

SUPERSEDED

**GUIDE
FOR
INSPECTION OF REFINERY EQUIPMENT**

**CHAPTER I
INTRODUCTION**

**SECOND EDITION
1976**

STACK



AMERICAN PETROLEUM INSTITUTE

**Refining Department
2101 L Street, Northwest
Washington, D.C. 20037**

Price: \$1.00

GUIDE
FOR
INSPECTION OF REFINERY EQUIPMENT

CHAPTER I
INTRODUCTION

SECOND EDITION
1976

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use in connection with any method, apparatus, or product covered by letters patent, nor as insuring anyone against liability for infringement of letters patent.

API publications may be used by anyone desiring to do so, and every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them. However, the Institute makes no representation, warranty, or guarantee in connection with API publications and hereby expressly disclaims any liability or responsibility for loss or damage resulting from their use; for any violation of any federal, state, or municipal regulation with which an API publication may conflict; or for the infringement of any patent resulting from the use of an API publication.

THE AMERICAN PETROLEUM INSTITUTE	
API Standards	
ACC. No.	
DATE	29/6/77
LIBRARY	

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	Unfired Pressure Vessels
Chapter VII	Heat Exchangers, Condensers, and Coolers
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	Inspection of 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
Appendix	Inspection of Welding

CONTENTS

CHAPTER I—INTRODUCTION

	PAGE
1.1 HISTORICAL DEVELOPMENT	1
1.2 PHILOSOPHY OF THE GUIDE	2
1.2.1 General	2
1.2.2 Use of the Guide	2
1.2.3 Intent of the Guide	2
1.3 CONTENTS OF THE GUIDE	3
1.3.1 General	3
1.3.2 Contents of the Chapters	3
1.4 THE INSPECTION FUNCTION	3
1.5 INSPECTORS	4
1.5.1 Definition of an Inspector	4
1.5.2 Qualifications of an Inspector	4
1.5.3 Functions of an Inspector	4
1.5.4 Communications Between Inspectors and Other Plant Personnel	4

CHAPTER I INTRODUCTION

1.1 Historical Development

Prior to World War I comparatively low pressures and temperatures were used by the petroleum industry, although installations of Burton pressure stills were coming into prominence. Burton processes used pressures up to 100 pounds per square inch (6.89×10^5 pascals) and temperatures up to approximately 750 degrees Fahrenheit (399 degrees Centigrade).

Shortly after World War I the rapid increase in the use of automobiles and the development of the diesel engine necessitated a large increase in the production of gasoline, kerosine, and diesel oil. Producing these larger quantities of light petroleum fractions without an undue increase in the production of the heavier fractions required cracking a part of the heavier molecules into lighter ones. To accomplish this the petroleum industry was compelled to resort to higher pressures and temperatures than had heretofore been used in the industry.

With the introduction of Dubbs, Cross, and other high-pressure and high-temperature cracking operations in the 1920's, it became apparent that some means of thorough inspection would be required to assure safe and continuous operation. Although inspections had been made of the riveted vessels in early distillation units, these inspections had been performed with the intent of making repairs to extend the service life, not with the concept of ascertaining remaining service or ultimately solving the deterioration problem. With the higher pressures, higher temperatures, and continuous operation, it became necessary to greatly expand and improve inspection methods. Tubes, reaction chambers, and fractionating towers necessitated a degree of technical proficiency far above that required previously.

At about the same time new oil fields were brought into production and it was discovered that the oil from these fields contained relatively large quantities of sulfur compounds. These crude oils were known as sour crudes and under certain processing conditions were extremely corrosive.

The increased demand for petroleum products also resulted in the design of large, high-capacity, costly units that were operated continuously over long periods

of time. The refiners organized inspection forces under the supervision of qualified engineers to assure continuity of operation; to anticipate and plan repairs in advance of shutdown; and to protect against loss of property caused by failures and fires, thus protecting a large investment and assuring the safety of operating personnel.

The first inspectors were pioneering in a field of work for which background information was lacking. Many techniques were tried, some of which were successful and many of which were abandoned or superseded by more scientific methods. Ingenuity on the part of early inspectors provided the tools of the craft (see IRE Guide, Chapter IV)—machinists' tools with modifications made to fill the needs of the equipment inspector. Extensions and offset arms were put on calipers; a three-point, expanding, inside micrometer was devised for measuring tubes; various modifications were made to the depth gage; and methods were conceived for using the plumb bob or taut parallel piano wires in measuring thick-walled vessels.

Improvements in gasoline and diesel engines required better fuels and lubricants. New processes were developed, many of which used extremely corrosive chemicals. To protect the increased investment, the petroleum industry rapidly extended its inspection to cover more types of equipment. Today nearly everything in a refinery is given a periodic scientific inspection. Improvements have been made in metallurgy, welding, and fabrication methods. Inspectors have looked for better methods to inspect the improved equipment. New or little-known phenomena were encountered, of which stress corrosion cracking, hydrogen embrittlement, fatigue, creep, and stress rupture are examples. Problems caused by these phenomena are normally handled by metallurgists and corrosion engineers.

Progress in inspection technology resulted in the use of X-ray, gamma-ray, ultrasonics, penetrants, and magnetic-particle inspection. During World War II advancements in technology which ordinarily would have required many years were made within only a few years. Thus, as soon as nonmilitary applications could be made, new instruments that used radioactive isotopes, ultrasonics, eddy current, and acoustic

emission were available to the industry. Some of these instruments are mentioned in the succeeding chapters.

Prior to 1940 little had been written of the development of inspection in the petroleum industry. The techniques had been passed on, verbally and by demonstration, from experienced personnel to men being trained. In the late 1930's the members of the Committee on Refinery Equipment of the American Petroleum Institute recognized the need for a medium of exchange of information on inspection procedures. As a result, the Subcommittee of Refinery Inspection Supervisors was organized on May 27, 1940 with the objective of improving inspection procedures throughout the industry by the dissemination of information and by the development of recommended practices.

The Subcommittee of Refinery Inspection Supervisors immediately started the formulation of *API Recommended Practices for Refinery Inspections*. World War II interrupted this work while it was still in a semifinished state. However, the Petroleum Administration for War (PAW) believed that a great need existed for a publication covering inspection because of the rapid expansion and modernization required to provide for the greatly increased demand for petroleum products by the armed forces. The American Petroleum Institute granted PAW permission to utilize the work it had done on such a publication. With minor changes, PAW in cooperation with *National Petroleum News* published this work as the *Wartime Recommendations for Refinery Inspections*. After the war the American Petroleum Institute continued its work on these recommended practices and between 1948 and 1954 published five of the proposed six parts.

In 1952 the engineers of the petroleum industry believed the work that had been done should be greatly amplified to cover all types of equipment—both mechanical and process—found in an oil refinery in order to preserve the experience gained in the past and insofar as possible prevent repetition of mistakes made during the development period. A comprehensive outline was prepared and in 1954 active work on writing the respective chapters was started. The *API Guide for Inspection of Refinery Equipment* (IRE Guide) is the result of this effort.

1.2 Philosophy of the IRE Guide

1.2.1 GENERAL

The purpose of this guide is to serve mainly as a compendium of recommended practices directed to those who will inspect any part of a refinery's equipment in order to assure safe, continuous, and efficient operation with minimum maintenance. This guide has been devel-

oped by engineers in the petroleum industry who have experience in all phases of inspection. It is intended to serve as a guide to the inspection procedures that will reveal defects or corrosion before these conditions become serious.

The guide has been written with the need and convenience of the user uppermost in mind. Primarily the user will be the person doing the inspection work; to a lesser extent, his supervisor; and to a minor extent, plant management. For this reason the content of this guide has not been restricted to avoid repetition (where clarification of a statement was required) or to avoid difficult explanations. Convenience of use and clarity (in order to avoid misunderstanding) have been the primary guides in the writing of the various chapters.

The user who has the greatest need for a guide will probably be the small refiner who, although experienced, does not have adequate personnel to maintain fulltime inspection activities. Therefore procedures that may seem obvious to experienced inspection personnel have been explained in the guide in detail. At the same time and more complicated problems of inspection have been covered, either directly or by reference to other publications, in order to make the guide useful to the widest variety of personnel. However, it is emphasized that inspection of any equipment should be made only by personnel with good knowledge of the specific equipment.

1.2.2 USE OF THE IRE GUIDE

This guide has been written primarily to aid personnel who will inspect various types of refinery equipment. Therefore an attempt has been made to cover in detail all phases of the inspection process related to a particular class of equipment. Each class of equipment has been covered in a separate chapter. There has been no intent to imply that the methods employed are the best or the only means of achieving the desired results.

The guide should also prove useful to other refinery personnel. Its use by manufacturers and builders of refinery equipment may create a better understanding of inspection and safety problems involved in the equipment. Although the guide does not touch directly upon the inspection of newly purchased equipment for conformance to specifications, some of the methods presented may also be valuable to inspectors of such equipment.

1.2.3 INTENT OF THE IRE GUIDE

The intent of the guide is to explain the problems encountered in the inspection of refinery equipment in such a manner that they will be clearly understood by

the inspector. He may then use the method that may be most appropriate to a particular problem or he may devise some method of his own that may be equally or more effective.

An effort has been made to keep the language at a readable and comprehensive level. Much information is contained in the guide, thereby in most cases eliminating the necessity for further reference before arriving at a method or procedure. With the use of this guide as a criterion, it is hoped that the technology of the art will be improved and, as revisions to the various chapters are made, that the entire petroleum industry will benefit.

Certain codes, regulations, and practices are referred to throughout the guide. These, for the most part, are established by engineering societies or regulatory bodies; no attempt is made to quote them but rather to inform the reader that they exist. Care has been taken to assure that documents referred to are readily accessible. Usually these will be available in the library of even the smallest refiner.

None of the procedures or recommendations of this guide are to be construed as mandatory, although some regulatory publications mentioned in the guide contain mandatory regulations. Procedures that are contrary to local regulations should be disregarded.

1.3 Contents of the IRE Guide

1.3.1 GENERAL

The IRE Guide consists of 20 chapters and any necessary appendixes. The first five chapters are general in nature and should be of interest to anyone engaged in inspection work.

1.3.2 CONTENTS OF IRE GUIDE CHAPTERS

IRE Guide, Chapter II discusses in detail the subjects of corrosion and erosion; the effects of high temperatures, subnormal temperatures, excessive pressures, overloading, earthquakes and earth settlements, and mechanical and wind damage. It also discusses situations leading to improper selection of material and equipment and the evidence of faulty material and equipment. It contains an appendix on common refinery metals and alloys.

IRE Guide, Chapter III discusses scheduling the shutdown of operating equipment to permit inspection and anticipated repairs, scheduling the inspection work to be done during the shutdown, checking inspection tools and instruments prior to shutdown, and preliminary work for a major inspection. This chapter is mainly of interest to those charged with inspection of process

equipment, which is usually carried out by a department of trained inspectors. However, personnel of other departments should be familiar with the procedures covered in this chapter so that inspections can be coordinated with general shutdowns.

IRE Guide, Chapter IV describes the various tools that may be used in inspection work and the method of using each tool. Reference is made to the source of instruction for the use of highly specialized tools.

IRE Guide, Chapter V discusses the preparation of process equipment for entry and cleaning and for various types of work as well as for safety inspections. It also covers the personal protective equipment that should be used for various conditions.

The remaining chapters, which cover specific classes of equipment, are divided into a number of sections that include: a description of the various types of equipment that may be found in each class; a statement of the reasons for inspection; a statement of the causes of the deterioration that may occur on each type of equipment (with reference to IRE Guide, Chapter II for detailed information about these causes); suggestions regarding the frequency and times of inspection; suggestions regarding the preliminary work required to expedite the inspection; a list of tools that should be on hand or easily available during the inspection; a comprehensive description of methods of inspection (including detailed inspection procedures); suggestions regarding methods for determining limits of thickness or reference to other publications containing such methods; and suggestions concerning the type of records that should be kept (with sample forms of such records) and the type of reports that may be necessary to inform all interested parties of the condition of the equipment.

The chapters covering specific types of equipment contain considerable repetition of information. This has been deemed necessary because the user who has the greatest need for this guide ordinarily will be interested in only one class of equipment at a time. Thus he will not be handicapped in making constant cross references. For the same reason, each chapter has been issued as a separate publication.

1.4 The Inspection Function

Maintaining safe refining facilities in optimum operating condition requires that a responsible individual or group not encumbered by the pressures of daily plant activities be able to focus maximum attention on future safe equipment operations. The primary function of inspection is to assure that operating equipment is in a

safe condition during periods of operation. This requires the gathering of equipment thickness data and other pertinent information that can be accurately projected into the future for at least the duration of the expected period of operation.

The purpose of this future vision is to determine when equipment repairs and replacements are necessary. It may actually influence the length of the equipment operating period. The equipment inspector must be cognizant of these time and rate factors since they have a direct bearing on the type and extent of inspection he will make.

Performing this inspection function requires the following four essential refinery inspection activities:

1. Gathering operating equipment data and information in the field.
2. Recording the data and information in some useful form of historical record.
3. Analyzing and reporting the results and recommendations of projected records to assure the safe achievement of the expected equipment period of operation.
4. Preparing for the next equipment shutdown to be sure the required data is obtained for the following operating period.

1.5 Inspectors

1.5.1 DEFINITION OF AN INSPECTOR

For the purpose of this guide, the term inspector refers to a person qualified to make an inspection, examination, check, or test or to perform any other operation to determine whether any piece of equipment is safe, deteriorated, accurate, or functioning properly. He may be a fulltime inspector, a high-caliber maintenance mechanic or supervisor, an engineer, or any other adequately qualified person to whom the management is willing to delegate responsibility while he is performing any of the previously mentioned duties.

1.5.2 QUALIFICATIONS OF AN INSPECTOR

There are many pros and cons regarding the qualifications of an inspector. Some favor the technical man; others favor the practical or experienced mechanic from the ranks. A combination of the two would probably be a good compromise; however, personnel with these qualifications are difficult to find.

An inspector should be thoroughly familiar with the class of equipment that he is inspecting. He should be observant, cooperative, inquisitive, careful, painstaking, and thorough. He should have good judgment and a

good sense of values, thereby commanding the respect of the workmen and supervisors with whom he is in contact. He should be fully cognizant of his responsibility and authority and be able to act without being arbitrary. He should be familiar with the causes of deterioration and the results of continued deterioration. Before being rated as an inspector, he should undergo thorough training under the guidance of a qualified inspector until he has demonstrated his ability to adequately perform the inspection work.

In some locations and for some classes of equipment an inspector may require licensing by a jurisdictional body.

API RP 510: Inspection, Rating, and Repair of Pressure Vessels in Petroleum Refinery Service presents recommended qualifications for inspectors of such equipment.

1.5.3 FUNCTIONS OF AN INSPECTOR

The broad function of an inspector is to thoroughly inspect the equipment in order to maintain it in a safe and efficient operating condition that will assure continuity of operation.

The importance of human safety is stressed throughout American industry. Failure of equipment can result in risk to personnel in the vicinity of the equipment. Thorough systematic inspection will reveal conditions which, if not corrected, may cause failures.

The large, costly equipment used in the petroleum refining industry requires long, continuous runs to justify the investment. A failure of a part may result in the shutdown of the equipment and cause considerable economic loss both in operating time and in the performance of costly cleaning operations. Product quality is dependent upon the maintenance of stable operating conditions. Failure or malfunction of auxiliary equipment may cause unstable conditions resulting in off-specification or unusable products. For these reasons thorough and efficient inspection is important for both safety and economy.

1.5.4 COMMUNICATIONS BETWEEN INSPECTORS AND OTHER PLANT PERSONNEL

The safe and proper maintenance of refinery equipment is a responsibility shared by all refinery groups. The operators of equipment can be of assistance by informing the inspectors of any difficulties as they are encountered. This will enable the inspectors to concentrate on parts of equipment that have given trouble. The maintenance people can also be of assistance in informing the inspectors of the condition of any equipment that they believe may be questionable.