GUIDE

FOR

INSPECTION OF REFINERY EQUIPMENT

CHAPTER XVIII
PROTECTION OF IDLE EQUIPMENT

FIRST EDITION
1959

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PREFACE

This chapter is one of a series which make up the manual, *Guide for Inspection of Refinery Equipment*. It is based on the accumulated knowledge and experience of engineers of the petroleum industry. All users are invited to submit suggested revisions to the director of the Division of Refining, American Petroleum Institute, 111 West 50th Street, New York 20, N. Y.

The information contained in this publication has been arranged in its present form as a means of facilitating continuity of presentation and convenience of reference. It does not constitute, and should not be construed to be, a code of rules, regulations, or minimum safe practices. It is not intended that the practices described in this publication supplant practices that have been proven satisfactory. Nor is it intended that this publication discourage innovation and originality in the inspection of refineries. Users of the publication are reminded that no book or manual is a substitute for the judgment of a responsible engineer.

The *Guide for Inspection of Refinery Equipment* is subdivided as follows:

TABLE OF CONTENTS

GUIDE FOR INSPECTION OF REFINERY EQUIPMENT

CHAPTER XVIII

PROTECTION OF IDLE EQUIPMENT

1801 BASIS OF PROTECTION

1801.01 General

The protection of idle equipment is an involved and detailed process of safeguarding inactive and unattended equipment from deterioration. The prime requisite of all protective measures is to insure that spare equipment can, after an extended period of idleness, be returned to service with a minimum of delay and expenditure.

1801.02 Causes of Deterioration

Usually, deterioration during periods of idleness is caused by conditions entirely different from those existing during operation. This must be carefully considered in determining the parts to be protected and the methods to be employed.

Primarily, moisture is the main cause of deterioration. Low temperature, generally atmospheric, permits condensation of moisture which is prevented during operation by the higher ambient temperature. Moisture combined with oxygen may cause rusting and pitting of surfaces similar to the atmospheric corrosion of structures or other metallic equipment operating at atmospheric temperatures. Moisture from rain or snow may seep in through small cracks and crevices in insulation, fireproofing, or other coverings or coatings and may accumulate to cause corrosion. If surfaces are not properly cleaned, chemicals, deposits, or products of corrosion remaining on the surface may become more corrosive due to the presence of moisture.

Steel and metal alloys, which have satisfactorily resisted corrosion from process streams at operating temperature, may be seriously affected by atmospheric conditions. Where the atmosphere may be polluted by various gases or dusts, moisture may cause these to be extremely corrosive.

Par. 202.04, Chapter II, *Conditions Causing Deterioration or Failures,* contains more details concerning atmospheric corrosion.

1801.03 Basis for an Effective Program

An effective program which will provide protection to idle equipment is the result of an understanding of conditions contributing to equipment deterioration and a knowledge of methods and facilities available for protecting the equipment. It is based on, and formulated after, an evaluation of the following items:

1. A complete inspection of the equipment after removal from service.
2. A review of the mechanical design of the equipment.
3. The determination of an estimated period of idleness.
4. A consideration of the methods of protection applicable to the piece or pieces of equipment.
5. The economics or costs involved in protecting the equipment.
6. Replacement value of the equipment.
7. Anticipated need for the equipment.

1801.04 Conditions Affecting Protective Requirements

The protective requirements for idle equipment will vary from one refinery to another. They will be greatly affected by the differences in:

1. Climatic conditions having varying degrees of:
   (a) Humidity.
   (b) Temperature extremes.
   (c) Precipitation.
2. Plant atmospheres affected by their proximity to:
   (a) Chemical plants.
   (b) Industrial plants.
   (c) Salt water.

1801.05 Determination of Protection Required

1801.051 INSPECTION: In evaluating the protective requirements for any piece of equipment, a complete and detailed inspection is paramount and should be the first step taken. The inspection will accurately disclose the condition of the equipment as it exists and will be instrumental in determining what protective action must be performed. Moreover, it will indicate whether or not the equipment is of sufficient value to warrant protection. Obviously, it is uneconomical to protect equipment which has deteriorated to the point where replacement is imminent.

The inspection should be recorded and the following information shown:

1. A detailed description of the condition of the equipment.
2. An estimated service life still available from the equipment. This information should be based on past inspection records.
3. A recommendation as to the cleaning required.
4. The immediate maintenance required if the equipment were to continue in operation.

An inspection of the idle equipment will show what maintenance and repairs are needed to facilitate im-

mediate use of the equipment when it is returned to service.

The inspection of equipment should not be limited to major pieces of equipment only; it should include all equipment worthy of protection.

1801.052 REVIEW OF EQUIPMENT DESIGN: A detailed review of the design of any piece of equipment will be beneficial in the determination of protective needs. It is apparent that equipment fabricated from materials impervious or highly resistant to the conditions prevailing will require but a minimum of protection. Conversely, equipment fabricated from materials subject to rapid deterioration from the same conditions must be given special consideration.

1801.053 EQUIPMENT ENCLOSURE: The nature of the enclosure of a particular piece of equipment can greatly affect the measures taken. For example, the protection required for explosionproof equipment need not be as extensive as that required for equipment unprotected from vapors or dust.

1801.054 INITIAL TYPE OF PROTECTIVE COATING: The type of protective coating initially specified in the design, such as provided by painting, metalizing, etc., must be considered in the light of its effectiveness and the amount of protection required. It is possible that sufficient external protection has been provided in the original protective coating if the idle period is of short duration.

1801.055 DETERMINATION OF PERIOD OF IDLENESS: Possibly the most indeterminate, and yet most singularly important factor in the protection of idle equipment, is the determination of the expected period of idleness. Its effect on any and all action taken is important. It is reflected in every aspect of planning, for it is obvious that the measures taken to provide protection for a month are incomparable to the efforts expended in safeguarding equipment for a period of many months.

A poor prediction of idle time will have an adverse effect on the cost of maintaining the equipment in a serviceable condition. An underestimate of idle time will result in either the loss of the equipment or a rehandling and retreatment of the equipment. An overestimate contributes to excessive cost in "gold plating" the protection. In either case, the consequence is an unsatisfactory use of company funds and energy.

1801.056 ECONOMIC CONSIDERATIONS: The selection of one or more protective methods will be based on the value of the equipment, cost of protecting, and quantity of protection needed.

Process equipment in a refinery represents a sizable capital investment, yet it is impractical to protect all equipment for extended periods of idleness. Many pieces of equipment, because of their comparatively low initial cost and comparatively high cost of protecting, should not be considered in a protective program. Equipment which will fall into this category includes:

1. Inexpensive instruments—mercury thermometers, manometers, small pressure gages, etc.

2. Small isolated electrical equipment—fractional horsepower motors, push buttons, dry transformers, etc.

3. Inexpensive mechanical equipment—pumps of small capacity and low head, cast-iron valves, small pipe and fittings.

A review of any protective action taken should show that the actual expenditure for protective measures does not approach the replacement cost of the equipment. In view of the constant evolution and improvement of processes and equipment designs, it is easy to appreciate that conceivably great sums of money may be expended for equipment which may soon become obsolete. Obviously, there are exceptions to this rule. Examples include storage vessels, large electric motors, compressors, etc.

1802 METHODS OF PROTECTION

1802.01 General

The procedures described in the ensuing paragraphs pertain to various types of equipment. The need for protection, the anticipated downtime, and the applicability of each method should be considered in deciding the method or methods to be employed. They should be used only after a thorough investigation into the condition of the equipment and an understanding of the costs involved.

1802.02 Exterior Protection

1802.021 ORGANIC COATINGS: One of the most common exterior surface coatings employed for protection is paint; varnish, lacquer, and similar materials are also used. Where surfaces have been protected by paint or other organic coatings during operation, they should be examined carefully. All loose or blistered coatings should be removed, and the areas thus exposed should be recoated. Where the coating is generally cracked or chipped over large areas, a complete recoating job may be required.

1802.022 HEAVY GREASE: Bearing and sliding surfaces, and others which for some reason cannot be protected with an organic coating, may be coated with a heavy grease.

1802.023 WRAPPING: Some surfaces may be wrapped with a heavy waterproofed paper or a plastic material. In some cases the waterproofed paper may be treated with a vapor-phase inhibitor. Vapor-phase inhibitors are proprietary materials, and the manufacturer should be consulted as to the one most suitable for the purpose.

1802.024 INSULATION AND FIREPROOFING: A careful examination should be made when equipment is insulated or fireproofed. All defective material should be removed; the surface below the defect should be cleaned and, if necessary, painted and the covering replaced. Care should be taken to assure that the exterior surface of the insulation or fireproofing is properly waterproofed.

1802.025 METALLIC COATINGS: Where surfaces have been protected by metallic coatings, they should be carefully examined. All defective areas should be thoroughly cleaned and recoated by flame spraying with the same metal used in the original coating.

1802.03 Interior Protection

1802.031 OIL COATING: The interior surfaces of all vessels, heat exchangers, piping, heater and furnace tubes and headers, compressor and pump cylinders, as well as valve chambers, turbine cases, and other closed equipment, can be protected by a coating of light oil, either inhibited or uninhibited, which has sufficient viscosity to adhere to the walls of the equipment. In equipment large enough to permit entry and work, and where all surfaces are available, this may be accomplished by spraying; care should be taken to coat all surfaces thoroughly. In other cases, the equipment may be completely filled with the oil and then drained, leaving a coating on all surfaces.

A suitable light oil is any oil with low viscosity which does not tend to evaporate rapidly. Inhibitors are proprietary materials, and the manufacturer should be consulted as to the one most suitable for the purpose.

1802.032 FILLING: All closed equipment may be protected by completely filling with a light, noncorrosive petroleum oil, such as gas oil; this may be either inhibited or uninhibited. In some cases, inhibited water may also be used for filling. (See Par. 1802.031 for reference to inhibitors.)

1802.033 VAPOR-PHASE INHIBITORS: The interior of vessels may be protected by vapor-phase inhibitors. Inasmuch as these are proprietary preparations, the manufacturer should be consulted regarding the type of inhibitor required and the method of its application. Vapor-phase inhibitors are also used in special impregnated waterproof wrapping papers and may be used in conjunction with cocooning.

1802.034 INERT GAS: All closed equipment may be protected by displacing the air with a dry, inert gas such as carbon dioxide.

1802.035 DESICCANTS: In closed vessels desiccants may be used to absorb moisture. The desiccant should contain an indicator to show when the saturation point has been reached. The use of this method requires opening the vessel periodically to examine the desiccant and to replace it when necessary.

1802.036 CAUTION: A protective coating or an inhibitor which is suitable for protection of one material may be harmful to another material. Care should be exercised in selecting a protective coating or inhibitor to assure that it is suitable for the intended service.

1802.04 Overall Protection

1802.041 COCOONING: Cocooning is the envelopment and protection of equipment by a sprayable plastic coating. It has been used extensively and successfully by the military services and by industry in the protection of idle equipment; its use is unlimited. The size and geometry of the equipment to be protected are not of great consequence in its application.

The proper application of the plastic coating can provide, up to a period of 10 years, a protective covering against:

1. Rain, snow, and moisture.
2. Industrial acids and vapors.
3. Mold and mildew.
4. Salt air.

The period of protection is determined by the thickness of the covering and the type of plastic used. Material specifications covering the physical and chemical properties of the various types of plastics are available from the manufacturers.

The application of the sprayable plastic coating is not an involved process. The process requires the following equipment:

1. Air compressor—60 cu ft per min, 90 psi to 100 psi.
2. Air-pressure regulator.
3. Pressure feed tank of 10- to 15-gal capacity with air-driven agitator.
4. Spray gun and connecting hoses.

The average maintenance man can become an expert cocooning applicator with very little practice. The actual application and information on the procedure for applying it can be obtained from any one of the several manufacturers of the sprayable plastics.

1802.042 PACKAGING: Small parts and instruments may be protected by placing them in plastic bags or packing them in moistureproof cartons or boxes.

1802.05 Protection by Alteration of Environment

1802.051 AIR-CONDITIONING: Where equipment is housed in an enclosed building, protection may be provided by air-conditioning the building to maintain a uniform temperature and low humidity.

1802.052 DEHUMIDIFYING: In certain cases, equipment may be stored in a sealed room which is kept dehumidified by mechanical dehumidification or by desiccants which contain an indicator to show when the

saturation point has been reached. When a desiccant is used, it should be placed where it is visible through a window to prevent anyone entering the building except to renew the desiccant when the saturation point has been reached.

1803 PROCEDURES FOR SPECIFIC EQUIPMENT

1803.01 General

The procedures described in the ensuing paragraphs pertain to specific types of equipment. The actions suggested should be weighed in the light of the need for protection and the anticipated downtime. These recommendations should be used only as guides, and only after the condition of the equipment has been thoroughly investigated and there is an understanding of the costs involved.

1803.02 Mechanical Equipment

1803.021 COMPRESSORS: The protection afforded large compressors, because of their original cost, should be extensive and detailed. Machinery of this type is complex and dictates that a thorough inspection and a detailed programing of protective measures be undertaken. The problem of evaluating the effect of an environment upon a compressor which is to remain in an operating position must be considered. Obviously, removing a large gas-engine-driven compressor from a field installation would be difficult and expensive, yet there are conditions when removal is justified and recommended.

Special consideration must be given to compressors removed and stored in areas remote from field positions. A compressor which is not resting on a foundation must be supported the full length of its frame to prevent any possible sag or distortion. Support can be provided by a frame of welded structural-steel members.

It is important, and in keeping with the value of a compressor, to protect it from the weather, either in a building or by a tarpaulin or similar covering. The use of an enclosed building is the most satisfactory because of the need for safeguarding protective surface coatings and the compressor in general from the elements.

The following steps are recommended for protecting a gas-engine-driven compressor in place for a period of extended idleness. They can also, in general, be applied to steam-driven or gasoline-driven compressors.

a. Pumping End

1. Drain water from all cylinder jackets and, where used, from intercoolers and intercooler moisture separators. Drain outlets sometimes plug during draining; therefore, when the flow stops, the outlets should be probed to assure that all water has been drained.

2. Fill all lubricators completely full of oil to prevent rusting of the pumping parts.

3. Remove all piston-rod packing rings and oil wiper rings and clean in a suitable solution. Apply a coating of a satisfactory rust preventive and wrap in a waterproof paper or place in a plastic container. A rust preventive may be grease, oil with a high viscosity, or a proprietary material. If a proprietary material is to be used, the manufacturer should be consulted as to the one most suitable for the service. Tag and properly identify the rings to assure reassembly in their original position.

4. Remove the inlet and discharge valves from the compressor cylinders, clean, and apply a coating of a satisfactory rust preventive. Completely coat the valve bores and piston rods with a spray or other suitable means while the valves are removed.

5. Rotate the gas-driven engine and completely cover all surfaces of the compressor cylinder bores with a protective coating of lubricating oil or suitable rust preventive.

6. Replace all valves in their original position and tighten in place.

b. Power End

1. Drain the cooling water from the power end. Remove the cylinder head and wipe the cylinder bore clean. Apply a protective coating of lubricating oil or a suitable rust preventive to as much of the bore as possible. Remove the power valves from the cylinder head and completely cover the valve bores and seats with a similar protective coating. Reassemble the head. Protect valve springs by adjusting screws, etc., when the exposed outer surface of the compressor is covered.

2. Remove side cover plates (access openings to crankshaft, camshaft, etc.) and wipe dry all interior surfaces of the crankcase and moving parts. The interior of the crankcase may be washed down with kerosine or another solvent before drying. Rotate the engine by barring, when required, and be certain that the following engine parts are completely covered with a protective spray coating of lubricating oil or suitable rust preventive:

(a) Crosshead guides and pins.
(b) Connecting rods.
(c) Crankshaft.
(d) Camshaft.
(e) Main and connecting rod bearings (to the exten possible).
(f) Crankcase interior.

3. Replace all side covers and be certain they are dust tight. After all covers have been replaced and barrin of the engine is no longer required, clean the externa surfaces and apply a protective coating to this entir outer area.

4. Thoroughly check the entire frame and be certai that all holes which could admit dust and moisture ar plugged or blocked off by satisfactory means.

5. Remove the magnetos, clean them, and store in dry, warm storage area. Protect the magnetos while storage by enclosing them in a heavy paper carton similar container.

6. Clean and apply a protective coating to all small auxiliary equipment, relief valves, piping, filters, etc.

A periodic inspection should be made of compressors which are to remain idle for a considerable length of time. A recommended interval between inspections is three to four months. During the inspections, it is recommended that small surfaces on cylinder bores, crankshafts, bearing journals, piston rods, crossheads, etc., be wiped free of protective coatings to determine their condition. When protection appears to be satisfactory, the same care as originally used in the application of the protective coating must be used in covering the exposed surfaces. If the compressor is protected by cocooning, the inspection interval may be lengthened as experience dictates.

If there is any sign of rust or corrosion on any of the aforementioned parts, they should be wiped clean and dry and the protective coating reapplied.

A modification of the foregoing procedure can be used in protecting compressors when the anticipated idle time is of a short duration. In most climates or plant atmospheres, it is unwise to permit either the interior or exterior of a compressor to be unprotected for longer than four to six weeks. Should it appear that this time will be exceeded, the necessary steps must be taken to clean and cover the compressor with a protective covering. In all events, in those areas where freezing occurs the water should be drained from the compressor cylinder jackets and the cooling system in the power end of the compressor. Drain outlets sometimes plug during draining; therefore, when flow stops, the outlets should be probed to assure that all water has been drained.

1803.022 PUMPS: Centrifugal, reciprocating, and injection-type pumps, because of the simplicity of their mechanical construction, lend themselves to effective and rather inexpensive preservation. Exclusive of the driver, treatment of the pump as a unit is practical. No detailed disassembly of the pump is required even when preparing the pump for long periods of idleness. In those services where the medium being handled is considered corrosive, the protective measures taken for either a short period of idleness (three to four months) or an extended period are similar. The only exceptions are the manner and extent of cleaning the pump.

a. Centrifugal Pumps: The following is a recommended procedure for safeguarding vertically split centrifugal pumps:

1. Open all vents and drains in the pump casing and bearing housing. Flush the casing and housing with a satisfactory solvent or cleaning material.

2. Break all pipe connections and blind suction and discharge flanges if the pump is to be removed and placed in storage. When the pump is to be maintained in a field position, be certain that the suction and discharge valves are closed and blanked off.

3. When single mechanical seals are used:

(a) Loosen the seal gland.
(b) Inspect the seal to determine that the sealing faces are satisfactory for continued service.
(c) Pack the seal with a light grease.
(d) Tighten seal gland lightly.

4. Where double mechanical seals are used, drain the stuffing box and flush with a cleaning agent. Plug the lower stuffing-box drain and fill with a lightweight grease or oil.

5. Where conventional packing is used, loosen the packing gland and remove all packing. Coat the interior of the stuffing box with a light grease. Repack the pump with a nonmetallic packing and retighten the packing gland. Tag the pump to indicate that the service packing has been removed.

6. Plug bearing-housing drains and fill with oil. Close off all bearing-housing vents.

7. Close all drains and fill the entire pump casing with a light oil. Slowly rotate the pump shaft to assure complete coating of the inner surfaces. Permit the pump casing to remain filled with light oil for at least one hour. The light oil used should be one with a low viscosity and which will not evaporate rapidly.

8. If the pump is to be placed in storage, draw the oil from the pump casing and close off all openings. If the pump is to be left in the field position, it is common practice to leave the casing filled with oil; however, it may also be drained if desired.

9. When single mechanical seals are used, the lightly tightened seal will have permitted oil to flow into the stuffing box and cover the seal. The seal should be retightened to prevent leakage.

10. Wrap the exposed pump shaft with plastic tape. At the points where the shaft enters the pump casing and the bearing housing, carefully wrap to seal off the openings.

11. Cover all other exposed surfaces with either paint or some suitable rust-preventive material.

Horizontally split centrifugal pumps can be preserved in a manner similar to the aforementioned procedure with but minor modifications.

b. Reciprocating Pumps: Steam pumps of the various types (simplex, duplex, etc.) can be protected by the following procedure:

1. Open all vents and drains on both the liquid and steam ends of the pump.

2. Break all pipe connections; blind off the suction, discharge, and steam flanges; and close drains.

3. Remove the valve cover plate from the liquid end of the pump and the slide valve cover from the steam end.

4. Remove a valve from each end of each cylinder on the liquid end. Fill all cylinders with a suitable rust preventive [see Par. 1803.021*a*(3) for definition of rust preventive]. Fill the steam cylinders through the slide

valve opening on the steam end. Slowly bar each piston back and forth.

5. Apply a suitable rust preventive to all valves and valve covers. Drain excess rust preventive from cylinders and close all vents and drains.

6. Replace valves and valve covers.

7. Remove packing from the stuffing box and coat stuffing box and rods inside of box with a suitable preservative. Replace packing and tighten gland.

8. Wrap any exposed rods with plastic tape.

9. Spray or brush all external surfaces with a suitable rust preventive.

10. Fill all lubricators with oil.

c. Injection-Type Pumps: Injection or metering pumps can be preserved by using the aforementioned methods as guides. Procedures to cover the peculiarities can be devised. Special attention should be given to the gear system of the pump.

1803.023 TURBINES: The rugged simplicity in the design of this high-speed rotating driver makes protective action easy and effective. There is no need for extensive disassembly or special action. The following procedure is suggested for a steam-driven turbine of the horizontal type; a simple modification or extension of this procedure can make it suitable for other types of turbines:

1. Open all drains on turbine case and bearing housing.

2. Blank off the inlet and exhaust flanges.

3. Close turbine-case drains.

4. Fill the turbine case with a light oil. Open the governor valve when filling the case to permit flooding the valve.

5. Rotate the turbine wheel slowly to permit covering all parts. Permit the oil to remain in the case for 30 min.

6. Drain oil from the case and close all vents and drains.

7. Fill the bearing housing with a lightweight grease.

8. Close all vents and drains in bearing housing.

9. As an alternative to steps 7 and 8, seal the bearing housing along the shaft with a nonhardening, plastic-type material or packing. The bearing housing should then be filled to the top with light oil, either inhibited or uninhibited (see Par. 1802.031 for reference to inhibitors). A periodic check should be made of the oil level. This alternative protects the shaft, bearings, seals, and inner housing and eliminates disassembly at startup for the purpose of removing grease from the housing. At the time of startup, remove the plastic seal from the shaft, drain and flush the bearing housing, and fill the housing with lubricating oil to the proper level.

10. Remove the governor housing.

11. Pack the overspeed trip mechanism with a light grease.

12. Remove packing from the governor valve and fill the stuffing box with a light grease.

13. Spray all exposed moving parts in the housing with a suitable rust preventive [see Par. 1803.021*a*(3) for definition of rust preventive].

14. Replace the governor housing.

15. Wire-brush and clean all exterior surfaces and either paint or spray with a rust preventive.

16. Tape the exposed drive shaft with a plastic wrapping.

When the turbine is to be stored for an extended period in an area which is neither heated nor dry, cocooning of the entire turbine is recommended as an effective protective measure.

1803.03 Coolers and Exchangers

1803.031 COOLING TOWERS: The originally specified materials of construction of a cooling tower will dictate the protective measures which must be taken while the tower is idle.

Inasmuch as the environment is less severe while the tower is idle than while in service, the problem of programing the protective action is not too difficult. Generally, it is the mechanical equipment and construction hardware which require attention.

The following procedure is suggested for a mechanical-draft cooling tower with concrete basin and redwood construction:

1. Open and drain all exposed piping.

2. Drain all water from basin and flush the basin clean.

3. Block open basin drain valves.

4. Replace all unsatisfactory structural members. Replace warped and missing slats.

5. Tighten all fasteners in the tower framework.

6. Remove the fan drive motor and protect as described in the section on electrical equipment.

7. Remove the gear reducer as follows:

   (a) Drain oil from reducer and refill with a high-grade mineral oil.
   (b) Clean exterior surfaces of gear-reducer housing and paint.
   (c) Wrap all exposed shafts with plastic tape.
   (d) Store in a warm, dry area.

8. Wire-brush and chemically clean the fan.

9. Cover the fan drive gear with a light grease and a waterproof paper.

10. Paint or metalize the fan.

11. Secure the fan blades to prevent rotation and to provide support.

In areas where it is undesirable or unnecessary to remove the fan drive components, it is recommended that:

1. The fan be operated every three to four weeks.

2. Normal preventive maintenance be provided.

When the wood dries out, cooling towers become a fire hazard. During prolonged shutdowns, the wood should be given a thorough periodic wetting.

1803.032 HEAT EXCHANGERS: The protective action required for a tubular heat exchanger is comparatively simple. In fact, it is only a minor extension of the routine maintenance resulting from tube fouling and shell buildup. The same methods of chemical or mechanical cleaning are applied. The following is a suggested procedure for protecting floating-head tubular heat exchangers, whether they are to be stored or maintained in field positions:

1. Drain the shell and tube sides of the exchanger.
2. Remove the shell cover, floating-head cover, and clamp ring.
3. Clean thoroughly to remove all deposits.
4. With a spray or brush, coat all surfaces of the floating-head cover and clamp ring and the inside surfaces of the shell cover with a light oil.
5. Remove the channel and channel cover.
6. Clean thoroughly to remove all deposits.
7. Cover the inside surfaces of the channel and channel cover with light oil.
8. Remove the tube bundle.
9. Clean the tube bundle and channel, following normal maintenance procedures.
10. Spray the interior of the shell and all nozzles with a light oil.
11. Immerse the cleaned tube bundle in a light oil bath for 30 min.
12. Reassemble the heat exchanger.
13. Blank off all flanges. Plug all vents and drains.
14. Protect all exposed bolting by spraying with oil.
15. Paint all exterior surfaces.
16. For brief shutdowns encase the bolted flanges in a heavy waterproof paper; for lengthy shutdowns cocooning is more effective.

It is very important, in cleaning heat exchangers, to remove all ammonium salts which promote corrosion of brass and all chlorides and sulfides which promote cracking of stainless steel.

When the tube bundle is not to be replaced in the shell, or when protection is to be given to spare bundles, the following additional measures should be taken:

1. Bolt a wooden flange to both tube sheets.
2. Wrap the tube bundle with waterproof paper or cocoon.
3. Securely attach the tube bundle to a pallet by strapping.

1803.033 SPRAY COOLERS: The operating conditions for spray coolers are similar to those enumerated for cooling towers. Of course, the materials of construction are very different; the usual spray coolers are fabricated from structural-steel members, piping, and concrete. The following procedure can be used in preserving a spray cooler:

1. Close the water inlet valve to the water trough and blank.
2. Drain the water trough.
3. Blank the product inlet line.
4. Flush product lines and drain.
5. Blank off cooler product lines.
6. Wire-brush and prime cooler piping and water troughs.
7. Clean and paint structural-steel members.
8. Cover water troughs with a watertight metal cover.
9. Drain the concrete catch basin.
10. Block open basin drain valves.

1803.034 FINNED AIR COOLERS: The fan for a finned air cooler should be protected as described in Par. 1803.031 for a mechanical-draft cooling tower, items 6 through 11. The tubes should be opened, thoroughly cleaned, and closed. Steel tubes should have a light oil pumped through them, they should be drained and blanked at the outlet and inlet, and the exterior should be sprayed with a suitable rust preventive [see Par. 1803.021*a*(3) for definition of rust preventive].

1803.04 Storage Tanks and Pressure Vessels

1803.041 GENERAL: Corrosive attack in storage tanks and pressure vessels will usually appear in varying degrees throughout all parts. Atmospheric corrosion will occur on external surfaces. The seriousness of this attack will depend on humidity and temperature conditions. Because of the ease in detecting external corrosion, prompt and effective corrective measures may be taken.

In most instances internal corrosion is of an insidious nature. Frequently, it is not detected until failure has occurred or a thorough cleaning and inspection are made. Often, by the time the attack is recognized within a tank or vessel, the cost of repairing has become substantial.

The procedure practiced in preparing tanks and vessels for periods of idleness should be given special consideration.

1803.042 STORAGE TANKS: Before entering any tank, it is necessary to take certain precautions. The procedures used in making a tank safe for various types of work are discussed in Chapter V, *Safe Practices and Safety Inspection*. Briefly, the tank must be freed of gas and any residues which might generate gas.

When pyrophoric iron sulfide or residues of leaded gasoline are present, precautions should be taken, as also explained in Chapter V.

When a tank is certified to be free of gas, clear of gas-generating residues and toxic materials, isolated

from any source of toxic or gas-generating material, and has an atmosphere containing sufficient oxygen, inspection should be made and protective measures should be taken.

It is advisable to make a visual internal inspection through available openings of overhead parts and supports before entering a tank, in order to assure that there are no loose purlins, large patches of loose scale, weakened support columns or brackets, or any other object which might fall and cause personal injury. After the tank is certified safe for entry and work, all loose scale should be removed and any necessary repairs should be made. The walls should be dried thoroughly; if necessary, an eductor should be used to draw air through the tank.

The following procedure can be used for protecting almost any type of tank against deterioration:

1. Coat interior surfaces by spraying or brushing structural members with a light oil.
2. Close all manholes with gasketed covers.
3. Wire-brush, sandblast, or hammer-chip external surfaces for proper surface preparation and cover with a suitable paint.

If the tanks are located in areas subjected to windstorms of high velocity, consideration should be given to filling the vessel with an inhibited water. A tank filled with water will be strengthened materially against strong winds and will not be subject to floating.

As a general rule, tanks removed from service should be inspected at least annually.

1803.043 PRESSURE VESSELS: Safety precautions must be taken before entering a vessel. Because of the limited access and confined space in most vessels, safety precautions are probably more important in vessel inspection and repair work than with any other type of equipment.

In particular, the vessel should be blanked off from all sources of liquids, gases, or vapors. It should be drained, purged, and cleaned before entering. This will minimize the dangers caused by toxic gases, oxygen deficiency, explosive mixtures, and irritating chemicals. Clothing which will protect the body and eyes from the hazards existing in the vessel should be worn. Details of the precautions to be followed are covered in Chapter V.

Before inspection and protective measures are started on the interior of a pressure vessel, all persons working around the vessel should be informed that men will be working inside. Posting tags on the manways of tall towers is a worthwhile precaution. Frequently, a helper can be stationed as a guard at the manway nearest the area where work is being done and can record information or otherwise assist in the work. Men working inside a vessel should be informed when any work is to be done on the exterior. This will avoid needless fright caused by unexpected noises.

After the vessel is certified safe for entry and work, the interior should be inspected and any necessary repairs should be made.

The following procedure can be used for protecting almost any type of pressure vessel:

1. Cover all manholes with a gasketed cover.
2. Close all other openings tightly.
3. Pressure-test with an inert gas for leaks.
4. Close the inert-gas inlet and leave the vessel blanketed with inert gas.
5. Wire-brush, sandblast, or hammer-chip external surfaces for proper surface preparation and cover with a suitable paint.

Other methods of protecting the interior of vessels are:

1. Oil coating, described in Par. 1802.031.
2. Filling, described in Par. 1802.032.
3. Use of vapor-phase inhibitors, described in Par. 1802.033.
4. Use of desiccants, described in Par. 1802.035.

1803.05 Instruments

1803.051 GENERAL: An appreciable percentage of the capital investment of any installation is in the cost of its control equipment. The accuracy and magnitude of control of such equipment are dependent upon the maintenance and the protection provided therefor. Fortunately, the geometry and size of control instruments virtually eliminate the need for expensive or intricate protective procedures.

The treatment of both primary and secondary instruments is similar despite the differences of the environments they normally encounter. Primary instruments, widely dispersed in the proximity of the lines and vessels they meter, are subject to deleterious atmospheres and the elements. On the other hand, secondary instruments are frequently located in structural enclosures remote from field conditions. In all instances primary instruments are treated individually. Because of the grouping of secondary instruments, group treatment, such as is afforded some electrical equipment, frequently can be employed.

For prolonged shutdowns it may be advisable to remove all primary and other scattered instruments and store them in a dehumidified sealed room, as described in Par. 1802.052.

For purposes of illustrating the simple protective measures which can be taken in place when removal is not justified, the following procedure may be used for a flow meter of the differential pressure type using a pneumatic transmission system to transmit its readings to a receiver-recorder:

a. For the Flow Meter

1. Disconnect the lines from the orifice flanges to the differential pressure cell.

2. Plug the connections in the orifice flanges.

3. Fill both chambers of the meter body with a light oil.

4. Plug the chamber inlets.

5. Disconnect the air lines at the pneumatic transmitter housing.

6. Plug the air inlets.

7. Spray the interior of the pneumatic transmitter housing and all components with a light oil.

8. Spray or brush the external surfaces of the cell with a protective coating of oil.

9. Enclose the entire cell in a plastic bag and secure with plastic tape. An alternative procedure would be cocooning the cell after the protective measures specified in items 1 to 7 are taken.

b. For the Receiver-Recorder

1. Break all lines entering the receiver-recorder case.

2. Plug all vents and openings.

3. Cover all junctures of the sheet-metal case with plastic tape.

4. Insert a small jar of silica gel or other chemical drying agent.

5. Seal the door with plastic tape.

6. Spray the outside of the case with a light oil.

As alternative measures consideration can be given to:

1. Heating the interior of the case with an electric light to prevent moisture from forming.

2. Purging the interior of the case by maintaining a positive internal pressure with instrument air.

3. Cocooning the entire unit.

When secondary instruments are grouped and enclosed in weatherproof structures, protection as recommended in the section on electrical equipment can be applied.

1803.06 Pipe, Valves, and Fittings

Pipe and valves typify that class of equipment which is best protected in periods of either operation or idleness by an original wise selection of materials, coverings, and method of installation. Frequently the location of lines makes protective procedures uneconomical, if not impossible. Inasmuch as numerous lines are insulated or wrapped with plastic tape to prevent external corrosion, it is impossible to inspect them.

Unless the location of pipe 2 in. and less is convenient for servicing, little effort or expense should be given to protecting it during periods of extended idleness. The following procedure is suggested for larger lines:

1. Flush lines clean.

2. Break flanges and open valves at low points to permit complete draining.

3. Dry lines or circulate an inhibited or uninhibited oil through them (see Par. 1802.031 for reference to inhibitors).

4. Inspect insulated and wrapped lines, uncovering pipe where leaks are suspected.

5. Repair all damaged insulation and wrapping. Bare pipe should be wire-brushed and painted.

6. Lubricate all valves.

7. Spray all external surfaces of the valves with a medium-weight oil and cover handwheels and exposed valve stems with grease.

8. Tighten all pipeline connections.

9. Operate valves and relubricate every three months.

1803.07 Electrical Equipment

1803.071 GENERAL: The preservation of electrical equipment is, in general, related to the mechanical aspect of the design of electrical equipment. Failure or deterioration will most likely be a matter of attack upon moving parts, fasteners, suspensions or supporting members, hardware, etc. The cleaning and protective action taken will be similar to methods used in protecting strictly mechanical devices and vessels. Unit treatment of the equipment, instead of disassembly and detailed treatment, will be the rule except in the case of electric motors.

The very nature of the installation of electrical equipment dictates that, whenever possible, equipment (other than spares) be protected in the field. Removal and storage in areas remote from operating positions would, in the case of most equipment, be expensive.

1803.072 MOTORS: Electric motors, because of their proximity to rotating and material transfer equipment, are frequently subjected to environments and conditions which are detrimental to the motor life. In most installations they are in constant contact with acid vapors, water vapors, harmful dusts, and the elements. Designers of electric motors have taken these factors into consideration, but because of the number and severity of services, it is impossible to design for all conditions.

The following procedure is recommended for motors to be removed from field positions and placed in storage:

1. Wire-brush and, with a suitable solvent, clean all exterior surfaces of the motor. Where the motor has been in a particularly difficult service and the outer surfaces have a hard residue covering them, it is frequently necessary to sandblast the motor. If sandblasting is required, protect the shaft before sandblasting by wrapping with a plastic tape or other satisfactory covering. In open motors, protect the windings against sand. With totally enclosed motors, plug or cover openings to air passages.

2. Disassemble the motor.

3. Steam-clean all parts except those containing windings, using a cleaning agent with the steam. Use suitable

solvents, such as trichloroethylene, carbon tetrachloride, etc., to clean windings.

4. Blow out all water possible.

5. Place the disassembled motor in a drying oven and bake dry.

6. Test the motor for shorts by "megging." Repair if necessary.

7. Apply a coating of air-drying insulating varnish to the motor windings.

8. Check the bearings and, if necessary, replace. Pack bearings with a satisfactory bearing grease.

9. Assemble the motor.

10. Wrap the motor shaft with plastic tape and cover the terminal leads with a sheet-metal box.

11. Paint and store in a warm, dry area.

Motors to be shielded in a field position can be protected by the following procedure:

1. Drain oil from the bearing housing if it is oil-lubricated.

2. Remove the outboard end bell.

3. Install a strip heater inside the motor near the windings, of sufficient size to maintain the temperature a few degrees above the ambient temperature and to keep the motor dry.

4. Replace the outboard end bell.

5. Completely fill the bearing housing with grease.

6. Seal off the opening where the shaft enters the bearing housing by wrapping with plastic tape. Continue the wrapping to completely cover the exposed shaft.

7. Plug all vents and openings.

8. Clean exterior surfaces by wire-brushing and paint.

9. Tie in power to strip heaters.

When electric motors are to remain in the field and continue to exist in corrosive and harmful environments, or when power is not available for operating strip heaters, consideration should be given to cocooning or providing some other protective unit housing.

1803.073 TRANSFORMERS: The average power transformer requires only a minimum of preservation during periods of idleness. By the very nature of its design and construction it is comparatively immune to deterioration. The need for protection is generally centered on the external surfaces and power tie-ins. The following procedure should apply whether a transformer is to be idle for several months or for an extended period:

1. Clean all power bushings with the use of a solvent and a wire brush.

2. Cover the metal portion of the bushing with a light grease.

3. Encase the entire bushing in a plastic bag or heavily wrap with a plastic tape or waterproof paper.

4. Clean the outer surface of the oil conservator tank when used, and inspect for leaks.

5. Install a small air dehumidifier in the breather o ventilator.

6. Check all valves and drains to assure that they ar closed and that there is no leak.

7. Clean all external surfaces and cover with a suitable paint. If the transformer is an uninstalled spare and it appears that idle time will be long, cocooning should be considered.

1803.074 SWITCHGEAR: Large switchgear is usually enclosed in sheet-metal cabinets which provide protection to electrical apparatus from the elements. In many installations, a secondary enclosure is located within the external or primary enclosure and further protects the necessary instruments and control and protective devices. This combination of enclosures is sufficient to provide most of the protection needed. To supplement the protection afforded in the normal design, it is necessary only to install strip heaters within the primary enclosure to maintain a dry atmosphere and clean and paint the external surfaces. If power is not available for strip heaters, a desiccant may be used.

Small switchgear, relays, push buttons, circuit breakers, etc., can be protected by enclosing them in plastic bags or by cocooning, when economical. Frequently normal maintenance procedures of cleaning, painting, and periodic inspection will suffice. This latter procedure can be augmented to include the installation of small quantities of chemical drying agents in the various enclosures.

In plants where much of the electrical control equipment is housed in enclosed structures, the most effective method of protecting the equipment is by controlling the atmosphere within the enclosure to assure that corrosive vapors are nonexistent. One effective and inexpensive method is the use of a commercial air-cooling and dehumidifying unit. Such an installation requires only a minor capital investment, and the effectiveness and reliability are excellent. A second method considered frequently employs the use of a ventilating fan installed in such a manner as to provide a slight positive pressure within the enclosure. The fan air intake should be provided with a dehumidifier and filter. The slight pressure will exclude outside air and will safeguard the equipment without further action.

1803.075 POWER LINES: The preservation of overhead power lines is a difficult and time-consuming process because of the inaccessibility and number of parts involved. Frequently, an inspection or maintenance of a line or section thereof requires scaffolding or special equipment. Power lines which fall in that category of equipment can be best protected at all times by a wise and advantageous selection of materials during the initial design.

Once a power line has been erected, there is little, if

any, protection which can be given the cable proper. Protective measures will usually center on pole hardware, guying materials, grounding equipment, wire holders and brackets, and strain and suspension members.

It is impossible to program a detailed procedure to be followed in protecting auxiliary equipment used in power-line construction. However, an inspection of any power line will reveal that unit treatment of auxiliary equipment is an outgrowth of equipment dispersion.

Pole-line hardware, guying materials, or strain and suspension material may be protected by the following method:

1. Clean by wire-brushing and hammer-chipping.
2. Inspect and determine the suitability of the materials used.
3. Replace with suitable materials items which need replacement.
4. Paint or metalize by flame spraying.

Metallically sheathed underground power lines should be inspected and protected from detrimental influences. Cathodic protection, if afforded, should remain in effect when the line is out of service.

1803.08 Fired Heaters and Stacks

1803.081 GENERAL: The descriptions given in Chapter IX, *Fired Heaters and Stacks,* break down the various types of such equipment. The intent of these suggested protective measures is to cover only those portions of this equipment which are subject to deteriorating effects while the equipment is idle. In general, this is the external steel and auxiliary equipment of the heaters.

No attempt is made to offer a means of protection for masonry, concrete, linings, and insulation inasmuch as it is common practice to inspect these items and make necessary repairs before the unit is returned to service. Should defects be noted while the equipment is idle which would tend to weaken the structure, repairs should be made immediately.

1803.082 FURNACE SETTINGS

a. Header Boxes and Casing: All painted metal should be treated in the same manner as structural steel. Hinges on header doors, peepholes, and access doors should be coated thoroughly with a heavy grease to permit immediate functioning when the unit is returned to service. In those openings where seating surfaces could corrode because of leakage of rain or moisture, it is advisable to seal the doors with a readily removable mastic or waterproofing compound such as is used in sealing joints in insulation.

b. Burners: Treatment of this equipment is dependent upon the type of burner used, and some will require more care than others. The movable parts should be covered with heavy grease to protect threads or adjusting mechanisms.

c. Breeching and Ducts: If the external surfaces of this equipment are protected by heat-resistant paint, all areas which show failure should be retouched as indicated from periodic inspections. When the breeching and ducts are not painted, all external surfaces should be cleaned of loose material and sprayed or brushed with a commercial rust preventive. It may be necessary to repeat this procedure during the idle period; however, application is much less expensive than in the case of paint, and the rust preventive will burn off readily when heat is applied again.

Internal surfaces, if not insulated, should be cleaned of any deposits or condensation. Rechecks should be made to insure no absorption of moisture during the idle period.

Operating mechanisms on the dampers should be coated with heavy grease to insure operability when returned to service.

d. Instruments: Care of instruments, such as draft gages, carbon dioxide indicators, fuel control valves, and flame monitors, will depend upon the service and complexity of the mechanism. An instrument such as a draft gage could be disconnected and completely enveloped in a plastic bag, whereas more complex instruments should receive treatment as suggested in the instrument section of this chapter.

Particular care should be given automatic fuel shutoff valves. This can be accomplished by removing the cover and spraying all parts with light oil, replacing the cover, and either sealing or cocooning. The inspection plate on the lower portion of the body should be sealed also.

e. Tubes: All tubes should be thoroughly cleaned inside, and the headers should be closed. All accessible tubes should be thoroughly cleaned on the outside.

1803.083 STACKS

a. Steel Stacks: Should external inspection reveal paint failures, it is advisable to touch up and maintain the paint on a regular schedule. Those areas, such as seams, cooling fins, or attachment lugs, which are more susceptible to holding condensation, should be painted even if an entire paint job is unnecessary. The stacks should be capped.

b. Attachments: It is good practice to replace guy lines at intervals established by experience; however, it is possible to combat corrosion by coating accessible guy lines with a nonhardening mastic.

Ladders on any type of stack fall in the category of a "must" maintenance item and should be painted at periodic intervals to insure adequate protection.

The painters' trolley is removed between periods of use; therefore, it should be maintained in the same manner as any piece of rigging equipment.

1803.09 Steam Boilers

Par. C7.301, C7.302, and C7.303 of *Care of Power Boilers,* Section VII of the *ASME Boiler and Pressure Vessel Code,* cover the "Laying-up of Boilers" and should be followed when steam boilers are to remain idle.

1803.10 Structural Steel

All exposed structural-steel members, such as columns, beams, supporting structures, stairways, walkways, and platforms, will be subject to atmospheric attack. Although in most cases this attack will not be serious, the necessary protection should be given. Because this equipment will not be under regular scrutiny, it is suggested that touchup painting be applied immediately upon shutdown and that a routine visual inspection be made for paint deterioration at intervals governed by the severity of the corrosion in that area. Where paint programs are set up which require one-coat applications at periodic intervals, it is considered economically feasible to continue such practice on idle equipment rather than to allow a breakdown of the system and, consequently, require application of a complete paint job including surface preparation.