

SUPERSEDED

Guide for Inspection of Refinery Equipment



Chapter V—Preparation of Equipment for Safe Entry and Work

THIRD EDITION, DECEMBER 1978

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American Petroleum Institute
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Refining Department

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PREFACE

This chapter is one of a series that 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 Refining Department, American Petroleum Institute, 2101 L Street, Northwest, Washington, D.C. 20037.

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 good judgment.

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

Chapter I	Introduction
Chapter II	Conditions Causing Deterioration or Failures
Chapter III	General Preliminary and Preparatory Work
Chapter IV	Inspection Tools
Chapter V	Preparation of Equipment for Safe Entry and Work
Chapter VI	Pressure Vessels (Towers, Drums, and Reactors)
Chapter VII	Heat Exchangers, Condensers, and Cooler Boxes
Chapter VIII	Direct-Fired Boilers and Auxiliary Equipment
Chapter IX	Fired Heaters and Stacks
Chapter X	Pumps, Compressors, and Blowers, and Their Drivers
Chapter XI	Pipe, Valves, and Fittings
Chapter XII	Foundations, Structures, and Buildings
Chapter XIII	Atmospheric and Low-Pressure Storage Tanks
Chapter XIV	Electrical Systems
Chapter XV	Instruments and Control Equipment
Chapter XVI	Pressure-Relieving Devices
Chapter XVII	Auxiliary and Miscellaneous Equipment
Chapter XVIII	Protection of Idle Equipment
Chapter XIX	Inspection for Accident Prevention
Chapter XX	Inspection for Fire Protection
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CHAPTER V

PREPARATION OF EQUIPMENT FOR SAFE ENTRY AND WORK

5.1 Scope

This chapter discusses the necessary preparatory work, inspections, and tests that should be made to ensure that equipment has been properly made safe for opening, entry, and work. The necessity for thorough removal of harmful liquids, sediments, and deposits; for freeing the equipment of flammable, inert, or toxic gases; and for preventing re-entry of such gases is emphasized. The types of inspections and tests that should be made to ensure the safety of personnel and to minimize the probability of fires and explosions are also covered.

Because of the wide scope of health and fire problems encountered in the preparation and inspection of enclosed spaces to make them safe to work in and because procedures vary greatly with the types of equipment and facilities available, it is not possible to recommend detailed procedures. Therefore, this chapter is limited to general principles. Chapter XIX, "Inspection for Accident Prevention," contains more details concerning inspections and tests required to safeguard personnel and to maintain testing equipment. Chapter XX, "Inspection for Fire Protection," covers similar information for the prevention of fires and explosions. The aforementioned chapters also suggest various types of written permits for different classes of work that may be conducted.

The term "inspector" is used throughout this chapter as a general term. It applies to any person qualified and authorized to make the various inspections and tests required to permit safe entry into equipment. An inspector making any inspections or tests mentioned in this chapter also should be familiar with the contents of Chapters XIX and XX.

5.2 General

Preparatory work usually involves storage tanks, spheres, process vessels, and other equipment that must be entered. In principle, this chapter also applies to furnace fireboxes, ducts, flues, large sewers, electrical vaults, deep sumps, pits, excavations, or any enclosed or confined area from which ready escape of workers may be difficult or in which flammable, inert, or toxic materials may be present.

The following factors should usually be considered:

1. Condition of the atmosphere for safe breathing;

2. Prevention of fires or explosions;
3. Provision for ready entry and exit;
4. Avoidance of contact with toxic and hot or cold substances that would be harmful to personnel;
5. Assurance of safe supports and footing for personnel and protection from falling material;
6. Assurance of safe working temperatures;
7. Awareness of electrical, radiological, oxygen content, or other special fire and safety problems; and
8. Assurance that ear protection is provided if noise is a problem.

5.3 Preparation for Inspection

Anyone who initiates or requests a permit from an inspector should know the safety precautions that will be required before the permit can be completed and issued. He should have completed as much of the preparatory work as possible prior to requesting a job check for the permit.

In all cases where personnel must enter equipment that has been connected to and is in operation with other equipment, the following tasks must have been completed:

1. Removal of excess liquid hydrocarbons, water or other materials. This task might require steaming or water-washing.
2. Isolation by blinding or disconnecting lines at points as near to the equipment as possible and isolation of power-driven items connected to equipment to be entered. The latter might involve tagging and locking-out the electrical power supply or blinding or disconnecting lines of units powered by air, steam, or hydraulic fluid.
3. Removal of vapors by ventilating and cooling.
4. Removal of radioactive process instrumentation if it causes a radiological hazard.
5. Specification of the proper protective equipment needed to perform the job.

A job should be scheduled so that other work to be conducted simultaneously within the area will not create additional safety problems. An operating supervisor of the

facility, insofar as possible, should have completed preparations for safe entry and for subsequent maintenance. A maintenance or craft supervisor should anticipate special requirements regarding the safety of his men. He should have completed necessary preparatory steps beforehand, and all necessary tools and equipment should be available. A supervisor should not rely upon an inspector to prescribe the necessary precautions and then comply only with the minimum requirements. **SAFETY PROCEDURES MUST BE CONSIDERED AS AN INTEGRAL PART OF THE WORK.**

By cooperative teamwork and proper preplanning, each job may be done safely and efficiently with minimum cost and effort. Preplanning involves joint consultation of all parties involved well in advance of commencing the job. As a rule, this procedure avoids last-minute and time-consuming changes.

When early preplanning is done, an inspector can independently check the area well in advance of the job and schedule his final checking so as not to prevent others from starting the main work. However, shortly before the permit is issued, the persons responsible for the job must make a final check in the field to be assured that the job can be done safely, that no factors have been overlooked, and that no conditions have changed.

5.4 General Precautions

The inspector should be familiar with Chapters XIX and XX and should consider the factors outlined in 5.4.1 through 5.4.5 when checking the job.

5.4.1 KNOWLEDGE OF WORK

An inspector should know the work to be done, how the job is to be conducted, and what potential safety problems may be encountered. He should feel free to ask others for information when in doubt, should picture in his mind all of the known facets of the job, and be certain that no conditions have been overlooked that may introduce a hazard.

5.4.2 VENTILATION AND GAS TESTING

Ventilation must be sufficient to ensure that workers will not be exposed to unsafe concentrations of flammable or toxic vapors or gases or to deficiencies in oxygen supply. This is especially applicable to vessels containing catalyst beds. Correct use of proper respiratory equipment will protect against toxic concentrations of vapors or gases and oxygen deficiencies. An inspector must make the necessary gas tests to determine whether a vessel's atmosphere is safe for breathing. He may wish to check the method of gas-freeing to determine whether the job was performed properly. If inert gas was used for purging, he

must know the gas used. New vessels, sometimes, are filled with an inert gas prior to shipment to prevent corrosion. This procedure, if used, creates an oxygen deficiency. This possibility must be considered when inspecting new equipment.

Gas tests must be made by using the appropriate approved combustible, toxic gas and oxygen analyzer. It is frequently necessary to conduct more than one type of test. An atmosphere that tests safe for combustible content may be unsafe in hydrogen sulfide or some other contaminant. In order to determine the required tests, knowledge of materials contained in the vessel or equipment to be tested is necessary. An inspector should be proficient in the use of testing apparatus, including interpretation of test results. (API RP 2015, *Cleaning Petroleum Storage Tanks*, describes combustible-gas indicators and the testing of motor fuel tanks that contain, or may be suspected of containing, lead antiknock sludge compounds. The toxicity of this compound is such that special precautions are required.)

An inspector should be sufficiently acquainted with the potential problems of the job to know where to sample the atmosphere for testing and how frequently to conduct check tests in case any change in the composition of the atmosphere occurs during the progress of the job. An inspector should recognize that some gases or vapors are both toxic and flammable, and he should test accordingly.

Some substances, such as nickel carbonyl and cobalt hydrocarbonyl, have extremely low threshold limits. Danger from such substances could not be detected by an ordinary toxic gas test. A knowledge of the conditions necessary for the formation of these extremely hazardous materials must be used to assess the potential danger and to apply appropriate test procedures.

An inspector should be alert to the possibility of release of any flammable or toxic vapors from sludge, scale, pockets, or recesses in some of the internal structures.

To protect personnel from possible toxic gas concentrations, it is considered good practice to install an air mover on an open top manway or nozzle before opening lower manways.

5.4.3 SAFE ENTRY AND EXIT

Provision should be made for ready entry and exit. Internal scaffolding, staging, and rigging should be erected so as not to hamper employee entrance or exit or rescue work in the case of an emergency. The location of wood or other combustible scaffolding subject to possible ignition should be given special attention with respect to escapeways.

When employees enter a vessel or tank through a manhole, proper exterior platforms may be needed to readily aid movement in and out of the opening. Where

practicable, entrance should be made through side openings or manholes at or near ground level.

In the event the work may involve a door, gate, or other closure that opens inward and serves as an escape-way, the door or gate should be removed or securely fastened in an open position.

Some jobs may require two means of escape when the lack of a second means would prevent escape in case of a fire or other emergency.

5.4.4 SPECIAL SAFETY CONSIDERATIONS

5.4.4.1 Safety Belts

Under certain conditions each employee working inside a confined space should be fitted with an approved safety belt equipped with a lifeline. If entry is made through a top opening, the belt should be of the harness type that suspends a person in an upright position. One end of the lifeline should be securely attached to the harness and the other end outside of the entry opening. At least one worker should remain outside near the opening to render assistance. In some jurisdictions, legislation requires that safety belts be worn under certain conditions. Personnel should be aware of such rules and wear appropriate protection.

5.4.4.2 Respiratory Equipment

In any situation where it is impossible to ventilate a unit adequately and reduce its vapor content to below 4.0 percent of the lower flammable limits, fresh air breathing apparatus must be used and special procedures regarding its use must be followed strictly. If the hydrocarbon concentration is 20 percent of the lower explosive limit, the equipment should be entered only under extreme emergency conditions even when breathing apparatus is used. Respiratory equipment is discussed in detail in API RP 2015. Also see API PSD 2211, *Precautions While Working in Reactors Having an Inert Atmosphere*.

In some special cases, such as when one or more workmen must wear respiratory equipment to work in a confined space, it may be advisable to have two other men, also wearing respiratory equipment, in attendance. One of the latter two men should be stationed inside the confined space with the workers and the other stationed outside near the entrance. It is advisable that the outside man have a means of warning others (a klaxon, for example) in the event of emergency. The signal system and emergency measures should be thoroughly understood and adhered to.

In some situations short work periods should be arranged for workers to avoid fatigue or other harmful effects.

5.4.4.3 Scaffolding, Staging, and Rigging

Where scaffolding, staging, and rigging are provided in vessels, fireboxes, or similar enclosed spaces the inspector should be alert to safety factors involving:

1. Proper design for maximum expected load with adequate bracing and good accessibility.
2. Floor planks with surfaces that provide satisfactory traction for workmen and that are securely held in position. Guard rails and toe boards should be provided where required.
3. Allowance for movement of heavy materials with minimum risk of falling objects, unbalanced loading, or damage of wooden structures by impact.
4. Risk of ignition of combustibles when welding and cutting.
5. Restriction of escapeways or passageways by temporary storage of equipment on platforms or at passageways and ladder footings.

5.4.4.4 Work in Fired Heaters

Local refinery safety rules usually specify the maximum temperature permitted within a firebox in which men are working. The maximum temperature may vary with exposure and the physical effort to be expended. A firebox must be ventilated and cooled to this temperature and snuffing steam, fuel oil, and gas lines blinded or disconnected before workers are permitted to enter. On coal fired furnaces, coal feeders and ash removal mechanisms should be decommissioned before fireboxes are entered.

Inspection can occur at two different times: initial inspection for safe entry of materials inspectors to determine the nature and amount of work to be done; and, later inspection for safe entry of craftsmen to perform the actual work. Inspectors must consider the physical fitness of the craftsmen who usually work at temperatures somewhat below that for inspection only. The degree to which working temperatures are lowered depends upon the humidity of the air.

Inspectors should ensure that fuel and steam lines to the burners and steam lines to the firebox are either disconnected or blinded. Sometimes flue-gas ducts from one furnace are manifolded to those from another furnace and lead to a common stack. When all furnaces to a common stack are down, the danger of an emergency fire or poisonous flue gas in one heater affecting the safety of men working in another may be neglected. If an adjacent operating heater has a flue-gas duct common to that of the heater to be entered, there must be a safe and positive method of blocking off the in-service portion before entry is permitted.

Before men are permitted to enter a furnace, an inspector should check the condition of the inside walls with regard to their security against the collapse or falling of loose brickwork or tube hangers. Goggles may be required to protect eyes from acidic dust. Special wooden-sole shoes may be required or protective planks may be placed on the firebox floor. Safe and adequate portable lighting should be supplied.

Inasmuch as an inspector is likely to be the first person to enter a firebox to check the air temperature and security of the walls, a workman should be posted at the entrance to the firebox to observe the inspector's safety.

5.4.5 PERSONAL PROTECTIVE EQUIPMENT

In addition to approved respiratory equipment, safety belts, and lifelines, other safety equipment may be needed on certain jobs. A lifeline or security line should be considered in addition to the main lifting or lowering line for personnel and equipment.

Special clothing may be required to avoid skin contact with oils, corrosives, and hot surfaces. Clothing that is wetted by contact with such materials should be removed promptly; clothing that is wetted by oil may ignite if hot work is in progress. Clothing to be worn while cleaning leaded gasoline storage tanks is described in API RP 2015.

A refinery worker should not work with a bare head, bare hands, bare arms, or exposed body if there is a potential risk of burns or other similar consequences. Safety hats are recommended for all workers.

Water showers or submersion vats may be needed on some jobs where corrosive chemicals are handled. Portable safety showers may be used.

In dusty or windy locations, lightweight protective goggles or face shields should be worn.

5.5 Hydrocarbon Vapor Problems

5.5.1 TESTING FOR HYDROCARBON VAPOR

In planning entry into oil tanks and process vessels, particular consideration of the petroleum vapor, toxic gas, and oxygen sufficiency is of prime importance. The atmosphere must be safe to breathe or approved respiratory equipment must be used. The area should be checked for potential fire hazards.

The only safe method to test for hydrocarbon vapor is the use of a suitable combustible-gas indicator. An inspector must be proficient in the operation of the instrument and be able to interpret the results correctly. When calibrating the instrument, the manufacturer's recommended procedures should be followed. Atmospheres that are hot, wet with steam, or that contain inert gas cannot be tested reliably.

To evaluate intelligently the many problems with which he is faced in approving jobs for safe work, an inspector should have a working knowledge of the toxicity and fire hazard potential of different concentrations of petroleum vapor in air.

5.5.2 HEALTH EFFECTS

Various safety codes and standards, including regulatory governmental standards, list threshold limit values (TLV) which refer to concentrations of vapors to which nearly all workers may be exposed without adverse effect. Where mixed aromatic hydrocarbons are present as in gasoline, the safe permissible limit for (8 hours of) the exposure period may be very low if benzene is present. Compliance with current standards should be ensured. Other aromatics commonly present in gasoline are toluene and xylene which are considerably less toxic than benzene. When the presence of benzene or other aromatics is known or suspected, test procedures of appropriate sensitivity and selectivity should be applied.

When multiple hydrocarbon vapors are present, the combined effect of the various hydrocarbon vapors rather than that of an individual component should be considered. Normally the effects of different components should be considered as additive.

Sometimes the TLV may be exceeded for short periods of unprotected exposure without risk of injury to health. However, many factors must be considered; in addition, expert guidance by medical or industrial hygiene personnel may be required. Refer to API 2015-1976, *Cleaning Petroleum Storage Tanks*, Paragraph 2.2.3.

When high concentrations of petroleum vapors such as gasoline are breathed, symptoms of intoxication may result, ranging from simple dizziness to excitement and possible unconsciousness similar to those produced by alcohol or anesthetic gases. An inspector should be able to recognize these symptoms and know that persons who are exposed to high-concentration vapors, even for short periods of time, may lose normal judgment and may not remove themselves from a contaminated area.

If oxygen content is below the normal 21 percent, it must be determined what other materials are present. The presence of hydrogen, hydrogen sulfide, hydrogen cyanide, sulfur dioxide, carbon monoxide, carbon dioxide, and other vapors must be determined as dangerous concentrations can be present. These vapors are discussed in 5.6.5.

It is not always possible to make an area totally gas-free before work can be permitted therein. Small amounts of vapor can be released from scale or sludge while work is underway. Adequate ventilation must be provided during work so that the vapors will be diluted by the airstream and a dangerous concentration will not develop.

5.5.3 FIRE PROBLEMS

5.5.3.1 General

To avoid duplication of basic instructions on this subject, reference is made to Section I, "Ignition and Combustion," of API RP 2001, *Fire Protection in Refineries*. This section provides valuable information on characteristics of hydrocarbons such as flammable limits, vapor pressures, and flash points.

5.5.3.2 Gas-Freeing

When a tank, vessel, or other enclosed space is prepared for hot work, it is necessary to purge flammable vapors and to remove flammable or combustible liquids that may be present. With regard to petroleum vapors such as those of gasoline, a vapor content reduced to below approximately 1 percent vapor in 99 percent air theoretically gives a mixture too lean to burn. From a health-effect standpoint, however, this 1 percent is equivalent to 10,000 parts per million (ppm)—much higher than can be tolerated for safe breathing even for a short period.

In practice, in order to secure an adequate factor of safety, the atmosphere must contain much less than 1 percent vapor. A vapor content known to be uniform at approximately 14 to 20 percent of the lower flammable limits may be considered safe from fire or explosion. If a combustible gas tester indicates presence of hydrocarbon vapor below the fire or explosion hazard level, respiratory protection is required for entry until other exposure standards concerning breathing hazards are satisfied.

If an inspector cannot be certain that the sample tested contains the maximum vapor content in the area being checked, or if a possibility exists that the vapor concentration may increase, he may choose one of two alternatives to be sure that the atmosphere is safe. He may recommend to—

1. Continue washing and ventilation until the atmosphere tests vapor-free and continues to test vapor-free; or
2. Ventilate the area during the progress of the work so that any vapors released will be quickly and adequately diluted by the airstream to keep vapor content at a safe, low concentration.

5.5.3.3 Protecting the Working Area

It is most important that an inspector thoroughly check the working area to be certain that steam, toxic material, flammable gas, vapors, or oil cannot enter the area from unsuspected sources during the progress of the work. Other equipment or piping that has contained hydrocarbon should not be opened during welding or burning in the immediate area. To ensure a safe condition, certain precautions can be taken.

Blind or disconnect all oil, gas, and steam piping that is connected to the container within which work is to be done. Blinds must be of proper rating and identifiable as such to withstand the maximum pressure that may be encountered. Blinding should be done as close to the container as possible to eliminate pockets or dead ends that may entrap toxic, flammable, or combustible liquids or gases. When close slip blinding cannot be done, it may be advisable to fill the dead ends with water or to test them individually.

Sometimes a group of interconnected vessels can be isolated and all made gas-free as a unit to avoid blinding between each one. When this procedure is followed, precautions must be taken to ensure that no possibility exists for accidental entry of harmful material into the system in conjunction with any work performed on associated piping, vessels, mechanical equipment, and the like.

Sewer catch basins should be covered and vents checked so that a flash fire will not occur and spread into the sewer system, even though the catch basins may be sealed. If lines that enter catch basins are disconnected, they should be sealed either by the basin water or by blinding.

Scale, coke, or deposits that may retain oil which will release gas or vapors should be cleaned out or covered with water (see API RP 2015).

Pockets, recesses, and spaces between double walls, under perforated bottoms, within double bulkheads, and within pipe roof supports and internal fittings such as swing lines can retain oil. These dead ends may not wash out or purge as expected. An inspector must check to be certain that these locations have not been overlooked. He can review structural drawings to better understand a unit's internal structure and not have to depend entirely upon on-the-spot visual inspection.

The inspector should know whether the equipment has been repaired or altered in a manner that may affect the safety of the job. Tanks with double bottoms or vessels with liners can pocket oil which may not be noticed in a casual inspection.

If work is to be done in a vessel or tank that is adjacent to operating equipment, proper safeguards must be set up to ensure safety of the workers in case of an emergency in the area. Consideration should be given to the following measures:

1. Provide proper escapeways in order to prevent entrapment of the men.
2. Establish an adequate warning system to alert personnel to any emergency situation that might arise and to signal their evacuation from vessels and other confined spaces.
3. Avoid drawing vapors or gas into a vessel or tank in which work is being done.

4. Avoid contamination of the air intake to blowers, or avoid shutting off the prime mover (manual or power operated) when fresh-air blowers are used.

5.5.3.4 Exterior Work on Vessels Containing Flammable or Toxic Material

Work on the exterior of vessels that contain oil vapors and liquids presents a wide variety of problems for an inspector. The evaluation of such potential hazards requires an inspector to use sound judgment based upon the following criteria:

1. An understanding of the fundamental flammable characteristics of oils, gases, and vapors.
2. The probability of ignition, depending upon the work being done.
3. The possibility of the presence of a flammable vapor mixture in the working area.
4. Adequate knowledge of the work to be performed to be certain that all factors have been considered, that proper safeguards have been established, and that there will be no unsuspected change in the situation which may alter working conditions.

Exterior work may include sandblasting on tanks, welding on the shell of the tank below the liquid level, or hot tapping (see API Publication 2201, *Procedures for Welding or Hot Tapping on Equipment Containing Flammables*). These operations may be done safely if the proper safeguards are established.

5.5.3.5 Necessity for Positive Knowledge of Fire-Protection Factors

Some jobs require specialized knowledge of fire-protection factors not commonly known or about which considerable misinformation is prevalent. An inspector should not be content to rely upon a casual knowledge of these subjects but should study authoritative literature. For example, API RP 2003, *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents* should be consulted for static electricity problems. For additional information, refer to API RP 500A, *Recommended Practice for Classification of Areas for Electrical Installations in Petroleum Refineries* and API RP 540, *Recommended Practice for Electrical Installations in Petroleum Processing Plants*.

5.6 Other Harmful Materials

5.6.1 GENERAL

Usually the presence of materials other than hydrocarbon liquid and vapors is known before inspection is

started. For example, oil storage tanks may contain hydrogen sulfide or pyrophoric iron sulfide. Water bottoms may contain caustic soda or other corrosive or irritating treating agents.

In the normal emptying, flushing, and ventilating of the tank most of these materials are removed. An inspector should be alert to the adequacy of their removal and be prepared to conduct the proper tests to ensure safety.

5.6.2 HYDROGEN SULFIDE

When hydrogen sulfide is involved, the inspection for entry may be preceded by inspection of the purging method to be certain that the ventilated hydrogen sulfide is disposed of safely. The planning and inspection of the preparatory work is usually done by the line supervisor. An inspector is not called upon to make his inspection and issue a permit until the job is ready for him although, in some cases, he may participate in the preparatory work depending upon the nature of the job.

Hydrogen sulfide (H_2S) is a highly toxic gas. It is 1.2 times as heavy as air, and its lower and upper flammable limits are approximately 4.3 percent and 45 percent, respectively. At low concentrations the gas may be readily identified by its characteristic "rotten egg" odor. However, higher concentrations (of the order of 100 ppm to 200 ppm or more) of the gas desensitize the olfactory nerves and so deaden one's sense of smell that its odor is no longer noticeable. For continuous work (8-hour exposure), the threshold limit value (TLV) of H_2S in air is 10 ppm. Frequent periodic checks of the gas concentration should be made to assure that conditions do not exceed this level.

An inspector responsible for checking a job for H_2S hazards should have a good working knowledge of the properties of the gas, know how to test for H_2S , and be able to interpret intelligently the results of the tests. Refer to API RP 2015 for additional information on H_2S hazards.

5.6.3 PYROPHORIC IRON SULFIDE

Pyrophoric iron sulfide is a corrosion product that may form on the walls of a vessel or tank containing high-sulfur, so-called "sour," stocks. In equipment vented to the air, iron sulfide normally is oxidized to iron oxide scale as the sulfide is formed. In gas-blanketed tanks or equipment where little or no air is present, great quantities of the sulfide may form. If such equipment was purged with air in preparation for entry, the vapor mixture in the equipment would reach its flammable range at some stage of the purging. At the same time, the pyrophoric iron sulfide would be exposed to the air and might start burning spontaneously. This ignition could cause the flammable atmosphere in the equipment to ignite or explode.

Hence, special precautions are required to prepare such equipment for gas-freeing. These precautions are discussed in API RP 2015. Safe disposal of scale or rust containing pyrophoric iron sulfide is also highly important. Such deposits must be kept damp until removed to a safe area or buried to prevent ignition.

5.6.4 OTHER TOXIC MATERIALS

Other toxic materials, such as sulfur dioxide and metal carbonyls may be encountered in special cases. Personal protective equipment, tests, and procedures may be required depending upon the nature of material. The important factor is anticipation of problems by the operating and maintenance supervisors and the inspector so that an accident or injury will not occur while the job is underway. An inspector may not be familiar with new and unsuspected risks and should question the line supervisors if he suspects any problem. Also, the supervisors must be alert to potential risks particularly if the job is new and untried.

5.6.5 MATERIALS ENCOUNTERED IN OPERATING UNITS

Many hazardous materials are encountered in the use of modern, complex process equipment. They include hydrogen, carbon monoxide, certain acids, hydrogen cyanide, arsine, methyl chloride, benzene, aromatic hydrocarbons, ammonia vapor, phenol, inert gases, various catalytic additives, and commercial re-agents. Some materials are integral parts of refining processes whereas others are reaction products.

Where the processes are new and experience with them is lacking, an inspector cannot be expected to fully anticipate new risks or plan all the safeguards that should be employed when preparing equipment for entry or inspection. The technical staff, the line foremen, and the fire and safety supervisors should plan jointly when considering the safety of such new work. The inspector should have training and experience so that he knows proper procedures. He should question appropriate people on any problems about which he has any doubt.

Considerable literature is available on the safe handling of various hazardous materials that are encountered in petroleum refining. It is suggested that safety supervisors avail themselves of such reference material for their office libraries. Although some of the material is technical, certain parts are essential for the proper training of inspectors. The safety supervisor should obtain publication lists from authoritative sources such as—

American Petroleum Institute, 2101 L Street, N.W., Washington, D.C. 20037

American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018

Manufacturing Chemists' Association, 1825 Connecticut Ave., N.W., Washington, D.C. 20009

National Board of Fire Underwriters, 85 John St., New York, N.Y. 10038

National Fire Protection Association, 470 Atlantic Avenue, Boston, Mass. 02110

National Safety Council, 425 North Michigan Ave., Chicago, Ill. 60611

5.7 Safety Permits

Various types of permits for documenting a safety inspection are used. Examples are—

1. General safety permits,
2. Vessel or tank entry permits,
3. Fire or hot-work permits,
4. Special permits as for excavating, electrical work, and the like, and
5. Radioactive materials handling permits.

Permit procedures vary. Some refineries require a safety permit to be signed not only by the safety inspector but also by the operating supervisor having jurisdiction over the unit to be entered and the maintenance supervisor of the men who are to work in or on the equipment. In addition, a checkoff list of blinds may be used—the list to be initialed by responsible supervisors as an added safety measure for installation and removal of blinds.

A safety permit may be an integral part of a job or work order, or it may be a document separate from the order. If fire prevention is involved, possibly a separate fire or hot-work permit also may be used. Sometimes the specific precautions or procedures to follow are listed briefly. Regardless of the methods used, they serve the same objective—to provide a record showing that a particular job has been checked by the proper responsible parties. As work continues, a permit may be issued daily or more often as required by circumstances.

Usually carbon copies are made so that each of the signatories will have a copy. In some plants a copy of a hot-work permit is retained by the craftsman and hot work is not permitted unless he has the permit with him. Also, the permit can be recalled or canceled if conditions change so that the work cannot be started or continued.

Some refineries use a tag-type permit that can be attached to a manhole flange of the tank or vessel to be entered. Some pitfalls are inherent in the safety permit procedure. For example—

1. In refineries where the written permit procedure is used, it should be followed for all applicable work. Verbal

permits should not be substituted for written permits since misunderstandings are less likely to occur when written permits are used.

2. One of the signatories might not personally inspect the job prior to signing the written permit. He might assume that it is safe or take someone else's word for it. The defects of this procedure are obvious also.

3. In some very small plants, one who supervises the entire job may also do the hot work without writing a permit to himself, unless required by law to do so.

5.8 Revising Inspection Procedures

If a mishap, close call, accident, or injury results from some error of inspection, the cause should be determined. The lessons learned should be used as a training aid to avoid subsequent trouble.

It is said that no two jobs are exactly alike; each job must be evaluated on its individual merits. However, the properly trained and supervised inspector will know that new lessons learned on one job should be made known and should be applied to subsequent jobs in order to constantly improve safety inspection procedures.

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