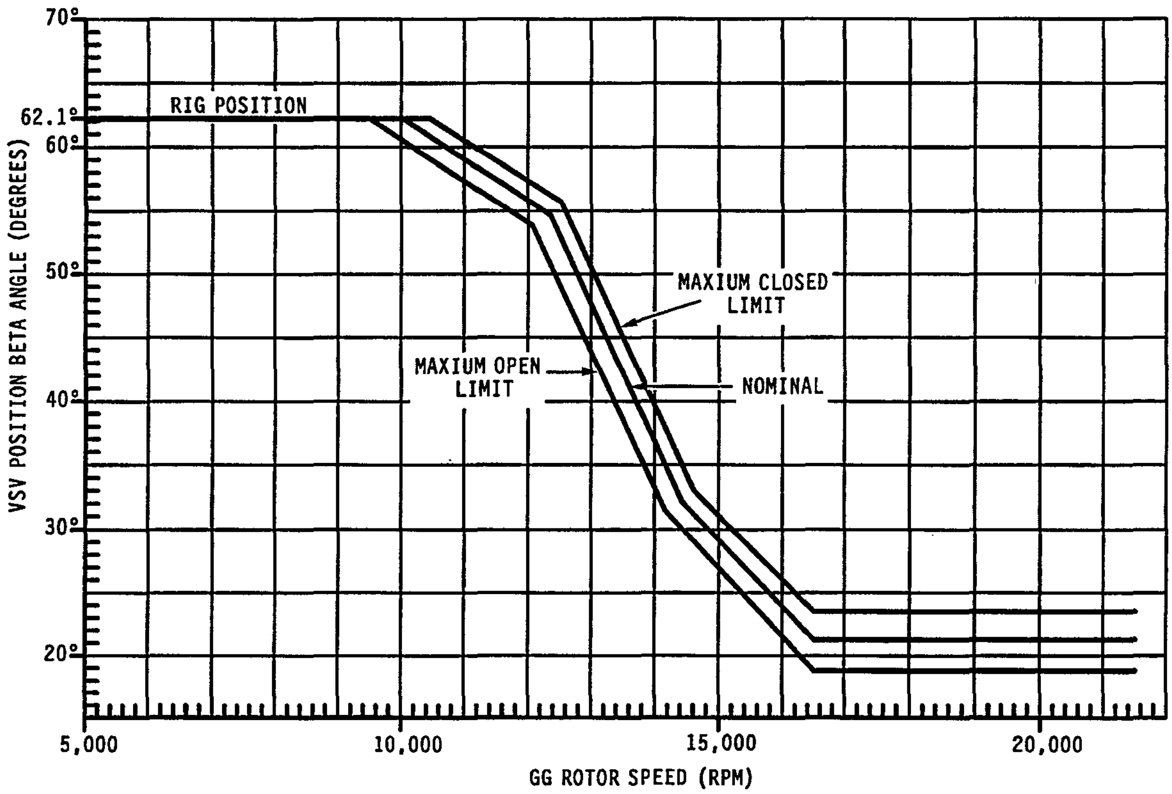
CONSTANT 13.939 RPM/DEGREE TO BE USED IN FIGURE 6 FOR CORRECTING INLET AIR TEMPERATURE.

C
000LM5-059000

Figure 5. VSV System Schedule (Not Corrected to Standard Temperature)

CAUTION

IF GAS TURBINE HAS BEEN OPERATED ABOVE IDLE SPEED WITH VSV POSITION (STAGE 1 STATOR VANE ANGLE) MORE THAN 3 DEGREES BELOW THE OPEN LIMIT AT THE IDLE CHECK POINT OR MORE THAN 2.5 DEGREES BELOW THE OPEN LIMIT AT THE HIGH SPEED CHECK POINT (15,000 - 16,720 RPM), STAGE 1 COMPRESSOR BLADES MUST BE REPLACED.



CORRECTION FOR AIR INLET TEMPERATURE

GG ROTOR SPEED (NOMINAL) = [GG ROTOR SPEED (ACTUAL)] + 13.939

1201075-00-A2A

Figure 6. VSV System Schedule (Corrected to Standard Temperature)

(c) Torque jamnuts to 135-150 lb in. (15.3-16.9 N·m).

(d) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire jamnuts using the double-strand method (WP 007 00).

CAUTION

Do not allow vane position to exceed the limits given in figure 6 during the running rig check. If limits are exceeded, stage 1 compressor blades will get damaged.

(7) Start gas turbine and stabilize at idle speed.

(8) While increasing GG rotor speed at increments of 1,000-1,500 rpm until vanes are fully open, do the following:

(a) Set control to AUTO position and increase gas turbine loads with bypass control to obtain GG rotor speed above idle with control system. Using procedures in steps (2) through (5), determine and plot VSV position at each set point. Do not adjust feedback cable length to reach nominal when GG rotor speed is above idle.

(9) Review VSV position schedule for data entered in figure 5 or 6 from step (8).

(10) If VSV position schedule is out of limits, troubleshoot for the following conditions:

- Loose or damaged feedback cable
- Improperly calibrated or loose VSV position indicator 1C7307G01
- Loss of hydraulic pressure
- Sticking VG actuator
- Defective VG control.

(11) If VSV position schedule is within limits, record final VSV position and GG rotor speed as baseline data. Retain data for future reference.

d. Removal of VSV Position Indicator 1C7307G01.

(1) Loosen bolt (15, figure 3) and clamps (6, 8). Remove position sensor assembly (14) from stage 1 third vane spindle.

(2) Remove three locknuts and three bolts (10) from bracket (1). Remove bracket from compressor casing-to-front frame flange.

(3) Reinstall three shoulder bolts (11), boltheads forward, into boltholes No. 60, 61, and 62. Secure bolts with locknuts.

(4) Torque locknuts to 105-115 lb in. (11.9-13.0 N·m).

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

CHIP DETECTORS AND DRAIN PLUG
REMOVAL, CLEANING, INSPECTION, AND INSTALLATION

(LEVEL 1 MAINTENANCE)

Effectivity:	L32119G01/-G03/G04/	
	-G05/-G06	MARINE GAS TURBINE
	L32119G02	INDUSTRIAL GAS TURBINE

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1. INTRODUCTION. This work package provides instructions for removing, cleaning, inspecting, and installing the chip detectors drain plug as determined by the periodic inspections and maintenance table in WP 008 00.

2. SUPPORT EQUIPMENT.

None

3. CONSUMABLE MATERIALS.

NOTE

Equivalent materials approved by GE Aircraft Engines may be substituted for items listed.

Consumable Materials

Description	Manufacturer
Cloth, Lint-Free	Local Purchase
Lockwire, 0.032 inch (0.81 mm) diameter	Local Purchase
Solvent, Dry Cleaning (Stoddard Solvent) P-D-680	Local Purchase
Tape, Masking	Local Purchase

4. GENERAL INFORMATION.

a. There are four chip detectors (see figure 1) on the LM500 gas turbine located at:

- One chip detector (3, view A) in fitting on A-sump scavenge tube (1)
- One chip detector (6, view B) in fitting on C-sump forward scavenge tube (4)
- One chip detector (9, view C) on aft end of accessory drive gearbox assembly (7)
- One chip detector (12, view D) in screen insert tee (10) on lube and scavenge pump

b. There is also a drain plug (13, view C) located approximately at the 6 o'clock position on the aft end of the accessory drive gearbox assembly (7). Materials such as non-metallic sludge, small silver or non-magnetic flakes, or bronze powder, or machining chips of aluminum will accumulate on drain plug.

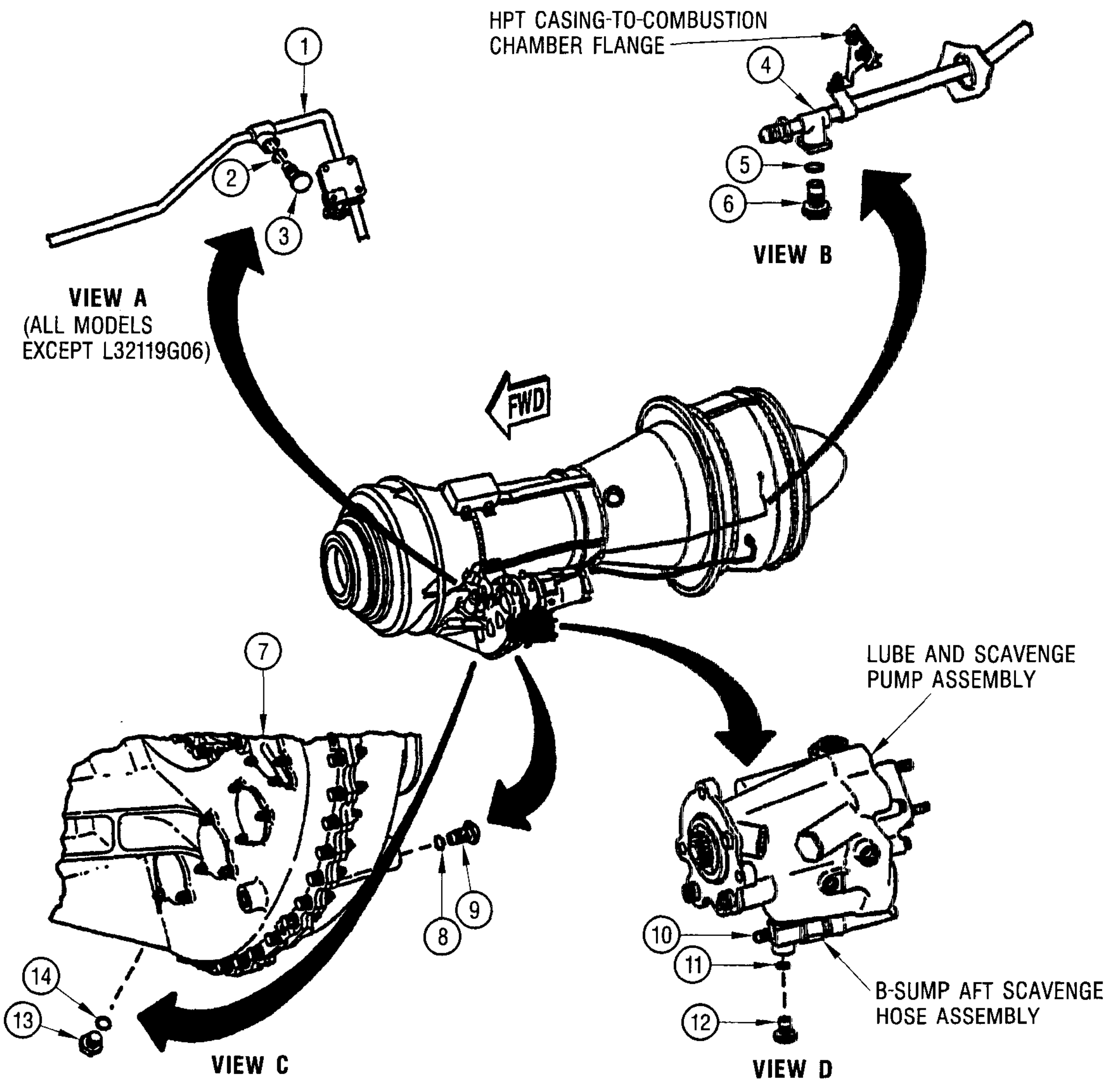
c. During normal gas turbine operation, some accumulation of fuzz-like magnetic particles (see figure 2, view A) will be found on chip detectors when they are removed and inspected. Other materials such as nonmetallic sludge, small silver or non-magnetic flakes, or bronze powder or machining chips of aluminum (the latter especially on new gas turbines) will accumulate on drain plug. The amount will vary but should not be cause for gas turbine removal.

d. Hair-like slivers of magnetic particles up to I inch (25 mm) long may be found on chip detectors and should not be cause for gas turbine removal.

e. Flakes of magnetic material (view B) 1/64 inch (0.4 mm) diameter or more may indicate a pending failure. This condition is cause for gas turbine removal.

f. Chunks of metallic material 1/32 x 1/32 inch (0.8 x 0.8 mm) or more, other than fuzz or hair-like slivers, are also cause for gas turbine removal.

g. If there is evidence of contamination on the chip detectors, service (WP 019 00) the lube filter, the lube and scavenge pump, and the A-sump scavenge pump.



1. A-SUMP SCAVENGE TUBE
2. PACKING
3. CHIP DETECTOR
4. C-SUMP FORWARD SCAVENGE TUBE
5. PACKING
6. CHIP DETECTOR
7. ACCESSORY DRIVE GEARBOX ASSEMBLY
8. PACKING
9. CHIP DETECTOR
10. SCREEN INSERT TEE
11. PACKING
12. CHIP DETECTOR
13. DRAIN PLUG
14. PACKING

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Figure 1. Location of Chip Detectors and Drain Plug

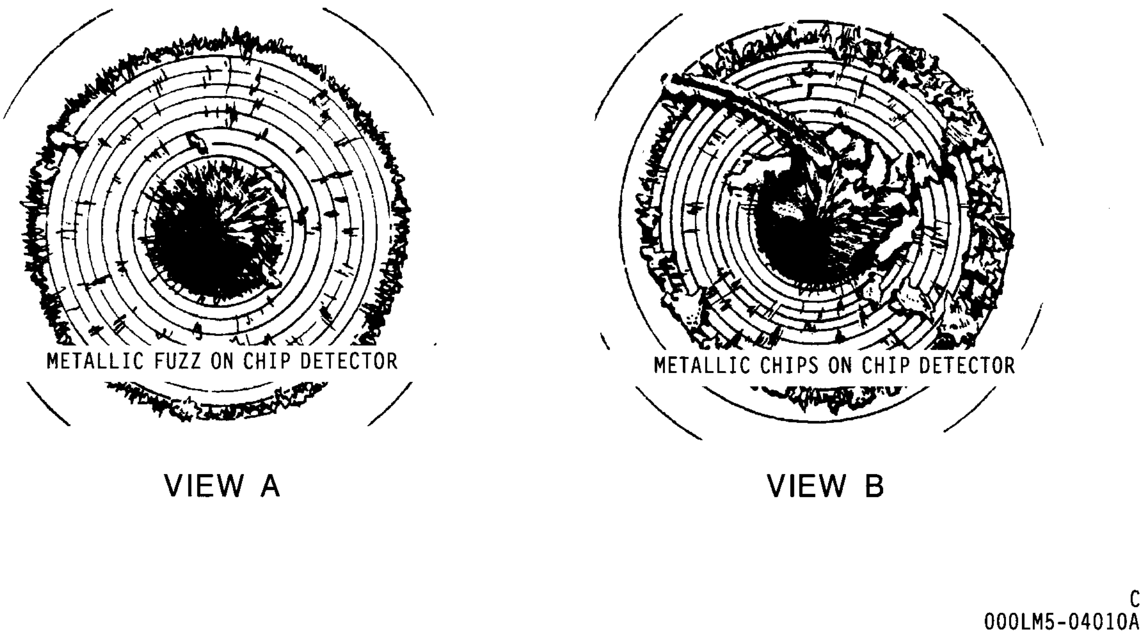

Figure 2. Accumulation of Metallic Material on Chip Detectors

5. REMOVAL OF CHIP DETECTORS AND DRAIN PLUG.

a. Remove lockwire from four chip detectors (3, 6, 9, 12, figure 1, views A through D), and from drain plug (13, view C).

WARNING

Removing Magnetic Chip Detectors

To prevent being burned by hot oil, wear protective gloves when removing chip detectors.

b. (All models except L32119G06) Remove chip detector (3, view A) from fitting on A-sump scavenge tube (1), located at the 4 o'clock position (forward looking aft), half way up the compressor casing. Discard packing (2).

c. Remove chip detector (6, view B) from fitting on C-sump forward scavenge tube (4), located at the 4 o'clock position (forward looking aft). Discard packing (5).

7. REPLACEMENT OF ANCHOR NUTS.

WARNING

Power Grinding

- Avoid prolonged or repeated contact with dust. Inhalation of dust may cause temporary coughing and wheezing, respiratory tract irritation, and permanent lung problems. If coughing or wheezing persists, get medical help.
- If dust contacts eyes, flush them thoroughly with water.
- When using an air-exhausted grinding wheel, wear approved respirator, goggles, or face shield.
- If grinder is not equipped with local exhaust ventilation, wear an appropriate respirator and goggles or face shield.

a. Using a hand-held rotary grinder, carefully grind off the damaged anchor nut. Do not grind into parent metal of exhaust frame.

b. Blend the area (WP 007 00) with abrasive cloth to remove all traces of nut retainer.

c. Using weld data (table 3), tackweld a new anchor nut at two locations 180 degrees apart.

TABLE 3. WELD DATA

Material to be Welded	Welding Rod Specification or Designation	Size (Dia)	Torch Gas Flow	Backup Gas Flow	Current (Amperes)	Weld Contour
AMS 5735	Hastelloy W (AMS 5786)	0.030-0.062 inch (0.76-1.57 mm)	Argon 8-14 CFH (0.23-0.40 m^3/hr)	Argon or Helium as required	25-30	Tack Weld

Elements of Turbine Blade Coat	Level
Oxygen	45%
Natrium	60%
Carbondioxcide	70%

d. Remove chip detector (12, view D) from the screen insert tee (10), located on the lube and scavenge pump assembly. Discard packing (11).

e. Remove chip detector (9, view C) from aft end of accessory drive gearbox assembly (7), located at the 7 o'clock position (aft looking forward). Discard packing (8).

f. Remove drain plug (13) from gearbox assembly (7). Discard packing (14).

6. CLEANING OF CHIP DETECTORS AND DRAIN PLUG.

Dry Cleaning Solvent (Stoddard Solvent), P-D-680 **32**

a. Immerse chip detector or drain plug in a container filled with clean dry cleaning solvent P-D-680, or equivalent. Swish part around several times to dislodge any material.

b. Using a lint-free cloth, wipe part clean.

WARNING

Compressed Air

- When using compressed air for any cooling, cleaning, or drying operation, do not exceed 30 psig (207 kPa) at the nozzle.
- Eyes can be permanently damaged by contact with liquid or large particles propelled by compressed air. Inhalation of air-blown particles or solvent vapor can damage lungs.
- When using air for cleaning at an air-exhausted workbench, wear approved goggles or face shield.
- When using air for cleaning at an unexhausted workbench, wear approved respirator and goggles.

c. Using filtered, clean, dry compressed air, remove any particles remaining on part.

d. Using masking tape, remove any small particles remaining on part by using the adhesive side of tape. Repeat this process until there are no metal particles on part.

7. INSPECTION OF CHIP DETECTORS AND DRAIN PLUG.

Go to table 1.

TABLE 1. INSPECTION OF CHIP DETECTORS AND DRAIN PLUG

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
Chip detectors and drain plug for:			
a. Cracks.	None allowed.	Not repairable.	Replace detector or plug.
b. Damaged, missing, or crossed threads.	Up to one full thread damaged or missing, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00) and chase damaged threads. Clean part (para. 6).
c. Leaks (during gas turbine operation).	None allowed.	Not repairable.	Replace detector or plug.
d. Magnet strength.	Magnet must support weight of detector or plug when inverted against a steel surface.	Not repairable.	Replace detector or plug.
e. Scratches on washer face.	Amy number, 0.003 inch (0.08 mm) deep, without high metal.	Not repairable.	Replace detector or plug.

8. INSTALLATION OF CHIP DETECTORS AND DRAIN PLUG.

a. (All models except L32119G06) Install chip detector (3, figure 1, view A) as follows:

(1) Install packing (2) onto chip detector (3).

(2) Install chip detector (3) into fitting on A-sump scavenge tube (1), located at the 4 o'clock position (forward looking aft).

(3) Torque chip detector (3) to 155-175 lb in. (17.5-19.8 N·m).

(4) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire chip detector (3) using the doublestrand method (WP 007 00).

b. Install chip detector (6, view B) as follows:

(1) Install packing (5) onto chip detector (6).

(2) Install chip detector (6) into fitting on C-sump forward scavenge tube (4), located at the 4 o'clock position (forward looking aft).

(3) Torque chip detector (6) to 155-175 lb in. (17.5-19.8 N·m).

(4) Using 0.032 inch (0.81 min) diameter lockwire, lock-wire chip detector (6) using the doublestrand method (WP 007 00).

c. Install chip detector (12, view D) as follows:

(1) Install packing (11) onto chip detector (12).

(2) Install chip detector (12) into screen insert tee (10), located on the lube and scavenge pump assembly.

(3) Torque chip detector (12) to 155-175 lb in. (17.5-19.8 N·m).

(4) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire chip detector (12) using the doublestrand method (WP 007 00).

d. Install chip detector (9, view C) as follows:

(1) Install packing (8) onto chip detector (9).

(2) Install chip detector (9) on aft end of accessory drive gearbox assembly (7) at the 7 o'clock position (aft looking forward).

(3) Torque chip detector (9) to 150-200 lb in. (16.9-22.6 N·m).

(4) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire chip detector (9) using the doublestrand method (WP 007 00).

e. Install drain plug (13, view C) as follows:

(1) Install packing (14) onto drain plug (13).

(2) Install drain plug (13) on the aft end of the accessory drive gearbox assembly (7) at approximately the 6 o'clock position.

(3) Torque drain plug (13) to 155-175 lb in. (17.5-19.8 N·m).

(4) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire drain plug (13) using the doublestrand method (WP 007 00).

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

PRESERVATION OF INSTALLED GAS TURBINES

(LEVEL 1 MAINTENANCE)

Effectivity:	L32119G01/-G03/-G04/ -G05/-G06	MARINE GAS TURBINE
	L32119G02	INDUSTRIAL GAS TURBINE

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1. INTRODUCTION. This work package defines the criteria and procedures for preserving the LM500 gas turbines for a short term (up to 30 days) or extended period (longer than 30 days). The purpose of these procedures is to limit or prevent contamination and corrosion in the gas turbine during layup or storage, when the gas turbine is not returned to the controlled environment of its shipping container.

2. SUPPORT EQUIPMENT.

Support Equipment

Part No.	Nomenclature
1C3569G03	Pump, Pressurizer

3. CONSUMABLE MATERIALS.

NOTE

Equivalent materials approved by GE Aircraft Engines may be substituted for items listed.

Consumable Materials

Description	Manufacturer
Caps, Protective	Protective Closures Co., Inc. 2166 Elmwood Avenue Buffalo, NY 14207 USA
Desiccant, Type I (MIL-D-3464)	Davidson Chemical Co. Baltimore, MD USA
Filter, 10-Micron	Local Purchase
Lockwire, 0.032 inch (0.81 mm) diameter	Local Purchase
Material, Waterproof/Vaporproof (MIL-B-131)	Local Purchase
Oil, Lubricating (MIL-L-6081) Grade 1010	Royal Lubricating Co., Inc. P.O. Box 518 River Rd. East Hanover, NJ 07936 USA
Oil, Lubricating (MIL-L-23699)	Local Purchase
Oil, Preservative (Brayco 599)	Bray Oil Company 1925 North Mariana Ave. Los Angeles, CA 90032 USA

4. PRESERVATION OF GAS TURBINES TO BE INACTIVE UP TO 30 DAYS.

a. Water-wash (WP 017 00) gas turbine.

b. Disconnect ignition system by removing the low-voltage input lead from ignition exciter (WP 023 00). Using protective cap, cover the input lead.

c. Cover all openings, including the gas turbine inlet and exhaust, using waterproof/vaporproof material MIL-B-131.

5. PRESERVATION OF GAS TURBINES TO BE INACTIVE FOR MORE THAN 30 DAYS, BUT ARE ON STANDBY STATUS. Gas turbines that will be inactive for more than 30 days, but are on standby status with all services available, must be started every 15 days as follows:

a. Do prestart system checks (WP 005 00 for Industrial Gas Turbines or WP 005 10 for Marine Gas Turbines).

b. Remove covers from all openings, including the gas turbine inlet and exhaust.

c. Operate gas turbine at idle speed for 5 minutes, or motor the gas turbine for 30 seconds, after indication of oil pressure. Allow gas turbine to coast down.

d. Cover all openings, including the gas turbine inlet and exhaust, using waterproof/vaporproof material MIL-B-131.

6. PRESERVATION OF GAS TURBINES TO BE INACTIVE FOR MORE THAN 30 DAYS WITHOUT STANDBY STATUS. Gas turbines that will be inactive for more than 30 days and will not be started, must be preserved as follows:

a. Install a multi-level humidity indicator in the gas turbine compartment. The indicator should be visible and should not interfere with any waterproof/vaporproof material.

b. Monitor the humidity level in the gas turbine compartment every 14 days. The humidity level must be within the limits given in table 1.

TABLE 1. HUMIDITY LEVEL LIMITS

Ambient Temperature	Relative Humidity
Above 35°F (2°C)	40% or less
-5°F to +35°F (-21°C to -2°C)	50% or less
Below -5°F (-21°C)	60% or less

c. If the humidity level in the gas turbine compartment is at the upper limit of acceptable range, monitor the compartment every 7 days until humidity level decreases.

d. If the humidity level in the gas turbine compartment is out of limits, take the following corrective actions within the time interval given in table 2:

(1) Replace desiccant bags, type I MIL-D-3464.

(2) Install mechanical dehumidifiers.

(3) Install pumps to draw dry air into the compartment.

TABLE 2. CORRECTIVE ACTION TIME LIMIT FOR UNACCEPTABLE HUMIDITY LEVELS

Humidity Indication at Ambient Temperatures of:			
Below -5°F (-21°C)	-5°F to +35°F (-21°C to +2°C)	Above 35°F (2°C)	Time for Corrective Action
Above 60%	Above 50%	Above 40%	3 weeks
Above 70%	Above 60%	Above 50%	2 weeks
Above 80%	Above 70%	Above 60%	1 weeks

e. If the corrective action given in step d is not accomplished within the time intervals of table 2, do the following:

(1) Oil-wet (slush) gas turbines bearings (para 7) every 60 days.

(2) Monitor the humidity level in the gas turbine compartment in accordance with table 1 within 60 days; otherwise, gas turbine bearings must be oil-wetted again.

7. <u>OIL WETTING (SLUSHING) OF GAS TURBINE BEARINGS</u>.

NOTE

The oil wetting (slushing) of gas turbine bearings must be done when the humidity level in the gas turbine compartment cannot be maintained below 40%.

a. Set up pressurizer pump 1C3569G03 (see figure 1) as follows:

Lubricating Oil **66**

(1) Thoroughly mix 6 gallons (23 liters) of lubricating oil MIL-L-23699 with 2 quarts (2 liters) of preservative oil Brayco 599.

(2) Pour oil mixture into reservoir of pressurizer pump.

b. Remove customer equipment that prevents access to applicable areas of gas turbine sump bearings and to AGB cranking pad.

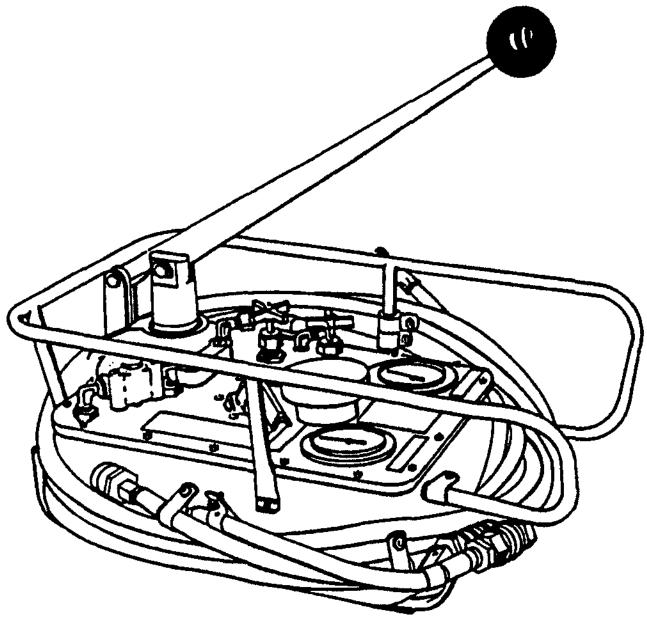

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Figure 1. Pressurizer Pump 1C3569G03

c. Oil-wet (slush) C-sump bearings (see figure 2) as follows:

(1) Place a suitable container under the resistance temperature detector (RTD) (1) to catch oil drainage.

Lubricating Oil 66

(2) Disconnect coupling nut (2) on C-sump oil supply tube (3) from RTD (1). Allow oil to drain into container.

(3) Connect pressurizer pump supply hose to coupling nut (2) on C-sump oil supply tube (3). Tighten nut.

(4) Reposition container under chip detector (6) located at the 5:30 o'clock position (forward looking aft) on C-sump aft scavenge tube (4).

(5) Remove lockwire from chip detector (6). Remove chip detector with packing (5). Remove and discard packing. Allow any oil to drain into container.

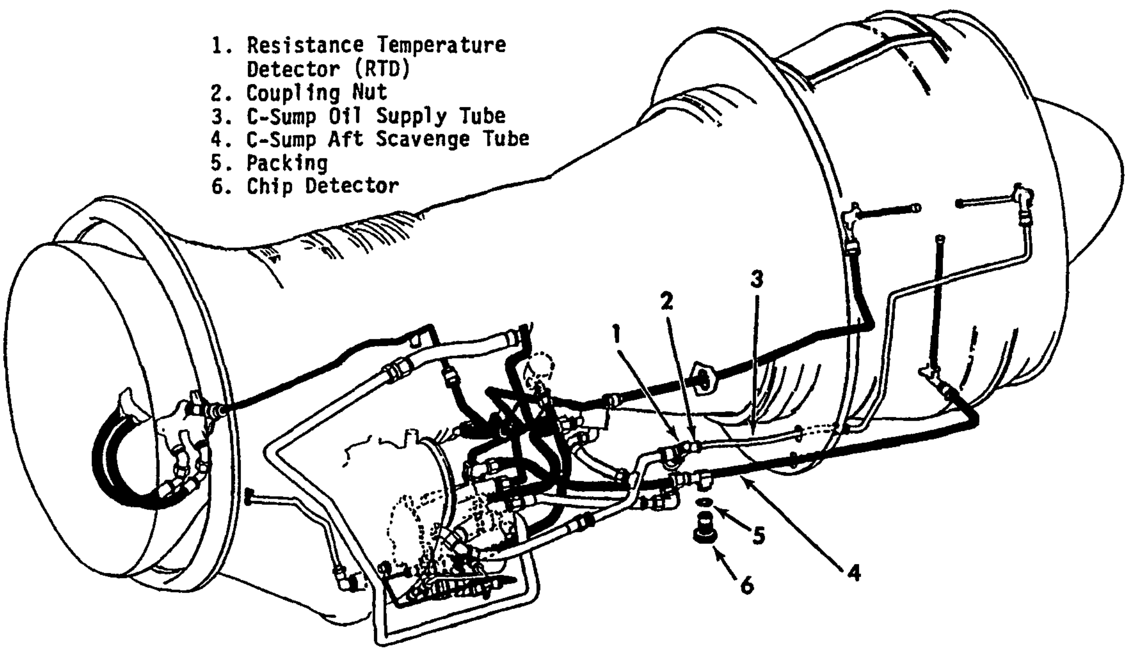

Figure 2. Oil Wetting (Slushing) of C-Sump Bearings

NOTE

The handle of pressurizer pump must be operated rapidly through the full piston stroke so that the proper amount of oil/preservative mixture is supplied to the C-sump bearings.

(6) Using a strap wrench or other acceptable methods, rotate the power turbine rotor at 5-10 rpm while operating pressurizer pump handle for a minimum of 2 minutes.

(7) Allow excess oil/preservative mixture to drain from port where chip detector (6) was removed. Pour mixture from container into reservoir of pressurizer pump. If reservoir is not full, fill reservoir.

(8) Re-install chip detector (6) as follows:

(a) Install packing (5) onto chip detector.

(b) Install chip detector (6) on C-sump aft scavenge tube (4).

(c) Torque chip detector to 155-175 lb in. (17.5-19.8 N•m).

(d) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire chip detector using the double-strand method (WP 007 00).

(9) Reconnect coupling nut (2, figure 2), on C-sump oil supply tube (3), onto fitting of RTD (1).

(a) Disconnect pressurizer pump supply hose from coupling nut (2).

(b) Connect coupling nut (2) to RTD (1). Torque nut to 270-300 lb in. (30.5-33.9 N·m).

d. Oil-wet (slush) B-sump bearings (see figure 3) as follows:

(1) Place a suitable container under the B-sump oil supply hose (1) near coupling nut (2).

Lubricating Oil **66**

(2) Disconnect coupling nut (2) from fitting. Allow oil to drain into container.

(3) Connect pressurizer pump supply hose onto coupling nut (2) on B-sump oil supply hose (1). Tighten coupling nut.

(4) Reposition container under chip detector (4) located under the lube and scavenge pump at the 6 o'clock position.

(5) Remove lockwire from chip detector (4). Remove chip detector with packing (3). Remove and discard packing. Allow any oil to drain into container.

CAUTION

Be careful not to let unwanted objects or material go into the opening in the accessory drive gearbox (AGB). Damage to the AGB can occur.

(6) Remove snapring and cranking pad cover (between fuel control and lube and scavenge pump) on the aft side of the accessory drive gearbox.

(7) Connect a 3/8-inch drive extension to a ratchet wrench. Put extension into the 3/8-inch square hole in gearshaft.

NOTE

The handle of pressurizer pump must be operated rapidly through the full piston stroke so that the proper amount of oil/preservative mixture is supplied to the B-sump bearings.

(8) Using the ratchet wrench, slowly rotate the gas generator at 5-10 rpm while operating pressurizer pump handle for a minimum of 2 minutes.

(9) Allow excess oil/preservative mixture to drain from port where chip detector (4) was removed. Pour mixture from container into reservoir of pressurizer pump. If reservoir is not full, fill reservoir.

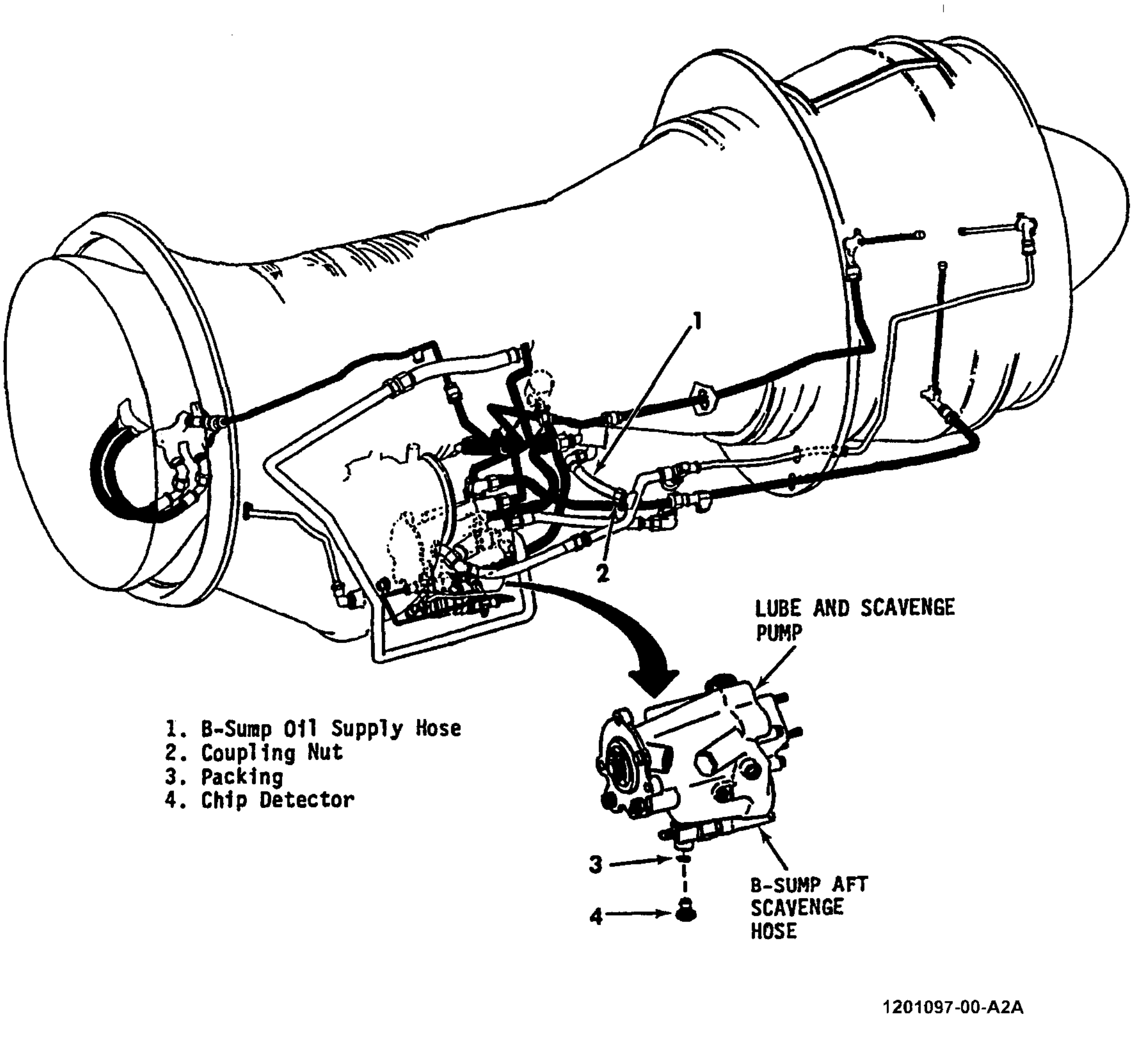

Figure 3. Oil Wetting (Slushing) of B-Sump Bearings

(10) Re-install chip detector (4) as follows:

(a) Install packing (3) onto chip detector.

(b) Install chip detector (4) at the 6 o'clock position under the lube and scavenge pump.

(c) Torque chip detector to 155-175 lb in. (17.5-19.8 N•m).

(d) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire chip detector using the double-strand method (WP 007 00).

(11) Reconnect coupling nut (2, figure 3), on B-sump oil supply hose (1), onto fitting as follows:

(a) Disconnect pressurizer pump supply hose from coupling nut (2).

(b) Connect coupling nut (2) to fitting. Torque nut to 270-300 lb in. (30.5-33.9 N·m).

e. Oil-wet (slush) A-sump bearings (see figure 4) as follows:

(1) Place a suitable container under the A-sump oil supply tube (6), near coupling nut (5) on the forward end of the accessory drive gearbox at the 5 o'clock position, forward looking aft.

(2) Disconnect coupling nut (5) from elbow (4). Allow oil to drain into container.

(3) Connect pressurizer pump supply hose onto coupling nut (5) on A-sump oil supply tube (6). Tighten coupling nut.

(4) On all models except L32119G06, reposition container under chip detector (3).

(5) On all models except L32119G06, remove lockwire from chip detector (3). Remove chip detector with packing (2). Remove and discard packing. Allow any oil to drain into container.

NOTE

The handle of pressurizer pump must be operated rapidly through the full piston stroke so that the proper amount of oil/preservative mixture is supplied to the A-sump bearings.

(6) Using the ratchet wrench previously connected to a 3/8-drive extension in gearshaft on accessory drive gearbox, slowly rotate the gas generator at 5-10 rpm while operating pressurizer pump handle for a minimum of 2 minutes.

(7) Allow excess oil/preservative mixture to drain from port where chip detector (3) was removed. Pour mixture from container into reservoir of pressurizing pump. If reservoir is not full, fill reservoir.

(8) On all models except 32119G06, re-install chip detector (3) as follows:

(a) Install packing (2) onto chip detector.

(b) Install chip detector (3) onto A-sump scavenge tube (1).

(c) Torque chip detector to 155-175 lb in. (17.5-19.8 N·m).

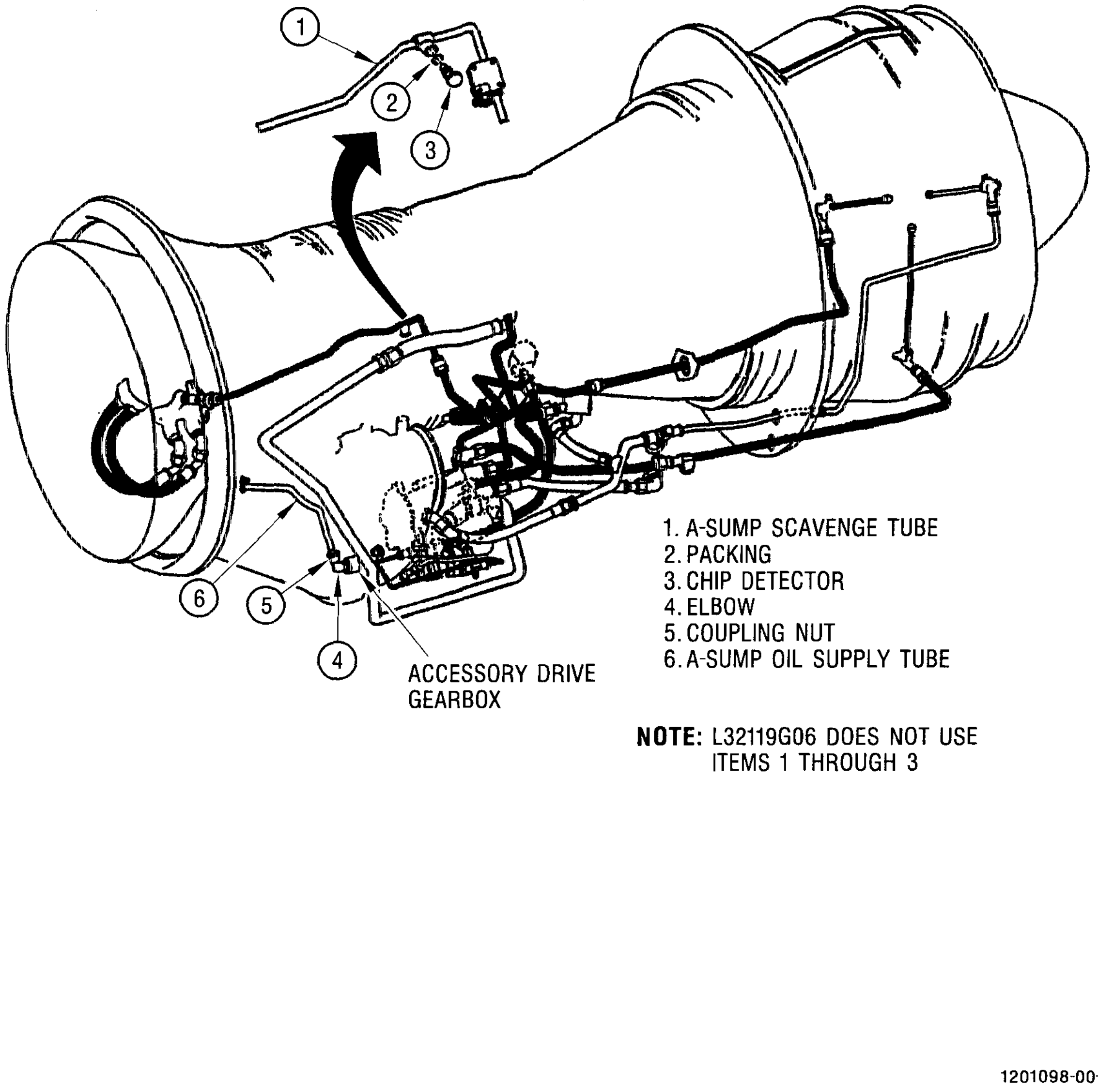

Figure 4. Oil Wetting (Slushing) of A-Sump Bearings

(d) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire chip detector using the double-strand method (WP 007 00).

(9) Reconnect coupling nut (5, figure 4), on A-sump oil supply tube (6), onto elbow (4) as follows:

(a) Disconnect pressurizer pump supply hose from coupling nut (5).

(b) Connect coupling nut (5) to elbow (4) on accessory drive gearbox. Torque nut to 270-300 lb in. (30.5-33.9 N·m).

f. Remove ratchet wrench and 3/8-inch drive extension from the cranking pad on the aft side of the accessory drive gearbox.

g. Install cranking pad cover and snapring.

h. Reinstall customer equipment that was removed to gain access to AGB cranking pad and to applicable areas of gas turbine.

i. Secure and store pressurizer pump (see figure 1).

8. PRESERVATION OF FUEL SYSTEM (MARINE ONLY).

NOTE

- This procedure is to be followed prior to removal of the gas turbine for shipment or storage.
- Only clean, new oil and clean containers must be used.

a. Place a suitable container under fuel pump (5, figure 5) to catch fuel drainage.

Aviation Turbine Fuel (Jet Fuel) 292

b. Remove lockwire and four bolts (1). Disconnect filter-to-pump hose (2) from fuel-in port (4). Do not remove gasket (3).

c. Connect a hose from a gravity-fed container (filled with approximately 2 gallons (8 liters) of lubricating oil MIL-L-6081 (Grade 1010) and filtered through a 10-micron filter) to fuel-in port (4) on fuel pump (5).

d. Secure gravity-fed hose with four bolts (1). Tighten bolts.

e. Place power lever in the FULL OPEN position and motor gas turbine with starter for 2 minutes so that a maximum of 1 gallon (4 liters) of oil will enter fuel pump. Disengage starter and place power level in CLOSED position.

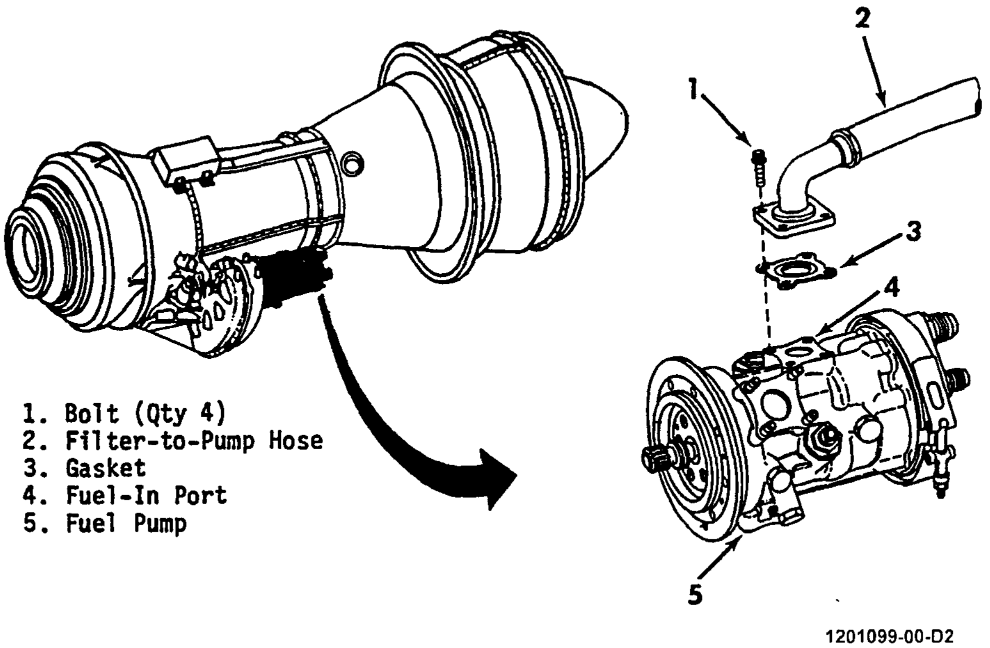

Figure 5. Preservation of Fuel System (Marine Only)

f. Remove four bolts (1) and disconnect gravity-fed hose from fuel-in port (4) on fuel pump (5).

g. Cover fuel-in port (4) with protective cover. Secure cover and gasket (3) with four bolts (1).

h. Cover filter-to-pump hose (2) with protective cover.

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL OPERATION

SPECTROMETRIC OIL ANALYSIS PROGRAM (SOAP)

(LEVEL 1 MAINTENANCE)

Effectivity:	L32119G01/-G03/-G04/ -G05/-G06	MARINE GAS TURBINE
	L32119G02	INDUSTRIAL GAS TURBINE

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1. **INTRODUCTION.** This work package provides instructions for determining the internal condition of the gas turbine oil-wetted components. The maintenance tool to accomplish this is called the Spectrometric Oil Analysis Program (SOAP).

2. **SUPPORT EQUIPMENT.**

None

3. **CONSUMABLE MATERIALS.**

None

4. **SPECTROMETRIC OIL ANALYSIS PROGRAM (SOAP).**

a. The Spectrometric Oil Analysis Program (SOAP) is in use as a maintenance tool in determining the internal condition of the gas turbine oil-wetted components, such as bearings, gears, lube pump and related parts. SOAP is used as a supplement to the normal maintenance procedures of chip detector and filter inspection, and does not replace these established safety checks.

NOTE

- A micron is a measurement equal to one-thousandth of a millimeter.
- The oil filter of the LM500 gas turbine is rated at 25 microns nominal.
- The lower limit of naked eye visibility is 40 microns.

b. As the gas turbine parts are operating, normal wear can be expected on gears, splines, and bearings. This wear causes metallic particles of microscopic size (less than 1 micron) to circulate freely within the lubrication system where they stay in suspension in the oil.

c. Samples of oil taken from the gas turbine after shutdown will contain varying amounts of wear-metal particles. The oil sample is analyzed by either a rotating-disk emission spectrometer or an atomic absorption instrument which translates the analytical information into parts per million (ppm) for the following elements:

Al - Aluminum	Sn - Tin
Fe - Iron	Si - Silicon
Cr - Chromium	Mo - Molybdenum
Ti - Titanium	Pb - Lead
Ag - Silver	Ni - Nickel
Cu - Copper	Mg - Magnesium
	V - Vanadium

d. Wear-metal content is the most important data to evaluate. The wear-metals build up to the normal concentration during the early hours of operation and then level off with no further increase throughout the life of the gas turbine, unless a discrepancy develops. Minor fluctuations are probably due to contamination during sampling procedures or to addition of new oil. In gas turbines where abnormal friction is developing, a pattern or trend of increasing wear-metal is critical. A rapid buildup may indicate imminent component failure. If the rate of wear-metals is slow and steady, there is some point where friction responsible for wear-metal exceeds normal and becomes abnormal. This critical point is called the "threshold limit". The threshold limits, or values, have been established by correlation with Disassembly-Inspection Reports, where the actual condition of gas turbine parts could be compared to the amount and rate of increase of suspended metals in SOAP samples prior to gas turbine removal and teardown.

e. The quantity of wear-metal as well as the type of wear-metal present must be evaluated. The type and combination of metals may help to determine which component is failing and to assess how serious it may be. For example, the presence of iron and silver may indicate bearing wear and gear wear. Iron alone may indicate gear wear. Differentiation of main shaft bearings and gears can only be positively detected by Spectro-Chemical analysis of metal chips because the percentage of chromium in bearings and nickel in gears is very small (less than 5%).

f. Oil samples must be taken at time intervals specified in WP 008 00 and care must be exercised while taking the sample. External contamination introduced to the oil sample will give a false indication of the exact internal condition of the gas turbine. The oil sample should always be taken from the same location, and in the same way as directed, to assure that a representative sample of the gas turbine lube oil will be analyzed. Submit samples to the operator's analysis laboratory, who will report results of analysis performed including recommended corrective action.

g. Table 1 lists all major lubrication system components. The following information may be helpful in determining the source of wear-metals:

- Rapid increase in iron is indicative of No. 3 bearing problem and may indicate a high vibration condition.
- High aluminum or combination aluminum/nickel usually indicates a fretting condition between the No. 3 bearing housing and the front frame, and may indicate a high vibration condition.
- High nickel may indicate wear of the No. 3 bearing antirotation key.

TABLE 1. LUBRICATION SYSTEM COMPONENTS

Wear-metal	Oil System Component
Fe	Main lube and scavenge pump gerotors and shaft
Fe, Ni, Cr	Radial drive shaft Power takeoff assembly gears
Fe, Cr, Ni, Mo	Compressor forward shaft
Fe, Cr, Mo, V	Typical for all main bearing races and balls/rollers
Fe, Ni, Ag Plating	No. 2, 3, 4, 5, 6, and 7 main bearing cages
Fe, Cr Plating	All main bearing rotating oil seals
Fe, Cr, Cu, Ni	No. 1, 2, 3, 4, 5, and 6 main bearing stationary oil seals No. 1 and 2 main bearing housings Power takeoff assembly bearing housing
Al, Si	Front frame or accessory gearbox Main lube and scavenge pump components
Cu	Main lube and scavenge pump bearings
Ni, Fe, Mo, Cr Plating	No. 7 main bearing rotating oil seal
Ni, Cr, Fe, Mo	No. 3, 4, 5, and 7 main bearing housings
Ni, Cr, Fe	No. 6 main bearing housing
Ni, Cu, Si, Ag Plating	No. 1 main bearing cage
Ti, Al, V	Output shaft Power takeoff assembly bearing housing No. 7 main bearing stationary oil seal

5. OIL SAMPLING PROCEDURE.

a. Observe the following precautions when taking oil samples:

(1) Sample should be taken as soon as possible after shutdown, while oil is still warm and of uniform viscosity.

(2) Take sample before servicing oil tank.

(3) Always use clean sample bottles and do not allow any foreign material to come in contact with oil or sampling equipment.

(4) Always take samples from the same location and in the same manner to ensure a representative sample that is similar to previous samples.

b. Obtain sample as follows:

Lubricating Oil 66

(1) Remove tank fill cap and fill port strainer.

(2) Insert sample tube or semi-rigid hose, 18 inches (46 cm) minimum length by 1/2 inch (13 mm) diameter, straight down into tank to lowest point.

(3) Place thumb over end of tube and withdraw sample from tank.

(4) Empty contents of tube or hose into a clean sample container.

(5) Repeat as often as necessary to obtain required sample quantity.

(6) Discard or clean sample tube. Replace tank fill strainer and cap.

(7) Tag or label sample bottles with the following information for identification:

- Unit number or location
- Gas turbine serial number
- Gas turbine operating hours since installation
- Date sample obtained
- Operator's name.

6. OIL ANALYSIS INTERPRETATION.

The values of wear-metal content and threshold limit values for these elements in parts per million (ppm) are given in tables 2 or 3, depending upon the laboratory analysis procedure and equipment utilized.

TABLE 2. SPECTROMETRIC ANALYSIS

	Fe	Ag	Al	Cr	Cu	Ni	Ti
Abnormal trend (ppm increase in 10 hours)	4	2	2	2	3	3	3
Normal range	0-15	0-3	0-3	0-3	0-10	0-5	0-5
Marginal range	16-18	N/A	N/A	N/A	11-14	6-7	6
High range	19-22	4	4	4	15-17	8-9	7-8
Abnormal	23+	5+	5+	5+	18+	10+	9+

Average concentration other elements: Pb=4 Si=14 Sn=11 Mo=1

TABLE 3. ATOMIC ABSORPTION ANALYSIS

	Fe	Ag	Al	Cr	Cu	Ni	Ti
Abnormal trend (ppm increase in 10 hours)	2	2	2	2	2	2	2
Normal range	0-5	0-3	0-3	0-3	0-4	0-3	0-2
Marginal range	6	N/A	N/A	N/A	5-6	4	N/A
High range	7	4	4	4	7	5	3
Abnormal	8+	5+	5+	5+	8+	6+	4+

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

GAS TURBINE EXTERNAL INSPECTION AND SPECIAL INSPECTIONS

(LEVEL 1 MAINTENANCE)

Effectivity:	L32119G01/-G03/-G04/	
	-G05/-G06	MARINE GAS TURBINE
	L32119G02	INDUSTRIAL GAS TURBINE

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Special Inspections of Gas Turbine	4
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1. INTRODUCTION. This work package provides instructions for periodic external inspection as determined in WP 008 00. This work package also provides special inspections of gas turbines that have been exposed to fire or fire extinguishing agents.

2. SUPPORT EQUIPMENT.

None

3. CONSUMABLE MATERIALS.

NOTE

Equivalent materials approved by GE Aircraft Engines may be substituted for items listed.

Consumable Materials

Description	Manufacturer
Gloves, Thermally Insulated	Local Purchase

4. EXTERNAL INSPECTION OF GAS TURBINE.

a. Before entering the gas turbine area to inspect the gas turbine, do the following:

(1) Shut down the gas turbine.

(2) Deactivate the fire extinguishing system.

WARNING

Handling Hot Parts

- When handling hot parts, wear approved gloves.
- Handling of hot parts with bare hands may cause reddening and blistering of skin, or third-degree bums.
- If skin is burned, immerse contacted area in cold water for 10 minutes. If pain or blistering persists, immediately get medical attention.

(3) Allow the gas generator to cool to room temperature. Avoid contact with hot parts: wear thermally insulated gloves, if necessary.

(4) Tag electrical switches "Out-of-Service" to prevent activation. Tag the gas turbine operating controls "Do Not Operate", to prevent starting during a desired shutdown condition.

b. Inspect gas turbine inlet (WP 009 00).

c. Inspect gas turbine tubes, hoses, tube/hose fittings, electrical cable assemblies, and electrical connectors for security, overheating, and damage due to leakage.

d. Inspect lube and scavenge pump, accessory gearbox, and gearbox mounted accessories for security, damage, and leakage.

e. Inspect ignition exciter (2, figure 1), igniter plugs (3), and igniter leads (4) for damage, overheating, and security.

f. Inspect gas turbine mounts for security and damage.

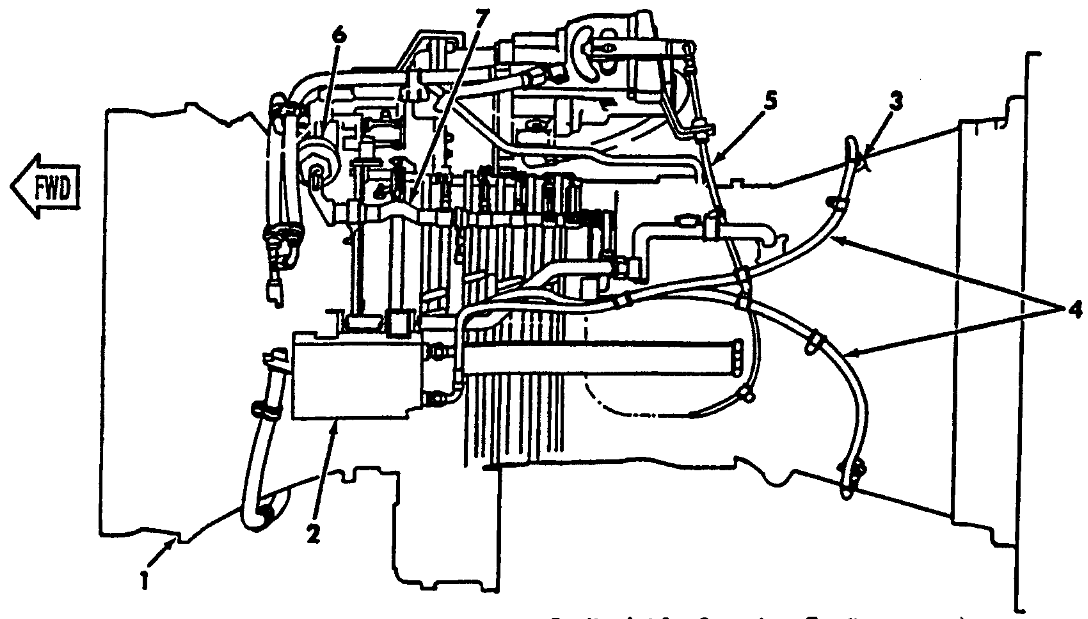
g. Check for loose or missing bolts on all flanges.

h. Inspect variable geometry feedback cable (5) for kinking, abrasion, and separation.

i. Check clevis pins for looseness and retention of cotter pins.

j. Check actuating shaft and VG control levers for security.

k. Inspect variable geometry linkages (7), actuators (6), and hydraulic hoses for security, damage, chafing, missing clamps, and leaks.



1. Inlet Duct
2. Ignition Exciter
3. Igniter Plugs
4. Igniter Leads
5. Variable Geometry Feedback Cable
6. Variable Geometry Actuators (Two)
7. Variable Geometry Linkages

1201100-00-D2

Figure 1. Gas Turbine External Inspection

l. Inspect components of variable stator vanes (VSV) (WP 029 00) for:

(1) Loose or missing locknuts on inlet guide vanes (IGV) through stage 5 vane levers.

(2) Wear or looseness in IGV lever spherical bearings.

(3) Presence of vane actuating arm pins and tabwashers at actuating ring.

(4) Security of all stages 1 through 5 vane lever retainers and ring connectors.

(5) Loose or worn spherical bearings or actuators, arm-to-ring links, VSV actuators, and actuating shafts.

(6) Presence and condition of plastic washers on either side of actuator mount.

(7) Security of all actuating arm levers and bearing mounts.

(8) Bent or deformed vane arms and actuating rings.

m. (Industrial Only). Inspect (WP 030 00) manifold assembly, fuel feed tubes, and fuel injectors for:

- Security or damage
- Loose, deformed, or missing brackets and clamps
- Loose tubing nuts or flange bolts
- Broken or missing lockwire.

n. (Marine Only). Inspect (WP 030 10) fuel injector hose assemblies and fuel distributor block assembly for:

- Security or damage
- Loose, deformed, or missing brackets and clamps
- Loose tubing nuts or flange bolts
- Broken or missing lockwire.

o. Inspect (WP 011 00) exhaust duct for cracks, dents, loose fasteners, and security.

5. SPECIAL INSPECTIONS OF GAS TURBINE.

Refer to table 1 for special inspections that have to be done when the gas turbine has been exposed to fire or fire extinguishing agents.

TABLE 1. SPECIAL INSPECTIONS

Event	Condition	Disposition
Gas Turbine Damaged by Fire	Obvious external or suspected internal damage.	Replace gas turbine.
Gas Turbine Flooded with Fire Extinguishing Agents	a. CO^2 (Carbon Dioxide).	No action required.
	b. Halogens (external surfaces).	Wash external surfaces.
	c. Others.	Replace gas turbine.
Gas Turbine Overtemperature	Violation of temperature limits given in WP 005 00.	Replace gas turbine.
Gas Turbine Overspeed	Violation of speed limits given in WP 005 00.	Replace gas turbine.

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

COMPRESSOR AND GAS TURBINE EXTERNAL SURFACES CLEANING

(LEVEL 1 MAINTENANCE)

Effectivity:	L32119G01/-G03/-G04/ -G05/-G06	MARINE GAS TURBINE
	L32119G02	INDUSTRIAL GAS TURBINE

Alphabetical Index

Subject	Page No.
Cleaning of Gas Turbine External Surfaces	7
Compressor Cleaning and Rinsing	4
Consumable Materials	2
Introduction	1
Preparation of Cleaning and Rinse Solutions	2
Support Equipment	1

1. INTRODUCTION.

a. This work package provides instructions for cleaning (water wash) the compressor and the external surfaces of the gas turbine. The compressor must be cleaned before preservation, when gas turbine performance is low, and when visual or borescope inspection shows a buildup of carbon, dirt, or oily deposits on compressor blades or vanes.

b. The compressor cleaning procedure consists of spraying water-wash solution into the inlet of the gas turbine, letting the solution soak, and then rinsing with rinse solution. If compressor contamination is severe and there is only little performance improvement, it may be necessary to repeat the cleaning procedure.

2. SUPPORT EQUIPMENT.

Support Equipment

Part No.	Nomenclature
---	Equipment, Steam Cleaning
---	Hose, Flexible (with Adjustable Spray Nozzle)
2C5952G01	Unit, Compressor Cleaning Pumping

3. CONSUMABLE MATERIALS.

NOTE

Equivalent materials approved by GE Aircraft Engines may be substituted for items listed.

Consumable Materials

Description	Manufacturer
Alcohol, Isopropyl (TT-I-735)	Local Purchase
Brush, Soft-Bristle	Local Purchase
Cleaner, B&B 3100	B&B Chemical Co., Inc. P.O. Box 796 Miami, FL 33166 USA
Cleaner, Rivenaes R-MC	STS West 18502 Laurel Park Road Compton, CA 90220 USA or STS Southeast 507 Industrial Way Boynton Beach, FL 33426 USA or STS Middle Atlantic 155 South Limerick Road Limerick, PA 19468 USA or IVAR Rivanaes A/S Damsgardsveien 35 500 Bergen Norway
Methanol (O-M-232)	Local Purchase

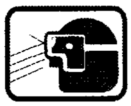
4. PREPARATION OF CLEANING AND RINSE SOLUTIONS.

a. Rivenaes R-MC and B&B 3100 are the only cleaners approved for use on the LM500 gas turbine.

b. If Rivenaes R-MC will be used, refer to table 1 for preparing the cleaning and rinse solutions to use at various temperatures.

c. If B&B 3100 will be used, refer to table 2 for preparing the cleaning and rinse solutions to use at various temperatures.

TABLE 1. RIVENAES R-MC CLEANING AND RINSE SOLUTIONS

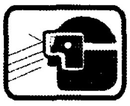
Temperature	Cleaning Solution	Rinse Solution
	 **R-MC or Rivenaes R-MC Cleaner/Mixture** **403**	
	 **Isopropyl Alcohol, TT-I-735** **11**	
	  **Methanol, O-M-232** **83**	

NOTE

- Rinsing of the gas turbine with Rivenaes R-MC is optional if drying cycling is performed.
- Rivenaes R-MC is supplied from the manufacturer ready to use. No further dilution is necessary.

41°F (+5°C) and above	100% R-MC	Fresh water.
23°F to 41°F (-5°C to +5°C)	Four parts R-MC; one part isopropyl alcohol or methanol.	Three parts fresh water; two parts isopropyl alcohol or methanol.
-6°F to +23°F (-21°C to -5°C)	Three parts R-MC; two parts isopropyl alcohol or methanol.	Three parts fresh water; two parts isopropyl alcohol or methanol.
Below -6°F (-21°C)	Do not wash; solution will freeze.	Do not rinse; solution will freeze.

TABLE 2. B&B 3100 CLEANING AND RINSE SOLUTIONS

Temperature	Cleaning Solution	Rinse Solution
	 **B&B 3100 Cleaner-Water Solution 18**	
	 **Isopropyl Alcohol, TT-I-735 11**	
	  **Methanol, O-M-232 83**	
41°F (4°C) and above	One part cleaner; four parts fresh water.	Fresh water.
14°F to 40°F (-10°C to +4°C)	One part cleaner; 2-1/2 parts isopropyl alcohol or methanol; 1-1/2 parts fresh water.	Two parts fresh water; three parts isopropyl alcohol or methanol.
Below 14°F (-10°C)	Do not wash; solution will freeze.	Do not rinse; solution will freeze.

5. COMPRESSOR CLEANING AND RINSING.

CAUTION

The gas turbine must be allowed to cool to 320°F (160°C) or less before cleaning the inlet airflow area (see figure 1).

a. Using a soft-bristle brush soaked with the cleaning solution, clean the inlet airflow area.

b. Using a soft-bristle brush soaked with the rinse solution, rinse the inlet airflow area.

c. Connect the inlet hose (6) of compressor cleaning pumping unit 2C5952G01 (5) to inlet tee (7) at the 6 o'clock position under the front frame (8). Tighten coupling nut on inlet hose to 5-10 lb in. (0.6-1.1 N·m).

d. Using the cleaning solution, clean compressor section as follows:

(1) Place the suction hose (3) of the pumping unit (5) into container with the cleaning solution.

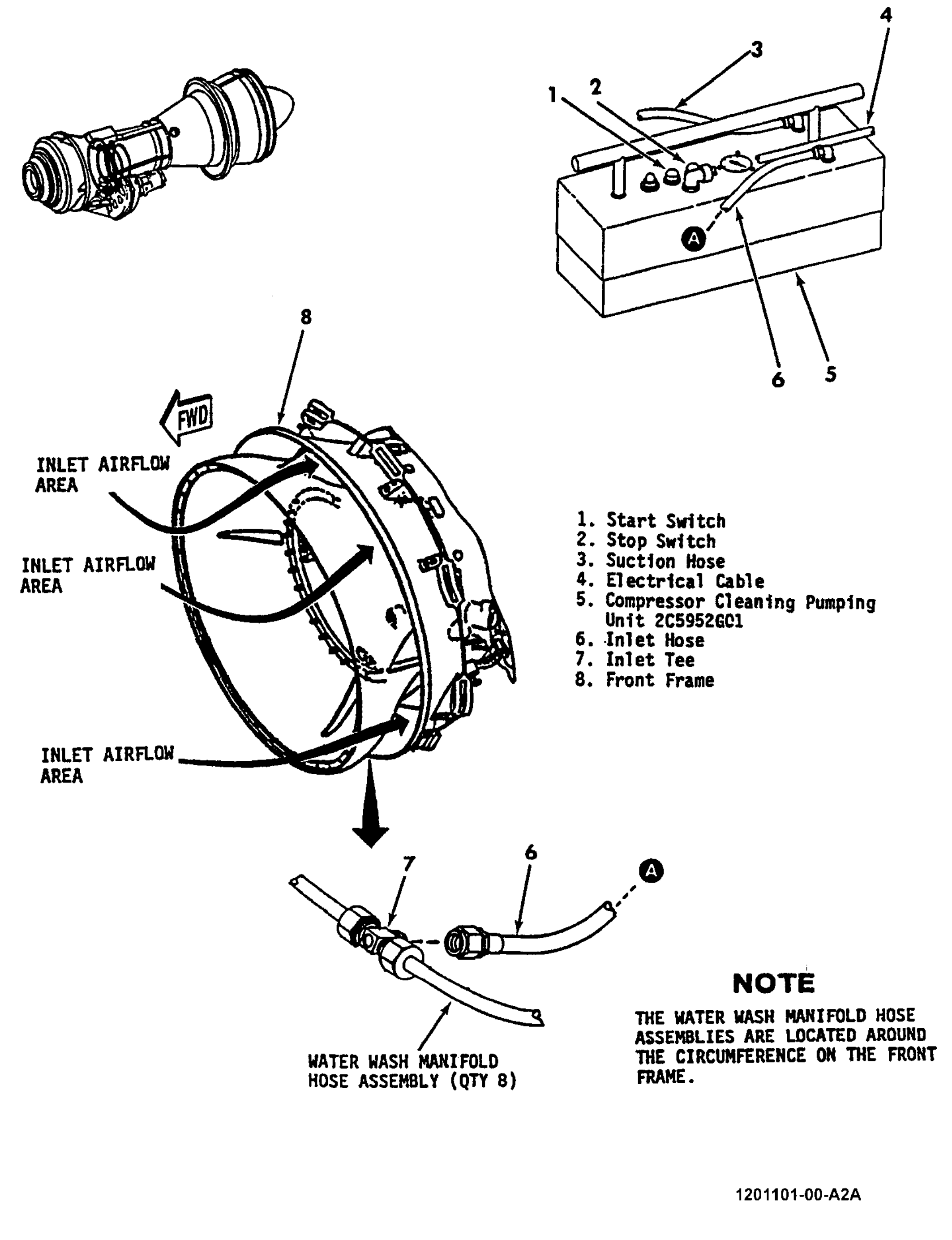


Figure 1. Compressor Cleaning and Rinsing

CAUTION

- Do not clean the compressor while the gas turbine is operating. Compressor temperatures at operating speed may cause the compressor casing to warp, causing blade rubs.
- The gas turbine must be allowed to cool to 320°F (160°C) or less before cleaning the compressor section.
- Do not exceed starter duty cycles. Observe required starter cooling intervals between cleaning cycles.
- Do not allow the cleaning solution into compressor until a motoring speed of 24-28% of power turbine shaft speed is reached.

NOTE

The motoring speed will decrease as the cleaning solution is ingested into gas turbine.

(2) Motor gas turbine to 24-28% of power turbine shaft speed.

(3) Push the start switch (1) on pumping unit (5). Adjust the pumping unit pressure so that the cleaning solution enters the compressor at a rate of 2-3 gallons per minute (8-11 liters per minute) and at 35-40 psig (241-276 kPa). Continue to motor the gas turbine for 35-40 seconds; do not exceed starter duty cycles.

(4) Check the solution exiting the exhaust end of gas turbine, to be sure that the solution is clean. If not clean, repeat the cleaning cycle.

CAUTION

Stop the operation of the pumping unit (5) before stopping the motoring of the gas turbine; otherwise, damage to gas turbine will occur.

(5) Using the stop switch (2) on the pumping unit (5), stop operation of the pumping unit while still motoring gas turbine.

(6) Stop motoring the gas turbine and allow the starter to cool for a minimum of 5 minutes.

e. Using the rinse solution, rinse the compressor as follows:

(1) Remove the suction hose (3) of the pumping unit (5) from container with the cleaning solution.

(2) Place the suction hose (3) into container with the rinse solution.

(3) Using instructions in steps d.(2) through d.(6), rinse the compressor.

f. Remove suction hose (3) from the rinse solution. Disconnect inlet hose (6) from inlet tee (7). Store the pumping unit (5).

g. Dry the gas turbine as follows:

(1) Start the gas turbine.

(2) Slowly accelerate the gas turbine to 85% power turbine shaft speed, and remain at this setting for no more than 2 minutes.

(3) Slowly decrease gas turbine speed to IDLE. Remain at IDLE for a minimum of 2 minutes.

(4) Shut down the gas turbine.

6. CLEANING OF GAS TURBINE EXTERNAL SURFACES.

a. If the external surfaces of the gas turbine (especially the variable stator vane system) have excessive dirt buildup, wash the external surfaces using the following:

- 50 to 60 gallons (190 to 227 liters) of clean potable water
- Flexible hose with adjustable spray nozzle
- Water pressure of 40-45 psi (276-310 kPa).

b. If the water will not remove the dirt, do the following:

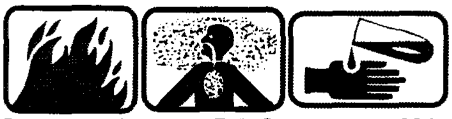
WARNING

Steam Cleaning

- Hot steam can burn exposed tissue. Dry material removed by steam spray can injure eyes.
- If dry material contacts eyes, flush affected area thoroughly with water. If steam contacts skin or eyes, immerse affected area in cold water for 10 minutes. If blistering occurs, immediately get medical help.
- When steam-cleaning, wear approved gloves, apron, and face shield.

(1) If steam cleaning equipment is available, steam-clean gas turbine.

(2) If steam cleaning equipment is not available, do the following:



R-MC or Rivenaes R-MC Cleaner/Mixture **403**

B&B 3100 Cleaner-Water Solution **18**

(a) Spray the cleaning solution (refer to table 1 or 2 for mixture) onto gas turbine. Allow the cleaning solution to soak for a minimum of 15 minutes.

(b) Spray the rinse solution (refer to table 1 or 2 for mixture) onto gas turbine.

(3) Start the gas turbine and operate at IDLE speed for a minimum of 5 minutes to dry excessive water.

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

IGNITION SYSTEM TEST

(LEVEL 1 MAINTENANCE)

Effectivity:	L32119G01/-G03/-G04/ -G05/-G06	MARINE GAS TURBINE
	L32119G02	INDUSTRIAL GAS TURBINE

Alphabetical Index

Subject	Page No.
Consumable Materials	1
Ignition System Test	1
Introduction	1
Support Equipment	1

1. **INTRODUCTION**. This work package provides instructions for testing the two igniter plugs.

2. **SUPPORT EQUIPMENT**. None

3. **CONSUMABLE MATERIALS**. None

4. **IGNITION SYSTEM TEST**.

a. Select switch to energize one igniter plug.

b. Start the gas turbine.

c. If the gas turbine starts, shut down. If the gas turbine does not start, test the other igniter plug before taking corrective action.

d. Select switch to energize the other igniter plug.

e. Start the gas turbine.

f. If the gas turbine starts on both igniter plugs, the test is complete. Return switch to normal position.

g. If the gas turbine starts on one igniter plug, but not the other, replace the suspect igniter plug (WP 023 00) and repeat the test.

h. If the gas turbine does not start, troubleshoot (WP 006 00 for Industrial Gas Turbine or WP 006 10 for Marine Gas Turbine).

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

LUBRICATION SYSTEM
SERVICING

(LEVEL 1 MAINTENANCE)

Effectivity:	L32119G01/-G03/-G04/ -G05/-G06	MARINE GAS TURBINE
	L32119G02	INDUSTRIAL GAS TURBINE

Alphabetical Index

Subject	Page No.
Consumable Materials	2
Introduction	1
Servicing	
A-Sump Scavenge Pump	8
Lube and Scavenge Pump	8
Lube Filter	2
Support Equipment	1

1. INTRODUCTION.

a. This work package provides instructions for servicing the lubrication system as determined by the periodic inspections and maintenance table in WP 008 00.

b. The lubrication system must be serviced on a scheduled basis, when the gas turbine performance has deteriorated, or when inspection reveals that dirt or foreign material has built up in the oil system or its components.

c. The lubrication system can become contaminated by metal, fuel, or water. Oil samples must be taken and tested for contamination as instructed in WP 015 00 (Spectrometric Oil Analysis).

2. SUPPORT EQUIPMENT.

Support Equipment

Part No.	Nomenclature
2C5615G01	Wrench, Lube Pump Insert

3. CONSUMABLE MATERIALS.

NOTE

Equivalent materials approved by GE Aircraft Engines may be substituted for items listed.

Consumable Materials

Description	Manufacturer
Lockwire, 0.032 inch (0.81 mm) diameter	Local Purchase
Oil, Lubricating (MIL-L-7808 or MIL-L-23699)	Local Purchase

4. SERVICING OF LUBE FILTER.

a. Remove lockwire from lube filter (1, figure 1) or filter assembly for configuration L32119G05/-G06.

Lubricating Oil **66**

NOTE

The lube and scavenge pump insert (2) may loosen when unthreading the lube filter (1) or filter carrier assembly for configuration L32119G05/-G06.

b. For configuration L32119G01/-G02/-G03/-G04, unthread and remove lube filter (1) from lube and scavenge pump (3). If insert (2) is loose, hand-tighten.

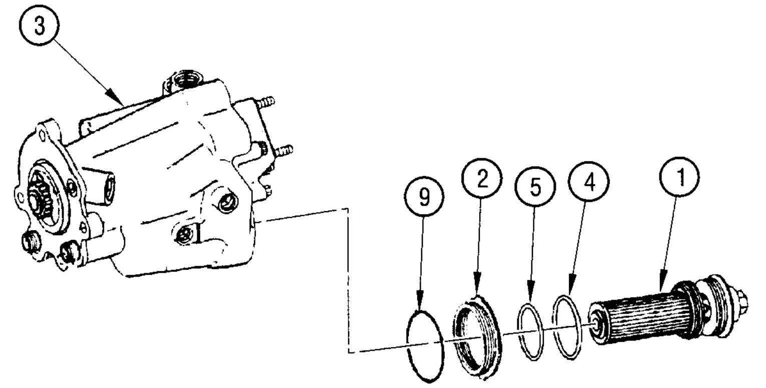
c. For configuration L32119G05/-G06, unthread and remove filter carrier assembly from lube and scavenge pump (3). If insert (2) is loose, hand-tighten insert.

d. For configuration L32119G01/-G02/-G03/-G04, remove and discard preformed packings (4 and 5) from lube filter (1).

e. For configuration L32119G05/-G06, remove and discard preformed packings (4 and 6) from filter carrier assembly.

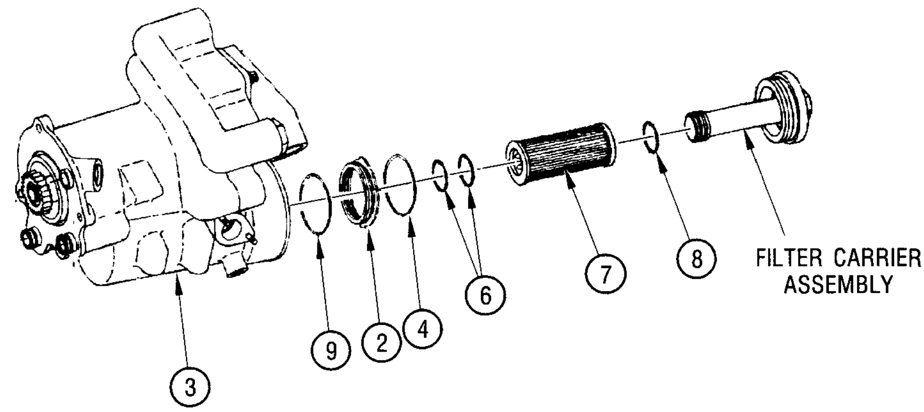
f. For configuration L32119G05/-G06, remove filter element (7) from filter carrier assembly. Remove and discard preformed packing (8).

g. Inspect lube filter and filter carrier assembly as instructed in table 1.



LEGEND:
1. LUBE FILTER
2. LUBE AND SCAVENGE PUMP INSERT
3. LUBE AND SCAVENGE PUMP
4. PREFORMED PACKING
5. PREFORMED PACKING
6. PREFORMED PACKING
7. FILTER ELEMENT
8. PREFORMED PACKING
9. PREFORMED PACKING

L32119G01/-G02/-G03/-G04



L32119G05/-G06

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Figure 1. Removal and Installation of Lube Filter

TABLE 1. INSPECTION OF LUBE FILTER

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Body of lube filter and filter carrier assembly (see figure 2) for:			
(1) Cracks.	None allowed.	Not repairable.	Replace lube filter or filter carrier assembly.
(2) Stripped threads.	One missing thread, without high metal.	Not repairable.	Replace lube filter or filter carrier assembly.
(3) Nicks, dents, and scratches in:			
(a) Packing grooves.	Any number, 0.005 inch (0.13 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).
(b) Body.	Any number, 0.010 inch (0.25 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).
(4) Broken lockwire holes.	Up to three broken holes.	Not repairable.	Replace lube filter.
b. Filter element for:			
(1) Holes.	None allowed.	Not repairable.	Replace lube filter for configurations L32119G01/-G02/-G03/-G04. Replace filter element for configurations L32119G05/-G06.
(2) Nicks, dents, and scratches at end.	Any number, 0.010 inch (0.25 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).
(3) Contamination (metallic fuzz or chips).	Not allowed.	Not repairable.	Replace lube filter for configurations L32119G01/-G02/-G03/-G04 or replace filter element for configurations L32119G05/-G06. Remove, inspect, and reinstall chip detectors (WP 013 00). Service the lube and scavenge pump (para 5). Service the A-sump scavenge pump for configurations L32119G01/-G02/-G03/-G04/-G05 (para 5).

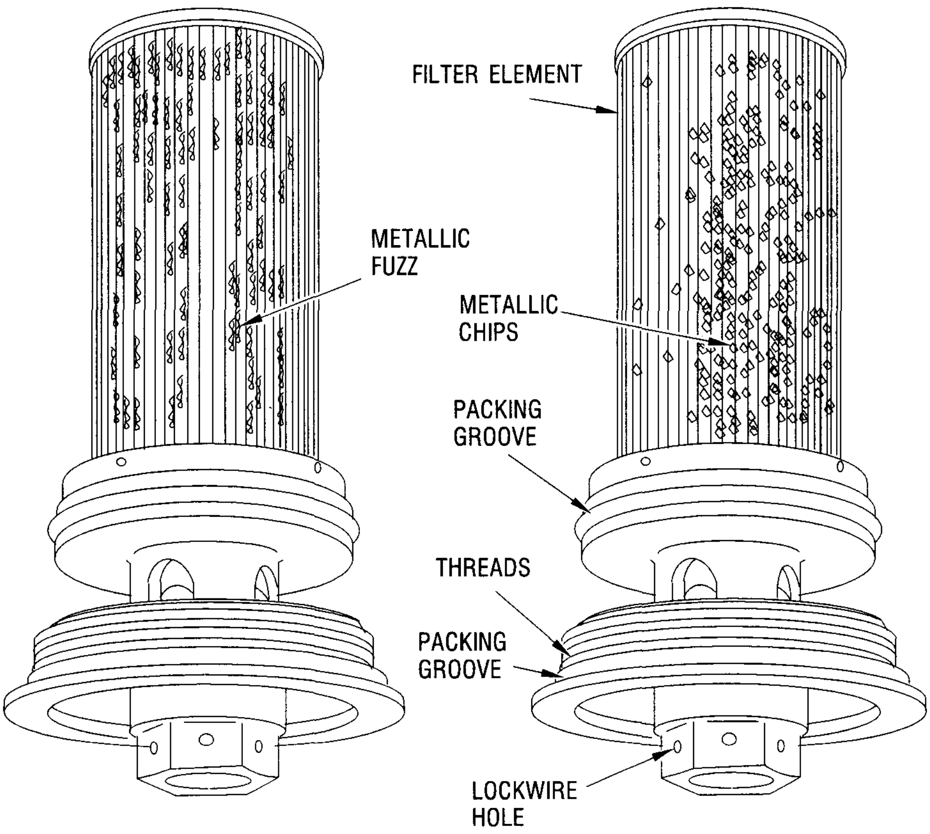


Figure 2. Inspection of Lube Filter (Sheet 1 of 2)

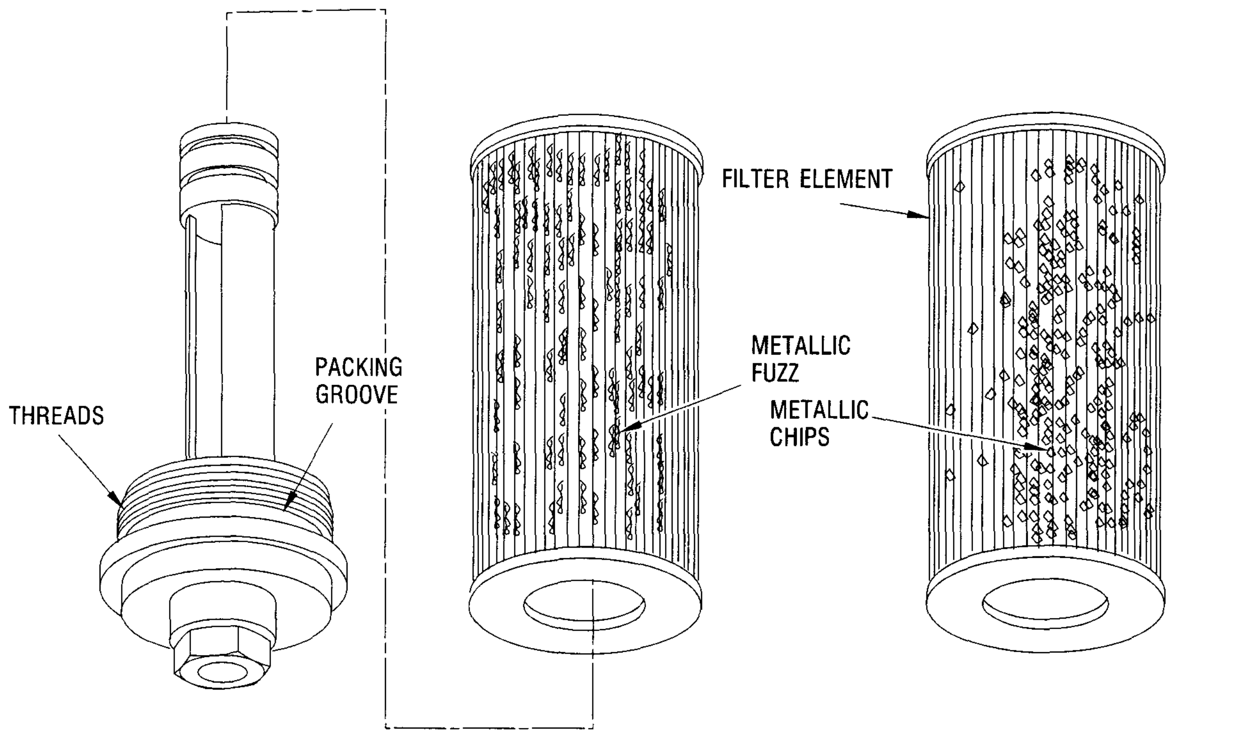


Figure 2. Inspection of Lube Filter (Sheet 2 of 2)

h. Install lube filter (1, figure 1) or filter carrier assembly for configurations L32119G05/-G06, as follows:

Lubricating Oil **66**

(1) Lubricate all preformed packings and packing grooves with a light coat of lubricating oil MIL-L-7808 or MIL-L23699.

(2) For configurations L32119G01/-G02/-G03/-G04, install packings (4 and 5) on lube filter (1).

(3) For configurations L32119G05/-G06, do the following:

(a) Install preformed packing (8) on filter carrier assembly.

(b) Install filter element (7) on filter carrier assembly.

(c) Install preformed packings (4 and 6) on filter carrier assembly.

(4) Before installing lube filter (1) or filter carrier assembly for configurations L32119G05/-G06, do the following:

(a) Using a flashlight, inspect the port cavity of pump (3), to be sure that the port is clean.

(b) Inspect the port cavity of pump (3) for burrs and high metal that may damage the preformed packings on lube filter (1) or filter carrier assembly for configurations L32119G05/-G06. Remove any burrs or high metal (WP 007 00) from port cavity and lead-in chamfer.

CAUTION

The lube and scavenge pump insert (2) must be checked for looseness before installing lube filter (1) or filter carrier assembly for configurations L32119G05/-G06; otherwise, leaks will occur.

(c) Check insert (2) for looseness and for leakage indications. If insert is loose or if there is indication of leakage around insert, do the following:

1 Using lube pump insert wrench 2C5615G01, remove insert (2) from pump (3).

2 Remove and discard preformed packing (9) from insert (2).

Lubricating Oil **66**

3 Using a light coat of lubricating oil MIL-L-7808 or MIL-L-23699, lubricate new preformed packing (9).

4 Install new preformed packing (9) onto insert (2).

5 Install insert (2) into pump (3).

6 Using wrench 2C5615G01, torque insert (2) to 480-500 lb in. (54.2-56.5 N·m).

CAUTION

- For configurations L32119G01/-G02/-G03/-G04, be careful not to damage preformed packings (4 and 5) when installing lube filter (1) into pump (3) or leaks will occur.
- For configurations L32119G05/-G06, be careful not to damage preformed packings (4 and 6) when installing filter carrier assembly into pump (3) or leaks will occur.

(5) For configurations L32119G01/-G02/-G03/-G04, install lube filter (1) into port of pump (3). Torque lube filter to 150-200 lb in. (16.9-22.6 N·m).

(6) For configurations L32119G05/-G06, install filter carrier assembly into port of pump (3). Torque filter carrier assembly to 150-200 lb in. (16.9 - 22.6 N·m).

(7) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire lube filter (1) using the double-strand method (WP 007 00).

5. SERVICING OF LUBE AND SCAVENGE PUMP AND A-SUMP SCAVENGE PUMP.

a. Using instructions in WP 031 00 or SWP 031 10, do the following:

NOTE

The following maintenance must be done only when there is evidence of contamination on the chip detectors or lube filter element.

(1) Remove lube and scavenge pump (1, figure 3) to gain access to scavenge screens (2).

(2) For configurations L32119G01/-G02/-G03/-G04, remove screen insert elbow (3), screen insert nipples (4 and 5), screen insert bulkhead tee (6), and scavenge screens (2) from pump (1).

(3) For configurations L32119G05/-G06, remove screen insert tube nipples (7 and 8), screen insert nipple (4), screen insert bulkhead tee (6), and scavenge screens (2).

(4) Place a tag on each part, and identify each part as shown in table 2.

(5) For configurations L32119G01/-G02/-G03/-G04/-G05, remove screen insert elbows (9 and 10) from A-sump scavenge pump (11).

(6) Place a tag on each elbow, and identify each elbow as shown in table 2.

TABLE 2. SCREEN INSERTS AND SCAVENGE SCREENS IDENTIFICATION

Part	Identification/Location
L32119G01/-G02/-G03/-G04/-G05	
90° Screen Insert Elbow (9)	A-Sump Scavenge (A-Sump Scavenge Pump)
45° Screen Insert Elbow (10)	Forward Bearing Sump Scavenge (A-Sump Scavenge Pump)
L32119G01/-G02/-G03/-G04	
Screen Insert Nipple (4)	C-Sump Aft Scavenge (Lube and Scavenge Pump)
90° Screen Insert Elbow (3)	C-Sump Forward Scavenge (Lube and Scavenge Pump)
Screen Insert Nipple (5)	B-Sump Forward Scavenge (Lube and Scavenge Pump)
Screen Insert Bulkhead Tee (6)	B-Sump Aft Scavenge (Lube and Scavenge Pump)
Scavenge Screens (2)	Accessory Drive Gearbox Assembly (Lube and Scavenge Pump)
L32119G05/-G06	
Screen Insert Tube Nipple (8)	B-Sump Forward Scavenge (Lube and Scavenge Pump)
Screen Insert Tube Nipple (7)	Oil Scavenge Tube (Lube and Scavenge Pump)
Screen Insert Bulkhead Tee (6)	B-Sump Aft Scavenge (Lube and Scavenge Pump)
Scavenge Screens (2)	Accessory Drive Gearbox Assembly (Lube and Scavenge Pump)
Screen Insert Nipple (4)	C-Sump Aft Scavenge (Lube and Scavenge Pump)

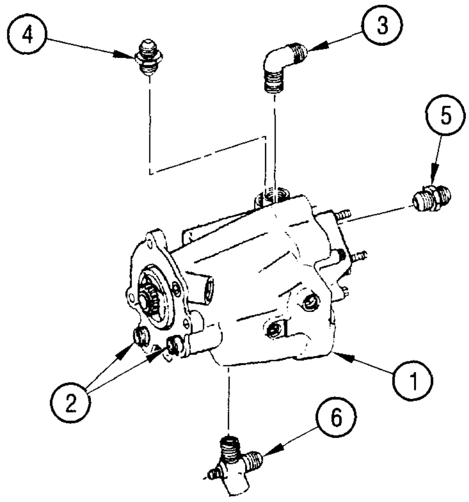
b. Visually inspect each screen for contamination. If there is contamination, analyze and identify contaminants, removed from screens, to determine the source as follows:

NOTE

- Bearing races, rollers, and balls are magnetic; therefore, separating the magnetic contaminant will help to identify the source.
- Failure of the main gas turbine bearings requires replacement of the gas generator or the power turbine, or both.

(1) If the contaminant is identified as bearing material (such as rollers, balls, or race fragments), replace the gas generator or the power turbine, or both.

(2) Because main gas turbine bearing distress also increases lube scavenge temperatures and gas turbine vibrations, review the log sheets for significant changes in gas turbine operating parameters.



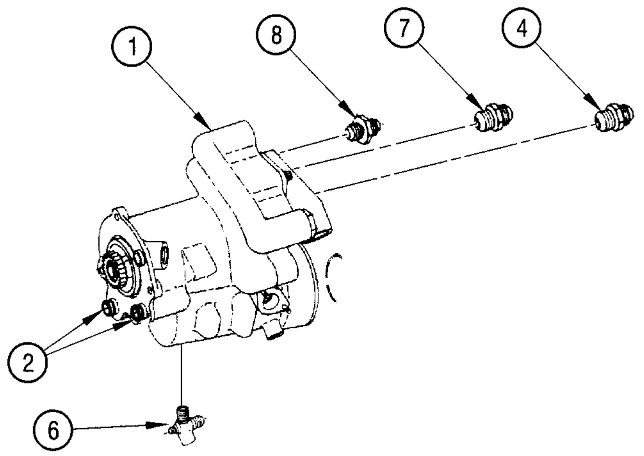
L32119G01/-G02/-G03/-G04

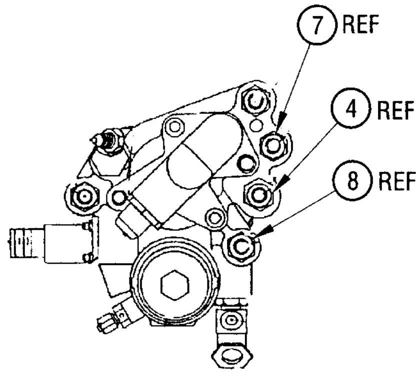
LEGEND:

1. LUBE AND SCAVENGE PUMP
2. SCAVENGE SCREENS
3. SCREEN INSERT ELBOW
4. SCREEN INSERT NIPPLE
5. SCREEN INSERT NIPPLE
6. SCREEN INSERT BULKHEAD TEE
7. SCREEN INSERT TUBE NIPPLE
8. SCREEN INSERT TUBE NIPPLE
9. SCREEN INSERT ELBOW
10. SCREEN INSERT ELBOW
11. A-SUMP SCAVENGE PUMP

1203199-00-A2A

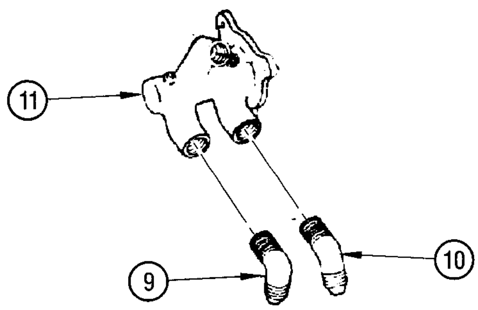
Figure 3. Servicing of Lube and Scavenge Pump, and A-Sump Scavenge Pump (Sheet 1 of 2)





VIEW AFT LOOKING FORWARD

L32119G05/-G06



L32119G01/-G02/-GO3/-G04/-G05

1203200-00-A2A

Figure 3. Servicing of Lube and Scavenge Pump, and A-Sump Scavenge Pump (Sheet 2 of 2)

(3) If the contaminant is identified as a fragment of a bolt or rivet, replace component as indicated by screen identity.

(4) If the contaminant is identified as pieces of packings, gasket, lockwire, debris of coked oil, machining chips, or seal rub strip material, do the following:

(a) Monitor the gas turbine for lube scavenge temperature and turbine vibrations.

(b) Inspect and clean the parts, listed in table 2, daily. Monitor lubrication system parameters until problem is found, or until the screens are found clean for two successive days; then resume normal inspection intervals.

c. Using instructions in WP 031 00 or SWP 031 10, clean and inspect parts listed in table 2.

d. Using instructions in WP 031 00 or SWP 031 10, re-install the following:

(1) For configurations L32119G01/-G02/-G03/-G04, install the screen insert elbow (3, figure 3), screen insert nipples (4 and 5), the screen insert bulkhead tee (6), and scavenge screens (2) into lube and scavenge pump (1) at locations identified in table 2.

(2) For configurations L32119G05/-G06, install screen insert tube nipples (4, 7 and 8), screen insert bulkhead tee (6), and scavenge screens (2) into lube and scavenge pump (1) at locations identified in table 2.

(3) Install lube and scavenge pump (1).

(4) For configurations L32119G01/-G02/-G03/-G04/-G05, install screen insert elbows (9 and 10) into A-sump scavenge pump (11) at locations identified in table 2.

(5) Remove all tags.

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

FUEL SYSTEM
SERVICING

(LEVEL 1 MAINTENANCE)

Effectivity: L32119G01/-G03/-G04/
-G05/-G06 MARINE GAS TURBINE

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1. **INTRODUCTION**. This work package provides instructions for servicing the fuel system when the bypass indicator button on fuel filter assembly has popped or when the fuel system is contaminated with water.

2. **SUPPORT EQUIPMENT**.

None

3. **CONSUMABLE MATERIALS**.

NOTE

Equivalent materials approved by GE Aircraft Engines may be substituted for items listed.

Consumable Materials

Description	Manufacturer
Brush, Soft-Bristle	Local Purchase
Cloth, Lint-Free	Local Purchase
Fuel, Type NATO-F-75 (MIL-F-1688A)	Local Purchase

Consumable Materials (Cont)

Description	Manufacturer
Lockwire, 0.032 inch (0.81 mm) diameter	Local Purchase
Petrolatum, Corrosion Preventive Compound (MIL-C-11796)	Local Purchase
Solvent, Dry Cleaning (Stoddard Solvent) (P-D-680)	Local Purchase

4. SERVICING OF FUEL SYSTEM WHEN BYPASS INDICATOR BUTTON HAS POPPED.

NOTE

The fuel filter assembly (7, figure 1) must be serviced when the delta P exceeds 16 psid (110 kPad), or when dirt or foreign material is found in the filter element (2). Also, a popped bypass indicator button indicates a contaminated filter element.

a. Remove filter element (2, figure 1) as follows:

(1) Remove lockwire from bowl (1).

Aviation Turbine Fuel (Jet Fuel) 292

CAUTION

Use a suitable container to catch fuel when bowl (1) is removed.

(2) Remove bowl (1) from head (5).

CAUTION

- Do not attempt to remove filter element (2) from bowl (1) by prying on end cap of element. End cap is constructed of a brittle nylon material which may crack if this is done.
- Filter element is easily damaged. Use care to avoid damage due to handling.

(3) Remove filter element (2) from bowl (1). If element is difficult to remove, apply fuel to sealing surface at bottom of bowl and use a twisting motion to free element.

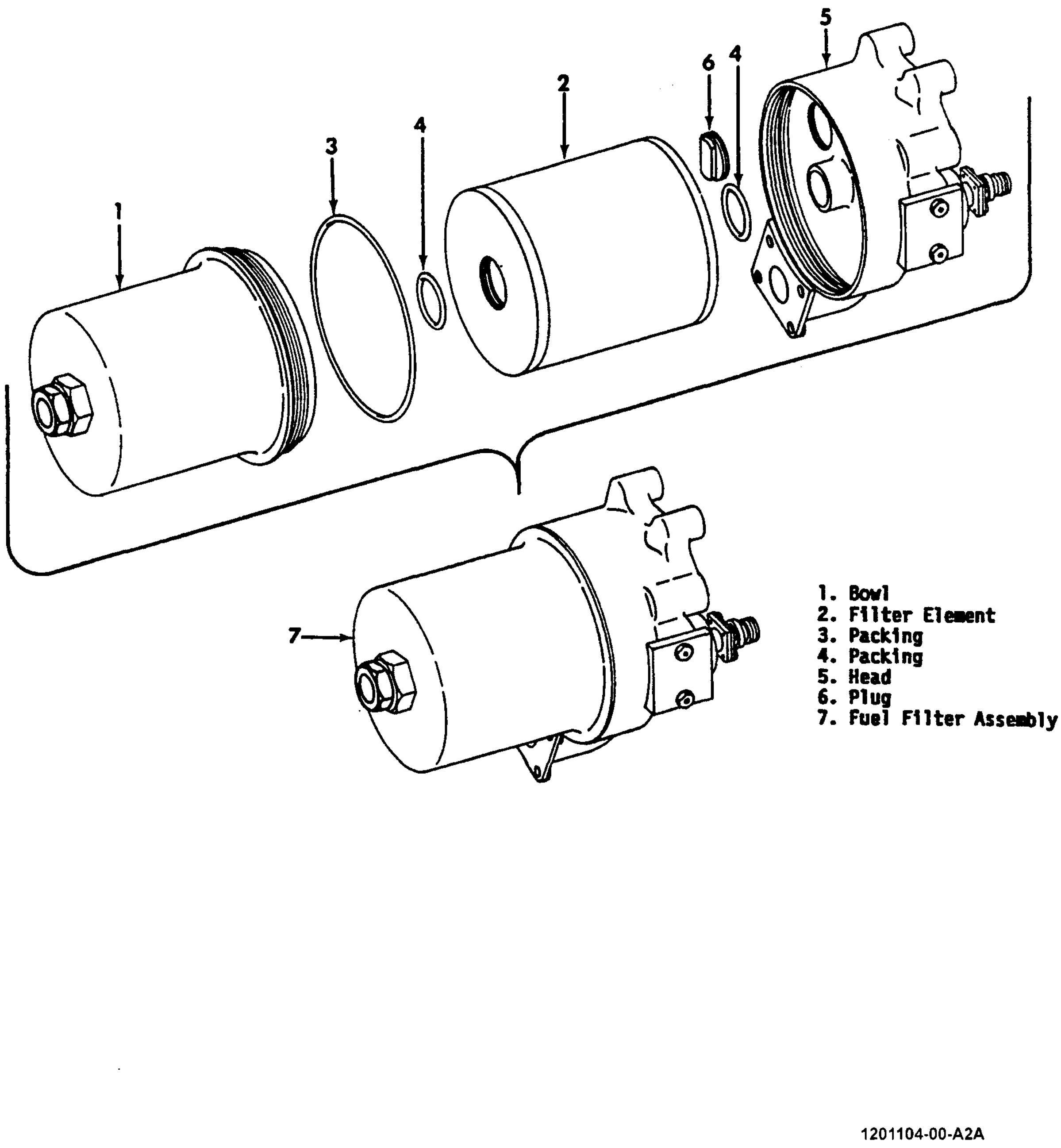

Figure 1. Removal and Installation of Bowl and Filter Element

(4) Remove and discard packing (3) and two packings (4).

b. Inspect filter element (2) for cuts, tears, and contamination and do the following:

(1) If filter element is damaged, replace filter element.

NOTE

Filter element (2) is not cleanable.

(2) If filter element (2) is contaminated, do the following:

(a) Replace filter element.

(b) Clean and inspect the head (step c) and the bowl (step d).

(c) Remove and inspect (WP 030 10) the following components:

- Main fuel pump
- Fuel distributor block and fuel distributor
- Fuel injector hose assemblies.

(d) Using applicable manuals, remove and inspect the following customer's components:

- No. 1 and No. 2 fuel shutoff valves
- Fuel metering valve
- Fuel pressurizing valve
- Fuel/Oil cooler.

c. Clean the head (5, figure 1) as follows:

Dry Cleaning Solvent **32**
(Stoddard Solvent), P-D-680

(1) Using a soft-bristle brush soaked with dry cleaning solvent P-D-680, clean the inside of fuel filter head to remove dirt. Be sure to clean the inlet and outlet ports.

(2) Using a lint-free cloth, wipe fuel filter head until dry.

d. Clean bowl (1) as follows:

Dry Cleaning Solvent **32**
(Stoddard Solvent), P-D-680

(1) Immerse bowl in a container with dry cleaning solvent P-D-680.

(2) Using a soft-bristle brush, clean bowl to remove dirt from the inside and outside surfaces.

WARNING

Compressed Air

- When using compressed air for any cooling, cleaning, or drying operation, do not exceed 30 psig (207 kPa) at the nozzle.
- Eyes can be permanently damaged by contact with liquid or large particles propelled by compressed air. Inhalation of air-blown particles or solvent vapor can damage lungs.
- When using air for cleaning at an air-exhausted workbench, wear approved goggles or face shield.
- When using air for cleaning at an unexhausted workbench, wear approved respirator and goggles.

(3) Using dry, filtered compressed air, dry bowl.

e. Inspect the head and bowl (refer to table 1).

TABLE 1. INSPECTION OF FUEL FILTER HEAD AND BOWL

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Bowl (see figure 2, view A) for:			
(1) Cracks.	None allowed.	Not repairable.	Replace bowl.
(2) Contamination.	No foreign material allowed inside the bowl.	Any amount.	Clean bowl.
(3) Nicks, burrs, and scratches on sealing surfaces and packing groove.	None allowed.	Not repairable.	Replace bowl.

TABLE 1. INSPECTION OF FUEL FILTER HEAD AND BOWL (Cont)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
(4) Nicks, burrs, and scratches on all other surfaces.	Any number, 1/32 inch (0.8 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove (WP 007 00) high metal and blend to adjacent controur. Refinish defective area with Alodine 1200 (WP 007 00).
(5) Wear at:			
NOTE If Alodine 1200 coating from a previous inspection is still intact (not worn away), no further inspection is required.			
(a) Area A.	Any amount up to 0.040 inch (1.02 mm).	Any amount.	Refinish defective area with Alodine 1200 (WP 007 00).
(b) Area B.	Any amount up to 0.045 inch (1.14 mm).	Any amount.	Refinish defective area with Alodine 1200 (WP 007 00).
b. Head (view B) for:			
(1) Nicks, burrs, and scratches on sealing surface.	None allowed.	Not repairable.	Replace fuel filter bowl and head (WP 030 10).
(2) Nicks, burrs, and scratches on all other surfaces.	Any number, 1/32 inch (0.8 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove (WP 007 00) high metal and blend to adjacent contour. Refinish defective area with Alodine 1200 (WP 007 00).
(3) Damaged insert.	One full thread missing or damaged with no high metal if normal installation with mating part can be made.	Not repairable.	Replace bowl and head (WP 030 10).
(4) Cracked, bent, or broken pins in electrical connector.	None allowed.	Not repairable.	Replace bowl and head (WP 030 10).

TABLE 1. INSPECTION OF FUEL FILTER HEAD AND BOWL (Cont)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
(5) Damaged electrical connector housing due to impact or excessive side loads.	There must be no evidence of dents. The housing must be parallel to the axis of the filter assembly.	Not repairable.	Replace bowl and head (WP 030 10).

f. Install filter element (2, figure 1) and bowl (1) as follows:

CAUTION

Filter element (2) is easily damaged. Use care to avoid damage due to handling.

(1) Install two packings (4) in filter element (2).

(2) If necessary, reset bypass indicator button by removing plug (6) and pushing the lever inside the head (5) towards the centerline of gas turbine, and at the same time push the red indicator button at the aft end of head. Hand-tighten plug.

(3) Install filter element (2) into bowl (1).


Corrosion Preventive Compound, Petrolatum, Hot Application, MIL-C-11796
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(4) Using petrolatum corrosion preventive compound MIL-C-11796, or equivalent, lubricate packing (3). Install packing into packing groove of bowl (1).

NOTE

Lockwire has to be inserted in hole of bowl (1) before bowl is threaded all the way into head (5).

(5) Insert 0.032 inch (0.81 mm) diameter lockwire in hole of bowl (1). Thread bowl into head (5). Hand-tighten bowl.

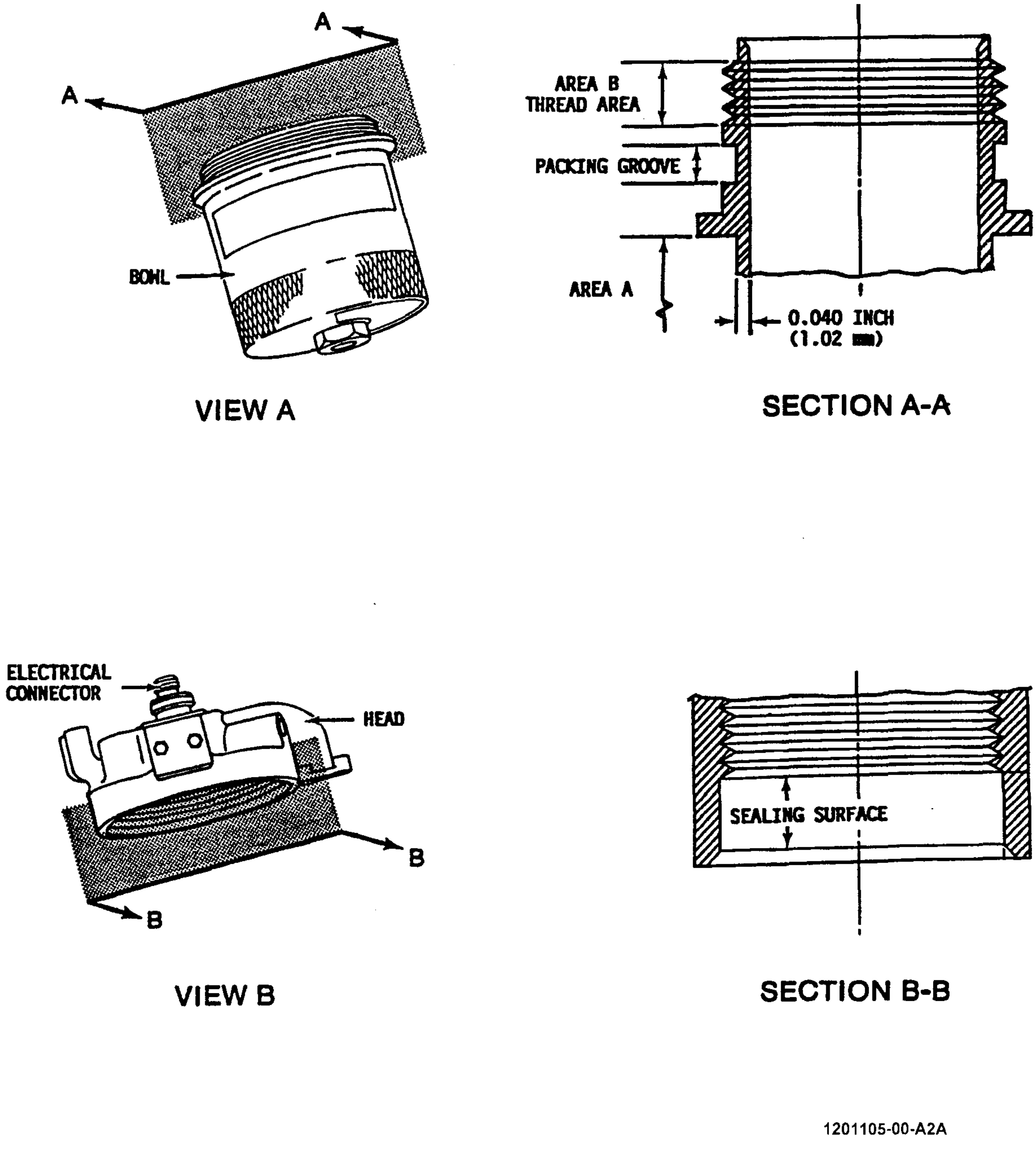

Figure 2. Inspection of Fuel Filter Head and Bowl

(6) Torque bowl to 200-250 lb in. (22.6-28.2 N·m).

(7) Using previously installed 0.032 inch (0.81 mm) diameter lockwire, lock-wire bowl using the double-strand method (WP 007 00).

5. CLEANING OF FUEL SYSTEM WHEN CONTAMINATED WITH WATER.

a. If the fuel system has been contaminated for less than 3 hours, flush the system with clean fuel as follows:

(1) Start gas turbine and stabilize at idle for 3 minutes.

(2) Slow accel to max and monitor T4.8.

(3) Slow decel to idle.

(4) Slow accel to max and stabilize for 2 minutes.

(5) Slow decel to idle.

(6) Slow accel to max and stabilize for 2 minutes.

(7) Chop to idle and stabilize for 2 minutes.

(8) Shut down gas turbine.

b. If the fuel system has been contaminated for more than 3 hours, or if the time period of contamination is not known, do the following:

(1) Remove and inspect (WP 030 10) the following components:

- Main fuel pump
- Fuel distributor block and fuel distributor
- Fuel injector hose assemblies.

(2) Using applicable manuals, remove and inspect the following customer's components:

- No. 1 and No. 2 fuel shutoff valves
- Fuel metering valve
- Fuel pressurizing valve
- Fuel/Oil cooler.

(3) Service fuel filter assembly (para 4).

(4) Flush fuel system (step a).

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

SEAL PRESSURIZING SYSTEM COMPONENTS
REMOVAL, CLEANING, INSPECTION, AND INSTALLATION

(LEVEL 2 MAINTENANCE)

Effectivity: L32119G02 INDUSTRIAL GAS TURBINE

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1. INTRODUCTION. This work package provides instructions for removing, cleaning, inspecting, and installing the seal pressurizing system components.

2. SUPPORT EQUIPMENT.

Support Equipment

Part No.	Nomenclature
21C5536	Kit Adapter (for testing the pressure regulating valve assembly)

3. CONSUMABLE MATERIALS.

NOTE

Equivalent materials approved by GE Aircraft Engines may be substituted for items listed.

Consumable Materials

Description	Manufacturer
Brush, Soft-Bristle	Local Purchase
Caps, Protective	Protective Closures Co., Inc. 2166 Elmwood Avenue Buffalo, NY 14207 USA
Cloth, Lint-Free	Local Purchase
Filter, 10-Micron	Local Purchase
Fluid, Calibrating (MIL-C-7024)	Local Purchase

Consumable Materials (Cont)

Description	Manufacturer
Lockwire, 0.032 inch (0.81 mm) diameter	Local Purchase
Oil, Lubricating (MIL-L-7808 or MIL-L-23699)	Local Purchase
Oil, Penetrating (VV-P-216)	Local Purchase
Plugs, Protective	Protective Closures Co., Inc. 2166 Elmwood Avenue Buffalo, NY 14207 USA
Solvent, Dry Cleaning (P-D-680)	Local Purchase

4. C-SUMP AFT TUBE.

a. Remove C-sump aft tube (1, figure 1) as follows:

(1) Remove bolt (3) and nut (4) that secure cushioned clamp (7) to bracket (32) on exhaust frame.

(2) Remove bolt (3) that secures cushioned clamp (7) to bracket (33) on low-pressure turbine (LPT) casing.

(3) Using two wrenches, disconnect coupling nuts on tube (1) from fitting on exhaust frame and from C-sump forward tube (2).

(4) Remove tube (1). Remove two cushioned clamps (7) from tube.

b. Install C-sump aft tube (1) as follows:

(1) Install and position two cushioned clamps (7) onto tube (1) at locations shown.

(2) Connect coupling nuts on tube (1), to fitting at the 12 o'clock position on exhaust frame and to C-sump forward tube (2). Hand-tighten coupling nuts.

(3) Using bolt (3) and nut (4), secure cushioned clamp (7) to bracket (32) on exhaust frame. Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(4) Using bolt (3), secure cushioned clamp (7) to bracket (33) on LPT casing. Torque bolt to 38-42 lb in. (4.3-4.7 N·m).

(5) Torque coupling nuts on tube (1) to 270-300 lb in. (30.5-33.9 N·m).

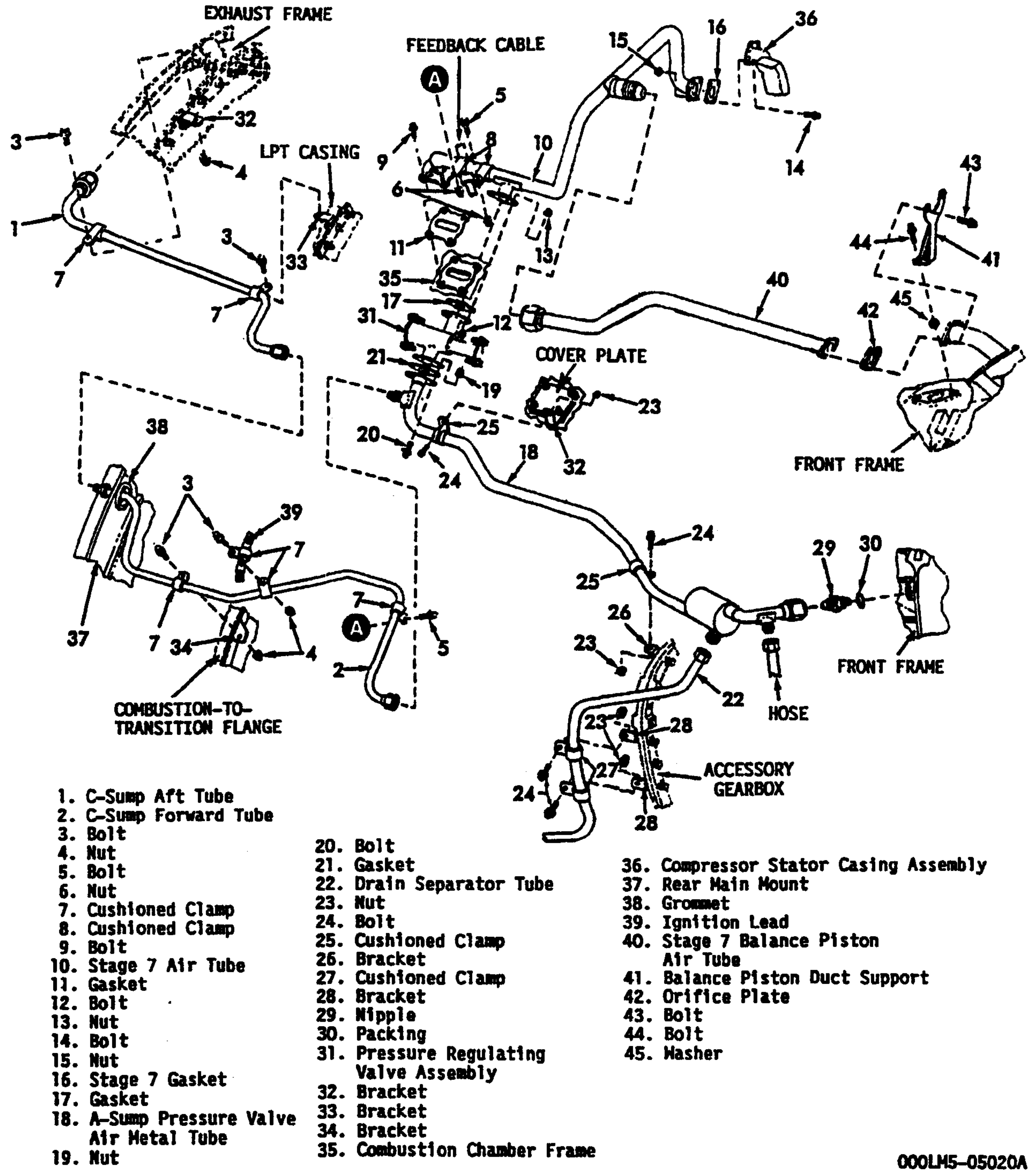


Figure 1. Removal and Installation of Seal Pressurizing System Components

5. STAGE 7 AIR TUBE.

a. Remove stage 7 air tube (10, figure 1) as follows:

(1) Remove bolt (5) and nut (6) that secure cushioned clamp (8) to clamp on feedback cable.

(2) Remove bolt (5) and nut (6) that secure cushioned clamp (8), on tube (10), to cushioned clamp (7) on C-sump forward tube (2).

(3) Remove two bolts (12) and nuts (13) that connect tube (10) to pressure regulating valve assembly (31).

(4) Disconnect coupling nut on stage 7 balance piston air tube (40), from fitting on tube (10).

(5) Remove four bolts (14) and nuts (15) that connect tube (10) to compressor stator casing assembly (36).

(6) Remove and discard lockwire from four bolts (9). Remove bolts (9) that secure tube (10) to boss on combustion chamber frame (35).

(7) Remove tube (10).

(8) Remove two clamps (8) from tube. Remove and discard gaskets (11, 16, 17).

b. Install stage 7 air tube (10) as follows:

(1) Install and position two clamps (8) onto tube (10) at locations shown.

(2) Install new gasket (11) onto boss of combustion chamber frame (35).

(3) Position tube (10), as shown, and secure flange of tube onto boss of combustion chamber frame (35) with four bolts (9). Hand-tighten bolts.

(4) Install new gasket (16) onto flange of compressor stator casing assembly (36). Position flange of tube (10) onto flange of casing assembly, and install four bolts (14) and nuts (15). Hand-tighten nuts.

(5) Using bolt (5) and nut (6), secure cushioned clamp (8) to clamp on feedback cable. Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(6) Using bolt (5) and nut (6), secure cushioned clamp (8) to cushioned clamp (7) on C-sump forward tube (2). Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(7) Torque four bolts (9) to 105-115 lb in. (11.9-13.0 N·m). Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire bolts using the double-strand method (WP 007 00).

(8) Torque four nuts (15) to 38-42 lb in. (4.3-4.7 N·m).

CAUTION

The mating flange of pressure regulating valve assembly (31) that will connect with the mating flange of tube (10) must not have an alignment pin hole. If the flange has an alignment pin hole, the valve assembly is not installed correctly and may fail during operation.

(9) Check the mating flange of valve assembly (31) to be sure that the flange does not have an alignment pin hole. If the flange has an alignment pin hole, remove and test valve assembly (para 13).

(10) Install new gasket (17) onto mating flange of valve assembly (31). Install two bolts (12) (boltheads facing down) and nuts (13) to secure tube (10) onto valve assembly. Torque nuts to 38-42 lb in. (4.3-4.7 N·m).

(11) Connect coupling nut on tube (40) to fitting on tube (10). Torque coupling nut to 900-1100 lb in. (101.7-124.3 N·m).

6. C-SUMP FORWARD TUBE.

a. Remove C-sump forward tube (2, figure 1) as follows:

(1) Remove bolt (3) and nut (4) that secure cushioned clamp (7) to bracket (34) on combustion-to-transition flange.

(2) Remove bolt (3) and nut (4) that secure cushioned clamp (7) on tube (2), to cushioned clamp (7) on ignition lead (39).

(3) Remove bolt (5) and nut (6) that secure cushioned clamp (7) on tube (2), to cushioned clamp (8) on stage 7 air tube (10).

(4) Using two wrenches, disconnect coupling nut on tube (2), from fitting on A-sump pressure valve air metal tube (18).

(5) Using two wrenches, disconnect coupling nut on C-sump aft tube (1), from fitting on tube (2).

(6) Remove grommet (38) from rear main mount (37).

(7) Slide tube (2) from rear main mount (37).

(8) Remove three cushioned clamps (7) from tube (2).

b. Install C-sump forward tube (2) as follows:

(1) Install and position three cushioned clamps (7) onto tube (2) at locations shown.

(2) Position tube (2) as shown. Slide one end of tube through hole in rear main mount (37).

(3) Install grommet (38) into rear main mount (37).

(4) Connect coupling nut on tube (2), to fitting on A-sump pressure valve air metal tube (18). Hand-tighten coupling nut.

(5) Connect coupling nut on C-sump aft tube (1), to fitting on tube (2). Hand-tighten coupling nut.

(6) Using bolt (5) and nut (6), secure cushioned clamp (7) to cushioned clamp (8) on stage 7 air tube (10). Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(7) Using bolt (3) and nut (4), secure cushioned clamp (7) on tube (2), to cushioned clamp (7) on ignition lead (39). Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(8) Using bolt (3) and nut (4), secure cushioned clamp (7) to bracket (34) on combustion-to-transition flange. Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(9) Torque coupling nut on tube (2), to 270-300 lb in. (30.5-33.9 N·m).

(10) Torque coupling nut on tube (1), to 270-300 lb in. (30.5-33.9 N·m).

7. DRAIN SEPARATOR TUBE.

a. Remove drain separator tube (22, figure 1) as follows:

(1) Remove two bolts (24) and nuts (23) that secure two cushioned clamps (27) to brackets (28) on accessory gearbox.

(2) Disconnect coupling nut on tube (22), from fitting on A-sump pressure valve air metal tube (18). Remove tube (22).

(3) Remove cushioned clamps (27) from tube.

b. Install drain separator tube (22) as follows:

(1) Install and position two cushioned clamps (27) onto tube (22) at locations shown.

(2) Connect coupling nut on tube (22), to fitting on tube (18). Hand-tighten coupling nut.

(3) Using two bolts (24) and nuts (23), secure cushioned clamps (27) to brackets (28) on accessory gearbox. Torque nuts to 38-42 lb in. (4.3-4.7 N·m).

(4) Torque coupling nut on tube (22), to 180-200 lb in. (20.3-22.6 N·m).

8. A-SUMP PRESSURE VALVE AIR METAL TUBE.

a. Remove A-sump pressure valve air metal tube (18, figure 1) as follows:

(1) Remove bolt (24) and nut (23) that secure cushioned clamp (25) to bracket (32) on cover plate.

(2) Remove bolt (24) and nut (23) that secure cushioned clamp (25) to bracket (26) on accessory gearbox.

(3) Using two wrenches, disconnect coupling nut on C-sump forward tube (2), from fitting on tube (18).

(4) Disconnect coupling nut on drain separator tube (22), from fitting on tube (18).

(5) Disconnect hose from tube (18). Using two wrenches, disconnect coupling nut on tube (18), from nipple (29) on front frame.

(6) Remove two bolts (20) and nuts (19) that secure tube (18) to pressure regulating valve assembly (31).

(7) Remove tube (18). Remove and discard gasket (21).

(8) Remove two cushioned clamps (25) from tube (18).

(9) Remove nipple (29) and packing (30) from front frame. Discard packing.

b. Install A-sump pressure valve air metal tube (18) as follows:

Lubricating Oil 66

(1) Using a light coat of lubricating oil MIL-L-7808 or MIL-L-23699, lubricate packing (30) and packing groove on nipple (29). Install packing onto nipple.

(2) Install nipple (29) into boss on front frame. Torque nipple to 270-300 lb in. (30.5-33.9 N·m).

(3) Install and position two clamps (25) onto tube (18) at locations shown.

(4) Position tube (18), as shown, between nipple (29) and pressure regulating valve assembly (31).

(5) Connect coupling nut on tube (18) to nipple (29). Hand-tighten coupling nut.

CAUTION

The mating flange of valve assembly (31) that will connect with the mating flange of tube (18) must have an alignment pin hole. If the flange does not have an alignment pin hole, the valve assembly is not installed correctly and may fail during operation.

(6) Check the mating flange of valve assembly (31) to be sure that the flange has an alignment pin hole. If the flange does not have an alignment pin hole, remove and test valve assembly (para 13).

CAUTION

The alignment pin on mating flange of tube (18) must align with the hole in gasket (21), and with the hole in mating flange of valve assembly (31). Otherwise, leaks will occur.

(7) Install new gasket (21) between mating flanges of valve assembly (31) and tube (18). Be sure that the alignment pin on tube aligns with hole in gasket, and with alignment pin hole on flange of valve assembly (31).

(8) Using two bolts (20) (boltheads facing down) and nuts (19), secure flange of tube (18) to flange of valve assembly (31). Hand-tighten nuts.

(9) Connect coupling nut on drain separator tube (22) to fitting on tube (18). Hand-tighten coupling nut.

(10) Connect coupling nut on C-sump forward tube (2) to fitting on tube (18). Hand-tighten coupling nut.

(11) Using bolt (24) and nut (23), secure cushioned clamp (25) to bracket (26) on accessory gearbox.

(12) Using bolt (24) and nut (23), secure cushioned clamp (25) to bracket (32) on cover plate. Torque bolt (24) to 38-42 lb in. (4.3-4.7 N·m).

(13) Torque two nuts (19) to 38-42 lb in. (4.3-4.7 N·m).

(14) Using two wrenches, torque coupling nut on tube (18) to 450-550 lb in. (50.8-62.1 N·m).

(15) Using two wrenches, torque coupling nut on tube (2) to 270-300 lb in. (30.5-33.9 N·m).

(16) Using two wrenches, torque coupling nut on tube (22) to 180-200 lb in. (20.3-22.6 N·m).

(17) Torque two nuts (23) to 38-42 lb in. (4.3-4.7 N·m).

(18) Connect hose to tube (18). Using two wrenches, torque coupling nut on hose to 270-300 lb in. (30.5-33.9 N·m).

9. STAGE 7 BALANCE PISTON AIR TUBE.

a. Remove stage 7 balance piston air tube (40, figure 1) as follows:

(1) Remove and discard lockwire from two bolts (43). Remove bolts that secure tube (40) to duct on front frame.

(2) Disconnect coupling nut on tube (40) from fitting on stage 7 air tube (10). Remove tube (40).

(3) Remove orifice plate (42) from tube (40).

(4) Remove and discard lockwire from bolt (44). Remove bolt (44), washer (45), and balance piston duct support (41) from front frame.

b. Install stage 7 balance piston air tube (40) as follows:

(1) Using washer (45) and bolt (44), secure support (41) onto front frame. Torque bolt to 38-42 lb in. (4.3-4.7 N·m). Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire bolt using the double-strand method (WP 007 00).

(2) Connect coupling nut on tube (40) to fitting on stage 7 air tube (10). Hand-tighten coupling nut.

(3) Install orifice plate (42) between flange of tube (40) and duct on front frame.

(4) Using two bolts (43), secure tube (40) to the flange on front frame and to the support (41).

(5) Torque bolts (43) to 105-115 lb in. (11.9-13.0 N·m). Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire bolts using the double-strand method (WP 007 00).

(6) Torque coupling nut on tube (40) to 900-1100 lb in. (101.7-124.3 N·m).

10. CLEANING OF TUBES.

a. Flush tubes in clean water, and air-dry them.

Dry Cleaning Solvent 32
(Stoddard Solvent), P-D-680

b. Using dry cleaning solvent P-D-680, flush the external and internal surfaces of tubes.

c. Rinse the external and internal surfaces of tubes with filtered water.

WARNING

Compressed Air

- When using compressed air for any cooling, cleaning, or drying operation, do not exceed 30 psig (207 kPa) at the nozzle.
- Eyes can be permanently damaged by contact with liquid or large particles propelled by compressed air. Inhalation of air-blown particles or solvent vapor can damage lungs.
- When using air for cleaning at an air-exhausted workbench, wear approved goggles or face shield.
- When using air for cleaning at an unexhausted workbench, wear approved respirator and goggles.

d. Using dry, filtered compressed air, dry the tubes.

11. INSPECTION OF TUBES.

Go to table 1.

TABLE 1. INSPECTION OF TUBES

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Tubes for:			
(1) Splits and cracks.	None allowed.	Not repairable.	Replace tube.
(2) Nicks, scratches, gouges, and chafing.	Any number, up to 0.008 inch (0.20 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).
(3) Dents.	Dented area must not exceed 20% of tube diameter.	Not repairable.	Replace tube.

TABLE 1. INSPECTION OF TUBES (Cont)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
(4) Flattened area.	Outside diameter must not be less than 3/4 of the original diameter.	Not repairable.	Replace tube.
(5) Distortion.	Any amount, if tube can be installed without force.	Any amount.	Cold-work (WP 007 00) tube to make it fit properly, without force. Cracks and kinks are not allowed. Pressure-test tube (para 12).
b. Hex coupling nuts for:			
(1) Cracks.	None allowed.	Not repairable.	Replace tube.
(2) Damaged corners.	Any amount, if a wrench can be used.	Not repairable.	Replace tube.
(3) Nicks and burrs.	Any number, without high metal.	Any number, with high metal.	Using a fine abrasive stone (WP 007 00), remove high metal.
(4) Damaged threads.	One-half of one thread (cumulative), without high metal.	Same as usable limits, with high metal.	Using a bottoming tap, chase threads.
c. Male fittings for:			
(1) Cracks.	None allowed.	Not repairable.	Replace tube.
(2) Circumferential nicks and scratches, and shiny, burnished surfaces on the seating surface.	Any number that cannot be felt with a scriber having a 0.030 inch (0.76 mm) tip radius, without high metal.	Same as usable limits, with high metal.	Using a fine abrasive stone, remove high metal (WP 007 00). Pressure-test tube (para 12).
(3) Axial nicks and scratches, and pits on the seating surface.	None allowed.	Any number.	Using a fine abrasive stone (WP 007 00), blend defect, maintaining original contour. Pressure-test tube (para 12).
(4) Damaged threads.	One-half of one thread (cumulative), without high metal.	Same as usable limits, with high metal.	Using a die, chase threads.

TABLE 1. INSPECTION OF TUBES (Cont)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
d. Femal fittings for:			
(1) Nicks, dents, scratches, ridges, and pits on seating surface.	Any number, if the defect does not extend more than half way across seating surface, without high metal.	Same as usable limits, with high metal.	Using a fine abrasive stone (WP 007 00), blend defect, maintaining original contour. Pressure-test tube (para 12).
(2) Nicks and gouges on tube flare.	Any number, 0.010 inch (0.25 mm) deep, without high metal, if tube passes the pressure test.	Same as usable limits, with high metal.	Blend high metal (WP 007 00). Pressure-test tube (para 12).
e. Tube flare ferrules for:			
(1) Cracks.	None allowed.	Not repairable.	Replace tube.
	 Penetrating Oil 234		
(2) Adhesion to coupling nuts.	Any amount, if nut turns smoothly on ferrule.	Any amount, if the nut can be worked free to turn smoothly on ferrule.	Apply penetrating oil VV-P-216 to the nut, and work it free. Using a lint-free cloth, remove all traces of penetrating oil.
f. Mating flanges for flatness (hold flange against a flat surface and try to insert a 0.005 inch (0.13 mm) shim).	Flange must be flat within 0.005 inch (0.13 mm).	Up to 25% of original flange thickness can be reworked to meet usable limits.	Rework flange to usable limits by lapping, stoning, or machining (if possible).

12. PRESSURE-TEST OF TUBES.

Calibrating Fluid, MIL-C-7024 **21**

a. Using calibrating fluid MIL-C-7024, flush tube thoroughly.

WARNING

High-Pressure Testing

- High pressures used during testing may cause rupturing or bursting of faulty tubes and hoses. The result could be serious injury.
- To prevent injury, cover all tubes and hoses with a suitable safety shield during testing.
- When caps or plugs are used, be sure they are securely installed to prevent them from being blown out.
- Be sure that pressures are bled off before exposing or touching hoses or tubes.

b. Restrict one end of tube. Using calibrating fluid MIL-C-7024, build up pressure to 200 psig (1379 kPa).

c. Maintain pressure for a minimum of 2 minutes. If there is a pressure drop, replace tube.

d. Thoroughly drain tube of excess fluid. Cap or plug open ends.

13. PRESSURE REGULATING VALVE ASSEMBLY.

a. Remove pressure regulating valve assembly (31, figure 1) as follows:

(1) Using instructions in paragraph 5, disconnect stage 7 air tube (10).

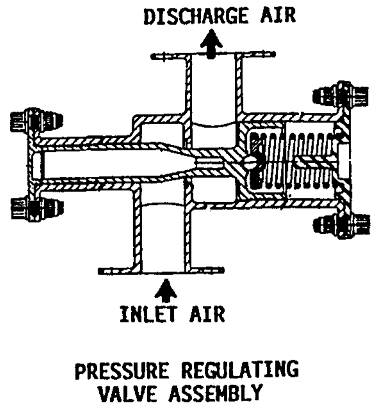
(2) Remove two bolts (20) and nuts (19) that secure the valve assembly (31) to A-sump pressure valve air metal tube (18).

(3) Remove valve assembly (31). Remove and discard gaskets (17, 21).

b. Test the valve assembly (see figure 2) as follows:

(1) Using kit adapter 21C5536, set up valve assembly for testing as shown in figure 2.

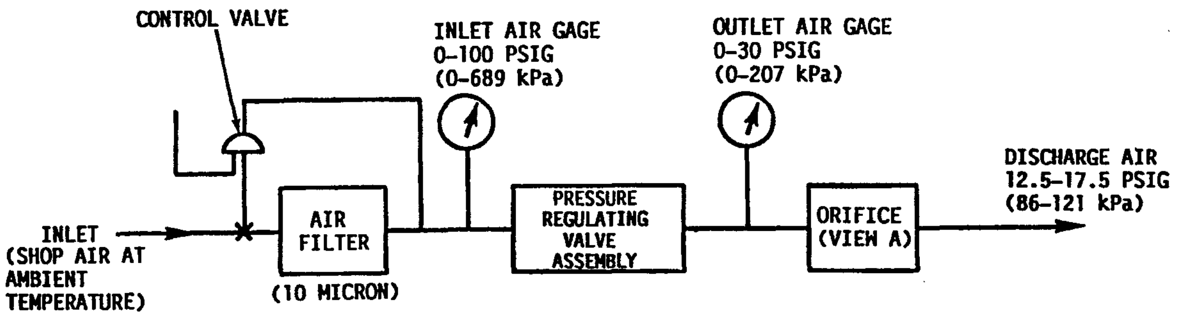
(2) Using the control valve, vary the inlet air pressure from 20 to 80 psig (138 to 552 kPa). The discharge (regulated) air pressure must be maintained at 12.5-17.5 psig (86-121 kPa), without resonance or instability. Record the minimum and maximum discharge (regulated) air pressure.



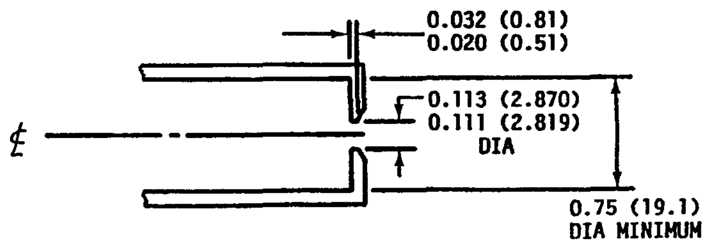
SECTION VIEW

REQUIREMENTS

- AIR SUPPLY: SHOP AIR REGULATED BETWEEN 20 AND 80 PSIG (138-552 kPa) FOR AIR FLOW FROM 0.003 TO 0.007 LB/SEC. (1.36-3.17 GRAMS/SEC.).
- DISCHARGE SIDE: FITTED WITH AN ORIFICE RESTRICTION (SEE VIEW A FOR DETAILS). VOLUME BETWEEN VALVE OUTLET AND ORIFICE RESTRICTION MUST BE 20-40 CUBIC INCHES (328-656 CUBIC CENTIMETERS).
- GAGES: ACCURATE WITHIN 1% OF FULL SCALE READING.



TEST SETUP



VIEW A

ALL DIMENSIONS ARE IN INCHES WITH MILLIMETERS IN PARENTHESES.

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Figure 2. Testing of Pressure Regulating Valve Assembly

(3) If the discharge (regulated) air pressure is not maintained throughout the range of supply air pressure, do the following:

(a) Disassemble valve assembly (see figure 3) as follows:

WARNING

Handling Spring-Loaded Parts

To avoid injury, use care when removing valve cap (3), because spring (5) is under compression.

CAUTION

The nuts (1) should be alternately loosened one turn at a time, to avoid deformation of valve cap (3) as spring pressure is relieved.

1 Alternately loosen two nuts (1) from valve cap (3), until spring pressure is relieved.

2 Remove two nuts (1) and bolts (2) from valve cap (3).

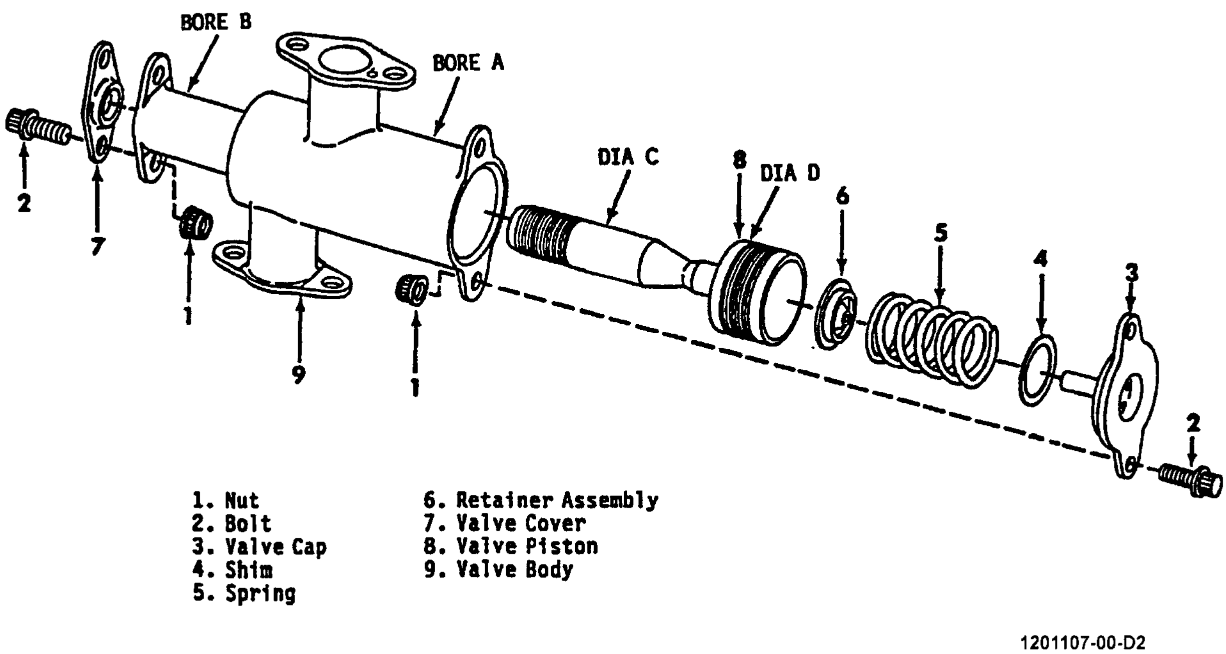

Figure 3. Disassembly, Inspection, and Assembly of Pressure Regulating Valve Assembly

NOTE

There may be more than one shim (4) between valve cap (3) and spring (5).

3 Remove valve cap (3) and shim (4). Save shim for installation.

4 Remove spring (5) and retainer assembly (6).

5 Remove two nuts (1), bolts (2), and valve cover (7).

6 Remove valve piston (8) from valve body (9).

(b) Clean the components of valve assembly as follows:

Dry Cleaning Solvent (Stoddard Solvent), P-D-680 **32**

1 Flush the components of valve assembly with dry cleaning solvent P-D-680.

2 Using a soft-bristle brush soaked with dry cleaning solvent P-D-680, remove any debris that has accumulated onto components.

3 Flush the components of valve assembly with dry cleaning solvent P-D-680.

WARNING

Compressed Air

- When using compressed air for any cooling, cleaning, or drying operation, do not exceed 30 psig (207 kPa) at the nozzle.
- Eyes can be permanently damaged by contact with liquid or large particles propelled by compressed air. Inhalation of air-blown particles or solvent vapor can damage lungs.
- When using air for cleaning at an air-exhausted work-bench, wear approved goggles or face shield.
- When using air for cleaning at an unexhausted work-bench, wear approved respirator and goggles.

4 Using dry, filtered, low-velocity compressed air, dry the components of valve assembly.

(c) Inspect components of valve assembly as instructed in table 2.

TABLE 2. INSPECTION OF PRESSURE REGULATING VALVE ASSEMBLY COMPONENTS

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Valve body (9, figure 3) for:			
(1) Cracks.	None allowed.	Not repairable.	Replace valve body.
(2) Wear in bore A.	1.002 inches (25.45 mm) maximum average diameter (measured at three locations).	Not repairable.	Replace valve body.
(3) Wear in bore B.	0.502 in. (12.75 mm) maximum average diameter (measured at three locations).	Not repairable.	Replace valve body.
(4) Nicks, dents, and scratches in:			
(a) Bores A and B.	None allowed.	Not repairable.	Replace valve body.
(b) Other areas.	Any number, 0.016 inch (0.41 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).
b. Valve piston (8) for:			
(1) Cracks.	None allowed.	Not repairable.	Replace valve piston.
(2) Wear on diameter C.	0.4955 inch (12.586 mm) minimum average diameter (measured at three locations).	Not repairable.	Replace valve piston.
(3) Wear on diameter D.	0.9955 inch (25.286 mm) minimum average diameter (measured at three locations).	Not repairable.	Replace valve piston.
(4) Nicks, dents, and scratches on:			
(a) Diameters C and D.	None allowed.	Not repairable.	Replace valve piston.
(b) Other areas.	Any number, 0.016 inch (0.41 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).
c. Spring (5) for:			
(1) Cracks.	None allowed.	Not repairable.	Replace spring.
(2) Rub marks on coils.	Rub marks allowed up to 0.020 inch (0.51 mm) wide.	Not repairable.	Replace spring.

TABLE 2. INSPECTION OF PRESSURE REGULATING VALVE ASSEMBLY COMPONENTS (Cont)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
(3) Relaxation and permanent set.	Length of spring must be 1.20-1.25 inches (30.5-31.8 mm) in free state.	Not repairable.	Replace spring.
(4) Nicks, dents, and scratches.	Any number, 0.016 inch (0.41 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).
d. Valve cap (3), retainer assembly (6), and valve cover (7) for:			
(1) Cracks.	None allowed.	Not repairable.	Replace part.
(2) Nicks, dents, and scratches.	Any number, 0.016 inch (0.41 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).

(d) Assemble valve assembly (see figure 3) as follows:

1 Install valve cover (7) onto valve body (9). Using two bolts (2) and nuts (1), secure valve cover. Torque nuts to 25-30 lb in. (2.8-3.4 N·m).

2 Install valve piston (8) into valve body (9) until piston bottoms.

3 Insert the retainer assembly (6) into the recess of valve piston (8), so that the ball end faces the valve piston.

4 Install spring (5) onto retainer assembly (6).

NOTE

- The regulated pressure from the valve assembly is determined by the spring preload. The shim PN 2018T15P01 (4) is used to set the preload.
- Adding one shim (4) increases the output pressure approximately 0.75 psi (5.2 kPa).

5 Using the test results recorded in step b.(2), change the number of shims (4) as required to adjust the discharge air pressure within limits. If more than six shims are required to achieve correct discharge air pressure regulation, replace valve assembly. Return the replaced valve assembly to the vendor for repair.

6 Install the required shims (4) into the inner recess of valve cap (3).

7 Install valve cap (3) onto valve body (9). Using two bolts (2) and nuts (1), secure valve cap.

CAUTION

The nuts (1) should be alternately tightened one turn at a time, to avoid deformation of valve cap (3) as spring pressure increases.

8 Alternately tighten nuts (1) on valve cap (3).

9 Torque nuts (1) to 25-30 lb in. (2.8-3.4 N·m).

10 Re-test valve assembly.

c. Install pressure regulating valve assembly (31, figure 1) as follows:

CAUTION

The mating flange of valve assembly (31) that will connect with the mating flange of A-sump pressure valve air metal tube (18) must have an alignment pin hole. If the flange does not have an alignment pin hole, the valve assembly will not be installed correctly and may fail during operation.

(1) Position the valve assembly (31) so that the mating flange with the alignment pin hole faces the mating flange of tube (18).

CAUTION

The alignment pin on mating flange of tube (18), must align with the hole in gasket (21), and with the hole in mating flange of valve assembly (31). Otherwise, leaks will occur.

(2) Install new gasket (21) between flanges of valve assembly (31) and tube (18). Be sure that the alignment pin on tube aligns with hole in gasket and with alignment pin hole on flange of valve assembly.

(3) Using two bolts (20) (boltheads facing down) and nuts (19), secure flange of tube (18) to flange of valve assembly (31). Torque nuts to 38-42 lb in. (4.3-4.7 N·m).

(4) Using instructions in paragraph 5, re-connect stage 7 air tube (10) to valve assembly (31).

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

SEAL PRESSURIZING AND B-SUMP REGULATING SYSTEM COMPONENTS REMOVAL, CLEANING, INSPECTION, AND INSTALLATION

(LEVEL 2 MAINTENANCE)

Effectivity: L32119G01/-G03/-G04/-G05/-G06 MARINE GAS TURBINE

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1. **INTRODUCTION.** This work package provides instructions for removing, cleaning, inspecting, and installing the seal pressurizing and B-sump regulating system components.

2. **SUPPORT EQUIPMENT.**

Support Equipment

Part No.	Nomenclature
21C5536	Kit Adapter (for testing the pressure regulating valve assembly)

3. **CONSUMABLE MATERIALS.**

NOTE

Equivalent materials approved by GE Aircraft Engines may be substituted for items listed.

Consumable Materials

Description	Manufacturer
Brush, Soft-Bristle	Local Purchase
Caps, Protective	Protective Closures Co., Inc. 2166 Elmwood Avenue Buffalo, NY 14207 USA
Cloth, Lint-Free	Local Purchase
Filter, 10-Micron	Local Purchase
Fluid, Calibrating (MIL-C-7024)	Local Purchase
Lockwire, 0.032 inch (0.81 mm) diameter	Local Purchase
Oil, Lubricating (MIL-L-7808 or MIL-L-23699)	Local Purchase
Oil, Penetrating (VV-P-216)	Local Purchase
Plugs, Protective	Protective Closures Co., Inc. 2166 Elmwood Avenue Buffalo, NY 14207 USA
Solvent, Dry Cleaning (P-D-680)	Local Purchase

4. <u>C-SUMP AFT TUBE</u>.

a. Remove C-sump aft tube (1, figure 1, sheet 1) as follows:

(1) Remove bolt (3) and nut (4) that secure cushioned clamp (7) to bracket (32) on exhaust frame.

(2) Remove bolt (3) that secures cushioned clamp (7) to bracket (33) on low-pressure turbine (LPT) casing.

(3) Using two wrenches, disconnect coupling nuts on tube (1) from fitting on exhaust frame and from C-sump forward tube (2).

(4) Remove tube (1). Remove two cushioned clamps (7) from tube.

b. Install C-sump aft tube (1) as follows:

(1) Install and position two cushioned clamps (7) onto tube (1) at locations shown.

(2) Connect coupling nuts on tube (1), to fitting at the 12 o'clock position on exhaust frame and to C-sump forward tube (2). Hand-tighten coupling nuts.

(3) Using bolt (3) and nut (4), secure cushioned clamp (7) to bracket (32) on exhaust frame. Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(4) Using bolt (3), secure cushioned clamp (7) to bracket (33) on LPT casing. Torque bolt to 38-42 lb in. (4.3-4.7 N·m).

(5) Torque coupling nuts on tube (1) to 270-300 lb in. (30.5-33.9 N·m).

5. <u>STAGE 7 AIR TUBE</u>.

a. Removal.

(1) On L32119G01 configuration, remove stage 7 air tube (10, figure 1, sheet 1) as follows:

(a) Remove bolt (5) and nut (6) that secure cushioned clamp (8) to clamp on feedback cable (70).

(b) Remove bolt (5) and nut (6) that secure cushioned clamp (8), on tube (10), to cushioned clamp (7) on C-sump forward tube (2).

(c) Remove two bolts (12) and nuts (13) that connect tube (10) to pressure regulating valve assembly (31).

(d) Disconnect coupling nut on stage 7 balance piston air tube (40) from fitting on tube (10).

(e) Remove four bolts (14) and nuts (15) that connect tube (10) to compressor stator casing assembly (36).

(f) Remove and discard lockwire from four bolts (9).

(g) Remove four bolts (9) that secure tube (10) to boss on combustion chamber frame (35).

(h) Remove tube (10) from GT.

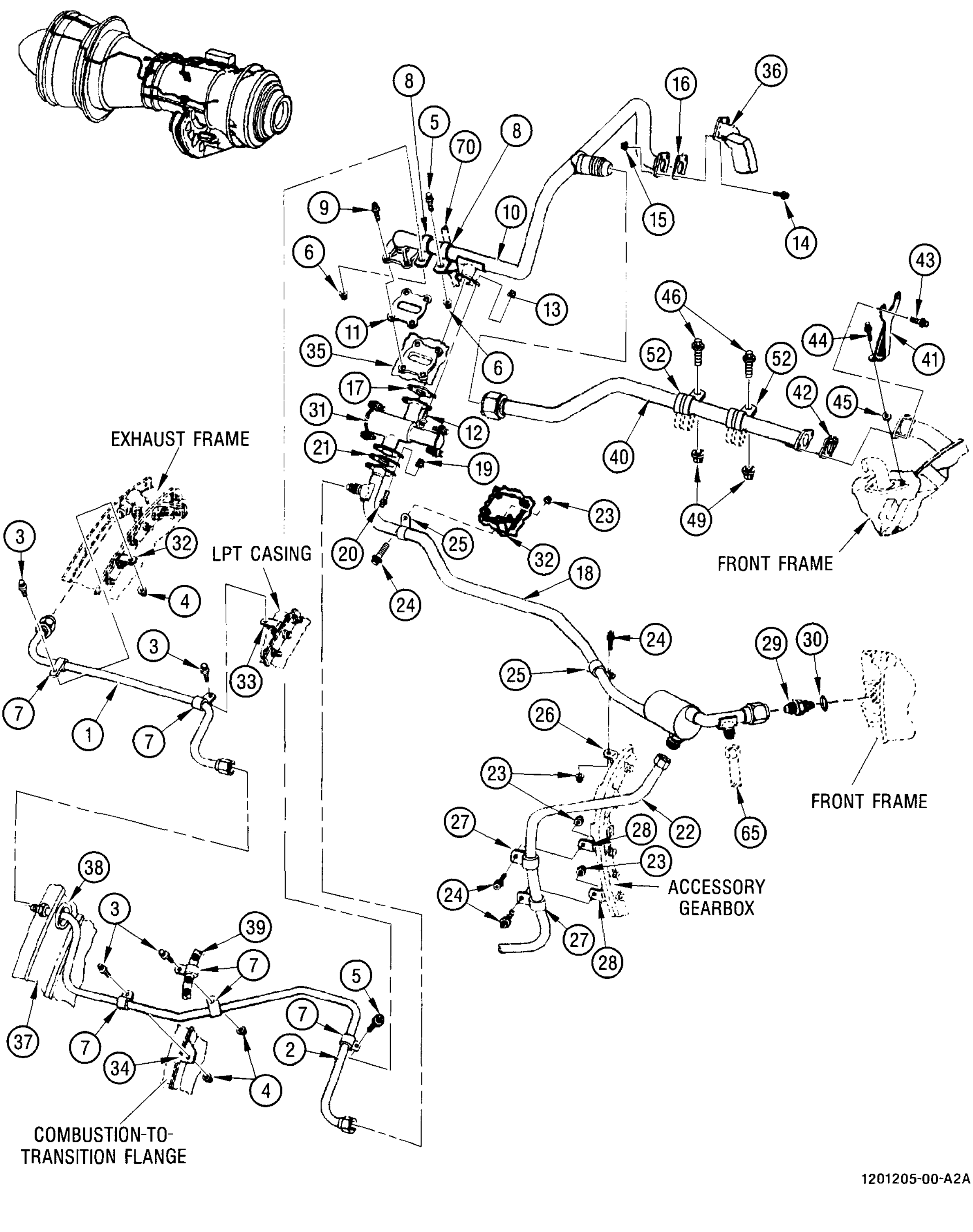

Figure 1. Removal and Installation of Seal Pressurizing and B-Sump Regulating System Components (Sheet 1 of 4)

LEGEND:

1. C-SUMP AFT TUBE
2. C-SUMP FORWARD TUBE
3. BOLTS
4. NUTS
5. BOLT
6. NUT
7. CUSHIONED CLAMPS
8. CUSHIONED CLAMP
9. BOLT
10. STAGE 7 AIR TUBE
11. GASKET
12. BOLT
13. NUT
14. BOLT
15. NUT
16. GASKET
17. GASKET
18. A-SUMP PRESSURE VALVE AIR METAL TUBE
19. NUT
20. BOLT
21. GASKET
22. DRAIN SEPARATOR TUBE
23. NUT
24. BOLTS
25. CUSHIONED CLAMP
26. BRACKET
27. CUSHIONED CLAMP
28. BRACKET
29. NIPPLE
30. PREFORMED PACKING
31. PRESSURE REGULATING VALVE ASSEMBLY
32. BRACKET
33. BRACKET
34. BRACKET
35. COMBUSTION CHAMBER FRAME
36. COMPRESSOR STATOR CASING ASSEMBLY
37. REAR MAIN MOUNT RING
38. GROMMET
39. IGNITION LEAD
40. STAGE 7 BALANCE PISTON AIR TUBE
41. BALANCE PISTON SUPPORT
42. ORFICE PLATE
43. BOLT
44. BOLT
45. WASHER
46. BOLTS
47. REGULATOR VALVE AFT AIR TUBE
48. CUSHIONED CLAMP
49. NUT
50. REGULATOR VALVE FORWARD AIR TUBE
51. CUSHIONED CLAMP
52. CUSHIONED CLAMPS
53. CUSHIONED CLAMP
54. B-SUMP VENT TEE
55. AIR REGULATOR VALVE TUBE
56. B-SUMP REGULATOR VALVE
57. CUSHIONED CLAMP
58. B-SUMP OIL TUBE
59. STAGE 7 REGULATOR AIR TUBE
60. BOLT
61. NUT
62. CUSHIONED CLAMP
63. CUSHIONED CLAMP
64. STAGE 7 VALVE AIR TUBE
65. HOSE
66. BOLT
67. NUT
68. CUSHIONED CLAMP
69. CUSHIONED CLAMP
70. FEEDBACK CABLE
71. BRACKET
72. BOLT
73. CUSHIONED CLAMP
74. BRACKET
75. GROMMET
76. BOLT
77. NUT
78. GASKET
79. BOLT
80. NUT
81. CUSHIONED CLAMP
82. CUSHIONED CLAMP

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Figure 1. Removal and Installation of Seal Pressurizing and B-Sump Regulating System Components (Sheet 2 of 4)

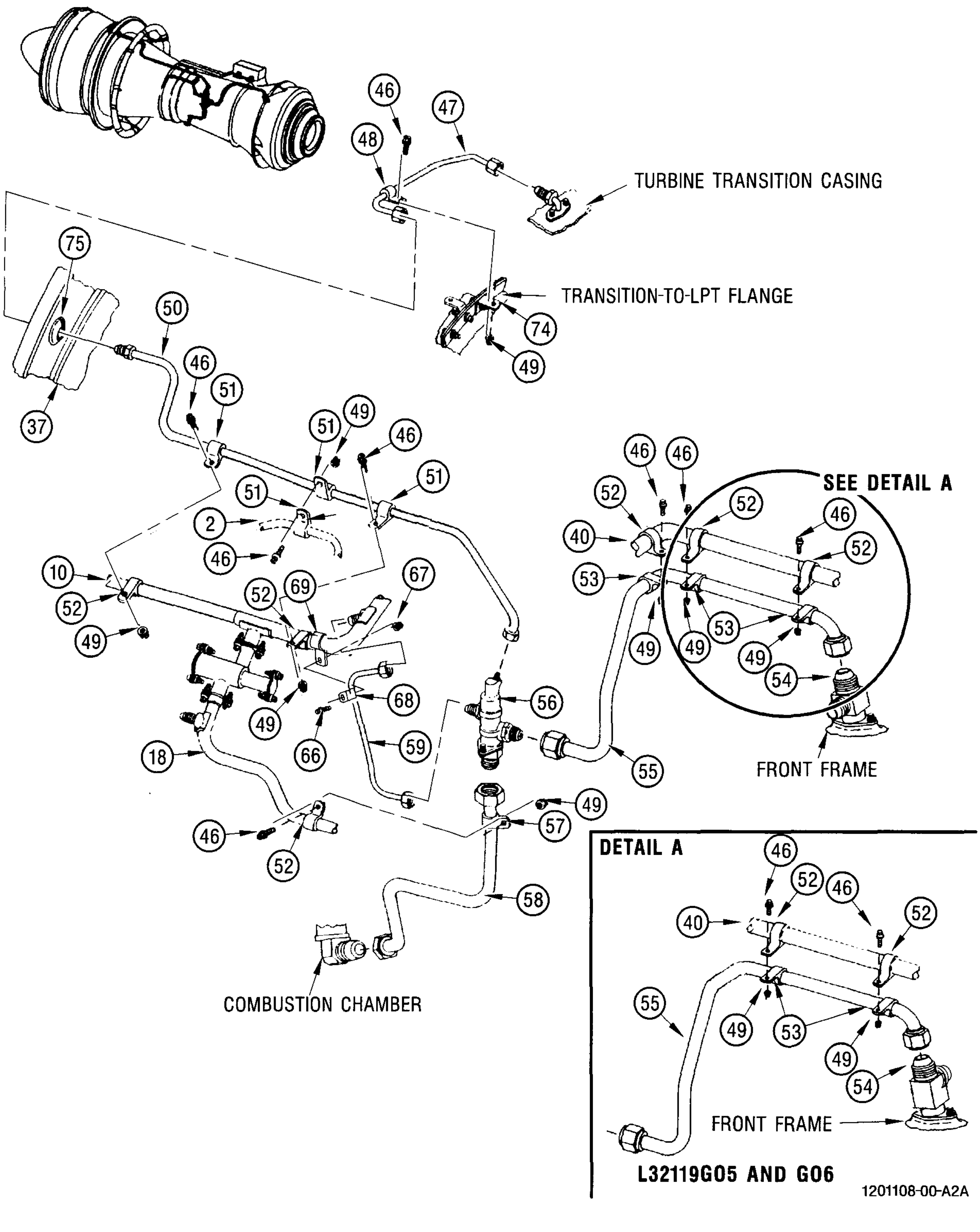


Figure 1. Removal and Installation of Seal Pressurizing and B-Sump Regulating System Components (Sheet 3 of 4)

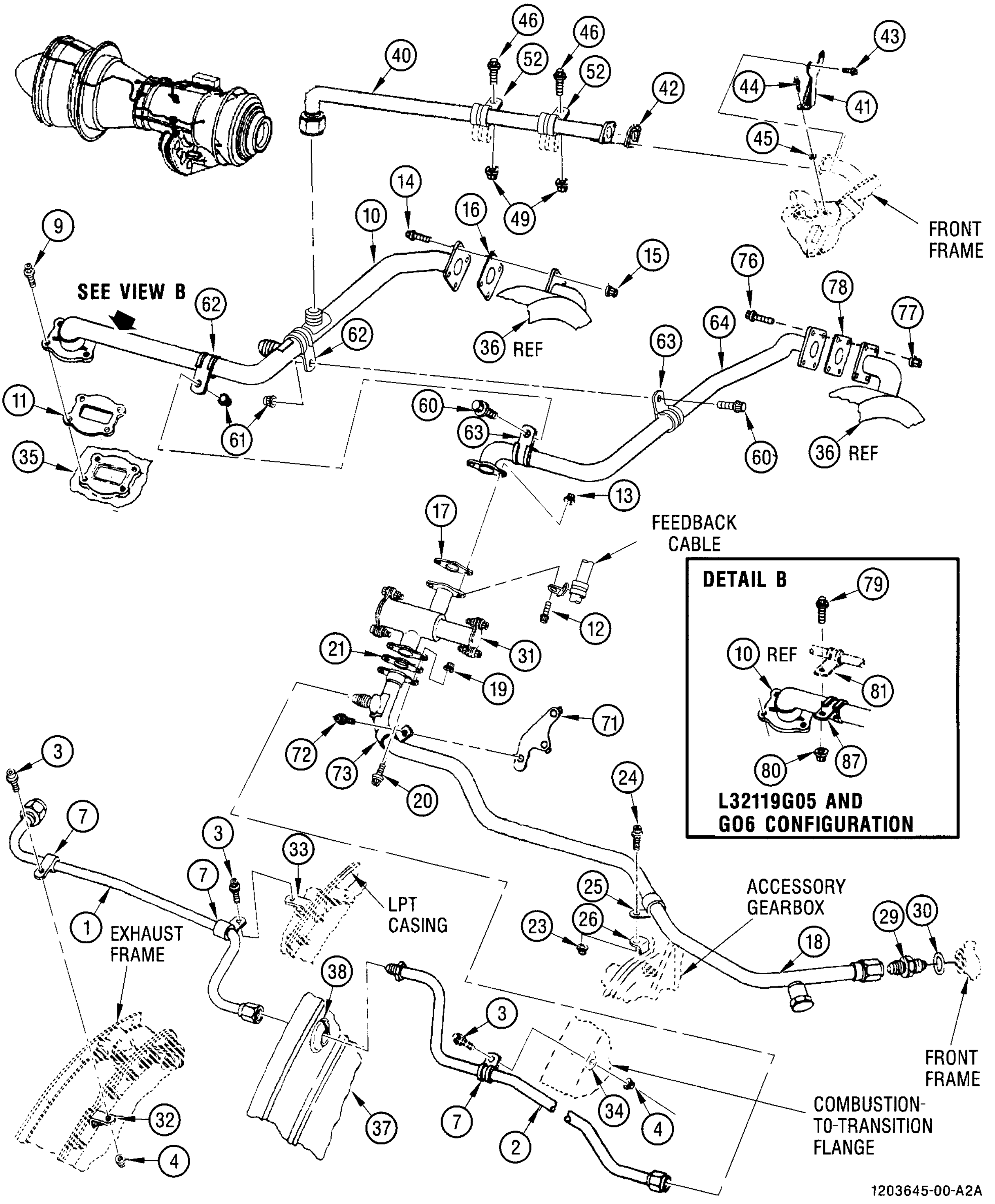


Figure 1. Removal and Installation of Seal Pressurizing and B-Sump Regulating System Components (Sheet 4 of 4)

(i) Remove clamps (8) from tube (10).

(j) Remove and discard gaskets (11, 16, and 17).

(2) On L32119G03 and G04 configurations, remove stage 7 air tube (10, figure 1, sheet 1) as follows:

(a) Remove bolt (5) and nut (6) that secure cushioned clamp (8) to clamp on feedback cable (70)

(b) Remove bolt (5) and nut (6) that secure cushioned clamp (8), on tube (10), to cushioned clamp (7) on C-sump forward tube (2).

(c) Remove two bolts (46, sheet 3) and nuts (49) that secure cushioned clamps (52), on tube (10), to cushioned clamps (51) on regulator valve forward air tube (50).

(d) Remove two bolts (12, sheet 1) and nuts (13) that connect tube (10) to pressure regulating valve assembly (31).

(e) Disconnect coupling nut on stage 7 balance piston air tube (40) from fitting on tube (10).

(f) Disconnect coupling nut on stage 7 regulator air tube (59, sheet 3) from fitting on tube (10).

(g) Remove four bolts (14, sheet 1) and nuts (15) that connect tube (10) to compressor stator casing assembly (36).

(h) Remove and discard lockwire from four bolts (9).

(i) Remove four bolts (9) that secure tube (10) to boss on combustion chamber frame (35).

(j) Remove tube (10) from GT.

(k) Remove clamps (8 and 52) from tube (10).

(l) Remove and discard gaskets (11, 16, and 17).

(3) On L32119G05 and G06 configurations, remove stage 7 air tube (10, figure 1, sheet 4) as follows:

(a) Remove two bolts (60) and nuts (61) that secure cushioned clamps (62), on tube (10), to cushioned clamps (63) on stage 7 valve air tube (64).

(b) On L32119G05 configuration, remove two bolts (46, sheet 3) and nuts (49) that secure cushioned clamps (52), on tube (10), to cushioned clamps (51) on regulator valve forward air tube (50).

(c) Remove bolt (79, sheet 4, detail B) and nut (80) that secures cushioned clamp (81) to cushioned clamp (82).

(d) Disconnect coupling nut on stage 7 balance piston air tube (40) from fitting on tube (10).

(e) Disconnect coupling nut, on stage 7 regulator air tube (59, sheet 3) from fitting on tube (10).

(f) Remove four bolts (14, sheet 4) and nuts (15) that connect tube (10) to compressor stator casing assembly (36).

(g) Remove and discard lockwire from four bolts (9).

(h) Remove four bolts (9) that secure tube (10) to boss on combustion chamber frame (35).

(i) Remove tube (10) from GT.

(j) Remove clamps (52 and 62) from tube (10).

(k) Remove and discard gaskets (11 and 16).

b. Installation.

(1) On L32119G01 configuration, install stage 7 air tube (10, figure 1, sheet 1) as follows:

(a) Install two clamps (8) onto tube (10) at locations shown.

(b) Install new gasket (11) onto boss on combustion chamber frame (35).

(c) Position tube (10) onto boss on frame (35).

(d) Install four bolts (9) to secure tube (10) and gasket (11) onto frame (35). Tighten bolts hand-tight.

(e) Install new gasket (16) onto compressor stator casing assembly (36).

(f) Position tube (10) onto flange of casing assembly (36).

(g) Install four bolts (14) and nuts (15) to secure tube (10) and gasket (16) to casing assembly (36). Tighten nuts hand-tight.

(h) Install bolt (5) and nut (6) to secure cushioned clamp (8) to clamp on feedback cable (70). Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(i) Install bolt (5) and nut (6) to secure cushioned clamp (8) to cushioned clamp (7) on C-sump forward tube (2). Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(j) Torque four bolts (9) to 105-115 lb in. (11.9-13.0 N·m).

(k) Lock-wire four bolts (9) with 0.032 inch (0.81 mm) diameter lockwire using double-strand method (WP 007 00).

(l) Torque four nuts (15) to 38-42 lb in. (4.3-4.7 N·m).

CAUTION

The mating flange of pressure regulating valve assembly (31) that connects to the mating flange of tube (10) must not have an alignment pin hole. If the flange has an alignment pin hole, the valve assembly is installed incorrectly and may fail during operation.

(m) Check the mating flange of valve assembly (31) to ensure that the flange does not have an alignment pin hole. If flange has an alignment pin hole, remove and test valve assembly (paragraph 19).

(n) Install new gasket (17) onto mating flange of valve assembly (31).

(o) Install two bolts (12) (boltheads facing down) and nuts (13) to secure tube (10) to valve assembly (31). Torque nuts to 38-42 lb in. (4.3-4.7 N·m).

(p) Connect coupling nut on air tube (40) to fitting on tube (10). Torque coupling nut to 900-1100 lb in. (101.7-124.3 N·m).

(2) On L32119G03 and G04 configurations, install stage 7 air tube (10, figure 1, sheet 1) as follows:

(a) Install two clamps (8) onto tube (10) at locations shown.

(b) Install two clamps (52) onto tube (10) at locations shown.

(c) Install new gasket (11) onto boss on combustion chamber frame (35).

(d) Position tube (10) onto boss on frame (35).

(e) Install four bolts (9) to secure tube (10) and gasket (11) onto frame (35). Tighten bolts hand-tight.

(f) Install new gasket (16) onto compressor stator casing assembly (36).

(g) Position tube (10) onto flange of casing assembly (36).

(h) Install four bolts (14) and nuts (15) to secure tube (10) and gasket (16) to casing assembly (36). Tighten nuts hand-tight.

(i) Install bolt (5) and nut (6) to secure cushioned clamp (8) to clamp on feedback cable (70). Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(j) Install bolt (5) and nut (6) to secure cushioned clamp (8) to cushioned clamp (7) on C-sump forward tube (2). Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(k) Install two bolts (46, sheet 3) and nuts (49) to secure cushioned clamps (52), on tube (10) to cushioned clamps (51) on regulator valve forward air tube (50). Torque nuts to 38-42 lb in. (4.3-4.7 N·m).

(l) Torque four bolts (9, sheet 1) to 105-115 lb in. (11.9-13.0 N·m).

(m) Lock-wire four bolts (9) with 0.032 inch (0.81 mm) diameter lockwire using double-strand method (WP 007 00).

(n) Torque four nuts (15) to 38-42 lb in. (4.3-4.7 N·m).

CAUTION

The mating flange of pressure regulating valve assembly (31) that connects to the mating flange of tube (10) must not have an alignment pin hole. If the flange has an alignment pin hole, the valve assembly is installed incorrectly and may fail during operation.

(o) Check the mating flange of valve assembly (31) to ensure that the flange does not have an alignment pin hole. If flange has an alignment pin hole, remove and test valve assembly (paragraph 19).

(p) Install new gasket (17) onto mating flange of valve assembly (31).

(q) Install two bolts (12), boltheads facing down, and nuts (13) to secure tube (10) to valve assembly (31). Torque nuts to 38-42 lb in. (4.3-4.7 N·m).

(r) Connect coupling nut on air tube (40) to fitting on tube (10). Torque coupling nut to 900-1100 lb in. (101.7-124.3 N·m).

(s) Connect coupling nut on stage 7 regulator air tube (59, sheet 3) to fitting on tube (10). Torque coupling nut to 90-100 lb in. (10.2-11.3 N·m).

(3) On L32119G05 and G06 configurations, install stage 7 air tube (10, figure 1, sheet 4) as follows:

(a) Install two clamps (62) onto tube (10) at locations shown.

(b) Install clamp (81, detail B) onto tube (10) as shown.

(c) Install two clamps (52, sheet 3) onto tube (10) at locations shown.

(d) Install new gasket (11, sheet 4) onto boss on combustion chamber frame (35).

(e) Position tube (10) onto boss on frame (35).

(f) Install four bolts (9) to secure tube (10) and gasket (11) onto frame (35). Tighten bolts hand-tight.

(g) Install new gasket (16) onto compressor stator casing assembly (36).

(h) Position tube (10) onto flange of casing assembly (36).

(i) Install four bolts (14) and nuts (15) to secure tube (10) and gasket (16) to casing assembly (36). Tighten nuts hand-tight.

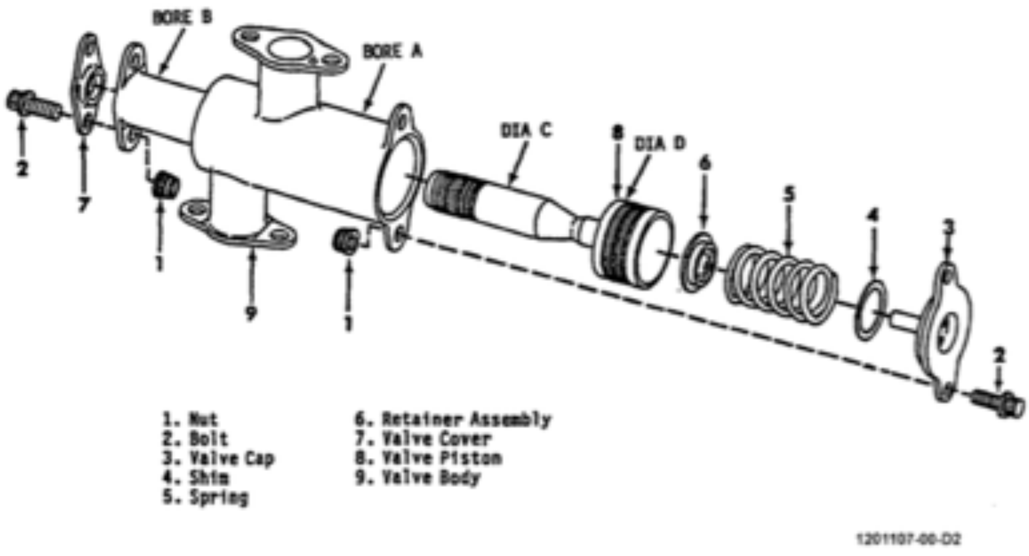
(j) Install two bolts (60) and nuts (61) to secure cushioned clamps (62) on tube (10) to cushioned clamps (63) on stage 7 valve air tube (64). Torque nuts (61) to 38-42 lb in. (4.3-4.7 N·m).

(k) Install one bolt (79) and nut (80) to secure cushioned clamp (81) to cushioned clamp (82). Torque nuts (61) to 38-42 lb in. (4.3-4.7 N·m).

(l) On L32119G05 configuration, install two bolts (46, sheet 3) and nuts (49) to secure cushioned clamps (52) to cushioned clamps (51) on regulator valve forward air tube (50).

(m) Torque four bolts (9, sheet 4) to 105-115 lb in. (11.9-13.0 N·m).

(n) Lock-wire four bolts (9) with 0.032 inch (0.81 mm) diameter lockwire using double-strand method (WP 007 00).



Blade Side #3	
Crack Length	**Action**
0-3 mm	none
4-5 mm	none
6-10 mm	none
11-13 mm	monitor
14-16 mm	repair on-site
16-18 mm	repair off-site
>18 mm	dispose

Blade Side # 4	
Crack Length	**Action**
0-3 mm	none
4-5 mm	none
6-10 mm	none
11-13 mm	monitor
14-16 mm	repair on-site
16-18 mm	repair off-site
>18 mm	dispose

(o) Torque four nuts (15) to 38-42 lb in. (4.3-4.7 N·m).

(p) Connect coupling nut on stage 7 balance piston air tube (40) to fitting on tube (10). Torque coupling nut to 900-1100 lb in. (101.7-124.3 N·m).

(q) Connect coupling nut on stage 7 regulator air tube (59, sheet 3) to fitting on tube (10). Torque coupling nut to 135-155 lb in. (15.3-17.5 N·m).

6. C-SUMP FORWARD TUBE.

a. Remove C-sump forward tube (2, figure 1, sheet 1) as follows:

(1) On L32119G01, G03, and G04 configurations, remove bolt (3) and nut (4) that secure cushioned clamp (7) to bracket (34) on combustion-to-transition flange.

(2) On L32119G01, G03, and G04 configurations, remove bolt (3) and nut (4) that secure cushioned clamp (7) on tube (2), to cushioned clamp (7) on ignition lead (39).

(3) On L32119G01, G03, and G04 configurations, remove bolt (5) and nut (6) that secure cushioned clamp (7) on tube (2), to cushioned clamp (8) on stage 7 air tube (10).

(4) On L32119G03, G04, and G05 configurations, remove bolt (46, sheet 3) and nut (49) that secure cushioned clamp (51) on tube (2), to cushioned clamp (51) on regulator valve forward air tube (50).

(5) On L32119G05 and G06 configurations, remove bolt (3, sheet 4) and nut (4) that secure cushioned clamp (7) to bracket (34) on combustion to transistor flange.

(6) Using two wrenches, disconnect coupling nut on tube (2, sheet 1) from fitting on A-sump pressure valve air metal tube (18).

(7) Using two wrenches, disconnect coupling nut on C-sump aft tube (1) from fitting on tube (2).

(8) Remove grommet (38) from rear main mount (37).

(9) Slide tube (2) from rear main mount (37).

(10) On L32119G01, G03, and G04 configurations, remove three cushioned clamps (7, sheet 1) from tube (2).

(11) On L32119G05 and G06 configurations, remove one cushioned clamp (7) from tube (2).

(12) On L32119G03, G04, and G05 configurations, remove one cushioned clamp (51, sheet 3) from tube (2).

b. Install C-sump forward tube (2, sheet 1) as follows:

(1) On L32119G03, G04, and G05 configurations, install one cushioned clamp (51, sheet 3) onto tube (2) as shown.

(2) On L32119G05 and G06 configurations, install one cushioned clamp (7, sheet 1) onto tube (2) as shown.

(3) On L32119G01, G03, and G04 configurations, install three cushioned clamps (7) onto tube (2) as shown.

(4) Position tube (2, sheet 1) as shown. Slide one end of tube through hole in rear main mount (37).

(5) Install grommet (38) into rear main mount (37).

(6) Connect coupling nut on tube (2), to fitting on A-sump pressure valve air metal tube (18). Hand-tighten coupling nut.

(7) Connect coupling nut on C-sump aft tube (1), to fitting on tube (2). Hand-tighten coupling nut.

(8) On L32119G01, G03, and G04 configurations, install bolt (5) and nut (6) to secure cushioned clamp (7) to cushioned clamp (8) on stage 7 air tube (10). Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(9) On L32119G01, G03, and G04 configurations, install bolt (3) and nut (4) to secure cushioned clamp (7) on tube (2), to cushioned clamp (7) on ignition lead (39). Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(10) On L32119G01, G03, and G04 configurations, install bolt (3) and nut (4) to secure cushioned clamp (7) to bracket (34) on combustion-to-transition flange. Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(11) On L32119G03, G04, and G05 configurations, install bolt (46, sheet 3) and nut (49) to secure cushioned clamp (51), on tube (2), to cushioned clamp (51) on regulator valve forward air tube (50). Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(12) On L32119G05 and G06 configuration, install bolt (3, sheet 4) and nut (4) to secure cushioned clamp (7) to bracket (34) on combustion-to-transition flange. Torque nut (4) to 38-42 lb in. (4.3-4.7 N·m).

(13) Torque coupling nut on tube (2, sheet 1) to 270-300 lb in. (30.5-33.9 N·m).

(14) Torque coupling nut on tube (1) to 270-300 lb in. (30.5-33.9 N·m).

7. DRAIN SEPARATOR TUBE (G01/-G03/-G04 only).

a. Remove drain separator tube (22, figure 1, sheet 1) as follows:

(1) Remove two bolts (24) and nuts (23) that secure two cushioned clamps (27) to brackets (28) on accessory gearbox.

(2) Disconnect coupling nut on tube (22), from fitting on A-sump pressure valve air metal tube (18). Remove tube (22).

(3) Remove cushioned clamps (27) from tube.

b. Install drain separator tube (22) as follows:

(1) Install and position two cushioned clamps (27) onto tube (22) at locations shown.

(2) Connect coupling nut on tube (22), to fitting on tube (18). Hand-tighten coupling nut.

(3) Using two bolts (24) and nuts (23), secure cushioned clamps (27) to brackets (28) on accessory gearbox. Torque nuts to 38-42 lb in. (4.3-4.7 N·m).

(4) Torque coupling nut on tube (22), to 180-200 lb in. (20.3-22.6 N·m).

8. A-SUMP PRESSURE VALVE AIR METAL TUBE.

a. Removal.

(1) On L32119G01, G03, and G04 configurations, remove A-sump pressure valve air metal tube (18, figure 1, sheet 1) as follows:

(a) On L32119G01 configuration, remove bolt (24) and nut (23) that secure cushioned clamp (25) to bracket (32) on cover plate.

(b) Remove bolt (24) and nut (23) that secure cushioned clamp (25) to bracket (26) on accessory gearbox.

(c) Remove bolt (46, sheet 3) and nut (49) that secure cushioned clamp (52) to cushioned clamp (57) on B-sump oil tube (58).

(d) Using two wrenches, disconnect coupling nut on C-sump forward tube (2, sheet 1), from fitting on tube (18).

(e) Disconnect coupling nut on drain separator tube (22), from fitting on tube (18).

(f) Disconnect hose (65) from tube (18).

(g) Using two wrenches, disconnect coupling nut on tube (18), from nipple (29) on front frame.

(h) Remove two bolts (20) and nuts (19) that secure tube (18) to pressure regulating valve assembly (31).

(i) Remove tube (18). Remove and discard gasket (21).

(j) Remove two cushioned clamps (25, sheet 1) and cushioned clamp (52, sheet 2) from tube (18).

(k) Remove nipple (29, sheet 1) and preformed packing (30) from front frame. Discard packing.

(2) On L32119G05 and G06 configurations, remove A-sump pressure valve air metal tube (18, figure 1, sheet 4) as follows:

(a) Remove bolt (24, sheet 1) and nut (23) that secure cushioned clamp (25) to bracket (32) on cover plate.

(b) Remove bolt (24, sheet 4) and nut (23) that secure cushioned clamp (25) to bracket (26) on accessory gearbox.

(c) Remove bolt (72) that secures cushioned clamp (73) on tube (18) to bracket (71).

(d) Using two wrenches, disconnect coupling nut on C-sump forward tube (2, sheet 1), from fitting on tube (18).

(e) Using two wrenches, disconnect coupling nut on tube (18), from nipple (29) on front frame.

(f) Remove two bolts (20) and nuts (19) that secure tube (18) to pressure regulating valve assembly (31).

(g) Remove tube (18). Remove and discard gasket (21).

(h) Remove two cushioned clamps (25, sheet 1) from tube (18).

(i) Remove nipple (29, sheet 1) and packing (30) from front frame. Discard packing.

b. Installation.

(1) On L32119G01, G03, and G04 configurations, install A-sump pressure valve air metal tube (18) as follows:

Lubricating Oil 66

(a) Using a light coat of lubricating oil MIL-L-7808 or MIL-L-23699, lubricate preformed packing (30) and packing groove on nipple (29). Install packing onto nipple.

(b) Install nipple (29) into boss on front frame. Torque nipple to 270-300 lb in. (30.5-33.9 N·m).

(c) Install and position two cushioned clamps (25, sheet 1) and cushioned clamp (52, sheet 3) onto tube (18) at locations shown.

(d) Position tube (18, sheet 1), as shown, between nipple (29) and pressure regulating valve assembly (31).

(e) Connect coupling nut on tube (18), to nipple (29). Hand-tighten coupling nut.

CAUTION

The mating flange of valve assembly (31) that will connect with the mating flange of tube (18) must have an alignment pin hole. If the flange does not have an alignment pin hole, the valve assembly is not installed correctly and may fail during operation.

(f) Check the mating flange of valve assembly (31) to be sure that the flange has an alignment pin hole. If the flange does not have an alignment pin hole, remove and test valve assembly (para 19).

CAUTION

The alignment pin on mating flange of tube (18) must align with the hole in gasket (21), and with the hole in mating flange of valve assembly (31). Otherwise, leaks will occur.

(g) Install new gasket (21) between mating flanges of valve assembly (31) and tube (18). Be sure that the alignment pin on tube aligns with hole in gasket, and with alignment pin hole on flange of valve assembly (31).

(h) Using two bolts (20) (boltheads facing down) and nuts (19), secure flange of tube (18) to flange of valve assembly (31). Hand-tighten nuts.

(i) Connect coupling nut on drain separator tube (22) to fitting on tube (18). Hand-tighten coupling nut.

(j) Connect coupling nut on C-sump forward tube (2) to fitting on tube (18). Hand-tighten coupling nut.

(k) Using bolt (24) and nut (23), secure cushioned clamp (25) to bracket (26) on accessory gearbox.

(l) On L32119G01 configuration, install bolt (24) and nut (23) to secure cushioned clamp (25) to bracket (32) on cover plate. Torque bolt (24) to 38-42 lb in. (4.3-4.7 N·m).

(m) Torque two nuts (19) to 38-42 lb in. (4.3-4.7 N·m).

(n) Using two wrenches, torque coupling nut on tube (18) to 450-550 lb in. (50.8-62.1 N·m).

(o) Using two wrenches, torque coupling nut on tube (2) to 270-300 lb in. (30.5-33.9 N·m).

(p) Using two wrenches, torque coupling nut on tube (22) to 180-200 lb in. (20.3-22.6 N·m).

(q) Torque two nuts (23) to 38-42 lb in. (4.3-4.7 N·m).

(r) Connect hose (65) to tube (18). Using two wrenches, torque coupling nut on hose to 270-300 lb in. (30.5-33.9 N·m).

(s) Using bolt (46, sheet 2) and nut (49), secure cushioned clamp (52) to cushioned clamp (57). Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(2) On L32119G05 and G06 configurations, install A-sump pressure valve air metal tube (18) as follows:

Lubricating Oil **66**

(a) Using a light coat of lubricating oil MIL-L-7808 or MIL-L-23699, lubricate preformed packing (30) and packing groove on nipple (29). Install packing onto nipple.

(b) Install nipple (29) into boss on front frame. Torque nipple to 270-300 lb in. (30.5-33.9 N·m).

(c) Install and position two cushioned clamps (25, sheet 1) and cushioned clamp (52, sheet 2) onto tube (18) at locations shown.

(d) Install cushioned clamp (73, sheet 4) onto tube (18) as shown.

(e) Position tube (18, sheet 1), as shown, between nipple (29) and pressure regulating valve assembly (31).

(f) Connect coupling nut on tube (18), to nipple (29). Hand-tighten coupling nut.

CAUTION

The mating flange of valve assembly (31) that will connect with the mating flange of tube (18) must have an alignment pin hole. If the flange does not have an alignment pin hole, the valve assembly is not installed correctly and may fail during operation.

(g) Check the mating flange of valve assembly (31) to be sure that the flange has an alignment pin hole. If the flange does not have an alignment pin hole, remove and test valve assembly (para 19).

CAUTION

The alignment pin on mating flange of tube (18) must align with the hole in gasket (21), and with the hole in mating flange of valve assembly (31). Otherwise, leaks will occur.

(h) Install new gasket (21) between mating flanges of valve assembly (31) and tube (18). Be sure that the alignment pin on tube aligns with hole in gasket, and with alignment pin hole on flange of valve assembly (31).

(i) Using two bolts (20) (boltheads facing down) and nuts (19), secure flange of tube (18) to flange of valve assembly (31). Hand-tighten nuts.

(j) Connect coupling nut on C-sump forward tube (2) to fitting on tube (18). Hand-tighten coupling nut.

(k) Using bolt (24) and nut (23), secure cushioned clamp (25) to bracket (26) on accessory gearbox.

(l) Using bolt (24) and nut (23) to secure cushioned clamp (25) to bracket (32) on cover plate. Torque bolt (24) to 38-42 lb in. (4.3-4.7 N·m).

(m) Install bolt (72) to secure cushioned clamp (73) on tube (18) to bracket (71). Torque bolt to 38-42 lb in. (4.3-4.7 N·m).

(n) Torque two nuts (19) to 38-42 lb in. (4.3-4.7 N·m).

(o) Using two wrenches, torque coupling nut on tube (18) to 450-550 lb in. (50.8-62.1 N·m).

(p) Using two wrenches, torque coupling nut on tube (2) to 270-300 lb in. (30.5-33.9 N·m).

(q) Torque nut (23) installed in step (k) to 38-42 lb in. (4.3-4.7 N·m).

9. STAGE 7 BALANCE PISTON AIR TUBE.

a. Removal

(1) On L32119G01, G03, and G04 configurations, remove stage 7 balance piston air tube (40, figure 1, sheet 1) as follows:

(a) Remove and discard lockwire from two bolts (43).

(b) Remove two bolts (43) that secure tube (40) to duct on front frame.

(c) Remove three nuts (49, sheet 3) and bolts (46) that secure cushioned clamps (52) to cushioned clamps (53) on air regulator valve tube (55). Remove cushioned clamps from tube.

(d) Disconnect coupling nut on tube (40, sheet 1) from fitting on stage 7 air tube (10). Remove tube (40).

(e) Remove orifice plate (42) from tube (40).

(f) Remove and discard lockwire from bolt (44).

(g) Remove bolt (44), washer (45), and balance piston duct support (41) from front frame.

(2) On L32119G05 and G06 configurations, remove stage 7 balance piston air tube (40, figure 1, sheet 4) as follows:

(a) Remove and discard lockwire from two bolts (43).

(b) Remove two bolts (43) that secure tube (40) to duct on front frame.

(c) Remove two nuts (49, sheet 3, View A) and bolts (46) that secure cushioned clamps (52) to cushioned clamps (53) on air regulator valve tube (55). Remove cushioned clamps from tube.

(d) Disconnect coupling nut on tube (40, sheet 1) from fitting on stage 7 air tube (10). Remove tube (40).

(e) Remove orifice plate (42) from tube (40).

(f) Remove and discard lockwire from bolt (44).

(g) Remove bolt (44), washer (45), and balance piston duct support (41) from front frame.

b. Installation

(1) On L32119G01, G03, and G04 configurations, install stage 7 balance piston air tube (40, sheet 1) as follows:

(a) Using washer (45) and bolt (44), secure support (41) onto front frame. Torque bolt to 38-42 lb in. (4.3-4.7 N·m).

(b) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire bolt (44) using the double-strand method (WP 007 00).

(c) Connect coupling nut on tube (40) to fitting on stage 7 air tube (10). Hand-tighten coupling nut.

(d) Install orifice plate (42) between flange of tube (40) and duct on front frame.

(e) Using two bolts (43), secure tube (40) to the flange on front frame and to the support (41).

(f) Torque bolts (43) to 105-115 lb in. (11.9-13.0 N·m).

(g) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire bolts using the double-strand method (WP 007 00).

(h) Torque coupling nut on tube (40) to 900-1100 lb in. (101.7-124.3 N·m).

(i) Install and position three cushioned clamps (52, sheet 3) onto tube (40) at locations shown.

(j) Using three bolts (46) and nuts (49), secure cushioned clamps (52) to cushioned clamps (53) on air regulator valve tube (55). Torque nuts to 38-42 lb in. (4.3-4.7 N·m).

(2) On L32119G05 and G06 configurations, install stage 7 balance piston air tube (40, sheet 1) as follows:

(a) Using washer (45) and bolt (44), secure support (41) onto front frame. Torque bolt to 38-42 lb in. (4.3-4.7 N·m).

(b) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire bolt (44) using the double-strand method (WP 007 00).

(c) Connect coupling nut on tube (40, sheet 4) to fitting on stage 7 air tube (10). Hand-tighten coupling nut.

(d) Install orifice plate (42, sheet 1) between flange of tube (40) and duct on front frame.

(e) Using two bolts (43), secure tube (40) to the flange on front frame and to the support (41).

(f) Torque bolts (43) to 105-115 lb in. (11.9-13.0 N·m).

(g) Using 0.032 inch (0.81 mm) diameter lockwire, lock-wire bolts (43) using the double-strand method (WP 007 00).

(h) Torque coupling nut on tube (40) to 900-1100 lb in. (101.7-124.3 N·m).

(i) Install and position two cushioned clamps (52, sheet 3) onto tube (40) at locations shown.

(j) Using two bolts (46) and nuts (49), secure two cushioned clamps (52) to cushioned clamps (53) on air regulator valve tube (55). Torque nuts to 38-42 lb in. (4.3-4.7 N·m).

10. REGULATOR VALVE AFT AIR TUBE (G03/-G04/-G05 only).

a. Remove regulator valve aft air tube (47, figure 1, sheet 3) as follows:

(1) Remove bolt (46) and nut (49) that secure cushioned clamp (48) to bracket (74) on transition casing-to-LPT flange.

(2) Using two wrenches, disconnect coupling nuts on tube (47) from fitting on turbine transition casing and from regulator valve forward air tube (50).

(3) Remove tube (47). Remove clamp (48) from tube.

b. Install aft air tube (47) as follows:

(1) Install and position cushioned clamp (48) onto aft air tube (47) at location shown.

(2) Connect coupling nuts on aft air tube (47) to fitting on forward air tube (50) and to fitting on turbine transition casing. Hand-tighten coupling nuts.

(3) Using bolt (46) and nut (49), secure cushioned clamp (48) to bracket (74) on transition casing-to-LPT flange. Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(4) Torque coupling nut on aft air tube (47) to fitting on turbine transition casing to 90-100 lb in. (10.2-11.3 N·m).

(5) Torque coupling nut on aft air tube (47) to fitting on forward air tube (50) to 135-155 lb in. (15.3-17.5 N·m).

11. REGULATOR VALVE FORWARD AIR TUBE (G03/-G04/-G05 ONLY).

a. Remove regulator valve forward air tube (50, figure 1, sheet 3) as follows:

(1) Remove two bolts (46) and nuts (49) that secure cushioned clamps (51) to cushioned clamps (52) on stage 7 air tube (10).

(2) Remove bolt (46) and nut (49) that secure cushioned clamp (51) on tube (50), to cushioned clamp (51) on C-sump forward tube (2).

(3) Using two wrenches, disconnect coupling nut on regulator valve aft air tube (47) from fitting on tube (50).

(4) Using two wrenches, disconnect coupling nut on tube (50) from B-sump regulator valve (56).

(5) Remove grommet (75) from rear main mount ring (37).

(6) Slide tube (50) from ring (37).

(7) Remove three cushioned clamps (51) from tube (50).

b. Install regulator valve forward air tube (50) as follows:

(1) Install and position three cushioned clamps (51) onto tube (50) at locations shown.

(2) Position tube (50) as shown. Slide one end of tube through hole in rear main mount ring (37).

(3) Install grommet (75) into ring (37).

(4) Connect coupling nut on tube (50), to fitting on B-sump regulator valve (56). Hand-tighten coupling nut.

(5) Connect coupling nut on aft air tube (47) to fitting on tube (50). Hand-tighten coupling nut.

(6) Using two bolts (46) and nuts (49), secure two cushioned clamps (51) to cushioned clamps (52) on stage 7 air tube (10). Torque nuts to 38-42 lb in. (4.3-4.7 N·m).

(7) Using bolt (46) and nut (49), secure cushioned clamp (51) on tube (50), to cushioned clamp (51) on C-sump forward tube (2). Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(8) Torque coupling nut on tube (50) to 135-155 lb in. (15.3-17.5 N·m).

(9) Torque coupling nut on aft air tube (47) to 135-155 lb in. (15.3-17.5 N·m).

12. STAGE 7 REGULATOR AIR TUBE (G03/-G04/-G05/-G06 only).

a. Remove stage 7 regulator air tube (59, figure 1, sheet 3) as follows:

(1) On L32119G05 configuration, remove bolt (66) and nut (67) that secure cushioned clamp (68) to cushioned clamp (69) on stage 7 air tube (10).

(2) Using two wrenches, disconnect coupling nuts on tube (59) from fitting on stage 7 air tube (10) and from B-sump regulator valve (56).

(3) Remove tube (59).

(4) On L32119G05 configuration, remove clamp (68) from tube (59).

b. Install stage 7 regulator air tube (59) as follows:

(1) On L32119G05 configuration, install clamp (68) onto tube (59) as shown.

(2) Connect coupling nuts on tube (59) to fitting on stage 7 air tube (10) and to B-sump regulator valve (56). Hand-tighten coupling nuts.

(3) On L32119G05 configuration, install bolt (66) and nut (67) to secure cushioned clamp (68) to cushioned clamp (69) on tube (10). Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(4) Torque coupling nuts on tube (59) to 135-155 lb in. (15.3-17.5 N·m).

13. B-SUMP OIL TUBE (G03/-G04/-G05/-G06 only).

a. Remove B-sump oil tube (58, figure 1, sheet 3) as follows:

(1) Remove bolt (46) and nut (49) that secure cushioned clamp (57) to cushioned clamp (52) on A-sump pressure valve air metal tube (18).

(2) Using two wrenches, disconnect coupling nuts on oil tube (58) from fitting on combustion chamber and from B-sump regulator valve (56).

(3) Remove oil tube (58).

(4) Remove cushioned clamp (57) from tube.

b. Install B-sump oil tube (58) as follows:

(1) Install and position cushioned clamp (57) onto oil tube (58) at location shown.

(2) Connect coupling nuts on tube (58) to fitting on combustion chamber and to B-sump regulator valve (56). Hand-tighten coupling nuts.

(3) Using bolt (46) and nut (49), secure cushioned clamp (57) to cushioned clamp (52) on tube (18). Torque nut to 38-42 lb in. (4.3-4.7 N·m).

(4) Torque coupling nuts on tube (58) to 650-770 lb in. (73.4-87.0 N·m).

14. AIR REGULATOR VALVE TUBE (G03/-G04/-G05/-G06 only).

a. Remove air regulator valve tube (55, figure 1, sheet 3) as follows:

(1) On L32119G03 and G04 configuration, remove three bolts (46) and nuts (49) that secure cushioned clamps (53) to cushioned clamps (52) on stage 7 balance piston air tube (40).

(2) On L32119G05 and G06 configurations, remove two bolts (46) and nuts (49) that secure cushioned clamps (53) to cushioned clamps (52) on stage 7 balance piston air tube (40).

(3) Using two wrenches, disconnect coupling nuts on tube (55) from B-sump regulator valve (56) and B-sump vent tee (54) on front frame.

(4) Remove tube (55).

(5) Remove three cushioned clamps (53) from tube (55).

b. Install air regulator valve tube (55) as follows:

(1) On L32119G03 and G04 configurations, install and position three cushioned clamps (53) onto tube (55) at locations shown.

(2) On L32119G05 and G06 configurations, install two cushioned clamps (53) onto tube (55) at locations shown.

(3) Position tube (55) as shown. Connect coupling nuts to B-sump regulator valve (56) and to B-sump vent tee (54) on front frame. Hand-tighten coupling nuts.

(4) On L32119G03 and G04 configurations, install three bolts (46) and nuts (49) to secure three cushioned clamps (53) to cushioned clamps (52) on air tube (40). Torque nuts to 38-42 lb in. (4.3-4.7 N·m).

(5) On L32119G05 and G06 configurations, install two bolts (46) and nuts (59) to secure two cushioned clamps (53) to cushioned clamps (52) on air tube (40). Torque nuts to 38-42 lb in. (4.3-4.7 N·m).

(6) Torque coupling nuts on tube (55) to 650-770 lb in. (73.4-87.0 N·m).

15. STAGE 7 VALVE AIR TUBE (G05/-G06 Only).

a. Remove stage 7 valve air tube (64, figure 1, sheet 4) as follows:

(1) Remove two bolts (60) and nuts (61) that secure cushioned clamps (63), on tube (64) to cushioned clamps (62) on stage 7 air tube (10).

(2) Remove two bolts (12) and nuts (13) that connect tube (64) to pressure regulating valve assembly (31).

(3) Remove four bolts (76) and nuts (77) that connect tube (64) to compressor stator casing assembly (36).

(4) Remove tube (64).

(5) Remove clamps (63) from tube (64).

(6) Remove and discard gaskets (17 and 78).

b. Install stage 7 valve air tube (64) as follows:

(1) Install two clamps (63) onto stage 7 valve air tube (64) as shown.

(2) Install new gasket (78) onto compressor stator casing assembly (36).

(3) Position tube (64) onto casing assembly (36).

(4) Install four bolts (76) and nuts (77) to secure tube (64) and gasket (78) to casing assembly (36). Tighten nut hand-tight.

CAUTION

The mating flange of pressure regulating valve assembly (31) that connects to the mating flange of tube (64) must not have an alignment pin hole. If the flange has an alignment pin hole, the valve assembly is installed incorrectly and may fail during operation.

(5) Check the mating flange of valve assembly (31) to ensure that the flange does not have an alignment pin hole. If flange has an alignment pin hole, remove and test valve assembly (para 19).

(6) Install new gasket (17) onto pressure regulating valve assembly (31).

(7) Install two bolts (12) and nuts (13) to secure tube (64) and gasket (17) to valve assembly (31). Tighten nuts hand-tight.

(8) Install two bolts (60) and nuts (61) to secure cushioned clamps (63), on tube (64) to cushioned clamps (62) on stage 7 air tube (10). Torque nuts to 38-42 lb in. (4.3-4.7 N·m).

(9) Torque four nuts (77) to 38-42 lb in. (4.3-4.7 N·m).

(10) Torque two nuts (13) to 38-42 lb in. (4.3-4.7 N·m).

16. CLEANING OF TUBES.

a. Flush tubes in clean water, and air-dry them.

Dry Cleaning Solvent (Stoddard Solvent), P-D-680 **32**

b. Using dry cleaning solvent P-D-680, flush the external and internal surfaces of tubes.

c. Rinse the external and internal surfaces of tubes with filtered water.

WARNING

Compressed Air

- When using compressed air for any cooling, cleaning, or drying operation, do not exceed 30 psig (207 kPa) at the nozzle.
- Eyes can be permanently damaged by contact with liquid or large particles propelled by compressed air. Inhalation of air-blown particles or solvent vapor can damage lungs.
- When using air for cleaning at an air-exhausted work-bench, wear approved goggles or face shield.
- When using air for cleaning at an unexhausted work-bench, wear approved respirator and goggles.

d. Using dry, filtered compressed air, dry the tubes.

17. INSPECTION OF TUBES.

Go to table 1.

TABLE 1. INSPECTION OF TUBES

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Tubes for:			
(1) Splits and cracks.	None allowed.	Not repairable.	Replace tube.

TABLE 1. INSPECTION OF TUBES (Cont)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
(2) Nicks, scratches, gouges, and chafing.	Any number, up to 0.008 inch (0.20 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).
(3) Dents.	Dented area must not exceed 20% of tube diameter.	Not repairable.	Replace tube.
(4) Flattened area.	Outside diameter must not be less than 3/4 of the original diameter.	Not repairable.	Replace tube.
(5) Distortion.	Any amount, if tube can be installed without force.	Any amount.	Cold-work tube to make it fit properly, without force (WP 007 00). Cracks and kinks are not allowed. Pressure-test tube (para 18).
b. Hex coupling nuts for:			
(1) Cracks.	None allowed.	Not repairable.	Replace tube.
(2) Damaged corners.	Any amount, if a wrench can be used.	Not repairable.	Replace tube.
(3) Nicks and burrs.	Any number, without high metal.	Any number, with high metal.	Using a fine abrasive stone, remove high metal (WP 007 00).
(4) Damaged threads.	One-half of one thread (cumulative), without high metal.	Same as usable limits, with high metal.	Using a bottoming tap, chase threads.
c. Male fittings for:			
(1) Cracks.	None allowed.	Not repairable.	Replace tube.
(2) Circumferential nicks and scratches, and shiny, burnished surfaces on the seating surface.	Any number that cannot be felt with a scriber having a 0.030 inch (0.76 mm) tip radius, without high metal.	Same as usable limits, with high metal.	Using a fine abrasive stone, remove high metal (WP 007 00). Pressure-test tube (para 18).
(3) Axial nicks and scratches, and pits on the seating surface.	None allowed.	Any number.	Using a fine abrasive stone, blend defect, maintaining original contour (WP 007 00). Pressure-test tube (para 18).

TABLE 1. INSPECTION OF TUBES (Cont)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
(4) Damaged threads.	One-half of one thread (cumulative), without high metal.	Same as usable limits, with high metal.	Using a die, chase threads.
d. Female fittings for:			
(1) Nicks, dents, scratches, ridges, and pits on seating surface.	Any number, if the defect does not extend more than half way across seating surface, without high metal.	Same as usable limits, with high metal.	Using a fine abrasive stone, blend defect, maintaining original contour (WP 007 00). Pressure-test tube (para 18).
(2) Nicks and gouges on tube flare.	Any number, 0.010 inch (0.25 mm) deep, without high metal, if tube passes the pressure test.	Same as usable limits, with high metal.	Blend high metal (WP 007 00). Pressure-test tube (para 18).
e. Tube flare ferrules for:			
(1) Cracks.	None allowed.	Not repairable.	Replace tube.

Penetrating Oil **234**

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
(2) Adhesion to coupling nuts.	Any amount, if nut turns smoothly on ferrule.	Any amount, if the nut can be worked free to turn smoothly on ferrule.	Apply penetrating oil VV-P-216 to the nut, and work it free. Using a lint-free cloth, remove all traces of penetrating oil.
f. Mating flanges for flatness (hold flange against a flat surface and try to insert a 0.005 inch (0.13 mm) shim).	Flange must be flat within 0.005 inch (0.13 mm).	Up to 25% of original flange thickness can be reworked to meet usable limits.	Rework flange to usable limits by lapping, stoning, or machining (if possible).

18. PRESSURE-TEST OF TUBES.

Calibrating Fluid, MIL-C-7024 **21**

a. Using calibrating fluid MIL-C-7024, flush tube thoroughly.

WARNING

High-Pressure Testing

- High pressures used during testing may cause rupturing or bursting of faulty tubes and hoses. The result could be serious injury.
- To prevent injury, cover all tubes and hoses with a suitable safety shield during testing.
- When caps or plugs are used, be sure they are securely installed to prevent them from being blown out.
- Be sure that pressures are bled off before exposing or touching hoses or tubes.

b. Restrict one end of tube. Using calibrating fluid MIL-C-7024, build up pressure to 200 psig (1379 kPa).

c. Maintain pressure for a minimum of 2 minutes. If there is a pressure drop, replace tube.

d. Thoroughly drain tube of excess fluid. Cap or plug open ends.

19. PRESSURE REGULATING VALVE ASSEMBLY (All Models).

a. Remove pressure regulating valve assembly (31, figure 1, sheet 1) as follows:

(1) On L32119G01, G03, and G04 configuration, disconnect stage 7 air tube (10) per paragraph 5.

(2) On L32119G05 and G06 configurations, disconnect stage 7 valve air tube (64) per paragraph 15.

(3) Remove two bolts (20) and nuts (19) that secure the valve assembly (31) to A-sump pressure valve air metal tube (18).

(4) Remove valve assembly (31). Remove and discard gaskets (17 and 21).

b. Test the valve assembly (see figure 2) as follows:

(1) Using kit adapter 21C5536, set up valve assembly for testing as shown in figure 2.

(2) Using the control valve, vary the inlet air pressure from 20 to 80 psig (138 to 552 kPa). The discharge (regulated) air pressure must be maintained at 12.5-17.5 psig (86-121 kPa), without resonance or instability. Record the minimum and maximum discharge (regulated) air pressure.

(3) If the discharge (regulated) air pressure is not maintained throughout the range of supply air pressure, do the following:

(a) Disassemble valve assembly (see figure 3) as follows:

WARNING

Handling Spring-Loaded Parts

To avoid injury, use care when removing valve cap (3), because spring (5) is under compression.

CAUTION

The nuts (1) should be alternately loosened one turn at a time, to avoid deformation of valve cap (3) as spring pressure is relieved.

1 Alternately loosen two nuts (1) from valve cap (3), until spring pressure is relieved.

2 Remove two nuts (1) and bolts (2) from valve cap (3).

NOTE

There may be more than one shim (4) between valve cap (3) and spring (5).

3 Remove valve cap (3) and shim (4). Save shim for installation.

4 Remove spring (5) and retainer assembly (6).

5 Remove two nuts (1), bolts (2), and valve cover (7).

6 Remove valve piston (8) from valve body (9).

(b) Clean the components of valve assembly as follows:

Dry Cleaning Solvent **32**
(Stoddard Solvent), P-D-680

1 Flush the components of valve assembly with dry cleaning solvent P-D-680.

2 Using a soft-bristle brush soaked with dry cleaning solvent P-D-680, remove any debris that has accumulated onto components.

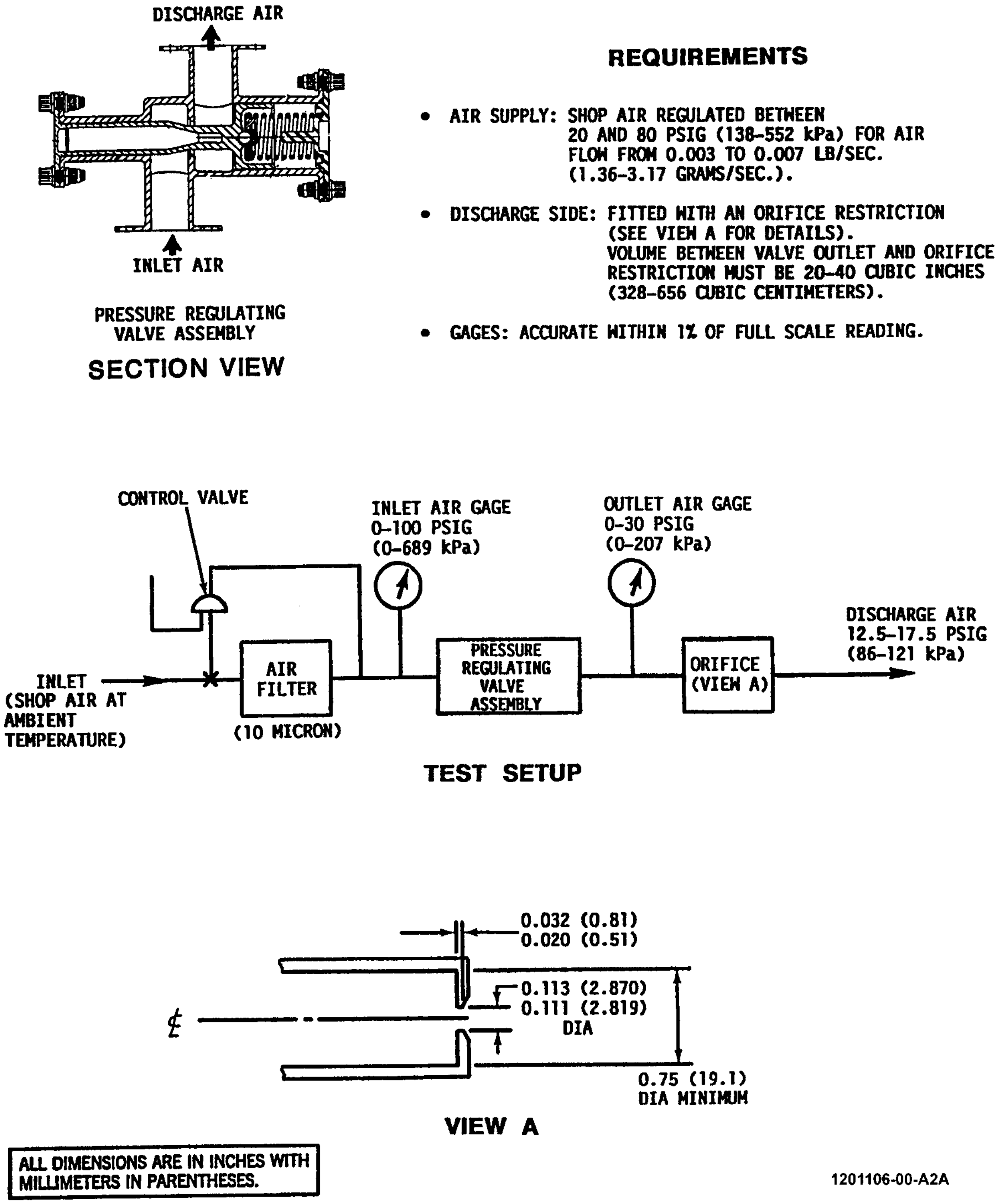


Figure 2. Testing of Pressure Regulating Valve Assembly

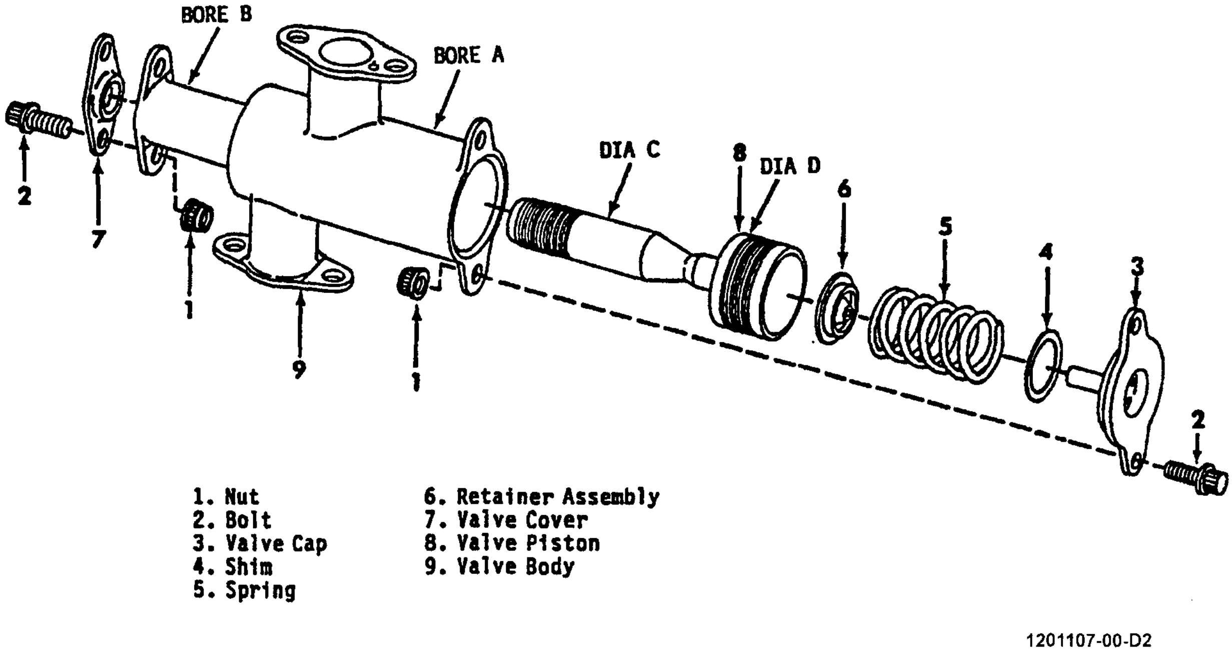


Figure 3. Disassembly, Inspection, and Assembly of Pressure Regulating Valve Assembly

3 Flush the components of valve assembly with dry cleaning solvent P-D-680.

WARNING

Compressed Air

- When using compressed air for any cooling, cleaning, or drying operation, do not exceed 30 psig (207 kPa) at the nozzle.
- Eyes can be permanently damaged by contact with liquid or large particles propelled by compressed air. Inhalation of air-blown particles or solvent vapor can damage lungs.
- When using air for cleaning at an air-exhausted workbench, wear approved goggles or face shield.
- When using air for cleaning at an unexhausted workbench, wear approved respirator and goggles.

4 Using dry, filtered, low-velocity compressed air, dry the components of valve assembly.

(c) Inspect components of valve assembly as instructed in table 2.

TABLE 2. INSPECTION OF PRESSURE REGULATING VALVE ASSEMBLY COMPONENTS

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Valve body (9, figure 3) for:			
(1) Cracks.	None allowed.	Not repairable.	Replace valve body.
(2) Wear in bore A.	1.002 inches (25.45 mm) maximum average diameter (measured at three locations).	Not repairable.	Replace valve body.
(3) Wear in bore B.	0.502 inch (12.75 mm) maximum average diameter (measured at three locations).	Not repairable.	Replace valve body.
(4) Nicks, dents, and scratches in:			
(a) Bores A and B.	None allowed.	Not repairable.	Replace valve body.
(b) Other areas.	Any number, 0.016 inch (0.41 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).
b. Valve piston (8) for:			
(1) Cracks.	None allowed.	Not repairable.	Replace valve piston.
(2) Wear on diameter C.	0.4955 inch (12.586 mm) minimum average diameter (measured at three locations).	Not repairable.	Replace valve piston.
(3) Wear on diameter D.	0.9955 inch (25.286 mm) minimum average diameter (measured at three locations).	Not repairable.	Replace valve piston.
(4) Nicks, dents, and scratches on:			
(a) Diameters C and D.	None allowed.	Not repairable.	Replace valve piston.
(b) Other areas.	Any number, 0.016 inch (0.41 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).
c. Spring (5) for:			
(1) Cracks.	None allowed.	Not repairable.	Replace spring.

TABLE 2. INSPECTION OF PRESSURE REGULATING VALVE ASSEMBLY COMPONENTS (Cont)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
(2) Rub marks on coils.	Rub marks allowed up to 0.020 inch (0.51 mm) wide.	Not repairable.	Replace spring.
(3) Relaxation and permanent set.	Length of spring must be 1.20-1.25 inches (30.5-31.8 mm) in free state.	Not repairable.	Replace spring.
(4) Nicks, dents, and scratches.	Any number, 0.016 inch (0.41 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).
d. Valve cap (3), retainer assembly (6), and valve cover (7) for:			
(1) Cracks.	None allowed.	Not repairable.	Replace part.
(2) Nicks, dents, and scratches.	Any number, 0.016 inch (0.41 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).

(d) Assemble valve assembly (see figure 3) as follows:

1 Install valve cover (7) onto valve body (9). Using two bolts (2) and nuts (1), secure valve cover. Torque nuts to 25-30 lb in. (2.8-3.4 N·m).

2 Install valve piston (8) into valve body (9) until piston bottoms.

3 Insert the retainer assembly (6) into the recess of valve piston (8), so that the ball end faces the valve piston.

4 Install spring (5) onto retainer assembly (6).

NOTE

- The regulated pressure from the valve assembly is determined by the spring preload. The shim PN 2018T15P01 (4) is used to set the preload.
- Adding one shim (4) increases the output pressure approximately 0.75 psi (5.2 kPa).

5 Using the test results recorded in step b.(2), change the number of shims (4) as required to adjust the discharge air pressure within limits. If more than six shims are required to achieve correct discharge air pressure regulation, replace valve assembly. Return the replaced valve assembly to the vendor for repair.

6 Install the required shims (4) into the inner recess of valve cap (3).

7 Install valve cap (3) onto valve body (9). Using two bolts (2) and nuts (1), secure valve cap.

CAUTION

The nuts (1) should be alternately tightened one turn at a time, to avoid deformation of valve cap (3) as spring pressure increases.

8 Alternately tighten nuts (1) on valve cap (3).

9 Torque nuts (1) to 25-30 lb in. (2.8-3.4 N·m).

10 Re-test valve assembly.

c. Install pressure regulating valve assembly (31, figure 1, sheet 1) as follows:

CAUTION

The mating flange of valve assembly (31) that will connect with the mating flange of A-sump pressure valve air metal tube (18) must have an alignment pin hole. If the flange does not have an alignment pin hole, the valve assembly will not be installed correctly and may fail during operation.

(1) Position the valve assembly (31) so that the mating flange with the alignment pin hole faces the mating flange of tube (18).

CAUTION

The alignment pin on mating flange of tube (18) must align with the hole in gasket (21), and with the hole in mating flange of valve assembly (31). Otherwise, leaks will occur.

(2) Install new gasket (21) between flanges of valve assembly (31) and tube (18). Be sure that the alignment pin on tube aligns with hole in gasket and with alignment pin hole on flange of valve assembly.

(3) Using two bolts (20) (boltheads facing down) and nuts (19), secure flange of tube (18) to flange of valve assembly (31). Torque nuts to 38-42 lb in. (4.3-4.7 N·m).

(4) On L32119G01, G03, and G04 configurations, re-connect stage 7 air tube (10) to valve assembly (31) per paragraph 5.

(5) On L32119G05 and G06 configuration, reconnect stage 7 valve air-tube (64) to valve assembly (31) per paragraph (15).

20. <u>B-SUMP REGULATOR VALVE (G03/-G04/-G05/-G06 only).</u>

a. Remove B-sump regulator valve (56, figure 1, sheet 3) as follows:

(1) On L32119G03, G04, and G05 configurations, disconnect coupling nut on regulator valve forward air tube (50) from valve (56).

(2) Disconnect coupling nut on air regulator valve tube (55) from valve (56).

(3) Disconnect coupling nut on B-sump oil tube (58) from valve (56).

(4) Disconnect coupling nut on stage 7 regulator air tube (59) from valve (56).

(5) Remove valve (56).

b. Inspect B-sump regulator valve as instructed in table 3.

TABLE 3. INSPECTION OF B-SUMP REGULATOR VALVE

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Valve body for:			
(1) Cracks.	None allowed.	Not repairable.	Replace valve.
(2) Nicks, dents, and scratches.	Any number, 0.016 inch (0.41 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).
b. Fittings for:			
(1) Circumferential nicks and scratches, and shiny, burnished surfaces on the seating surface.	Any number that cannot be felt with a scriber having a 0.030 inch (0.76 mm) tip radius, without high metal.	Same as usable limits, with high metal.	Using a fine abrasive stone, remove high metal (WP 007 00).
(2) Axial nicks and scratches, and pits on the seating surface.	None allowed.	Any number.	Using a fine abrasive stone, blend defect, maintaining original contour (WP 007 00).
(3) Damaged threads.	One-half of one thread (cumulative), without high metal.	Same as usable limits, with high metal.	Chase threads.

c. Install B-sump regulator valve (56) as follows:

(1) Position valve (56) as shown.

(2) On L32119G03, G04, and G05 configurations, connect coupling nut on regulator valve forward air tube (50) to valve (56). Hand-tighten coupling nut.

(3) Connect coupling nut on air regulator valve tube (55) to valve (56). Hand-tighten coupling nut.

(4) Connect coupling nut on B-sump oil tube (58) to valve (56). Hand-tighten coupling nut.

(5) Connect coupling nut on stage 7 regulator air tube (59) to valve (56). Hand-tighten coupling nut.

(6) On L32119G03, G04, and G05 configuration, torque coupling nuts on forward air tube (50) to 135-155 lb in. (15.3-17.5 N·m).

(7) Torque coupling nut on regulator airtube (59) to 90-100 lb in. (10.3-11.3 N·m).

(8) Torque coupling nuts on oil tube (58) and valve tube (55) to 650-770 lb in. (73.4-87.0 N·m).

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

WATER WASH HOSES AND SPRAY NOZZLES
REMOVAL AND INSTALLATION

(LEVEL 2 MAINTENANCE)

Effectivity:	L32119G01/-G03/-G04/ -G05/-G06	MARINE GAS TURBINE
	L32119G02	INDUSTRIAL GAS TURBINE

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1. INTRODUCTION. This work package provides instructions for removing and installing the water wash hoses and spray nozzles from the front frame.

2. SUPPORT EQUIPMENT.

None

3. CONSUMABLE MATERIALS.

None

4. REMOVAL.

a. If applicable, disconnect customer-supplied hose from hose inlet tee (8, figure 1) at the 5:30 o'clock position (forward looking aft) under the front frame (6).

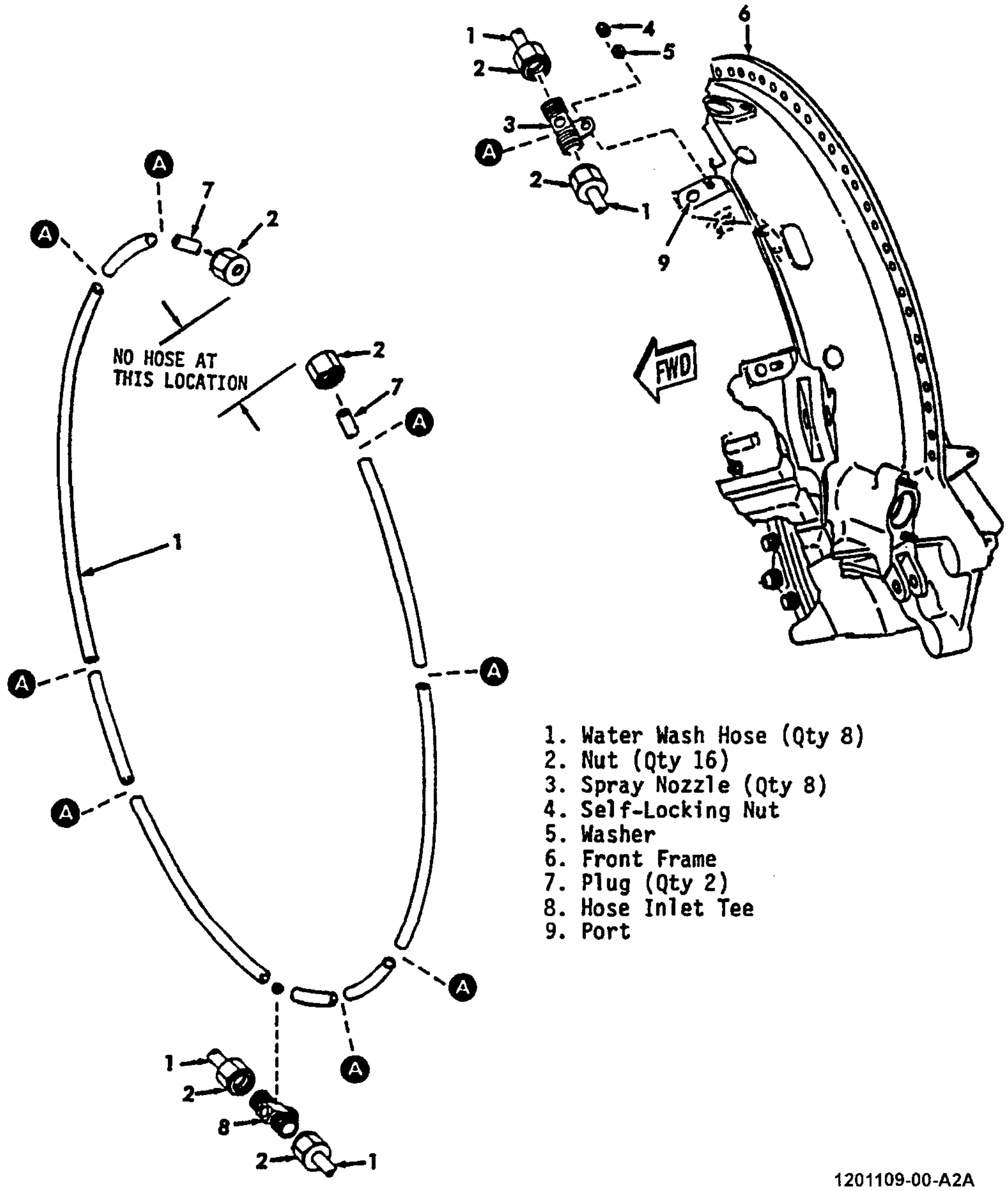

Figure 1. Removal and Installation of Water Wash Hoses and Spray Nozzles

CAUTION

The five shortest water wash hoses (1) must not be disconnected from spray nozzles (3); otherwise, hoses will be damaged.

NOTE

There are eight hoses (1) around the circumference of the front frame (6):

- One hose is 3.36 inches (85.3 mm) long
- One hose is 8.75 inches (222.3 mm) long
- Two hoses are 12.42 inches (315.5 mm) long each
- Four hoses are 4.96 inches (126.0 mm) long each.

b. Loosen nuts (2) from the longest hoses (1). Remove hoses from spray nozzles (3).

c. Remove self-locking nuts (4) and washers (5) securing spray nozzles (3) to ports (9) in front frame (6).

d. Loosen nuts (2) from the shortest hoses (1). Remove hoses from spray nozzles (3).

e. Loosen two nuts (2) from hose inlet tee (8). Remove hose inlet tee.

f. Remove nut (2) and plug (7) from two spray nozzles (3).

5. **INSTALLATION.**

a. Install spray nozzles (3, figure 1) into each port (9) on front frame (6).

b. Using washers (5) and self-locking nuts (4), secure each spray nozzle (3). Torque nuts to 10-15 lb in. (1.1-1.7 N·m).

CAUTION

Do not over-torque nuts (4); otherwise, spray nozzles will be damaged.

c. Check washers (5) for looseness. If washers are loose, torque nuts (4) to 20 lb in. (2.3 N·m) maximum.

NOTE

- The location of the spray nozzles (3) will determine the size of the water wash hoses (1) to be installed around the circumference of the front frame (6).
- Between the 11 and 1 o'clock positions there will not be a hose (1). The end of the two spray nozzles (3) at this location will be plugged.

d. Install plug (7) into each end of the two spray nozzles (3) between the 11 and 1 o'clock positions. Install nut (2) onto each plug. Torque nuts to 5-10 lb in. (0.6-1.1 N·m).

NOTE

The hose inlet tee (8) will be positioned between the two hoses (1) at the 5:30 o'clock position (forward looking aft) under the front frame (6).

e. Install the shortest hoses (1) into spray nozzles (3) and into hose inlet tee (8).

f. If nuts (2) were removed from hoses (1), slide nuts onto hoses and hand-tighten nuts onto spray nozzles (3) and hose inlet tee (8).

g. Install the remaining hoses (1) into spray nozzles (3) and into hose inlet tee (8).

h. Torque all nuts (2) to 5-10 lb in. (0.6-1.1 N·m).

i. If applicable, connect customer-supplied hose onto hose inlet tee (8).

LM500 GAS TURBINE
Operating Instructions and On-Site Maintenance

TECHNICAL PROCEDURES

IGNITION SYSTEM COMPONENTS
REMOVAL, CLEANING, INSPECTION, AND INSTALLATION

(LEVEL 2 MAINTENANCE)

Effectivity:	L32119G01/-G03/-G04/ -G05/-G06	MARINE GAS TURBINE
	L32119G02	INDUSTRIAL GAS TURBINE

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1. **INTRODUCTION**. This work package provides instructions for removing, inspecting, cleaning, and installing ignition system components.

2. SUPPORT EQUIPMENT.

Support Equipment

Part No.	Nomenclature
8600A	Voltmeter, Digital
--	Iron, Soldering (200-WATT)

3. CONSUMABLE MATERIALS.

NOTE

Equivalent materials approved by GE Aircraft Engines may be substituted for items listed.

Consumable Materials

Description	Manufacturer
Acetone (O-A-51)	Local Purchase
Alcohol, Isopropyl (TT-I-735)	Local Purchase
Brush, Soft-Bristle	Local Purchase
Brush, Stiff-Bristle	Local Purchase
Caps, Protective	Protective Closures Co., Inc. 2166 Elmwood Avenue Buffalo, NY 14207 USA
Cloth, Lint-Free	Local Purchase
Copper Strip (Electrolytic or Grade OFHC) 0.025 inch (0.64 mm) thick	Local Purchase
Lockwire, 0.020 inch (0.51 mm) diameter	Local Purchase
Solder, Resin Core	Local Purchase
Solvent, Dry Cleaning (Stoddard Solvent) (P-D-680)	Local Purchase
Solvent, Miller-Stephenson (MS-160)	Miller-Stephenson Chemical Co., Inc. George Washington Hwy. P.O. Box 950 Danbury, CT 06810 USA

Consumable Materials (Cont)

Description	Manufacturer
Tape, Silicone (PN 3003M70P01)	GE Aircraft Engines 1 Neumann Way Box 156301 Cincinnati, OH 45215 USA

4. IGNITION EXCITER.

a. Removal.

(1) Remove lockwire from coupling nuts that connect ignition leads (2, 6, figure 1, sheet 1) to ignition exciter (1).

WARNING

Disconnecting Ignition Leads

- High voltage may be present. Contact with center conductor of electrical cable or center electrode of igniter plug will cause electric shock if the bleed resistors inside ignition unit have failed.
- Before removing igniter plug, be sure that discharge connector is grounded.

(2) Disconnect ignition leads (2, 6) from ignition exciter (1).

(3) Remove lockwire from connector on electrical cable (5).

(4) Disconnect electrical cable (5) from ignition exciter (1).

(5) Remove and discard sealing disk (3) and packing (4) from electrical cable (5).

(6) On L32119G01, G02, G03, and G04 configurations, loosen four bolts (7) until ignition exciter (1) can be removed from support beam assembly (12). Do not remove bolts from isolators (11).

(7) Remove ignition exciter (1) from support beam assembly (12).

(8) On L32119G05 and G06 configurations, loosen four bolts (7, sheet 2) until ignition exciter (1) can be removed from exciter bracket (16).

(9) Remove ignition exciter from exciter bracket (16).

(10) If ignition exciter (1) is to be replaced, remove the following:

(a) Remove four bolts (7).

(b) Remove ferrules (10, 15) and isolators (11).

(c) Remove bolt (14) and self-locking nut (8).

(d) Remove grounding strap (9).

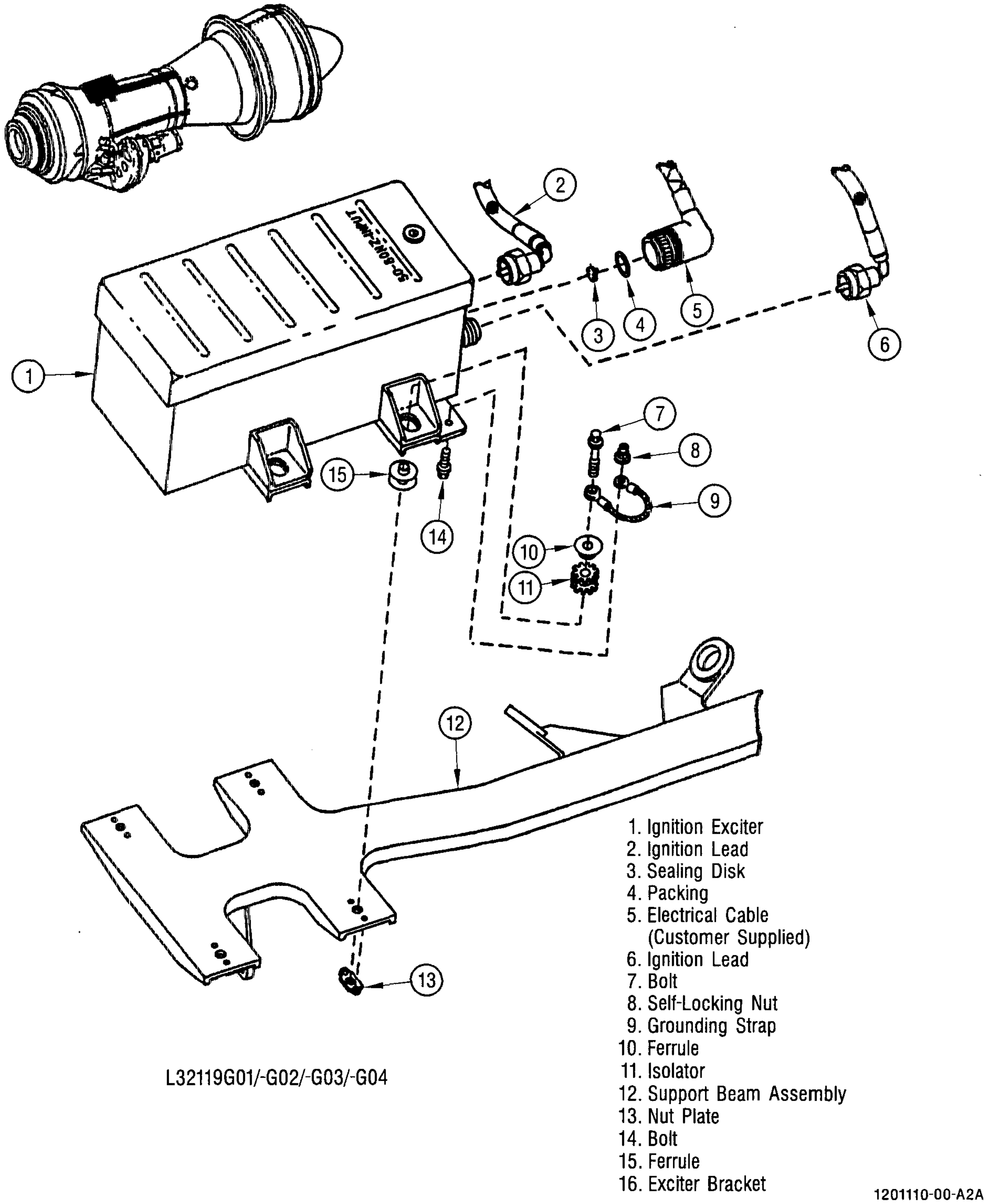
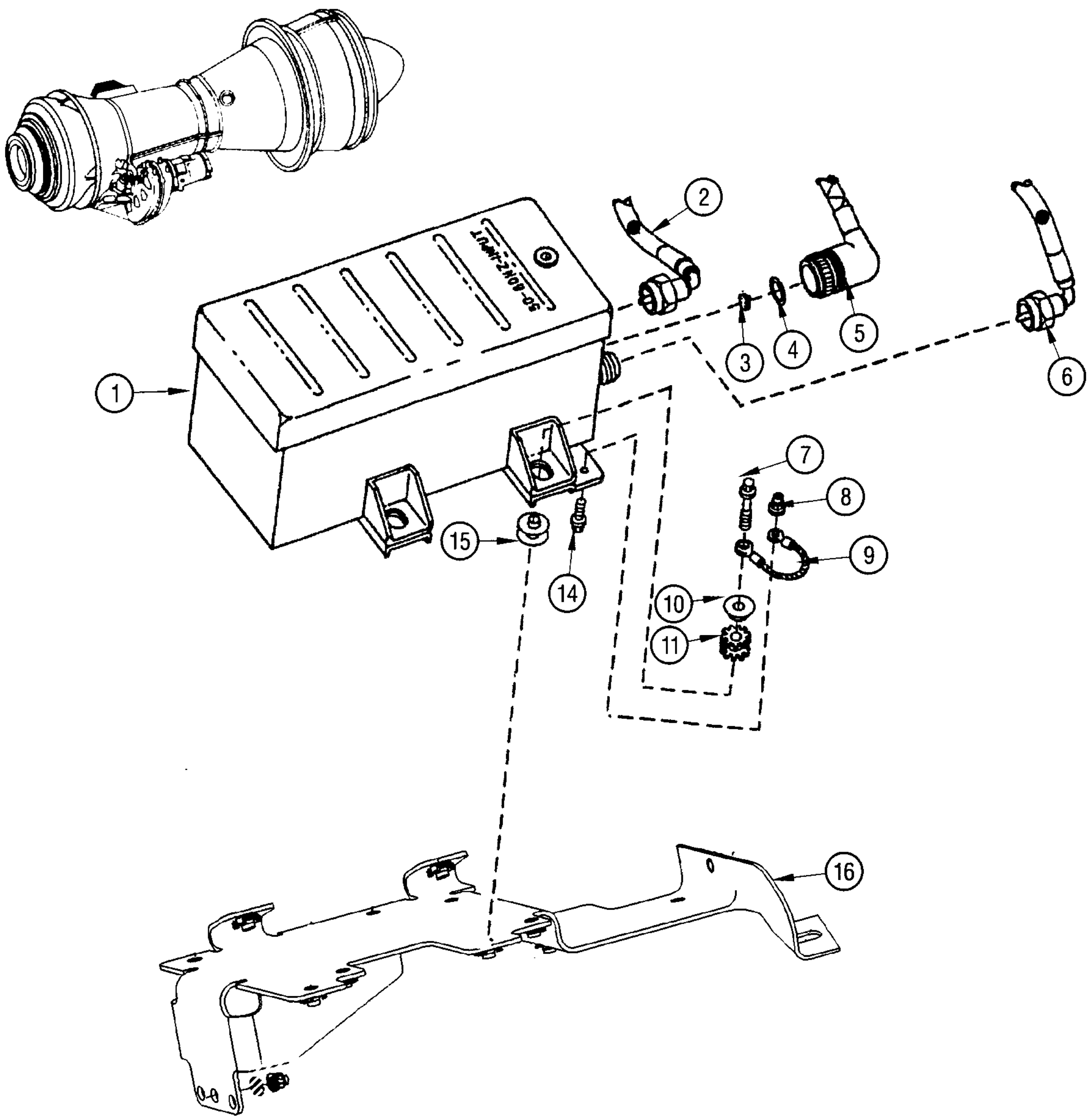


Figure 1. Removal and Installation of Ignition Exciter (Sheet 1 of 2)



L32119G05/-G06

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Figure 1. Removal and Installation of Ignition Exciter (Sheet 2 of 2)

b. Cleaning.

(1) If electrical connectors are contaminated, clean connectors as follows:

Isopropyl Alcohol, TT-I-735 **11**

(a) Using isopropyl alcohol TT-1-735 and holding spray nozzle 4-6 inches (100-150 mm) away, spray electrical connector to loosen contaminants.

WARNING

Compressed Air

- When using compressed air for any cooling, cleaning, or drying operation, do not exceed 30 psig (207 kPa) at the nozzle.
- Eyes can be permanently damaged by contact with liquid or large particles propelled by compressed air. Inhalation of air-blown particles or solvent vapor can damage lungs.
- When using air for cleaning at an air-exhausted workbench, wear approved goggles or face shield.
- When using air for cleaning at an unexhausted workbench, wear approved respirator and goggles.

(b) Drain excess liquid immediately. Blow-dry with low velocity 15 psig (103 kPa), dry, filtered compressed air. Allow connector seals to dry for 1 hour minimum.

(c) Install protective caps on electrical connectors.

(2) Clean external surfaces of ignition exciter as follows:

Dry Cleaning Solvent (Stoddard Solvent), P-D-680 **32**

(a) Using a lint-free cloth saturated with dry cleaning solvent P-D-680, remove grease, dirt, and oil deposits.

(b) Using filtered, dry compressed air, blow-dry external surfaces of ignition exciter.

c. Inspection. Go to table 1.

TABLE 1. INSPECTION OF IGNITION EXCITER

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Case (see figure 2) for:			
(1) Cracks.	None allowed.	Not repairable.	Replace ignition exciter.
(2) Nicks and scratches.	Any number, if defect does not penetrate case.	Not repairable.	Replace ignition exciter.
(3) Dents and bulges.	Any number, if there is no loss of hermetic seal or structural integrity.	Not repairable.	Replace ignition exciter.
(4) Chipped or flaked paint.	Any amount.	Not applicable.	Not applicable.
b. Input and output connectors for:			
(1) Burrs, nicks, and dents.	Any number, without high metal, if connector can be installed to mating connector without cross-threading.	Same as usable limits, with high metal.	Remove high metal (WP 007 00) and blend to adjacent contour. Check alignment with mating connector.
(2) Damaged threads.	Any number, without high metal, if connector can be installed to mating connector without cross-threading.	Same as usable limits, with high metal.	Chase threads.
(3) Bent pins.	None allowed.	Up to 1/8 inch (3.2 mm) out-of-position.	Straighten pin. Check alignment with mating connector.
(4) Cracked or missing insulation.	Not allowed.	Not repairable.	Replace ignition exciter.
(5) Contamination or moisture.	Not allowed.	Any amount.	Clean connectors (para b).
c. Connector resistance, using digital voltmeter 8600A, at:			
(1) Input connector:			
(a) Pin A to ground.	43 to 53 ohms.	Not repairable.	Replace ignition exciter.
(b) Pin C to ground.	43 to 53 ohms.	Not repairable.	Replace ignition exciter.
(c) Pin B to ground.	There must be continuity.	Not repairable.	Replace ignition exciter.

TABLE 1. INSPECTION OF IGNITION EXCITER (Cont)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
(2) Output connector pins to case.	540 to 660 ohms.	Not repairable.	Replace ignition exciter.

d. Installation.

(1) If the ignition exciter (1, figure 1, sheet 1) was replaced, install the following parts onto the replacement ignition exciter:

(a) Install each of the four isolators (11) into holes on ignition exciter (1).

(b) Install ferrules (10, 15) on both sides of isolators (11).

(c) Install bolt (7) and one end of grounding strap (9) at location shown on ignition exciter (1).

(d) Install remaining three bolts (7) through ferrules and isolators.

(e) Using bolt (14) and self-locking nut (8), secure other end of grounding strap (9) to ignition exciter (1). Torque nut to 24-27 lb in. (2.7-3.1 N·m).

(2) On L32119G01, G02, G03, and G04 configurations, install ignition exciter (1) onto support beam assembly (12) as shown. Thread bolts (7) into nut plates (13) on support beam assembly. Torque bolts to 24-27 lb in. (2.7-3.1 N·m).

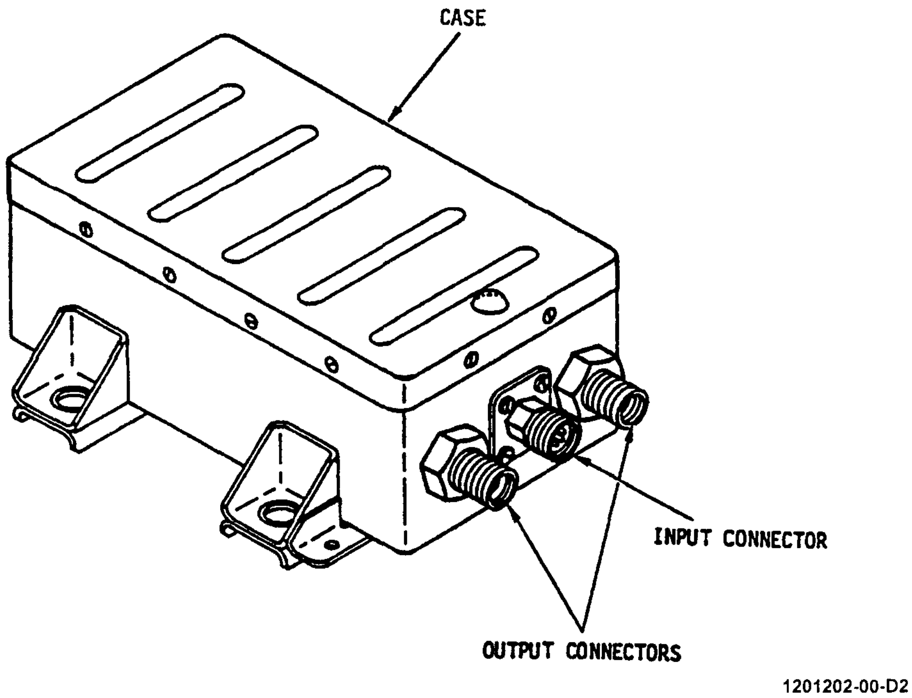


Figure 2. Inspection of Ignition Exciter

(3) On L32119G05 and G06 configurations install ignition exciter (1, sheet 2) onto exciter bracket (16).

(4) Install four bolts (7) to secure ignition exciter (1) to exciter bracket (16). Torque bolts to 24-27 lb in. (2.7-3.1 N·m).

CAUTION

- Do not use tools to install connector of electrical cable (5). If difficulty is encountered in connecting connectors, check cable connectors and mating connectors for crossed threads, bent pins, and damaged keys or slots.
- Do not lubricate electrical connectors or packings.

(5) Install sealing disk (3) onto the center connector on ignition exciter (1). Install packing (4) onto connector of electrical cable (5). Connect electrical cable to center connector of ignition exciter.

CAUTION

Ignition lead connectors can be easily distorted. To avoid damaging connectors, use a box-end crowfoot wrench when torquing connectors.

(6) Connect two ignition leads (2, 6) to ignition exciter (1). Torque coupling nuts on ignition leads to 95-120 lb in. (10.7-13.6 N·m).

(7) Using 0.020 inch (0.51 mm) diameter lockwire, lock-wire ignition leads (2, 6) and electrical cable (5) using the double-strand method (WP 007 00).

5. SUPPORT BEAM ASSEMBLY (L32119G01/-G02/-G03/-G04).

a. Removal.

(1) Remove ignition exciter (para 4. a).

(2) Remove four self-locking nuts (3, figure 3), eight flat washers (2), and four bolts (1) from front frame-to-compressor casing flange.

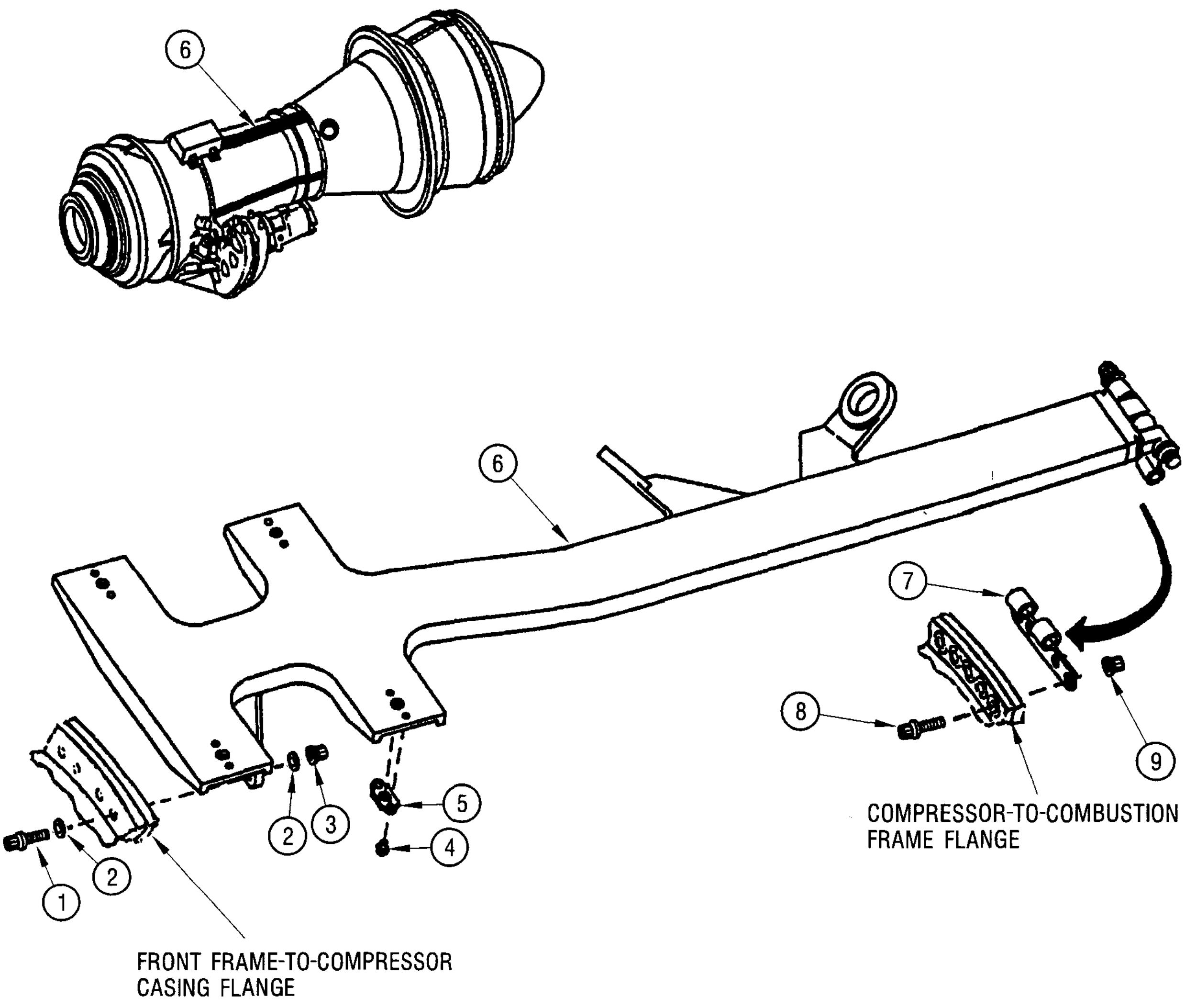
(3) Remove five self-locking nuts (9), and bolts (8) from hinge (7) at compressor-to-combustion frame flange.

(4) Remove support beam assembly (6).

b. Cleaning.

Dry Cleaning Solvent 32
(Stoddard Solvent), P-D-680

(1) Using a lint-free cloth saturated with dry cleaning solvent P-D-680, remove grease, dirt, and oil deposits from support beam assembly.



LEGEND:

1. BOLT
2. FLAT WASHER
3. SELF-LOCKING NUT
4. RIVET
5. NUT PLATE
6. SUPPORT BEAM
7. HINGE
8. BOLT
9. SELF-LOCKING NUT

L32119G0I/-G02/-G03/-G04

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Figure 3. Removal, Inspection, and Installation of Support Beam Assembly

WARNING

Compressed Air

- When using compressed air for any cooling, cleaning, or drying operation, do not exceed 30 psig (207 kPa) at the nozzle.
- Eyes can be permanently damaged by contact with liquid or large particles propelled by compressed air. Inhalation of air-blown particles or solvent vapor can damage lungs.
- When using air for cleaning at an air-exhausted work-bench, wear approved goggles or face shield.
- When using air for cleaning at an unexhausted work-bench, wear approved respirator and goggles.

(2) Using dry, filtered compressed air, blow-dry support beam assembly.

c. Inspection. Go to table 2.

TABLE 2. INSPECTION OF SUPPORT BEAM ASSEMBLY

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Support beam assembly (6, figure 3) for:			
(1) Cracks and buckling.	None allowed.	Not repairable.	Replace support beam assembly.
(2) Distortion.	Any amount, if support beam assembly can be installed normally to mating parts.	Same as usable limits.	Cold-work (WP 007 00) support beam assembly. Using a 10X magnifying glass, inspect for cracks. No cracks are allowed.
(3) Nicks, dents, and scratches.	1/32 inch (0.8 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).
b. Nut plate (5) for loss of self-locking feature or damaged threads.	Usable if mating bolt cannot be threaded through nut by hand.	Not repairable.	Remove nut plate (5) by drilling head of rivets (4) using 1/16 inch (1.6 mm) drill followed by a 3/32 inch (2.4 mm) drill. Remove old rivets and install new nut plate and new rivets.

d. Installation.

(1) Position support beam assembly (6, figure 3), as shown, between the front frame-to-compressor casing flange and compressor-to-combustion frame flange.

(2) Using five bolts (8), and self-locking nuts (9), secure hinge (7) of support beam assembly (6) onto aft end of compressor-to-combustion frame flange.

(3) Using four bolts (1), eight flat washers (2), and four self-locking nuts (3), secure the forward end of support beam assembly (6) onto aft end of front frame-to-compressor casing flange.

(4) Torque self-locking nuts (9) to 160-170 lb in. (18.1-19.2 N·m).

(5) Torque self-locking nuts (3) to 105-115 lb in. (11.9-13.0 N·m).

(6) Install ignition exciter (para 4. d).

6. <u>EXCITER BRACKET ASSEMBLY (L32119G05/-G06).</u>

a. Removal

(1) Remove ignition exciter (para 4.a).

(2) Remove three bolts (1, figure 4), nuts (2), and washers (3) from front frame-to-compressor casing flange.

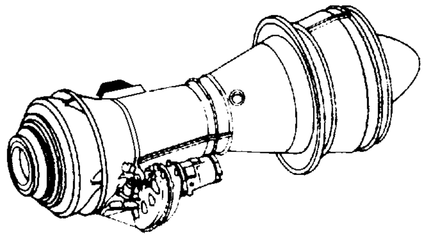
(3) Remove bolt (4), inside spacer bushing (5), and outside spacer bushing (6) from upper support beam assembly.

(4) Remove exciter bracket assembly (7).

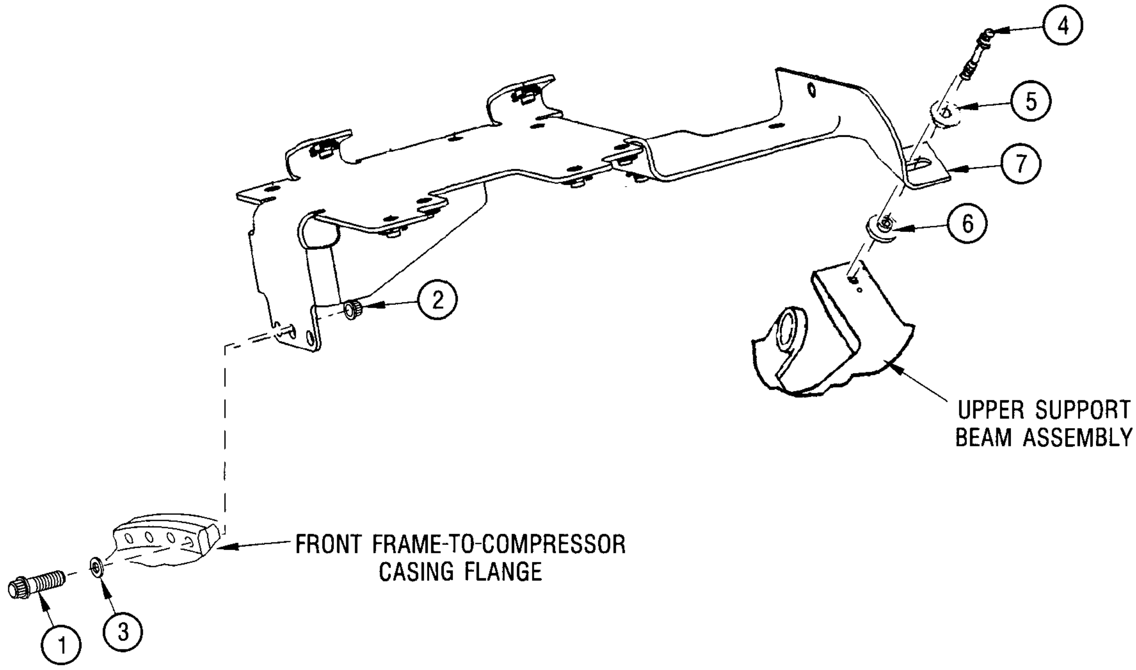
b. Cleaning.

Dry Cleaning Solvent **32**
(Stoddard Solvent), P-D-680

(1) Using a lint-free cloth saturated with dry cleaning solvent P-D-680, remove grease, dirt, and oil deposits from exciter bracket assembly.



LEGEND:
1. BOLT
2. NUT
3. WASHER
4. BOLT
5. INSIDE SPACER BUSHING
6. OUTSIDE SPACER BUSHING
7. EXCITER BRACKET ASSEMBLY



L32119G05/-G06

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Figure 4. Removal, Inspection and Installation of Exciter Bracket

WARNING

Compressed Air

- When using compressed air for any cooling, cleaning, or drying operation, do not exceed 30 psig (207 kPa) at the nozzle.
- Eyes can be permanently damaged by contact with liquid or large particles propelled by compressed air. Inhalation of air-blown particles or solvent vapor can damage lungs.
- When using air for cleaning at an air-exhausted work-bench, wear approved goggles or face shield.
- When using air for cleaning at an unexhausted work-bench, wear approved respirator and goggles.

(2) Using dry, filtered compressed air, blow-dry exciter bracket assembly.

c. Inspection. Go to table 3.

TABLE 3. INSPECTION OF EXCITER BRACKET ASSEMBLY

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Exciter bracket assembly (7, figure 4) for:			
(1) Cracks and buckling.	None allowed.	Not repairable.	Replace exciter bracket assembly.
(2) Distortion.	Any amount, if exciter bracket assembly can be installed normally to mating parts.	Same as usable limits.	Cold-work exciter bracket assembly (WP 007 00). Using a 10X magnifying glass, inspect for cracks. No cracks are allowed.
(3) Nicks, dents, and scratches.	1/32 inch (0.8 mm) deep, without high metal.	Same as usable limits, with high metal.	Remove high metal (WP 007 00).
b. Nut plates for loss of self-locking feature or damaged threads.	Usable if mating bolt cannot be threaded through nut by hand.	Not repairable.	Remove nut plate by drilling head of rivets using 1/16 inch (1.6 mm) drill followed by a 3/32 inch (2.4 mm) drill. Remove old rivets and install new nut plate and new rivets.

d. Installation.

(1) Position exciter bracket assembly (7, figure 4) as shown, between front frame-to-compressor casing flange and upper support beam assembly.

(2) Install bolt (4), inside spacer bushing (5), and outside spacer bushing (6) to secure exciter bracket assembly (7) to upper support beam assembly. Tight bolt hand-tight.

(3) Install three bolts (1), nuts (2), and washers (3) to secure exciter bracket assembly (7) to front frame-to-compressor casing flange. Torque nuts to 105-115 lb in. (11.9-13.0 N·m).

(4) Torque bolt (4) to 55-70 lb in. (6.2-7.9 N·m).

7. IGNITION LEADS.

a. Removal.

(1) On L32119G01, G02, G03, and G04 configurations remove ignition leads as follows:

(a) Remove lockwire from coupling nuts that connect ignition leads (2, 3, figure 5, sheet 1) to ignition exciter (1).

WARNING

Disconnecting Ignition Leads

- High voltage may be present. Contact with center conductor of electrical cable or center electrode of igniter plug will cause electric shock if the bleed resistors inside ignition unit have failed.
- Before removing igniter plug, be sure that discharge connector is grounded.

(b) Disconnect ignition leads (2, 3) from ignition exciter (1).

(c) Remove lockwire from coupling nuts that connect ignition leads (2, 3) to igniter plugs (19, 17) at the 2 and 10 o'clock positions on combustion chamber frame (18).

(d) Disconnect ignition leads (2, 3) from igniter plugs (19, 17).

(e) (Marine Only). Remove self-locking nut (4) and bolt (7) from cushioned clamps (5, 6).

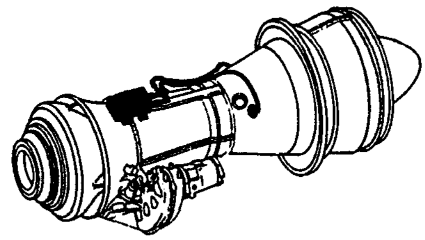
(f) Remove self-locking nut (9) and bolt (10) from cushioned clamp (8).

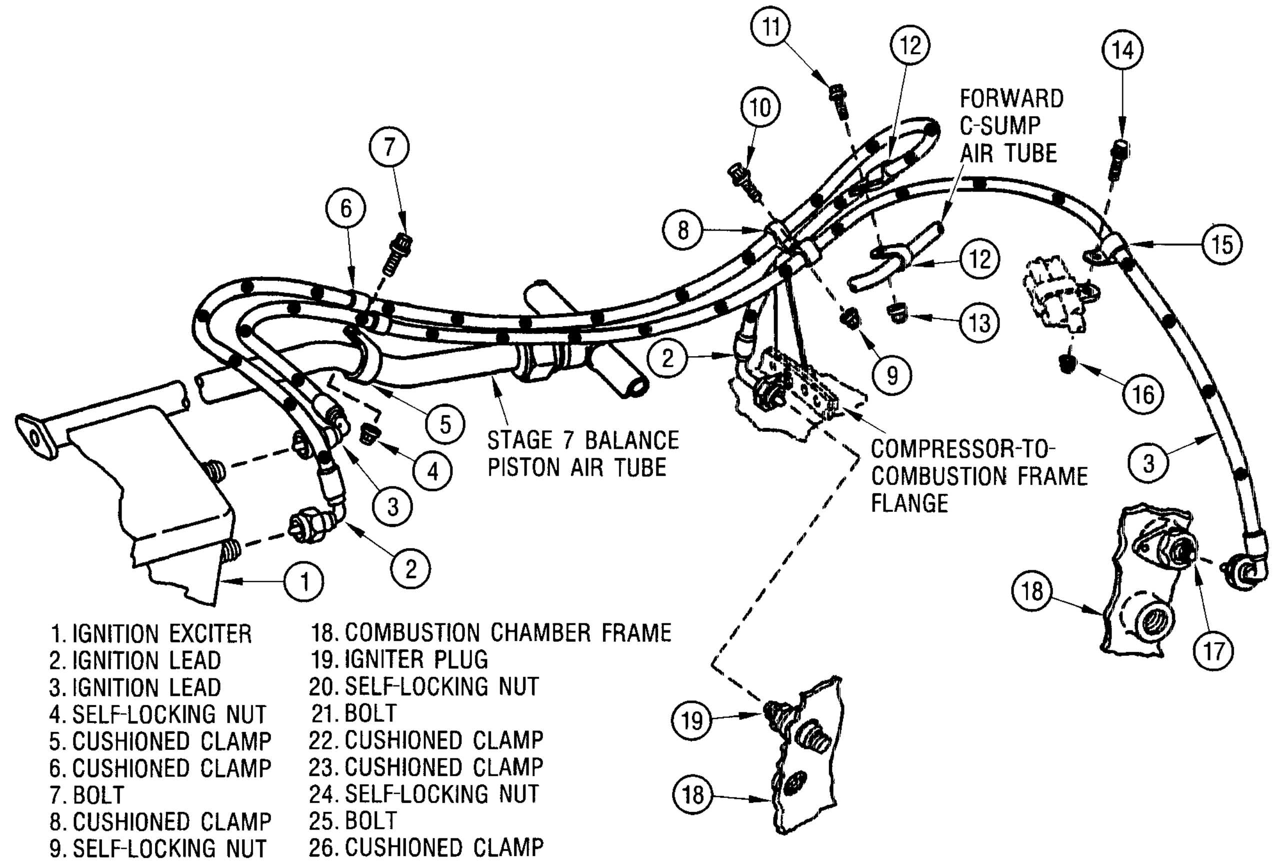
(g) Remove self-locking nut (13) and bolt (11) from cushioned clamps (12).

(h) Remove ignition lead (2).

(i) Remove self-locking nut (16) and bolt (14) from cushioned clamp (15).

(j) Remove ignition lead (3).





1. IGNITION EXCITER
2. IGNITION LEAD
3. IGNITION LEAD
4. SELF-LOCKING NUT
5. CUSHIONED CLAMP
6. CUSHIONED CLAMP
7. BOLT
8. CUSHIONED CLAMP
9. SELF-LOCKING NUT
10. BOLT
11. BOLT
12. CUSHIONED CLAMP
13. SELF-LOCKING NUT
14. BOLT
15. CUSHIONED CLAMP
16. SELF-LOCKING NUT
17. IGNITER PLUG
18. COMBUSTION CHAMBER FRAME
19. IGNITER PLUG
20. SELF-LOCKING NUT
21. BOLT
22. CUSHIONED CLAMP
23. CUSHIONED CLAMP
24. SELF-LOCKING NUT
25. BOLT
26. CUSHIONED CLAMP
27. HARNESS SUPPORT BRACKET
28. SELF-LOCKING NUT
29. BOLT
30. CUSHIONED CLAMP
31. ANGLE BRACKET
32. BOLT
33. CUSHIONED CLAMP

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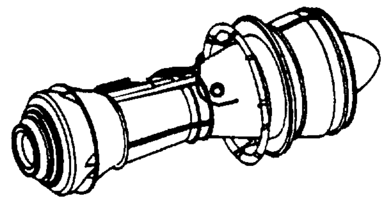
Figure 5. Removal and Installation of Ignition Leads (Sheet 1 of 3)



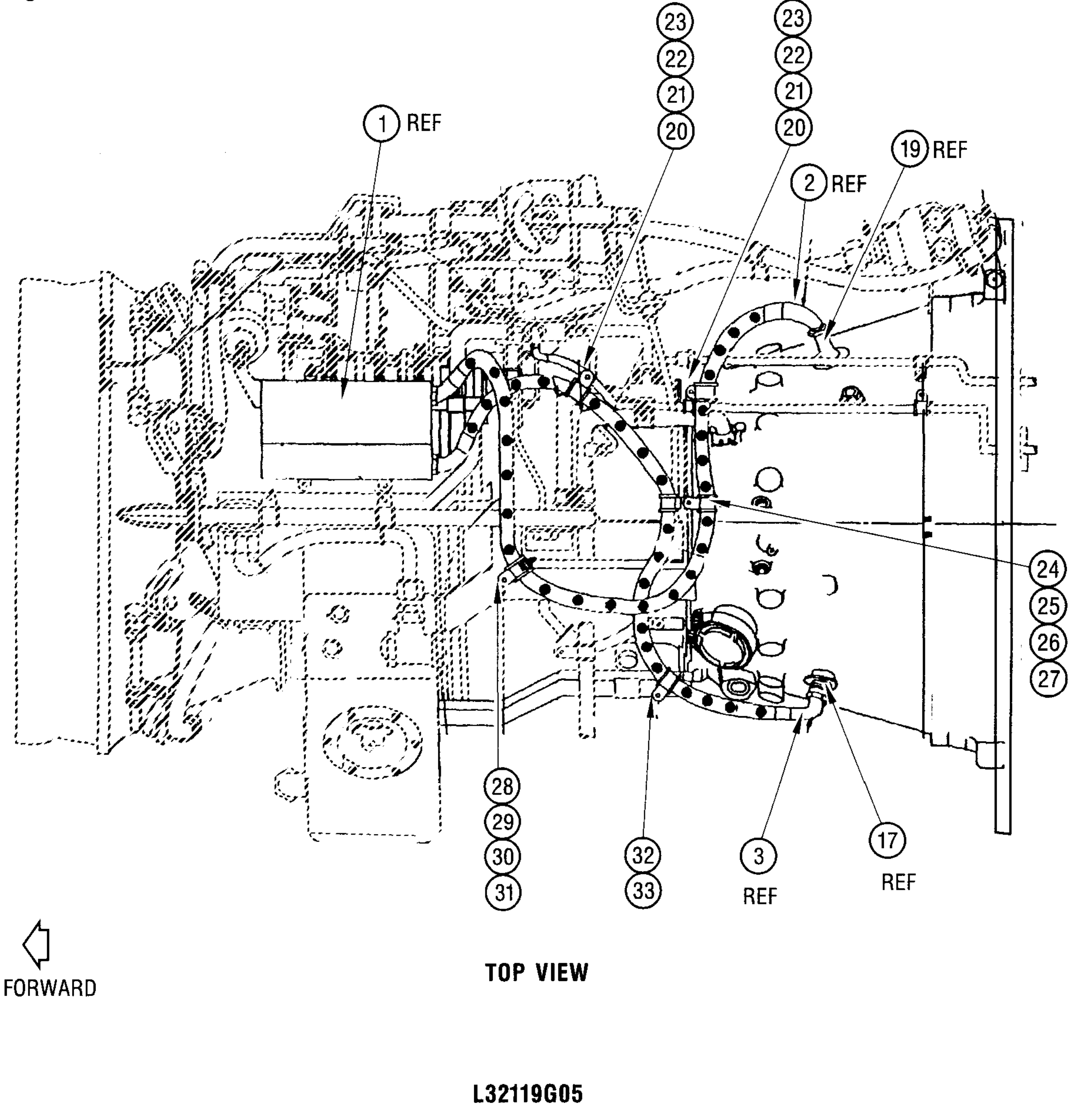
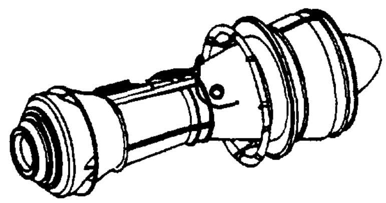
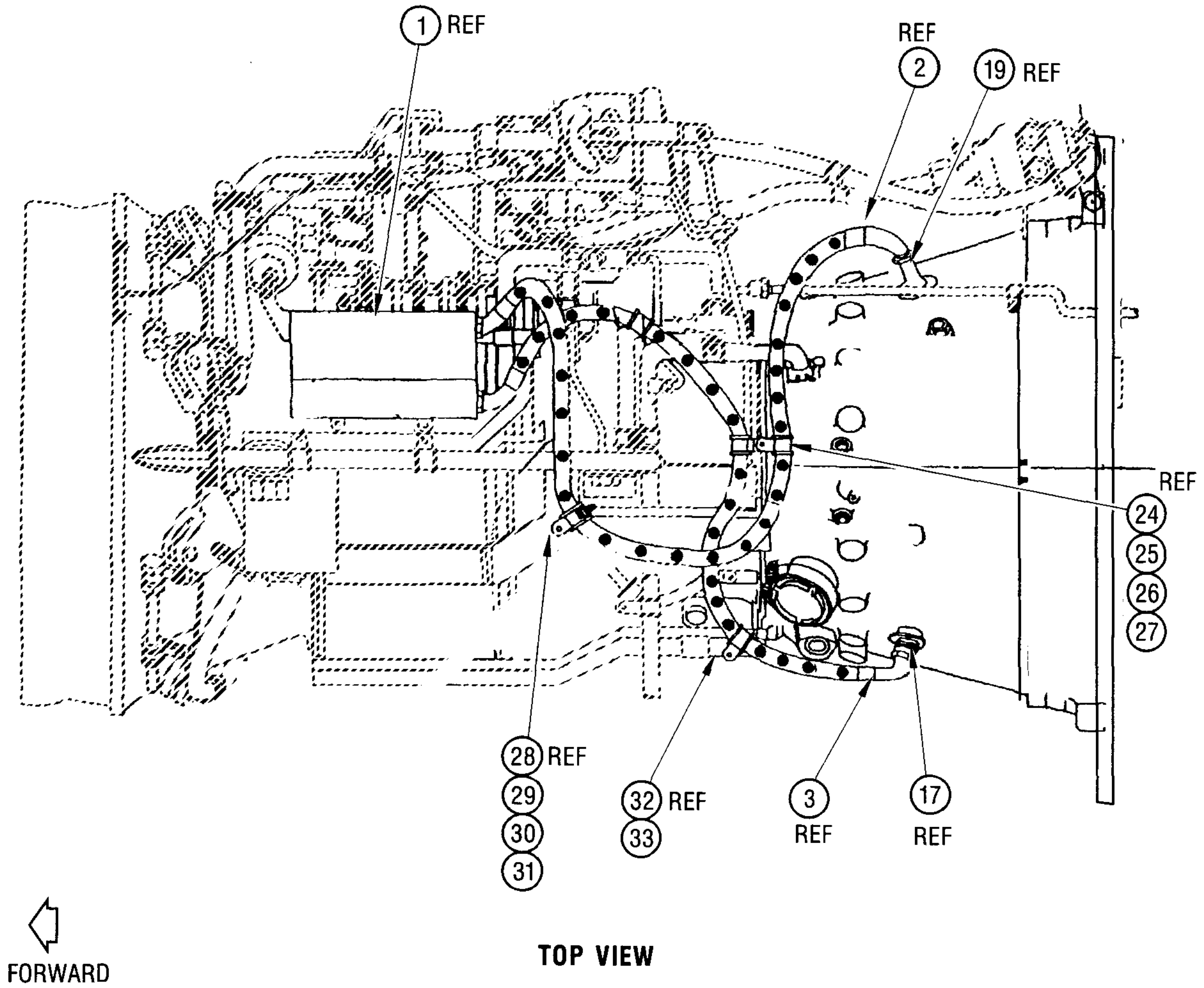


Figure 5. Removal and Installation of Ignition Leads (Sheet 2 of 3)





L32119G06

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Figure 5. Removal and Installation of Ignition Leads (Sheet 3 of 3)

(2) On L32119G05 configuration remove ignition leads as follows:

(a) Remove lockwire from coupling nuts that connect ignition leads (2, 3, figure 5, sheet 2) to ignition exciter (1).

WARNING

Disconnecting Ignition Leads

- High voltage may be present. Contact with center conductor of electrical cable or center electrode of igniter plug will cause electric shock if the bleed resistors inside ignition unit have failed.
- Before removing igniter plug, be sure that discharge connector is grounded.

(b) Disconnect ignition leads (2, 3) from ignition exciter (1).

(c) Remove lockwire from coupling nuts that connect ignition leads (2, 3) to igniter plugs (19, 17) at the 2 and 10 o'clock positions on combustion chamber frame (18).

(d) Disconnect ignition leads (2, 3) from igniter plugs (19, 17).

(e) Remove two self-locking nuts (20, sheet 2) and bolts (21) from cushioned clamps (22, 23).

(f) Remove self-locking nut (24) and bolt (25) from cushioned clamps (26) securing ignition leads (2, 3) to harness support bracket (27).

(g) Remove self-locking nut (28) and bolt (29) from cushioned clamp (30) securing ignition lead (2) to angle bracket (31).

(h) Remove ignition lead (2).

(i) Remove bolt (32) from cushioned clamp (33).

(j) Remove ignition lead (3).

(3) On L32119G06 Configuration, remove ignition leads as follows:

(a) Remove lockwire from coupling nuts that connect ignition leads (2, 3, figure 5, sheet 3) to ignition exciter (1).

WARNING

Disconnecting Ignition Leads

- High voltage may be present. Contact with center conductor of electrical cable or center electrode of igniter plug will cause electric shock if the bleed resistors inside ignition unit have failed.
- Before removing igniter plug, be sure that discharge connector is grounded.

(b) Disconnect ignition leads (2, 3) from ignition exciter (1).

(c) Remove lockwire from coupling nuts that connect ignition leads (2, 3) to igniter plugs (19, 17) at the 2 and 10 o'clock positions on combustion chamber frame (18).

(d) Disconnect ignition leads (2, 3) from igniter plugs (19, 17).

(e) Remove self-locking nut (24) and bolt (25) from cushioned clamps (26) securing ignition leads (2, 3) to harness support bracket (27).

(f) Remove self-locking nut (28) and bolt (29) from cushioned clamp (30) securing ignition lead (2) to angle bracket (31).

(g) Remove ignition lead (2).

(h) Remove bolt (32) from cushioned clamp (33).

(i) Remove ignition lead (3).

b. Cleaning.

Miller-Stephenson Solvent MS-160 (Or Freon, TP-35) **85**

(1) Using a stiff-bristle brush soaked with Miller-Stephenson solvent (MS-160), clean the Teflon chafing sleeve (see figure 6) of ignition lead.

(2) Using a soft-bristle brush soaked with solvent MS-160, clean ceramic insulator, socket contact, and Teflon bushing.