

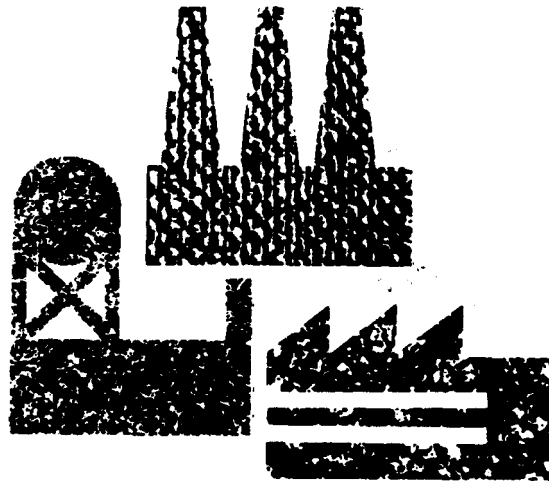
**Naval Facilities Engineering Command**

200 Stovall Street  
Alexandria, Virginia 22332-2300

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# Inspection Of Shore Facilities



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## FOREWORD

The establishment of a continuous inspection program is paramount to controlling the physical condition of a shore activity. Control Inspections are a major part of a continuous inspection program. Control Inspections are scheduled examinations and/or tests of shore facilities to determine the physical condition with respect to the required level of maintenance. A well planned and scheduled implementation of a Control Inspection program will generally reduce overall maintenance costs and preserve mission readiness. Facilities kept in good condition reduce costly repairs and the resulting disruptions to planned maintenance and facility users' work schedules.

The primary goal of this publication is to provide a system and recommended procedures to permit cost effective, quality, and responsive real property inspections. Use of this guidance will assure economical maintenance and maximum reliability of facilities and equipment.

Additional information or suggestions to improve this publication are invited and should be submitted through appropriate channels to the Naval Facilities Engineering Command (Attention: Code 163), 200 Stovall Street, Alexandria, VA 22332-2300. This publication supersedes **NAVFAC MO-322 Vol II of May 1978**.

This publication has been reviewed in accordance with the Secretary of the Navy Instruction 5600.16A and is certified as an official publication of the Naval Facilities Engineering Command.



E. R. HAMM  
CAPTAIN, CEC, U. S. Navy  
Assistant Commander for  
Public Works Centers and Departments



## **ABSTRACT**

This publication provides procedural guidance and inspection guides needed to perform Control Inspections. A systems approach is used to facilitate inspections by trade or craft. The publication is designed to aid the facilities inspector in preparing and performing facility inspections and reporting facility deficiencies.

The contents include inspection guides for Structural, Electrical, Mechanical, and Roofing categories. Each guide is formatted into sections including a definitions section, an instructions section and a repair/replacement criteria section. The definitions section provides a listing of related terms and their meanings and scope with respect to performance of physical inspection. The instructions section is the basic trade inspection guide. The repair/replacement criteria section provides guidance to determine the best course of action to correct reported deficiencies.









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## CHAPTER 1. INTRODUCTION

The Shore Facilities Inspection System includes three (3) inspection categories: Operator Inspection, Preventive Maintenance Inspection (PMI) and Control Inspection. Specialized Inspection is included within the Control Inspection category. This manual provides procedural guidance and Inspection Guides needed to perform Control Inspections.

Control Inspection is a scheduled examination and/or test of shore facilities to determine the physical condition with respect to the required level of maintenance. Control Inspection objectives are to:

- Provide a thorough examination of each facility and its components and make uniform assessment of condition,
- Appraise the adequacy of Operator and Preventive Maintenance Inspections,
- Assure adequate, consistent levels of maintenance by detecting over or under maintenance,
- Minimize system breakdowns and repair costs,
- Regulate the input of work for Public Works shops or contract,
- Provide Annual Inspection Summary (AIS)/BASEREP reporting data, and
- Identify facility maintenance and repair resource requirements and provide a basis for developing a meaningful, executable resource plan.

While this manual does not cover Specialized Inspections performed by Engineering Field Divisions, Public Works Centers, etc., results of Specialized Inspections should be integrated with findings of the Control Inspection program to determine overall facility condition.

A well planned and scheduled implementation of a Control Inspection program will generally reduce overall maintenance costs and preserve mission readiness. Facilities kept in good condition reduce costly repairs and the resulting disruptions to planned maintenance and facility users' work schedules. Control Inspections go beyond the findings of superficial, aesthetic and cosmetic imperfections. Control Inspections are framework-based inspections performed to seek and document basic deficiencies. Performance of Control Inspections will provide the following:

- Identification of existing and potential problems in a facility, for which cost estimates can be made or, when appropriate, Emergency/Service calls can be initiated,
- Assessment of facility condition,
- Reassessment of previously identified maintenance and repair work, and
- Information to maintain and update the inventory of facility components.

Control Inspections should be planned, scheduled and systematically performed by qualified Public Works inspectors. Control Inspections should be performed by personnel familiar with the facilities and equipment to be maintained, who know the accepted condition standards and guides, and who operate on a planned schedule. Inspector qualification requirements are discussed in NAVFAC MO-322, Volume I, the **Inspection of Shore Facilities** manual.



## CHAPTER 2. APPLICATION

This manual is designed to aid the facilities inspector in preparing and performing facility inspections and reporting facility deficiencies. A systems approach is used to facilitate inspections by trade or craft. Generally, inspections are divided into Structural, Electrical, Mechanical, and Roofing. This manual includes inspection guides for these categories.

This manual provides generic Control Inspection guidance. It should be used as a reference only, and not a substitute for sound engineering judgement. In all cases, manufacturer's instructions and local governmental codes should be consulted and used in conjunction with Control Inspection Guides. Appropriate precautions should be exercised when inspecting hazardous material and other environmentally unsafe areas. Where replacement of parts is necessary, the materials used should be of equal or better quality.

Application of Control Inspections with regard to the overall Shore Facilities Inspection System is explained in NAVFAC MO-322, Volume I, the **Inspection of Shore Facilities** manual. Application of Control Inspections with regard to the overall Facilities Maintenance Management program is explained in NAVFAC MO-321, the **Facilities Management** manual.

## CHAPTER 3. GENERAL INSPECTION INSTRUCTIONS

3.1 **OVERVIEW:** Each inspection begins with planning, scheduling, research and folder preparation. Inspections are performed by inspectors with trade expertise so the best quality inspection may be made. Each inspector must use their own trade knowledge when inspecting. The key to good facility maintenance planning is the performance of complete inspections. Considerations as to repair versus replacement, methods, materials, conditions, economics, etc. must be considered for each deficiency noted from the inspection. After inspectors finish facility inspections, they make cost estimates for the deficiencies found, prioritize the deficiencies and prepare a facility Inspection Report.

3.2 **SCOPE:** A facility inspection includes all systems and components on the facility, in the facility and within 5 feet of the outside shell of the facility. This includes piping, wiring, steps, awnings, and sidewalks.

3.3 **WORKLOAD PLANNING:** Inspector Supervisors should establish a schedule of inspections to be performed from the latest inventory of facilities. Recommended inspection frequencies and estimated times are provided in MO-322, Volume I. Inspector Supervisors should plan the total inspection workload to the extent it can be evenly distributed from fiscal year to fiscal year. This process will add stability to the amount of deficiency backlog and associated budgeting and resource use to execute corrections. Inspection workload should be evenly distributed and assigned to the inspectors. It is recommended that assignments be made on a weekly basis.

### 3.4 INSPECTOR FITNESS AND INSPECTION EQUIPMENT:

**Have a physical** - The physical must certify that you are healthy enough to:

- Wear a respirator
- Crawl in attics and crawl spaces
- Endure other daily tasks of inspectors

**Have a respirator fitted for you** - You must use and take care of the respirator. Whenever you are in a crawl space, an attic, or other space that might have asbestos, you must wear a respirator.

**Collect other safety equipment** - Along with a respirator, the following safety equipment should be assembled:

- Hard hat - to be worn in designated areas
- Safety glasses - to be worn in designated areas

- Safety shoes - to be worn during all inspections
- Coveralls - to be worn as necessary
- Asbestos coveralls & booties - to be worn in all attics, crawl spaces, and areas that might have asbestos
- Gloves - to be worn as necessary
- Ear plugs - to be worn in designated areas
- Knee pads - to be worn when crawling

**Collect inspection tools** - The following items will be useful during inspections:

- Group items for all trades:
  - Ladders
  - Trucks
  - Cameras
    - Polaroid
    - 35 MM
  - Sonic tape
  - Micro cassette recorder
  - Measuring wheel
- Individual items for all trades:
  - Employee Identification Card - to be worn or carried during all inspections
  - Note pad
  - Inspection Report Forms
  - Inspection instructions for your trade
  - Flashlight
  - Tape measure
  - Rule
  - Rain suit
  - Tool bag
  - Clip board
  - Screwdrivers
    - Phillips
    - Straight slot

- Structural:
  - Hammer
  - Sharp, pointed instrument - knife, etc.
  - Adjustable wrench
  - Pliers
- Mechanical:
  - Socket wrench
  - Nut driver set
  - Allen wrench
  - Adjustable wrench
  - Amp probe
- Electrical:
  - Nut driver set
  - Amp probe
  - Side cutters (9" handle recommended)
  - Crescent wrench (6" recommended)
  - Slip joint pliers
  - Knife
- Waterfront:
  - Adjustable wrench
  - Phillips head screwdriver
  - Socket wrench
  - Nut driver set
  - Boat with life preserver and/or vest
- Pavement:
  - PAVER book
  - Tape measure
  - Rule
- Utilities:
  - Manhole cover puller
  - Blower for manholes (if going in)

**Note: It the inspection requires going into the manhole, a gas free test must be made before entry.**

### **3.5 INSPECTOR PLANNING AND PREPARATION:**

**3.5.1 Inspector Responsibilities.** For the inspector, inspections begin only after inspection assignments are made and research is completed. The inspector is assigned an individual schedule of facilities to be inspected by an assigned deadline, usually weekly. The inspector is responsible to schedule time to make sure that all facilities on the list are done on time. Completion of a facility inspection means that physical inspection, writing of inspection reports, data entry to any required data bases, cost estimates, and inventory updates have all been done.

**3.5.2 Inspector Scheduling.** To begin, the inspector should schedule to meet the facility point-of-contact to discuss problems about the facility prior to actual inspection. If the facility has any security restrictions, make arrangements to gain access and follow procedures as prescribed by local regulations before beginning inspection.

**3.5.3 Research and Folder Preparation.** Before going to the facility, inspectors should collect all information available about the area to be inspected. It is important to determine problems known and previously reported for revision and update in the scheduled inspection. Sources of this information include previous inspection reports and cost estimates, currently scheduled or in-process minor and specific (Labor Class Codes 06-07) jobs, related contract jobs and warranty data, in-process Emergency and Service jobs, Military Construction (MCON) and Special Projects. 'Much of this information can be obtained in the form of data base reports where automated systems are in use. Scaled floor plans (one line drawings) should also be obtained for marking deficiency locations. Inspection Report forms should be obtained and topical information completed. All of this information should be organized into a facility inspection folder for ready use until the job is complete.

### **3.6 PREVENTIVE MAINTENANCE INSPECTION (PMI) OVERSIGHT:**

During inspection, inspectors should determine that equipment covered by PMI job orders are being properly maintained. Inspectors should also note in the Inspection Report whether equipment requires replacement due to age or condition.

### 3.7 INSPECTION PROCEDURE:

Begin inspection by talking to the facility point-of-contact and other knowledgeable facility occupants about current and past facility problems. Ask specifically about:

- Structural:
  - Safety hazards
  - Roof or other leaks - note locations of these from the inside so you know where to look for a cause of the problem from the outside
- Mechanical:
  - Safety hazards
  - Air temperature
  - Plumbing problems
- Electrical:
  - Safety hazards
  - Flickering lights or other electrical devices
  - Sparks from panels, lights, or outlets

Using Inspection Guides from Chapter 4, conduct physical inspection of the facility. As you inspect the facility, fill out Inspection Report forms with the required information. Mark the floor plans to note deficiency locations. Each system related to your trade should be checked as a whole (heating system, lighting system, window system, etc.). Start from the outside of the facility and work in.

- Walk around the outside of the facility inspecting the exterior:
- Go into the facility:
- Start at lowest floor and inspect all spaces on the floor, including all:
  - Open areas
  - Rooms
  - Areas above drop ceilings
  - Closets
  - Mechanical rooms
- Continue inspecting floors until all have been done:
- Inspect attic space (crawl in it if you can't walk through it):
- Inspect roof:
- Inspect under the facility, crawl in crawl spaces where found:

### 3.8 ADDITIONAL INSPECTOR DUTIES:

**3.8.1 Emergency/Service Work.** For minor deficiencies (where labor is estimated to be less than 16 hours), Inspector should submit a Service call. If there could be loss or damage to government property, essential services have been disrupted or a personnel hazard exists, Inspector should submit an Emergency call. The Inspection Report should be annotated accordingly.

**3.8.2 Safety Hazards.** Where safety hazards are found, Inspector should immediately notify:

- Activity's Safety Office
- Inspector Supervisor
- Activity's Staff Civil Engineer or Facilities Management Engineering Division Director

#### **3.8.3 Use of Repair/Replacement Criteria:**

Repair/replacement criteria in the Inspection Guides should be used to determine if a system or component should be repaired or replaced. Inspectors should use trade knowledge along with these Guides to make repair or replacement decisions. Age alone may not be sufficient reason to replace something. Use the axiom 'If this were your house, would you replace it or repair it?'. If there is any doubt in what to do, consult the Inspection Supervisor.

### 3.9 SPECIAL PROJECT CONSIDERATIONS:

**Note:** To determine if a Special Project should be written and how to write a Step 1 and Step 2 of a Special Project, see NAVFAC INST 11010.20(Series). Anyone creating Special Projects should attend the class on Special Projects offered by Civil Engineering Corps Officer School (CECOS) or an Engineering Field Division/Engineering Field Activity (EFD)/(EFA).

Based on physical inspection, determine the following about the Special Project:

- Is the scope correct?
- Is the cost accurate?
  - Has inflation been considered?
  - Have parts or labor for the tasks increased faster than inflation?
- Is the proposed method of correction appropriate?
- Does the Project still need to be done?

- Does the Project have sufficient detail?

Based on the findings above, process Special Project as follows (provide any amendments recommended to special projects):

- Special Project looks correct, no changes are recommended - Don't do anything to the Project.
- Incorrect scope or cost - Suggest an amendment to the Project.
- Project unnecessary - Suggest cancellation of the Project.
- Lack of detail - Suggest an amendment to the Project.

### **3.10 INCORRECT OR CONFLICTING INFORMATION HANDLING:**

During inspection, information in the facility folders may be determined to be incorrect or conflicting. When this happens, make note of these discrepancies, notify the Inspector Supervisor, and include your assessment of the situation in your Inspection Report.

### **3.11 INSPECTION PROGRAM QUALITY ASSURANCE:**

Discrepancies, omissions and understated cost estimates will negatively impact resource budgeting and workload planning. Therefore, it is important to obtain high quality inspection results. To monitor inspection quality, a team consisting of one Inspector, the Inspector Supervisor, and one Maintenance Supervisor and/or Engineer should periodically spot inspect 10% of the completed facilities inspected. By doing this, statistically tracking results, correcting problems, and training people not to make the same mistakes, the Inspection Program will yield high quality inspection results.



## CHAPTER 4. INSPECTION GUIDES

### 4.1 INSPECTION GUIDE FORMAT:

This chapter includes Inspection Guides which are trade oriented. Each Guide is formatted into sections generally including a definitions section, an instructions section and a repair/replacement criteria section. The definitions section provides a listing of related terms and their meanings with respect to performance of physical inspection. The instructions section is the basic trade inspection guide. The repair/replacement criteria section provides guidance to determine the best course of action to correct reported deficiencies. Cost estimates should be developed using applicable criteria.

### 4.2 INSPECTION GUIDE USE:

Inspectors should use these Guides to supplement the General Instructions provided in Chapter 3. These Guides should be used as a reference and should be complimented with sound engineering judgement. Each facility is unique; therefore, a complete inspection may require inspection of components and systems not included in the Guides. Manufacturer's instructions and local governmental codes should be consulted and used in conjunction with these Guides.

### 4.3 MULTI-TRADE INSPECTIONS:

***Beware of Omissions.*** An Inspector performing a general (i.e., a complete turn-key) inspection should know to cover all systems and components in a facility without question. Inspectors should read and become familiar with all Guides to know what is expected of each trade and to recognize what may be part of a facility not included in the Guides. When multiple Inspectors are assigned to inspect various components and systems by trade, it is important that the inspection be coordinated. In this case, the Inspector Supervisor should assign a Lead Inspector responsible to make sure the entire facility gets inspected. Any questions should be resolved by the Inspector Supervisor.

## STRUCTURAL

### CHAPTER 5. STRUCTURAL INSPECTION GUIDE

#### 5.1 DEFINITIONS:

**Aircraft Power Check Facility** - consists of aircraft securing fittings and mooring eyes anchored in concrete, tie-down chain assembly with aircraft holdback fitting and blast deflectors.

**Ammunition Storage (Aboveground)** - Ammunition storage facilities that are covered with earth, but aboveground.

**Antenna-Supporting Towers and Masts** - includes guyed radiators and guys, antenna-supporting strongbacks, strongback insulation to towers, elevating mechanisms, and obstruction and navigation lighting, but does not include inspection of antenna.

**Asbestos** - minerals used as a noncombustible or chemically resistant material.

**Bridges and Trestles** - includes those constructed of steel, timber, masonry, concrete, and composite materials. It does not cover concrete boxes with integral floor, which are classed as culverts regardless of span, and are included in Storm Drainage Systems.

**Brows and Gangways** - includes brows and gangways constructed of steel, wood, and aluminum.

**Ceiling** - what can be seen from the inside of a room

**Construction** - the general structure or mainframe of the facility

**Doors and Gates** - the door package and the interface with the facility and fence gates

**Exterior walls** - what can be seen from the outside of a facility

**Fencing** - fencing attached to a facility or as its own facility

**Floor** - from top of the foundation to the air in the room, including carpet, tiling, painting, etc.

**Foundation** - from the ground to below the floor of a facility

**Fresh Water Storage** - includes ground storage reservoirs and tanks and elevated

## STRUCTURAL

storage tanks in fresh water systems. Included also are the various accessories normally associated with fresh water tanks.

**Grounds** - includes lawn and turf areas, areas seeded to rough grasses, agricultural and grazing lands, woodlands, trees and shrubs, runoff and erosion control works, fill and cut slopes, gullies, irrigation systems, and weed control.

**Interior Walls** - what can be seen from the inside of a facility

**Painting** - preparing and painting or coating of an inspected surface

**Pavement** - concrete and asphalt roads, parking lots, sidewalks and airfields

**Railroad Trackage** - includes running tracks, access tracks, classification yards, sidings, and storage track

**Retaining Walls** - retaining walls of all kinds, including cribbing and sheet piling when used as retaining walls.

**Stair** - stairs go from one level to another with 8 treads or more, steps are less than 8 treads.

**Storm Drainage Systems** - includes catch-basins, curb inlets, pipelines, headwalls, outfalls and tide gates, drop structures and spillways, manholes, culverts, subsurface drainage, gutters, and ditches. A plan of the entire storm drainage system from inlets to outfall ditches should be used.

**Swimming Pools** - includes swimming pools, wading pools, and accessories, such as spring boards and diving towers.

**Tunnels and Underground Structures** - including ammunition storage tunnels; pipeline tunnels, vehicular tunnels, and water tunnels; also, underground structures housing utilities, service installations, and similar equipment or operations. It does not include underground tanks, or earth-covered ammunition magazines that are wholly or partly aboveground.

**Waterfront** - (refer to MO-104 for additional definitions)

**Topside** - what can be inspected by walking on the top of the structure

**Underside** - what can be inspected from a boat by or under the structure at mean low water

**Underwater** - what can be inspected by a diver during an under water inspection

**Window** - the window package and the interface with the facility

**STRUCTURAL****5.2 STRUCTURAL INSPECTION INSTRUCTIONS:**

**5.2.1 Aircraft Power Check Facility:** Comply with all current safety precautions.

Check For:

- Aircraft Securing Fittings and Mooring Eyes:
  - cracked, broken or spalled concrete
  - settlement, movement or heave in vicinity of fittings
  - rusted, loose, bent or broken anchor plates and bolts
- Chain:
  - breakage, rust, corrosion and wear between individual links and between links and fittings
  - check chain dimensions for distortion in accordance with NAVSHIPS 0901-260-0001
- Aircraft Holdback and Deck Fittings:
  - rust
  - corrosion
  - bent, worn or damaged parts
- Blast Deflectors:
  - rust
  - corrosion
  - bent, missing or damaged parts

**5.2.2 Ammunition Storage (Aboveground):** Comply with all current safety precautions. Check for:

- Main, Foundation, and Retaining Walls:
  - Cracks
  - Spalling
  - Broken areas
  - Settlement
  - Failure to maintain 3 ft minimum earthfill width at tops of retaining walls and minimum side slope of 1-1/2 to 1 at earth embankments
  - Drainage problems resulting in surface ponding or other evidence of subsurface draining failure

## STRUCTURAL

### Ammunition Storage (Aboveground) -Continued

- Floors:
  - Leakage at juncture of metal wall with concrete wall
  - Improper floor slab grading resulting in poor floor drainage
- Metal Surfaces:
  - Punctures
  - Breaks
  - Bends/Bulges
  - Rust
  - Corrosion
  - Mechanical damage
- Damaged roof, wall surfaces, or waterproofing, resulting in leakage.  
Refer to Chapter 8, Roofing Inspection Guide:
- Painted Surfaces:
  - Rust
  - Corrosion
  - Cracking
  - Scaling
  - Peeling
  - Wrinkling
  - Alligatoring
  - Chalking
  - Fading
  - Complete loss of paint
- Doors:
  - Sagging
  - Binding
  - Broken
  - Defective, or inadequate hinges
  - Missing, broken, or other damage to locks and latches

**STRUCTURAL****Ammunition Storage (Aboveground) -Continued**

- Sodded areas:
  - Poor condition, presence of bare spots
  - Weeds, trash, debris, or other detrimental conditions constituting a fire hazard or tending to promote erosion
- Inorganic Mulch (gravel, slag, etc.):
  - Insufficient thickness
  - Vegetation growing through
- Ventilators:
  - Rust
  - Corrosion
  - Torn or missing insect screens
  - Water leakage
- Grounding Connections: Test with earth ground tester or ohmmeter to assure electrical continuity and maximum ground impedance and a megger to assure isolation to the building. Refer to Chapter 7, Electrical Inspection Guide, Grounds and Grounding Systems. Check for:
  - Corrosion
  - Mechanical Damage

**5.2.3 Antenna-Supporting Towers and Masts:** Comply with all current safety precautions. Check for:

- Foundations:
  - cracked, broken, or spalled concrete
  - exposed reinforcing
  - movement or settlement
  - heaving from frost action
- Anchor Bolts and Straps:
  - rust
  - corrosion
  - loose, missing, or damaged parts

**STRUCTURAL****Antenna-Supporting Towers and Masts-Continued**

- Structural Steel Towers, Ladders, and Safety Cages:
  - rust
  - corrosion
  
  - loose, missing, twisted, bowed, bent, or broken members
- Splices, Bolts, and Rivets:
  - rust
  - corrosion
  - loose, missing, other damage, broken welds
- Timber Towers and Ladders:
  - loose, missing, twisted, bowed, cracked, split, rotted
  - termite or other insect infestation of wooden members
- Guys and Anchorage:
  - cracked, split, rotted
  - loose, missing or damaged vibration dampers
  - termite or other insect infestation
  - looseness of wooden parts
  - metal parts for rust, corrosion, loose, missing, or other damage
  - frayed or broken strands or unequal tension of guys
  - inadequate deadman anchorage
  - missing or improper safety securing of hardware (i.e., mousing, double nuts)
  - broken or missing ground straps and bonding connections
- Deviations from plumb:
- Painted Surface:
  - rust
  - corrosion
  - cracking
  - scaling
  - peeling

## STRUCTURAL

**Antenna-Supporting Towers and Masts-Continued**

- wrinkling
- alligatoring
- chalking
- fading
- complete loss of paint
- Obstruction and Navigation Lights: relamping:
- Improper operation and lack of cleanliness of lights, shields, hoods, and receptacle fittings:
- Sticking, binding, arcing, or burning of relay contacts; loose connections, missing parts of relays:
- Lightning Rods and Aerial Terminals: damage from burning:
- Conduits, Terminals, and Downleading Cables:
  - corrosion
  - loose or missing attachments to structures
  - other damage
- Poor or unsatisfactory mechanical bonding of joints of aerial terminals, downleading cables, and ground connections:
- Lack of electrical continuity from aerial terminals through ground connections:
- Dirt, dust, grease, or other deposits on insulators, or cracks, breaks, chips, or checking of the porcelain glaze or signs of arc tracking:
- Pulleys, winches, cables, ropes, or the elevating mechanisms and gear for inadequacy or improper operating condition:

**5.2.4 Asbestos:** Asbestos was used before 1970 mainly for insulation purposes. Asbestos is a general term for several fibrous mineral silicates. It is difficult to detect. Technical Note N-1576 **Characterization of Asbestos Construction Products at Naval Shore Facilities** of May 1980 and Technical memorandum M-52-77-7 **Characterization of Asbestos Construction Materials at Naval Shore Facilities** of April 1977 provide extensive lists of asbestos containing materials. Do not disturb something that could contain asbestos. Asbestos is commonly found in:



**STRUCTURAL****Asbestos-Continued**

- Friable forms: (dry material which can be crumbled or reduced to powder by hand pressure.):
  - Pipe Lagging
  - Sprayed on insulation
  - Troweled on insulation
  - Tile
    - Ceiling
    - Acoustic
    - Insulating
- Nonfriable forms: (dry material which can be dispersed into atmosphere by mechanical actions such as sawing.):
  - Floor Tile
  - Roofing
  - Sheathing
  - Piping
  - Concretes

**5.2.5 Bridges and Trestles:** Comply with all current safety precautions. Check for:

- Side Slopes:
  - failure to maintain slopes of 1-1/2 to 1 or more
  - soil erosion
  - inadequately protected with vegetation or mulch
  - concrete overlays (if applicable)
    - cracking
    - spalling
    - broken areas
    - other damage
    - erosion
    - settlement

**STRUCTURAL****Bridges and Trestles-Continued**

- Bridge and Foundation Protective Structures, such as Riprap Cribbing, Bulkheads, Dolphins, Piles, or Other:
  - missing
  - broken
  - insect and other pest infestation
  - decay
  - erosion
  - undermining
  - scouring
  - other damage
- Drainage Ditches:
  - loose bottom and sides
  - improper side sloping
  - silting
  - failure to protect surrounding areas at outfalls from erosion
  - vegetation encroachment
- Roadway of Approaches:
  - cracked
  - settlement
  - broken
  - corrugated
  - and disintegrated concrete or bituminous surfaces
    - cracked
    - broken
    - other damage to curb and gutter sections
- Approach Fill: settlement, particularly at joint between fill and structure:
- Fences, Barricades, and Railings at Approaches:
  - inadequacy or structural damage
  - missing or illegible load and speed limit signs

## STRUCTURAL

### Bridges and Trestles-Continued

- Drainage Channels:
  - erosion
  - scouring
  - accumulations of driftwood and debris above, below, and at structure
  - evidence of possible course diversion resulting from obstructions, erosion, or other
  - vegetation
- Concrete Foundation:
  - cracks, scaling
  - disintegration
  - exposed reinforcing
  - wood piling and pads
    - missing
    - broken
    - ineffective bearing
    - decay
    - termite and other pest infestation
  - all foundations
    - scouring
    - undermining
    - settlement
- Abutments and Piers:
  - cracks
  - breaks
  - scaling
  - spalling
  - disintegration
  - open joints
  - other damage
  - evidence of damage from impact and vibration

## STRUCTURAL

### Bridges and Trestles-Continued

- failure of expansion devices
- damage from floating debris, ice, and waterborne traffic
- Timber Framing:
  - loose
  - missing
  - twisted
  - bowed
  - warped
  - split
  - checked
  - unsound members
  - deteriorated joints
  - rot
  - termite and other insect infestation
- Steel Framing:
  - rust
  - corrosion
  - loose
  - missing
  - bowed
  - bent
  - broken members
- Concrete and Masonry Structures:
  - weathering
  - cracks
  - spalling
  - exposed reinforcing
  - open, eroded, and sandy mortar joints
  - broken and missing stones

**STRUCTURAL****Bridges and Trestles-Continued**

- missing, corroded, rotted embedded support members (headers, lintel, frames, etc.)
- All Superstructures:
  - damage from floating debris, ice, and waterborne traffic
  - misalignment both horizontal and vertical
- Wood Flooring:
  - loose, missing, broken, rotted pieces
  - protruding nails and other fastenings
  - checkered wearing plates
    - loose
    - missing
    - other damage
- Structure Roadways:
  - cracked
  - broken
  - corrugated
  - disintegrated concrete or bituminous surfaces
- Concrete Curbs and Gutters and/or Concrete or Masonry Handrails and Handrail Walls:
  - loose, missing, and broken individual sections
  - misalignment
  - sandy and eroded mortar joints
  - loose or missing capstones
  - other damage
- Expansion Joints:
  - improper sealing
  - loose or missing filler
  - failure to allow movement when filled with trash or debris
  - misaligned

## STRUCTURAL

### Bridges and Trestles-Continued

- Metal Handrails:
  - rust
  - corrosion
  - loose
  - missing
  - broken
  - misalignment
  - other damage
- Bridge Seats, Bearing and Cover Plates:
  - rust
  - corrosion
  - missing
  - loose
  - other damage
  - failure to cover ranges of movement
- Rollers and Other Similar Devices:
  - rust
  - corrosion
  - inadequate lubrication
  - failure to allow movement
  - failure to cover ranges of movement
- Cables:
  - frayed, raveled, or broken strands
  - inadequate lubrication
  - defective anchorage
  - interference from over-hanging objects

**STRUCTURAL****Bridges and Trestles-Continued**

- Splices, Bolts, Rivets, Screws, and Other Connections:
  - rust
  - corrosion
  - lose
  - missing
  - broken welds
  - other damage
- Movable Bridges:
  - rust
  - corrosion
  - wear
  - inadequate lubrication. (Examine through complete operating cycle.)
- Utility Supports:
  - rust
  - corrosion
  - loose
  - missing
  - or broken parts
- Utility Lines:
  - corrosion
  - leaks
  - sagging
  - insulation and waterproofing defects
  - mechanical damage
  - inadequate or missing protection barriers

## STRUCTURAL

**Bridges and Trestles-Continued**

- Painted Surfaces:
  - rust
  - corrosion
  - cracking
  - scaling
  - peeling
  - wrinkling
  - alligatoring
  - chalking
  - fading
  - complete loss of paint

**5.2.6 Brows and Gangways:** Comply with all current safety precautions. Check for:

- Abnormal deflection or side sway:
- Steel and Aluminum Structural Members:
  - rust
  - corrosion
  - loose
  - missing
  - bent
  - buckled
  - broken
- Steel and Aluminum Flooring Members:
  - mechanical damage
  - excessive wear
  - slippery walking surfaces
- Handrails (or cables) and Stanchions:
  - damaged or loose members and fittings
  - wire rope for looseness
  - frayed or broken strands



## STRUCTURAL

### Brows and Gangways-Continued

- Rollers and Wheels:
  - hard to move
  - lack of lubrication
- Connections:
  - rust
  - corrosion
  - loose
  - missing
  - broken
  - other damage
- Wooden Structural Members:
  - loose
  - missing
  - twisted
  - bowed
  - cracked
  - split
  - broken
  - rotted members, particularly at joints
- Wooden Flooring Members:
  - mechanical damage
  - excessive wear
  - slippery walking surfaces
- Wooden Handrails:
  - loose
  - missing
  - broken

## STRUCTURAL

**Brows and Gangways-Continued**

- Painted Surfaces:
  - rust
  - corrosion
  - cracking
  - scaling
  - peeling
  - wrinkling
  - alligating
  - chalking
  - fading
  - complete loss of paint

**5.2.7 Ceiling:** Check for:

- Deflection or warping:
- Tile:
  - Missing tile
  - Damage
  - Soil
- Plaster:
  - Cracks
  - Damage
  - Loose sections
- Water stains:

**5.2.8 Chimneys and Stacks (Structural):** Comply with all current safety precautions. Also refer to Chimneys and Stacks (Electrical). Inspect after any severe storm. Check for:

- Foundations:
  - settlement
  - cracks due to heat, shocks, vibrations

## STRUCTURAL

### Chimneys and Stacks (Structural)-Continued

#### ■ Brick and Concrete Walls:

- weathering
- cracking
- spalling
- eroded or sandy mortar joints
- expansion and contraction cracks
- deteriorated paint
- damage from gases
- missing, corroded, rotted embedded support members

#### ■ Caps:

- weathering
- cracking
- spalling
- loose material

#### ■ Exposed Metal Surfaces:

- rust, corrosion, and deteriorated paint
- broken, loose, missing, other damage to bolts, rivets, and welds

#### ■ Linings, Supporting Corbels, and Baffles:

- cracks
- spalling
- damage from gases

#### ■ Guys, Anchorage, and Bands:

- lack of tautness
- rust
- corrosion
- frayed, broken, loose, missing or mechanically damaged anchorage

**STRUCTURAL****Chimneys and Stacks (Structural)-Continued**

- **Ladders:**
  - rust
  - corrosion
  - paint scaling
  - poor anchorage
  - broken, loose, or missing ladder rungs
  - missing or damaged safety cages, platform railings, etc.
- **Painters Trolley:**
  - wear, corrosion, other damage to tiller ropes, pulleys, and pulley supports
  - poor pulley support anchorage
- **Openings for Cleanout Doors, Breechings and Flues:**
  - cracking or spalling of the masonry surfaces
  - metal frames for distortion, rust, corrosion
  - broken, loose, missing, other damage to bolts, rivets, and welds
- **Cleanout Doors and Fastenings:**
  - distortion
  - rust
  - corrosion
  - wear
  - broken
  - cracked
  - missing parts
  - other damage
- **Spark Arrester Screens:**
  - clogged with fly ash
  - rust, tears, and other damage
  - bolts and screws for rust, and corrosion
  - loose, broken, or missing parts

**STRUCTURAL****5.2.9 Construction:** Check the structure for:

- Rot:
- Water damage:
- Bug infestation:
- General deterioration:
- Cracking, splitting, distortion of members:
- Proper connections of members:
  - Settling:
  - Corrosion/rusting:

**5.2.10 Doors and Gates:** Check for:

- Operation:
- Fit:
- Seal:
- Rust:
- Rot:
- Damage:
- Wear:
  - Lock sets
  - Hinges
  - Safety/panic hardware
- Cracks:

**5.2.11 Exterior wall:**

- Gutter and downspouts - Check for:
  - Missing sections
  - Damage
  - Rust
  - Loose sections
  - Missing splash blocks
  - Damaged splash blocks
  - Proper slope
  - Obstructions/clogging

## STRUCTURAL

### Exterior wall-Continued

- Wall coverings - Check for:
  - Missing sections
  - Loose sections
  - Damage
  - Cracks
  - Spalls
  - Bulges
- Trim and cornices - Check for:
  - Missing Sections
  - Loose sections
  - Damage
  - Rot
- Steps, stoops, and porches - Check for:
  - Loose sections
  - Damage
  - Rot
  - Bug infestation
  - Cracks
  - Spalling
  - Separation of concrete components
  - Settlement
  - Missing members
- Water penetration - Look closely at the areas with water damage or water spots and stains. Check for:
  - Openings
    - Caulking
    - Seals
  - Exterior wall surfaces
    - Holes
    - Cracks

**STRUCTURAL****Exterior wall-Continued**

- Mortar joints
  - Spalling
  - Cracks
- Flashing deficiencies
- Condensation
- Equipment/piping leaks

**5.2.12 Fencing:** Refer to Doors and Gates above for fence gates. Check for:

- Missing sections and parts:
- Damage:
- Rust:
- Tunneling and erosion:

**5.2.13 Floor:** Check for:

- Standing Water:
  - Grade
  - Leaks
  - Clogged drains
- Carpet:
  - Wear
  - Soil
  - Damage
- Tile:
  - Wear
  - Missing and loose tiles
  - Damage
- Deflection:

**STRUCTURAL****5.2.14 Foundation:**

- Wood - Probe the wood frames with a sharp instrument to check for:
  - Rot
  - Water damage
  - Bug infestation
  - Deterioration
  - Settling
  - Leaks
- Concrete/masonry - Check for:
  - Settling
  - Deterioration
  - Spalling/cracking
  - Leaks

**5.2.15 Fresh Water Storage:** Comply with all current safety precautions. The health of personnel who enter reservoirs or tanks for inspection must be approved by the medical officer of the activity. To assure against contamination of potable water, procedures established by the Public Works Officer must be carried out. Check for:

- Concrete Foundations:
  - settlement
  - cracks
  - spalling
  - exposed reinforcing
  - insect infestation
  - erosion & undermining
- Wood Foundations and Pads:
  - checked
  - split
  - rot
  - insect infestation
  - direct soil contact of untreated wood
  - settlement



**STRUCTURAL****Fresh Water Storage-Continued**

- Anchor Bolts and Straps:
  - loose or missing pieces
  - rust
  - corrosion
  - physical damage
- Steel Tanks:
  - rust
  - corrosion
  - leakage
  - damaged protective coatings
  - bent, bowed or broken members
  - loose scale
  - damaged or deteriorated riveted welded seams
- Concrete Tanks:
  - settlement
  - cracks
  - spalling
  - leakage
  - defective joint at juncture of floor and walls
  - exposed reinforcing
  - damaged protective coatings
- Wood Tanks:
  - leakage
  - cracked, checked, split, warped, or mechanically damaged pieces
  - rot
  - termite infestation
  - wall and base sections for vertical and horizontal misalignment
  - bands or hoops for rust, corrosion, looseness or missing

**STRUCTURAL****Fresh Water Storage-Continued**

- Steel Tower Structure:
  - rust
  - corrosion
  - loose, missing, bowed, bent or broken members
  - loose sway bracing
  - misalignment of tower legs
  - evidence of unstableness
- Wood Towers:
  - loose, missing, twisted, bowed, cracked or split pieces
  - rot
  - termite infestation
  - misalignment of tower legs
  - evidence of unstableness
- Wood and/or Steel Ladders, Walkways, Guardrails, Handrails and Stairways:
  - rust corrosion
  - poor anchorage
  - loose or missing pieces
  - other damage
- Handholes, Manholes, Access Doors, Hatchways and Other Covers:
  - loose
  - missing
  - broken
  - rust
  - corrosion
  - improper fit
  - damaged or missing hardware

**STRUCTURAL****Fresh Water Storage-Continued**

- Concrete Reservoirs:
  - settlement
  - cracks
  - spalling
  - leakage
  - exposed reinforcing
- Expansion Joints:
  - improper sealing
  - loose or missing filler
  - failure to allow movement when filled with trash and debris
  - failure to allow adequate movement
- Earth Embankments:
  - erosion resulting from lack of full sod or vegetation coverage
  - burrowing animals
  - improper drainage
  - ponding water along base
  - leakage through embankment or along outlet piping
- Improper Operation of Valve Control:
  - illegible and improper operating condition of water level indicator
- Valves, Piping, Fittings, Sleeves and Other Accessories:
  - broken
  - loose
  - missing
  - rust
  - corrosion
  - leakage
  - other damage
- Nonintegrity of riser frost casings or insulating materials:

## STRUCTURAL

### Fresh Water Storage-Continued

- Splices, Bolts, Rivets, Screws and Other Connections:
  - loose
  - missing
  - broken welds
  - rust
  - corrosion
  - other damage
- Painted Surfaces:
  - rust
  - corrosion
  - cracking
  - scaling
  - peeling
  - wrinkling
  - alligatoring
  - chalking
  - fading
  - complete loss of paint
- Cathodic Protection Anodes:
  - defects and broken segments
  - failure to remove anodes where ice forms in freezing weather
- Accumulations of dirt:
  - trash
  - debris
  - foliage

**STRUCTURAL****Fresh Water Storage-Continued**

- Lightning Rods, Terminals, Cables and Ground Connections:
  - rust
  - corrosion
  - loose, burned, missing or other damage to parts and connections
  - test for electrical continuity through ground connections
- Obstruction and Navigation Lights:
  - need of relamping
  - other damage
- Lights, Hoods, Shields and Receptacle Fittings:
  - missing
  - loose
  - damaged parts
  - failure to operate
- Conduit:
  - breaks
  - other damage
  - water leakage, seals
- Remove conduit inspection plates and examine internal connections for:
  - looseness and inadequacy
  - relays for loose or weak contact springs
  - worn or pitted contact
  - defective operation

**5.2.16 Grounds: Check for:**

- Lawn and Other Turf Areas including Borders:
  - traffic damage
  - loss of color
  - density
  - sparse and bare spots
  - weeds
  - undesirable grasses

**STRUCTURAL****Grounds-Continued**

- diseases
- insect damage
- erosion
- silt deposits
- waterborne debris
- excessive height
- bruised or damaged ends from dull mower
- Trees and Shrubs in Landscaped Areas:
  - lack of vigor
  - need of trimming
  - interference with utilities or buildings
  - injury from mowers
  - structural weaknesses
  - storm, disease or insect damage
- Border Strips and Areas Seeded to Rough Grasses for Erosion Control:
  - poisonous or noxious weeds
  - seedling trees that may hinder future mowing
  - erosion and siltation
  - lack of vigor
  - inadequacy of coverage
  - evidence of burning
- Woodlands:
  - erosion
  - dead, diseased, or damaged trees
  - fire-lanes for being impassable
  - vegetation growth that may carry ground fires
  - hollow trees

**Grounds-Continued**

- **Earth Dams and Dikes:**
  - damage from erosion
  - burrowing animals
  - seepage
  - lack of vegetation density or vigor of growth
  - drop inlet pipes for stoppage
  - logs
  - debris
  - outlet ends for erosion
  - piping damage or failure
- **Emergency Spillways of Drop Inlet Dams:**
  - blockage
  - erosion damage
- **Permanent Check Dams in Water Course:**
  - overflow at notch section
  - bypassing at ends
  - erosion on downstream side
  - damaged and deteriorated walls and apron
- **Hillside and Terrace Diversion Embankment, Channels, and Culverts:**
  - silt
  - debris
  - rank vegetation
  - low and weak sections
  - overflow
  - erosion
  - gullying
  - burrowing animals

## Grounds-Continued

- Valley Drainage Channels including Culverts and Lateral Drains and Tile at Entrance Points:
  - overflow
  - stoppage
  - silt
  - debris
  - bank vegetation
  - erosion
  - caving
  - sloughing
  - scour
- Vegetated Waterways:
  - inadequate vegetation fullness and cover in relation to ground surface area that should be shielded
  - erosion of waterway and along sides
  - debris
  - overflow
- Fill Slopes on Barricades, Highways, Railways, Airfield Runways, Igloos and other Soil-Covered Buildings:
  - erosion
  - burning
  - steepness
  - lack of vigor and insufficient vegetation coverage for protection against beating rain and direct sunshine
  - inadequate fill depth at top of slope wherever buildings and weather conditions necessitate variations on different slopes
  - inadequate surface runoff piping
  - insufficient thickness of organic mulch (gravel, slag, etc)



## STRUCTURAL

### Grounds-Continued

- Cut Slopes and Diversion Channels:
  - erosion
  - scour
  - burning
  - weaknesses from past or possible overflow
  - lack of vigor or growth and insufficient vegetation coverage
  - inadequate surface runoff piping
- Gulleys including all Surface Water Entrances and Upstream Ends or Head where Mainstream Enters:
  - current rate of erosion
  - resulting pollution and sedimentation of downstream lakes
  - channels
  - damaged lands
  - impairment of bridges and other structures
  - need of erosion control such as temporary brush and wire dams and plantings
- Sprinkler System Nozzles, Sprays, Hose, Pipe and Valves:
  - rust
  - corrosion
  - clogging
  - inadequate width or pressure
  - leakage
  - defective operation
  - evidence of water usage waste indicated by metering records or computations from nozzle hours per acre per annum

## STRUCTURAL

**Grounds-Continued**

- Flood Irrigation Systems including Delivery Channels, Gates, Flow-Control and Water Turnout Works, and Border-Dikes:
  - defective operation
  - erosion
  - silting
  - scour
  - water loss
  - improper application
  - failure to supply to all parts of tract
- Windbreaks of Trees:
  - breakage
  - lack of vigor
  - dead or dying trees requiring replacement
  - disease and insect damage indicated from condition of leaves
  - branches interfering with utility lines
  - contour ridges in arid sections inadequate to prevent surface runoff and retain and cause absorption of storm waters around tree
- Weed Control:
  - vigor and rapid growths indicating need of reapplying soil sterilents
  - erosion damage where soil sterilents were used
  - check for emergence of any and all types of vegetation as an index of the efficacy of the remaining soil chemicals and a need for applying additional chemicals to the soil
  - where selective contact sprays are used, check for percentage of kill and injury to vegetation that is to be preserved
  - check vegetation on adjoining lands for damage by spray drift

**5.2.17 Imhoff and Septic Tanks:** Refer to NAVFAC Technical Publication DM-5 for standards.

- Visit all septic and Imhoff tanks and manholes to determine proper operation:
- Note any indication of oil, gasoline, or lubricating grease entering the system:

**STRUCTURAL****Imhoff and Septic Tanks-Continued**

- Note the existence and location of any septic sewage or accumulation of solids in the system:
- Look for sand, mud or grit in the system:
- Note and immediately report the presence of noxious or explosive gas:
- Structural cracks:
- Look for signs of no/inadequate drainage from leach fields:

**5.2.18 Interior wall:** Check for:

- Bulges:
- Water intrusion of exterior walls:
- Separation of wall and floor:

**5.2.19 Paint:** Check paint condition of the following:

- Exterior walls:
- Interior walls:
- Floors:
- Doors:
- Windows:
- Fences:
- All other painted surfaces:

5.2.20 **Railroad Trackage:** Comply with all current safety precautions. Refer to NAVFAC MO-103 for additional information. This guide is not intended to be a complete inspection procedure. Inspectors should refer to NAVFACINST 11230.1(Series) for more complete inspection guidance. Check for:

- Tracks: Examine closely where track passes from earth fill to bridges or trestles. (Standard gage is 4' 8-1/2" which is increased on sharp curves. Maximum gage is 4' 9-3/4" and minimum gage is 4' 8"):
  - Vertical and horizontal misalignment caused by heaving
  - sinking
  - churning
  - inadequate expansion
  - particularly during hot weather
  - rough spots (ask train crews)

**STRUCTURAL****Railroad Trackage-Continued**

## ■ Rails:

- Breaks
- splits
- cracks in head, web or base
- damage from flat wheels
- wear
- head wear
- creeping or shoving, particularly at curves or ends
- batter
- overflow
- chipping
- joints
  - loose angle or splice bars
  - loose or missing bolts
  - inadequate expansion. Ends of 39 ft. rails should butt at 85°F. At lower temperatures, clearance of 1/16 inch for every 20° difference or part thereof
- loose spikes/fasteners or failure to provide sufficient quantity per tie
- improper tie plate seating
- improper support of rail
- obstructed flangeways of girder-type rails
- obstructed flangeways and tops not flush with pavement or crossing for standard-type rails
- Road Crossing
  - poor condition
  - roughness to road traffic
  - obstructions

## ■ Ties:

- Decay
- splitting
- general deterioration

**STRUCTURAL****Railroad Trackage-Continued**

- rail cutting
- insufficient or improper embedment in ballast to prevent movement
- inadequate drainage
- Ballast:
  - Dirt and mud accumulations
  - soft or wet spots
  - grass or weeds
  - washing away and settlement
  - inadequate extension beyond ties
  - slope to grade steeper than 2 to 1
- Drainage:
  - Obstructed drainage ditches and culverts
  - erosion of side slopes and shoulders
  - actual or potential slides onto or close to track
  - washing or erosion at head-walls
  - inlets discharge openings
- Turnouts: Refer to NAVFACINST 11230.1(Series) to determine proper gages, for example, between frogs and flange faces and on tangents and curves:
  - Lack of lubrication
  - clogged with debris or dirt
  - inadequately spiked
  - out-of-gage
  - improper operating condition of switch points, switch latches, targets, and lamps:
  - loose/missing rail braces
  - worn/damaged switch and frog points
- Tank Car Unloading Tracks:
  - Bonding wires across rail joints, between rails and unloading header pipelines, and connections between rails and ground rods, and insulated rail joints

**STRUCTURAL****Railroad Trackage-Continued**

- loose connections
- corrosion
- frayed or broken strands. (Repair when one strand broken in 7-strand, or more than 3 broken in 19-strand.)
- Protective Devices:
  - Warning Signs
    - inadequate
    - improperly placed
    - illegible
    - telltales improperly placed and in poor condition
  - Warning signals/gates
  - inadequate and poor structural stability of bumper blocks and cattle guards.
  - Guard Rails:
    - poor structural condition and improper placing at sharp curves
    - steep embankments
    - trestles, bridges, or other locations where derailment would be serious
  - Retaining Walls:
    - undermining
    - misalignment
    - weephole obstructions
    - other deficiencies that would tend to endanger tracks
- Clearances:
  - Clearances at warehouses and structures less than 8' from center line of track from rail to 22' above rail
  - Clearances of overhanging shed roof less than 5'6" from centerline of track and from rail to 15'6" above rail
  - Clearances that do not conform to AREA standards and are less than those required by serving railroad

**STRUCTURAL****Railroad Trackage-Continued**

- Presence of weeds or other obstructions blocking view, creating fire hazard, or reducing clearances

**5.2.21 Retaining Walls:** Check for:

- Concrete Foundations:
  - cracked
  - broken
  - scoured
  - spalling
  - exposed reinforcing
  - evidence of lateral movement, settlement, undermining and rotation
- Concrete or Masonry Walls:
  - cracked
  - broken
  - spalling
  - misplaced sections
  - general deterioration
  - exposed reinforcing
  - eroded and sandy mortar joints
  - bulging
  - vertical and horizontal misalignment
- Timber Walls and Cribbing:
  - cracked
  - broken
  - loose
  - missing
  - wearing
  - undermining
  - rotting
  - insect infestation
  - bulging

**STRUCTURAL****Retaining Walls-Continued**

- vertical and horizontal misalignment
- Sheet Piling and Bulkheads:
  - rust
  - corrosion
  - bulging
  - vertical and horizontal misalignment
- Evidence of seepage resulting from obstruction in weepholes or other drainage outlets:
- Loose or missing premolded expansion joint material allowing washout of backfill:
- Structural inadequacy and poor physical condition of deadman anchors, other attachments and fastenings:
- Embankment Slopes and Areas Behind Walls:
  - erosion, settlement or slippage resulting from improper drainage
  - lack of full sod or vegetation coverage
  - damage from burrowing animals
  - slopes steeper than angle of repose

**5.2.22 Pavement:**

- Asphalt - Check for:
  - Alligatoring
  - Bleeding
  - Blade cracking
  - Bumps and sags
  - Conjugation
  - Depression
  - Edge cracking
  - Joint reflection
  - Lane/shoulder
  - Longitudinal
  - Patching
  - Polished



## STRUCTURAL

**Pavement-Continued**

- Potholes
- Railroad
- Rutting
- Shoving
- Slippage
- Swell
- Weathering
- Concrete - Check for:
  - Blow-up buckling
  - Comer breaks
  - Joint repairs
  - Spalling comer or joint
  - Pop-outs
  - Partial slab replacement
  - Full slab replacement
  - Partial depth replacement
  - Full depth replacement
  - Linear cracking
  - Shrinking
  - Scaling
  - Faulting
  - Exposed reinforcement

**5.2.23 Stair:** Exterior stairs, ladders and handrails - Check for:

- Rust:
- Rot:
- Damage:
- Deterioration:

**STRUCTURAL****5.2.24 Storm Drainage System:** Comply with all current safety precautions.

Check for:

- Ascertain that invert elevation on nonsedimentation basin and pipe are same:
- Catch-Basins and Curb Inlets:
  - debris
  - obstructions
  - cracked, broken or improperly seated grating
  - settlement
  - Top elevation adequate and compatible to prevent ponding
- Pipelines: Inspect pipe smaller than 48" diameter by using a light between manholes. Crawl through pipe 48" diameter or larger. Tightness of joints may be checked by blocking off a section between manholes for 24 hours to determine amount of ground water infiltration. Use a watchman to open line in event of rain:
  - Misalignment
  - settlement
  - cracked
  - broken
  - open joints
  - sediment
  - debris
  - tree roots
  - erosion in concrete pipes
  - erosion and corrosion in corrugated metal pipes
- Headwalls:
  - cracked
  - broken
  - spalling
  - exposed reinforcing
  - settlement
  - undermining
  - improper condition of pipe joint at headwall

## STRUCTURAL

### Storm Drainage System-Continued

- Approach Channels:
  - evidence of water channeling under and around pipe or headwall
- Outfall and Channel Beyond Headwall:
  - sediment
  - debris
  - other obstructions
  - evidence of erosion of adjoining property
- Tide Gates:
  - restricted or tight motion
  - loose closure
  - outfall line and bar screens for sediment and obstructions
- Drop Structures and Spillways:
  - silt accumulation and erosion
- Manhole Frames and Covers:
  - rust
  - corrosion
  - poor fit
  - ladder rungs for rust
  - corrosion
  - broken parts
  - damaged supports
- Manhole Walls:
  - cracking
  - spalling
  - exposed reinforcing
  - eroded or sandy mortar joints
  - loose, broken or displaced brick

## STRUCTURAL

**Storm Drainage System-Continued**

- Manhole Bottoms:
  - clogging
  - restricted flow
  - silt
  - sewer pipe fragments (indicating broken pipe)
  - invert elevation of outlet pipe not flush with bottom
- Culverts: Cracks in pavement over subsurface drainage and culverts indicate washout of soil from cracked or broken pipe. Obstructions are indicated by restricted flow after prolonged rainfall:
  - sediment
  - obstructions at inlets and outlets
  - ditch bottoms not flush with pipe inverts
  - noncompacted or previous soil resulting in channeling
- Gutters and Ditches:
  - cracked, broken, or eroded concrete surfaces
  - defective expansion joint
  - misalignment
  - obstructions
  - ponding of water
  - silting or sloughing-off of sides
  - inadequate side vegetation coverage necessary to prevent erosion
- Standing water which would permit mosquito breeding in drainage system:

**5.2.25 Swimming Pools: Check for:**

- Concrete:
  - cracks
  - breaks
  - spalling
  - exposed reinforcing
  - settlement

**STRUCTURAL****Swimming Pools-Continued**

- Tile:
  - chipped
  - cracked
  - loose and missing pieces
  - defective mortar joints
- Expansion Joints:
  - leakage
- Wall and Floor Finishes:
  - roughness
  - dirty
- Depth Markers, Safety Markings, and Lane Strips:
  - illegible
- Springboards:
  - cracks
  - breaks
  - splintered
  - other damage
  - loose or missing fastenings
  - absence of nonslip coverings
- Ladders:
  - rust or corrosion of metal parts
  - loose
  - missing
  - broken
  - rot
  - other damage to wooden parts
  - misalignment of towers
- Other Metal Accessories:
  - rust
  - corrosion

## STRUCTURAL

### Swimming Pools-Continued

- broken or missing parts
- other damage
- Other Wooden Parts:
  - cracks
  - breaks
  - splintered
  - loose joints or fastenings
  - rot
  - insect
  - other damage
- Main Drains:
  - sediment
  - rust.
- Gutter Drains:
  - obstructions
- Walls:
  - stains from corroded fittings
- Fences, Barricades, Dividing Walls and Footings:
  - broken
  - loose
  - missing
  - other damage
- Painted Surfaces:
  - blistering
  - checking
  - cracking
  - scaling
  - wrinkling
  - flaking
  - peeling

**Swimming Pools-Continued**

- rust
- corrosion
- complete absence of paint

**5.2.26 Tunnels and Underground Structures:** Comply with all current safety precautions. Check for:

- Portal Structures:
  - drainage defects
  - cracks
  - breaks
  - leaks in face and between face and tunnel lining
  - eroded slopes or undermining
- Wing and Face Walls:
  - inadequate protection to personnel
  - erosion of slopes
  - loose rocks
  - actual or potential slides
  - scouring or undermining of walls
- Door and Gate Operation and Locking Devices:
  - rust
  - corrosion
  - loose, missing or damaged parts
  - improper operation
- Concrete Floors:
  - cracks
  - breaks
  - scaling
  - other damage surface dusting
  - settlement
- Earth and Gravel Floors:
  - improper grading and drainage

**STRUCTURAL****Tunnels and Underground Structures-Continued**

- soft and muddy areas
- Vehicular Tunnel Floors:
  - faulting at joints
  - scaling
  - abrasion
  - depression
  - buckling
- Tracks for misalignment:
  - rails for damage
  - inadequate or loose connection and supports
  - ties for rot or other damage
- All Linings:
  - leakage
  - settlement
  - displacement
  - concrete
    - cracks
    - breaks
    - exposed metal
  - looseness
  - rust
  - corrosion
  - timber
    - cracks
    - breaks
    - rot
- Unlined Tunnels:
  - spalling
  - disintegration
  - loose or fallen rocks



**Tunnels and Underground Structures-Continued**

- Metal Roofs:
  - rust
  - corrosion
  - inadequate supports
- Pipeline Tunnels:
  - rust
  - corrosion
  - misalignment
  - broken
  - leakage
- Pipeline Supports and Anchors:
  - rust
  - corrosion
  - loose, missing or broken parts
- Defective drainage systems or facilities:
  - particularly in ammunition tunnels
  - indicated by dampness
  - flooding
  - ponding
- General Condition or Ventilation Equipment:
  - apparent defects in operation
  - rust
  - corrosion
  - loose, missing or other damage to related parts
- Lighting Systems and Fixtures:
  - poor operating condition
  - inadequate
  - improper type

**STRUCTURAL****Tunnels and Underground Structures-Continued**

- **Grounding Connections:** Grounding of metal parts is required in ammunition tunnels. Refer to Chapter 7, Electrical Inspection Guide, Grounds and Grounding Systems:
  - electrical discontinuity
  - loose, missing, corrosion or other damage to the connections

**5.2.27 Waterfront:****Topside -**

- **Concrete or wood structures - Check for:**
  - Horizontal and vertical alignment
  - Missing or broken sections, loose connections, traffic obstructions, and other hazardous conditions of
    - Curbing
    - Handrails
    - Catwalks
  - Wear, breaks, rough or sharp surfaces or edges, and missing bolts of
    - Bollards
    - Bits
    - Cleats
    - Capstans
  - Loose, missing, or broken screws, and wear on
    - Deck drains
    - Scuppers
  - Rust, corrosion, damage, and bent or worn hinge pins of
    - Manhole covers
    - Gratings
  - Rust, cracking, spalling, and other damage of
    - Deck surface
    - Curbs
  - Cracks, holes, and other damage of asphalt coverings
  - Corroded, broken, bent, or missing ladder rungs

**STRUCTURAL****Waterfront-Topside-Continued**

- Cracked, rotted, loose, or worn decking of wood structures only
- Synthetic material:
  - Structures - Check for
    - Cracked, worn, brittle, or deformed plastic
      - Railing
      - Stanchions
      - Gratings
      - Lighting devices
      - Piping
    - Loose or damaged
      - Fittings
      - Connections
    - Exposed fiberglass
    - Cracked, worn, or deformed rubber fender components
  - Coatings, patches, and jackets - Check for
    - Pits, cracks, scars, or abrasions of coatings
    - cracked, loose, or dislodged epoxy patches
    - Punctures, brittleness, tears, abrasions, seam splitting of fabric in pile jackets
  - Foam filled fenders
    - Fender-to-pier connection hardware - Check for
      - Condition
      - Proper operation
      - Corrosion
      - Proper horizontal constraint
      - Proper vertical and rotational motion allowable
    - Chain and tire net - Check for
      - Proper operation of end fittings
      - Chain symmetry on the fender
      - Proper protection of the chains by the tires

## STRUCTURAL

### Waterfront-Topside-Continued

- Proper net tension
- End fittings - Check for
  - Proper operation
  - Corrosion
  - Cracking or separation of fender shell around end fittings

### Underside -

- Elastomer shell - Note the size and location of the damage on a sketch.  
Check for
  - Cuts
  - Tears
  - Punctures
- Concrete:
  - Pile caps - Check for
    - Damage
    - Broken or missing members
    - Cracks
    - Spalling
    - Rust
    - Exposed steel reinforcement
  - Bearing, batter, and fender piles - Check for
    - Damage
    - Broken or missing members
    - Cracks
    - Spalling
    - Rust
    - Exposed steel reinforcement

**Waterfront-Underside-Continued**

- Pilings or structure - check for loose layers of concrete or hollow spots by sounding with a hammer. A sharp ring noise indicates sound concrete. A soft surface will be detected, not only by sound change, but also by a change in the rebound, or feel of the hammer. A thud or hollow sound indicates a delaminated layer of concrete, most likely from corrosion of steel reinforcement.
- Wood:
  - Stringers and pile caps - Check for
    - Damage
    - Broken or missing members
  - Bearing, batter, and fender piles - Check for
    - Damage
  
    - Broken or missing members
  - Dolphins - Check for
    - Broken, worn or corroded
      - Cables
      - Cable connections
    - Corroded, loose, broken, or missing
      - Wedge block
      - Chafing strips and bands
      - Chock bolt hangers
  - Pilings - Check for
    - Rot
    - Fungi
    - Marine borer damage
  - Interior rot by sounding with hammer and probing suspect areas with a sharp, thin, pointed object. If an area is in question, take a small boring for laboratory analysis using an increment borer. Once the core is extracted, seal the hole with a creosote treated plug to prevent easy access of borers to the interior of the pile

**STRUCTURAL****Waterfront-Underside-Continued**

## ■ Steel structures - Check for:

- Corrosion - Corrosion may be evident during visual inspection in the H-piles and sheet piles in two areas, the splash zone and approximately two feet below mean low water. Inside steel pipe piling, anaerobic bacterial corrosion caused by sulphate-reducing bacteria may also be found to exist
- Abrasion - Abrasion of steel structure can generally be recognized by worn smooth polished areas
- Fatigue distress - Fatigue distress can be recognized by a series of small hairline fractures perpendicular to the line of stress in the member. Fatigue cracks are difficult to locate by visual inspection. This problem is more common in offshore platforms with welded structural connections than in standard piers and wharves
- Overload damage - Overloading can be recognized by deformation or distortion of a structural member in the form of a sharp crimp or compression of a bearing or batter pile, deflection of steel sheet piling caused by failure of tie-backs or excessive overload of back-fill or live load
- Loss of foundation material - Erosion may cause loss of foundation material around the piles supporting the structural element. A loss of foundation material in front of the sheet pile bulkhead may cause kick-out of the toe of the wall and result in bulkhead or pile collapse

**Underwater -**

A recommendation for an underwater inspection should be considered if the facility maintenance specialist suspects underwater damage. This damage, usually to the piles, may be due to unique environmental factors or marine borer damage. The check-lists above may be used when performing and evaluating an underwater inspection.

## STRUCTURAL

**5.2.28 Window: Check for:**

- Fit:
- Seal:
- Air infiltration:
- Rust:
- Rot:
- Water intrusion:
- Insect damage:
- Glazing condition:
- Broken/cracked panes:
- Missing panes:
- Sash:
  - Fit
  - Seal
- Lock condition:
- Screen condition:

**5.3 REPAIR/REPLACEMENT CRITERIA:**

**5.3.1 Asbestos:** Asbestos in good condition will be maintained in place until it must be repaired, replaced with a non-asbestos material, or removed prior to renovations and demolitions in accordance with OPNAVINST 510023C. Asbestos abatement projects should be prepared in accordance with OPNAVINST 11010.20 (Series). Abatement actions should be taken to minimize or eliminate the hazardous exposure to asbestos. These actions include:

- Operation and Maintenance (O&M) Program:
- Encapsulation or enclosure:
- Removal:

**5.3.2 Ceiling:** Renewal of ceiling finishes is cyclic maintenance. Each situation must be assessed by the inspector before preparing an estimate.

**5.3.3 Construction:** If in doubt about repairing or replacing the construction of a facility have an engineering study performed to review the situation. For wood, load bearing members use the following, criteria for repair:

- Good overall condition:

**STRUCTURAL**

- Moderate to severe deflection:
- No deterioration:
- change in facility mission has overloaded members (installation of heavy equipment):

**5.3.4 Door.**

- Exterior:
  - Wood
    - Repair
      - General good condition
      - Damaged or inoperable hardware
      - Superficial damage or deterioration
    - Replacement
      - General poor condition
      - Doors and frames are rotted or deteriorated
      - Doors are warped
      - Doors are out of plumb due to glue joint failure
  - Steel
    - Repair
      - General good condition
      - Damaged or inoperable hardware
      - Superficial damage or deterioration
    - Replacement
      - General poor condition
      - Doors do not operate properly
      - Major damage or deterioration to doors or frame
- Interior
  - Repair
    - General good condition
    - Minimum damage
    - Replacement hardware easily accessible



**STRUCTURAL**

- Replacement
  - General poor condition
  - Replacement hardware difficult to obtain

**5.3.5 Exterior walls:** Walls will normally only be repaired. If replacement is considered, have an engineering study performed.

**5.3.6 Fencing:**

- Repair:
  - Minor, spotty, or no rust (on metal fencing)
  - Minor damage or deterioration over small sections of fencing
  - General good appearance
- Replacement:
  - Severe rusting (on metal fencing)
  - Major damage or deterioration over a large part of fencing
  - General poor appearance

**5.3.7 Floor:** (tile, carpet, painted, etc)

Renewal of floor finishes is cyclic maintenance. Each situation must be assessed by the inspector before preparing an estimate.

**5.3.8 Foundation:** If in doubt about repairing or replacing the construction of a facility have an engineering study performed to review the situation.

**5.3.9 Interior walls:** Walls will normally only be repaired. If replacement is considered, have an engineering study performed.

**5.3.10 Painting:** Painting is cyclic maintenance. Normally every 5 years the interior and exterior surfaces of a facility should be repainted. Some factors to consider before specifying a paint job are the:

- Item to be painted:
- Surface type, age, and condition - old and weathered surfaces would require more frequent applications of paint:
- Time since last painting:

## STRUCTURAL

**5.3.11 Pavement** : Divide the pavement area into Branches, Sections using MO-102.5, **Pavement Maintenance Management**. This will translate inspection results into types of distress and rate the severity level. Use NAVFAC MO-102.1 (**Asphalt Surfaced Roads and Parking Lots**), NAVFAC MO-102.2 (**Jointed Concrete Roads and Pavement-Continued Parking Lots**), NAVFAC MO-102.3 (**Asphalt Surfaced Airfields**), NAVFAC MO-103.4 (**Jointed Concrete Airfields**). They contain pictures of the types of distress in asphalt and concrete pavements along with providing the inspector with a method of determining the severity rating. Record the distress types and their severity levels. Then calculate the pavement condition index (PCI). The PCI measures the pavement's structural integrity and surface operating condition on a scale from 0-100, where 0 = failed and 100 = excellent condition. Use a PCI chart to rate the pavement condition for repair or replacement.

**5.3.12 Stair:** Each situation must be assessed by the Inspector before preparing an estimate. Normally stairs are only repaired.

**5.3.13 Waterfront:** Generally the waterfront facilities should be repaired. If replacement is considered, request that an engineering evaluation be done to better assess the situation.

**5.3.14 Window:**

■ Steel:

- Repair
  - General good condition
  - Proper operation
  - Good fit
- Replacement
  - Badly rusted window frame
  - Leaks evident
  - Single pane
  - Many broken, cracked, or deteriorated frames
  - Poor frame to wall connection
  - Poor operation
  - Poor fit

## STRUCTURAL

### Window-Continued

#### ■ Wood:

- Repair
  - General good condition
  - Good operation
  - Good fit
- Replacement
  - Bad rot or deterioration
  - Worn tracks (opening and closing difficult)
  - Leaks evident
  - Single pane
  - Many broken, cracked, or deteriorated frames
  - Total reglazing of windows required to assure good condition

## MECHANICAL

### CHAPTER 6. MECHANICAL INSPECTION GUIDE

#### 6.1 DEFINITIONS:

**Air conditioning** - devices that cool air including heat pumps

**Air handler** - devices that move heated, cooled, and untreated air and the associated ductwork

**Boilers** - includes boilers, expansion drums on high temperature water installations, boiler auxiliaries, and controls

**Emergency eyewash/shower** - all eyewashes, showers, and exposed pipe used to wash eyes or body when contaminated with hazardous materials

**Exhaust** - devices that cause or allow air to leave a facility (fans, vent, etc.)

**Fire protection** - everything from the first valve outside of the facility to the discharge point, includes sprinkler systems and hose outlets, note fire extinguishers

#### **Fuel Facilities** -

**Distribution** - fuel distribution facilities include piping, valves, accessories, signs and markings, ground connections, pits, tunnels, and ladders

**Receiving and Issue** - includes platforms and islands, small structures, fuel hose, hose connections, and adapters, hose racks and reels, grounding connections, portable ladders and steps, portable gangplanks, signs and markings, general cleanliness, and painting

**Storage** - includes surface and subsurface tanks, tank enclosures, and tank fittings and appurtances

**Heating** - devices that heat air for a facility, not heat pumps

**Incinerators** - includes incinerators used for refuse and garbage disposal, including special-purpose types

## MECHANICAL

### **Piping -**

**Chilled/Hot Water System** - from the first valve off the heat exchanger or chiller to the destination inside the facility

**Compressed Air** - from the first valve off of the compressor to the destination inside the facility

**Natural Gas** - from the first valve on the facility side of the facility water meter to the destination inside the facility

**Sewage** - from 5 feet outside the facility to the source inside the facility

**Steam** - from the first valve on the facility side of the pressure reducing station closest to the facility, to the destination inside the facility

**Water** - from the first valve on the facility side of the facility water meter to the destination inside the facility

**Plumbing** - all fixtures and exposed pipe related to the distribution and use of water in a facility

**Sanitary Sewage Utility System** - the sewage lines from the facilities to the sewage treatment plant

**Steam Utility System** - the steam distribution system piping from the steam plant to the point where the steam enters the facility

**Unfired Pressure Vessels** - includes all closed vessels in which internal pressure is above atmospheric pressure and the pressure is obtained from an external source except (a) cylinders for shipment of compressed or liquified gasses; (b) air tanks for brakes on vehicle; (c) unfired pressure vessels having a volume of 5 cubic feet or less; (d) unfired pressure vessels designed for a working pressure not exceeding 15 pounds per square inch gage; (e) unfired pressure vessels containing only water under pressure for domestic supply purposes, including those containing air, the compression of which serves only as a cushion; (f) unfired pressure vessels used as refrigerant receivers for refrigerating and air conditioning equipment; (g) expansion or accumulator tanks used in conjunction with high temperature water installations

**Water heaters** - devices that heat water for domestic purposes (including converters and storage tanks when used for domestic hot water)

**MECHANICAL**

**Water Utility System** - the water lines from the base's source (city line, well, reservoir, etc.) through any storage tanks to the destination (facility, fire line, etc.)

**6.2 MECHANICAL INSPECTION INSTRUCTION:****6.2.1 Air conditioning:**

- Condenser - Check for:
  - Metal cabinet condition
  - Fan and coil condition
- Evaporator - Check for:
  - Metal cabinet condition
    - Fan and coil condition
    - Proper drainage of drain pan
    - Electrical wiring condition
    - Condition and proper operation of control circuits
  - Refrigeration piping and insulation - Check for
    - Hanger system condition
    - Deteriorated piping
    - Leaking and weeping joints
    - Insulation condition and type
    - Asbestos insulation condition whether encapsulation or removal is necessary
    - Piping to ensure that piping is same throughout (copper, black, and galvanized are not mixed)
  - Fan coil units - Check for
    - Proper operation of unit
    - Cabinet damage
    - Drainage of drain pan
    - Leaks
    - Proper mounting
  - Duct system including air diffusers and return air grills - Check for
    - Cleanliness
    - Proper operation of dampers

**MECHANICAL****Air conditioning-Continued**

- Insulation damage and type
- Diffuser operation
- Return air grills operation and condition
- Compressors - Check for
  - Excessive noise
  - Oil on deck
  - Leaks at connections to compressors
- Pumps - Check for
  - Leaking at packing glands
  - Excessive noise
  - Leaking at connections
- Electric and pneumatic controls - check for proper operation
- Check water treatment chemicals and system
- Water cooling towers, casings, baffles, fans and tower water distribution system including piping and insulation, sump heaters (steam and electric) - check condition and operation
- Absorption chillers (centrifugal and reciprocating) - check for proper operation and condition
- Expansion tanks - check for condition and proper operation
- Vacuum pumps - check for condition and proper operation

**6.2.2 Air handlers:**

Check for:

- Condition and operation of
  - Fan motors
  - Squirrel cages
  - Fan belts
- Condition of flexible connection between duct and air handler
- Proper lubrication

**6.2.3 Boilers:** Comply with all applicable safety precautions. This procedure does not include all requirements and specifications to perform this inspection. Refer to NAVFAC MO-324, **Inspection and Certification of Boilers and Unfired Pressure**

**MECHANICAL****Boilers-Continued**

**Vessels** for more information. Inspectors must obtain and possess a valid NAV-FACENGCOCM Certificate of Competency and a current license issued by the geographic Engineering Field Division/Engineering Field Activity (EFD)/(EFA). Contracted inspectors must possess a state certificate and a current license issued by the EFD/EFA. Before entering the shell or drums of the boiler, make sure that they have been properly ventilated; that there is no inflammable gas present; that the blow-off and surface blow-off valve, the main and auxiliary steam valves, feed-water valves, and all other valves on connecting pipes are closed; and that a reliable method is used to safeguard these valves while anyone is inside the boiler. When electric cords are used inside a boiler they should be in good condition, well insulated, designed to withstand mechanical injury and provided with a suitable guard. **Naked lights are prohibited.** On this inspection report, indicate decrease in pressure-carrying capacity and recommendations not completed or scheduled for completion from previous inspection reports and log sheets. Check for:

**EXTERNAL INSPECTION**

- Safety and Relief Valves:
  - accumulated rust, scale or debris
  - obstructed drain
  - hazardous conditions created by discharge
  - try lever not free
  - gags removed
  - stems not bent
- Automatic Low-Water (Level or Flow) Fuel Cut-Off and/or Water Feeding Device:
  - rust
  - corrosion
  - deteriorated or defective parts
  - improper function
- Gages:
  - cracked, broken, missing or dirty glass
  - illegible markings
  - bent pointer



**MECHANICAL****Boilers-Continued**

- leaking connections
- improper function of cock between gage and boiler
- Water Columns and Gage Glasses:
  - excessive corrosion
  - cracked or dirty glasses
  - leakage
  - improper drainage
- Material Storage: lumber or other material on boiler or setting:
- Lagging:
  - loose or missing material
  - cracks
  - open seams
  - evidence of vapor or water leaks
- Casing:
  - distortion
  - slippage of bricks
  - open seams, cracks
  - looseness
  - sheared bolts
- Shell:
  - corrosion
  - cracks
  - leaking roofs, valves, pipes
  - rust streaks on covering
- Boiler Doors:
  - sagging
  - warping
  - cracking
  - chipped or broken edges
  - worn hinges

**MECHANICAL****Boilers-Continued**

- defective locks or latches
- improper operation
- deteriorated or damaged blast deflectors
- condition of gasket
- Breechings:
  - excessive corrosion
  - cracked welds
  - loose or broken connections
  - separated sections
- Overhead Machinery: loose parts or material that may drop on or strike boiler:
- Foundation: settlement, improper level:
- Piping:
  - leakage
  - strain or torsion
  - excessive corrosion
  - improper drainage
  - misalignment
  - lack of support
  - inadequate provision for expansion or contraction
  - excessive vibration
  - water pockets at valves and connections
  - loose, deteriorated, strained, inadequate connections
  - settlement
  - improper tension or alignment in supports
- Stop and Check Valves:
  - loose, missing, broken parts
  - excessive wear or corrosion
  - leakage
  - obstructed drain openings

**MECHANICAL****Boilers-Continued**

- Pressure Reducing Valves:
  - loose, missing, broken parts
  - rust, scale, other substance preventing proper operation
- Blow-Off Tanks:
  - excessive corrosion
  - cracks
  - distortion, other weakness
  - leaks, water pockets
  - improperly placed valves
- Ladders and Runways:
  - broken, cracked, split, badly worn members
  - excessive corrosion
  - loose or missing bolts or other connections
  - broken welds
  - abnormal deflection
  - loose or warped sections
  - slippery surfaces
  - inadequate anchorage
- Electric Steam Generators: Refer to Chapter 7, Electrical Inspections Guide, Motors and Generators. Check for:
  - burnt, corroded, frayed, or broken strands in grounding cable
  - loose connections
  - broken or deteriorated screens and guards
  - missing, illegible, or improperly posted warning signs

**INTERNAL INSPECTION**

- Contamination:
  - connection of potable water to sewer system
  - absence of air gap between potable water and waste pipe
- Preparation for Inspection:
  - inadequate

**Boilers-Continued**

- incomplete
- untimely
- Steam Gage: improperly calibrated. Recalibrate:
- Boilers Secured or Stored:
  - Wet Lay-up
    - incompletely filled
    - improper pH and sulfite concentration
  - Dry Layup
    - not completely dry
    - inadequate supply of desiccant
    - improper or inadequate placement of desiccant
- Waterside Metal Surfaces:
  - evidence of oil. Report presence of oil
  - indications of scale. Report location, amount, density, degree of hardness, and age of scale
- Plates:
  - cracks
  - defective joints
  - distortion
  - erosion
  - excessive corrosion
  - grooving
  - lap seam cracks
  - cracked or severely corroded rivets
  - cracked welds
  - Determine minimum thickness and calculate new maximum allowable working pressure
- Stays and Braces:
  - cracks
  - bends
  - looseness

**MECHANICAL****Boilers-Continued**

- uneven tension
- excessive corrosion or erosion
- loose, cracked, broken connections
- Reinforcing Plates:
  - excessive corrosion
  - worn
  - cracked
  - deformed
  - insecurely fastened
  - openings obstructed
- Openings and Connections for Piping and External Attachments:
  - obstructed
  - inadequate
  - excessive corrosion
- Internal Piping and Fittings:
  - loose connections
  - breaks
  - cracks excessive corrosion
  - clogging
- Protection for Blow-Off Connection:
  - spalling
  - cracking
  - looseness
  - missing or worn parts
- Manholes and Handholes:
  - corrosion
  - leakage
  - distorted
  - elongated
  - excessively corroded holding clamps

**Boilers-Continued**

- Tubes:
  - deterioration
  - excessive reduction in thickness
  - bulges
  - cracks
  - defective welds
  - erosion
  - corrosion
  - waste pockets
  - scale
  - distortion
- Ligaments: broken, cracked, leaks:
- Drumheads: cracks, deformation, excessive corrosion:
- Flanging: grooving:
- Soot Blowers:
  - worn, loose, or inadequate bearings and parts
  - incorrect alignment of nozzles
  - excessive scouring of refractory baffles
  - incorrect blowing ranges
  - inadequate traps
  - condition of packing
  - signs of direct impingement of steam on tubes
- Fireside Surfaces or Gas Passages:
  - steam pockets
  - corrosion
  - bulging
  - blistering
  - distortion
  - deformation
  - excessive burning action

**Boilers-Continued**

- fly ash deposits
- flame leakage
- localization of heat
- deteriorated or loose tie rods and buck stays
- Fusible Plugs:
  - poor condition
  - unsound metal
  - in service more than one year
  - exposed to steam temperature in excess of 425°F
- Setting:
  - improper level
  - tendency to settlement
  - inadequate provision for expansion and contraction
  - excessive corrosion
  - holes
  - cracks
  - slippage
  - distortion
  - binding
  - loose bricks
  - improper air space
  - poor insulation of steel supporting members
  - excessive vibration
- Furnaces and Baffles:
  - spalling
  - cracking
  - settlement
  - distortion
  - abnormal cracks and seams
  - excessive burning and corrosion

**Boilers-Continued**

- fly ash deposits
- inadequate expansion joints
- improper protection of mud drums
- loose, missing, deteriorated, improperly placed baffling
- Firing Equipment and Dampers:
  - Burners
    - loose, broken, or missing parts
    - excessive wear or corrosion
  - Grates, Stokers and Feeders
    - loose, broken or missing parts
    - excessive wear or corrosion
  - Dampers
    - loose, broken, missing, bent, warped, or binding parts
    - excessive wear or corrosion
    - improper operating condition
- Low-Water Fuel Cut-Off and/or Water Feeding Device:
  - scale or dirt deposits
  - restricted moving parts
  - excessive wear
  - loose, broken, or missing parts
  - improper function

**HYDROSTATIC TEST**

- Preparation: inadequate, incomplete:
- Inspection:
  - leakage
  - loose parts
  - distortion
  - deformations
  - Report row and number of tubes requiring rolling or replacement



**Boilers-Continued**

- Maximum allowable Working Pressure: Recalculate:

## INSPECTION OF OPERATION

- Firing Equipment: improper or inefficient operation:
- Controls:
  - inability to maintain proper steam pressure or water temperature and air-fuel ratio throughout capacity range of boiler with load swings of the rapidity encountered in operation
  - improper programming sequence and timing
  - improper cutoff of fuel supply; inability to maintain proper water level or to operate cutoff devices
  - Test flue gas for CO
  - Check air-fuel ratio with CO<sub>2</sub> and O<sub>2</sub> measuring devices
- Steam and Water Piping:
  - leakage
  - excessive vibration
  - water-hammer
  - tendency to crystallize
- Water Columns and Gage Glasses: restricted connections:
- Steam Gages:
  - stuck pointer
  - restricted movement of pointer
  - obstructed connections
- Temperature Indicating Devices: excessive temperatures indicated, particularly during and immediately after high load demands:
- Blow-Off Valves:
  - restricted openings
  - excessively worn or otherwise defective
- Stop and Check Valves:
  - excessive vibration
  - ineffective or defective operation

**MECHANICAL****Boilers-Continued**

- Pressure Reducing Valves: defective, inadequate, improper operation:
- Metering and Recording Devices: improper operation:
- Boiler Auxiliaries:
  - steam leakage
  - wastage to atmosphere
  - unnecessary use
  - inadequate or improper functioning
- Boiler Safety and Water-Pressure Relief Valves:
  - improper operation
  - obstructed discharge
  - does not release at required pressure
  - have qualified personnel adjust to proper setting requirements (See MO-324 for appropriate organizations/personnel authorized to perform this function)
- Feedwater Treatment:
  - Equipment: ineffective, inadequate, improper operation
  - Materials: incorrect, insufficient
- Feedwater Quality:
  - proper analyses
  - allowable ranges
  - periodic checks
- Fuel Handling Practices:
  - multiple handling
  - use of duplex equipment for small loads
  - unnecessary heating
  - improperly maintained equipment
  - insufficient operation
- Partial Loading: unnecessary use of similar equipment at part load when one unit could carry load:

**MECHANICAL**

**6.2.4 Elevators:** Check certification to ensure it is current. Record and immediately advise if certification is expired.

**6.2.5 Emergency eyewash or shower:** Check for:

- Proper operation:
- Condition:

**6.2.6 Exhaust:**

- Fans - Check for:
  - Proper rotation
  - Belts and sheaves for proper condition, alignment and tension
  - Fan inlet and outlet for system defects
  - Measure fan speed, motor speed, voltage, amperage, static pressure at the fan inlet and outlet, total flow rate at the fan inlet. Request Mechanical Engineering assistance from EFD/EFA/NEESA if inspection capability is not available at local Public Works Department. Request technical support for proper selection of fans to meet special activity requirements of temperature, corrosiveness, abrasiveness, and flammability.
- Bathroom exhaust fan - Check for:
  - Proper ventilation
  - Proper operation
  - Cleanliness of filters
  - Proper operation of dampers
- Exhaust system for clothes dryer - Check for:
  - Proper operations
  - Cleanliness of filters

**6.2.7 Fire Protection:**

- Sprinkler system piping - Check for:
  - Check for painted fusible elements on sprinkler heads. Painted fusible elements will cause an unwanted delay in sprinkler head operation.
  - Check for painted heat activated devices (HAD's). If heat detectors are used to activate a sprinkler system (i.e., deluge or pre-action systems) the HAD's cannot be painted.

**MECHANICAL****Fire Protection- Continued**

- Rusted piping
- Leaking threaded or mechanical joints
- Rusted or broken hangers
- Bent pipe
- Combustible materials above sprinkler heads - It is illegal to have flammable material above a drop ceiling without a sprinkler head to serve that area:
- Connections between fire protection and domestic water (fire water should not be allowed to flow back to the domestic water system). Backflow preventers are required on foam water sprinkler systems. Conventional wet-pipe, dry-pipe, pre-action and deluge sprinkler systems only require a check valve between the sprinkler system and the domestic water.:
- Deterioration of fusible elements on sprinkler heads especially in corrosive or exterior atmospheres. There are no fusible links on halon systems:
- Certification of all components:

**6.2.8 Fuel Facilities:****Distribution -**

- Above-Ground Piping:
  - leakage
  - loose connections
  - damaged or missing hangers and supports
  - misalignment causing undue stresses at pipe joints or failure to allow freedom of movement at expansion joints
  - defective gland nuts and bolts at expansion joints and clamp-type couplings
  - deteriorated or damaged paint or protective coverings. Stop leaks by takeup within limits of packing gland adjustments
  - defective packing
  - defective hangers and supports
  - defective gland nuts and bolts

**MECHANICAL****Fuel Facilities-Distribution-Continued**

- defective anchorage
- **Underground Piping:** Location of underground leaks may be determined by sectioning the pipelines and performing hydrostatic tests. See Military Fuel Operations Handbook, Office of the Assistant Secretary of Defense (Supply and Logistics):
  - leakage indicated by earth discoloration
  - dead vegetation
  - presence of odors
  - review periodic oil sampling records to determine if there is entrainment of ground water
  - review and compare fuel and replenishment records to determine if there is a loss of fuel
- **Valves:**
  - leaks
  - corrosion
  - visible defects in stem, operating handwheel or lever, body packing, gland, flanges, and gaskets
  - inadequate lubrication, wear, mechanical damage
  - damage to protective coatings
  - difficult operation
  - Where operational functions of the system will permit and where precautions are feasible against contamination of the fuel, the following inspections should be performed
    - Operate gate and plug-type valves to fully closed and open position, to ascertain condition of valve seats and stem threads and to test limit cutout of remote-controlled valves
    - Inspect plug valves for incorrect adjustment
    - Remove inspection covers of check valves and inspect such parts as valve seats, gates, and hinges, for wear and damage
    - Lift pressure vacuum relief valves by hand to assure against sticking; if setting is questionable, check and reset as specified by the manufacturer's instructions

**MECHANICAL****Fuel Facilities-Distribution-Continued**

- Check for
  - loose flanges at leaking gaskets
  - defective gaskets
  - leaking stems, within the limit of packing gland adjustment
  - defective packing
  - defective or missing bolts and nuts, handwheels, and operating levers
- Meters and Pressure Gages:
  - significant drop in pressure after 15 minutes
  - leakage
  - cracked dial cover glasses
  - defective gaskets
  - moisture behind glasses
  - mechanical damage
  - inaccuracy of indicating and recording mechanisms
- Thermometers:
  - inaccuracy
  - mechanical damage
  - loss of indicating fluid
- Strainers: Remove obstructions. Remove and examine for wear, damage, obstructions, and replace defective screens:
  - leaks
  - defective operation
- Shock Absorbers:
  - leaks and mechanical damage
  - liquid in U-bend of liquid-cushion type not at proper level
  - tube pressure at which pneumatic-tube type operates is below normal pressure plus the amount specified by manufacturer
    - low pressure

**Fuel Facilities-Distribution-Continued**

- hammering sound in pipelines of bellows-type after previous satisfactory operation indicates probable damage and must be repaired or replaced
- liquid in air-chamber type
- Vents:
  - damaged screens
  - dirt or other obstructions blocking discharge to atmosphere
  - restricted by paint or corrosion
- Grounding Connections:
  - loose
  - missing
  - mechanical or corrosive damage
  - failure to maintain electrical continuity
- Grading at Pits and Tunnels: Adjacent earth surface improperly sloped and does not divert surface water away from pits and areas above tunnels:
- Pits for Valves, Meters, and Pumps:
  - defective cover gaskets, hinges, locks
  - dry hinges
  - trash and debris
  - cracked, spalled, or broken concrete areas
  - rotted, splintered, broken, and other damage to wooden parts
  - rust, corrosion, and cracks in metal covers and frames
  - defective gaskets, hinges, locks
  - unlubricated hinges
  - trash and debris in pits
  - other deficiencies
- Underground Tunnels:
  - deteriorated protective coatings
  - rust
  - corrosion
  - decay

**MECHANICAL****Fuel Facilities-Receiving and Issue**

- mechanical damage
- defective hinges and locks for access hatches and covers
- leakage at roof seams and caulked pipe seams in concrete walls and other locations
- settlement
- cracked or broken concrete areas
- Ladders:
  - rust
  - corrosion
  - broken welds
  - rot
  - splitting
  - broken
  - loose, missing, or damage to individual parts or connections
  - unsafe
  - deteriorated paint
  - tighten or replace loose, missing, or defective bolts and rungs
- Signs and Markings:
  - inaccuracy
  - illegibility
- Wooden Platforms and Islands:
  - loose
  - missing
  - worn
  - rotted
  - other damage to individual planks
- Wood Framing, Supports, Stairs, and Guardrails:
  - loose
  - missing
  - worn



## MECHANICAL

### **Fuel Facilities-Receiving and Issue-Continued**

- rotted
- broken parts
- Metal Framing, Supports, Stairs, and Guardrails:
  - rust
  - corrosion
  - loose
  - missing
  - twisted
  - bowed
  - bent
  - broken parts
- Metal Platforms:
  - worn
  - bent
  - broken
  - defective gratings and plates
  - connections
  - rust
  - corrosion
  - loose
  - missing
  - broken
  - other damage
- Concrete Islands:
  - cracks
  - breaks
  - settlement that may lead to failure of pipe or valves
  - damage to related equipment

## MECHANICAL

### **Fuel Facilities-Receiving and Issue-Continued**

- Small Structure Concrete Foundations:
  - cracks
  - breaks
  - settlement that may lead to structure failure
- Metal Area:
  - rust
  - corrosion
  - wear
  - other damage
- Wood Framing:
  - wear
  - rot
  - insect infestation
  - other damage
- Roofs and/or Walls:
  - leakage
  - wear
  - rot
  - insect infestation
  - other damage
- Doors and Windows:
  - sagging
  
  - binding
- Hardware:
  - defective hinges
  - locks
  - broken glass
- Hose Racks and Reels:
  - corrosion of metal

**MECHANICAL****Fuel Facilities-Receiving and Issue-Continued**

- rotting and other damage to wood
- mechanical damage
- other defects that may result in injury to stored hose
- Portable Ladders, Steps, and Gangplanks:
  - wear
  - mechanical damage
  - breakage
  - loose, missing, or damaged bolts or connections
  - other defects that may be a safety hazard
- Signs and Markings:
  - inaccurate
  - illegible
- Debris and spillage that may cause safety or fire hazard:
- Permanent and Portable Grounding Connections for Steel Structures, Piping, and Railway Trackage at Fuel Piers and at Receiving and Issue Stands: Test permanent and portable grounding connections with megger or ohmmeter to assure electrical continuity and zero grounding. Refer to Chapter 7, Electrical Inspection Guide, Grounds and Grounding Systems:
  - mechanical damage
  - corrosive damage
- Painted Surfaces:
  - rust
  - corrosion
  - cracking
  - scaling
  - peeling
  - wrinkling
  - alligatoring
  - chalking
  - fading
  - complete loss of paint

## MECHANICAL

### **Fuel Facilities-Storage -**

- Foundations:
  - settling movement
  - upheaving
  - inadequate soil coverage
- Exterior Concrete Surfaces:
  - spalling
  - cracking
  - exposed reinforcing
  - leakage
- Exterior Steel Surfaces:
  - rust
  - corrosion
  - distortion or other structural failure
  - leakage
  - deteriorated paint
- Roof Surfaces:
  - defects in waterproofing
  - heat-reflecting coatings, coverings
- Floating and Expansion-Type Roofs, Seals, Supports, and Support Guides:
  - rust
  - corrosion
  - improper sealing
  - deteriorated paint
  - structural or mechanical damage caused by freezing weather conditions
- Structural Supports and Connections:
  - rust
  - corrosion
  - rot

**MECHANICAL****Fuel Facilities-Storage-Continued**

- broken
- cracked
- distorted
- loose
- missing
- deteriorated paint
- Tank Linings:
  - loss of elasticity
  - granulation
  - discoloration
  - cracks
  - peeling
  - sloughing off
- Tank Interior:
  - rust
  - corrosion
  - scale
  - deteriorated protective coatings
- Frames and Covers on Manholes and Hatches:
  - rust
  - corrosion
  - cracks
  
  - breaks
  - missing or damaged bolts
  - worn defective hinges and gaskets
- Vents:
  - rust
  - corrosion
  - dirty screens

**MECHANICAL****Fuel Facilities-Storage-Continued**

- Pressure and Vacuum Relief Valves:
  - defective operation
  - leakage
  - improper adjustment
- Manometers and Thermometers:
  - inaccuracy
  - mechanical damage
  - loss of fluid
- Float Gages:
  - wear
  - binding
  - apparent inaccuracy
- Cables, Sheaves, and Winch of Swing Lines:
  - wear
  - mechanical damage
  - stuffing boxes and liquid seals
  - deterioration
  - improper operation
- Stairs, Ladders, Platforms, and Walkways:
  - rust
  - corrosion
  - rot
  - broken
  - cracked
  - loose
  - missing
  - members or connections
  - deteriorated paint

**MECHANICAL****Fuel Facilities-Storage-Continued**

- Roof Drains and Screens:
  - missing
  - rust
  - clogging
- Ground Connections:
  - loose
  - missing
  - mechanical damage
  - corrosion interfering with electrical continuity
- Interior Heating, Inlet and Outlet Pipes, Nozzles, Supports, Sumps, and Sump Drains:
  - rust
  - corrosion
  - wear
  - loose or missing parts
  - obstructions
  - other defects
- Dikes:
  - cracks
  - breaks
  - spalling
  - rust
  - corrosion
  - settlement
  - heaving
  - soil erosion
  - water seepage
  - inadequate sod cover on outer face where earth-filled
  - inadequate treatment of inner face to prevent vegetation growth
  - access steps for settlement

**MECHANICAL****Fuel Facilities-Storage-Continued**

- breaks
- other damage
- Drainage Ditches, Sumps and Earth Surfaces between Ditch and Foundation:
  - improper slope to divert surface water away from foundation and berm
  - trash and debris
  - erosion
- Leakage: Locate leaks by filling completely with water and applying hydrostatic pressure of 4 ft. of water for not less than 4 hours:
  - review records to determine indication of fuel losses
  - review oil sample records to determine if water infiltration

**6.2.9 Heating:**

- Thermostats - Check for:
  - Proper operation (if possible)
  - Vacuum or air leaks
  - Proper location
- Coils - Check for:
  - Leaks
  - Proper vacuum breaker on condensate return for steam coils
- Zone pumps - check for proper operation:
- Radiators - Check for:
  - Radiator valves and traps condition
  - Leaks at push nipples
  - Operation of automatic air vents on hot water systems
- Baseboard radiators - Check for:
  - Leaks in fin tubes
  - Damaged cover and mounting frame
  - Leaks of radiator valves and traps on steam units
  - Leaks of automatic air vents on hot water units



**Heating-Continued**

- Fan coil units - Check for:
  - Proper operation
  - Damaged cabinet
  - Proper drainage of drain pan
  - Leaks
  - Proper mounting
- Duct system and components - Check for:
  - Cleanliness
  - Proper operation of dampers
  - Insulation damage and type
  - condition and operation of diffusers
- Control valves - Check for:
  - Vacuum or air leaks at connections
  - Proper operation
- Heat exchangers - Check for:
  - Casing leaks
  - Condition and proper operation of traps
  - Proper operation of associated valves and pumps
  - Proper operation and condition of vacuum breaker on condensate return
- Expansion tanks - Check for:
  - Leaks
  - Deterioration
  - Proper operation
- Boilers: Perform general inspection of boilers and unfired pressure vessels. Use ASHRAE guidelines for life expectancy. Refer to Boilers and Unfired Pressure Vessels sections in this chapter:
  - Stack - Check for:
    - Deteriorated metal
    - Proper stack cap and tension cables

**MECHANICAL****Heating-Continued**

- Check certification to ensure it is current
- Casings - Check for
  - Deterioration
  - Insulation deterioration and type

**6.2.10 Incinerators:** Comply with all current safety precautions. Before inspection, operating personnel should thoroughly clean inside of furnace. Check for:

- Refractory Linings at Throats, Roof Arches, Door Arches and Jambs, Target Wall, Charging Hole Covers, Guillotine Doors, and Combustion Chambers:
  - spalling
  - loosening
  - deterioration of areas or individual units
- Combustion Chambers:
  - deformations
  - breaks
  - wear
  - corrosion
  - soot deposits
  - clinkers
  - ashes
  - excessive slag formations indicating excessive lining deterioration
  - depositing of an excessive amount of noncombustibles
- Drying Hearths and Grates:
  - warped sections
  - burned-out areas
- Exterior Settings:
  - settlement
  - cracks
  - broken areas
  - eroded and sandy mortar joints

**MECHANICAL****Incinerators-Continued**

- failure to provide adequate expansion and contraction between furnace setting and building and between flue and chimney
- If leakage is suspected, make open flame test and draft gage, arch, door frames, and wall surfaces:
- Failure of furnace steel framing supports are indicated by damage to arches and roof areas, door casings, and walls:
- Cables and Rigging of Adjustable Dampers and Counterweighted Doors:
  - rust
  - corrosion
  - inadequate lubrication
  - damaged or frayed strands
  - improper operation through defective pulleys, wheels, or other parts
- Doors:
  - rust
  - corrosion
  - warped
  - loose fit
  - damaged or missing parts of latches and hinges
- Tuyeres and Tuyere Plates:
  - warped
  - burned-out areas
- Charging Chute Frames and Covers:
  - rust
  - corrosion
  - broken
  - loose
  - missing parts
- Inadequate ash-handling and ash-removal facilities:
- Portable-Type Pyrometers and Recording or Indicating Types fitted with High and Low Temperature Warning Lights:

**Incinerators-Continued**

- inadequate
- inaccurate
- Combustion Chamber Draft Gage:
  - improper operating condition
  - inaccuracy
- Need of supplementary fuel:
- Burner Assemblies:
  - improper fuel-air mixtures
  - leakage
  - clogged jets, orifices, petcocks, valves
  - improper positioning of pilot light
  - nonuniform flame spread
  - dirty filters
- Wiring and Controls:
  - loose connections
  - damaged insulation
  - evidence of short circuits
  - loose or weak contact springs
  - worn or pitted contacts
- Examine motor windings and brush rigging:
- Operate control mechanisms through complete cycle of operation:
- Nonavailability and poor condition of operating tools:
- All-Metal Trash Burners and Incinerators:
  - rust
  - corrosion
  - burned-through areas
  - warped and buckled surfaces

**MECHANICAL****Incinerators-Continued**

- Can-Washer Equipment:
  - vacuum breakers not installed in water lines
  - improper operating conditions
  - improper drainage for cleaning areas
- Painted Surfaces:
  - rust
  - corrosion
  - cracking
  - scaling
  - peeling
  - wrinkling
  - alligatoring
  - chalking
  - fading
  - complete loss of paint

**6.2.11 Piping:**

- Drain vent and waste - Check for:
  - Hanger system condition
  - Proper grading
  - Weeping or leaking joints
  - Deteriorated piping
- Steam and water distribution - Check for:
  - Pipe type
  - Hanger system condition
  - Deteriorated piping
  - Leaking, and weeping joints
  - Insulation condition and type - if asbestos, determine if it needs to be encapsulated or removed
  - Proper grade on condensate return
  - Type of pipe on condensate return (when applicable)

**MECHANICAL****Piping-Continued**

- Proper operation of steam traps
- Proper drainage, cracking, and proper venting of cooling wells
- Valves - Check for
  - Leaking flanges
  - Packing condition
  - Test operation where practical
- Expansion joints - Check for
  - Leaks at packing glands
  - Anchor points and slip guides
- Pressure reducing valves and components - Check for
  - Chattering
  - Leaking packing glands
- (Water distribution only) Check water for rust and color of water (Cold water rust may require filter where water enters building or shows signs of rusting. Hot water rust only may require hot water tank to be flushed or replaced.)

**6.2.12 Plumbing:**

- Sinks/tubs - Check for:
  - Cracks and wear of porcelain or other surface
  - Inoperative or leaking mixing valves
  - Pop-up waste (drain plug) operation
  - Proper installation
  - Proper drainage
- Showers - Check for:
  - Proper drainage
  - Leaking valves
  - Leaks through floor
- Water closet - Check for:
  - Proper flush cycles
  - Cracked bowls or tanks
  - Proper securing of flanges

**Plumbing-Continued**

- Leaks around flushometer connections

- **Urinals** - Check for:

- Proper flush cycles
- Cracks
- Proper securing of flanges
- Deteriorated “P” traps
- Deteriorated wall connections

**6.2.13 Pump (Submersible Sump):** Check for water and debris in pits and drain if necessary. Check pump for proper operation.

**6.2.14 Sanitary Sewage Utility System:** Start the inspections at the facilities and follow the lines until they reach the water treatment facility. Obtain sanitary sewage utility system drawings before inspections. Nothing should be turned on or off and nothing should be opened or closed unless special arrangements have been made with the activity. Notify the local utility department before starting the inspections. Check for:

- Proper operation of lift stations:
- Proper inflow of the sewage into the treatment plant (check with the plant operator about problems):
- Proper flow through manholes:

**6.2.15 Steam Utility System:** Start the inspection from the steam generating plant and follow the lines until they reach a facility or other destination. Obtain steam utility system drawings before inspections. Nothing should be turned on or off and nothing should be opened or closed unless special arrangements have been made with the activity. Coordinate any inspection with the station utility department before starting the inspections. Have operating personnel available during the inspection to provide information on conditions and to provide access to pits, mechanical rooms, and fenced enclosures. Check through a visual inspection for:

- Leaks:
- Proper insulation. (The insulation should meet current criteria and be serviceable:)
- Condition of all components, including:
  - Pipe
  - Valves
  - Flanges

## MECHANICAL

**Steam Utility System-Continued**

- Pumps
  - Expansion loops
  - Expansion joints
  - Steam traps
  - Anchors
  - Alignment of guides and roller supports
  - Check trouble logs for recurring outages or areas that require continuing repairs
  - Have steam pits opened and check for condition and water intrusion
- Proper pressure drop across pressure reducing stations:
  - Hanger and support condition:

**6.2.16 Unfired Pressure Vessels:** Comply with all applicable safety precautions.

This procedure does not include all requirements and specifications to perform this inspection. Refer to NAVFAC MO-324 "Inspection and Certification of Boilers and Unfired Pressure Vessels" for more information. Inspectors must obtain and possess a valid NAVFACENGCOCOM Certificate of Competency and a current license issued by the geographic Engineering Field Division/Engineering Field Activity (EFD/EFA). Contracted inspectors must possess a state certificate and a current license issued by the EFD/EFA. Before entering an unfired pressure vessel make sure that it has been properly ventilated, that there is no inflammable gas or toxic material present, that all valves on connecting pipes are closed, and that a reliable method is used to safeguard these valves while anyone is inside the vessel. When electric cords are used inside an unfired pressure vessel they should be in good condition, well insulated, designed to withstand mechanical injury, and provided with a suitable guard. **Naked lights are prohibited.** From previous inspection reports, indicate decrease in pressure-carrying capacity and note any recommendations in previous reports not completed or not scheduled for completion. Check for:

## EXTERNAL INSPECTION

- Safety and Relief Valves:
  - accumulated rust, scale or other debris
  - obstructed drain
  - hazardous conditions created by discharge
  - levers do not operate freely



**Unfired Pressure Vessels-External Inspection-Continued**

- stems bent
- Rupture Disks:
  - burst
  - leaking
  - deteriorated
  - plugged vent
- Pressure Indicating Gages:
  - broken, missing or dirty glass
  - illegible markings
  
  - bent pointer
  - leaking connections
  - inoperative
- Lagging:
  - loose or missing material
  - cracks
  - open seams
  - evidence of vapor or water leaks
- Shell:
  - corrosion
  - leakage
  - cracks
  - distortion
  - cracked or broken welds
  - loose or cracked rivets
  - loose or missing caulking
- Supports:
  - settlement
  - deterioration
  - lack of rigidity

**Unfired Pressure Vessels-External Inspection-Continued**

- cracks
  - loose or dislodged material
  - excessive corrosion
  - cracked or broken welds
  - loose or missing bolts or rivets
  - warped or bent structural members
- Piping:
- leakage
  - strain or torsion
  - excessive corrosion
  - improper drainage
  - misalignment
  - lack of support
  - inadequate provision for expansion or contraction
  - excessive vibration
  - pockets at valves and connections
  - loose
  - deteriorated
  - strained
  - inadequate connections
  - settlement
  - improper tension and alignment in supports
- Stop and Check Valves:
- loose, missing or broken parts
  - excessive wear or corrosion
  - leakage
  - obstructed drain openings
- Pressure Reducing Valves:
- loose, missing or broken parts
  - rust, scale or other substance preventing proper operation

## MECHANICAL

### Unfired Pressure Vessels-External Inspection-Continued

- Pressure Control Switch:
  - loose, missing or broken parts or connections
  - corrosion
  - rust or other substance preventing proper operation

### INTERNAL INSPECTION

- Preparation for Inspection:
  - inadequate
  - incomplete
  - untimely
- Pressure Gage:
  - improperly calibrated. Recalibrate
- Vessels Secured or Stored:
  - not completely dry
  - inadequate supply of desiccant
  - improper or inadequate placement of desiccant
- Corrosion Resistant Lining:
  - cracks
  - corrosion behind lining
  - corrosion behind deposits on lining
- Minimum Thickness (Surfaces exposed to Corrosion from Vessels' Contents):
  - determine
- Maximum Corrosion Rate:
  - determine
- Shell Plates:
  - cracks
  - defective joints
  - distortion
  - erosion

**MECHANICAL****Unfired Pressure Vessels-Internal Inspection-Continued**

- corrosion
- grooving
- lap seam cracks
- cracked or severely corroded rivets
- cracked welds. Determine minimum thickness and calculate new maximum allowable working pressure
- Heads:
  - cracks
  - deformation
  - excessive corrosion
- Stays and Braces:
  - cracks
  - bends
  - looseness
  - excessive tension
  - excessive corrosion or erosion
  - loose, cracked or broken connections
- Nozzles:
  - distortion
  - excessive corrosion
  - cracked welds
  - loose, cracked or severely corroded rivets or bolts
  - poor or ineffective threaded conditions
- Reinforcing Plates:
  - cracks
  - deformations
  - other weaknesses
- Openings and Connections for Piping and External Attachments:
  - obstructed
  - inadequate

### **Unfired Pressure Vessels-Internal Inspection-Continued**

- excessive corrosion

#### HYDROSTATIC OR PNEUMATIC TEST

- Preparation:
  - inadequate
  - incomplete
- Inspection:
  - significant drop in pressure in 15 minutes
  - leakage
  - loose parts
  - deformations
  - Maximum Allowable Working Pressure
  - Recalculated

#### INSPECTION OF OPERATION

- Controls:
  - inability to maintain proper pressures
  - improper adjustment for cut-out and cut-in devices
- Piping:
  - leakage
  - excessive vibration
  - tendency to crystallize
- Pressure Indicating Gages:
  - stuck pointer
  - restricted movement of pointer
  - obstructed connections
- Temperature Indicating Devices:
  - excessive temperatures indicated
  - particularly during and immediately after high load demands
- Stop and Check Valves:

## MECHANICAL

**Unfired Pressure Vessels-Inspection of Operation-Continued**

- excessive vibration
- ineffective or defective operation
- Pressure Reducing Valves:
  - defective
  - inadequate
  - improper operation
- Metering and Recording Devices:
  - improper operation
- Safety and Relief Valves:
  - improper operation
  - obstructed discharge
  - does not release at required pressure. Have qualified personnel adjust to proper setting requirements (See MO-324 for appropriate organizations/personnel authorized to perform this function)

**6.2.17 Water heater:** (including convertors and storage tanks where applicable).

Check for:

- Age
- Proper temperature
- Proper relief valve installation
- Capacity of each tank in the building
- Holding tank condition (rusting, weeping, or deteriorating)
- Insulation condition and type of insulation
- Type of hot water tank (steam, electric, or reclaim)
- Location of each tank
- Leaks

**6.2.18 Water Utility System:** **Start** the inspection from the source (water treatment plant, well, local water main, etc.) and follow it until the lines reach a facility or other destination. Obtain water utility system drawings before inspections. Nothing should be turned on or off and nothing should be opened or closed unless special arrangements have been made with the activity. Notify the local utility department before starting the inspections. Check for:

- Valve leaks

**Water Utility System-Continued**

- Valve box wetness
- Line leaks
- Proper operation of
  - Wells
  - Pumps
- Proper operation of chlorination plant (check with the operator about problems)

**6.3 REPAIR/REPLACEMENT CRITERIA:****6.3.1 Air conditioning -**

- Chillers:
  - Repair
    - General good condition
    - Only specific parts require replacement or repair
    - Parts are easy to procure
    - Replacing or repairing parts is cost effective
  - Replacement
    - Over 20 years old
    - Badly rusted, damaged, deteriorated
    - Leaking refrigerant or oil (indications of frequent or continuous leaks)
    - Many breakdowns and repairs (check activity record)
    - Parts difficult or impossible to procure
    - Replacing or repairing parts is not cost effective
- Cooling towers:
  - Repair - Only minor repairs required
  - Replacement
    - Over 15 years old
    - Many or severe leaks
    - Heavy corrosion and deterioration
- Controls (electric/pneumatic):

**MECHANICAL****Air Conditioning-Continued**

- Repair
  - Only minor adjustments required
  - Repair is cost effective
- Replacement
  - Old, broken, damaged, or inoperative thermostats, valves, and/or other major components
  - Uncontrollable temperature variations throughout facility

**6.3.2 Air handler -**

- Repair:
  - General good condition
  - Only specific parts require replacement or repair
  - Parts are easy to procure
  - Replacing or repairing parts is cost effective
- Replacement:
  - Over 12 years old
  - Badly corroded or otherwise deteriorated
  - Fan motors inoperative
  - Coil stopped up
  - Fins fall off when touched
  - Parts difficult or impossible to procure
  - Replacing or repairing parts is not cost effective

**6.3.3 Eye wash/shower -**

- Repair - Minor problems:
- Replacement:
  - Cracked fixtures
  - Not conforming with applicable codes

**6.3.4 Exhaust -**

- Repair:
  - General good condition
  - Parts are easy to procure



**MECHANICAL****Exhaust -Continued**

- Replacing or repairing parts is cost effective
- Minor parts required to make operable
- Replacement:
  - Over 15 years old
  - Badly corroded or rusted
  - Undersized
  - Inoperable
  - Parts difficult or impossible to procure
  - Replacing or repairing parts is not cost effective

**6.3.5 Fire protection :** Any type of fire suppression or detection system that has not been actually tested for a long period of time should be tested by the EFD/EFA/PWC fire protection engineer. Consult with them for testing frequency of fire protection systems. Also see NAVFAC MO-117, Maintenance of Fire Protection Systems.

**6.3.6 Heating :**

- Radiators/convectors (steam or hot water):
  - Repair
    - General good condition
    - Only specific parts require replacement or repair
    - Parts are easy to procure
    - Replacing or repairing parts is cost effective
  - Replacement
    - Over 15 years old
    - Unit doesn't work
    - Badly corroded
    - Fins fall off when touched
    - Parts difficult or impossible to procure
    - Replacing or repairing parts is not cost effective

## MECHANICAL

**Heating -Continued**

- Boilers and related piping:
  - Repair
    - Less than 20 years old
    - Adequate output
    - Parts are easy to procure
    - Replacing or repairing parts is cost effective
    - Records show few repairs
  - Replacement
    - Over 20 years old
    - Records show many repairs
    - Related piping badly deteriorated
    - Inadequate output
    - Parts difficult or impossible to procure
    - Replacing or repairing parts is not cost effective
- Controls (electric/pneumatic):
  - Repair
    - Only minor adjustments required
    - Repair is cost effective
  - Replacement
    - Old, broken, damaged, or inoperative thermostats, valves, and/or other major components
    - Uncontrollable temperature variations throughout facility

**6.3.7 Insulation:** - (Fiberglass, Armaflex)

- Repair:
  - Only small areas tom or damaged
  - Repair would be cost effective
- Replacement:
  - Over 50% tom or damaged
  - Repair not cost effective

**MECHANICAL****6.3.8 Piping -**

- Pipe oil and lubricants (POL): Making repair/replacement recommendations for above ground POL lines is very difficult because of the many factors to consider. POL lines located near the waterfront deteriorate about 50% faster than those away from the water. This deterioration is due to the constant exposure to salt, water, and air (if above ground):
  - Waterfront
    - Repair
      - Less than 10 years old
      - Random or spot corrosion or rust
      - General good condition
    - Replacement
      - Over 10 years old
      - Wall thickness reduced 50% (NDT check)
      - Evidence of numerous repairs
      - Evidence of line stress (possibly due to hanger failure)
      - Many and major leaks
      - Large areas of deterioration or rust
  - Above ground, away from waterfront
    - Repair
      - Less than 20 years old
      - Little or no loss in wall thickness (NDT check)
      - Little or no rust or deterioration
    - Replacement
      - Over 20 years old
      - Wall thickness reduced 50% (NDT check)
      - Evidence of numerous repairs
      - Evidence of line stress (possibly due to hanger failure)
      - Many and major leaks
      - Large areas of deterioration or rust

**MECHANICAL****Piping-Continued**

- All but pipe oil and lubricants (POL):
  - Repair
    - Less than 20 years old
    - Minor, isolated leaks
    - Little or no corrosion
    - General good condition
  - Replacement
    - Over 20 years old
    - Frequent, bad leaks (joints, other places)
    - Bad corrosion
    - Frequent repairs (check with activity records)
    - Evidence of blockages in pipe due to corrosion

**6.3.9 Plumbing:**

- Repair - Minor problems:
- Replacement:
  - Cracked fixtures
  - Not conforming with applicable codes

**6.3.10 Water heaters:**

- Repair - Minor rusting:
- Replacement:
  - Leaking water jackets
  - Leaking steam bundle
  - Replace water heater converters when over 20% of the tubes are plugged

**ELECTRICAL****CHAPTER 7. ELECTRICAL INSPECTION GUIDE****7.1 DEFINITIONS:**

**Cathodic Protection Systems** - includes wood poles used to support overhead electric distribution systems and/or telephone open wire or serial cable systems and such accessories and related items as crossarms, insulators, pins, tie wires, hardware, line wires near the pole, guywires, and groundwires

**Disconnecting Switches** - includes manually group-operated and hook-stick-operated disconnecting switches used on transmission lines and distribution systems, including grounding switches

**Distribution Transformer** -

**Deenergized** - includes deenergized electric distribution transformers used for voltage reduction

**Energized** - includes energized electric distribution transformers used for voltage reduction

**Electrical Utility System** - the overhead and underground power transmission and distribution lines from the source (base power plant, local utility feed, etc.) to the facility or other final destination

**Fire Alarm** - the electronic warning system for fire. From the panel to the activating device to the alarm

**Fuses and Small Circuit Breakers (Under 600 Volts and 30 Amperes)** - Visual inspection only of fuses and small circuit breakers and their enclosures in electrical circuits operating at 600 volts or below and rated at 30 amperes and below

**General wiring** - all wiring throughout a facility including attic and crawl space wiring

**Grounds and Grounding Systems** - includes electrical grounds and grounding systems for all electrical equipment, apparatus, machinery, metallic conduit, and all accessories that are a part of the outdoor electrical power distribution system. It also includes grounds of structural supports, frames, towers, safety fencing, hardware, equipment enclosures, system neutrals, and buried ground cable networks and counter-poles used in substation and similar areas. In such places, good engineering practice, Bureau

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specifications, and other controlling rules and regulations such as National Electric Code, National Electrical Safety Code, and United States Navy Safety Precautions for Shore Activities, NAVSO P-2455, require grounding for operational and personnel safety. Proper operation of grounding systems for Ordinance Storage Facilities is especially important

**Instruments** - includes electrical AC and DC indicating, recording, and portable instruments and associated equipment used for measurement of electrical power quantities

**Lighting** - all the devices that produce light in or around the facility, going from the panel to the light

**Motors and Generators** - includes AC and DC electric motors, generators, exciters, M-G sets, synchronous converters and condensers, other electrical rotating equipment

**Panels** - breaker boxes that have one power input and usually many distribution output lines. Panel types are:

**Primary** - the main power coming into a facility going into the primary panel

**Secondary** - the second source of power coming into a facility. This will be rated equal to or less than that of the primary panel

**Sub** - panels off the primary or secondary panel. Note in the comment area if these panels serve other panels

**Potheads** - includes electrical potheads used in power distribution systems, including potheads used as terminals of underground cables as well as those incorporated as terminals of equipment and a part thereof

**Power Plants** - includes electrical equipment and apparatus in electric power generating plants of the station type

**Relays** - Protective relays located in electrical power circuits only. It does not include relays used to protect or control utilization equipment. Inspection is limited to those aspects that relate to care rather than to the operating characteristics of relays

**Steel Power Poles and Structures** - Steel power poles and towers, metallic street lighting standards, A-frames, and all other steel structures used to support electric power lines or equipment, including those used for transmission lines, distribution systems, substations, and switching stations

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**Switchgear** - includes electrical switchgear, associated apparatus, and equipment connected to distribution circuits in buildings, 600 volts and under, and not located in vaults or fire-resistant rooms. It includes, primarily, switchgear known as “metal clad”, “drawout”, “cubicle”, or “truck” type

**Wood Poles and Accessories** - Wood poles used to support overhead electric distribution systems and/or telephone open wire or aerial cable systems. Included are such accessories and related items as crossarms, insulators, pins, tiewires, hardware, line wires near the pole, guywires, and ground-wires. Inspection of equipment such as transformers, cutouts, lightning arresters, or terminal boxes that are mounted on wood poles is covered elsewhere

**7.2 ELECTRICAL INSPECTION INSTRUCTIONS:**

**7.2.1 Cathodic Protection Systems:** Comply with all current safety precautions. Do not bridge insulated couplings. Do not make or break electrical connections. Determine if preventive maintenance inspections are adequate. Check for:

**GALVANIC OR SACRIFICIAL ANODE SYSTEMS:**

- Terminals and Jumpers of Test Leads (permanently installed and accessible on underground systems):
  - rust
  - corrosion
  - broken or frayed wires
  - loose connections
  - similar deficiencies. Tighten connections
- Anode Suspensions (elevated water tanks and systems for waterfront structures):
  - rust
  - corrosion
  - bent or broken suspension members or braces
  - frayed or broken suspension lines or cables
  - loose bolts
  - loose cable connections
  - frayed or broken wiring

**ELECTRICAL****Cathodic Protection Systems-Continued**

- Anodes (waterfront and water tank structures where visible):
  - clean corrosion product off and measure/report the diameter of anodes every three years or when significant deterioration from past inspection is noted
  - report apparent average diameter remaining so arrangements can be made for replacement or adjustment
- Bushing (supporting anode):
  - severe rust and corrosion where resistors including variable types are installed in circuit
  - examine units for corrosion
  - broken or frayed wires
  - loose connections
- Electric Wiring (hot water tanks):
  - poor insulation
  - loose connections

**RECTIFIER-POWERED SYSTEMS:** Record voltmeter and ammeter readings where installed.

- Exterior of Enclosure:
  - rust
  - corrosion
  - mechanical damage
- Cover Hinges and Locks:
  - inadequate lubrication
  - rust
  - other deficiencies
- Wiring and Fastenings Near Rectifier:
  - broken or damaged insulation
  - rust
  - corrosion on conduit



**ELECTRICAL****Cathodic Protection Systems-Continued**

- Interior of Enclosure:
  - rust
  - deteriorated/damaged rubber gaskets
  - dirty insulating oil or improper oil level (oil cooled rectifiers only)
  - drops of moisture
  - loose wiring
  - signs of excessive heating. (Do not put hand or tools inside enclosure.)
- Anodes (waterfront structures where visible):
  - clean corrosion product off and measure/report the diameter of anodes every three years or when significant deterioration from past inspection is noted
  - report apparent average diameter remaining so arrangements can be made for replacement or adjustment
- Bushing (supporting anode):
  - severe rust and corrosion where resistors including variable types are installed in circuit
  - examine units for corrosion
  - broken or frayed wires
  - loose connections
- Exposed Wires and Cables:
  - insecure fastenings
  - frayed or broken insulation
- Electrical Connections (wires and cables connected to anode junction boxes and/or other equipment except rectifier enclosures):
  - poor condition
  - loose connections
  - other deficiencies

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**7.2.2 Chimneys and Stacks (Electrical):** Comply with all current safety precautions. Also refer to Chimneys and Stacks (Structural). Check for:

- Lightning Rods, Terminals, Cables, and Ground Connections: Test for electrical continuity from aerial terminals through ground connections:
  - corrosion
  - loose
  - burned
  - missing
  - other damaged parts and connections
- Lights, Hoods, Reflectors, Shields, and Receptacle Fittings:
  - failure to operate
  - missing, loose, or damaged parts
  - moisture
  - need of relamping
- Conduit:
  - breaks and other damage
  - remove conduit inspection plates and examine internal connections
    - for lack of tightness and inadequacy
    - relays for defective operation
    - for loose or weak contact springs
    - worn or pitted contacts
    - moisture

**7.2.3 Disconnecting Switches:** Comply with all current safety precautions. **DO NOT** operate until tests show circuit is dead and grounding harnesses have been attached. **DO NOT operate without prior clearance from operating forces.** Inspection of pole-mounted switches requires an assistant to operate the switch from the ground. Determine if the preventive maintenance inspections are adequate. Check for:

- Group-Operated Switches:
  - rust
  - corrosion
  - loose brackets and holding bolts
  - nonrigid bearings and supports

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**Disconnecting Switches- Continued**

- Grounding Cables, Clamps and Straps:
  - weak supports
  - broken or frayed portions of conductors
  - loose connections
- Insulating Section of Operating Rod:
  - indications of cracks or signs of flashovers
- Movable Connections:
  - inadequate lubrication
  - rust
  - corrosion
  - other conditions resulting in malfunctioning
- Switch:
  - gears stiff or adjustment needed. (Operate switch several times to determine. **DO NOT operate without prior clearance.**)
- Locking and Interlocking Devices and Mechanism:
  - functional inadequacy to prevent unauthorized operation
- Mounting and Bases:
  - rust
  - corrosion
  - twisted, bent, or warped
  - loose or missing ground wire
- Insulators:
  - cracks, breaks, chips or checking of porcelain glaze, more than thin or transparent film of dirt
  - dust
  - grease
  - other deposits on porcelain
  - damage indicated by streaks of carbon deposits from flashovers
  - loose, broken or deteriorated cement holding insulator to other parts. (**Arrange for insulator cleaning during this inspection since it is performed only when line is deenergized.**)

**ELECTRICAL****Disconnecting Switches- Continued**

- **Blades and Contacts:**
  - excessive discoloration from overheating
  - roughness and pitting from arcing
  - misalignment of blades with contacts
  - Arcing Horn Contacts
    - burns
    - pits
    - failure to contact each other throughout their length when switch is opened and closed
  - inadequate tension of bolts and springs
  - inadequate blade stop
  - lack of hinge lubrication
  - insufficient nonoxide grease for blades and contacts
- **Cable or Other Electrical Connections:**
  - loose bolts
  - discolorations indicating excessive heating at connection points
  - corrosion particularly that resulting from atmospheric conditions
- **Electrical Clearances of Cable or Other Conductor:**
  - inadequate to other phases or to ground for applicable circuit voltage. (Switch both open and closed,)
- **Flexible Connections:**
  - frayed, broken or brittle. (Excessive discoloration indicates overheating.)
- **Cable from Grounding Switch to Grounding System:**
  - frayed
  - broken strands
  - loose connections

**ELECTRICAL**

**7.2.4 Distribution Transformer:** Comply with all current safety precautions. Determine if preventive maintenance inspections are adequate.

**Deenergized:** TRANSFORMER MUST BE DEENERGIZED AND CIRCUIT SWITCHES LOCKED OUT. USE GROUNDING HARNESSSES ON INPUT TERMINALS. Before inspection, make arrangements to have electricians and other required labor available. **Note: Inspections described in the Energized section are to be performed as part of this inspection.** Check for:

- Bushings and Insulators:
  - grease
  - dirt
  - other foreign materials
  - improper oil level in oil-filled bushings
- Insulators and Porcelain Parts: Report for investigation by a qualified electrical engineer any chipped glaze exceeding 1/2 inch in depth or an area exceeding one square inch on any insulator or insulator unit:
  - cracks
  - checks
  - chips
  - breaks
  - where flashover streaks are visible, reexamine for injury to glaze or for presence of cracks
  - severe cracks, chipped cement, or indications of leakage around bases of joints of metal to porcelain parts at terminal and transformer ends
- Terminal Ends:
  - mechanical deficiencies
  - looseness
  - corrosion
  - damage to cable clamps
- Connections:
  - heating evidenced by discolorations
  - looseness
  - frayed or broken strands

**ELECTRICAL****Distribution Transformer-Continued**

- broken cable insulation
- corrosion indicated by blue, green, white, or brown corrosion products on metallic portions of all main and ground terminals, including terminal board and grounding connections inside transformer case
- Enclosure and Cases:
  - signs of moisture if case is opened
  - plugged breathers
  - inactive desiccant
  - enclosure leakage
  
  - weathertightness
  - rust or corrosion on inside cover
- Coils and Cores: If feasible, probe down side with glass rod, and if dirt and sludge exceed approximately 1/2 inch, arrange to change or filter insulating oil, and have coils and cores cleaned. Use low-pressure air, if available, to blow out dust from air-cooled transformers, or pull out dust with vacuum equipment:
  - interior deficiencies
  - dirt
  - sludge
- Gages and Alarms: ENGINEERING TESTS should be performed under supervision of qualified electrical engineer before, during, or after inspection as applicable. Assistance of inspectors and craft personnel is required, and arrangements should be made with proper authority to assure coordinated effort by everyone taking part:
  - liquid Level Gage and Alarm System
    - dirty
    - not readable
    - improper frequency of calibration
  - test grounding system
  - test dielectric strength of insulating liquid. Refer to NAVFAC MO-200

**ELECTRICAL****Distribution Transformer-Continued**

- test insulation resistance. Refer to NAVFAC MO-200
- measure load current with recording meter over period of time when load is likely to be at its peak
- measure peakload voltage
- make regulation tests and tests of operating temperature during peak-load-current tests
- test and calibrate thermometers or other temperature alarm systems

**Energized:** DO NOT CONTACT ANY PART OF THE TRANSFORMER OR ASSOCIATED EQUIPMENT. Check for:

- Concrete Foundations and Supporting Pads:
  - settling and movement
  - surface cracks exceeding 1/16 inch in width
  - breaking or crumbling within 2 inches of anchor bolts
- Anchor Bolts:
  - loose or missing parts
  - corrosion, particularly at points closest to metal base plates and concrete foundations resulting from moisture or foreign matter, and exceeding 1/8 inch in depth
- Mounting Platforms, Wooden:
  - cracks
  - breaks
  - signs of weakening around supporting members
  - rot, particularly at bolts and other fastening, holes through which bolts pass, wood contacting metal
  - burning and charring at contact points, indicating grounding deficiency
  - inadequate wood preservation treatment
- Mounting Platforms, Metallic:
  - deep pits from rust
  - corrosion
  - other signs of deterioration likely to weaken structure

**ELECTRICAL****Distribution Transformer-Continued**

- Hangers, Brackets, Braces and Connections:
  - rust
  - corrosion
  - bent
  - distorted
  - loose
  - missing
  - broken
  - split
  - other damage
  - burning or charring at wood contact points resulting from grounding deficiency
- Enclosures, Cases and Attached Appurtenances:
  - collections of dirt and other debris close to enclosure that may interfere with radiation of heat from transformer or flashover
  - dirt, particularly around insulators, bushings, or cable entrance boxes
  - leaks of liquid-filled transformers
  - deteriorated paint
  - scaling
  - rust
  - corrosion, particularly at all attached appurtenances, such as lifting lugs, bracket connections, and metallic parts in contact with each other
- Nameplates and Warning Signs:
  - dirty
  - chipped
  - worn
  - corroded
  - illegible



**ELECTRICAL****Distribution Transformer-Continued**

- improperly placed
- Grounding:
  - loose, missing, broken connections
  - signs of burning or overheating
  - corrosion
  - rust
  - frayed cable strands
  - more than 1 strand broken in 7-strand cable
  - more than 3 strands broken in 19-strand cable
- Bushings and Insulators:
  - cracked, chipped, or broken porcelain
  - indication of carbon deposits
  - streaks from flashovers
  - dirt, dust, grease, soot, or other foreign material on porcelain parts
  - signs of oil or moisture at point of insulator entrance
- Grounding and Phase Terminals:
  - overheating evidenced by excessive discolorations of copper
  - loose connection bolts
  - defective cable insulation
  - no mechanical tension apparent as a result of temperature changes
  - leads appear improper and create danger of flashovers from unsafe phase-to-phase or phase-to-ground clearances caused by deterioration of leads or expansions during temperature changes.
- Lightning Arresters:
  - where attached to or mounted on, refer to Ground Test (Lightning Protection) (Electrical)
- Breathers:
  - holes plugged with debris
  - desiccant-type breathers need servicing or replacement

## ELECTRICAL

**Distribution Transformer-Continued**

- Grills and Louvers for Ventilation of Air-Cooled Transformers:  
Openings located near floor or ground line can be inspected with small nonmetallic framed mirror having long insulated handle, used in conjunction with light from hand flashlamp having insulated casing. Throw light beam onto mirror and reflect upward into openings:
  - plugged with debris or foreign matter, interfering with free passage of air.

**7.2.5 Electrical Utility System:** Start the inspections from the source (power plant, local power company feed, or where the power lines come up from the ground.) Obtain electrical utility system drawings before inspections. **Nothing should be turned on or off and nothing should be opened or closed unless special arrangements have been made with the activity. Notify the local utility department before starting the inspections.**

- Overhead - Check for:
  - Condition of all components, especially
    - Rusting of metal parts
    - Rotting of pole (knock the base of the pole with a hammer and listen to sound)
    - Broken insulators
  - Proper sag of conductors
  - Proper installation of components
  - Leaking transformers
- Underground:

The underground electrical system may only be checked by a visual inspection of opened pad mounted transformers and other devices. A maintenance representative from the activity should open the devices. **Inspector should not attempt to open or touch parts of an open device.** Check for:

- Cleanliness inside and out
- Proper gage readings
- Proper installation of all components
- Condition of all components

**ELECTRICAL****7.2.6 Fire alarm:** Check condition of:

- Pull stations:
- Bells and horns:
- Smoke/heat detectors:
- Control panel:
  - Verify that the power is on. These are generally supplied by 120 volt AC power sources which are then transformed to 24 volt DC within the panel
  - Verify that the battery backup is fully charged
  - Verify that there are no trouble lights on. If trouble lights are illuminated, the panel or field devices need to be serviced
- Annunciator panel:
- Wiring:

**7.2.7 Floors (Conductive Test):**

- Specifications: Conductive floors may be made of lead, conductive rubber or plastic, conductive masonry material, or conductive composition material. Floors must comply with the following requirements:
  - The surface of the floor must be free from cracks and reasonably smooth. If washing of floors is necessary, the material as installed must be capable of withstanding repeated washing with hot water. If conductive floors are to be waxed, a conductive wax approved by Underwriters' Laboratories, Inc. shall be used
  - The material must not produce sparks when stroked briskly and firmly with a hardened steel file
  - The material must not slough off, wrinkle, or buckle under normal conditions of use
  - The electrical resistance measured between ground and a S-pound electrode in direct contact with 5 square inches of floor area must not exceed 1,000,000 ohms
  - In areas where conductive floors and conductive shoes are required, the total resistance between the ground and the wearer shall not exceed 1 megohm (1 million ohms). Where conductive floors and conductive shoes are required, table tops on which exposed explosives are handled or where explosive dust is encountered shall be covered with properly grounded, conductive, sparkproof material

## ELECTRICAL

**Floors (Conductive Test)-Continued**

- **Testing:** Ensure that conductive floors were tested at the time of installation and thereafter at least semi-annually. The tests shall determine if the floors meet the requirements above. The results of these tests should be posted in preventive maintenance records or a log and maintained on file:
- **Type of Instrument:** Instruments used in testing floors should be of a type specifically designed for this purpose. It is recommended that the voltage applied by the testing instrument be between 90 and 500 volts. Tests may be conducted with low voltage instruments, but if the floors show more than the maximum resistance by tests with instruments of less than 500 volts, a test with a 500-volt instrument should be made to confirm the results. The instrument used should consist of two dry electrodes, one of which should be a piece of metal which weighs 5 pounds and makes contact with 5 square inches of floor area. The other electrode should consist of a spring clip for attachment to a permanent ground:
- **Use of instrument:** **Instruments for testing the conductivity of floors shall be used inside the room only if the room is free of explosives;** otherwise, the test instrument shall be placed outside the room. In any case, the floor in the immediate area of electrode contact shall be thoroughly cleaned of all explosive material:

**7.2.8 Fresh Water Storage (Cathodic Protection System):** See paragraph 7.2.1 for the cathodic protection requirements of fresh water storage. For water tank structure inspection check for:

**GALVANIC OR SACRIFICIAL ANODE SYSTEMS:**

- **Terminals and Jumpers of Test Leads (permanently installed and accessible on underground systems):**
  - rust
  - corrosion
  - broken or frayed wires
  - loose connections
  - similar deficiencies. Tighten connections

**ELECTRICAL****Fresh Water Storage (Cathodic Protection System)-Continued**

- Anode Suspensions (elevated water tanks and systems for waterfront structures):
  - rust
  - corrosion
  - bent or broken suspension members or braces
  - frayed or broken suspension lines or cables
  - loose bolts
  - loose cable connections
  - frayed or broken wiring
- Anodes (waterfront structures where visible):
  - when more than 3/4 spent
  - report apparent average diameter remaining so arrangements can be made for replacement or adjustment
- Bushing (supporting anode):
  - severe rust and corrosion where resistors including variable types are installed in circuit
  - examine units for corrosion
  - broken or frayed wires
  - loose connections
- Electric wiring (hot water tanks):
  - poor insulation
  - loose connections

RECTIFIER-POWERED SYSTEMS: Record voltmeter and ammeter readings where installed.

- Exterior of Enclosure:
  - rust
  - corrosion
  - mechanical damage
- Cover Hinges and Locks:
  - inadequate lubrication

## ELECTRICAL

**Fresh Water Storage (Cathodic Protection System)-Continued**

- rust
- other deficiencies
- Wiring and Fastenings Near Rectifier:
  - broken or damaged insulation
  - rust
  - corrosion on conduit
- Interior of Enclosure:
  - rust
  - deteriorated/damaged rubber gaskets
  - dirty insulating oil or improper oil level (oil cooled rectifiers only)
  - drops of moisture
  - loose wiring
  - signs of excessive heating. (**Do not put hand or tools inside enclosure.**)
- Exposed Wires and Cables:
  - insecure fastenings
  - frayed or broken insulation
- Electrical Connections (wires and cables connected to anode junction boxes and/or other equipment except rectifier enclosures):
  - poor condition
  - loose connections
  - other deficiencies
- Concrete Foundations:
  - settlement
  - cracks
  - spalling
  - exposed reinforcing
  - termite tubes

## ELECTRICAL

### Fresh Water Storage (Cathodic Protection System)-Continued

- Wood Foundation and Pads:
  - checked
  - split
  - rot
  - termite infestation
  - direct soil contact of untreated wood
- Anchor Bolts and Straps:
  - loose or missing pieces
  - rust
  - corrosion
- Steel Tanks:
  - rust
  - corrosion
  - leakage
  - damaged protective coatings
  - bent, bowed or broken members
  - loose scale
  - damaged or deteriorated riveted or welded seams
- Concrete Tanks:
  - settlement
  - cracks
  - spalling
  - leakage
  - defective joint at juncture of floor and walls
  - exposed reinforcing
  - damaged protective coatings
- Wood Tanks:
  - leakage
  - cracked, checked, split, warped or mechanically damaged pieces
  - rot

## ELECTRICAL

### Fresh Water Storage (Cathodic Protection System)-Continued

- termite infestation
- wall and base sections for vertical and horizontal misalignment
- bands or hoops for rust
- corrosion
- looseness or missing
- Steel Tower Structure:
  - rust
  - corrosion
  - loose, missing, bowed, bent or broken members
  - loose sway bracing
  - misalignment of tower legs
  - evidence of unstableness
- Wood Towers:
  - loose, missing, twisted, bowed or cracked split pieces
  - rot
  - termite infestation
  - misalignment of tower legs
  - evidence of unstableness
- Wood and/or Steel Ladders, Walkways, Guardrails, Handrails and Stairways:
  - rust
  - corrosion
  - poor anchorage
  - loose or missing pieces
  - other damage
- Handholes, Manholes, Access Doors, Hatchways and Other Covers:
  - loose
  - missing
  - broken
  - rust



**ELECTRICAL****Fresh Water Storage (Cathodic Protection System)-Continued**

- corrosion
- improper fit
- damaged or missing hardware
- Concrete Reservoirs:
  - settlement
  - cracks
  - spalling
  - leakage
  - exposed reinforcing
- Expansion Joints:
  - improper sealing
  - loose or missing filler
  - failure to allow movement when filled with trash and debris
- Earth Embankments:
  - erosion resulting from lack of full sod or vegetation coverage
  - burrowing animals
  - improper drainage
  - ponding water along base
  - leakage through embankment or along outlet piping
- Improper Operation of Valve Control:
  - illegible and improper operating condition of water level indicator
- Valves, Piping, Fittings, Sleeves and Other Accessories:
  - broken
  - loose
  - missing
  - rust
  - corrosion
  - leakage
  - other damage

**ELECTRICAL****Fresh Water Storage (Cathodic Protection System)-Continued**

- Nonintegrity of riser frost casings or insulating materials:
- Splices, Bolts, Rivets, Screws and Other Connections:
  - loose
  - missing
  - broken welds
  - rust
  - corrosion
  - other damage
- Painted Surfaces:
  - rust
  - corrosion
  - cracking
  - scaling
  - peeling
  - wrinkling
  - alligatoring
  - chalking
  - fading
  - complete loss of paint
- Anodic Rods:
  - defects and broken segments
  - failure to remove anodes where ice forms in freezing weather
- Accumulations of dirt, trash, debris or foliage:
- Lightning Rods, Terminals, Cables, and Ground Connections:
  - rust
  - corrosion
  - loose
  - burned
  - missing
  - other damage to parts and connections

**ELECTRICAL****Fresh Water Storage (Cathodic Protection System)-Continued**

- test for electrical continuity through ground connections
- Obstruction and Navigation Lights:
  - need of relamping
  - other Lights
- Hoods, Shields and Receptacle Fittings:
  - missing
  - loose
  - damaged parts
  - failure to operate
- Conduit:
  - breaks
  - other damage
- Remove conduit inspection plates and examine internal connections for:
  - looseness and inadequacy
  - relays for loose or weak contact springs
  - worn or pitted contacts
  - defective operation

**7.2.9 Fuses and Small Circuit Breakers (Under 600 Volts and 30 Amperes):**

Comply with all current safety precautions. **DO NOT contact fuses. DO NOT remove covers. DO NOT deenergize.** Check for:

- By-passing:
  - report apparent by-passing of fuses or circuit breakers for further investigation
- Housekeeping:
  - dust
  - dirt
  - oil
  - grease
  - corrosion
  - foreign matter within enclosure
  - inadequate identification of circuits

**ELECTRICAL****Fuses and Small Circuit Breakers (Under 600 Volts and 30 Amperes)-Continued**

- Enclosures:
  - deterioration of enclosures or connecting conduit or cable due to rust or corrosion
  - loose, corroded, or missing covers
- Connections (if visible without removing covers):
  - loose
  - corroded
  - inadequate
  - deteriorated insulation
- Capacity:
  - Check size of existing fuses or circuit breakers against system engineering drawings. Report oversized fuses and circuit breakers
- Fuses:
  - overheating indicated by discoloration of brass or copper at contact points
  - distortion
  - charring
  - deterioration of fiber cases of cartridge type cases
- Circuit Breakers:
  - distortion
  - charring
  - deterioration of molded portions of case
- Grounding:
  - loose corroded connections
  - deteriorated or abraded insulation
  - frayed or broken cables

**7.2.10 General wiring: Check for:**

- Broken conduit:
- Exposed wiring:
- Missing box and conduit covers missing:

**ELECTRICAL****General Wiring-Continued**

- Deterioration of conductor insulation:
- Sagging or improperly supported conduit:
- Condition of electrical devices, receptacles, switches, electrical equipment, motors, etc.:
- Romex wiring exposed to physical damage:

**7.2.11 Ground Test (Lightning Protection):**

- Lightning Protection System Requirements:

The resistance of the primary and secondary system shall not exceed 10 ohms. When the primary system is installed in wet ground, its resistance shall not exceed 3 ohms. To obtain continuous and reliable protection, the systems shall be maintained to function efficiently. A higher resistance caused by any parts of the system being corroded, broken, or poorly installed may cause lightning discharged or current to take a less resistant path through the building and its contents thereby causing fires and explosions. Deterioration is most active at the places where the conductors enter the ground.

- Semiannual Inspection:

Ensure that the primary and secondary systems are visually inspected semiannually for evidence of corrosion and broken connections. Repairs for all discrepancies found during these inspections shall be made immediately.

- Annual Test:

Ensure that the lightning protection system is tested electrically annually. The results of these tests, together with the description of the defects noted and repairs made, shall be submitted to the person responsible for the efficient operation of the lightning protection systems and entered in the station records.

- Equipment Used:

Electrical tests consist of measuring the ohms resistance of the system to ground and the ohms resistance of any grounding system or individual ground connection. An instrument such as an ohmmeter or a megger should be used to measure the resistance. The procedures outlined below are based on the use of a testing instrument which is equipped with a test ground. If an instrument such as a megger is used, two instrument grounds are needed. The manufacturer's instructions for using the instrument should be followed carefully to avoid damage to the instrument and to insure valid results.

## ELECTRICAL

**Ground Test (Lightning Protection)-Continued**

## ■ Measurement of Ground Resistance:

A copper-clad steel rod from 3/8 inch to 1 inch in diameter and long enough to be driven into the ground so it makes good contact with permanently moist soil should be used for the test ground. The diameter of the rod has little effect on the magnitude of the electrical resistance to ground.

## ■ Method of Test:

Primary and secondary lightning protection systems shall be tested as follows:

## Primary System:

One lead of the test instrument should be connected to the test ground and the second lead in turn to each of the air terminals. The resistance to ground for each air terminal shall be recorded.

## Secondary System:

The resistance to ground and the electrical continuity of all grounded doors, windows, gutters, downspouts, shutters, trusses, columns, girders, reinforcing rods, and other metal objects in buildings and magazines should be tested by securing one lead of the test instrument to the part being tested and the other lead to the test ground.

## ■ Electrical Connections:

In order to assure low contact resistance, the metallic surfaces forming each electrical contact must be carefully scraped until they are bright and shiny to remove any paint and oxide film. The teeth of terminal clips should similarly contact a bright and shiny metallic surface. If the surface film is not removed, sufficient pressure must be applied to terminal clips to cause their teeth to break through to the basic metal conductor underneath.

**7.2.12 Grounds and Grounding Systems:** Comply with all current safety precautions. The condition of the grounding system is important both for proper operation of the distribution system to obtain indications of improper or unsafe conditions affecting operation of the system and to protect personnel from electric shock that might result in injury or death. **Grounds and grounding systems require maintenance at much higher levels of perfection than most other facilities, to assure the required degree of safety to personnel.** Because a current as low as 5 milliamperes is considered

**ELECTRICAL****Grounds and Grounding Systems-Continued**

dangerously high and current as low as 10 milliamperes may be fatal, extreme care must be exercised in inspecting and testing ground and grounding systems to minimize danger of electric shock and possible resulting injury or death. In general, **NEVER** open a grounding circuit connection when the equipment it is intended to protect is energized. This applies equally to grounds on structural or supporting members, to grounds on equipment enclosures, and to grounds on either primary or secondary system neutrals. The life and safety of everyone approaching, or coming in contact with, electrical facilities depends on how carefully and completely inspections of grounds and grounding systems are performed. When equipment is energized, **DO NOT** make inspection at bases of electrical equipment, regardless of circuit voltage. Determine if preventive maintenance inspections are adequate. Check for:

- Visual Connections:
  - loose, missing, broken connections
  - signs of burning or overheating
  - corrosion
  - rust
  - frayed cable strands, more than one strand broken in 7-strand cable, more than 3 strands broken in 19-strand cable
- Underground Connections:
  - unsatisfactory condition or defects uncovered when 4 or 5 connections are exposed to view by digging
- Electrical Resistance Tests:
  - From point of connection on structure, equipment enclosure or neutral conductor to top of ground rod, allowable resistance can be obtained from maximum permissive resistance below
  - From ground rod, mat or network to earth ground, allowable resistance can be obtained from max. permissive resistance below
  - From gates to gateposts, allowable resistance is 1/2 ohm
  - From operating rods and handles of group-operated switches to supporting structures, allowable resistance is 1/2 ohm
  - From metallic-cable sheathing to ground rod, cable, or metal structure, allowable resistance is 1/2 ohm

**ELECTRICAL****Grounds and Grounding Systems-Continued**

- From equipment served by rigid conduit to the nearest grounding cable attachment on conduit runs of less than 25 feet, allowable resistance is 10 ohms
- Maximum permissive resistance for grounds and grounding systems between equipment or structure being grounded and solid (earth) ground:
  - For generating stations, maximum permissive resistance is 1 ohm
  - For main substations, distribution substations, and switching-stations on primary distribution systems, maximum permissive resistance is 3 ohms
  - For secondary distribution system (neutral) grounding, noncurrent-carrying parts of the distribution system itself, and enclosures of electrical equipment not normally within reach of other than authorized and qualified electrical operating and maintenance personnel, maximum permissive resistance is 10 ohms
  - For individual transformer and lighting-arrester grounds on distribution system, maximum permissive resistance is 10 ohms
- When total resistance in either of the above tests exceeds allowable, measure resistances of individual portions of the circuits to determine the points of excessive resistance and report:
- Substandard resistance values resulting from poor contact between metallic portions of grounding system and earth:
- Structural steel, piping, or conduit run exceeding 25 ft used as a current-carrying part of grounding circuit for protection of equipment:
- Absence of ground-cable connections:

**7.6.13 Instruments:** Comply with all current safety precautions. Determine if preventive maintenance inspections are adequate. Check for:

- Electrical Instruments:
  - improper shielding, mounting, or enclosures when located near strong magnetic fields, subject to vibrations, extremes in temperature, moisture, metallic and other dust, and acid or corrosive vapors
  - inadequately, improperly or not neatly stored in cases or cabinets that are free from dust, corrosive fumes, excessive heat, moisture, vibration, strong magnetic fields
  - not clean



**ELECTRICAL****Instruments-Continued**

- improperly marked and identified
  - incorrect type and range for application
  - no manufacturers' instructions for servicing
  - poor physical condition of instrument cases, portable cases, handles nameplate, leads, calibrated leads, shunts, multipliers
  - loose electrical connections
  - dirty or corroded contact surfaces
  - inadequate, poorly arranged, improperly insulated wire, cable, and leads
  - broken glass
  - pointer friction
  - warped or dirty scale
  - bent pointers
  - missing parts
  - moving elements not locked when instruments provided with locking devices are not in use
  - inkwell not clean and dry when portable type recording instruments are in storage
- Calibration:
- Not serviced, calibrated, or tested at appropriate intervals to accepted standards of accuracy for particular instrument
  - records of tests not available
- Watt-Hour Meters:
- nonoperative voltage (power-on) indicating lamps
  - Outdoor Service Meters
    - poor physical condition
    - loose weather seals
    - moisture or dirt in enclosure
    - corrosion
    - loose connections
    - missing parts

**ELECTRICAL****Instruments-Continued**

- DC Ammeters:
  - improperly connected in grounded leg of grounded DC circuits
- Instrument Transformers:
  - poor physical condition
  - dirty
  - inadequate connections
  - visual evidence of overloading or overheating

**7.2.14 Lighting:** Check condition and operation of:

- Diffusers, lens, globes:
- Broken or aging fixture:
- Proper wiring and mounting of fixtures:
- Proper operation of all emergency lighting fixtures:
- Assure that emergency lights are wired into dedicated circuits:

**7.2.15 Motors and Generators:** Comply with all current safety precautions. Determine if preventive maintenance inspection is adequate. When practicable, start, run, and cycle motor and generator equipment through load range. Take care in starting motors and generators. On standby or infrequently operated equipment, check rotor freedom and lubrication. At humid locations check records for evidence of regular exercise; if not found arrange for drying out windings; megger windings before starting motor. Check for:

**RUNNING INSPECTION (While Equipment Operates)**

- Log or Operator Records:
  - evidence of motor or generator overload
  - induction motor underload
  - low power factor of load
  - excessive variations in bearing temperature
  - operating difficulties
- Exposure:
  - unsafe accessibility for maintenance of instrumentation
  - exposed to physical or other damage from normal plant functions, processes, traffic, and radiant heat

**ELECTRICAL****Motors and Generators-Continued**

- inadequate personnel guards, fences
- insufficient, missing, or illegible signs, identification, or operating instructions
- Housekeeping: Identify need to remove oil and solvent cans, oil or solvent soaked rags and waste, other combustibles, particularly those near commutating machinery. Identify need to remove obstructions that may interfere with rotation or ventilation:
  - dust, dirt, airborne grit, sand
  - dripping oil, water, other fluids
  - vapors
  - rust
  - corrosion
  - peeling, scratches, abrasions or other damage to painted surfaces
- Machine Operation:
  - noisy
  - unbalanced
  - rubbing
  - excessive vibration
  - rattling parts
- Structural Supports:
  - inadequate
  - cracks
  - settlement
  - defective or inadequate vibration pads, shockmounts and dampers
  - loose, dirty or corroded bolts and fittings
- Ventilation:
  - dirty
  - inadequate amount of air passing through machine
  - dirty
  - clogged

**ELECTRICAL****Motors and Generators-Continued**

- stator-iron air slots causing excessive temperature. (Too hot to touch. Measured temperature should not exceed 80°F for open frames, or 90° for enclosed frames. Compare with manufacturer's data.)
- Motor and Generator Leads:
  - exposed bare conductors
  - frayed, cracked or peeled insulation
  - poor taping
  - moisture
  - paint
  - oil or grease
  - vibration
  - abrasions
  - breaks in insulation at entrance to conduit or machines
  - arcs or burns
  - overheated
  - inadequate terminal connections
  - lack of resiliency, lack of life or dried-out insulation
  - exposure to physical damage, traffic, water, heat, for semipermanent, temporary, or emergency connections
- Bearings:
  - improper lubrication (check lubrication schedules for lubricant used and frequency)
  - improper oil level in oil gages
  - incorrectly reading gages
  - noisy bearings
  - overheated bearing caps or housings. (If bearings are too hot to touch, determine causes. A slow but continuous rise in bearing temperature after greasing indicates possible overlubrication or underlubrication, improper lubricant, or deteriorated bearings. Under normal conditions, the temperature of ball or roller bearings will vary from 10° to 60°F above the ambient temperature.)

**ELECTRICAL****Motors and Generators-Continued**

- Collector Rings, Commutators, Brushes:
  - excessive sparking
  - surface dirt
  - grease (check cleanliness with clean canvas paddle)
  - sparking or excessive brush movement caused by eccentricity, sprung shaft, worn bearings, high bars or mica
  - surface scratches
  - roughness
  - end-play resulting from magnetic-center hunting of rotor
  - inadequate brush freedom
  - nonuniform brush wear
  - poor commutation
  - improper brushes
  - incorrect brush pressure. Brush spring pressure should be between 1-3/4 to 2-1/2 psi of brush-commutator contact area for light metallized carbon or graphite brushes; for pressure for other type brushes, check manufacturer's data. (Measure with spring scale.)
- Starters, Motor Controllers, Rheostats, Associated Switches:
  - damaged or defective insulation
  - loose laminations
  - defective heater or resistance elements
  - worn contacts
  - shorts between contacts
  - arcing
  - grounds
  - loose connections
  - burned or corroded contacts. Worn contacts and defective heater resistance elements should be replaced

## Motors and Generators-Continued

- Protective Equipment:
  - dirty
  - signs of arcing
  - symptoms of faulty operation
  - improper condition of contacts
  - burned-out pilot lamps
  - burned-out fuses

SHUTDOWN INSPECTION (while equipment is not in operation and is electrically disconnected. A shutdown inspection includes a running inspection.)

- Stators:
  - dirt
  - debris
  - grease
  - coils not firmly set in slots
  - burns
  - tears
  - aging
  - embrittlement
  - moisture in insulation
  - clogged air slots
  - rubbing
  - corrosion
  - loose laminations of stator-iron
  - charred or broken slot wedges
  - abrasion of insulation or chafing in slots
  - signs of arcing or grounds
- Rotors:
  - difficult turning
  - rubbing
  - excessive bearing friction

**ELECTRICAL****Motors and Generators-Continued**

- end play
- overheating
- looseness of windings
- charred wedges
- broken
- cracked
- loosely welded or soldered rotor bars or joints
- cracked end rings in squirrel cage motors
- loose field spools and deteriorated leads and connections in synchronous motors
- deteriorated insulation in wound rotors
- Roto-Stator Gaps:
  - Check gaps on 5 hp or larger induction motors, particularly of the sleeve bearing type
  - Where practicable, measure and record gaps on the load, pulley or gear end of the motor
  - Measure at 2 rotor positions, 180° apart, 4 points for each rotor position. If there is more than 10% variation in gaps, arrange for realignment
- Mechanical Parts:
  - corrosion
  - improper lubrication
  - misalignment
  - end play
  - interference
  - inadequate chain or belt tension
- Insulation Resistance:
  - Test insulation resistance of motor and generator windings. Compare results with table below
  - Insulation resistance values are arbitrary and should be correlated with operating conditions, exposure to moisture, metallic dust, age, length of time in service, severity of service, and maintenance levels

**ELECTRICAL****Motors and Generators-Continued**

- Permanent records should be kept of measured insulation values on all integral hp motors
- To ascertain trends, graphs showing the long-time relationship of insulation resistance to time should be prepared on all large or critical equipment

**INSULATION-RESISTANCE VALUES**

<b>Machine Rating (volts)</b>	<b>Insulation Resistance Minimum (Megohms)</b>	<b>Insulation Resistance Preferred (Megohms)</b>
110	0.11	0.20
220	0.22	0.50
440	0.42	0.75

**SYMPTOM OBSERVED/Probable Cause****NOISY BEARING (Popping or churning):**

Overlubrication  
Excessive moisture in lubricant

**EXCESSIVE ARCING AT BRUSHES:**

Incorrect brush position  
Improper type, size or span of brushes  
Incorrect brush pressure or contact  
Loose brush rigging  
Dirty or rough commutator or slip ring  
High or low commutator bars  
Short-circuited commutator bars  
Overload or excessive vibration

**NOISY BRUSHES (SINGING):**

Excessive brush pressure  
Brushes too hard  
Holders improperly adjusted  
High and low commutator bars  
Loose commutator bars  
High mica between commutator bars



## ELECTRICAL

### Motors and Generators-Continued

Brushes set at improper angle

#### RING FIRE AND FLASHING ON COMMUTATOR:

Short or open circuit in armature coil

#### OVERHEATING:

Overload  
Field or armature short circuit  
Poor ventilation  
Rotor off center  
Unbalanced phase currents  
Excessive field current  
Line voltage too low  
Bearing friction

#### SPEED TOO HIGH:

Weak field current  
Prime mover speed too high

#### SPEED TOO LOW:

Overload  
Low line voltage  
Bearing friction  
Dragging rotor  
Prime mover speed too low

#### HUNTING ACTION:

Load variation  
Variation in voltage frequency (unstable speed of prime mover)

#### **7.2.16 Navigation Lights:** Check for:

- Cable and Wiring:
  - dirty
  - poor ventilation
  - detrimental ambient conditions
  - presence of moisture, greases, oil or chemical fumes
  - damaged wiring devices

**ELECTRICAL****Navigation Lights-Continued**

- defective insulators, cleats, and cable supports
  - broken or missing parts
  - exposed live parts
  - evidence of overheating
  - grounds and short circuits
  - overheated splices
  - damaged or defective insulation
  - need for painting of noncurrent-carrying parts subject to corrosion
  - defective operation (try manually and electrically when practicable)
- Battery:
    - Connections
      - loose
      - corroded
      - dirty
      - inadequate
    - proper output voltage

**7.2.17 Panels:** (primary, secondary, and sub)

Check for:

- Ground wire and buss:
- Proper wire connections:
- Correct circuit breaker size (Ampere):
- Deterioration of conductor insulation:
- Unprotected or tapped circuits:
- Excessive heat:
- Proper feeder and branch circuit conductors:
- Proper load amps and feeder conductor size:
- Unbalanced load:
- Circuit capacity (to see if circuits could be added):
- Age of panel (economical availability of replacement parts):

**ELECTRICAL**

**7.2.18 Potheads:** Comply with all current safety precautions. **DO NOT TOUCH** when energized. Determine if preventive maintenance inspections are adequate. Check for:

- Porcelain:
  - cracks
  - breaks
  - chips
  - checking of porcelain glaze
  - streaks of carbon deposits indicating flashovers and possible damage
  - dirt, dust, grease or other deposits
  - cracks, breaks, or deterioration of cement sealing compound
  - leakage
  - signs of moisture
- Cable Clamps:
  - corrosion
  - loose bolts, solder or **GROUND CONNECTION**
  - poor mechanical connections. (Corrosion of lead cables and connections at potheads indicated by presence of a white, brownish, or reddish product.)
- Terminal Studs and Bolting Pads:
  - corrosion
  - loose connections
  - poor contacts evidenced by discolorations from heating.
- Mountings:
  - corrosion
  - other weakness

**7.2.19 Power Plants:** Comply with all current safety precautions. Check for:

- General:
  - Housekeeping: lack of cleanliness or orderliness
  - Safety Signs and Posted Instructions
    - inadequate
    - illegible

**ELECTRICAL****Power Plants-Continued**

- improper location
- Operating Log, Plant Log, and Maintenance Records
  - failure to record pertinent readings
  - other information necessary to locate and evaluate trouble areas and trends
- Evidence of need to follow up deficiencies that may lead to breakdown
- Generator Loading Operating Log:
  - review for duration and amount of overload, ambient temperature, temperature rise. Note when rated temperature is approached or exceeded
- Insulation:
  - Make insulating test measurements of generator field, armature windings, and cable from main breaker terminals. Note evidence of electrical weakness to extent that normal operating voltage or surges may result in failure
- Generator Excitation Systems:
  - inadequate
  - not serviceable
  - unreliable
  - poor physical condition of emergency exciters and associated equipment, including rheostats, pilot exciters, voltage regulators, motor drives
  - inadequate ground indicating system in ungrounded exciter circuits
- Plant Battery:
  - Battery Room or Enclosure:
    - lack of cleanliness
    - unacceptable temperature
    - inadequate ventilation
    - unsatisfactory condition of floor
    - fire hazard from lighting and power fixtures, fittings, and cable

**ELECTRICAL****Power Plants-Continued**

- Operating and Maintenance Records:
  - review for deficiencies in specific gravity levels
  - cell temperature
  - makeup water history
  - equalizing charge practices
  - sustained overcharges and discharges
- Connections:
  - loose
  - corroded
  - dirty
  - inadequate
- Cells:
  - oversulphated plates
  - physical erosion
  - internal shorts
  - buckled plates
  - cracked grids
  - dirty electrolyte
  - improper electrolyte level
  - excessive sedimentation
- Chargers and Controls: poor physical condition
- Instruments: inaccurate, (check frequency of calibration)
- Buses:
  - poor condition
  - dirty
  - structural distortion
  - loose joints and connections
  - evidence of overheating

## ELECTRICAL

## Power Plants-Continued

- Control Switchboards:
  - poor physical condition
  - dirty
  - Wiring and Connections
    - lack of neatness
    - looseness
  - Fuses in Control Wiring System: improper size
  - Indicating Lamps: not operating
  - Mimic Buses
    - illegible
    - inaccurate

**7.2.20 Rectifiers:** Comply with all current safety precautions. Rectifier cabinets and enclosures contain energized electrical equipment. **DO NOT tighten wires, make adjustments, or disturb any valve, control, or other adjustment device.** Check for:

## ENCLOSURES

- General Area Housekeeping:
  - dust
  - dirt
  - trash
  - debris
- Exterior:
  - mechanical damage
  - excessive corrosion (more than two rust spots 1/2 inch diameter)
  - corroded, binding or unlubricated hinges and latches
- Interior:
  - rust
  - corrosion
  - moisture condensation
  - indications of excessive heating

**ELECTRICAL****Rectifiers-Continued**

- Wiring:
  - broken
  - damaged
  - deteriorated
  - missing insulation or clamps
  - corroded or mechanically damaged conduit
  - cracked or broken sleeves on floor or wall bushings

**METALLIC RECTIFIERS**

- Electric Meters:
  - Record readings from all AC and DC ammeters and voltmeters. Report if supply voltage is more than 5% below or above nameplate rating. Report defective meters
- Temperature:
  - Record readings of water temperature indicators, if provided. On indoor installations record ambient temperature at apparent hottest point five feet from units. Report if temperature of cooling water is more than 10% above that recommended by manufacturer
- Fan:
  - dirt
  - excessive vibration
  - loose hold-down bolts
  - loose or worn bearings
  - inadequate or improper lubrication

**MERCURY-ARC RECTIFIERS**

- Meters and Gages:
  - illegible
  - inadequate lighting
  - cracked, broken, dirty or badly stained viewport glasses

**ELECTRICAL****Rectifiers-Continued**

- Water Cooling Systems:
  - leaks
  - rust
  - corrosion
  - mechanical damage
  - excessive vibration
- Pumps, Fans, and Motors:
  - leaks
  - excessive vibration
  - loose or missing hold-down bolts
  - deteriorated mounting pads or shock pads
  - inadequate or improper lubrication

**7.2.21 Relays:** Comply with all current safety precautions. Determine if preventive maintenance inspections are adequate. Check for:

- Relays (General):
  - dirty
  - evidence of moisture
  - high temperature
  - other adverse conditions
  - visible corrosion
  - deterioration or pitting of contacts, pivots, and coils
  - broken or loose parts and connections
- Temperature and Pressure Relay:
  - settings at improper temperature and pressure limits
  - evidence of damaging temperature or pressure conditions



**ELECTRICAL**

**7.2.22 Steel Power Poles and Structures:** Comply with all current safety precautions. Remember these structures are part of an Electrical system and may be conducting current. Avoid contact with line poles and structures until they have been grounded and/or deenergized. Check for:

- Ground Area:
  - trash, debris, weeds or brush one foot in height within 3 feet of pole or structure
- Concrete Bases, Pads and Anchor Bolts:
  - cracks, including surface cracks wider than 1/16 inch
  - breaks
  - chipped areas deeper than 1/2 inch
  - settlement
  - movement
  - defective paint/galvanizing
  - visible rust or corrosion to depths exceeding 1/16 inch
  - loose or missing nuts/bolts
  - where visible, inspect all metal where it enters concrete
- Street Light Standard Handholes and Bell Interiors: Visual Inspection Only, If Energized:
  - rust
  - corrosion
  - installed transformers
    - loose wires
    - excessive discolorations from heating and sparking
    - signs of insulating compound or other leakage
    - charred, burned, or missing insulation
- Poles, Structures, Crossarms and Beams: Inspection from Ground, Use Field Glasses:
  - defective paint/galvanizing
  - visible rust or corrosion, especially pitting where visible
  - inspect all metal in contact with, or entering concrete
  - loose bolts and pins

**ELECTRICAL****Steel Power Poles and Structures-Continued**

- excessive rust and corrosion between pole and/or structure and braces, equipment supports, insulator pins, guy fastenings, and similar locations
- checking, chipping, flaking, or scaling of paint on pole and attachments
- broken or bent structural or accessory members, especially near bolts
- misalignment. (Top of unguyed pole is out of line more than 1 foot in any direction.)
- Guys and Anchors:
  - corroded, cracked or worn hardware at guy takeoffs, anchors and insulators
  - cracked, broken, or dirty insulators
  - missing insulators
  - defective galvanizing
  - corrosion
  - broken strands
  - battered or corroded guy shields
  - excessive sag or tautness
  - guy anchor movement
- Ground Wire: Visual Inspection Only:
  - failure to install at least one wire at every steel pole or structural support, including each steel column in substation or switching station
  - Connections
    - rust
    - corrosion
    - looseness
    - discolorations from overheating
    - substandard conditions

**ELECTRICAL**

**7.2.23 Switchgear:** Comply with all current safety precautions. Check for:

- Asbestos: Inspect ARC chutes and flash pads for friable asbestos. Vacuum to eliminate safety and health hazard using high efficiency particulate air vacuum (HEPA VAC) Do not use compressed air. Avoid dispersing asbestos. Then encapsulate and seal with insulating paint such as “Gyptal” or equivalent from any manufacturer. Use protective clothing and respirator as required. Empty HEPA VAC into plastic bag for disposal at approved asbestos disposal facility:
- Are preventive maintenance inspections adequate?
- Housekeeping:
  - dampness
  - dirty
  - inaccessibility
  - detrimental conditions such as ambient temperatures in excess of 100°F
  - humidity causing sweating of metal enclosures
  - rodents or insect infestations
  - stored combustibles
  - trash, dirt or dust accumulations
  - poor location
  - poor ventilation
  - gas, steam or water leakage
- Exterior Housing and Enclosure Ground:
  - rust
  - corrosion
  - need for painting
  - signs of abuse
  - unauthorized or improper signs
  - storage materials or dust accumulating on top of enclosures
  - missing parts or other items
  - poor condition or inadequacy of enclosure ground

**ELECTRICAL****Switchgear-Continued**

- Interior of Compartments, Cubicles and Drawers:
  - dirty
  - condensation
  - symptoms of overheating
  - burns from ground and short circuits
  - defective insulation
  - defective operation of locks, doors, and drawers
- Air and Oil Circuit Breakers, Oilless-Type Air Blast Breakers (Deenergized/50 Amperes and above):
  - incorrect wipe of main and arcing contacts on opening and closing
  - overheating
  - lack of continuity
  - looseness of connections on all mechanisms
  - incorrectly placed pins and cotter pins
  - improper functioning of rods and moving parts and binding occurs when breaker is operated
- Tests:
  - Measure operating voltage on electrically-operated breakers
  - Measure operating voltages in switchgear control circuits
  - Make liquid dielectric strength tests. Liquid should be changed if tests under 18,000 volts
  - Measure insulation resistance and evaluate
    - minimum value or low limit recommended is 2 megohms total (after one minute at approximately 25 degrees C.) for safe operation or before making high-potential tests
    - make high-potential tests at 65 percent of initial installed value, or in accordance with manufacturer's recommendation

**7.2.24 Wood Poles and Accessories: Comply with all current safety precautions.**

Because overhead electric distribution systems are energized almost continuously, inspection of such items as poles, hardware, and associated accessories should be made from the ground using field glasses except during those periods when placed outages of the various systems will permit a climbing inspection. Ordinarily such climbing inspections will occur very infrequently and should be performed only when it is certain

**ELECTRICAL****Wood Poles and Accessories-Continued**

that all line wires attached to the pole are deenergized and provided with safety grounding. Poles supporting only telephone open wires or telephone aerial cables should not be climbed unless an obvious defect indicates the necessity of climbing to permit a closer inspection. It is essential that questionable poles be tested and supported before the pole is subjected to the unbalanced load caused by climbing for closer inspection. Particular attention shall be given to weather conditions, power hazards, traffic warning procedures, and tree and brush cuttings. Check for:

- Ground Area:
  - water ponding at base
  - debris, trash, or weeds within 3 feet in any direction
- Poles: Visual Inspection, Except as Indicated:
  - sound-test with unpointed hammer for hollowness caused by termites, carpenter ants, and/or decay fungi. Sounding should be from groundline to the highest point reached from standing position; actual condition of questionable poles should be confirmed by drilling a 3/8" hole(s) with a wood bit to center of pole in the area under suspect. Test holes must be plugged with a 7/16" preservative treated wood dowel. Check for external decay most prevalent in the vicinity of the ground-line area, knotholes, large splits and checks, and in and around woodpecker holes
  - splits
  - lightning, bird, insect, vehicle, or other damage
  - make shallow excavation around pole and take increment boring if a faulty condition below ground is suspected. (Upon completion of boring treat hole with wood preservative, drive treated plug into hole, sterilize soil, backfill and tamp excavation.)
  - ground-line treatment of untreated poles required in addition to all poles in-service at least ten (10) years. Pole ground-line re-treatments should be conducted on a ten year cycle. Preparers of pole maintenance contracts should refer to NAVFAC Specification TS-20212 for guidance.
  - failure of originally installed protective treatment of pole

**ELECTRICAL****Wood Poles and Accessories-Continued**

- poles should not lean except for special reasons. When lean is more than 1 foot at top, pole should be straightened and if necessary guyed. (To determine whether top of pole is out of alignment, sight the pole from those adjacent to it.)
- structural inadequacy or other deficiencies requiring stub reinforcement or complete replacement

Note: Pole plant inspectors should become familiar with NAVFAC MO-312.3, **Inspection, Maintenance and Procurement Procedures for Wood Poles**. This handbook provides detailed guidance on inspection and maintenance procedures for wood pole plants.

■ Crossarms and Buckarms: Use Field Glasses:

- splits
- bum
- decay
- twists
- weathering damage
- other defects

■ Insulators and Pins: Use Field Glasses:

- cracks
- breaks
- chips
- dirty or missing insulators
- cracked, broken or missing pins
- rust
- corrosion
- looseness of insulator bolted connections and fastenings to crossarms resulting in strains on line wires or movement of wires on insulators

## ELECTRICAL

## Wood Poles and Accessories-Continued

- Tie-Wires and Line Wires: Use Field Glasses:
  - looseness
  - chafing
  - slippage
  - other damage within 1-2 feet of insulators and corrosion at points where linewires and tie-wires come together near insulators
- Hardware Pole Steps, Crossarm Braces, Grounding Bonds, Brackets, Through Bolts or Other: Use Field Glasses:
  - signs of fire damage and rot or insect damage around all hardware in contact with pole or crossarms
  - rust
  - corrosion
  
  - looseness of any parts
- Ground Wires: Use Field Glasses:
  - rust
  - corrosion
  - frayed or broken strands
  - discoloration that may indicate overheating or complete failure of connections, including connection to ground rod at base of pole. **(Do not disconnect or allow contact with body if overhead lines are energized.)**
  - Protective Moldings
    - looseness
    - missing
    - broken
    - cracks
    - decay

**ELECTRICAL****Wood Poles and Accessories-Continued**

- Guywires:
  - loose, missing, or corroded clamps, wires or holding bolts, and brackets
  - broken or cracked insulators and complete absence of insulators on circuits over 300 volts
  - excessive tautness or looseness and failure of guys and guy anchors
  - vehicle damage
  - inadequacy and nonvisibility of shields or protectors
  - corrosion
  - fraying or broken strands
- Clearances and Tree Limbs: Use Field Glasses:
  - inadequate separation from limbs, branches, and foliage
  - dead trees or limbs that may fall on line
  - brush and tree prunings have not been removed
  - inadequacy and poor condition of tree guards and attachments on insulated wire

**7.3 REPAIR/REPLACEMENT CRITERIA:**

**7.3.1 Fire Alarm:** Since the fire alarm may not be tested, it's true condition may not be determined. If replacement is considered, consult with the fire department serving the facility. An engineering evaluation may be necessary to determine the correct action.

**7.3.2 General wiring:**

- Repair:
  - General good condition
  - Problem area can be spliced in an accessible area
- Replacement:
  - Insulation badly cracked, damaged, deteriorated
  - Undersized conductor



**ELECTRICAL****7.3.3 Lighting:**

- Repair:
  - Less than 20 years old
  - Replacement parts available
  - Replacing/repairing parts is cost effective
  - General good condition and appearance
- Replacement:
  - Over 20 years old
  - Badly damaged or deteriorated beyond repair
  - Parts difficult or impossible to procure
  - Replacing or repairing parts is not cost effective
  - Lighting replacement should be considered when a new suspended ceiling is to be installed.

**7.3.4 Panels: (Primary, Secondary, and Sub)**

- Repair:
  - General good condition
  - No overloading
  - No evidence of burning or arcing (fire or shock hazard)
- Replacement:
  - Over 20 years old
  - Badly damaged or deteriorated
  - Panel overloaded
  - Panel displays evidence of burning or arcing (fire or shock hazard)

## CHAPTER 8. ROOFING INSPECTION GUIDE

### 8.1 DEFINITIONS:

**Roofing System** - an assembly of interacting components designed to weatherproof, and normally to insulate, a building's top surface. Normally from above the ceiling of the top floor or the ceiling of an attic to the top most surface of the facility

**Test Cuts** - destructive tests used to determine primarily the composition of the roofing system, conformance with specification, i.e., bitumen weights, and condition. Normally test cuts are limited in number and therefore are not a complete indication of the condition of a roof structure.

**Infrared Thermography** - is a non-destructive method of inspecting roofs. The equipment can be hand-held or used from an aircraft, to determine heat retained by wet insulation.

**Nuclear moisture surveys** - Nuclear moisture surveys require a minimum of core samples be taken to verify moisture content. They are non-destructive tests used to determine the condition of roof insulation. A nuclear moisture survey can detect moisture in a roof which could contribute to leaks and rapid deterioration of the roof

**Trusses** - includes all types of building trusses that are normally designed for the express purpose of supporting roof loads as well as ceilings where applicable. All lateral and vertical bracing and ties between trusses are included

### 8.2 ROOFING INSPECTION INSTRUCTIONS:

#### 8.2.1 Asphalt strip shingled roof: Check for:

- Flashings - Pay particular attention to the flashing around penetrations or between roofs of different ages. Check for:
  - Missing sections
  - Rust
  - Damage
- Valleys:
  - Punctures
  - Weathering
  - Deterioration

**ROOFING****Asphalt strip shingled roof-Continued**

- Shingles:
  - Brittleness
  - Clawed edges
  - Absence of minerals
  - Cracking
  - Missing tabs/shingles
  - Breaking
  - Weather damage
- Penetrations:
  - Deterioration
  - Deterioration of the surrounding flashing

**8.2.2 Built-up roof: Check for:**

- Gravel Stops:
  - Missing stops
  - Loose stops
  - Rust
  - Evidence of numerous repairs
  - Problems at the creased corner which forms a 90 degree angle
- Flashings:
  - Metal
    - Check the valley, step, and cap flashings for
      - Missing sections
      - Rust
      - Punctures
      - Wind damage
    - Check the cap and step flashings for
      - Proper reglet seals
      - Separation from vertical surfaces

**ROOFING****Built-up roof-Continued**

- Bituminous
  - Splits
  - Tears
  - Punctures
  - Absence of protective coatings
  - Separation from vertical surfaces
- Bare spots - Bare spots expose the plies directly to the elements which can accelerate deterioration. Check for:
  - Cracking
  - Alligatoring
  - Deteriorated felt
- Blisters - Blisters are an indication of moisture or gas between roof plies. Do not apply enough pressure to rupture blisters as this will allow water intrusion. Blisters do not necessarily indicate roof system failure. Check for:
  - Punctures
  - Splits
  - Water - by gently touching to see if water will come out of blister
- Pitch pockets
  - Cracking
  - Shrinkage
  - Absence of bitumen
  - Deterioration of perimeter metal
- Ponding water - Ponding around roof penetrations will result in leaks. Ponding of a large area could indicate a possible structural defect. Stopped up roof drain will cause ponding. Check for:
  - Location
  - Percentage of roof surface which displays ponding
- Penetrations - The majority of roof failures begin in areas near penetrations. Check for:
  - Proper flashings
  - Ponding of water near penetration

**ROOFING****Built-up roof-Continued**

- General surface appearance:
  - Displacement of aggregate
  - Weathering
  - Debris

**8.2.3 Metal roof: Check for:**

- Surface:
  - Rust
  - Punctures
  - Tears
  - Wind damage
- Fasteners:
  - Loose fasteners
  - Missing fasteners
  - Deterioration
- Seams:
  - Looseness
  - Rust
- Penetrations:
  - Deterioration
  - Deterioration of surrounding flashing

**8.2.4 Slate roof: (Do not walk on slate roof if possible.) Check for:**

- Flashings:
  - Missing sections
  - Punctures
  - Rust
  - Separation of strip flashing from vertical surfaces
  - Reglet seals
- Valleys - Check flashing:
- Penetrations - Check flashing:

**ROOFING****Slate Roof-Continued**

- Missing slate percentage - If twenty five percent (25%) or more of the slate is missing, consider roof replacement. If this much slate is missing, the fasteners have probably failed. Reuse some of the slate if possible during roof replacement:

**8.2.5 Trusses:** Comply with all current safety precautions. To identify truss members for the report, use a sketch of the truss and label the panel points either numerically or alphabetically. The deficient member may then be identified by indicating the panel points between which it lies. Check for:

- Truss Sag: Examine trusses for sagging by stretching piano wire between supports and measuring vertical defections at panel points or use a surveying instrument:
- Painted Surfaces:
  - blistering
  - checking
  - cracking
  - scaling
  - wrinkling
  - flaking
  - mildew
  - bleeding
  - rust
  - corrosion
  - complete absence of paint, particularly at end of members
  - record film thickness and condition on metal surfaces

**TIMBER**

- From Ground: Use field glasses:
  - twisted and bowed members
  - excessive number and size of knots
  - slope of grain over one inch in ten
  - checks and splits in ends of web members
  - separation or slippage at joints

**ROOFING****Trusses-Continued**

- sag
- overloading
- From Truss:
  - loose bolts
  - split rings
  - shear plates
  - fastening devices
  - checks and splits in bracing, chord members, splice plates (scabs), web members and filler blocks
  - missing filler blocks
  - improper end and edge distances
  - looseness of tie rods. (Bolts may be considered loose if after striking head of bolt a sharp blow with a hammer, the nuts can be taken up two full turns or more.)
- Steel Splice Plates:
  - rupture
  - shearing
  - crushing
  - rust
- Wooden Parts:
  - dry rot
  - dampness and surface moisture of long duration
  - termite and other insect, and fungus infestation. Termite and fungus infestations are often detected prior to actual visual damage by probing with a sharp-pointed instrument those areas where prolonged dampness is not directly associated with rainfall or damp climate
- Wooden Supports near or at Ground Level:
  - termite tubes or tunnels
  - dirt piled up to wood level

**Trusses-Continued**

- need of protective treatment. If removal of dirt piles is impracticable, wood in direct contact with, or less than 8 inches from ground level should be given protective treatment

**STEEL**

- From Ground:
  - twisted
  - bowed
  - deformed
  - broken members
- From Truss:
  - loose bolts
  - rivets
  - defective welds
- From Truss: rupture, shearing, or crushing of steel plates, members, bolts, and rivets:

**8.2.6 Moisture Survey Instructions for Built-Up Roofs:** Partial or total built-up roof replacement recommendations can be made using moisture survey results. NAV-FAC prefers a moisture survey to be completed before any built-up roof is replaced.

- Mark out a grid on the roof:
- Using the nuclear moisture detector test and record the moisture level at each marked point:
- Map out the grid and test results:
- Draw conclusions and make recommendations from the test results:
- Prepare cost estimates based on your recommendations:

**8.3 REPAIR/REPLACEMENT CRITERIA:****8.3.1 Asphalt strip shingles:**

- Repair:
  - Uniform and flat shingles
  - Ample minerals
  - Pliable



**ROOFING****Asphalt strip shingles-Continued**

- No rust on valley, step, or vent flashings
- No evidence of previous repairs
- Replacement:
  - Brittle shingles -they crush and break under foot
  - Clawed and turned under shingles
  - Missing shingle tabs -possibly due to bad weather
  - Mineral loss on shingles
  - Bond deterioration
  - Rusting valley, step, and vent flashings
  - Frequent leaks -check with activity's records
  - Many repairs evident

**8.3.2 Built-up Roof:**

- Repair:
  - Flashing responsible for leaks
  - Generally good condition, no membrane splits, tears, etc.
  - No history of major leaks
  - Attic or overhead inspection indicated good condition of underside of roof
  - Nondestructive testing indicates majority of insulation is dry
- Replacement:
  - Membrane is cracking, splitting or slipping
  - Membrane condition is poor
  - Nondestructive testing indicates majority of insulation is wet
  - Roofer recommends replacement as most cost effective
  - Many repairs are evident
  - Frequent leaks -check with the activity records
  - Leaks are interfering with the mission
  - Water ponding evident and associated with leaks
  - Lack of sufficient aggregate and advanced membrane deterioration such as brittle condition

**ROOFING****8.3.3 Metal:**

- Repair:
  - Repair should always be first consideration for metal roofing as it is often impractical to replace metal roofs.
  - General good appearance
  - No deep rust, only surface rust if there is any
  - No major deterioration
- Replacement:
  - Last resort, if repairs are not possible
  - Many repairs evident
  - Frequent leaks -check activity's records
  - Leaks interfering with mission
  - Deep rust
  - Deterioration on underside of roof
  - General poor appearance

**8.3.4 Slate:**

- Repair:
  - Few if any leaks
  - Few broken, missing, or deteriorated slates
  - Good appearance
- Replacement:
  - Many and frequent leaks
  - Many repairs evident
  - Leaks interfering with the mission
  - Missing 25% or more of slate
  - Large number of deteriorated or broken slate

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