CHAPTER 5

GENERAL AIRCRAFT MAINTENANCE

This chapter discusses the various types of routine aircraft maintenance performed by the mechanics. When performing maintenance, it is your responsibility to comply with all safety procedures and tool control requirements. Because no single set of rules applies to all aircraft, you should refer to the maintenance instruction manual (MIM) for the tools, materials, and procedures required for that particular aircraft or piece of equipment.

LEARNING OBJECTIVES

When you have completed this chapter you will be able to do the following:

1. State the importance of the Navy's Tool Control Program (TCP).
2. Identify sources of information regarding hazards and terms applicable to hazardous situations and materials.
3. Explain basic steps used in troubleshooting aircraft systems.
4. Recognize the definition of troubleshooting. Identify the seven steps in the troubleshooting procedures.
5. Describe the different types of lubricants. Recognize the different methods of application. Understand the use of lubrication charts.
6. State the different types of aircraft hoisting slings and hoisting requirements for naval aircraft.
7. Explain the procedures for the safe raising and lowering of aircraft by the proper use of aircraft jacks. Identify the various types of jacks presently found in the naval inventory.
8. State the purpose and procedures of the Navy's Hydraulic Contamination Control Program.
9. Identify the types and sources of hydraulic contamination found in naval aircraft.
10. Define the procedures for sampling hydraulic fluid. Identify the sampling point requirements.
11. Recognize the analysis methods used to identify and measure fluid contamination.

TOOL CONTROL PROGRAM

Major problems, such as aircraft accidents and incidents, may result from tools left in an aircraft after maintenance has been performed. Tools out of place may result in foreign object damage (FOD). To reduce the potential for tool FOD-related mishaps, the Tool Control Program (TCP) provides a means of rapidly accounting for all tools after completing a maintenance task on an aircraft or its related equipment.

TOOL CONTAINERS

The means by which tools can be rapidly inventoried and accounted for is accomplished by using silhouetted tool containers. All tools have individual silhouetted locations that highlight a missing tool. These containers are called "shadow boxes." A shadow (silhouette) of the tool identifies the place where the tool belongs. The TCP is based on the instant inventory concept and is accomplished, in part, through the use of shadow boxes. (See Figure 5-1.) On containers where silhouetting is not feasible, a note with the inventory and a drawing of the container is included. Either system enables
the work center supervisor or inspector to quickly ensure that all tools have been retrieved after a maintenance action.

The material control officer is responsible for coordinating the TCP and for ensuring that tools are procured and issued in a controlled manner consistent with the approved tool control plan (TCPL). A TCPL contains information that includes material requirements, tool inventories, and detailed instructions for the implementation and operation of the TCPL for a specific type/model of aircraft. But the main responsibility remains with the work center and quality assurance.

QUALITY ASSURANCE/ANALYSIS (QA/A) RESPONSIBILITIES

The QA/A division is responsible for monitoring the overall TCP in the command. While monitoring the program or performing "spot checks," the QA/A division will ensure that tool control procedures are being followed. Some of the special requirements are to ensure the following:

1. All tools are etched with the organization code, work center, and tool container number.
2. Special accountability procedures are being complied with for those tools not suitable for etching; for example, drill bits (too hard) and jewelers' screwdrivers (too small).
3. Work center inventories are being conducted and procedures are being followed during work center audits and periodic spot checks.
4. All equipment in the work centers or tool control centers that require calibration is scheduled and calibrated at the prescribed interval.
5. Defective tools received from supply are reported to the Fleet Material Support Office (FLEMATSUPPO) via CAT II Quality Deficiency Reports (QDRs).
6. Tools of poor quality are reported to FLEMATSUPPO via CAT II QDRs.
7. Visual Information Display System Maintenance Action Forms (VIDS/MAFs) are annotated with a tool container number and appropriate initials are obtained following task completion/work stoppage.
8. The department's tool control environment is maintained when work is to be performed by contractor maintenance teams or depot field teams.

A Quality Assurance Representative (QAR) will brief field team/contractor supervisor/leader(s) upon their arrival regarding the activity's TCP. Depot teams working in O- or I-level facilities will comply with the host activity's TCP.
WORK CENTER RESPONSIBILITIES

All work center supervisors have specific responsibilities under the TCP. All tool containers should have a lock and key as part of their inventory. The supervisor should be aware of the location of each container's key and have a way of controlling it. When work is to be completed away from the workspaces (for example, the flight line/flight deck), complete tool containers—not a handful of tools—should be taken to the job. If more tools are needed than the tool container contains, tool tags can be used to check out tools from other tool containers in a work center. The following is a list of additional responsibilities of the work center supervisor.

1. Upon task assignment, note the number of the tool container on copy 1 of the VIDS/MAF, left of the accumulated work hours section. Ensure a sight inventory is conducted by the technician prior to commencement of each task and all shortages are noted. Every measure must be taken to ensure that missing tools do not become a cause of FOD. Check to see inventories are performed before a shift change, when work stoppage occurs, after maintenance has been completed, and before conducting an operational systems check on the equipment.

2. When all tools are accounted for and all maintenance actions have been completed, sign the VIDS/MAF signifying that this has been done.

3. If any tool is found to be missing during the required inventories, conduct an immediate search prior to reporting the work completed or signing off the VIDS/MAF. If the tool cannot be located, notify the maintenance officer or assistant maintenance officer via the work center supervisor and maintenance control to ensure that the aircraft or equipment is not released. If the tool cannot be located after the maintenance officer's directed search, the person doing the investigation will personally sign a statement in the Corrective Action block of the VIDS/MAF that a lost tool investigation was conducted and that the tool could not be found. Subsequently, the normal VIDS/MAF completion process will be followed.

The flight engineer/crew chief (or senior maintenance man in the absence of an assigned crew chief) will assume the responsibilities of the work center supervisor applicable to the TCP in the event of in-flight maintenance or maintenance performed on the aircraft at other-than-home station.

OCCUPATIONAL AWARENESS

Many different materials are used in the workplace. Some are hazardous. You must know where to retrieve information on these materials used in and around naval aircraft. The MIMs give information on correct maintenance practices, but may not always give complete information regarding necessary safety practices.

The Navy Occupational Safety and Health (NAVOSH) program was established to inform workers about hazards and the measures necessary to control them. The DOD has established the Hazardous Material Information System (HMIS), which is designed to acquire, store, and disseminate data on hazardous material procured for use. The primary source for you to get the necessary information before beginning any operation involving the use of hazardous material is the Material Safety Data Sheet (MSDS). The MSDS, known as Hazard Communication Standard, 29 CFR 1910.1200, is shown in Figure 5-2. This nine-section form informs you of hazards ingredient/identity information; physical and chemical characteristics; fire and explosive hazards; health hazards; and precautions for safe handling in case of spills, fire, overexposure, or other emergency situations.
Material Safety Data Sheet

Complies with OSHA’s Hazard Communication Standard, 29 CFR 1910.120

I. Trade Name: Spectracide Stump Remover

Product Type: Granular Stump Decomposer

Product Item Number: 56420

Formula Code Number: E

II. Hazards Ingredient/Identity Information

Chemical                  %           OSHA PEL                ACGIH ILV
Potassium Nitrate         100.0            NE                                 NE
CAS #7757.79.1

Appearance & Odor:   White to off-white granules.  No odor.
Boiling Point:               NA
Melting Point:          $633^\circ F$
Vapor Pressure:         78lb/ft$^3$
Bulk Density:               NA
% Volatile (by vol):      NA
Solubility in Water:      31g in 100g water

III. Physical and Chemical Characteristics

Appearance & Odor:   White to off-white granules.  No odor.
Boiling Point:               NA
Melting Point:          $633^\circ F$
Vapor Pressure:         78lb/ft$^3$
Bulk Density:               NA
% Volatile (by vol):      NA
Solubility in Water:      31g in 100g water

IV. Fire and Explosive Hazards Data

Flash Point:                                           NA
Flame Extension:                                  NA
Flammable Limits:                                 NA
Autoignition temperature:                        NA
Fire Extinguisher Media:                       Water fog
Decomposition Temperature:          $752^\circ F$
Special Fire-fighting Procedures:          Do not use Dry Chemicals. Carbon Dioxide or Halogenated agents.
Unusual Fire & Explosion Hazards This material is an oxidizer which may support burning or explosion when mixed with combustible materials and ignited

V. Reactivity Data

Stability: Stable under normal storage conditions
Polymerization: Will not occur
Conditions to Avoid: May burn vigorously or explode when mixed with combustible materials and ignited
Incompatible Materials:
Hazardous Decomposition Or Byproducts: NA

VI. Health Hazard Data

Ingestion:           Harmful if swallowed. First Aid: Give one or two glasses of water or milk and call a physician.
Eye Contact:         May Cause irritation. First Aid: Rinse with plenty of water. Call a physician if irritation persists
Skin Contact:        May Cause irritation. First Aid: Rinse with plenty of water. Call a physician if irritation persists
Health conditions Aggravated by Exposure: None under normal use.
Ingredients listed by NTP, OSHA, or IARC as Carcinogens or Potential Carcinogens: None

VII. Precautions for Safe Handling and Use

Steps to be Taken in case Material is Released or Spilled:
Avoid contact with granules. Sweep up and place in waste container.
Avoid contact with combustible materials.
Waste Disposal: Do not reuse container. Place container in trash.
Handling & Storage Precautions:
Store in cool area.

VIII. Control Measures

Read and follow label direction. They are your best guide to using this product effectively, and give necessary safety precautions to protect your health.

IX. Transportation Data

DOI Shipping Name: Stump decomposer
DOI Hazard Class: None

The information and statements herein are believed to be reliable but are not to be construed as warranty or representation for which we assume legal responsibility. Users should undertake sufficient verification and testing to determine the suitability for their own particular purpose of any information or products referred to herein. NO WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE IS MADE.

Figure 5-2 — Material safety data sheet.
The maintenance of safe and healthful working conditions is a chain-of-command responsibility. Implementation begins with the individual sailor and extends to the commanding officer. The chain of command responsibilities are covered in OPNAVINST 5100.19 (series) and OPNAVINST 5100.23 (series).

Work center supervisors are responsible for training work center personnel in the use of the MSDS. Furthermore, they must ensure that personnel under their supervision are trained on the hazards associated with the material and are equipped with the proper protective equipment before using any hazardous materials.

All sections of the MSDS are important, and contain information to accomplish tasks without causing damage to equipment or personnel. Always ensure that you are using the correct MSDS for the material being used. You should check the Military Specification (MILSPEC), part number, federal stock number, and the name of the manufacturer. Never use an MSDS from a different manufacturer. The formula for a given product may differ, but still meet the specification requirements. The handling and safety requirements may therefore change from manufacturer to manufacturer.

Threshold Limit Values (TLVs) in section II of the MSDS are established by the American Conference of Governmental Industrial Hygienists (ACGIH). TLVs refer to airborne concentrations of a substance and represent conditions that nearly all workers may be exposed, day after day, without adverse effects. You should know the effects of overexposure and the emergency procedures required before using any material.

Section V (Reactivity Data) of the MSDS contains a list of materials and conditions to avoid that could cause special hazards. Prompt cleanup of spills and leaks will lessen the chance of harm to personnel and the environment. Section VII (Precautions for Safe Handling and Use) of the MSDS lists the required steps to be taken for cleanup and proper disposal methods.

You should be familiar with section VIII (Control Measures) of the MSDS. In doing so, you will protect yourself and others from dangerous exposure. Some protective equipment is complex and requires special training in proper use and care. Never use a respirator that you have not fit-tested to wear. Always check to see that the cartridge installed meets the requirements of the MSDS. If you haven’t been trained and use a respirator that doesn’t fit or has the wrong cartridge installed, it could be as dangerous to your health as wearing no protection at all.

You need to be aware of word usage and intended meaning as it pertains to hazardous equipment and/or conditions. These terms are used in most technical manuals prepared for the Navy.

The following is a list of safety hazard words and definitions as they appear in most naval aviation technical manuals.

| WARNING | An operating procedure, practice, or condition, etc., that may result in injury or death if not carefully observed or followed. |
| CAUTION | An operating procedure, practice, or condition, etc., that may result in damage or destruction to equipment if not carefully observed or followed. |
**NOTE**
An operating procedure, practice, or condition, etc., that is essential to emphasize.

**SHALL** is used only when application of a procedure is mandatory.

**SHOULD** is used only when application of a procedure is recommended.

**MAY** and **NEED NOT** are used only when application of a procedure is optional.

**WILL** is used only to indicate futurity, never to indicate any degree of requirement for application of a procedure.

**AIRCRAFT DRAWINGS**

Much of the information contained in the various manuals issued by the Naval Air Systems Command for Navy aircraft and equipment is in the form of schematic, block, and pictorial drawings or diagrams. To understand how a system or component of the aircraft functions, you must be able to read and understand these drawings and diagrams.

**MEANING OF LINES**

The alphabet of lines is the common language of the technician and the engineer. In drawing an object, a draftsman not only arranges the different views in a certain manner, but also uses different types of lines to convey information. Line characteristics, such as width, breaks in the line, and zigzags, have meanings, as shown in *Figure 5-3.*
<table>
<thead>
<tr>
<th>Name</th>
<th>Convention</th>
<th>Description &amp; Application</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center Lines</td>
<td></td>
<td>Thin lines made up of alternating long and short dashes consistent in length</td>
<td><img src="image1" alt="Example" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Used to indicate symmetry about an axis and location of centers</td>
<td></td>
</tr>
<tr>
<td>Dimension Lines</td>
<td></td>
<td>Thin lines terminating with arrowheads at each end</td>
<td><img src="image2" alt="Example" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Used to indicate distance measured</td>
<td></td>
</tr>
<tr>
<td>Extension Lines</td>
<td></td>
<td>Thin, unbroken lines</td>
<td><img src="image3" alt="Example" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Used to indicate extent of distance</td>
<td></td>
</tr>
<tr>
<td>Hidden Lines</td>
<td></td>
<td>Medium lines with short, evenly spaced dashes</td>
<td><img src="image4" alt="Example" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Used to indicate concealed edges</td>
<td></td>
</tr>
<tr>
<td>Leader Lines</td>
<td></td>
<td>Thin lines terminating with an arrowhead or dot at one end</td>
<td><img src="image5" alt="Example" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Used to indicate a part, dimension, or other reference</td>
<td></td>
</tr>
<tr>
<td>Visible Lines</td>
<td></td>
<td>Heavy, unbroken lines</td>
<td><img src="image6" alt="Example" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Used to indicate visible edges of an object</td>
<td></td>
</tr>
<tr>
<td>Break (Long)</td>
<td></td>
<td>Thin, solid-ruled lines with freehand zigzags</td>
<td><img src="image7" alt="Example" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Used to reduce the size of drawing required to delineate an object and reduce detail</td>
<td></td>
</tr>
<tr>
<td>Break (Short)</td>
<td></td>
<td>Thick, solid with freehand zigzags lines</td>
<td><img src="image8" alt="Example" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Used to indicate a short break</td>
<td></td>
</tr>
<tr>
<td>Cutting or Viewing Plane</td>
<td><img src="image9" alt="Example" /></td>
<td>Thick, solid lines with arrowheads to indicate direction in which section or plane is viewed or taken</td>
<td><img src="image10" alt="Example" /></td>
</tr>
<tr>
<td>Viewing Plane Optional</td>
<td><img src="image11" alt="Example" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cutting Plane for Complex or Offset Views</td>
<td><img src="image12" alt="Example" /></td>
<td>Thick lines of short, evenly spaced dashes with arrowheads to indicate the direction in which the cutting is viewed</td>
<td><img src="image13" alt="Example" /></td>
</tr>
<tr>
<td>Phantom or Datum Lines</td>
<td><img src="image14" alt="Example" /></td>
<td>Medium series of one long dash and two short dashes Used to indicate alternate position of parts or a datum plane</td>
<td><img src="image15" alt="Example" /></td>
</tr>
</tbody>
</table>

Figure 5-3 — Line characteristics.
INTERPRETATION OF DRAWINGS

Schematic drawings are usually used to illustrate the various electrical circuits, hydraulic systems, fuel systems, and other systems of the aircraft. The components of an electrical circuit are normally represented by the standard electrical symbols shown in Figure 5-4. Look at this figure and notice the electrical symbols for fuse, splice, ground, and polarity.

Figure 5-5 is a schematic diagram that shows an arresting gear system. Different symbols in the legend indicate the flow of hydraulic fluid. The diagram also indicates energized and nonenergized wires. Each component is illustrated and identified by name. Arrows indicate the movement of each component.

![Electrical symbols](image-url)

Figure 5-4 — Electrical symbols.
Figure 5-5 — Arresting gear system schematic.
Block diagrams may be used to illustrate a system. The nosewheel steering system in Figure 5-6 is a good example of the use of a block diagram.

In the block diagram, each of the components of the system is represented by a block. The name of the component represented by each block is near that block. Block diagrams are also useful in showing the relationship of the components. In addition, they may show the sequence in which the different components operate.

A pictorial drawing is a representation of both the detail and the entire assembly. Figure 5-7 is an example of a pictorial drawing. Another use of this type of drawing is to show disassembly, or an exploded view. This type of drawing enables the mechanic to see how the parts of a particular piece of equipment are put together.

Orthographic drawings are used to show details of parts, components, and other objects, and are primarily used by the manufacturer of the object. Usually, two or more views of the object are given on the drawing. Detailed instructions on reading orthographic, as well as all other types of drawings, are contained in *Blueprint Reading and Sketching*, NAEDTRA 12014.

**Figure 5-6 — Nosewheel steering system schematic.**

**Figure 5-7 — Pictorial drawing with exploded view.**
DIAGRAMS

One of the more important factors in logically troubleshooting a system is your understanding of the components and how they operate. You should study the information and associated schematics provided in the MIM. The function of each component and possible malfunctions can be used in the process of analyzing actual malfunction symptoms.

A primary concern in troubleshooting an aircraft hydraulic system is to determine whether the malfunction is caused by hydraulic, electrical, or mechanical failure. Actuating systems are dependent on power systems. Some of the troubles exhibited by an actuating system may be caused by difficulties in the power system. A symptom indicated by a component of the power system may be caused by leakage or malfunction of one of the actuating systems. When any part of the hydraulic system becomes inoperative, use the diagrams in conjunction with the checkout procedures provided in the aircraft MIM. Possible causes of trouble should always be eliminated systematically until the pertinent cause is found. No component should be removed or adjusted unless there is a sound reason to believe the unit is faulty.

In order to gain a complete knowledge of a specific system, you should familiarize yourself with two classes of diagrams. These are the schematic and installation diagrams. A diagram—whether it is a schematic diagram or an installation diagram—may be defined as a graphic representation of an assembly or system.

Schematic Diagrams

*Figure 5-8* is another example of a schematic diagram. Diagrams of this type do not indicate the actual physical location of the individual components in the aircraft. They do, however, locate components with respect to each other within the system. Various components are indicated by symbols in schematic diagrams, while drawings of the actual components are used in the installation (pictorial) diagrams. The symbols used in the schematic diagrams conform to the military standard mechanical symbols provided in MIL-STD-17B-1 and MIL-STD-17B-2. Most manufacturers improve upon these basic symbols by showing a cutaway portion on each component. These cutaways aid in clarifying the operation of that component. You should be able to trace the flow of fluid from component to component. On most diagrams of this type, an uncolored legend or different colors are used to represent the various lines. The legend identifies the lines in relation to their purpose and the mode of operation being represented. Each component is further identified by name, and its location within the system can be determined by noting which lines lead into and out of the component.
Since many systems are electrically controlled, you should be capable of reading the electrical portion of a schematic diagram. Knowledge of the electrical symbols and the use of a multimeter in making voltage and continuity checks will contribute significantly to efficient troubleshooting. If a malfunction is caused by electrical problems, the assistance of Navy Aviation Electrician’s Mate (AE) personnel may be required.

All electrical wiring in the aircraft is marked at specified intervals with a wire identification code. These identification codes are defined in the electrical volume(s) of the MIM, and they are useful in tracing wires throughout the aircraft. If an elusive malfunction is reasonably traced to or considered to be of an electrical nature, the electrical circuit should be checked by a qualified AE. Many wires can give a good continuity reading under a no-load or low-current condition and still be malfunctioning when under a load condition.

**NOTE**

Electrical schematics are especially useful in determining annunciator panel malfunctions.
Installation Diagrams

*Figure 5-9* is an example of an installation diagram. This is a diagram of the motor-driven hydraulic pump installation. Installation diagrams show general location, function, and appearance of parts and assemblies. On some installation diagrams, letters on the principal view refer to a detailed view located elsewhere on the diagram. Each detailed view is an enlarged drawing of a portion of the system identifying each of the principal components for purposes of clarification. Diagrams of this type are invaluable to maintenance personnel in identifying and locating components. Installation diagrams will aid you in understanding the principle of operation of complicated systems.

TROUBLESHOOTING AIRCRAFT SYSTEMS

Troubleshooting/trouble analysis may prove to be the most challenging part of system maintenance. Troubleshooting is the logical or deductive reasoning procedure used when determining what unit is causing a particular system malfunction. The MIM for each aircraft generally provides troubleshooting aids that encompass the following seven steps:

1. Conduct a visual inspection.
2. Conduct an operational check.
3. Classify the trouble.
4. Isolate the trouble.
5. Locate the trouble.
6. Correct the trouble.
7. Conduct a final operational check.

*Table 5-1* shows a representative troubleshooting table. The troubles in this table are numbered to correspond with the step of the operational check procedures where the trouble will become apparent.

Other MIMs use trouble analysis sheets to pursue a trouble to a satisfactory solution by the process of elimination. The symptom is defined in tabular form with a remedy for each symptom. Example trouble analysis sheets are shown in *Tables 5-2* and 5-3. The sheets used with the checkout procedures relate to checkout steps by direct reference or to discrepancies occurring in flight or during ground operations. Each table provides a remedy for each symptom.
When the remedy is as simple as replacing a component or making an adjustment, this fact will be stated. When the remedy requires further analysis, the entry in the REMEDY column will be a reference to an applicable paragraph, figure, or possibly another manual. See Tables 5-1 and 5-2.

Each trouble analysis procedure provides preliminary data, such as tools and equipment, manpower requirements, and material. In the block type of troubleshooting sheet, the procedure is arranged in the order of most likely occurrence. The sheet contains a series of NO-YES responses to direct maintenance personnel through a logical series of steps. These directed responses assist in isolating the malfunction. When the requirements of a step are satisfactory, you go to the YES column and perform the referenced step. When the requirements of a step are not satisfactory, you go to the NO

<table>
<thead>
<tr>
<th>Probable Cause</th>
<th>Isolation Procedure</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEP f. TROUBLE: HYD FLT LEVEL WARNING LIGHT IS ON WHEN RESERVOIR IS FULL.</td>
<td>Microswitch not actuating. Actuate microswitch manually and observe warning light in cockpit.</td>
<td>Adjust microswitch contact to make or break properly.</td>
</tr>
<tr>
<td>STEP f. TROUBLE: HYD FLT LEVEL WARNING LIGHT CAME ON AT ALTITUDE, HOWEVER RESERVOIR SLUG RETURNS TO PREFLIGHT LEVELS DURING DESCENT.</td>
<td>Water in Chemical Dryer. Replace Chemical Dryer Cartridge (WP018 00).</td>
<td>If trouble is not corrected and no water found in Chemical Dryer continue troubleshooting.</td>
</tr>
<tr>
<td></td>
<td>Air in System. Check for loose hydraulic connections, leakage, or pulling in air. Check bleed air line fittings for leakage.</td>
<td>Retighten loose bleed air line fittings.</td>
</tr>
<tr>
<td></td>
<td>Clogged or malfunctioning Air Pressure Regulator. Replace Air Pressure Regulator with one known to operate correctly (WP020 00).</td>
<td>If normal operations results after replacement, forward defective component to next higher maintenance level.</td>
</tr>
<tr>
<td>STEP i. TROUBLE: ACCUMULATOR PRESSURE GAUGE INDICATES BELOW 2,000 PSI.</td>
<td>Insufficient accumulator preload. Check accumulator preload.</td>
<td>Service accumulator (WP009 00).</td>
</tr>
<tr>
<td></td>
<td>Pressure gauge. Replace gauge with one know to operate correctly (WP030 00).</td>
<td>If normal operation results after replacement, forward defective component to next higher maintenance level.</td>
</tr>
<tr>
<td></td>
<td>Filler valve. Check filter valve for leakage. Replace filter valve (WP029 00).</td>
<td>Replace filter valve (WP029 00).</td>
</tr>
<tr>
<td></td>
<td>Accumulator. Check accumulator for leakage. Replace accumulator (WP028 00).</td>
<td>Replace accumulator (WP028 00).</td>
</tr>
<tr>
<td></td>
<td>Pneumatic lines. Check pneumatic lines for leakage. Replace leaking pneumatic line (NAVAIR 01-1A-20).</td>
<td>Replace leaking pneumatic line (NAVAIR 01-1A-20).</td>
</tr>
<tr>
<td>STEP k. TROUBLE: NUMBER 1 OR NUMBER 2 NEEDLE OF COPILOT'S FLT HYD PRESS INDICATOR INDICATES BELOW NORMAL, WHILE ACCUMULATOR PRESSURE GAUGE INDICATES 3,000 PSI.</td>
<td>Copilot's FLT HYD PRESS indicator. Replace indicator with one known to operate properly (NAVAIR 01-E2AAA-2-8, WP082 00).</td>
<td>If normal operation results after replacement, forward defective component to next higher maintenance level.</td>
</tr>
<tr>
<td></td>
<td>Pressure transmitter. Replace transmitter with one known to operate properly (WP039 00).</td>
<td>If normal operation results after replacement, forward defective component to next higher maintenance level.</td>
</tr>
<tr>
<td></td>
<td>Hydraulic lines. Check hydraulic lines for leakage. Replace leaking hydraulic lines (NAVAIR 01-1A-20).</td>
<td>Replace leaking hydraulic lines (NAVAIR 01-1A-20).</td>
</tr>
</tbody>
</table>
column and perform the referenced step. This process is continued until the malfunction is isolated and corrected. The original checkout procedure must then be repeated to ensure that the malfunction has been corrected.

Table 5-2 — Troubleshooting Wheel Brake System

<table>
<thead>
<tr>
<th>TROUBLE</th>
<th>PROBABLE CAUSE</th>
<th>CORRECTIVE ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>All brakes dragging.</td>
<td>1. Air in system.</td>
<td>Bleed brakes. (See NAVAIR 01-75PAA-2.1)</td>
</tr>
<tr>
<td></td>
<td>2. Brake control valve out of adjustment</td>
<td>Verify brake control valve control levers are against off stops. If not, check pedal breakaway force. (See WP 004 00 for normal brake system rigging and adjustment procedure.) If breakaway tool is not readily available, apply 12.5 (± 2) pounds of force, 6 inches from pedal pivot, using a 40-pound push-pull spring scale to start pedal moving. Readjust breakaway spring tumbarreals as necessary.</td>
</tr>
<tr>
<td>In-flight brake pressure regulator</td>
<td>3. In-flight brake pressure regulator valve does not fully release brakes</td>
<td>Check as follows: install ground safely pin in jury struts. Select gear up with hydraulic pressure No. 1. Select gear down and turn off pressure. If brakes not fully release, (running clearance should be 0.090 inch minimum between pressure plate and rotor when brakes are released), break a B-nut between brake control valve return port and in-flight brake pressure regulator. If fluid flows, and brakes release, trouble is isolated to in-flight brake pressure regulator. Replace in-flight brake pressure regulator. (See WP 019 00 for in-flight brake pressure regulator removal and installation procedures.)</td>
</tr>
</tbody>
</table>
Troubleshooting procedures are similar in practically all applications, whether they are mechanical, hydraulic, pneumatic, or electrical. These procedures are certainly adaptable to all aircraft maintenance, as well as other types of installations. Auto mechanics use these steps to find and repair malfunctions in automobiles. You will use the same procedure to find and repair malfunctions within aircraft systems.

Clarification of the seven distinct troubleshooting steps previously mentioned is as follows:

1. Conduct a visual inspection. This inspection should be thorough and searching, to include checking all lines, units, mechanical linkage, and components for evidence of leaks, looseness, security, material condition, and proper installation. During this visual inspection, the hydraulic system should be checked for proper servicing, the reservoir for proper level, and accumulators for specified preload, etc.

2. Conduct an operational check. The malfunctioning system or subsystem is checked for proper operation. This is normally accomplished by attaching the support equipment to the aircraft, which supplies a source of electrical power and pressurized fluid to operate the hydraulic system. In some instances, however, the aircraft may be ground-checked by using aircraft power and equipment. Depending on the circumstances, during movement of the malfunctioning unit, check for external leakage, the correct direction of component movement, its proper sequence of operation, speed, and whether the complete cycle was obtained.

3. Classify the trouble. Malfunctions usually fall into four basic categories—hydraulic, pneumatic, mechanical, or electrical. By using the information gained from steps 1 and 2 above, you can determine under which classification the malfunction occurs.

Something affecting normal flow of hydraulic fluid would be classified under the hydraulic classification. The flow of fluid may be affected by external and internal leakage, total or partial restriction, or improper lubrication.
Something affecting the normal flow of compressed gases is classified as a pneumatic malfunction. This type of malfunction stems from the same general sources as hydraulic malfunctions.

Most units that operate hydraulically or pneumatically incorporate mechanical linkage. If a discrepancy in the linkage exists, it will affect the system's operation. Mechanical discrepancies should be identified during visual inspections, and they are usually in one of the following categories: worn linkages, broken linkages, improperly adjusted linkages, or improperly installed linkages.

Many hydraulic units incorporate electrical components to operate or control them. You must be able to determine if the electrical system is functioning normally; electrical malfunctions will usually be a complete power failure, circuit failure, or component failure.

4. Isolate the trouble. This step calls for sound reasoning, and a full and complete knowledge of hydraulic theory, as well as a complete understanding of the affected hydraulic system. During this step, you must use your knowledge and the known facts to determine where the malfunction exists in the system. Usually the trouble can be pinned down to one or two areas. Eliminating those units that could not cause the known symptoms and those that can be proved to be operating normally will usually identify the malfunction.

5. Locate the trouble. This step is used to eliminate unnecessary parts removal, thus saving money, valuable time, and man-hours. Often, you have determined what unit or units in the system could have caused the malfunction, thus verifying the isolation step.

Both hydraulic and pneumatic malfunctions are verified in the same manner. You remove lines and inspect them for the correct flow in or at the suspected unit. Internal leaks may occur in valves, actuators, or other hydraulic units. Any unit that has a line that could carry fluid to "return" is capable of internal leakage.

Mechanical malfunctions are located by closely observing the suspected unit to see if it is operating in accordance with the applicable aircraft MIM. Mechanical discrepancies are usually located during the visual inspection in step 1 above.

Electrical malfunctions are located, with the assistance of AEs, by tracing electrical power requirements throughout the affected system.

6. Correct the trouble. This step is accomplished only after the trouble has been definitely located and there is no doubt that your diagnosis is correct. Malfunctions are usually corrected by replacement of units or components, rigging and adjustments, and bleeding and servicing.

NOTE

Always check the applicable MIM for CAUTION, WARNING, and SAFETY notes concerning maintenance procedures.

7. Conduct a final operational check. The affected system must be actuated a minimum of five times, or until a thorough check has been made to determine that its operation and adjustments are satisfactory.

TESTING AND OPERATIONAL CHECKS

Aircraft systems tests and operational checks should be performed under conditions as nearly operational as possible. Such tests or checks should be performed in accordance with the instructions outlined in the applicable MIM. Make the operational checks in the sequence outlined in the MIM. Any discrepancies you find when performing a step should be corrected before proceeding. The operational check and the troubleshooting charts have been coordinated so that malfunctions
can be isolated in an efficient manner. If the troubleshooting aids do not list the trouble being experienced, you will have to study the system schematics and perform the operational check. Use logic and common sense in pinpointing the cause of the malfunction. The test stand to be used in performing the operational check must be capable of producing the required flow and pressure required for proper operation. Check all electrical switches and circuit breakers, as well as hydraulic selector valves, for proper position. Perform this check before applying external electrical and hydraulic power. Perform all maintenance in accordance with the MIM. Observe all maintenance precautions and requirements for quality assurance verification.

Personnel involved in troubleshooting and performing operational checks should consult the records maintained in maintenance control and/or the work center register. Reference to records of previous maintenance may show a progressive deterioration of a particular system or a previous discrepancy. This procedure could be helpful in pinpointing the cause of the malfunction currently being experienced.

**ELECTRICAL FAILURES**

Since practically all systems now have some electrically controlled components, troubleshooting in many instances must also include the related electrical circuits. Although an AE is generally called upon to locate and correct electrical troubles, you should be able to check circuits for loose connections and even perform continuity checks when necessary. Therefore, knowledge of electrical symbols and the ability to read circuit diagrams is necessary. Figure 5-4 illustrates the electrical symbols commonly found in schematic diagrams.

Loose connections are located by checking all connectors in the circuit. A connector that can be turned by hand is loose and should be hand tightened.

A continuity check is simply a matter of determining whether or not the circuit to the selector valve, or other electrically controlled unit, is complete. Continuity checks are made with the use of a multimeter. The name multimeter comes from MULTIPLE METER, and that is exactly what a multimeter is. It is a dc ammeter, an ac ammeter, a dc voltmeter, an ac voltmeter, and an ohmmeter—all in one package. Figures 5-10 and 5-11 show the faces of commonly used multimeters. The applicable instructions should be consulted prior to equipment operation.
LUBRICATION

Perhaps the only connection you have had with lubrication was taking the car to the garage for greasing and oil change. If your car has ever burned out a bearing, you have learned the importance of lubricants. The proper lubrication of high-speed aircraft is very important. You should be familiar with the various types of lubricants, their specific use, and the method and frequency of application.

Lubricants are used to reduce friction, to cool, to prevent wear, and to protect metallic parts against corrosion. In the aircraft, lubrication is necessary to minimize friction between moving parts. Only the presence of a layer or film of lubricant between metal surfaces keeps the metals from touching. As a result, friction is reduced between moving parts. Prolonged operating life is ensured when the lubricant keeps metal surfaces from direct contact with each other. If the film disappears, you end up with burned out or frozen bearings, scored cylinder walls, leaky packings, and a host of other troubles. Appropriate use of proper lubricants minimizes possible damage to equipment.

LUBRICANTS

You can get lubricants in three forms. They are fluids, semisolids, and solids. Additives improve the physical properties or performance of a lubricant. We all know that oils are fluids, and greases are semisolids. You probably think of graphite, molybdenum disulfide, talc, and boron nitride as additives. In fact, they are solid lubricants. A solid lubricant's molecular structure is such that its platelets will readily slide over each other. Solid lubricants can be suspended in oils and greases.

There are many different types of approved lubricants in use for naval aircraft. Because the lubricants used will vary with types of aircraft and equipment, it is impractical to cover each type. Some of the more common types are described in Table 5-4.
<table>
<thead>
<tr>
<th>TITLE AND SPECIFICATION</th>
<th>RECOMMENDED TEMPERATURE RANGE</th>
<th>GENERAL COMPOSITION</th>
<th>INTENDED USE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIL-PRF-23827C [Grease, Aircraft, Synthetic, Extreme Pressure]</td>
<td>-100 to 250 °F</td>
<td>Thickening agent, low-temperature synthetic oils, or mixture EP additive</td>
<td>Actuator screws, gears, controls, rolling-element bearings, general instrument use</td>
</tr>
<tr>
<td>MIL-PRF-21164D [Grease, Aircraft, Synthetic, Molybdenum Disulfide]</td>
<td>-100 to 250 °F</td>
<td>Similar to MIL-PRF-23827 plus molybdenum disulfide</td>
<td>Sliding steel on steel, heavily loaded hinges, rolling element bearing where specified</td>
</tr>
<tr>
<td>MIL-PRF-81322G [Grease, Aircraft, General Purpose, Wide Temperature Range]</td>
<td>-65 to 350 °F</td>
<td>Thickening agent and synthetic hydrocarbon. Has cleanliness requirements</td>
<td>O-rings, certain splines, ball and roller bearing assemblies, primarily wheel bearings in internal brake assemblies, and where compatibility with rubber is required</td>
</tr>
<tr>
<td>MIL-PRF-4343 [Grease, Pneumatic System]</td>
<td>-65 to 200 °F</td>
<td>Thickening agent and blend of silicone and diester</td>
<td>Rubber to metal lubrication: pneumatic and oxygen systems</td>
</tr>
<tr>
<td>MIL-G-25537C [Grease, Helicopter Oscillating Bearing]</td>
<td>-65 to 160 °F</td>
<td>Thickening agent and mineral oil</td>
<td>Lubrication of bearings having oscillating motion of small amplitude</td>
</tr>
<tr>
<td>MIL-G-6032D [Grease, Plug Valve, Gasoline and Oil Resistant]</td>
<td>32 to 200 °F</td>
<td>Thickening agent, vegetable oils, glycerols, and/or polyesters</td>
<td>Pump bearings, valves and fittings where specified for fuel resistance</td>
</tr>
<tr>
<td>MIL-PRF-2617F [Grease, Aircraft Fuel and Oil Resistant]</td>
<td>-30 to 400 °F</td>
<td>Thickening agent and fluorocarbon or fluorosilicone</td>
<td>Tapered plug and oxygen system valves; certain fuel system components; antiseize</td>
</tr>
<tr>
<td>MIL-G-25013E [Grease, Ball and Roller Bearing, Extreme High Temp]</td>
<td>-100 to 450 °F</td>
<td>Thickening agent and silicone fluid</td>
<td>Ball and roller bearing lubrication</td>
</tr>
</tbody>
</table>
Methods of Application

Different types of lubricants may be applied by any one of several methods. Common methods are by grease gun, by oil/squirt cans, by hand, and by brush.

**GREASE GUNS** — There are numerous types and sizes of grease guns available for different equipment applications. The lever and one-handed lever guns are two of the most common types in use. The grease gun may be equipped with a flexible hose instead of a rigid extension. Different nozzles can be attached to the grease guns for different types of fittings. See *Figure 5-12*.

**OIL/SQUIRT CAN** — Oil/squirt cans are used for general lubrication. Always use the specified oil for the part being lubricated. Before using oil cans, always check to make sure the oil can contains the proper lubricant.

**HAND** — This method of lubrication is generally used for packing wheel bearings. It involves using grease in the palm of your hand to pack the bearings.

**BRUSH** — This method of lubrication is used when it is necessary to cover a large area, or for coating tracks or guides with a lubricant.

Lubrication Fittings

There are several different types of grease fittings. They are the hydraulic (Zerk fitting), the buttonhead pin, and the flush type of fittings. (See *Figure 5-13.*) The two most commonly used fittings in naval aviation are the hydraulic-and flush-type fittings. These fittings are found on many parts of the aircraft.

**HYDRAULIC FITTINGS** — This type protrudes from the surface into which it is screwed, and it has a rounded end that the mating nozzle of the grease gun grips. A spring-loaded ball acts as a check valve. *Figure 5-13* shows a cross-sectional view of a straight hydraulic fitting and an angled hydraulic fitting made for lubricating parts that are hard to reach.

**FLUSH FITTINGS** — This type of fitting sits flush with the surface into which it is placed. It will not interfere with moving parts.
LUBRICATION SELECTION

How do you know what grease or oil to select for a particular application? Lubrication instructions are issued for all equipment requiring lubrication. You will find that the MIM or Maintenance Requirements Cards (MRCs) provide you with lubrication information. In the event that the exact lubricant is not available and a substitution is not listed, request substitution through the chain of command.

LUBRICATION CHARTS

The lubrication requirements for each model of aircraft are given in the “General Information and Servicing” section of the MIM. In the MIM you will find the necessary support equipment and consumable material requirements. A table/chart similar to the one shown in Figure 5-14 lists all of the various types of lubricants used in lubricating the whole aircraft. Additional information, such as application symbols, specification numbers, and symbols are provided in this table.

<table>
<thead>
<tr>
<th>IDENTIFICATION LETTERS</th>
<th>SPECIFICATION</th>
<th>TYPE OF LUBRICANT/COMPOUND</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRW</td>
<td>MIL-PRF-81322G</td>
<td>Grease Aircraft, General Purpose, Wide Temperature.</td>
</tr>
<tr>
<td>GIA</td>
<td>MIL-PRF-23827C</td>
<td>Grease Aircraft And Instrument, Gear And Actuator Screw.</td>
</tr>
<tr>
<td>GMD</td>
<td>MIL-PRF-21164D</td>
<td>Grease, Molybdenum Disulfide (For Low And High Temperature).</td>
</tr>
<tr>
<td>OAI</td>
<td>MIL-PRF-6085D</td>
<td>Lubricating Oil; Aircraft Instrument, Low Volatility.</td>
</tr>
<tr>
<td></td>
<td>MIL-PRF-6083F</td>
<td>Hydraulic Fluid, Petroleum Base, Preservative.</td>
</tr>
<tr>
<td>PL-SPECIAL</td>
<td>MIL-PRF-32033</td>
<td>Lubricating Oil, General Purpose, Preservative (Water Displacing, Low Temperature).</td>
</tr>
<tr>
<td>GOS</td>
<td>MIL-PRF-10324A or Silogram APG 75 (Alternate)</td>
<td>Lubricating Oil, Gear, Sub-Zero.</td>
</tr>
<tr>
<td>†(NONE)</td>
<td>MIL-PRF-16173E</td>
<td>Corrosion Preventive Compound, Solvent Cutback, Cold Application.</td>
</tr>
<tr>
<td>††(NONE)</td>
<td>MIL-PRF-81309</td>
<td>Corrosion Preventive Compound, Water Displacing, Ultra Thin Film.</td>
</tr>
</tbody>
</table>

Figure 5-14—Lubrication chart.
You should use the MRCs as a guide to the lubrication of aircraft. Figure 5-15 shows the front and back of these cards, which cover one specific area of aircraft lubrication. The top section of the card gives the card number, MRC publication number, frequency of application, time to do this section of cards, manpower required, name of area being lubricated, and if electrical/hydraulic power is needed. The card illustrates the unit to be lubricated, and the number and types of fittings. The type of grease or oil to be used is listed with each item.

![Figure 5-15 — Typical lubrication MRC.](image)
2. Lubricate right main landing gear and doors as follows:

<table>
<thead>
<tr>
<th>ITEM NOMENCLATURE</th>
<th>NO. OF POINTS</th>
<th>SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timer Valve Striker</td>
<td>2</td>
<td>MIL-PRF-23827</td>
</tr>
<tr>
<td>Actuating Cylinder Wiper Seal</td>
<td>1</td>
<td>MIL-PRF-83282</td>
</tr>
<tr>
<td>Downlock Mechanism</td>
<td>6</td>
<td>MIL-PRF-23827</td>
</tr>
<tr>
<td>Drag Brace Center Pivot</td>
<td>2</td>
<td>MIL-PRF-23827</td>
</tr>
<tr>
<td>Lower Drag Brace, Lower End</td>
<td>3</td>
<td>MIL-PRF-23827</td>
</tr>
<tr>
<td>Upload Rollers</td>
<td>2</td>
<td>MIL-PRF-81322</td>
</tr>
<tr>
<td>Shock Absorber Swivel Mechanism</td>
<td>7</td>
<td>MIL-PRF-23827</td>
</tr>
<tr>
<td>Actuating Cylinder</td>
<td>2</td>
<td>MIL-PRF-23827</td>
</tr>
<tr>
<td>Shock Absorber Tunion</td>
<td>2</td>
<td>MIL-PRF-23827</td>
</tr>
<tr>
<td>Tie-down Shackles</td>
<td>4</td>
<td>MIL-PRF-23827</td>
</tr>
<tr>
<td>Lower Drag Brace, Upper End</td>
<td>2</td>
<td>MIL-PRF-23827</td>
</tr>
<tr>
<td>Torque Links</td>
<td>6</td>
<td>MIL-PRF-23827</td>
</tr>
<tr>
<td>Upper Drag Brace, Lower End</td>
<td>1</td>
<td>MIL-PRF-23827</td>
</tr>
<tr>
<td>Upload Mechanism</td>
<td>2</td>
<td>MIL-PRF-23827</td>
</tr>
</tbody>
</table>

3. Repeat task 2 for left main landing gear and doors.

NOTE: All removed screws/fasteners are to be dipped or sprayed with corrosion preventive compound (Grade 4) prior to installing. Covers must be wiped clean after installation.

4. Install access panels 318, 356, 372 and 404.

Figure 5-15 — Typical lubrication MRC—Continued.
Prior to lubricating any parts, consult the MIMs or MRCs for proper equipment and type of lubricant. Consult the MSDS for any special safety precautions. Remove all foreign matter from joints, fittings, and bearing surfaces. A clean, lint-free cloth soaked with a cleaning solvent may be used for this purpose. The lubricant should be applied sparingly to prevent accumulation of dust, dirt, and other foreign matter.

When you apply lubricants through pressure-type fittings with a grease gun, make sure the lubricant appears around the bushing. If no grease emerges around the bushing, check the fitting and grease gun for proper operation. You should make sure the grease gun is properly attached to the fitting, and wipe up all excess grease when done. If the flush-type fitting is being used, the grease gun must be equipped with the flush-type adapter. Hold the adapter perpendicular to the surface of the fitting when you use the gun. A 15-degree variation is permitted.
AIRCRAFT HOISTING SLINGS

There are three main conditions that might require you to hoist an aircraft or its components. They are aircraft mechanical problems, ship mechanical problems, and aircraft mishap afloat or ashore. Aircraft lifting slings are specialized items of support equipment whose function is to aid in the hoisting of aircraft and aircraft components. Each airframe has structural lifting points for the attachment of a sling designed to lift that aircraft or aircraft subassembly. Slings are used to hoist aircraft from the pier to the carrier deck, clear crash-damaged aircraft, and to remove and install engines and other components during maintenance operations. In general, slings are hand portable and attach to a single suspension hook of a crane or other hoisting equipment.

LIFTING SLINGS IDENTIFICATION

Aircraft lifting slings are constructed in accordance with MILSPEC MIL-S-5944, and can be classified under four types of construction or combinations of type. The four types are the wire rope, the fabric or webbing type, the structural steel or aluminum type, and the chains.

Wire Rope

Slings of this type employ wire rope or cable. The wire rope sling is the most common type, and it combines high strength, ease of manufacture, and a great deal of flexibility for compact storage. There are two basic types of wire rope slings. The simplest is a multi-legged wire rope sling with an apex-lifting link. The other is one built with structural steel or aluminum in combination with wire rope supports. See Figure 5-16.

Fabric or Webbing

Fabric or webbing-type slings are generally reserved for lifting lightweight objects or applications where contact between wire rope and the component being lifted could result in damage.

Structural Steel or Aluminum

Slings of this type are constructed with plates, tubing, I-beams, and other structural shapes, and they do not contain flexible components. (See Figure 5-17.) Structural steel and aluminum slings are generally compact in size, and they are often used for lifting aircraft subassemblies.
Chains
Chains are generally used in combination with one of the other types of sling construction. (See Figure 5-18.) A chain with a chain adjuster provides a simplified method of shifting the lifting point on a sling to match the component's center of gravity under a variety of hoisting configurations.

Figure 5-18 — Combination wire rope and chain sling.

LIFTING SLING MAINTENANCE
Load-bearing cables, chains, straps, and other structural members of hoisting and restraining devices are subject to wear and deterioration. It is necessary that these components be inspected and lubricated periodically to ensure safe and proper operation. On initial receipt of equipment or return of equipment from depot-level repair, the Fleet Repair Center (FRC) will perform a visual inspection of the hardware for missing or damaged components. Upon completion of the inspection, the FRC will tag all equipment in accordance with the Inspection and Proofload Testing of Lifting Slings and Restraining Devices for Aircraft and Related Components manual, NAVAIR 17-1-114.

Preinstallation Inspection
Before each use, or once a month as in the case of emergency handling slings, a complete visual inspection of wire rope, fabric or webbing, structural steel or aluminum, and chain slings must be performed.

WARNING
Slings that fail to pass the inspections, or slings suspected of having been used during hoisting operations beyond the rated capacity of the sling, will not be used under any circumstance. Unsuitable slings are forwarded to the applicable Aircraft Intermediate Maintenance Department for further analysis and disposition.
WIRE ROPE — To assist in understanding various inspection criteria for wire rope, a basic knowledge of wire rope construction is required. Each individual cylindrical steel rod or thread is known as a wire. Each group of wires twisted together forms a strand. A group of strands twisted around a central core is known as a wire rope or cable. A filler wire is a wire used to fill the voids between wires in a strand and between strands in a wire rope. They provide stability to the shape of the strand or wire rope with little strength contribution. Wire rope construction is designated by two numbers, the first being the number of strands in a cable, and the second being the number of wires in each strand. The following wire rope constructions are used in the fabrication of aircraft hoisting slings. See Figure 5-19.

7 Wires per strand

7 x 7 Wire Rope

6 Wires per cable

6 x 19 (IWRC) Wire Rope

$7 \times 7$ Independent Wire Rope Core (IWRC)

19 Wires per stand

$7 \times 19$ Wire Rope

19 Wires per stand

$7 \times 19$ Independent Wire Rope Core (IWRC)

Figure 5-19 — Cross sections of wire rope.

A $7 \times 7$ wire rope consists of six strands of seven wires each twisted around a single core strand of seven wires. The $7 \times 7$ construction is used on wire ropes measuring 1/16 and 3/32 inch in diameter. Similarly, $7 \times 19$ wire rope is constructed with six strands of 19 wires each twisted about a core strand also containing 19 wires. The $7 \times 19$ wire ropes measure from 1/8 to 3/8 inch in diameter. A $6 \times 19$ independent wire rope core (IWRC) cable consists of six strands, each containing 19 wires twisted about a core that is of a $7 \times 7$ construction. The $6 \times 19$ (IWRC) wire rope measures from 7/16 to 1 1/2 inches in diameter. During the inspection of a wire rope, the measurements of the diameter and lay length (pitch length) often lead to confusion. The diameter and lay length are defined as follows:

1. Diameter. The diameter of a wire rope is the diameter of a circle circumscribed around the cable cross section. Figure 5-20 shows the proper method of measuring the diameter of a wire rope.

2. Lay Length. The distance, parallel to the axis of the cable, in which a strand makes one complete turn about that axis is known as the lay length or pitch length. Figure 5-21 shows the lay length of a wire rope.

Wire rope cables are visually inspected for knots, fraying, stretching, abrasions, severe corrosion, and other signs of failure. Of particular importance is the detection of a cable in which a kink has been
pulled through in order to straighten the cable. The resultant deformation is known as a bird cage. See Figure 5-22. In such a case, the sling should be discarded.

The presence of one or more broken wires in one rope lay length or one or more broken wires near an attached fitting is cause for replacement. If a broken wire is the result of corrosion or if the cable is excessively corroded, the cable must not be used regardless of the number of broken wires. Replace cables exhibiting rust and development of broken wires in the vicinity of attached fittings. Replace wire ropes evidencing bulges, core protrusions, or excessive reductions in rope diameter.

**FABRIC OR WEBBING** — Fabric or webbing straps must be visually inspected for cuts, holes, severe abrasions, mildew, dry rot, broken stitches, frays, and deterioration. Deterioration may be caused by contact with foreign materials such as oil, fuel, solvents, caustic fluids, dirt, and lye. The existence of any of the above conditions renders the sling unserviceable. Twists, knots, and similar distortions must be corrected before use.

**STRUCTURAL STEEL OR ALUMINUM** — Visually inspect all terminals, shackles, lugs, and structural members for misalignment, wear, corrosion, deformation, loosening, slippage, fractures, open welds, pitting, and gouges. Examine slides and screw adjusters for burrs, misalignment, and ease of operation. Inspect sling attachment bolts and pins for elongation, wear, deformed threads, and other signs of imminent failure.

**CHAINS** — Chains must be visually inspected for stretched links, wear gouges, open welds, fractures, kinks, knots, and corrosion. Examine chain attachment fittings and adjusters for security, wear, corrosion, and deformation.

**Lubrication, Transportation, and Storage Requirements**

Examine and lubricate all slings once a month in accordance with NAVAIR 17-1-114. When transporting slings, they should be carried at all times. Dragging slings over floors, runways, decks, and obstructions can cut or severely abrade the material. This malpractice results in an unserviceable sling. Whenever possible, slings should be stored indoors in a clean, dry, well-ventilated area so as to be protected from moisture, salt atmosphere, and acids of all types. In addition, slings constructed with nylon or other fabric materials should be stored in such a way as to prevent contact with sharp objects, high temperatures, and sunlight. Fabric materials deteriorate rapidly from prolonged exposure to sunlight or excessive heat, severely reducing strength and service life. Where practicable, slings should be securely fastened to overhead storage racks to prevent accidental damage. Avoid laying slings on ash or concrete floors.
**Hoisting Restrictions**

There are many restrictions to hoisting for each type of aircraft. Most hoisting restrictions are the same as for jacking aircraft. If you violate any of these restrictions, there is a good chance that you will have an accident, damage the aircraft, or injure someone. The restrictions generally concern aircraft gross weight and configuration. Some of the considerations are access (stress) panels on or off, external stores on or off, and wings folded or spread.

There are many factors that can affect the safety of the aircraft and personnel during hoisting operation. For details on restrictions and for the proper installation of any sling, consult the applicable MIM. Don't forget that many squadrons have their own local standing instructions for hoisting aircraft that contain additional safety precautions and restrictions. You must know these precautions and restrictions as well.

Prior to carrier operation, aircraft hoist points are inspected for serviceability and easy access in an emergency. For details on how to accomplish this inspection on your aircraft, consult the applicable MIM.

**AIRCRAFT JACKING**

The following text will familiarize you with the various types of jacks, their use, and general safety procedures. You will become familiar with jack identification, preoperational inspections, and jacking procedures.

**JACK IDENTIFICATION**

All aircraft hydraulic jacks are either axle or airframe (tripod) jacks. These jacks use standard, authorized aircraft hydraulic fluid. They have a safety bypass valve that prevents damage when a load in excess of 10 percent over the rated capacity is applied. For example, the safety valve on a 10-ton jack will bypass fluid at 11 tons of pressure.

**Axle Jacks**

Axle jacks are used for raising one main landing gear or the nose gear of an aircraft for maintenance of tires, wheels, and struts. There are four different types of axle jacks and many different sizes (lifting capacity in tons). The smaller hydraulic axle jacks are normally squadron or unit permanent custody equipment. That means your outfit is responsible for making sure the jacks are load tested at the support equipment (SE) division of the FRC before being put into service, and annually thereafter. Special inspections include 13-week inspections at FRC SE, but a load test is not required every 13 weeks. A record of maintenance, inspections, technical directives, and load testing is kept on OPNAV Form 4790/51.

All model designations for axle jacks begin with the letter A, for axle, such as A10-1HC. The number following the A shows the jack capacity in tons, such as 10 for a 10-ton jack. This is followed by a dash (-) and the specific jack identification number. Then comes two letters that show the type of jack (HC = hand-carried, HS = horseshoe, and OR = outrigger). The three types of axle jacks are discussed in the following text.
HAND-CARRIED — These axle jacks (Figure 5-23) are portable, self-contained units, with single or double manually operated pumps. They have carrying handles, pump handles, reservoir vent valves, release valves, and safety valves. The different model sizes vary from 4 3/4 inches to 9 inches high (closed). Their weights vary from 26 to 120 pounds.

HORSESHOE — Horseshoe axle (Figure 5-24), or crocodile jacks, consist of a lifting arm supported by two hydraulic cylinders. The cylinders move up over the stationary pistons when the manual pump operates. The A25-1HS is a large jack—5 feet long, 5 feet 8 inches wide, standing 2 feet 1 3/4 inches high, and weighing 900 pounds.

OUTRIGGER — This cantilever axle jack (Figure 5-25) is a very large and heavy jack. It weighs 2,190 pounds and is 7 feet 3 inches long, 6 feet 8 inches wide, and 2 feet 3 inches high. A double (two-speed) pump mounts on the left-hand side of the frame to operate the hydraulic cylinder.

Airframe (Tripod) Jacks

Airframe (tripod) jacks are used for lifting the entire aircraft off the ground or deck. Airframe jacks are commonly called tripod jacks. You may hear them called wing, nose, fuselage, or tail jacks. These names come from the jack placement on the aircraft. The points for jacking vary with the type of aircraft, and can be found in the MIM for each type of aircraft.

There are two different types of tripod jacks—fixed height and variable height. Both are mobile, self-contained, hydraulically operated units. They consist of three basic assemblies. These assemblies are the hydraulic cylinder, the tubular steel wheel tripod leg structure, and the hydraulic pump. The main difference between the two types is that the tripod structure on a variable height jack can be adjusted to different heights by adding leg extensions.

All model designations for tripod jacks begin with the letter T, for Tripod, such as T10-2FL or T20-1VH5. The number following the T indicates the jack capacity in tons, such as 10 for a 10-ton jack. This is followed by a dash (-) and the specific jack identification number. Then comes two letters indicating the type of tripod jack (FH = fixed height, or VH = variable height). The number that follows the VH in variable height jacks indicates the number of leg extension
Figure 5-26 shows a T20-1VH5 jack with only two of five extension leg kits installed. Each leg extension kit increases the effective height of the basic jack by 18 inches. The airframe tripod jacks weight varies from 275 pounds to 837 pounds.

Several safety features are built into the tripod jacks. A locknut—also called a ring or collar—on the ram mechanically locks the ram in position. The locknut prevents the ram from settling in the event of hydraulic failure or inadvertent lowering. A safety bypass valve in the system bypasses fluid from the pump or ram when excessive pressure is built up.

Airframe (tripod) jacks are normally checked out from the SE division (FRC) when needed. Since transporting these heavy and cumbersome jacks is a problem, they often remain in custody of an organization for a prolonged period of time. The organization must be responsible for their care and cleanliness during periods when not in use. As with axle jacks, these jacks need to be load tested prior to being placed in service—and annually thereafter. Special inspections are performed every 13 weeks at FRC SE and recorded on the OPNAV Form 4790/51.

The MIM will show what type of aircraft jack to use at each position. During deployment, the jacks that are called for in the MIM may not be available. The Index and Application Tables for Aircraft Jacks, NAVAIR 19-70-46, contain a list of approved prime and alternate jacks for all Navy and Marine aircraft. It was prepared under the direction of the Commander, Naval Air System Command, by the Naval Air Engineering Center.
PREOPERATIONAL INSPECTION

The same basic safety precautions apply to all jacks. A good preoperational inspection should be conducted before use. NAVAIR 19-600-135-6-1 is the general pre-op MRC for all jacks. The jack must have been tested within the last 13 weeks and if the jack is dirty, it should be wiped down. Cracks or broken welds can’t be seen under dirt. If the jack is covered with hydraulic fluid, it may be leaking and should be inspected more closely.

The reservoir should be checked and it should be full with the jack ram fully collapsed. If the reservoir is low, it should be checked for leaks somewhere. The reservoir should be filled with clean, fresh, hydraulic fluid and the filler plug vent valve checked to make sure it is not clogged. If the plug is blocked, it may get an air lock, and the jack may not operate correctly. Pressure could also build up in the reservoir and cause a rupture. The pump handle needs to be checked for bends and the pump rocker arm and link for elongated or out-of-round holes. These are signs that the jack may have been overloaded, and that the safety bypass valve is malfunctioning.

With the filler plug air vent valve open and the release valve closed, the ram should be pumped up and checked for leaks and full extension. When the ram reaches full extension, the pumping pressure will increase. It is important not to continue to pump or it may cause damage to the internal ram stops because there is no load on the jack.

The ram and screw should be lowered out the extension screw, but not forcibly overextended past the internal stops. It should be checked that it is clean and oiled. If it is dirty, it should be wiped clean and coated with a light film of MIL-PRF-7870 oil.

On jacks equipped with wheels, the wheels and springs suspension assemblies must be checked to make sure they are in good condition. Towing or dragging these jacks around with broken wheels will damage the frame or reservoir.

Since many leaks in jacks will only appear when the jack is under a load, possible leaks can be found when jacking the aircraft. If a leak or other defect is found during the preoperational inspection, use of the jack should be discontinued. The jack should be downed, red-lined, tagged as bad, reported, and turned into the SE division (FRC) for repairs. A defective jack should never be left where someone else may use it.

HANDLING AND MOVEMENT

Handling airframe jacks can be hazardous. The jacks are heavy—anywhere from 110 to 900 pounds—and the wheels are free-swiveling and small. Directional stability is poor, and pushing one into position around an aircraft is no simple chore. A jack moved or positioned by one person is hazardous. If the jack is dirty and covered with grease or fluid, it’s even more hazardous. The jack footplates and wheels at the base of the tripod stick out, and are notorious "foot-crunchers" and "shin-knockers." It's not hard to damage an aircraft tire, wheel brake assembly, hydraulic lines, landing gear door, or any other part of an aircraft if someone is careless and rams it with a jack.

Movement of jacks aboard ship during any pitch or roll of the deck is extremely hazardous. Even with a calm sea, a smart turn into the wind by the ship while you’re moving an airframe jack can be disastrous. Movement of jacks from hangar to hangar, through hangar bays, and across hangar tracks and ramp seams can easily damage a jack and put it out of commission—just when someone needs it!

Transportation of jacks over longer distances ashore, such as from the SE pool to a hangar on the other side of the field, can be a real problem. If the SE division (FRC) has locally fabricated a special "jack transporter" trailer, you’re in luck. If any other type of trailer, truck, or flatbed is used, sufficient manpower must be available to get the jacks on and off the vehicle safely. Jacks are heavy and cumbersome to handle. Loading and unloading is hazardous even when there are enough people.
Usually, a locally fabricated sling and some sort of hoist are necessary. Forklifts should never be used to handle or lift jacks. The tripod cross braces are not strong enough, and this will damage the jack. The chances of dropping it are also high. Forklifts must NOT be used to handle jacks.

The wheels on a tripod jack are not made for towing the jack. They are small, allow only a couple of inches of clearance, and are spring loaded. Bouncing over uneven surfaces will usually cause the jack footplates to hit the ground, and that can spin the jack around, tip it over, or damage the tripod structure. Airframe jacks don't have tow bars, the wheels can't be locked in position so they track, and there are no brakes. NEVER try to tow airframe jacks.

Free-swiveling casters and no brakes also mean that jacks can move by themselves if not properly secured. A loose, 900-pound tripod jack on a pitching hangar deck could be disastrous. Jacks can also be moved by jet or prop blast. Therefore, any jack that isn't tied down can be a hazard. Since there are no tie-down rings on the jacks, care must be taken in attaching the tie-down chains or ropes to prevent damage to the jack. This is particularly true aboard ship where the jacks are likely to be "working" against the tie-downs in rough seas.

**General Hazards**

The extension screws on jacks have a maximum extension range. This range is stenciled on the jack. An internal stop prevents overextending the screw. If the screw is forcibly overextended—which isn't hard to do—not only could damage be done to the internal stop mechanism, but the jack may be rendered unsafe and hazardous to use. An overextended screw is very likely to bend or break off from any side motion.

Each extension screw on a jack is equipped with a jack pad socket. The aircraft jack pad fits into this socket and into a fitting or socket in the aircraft. The sockets and pads are designed to take vertical loads but not much horizontal pressure. The pads can shear or slip from either the jack or aircraft socket if enough side load is applied.

Side loads normally result when the jacks are not raised at the same rate. This causes the aircraft to tilt or pitch. When that happens, the distance between the jacking points becomes closer in the ground plane—like the ends of a ruler will cover less distance across a desk top as you raise one end. With the weight of the aircraft holding the jacks in one place, that "shrink" in distance between the jack points creates a tremendous side load on the jacks, and eventually they will break or slip. The same thing happens if all the jacks aren't lowered at the same rate to keep the aircraft level or at the same attitude it was in when jacking started.

Lowering the jack can be very hazardous. The rate of descent of a jack depends on how far the release valve is opened. Control can be very tricky when trying to coordinate three jacks at once. Usually, it takes only a small amount of rotation on the valve to get a fast rate of descent. If the valve was tightened hard before jacking, it will take force to open it. Care must be taken so extra force doesn’t cause the valve to open more than expected. The valves may vary in different jacks, so it is best to get an idea of how an individual release valve reacts during the preop check. But remember it comes down a lot quicker with a 30-ton load than with a 5-ton load.

There is a safeguard to prevent the jack from lowering too fast—the safety locknut. The safety locknuts on jacks are a very important safeguard in preventing the aircraft from falling off the jacks in the event of jack failure. However, using them during raising, and particularly during lowering operations, is hazardous to hands and fingers. To be effective, the locknut must be kept about one-half thread above the top surface of the jack (the top of the ram cylinder or second ram, depending upon the model of jack). It is important to carefully keep fingers and hands clear of the area between the locknut and cylinder head so they won't be pinched or crushed. This will be easier while the jack is being raised and the locknut rotated down. Variable height jack rams have spiral grooves, which allow the locknut to rotate down the ram by its own weight. However, this means that while lowering
the jack, the locknut must be held up as it is rotated up the ram. This makes it more dangerous. Depending upon the height of the jack, it normally takes two people to operate the jack and the safety nut. Do NOT try to do it by yourself.

**Jacking Restrictions**

There are many restrictions to jacking for each type aircraft. If any of these restrictions are violated, there is a good chance that there will be an accident, damage to the aircraft, or injury. The restrictions generally concern aircraft gross weight and configuration. Some of the considerations are fuel dispersion in fuselage and wing tanks, engines in or out, and tail hook up or down.

Details on restrictions and procedures are in the MIMs. These should be learned and followed exactly. Many squadrons will have their own local standing instructions for jacking aircraft, which contain additional safety precautions and restrictions to be followed.

**JACKING PROCEDURES**

The jacking procedures vary for each aircraft type and configuration. The procedures that follow are examples of what could be encountered. Fairly exacting steps are given to provide clarity. Remember, these steps are for representative type aircraft, and are not necessarily accurate for all. When actually jacking aircraft, the exact procedures described in the MIMs must be followed.

The location of the aircraft will determine what is needed for equipment. Jacking procedures on a ship require tie-down procedures to prevent aircraft from shifting on jacks. When tie-down chains are to be used, they should be positioned in accordance with the MIM, so as not to interfere with the landing gear during the drop check of the gear. Jacking procedures on land do not require tie-downs, except in high-wind conditions.

Aboard ship, squadron maintenance controls will request, through the carrier air group (CAG), permission to place an aircraft on jacks. The MIM should be checked for jacking restrictions, warnings, and cautions. The support equipment required by the MIM should be obtained, ensuring all preoperational inspections have been completed. All protective covers and ground safety devices should be installed, as required by the MIM. The surrounding area around the aircraft must be roped off during the entire aircraft jacking operation, and signs posted stating "**DANGER: AIRCRAFT ON JACKS.**" The area below and around the aircraft must be cleared of all equipment not required for the jacking operation. Jack adapters must be installed, as well as aircraft mooring adapters and tie-down chains as required by the MIM. *Figure 5-27* shows an example of carrier tie-down for aircraft jacking. Wing and nose jacks must be positioned and extended until seated on wing jack and tie-down adapters.
Raising Aircraft

Jack pressure should be applied on each jack without lifting the aircraft, and checked to see that the base of each jack is evenly seated. The base position of the jack should be corrected, as required, for firm base seating. For shipboard operations, all jacks must be tie-down before jacking aircraft with a minimum of three tie-down chains per jack. The jack must be tied down at the spring-loaded wheel caster mounts, allowing the jacks to make small movements with the aircraft jack points. The aircraft parking brake must be released and main landing gear chocks removed. The aircraft should be jacked evenly and tie-down chains extended while jacking. Extension of tie-down chains must be coordinated in a way that preload on each tie-down chain is partially removed before jacking. Partial preload is maintained with jacking of aircraft by rotation of the chain tensioning grip.

NOTE

Some aircraft require the extension of the center screw to provide for clearance of the gear doors.
As each jack is being extended, the lock collar must be screwed down. The aircraft should be jacked until its wheels clear the deck, and the lock collar set hand tight. Each tie-down chain must be set to preload by manually rotating and tightening tensioning grip.

**Leveling Aircraft**

An aircraft leveling technique is shown in *Figure 5-28*. Aircraft should be jacked at wing and nose jack point as described earlier. The plumb bob and string should be attached to the eye bolt at FS 259 (fuselage station) and positioned directly over the leveling plate on floor of aircraft. The aircraft should be leveled laterally (left to right) by adjusting wing jacks until the plumb bob tip is directly above the center line in the leveling plate. The aircraft should be leveled longitudinally (forward and aft) by adjusting the nose jack until the plumb bob tip is directly above FS 259 line on the leveling plate. This procedure varies greatly with different types of aircraft. The applicable MIM must be used to perform a leveling procedure.

**Lowering Aircraft**

The landing gear safety pins must be safely installed. The arresting hook should be retracted. The arresting hook safety pin should be installed or verified that it is installed. It must also be verified that the landing gear handle in the flight station is in the DN (down) position. Any exposed surfaces of the shock strut piston and nose oleo strut should be lubricated with clean hydraulic fluid.

**NOTE**

Wiping down oleo struts with hydraulic fluid helps to prevent them from sticking.

Jacking pressure should be applied and the lock collar on wing jacks and nose jack loosened. All jacks should be lowered evenly and slowly, while maintaining preload on tie-down chains by manually rotating tensioning grips. Jacks should be lowered until landing gear wheels are on deck and jacks are clear of jack pads by a safe margin.
The chocks must be installed and the parking brakes applied. The jacks should be removed. As required by the MIM, the jack adapters should be removed and the aircraft mooring adapters and tie-down chains installed or removed as required by the MIM. After the aircraft is secured and all protective covers and ground safety devices are installed, the area should be cleaned up and all equipment stowed.

HYDRAULIC CONTAMINATION CONTROL PROGRAM

Hydraulic contamination in Navy and Marine Corps aircraft and related support equipment (SE) is a major cause of hydraulic system and component failure. Every technician who performs hydraulic maintenance should be aware of the causes and effects of hydraulic contamination. Correct practices and procedures should be followed to prevent contamination. Supervisory and quality assurance personnel must know and ensure compliance with accepted standards. Each maintenance level needs to accept their applicable responsibility. Supervisory personnel at each level of maintenance should indoctrinate and train personnel and implement procedures that apply to that level of maintenance.

The Hydraulic Contamination Control Program is defined in the COMNAVAIRFORINST 4790.2 (series). Within the scope of this program, training must be consistent with the objectives of an effective aircraft hydraulic contamination control program. At all maintenance levels, personnel must be trained in matters pertaining to hydraulic systems contamination control using the Hydraulic Contamination Control Training Device 4B38A or Videotape Number 802577DN. The Hydraulic Contamination Control Program requires that the correct procedures be followed during fluid sampling, maintenance procedures, and practices.

FLUID SAMPLING

Contamination measurement standards and acceptability limits define and control hydraulic contamination levels. The maximum acceptable hydraulic fluid particulate level is Navy Standard Class 5 for naval aircraft and Navy Standard Class 3 for related SE. The contamination level of a particular system is determined by analysis of a fluid sample drawn from the system. Analysis is accomplished at all levels of maintenance through the use of the HACH Ultra Analytics Portable Oil Diagnostic System (PODS). Hydraulic system fluid sampling is accomplished on a periodic basis according to the applicable maintenance instruction manual (MIM), maintenance requirement cards (MRC), and rework specification. Figure 5-29 shows the requirements for periodic fluid surveillance.

CAUTION

Jacks should be promptly removed from the aircraft's underside to prevent structural damage to the aircraft in the event of settling.

WARNING

Make sure that the aircraft main and nose landing gear struts have settled to their normal position prior to entering main or nose landing gear wheel wells. Failure to allow landing gear to settle could result in personnel injury.
Analysis of hydraulic systems should be performed if extensive maintenance and/or crash/battle damage occurs. Analysis should be performed when a metal-generating component fails, an erratic flight control function or a hydraulic pressure drop is noted, or there are repeated and/or extensive system malfunctions. Analysis is performed when there is a loss of system fluid, or when the system is subjected to excessive temperature. Analysis is also performed when an aircraft is removed from storage in accordance with NAVAIR 15-05-500. An analysis of the hydraulic system should also be performed any time hydraulic contamination is suspected.

![Figure 5-29 — Periodic fluid surveillance requirements.](image)

**MAINTENANCE PROCEDURES**

The general contamination control procedures and testing of hydraulic systems, subsystems, components, and fluids are requirements for each maintenance level. Hydraulic fluid contamination controls ensure the cleanliness and purity of fluid in the hydraulic system. Fluid sampling and analysis is performed periodically. Checks are made sufficiently before the scheduled aircraft induction date so that if fluid decontamination is required, it may be accomplished at that time. The condition of the fluid depends, to a large degree, on the condition of the components in the system. If a system requires frequent component replacement and servicing, the condition of the fluid deteriorates proportionately.

Replacement of aircraft hydraulic system filter elements takes place on a scheduled or conditional basis, depending upon the requirements of the specific system. A differential pressure flow check and bubble point test are performed to properly evaluate the condition of a cleanable filter element. These two checks are done to verify that the element is good before it is installed in a system or component. Many filter elements look identical, but not all of them are compatible with flow requirements of the system.

If the hydraulic system fluid is lost to the point that the hydraulic pumps run dry or cavitate, the defective pumps should be changed, the filter elements checked, and the system decontaminated as
required. The applicable MIM should be checked for corrective action to be taken regarding decontamination of the system. If this action is not taken, the complete system could be contaminated. Hydraulic systems and components are serviced by using approved fluid dispensing equipment only. Unfiltered hydraulic fluid should NEVER be introduced into systems or components.

All portable hydraulic test stands must receive the required periodic maintenance checks. Each unit must be approved and the applicable MIM should be readily accessible and up to date. When the portable hydraulic test stand is not in use, it should be protected against contaminants such as dust and water. It is important to ensure that correct hoses are used on each stand, and that they are approved for the type of fluid being used. Hoses should be properly capped when they are not being used. Hoses must be serialized and must remain with the equipment. The hoses must be coiled, kept free of kinks, and properly stowed. They should be in satisfactory condition and checked periodically. Any hose that exhibits fluid seepage from the outer cover or separation between the inner tube and the outer cover should be replaced. Portable hydraulic test stands that show indications of contamination or that have loaded (clogged) filters should be removed from service immediately and returned to the supporting activity for maintenance.

Only approved lubricants for O-ring seals should be used; incorrect lubricants will contaminate a system. Many lubricants look alike, but few are compatible with hydraulic fluids. The only approved O-ring seal lubricants are hydraulic fluid MIL-PRF-5606H, hydraulic fluid MIL-PRF-83282C, hydraulic fluid MIL-PRF-46170D, or a thin film of grease, MIL-PRF-81322F.

MAINTENANCE PRACTICES

Good housekeeping and maintenance practices help eliminate problems caused by contamination. Care must be taken when working on a hydraulic system in the open, especially under adverse weather conditions. Caution should be used when working on hydraulic equipment near grinding, blasting, machining, or other contaminant-generating operations. Often, harmful grit cannot be seen. Hydraulic systems should not be broken into unless absolutely necessary (this includes cannibalization). Proper tools should be used for the job. It is important to use only authorized hydraulic fluid, O-rings, lubricants, or filter elements. When dispensing hydraulic fluid, only an authorized fluid service unit should be used. The hydraulic fluid must be clean before it is installed. All empty hydraulic fluid cans and used hydraulic fluid must be disposed of in accordance with Navy and local hazardous material (HAZMAT) instructions. All hydraulic fluid should be in a closed container at all times.

All hydraulic test stand reservoirs should be kept above three-quarters full. All hydraulic lines, tubing, hoses, fittings, and components should be sealed with approved metal closures. Plastic plugs or caps should not be used because they are possible contamination sources. Quick-disconnect dust covers should be installed and unused caps and plugs should be stored in a clean container.

Exterior contaminants should be removed by using approved wiping cloths.Lint-free wiping cloths should be used on surfaces along the fluid path. If possible, the replacement component should be kept on hand for immediate installation upon removal of defective component. Filters should be replaced immediately after removal. If possible, the filter bowl should be filled with proper hydraulic fluid before it is installed to minimize the induction of air into the system. The differential pressure indicators should not be reset if the associated filter element is loaded and in need of replacement. When cleanable filter elements are removed from hydraulic systems, they should be put in individual polyethylene bags and forwarded to the intermediate- or depot-level maintenance activity for cleaning. Cleanable filter elements should NOT be cleaned by washing them in a container and blowing them out with shop air. Cleanable filter elements must be cleaned and tested according to applicable procedures before they are reused. All connections should be cleaned and the pressure and return lines of the stand should be interconnected. The hydraulic fluid should be circulated through the test stand filters before connecting portable hydraulic test stands to aircraft.
O-rings, tubing hoses, fittings, and components should be stored in clean packaging. Individual packages of O-rings or backup rings should not be opened or punctured until just before they are used. Used or unidentifiable O-rings should not be used. Seals or backup rings should be replaced with new items when they have been disturbed. The correct O-ring should always be used when O-rings are installed over threaded fittings to prevent threads from damaging the O-ring.

If packages of tubing, hoses, fittings, or components are opened when received or found opened, their contents should be decontaminated. The system should be decontaminated if it is suspected the system is contaminated with anything (including water). The working area where hydraulic components are repaired, serviced, or stored should be kept clean and free from moisture, metal chips, and other contaminants. Required period checks should be performed on equipment used to service hydraulic systems. Hydraulic fluid MIL-PRF-46170D should be used in stationary hydraulic test stands.

**TYPES OF CONTAMINATION**

There are many different forms of contamination, including liquids, gases, and solid matter of various compositions, sizes, and shapes. Normally, contamination in an operating hydraulic system originates at several different sources. The rate of its introduction depends upon many factors directly related to wear and chemical reaction. Contamination removal can reverse this trend. Production of contaminants in the hydraulic system increases with the number of system components. The rate of contamination from external sources is not readily predictable. A hydraulic system can be seriously contaminated by poor maintenance practices that lead to introducing large amounts of external contaminants. Poorly maintained SE is another source of contamination.

Contaminants in hydraulic fluids are classified as particulate and fluid contamination. They may be further classified according to their type, such as organic, metallic solids, nonmetallic solids, foreign fluids, air, and water.

**PARTICULATE CONTAMINATION**

The type of contamination most often found in aircraft hydraulic systems consists of solid matter. This type of contamination is known as “particulate contamination.”

The size of particulate matter in hydraulic fluid is measured in microns (millionths of a meter). The largest dimensions of the particle (using points on the outside of the particle as reference) are measured when determining its size. The relative size of particles, measured in microns, is shown in Figure 5-30. Table 5-5 shows the various classes of particulate contamination levels.
Contamination of hydraulic fluid with particulate matter is a principal cause of wear in hydraulic pumps, actuators, valves, and servo valves. Spool-type electro-hydraulic valves have been used in particle contamination experiments. The valves are easy to control and respond rapidly to repositioning. In these experiments, the valves were operated with both ultra clean and contaminated hydraulic fluids. The experiments proved that wear is accelerated by even small amounts of contamination. Contamination increases the rate of erosion of the sharp spool edges and general deterioration of the spool surfaces. Because of the extremely close fit of spools in servo valve housings, the valves are particularly susceptible to damage or erratic operation when operated with contaminated hydraulic fluid.

**Organic Contamination**

Organic solids or semisolids are one of the particulate contaminants found in hydraulic systems. They are produced by wear, oxidation, or polymerization (a chemical reaction). Organic solid contaminants found in the systems include minute particles of O-rings, seals, gaskets, and hoses. These contaminants are produced by wear or chemical reaction.

Oxidation of hydraulic fluids increases with pressure and temperature. Antioxidants are blended into hydraulic fluids to minimize such oxidation. Oxidation products appear as organic acids, asphalts, gums, and varnishes. These products combine with particles in the hydraulic fluid to form sludge. Some oxidation products are oil soluble and cause an increase in hydraulic fluid viscosity, while other oxidation products are not oil soluble and form sediment. Oil oxidation products are not abrasive. These products cause system degradation because the sludge or varnish-like materials collect at close-fitting, moving parts, such as the spool and sleeve on servo valves. Collection of oxidation products at these points causes sluggish valve response.

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Table 5-5 — Particle Contamination Level by Class

<table>
<thead>
<tr>
<th>MICRON SIZE RANGE</th>
<th>ACCEPTABLE</th>
<th>UNACCEPTABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2,700</td>
<td>128,000</td>
</tr>
<tr>
<td>1</td>
<td>4,600</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>9,700</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>24,000</td>
<td></td>
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<tr>
<td>4</td>
<td>32,000</td>
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</tr>
<tr>
<td>5</td>
<td>87,000</td>
<td></td>
</tr>
<tr>
<td>6</td>
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<td>10</td>
<td>670</td>
<td>42,000</td>
</tr>
<tr>
<td>25</td>
<td>210</td>
<td>6,500</td>
</tr>
<tr>
<td>50</td>
<td>16</td>
<td>1,000</td>
</tr>
<tr>
<td>OVER 100</td>
<td>1</td>
<td>92</td>
</tr>
<tr>
<td>Total</td>
<td>3,480</td>
<td>177,592</td>
</tr>
</tbody>
</table>

Notes:
1. The class of contamination is based upon the total number of particles in any size range per 100 ml of hydraulic fluid. Exceeding the allowable particle count in any one or more size range requires that the next higher class level be assigned.
2. Class 5 is the maximum acceptable contamination level for hydraulic systems in Naval aircraft. Fluid delivered by SE to equipment under test or being serviced must be Class 3, or cleaner.
3. The Class 5 level of acceptability shall be met at the inspection interval specified for the equipment under test.
Metallic Solid Contamination

Metallic solid contaminants are usually found in hydraulic systems. The size of the contaminants will range from microscopic particles to those you can see with the naked eye. These particles are the result of the wearing and scoring of bare metal parts and plating materials, such as silver and chromium. Wear products and other foreign metal particles, such as steel, aluminum, and copper, act as metallic catalysts in the formation of oxidation products. Fine metallic particles enter hydraulic fluid from within the system. Although most of the metals used for parts fabrication and plating are found in hydraulic fluid, the major metallic materials found are ferrous, aluminum, and chromium particles.

Hydraulic pumps usually contribute the most contamination to the system because of their high-speed, internal movement. Other hydraulic systems produce hydraulic fluid contamination due to body wear and chipping.

Hydraulic actuators and valves are affected by contamination. Large metallic or hard nonmetallic particles collect at the seal areas. These particles may groove the inside wall of the actuator body due to a scraping action. Smaller particles act as abrasives between the seals and the actuator body, causing wear and scoring. Eventually, the fluid leaks and the seals fail because the seal extrudes into the enlarged gap between the piston head and the bore of the actuator body. Once wear begins, it increases at a faster rate because wear particles add to the abrasive material. In a similar manner, metallic or nonmetallic parts may lodge in the poppets and poppet-seat portions of valves and cause system malfunction by holding valves open.

Inorganic Solid Contamination

The inorganic solid contaminant group includes dust, paint particles, dirt, and silicates. These and other materials are often drawn into hydraulic systems from external sources. The wet piston shaft of a hydraulic actuator may draw some of these foreign materials into the cylinder past the wiper and dynamic seals. The contaminant materials are then dispersed in the hydraulic fluid. Also, contaminants may enter the hydraulic fluid during maintenance when tubing, hoses, fittings, and components are disconnected or replaced. To avoid these problems, all exposed fluid ports should be sealed with approved protective closures.

Glass particles from glass bead peening and blasting are another contaminant. Glass particles are particularly undesirable because glass abrades synthetic rubber seals and the very fine surfaces of critical moving parts.

FLUID CONTAMINATION

Hydraulic fluid can be contaminated by air, water, solvents, and foreign fluids. These contaminants and their effects are discussed in the following text.

Air Contamination

Hydraulic fluids are adversely affected by dissolved, entrained, or free air. Air may be introduced through improper maintenance or as a result of system design. Air is sometimes introduced when changing filters. This kind of contamination can be minimized by putting hydraulic fluid into the filter holder before reassembling the filter. By doing this, less air is introduced into the hydraulic system. The presence of air in a hydraulic system causes spongy response during system operation. Air causes cavitation and erodes hydraulic components. Air also contributes to the corrosion of hydraulic components.

Water Contamination

Water is a serious contaminant of hydraulic systems. Corrective maintenance actions must be taken to remove all free or emulsified water from hydraulic systems. Hydraulic fluids and hydraulic system
components are adversely affected by dissolved, emulsified, or free water. Water may be induced through the failure of a component, seal, line, or fitting; poor or improper maintenance practices; and servicing. Water may also be condensed from air entering vented systems.

The presence of water in hydraulic systems can result in the formation of undesired oxidation products, and corrosion of metallic surfaces will occur. These oxidation products will also cause hydraulic seals to deteriorate and fail, resulting in leaks. If the water in the system results in the formation of ice, it will reduce fluid flow and impede the operation of valves, actuators, or other moving parts within the system. This is particularly true of water located in static circuits or system extremities and subject to high-altitude, low-temperature conditions. Microorganisms will grow and spread in hydraulic fluid contaminated with water. These microorganisms will clog filters and reduce system performance.

**Solvent Contamination**

Solvent contamination is a special form of foreign-fluid contamination. The original contaminating substance is a chlorinated solvent introduced by improper maintenance practices. It is extremely difficult to stop this kind of contamination once it occurs. This type of contamination can be prevented by using the right cleaning agents when performing hydraulic system maintenance.

Chlorinated solvents, when allowed to combine with minute amounts of water, hydrolyze to form hydrochloric acids. These acids attack internal metallic surfaces in the system, particularly those that are ferrous, and produce severe rust-like corrosion that is virtually impossible to arrest. Extensive component overhaul and system decontamination are generally required to restore the system to an operational status.

**Foreign Fluids Contamination**

Contamination of hydraulic fluid can occur when the wrong fluids get into the system, such as oil, engine fuel, or incorrect hydraulic fluids. For instance, hydraulic oil coolers, which are used in some aircraft, may leak and cause contamination of hydraulic fluids. If contamination has occurred, the system must be checked by chemically analyzing fluid samples. This analysis is conducted by the cognizant engineering activity, which verifies and identifies the contaminant and directs decontamination procedures.

The effects of foreign fluid contamination depend upon the nature of the contaminant. The compatibility of the construction materials and the system hydraulic fluid with the foreign fluid must be considered when dealing with contamination. Other effects of this type of contamination are hydraulic fluid reaction with water and changes in flammability and viscosity characteristics. The effects of contamination may be mild or severe, depending upon the contaminant, how much is in the system, and how long it has been there.

**SAMPLING POINTS**

A fluid sampling point is a physical point in a hydraulic system from which small amounts of hydraulic fluid are drawn to analyze it for contamination. Sampling points include air bleed valves, reservoir drain valves, quick-disconnect fittings, removable line connections, and special valves installed for this specific purpose.

Hydraulic fluid sampling points for most naval aircraft are designated in the applicable MIM. Two major factors determine if a sampling point is adequate—its mechanical feature and its location in the system. To determine the contamination level, a single fluid sample is required. This sample must be representative of the working fluid in the system, and it should be a "worst case" indication of the system particulate level. The worst case requirement is necessary because the particulate level in an
operating system is not constant throughout the system. Instead, particulate levels differ because of the effects of components (such as filters) on circulating particulates.

The mechanical features of a prospective sampling point are evaluated on the basis of accessibility and ease of operation. The sampling point should not distort the particulate level of the sampled fluid either by acting as a filter or by introducing external or self-generated contaminants. The latter point is particularly critical. The introduction of external or self-generated contaminants can be minimized before collecting a sample by cleaning the external parts of the valve or fitting and by dumping a small amount of the initial fluid flow.

Consideration must also be given to removal of any static fluid normally entrapped between the actual sampling point and the main body of the fluid to be sampled. To remove this, an initial quantity of the sampled fluid should be dumped. Problems may be encountered where a long line is involved, as in certain reservoir drain lines. The fluid sample should be taken from a main system return line, pump suction line, or system reservoir. Also the sample should be taken upstream of any return or suction line filters that may be present. Reservoir samples should not be taken in a system that has a makeup reservoir, or if the reservoir is bypassed during SE-powered operation. A makeup reservoir is a configuration in which all of the system’s return line fluid does not pass through the reservoir. Fluid exchange in the reservoir is limited, and results only from the changes in fluid volume that occurs elsewhere in the system.

The sampling point should be usable after an aircraft flight, without requiring the use of external SE. Taking a sample with the aircraft engines turning is satisfactory, provided no personnel hazards are involved. The sampling point should be usable when the system is being powered by external SE, or immediately after such an operation.

The sampling point should be next, or reasonably close, to the main body or stream of fluid being sampled. A minimum amount of static fluid is acceptable; however, it should be purged when the sample flow is started. The sample should not be taken from a point in an area of high sedimentation. If this cannot be avoided, care must be taken that sedimentation effects are minimized by discarding an initial quantity of the sample fluid drawn. Ideally, sample fluid should be obtained from turbulent high-flow areas.

When a sample is taken at the sampling point, significant external contaminants should not be introduced into the fluid collected. The background level attributable to the sample point itself should not exceed 10 percent of the normally observed particulate level if the external parts of the valve or fitting are pre-cleaned and the valve or fitting is self-flushed before the sample is taken. The internal porting of the sampling point should not impede the passage of hard particulate matter up to 500 microns in diameter. The sampling point should be accessible and convenient. There must be sufficient clearance beneath the valve or fitting to position the sample collection bottle. Under normal system operating pressure, the sample fluid flow rate should be between 100 and 1,000 milliliters per minute (approximately 3 to 30 fluid ounces). The flow rate should be manageable, and the time required to collect the required sample should not be excessive. The mechanical integrity of the sampling valve or fitting should not degrade because of repeated use. When not in use, it is mechanically secured in the closed position.

**ANALYSIS METHODS**

Contamination analysis is used to determine the particulate level of a hydraulic system and the presence of free water or other foreign substances. The methods used to identify and measure contamination is the HACH Ultra Analytics Portable Oil Diagnostic System (PODS) and the patch testing System. The Contamination Analysis Kit 57L414 shall be used for testing only if electronic particle count testing is not available either directly or via the appropriate supporting Intermediate Level (I-level) activity or Navy Oil Analysis Program (NOAP) laboratory.
HACH Ultra Analytics Portable Oil Diagnostic System (PODS)

The PODS is an intelligent, portable, and durable analysis instrument for measuring, storing, and reporting oil contamination levels important for maintaining reliable hydraulic systems operation, shown in Figure 5-31. The PODS can analyze fluid either in the bottle sampling mode or the online sampling mode. There are currently two versions of the PODS: Type 1, MXU-973E and Type 2, MXU-976E. Type 1 can analyze MIL-PRF-83282C and MIL-PRF-5606H and is compatible with most petroleum-based fluids. Type 1 is not compatible with phosphate ester-based fluids (e.g. Skydrol). Type 2 is compatible with phosphate ester-based hydraulic fluids, synthetic and petroleum-based fluids. Figure 5-32 shows the features included on the keypad. To prevent fluid cross contamination, the Type 2 PODS is used only for phosphate ester-based hydraulic fluids. The unit is capable of online sampling at pressures and temperatures up to 13.8 bar (200 psig) and 131°F (55 °C), respectively. In bottle sampling mode, the PODS require a clean, dry, steady, pressurized air source. The PODS accessory case contains both an electric-driven compressor and two refillable CO2 bottles. The CO2 bottles are quieter and take less space than the compressor. Electronic particle counters are used to determine counts of the number of particles in the various size ranges. The counts obtained are compared with the maximum allowable under Navy Standard Class 5. Counts that exceed the maximum allowable in any size range make the fluid unsuitable for use in Navy aircraft. The test results obtained by using automatic particle counters and the contamination analysis kit are not always precisely the same. Automatic particle counters optically sense particles contained in the fluid sample and electronically size and count them. Most fleet equipment is calibrated so that the smallest particle counted has an effective diameter of 5 microns. Particles smaller than 5 microns, although always present, do not affect the particle count. The contamination analysis kit uses a patch-test method in which the fluid is filtered through a test-filter membrane. The sample causes the membrane to discolor proportionally to the particulate level. The test filters used have a filtration rating of 5 microns (absolute). However, they also retain a large percentage of those particles less than 5 microns in size. The contamination standards provided with the contamination analysis kit are representative of test indications that result if the fluid sample has a particle size distribution (number of particles versus size) typical of that found in the average naval aircraft. Samples from aircraft systems having typical particle size distributions will, therefore, show good correlation if tested using both particle count and patch test methods.
Some operating hydraulic systems have peculiar design characteristics, so they produce a particle size distribution different from that found in typical naval aircraft. Fluid samples from these systems generally contain an abnormally large amount of silt-like particles smaller than 5 microns in size. Experience has shown that this condition results from inadequate system filtration or from using hydraulic components that have abnormally high wear rates. It is this type of fluid sample that could produce different results when tested, using both particle-counting and patch-test methods. The difference is caused by the particle counter not counting those particles smaller than 5 microns, while many of them are retained by the patch-test filter membrane, causing it to discolor proportionately. When test results conflict, the equipment tested is considered unacceptable if it fails either test method. The equipment should then be subjected to decontamination. It must be recognized that the differing test results may indicate system deficiencies and justify a request for an engineering investigation of the equipment. Poor correlation between particle counts and patch tests can result from improper sample-taking procedures, incorrect particle counter calibration, or faulty test procedures. These possibilities must be carefully investigated if a correlation problem is encountered.
End of Chapter 5

General Aircraft Maintenance

Review Questions

5-1. The tool control program is based on what inventory concept?

A. Daily inventory
B. Instant inventory concept
C. Log books
D. Tool tags

5-2. What officer is responsible for coordinating the tool control program?

A. Admin Officer
B. Commanding Officer
C. Maintenance Officer
D. Material Control officer

5-3. What division is responsible for monitoring the tool control program?

A. Aircraft Division
B. First Lieutenant
C. Line Division
D. Quality Assurance

5-4. What two manuals outline the chain of command responsibilities regarding occupational safety?

A. NAVAIR 01-1A-509-1
B. OPNAVINST 5100.19 and OPNAVINST 5100.23
C. OPNAVINST 5355.1 and OPNAVINST 5370.5
D. OPNAVINST 5100.13 and OPNAVINST 5100.14

5-5. What is the primary source of information involving the use of hazardous materials?

A. Corrosion Control Division
B. Manufacturer labels
C. Material Safety Data Sheet
D. Quality Assurance

5-6. Who is responsible for training shop personnel in the use of the Material Safety Data Sheet?

A. Commanding Officer
B. Material Control
C. Quality Assurance
D. Work center supervisor
5-7. What type of diagram is useful for showing the relationship of components of a system and the sequence in which the different components operate?

A. Block  
B. Orthographic drawing  
C. Pictorial drawing  
D. Schematic diagram

5-8. What type of diagram is a graphic representation of a system that shows how a component fits with other components but does not indicate its actual location in the aircraft?

A. Block  
B. Orthographic drawing  
C. Pictorial drawing  
D. Schematic

5-9. What type of diagrams use actual drawings of components within the system?

A. Installation  
B. Pictorial drawing  
C. Orthographic drawing  
D. Schematic

5-10. The logical/deductive reasoning process for finding a malfunction is known by what term?

A. Drop check  
B. Functional check flight  
C. Process of elimination  
D. Troubleshooting

5-11. What are the seven steps encompassed in the troubleshooting aids generally found in the aircraft MIMS?

A. Visual inspection, operate system, isolate the trouble, remove and replace, operational check, clean up, and account for tools  
B. Visual inspection, operational check, classify the trouble, isolate the trouble, locate the trouble, correct the trouble, and conduct final operational check  
C. Visual inspection, operational check, classify the trouble, isolate the trouble, locate the trouble, correct the trouble, and drop check  
D. Visual inspection, drop check A/C, classify the trouble, isolate the trouble, locate the trouble, correct the trouble, and conduct final operational check

5-12. During a visual inspection, a hydraulic system should be checked for what primary concerns?

A. Air  
B. Fuel in the system  
C. Leaks  
D. Proper servicing levels
5-13. What substance is used to reduce friction, cool metallic parts, prevent wear, and protect against corrosion?

A. Corrosion preventive compounds  
B. Graphite  
C. Lubricants  
D. Water

5-14. What are the four methods of applying lubricants?

A. Grease gun, squirt can, hand, and air brush  
B. Grease gun, squirt can, hand, and brush  
C. Paint roller, squirt can, hand, and brush  
D. Spray can, paint gun, power pack, paint roller

5-15. What type of lubrication fittings rests level with the surface and will not interfere with moving parts?

A. Button-head  
B. Flush fittings  
C. Pin-head  
D. Straight hydraulic

5-16. What are the four types of aircraft slings?

A. Reinforced cable, fabric or webbing, log chains, cable winch  
B. Reinforced cable, fabric or webbing, structural steel or aluminum, and chain  
C. Structural steel or aluminum, reinforced cable, aircraft crane, and log chain  
D. Wire rope, fabric or webbing, structural steel or aluminum, and chain

5-17. What is the most common type of aircraft lifting sling used today?

A. Chain  
B. Fabric or webbing  
C. Reinforced cable  
D. Wire rope

5-18. What types of slings do not contain flexible components?

A. Chains  
B. Fabric or webbing  
C. Structural steel  
D. Wire rope

5-19. What are the two types of hydraulic aircraft jacks used by the Navy?

A. Axle and outrigger  
B. Axle and tripod  
C. Tripod and horseshoe  
D. Tripod and outrigger

5-50
5-20. Aircraft jacks are serviced with what type of fluid?

A. MIL-H-5606A  
B. MIL-PRF-23699  
C. MIL-PRF-32033  
D. Standard authorized aircraft hydraulic fluid

5-21. What type of jack is used for changing aircraft tires?

A. Axle  
B. Fixed height tripod  
C. Horseshoe  
D. Variable height jack

5-22. The hydraulic contamination control program is defined in what publication?

A. COMNAVAIRFORINST 4790.2  
B. COMNAVAIRFORINST 4730.2  
C. AIRPACINST 4790.2  
D. AIRPACINST 4730.2

5-23. What is a major cause of hydraulic system and component failures?

A. Hydraulic contamination  
B. Magnesium  
C. Steel  
D. Oil

5-24. What is the maximum acceptable hydraulic fluid particulate level for naval aircraft?

A. Class 3  
B. Class 5  
C. Class 6  
D. Class 10

5-25. What is the maximum acceptable hydraulic fluid particulate level for support equipment (SE)?

A. Class 3  
B. Class 5  
C. Class 6  
D. Class 10
5-26. What is the primary use for MIL-PRF-46170D hydraulic fluid?
A. Extremely low surrounding temperatures
B. Preservative hydraulic fluid
C. Principal hydraulic fluid used in military aircraft
D. Support equipment only

5-27. What is the first step in periodic fluid surveillance?
A. Analyze fluid sample
B. Certify cleanliness
C. Obtain fluid sample
D. Replace filter

5-28. What is the size of particulate matter measured in?
A. Centimeter
B. Millimeter
C. Megahertz
D. Microns

5-29. What does the presence of air in a hydraulic system cause?
A. Abraded synthetic rubber seals
B. Spongy response during system operation
C. Undesired oxidation
D. Rust-like corrosion

5-30. What does the presence of water in a hydraulic system cause?
A. Abraded synthetic rubber seals
B. Spongy response during system operation
C. Undesired oxidation
D. Tight response during system operation

5-31. What is a physical point in a hydraulic system from which small amounts of hydraulic fluid are drawn to analyze it for contamination?
A. Fluid sampling point
B. Fluid system point
C. Fluid contamination point
D. Fluid access point

5-32. Most fleet equipment is calibrated so that the smallest particle counted has an effective diameter of how many microns?
A. 1
B. 3
C. 5
D. 7
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5-53