



RP 32-4

INSPECTION & TESTING OF IN-SERVICE CIVIL AND MECHANICAL PLANT - TECHNICAL GUIDANCE

March 1996

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BP GROUP RECOMMENDED PRACTICES AND SPECIFICATIONS FOR ENGINEERING											
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Document Title INSPECTION AND TESTING OF IN-SERVICE CIVIL AND MECHANICAL PLANT - TECHNICAL GUIDANCE (Replaces the relevant parts of BP Engineering CP 52)											
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SCOPE AND PURPOSE This Recommended Practice gives technical guidance for the inspection and testing of in-service civil and mechanical plant. It is applicable to oil refineries, petrochemical and chemical plant, onshore and offshore production facilities, transmission pipelines and storage and distribution facilities for finished products. It is not applicable to road, rail or sea transportation. The main purpose of this document is to provide guidance to all operating assets to develop and maintain detailed written inspection procedures for all tasks related to safety/technical integrity.											
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FOREWORD

Introduction to BP Group Recommended Practices and Specifications for Engineering

The Introductory Volume contains a series of documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the 'General Foreword' sets out the philosophy of the RPSEs. Other documents in the Introductory Volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

Value of this Recommended Practice

This document represents current technical guidance and accumulated experience in the Inspection and Testing of In-Service Civil and Mechanical Plant, for ensuring a high standard of plant integrity based on safe economical practice.

Application

Text in italics is Commentary. Commentary provides background information which supports the requirements of the Recommended Practice, and may discuss alternative options.

This document may refer to certain local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirements lies with the user. The user should adapt or supplement this document to ensure compliance for the specific application.

Principal Changes from Previous Edition

This Recommended Practice is part of a major revision of BP Engineering Code of Practice CP 52 - Inspection and Testing of Plant in Service which was last revised in January 1991 and which has now been split into four separate documents.

Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in the application of BP RPSE's, to assist in the process of their continuous improvement.

For feedback and further information, please contact Engineering Practices Group, BP International or the Custodian. See Quarterly Status List for contacts.



INTRODUCTION

The format of this RP represents a significant change from that of its predecessor, CP 52 Parts 2 and 3, although its scope and intent are essentially unchanged. It is not considered practicable or necessary to embody in a single document detailed inspection guidance and procedures for the range of equipment defined (see data page - SCOPE AND PURPOSE). There are now many excellent equipment-specific inspection guidance documents available both internally and externally, and in many cases little more than reference to these is required. Where such guidance documents are considered either unavailable or inadequate, then more detailed guidance is provided in this RP.

There is a clear requirement in BP Operations Integrity Assurance Systems for all operating assets to develop and maintain detailed written inspection procedures for all tasks related to safety/technical integrity.

The main intent of this RP is to provide guidance to the assets to help achieve this requirement.

It is recognised that many assets already have detailed written schemes of examination or inspection procedures in place, either through their own proactivity or through external statutory or quality-scheme requirements. It is recommended that all such assets regularly review their schemes and procedures against this RP and against those of selected similar assets within the Company.

This RP should be read and interpreted in conjunction with BP Group RP 32-3, which sets out the main management principles to be considered, and provides guidance on maximum recommended inspection intervals for most types of equipment.



DEFINITIONS AND ABBREVIATIONS

Definitions

Standardised definitions may be found in the BP Group RPSEs Introductory Volume.

Abbreviations

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
BPE	BP Engineering
CICIND	International Chimneys Construction Industry
CO	Carbon Monoxide
CRA	Corrosion Resistant Alloy
CUI	Corrosion under Insulation (Also - Committee of User Inspectors)
DC	Direct Current
EEMUA	Engineering Equipment and Materials Users Association
ER	Engineering Report
ESR	Engineering Shared Resource
ETC	Engineering Technical Centre
GS	Guidance for Specification
H ₂ S	Hydrogen Sulphide
HMSO	Her Majesty's Stationery Office
HP	High Pressure
HSE	Health and Safety Executive
HVAC	Heating Ventilation and Air Conditioning
ID	Internal Diameter
KW	Kilowatt
LNG	Liquified Natural Gas
LP	Low Pressure
LPG	Liquified Petroleum Gas
MOC	Main Operating Centre
NDT	Non Destructive Technology
pH	A scale indicating the acidity of a solution
ppm	Parts per million
RP	Recommended Practice
SCC	Stress Corrosion Cracking
SI	Statutory Instrument
TEMA	Tubular Exchanger Manufacturers Association



PART A - GLOSSARY OF INSPECTION-RELATED DOCUMENTS

Part A comprises a glossary of documents which are available both internally and externally, and are those which find the most common application in inspection engineering. They variously relate to equipment design, materials, fabrication, inspection, testing, corrosion control, maintenance, repair and operation. All assets are encouraged to advise the Inspection Network of any additional documents which are considered of value so that this section of the RP can be maintained 'live'. Where appropriate, a brief summary of the document is provided, and further references are made in the equipment-specific sections of Part B. National and international Design Codes and Standards are not included since these are generally well known.

A.1 COMPANY DOCUMENTS

A.1.1 **BP Group Recommended Practices & Specifications for Engineering**

RP 6-1	Corrosion Monitoring (replaces BP CP 50)
RP 22-1	Fired Heaters (replaces BP CP 7)
RP 26-1	Heat Exchange Equipment (replaces BP CP 9)
RP 32-1	Inspection and Testing of New Equipment in Manufacture (replaces BP CP 51)
RP 32-2	Site Inspection, Testing and Precommissioning of New Plant (replaces BP CP 20)
RP 32-3	Inspection and Testing of In-Service Civil and Mechanical Plant - Management Principles (replaces the relevant parts of BP CP 52)
RP 32-4	Inspection and Testing of In-Service Civil and Mechanical Plant - Technical Guidance (replaces the relevant parts of BP CP 52)
RP 32-5	Inspection and Testing of In-Service Electrical Plant (replaces the relevant parts of BP CP 52)
RP 32-6	Inspection and Testing of In-Service Instrumentation



RP 34-1	Rotating Machinery (replaces BP CP 10)
RP 38-1	Lifting Equipment (replaces BP CP 28)
RP 38-3	Inspection and Maintenance of Offshore Pedestal Cranes
RP 42-1	Piping Systems to ANSI B31.3 (replaces BP CP 12)
RP 43-1	Transmission Pipelines to BS 8010 (replaces BP CP 43)
RP 44-1	Overpressure Protection Systems (replaces BP CP 14)
RP 46-1	Unfired Pressure Vessels (replaces BP CP 8)
RP 50-2	Guide to Reliability Engineering (replaces BP CP 62)
RP 52-1	Thermal Insulation (replaces BP CP 13)
RP 56-1	Steam Generation (replaces BP CP 11)
RP 56-2	Water Treatment for Boiler Installations (replaces BP CP 26)
RP 58-1	Non-Refrigerated Petroleum & Petrochemical Storage (replaces BP CP 21)
RP 60-1	Cooling Water Treatment (replaces BP CP 27)
RP 62-1	Guide to Valve Selection
GS 106-2	Painting of Metal Surfaces (replaces BP Std 141)
GS 106-4	Polychloroprene Coating of Offshore Risers, Guides and Supports (replaces BP Std 171)
GS 106-5	Painting of Offshore Packages



GS 118-5	The Fabrication, Assembly, Erection and Inspection of Carbon, Carbon Manganese and Low Alloy Ferritic Steel Pipework to ANSI/ASME B31.3 (replaces BP Std 167 Parts 1 & 2)
GS 118-7	Fabrication of Pipework to ANSI B31.3. Part 3: Austenitic and Duplex Steel Pipework, Cupro-Nickel and Nickel Base Alloy Pipework (replaces BP Std 167 Part 3)
GS 118-8	Tube End Fixing of Heat Exchanger Tubes (replaces BP Std 191)
GS 126-1	Shell & Tube Heat Exchangers, TEMA-Type (replaces BP Std 160)
GS 126-2	Air Cooled Heat Exchangers to API 661 (replaces BP Std 161)
GS 136-1	Materials for Sour Service (replaces BP Std 153)
GS 138-3	Marine Loading Arms (replaces BP Std 178)
GS 138-4	Overhead Travelling Cranes and Monorail Cranes (replaces BP Std 113)
GS 143-1	Pig Launchers & Receivers (replaces BP Std 159)
GS 146-2	Unfired Pressure Vessels: Vessels to BS 5500 (replaces BP Std 194 Part 1)
GS 146-4	Unfired Pressure Vessels: Vessels not exceeding 20 mm thick (replaces BP Std 194 Part 3)
GS 146-5	Unfired Pressure Vessels: Vessels operating close to Atmospheric Pressure (replaces BP Std 194 Part 4)
GS 146-6	Mechanical Design for High Pressure Offshore Scrubbers, Separators and Dehydrators
GS 156-3	Water-Tube Type Fired Steam Generating Plant (replaces BP Std 211)



GS 156-4	Shell Type Fired Steam Generating Plant (replaces BP Std 212)
GS 156-5	Boiler Feed Water Deaerators (replaces BP Std 213)
GS 158-2	Vertical Tanks for Non-Refrigerated Fluids: Tanks to BS 2654 (replaces BP Std 163 Part 1)
GS 162-1	Steel Gate, Globe and Check Valves (replaces BP Std 150 & 181)
A.1.2	BP - Engineering Reports
ETC.82.ER.032	Guidance Notes on the Avoidance of Brittle Fracture in Operating Equipment <i>These guidance notes are intended to provide operators with an outline description of the factors likely to give rise to brittle fracture of pressure-containment equipment, and the way in which these are affected by service history. Means of assessing the degree of susceptibility and minimising the risk of such failures is presented. Although this report is now fairly old, the principles described are still valid. It should be read and interpreted in conjunction with API RP 920.</i>
ETC.86.ER.137	Guidelines for Corrosion Defect Evaluation in Pipelines <i>A report presenting methods of assessing the acceptability of metal wastage in transmission pipelines by internal and/or external corrosion.</i>
ETC.89.ER.046	The Heater Inspection Manual <i>This is a comprehensive guide, complementary to API RP 573. It comprises sections on types of heaters, structural steelwork and casings, refractory, heating coils, burners, ducting and stacks.</i>
BPE.89.ER.132	BPOI Pipeline Integrity Study <i>This report describes the methods used by BP to design, construct, operate and maintain pipelines.</i>
BPE.89.ER.141	Magnetic Inspection of Offshore Crane Wire Ropes <i>This report describes the use of magnetic inspection for offshore crane wire ropes and concludes that the method is both feasible and desirable. Discard criteria are included.</i>
BP Oil	Pipeline Integrity Guidelines: Underwater Pipelines. Issue 1, August 1990 <i>A comprehensive pipeline integrity management guide, including sections on procedures, documentation, areas for concern, inspection techniques, defect assessment and integrity auditing.</i>



BPE.90.ER.002	Pipeline Defect Analysis <i>A report describing methods for the evaluation of mechanical damage to pipelines, particularly denting and gouging. This report is complimentary to the corrosion damage assessment report ETC.86.ER.137.</i>
BPE.90.ER.174	Remanent Life Assessment <i>This document reviews the technique available for RLA to enable those responsible for the operation of high temperature plant to select the most appropriate for their situation. It also reviews BP Group experience with RLA to 1990.</i>
BPE.91.ER.008	1990 Intelligence Pigging Review <i>A state of the art review of intelligent pigging technology, and BP experience to date (1990).</i>
BPE.91.ER.028	Heat Exchanger Tube Inspection Methods Used by BP <i>The usage of IRIS, Steeltest, Radiography and Eddycurrent heat exchanger tube inspection techniques in BP is discussed. Recommendations are made for optimum performance, and costs are compared. See also ESR.95.ER.035.</i>
BPE.91.ER.049	Storage Tank Maintenance, Inspection and Repair <i>A comprehensive and authoritative guide which is complimentary to API RP 653 and EEMUA 159. Inspection checklists for various tank designs are included.</i>
BPE.91.ER.083	Guidelines for the Use of the Trevitest Method for Testing Safety Relief Valves <i>Guidelines indicating how the Trevitest system can be used for testing relief valves on-line.</i>
BPE.91.ER.109	Guidelines for the Inspection of Corrosion Under Insulation (CUI) <i>Guidelines for inspection personnel in the detection of CUI, and the development of site-specific written schemes of examination.</i>
BPE.91.ER.186	A User's Guide to Cost Effective Machinery Condition Monitoring Techniques <i>This report cross evaluates machinery types, basic machinery faults, and optimal CM techniques for fault detection and analysis. It includes a review of permanent monitoring systems available for machinery.</i>
BPE.92.ER.086	Temper Embrittlement Studies on Hydrocracking Reactors <i>A review of the temper embrittlement characteristics of first-generation and second-generation grades of 2 1/4%Cr-1%Mo steels and weldments used in BP hydrocracking reactors.</i>
BPE.92.ER.171	NDT Trials on Duplex (22%Cr) Stainless Steel



Results of trials comparing the crack detection capability of a variety of NDT techniques on duplex stainless steel.

ESR.93.ER.003 **Detection of Hydrogen Damage in Carbon 1/2% Molybdenum Material**

A project report describing the development and validation of an ultrasonic back-scatter method to detect hydrogen damage. Detailed inspection procedures are included.

ESR.93.ER.139 **Detection of Corrosion Under Insulation (CUI)**

A review and site-trial report of an eddy-current system for detecting CUI without the need to remove the insulation.

ESR.94.ER.120 **Development of a Flexible Ultrasonic Transducer Mat (Fleximat)**

A project report detailing the development of fleximat technology and its potential range of application for internal corrosion monitoring.

ESR.95.ER.035 **Evaluation of NDT Techniques Used in the Inspection of Heat Exchanger Tube Bundles.**

A project report evaluating the capabilities of ultrasonic, eddy-current and flux leakage inspection methods of detection and sizing of artificial and corrosion-induced defects in heat exchanger tubes of various materials.

A.1.3 **BP Engineering and Technical Bulletins**

#250 **Material Toughness for Resisting the Initiation of Brittle Fracture in Pressure Vessels and Piping"**

#252 **"Relief System Design: Register of Safety Related Devices"**

Pipeline Corrosion Advisory Group Technical Briefing Notes

A series of bulletins covering external pipeline coatings, internal liners, rehabilitation, inhibition, multi-phase flow, preferential weld corrosion, polymers and intelligence pigging (1991-1992).

TB0002 **Inspection of Small-Bore Fittings and Pipework**

A review and best-practice guide to this still troublesome area.

A.1.4 **BP Oil US Refinery Practices**

Available internally within the BP Group to BP Businesses/BP Projects

RP 6-1-3 **Register of Safety Related Devices**

RP 7-3-1 **Rerating Pressure Vessels**



RP 8-1-2	Tube Bundle Replacement
RP 11-1-5	Tank Inspection, Repair, Alteration and Reconstruction
RP 13-2-1	Material Requirements for Aggressive Environmental Services
RP 15-1-1	Internal Insulating and Refractory Linings
RP 15-1-2	Fired Heater Refractory
RP 20-1-4	Positive Metals Identification
RP 20-3-1	Training, Qualifying and Certifying Personnel for Inspection and Testing of Refinery Equipment
RP 20-3-2	Training, Qualifying and Certifying Personnel for NDE of Refinery Equipment
RP 20-4-2	In Plant Inspection of Existing Piping Systems
RP 20-4-3	In Plant Inspection of Existing Pressure Vessels
RP 20-4-4	In Plant Inspection of Existing Tankage
RP 20-4-5	In Plant Inspection of Existing Boilers
RP 20-4-6	In Plant Inspection of Existing Fired Heaters
RP 20-4-7	In Plant Inspection of Refractories
RP 20-4-8	In Plant Inspection of Existing Stacks
RP 20-4-9	In Plant Inspection of Pressure Relief Valves

A.1.5 BP Exploration Documents

[Rigging and Lifting Handbook](#)

[Offshore Thorough Examination and Testing Procedures of Lifting Equipment](#)

[Structural Inspection Philosophy for Offshore Fixed Structures \(XEU\) Doc No XEG/G/94/0079](#)



PART A - GLOSSARY OF INSPECTION-RELATED DOCUMENTS

A.2 EXTERNAL DOCUMENTS

A.2.1 American Petroleum Institute Publications

The chapters of the "Guide for Inspection of Refinery Equipment" are out of print. They are being progressively replaced with new recommended practices containing updated information. The chapters are 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

Appendix Inspection of Welding

The following publications are available:-

API 510 Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration, Seventh Edition, March 1992 (ANSI/API Std 510-1992)

This inspection code covers the maintenance inspection, repair, alteration, and rerating procedures for pressure vessels used by the petroleum and chemical process industries. The application of this code is restricted to organisations that employ or have access to an authorised inspection agency as defined in the inspection code. Except as provided in the code, the use of the code is restricted to organisations that employ or have access to engineering and inspection personnel or organisations that are technically qualified to maintain, inspect, repair, alter, or rerate pressure vessels. Pressure vessel inspectors are to be certified as stated in the code. Since other codes that cover specific industries and general service applications already exist, the industries that fit within the restrictions above have developed this code to fulfil their own specific requirements.

RP 520 Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries (ANSI/API Std 520-1992)

Part I "Sizing and Selection," Sixth Edition, March 1993 (ANSI/API RP 520-1-1992)

This recommended practice applies to the sizing and selection of pressure relief devices used in refineries and related industries for equipment that has a maximum allowable working pressure of 15 pounds per square inch gauge or greater. The pressure relief devices covered in this recommended practice are intended to protect unfired pressure vessels and related equipment against overpressure from operating and fire contingencies.

Part II Installation, Third Edition, November 1988 (ANSI/API RP 520-1992)

This recommended practice applies to installation of pressure relief valves and rupture disks in gas, vapour, and liquid service. It includes information on inlet and discharge piping; valve location and position; bolting and gasketing; valve settings; and handling, inspection, and testing.

RP 521 Guide for Pressure-Relieving and Depressuring Systems, Third Edition, November 1990 (ANSI/API RP 521-1992)

This recommended practice has been developed as a guide for plant engineers in the design, installation, and operation of pressure-relieving and depressuring systems. It supplements the material set forth in API RP 520, Part I. Guidelines are provided for examining the principal causes of overpressure, determining individual relieving rates, and selecting and designing disposal systems, including such component parts as vessels, flares, and vent stacks.



- Std 527** Seat Tightness of Pressure Relief Valves, Third Edition, July 1991 (ANSI/API Std 527-1992)
- This standard describes methods of determining the seat tightness of metal- and soft-seated pressure relief valves, including those of conventional, bellows, and pilot-operated designs.*
- RP 530** Calculation of Heater Tube Thickness in Petroleum Refineries, Third Edition, September 1988 (ANSI/API RP 530-1992)
- This recommended practice suggests procedures and design criteria for calculating the required wall thickness of new tubes for petroleum refinery heaters. The procedures described are appropriate for designing tubes in both corrosive and non-corrosive services. Allowable stress curves providing the elastic allowable and rupture allowable for most common heater tube alloys are included.*
- API 570** Piping Inspection Code: Inspection, Repair, Alteration, and Rerating of In-Service Piping Systems, First Edition, June 1993
- API 570 covers inspection, repair, alteration, and rerating procedures for metallic piping systems that have been in-service.*
- This publication was developed for the petroleum refining and chemical process industries but may be used, where practical, for any piping system. The purpose of the publication is to establish requirements and guidelines that will allow owners and users of piping systems to maintain the safety and integrity of the systems after they have been placed into service.*
- RP 571** Recognition of Conditions Causing Deterioration or Failure of Refinery Equipment, First Edition, (in preparation)
- RP 572** Inspection of Pressure Vessels, First Edition, January 1992 (ANSI/API Std 572-1992)
- This recommended practice covers the inspection of pressure vessels. It includes a description of the various types of pressure vessels and heat exchangers and the standards that can be used for their construction and maintenance. The reasons for inspection, the causes of deterioration, the frequency and methods of inspection, the methods of repair, and the preparation of records and reports are also covered. Safe operation is emphasised.*
- The information contained in the publication was previously presented as Chapters VI and VII of the Guide for Inspection of Refinery Equipment.*
- RP 573** Inspection of Fired Boilers and Heaters, First Edition, October 1991 (ANSI/API Std 573-1992)
- This recommended practice combines the Guide for Inspection Refinery Equipment," Chapter VIII, "Direct-Fired Boilers and Auxiliary Equipment", with Chapter IX, "Fired Heaters and Stacks", and provides guidance on the inspection of fired boilers and heaters.*
- RP 574** Inspection of Piping, Tubing, Valves and Fittings, First Edition, June 1990 (ANSI/API RP 574-1992)



This recommended practice covers the inspection of piping, tubing, valves (other than control valves), and fittings used in petroleum refineries.

- RP 575** Inspection of Atmospheric Storage Tanks (in preparation)
- RP 576** Inspection of Pressure Relieving Devices, First Edition, September 1992 (ANSI/API RP 576-1992)
- This recommended practice describes automatic pressure-relieving devices commonly used in the oil and petrochemical industries. As a guide to the inspection and control of these devices in the users plant, it is intended to ensure their proper performance. This recommended practice covers such automatic devices as spring-loaded pressure relief valves, pilot-operated valves, and rupture disks.*
- This recommended practice covers the material previously presented as Chapter XVI of the API Guide for Inspection of Refinery Equipment.*
- RP 577** Welding Inspection and Metallurgy (in preparation)
- RP 578** Construction Material Quality Control and Positive Identification (in preparation)
- RP 579** Fitness for Service Analysis (in preparation)
- RP 580** Risk Based Inspection (in preparation)
- Std 598** Valve Inspection and Testing, Sixth Edition, September 1990
- This standard covers inspection, supplementary examination, and pressure test requirements for both resilient-seated and metal-to-metal-seated gate, globe, plug, ball, check, and butterfly valves. The inspection requirements pertain to inspection by the purchaser and to any supplementary examinations the purchaser may require at the valve manufacturer's plant.*
- API RP 651** Cathodic Protection of Aboveground Petroleum Storage Tanks, First Edition, April 1991 (ANSI/API Std 651-1992)
- This recommended practice describes the corrosion problems characteristic in aboveground steel storage tanks and associated piping systems and provides a general description of the two methods currently used to provide cathodic protection against corrosion.*
- API RP 652** Lining of Aboveground Petroleum Storage Tank Bottoms, First Edition, April 1991 (ANSI/API Std 652-1992)
- This recommended practice describes the procedures and practices for achieving effective corrosion control in aboveground storage tanks by application of tank bottom linings to both existing and new storage tanks.*
- API Std 653** Tank Inspection, Repair, Alteration and Reconstruction, First Edition, January 1991 (Supplement 1, January 1992) (ANSI/API Std 653-1992)



The object of this publication is to provide guidance in the inspection repair, alteration, and reconstruction of steel storage tanks used in the petroleum and chemical industries. This standard provides the minimum requirements for maintaining the integrity of welded or riveted, non-refrigerated, atmospheric pressure, aboveground storage tanks after they have been placed in service.

API RP 920

Prevention of Brittle Fracture of Pressure Vessels, First Edition, March 1990 (ANSI/API Publ 920-1992)

This publication offers guidance in the selection of steels for new pressure vessels and in the inspection and operation of existing pressure vessels to minimise the probability of brittle fracture caused by low toughness at temperatures below 120°F.

Publ 939

Research Report on Characterisation and Monitoring of Cracking in Wet H₂S Service

This report presents the experimental methods and findings of a research programme, the main objectives of which were to study the performance in wet H₂S of welded steel plate of various qualities and microstructures, and evaluate the effectiveness of NDE techniques to characterise and monitor the cracking.

API Publ 941

Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants, Fourth Edition, April 1990 (ANSI/API Publ 941-1992)

This publication presents suggested operating limits for steels used in equipment at petroleum refineries and petrochemical plants in which hydrogen or hydrogen-containing fluids are processed at elevated temperatures and pressures.

API RP 945

Avoiding Environmental Cracking in Amine Units, First Edition, August 1990 (ANSI/API Publ 945-1992)

This publication covers problems with environmental cracking of carbon steel in amine units. It provides guidelines for fabrication, inspection, and repair to help ensure safe, reliable operation.

Publ 946

The Effect of Outgassing Cycles on the Hydrogen Content in Petrochemical Reactor-Vessel Steels, First Edition, 1981

This report summarises Battelle Columbus Laboratories' studies on the distribution of hydrogen through petrochemical reactor vessel walls. The collected data allow the estimation of the hydrogen content and distribution through reactor vessel walls during and after shutdown (outgassing) procedures.

Std 1104

Welding of Pipelines and Related Facilities, Eighteenth Edition, May 1994

Standard 1104 covers gas and arc welding for the production of high-quality welds in carbon and low-alloy steel piping used in the compression, pumping, and transmission of crude petroleum, petroleum products, and fuel gases, and where applicable, to distribution systems.



RP 1107 Pipeline Maintenance Welding Practices, Third Edition, April 1991 (ANSI/API RP 1107-1991)

This recommended practice covers recommended maintenance welding practices that may be used when repairing or installing appurtenances on pipeline systems that are or have been in service in the compression, pumping, and transmission of crude petroleum, petroleum products, and fuel gases. It is also intended to apply, where applicable, when making repairs to the distribution piping systems for these products.

RP 1110 Pressure Testing of Liquid Petroleum Pipelines, Third Edition, December 1991

This recommended practice covers the hydrostatic testing of new and existing liquid petroleum pipelines. It recommends minimum procedures to be followed, suggests equipment to be used, and points out factors to be considered during the hydrostatic testing of pipelines. Liquid petroleum pipelines are pressure tested to verify that their test segments have the requisite structural integrity to withstand normal and maximum operating pressure and to verify that they are capable of liquid containment.

Std 2000 Venting Atmospheric and Low-Pressure Storage Tanks: Non-refrigerated and Refrigerated, Fourth Edition, September 1992 (ANSI/API Std 2000-1992)

This standard covers the normal and emergency venting requirements for aboveground liquid petroleum or petroleum products storage tanks and aboveground and underground refrigerated storage tanks designed for operation at pressures from vacuum through 15 pounds per square inch gauge (1.034 bar gauge). Also discussed in this standard are the causes of overpressure of vacuum; determination of venting requirements; means of venting; selection, installation, and maintenance of vents; and testing and marking of relief devices.

Publ 2200 Repairing Crude Oil, Liquefied Petroleum Gas, and Product Pipelines, Third Edition, May 1994

This recommended practice provides guidance to the petroleum industry and others that wish to develop safe practices for the repair of pipelines for crude oil, liquefied petroleum gas, and product service. Although it is recognised that the conditions of a particular job will necessitate an on-the-job approach, the suggestions in this document, which represent a consensus on desirable approaches to repairs, should improve the probability that repairs will be completed without accidents or injuries.

Std 2610 Design, Construction, Operation, Maintenance, and Inspection of Terminal and Tank Facilities, First Edition, July 1994 (ANSI/API 2610-1994)

This standard covers the design, construction, operation, inspection, and maintenance of petroleum terminal and tank facilities associated with marketing, refining, pipeline, and other similar activities. Specific sections of the standard cover site selection and spacing, pollution prevention and waste management, safe operations, fire prevention and protection, tanks, dikes and berms, mechanical system (pipe, valves, pumps and piping systems), product transfer, corrosion protection, structures, utilities and yard, and removals and decommissioning.



A.2.2 Institute of Petroleum:

Model Code of Safe Practice in the Petroleum Industry:-

Part 6	Petroleum Pipeline Safety Code
Part 9	LPG Vol.1: Large Bulk Pressure Storage and Refrigerated LPG
Part 12	Pressure Vessels Systems: Inspection Safety Code
Part 13.	Pressure Piping Systems: Inspection Safety Code

These IP Codes provide a guide to safe practices related to the in-service inspection and testing of equipment used in the petroleum industry. Modification, repairs and inspection gradings are also covered in a manner similar to BP Group RP 32-3.

A.2.3 National Association of Corrosion Engineers (NACE)

RP 0170-93	Protection of Austenitic Stainless Steels and Other Austenitic Alloys from Polythionic SCC during Shutdown of Refinery Equipment
RP0590-90	Recommended Practices for Prevention, Detection and Correction of Deaerator Cracking
MR0175-94	Sulphide Stress Cracking Resistant Metallic Materials for Oilfield Equipment
T8-16F * Committee	Guidelines for the Detection, Repair and Mitigation of Cracking of Existing Petroleum Refinery Pressure Vessels in Wet H ₂ S Environments (* in draft form - June 95).
Publ 8X194	Materials and Fabrication Practices for New Pressure Vessels used in Wet H ₂ S Refinery Service

A.2.4 Engineering Equipment and Materials Users Association (EEMUA)

Publ 149	Code of Practice for the Identification and Checking of Materials of Construction in Pressurised Systems in Process Plants. <i>This document describes the principles and practices of positive materials identification as applied to new constructions.</i>
Publ. 159	Users Guide to the Maintenance and Inspection of Aboveground Vertical Cylindrical Steel Storage Tanks.



This guide is a useful supplement to the BP Guide (BPE.91.ER.049) and API 653, and includes numerous references to the inspection of important tank appurtenances such as vents, seals and drains.

Publ. 168 **A Guide to the Pressure Testing of In-Service Pressurised Equipment.**

This document is a valuable summary of the principles and practices which relate to the pressure testing of equipment which has been in service.

Publ 177 **Selective Guide to the Pressure Systems and Transportable Gas Containers Regulations**

Publ 179 **Working Guide for Carbon Steel Equipment in Wet H₂S Refinery Service (draft)**

A.2.5. **Institute of Chemical Engineers/Chemical Industries Association**

Relief Systems Handbook (1992), ISBN 0 85295 267 8

A thorough and informative review of the whole subject of relief system design, operation and maintenance.

Guidance for Large Scale storage of Fully Refrigerated Anhydrous Ammonia,
ISBN 0 90062 359 4

A.2.6 **CICIND**

Manual for Inspection and Maintenance of Brickwork and Concrete Chimneys (1993)

A comprehensive manual covering the inspection and maintenance of chimneys with brickwork or concrete shells and brickwork or steel linings and with accessible and inaccessible air spaces between shell and lining.

A.2.7 **British Standards Institute**

BS 2853 : 1957 **Specification for the Design and Testing of Steel Overhead Runway Beams**

Specifies the minimum requirements for the design and testing of fixed overhead runway beams made from rolled sections of steel.

BS 3243 : 1990 **Specification for Hand-Operated Chain Blocks**

Requirements for chain blocks to ensure safety in use. Includes performance testing and marking and a system of classification based on ISO 4301.

BS 5045 **Transportable Gas Containers**



Requirements for the materials, design, construction and testing of steel and aluminium alloy gas containers.

BS 5430 : 1990 Periodic Inspection, Testing and Maintenance of Transportable Gas Containers (excluding dissolved acetylene containers)

Periodic inspection, testing and maintenance requirements to establish suitability of containers for future service.

BS 6129: Pt 1: 1981 Metallic Bellows Expansion Joints

Guidance on selection, application and location of various forms of joints with particular reference to choice of materials, shop tests, packing, protection, installation, system tests and maintenance.

BS 8010 Code of Practice for Pipelines

The scope of this CP covers landlines in a variety of materials, steel lines for oil and gas, and subsea pipelines.

PD 6493 : 1991 Guidance on Methods for Assessing the Acceptability of Flaws in Fusion Welded Structures

Simplified treatment of use of fracture mechanics methods to establish acceptance levels based on fitness for purpose. Applies basically to fusion welded joints in ferritic steels, austenitic steels and aluminium alloys.

PD 6510 : 1983 A Review of the Present State of the Art of Assessing Remanent Life of Pressure Vessels and Pressurised Systems designed for High Temperature Service

Review of the techniques which are available to demonstrate the continuing fitness for purpose of high temperature of pressurised systems, including the use of operating history, physical examination and interpretation of observations, metallographic techniques, post exposure tests, environment effects, creep and fatigue, and statistical methods.



PART B - TECHNICAL GUIDANCE

SECTION B.1 COMMON REQUIREMENTS

The following are common requirements, but should be interpreted in relation to the specific type of equipment under consideration.

B.1.1 Legislative Requirements

Many items of equipment are subject to varying degrees of legislative control relating to their design, construction, inspection and operation depending on the country in which the equipment is being operated.

Conditions range from total statutory inspection of all equipment by government authorised or approved agencies, to a complete absence of statutory regulation.

B.1.2 Preparations for Inspection

Appropriate preparations must be made to enable a meaningful inspection or examination to be conducted.

This will include the following as appropriate:-

- (a) Isolation
- (b) Opening up
- (c) Cleaning and gas freeing
- (d) Obtaining the necessary permits to work
- (e) Removal of internal fittings or components as appropriate
- (f) Provision of facilities for access, both internal and external
- (g) Removal of insulation, passive fire protection and any other form of covering
- (h) Provision of personnel aids such as lights or lighting, ropes, gangways, breathing apparatus etc.
- (i) Provision of test equipment

(j) Provision of the necessary utility services

The inspection authority should advise its probable requirements in advance.

Prior to field inspection, it is essential that previous reports and other relevant data is consulted to get a full appreciation of the previous condition of the equipment and the probable areas of deterioration.

The importance of this data gathering and analysis stage cannot be overstated, particularly for equipment types which are inherently difficult to inspect thoroughly on account of limited access/visibility e.g. heat exchanger bundles, boiler tube banks.

"Relevant data" in this context would include the following:-

- (i) Previous inspection, maintenance and failure investigation reports
- (ii) Details of recent operating conditions, particularly if these have departed from design
- (iii) On-stream factors, cyclic operation
- (iv) On-stream condition monitoring/corrosion monitoring data
- (v) Corrosion control design and operation data e.g. inhibitor/neutraliser injection, pH control wash water injection, oxygen scavengers, boiler feedwater treatment, fuel oil/gas quality control
- (vi) Details of any relevant modifications

B.1.3 Testing

B.1.3.1 Strength Testing

The statutory legislation of some countries requires periodic strength tests of pressure vessels, pressure envelopes, piping systems or lifting appliances, to verify and demonstrate their continued fitness for service.

Strength tests should also be applied when repairs or modifications have been carried out that could affect the integrity of the pressure shell or the lifting appliance.

B.1.3.1.1 Hydraulic Testing

B.1.3.1.1.1 Safety Factors



The following safety factors must be borne in mind whenever conducting strength tests:-

- (a) The equipment foundation and supporting structure must be checked for their ability to support the combined weight of the equipment and the liquid required to fill it.
- (b) Precautions must be taken to avoid the possibility of test fluids freezing or expanding in a closed test system, either of which could lead to rupture of a shell or pressure envelope.
- (c) When filling vessels, equipment or pipes, adequate vents must be provided to avoid entrapped air.
- (d) When emptying vessels, adequate vents must be provided to avoid the possibility of drawing a partial vacuum in a pressure vessel shell.
- (e) In determining test pressures, due allowance should be made for the actual condition of the equipment under consideration. Usually, the equipment is not in the 'new and cold' condition of original construction. The test pressure should be gradually applied.
- (f) The specified test pressure includes the amount due to static head acting at any point under consideration. Particular care should be taken when applying an hydraulic test to a vertically-mounted vessel, which may have been initially tested in the horizontal plane.
- (g) Care must be taken to ensure that pressure-indicating devices used in tests are properly connected and accurately calibrated.
- (h) Care must be taken to ensure that the materials of construction have the required ductility at the test temperature. In some cases, it may be necessary to raise the temperature of the test fluid to provide a safeguard against brittle fracture.

B.1.3.1.1.2 Test Fluid

Water will normally be used. For austenitic stainless steels, the water should preferably be condensate or demineralised, and contain less than 30 ppm chloride ions.

Other test fluids may be used for process reasons or where there is risk of freezing. Such fluids should have a flash or boiling point well above the anticipated test temperature.



Hydrocarbon fluids such as kerosene or gas oil have considerable capillary attraction but the leakage rate of these fluids under pressure through a small orifice or leak path is considerably less than that for water. The consequences of failure and major loss of containment should be considered prior to specifying hydrocarbons as test fluids.

B.1.3.1.2 Pneumatic Testing

Pneumatic strength testing of equipment that has not previously been hydraulically tested should be avoided, because of the potential hazard of the release of stored energy. On the occasions when no other form of strength test can be applied a pneumatic test may be used, provided the following precautions (additional to those relevant in B.1.3.1.1) are taken:-

- (a) The test should be carried out under the direct supervision of a suitably competent person.
- (b) The equipment to be tested should be subjected to as thorough an examination as possible prior to testing, including the use of NDT as necessary.
- (c) Except where it is necessary to meet design code or statutory requirements, the test pressure should be limited to 110% of the maximum allowable working pressure, should be applied in small increments, and should be reduced to a pressure not exceeding the maximum allowable working pressure before any close examination is carried out.
- (d) A safety valve should be fitted to the vessel or system being tested, set to relieve at a pressure marginally above the test pressure and of adequate discharge capacity.

B.1.3.1.3 Duration of Test

The test pressure should be held for a sufficient length of time to allow:-

- (a) All parts of the equipment under test to be examined
- (b) Sufficient time for any weakness or defects in the equipment to manifest themselves and to be observed

B.1.3.1.4 Test Temperature

The temperature of the material under test (and the test fluid) should be above that at which a brittle failure may be initiated. Account should be taken of the possible shift of the notch ductility transition temperature of certain materials exposed to high temperatures or a hot charging hydrogen atmosphere for long periods.



Special care should be exercised when pneumatic tests are conducted with works compressed air since the auto refrigeration effect of rapid depressurising can significantly lower the temperature of it and the material under test.

For further guidance on the subject of pressure testing reference should be made to EEMUA publication 168.

B.1.3.1.5 Load Testing

Certain items of equipment such as lifting appliances may require load testing at pre-determined intervals.

Such load tests may require deflection measurements of beams and struts during the application of the load and the demonstration of full traverse and lift, except where slewing or luffing may lead to undesirable overload conditions. When applying test weights care must be taken to ensure that the load on the lifting appliance is distributed as for its normal use, otherwise local deformation may occur.

B.1.3.2 Leak Testing

Leak testing is for the purpose of detecting leakage paths through the pressure shell in either direction. The methods used may be water or air pressure test or the use of trace gases. Leakage detection may be visual or by measurements of pressure drop or pressure or vacuum decay rate, trace gas response to detection instruments, audible, ultrasonic.

The pressures applied should, in the case of trace gas techniques, be of a very low order and for audible or visual techniques, be related to the working pressure of the vessel with a small multiplying factor, but should not in any circumstances exceed 110% of the maximum allowable working pressure. When trace gases are used it should be recognised that gasketed joints will often allow minor leaks and these should be isolated from the test or suitable acceptance limits identified.

Leak testing is also used to detect leakage paths through heat exchanges tube to tubesheet joints, sometimes at low pressures using gases such as helium.

B.1.3.3 Non-Destructive Testing

Various forms of non-destructive testing may be used during shutdown overhaul, or inspection periods and may include such conventional techniques as ultrasonic (flaw detection and wall thickness measurements), radiography, dye-penetrant, magnetic particle, eddy current and similar methods, supported by other equipment such as cameras, introsopes, microscopes, miniature television cameras, thermal imaging cameras, associated infra-red equipment, surface replica techniques, metallurgical analysis, failure analysis, etc.

It may be necessary to obtain the information while the equipment is still in operation. Examples of the capabilities and typical applications of on-stream NDT/condition monitoring techniques are shown in the following table:-



TECHNIQUE	DETECTION OF
<i>Visual</i>	<i>External corrosion, cracking, vibration, bulging, overheating etc.</i>
<i>Ultrasonics</i>	<i>Various cracking problems e.g. fatigue, stress corrosion, hydrogen-induced</i> <i>Reduction in material wall thickness due to corrosion or erosion.</i>
<i>Radiography</i>	<i>Corrosion, erosion, cracking, fouling</i>
<i>Magnetic Particle Inspection/Dye-Penetrant Inspection</i>	<i>Surface opening cracks</i>
<i>Eddy-Current Testing</i>	<i>Surface opening cracks and their depth</i>
<i>ACPD (Alternating current potential drop)</i>	<i>Surface opening cracks and their depth</i>
<i>Magnetic Flux Leakage</i>	<i>Corrosion of transmission pipelines</i>
<i>Thermography</i>	<i>Loss of thermal insulation (refractory), detection of wet lagging, furnace tube temperatures, internal fouling</i>
<i>Hot Camera</i>	<i>Internal condition of chimney stacks</i>
<i>Dimensions</i>	<i>Creep, distortion</i>
<i>Surveying</i>	<i>Settlement of structures, tanks etc.</i>
<i>Coring</i>	<i>Concrete condition, carbonation, delamination</i>
<i>Corrosion Monitoring</i>	<i>Internal corrosion</i>

For rotating machinery, condition monitoring may require information from vibration measurement, on an ad hoc or continuous basis, change of physical property (lubricating oil) by ferrography, change of performance such as monitoring of separation or thermodynamic efficiencies.

There are several specialist methods to assess the condition of equipment or structures covered by insulation or passive fire protection without the need to remove it. These include:-

- (a) Thermographic imaging*
- (b) Neutron back scatter and heat flux measurement*

(c) *Flash radiography*

New methods and techniques, and new applications of existing NDT methods are being developed continuously and, where appropriate, procedures should be modified to take advantage of enhanced techniques.

B.1.3.4 Destructive Testing

This can be carried out on specimens of the materials of construction and welds, to determine the metallurgical and mechanical properties of those materials.

e.g. Yield and tensile strength, fracture toughness, creep strength, microstructure, etc.

B.1.3.5 Functional Testing

This is carried out by the application of simulation of service conditions to determine that the equipment will operate satisfactorily.

e.g. Safety valve testing, governor overspeed trips, emergency trips, alarms and other protective devices, etc.

B.1.4 Re-Rating

If due to process changes, design changes or deterioration of plant or equipment as a result of service conditions, it is necessary to re-rate such equipment for operation at other levels of pressure, temperature or mechanical loading, then appropriate new design calculations should be made and approved, inspections carried out and the details recorded in the equipment records. Particular care should be taken to ensure that the associated safety devices are re-set or renewed for the new design and operating conditions. All re-rating exercises should be conducted under the site "Management of Change" procedure.

B.1.5 Repairs

Repairs made to any registered item of equipment should be formally authorised and approved. The system should ensure that the design, inspection and test requirements are fully considered.

Where the original criteria cannot be met, the equipment will require to be re-rated (see B.1.4) and appropriate considerations made regarding its new allowable maximum operating limits.

Strength or load testing will normally be required following significant repair or modification to equipment. If these cannot be carried out, other means of verifying the condition of the equipment must be employed.

B.1.6. Modifications

Significant physical modifications to registered items of equipment should be formally authorised and approved under the site "Management of Change" procedure. This procedure should involve the relevant Inspection Authorities to ensure that the original design intent has not been compromised, and that future inspection, testing and maintenance requirements have been taken into account.

A common problem here is the definition of the type of physical modifications which are "significant" and which therefore need to be formally implemented by MOC procedures. The fitting of new nozzles or connections into a pressure vessel, or the resetting of a safety relief-valve, are clear examples of where the full MOC procedure must be rigorously applied. On the other hand the renewal, in kind, of a component is clearly a repair for which no design approval procedure is required. But between these extreme cases are potential grey areas, examples of which might be:

- (a) *change of vessel internal lining specification*
- (b) *heat exchanger bundle retubing using heavier gauge tubes*
- (c) *pipework replacement in heavier schedule*
- (d) *change of joint design (butt weld, socket weld, screwed)*
- (e) *change of welding consumable*
- (f) *retrofitting of wear plates, patches, stiffeners, supports*
- (g) *permanent removal of insulation*
- (h) *additional flanged joints to facilitate inspection/maintenance*

Some sites deal with these kinds of "minor modifications" using a streamlined approval procedure, and this approach is generally favoured. Inspection personnel should receive clear guidance in this area, and should avoid making repair recommendations which involve modifications unless the appropriate approval procedure has been or will be completed prior to the modification being made.

B.1.7 Risk-Based Inspection

BP Group [RP 32-3](#) recommends a risk-based approach to the allocation of inspection grades by taking into consideration both the probability and the consequence of failure (refer BP Group [RP 32-3](#), para. 5.2.2). The use of criticality rating systems is also discussed.

Historically there has been a tendency for inspection personnel at some sites to place too much emphasis on equipment reliability (probability of failure) in allocating inspection grades, with inadequate consideration of the safety and/or financial consequences of failure. This has sometimes led to excessive inspection effort being expended on low criticality equipment. Various models now exist to derive equipment criticality in a more balanced, consistent and auditable manner, and the use of these models is generally encouraged.



In a typical system, equipment is categorised by criticality into, say, five groups i.e. high risk, medium - high risk, medium risk, medium - low risk and low risk.

Inspection intervals and scope for high risk equipment should generally coincide with the requirements for Grade 0; medium - high risk with Grade 1; medium risk with Grade 2; medium - low risk with Grade 3.

For low risk equipment, inspection intervals and scope can either be established which are even less onerous than for Grade 3, or a decision can be made to allocate the equipment to Class C (ref. BP Group [RP 32-3](#) para. 5.3).

Criticality ratings should be regularly reviewed, particularly in the light of inspection findings. Although the consequence of failure is unlikely to change, the probability of failure may well change as the equipment ages and as deterioration rates are more accurately assessed.

B.1.8 Fitness for Service Assessment (FFSA)

FFSA methods are finding increased application for the analysis of defects which exceed Code "Workmanship" tolerances eg. cracks, localised thinning due to wear or corrosion. These methods can also be used to provide a technical justification for non-invasive inspections, based on the calculated defect tolerance criteria of the item, and the sensitivity of the inspection techniques employed.

FFSA will usually require specialised assistance since concepts of fracture mechanics are applied, typically using procedures in [BS PD 6493](#) or [API RP 579](#). It is important that Inspection Engineers are at least familiar with the principles of FFSA.

B.1.9 Remanent Life Assessment (RLA)

In the context of this document, RLA refers to those methods and procedures which estimate the remaining life of high temperature components which are working in the creep range of the material (or which could enter the creep range due to associated degradation mechanisms).

RLA will usually require specialised assistance. Once again, it is important that Inspection Engineers are at least familiar with the concepts involved.

PART B - TECHNICAL GUIDANCE

SECTION B.2 STEAM BOILERS

B.2.1 Introduction

This Section applies to all forms of steam boilers of all types of construction and will apply to both direct fired boilers and waste heat boilers or generators utilising the waste heat of gases or process fluids.

B.2.2 Guidance Documents

API RP 573	Inspection of Fired Boilers and Heaters
ASME Section VII	Recommended Rules for the Care of Power Boilers
HSE Gdnce Nt PM5	Automatically Controlled Steam and Hot Water Boilers
BP Oil US RP 20-4-5:	In-Plant Inspection of Existing Boilers
NACE RP0590	Recommended Practices for Prevention, Detection and Correction of Deaerator Cracking
BPE.90.ER.174	Remanent Life Assessment

B.2.3 Inspection Frequency

The interval between boiler inspections will usually be governed by the relevant statutory controls. Where none exists, UK legislation may be used as a guide (see Part C of this RP) since this scheme is essentially self-regulatory.

Inspection intervals for directly-fired boilers will generally be dictated by the following:-

- (a) the feedwater quality (refer BP Group [RP 56-2](#))
- (b) firing control i.e. avoidance of flame impingement and local overheating
- (c) fuel quality, particularly sulphur and metals content which can lead to hot corrosion of uncooled furnace parts, and acid dewpoint corrosion and fouling at the cold end of the boiler



- (d) steam temperature and drum water level controls
- (e) the age of parts operating in the creep range and the need to perform remanent life assessments.
- (f) safety valve reliability
- (g) specific inspection and maintenance history of the boiler

Inspection periods greater than 14 months should only be considered where water quality is excellent or effective water treatment is maintained, and the boilers have well maintained control systems.

Note that BP Group [RP 32-3](#) does not recommend the allocation of Grade 3 to direct fired boilers, and that the maximum recommended inspection interval for Grade 2 is 72 months.

In the case of waste heat boilers or generators utilising waste heat gases or process fluids, where the rate of deterioration can be predicted with accuracy, the inspection frequency may be related to the associated parent equipment.

B.2.4 Inspection Procedures

Statutory inspection requirements may not fully meet BP's need for longer-term reliability forecasting, and additional inspection will normally be carried out. This is particularly relevant to waste heat boilers or superheaters which are part of a continuous flow process plant.

It is recommended that all site-specific inspection procedures for boilers incorporate a checklist which should include all known areas of vulnerability. A typical checklist for a direct fired utility boiler is given below:-

- ladders, walkways, platforms
- foundations, supports
- boiler casing and insulation
- piping leaks and CUI
- furmanited/clamped leaks
- forced draft fan, air ducting and air preheater
- flue gas ducting and induced draft fan
- external pressure parts, headers, downcomers
- sootblowers
- steam drum and internals
- water drum
- furnace tubes
- superheater tubes/headers
- convection/economiser tubes
- refractory



- burners and burner tiles
- manholes/peepholes
- safety valves (overhaul)
- bellows/expansion joints
- gauge glass connections
- dampers and controls
- hydrotest
- safety valve (float)
- isolation valves
- blowdowns
- protective instrumentation

B.2.5 Safety Devices

For steam boilers subject to statutory control, the requirements for safety devices and other fittings and attachments are normally included in the regulations. The inspection procedures for safety devices are covered in Section B.9 of this RP.



PART B - TECHNICAL GUIDANCE

SECTION B.3 UNFIRED PRESSURE VESSELS

B.3.1 Introduction

This Section applies to process pressure vessels and pressure storage vessels including towers, columns, reactors, drums, heat exchanger shells, spheres, steam receivers and air receivers.

In many countries the inspection of pressure vessels is subject to statutory control. These requirements are usually solely for confirming the integrity of the pressure shell for the period up to the next inspection.

BP's operational requirements will normally dictate that the inspection of all pressure vessels be concerned with establishing the long-term life of the shell, the condition of vessel supports, foundations and any internal lining and fittings as applicable, and the need for repairs.

B.3.2 Guidance Documents

API 510	Pressure Vessel Inspection Code
API RP 572	Inspection of Pressure Vessels
IP Model Code of Safe Practice	Part 12: Pressure Vessels Systems: Inspection Safety Code
API RP 920	Prevention of Brittle Fracture of Pressure vessels
NACE RP 0590	Recommended Practice for Prevention, Detection and Correction of Deaerator Cracking
NACE RP	Guidelines for the detection, Repair and Mitigation of Cracking in existing Petroleum Refinery Pressure Vessels in Wet H2S Environments
EEMUA Publ 168	A Guide to the Pressure Testing of In-Service Pressurised Equipment
BPE.90.ER.174	Remanent Life Assessment



ETC.82.ER.032	Guidance Notes on the Avoidance of Brittle Fracture in Operating Equipment
ESR.93.ER.003	Detection of Hydrogen Damage in Carbon 1/2 Molybdenum Material
BP Oil US RP 20-4-3	In Plant Inspection of Existing Pressure Vessels
BP Oil US RP 7-3-1	Re-rating Pressure Vessels

B.3.3 Inspection Frequency

The choice of inspection frequency is primarily a matter of making the correct Inspection Grade/criticality assessment, and should include the following factors:-

- (a) Statutory regulations (where applicable).
- (b) The quality of internal linings.
- (c) Information derived from on-stream inspection or current service conditions.
- (d) The possible effects of cyclic operation, from both thermal and pressure loading.
- (e) The possible effects of high temperature exposure and any requirement to make a remanent creep life assessment.
- (f) Degradation of the pressure shell material due to exposure to conditions it was not designed to withstand.
- (g) Consequences of failure.
- (h) Process needs e.g. to change catalyst

B.3.4 Inspection Procedures

Site specific procedures should be developed, using the guidance documents listed in B.3.2. The following additional guidance is offered.

B.3.4.1 Lined vessels



Linings are applied internally to protect the pressure shell from thermal, corrosive or erosive conditions which, should the lining fail, will expose the pressure shell to conditions which it was not designed to withstand. It is the possibility of, and the consequences arising from, failure of the lining which must be taken into account when deciding on the inspection interval, together with the speed and facility with which lining failures may be detected whilst the vessel is in service.

B.3.4.2 Internal Fittings

The presence of internal fittings and the difficulties of removing some of them will be a further factor influencing inspection intervals. Parts of the shell may be inaccessible and it is often those areas which may be most susceptible to corrosion due to an inability to clean the areas adequately, creating a trap for a corrosive environment.

At some stage, it will be necessary to remove all or representative sections of internal fittings so that the shell can be adequately examined consistent with the requirements of a thorough inspection.

B.3.4.3 External Lagging and Cleading

Sections of the outer surface of the shell should be examined at each thorough inspection, including locations of possible water ingress, and such points as holding-down bolts, skirt attachments or the surfaces under saddle supports. However, at intervals equal to the Grade 3 allocation, sections of the lagging and cleading should be removed to expose the outer surfaces to detect the presence and extent of external corrosion, especially if the vessel is in intermittent service or operates in the temperature range 0-150°C.

Vessels constructed of austenitic steels should be particularly examined at areas of stress concentrations for possible surface cracking due to chloride ions from atmospheric sources, or leached from the insulation, which may accumulate and concentrate. Austenitic stainless steel vessels which operate in the 40° - 200°C range are particularly at risk.

B.3.4.4 Stress-Relieved or Heat Treated Vessels

Vessels which have been stress-relieved or heat-treated as part of their manufacturing process should not be subject to welding repairs or hot work of any kind without approval of a BP metallurgical or welding specialist. The welding procedure, materials, weld set-up, equipment and final heat treatment (if any) should also be approved.

B.3.4.5 Spheres

In addition to the normal thorough examination of all internal surfaces, particular attention should be paid to the external support legs, particularly when these legs are fireproofed.



Experience indicates that it is common for heavy corrosion to take place on the support legs behind the fireproofing due to faulty sealing allowing ingress of water.

During any in-service hydrostatic test due care shall also be taken not to overload the sphere by overfilling with water. In some cases, spheres are designed using a liquid loading based on the specific gravity of the actual product, and filling to 100% with water may overload the legs - particularly if corrosion has weakened them appreciably.

B.3.4.6 Horizontal Storage Vessels or Drums

Whilst the design of the vessels is conventional, care must be taken to check for corrosion at the points of support.

Faulty sealing, allowing ingress of rain water, has been known to cause heavy, rapid corrosion and such locally-corroded areas are subjected to additional local loadings - in addition to bi-axial stresses due to internal pressure - as a result of the stresses due to the reactions at the supports and the bending moments.

B.3.4.7 Inspection Checklists

Typical pressure vessel checklists should include:-

- ladders, walkways, platforms, stairways
- supports, foundations, anchor bolts, skirts
- under lagging/underfireproofing corrosion
- shell internal/external
- heads internal/external
- nozzles and manways, internal/external, flanges, bolting
- earthing
- instrument connections, bridles, standpipes
- external painting/insulation
- internal linings/coatings
- internal fittings
- davits, lifting devices, lifting lugs

B.3.5 Safety Devices

The inspection procedures for safety devices are covered in Section B.9 of this Code. Where their inspection frequency is different from that quoted for the pressure vessel, it may be necessary to consider their duplication and isolation to permit removal of one device whilst retaining full protection.

B.3.6 Pressure Testing

The strength testing requirement for pressure vessels following a period of service is a subject of some complexity, but as a general rule,

pressure vessels should not be subject to regular or periodic tests except where:-

- (a) Statutory regulations make it a mandatory requirement.
- (b) Repairs or modifications have been made and the basic design, strength, and integrity of the vessel must be verified.
- (c) The pressure vessel is to be re-rated.
- (d) Lack of internal access prevents meaningful inspection and a hydraulic test is acceptable in lieu.

It is not normally necessary nor desirable to pressure test thick wall vessels or reactors. This is partly because they are not usually subject to modifications or repairs, but also because of the risk of initiating a brittle fracture.

It should also be remembered that pressure testing gives a degree of assurance at a point in time only, and gives no information on deterioration rates or inherent faults which are sub-critical at the time of the test.

B.3.7 Modification and Repair of Pressure Vessels

Significant variations can occur in the design, modification and repair requirements for vessels according to the original design code used.

The design calculations are often of a complexity such that modifications or repairs must not be carried out unless authorisation is obtained. Equally, the materials used may have been subject to special heat treatment following forming and welding, and care should be taken not to destroy or diminish the mechanical properties of the materials by further hot work.

Authorisation for the welding procedures and materials should be obtained from the appropriate BP engineering authority, with specialist advice and to the satisfaction of the inspection authority.

PART B - TECHNICAL GUIDANCE

SECTION B.4 LIFTING EQUIPMENT

B.4.1 Introduction

This Section applies to lifting machines, lifting tackle, lifting gear, lifting appliances, hoists and lifts.

B.4.2 Inspection Frequency

The interval between inspections will generally be governed by the relevant statutory controls. In countries where none exists UK legislation may be used as a guide in formulating an inspection control system.

A summary of the various UK Regulations applicable to lifting equipment is provided in Part C of this RP.

B.4.3 Inspection Procedures

B.4.3.1 Preparation for Inspection

The adequate and thorough inspection of a lifting appliance may of necessity require certain preparations, e.g.

- (a) the provision of access
- (b) the cleaning and dismantling of equipment
- (c) the provision of test equipment
- (d) the transportation of equipment to be inspected to a suitable location
- (e) the presence of operational personnel

B.4.3.2 Periodic Thorough Inspections.

Are required, to ensure that:-

- (a) Statutory requirements, including the provision of necessary information, are satisfied.
- (b) Detailed reports on the condition of lifting appliances are produced.

- (c) The integrity of lifting appliances is maintained by routine examination to determine the extent of any corrosion wastage, structural defects or mechanical damage.
- (d) Lifting appliances in need of repair are reported and withdrawn from service until properly repaired (where repair possible), and that the statutory authority and user (or owner) are advised accordingly.
- (e) New, altered or repaired lifting appliances are proof tested, prior to being taken into use.

In order to verify the continued fitness for service of lifting equipment it may be necessary to obtain specialist assistance during the thorough examination of such equipment.

PART B - TECHNICAL GUIDANCE

SECTION B.5 STORAGE TANKS

B.5.1 Introduction

This Section applies to tanks which are used for the storage of fluids at atmospheric pressure, or at a low positive pressure normally not exceeding 56 mbar.

B.5.2 Guidance Documents

BPE.91.ER.49	Tank Maintenance Inspection and Repair
API Std 653	Tank Inspection, Repair, Alteration and Reconstruction
API RP 575	Inspection of Atmospheric Storage Tanks (In preparation)
EEMUA Publ. 159	Users Guide to the Maintenance and Inspection of Aboveground Vertical Cylindrical Steel Storage Tanks
BP Oil US RP 11-1-5	Tank Inspection, Repair, Alteration and Reconstruction
Chemical Industries Association	Guidance for Large Scale Storage of Fully Refrigerated Anhydrous Ammonia

B.5.3 Inspection Frequency

The subject of storage tank inspection frequency is dealt with in depth in the BPE Report referred to above. The recommended intervals shown in Table B.5.1 derive mainly from this report.

The 'regular visual' inspections relate to routine checks by operations staff and are particularly relevant to floating roof designs (checks on roof pontoons, seals, drainage, leakage, vents, rolling ladder, etc.). It is recommended that such operational 3-6 monthly inspections are performed against site-specific checklists, and that an auditable record of inspections is maintained.

The 'thorough' external inspections relate to planned thorough on-stream examinations by qualified or suitably experienced inspection staff. These may or may not include ultrasonic thickness surveys, dependent upon the tank duty, internal coatings and previous history.

The following supplementary notes to the Table are also taken from the BPE Report.



"Table B.5.1 has been compiled with information received following the circulation of a questionnaire on the subject of product storage tank leaks. On the basis of these returns, the overall percentage of tanks found to have floor leaks was 8%.

The probability of tank floor leaks increases with age. Comparing leaks with age of tank reveals the following:-

Tank Age	Total Numbers (1908)	% Tanks in Age Group	Tanks in Age Group with leaks
0 - 10 years	125	6.5	-
10 - 20 years	195	10	3
20 - 30 years	707	37	7
30 - 40 years	450	23.5	7
over 40 years	431	23	16.5

Of the tanks with leaks, about 50% were discovered at the time of cleaning and inspection, the remainder were found by some other means. We can only speculate as to the number of tanks that may be leaking without our knowledge. However, it is possible that more tanks may be leaking without giving any indication. This has proved to be the case in locations where non-invasive inspection techniques have been employed.

Of all tanks found to be leaking and repaired, 16.5% leaked subsequently.

These results demonstrate the need for increased vigilance and an enhanced tank inspection programme for tanks over 40 years old. Tanks receiving product from ships where lines were cleared with sea water (a practice abandoned some 15 years ago) had a much higher probability of leakage than other tanks. The same will be true for tanks that used water bottoms and no protection. It is suggested therefore that for tanks under 40 years old, that have operated with water bottoms or with the water flushing of pipelines, should be subjected to an enhanced inspection programme.

In view of this experience, it is suggested that the frequency for Group 3 tanks be increased to a maximum of 8 years for tanks with bottoms over 24 years old that have operated with water bottoms, and to every 4 years for tanks with bottoms over 40 years old. These suggested values can of course be varied depending on the history of the site and tank, in particular, with due credit given for bottom painting."

B.5.4 Inspection Procedures and Checklists

Site-specific procedures should be developed for all the main design types i.e. fixed roof, floating roof, refrigerated. The documents listed in para. B.5.2 contain ample guidance to do this, and they also include checklists.

MAXIMUM RECOMMENDED INTERVALS BETWEEN INSPECTIONS					
CLASSIFICATION	SERVICE CONDITIONS	External Regular Visual (Mths)	External Thorough (Yrs)	Internal Sample of Single Tank (Yrs)	Internal Max for Group (Yrs)
Group 1	Slops, corrosive or aggressive chemicals, raw water, brine. No coating, carbon steel construction	6	1	3	10
Group 1A	With proven internal coating	6	3	7	12
Group 2	Refrigerated storage for butane/propane, natural gas, ammonia, nitrogen	6	3	Not required, except for ammonia (see B.5.2)	Not required, except for ammonia (see B.5.2)
Group 3	Crude oil storage, intermediate products, i.e. white oil storage, treated water	6	3	8	16
Group 4	Fuel oil storage, gas oil and lub oil storage. Inert or non aggressive chemicals	6	3	16	20
Group 5	JET A1 (Fully coated)	6	3	15	30
Group 6	Light product kerosine gasoline cracked distillates and JET A1 (uncoated)	6	3	10	20

Note 1 For tanks with proven internal protective coatings, linings or materials, consideration may be given to a further extension of the intervals.

Note 2 Sample inspections in accordance with BP Group [RP 32-3](#) may be deemed to meet the full requirements of this Table, at the discretion of the inspection function.

TABLE B.5.1
INSPECTION INTERVALS FOR STORAGE TANKS



PART B - TECHNICAL GUIDANCE

SECTION B.6 HEAT EXCHANGERS

B.6.1 Introduction

This Section applies to shell-and-tube heat exchangers, condensers, coolers, plate exchangers and air cooled exchangers of which there are a wide variety of designs and types. Since it is not practicable to provide detailed guidance on all the various designs, attention will be given to the most common ones only, i.e.

- shell-and-tube, TEMA-type
- double pipe exchangers
- plate exchangers
- air-fin coolers

However, the principles of inspection of these designs are generally applicable to all other designs.

B.6.2 Guidance Documents

ESR.95.ER.035	Evaluation of NDT Techniques Used in the Inspection of Heat Exchanger Tube Bundles
API RP 572	Inspection of Pressure Vessels
BP Oil US RP 8-1-2	Tube Bundle Replacement

B.6.3 Common Requirements

In certain countries, the pressure containing parts such as the shell, bonnet, channel, headers, tubes, etc. will be considered as pressure vessels and subject to statutory control and survey by external inspection authorities. The principles of pressure vessel inspection are addressed in Section B.3, and are applicable irrespective of legislative requirements. The following additional items particularly relevant to exchangers should be addressed as appropriate:

- (a) corrosion or mechanical damage to gasket faces
- (b) damage to protective coatings or metallic linings
- (c) excessive wastage of sacrificial anodes
- (d) deformation of division plates



- (e) circumferential grooving of shell internal at baffle locations
- (f) scoring of shell caused by bundle pulling

B.6.4 Inspection Frequency

The choice of inspection frequency, as listed in BP Group [RP 32-3](#) Table 1, is primarily a matter of Inspection Grade/Criticality assessment. Technical guidance for the four most common exchanger designs is provided in the following paragraphs, with particular emphasis given to the inspection of tube bundles.

B.6.5 Shell-and-Tube (TEMA-type) Designs

B.6.5.1 Preparatory Work

Shell and tube exchanger bundles are difficult to inspect on account of the limited visibility on both sides. In order to stand a good chance of making an accurate assessment of an exchanger's condition, the inspector should know:-

- (a) the design and operating conditions on both sides
- (b) the process streams on both sides and their corrosivity
- (c) the materials of construction
- (d) the most likely deterioration mode(s) and location(s)
- (e) full details of the exchanger's inspection, operational and maintenance history

In addition it is important to know the criticality of the exchanger to the unit, and understand the likely consequence of an internal leak. This criticality will have a major influence on the scope of the inspection, the use of specialised NDT techniques and any repair recommendations.

Fixed tubesheet designs are not capable of being dismantled, and so other means must be provided to facilitate a thorough examination of the shell, usually involving NDT.

B.6.5.2 Inspection of Bundles

- (1) The degree of fouling on each side of the bundle should be recorded, photographically if severe. Samples for analysis may prove useful if the origin of the foulants is unclear, or if the

presence of corrosion products is suspected. Local fouling can be indicative of corrosion in these areas. Copper alloy corrosion products are usually green or blue.

- (2) Bundle cleaning should be sufficiently thorough to permit a detailed inspection: inspection of dirty bundles should be avoided.
- (3) Tube/baffle distortion and mechanical damage are usually fairly obvious and are best recorded photographically. Unacceptably severe damage to tubes should be addressed by (preferably) renewal, or taper plugging
- (4) Corrosion of baffles, tie-rods and spacers is also usually fairly obvious and should be recorded: enlargement of the baffle holes should also be checked (e.g. due to vibration and fretting).
- (5) Tubesheets should be visually checked, both sides if possible, for evidence of corrosion, erosion, distortion, mechanical damage. Brass tubesheets should be examined for evidence of dezincification.
- (6) Tube ends should be visually checked for thinning, impingement erosion and cracking. Ferrules should be removed as necessary to permit a thorough inspection, and damaged ferrules should be renewed. Locations of any plugged-off tubes should be checked against the previous Inspection Report.
- (7) Tube end welds should be visually examined for evidence of preferential corrosion and cracking. Crack detection by NDE should also be considered.
- (8) Tube internal surfaces should be examined using specialised NDT and/or a boroscope, especially when the tubeside stream is corrosive. Tube inside diameters should be recorded at representative locations at both ends. Particular attention is required for copper alloy bundles in sea water service where fouling and tube end erosion are frequent problems.
- (9) Tube external surfaces of copper alloy and steel bundles should be visually inspected and carefully hammer tested over the full bundle length and from top to bottom; rotation of the bundle is normally required to achieve this. Hammer testing is not recommended for thin wall tubes. General roughening, pitting and grooving at the back of the tubesheets and at the baffle

locations should be recorded, and outside diameter measurements taken at representative worst areas. Particular attention should be paid towards erosion of the tubes adjacent to the shell inlet nozzles and impingement plates. Dependent upon the baffle design there may be 'dead-spaces' between the end baffles and tubesheets - areas where fouling and under-deposit corrosion are common.

Titanium, stainless steel and other CRA bundles are usually very reliable, but can deteriorate due to localised corrosion (pitting, crevice, scc). They should not be hammer tested.

Tube extraction, if possible, should be considered when the above listed inspections and the bundle history leave any doubt about the ability to operate for another run without leakage. This requirement applies mainly to critical bundles whose failure in service would result in production loss, or when retubing would be difficult or uneconomic within a unit overhaul. Tubes should be selected for extraction based upon the results of visual and/or specialised NDT, ensuring adequate coverage of the bundle cross-section. Typically, about 2% minimum of tubes should be extracted, and then split for about 1m at each end for visual inspection and determination of minimum wall thickness using a point micrometer. Grit blasting both sides of the tubes after splitting will improve accuracy of measurements. Similar tube inspections should be made on bundles being re-tubed or replaced.

Specialised NDT techniques should be considered for high criticality bundles, especially if tubes cannot be easily extracted e.g. welded and "U" tube designs. The options include:-

- (a) 'Steeltest' a relatively fast magnetic flux leakage screening technique for steel bundles, normally followed up by selective tube extraction or a more sensitive technique such as IRIS.
- (b) "IRIS" a slower but more accurate ultrasonic technique applicable to most materials.
- (c) Eddy Current for non-ferrous bundles
- (d) Radiography for all materials, though only outer rows can be checked: particularly suited to detect or confirm internal pitting.

As it may not be possible to arrange some of these tests at short notice, their requirement should be anticipated as far as possible at the planning stage of the overhaul. In all cases thorough internal cleaning of the tubes will be required for reliable results. Whenever possible the worst identified tubes should be extracted for confirmatory checks. Refer to [ESR.95.ER.035](#) for further guidance on the relative capabilities of these techniques.



B.6.5.3 Pressure Testing

Pressure tests for shell-and-tube exchangers fall into the following categories. (see also B.1.3).

B.6.5.3.1 Shell Test

This is performed with the channel cover, shell cover and floating head cover removed, and a test-ring closure between the shell and the floating tubesheet (obviously not necessary for "U" tube bundles). Pressure is applied to the tube bundle exterior and will reveal leaks in the shell, tubesheets, tubes, tube-to-tubesheet joints and the fixed tubesheet-to-shell joint.

B.6.5.3.2 Tube Test

This is performed with only the shell cover removed (straight bundles). Pressure is applied to the tube interior and will reveal leaks in the floating head cover, floating head cover-to-floating tubesheet joint, tube-to-floating tubesheet joints, tubes (but not necessarily their location), fixed tubesheet-to-channel joint, channel, channel-to-channel cover joint, and channel cover.

B.6.5.3.3 Reverse Shell Test (Straight Bundles)

This is performed last and mainly tests the shell-to-shell cover joint, though leaks in the shell cover itself would be revealed. Care must be exercised in this test since some floating head covers are not designed to withstand full shell test pressures, hence a tightness test may be appropriate.

Test pressures should be maintained for a minimum of 30 minutes for the first two tests, and 15 minutes for the third test. In the event that an unexpected tube leak occurs, every effort must be made to determine the cause. Ideally the tube(s) should be extracted for inspection, particularly for critical bundles. It is usually preferable to determine the cause of leakage, even if this incurs a slight delay to the schedule: the leak may be predictive of in-service failures, which may not be tolerable.

Taper plugging should follow approved procedures.

For known "bad performer" bundles which are candidates for possible retubing, hydrotesting prior to bundle removal should be considered. This helps avoid last minute retubings and consequent delays. Any such bundles should be identified and entered for pre-testing in the overhaul plan.

The preferred method for shell-side testing is with the channel section fitted, the channel cover removed, and a test-ring fitted at the floating head end only. In this method no relaxation of the fixed tubesheet-to-shell gasket occurs.

For bundles which are removed for cleaning only (i.e. not scheduled for thorough inspection) it may be permissible to waive the first shell test.



Replacement tube-end ferrules should be installed after the first hydrotest so that roll joint leaks are more easily revealed. Tube internals should be air-blown dry before applying the first test.

Very minor leakage of tube end welds, roll joints or floating head gaskets may be permissible, particularly if the shell and tubeside operating pressures are nearly equal and if a minor leak would be operationally tolerable.

B.6.5.3.4 Differential Pressure Testing

In some high pressure exchangers the tubesheets may not be designed to withstand the individual pressures of the shell and tube-sides, but to a maximum differential pressure. Hence for testing either side individually, the test pressure will be determined by the tubesheet differential design pressure. To test each side to its full test pressure, both sides must be pressurised simultaneously, ensuring that the tubesheet differential test pressure is never exceeded. Pressures must therefore be increased and let down on each side very gradually. If the differential test pressure is exceeded at any time during the test, then the tubesheet may have been damaged.

B.6.6 Double Pipe Exchangers

The principles and practices of inspection and testing of double pipe exchangers are essentially the same as TEMA-type shell-and-tube designs:

- (a) The exchanger must be prepared and cleaned in such a manner so as to permit a thorough inspection of all pressure containing parts. The inner elements should be withdrawn and cleaned where practicable.
- (b) The shell and elements, whether single or multiple tubes, plain or finned, should be examined to detect the degree and extent of corrosion, erosion or other defects.

B.6.7 Plate Exchangers

Thorough inspection of plate exchangers requires full dismantling, with all plates being separated and cleaned. Plates and platens should be examined for corrosion, erosion or other defects, paying particular attention to the gasket locations where crevice corrosion may have developed. Tie-bolts should be checked for possible deformation and cracking. Reassembly and pressure testing should follow the vendor's procedures.

Plate exchangers are almost invariably constructed to proprietary designs using corrosion resistant materials such as stainless steel and titanium. As such they are usually very reliable, requiring relatively infrequent inspection.



In some designs (e.g. Packinox) the plates are edge-welded together into a block and this of course makes dismantling impossible. The scope of inspection is then very limited and proof of integrity can only be demonstrated by special pressure and leak testing techniques as specified by the vendor.

B.6.8 Air-Fin Coolers

Once again, the principles of the inspection and testing of air-fin coolers are similar to those for shell-and-tube designs, but with one important difference: tube failure results in loss of containment. This means that air coolers in hazardous duties tend to be of higher criticality than equivalent shell-and-tube exchangers.

B.6.8.1 External Inspection

External inspections can usually be made whilst the air cooler is in operation, as follows:-

- (a) Ladders, walkways, platforms and stairways should be inspected for:-
 - (i) corroded, damaged or missing structural parts
 - (ii) loose or missing bolting
 - (iii) corroded floor plates
- (b) Foundations and supports should be inspected for:-
 - (i) spalling, cracking or settlement of concrete
 - (ii) anchor bolt corrosion or looseness
 - (iii) corrosion, distortion and cracking of steel supports and welds
 - (iv) freedom of movement for thermal expansion/contraction
- (c) Louvres and associated drive/positioning mechanisms should be inspected for evidence of damage or malfunction.
- (d) Tubes should be inspected for corrosion, sagging and distortion. If thermal distortion associated with fouling is suspected, top row tube metal temperatures should be measured across the full width of the cooler, and at both ends where the tubes are not finned.

- (e) Fins on the top row tubes should be inspected for corrosion and mechanical damage.
- (f) Fan guards should be inspected for corrosion and break-up.
- (g) Plenum plates should be inspected for corrosion or other deterioration.

B.6.8.2 Internal/Off-Stream Inspection

- (a) Sufficient plugs or cover plates should be removed to permit a representative thorough inspection. Partial plug removal should be done on a regular pattern to cover the full width and height of the bundle(s) in a representative manner.
- (b) Tubes should normally be hydrojetted clean before inspection. For specialised NDT techniques very thorough cleaning is required in order to obtain reliable results.
- (c) Tube ends and tubesheets should be visually inspected for evidence of corrosion/erosion. Note that it is not possible to easily remove stainless steel tube end ferrules since these are usually roller expanded in. Representative ID measurements can be made on plain end tubes in cover plate design headers.
- (d) Header boxes, cover plates and nozzles should also be visually inspected for evidence of internal corrosion/erosion, as far as access permits. Ultrasonic wall thickness checks on the nozzles should be recorded. Carbon steel outlet nozzles should receive particular attention if the cooler results in the internal condensation of a corrosive liquid phase.
- (e) Tube internal surfaces can usually be inspected by boroscope. For bundles in potentially corrosive service, radiography of the top tube rows can be selectively performed at both ends. If pitting or other internal damage is detected, tube extraction should be considered for the accurate determination of remaining wall thickness.
- (f) Specialised NDT of the tubes can usually be performed, using the techniques described in B.6.5.2.
- (g) Tube fins on the bottom rows should be inspected for evidence of corrosion and fouling. Water or solvent washing may be required to help clean clogged fins, improve heat transfer and reduce fin corrosion.



- (h) Fan blades and hubs should be inspected for evidence of corrosion or mechanical damage. Dependent upon design, and upon any history of vibration, dye penetrant examination of the high stress concentration areas of the hub and blade attachment may be required.
- (i) Plugs and plugsheets should be inspected for thread damage. Gaskets should not be re-used.

B.6.8.3 Pressure Testing

Air coolers opened for inspection should be tightness tested as a minimum requirement. A full strength test should be applied if repairs to pressure containing components have been made (including cutting out of tubes), or if the results of inspections leave any doubt as to the integrity of the cooler.

B.6.9 Inspection Procedures

Site-specific procedures should be developed for the main design types, typically shell-and-tube exchangers and air coolers as a minimum requirement. Checklists should be developed, and these would typically include the following:

(a) Shell-and-Tube

- Shell and nozzles
- Shell cover
- Channel and nozzles
- Channel cover
- Floating head cover
- Tubesheets
- Tubes
- Bundle trim
- Anodes
- Insulation
- Painting/lining
- Foundations/supports
- Earthing
- Platform/ladders

(b) Air Cooler

- Headers, coverplates



- Tubesheets
- Nozzles
- Tube fins
- Tubes
- Plugs/plugsheets
- Louvres
- Fan blades/hubs/guards
- Plenum chamber
- Foundations/supports
- Platforms, stairways



PART B - TECHNICAL GUIDANCE

SECTION B.7 PIPING SYSTEMS

B.7.1 Introduction

This Section applies to process piping systems (i.e. within the plot limits of processing plants), offsites and utilities piping systems. Piping expansion bellows (PEBs) are dealt with in Section B.7A

B.7.2 Guidance Documents

BPE.90.ER.174	Remanent Life Assessment
ESR.93.ER.003	Detection of Hydrogen Damage in C1/2Mo Material
ESR.93.ER.139	Detection of Corrosion Under Insulation (CUI)
ESR TB 0002	Inspection of Small-Bore Fittings and Pipework
BP Oil US RP 20-4-2	In Plant Inspection of Existing Piping
API 570	Piping Inspection Code
API RP 574	Inspection of Piping, Tubing, Valves and Fittings
IP Code Part 13	Pressure Piping Systems: Inspection Safety Code

B.7.3 Frequency and Scope of Inspection

Inspection of process, offsites, utilities and firewater piping poses particular challenges because:-

- (a) the amount of piping on most plants is large
- (b) much of it is run along elevated pipe-racks or in other relatively inaccessible locations
- (c) much of it is externally insulated
- (d) internal access is usually impractical/impossible.

In order to deal with these problems the adoption of a risk-based approach is recommended. Classification of piping into criticality



ratings can be done relatively simply e.g. by using the scheme in [API 570](#). Alternatively the more detailed methodology of a proprietary criticality assessment scheme can be used.

Frequencies and scopes of piping inspection should follow the principles described in the guidance documents (B.7.2) and BP Group [RP 32-3](#).

As an additional aid in determining inspection frequency the use of a computer aided corrosion monitoring system should be considered for all pipework in internally corrosive duty, except very small or simple systems where such a computer aided system may be uneconomical or impractical. This approach to pipework inspection should be used in conjunction with the previously mentioned piping classification system and criticality assessment.

Firewater piping systems are high criticality for most plants on account of the potential consequences of failure on demand, and their detailed inspection and fitness-for-purpose assessment should not be overlooked.

An awareness of the developments and capabilities of "advanced" NDT for piping inspection should be maintained as there is considerable ongoing R & D activity in this area. Techniques include:-

- (a) thermography
- (b) flash and real time radiography
- (c) neutron backscatter
- (d) pulsed eddy current
- (e) low frequency, long range ultrasonics
- (f) high temperature ultrasonics
- (g) time of flight diffraction
- (h) fleximats
- (i) magnetic flux leakage
- (j) acoustic emission
- (k) cable operated ultrasonic pigs

B.7.4 Inspection Procedures

Site-specific procedures should be developed, using the guidance documents listed in B.7.2. A typical checklist is included in [API 570](#), Appendix E.

B.7.5 Pressure Testing

Normally, it is not necessary to apply pressure tests - either hydraulic or pneumatic - to piping systems except to carry out leak tests, or where a strength test is required e.g.

- (a) due to statutory regulations
- (b) following major repairs or modifications - which will affect the strength and integrity of the piping system



- (c) when the piping system is to be re-rated
- (d) when it is not possible to carry out a thorough inspection and a hydraulic test may be substituted in lieu
- (e) when doubts about a piping system's integrity exist

Precautions should be taken during hydraulic testing and careful reference should be made to the requirements and recommendations of Section B.1.3 of this RP.



PIPING EXPANSION BELLOWS

B.7A.1 Introduction

The purpose of this Section is to offer additional advice on the inspection of in-service piping and pipeline expansion bellows (PEB's).

B.7A.2 Guidance Document

[BS 6129](#) Metallic Bellows Expansion Joints

B.7A.3 Registration

When the Inspection Authority or local legislation dictate, a system whereby each PEB is registered for inclusion onto the inspection/maintenance schedule should be implemented.

B.7A.4 Inspection Frequency and Scheduling

PEB's shall be considered as a part of the piping system in which they are contained and have the same maximum thorough inspection intervals unless governed by other factors (legislation, operating experience).

Periodic routine in-service inspections should be carried out at intervals of 12 months to ensure that:-

- (a) all anchors are firm in their foundations and that the pipe is securely attached.
- (b) all guides are in good condition with no distortions and the pipe can move freely in them.
- (c) all insulation is in good condition, adequate to prevent heat loss and possible condensation and is cut away from the bellows allowing free movement.
- (d) the bellows is deflecting correctly with no evidence of excessive distortion, squirming or vibration.
- (e) external surfaces are examined for corrosion.

- (f) threaded fastenings are checked for tightness.

B.7A.5 Inspection During Start-up

Initial cold (prior to start-up) and hot (at normal operating conditions) squirm readings should be taken and be included on the Data Sheet.

B.7A.6 Inspection Procedures

The following additional items should be considered for inclusion into specific site inspection procedures;-

- (a) Prior to shutdown a visual inspection of the bellows may be carried out to ensure that there is no evidence of excessive distortion or squirming whilst in service.
- (b) A close inspection of cuff to flange welds on slip-on type connections using appropriate NDT, should any surface breaking defects be suspected.
- (c) A close inspection of any longitudinal seam welds, using appropriate NDT, should any surface breaking defects be suspected.
- (d) A close inspection of the internal surfaces for evidence of contact with corrosive chemicals or condensate which may cause stress corrosion cracking.
- (e) Where internal sleeves are fitted and the flow is vertical it is important to ensure that the drain holes are clear.
- (f) Records of the amount of squirm, both cold and under normal operating conditions, should be maintained by the Inspection Authority.
- (g) Any squirm, distortion or deflection in excess of design should be considered as cause for renewal unless this can be rectified by restoring the pipework to its original alignment without any modification.
- (h) PEB's which have internal packing should have periodic thermographic surveys to ensure that the operating temperature is not exceeding the design temperature of the bellows material. It is recommended that a survey also be considered prior to shutdown.

- (i) A close inspection of the seals on PEB's with internal packing should be carried out to ensure their integrity.
- (j) Details of the operating hours/conditions and estimated cycles should be logged to allow constant re-assessment of design life and projected renewal.

B.7A.7 Modifications

Previous experience has highlighted the serious consequences of incorrectly designed modifications to piping containing PEB's.

Any modification to such a piping should only take place with the approval of the Design Authority, under the site's MOC procedures (see para. B.1.6).

B.7A.8 Glossary of Terms relevant to the Inspection of P.E.B.'s.

Nominal size	A convenient round number designation of size which is common to all other components in a piping system and only loosely relates to manufacturing dimensions.
Movement	The various dimensional changes which an expansion joint is required to absorb, e.g. resulting from thermal changes in a piping system.
Axial compression	The dimensional shortening of an expansion joint along its longitudinal axis. <i>Also referred to as: axial movement.</i>
Axial extension.	The dimensional lengthening of an expansion joint along its longitudinal axis. <i>Also referred to as: axial movement or elongation.</i>
Lateral deflection	The relative displacement of the two ends of an expansion joint perpendicular to its longitudinal axis. <i>Also referred to as: lateral offset, lateral or transverse movement, parallel misalignment, direct shear.</i>
Angular rotation	The relative angular displacement of the two ends of the expansion joint so as to displace the longitudinal axis from its initial straight line position into a circular arc. <i>Also referred to as: angular or rotational movement.</i>



Rated movement	The maximum amount of movement (any combination of the above) which an expansion joint can absorb. <i>This rating will be specific to each expansion joint size/type/make and will be established by the manufacturer.</i>
Cyclic life	The minimum number of cycles of movement at the specified conditions which an expansion joint is designed to withstand without failure.
Squirm	This is the situation as when the internal pressure has caused the bellows convolutions to be distorted and have uneven spacing and/or lack of parallelism.
Expansion joints	Devices containing one or more bellows used to absorb dimensional changes, e.g. thermal expansion/contraction of a pipeline.

Expansion Joint Components

The following are part of or used in connection with expansion joints:-

Bellows	The flexible section of the expansion joint, consisting of one or more convolutions and, where fitted, end cuffs.
Convolution	The folded sections of the bellows; one convolution is the smallest flexible unit of a bellows. The rated movement of a bellows is proportional to the number of convolutions.
Cuffs	The straight unconvoluted portions at the ends of the bellows, also referred to as tangents or tails.
Weld and flanged	The ends of an expansion joint equipped ends with ends either bevelled for welding or flanges for bolting to adjacent pipe/fittings/equipment.
Internal sleeve	A device which shields the convolutions from direct contact with the flow of fluid, also known as a liner, telescopic or baffle sleeve.
Cover	A device fitted to provide limited protection to the external surfaces of the bellows from mechanical damage, also known as a shroud or external sleeve.
Root reinforcing rings	Devices which fit snugly into the roots of the convolutions to reinforce the bellows against internal pressure and are normally fabricated from tubing or solid round bars of suitable alloys (carbon, stainless steel etc.).



Reinforcing collars	Devices used to reinforce the cuffs of bellows.
Equalising rings	Rings usually T-shaped in cross section, used to distribute movement equally between the convolutions of the bellows and are usually designed to act as reinforcing rings.
Tie rods	Devices in the form of rods or bars attached to the expansion joint assembly, whose primary function is to restrain the pressure thrust or pull due to internal pressure or vacuum. They may also be designed to provide the features of control rods.
Shipping restraints	Temporary rigid or adjustable support devices installed to maintain the overall length of the assembly for shipment and may be used to precompress, pre-extend or laterally offset the bellows to facilitate correct installation. <i>Also known as sizing bars.</i>
Movement indicator	A device used to indicate the axial or angular movement, relative to its free position, to which the expansion joint is being subjected. It is particularly useful when checking that the correct cold pull has been applied to the system.
Lagging shroud	A device used to prevent lagging inhibiting free movement of convolutions.

Associated Equipment

The following equipment is associated with systems containing expansion joints:-

Main anchor	A anchor which is designed to withstand the full thrust due to pressure, flow, spring forces etc. <i>A main anchor connection can be designed as an integral part of the expansion joint if required.</i>
Intermediate	A anchor which is designed to withstand anchor the full thrust due to pressure, flow, spring forces etc. <i>An intermediate anchor connection can be designed as an integral part of the expansion joint if desired.</i>
Directional restraint	A restraint designed to absorb loading in one direction while permitting motion in another.

It may be either a main or intermediate anchor, depending upon the application involved and when so designed may function as a pipe alignment guide.

Also known as a sliding restraint.

Pipe alignment A guide in the form of a sleeve or framework fastened to a rigid part of the installation which permits the pipeline to move in one direction only (designed primarily for use in applications involving axial movement only, but may also be used in certain applications which involve lateral deflection and angular rotation).

Single plane A guide which allows lateral deflection pipe guide and/or angular rotation of the pipeline in one plane only. Commonly used in applications involving lateral deflection or angular rotation resulting from 'L' or 'Z' shaped piping configurations.

Pipe support. A support designed to carry the weight of a pipe, its contents, insulation, etc. and is not necessarily intended to act as a guide.

Normally required at more frequent intervals than alignment guides or other forms of restraints.

Most pipework systems require both supports and guides.

DATA REQUIREMENTS FOR A TYPICAL BELLOWS DATA SHEET

Bellows Type
Design Code
Design Pressure
Design Temperature
Operating Pressure
Operating Temperature
Design Axial Compression
Design Axial Extension
Design Lateral Movement
Design Angular Movement
Rated Movement
Cold Pull or Draw
Pipeline Size
Test Pressure and Medium
Materials of Construction
Cyclic Life
External Insulation
Internal Packing
Cold Squirm Reading
Hot Squirm Reading

Associated Items

Other Information

Note: If internally packed, design and operating details will have to take account of difference between internal and external surfaces.



PART B - TECHNICAL GUIDANCE

SECTION B.8 FIRED HEATERS

B.8.1 Introduction

This Section applies to fired tubular process heaters and their essential ancillary equipment.

Direct fired process heaters differ from other types of process equipment in that there are no commonly accepted industry codes or standards relating to their design (although within BP they should meet the requirements of BP Group [RP 22-1](#)), and being direct fired increases the risks inherent in the operation of equipment processing flammable substances.

Considerable care must therefore be exercised during the inspection of fired heaters to detect and identify those parts of the heater coil or structure which may have been exposed to abnormal conditions, thereby affecting their integrity.

Flue gas uptakes and ducting, up to the stack or isolating spade and damper servo mechanism, should be considered as being part of the heater and examined accordingly.

B.8.2 Guidance Documents

ETC.89.ER.046	The Heater Inspection Manual
BPE.90.ER.174	Remanent Life Assessment
BP Oil US RP 20-4-6	In Plant Inspection of Existing Fired Heaters
BP Oil US RP 20-4-7	In Plant Inspection of Refractories
API RP 573	Inspection of Fired Boilers and Heaters
API RP 530	Calculation of Heater Tube Thickness in Petroleum Refineries
NACE RP 0170-93	Protection of Austenitic Stainless Steels and Other Austenitic Alloys from Polythionic SCC during Shutdown of Refinery Equipment

B.8.3 Frequency of Inspection

Refer to Table 1 of BP Group [RP 32-3](#). Note that Inspection Grade 3 is not recommended for fired heaters, and that the maximum



inspection interval is 72 months for Grade 2. The main factors to consider in the allocation of Inspection Grades are as follows:-

- (a) the feedstock quality control
- (b) flow control through the coil(s)
- (c) firing controls i.e. avoidance of flame impingement and local overheating
- (d) fuel quality, particularly sulphur and metals content which can lead to hot corrosion of uncooled furnace parts, and acid dewpoint corrosion and fouling in the heat recovery or air-preheater sections.
- (e) process and fire-box temperature measurement and control
- (f) the age of parts operating in the creep range and the need to perform remanent life assessments
- (g) specific inspection and maintenance history of the heater

It must be appreciated that when making future safe life predictions, the inspection authority is, of necessity, extrapolating from existing data. Wear rates are based upon past modes of operation, and every care should be taken to ensure that future operation is fully taken into consideration and the wear rates modified accordingly. Operating conditions can change rapidly. Maladjustment of burners (or incorrect operation of them), low flow conditions, etc., can all lead to local overheating of tubes within a very short time, nullifying long term life predictions based on average corrosion or wastage rates. The inspection authority cannot therefore make safe life predictions without making them being conditional upon normal operating conditions and they must be aware of changes in operational circumstances which could affect safe life predictions.

B.8.4 Safety Devices

Fired heaters can experience abnormal conditions (particularly as a result of temperature excursions) and therefore certain safety devices are fitted to protect against failure modes or to help mitigate the consequences of failure.

The inspection procedures for safety devices are covered in Section B.9 of this RP, to which reference should be made. The inspection frequency of such devices may well be different to that quoted for the heater generally and in accordance with Table 1 of BP Group [RP 32-3](#), in which case it may be necessary to consider the duplication and isolation of such devices.

Fired heaters safety devices include:-



- (a) pressure relieving valves
- (b) explosion doors
- (c) isolating doors
- (d) blowdown valves
- (e) pilot burners
- (f) flame-out warning devices
- (g) automatic ignitors
- (h) skinpoint thermocouples
- (i) alarms and trips

All of the above, when fitted, should be examined and tested for correct functioning by the appropriate specialists

B.8.5 Pressure Testing

Where statutory rules call for hydrostatic testing, these shall apply, otherwise:-

- (a) If no repairs or renewals are carried out, testing shall be for the sole purpose of confirming the leak tightness of the coil.
- (b) Where repairs or renewals are carried out, a strength hydraulic test should be carried out.

Recommendations on pressure testing are given in Section B.1 of this RP.

B.8.6 Inspection Procedures

Site specific procedures and checklists should be developed, and these should relate both to "conventional" process heater designs and to proprietary designs e.g. hydrogen reforming, ethylene pyrolysis. The Heater Inspection Manual referenced in B.8.2 represents a primary reference point for this task.



PART B - TECHNICAL GUIDANCE

SECTION B.9 PROTECTIVE DEVICES

B.9.1 Introduction

This Section applies to a wide range of protective (safety) devices used for the protection of equipment. They may be used singly, or as an integral part of a protective system. Such devices may be classified into two distinct groups to facilitate a risk-based approach to inspection and testing:-

Group 1 devices:- are devices where failure to operate on demand could result in serious equipment failure or other consequences.

Group 2 devices:- are devices where adequate back-up facilities are available to prevent hazard if the protective device fails, or where the consequences of failure are deemed acceptable by the site.

Tables B.9A and B.9B give a typical but not exclusive list of examples of Group 1 and 2 devices.

B.9.2 Inspection Authority

The inspection and test of safety devices fitted to equipment subject to statutory control will usually form part of a statutory examination of the equipment they protect.

The responsibility for carrying out the inspection and test of all non-statutory protective devices should be formally assigned to an appropriate department.

B.9.3 Inspection and Test Schedule

An inspection and test schedule should be prepared for each plant or operational facility, listing all protective devices which are considered to require periodic inspection or functional test.

The categorisation, inspection and testing of protective devices by an auditable management system is a fundamental requirement for all sites and is a clear expectation in all BP's Operations Integrity Assurance Systems.

B.9.4 Inspection Frequency

The frequency of inspection will be affected by the following factors:-

- (a) Statutory regulations, where applicable.



- (b) Severity of duty.
- (c) Provision of duplicate protection.
- (d) Downstream conditions.
- (e) Process conditions (leading to corrosion, gumming or fouling).
- (f) Consequences of a failure to operate correctly.
- (g) Previous operational history of the devices or system (reliability).

These factors should be considered in addition to any local matters and an Inspection Grade/Criticality Rating allocation made, subject to the maximum intervals recommended in Table 1 of BP Group [RP 32-3](#), as appropriate to the duty of the device. In the case of Group 1 instrumentation systems, a reliability analysis may be required to determine the optimum inspection frequency.

Guidance rules for a more rigorous approach to risk-based inspection and testing of safety relief valves are currently being developed in BP (1995).

B.9.5 Inspection Procedures

B.9.5.1 Safety Valves on Equipment Subject to Statutory Regulations

The inspection requirements for these valves should be determined by the inspection authority in accordance with the relevant legislation. In general, they will be treated as valves in the non-statutory category below except that, in the case of steam boilers and superheaters, they should be finally adjusted and floated in situ. The test will be witnessed, or carried out as directed, by the inspection authority.

B.9.5.2 Safety Valves on Non-statutory Items (pressure and vacuum)

At intervals appropriate to their duty (see B.9.4 above), safety valves should be removed for inspection, overhaul, examination and resetting.

The complex subject of safety relief valve inspection, testing and endorsement is currently under review within BP, and new guidelines will shortly be issued to which reference should be made in formulating/updating site-specific procedures (1995).

B.9.5.3 Bursting Discs

Bursting discs should be renewed at intervals dictated by the life and reliability of the disc.



When a new disc is fitted, the manufacturer's certificate of compliance with the appropriate standard may be accepted. Alternatively, a sample of the same size and batch as those to be used, should be tested in a carrier of the same form and dimensions as that with which the disc is to be used, when the disc should burst within $\pm 5\%$ of its specified bursting pressure. Due allowance should be made for the difference in temperature between test and operating conditions.

B.9.5.4 Low Pressure and Vacuum Breaker Valves on Storage Tanks

At the discretion of the inspection authority, testing of these valves may be waived if visual inspection, plus a check calculation, shows the valve to be satisfactory for its intended duty. The valves should be given a full overhaul and inspection at the tank thorough inspection.

B.9.5.5 Mechanical Devices

If any of the following devices are fitted, they should be functionally tested at appropriate intervals:-

- Speed governors
- Governing valves and actuators
- Overspeed trips
- Emergency stop valves
- Master trip systems
- Sidestream control valves
- Tripcocks
- Trip oil systems
- Gas turbine fuel valves
- Diesel engine gas ignition protection
- Reverse rotation protection

B.9.6 Change of Duty

Should it be necessary to raise or lower the set pressure of a safety valve without changing the spring, the following limitations are placed on the existing spring:-

- (a) For continuous operation - the existing spring may be used at 10% of its range above or below the extremes of that range.
- (b) For temporary operation up to and including 17 barg (245 psig) - the existing spring may be used for pressures 10% above or below the previous cold set pressure.



- (c) For temporary operation above 17 barg (245 psig) - the existing spring may be used for pressures 5% above or below the previous cold set pressure.

All such changes must take place under the site's MOC procedures (see Section B.1.6).

B.9.7 Reports and Records

Adequate records should be maintained of all protective devices including such technical details as may be necessary to ensure that replacement components may be correctly identified and that the essential characteristics of the device are known and of the operational history of the device and of all inspections and tests carried out on the device or system.

All Group 1 devices should be identified and described in a Register of Safety Related Devices, and this document should be maintained up-to-date at all times. The recommended contents of this Register are described in BP Group [RP 44-1](#), para. 3.4.



DESCRIPTION OF FUNCTION	TYPICAL EXAMPLES	POSSIBLE CONSEQUENCES OF FAILURE
Devices to protect against overpressure.	Relief valves and Bursting discs.	Failure of equipment because of overpressure.
Devices to prevent a pre-determined temperature level from being exceeded.	Reactor bed temperature trips or actuators. Fusible plugs or links. High temperature trips. Low temperature trips.	Failure of the protected vessel or system due to loss of strength as a result of exposure. Loss of ductility at low temperature.
Devices to cut off fuel due to sensing flame failure in combustion space.	Flame failure sensor.	Explosion due to fuel flow being re-established prior to purging of combustion chamber.
Devices to cut off heat input due to sensing low flow conditions.	Heat-off systems on fired heaters.	Tube rupture due to over-heating followed by fire.
Devices to prevent over speeding in normal and reverse directions of rotation.	Over-speed trip. Emergency stop valve. Loss of excitation trip. Non-return valves.	Failure of rotary or reciprocating machines due to over-speeding.
Devices to prevent machinery damage.	Lube oil pressure failure trip. Seal oil pressure failure trip. High liquid level trip. High/low temperature trips.	Failure of machine parts.
Devices to cut off liquid flow when a pre-determined flow is exceeded.	Excess flow valves.	Discharge of hazardous liquids to atmosphere.

TABLE B.9A GROUP 1 PROTECTIVE DEVICES



DESCRIPTION OF FUNCTION	TYPICAL EXAMPLES	POSSIBLE CONSEQUENCES OF FAILURE
Devices to prevent a predetermined level of voltage or current flow to be applied to equipment of circuits. (Note:- some equipment of this nature may be Class 1 devices).	Fuses. Overloads. Cut-outs.	Physical damage to the protected equipment.
Devices to warn of abnormal liquid levels.	High/low level liquid alarms. Gauge glasses. Remote level indicators.	Physical damage to the protected equipment.
Devices to warn of abnormal temperature levels.	Temperature alarms.	Physical damage to the protected equipment.
Devices to control rotating machinery speed and load.	Governors. Overload alarms.	Physical damage to the protected equipment.
Devices to warn of abnormal operating conditions.	Low flow alarms. pH meters. Gas detectors. Purge systems. Vibration trips.	Physical damage to the protected equipment.

NOTE TO TABLES B.9A and B.9B.

1. The above tables are purely for purposes of illustration and must not be regarded as definitive. The allocation of devices to Group 1 or 2 and their inspection classification is dependent on a number of related circumstances and the allocations must, in each case, be considered by the review body.
2. Inspection and testing of protective instrumentation is dealt with in BP Group [RP 32-6](#).

TABLE B.9B GROUP 2 PROTECTIVE DEVICES



PART B - TECHNICAL GUIDANCE

SECTION B.10 STACKS, CHIMNEYS AND COOLING TOWERS

B.10.1 Introduction

This Section applies to stacks and chimneys discharging flue and other gases, flare stacks and cooling towers of both natural and forced draught types.

B.10.2 Guidance Document

[CICIND](#) Manual for Inspection and Maintenance of Brickwork and Concrete Chimneys (1993).

B.10.3 Inspection Authority

The inspection of stacks, chimneys or cooling towers should be carried out to the requirements of the inspection authority but with approved specialist assistance as necessary.

It is general practice to employ specialist contractors to carry out inspection and remedial work on high stacks, cooling towers, and guy ropes.

B.10.4 Inspection Frequency

Inspection frequency will be as set out in Table 1 of BP Group [RP 32-3](#) subject to recommendation from specialist contractors.

Advice should be sought from BP Civil Engineers or suitably experienced consultants regarding these recommendations and the setting of inspection frequencies.

Flue gas ducts, lightning protection strips and trunking should be inspected at similar intervals or as determined by experience and the item history.

Flare stacks should be inspected at intervals dictated by the condition of either the flare tip and associated fittings or molecular seal drains. Fired heater stacks should be inspected coincident with the associated equipment. Guy ropes should preferably be checked and retensioned (if permitted by safety considerations) whilst the equipment is operating.

B.10.5 Preparation for Inspection

The preparation of the equipment will normally include cleaning, and dismantling, to permit a thorough inspection of all the essential



components. However, in the case of stacks, chimneys and towers, etc., a major part of the preparation is in the provision of adequate and safe access either by scaffolding or by the provision of personnel lifting equipment. Where such access is deemed necessary the work is to be included within the workscope of a specialist contractor.

Much valuable inspection work can usually be made with the items in service, particularly for chimney stacks. External on-line surveys can be made and specialist techniques such as concrete coring and hot cameras can be considered. The condition of most of the external parts e.g. ladders, platforms, structures can be assessed. This external examination may provide important information relating to internal parts and may assist in the planning of a thorough inspection.

Operational information is also very relevant to chimney stacks, particularly details of flue gas quality and temperatures; where these have departed significantly from design then some damage mechanisms may be anticipated. Explosions in furnace fireboxes can transmit pressure waves into chimneys which can cause damage to brick linings.

B.10.6 Scope of Inspection

The scope of work required by the specialist contractor must be sufficient to ensure that:-

- (a) any additional cleaning, dismantling or the provision of safe access to enable a thorough inspection and repair can be carried out.
- (b) all recommendations for repair or renewal made at the time of the previous inspection are either implemented or a record is made of the justification for delaying or deleting such work.
- (c) the overall mechanical design and construction of the equipment, following a period of service, is sound and that any deficiencies are thoroughly investigated and corrected or identified as actions to be undertaken at subsequent inspections.
- (d) standards of fabrication and material quality are adequate for their purpose and, if not, are corrected.
- (e) all essential components of the equipment are examined and that measurements (or inspection results) are recorded to form the basis for assessment of corrosion or wastage patterns for future safe life predictions.
- (f) a report, detailing the condition of the equipment and any repairs or modifications carried out or required at subsequent inspections is supplied to the inspection authority.

- (g) the Inspection Grade allocated to each piece of equipment is reviewed and the date of the next thorough inspection is clearly defined.

B.10.7 Particular Inspection Requirements

B.10.7.1 Flare Stacks

In addition to the physical inspection of the stack structure, the flare tip (and all its ancillary devices) and the guy rope tension levels, it will be necessary to check for verticality of the structure itself and possible settlement of the stack foundations.

Verticality checks of flare stacks may need to be at more frequent intervals than those for physical inspection.

B.10.7.2 Unlined Steel Stacks and Blowdown Stacks

Rapid and heavy internal corrosion can occur on both types due to either low temperature acidic attack (dew-point corrosion) or rapid oxidation due to continuous or intermittent steam purging giving a wetted surface. Both possibilities should be considered when deciding on the inspection frequency to be given to the equipment. Stay wires, when fitted, should also be carefully examined.

B.10.7.3 Lined Steel or Concrete Flue Gas Stacks

Both types may have either a brick or monolithic refractory internal lining, the upper levels usually being of acid-resisting materials to combat dew-point corrosion. Should the lining or joints be inadequate, acidic gases may pass through and condense on the outer shell, leading to rapid corrosion of steel or degradation of concrete, both of which may be hidden from view during an internal inspection of the refractory lining.

This possibility should be considered and taken into account when deciding elapsed intervals between inspections.

B.10.7.4 Reinforced Concrete Cooling Towers

The design and maintenance of cooling towers is a specialist field and it is recommended that this work should be supervised by BP Civil Engineers or appropriate consultants.

Major inspections should be carried out at close range from cradle access and be recorded as follows:-

- (a) Video film record of each drop.
- (b) Still photographs of major defects.



- (c) Exploded elevation drawing of the tower shell recording all defects in relation to grid references based on shutter pours and leg positions.
- (d) Crack width estimation and extent of steel corrosion.
- (e) Estimation of the extent of delamination detected by tapping the concrete, before spalling has occurred.

A telescope, theodolite and level survey should be carried out from ground level to establish any imperfections in the shell profile and foundation movements.

These factual reports should be made available to BP Civil Engineers and the consultants for the initial categorisation of each tower.

The consultants' report will contain recommendations for repairs and any other necessary actions as well as the tower categorisation and should be used as a basis for the development of certification and future inspection requirements.

In addition to the established programme, natural draught concrete cooling towers should be inspected for damage (crack propagation) following exposure to high wind loadings. In addition to the categorisation of each tower the consultant will calculate the theoretical critical wind speed, ie. factor of safety of 1.0 against uplift failure. The tower categorisation and critical wind speed will be used to establish a safe wind speed for each tower. When the wind speed regularly exceeds the established safe wind speed, a safety zone will be required. The safety zone will be a minimum of 25 metres from the base of the tower, and should be agreed with BP Civil Engineers in close consultation with the operating authority.

B.10.7.5 Forced Draught Cooling Towers (Wood Construction)

Inspection, principally for corrosion and fatigue, should be carried out on fans, motors and their support bolting. Nozzles should be inspected for fouling and woodwork should be inspected for fungi attack and displacement, inspection personnel exercising care not to put their weight on unsound structures.

Samples of the wooden structure should be removed periodically and submitted to expert examination for assessment of incipient fungi problems.

PART B - TECHNICAL GUIDANCE

SECTION B.11 STEEL STRUCTURES

B.11.1 Introduction

This Section applies to land based steel structures (including stairs, ladders and access ways) within an operating centre. It covers structural steelwork for process units, steel bridges, offsite supporting steelwork for spheres, elevated vessels or tanks, structural steelwork for overhead gantries, pipe tracks loading gantries, etc. It excludes steel structures for jetties and offshore platforms, which are dealt with separately in Sections 13 and 20 of this Recommended Practice respectively.

B.11.2 Inspection Authority

Generally, such structural steelwork is not normally subject to statutory requirements, except where it may be an integral part of a pressure storage vessel.

The inspection authority will normally be responsible for the certification of steel structures within the operating centre.

B.11.3 Inspection Frequency

General guidance on the frequency of inspection is given in Table 1 of BP Group [RP 32-3](#). These periods however may have to be modified depending on the influence of the following:-

- (a) Climatic conditions including proximity to coastline or areas of heavy industry.
- (b) Whether structures are subject to regular or frequent wetting due to draining of cooling water from equipment on upper levels, and whether the cooling system uses fresh, brackish or sea water.
- (c) Provision of protective coatings to the steelwork and any fireproofing.
- (d) The provision of proper and adequate water sheds or flashings at the interface of steel and fireproofing material.
- (e) Proper drainage from flat horizontal surfaces, water traps or pockets.



- (f) Inspection frequency of associated process equipment or storage facilities.
- (g) Accessibility.
- (h) History of similar structures in a similar environment.

B.11.4 Inspection Procedures

The procedures described in this section are for application to structural steelwork following a period of service.

B.11.4.1 Preparation for Inspection

On plain (painted) steelwork, there is normally little preparation required except for general cleaning. However, it may be necessary to provide access to many parts of the structure which are normally inaccessible.

On coated steelwork, (either firecrete or other such insulating medium), it will be necessary to remove sections of the coating to expose the steelwork beneath, particularly where water may collect, e.g. at the bottom of vertical legs, changes of section, gusset or knee-brackets and the trough in the upper half of H section beams where the web is in the horizontal axis.

Where cracking of the coating (other than surface damage) has taken place, these areas should be investigated to establish the condition of the steelwork beneath.

B.11.4.2 Inspection

The requirements of this sub-section are for periodic inspection of structural steelwork to ensure that:-

- (a) the overall design and initial construction of the steelwork is sound and that any deficiencies are thoroughly investigated.
- (b) the standards of fabrication and material quality are adequate and fit for their purpose and, where not, that steps are taken to correct the deficiency.
- (c) all major components are visually examined for corrosion or cracking.
- (d) steelwork exposed for inspection is given a protective paint coating before being re-covered with fireproofing.
- (e) the water sheds or flashings at the upper levels of insulating coatings are satisfactory and adequate for this purpose.

- (f) prior to transport of maximum design axle loads over steel bridges, all major components are examined for wastage or fatigue and any deficiencies thoroughly investigated.



PART B - TECHNICAL GUIDANCE

SECTION B.12 CIVIL WORKS

B.12.1 Introduction

This Section applies to general civil works not covered in other sections of this Code. It includes but is not limited to:-

- Earthworks and bunds
- Foundations
- Drainage; closed pipe and open systems.
- Roads and paving
- Concrete structures
- Buildings and services
- Pits and ponds
- Site perimeter fencing and seawalls
- Temporary works

B.12.2 Inspection Authority

Unless there is a specific statutory requirement, inspection should be by a competent person employed by the inspection, maintenance or operating authority.

Accountability for all civil items should be made clear.

B.12.3 Inspection Frequency

The frequency of inspection should be determined by consideration of a number of factors, including:-

- (a) Inspection frequency of plant which is dependent on that part of the civil works.
- (b) Consequence of failure.
- (c) Specific requirements of the design authority.
- (d) Operational experience of similar civil works in the same environment.



The consequences of failure of several of the civil items listed above should not be underestimated. Historically these items have often received less frequent and/or thorough inspection than would be warranted by a criticality assessment.

B.12.4 Inspection Procedures

B.12.4.1 Unplanned Inspections

All persons regularly employed in the operating centre would be expected to notice changes or circumstances and condition of civil works.

Such changes should be brought to the attention of suitably experienced Civil Engineers. Examples include:-

- (a) Earth slips in embankments or settlement at grade.
- (b) Movement of foundations, the most critical of which can be checked against a fixed and stable datum.
- (c) Blockage or fracture in drainage systems.
- (d) Subsidence or cracking in roads and paving.
- (e) Cracks and obvious distress to concrete structures, bases, plinths, pits, etc.
- (f) Cracks and obvious distress to buildings.
- (g) Failure or malfunction of services to buildings including pressurised systems, HVAC systems, fire protection and alarms, and foul effluent treatment.
- (h) Loss of fluid containment in pits, or signs of leakage.
- (i) Improper or damaged temporary works including bridges, scaffolding, temporary drainage, excavations, etc.

B.12.4.2 Planned Inspections

These may comprise of the following:-

- (a) Statutory inspection of manned buildings
- (b) Regular surveys of major foundations, buildings and concrete structures for evidence of movement

- (c) Regular cleaning and internal inspection of closed drainage systems e.g. oily water, effluent
- (d) Thorough visual inspections for the features listed in B.12.4.1



PART B - TECHNICAL GUIDANCE

SECTION B.13 JETTIES

B.13.1 Introduction

This Section applies to jetties and associated marine structures including walkways and auxiliary structures such as mooring and breasting dolphins.

Installed equipment is outside the scope of this Section and as such should be inspected in accordance with the appropriate sections of this RP. Jetty loading arms are dealt with in Section B.19.

B.13.2 Inspection Authority

It is unlikely that jetty structures will be subject to any regulations regarding their regular examination by an external authority although certain operational components, such as hose gantries, flow-booms and lifting equipment may be subject to such control.

In the absence of any statutory regulation or other directives calling for inspection by outside bodies, the inspection authority will be that person or body deemed responsible for the inspection of jetties by the operating centre management. This may be a BP engineer or external body specialising in the inspection of jetties.

B.13.3 Inspection Frequency

The frequency and extent of inspection will be determined by consideration of a number of factors including the following:-

- (a) Climatic conditions and general corrosive environment.
- (b) Cathodic protection system installed and its viability and reliability.
- (c) Original design criteria.
- (d) Water depth, scour and sedimentation.
- (e) Collision damage and previous repairs.
- (f) Accessibility of structure both above and below the water line.
- (g) History of similar structures in a similar environment.



- (h) Corrosion allowance.
- (i) The quality of corrosion resistant paint coatings and their upkeep.

The maximum recommended intervals between inspections are given in BP Group [RP 32-3](#). In addition to these major reviews of the structure it is recommended that visual inspections of the accessible elements of the jetty, the cathodic protection system and the mooring fenders are carried out on an annual basis.

B.13.4 Inspection Procedures

B.13.4.1 A thorough inspection of the jetty should ensure that:-

- (a) The overall design and construction of the structure initially was sound and that any deficiencies are thoroughly investigated.
- (b) The soundness and integrity of the structure as a whole remains satisfactory.
- (c) The cathodic protection system applied to the steel components remains in an efficient and operable condition.
- (d) The surface coatings applied both above and below the water line are examined and their condition noted.
- (e) All major components are examined for corrosion, wastage or damage.
- (f) Items which require repair or renewal are advised to the operating authority.
- (g) Specialist assistance is obtained where necessary in order to verify the condition of underwater parts of the structure.

B.13.4.2 Energy Absorbing Fenders

When fitted, energy absorbing fenders are a major safety feature on jetties which handle large vessels.

A thorough inspection should be carried out annually at low tide conditions to verify the integrity of the supporting structure, moving parts and safety features of the fender installation.

Where energy indicators are installed the readings should be recorded during each berthing operation and, should excessive values be



obtained, the fender installation should be examined prior to further use to determine the effects of the impact.

B.13.5 Reports and Records

In addition to the reporting requirements of BP Group [RP 32-3](#) which relate to planned inspection, detailed inspection reports will be required following any berthing incidents in which jetty damage may have been incurred.

Such reports are normally required for insurance purposes and the damage assessment inspections may be undertaken by the inspection authority accompanied by representatives of the insurance company and the vessel operator.



PART B - TECHNICAL GUIDANCE

SECTION B.14 FLEXIBLE HOSES

B.14.1 Introduction

This Section applies to flexible hoses used for the transfer of crude oil, reduced crude oil, petroleum products (including liquefied gases), petro-chemical feedstocks, intermediates and products, and chemicals in the petroleum and petro-chemical industries. It does not apply to hoses which form part of a proprietary item such as hydraulic hoses on machinery or transport, or to snuffing steam hoses, or to floating roof storage tank roof drains.

These hoses are not normally subject to specific statutory regulations except for those few cases where flexible hoses are used for marine tanker loading or unloading.

Hoses in non-hazardous/utility duties such as compressed air, nitrogen, water and steam are only normally registered for inspection if they are permanent features of the installation, and, in the opinion of the inspection function, would cause an unacceptable loss or hazard if subject to failure. Registration of hoses which are owned and used by maintenance staff is often not practicable.

B.14.2 Inspection Frequency

Many factors will influence the choice of frequency of inspection, including the following:-

- (a) Type of crude, product or chemical handled, and its effect on the hose material, (e.g. aromatic content)
- (b) Service temperature
- (c) Service pressure
- (d) Frequency of use
- (e) Ambient temperature
- (f) Nature of storage
- (g) Handling facilities
- (h) Type of hose construction
- (i) Need for electrical conductivity



The final choice of inspection frequency should be decided (when not subject to statutory control) using the guidance in Table B.14.1.

B.14.3 Inspection Procedures

- B.14.3.1** Prior to being taken into use, each hose should be given a rigorous pre-commissioning inspection, registered and marked with its registration number either by stamping on the end connections or flange rim or by the provision of a separate but irremovable brass or stainless steel sleeve or tag.

Prior to being taken into use for the first time, each hose should be visually examined for evidence of transit or other damage or deterioration. Each hose should also be subject to an initial hydraulic test so as to establish its elongation under pressure and, where applicable, to test the electrical continuity or resistance, as a base line against which to judge its deterioration subsequent to its being exposed to service conditions. Details of these tests, plus all other relevant data, should be recorded for future reference.

The registration record should include the following information:-

- (a) Registration number
- (b) Title or name of hose
- (c) Fluid to be transferred
- (d) Location where the hose is normally used
- (e) Location where the hose is normally stored
- (f) Description of hose, length, diameter and materials of construction

- B.14.3.2** A thorough inspection, at intervals prescribed by the inspection engineer, based on the guidance given in B.14.2 should include the following where applicable:-

B.14.3.2.1 Composition Hoses

- (a) Internal Inspection (visual)
 - (i) for signs of decomposition, cracking or swelling of inner lining
 - (ii) bulging due to lack of bonding between layers



- (iii) sagging or pulling away of inner lining due to high flow rates
 - (iv) fracture or corrosion of steel wire helix in rough bore hoses
 - (v) fracture or crushing of wire helix or metal reinforcement, thread damage, distortion or cracking of end couplings, corrosion of end connections.
- (b) External Inspection (visual)
- (i) for signs of blistering of outer cover (lack of bonding or inner lining failure)
 - (ii) abrasion, cracks, wear, cuts, gashes, etc.
 - (iii) deterioration of outer casing
 - (iv) mechanical damage or crushing of helix or kinking of hose
 - (v) local swelling or weakness under pressure
 - (vi) leakage
 - (vii) sweating of LPG or other gas or chemical hoses
 - (viii) damage to end connections

B.14.3.2.2 Metallic Hoses

- (a) Internal Inspection (Visual and NDT)
- (i) For deformation of hose corrugations,
 - (ii) thread damage, corrosion, distortion or
 - (iii) cracking at end couplings or connections.

For signs of corrosion, pitting or cracking of the inner surface, dye penetrant examination of surface may be carried out where accessible.

- (b) External Inspection (Visual and NDT)
- (i) for signs of stress corrosion cracking, fatigue or mechanical wear



- (ii) mechanical damage such as crushing, kinking or squirming of the metallic convolutions
- (iii) damage to external braiding
- (iv) damage to end connections and screwed or welded attachments.

Dye penetrant examination of surfaces and weld areas should be carried out where accessible.

B.14.4 Hoses for LPG Service

The recommendations of [API Std. 2510](#) Section 7 (Paragraphs R7.1.3 to R7.1.6 and 7.4.1 to 7.4.2) and of the [I.P. Model Code of Safe Practice in the Petroleum Industry](#) Part 9 (Paragraph 2.5.13) may be used for guidance in the inspection of hoses handling LPG.

It should be noted that the UK HSE guidance note CS5, Recommendations on LPG Service Hoses, limits maximum service life to 5 years (Paragraphs 194 to 196).

B.14.5 Testing

Hoses should be tested at intervals prescribed by the inspection engineer, based on the guidance given in B.14.2. The test pressure applied should be greater than the maximum shut-in head of the system to which the hose is attached but should not exceed the manufacturer's maximum rated working pressure. The test pressure should be held for as long as necessary to permit a full visual examination, electrical continuity tests (where applicable), and a measurement of the overall length, which should also be measured before and after pressure test.

B.14.6 Rejection

Hoses may be rejected for further service at the discretion of the inspection engineer, taking into consideration the following points:-

- (a) transit or other damage
- (b) leakage
- (c) sweating
- (d) failure of inner lining
- (e) weakness in hose reinforcement
- (f) severe damage to outer casing

- (g) failure to meet electrical continuity requirements (where applicable)
- (h) cracking, corrosion or other defects to end couplings, flanges or nipples
- (i) elongation under test exceeding prescribed limits (where applicable)

B.14.7 Downrating

Hoses which are rejected for their primary service duty may, under certain circumstances - and at the discretion of the inspection engineer - be downrated and used on less arduous services.

In such circumstances the registration tag and records should be amended accordingly.

B.14.8 Additional Guidance Notes

When hoses are new or not in use, they should be stored out of direct light and be supported along their length to prevent sagging and contact with the ground.

Any slinging necessary during transportation should be made using wide braided nylon slings or cradle supports to prevent any kinking, throttling or local crushing.

Slinging support during loading and unloading operations between gantry and ship should be by wide braided nylon slings. Under no circumstances should wire strops be used to lift or support hoses without adequate precautions to prevent damage.

Service Conditions	Maximum Recommended Interval Between Thorough Inspection (months)
Oil suction and discharge hoses used exclusively on black oils. Hoses in non-hazardous duty (see B.14.1)	24
Oil suction and discharge hoses used exclusively on white oils or on mixed black and white oils.	12
LPG or other petroleum liquid/gas hoses.	12
Vacuum service for chemicals or petro-chemicals.	12
Pressure service for chemicals or petro-chemicals.	liquids: 12
	liquefied gas: 12

Note 1: This table is not applicable to hoses used on offshore tanker loading duties or high pressure oil production service or for roof drains on floating roof storage tanks.

Note 2: Where defined, for particular applications, statutory inspection intervals must be applied.

TABLE B.14.1
FLEXIBLE HOSES: INSPECTION INTERVALS



PART B - TECHNICAL GUIDANCE

SECTION B.15 GAS CYLINDERS

B.15.1 Introduction

This Section applies to cylinders and containers for the land based transport and storage of compressed and liquefied gases.

Gas cylinder means any closed metal vessel used to convey compressed gas, gas liquefied under pressure, or gas dissolved under pressure in a solvent.

Gas cylinders designed for transport duties are sometimes used for static firefighting installations or for emergency use; in these cases separate consideration is given.

B.15.2 Inspection Authority

In many countries, the periodic inspection of gas cylinders must be carried out by designated authorities.

Where there are no such regulations, the inspection authority will be that person or body responsible for the inspection and certification of gas cylinders. This may be a BP inspection engineer or external body specialising in the inspection of gas cylinders.

B.15.3 Inspection Frequency

Except where required otherwise by national regulation each gas cylinder should be inspected in accordance with the requirements of Table B.15.1.

Table B.15.1 is based on the recommendations in the [UK Home Office Gas Cylinders and Containers Report 1968](#) and [BS 5430](#), as directed by regulation 18 of the UK Pressure Systems Regulations.

Specific attention should be given to the materials of construction, bearing in mind that service temperatures may be lower than ambient.

Statutory regulations may include requirements for marking in accordance with materials of construction or gas contained within the cylinder.

B.15.4 Preparation for Inspection

The cylinder or container should be thoroughly cleaned and examined externally and as far as practicable internally, for surface defects, corrosion, or foreign matter. External paint, if in good condition, need not be removed.



In the case of lagged welded containers external examination may be restricted or dispensed with at the discretion of the competent person.

B.15.5 Inspection Procedure

All containers and cylinders should be examined externally at the time of filling. Any out-of-test or apparently defective cylinder or container should be segregated and unless it then satisfies the requirements of the periodic examination and test, whether or not an interval of five years has elapsed since its last periodic examination, it should be made unserviceable for containing gas under pressure. Such examination is more important in the case of thin wall cylinders or containers which may have been dented during use e.g. air cylinders used for self-contained breathing apparatus (SCBA) or self-contained underwater breathing apparatus (SCUBA).

It is not possible to specify in detail rejection limits to be applied in the external examination of cylinders or containers and it is for this reason that the person carrying out such inspection should be competent in this task. The following points should be taken into consideration during the inspection:-

- (a) Damage by indentation.
- (b) Damage by corrosion and pitting.
- (c) Damage by cuts or gouges.
- (d) Bulging of the cylinder walls.
- (e) Laminations.
- (f) Any unauthorised alterations to the cylinder or container.
- (g) Threads in the cylinder or container neck, and the valve protection cap if required to be fitted. These threads should be cleaned and examined to ensure that they are of good form and of full thread. Gauges should be used to verify that the threads are of correct diameter and taper.

Any container found to be unsatisfactory due to corrosion or the presence of internal foreign matter should be cleaned in an approved manner and re-examined after cleaning.

B.15.6 Pressure Testing

B.15.6.1 Periodic tests should be made at the prescribed intervals.

The applied test pressure should be in accordance with the specification to which the cylinder or container was manufactured

except where an amended value has been agreed by the appropriate authorities. Where a proof hydraulic test is specified, the proof pressure shall be applied for not less than the following:-

- (a) Cylinders less than 130 litres (4.2 ft³) capacity:- 2 minutes
- (b) Cylinders more than 130 litres (4.2 ft³) capacity:- 10 minutes
- (c) Large Welded Containers:- 30 minutes

B.15.6.2 Any cylinder in which there is a reduction of pressure under test should be made unserviceable for containing gas under pressure, e.g. by cutting in two.

B.15.6.3 When specified, the hydraulic volumetric expansion test (applicable only to cylinders) shall either be by the 'water-jacket' or by the 'non-jacket' method, both of which are fully described in BS 5045 Parts 1 and 2. The water jacket method is preferred. If, by either method, the permanent volumetric expansion expressed as a proportion of the total expansion under test pressure exceeds 5%, the container shall be made unserviceable for refilling with gas.

B.15.6.4 Large Welded Containers fitted with a Manhole or Handhole.

Each container should, at intervals not greater than 5 years, be examined externally and internally by a competent person. If the manhole or handholes are not large enough to permit a thorough examination of the whole of the interior surface then the requirement for a hydraulic proof test and/or NDT should be considered

Following any repairs to the pressure vessel a hydraulic test will be necessary together with any non-destructive tests the inspection engineer may require.

B.15.7 Gas Containers Used for Fire Fighting

B.15.7.1 Where portable cylinders are used on a static fire installation or for other emergency use, it is considered unreasonable to discharge the cylinders every five years for internal inspection.

B.15.7.2 Provided each container or cylinder is submitted to a full external examination every twelve months from the date it is taken into service and that there has been no more than 3% loss of contents or excessive external corrosion, the first periodic inspection and test may be extended to 20 years from date of installation.

If a container or cylinder loses its contents or is discharged after five years service a full inspection and test should be carried out.

After the first thorough inspection, each cylinder or container should be internally inspected and hydraulically tested at intervals of ten years to the second thorough inspection, and then every 5 years for the third and subsequent thorough inspections.

B.15.8 Reports and Records

Records should contain the following data:-

- (a) Maker's name or mark
- (b) Serial numbers of both maker and owner
- (c) Specification
- (d) Test pressure, and working pressure where relevant
- (e) Tare (i.e. empty) weight including fittings but excluding valve protection cap or cover

For cylinders and drums:

- (f) Dates and details of any repairs
- (g) Date and initial hydraulic test (and stretch test where relevant)
- (h) The charging pressure at 15°C if the container is to be used for permanent gases
- (i) The water capacity if it is intended to be used for liquefied gases

Detailed reports on all cylinder inspections and tests should be maintained for the entire life of the cylinders.

Classification	Periodic Examination (years)	Periodic Hydraulic Test (years)	Periodic Tare Check (years)	Remarks
LP Liquefied Gas Cylinders				
(a) Non-Corrosive	5	10	5	
(b) Corrosive	5	5	5	
Permanent and HP Liquefied Gas Cylinders and Containers	5	5	5	
Container tared as a complete Rail Vehicle	5	5	Each filling and Periodic Examination	
Container as part of complete vehicle or demountable	5	*Not Required	Each filling and Periodic Examination	* Provided sufficient access to conduct a meaningful examination, otherwise test every 5 years.

TABLE B.15.1
EXAMINATION PROCEDURE FOR PERMANENT AND LIQUEFIED GAS
CYLINDERS AND CONTAINERS



PART B - TECHNICAL GUIDANCE

SECTION B.16 TRANSMISSION PIPELINES

B.16.1 Introduction

This Section applies to land based and submarine pipelines used for the transportation of liquids and gases. It includes flowlines and risers, but is not concerned with piping systems within plants or to utility or gas distribution systems.

B.16.2 Guidance Documents

ETC.86.ER.137	Guidelines for Corrosion Defect Evaluation in Pipelines
BPE.89.ER.132	BPOI Pipeline Integrity Study
BP Oil	Pipeline Integrity Guidelines: Underwater Pipelines
BPE.90.ER.002	Pipeline Defect Analysis
BPE.91.ER.008	1990 Intelligence Pigging Review
API RP 1107	Pipeline Maintenance Welding Practices
API RP 1110	Pressure Testing of Liquid Petroleum Pipelines
API Publ. 220	Repairing Crude Oil, LPG and Product Pipelines
IP Code Part 6	Petroleum Pipeline Safety Code
BS 8010	Code of Practice for Pipelines

B.16.3 Inspection Authority

In many countries in which BP operates, there are statutory regulations relating to pipelines which must be complied with.

Except where required otherwise by statutory regulation, the inspection authority will be responsible for the inspection and certification of pipelines. This may be a BP engineer or an external body specialising in pipeline inspection.



B.16.4 Inspection Frequency

Because of the wide range of locations, size and duties, the principles of inspection grading cannot readily be applied and each pipeline should be considered on an individual basis. The extremes are:-

- (a) Pipelines in or near to residential or industrial areas which are liable to interference or damage.
- (b) Buried submarine pipelines, protected by heavily reinforced coatings and sacrificial anodes, which are stable in operation.

The frequency of inspection will depend on a number of factors, including the following:-

- (i) *Original design criteria.*
- (ii) *Effectiveness of corrosion protection systems throughout the length of the pipeline.*
- (iii) *Nature of the product.*
- (iv) *Environmental conditions and loadings.*

B.16.5 Pipeline Corrosion

Corrosion is by far the most common cause of pipeline degradation in service. The nature of the corrosive environment, both externally and internally, can vary considerably along the length of a pipeline.

External changes in the corrosive environment can typically be caused by:-

- (a) Variations in substrata i.e. acidic to alkaline.
- (b) Underground to overground.
- (c) Landfalls for water crossings.
- (d) Fresh to salt water e.g. crossing an estuary.
- (e) Deterioration in corrosion protection systems with time.

Internal changes in the corrosive environment can typically be caused by:-

- (f) Variations in temperature due to heat loss or gain with distance from origin.
- (g) Variations in flow profile along the line.



- (h) Separation of water from product, particularly associated with long straight runs.
- (i) Gradual changes in operating parameters with time.

These may be due to oil-field decline, admission of third party product, minor changes to the chemical composition and/or changes in transmission temperatures and pressures.

The periodic inspection and monitoring regime applied must take full account of all the above throughout the complete length of the line. It is important when using sample inspection techniques along the length of the line that the exact location of the most susceptible areas (to the particular type of deterioration to be detected) is known.

B.16.6 Inspection Guidelines

For each particular pipeline system consideration should be given to the following:-

B.16.6.1 All Pipelines:-

- (a) Monitoring of cathodic protection systems, including protection levels and, where appropriate, anode wastage.
- (b) Monitoring pipeline corrosion by product sampling, coupons or probes.
- (c) Regular survey of the pipeline to enable early identification of third party activity, signs of leakage or possible damage.
- (d) Monitoring of operating parameters (temperature, pressure, flowrate), evaluating any effect that changes may have on flow characteristics, product separation etc., throughout the pipeline. Any changes identified must be used to ensure that the interpretation of results from corrosion monitoring are constantly representative of the conditions throughout the various sections of the pipeline.
- (e) For pipelines considered to be subject to a high risk of internal or external wastage it is recommended that inspection utilising an intelligent pig capable of detecting and quantifying both external and internal defects is considered.
- (f) Use of alternative inspection techniques.

There are practical limitations in the use of alternative inspection techniques and each individual application must be subject to careful study. Advice may be obtained from BP.



B.16.6.2 Landlines:-

- (a) A visual survey of the pipeline route, any evidence of subsidence, land-slip or unauthorised excavation which might result in damage.
- (b) Internal inspection where accessible, e.g. during valve replacement, repairs or modification.
- (c) Excavation for external inspection; advantage should be taken of excavation for any other reason.

B.16.6.3 Sub-Sea Lines:-

- (a) Visual, photographic or closed circuit television survey using divers, manual or remote operated vehicles as appropriate.
- (b) Effects of scour or changes in the seabed profile resulting in pipe spans or exposure of the pipe.
- (c) Damage as a result of impact.
- (d) Condition of protective or weight coatings
- (e) Pipeline crossings, junctions, subsea valve assemblies, spoolpieces and flanged joints.
- (f) Evidence of marine growth.

B.16.6.4 Risers:-

- (a) General survey as for subsea lines.
- (b) Condition of metallic sheathing or other protective coating.
- (c) Evidence of mechanical damage.
- (d) Evidence of marine growth.
- (e) Security of supports and clamps.
- (f) Effect of debris from the platform.
- (g) Security of flange bolts.



B.16.7 Safety Devices

Such devices should be inspected and tested in accordance with Section B.9 of this RP.

Protective devices for pipelines are often in the highest criticality category, and must be inspected and tested accordingly.

B.16.8 Testing

Strength testing in accordance with the original design requirements will not normally be required unless major repairs or modifications have been carried out.

Service testing within the maximum operating conditions may be required for statutory purposes.

Guidance on testing may be found in Section B.1.3 of this RP, as well as the Guidance Documents listed in B.16.2.

B.16.9 Reports and Records

The internal and external inspection of pipelines is particularly difficult and expensive. It is essential that accurate comprehensive records are maintained of:-

- (a) Historical Operating Data
- (b) Predictions of Future Operation
- (c) Inspection Data
- (d) Corrosion Monitoring Data
- (e) Chemical Additions.

The above data should be summarised and reviewed on an annual basis, highlighting any significant changes in any aspect of the above information and recommending appropriate actions. Outstanding actions from previous reports should be highlighted.

PART B - TECHNICAL GUIDANCE

SECTION B.17 ROTATING MACHINERY

B.17.1 Introduction

This Section is for use in relation to rotating machinery, but excludes specific electrical requirements of rotating electrical machines which are covered by BP Group [RP 32-5](#).

B.17.2 Inspection Frequency

The choice of inspection frequency is primarily a matter of making the correct Inspection Grade/Criticality allocation. The principal factors which govern the Inspection Grade allocation are covered in Section 5 of BP Group [RP 32-3](#).

Other factors which should be taken into account are:-

- (a) Design life of the individual components.
- (b) Creep limitations.
- (c) Availability of standby equipment.

In order to provide structural stability, the pressure containing parts of machinery are generally designed on a very conservative basis; exceptions are small bore vent and drain connections (and other small-bore branches on associated pipework) which can be prone to fatigue cracking due to vibration. The requirements for inspection are, therefore, more likely to be related to operational reliability rather than pressure integrity, and may well be limited to major or critical items whose failure would result in unacceptable economic or safety consequences.

The frequency of inspections will also be influenced by the extent to which the machine can be monitored in service (condition monitoring). The need for and frequency of condition monitoring is a matter of economic judgement taking into account those factors which determined the Inspection Grade/Criticality allocation.

B.17.3 Maximum Intervals

The maximum recommended intervals between inspections are given in Table B.17.1. If condition monitoring techniques are used these intervals may be extended.

B.17.4 Safety Devices

The inspection procedures for safety devices are dealt with in Section B.9 of this RP. The inspection frequency for such devices may well be different from that quoted for machinery in Table B.17.1, in which



case it will be necessary to consider the duplication or isolation of such devices to permit their overhaul or test, without affecting the basic safety of the machine.

B.17.5 Inspection Procedures

In view of the wide range of size and type of machines in service, it is necessary for practical judgement to be made on the scope of inspection for individual items. Appendix B.17(1) gives guidance on the various factors which need to be taken into account in making this judgement.

B.17.6 Pressure Testing

As a general rule, machinery will not be subject to periodic strength testing except in the following circumstances:-

- (a) Where statutory regulations make it a mandatory requirement.
- (b) Where repairs or modifications have been made and the basic design and strength and integrity of the machine must be verified.
- (c) Where the machine is to be re-rated.
- (d) Where lack of internal access prevents a thorough inspection, and an hydraulic test is acceptable in lieu.

For practical purposes, it may be necessary to carry out some form of leak testing following overhaul or repair (e.g. seal replacement), in order to gain confidence in the effectiveness of the work.

B.17.7 Condition Monitoring

Appendix B.17(2) gives guidance in this area. Further guidance is available in [BPE.91.ER.186](#) "A User's Guide to Cost Effective Machinery Condition Monitoring Techniques".

**MAXIMUM recommended interval
between Thorough Inspections
(months)**

Plant or Equipment	Grade 0	Grade 1	Grade 2	Grade 3	Review Period for Grade 3 (months)
Rotating Machinery	24	48	96	120	84

TABLE B.17.1



ROTATING MACHINERY

INSPECTION PROCEDURES - GUIDANCE

B.17(1).1 Inspection check lists or tabular forms should be produced for each item of equipment, and for each level of inspection, i.e. condition monitoring, external inspection, full inspection. Where possible, maximum acceptable limits of deterioration should be stipulated.

B.17(1).2 The API Guide for [Inspection of Refinery Equipment](#), Chapter X, gives some general guidance about inspection methods. The following draws attention to particular aspects of different machinery types and of various components. It is not intended to be a comprehensive list of inspection methods.

(a) Rolling-Element Bearings

Clearance and freedom of rotation checks may indicate some faults but will not necessarily reveal incipient failure.

(b) Hydrodynamic Radial Bearings

Bearings should be checked for wear (clearance), fatigue cracks, white metal bonding, scoring and electrical and cavitation erosion. For tilting pad bearings the method of clearance checking must be carefully selected (e.g. taper mandrel), and the pad pivots should be examined for crushing or brinelling. For multi-lobe plain bearings the directions of clearance measurements must be specified.

(c) Hydrodynamic Thrust Bearings

Thrust pads should be checked for fatigue cracks, white metal bonding, scoring, electrical and cavitation erosion, and crushing or brinelling of the pivots. Axial float between the main and reverse thrust bearings must be obtained by a method that accounts for any spring in the bearing supports. Run-out of thrust collars or shoulders must be checked. It may be possible to do this using the axial proximity probe, if it reads on the thrust face, using rotor "slow roll".

If the bearing does not incorporate a pad-load equalising arrangement, the load distribution between the pads should be checked by blueing.

Note that on some machines useful information can be obtained by a rotor "bump check" i.e. shuttling the rotor between its limits with the thrust bearings removed.

(d) Rotors

Some rotor information can be obtained from an external inspection as follows:-

- (i) Vibration response as rotor runs down.
- (ii) Freedom of rotation with no rubbing or tinkling noise, and unbiased stopping position.
- (iii) Axial and radial "bump checks", with bearings removed (indicating minimum internal clearances).
- (iv) Rotor run-out check
- (v) Dimensional check.

Balancing will be part of some thorough inspections. Methods to be used and permissible unbalance limits must be clearly defined. The locations at which metal is to be removed must be carefully considered.

Whenever possible, new or repaired high speed rotors should be over-speed proof-tested in a bunker, with inspection and balance checks before and after.

(e) Oil Systems

Shut-down checks should include inspection to check filter condition.

(f) Gearing

Inspection checks may include gear marking, backlash, tooth profile, run-out at pitch circle.

(g) Gear-Tooth Couplings

If the coupling is of the "tip-piloted" type the radial clearance should be checked by moving the sleeve radially. Teeth should be inspected for wear and marking, and the backlash checked by feelers. Sleeve axial float must be determined.

(h) Coupling Alignment

Misalignment will sometimes be indicated by its influence on bearing vibration. For a few critical applications, optical alignment checking may be necessary. The on-line bar or proximity probe method of monitoring alignment is only applicable to machines having the bearings rigidly mounted from the casing (i.e. not separate bearing pedestals).

The alignment check method should be selected to give the maximum accuracy for the particular machine (e.g. radial and face, reverse reading). Proper clock jigs must be used and the exact planes and radii of measurement defined. Pipe support settings must be specified. Permissible misalignment should be determined as necessary to suit wear or strength criteria (e.g. tooth sliding velocity for a gear tooth coupling; fatigue stress limits for a flexible disc type).

(i) Pipework Alignment to the Machine

Security of the support adjacent to the machine should be checked and spring settings checked against design; an interval of twelve months should be adequate. This is particularly important for reciprocating compressors.

The original commissioning alignment checks should be repeated at a full inspection.

(j) Centrifugal Compressors

Shut-down checks may include the following:-

- (i) Crack detection of impellers and diaphragms.
- (ii) Labyrinth condition and clearance checks (method of checking top half clearances to be specified).
- (iii) Diaphragm centre-line joint gap.
- (iv) Balance piston clearance and condition.



- (v) Fluid film seals - similar checks to (b), in addition - condition of "O" rings, and radial freedom of seals.
 - (vi) Mechanical seals - amount of carbon ring wear (for information on rate of wear experienced - rings should be replaced at all inspections).
 - (vii) Fouling, particularly at diffusers.
 - (viii) Suction strainer, if fitted.
- (k) Centrifugal Pumps
- Shut-down checks may include the following:-
- (i) Extent of erosion.
 - (ii) Wear ring clearance.
 - (iii) Shaft run-out.
 - (iv) Wear of mechanical seals (for information on wear rate; seals would be expected to be replaced).
- (l) Steam Turbines
- Shut-down checks may include the following:-
- (i) Axial and radial labyrinth clearances.
 - (ii) Shaft run-out.
 - (iii) Disc, blading and shrouding cracks (blades may be 'rung' as a preliminary check).
 - (iv) End clearances on integrally shrouded blades.
 - (v) Fouling and corrosion, particularly in wet-dry zone.
 - (vi) Blade surface pits and scratches that could initiate fatigue.
 - (vii) Erosion of wet region blading (photographs or moulds may be necessary for record purposes).
 - (viii) Security of lacing wire.



(m) Gas Turbines

Shut-down checks:-

The safe operating period will normally be determined by the 'hot-path' component life (creep and hot corrosion). Component change will be essential when the component life has expired.

For internal inspections, full use should be made of borescope inspection facilities.

(n) Reciprocating Compressors

Shut-down checks may include the following:

- (i) Wear on cylinder bore, piston rings, rider rings, piston rod and packing.
- (ii) Cross head to cylinder alignment.
- (iii) Security of motion bolting e.g. piston unit, big-end bolting (torque figures may be specified).
- (iv) Crankcase/drive alignment.
- (v) Ring/packing.

The life of valves, rings and rod packing will normally limit periods of operation. Machines are normally spared in which case more emphasis will be placed on inspection rather than condition monitoring.

(o) Pressure Testing of Cylinders

This is generally very difficult to arrange in situ on a machinery casing because of the large number of connections and the seal arrangements. In addition, on multi-stage machines it is not possible to simulate the actual pressure and temperature distribution. Tests may, however, be usefully made on pumps when these are removed from site to a workshop for overhaul or testing.

Ordinary vessels and exchangers associated with the machine, e.g. in oil and seal systems, will be subject to consideration under the appropriate section of this Recommended Practice.

ROTATING MACHINERY**CONDITION MONITORING - METHODS AND APPLICATIONS**

Condition monitoring techniques and potential applications are listed below. The selection of a particular technique will require consideration of the machinery concerned and the probable faults.

Application of an analysis method to establish these will focus the selection and application and provide an auditable basis for the Condition Monitoring Program.

(a) Vibration

Method	Application
Fixed eddy current systems	Critical Machinery, with sleeve bearings
Hand held meters with accelerometers or velocity pick ups	General machinery, pumps, turbines, motors, blowers, etc.
Fixed systems with accelerometers or velocity pick ups	Important machinery with rolling element bearings or no access for eddy current probes
High frequency techniques e.g. Envelope Analysis, Acoustic Emission	Rolling element bearings

(b) Noise

Method	Application
Subjective assessment	General
Full noise survey	General, with more information
Ultrasonic noise survey. Acoustic Emission	Leaks

(c) Temperature

Method	Application
	Bearings
	Lube oil
	Valves (reciprocating machines)
	Exhaust (turbine performance)

(d) Oil

Method	Application
Magnetic Plug	Rolling element bearings, gearbox (magnetic wear debris)
Ferrography	Rolling element bearings, gearbox, (mostly magnetic debris)
Spectrographic oil analysis procedures (SOAP)	Rolling element bearings, gearbox turbines, compressor (all debris)



(e) Performance Analysis

Method	Application
Measurement of speed, flow, temperature, pressure, power, etc.	Internal fluid passages, Labyrinths, balance piston (Compressors)

(f) Visual - General

(g) Seal Flowrate - Seal condition

(h) During operation, routine visual examination by operations and engineering personnel would establish the general condition of equipment and such checks should include the following:-

- (i) Foundation conditions
 - (ii) Gland, seal leakage and vent flows
 - (iii) Mechanical damage to systems and general leakage
 - (iv) Signs of corrosion
 - (v) Excessive vibration, loose parts, cracks
 - (vi) Integrity of auxiliary equipment and fittings
 - (vii) Speed, temperature, pressure, noise levels and vibration indicators (if fitted)
 - (viii) Insulation
 - (ix) The condition of safety equipment such as coupling guards, etc.
 - (x) Satisfactory levels of lubrication
 - (xi) Operation of any on-line test devices
- (i) The following paragraphs draw attention to particular aspects of different machinery types and of various components. It is not intended to be a comprehensive list of condition monitoring methods.
- (i) Rolling-Element Bearings



To check bearing condition, an acoustic method is necessary, e.g. envelope analysis or high frequency response accelerometer. These may not indicate other machine defects such as an unbalanced rotor, and for these cases, monitoring with the seismic velocity pick up type of equipment may also be justified (proximity probe monitoring is of little value). If a bearing is allowed to approach or exceed its L10 rating life an increased frequency of monitoring may be justified depending on the consequence of failure.

Oil particle analysis can be applied, but will only be justified on particularly critical items.

Bearing temperature as measured at the housing is of limited value. It may indicate over-greasing, insufficient oil lubrication, excessively tight fits, or an actual failure.

(ii) Hydrodynamic Radial Bearings

The most satisfactory method of vibration monitoring is proximity probe measurement. This will indicate shaft as well as bearing defects. For detailed investigation, amplitude, frequency and phase trends should all be examined.

Journal position in the bearing (indicated by the D.C. signal component) is also a possible source of information. However, because of instrument drift over long periods this is usually only applicable to short-term monitoring.

It is desirable to use both discharge oil temperature and bearing metal temperature measurements. Any increase in discharge temperature not due to load, speed or inlet temperature will indicate a defect. Permissible metal temperatures depend on bearing design and actual bearing metal. A typical white metal limit is 115°C (240°F). Oil particle analysis is not normally useful, as wear only occurs at start-up or under fault conditions (note that if start-ups are frequent, more frequent monitoring may be necessary).

(iii) Hydrodynamic Thrust Bearings

Proximity probe axial position indication, and pad metal temperature indicators will normally be provided on critical duty machines. The unfiltered probe output can also be used to check axial vibration. For critical applications, load cell indication may also be useful.

(iv) Rotors

Condition monitoring will be mainly by vibration.

(v) Oil Systems

On-line checks may include the following:-

- Pump (possible from spill-back valve position).
- Oil Analysis, to check for deterioration and contamination.
- Oil debris analysis e.g. SOAP, Ferrograph (where applicable).
- Accumulator bladder charge pressure.

(vi) Vibration Monitoring

Consideration must be given to the way in which data is processed (e.g. to determine trends and step changes, and for fault analysis). Maximum use should be made of recording and computerisation to extend the scope of monitoring and to minimise the man-hours required.

Although some literature guidance is available, permissible vibration limits will have to be set for the particular machine or group of machines. Factors to be considered will include the following:-

- Relationship between shaft deflection and vibration levels.
- Bearing type, clearance and stiffness.
- Machine support stiffness.

- Likely vibration frequencies.

(vii) Gearing

Each of the vibration monitoring methods will give some useful information. Band analysis of noise can also be used. The best method(s) must be decided for the particular machine. For critical duty applications, oil debris analysis may also be justified.

(viii) Gear-Tooth Couplings

There is little on-line monitoring that can be made, except in so far as coupling faults may influence bearing vibration readings.

(ix) Centrifugal Compressors

On-line checks may include the following:-

- Vibration monitoring
- Noise analysis (fouling)
- Performance analysis
- Sour-oil leakage rates
- Seal-oil flow rate (i.e. both sweet and sour leakage)
- Seal-oil reservoir make-up (indicating oil loss into the process)
- Buffer gas flow rate (including state of gas baffles)
- Stage pressure ratios (fouling)
- Balance piston line flow (pressure drop)
- Sour-oil trap vent flows
- Seal 'throw-off' oil temperature

- Surge point checks (may be possible with only a momentary interruption of operation e.g. on air compressors)

Performance testing may include determination of polytropic or isentropic (adiabatic) expansion, and poly efficiency and power absorbed. Consideration must be given to the effect of variation of gas properties. Specific gravity meter readings or gas analysis may be necessary.

(x) Centrifugal Pumps

On-line checks may include the following:-

- Vibration
- Noise
- For double seals with gas outboard seals, seal condition may be checked by taking seal chamber pressure and gas leakage flow (e.g. Borg-Warner technique)
- Performance - pressures, flow (if available), driver power

Note that for variable speed machines, accurate determination of speed is essential. Non-contact, digital type tachometers should be used.

Where wasting of the casing is expected, full use should be made of ultrasonic testing.

(xi) Steam Turbines

On-line checks may include the following:-

- Vibration monitoring
- Interstage pressures (fouling)
- Balance piston leak-off flow (line pressure drop)
- Nozzle box pressures for nozzle controlled machines (correct operation of control valves)



- Flow from gland leak-offs (possible use of pilot-static tubes)
- Exhaust temperature (back-pressure turbines)
- Condenser air ejector stage pressures and temperatures
- Ejector vent air flow (possible use of pilot static tube)
- Performance analysis.

Steam flows are accurately required. For condensing turbines, where the exhaust steam condition is not known, efficiency may have to be obtained from the estimated power consumed by the driven machine. Condenser cooling water flow and temperature rise can alternatively be used if measurements are available and are of sufficient accuracy.

(xii) Gas Turbines

On-line checks as follows:-

- Casing mounted accelerometer readings may be of value besides proximity probes
- Air compressor discharge temperature, and turbine exhaust temperature are crucial
- It is vital that records are kept of running hours and turbine operating temperatures
- Performance checking must cover both compressor and turbine performance

(xiii) Reciprocating Compressors

On-line checks may include the following:-

- Vibration checks, including main pipework and vessels adjacent to the machine (deterioration of supports, foundation, and snubbers)
- Noise - particularly for indicating faulty valves, and loose motion bolting
- Temperature at valves (faulty valves)



- Discharge temperature and flow
- Indicator diagrams
- Proximity probe to indicate fall in piston rod with rider ring wear

(xiv) Diesel and Gas Engines

The period between valve, injector and piston changes will be comparatively short giving downtime that will reduce the need for on-line monitoring. However, oil debris analysis (e.g. Ferrography) may be useful, particularly where several machines are involved.



PART B - TECHNICAL GUIDANCE

SECTION B.18 CRYOGENIC EQUIPMENT

B.18.1 Introduction

This Section applies to equipment in cryogenic service which, for the purposes of this RP is defined as operating at temperatures below 120°K (-153°C). Cryogenic plants may include a wide range of equipment such as vessels, heat exchangers, pumps and piping systems.

B.18.2 Inspection Frequency

By nature of the design and operation of cryogenic equipment, conventional inspection practices may not be readily applicable. It is also possible that greater harm may result from temperature cycling in removing equipment from service than from constant operation.

The principal factors which govern the inspection frequency are covered in BP Group [RP 32-3](#) to which reference should be made. In addition, due regard should be given to the following:-

- (a) Statutory regulations, where they exist, which must be complied with.
- (b) Materials of construction

The materials of construction generally used for vessels and equipment in cryogenic service are aluminium and its alloys, copper and its alloys, austenitic stainless steel, and other suitable steels containing nickel. These materials are also more resistant to corrosion than other materials used for vessels in general service.

B.18.3 Maximum Intervals

The maximum recommended intervals between inspection for items in cryogenic service are given in Table B.18.1.

B.18.4 Specific Considerations for Cryogenic Service

B.18.4.1 Materials

Mechanical (tensile) properties of the materials used in the construction of cryogenic equipment are enhanced at cryogenic operating conditions. The enhanced strength is not usually taken into account in stress calculations according to the pressure vessel codes,



consequently providing an additional safety margin at the operating condition.



B.18.4.2 Construction

Cryogenic vessels are operated at pressures at or above atmospheric and are therefore designed, manufactured, tested and inspected to the standards of recognised pressure vessel codes. Vacuum insulated vessels are manufactured and tested to ensure and maintain a vacuum of less than 0.01 mbar in the interspace between the outer shell and the inner vessel.

Vessel parts, piping and fittings are connected by welding or brazing. Flanged and screwed fittings are eliminated as far as possible to avoid leakage of gas or liquid, which if it occurred could damage the foundation and insulation containment. In cases of vacuum insulated vessels, such a leak would badly affect the properties of the insulation. This is one reason why cryogenic vessels normally have no manholes, and have the final seams welded from the outside.

B.18.4.3 Corrosion

The wall of the vessel in contact with the cryogenic fluid is not subject to corrosion, because cryogenic fluids are dry and clean, and corrosion is non-existent at these low temperatures. Furthermore, the outside of the vessel walls are protected from corrosion by the chemically inert purge atmosphere (or vacuum) in the insulation.

B.18.4.4 Insulation

Due to the extreme low temperature, special insulation is necessary and is either densely packed mineral wool or expanded powder. Both materials are chemically inert in the dry state. To maintain this condition in the insulation and to prevent liquefaction of oxygen from the air if contained in the insulation space, a nitrogen purge gas is introduced, except where a vacuum condition or solid insulation applies. The insulation thickness may be in excess of 0.5m (1ft 8in) and this causes difficulty in providing access for external and internal visual inspection of the vessels.

B.18.4.5 Cleanliness

The need for very high standards of cleanliness for equipment used in oxygen service requires particular attention during manufacture and construction, including special care during pressure testing by using clean gases. Experience shows that the service conditions during normal operation ensures that the equipment retains its required standard of cleanliness. Opening cryogenic vessels under site conditions introduces the possibility of ingress of contaminants, foreign matter and moisture, which may result in a greater potential risk than if no such an action was taken.

B.18.4.6 Pneumatic Pressure Testing

This should be carried out when considered necessary by statutory requirement or following modification or repairs. Pneumatic testing with dry air or inert gas is normally carried out on cryogenic equipment since any residual water or humidity would freeze and



block up or damage equipment. This practice is in accordance with the pressure vessel codes and acceptable to the major pressure vessel approval authorities. Additional requirements for pneumatic testing are given in Section B.1.3.1.2 of this RP.

B.18.4.7 Inspection During Service

External inspection of the cryogenic equipment is not usually practical due to the presence of insulation in the cold box or vacuum vessel interspace.

Visual internal inspection of equipment is also not normally practical due to the elimination of bolted manholes and connections. This is because cryogenic equipment is subject to large temperature changes when the plants are started up and shut down and it is very difficult to design and achieve leak tight flanged joints. These are preferably eliminated in the design.

In the major vessels (distillation columns, matrix heat exchangers) the existence of internal tray assemblies, complex matrix construction etc. severely limits the amount of inspection if access were available.

B.18.4.8 Thermal Cycling

In large vessels and tanks there is a risk of cracking of the attachment welds on stiffening brackets and support ring as a result of thermal cycling.

B.18.5 Inspection Procedures

The possible variations in design of cryogenic equipment are numerous, calling for equivalent variations in inspection procedures. Site-specific procedures and checklists should be developed.

B.18.6 Inspection Guidance

B.18.6.1 General

The recommendations of this section are for periodic inspections. However, for many items of equipment it will not be reasonable to have an initial thorough inspection after a period of service notably shorter than that which will apply to intervals between thorough inspections.

During operation, routine visual examination by operations and engineering personnel would establish the general condition of equipment and such checks should include the following:-

- (a) Foundation temperature and condition.
- (b) Gland, seal leakage and vent flows.



- (c) Mechanical damage to systems and general leakage.
- (d) Signs of corrosion.
- (e) Excessive vibration of piping, etc.
- (f) Temperature, pressure, noise levels.
- (g) Insulation.

Maximum use should be made of on-line monitoring techniques. These will include performance testing, product purity, differential operational temperatures, temperature fluctuations, evaporation rates, hydrocarbon vapour detection, etc.

Whenever a cryogenic plant or piece of cryogenic equipment is taken out of service for modification or maintenance, then accessible areas should be examined by a competent person and a record made of the results of the inspection.

B.18.6.2 Bulk Liquid Storage Tanks

The following is recommended:-

- (a) Periodic monitoring of the insulation purge gas to identify the existence of external leaks and an annual visual check of the conditions of the outer containment shell, exposed pipework and controls.
- (b) Where soil conditions demand, that a regular monitoring of the stability of the tank foundations be undertaken.

B.18.6.3 Vacuum Insulated Storage Tanks

An annual visual check of the condition of the outer jacket, exposed pipework and controls and the jacket blow-out disc should be carried out. In addition other checks may be appropriate, e.g. the level of vacuum in the interspace or the evaporation rate of the cryogenic liquid or the rate of pressure rise of the inner tank, should be checked periodically to confirm the soundness of the insulation.

B.18.6.4 Cryogenic Vaporisers

These are usually shell and tube vaporisers. A periodic examination of the shell on the external tubular side and a pneumatic leak test of tube side at design pressure is recommended.



B.18.6.5 Regenerators

The following is recommended:-

- (a) Where a regenerator includes a carbon steel section at the warm end of the vessel, when access is possible, inspection of that section of the vessel should be carried out followed by a pneumatic leak test.
- (b) Periodic monitoring of the purity levels of the product to locate evidence of internal leaks, and also monitoring of the cold box insulation purge gas to identify the existence of external leaks.



Plant or Equipment	On-line Monitoring	Maximum Interval Inspections	Recommended Between (months)
		External Visual (see Notes 2)	Thorough
Cryogenic cold box vessels	Daily	40	120
Reversing heat exchangers	Daily	40	120
Regenerators	Daily	40	120
Bulk liquid tanks	Daily	40	120
Vacuum insulated tanks	Daily	40	120
Cryogenic vaporisers	Daily	40	120
Piping systems	Monthly	12	120
Pressure relief and other safety devices	Daily (see Notes 1)	12	48

- Notes: 1. (a) Visual examination to monitor for seat leakage, corrosion, icing or other blockage.
- (b) Bursting discs should be replaced with new elements on each occasion the equipment being protected is shut down for overhaul.
- Notes 2. (a) External examination does not mean any removal of insulation except when plant is completely shut down and has reached ambient temperature at the points or parts selected for inspection.
- (b) Any build-up of ice on outside or insulation should be investigated and corrected at the first opportunity the plant or equipment is shut down.
- Note 3. Where defined, statutory inspection requirements must be complied with.

TABLE B.18.1
CRYOGENIC EQUIPMENT: INSPECTION INTERVALS
 (see Note 3)



PART B - TECHNICAL GUIDANCE

SECTION B.19 LOADING ARMS

B.19.1 Introduction

This Section relates to loading arms used for the transfer of hydrocarbon or other hazardous substances at jetties and terminals. Loading arms are supplied to proprietary designs, and recommendations for inspection and maintenance are normally provided by the vendor. These recommendations should obviously be followed as far as practicable, but the comments in this Section should also be noted when developing site-specific inspection procedures.

B.19.2 Inspection Intervals

The maximum recommended intervals are as follows:-

- (a) Visual inspection : 12 months
- (b) Thorough inspection : 60 months

Operational inspections are normally recommended by the manufacturers, to be carried out prior to each tanker loading/unloading operation. These inspections should include:-

- (i) *visual general check on hoses, flanges and appurtenances for signs of damage or leaks (see also Section B.14)*
- (ii) *check on the sealing face of the manifold flange for damage, in particular any seal recesses.*
- (iii) *check on the hydraulic control cabinet for signs of leakage, and on fluid levels*
- (iv) *check that accumulator units are correctly charged when the loading arm hydraulic control system is started*
- (v) *check on freedom of motion after unlocking stowage locks*
- (vi) *test of the emergency release system*

Loading arms should be subject to a programme of regular maintenance, including inspection and lubrication, in accordance with the manufacturers instructions.

B.19.3 Visual Inspections

Regular visual inspections are recommended due to the following:-



- (1) The corrosive (marine) nature of the environment in which most loading arms are located.
- (2) The potentially serious operational, safety and environmental consequences of failure.
- (3) The relatively large number of moving parts and joints.
- (4) The ever-present risk of incurring mechanical damage during operation.

Visual inspections should be made using all the available access points. The following checks should be made and recorded (as appropriate to the particular design):-

- (a) evidence of leakage from joints and swivels
- (b) condition of hoses (see B.14)
- (c) evidence of external corrosion/paint breakdown
- (d) condition of bolting
- (e) condition of wire ropes, fixings and turnbuckles
- (f) condition of wheels
- (g) condition of hydraulic system, evidence of leakage
- (h) corrosion of counterweight assembly
- (i) corrosion of mechanical damage to ladders, platforms, etc.
- (j) condition of lock operating mechanism
- (k) underlagging corrosion
- (l) earthing
- (m) foundation/baseplates/anchoring/pedestals
- (n) condition of passive fireproofing

B.19.4 Thorough Inspections

In addition to B.19.3, the following inspections should be considered. These will normally require scaffolding:-



- (a) Ultrasonic thickness gauging of the inboard and outboard arms, especially for arms in light hydrocarbon duty where protective oil films may not be retained between successive operations.
- (b) Selective radiography of welds if preferential corrosion is suspected.
- (c) Opening of the swivel at the coupler end to permit internal inspection.
- (d) Radiography of vents and drains (which often suffer internal corrosion).
- (e) Pressure testing.

For newly assembled arms, or where major repairs or swivel seal replacements have been made, full strength hydrostatic testing is recommended. Reduced test pressures should be considered in all other cases, typically 1.5x the maximum operating pressure. This is because on some designs there is an unnecessary risk of damaging the elastomer seals by applying a strength test.

Pressure testing of loading arms used for LPG, LNG or other liquefied gas products should normally be performed using an inert gas, in accordance with BP Group [GS 138-3](#). Water or other liquids may not be suitable due to the risk of freezing, causing damage to the swivel and seal assemblies.



PART B - TECHNICAL GUIDANCE

SECTION B.20 OFFSHORE INSTALLATIONS

B.20.1 Introduction

This Section applies to offshore production installations based on tubular steel jacketed structures. It is not intended for application to concrete gravity structures or to steel mobile drilling installations, barges or drillships; neither does it apply to jetties or dolphins. In the case of mobile drilling installations (rigs) these are usually classified and are hence governed by Classification Society Rules. Where floating steel structures are used for offshore production this section can be taken as a guidance where appropriate.

Primarily this section of the RP refers to the structure itself but some other specific items of equipment relating to offshore installations are also mentioned as additional examples.

This Section is intended to give general guidance only, and hence it is recommended that operating centres develop their own additional manuals as appropriate. Other sections of this RP should be taken into consideration for pipelines and installed topsides equipment.

XEU have developed their own inspection philosophy for fixed offshore structures, as referenced in A.1.5.

B.20.2 Inspection Authority

In many countries in which BP operates, the inspection of offshore installations is subject to some form of statutory regulations, the requirements of which must be fully met.

In complying with statutory regulations it may be that the controlling body does allow the operating centre to nominate the inspection authority for specific items, or all items, providing that the inspection authority remains independent within the operating centre. This nominated body may be a BP engineer or external body specialising in the inspection of offshore installations. In such cases it would be normal for the inspection authority to be audited by the statutory authority from time to time.

For areas not subject to statutory regulations, the inspection authority will be that person or body responsible for the examination and certification of offshore installations within the operating centres. This may be a BP engineer or external body specialising in the inspection of offshore installations.



B.20.3 Inspection Frequency and Scope

Where statutory regulations apply they will normally specify intervals of inspection generally in terms of major and periodic surveys. Notwithstanding these regulations the following surveys are recommended.

B.20.3.1 Base Line Survey

It is recommended that a baseline survey of an offshore structure is carried out in the fabrication yard immediately prior to float-out.

The purpose of the survey is to give baseline data on brace members, weld identification, jacket attachments, NDT history summary and location references. This will assist divers or other remote inspection techniques to establish precise locations when carrying out subsea inspections.

B.20.3.2 In Service Inspection

The construction of offshore installations is such that the principles of inspection grading cannot readily be applied and each installation should be considered on an individual basis.

The frequency and extent of inspection will depend on a number of factors including the following:-

- (a) Original and currently applicable design criteria, e.g. loading and fatigue data with subsequent design reviews as appropriate.*
- (b) Water depth.*
- (c) Climatic conditions.*
- (d) History of similar structures in a similar environment.*
- (e) Possible redundancy of structural components.*
- (f) Fabrication standard and any previous repairs.*
- (g) Location of members above or below the waterline.*
- (h) Marine growth predictions.*
- (i) Accessibility of structure below water line and means of access.*
- (j) Collision damage and the accumulation of such damage.*
- (k) Corrosion allowance.*
- (l) Cathodic or other protective system.*

For a major structure it is recommended that the initial and subsequent inspection frequency is decided in conjunction with the responsible structural engineer who should advise on critical areas of the structure.

The size of many offshore structures makes it impractical to carry out a full inspection over any one year and hence it is essential that a



representative sample of the structure is inspected at an appropriate interval. The inspection engineer will therefore be expected to develop for the primary structure an inspection strategy based on grading all members and nodes in order of criticality derived from design fatigue lives. The formulation of an inspection scheme can then be developed by specifying inspections for given areas, capable of detecting the mechanism or mode of deterioration anticipated. The results of each year's inspection should be reviewed with the objective of identifying potential problems which could affect future programmes or parts of programmes.

Any such problems should be discussed with the structural engineers and any modification to the programmes jointly agreed. A normal cycle for a full jacket inspection depending upon size would not normally be greater than 5 years.

In addition to the primary structure it is recommended to have in place an annual inspection programme which covers areas such as module superstructure, access ways, stairs, ladders, gratings, helideck, flare tower, risers, pipe supports etc., such that the operational condition of the structure as a whole can be made known to those responsible.

B.20.4 Inspection Procedures

B.20.4.1 Preparation for Inspection

Preparation for offshore inspection may involve a number of requirements not normally identified with more conventional inspection such as the provision of support vessels, tidal constraints, limited accommodation and interface with topside activities. There will also be a requirement for a high degree of safety awareness. It is therefore essential that all offshore and particularly sub-sea work is subject to the most careful planning and control.

As with most structural inspection work, the primary requirements are to identify and provide adequate access to the parts of the structure which require inspection such as nodal joints, members, site welds, structural damage, etc. For above water locations, access may be by temporary platforms, permanent access platforms or mobile personnel carriers. For sub-sea work, other specialist services and equipment, including manned and remote controlled vehicles, will normally be provided by a specialist contractor.

Specific guidance on the particular requirements for inspection of components in a sub-sea environment are given in Appendix B.20(1). The inspection authority should maintain an up-to-date awareness of inspection techniques and equipment developments in order to ensure that work is executed as effectively and economically as possible.

B.20.4.2 Inspection

The requirements of this Section are for the periodic inspection of offshore structures to ensure that:-

- (a) The condition of the structure has not deteriorated beyond acceptable limits.
- (b) Any deterioration resulting from corrosion, protection coating breakdown and weld cracking, has been identified and measured for assessment of the overall integrity.
- (c) The efficiency of cathodic protection systems is checked.

Care should be taken in assessing possible interference with other cathodic protection systems such as that of risers.

- (d) The integrity of riser clamps which form part of the structure has been ascertained.

Riser inspections, are detailed in Section B.16 of this RP.

- (e) The structure is checked to ensure the acceptability of marine growth with regard to overall loadings, both static and wave action.
- (f) The structure/seabed is checked for debris.
- (g) The seabed is checked for scour around legs, piles, and conductors.
- (h) Specialised assistance and equipment is obtained in order to carry out the objectives set out above.
- (i) The information required in order to satisfy statutory requirements is provided where necessary.
- (j) The management is provided with a detailed report on the condition of the platform structure.

It should be recognised that most standard NDT techniques can be applied for subsea use.

Environmental and practical problems can limit the effectiveness and so in all cases special attention should be given to the formulation and approach of such techniques. In addition, the diver's approved qualifications and training should be assessed prior to commencement of the work.

B.20.5 Equipment Used on Offshore Structures

(Not Covered by Other Sections of this Recommended Practice.)

This Section gives some guidance on the inspection of specific examples of equipment not detailed in other Sections of this RP,



although it is not a full list. The operating centre should identify all such equipment which could be applicable on its installation and provide guidance on those items.

B.20.5.1 Well Control Equipment

Well control equipment is a general term for such items as blowout preventors, christmas trees, marine risers, etc.

Equipment under this heading which directly forms part of the well pressure envelope should be treated in a similar manner to other pressure equipment as detailed in other Sections of this RP.

An inspection scheme should be developed for this equipment, taking into consideration the constituents of the well fluids and the production testing routines carried out by the production department.

Particular attention should be given to the establishment of an auditable system of protective device testing. This should include all emergency well shut-in devices, both topside and downhole.

B.20.5.2 Diving Equipment

In some offshore installations diving spreads are permanently installed and these can be subject to statutory regulations in addition to those governing the offshore installations. The Inspection Authority should be aware of these requirements, but in the absence of such statutory control, a diving spread can be treated as a pressure system and the appropriate sections of this RP applied. When carrying out inspections of entry points into the diving spread, attention should be paid to locking devices as these are operated frequently compared to similar attachments on normal pressure vessels. Special attention should be given to the testing and inspection of safety devices on the diving bell's retrieval system.

B.20.5.3 Other Equipment to Which Consideration Should be Given

A list of other possible equipment includes the following:-

- (a) Pedestal Cranes (see specific guidance in Appendix B.20(2))
- (b) Lifeboats and their launching systems (see specific guidance in Appendix B.20(3)).
- (c) Tensioning equipment (mobile installations).
- (d) Drilling derricks and associated equipment.
- (e) Fire walls and dampers.
- (f) Portable wireline equipment.



SUB-SEA INSPECTION TECHNIQUES

B.20(1).1 Surface Preparation

The application of inspection techniques in a sub-sea environment may require some form of surface preparation. The following are typical examples of the methods used.

(a) Manual Scraping or Wire Brushing

Generally suitable for localised areas with low inspection sensitivity. Not to be used on welds and adjacent plate.

May be used for large area of marine growth removal. Soft-nose scrapers are preferred on painted surfaces.

(b) Powered Brushes and Abrasive Tools

As above, but used on larger areas and where paint coat removal is required.

(c) High Pressure Water Jetting

Suitable for localised or extensive areas where good surface finish is required. Usually enhanced with abrasive particle entrainment for efficiency and dull SA2-3 finish. Silica sand (subject to appropriate safety precautions) is the preferred abrasive, with slag grit such as J-Blast not recommended. This is the preferred surface preparation technique for subsequent inspection of welds.

B.20(1).2 Inspection and NDT Techniques

The following are the most commonly used inspection and NDT techniques for use sub-sea. Their use requires operators with particular skills and attributes, and special attention should be given to their selection and to monitoring the quality of their work.

(a) Visual Inspection

This may be carried out by a diver or from a manned or unmanned underwater vehicle.

This technique provides general information on the platform condition, such as location of structural members, collision damage, marine growth and can be used for detailed reporting of specific damage or defects.



Categories of Visual Inspection

Underwater visual inspection can be categorised into two basic levels:-

- (i) General visual inspection
- (ii) Specific visual inspection

The major difference is the degree of detail in the information required on the item under inspection and thus is directly related to the degree of surface preparation.

General visual inspections are carried out without any surface preparation. Therefore, this inspection is extremely limited in the level of information that it can provide.

Specific visual inspections are usually subdivided into the further categories such as detailed visual and close visual, again differentiated by the degree of surface preparation. Detailed visual may require removal of marine growth but not paint coat, whereas close visual usually requires cleaning to bare metal.

Methods of Visual Inspection

There are three basic methods of carrying out underwater visual inspection:-

- (1) Remotely Operated Vehicle (ROV).
- (2) Diver inspector.
- (3) Diver inspector supplemented by photography and video.

Where feasible, diver inspection is the preferred option. The main drawback is the lack of a permanent recording system for the human visual observations.

Methods of recording visual observations are:-

- (i) Still Photography

Still photography is an accepted permanent recording method for visual information. Resolution is good, particularly in the close up mode and high quality colour reproduction is possible with suitable procedures, film, and equipment.

Interpretation of features in photographs requires considerable caution due primarily to the two dimensional nature of the image but also due to inherent distortions in the underwater still photography process. These drawbacks can be minimised by

applying corrections to lens, using large format film, or, where depth perception is required, applying stereo photography.

(ii) Closed Circuit Television (CCTV)

Video systems are capable of providing on line visual information and permanent recording. Current video systems however, have relatively poor resolution compared to still photography and diver's eyes. Colour video is now in general use and the advantage of good colour reproduction is generally considered to compensate for the poorer resolution capability of colour systems compared to monochrome. Stereo video is still in the development phase for underwater applications.

The resolution limits of video restrict its application to general visual inspection and as a monitoring or permanent recording medium for diver based inspections.

(b) Magnetic Particle Inspection

This is a well proven technique for the detection of surface breaking crack-like defects. The coil/parallel conductor method and fluorescent inks are currently best suited to underwater application. Detailed technical specifications are essential for adequate confidence in the results.

(c) Radiography

This may be used in a conventional way underwater. However, both source and film have to be protected from the water environment.

This can be done by building a habitat around the item under inspection or by encapsulating the source and film. To date, only gamma sources have been encapsulated in this way.

(d) Ultrasonics

Thickness Measurement

This may be carried out using pulse echo instruments capable of measuring over a minimum to maximum thickness range, e.g. 5 - 99.9 mm is typical.

Where detailed wall thickness scanning is required the use of encapsulated flaw detection instruments is recommended.

Flaw Detection

This may be carried out in the conventional way underwater using encapsulated flaw detection equipment, or purpose built underwater flaw detection equipment. In both cases it is recommended practice that topside readout is available.

(e) Cathodic Protection

There are three basic techniques for cathodic protection (CP) monitoring:-

- (i) point contact
- (ii) 'dip' technique
- (iii) potential gradient measurement.

The point contact requires electrical contact with bare steel using purpose built underwater CP probe instruments.

The 'dip' technique uses standard half cells with an earthing wire to the structure. The attachment of the earthing wire can be above surface.

The potential gradient technique is mostly used on pipelines and uses two standard half cells a known distance apart located close to the item with their potential measured against a reference half cell some distance away.

(f) Others

The above is not an exhaustive list of subsea inspection techniques. Almost all traditional and novel inspection techniques can be used underwater and some techniques have been developed specifically for underwater application. The high costs of underwater inspection mean that careful consideration has to be given to the selection of the technique and to its effective and efficient utilisation.

INSPECTION OF OFFSHORE PEDESTAL CRANES

B.20(2).1 Introduction

The recommendations of this Appendix are for the periodic thorough inspection of Offshore Pedestal Cranes.

B.20(2).2 Scope

This Section applies specifically to Deck Mounted Pedestal Cranes and specific items of associated equipment, the cranes being situated on either fixed or mobile offshore installations.

The main parts of pedestal cranes for which an inspection scheme should be drawn up are the pedestal, slew rings, slew ring bolts, booms, and the wire ropes. As such cranes can often be subjected to the most arduous duties during construction of the installation, this should be taken into consideration when scheduling the first inspections. Where the design of the slew ring dictates that normal inspection methods can only be carried out by removing the ring then other monitoring techniques should be considered.

B.20(2).3 Inspection Authority

In many countries in which BP operates the inspection of Offshore Pedestal Cranes together with specific items of associated equipment are subject to some form of statutory regulations, the requirements of which must be fully complied with.

In order to comply with statutory regulations it may be that the inspection (or certifying) authority has to be appointed by the Controlling Body or the Controlling Body may allow the Operating Centre to nominate the inspection authority, providing that the inspection authority has sufficient independence within the operating company. This may be a BP engineer or external body specialising in such equipment.

For areas not subject to statutory regulations the inspection authority will be the nominated person or body responsible for the inspection and certification of life-saving equipment within the operating centre. This may be a BP Engineer or external body specialising in the inspection of such equipment.

B.20(2).4 Inspection Frequencies

The maximum intervals between inspections for Offshore Pedestal Cranes and associated equipment may be governed by statutory regulations which must be complied with. Where no statutory



regulations exist the maximum recommended inspection interval is six months.

B.20(2).5 Inspection Procedures

(a) Preparation for Inspection

The adequate and detailed inspection of Pedestal Cranes may of necessity require certain preparations such as the following:-

- (i) The provision of access
- (ii) The dismantling of equipment
- (iii) The provision of test equipment
- (iv) The transportation of equipment to a suitable location
- (v) The presence of operating personnel

Inspection procedures should highlight the need for such provisions and be specific where practicable.

(b) Inspection

Detailed procedures for the inspection of cranes, pedestals and specific items of associated equipment should be developed by individual operating centres in conjunction with specific contractors as appropriate.

These procedures should ensure that:-

- (i) Statutory regulations are fully complied with and that the integrity of cranes, pedestals and their associated equipment is fully maintained.
- (ii) Regular audits are carried out to ensure that the standard of any independent inspection, reporting and certification is being maintained at an acceptable level.
- (iii) Specialist assistance is obtained as necessary to verify the condition of the equipment being inspected.
- (iv) That management, the engineering authority, the inspection authority and others as appropriate, are formally advised of any significant defects found in lifting equipment, and that the equipment is withdrawn

from service as necessary until the proper repairs (or renewals) are carried out.

- (v) Full access is gained periodically to normally inaccessible areas such as A frames, booms and pedestals to access structural integrity and that the appropriate non-destructive examination techniques are specified for selected weldments in these structures.
- (vi) Specific inspection procedures are developed for slew rings which incorporate the appropriate non-destructive examination techniques.

When no satisfactory monitoring technique is available slew rings will require to be periodically dismantled for thorough inspection at intervals which satisfy any statutory regulations. Where no statutory regulations exist these intervals should be based on crane utilisation statistics with particular attention being paid to periods in which they are subjected to the most arduous duties such as during construction phases.

- (vii) Hook roller and bearing assemblers are subject to periodic thorough inspection.
- (viii) Individual items such as hooks, swivels, blocks, ropes and terminations are all regularly and adequately inspected.

Consideration should be given to the use of non-destructive examination of ropes.

- (ix) Rope change out frequencies are established and are being maintained.
- (x) Regular pressurised lubrication of ropes is scheduled and that the schedules are being maintained.
- (xi) Functional testing of the crane and associated safety devices is carried out at regular intervals.

This should include testing of the overspeed trips on diesel engines.

- (xii) Overload testing is specified where appropriate, such as after major repairs or alterations and after slew ring change outs.

Overload testing at set intervals is mandatory in certain countries.

- (xiii) Associated items of plant and equipment such as air receivers, nitrogen receivers, relief valves, lub oil tanks and diesel tanks are periodically inspected and tested in accordance with BP Group [RP 32-3](#).
- (ixv) Associated items of lifting equipment fitted to the crane such as runway beams, hoists, etc. are thoroughly inspected at regular intervals.
- (xv) Winch drum mountings are regularly inspected.
- (xvi) There is no overlap or conflict with any inspection elements of planned maintenance routines which are normally the responsibility of maintenance departments.
- (xvii) There is an immediate response to recommendations from Safety Alerts and Circulars and that procedures are modified to take account of these recommendations where considered necessary.
- (xviii) That all inspection methods comply with recognised codes and standards and are approved by BP.

B.20(2).6 Testing and Thorough Inspection Before Being Taken Into Use

Offshore cranes and associated pedestals should be overload tested and subjected to thorough inspection prior to being returned to service for the first time.

B.20(2).7 Major Repairs and Modifications

Where major repairs or modifications are approved and undertaken, cranes and pedestals should be overload tested and subjected to thorough inspection prior to being returned to service. Detailed records should be kept of all major repairs or alterations.

B.20(2).8 Failure

Where any significant failure of equipment occurs which could affect the safe operation of a crane, notification of such should be given to the Operating Centre management, the Engineering, Inspection and Regulatory authority as appropriate. Detailed records of all significant failures should be kept.



B.20(2).9 Markings

Each crane should be clearly marked with a plant or works identification number and safe working loads. Individual items of lifting equipment installed on the crane and all equipment within the scope of this Recommended Practice should also be clearly marked with a plant or works identification number together with operational details such as safe working load, safe working pressure etc.

LIFEBOATS, FAST RESCUE CRAFT AND LAUNCHING DAVITS ON OFFSHORE INSTALLATIONS

B.20(3).1 Introduction

The recommendations of this Appendix are for the periodic thorough inspection of lifeboats, fast rescue craft and their associated launching davits or systems.

B.20(3).2 Scope

This Section applies specifically to lifeboats, fast rescue craft and associated launching davits or systems situated on fixed or mobile offshore installations, or situated on emergency support or stand-by vessels operating within the controlled zones around such installations.

B.20(3).3 Inspection Authority

In many countries in which BP operates the inspection of lifesaving appliances is subject to some form of statutory regulations, the requirements of which must be fully complied with.

In complying with statutory regulations it may be that the inspection (or certifying) authority has to be appointed by the Controlling Body or the Controlling Body may allow the Operating Centre to nominate the inspection authority, providing that the inspection authority has sufficient independence within the operating company. This may be a BP engineer or external body specialising in such equipment.

For areas not subject to statutory regulations the inspection authority will be the nominated person or body responsible for the inspection and certification of life saving equipment within the operating centre. This may be a BP engineer or external body specialising in the inspection of such equipment.

B.20(3).4 Inspection Frequencies

The maximum intervals between inspections for lifesaving appliances on offshore installations may be governed by statutory regulations which must be complied with. Where no statutory regulations exist the maximum recommended inspection interval is six months. In addition there will normally be daily and weekly inspections and functional tests associated with planned maintenance routines.



B.20(3).5 Inspection Procedures

(a) Preparation For Inspection

The adequate and detailed inspection of life saving appliances may of necessity require certain preparations such as:

- (i) provision of access
- (ii) dismantling of equipment
- (iii) provision of test equipment
- (iv) transportation of equipment to a suitable location
- (v) presence of operating personnel

Inspection procedures should highlight the need for such provisions and be specific where practicable.

(b) Inspection

Detailed procedures for the inspection of lifeboats, fast rescue craft and their associated launching Davits (Systems) should be developed by individual operating centres in conjunction with specialist contractors as appropriate.

These procedures should ensure that:-

- (i) Statutory regulations are fully complied with and that the integrity of such lifesaving appliances and associated equipment is fully maintained.
- (ii) Regular audits are carried out to ensure that the standard of any independent inspection, reporting and certification is being maintained at an acceptable level.
- (iii) Specialist assistance is obtained as necessary to verify the condition of the equipment being inspected.
- (iv) That management, the engineering, inspection and regulatory authority as appropriate are formally advised of any significant defects found in lifesaving appliances and that equipment is withdrawn from service as necessary until the proper repairs (or renewals) are carried out.

- (v) Full access is gained periodically to normally inaccessible areas such as lifeboat Davit mountings and structures to assess structural integrity and that the appropriate non-destructive examination techniques are specified for selected weldments in these structures.
- (vi) Full access is gained periodically to the external surfaces of lifeboat hulls to determine if any damage or deterioration has occurred.
- (vii) Regular inspections are carried out on fast rescue craft hulls and sponsons, self righting gear and lifting points.
- (viii) Quick release assemblies and lifting points on lifeboats are subject to regular inspection with non-destructive examination techniques specified on selected weldments as required.
- (ix) Associated individual items of lifting equipment such as ropes, hooks, swivels, shackles, pendants, slings, sheaves and terminations are regularly and adequately inspected.
- (x) Rope turning (end for ending) and change out frequencies are established and are being maintained. Remote winching operating lanyards should also be subjected to periodic change out.
- (xi) Winches and clutches are periodically inspected and that non-destructive examination techniques are utilised on selected weldments on fabricated assemblies as appropriate.
- (xii) Functional testing of the equipment and the associated safety devices is carried out at regular intervals.
- (xiii) Overload testing is specified where appropriate, such as after major repairs or modifications.

Overload testing at set intervals is mandatory in certain countries.
- (xiv) Associated items of equipment such as air cylinders and hydraulic accumulators are subject to periodic inspection.

- (xv) Lifeboat and Fast Rescue Craft consumables are regularly inspected to ensure that they remain in good condition and in date.
- (xvi) There is no conflict or overlap with any inspection elements of planned maintenance routines which are normally the responsibility of maintenance departments.
- (xvii) There is an immediate response to recommendations from Safety Circulars and Safety Alerts and that inspection procedures are modified to take account of these recommendations where considered necessary.
- (xviii) That inspection methods used comply with recognised codes and standards and are BP approved.

B.20(3).6 Reports and Records

Recommendations on reporting and recording procedures are given in Section 6 of BP Group [RP 32-3](#).

Statutory report forms may be required in certain countries.

B.20(3).7 Testing and Thorough Inspection Before Being Taken into Use

Lifeboats, fast rescue craft and associated launching units (systems) should be overload tested and subjected to thorough inspection prior to being taken into service for the first time.

B.20(3).8 Major Repairs and Modifications

Where major repairs and modifications are approved and undertaken to launching davits (systems) or to the load bearing arms of the lifeboats or rescue craft, the equipment should be load tested prior to being returned to service. Detailed records should be kept of all major repairs or alterations.

B.20(3).9 Failures

Where any significant failure occurs which could affect the safe operation of the equipment, notification of such should be given to the operating centre management, the engineering, inspection and regulatory authority as appropriate. Detailed records of all significant failures should be kept.



B.20(3).10 Markings

Lifeboats and rescue craft require to be marked in accordance with the appropriate national legislative requirements. Equipment should also be clearly marked with a plant or works identification number.

PART C - REGIONAL ANNEX - UK STATUTORY INSPECTION REQUIREMENTS

SECTION C.1 OVERVIEW OF UK PRESSURE SYSTEMS REGULATIONS

C.1.1 Introduction

[SI 2169](#) "The Pressure Systems and Transportable Gas Container Regulations 1989" became fully effective within the UK on 1st July, 1994.

The Regulations contain provisions for the repeal of the sections of the Factories Act 1961 which deal with the inspection and maintenance of steam boilers, superheaters, economisers, steam receivers and air receivers, and the revocation of certain Statutory Instruments which refer to these items plus gas cylinders and containers.

Legislation with regard to Lifting Appliances, Gas Holders and Offshore Installations remains unchanged.

C.1.2 Guidance Documents

Accompanying the Regulations are '[A Guide to the Pressure Systems and Transportable Gas Containers Regulations 1989](#)' and two approved Codes of Practice for pressure systems and transportable gas containers. The guide amplifies and interprets the Regulations and attempts to clarify definitions. The codes of practice endeavour to assist users and owners of equipment covered by the Regulations to apply, and comply with, the Regulations. The basic definitions given in the Regulations are part of a legal document and any interpretations of them, or any regulation, can only be made by the courts.

Additional guidance is available in the [EEMUA Publication No 177](#) : "Selective Guide to the Pressure Systems and Transportable Gas Containers Regulations", dated 1993. This Guide was developed by the Committee of User Inspectors (CUI) in parallel with revisions of the Institute of Petroleum Model Codes of Safe Practice (Part 12 Pressure Vessel Examination and Part 13 Piping System Examination). The Guide makes reference to these Codes for detailed recommendations on the management of Schemes of Examination for in-service equipment, and focuses in particular on the interpretation of Regulations 2, 7, 8 and 20.

C.1.3 Outline

The Regulations place obligations on the employer/owner/user of equipment with regard to design, construction, repair, modification, records, installation, operation and examination of the equipment. Amongst these obligations is the requirement to define the scope of a



pressure system and to have a written scheme of examination drawn up, or certified as being suitable, by a competent person. The examination in accordance with the written scheme should be carried out by the same, or another, competent person who should make and send to the owner/user, a written report of the examination.

Similar obligations are placed on the owners of transportable gas containers and those filling such containers.

C.1.4 Definitions

Regulation 2.-(1) contains basic definitions of key words amongst which are:-

C.1.4.1 Pressure System

A system, containing a relevant fluid, comprising one or more pressure vessels of rigid construction, any associated pipework and protective devices.

The pipework with its protective devices to which a transportable gas container is, or is intended to be connected.

A pipeline and its protective devices, which contains, or is liable to contain a relevant fluid, but does not include a transportable gas container.

C.1.4.2 Transportable Gas Container

A container, including any permanent fitting of such a container, which is used, or is intended to be used, to contain a relevant fluid and is:-

Designed to be transportable for the purposes of refilling and has an internal volume of at least 0.5 litres and not greater than 3000 litres;

A non-refillable container having an internal volume of at least 1.4 litres and not greater than 5 litres, or;

In the case of Regulation 17(3) only, a non-refillable container.

C.1.4.3 Relevant fluid

(a) Steam

(b) Any fluid or mixture of fluids which is at a pressure greater than 0.5 bar above atmospheric pressure, and which fluid or mixture of fluids, is:-

(i) a gas, or



- (ii) a liquid which would have a vapour pressure greater than 0.5 bar above atmospheric pressure when in equilibrium with its vapour at either the actual temperature of the liquid or 17.5 degrees Celsius, or
- (iii) a gas dissolved under pressure in a solvent contained in a porous substance at ambient temperature and which could be released from the solvent without application of heat.

C.1.5 Pressure Testing

Except in the case of gas containers, where it is recommended by BS 5430, regular pressure testing is not specifically recommended by the Regulations. Where pressure testing is considered necessary, guidance on the subject may be found in Part B para B.1.3 of this RP.

C.1.6 Explosions

The regulating statutes are '[Reporting of Injuries, Diseases, and Dangerous Occurrences Regulations 1985](#)' (RIDDOR) which state in Schedule 1 -

"Pressure Vessels

Explosion, collapse or bursting of any closed vessel, including a boiler or boiler tube, in which the internal pressure was above or below atmospheric pressure, which might have been liable to cause the death of, or any of the injuries or conditions covered by Regulation 3(2), to any person, or which resulted in the stoppage of the plant involved for more than 24 hours."

and

'...where there is a dangerous occurrence, the responsible person shall -

- (a) forthwith notify the enforcing authority thereof by the quickest practicable means; and
- (b) within 7 days send a report thereof to the enforcing authority on a form approved for the purposes of this regulation.'

The above notification is required whether or not any person is killed or injured.



C.1.7 Competent Persons

C.1.7.1 General

The term 'competent person' is used in connection with two distinct functions under Part 3 of The Regulation, namely:-

- (a) The drawing up or certifying of written schemes of examination.
- (b) The carrying out of examinations in accordance with the written scheme.

The outline requirements for each are given below. For further information reference shall be made to the approved codes of practice to the Regulations.

Pressure systems vary greatly in complexity and sophistication, and a person competent to draw up schemes of examination or to examine a simple system may well not have the expertise to function adequately as a 'competent person' for complex systems. In this context users shall note that "person" is not limited to individuals. For a number of systems, including the larger or more complex, no one individual will have sufficient knowledge and expertise to act as a 'competent person' and a suitable body shall be chosen.

Any person or body when acting as a competent person shall be sufficiently independent from the interests of all other functions to ensure adequate segregation of accountabilities.

The competent person or body shall act in a professional manner uninfluenced by financial considerations, and draw up or certify written schemes, or carry out examinations solely on the basis of an impartial assessment of the condition of the system under review.

C.1.7.2 Competent Person - Written Schemes

Guidance is given in Appendix 1 of the Code of Practice for Pressure Systems. The appendix divides pressure systems into three categories i.e.. Minor Systems; Intermediate Systems; Major Systems. The attributes needed for competent persons to draw up or endorse written schemes of examination are given in terms of staff qualifications, access to specialist services, and organisation (records, supervision, training and recruitment, independence) for each category. Qualifications are not given in strict academic terms but are related to CEI 'status' e.g.. C.Eng.; I.Eng.; etc. The categorisations suggest that all but the most simple of 'minor systems' require a body rather than an individual as 'competent person'.

C.1.7.3 Competent Person - Examinations

The Code of Practice to the regulations states that this class of 'competent person' who carries out the examination, should have such



practical and theoretical knowledge and actual experience of the type of system which is to be examined as will enable defects or weaknesses, which it is the purpose of the examination to discover, to be detected and their importance in relation to the integrity and safety of the system to be assessed.

C.1.8 Safe Operating Limit (Regulation 7)

The user of an installed system and owner of a mobile system shall not operate the system or allow it to be operated unless (s)he has established the safe operating limits of that system.

C.1.9 Written Scheme of Examination (Regulation 8)

C.1.9.1 The user of an installed system and the owner of a mobile system shall:-

- (a) have written scheme for the periodic examination by a competent person of those parts of the pressure system in which a defect may give rise to danger;
- (b) ensure that the scheme has been drawn up by or has been certified as being suitable by a competent person;
- (c) ensure that:-
 - (i) the content of the scheme is reviewed at appropriate intervals by a competent person; and
 - (ii) the content of the scheme is modified in accordance with the recommendations made by that competent person and arising out of that review.

C.1.9.2 No person shall draw up or certify a scheme of examination unless the scheme is suitable for the purpose of preventing danger from the pressure system and:-

- (a) specifies the nature and the frequency of the examination;
- (b) specifies any safety measures necessary to prepare the pressure system for examination other than those it would be reasonable to expect the user (in the case of an installed system) or the owner (in the case of a mobile system) to take without specialist advice;



- (c) where appropriate, provides for an examination to be carried out before the pressure system is used for the first time.

This Regulation (N.B. this refers to all of Section C.1.9 of this Code) shall only require pipework to be included in the scheme of examination to the extent that it is necessary to include it to prevent danger.

C.1.10 Examination in Accordance with the Written Scheme (Regulation 9)

C.1.10.1 Subject to paragraph C.1.10.6 the user of an installed system and the owner of a mobile system shall:-

- (a) ensure that those parts of the pressure system included in the scheme of examination are examined by a competent person within the intervals specified in the scheme and, where the scheme provides, before the system is used for the first time; and
- (b) before each examination take all appropriate safety measures to prepare the system for examination.

C.1.10.2 A person making an examination for the purposes of paragraph C.1.10.1. shall ensure that the nature of the examination (s)he carried out is in accordance with the scheme of examination.

C.1.10.3 The competent person making an examination under the scheme of examination shall make a written report of the examination, sign or otherwise authenticate it, date it, and send it to the user (in the case of an installed system) or owner (in the case of a mobile system); and the said report shall be so sent as soon as it is practicable after making the examination and in any event to arrive -

- (a) within 28 days of the completion of the examination, or in the case of integrated installed systems where the examination is part of a series, the last examination in that series, or
- (b) before the date specified in paragraph C.1.10.4.(b), whichever is the sooner.

C.1.10.4 The report required by paragraph C.1.10.3. shall:-

- (a) state which parts of the pressure system have been examined, the condition of those parts and the results of the examination;
- (b) specify any repairs to, or changes in operating limits of the parts examined which, in the opinion of the competent person,



are necessary to prevent danger or to ensure the continued effective workings of the protective equipment, and specify the date by which any such repairs must be completed or any such changes made to the specified safe operating limits;

- (c) specify the date within the limits set by the scheme of examination after which the pressure system may not be operated without a further examination; and
- (d) state, with reasons, whether in the opinion of the competent person the scheme of examination is suitable or should be modified.

C.1.10.5 The user of an installed system and the owner of a mobile system which has been examined under this Regulation shall ensure that the system is not operated, and, no employer shall supply a mobile system for operation, after (in each case):-

- (a) the date specified under paragraph C.1.10.4(b), unless the repairs specified under that paragraph have been completed, and the changes in the safe operating limits so specified have been made; or
- (b) the date specified under paragraph C.1.10.4(c) (or, if that date has been postponed under paragraph C.1.10.6, the postponed date) unless a further examination has been made under the scheme of examination.

C.1.10.6 The date specified in a report under paragraph C.1.10.4(c) may be postponed to a later date by agreement in writing between the competent person who made the report and the user (in the case of an installed system) or owner (in the case of a mobile system) if:-

- (a) such postponement does not give rise to danger;
- (b) that only one such postponement is made for any one examination; and
- (c) such postponement is notified (by the user or his nominated representative) in writing to the enforcing authority for the premises at which the pressure system is situated, before the date specified in the report under paragraph C.1.10.4(c).

C.1.10.7 The owner of a mobile system shall ensure that the date specified under paragraph C.1.10.4(c) is legibly and durably marked on the mobile system and that the mark is clearly visible.



C.1.11 Action in Case of Imminent Danger (Regulation 10)

If the competent person carrying out the examination under the scheme of examination is of the opinion that the pressure system or part of the pressure system will give rise to imminent danger unless certain repairs have been carried out or unless suitable modifications to the operating conditions have been made, then without prejudice to the requirements of C.1.10, (s)he shall forthwith make a written report to that effect specifying the repairs or modifications concerned and give it:-

- (a) in the case of an installed system, to the user; or
- (b) in the case of a mobile system, to the owner and to the user, if any:

and shall within 14 days of the examination send a copy to the enforcing authority for the premises at which the pressure system is situated.

Where such a report is given in accordance with C.1.11.1 to:-

- (a) the user of a pressure system, he shall ensure that the system (or, if the report only affects a discrete part of the system, that part) is not operated:
- (b) the owner of a mobile system, he shall take all reasonable practicable steps to ensure that the system (or, if the report only affects a discrete part of the system, that part) is not operated, until the repairs or modifications, as the case may be, have been carried out or made.

C.1.12 Exemptions

Certain exemptions to the requirements of the Regulations are listed in Schedule 1 to the Regulations. Some of these relate to the petroleum and petro-chemical industry, including:-

PART I (Exemption from the whole of the Regulations)

- 5. Any pipeline and its protective devices in which the pressure does not exceed 2.7 bar above atmospheric pressure under pressure relief conditions (i.e. normal operating pressure, 2 bar or less).
- 6. Any pressure system or part thereof, or transportable gas container which:-



- (a) is the subject of a research experiment.
 - (b) comprises of temporary apparatus being used in a research experiment if in the case of regulations 4, 5, 6, 7, 11 and 13, it is not reasonably practicable to comply with them.
18. Any vapour compression refrigeration system incorporating compressor drive motors, including standby compressor motors, having a total installed power not exceeding 25 kW.
 24. Any portable fire extinguisher with a working pressure below 25 bar at 60°C and having a total mass not exceeding 23 kilograms.

PART II (Exemption from certain Regulations)

1. Regulations 8 to 11 (C.1.9, C.1.10, C.1.11 of this Code) and 13 (keeping of documents etc.) shall not apply to a pressure system containing a relevant fluid (other than steam) if the product of the pressure in the pressure vessel (or, in the case of a system having more than one pressure vessel, the vessel with the largest volume) (in bars) and internal volume (in litres) is less than 250.

C.1.13

Key Points

Key points of Regulations 8 and 9 are:-

- user/owner of a system must have a written scheme of examination drawn up or certified by a competent person.
- scheme must specify nature and frequency of examination.
- only vulnerable pipework to be included in scheme.
- report of examination to be with user/owner within 28 days of completion of examination or before the date specified for repairs.
- one postponement of next inspection is permitted subject to agreement between user and competent person.
- pressure systems whose major pressure vessel does not have a product of pressure and volume exceeding 250 bar litres, are exempt from regulation 5(4) manufacturers plating (name



plate) requirements, 8 to 11 written schemes of examination, examinations and operating instructions and 13 records.

C.1.14 Extensions Beyond the Due Date

The date specified for re-examination in accordance with the written scheme may be postponed to a later date by agreement in writing between the competent person and the operator of the systems provided that:-

- (a) such postponement is made for any one examination; and
- (b) such postponement is notified to the enforcing authority for the premises at which the pressure system is situated, before the original due date.

C.1.15 28 Day Report Format

C.1.15.1 Paragraph C.1.10.3 requires a report to be submitted to the user of the system within 28 days detailing the information specified in para. C.1.10.4. A suggested format is given in appendix C.1. to this Section.

C.1.15.2 In normal circumstances the inspection reports required by BP Group RP 32-3 shall be modified to include the information required by the regulations (see appendix C.1.) This will result in the system report being completed from the reports on all of the relevant items within the system.

C.1.15.3 During turn-arounds or periods of high work load where the production of all the reports within 28 days maybe considered too onerous, the use of one 28 day report to cover all of the items examined (using the format indicated in Appendix C.1) is permitted.



SUGGESTED FORMAT FOR EXAMINATION REPORT FORMS

[Health and Safety at Work etc. Act 1974](#)

[Pressure Systems and Transportable Gas Containers Regulation 1989](#)

Report of Examination of a Pressure System under the Scheme of Examination

All Systems

- (a) Name and address of owner
- (b) Whether subject to a written agreement under Schedule 3 (Hired/leased equipment only).

YES/NO

Installed Systems

Address of location of system and name of user if different from above.

All Systems

- (a) Identification of system or part(s) of system examined. (i.e. vessel no. etc.).
- (b) Condition of system or parts examined.
- (c) Result of examination.
- (d) Any repairs which are needed and the time within which they should be completed.
- (e) Any changes in the safe operating limits of the system and the date by which those changes should be made.
- (f) In the light of any deterioration, or other circumstances, whether any change is advised in the scheme of examination.
- (g) Date by which the next examination is required to have been completed.
- (h) Where the current examination has been postponed in accordance with Regulation 9(7) names of appropriate members of both the competent person's and the user's/owner's



organisation, date of giving the relaxation, and the new date by which the examination is to be completed.

(i) Other observations.

(NB: This examination relates to those parts of the pressure system where there is a reasonably foreseeable risk of injury from system failure).

(j) Date of current examination.

(k) Name and address of competent person carrying out the examination.

(l) Signature (or authentication) on behalf of
(competent person).

(m) Date of report.





HEALTH AND SAFETY AT WORK ACT 1974 PRESSURE SYSTEMS AND TRANSPORTABLE GAS
CONTAINERS REGULATIONS 1989
REPORT OF EXAMINATION OF A PRESSURE SYSTEM UNDER A SCHEME OF EXAMINATION

SHEET	OF	DATE
SYSTEM NUMBER:	DESCRIPTION	LOCATION:
SCHEDULE 3 AGREEMENT YES/NO (Hired/Leased Equipment)	NAME AND ADDRESS OF USER	NAME AND ADDRESS OF OWNER: (If different from user)
WAS THIS EXAMINATION POSTPONED ? FROM: TO:		

PARTS EXAMINED								
TAG.. NO	WI NO.	DESCRIPTION	INSPECTION TYPE	CONDITION FOUND	REPAIRS	REQ'D COMPLETION (IF COMPLETE STATE COMPLETE)	LIMITATIONS IF ANY	NEXT DUE DATE

NAME OF USERS AUTHORISATION SIGNATORY :	NAME OF INSPECTION AUTHORITIES AUTHORISED SIGNATORY :
---	---

RECOMMENDED CHANGES TO SCHEME OF EXAMINATION (IF ANY)	REVISIONS TO SAFE OPERATIONS LIMITS :	OTHER OBSERVATIONS :
NAME OF COMPETENT PERSON	SIGNATURE ON BEHALF OF COMPETENT PERSON :	NB: DETAILED INSPECTION REPORTS FOR EACH ITEM WILL BE ISSUED UNDER SEPARATE COVER:

PART C - REGIONAL ANNEX - UK STATUTORY INSPECTION REQUIREMENTS

SECTION C.2 STEAM BOILERS

C.2.1 Introduction

Steam boilers are subject to statutory control under the provisions of [SI 2169](#), The Pressure Systems and Transportable Gas Containers Regulations 1989. These requirements may be amended from time to time by the issue of further Statutory Instruments or by the issue of Certificates of Exception which may exempt specific items from certain of the provisions of the Regulations.

Exception Certificates are issued, when appropriate, by the Department of Employment under the signature and authority of H.M. Chief Inspector of Factories. Future changes in the regulations applicable to steam boilers will be authorised by the UK Health and Safety Executive.

C.2.2 Definitions

Under the Regulations steam boilers are not considered separately from other pressure systems. Part (a) of the definition of pressure system therefore encompasses steam boilers, waste heat boilers, CO boilers, steam generators, economisers, steam superheaters etc. and includes all protective devices and some associated pipework. Note also that no distinction is drawn between fired and unfired pressure systems.

C.2.3 Inspection Frequency

The regulations do not specify intervals between inspection but the Codes of Practice give some guidance in setting intervals. Generally, existing inspection intervals 'shall be taken as a basis of the new schemes except where there is evidence that longer or shorter intervals are more appropriate'. Also 'Although it is intended that some flexibility in setting intervals shall occur, existing plant shall not have the intervals significantly extended over present practice without authoritative review both by the user and the competent person of all relevant factors'.

C.2.4 Code of Practice to the Regulations

The code of practice to the Regulations provides guidance on Design, Construction, Repair, Modification, Scheme of Examination, Examination and Operation as detailed below.

- C.2.4.1 General
- C.2.4.1.1 This section provides some additional guidance for systems for steam or pressurised hot water generation, distribution and use. The guidance is directed at systems which have a separate steam or pressurised hot water generator (boiler), distribution pipework and apparatus or vessels where the steam or hot water is used for any purpose. There may then be a return system of pipework for recirculating the steam or hot water back to the boiler. The boiler blow down arrangements may also need to be considered as part of the pressure system.
- C.2.4.1.2 The guidance may be relevant to other steam or hot water systems but it must be recognised that the precautions may not be appropriate in all such cases.
- C.2.4.2 Design Construction, and Repair and Modification - Regulation 4.
- C.2.4.2.1 Steam systems are very prone to water hammer which can have disastrous effects. Pipework should therefore be designed and constructed so that any water only collects at suitable points in the system where drains are provided (see para. C.2.4.2.9).
- C.2.4.2.2 Boilers should be protected by at least one suitable safety valve. Sufficient safety valves should be fitted at other points to ensure that the pressures inside the system do not rise above the safe operating limits. Receivers do not necessarily have to have individual safety valves, but it shall not be possible to isolate them from the device which is providing protection if the source of pressure can still be applied to the receiver.
- C.2.4.2.3 Suitable pressure reducing valves, safety valves and pressure indicating devices should be fitted if a part of the system has a lower safe operating limit for pressure than the boiler.
- C.2.4.2.4 Boilers should be fitted with suitable pressure indicating devices. Devices should also be fitted to other parts of the system so that the pressures in the system may be known and limiting values observed.
- C.2.4.2.5 Any boiler in which a low level, or into which a low flow rate, of water could lead to unsafe conditions should be fitted with at least one suitable water level indicator connected directly to the boiler and an alarm which sounds when the water level drops to a predetermined value. Steam boilers with a rating of more than 100 kw should be fitted with at least two water level indicators. At least one of these water level indicators should be a suitable water gauge connected directly to the boiler.

- C.2.4.2.6 Boilers should be provided with a suitable stop valve. Cast iron boiler stop valves are not recommended. Where more than one boiler is connected to a common pipe then an additional isolating valve should be fitted in series with each boiler stop valve. Other stop valves should be fitted as needed so that parts of the system can be safely isolated. Means should be provided to isolate positively any boiler from both pressure supply and return systems.
- C.2.4.2.7 Boilers which are fitted with fuel/air burners and whose safety functions are controlled automatically should have controls which:-
- (a) automatically maintain the water level in, or water safety flow into, the boiler between the design limits;
 - (b) automatically control the supply of fuel and air to the burners to keep the boiler within the safe operating limits and to shut off the supply of fuel and, if appropriate, air in the event of flame or pilot flame failure, lack of ignition or failure of any induced draught fan; and in addition,
 - (c) an independent overriding control system which automatically shuts and locks off the fuel and, if appropriate, air supply to the burners and sounds an audible alarm in the event of a low level or low flow of water which could be liable to give rise to a dangerous condition. This control system should be so arranged that it has to be reset by hand.
- C.2.4.2.8 Steam boilers should be fitted with at least one blowdown valve at, or as near as practicable to, the point in the boiler where sludge or sediment is liable to accumulate. Where several boilers blow down into a common tank, sump or pipe positive means should be provided to prevent steam or hot water from being blown out of one boiler into any other boiler.
- C.2.4.2.9 Suitable drains should be provided on other plant items and on pipework at places where sediment or water is liable to accumulate. If necessary, devices should be fitted at appropriate points in the system to allow venting of vapour and/or prevent a vacuum forming.
- C.2.4.2.10 Safety valves and associated inlet and outlet pipework should have an adequate discharge capacity which will limit the pressure to the safe operating limit. Lever and weight type safety valves should not be fitted to new plant.

- C.2.4.2.11 The gauge glasses of tubular water level gauges should be effectively guarded to protect persons against the effects of the glass breaking and steam or hot water being ejected.
- C.2.4.2.12 Fusible plugs should only be used as the sole low water alarm when other types of low water alarm are not practicable. They may be used in addition to other types of low water alarm where suitable for the type of boiler. They should be fitted at the point or points where overheating is first likely to occur if the water level drops.
- C.2.4.3 Written Scheme of Examination - Regulation 8
- C.2.4.3.1 The period laid down in the scheme between examinations for boilers should not generally exceed the recommended intervals in BP Group RP 32-3. Shorter periods will be necessary for boilers operating under arduous conditions or when the condition of the boiler has deteriorated. Longer periods up to the maximum 72 months, should only be set for boilers where experience of the type of boiler shows that it is reasonable to do so and the arrangements for maintaining the safety of the system are to a high standard. In particular it will be necessary to consider water treatment arrangements.
- C.2.4.3.2 There were provisions in previous legislative requirements in the case of some types of boiler for the method of examination to be set, information to be gathered and assessed and the periods between examinations to be extended and for those types of boiler the previously accepted intervals should be taken as a basis for the written scheme.
- C.2.4.3.3 The first examination should be set so that boilers are examined before being taken into use for the first time.
- C.2.4.3.4 Superheaters and similar plant items should be examined at the same intervals as boilers of similar size and complexity.
- C.2.4.3.5 More flexibility can be allowed for the period between examination of receivers. This should generally be in the range 26-38 months. It may be convenient to examine them at the same time as the boilers to which they are connected. The periods may be set by reference to the provisions of previous legislative requirements as in the case of boilers.
- C.2.4.3.6 Protective devices should be examined at least as frequently as the plant to which they are fitted. Consideration should be given however to checking them more frequently. Devices which are on parts of the system which do not need to be examined should nevertheless be included in the scheme.

- C.2.4.4 Examination in Accordance with the Written Scheme - Regulation 9.
- C.2.4.4.1 The preparation of boilers for examination should be sufficient to enable the competent person to assess its condition and may include any of the following, or other preparation the competent person wishes:-
- (a) the opening out, cleaning and descaling of the boiler
 - (b) the removal and cleaning of the firing appliances
 - (c) the removal of brickwork
 - (d) the removal of protective devices
 - (e) opening out of float/probe control chambers
 - (f) the removal of lagging; and
 - (g) the removal of the boiler from its frame (in the case of locomotive or similar boilers).
- C.2.4.4.2 After preparation, the competent person should examine the boiler when cold and subsequently at normal operating pressure and temperature. There should not be undue delay between the two parts of the examination, which need both to be done for the examination to be completed. After pressure has been raised and the boiler brought up to temperature the second part of the examination should be completed as soon as possible thereafter. In the case of boilers of preserved locomotives the pattern of examinations will depend upon the operational requirements for the locomotive. Where a cold examination takes place late in the year so that necessary repairs may be done out of season, and eight or more weeks elapse between the two parts of the examination, the competent person may require the next cold examination of the boiler to be carried out in less than 12 months.
- C.2.4.4.3 Receivers should be examined when cold and should also be examined under normal operating conditions if so required by the scheme of examination.
- C.2.4.4.4 Safety valves should be properly adjusted and tested at each examination.

C.2.4.5 Operation - Regulation 11

C.2.4.5.1 Pre-firing and start-up instructions should include:-

- (a) methods of establishing the proper water level in the boiler and maintaining adequate water supplies;
- (b) methods of carrying out any necessary flue gas side purging;
- (c) methods of establishing correct firing conditions in order that pressure/temperature are raised carefully, preventing undue thermal shock; and
- (d) procedures to avoid water hammer.

C.2.4.5.2 There should be instruction covering:-

- (a) if appropriate, the feed water treatment;
- (b) the safe blow down of the boiler and any other parts of the system requiring such treatment;
- (c) the precautions to be taken when emptying the boiler, e.g. by allowing it to cool down sufficiently before emptying it; and
- (d) the procedures to be followed in the event of a shortage of water, bursting of tubes or other event requiring the boiler to be shut down.

PART C - REGIONAL ANNEX - UK STATUTORY INSPECTION REQUIREMENTS

SECTION C.3 UNFIRED PRESSURE VESSELS

C.3.1 Introduction

Unfired Pressure Vessels are subject to statutory control under the provisions of [SI 2169](#), The Pressure Systems and Transportable Gas Containers Regulations 1989 where they contain or are liable to contain a relevant fluid and incur the associated requirements of the Regulations.

C.3.2 Definitions

Regulation 2 of [SI 2169](#), "Interpretation" should be used to establish definitions applicable to Unfired Pressure Vessels subject to the Regulations.

C.3.3 Inspection Frequency

The regulations do not specify intervals between inspection but the Codes of Practice give some guidance in setting intervals. Generally existing inspection intervals 'shall be taken as a basis of the new schemes except where there is evidence that longer or shorter intervals are more appropriate'. Also 'Although it is intended that some flexibility in setting intervals shall occur, existing plant shall not have the intervals significantly extended over present practice without authoritative review both by the user and the competent person of all relevant factors'.

In setting intervals the philosophy and intervals recommended for Class B (Non-Statutory) equipment in BP Group [RP 32-3](#) should be followed.

C.3.4 Inspection Requirements

The Approved Code of Practice (ACOP) and Guidance on Regulations should be used to ensure that compliance with the Regulations is achieved.

Regulation 8, Written Scheme of Examination, should contain appropriate inspection requirements deemed necessary to carry out a meaningful examination.

The distinction is no longer made between steam receiver and steam container. Steam at any pressure is a 'relevant fluid' and thus any vessel containing steam must be treated as a pressure system or part of a pressure system even where covered by Part IV of the Regulations (vessels whose contents are at atmospheric pressure).



Inspection of pressure vessels should generally be carried out in accordance with the guidance set out in Section B.3 of this RP.



PART C - REGIONAL ANNEX - UK STATUTORY INSPECTION REQUIREMENTS

SECTION C.4 LIFTING EQUIPMENT

C.4.1 Applicable Acts and Regulations

The principal Acts and Regulations governing the use of lifting equipment in places of work are:-

- (a) [The Health and Safety at Work Act, 1974](#);
- (b) [The Factories Act, 1961](#);
- (c) [Docks Regulations \(SR and O 1934, No. 279\)](#);
- (d) [Construction \(Lifting Operations\) Regulations \(SI 1961 No. 1581\)](#);
- (e) [Construction \(Working Places\) Regulations \(SI 1966 No. 94\)](#);
- (f) [The Offshore Installations \(Operational Safety, Health Welfare\) 1976 SI 1019](#);
- (g) [The Chains, Ropes and Lifting Tackle \(Register\) Order 1938 \(SR and O 1938, No. 599\)](#);
- (h) [The Construction \(General Provisions\) Regulations 1961 \(SI 1961 No. 1580 as amended by SI 1966 No. 94 and SI 1974 No. 1681\)](#);
- (i) [Lifting Machines \(Particulars of Examinations\) Order 1963 \(SI 1963 No. 1382\)](#);
- (j) [The Hoists Exemption Order 1962 \(SI 1962 No. 715 as amended by SI 1967 No. 759\)](#);
- (k) [The Shipbuilding and Ship Repairing Regulations 1960](#).

C.4.2 Application

- C.4.2.1 The requirements of the Factories Act 1961 apply to all existing land installations except for jetties, docks or harbour installations, where the Docks Regulations will apply.



C.4.2.2 The Construction Regulations apply only to those sites (land based) where new works are being built or erected.

To avoid confusion with operating sites, it is common practice to isolate the construction site from the operational site by a boundary fence enclosing the former.

C.4.2.3 Normal maintenance activities such as the removal, reinstallation or replacement of equipment is not regarded as 'construction' and the provisions of the Factories Act continue to apply.

C.4.2.4 [SI 1019](#) applies to all offshore installations, fixed or mobile, regardless of the state of the operation, e.g. production, construction.

C.4.3 Definitions

The following definitions apply in the UK statutory regulations on lifting equipment:-

A machine or appliance used for the purpose of moving or suspending persons, goods or materials.

(a) Lifting Appliances

- Lifting blocks - chains and rope
- Cranes - all types
- *Derricks - drilling
- Excavators Pull lifts
- Fork and stacking trucks
- Hoists - all types
- *Lifeboat davits
- Lifting jacks - all types
- Overhead runway/beam hoists
- Passenger and goods lifts
- Pile drivers
- Sheerlegs
- Tirlors (horizontal pulls only)
- Winches
- Davits - general

*Included when applying [SI 1019](#) by virtue of the definition



(b) Competent Person

A person who, by reason of his training, experience, knowledge and judgement of the type of equipment he has to inspect, examine or test, is able to detect defects or weaknesses, which is the purpose of the examination or test, and to assess their importance in relation to the safety of the equipment both present and for continued use.

(c) Inspection

Where specified in the appropriate legislation, this means a visual inspection of lifting equipment carried out by a competent person to decide whether or not the equipment is safe for use. Inspection periods and frequencies are generally less than examination periods. In certain circumstances, the driver or operator may carry out an inspection prior to operating the lifting equipment.

(d) Examination

Taken to mean thorough examination.

(e) Thorough Examination

A visual examination by a competent person, supplemented by any other means or form of testing as may be considered necessary by the person conducting the examination which will allow a reliable conclusion as to the safety of the parts examined and to establish the condition of the equipment for continued safe use. As and where necessary, parts of the lifting equipment shall be dismantled to permit the examination.

(f) Test

The application in a manner specified of a proof load or loads on the actual lifting equipment and, if fixed, its fixings.

(g) Proof Load

A specified load which an item will withstand without showing permanent deformation or other defect.

(h) Test Load

The same as Proof Load.



(i) Safe Working Load

The maximum load as assessed by a competent person which an item of lifting equipment may raise, lower or suspend under the particular service conditions.

C.4.4 Test and Examination Before Being Taken into Use

C.4.4.1 Both the [Factories Act](#) and the Construction (Lifting Operations) Regulations call for inspection and test of every lifting appliance prior to their being taken into use or following any alteration or repair affecting their safety or stability. The [Factories Act](#), Section 26 (1) (e), 27 (6) applies: as does [SI 1961 No. 1581](#) paragraph 28 (1) (2) (3) (4) (5), paragraph 34 (1) (b), paragraph 46 (1) (a) and (b), and the Docks regulation paragraph 18 (a) 19 (a) and 20 (a).

C.4.4.2 The competent person making such tests and examination shall sign a certificate of test specifying the safe working load or loads for the appliance.

Certain items such as fibre ropes, fibre rope slings, thimbles and bulldog grips are exempt from testing.

C.4.4.3 Particulars of all tests shall be entered on the prescribed form or register.

C.4.5 Registration

C.4.5.1 Each lifting appliance shall be given an identification number or mark and this number shall be quoted on all certificates and documents referring to that appliance.

These requirements are called for in The Chains, Ropes and Lifting Tackle (Register) Order 1938 ([SR and O 1938, No. 599](#)) and the Lifting Machines (Particulars of Examinations) Order 1963 ([SI 1963 No. 1382](#)). [Factories Act](#) Section 22 (2) 26 (1) (g) 27 (2) and Docks Regulations paragraphs 22 (b) and 51.

C.4.5.2 [SI 1019](#) (1976) makes no direct reference to the registration of equipment other than providing a typical examination record form (Part IV). The certification by inference requires the above function to be completed.

C.4.6 Marking

Every lifting appliance shall be clearly marked or have permanently attached to it plainly legible figures and letters indicating:-



- (a) the identification number or mark
- (b) the safe working load

These requirements are made in the [Factories Act 1961](#), Section 27 (4) Statutory Instruments [SI 1961 No. 1581](#) Sections 29 and 34 and Docks Regulations Section 23, 24 and 29.

C.4.7 Records

A register shall be kept containing the prescribed particulars of all lifting appliances (The Lifting Appliances Register), and all certificates, reports of examinations, inspections, repairs or renewals or other particulars as may be prescribed shall be entered in or attached to it.

C.4.8 Special Case Considerations

C.4.8.1 Crane Gantries, Rails, Tracks etc.

Section 27 sub-section (3), of the [Factories Act 1961](#), requires that these items, although not subject to specified inspection intervals, shall be adequate for their duty and be properly maintained.

Each operating centre should allocate a suitable inspection interval to rails, tracks, and supporting structures.

C.4.8.2 Runway Beams

Although not directly referred to in the Factories Act it may be inferred that Section 27 sub-section (3) will apply.

C.4.8.3 Personnel Safety Carriers

Sections 20 and 22, of the Construction (Working Places) Regulations 1966, make reference to Boatswains' Chairs, Cages, Skips, etc. Users of these items shall ensure that the requirements of the regulations are complied with.

C.4.8.4 Flow Booms

The lifting mechanisms of flow booms shall be regarded as lifting tackle and be subjected to the requirements of The [Factories Act 1961](#).

C.4.9 Failure of Equipment

C.4.9.1 Failure of Equipment (Land Based)

In all cases of land based failure or collapse of a crane, derrick, winch, hoist or other equipment used in raising or lowering of persons or



goods or any part thereof (except the breakage of chains or rope slings) or the over-turning of a crane, written notice of the incident, whether personal injury or disablement is caused or not, shall be sent to the Principal Inspector, Health and Safety Executive (HSE) (NADO, see 2A.12).

Any reports of Failure of Equipment to the HSE should only be issued through the respective District/Departmental Management and the Health and Safety Department.

C.4.9.2 Failure of Equipment (Offshore)

The Offshore Installations Regulations ([Statutory Instrument 1019](#)) do not specifically state the action necessary in the event of lifting equipment failure, but require that:-

Where an examination or test shows that equipment cannot be safely used until repaired, the person who made the examination or test shall immediately report the fact in writing to the installation manager, who shall read and sign the report and enter the report in the installations logbook and such equipment shall not be used by any person until repaired and found satisfactory by a responsible person.

C.4.10 Statutory Forms

The following are commonly used Statutory Forms available from HMSO and their use is described in the relevant Regulations.

Note:- The references below to various sections are to sections of the Acts or Regulations, not to sections of this code.

C.4.10.1 Factories Act - 1961

C.4.10.1.1 Form No. 88

['Register of Chains, Ropes and Lifting Tackle and Lifting Machines'](#). This is in four parts:-

- Part 1 (a) Test and thorough examination of Chains, Ropes or Lifting Tackle (except Fibre Ropes or Fibre Rope Slings) before being taken into use in any Factory for the first time in that Factory.
- Part 1 (b) Six monthly thorough examination of all Chains, Ropes, or Lifting Tackle.
- Part 1 (c) Annealing or other Approved Form of Heat Treatment of Chains or Lifting Tackle except Rope Slings.
- Part 2 Thorough examination of Cranes and other Lifting Machines (See Section 26 (g)).

C.4.10.1.2 Form No. 31



General Register to which shall be attached the reports of the results of 6-monthly thorough examination of hoists and lifts (See Section 140 (1)).

C.4.10.1.3 Form No. 54

Report of Examination of Hoist or Lift (See Section 22 (2)).

C.4.10.1.4 Form No. 661

Certificate of Exemption No. 1. (Pertaining to Section 26, sub-section 1 para. (f) relating to heat treatment of components).

C.4.10.2 Construction Regulations

C.4.10.2.1 Form No. 91

Register of Lifting Appliances - in six parts:-

Part (a) Inspection of scaffolds, including boatswain's chairs, cages, skips or similar plant or equipment (as required by Regulation 22 of the Construction (Working Places Regulations, 1966)

Part (b) Examination of excavations, shafts, earthworks, tunnels, cofferdams and caissons (as required by regulations 9 and 18 of the Construction (General Provisions) Regulations 1961).

Part (c) Inspections of lifting appliances and automatic safe load indicators (as required by regulations 10 and 30 of the Construction (Lifting Operations) Regulations 1961).

Part (d) Tests of stability of cranes (as required by regulation 19 of the Construction (Lifting Operations) Regulations 1961).

Part (e) Tests of automatic safe load indicators (as required by regulation 30 of the Construction (Lifting Operations) Regulations 1961).

Part (f) Tests and examinations of passenger hoists after erection or alteration of height of travel (as required by regulation 46 of the Construction (Lifting Operations) Regulations 1961).



- C.4.10.2.2 Form No. 75
- Certificate of Test and Thorough Examination of Hoist (See Regulation 46 (a)).
- C.4.10.2.3 Form No. 80
- Certificate of Test and Thorough Examination of Crab, Winch, Pulley Block or Gin Wheel. (See Regulation 28).
- C.4.10.2.4 Form No. 87
- Certificate of Test and Examination of Wire Rope, before being taken into use (See Regulation 34 (1) (b)).
- C.4.10.2.5 Form No. 96
- Certificate of Test and Thorough Examination of Crane (See Regulation 28).
- C.4.10.2.6 Form No. 97
- Certificate of Test and Examination of Chains and Lifting Gear (See Regulation 34 (1) (b)).
- C.4.10.3 Docks Regulations
- Form No. 99
- Register of Machinery, Chains, etc., and Wire Ropes in four parts:-
- | | |
|----------|--|
| Part I | Annual Inspection and Quadrennial Thorough Examination of Derricks and Permanent Attachments (including Bridle Chains) to the Derricks, Masts and Decks. |
| Part II | Annual Thorough Examination of Cranes, Winches, Hoists and Accessory Gear other than Derricks and Permanent Attachments thereto. |
| Part III | Annual Thorough Examination of Gear Exempted from Annealing. |
| Part IV | Annealing of Chains, Rings, Hooks, Shackles and Swivels (other than those exempted). (See Regulation 22 (a) and (b)). |
- Form No. 86
- Certificate of Test and Examination of Chains, Rings, Hooks, Shackles, Swivels and Pulley Blocks, before being taken into use (See Regulation 19 (a)).



Form No. 87

Certificate of Test and Examination of Wire Rope, before being taken into use (See Regulation 20 (a)).

Form No. 1944

Certificate of Test and Examination of Winches, Derricks and Accessory Gear, before being taken into use (See Regulation 18 (a)).

Form No. 1945

Certificate of Test and Examination of Cranes or Hoists and their Accessory Gear, before being taken into use (See Regulation 18 (a)).

Form No. 1946

Certificate of Annealing of Chains, Rings, Hooks, Shackles and Swivels (See Regulation 19 (b)).

Form No. 1950

Certificate of Exemption No. 1 - Annealing of certain classes of Lifting Gear (See Regulation 19 (b)).

Form No. 1951

Certificate of Exemption No. 2. Manner of Test of Lifting Gear before being taken into use (See Schedule to Regulations, Para. (c)).

Form No. 1952

Certificate of Annual Thorough Examination of Gear Exempted from Annealing (See Certificate of Exemption No. 1, Form 1950).

C.4.10.4 Offshore Regulations - SI 1019 (1976)

Certificate of Thorough Examination of Lifting Appliances or Lifting Gear.

Non-HMSO Forms

It should be noted that various testing and inspection companies including insurance companies may use their own design of form for test or inspection reports.

These forms should have had the approval of the relevant authority, and whilst the format varies, the content should be the same as the HMSO forms.





TABLE C4 - SUMMARY OF LIFTING APPLIANCE INSPECTION INTERVALS

		Factories Act 1961		Docks Regulations 1934		Construction (Lifting Operations) Regs. 1961		SI 1019 (1976) Offshore Installation Regs.
		Examination	Inspection	Examination	Inspection	Examination	Inspection	Examination -F-
Lifting Gear	Chains, Ropes and Lifting Tackle	6 months Para. 62(d)	None -A- -E-	12 months Cert of Exempt 1	3 months Para. 19(c)	6 months Para. 40	-	6 months Sch.1 Part III
Lifting Appliances	Crane and Other Lifting Machines	14 months para. 27 (2)	None -A- -E-	12 months -B- Para. 18(b) (i)	12 months (derricks only) Para. 18(b) (i)	14 months -C- h Para. 28 (1, 2 & 3)	Weekly Para. 10 (c)	6 Months Sch. 1 Part III 7 days Operational; Check -D-
	Hoist and Lifts	6 months Para. 22(2)	None -A- -E-	12 months SR and O 279 Para. 18(b) (ii)	-A-	6 months Para. 46 (c)	Weekly Para. 10 (c)	6 months Sch.1 part III

Notes:

- A- Except where arduous duties make it desirable to do so.
- B- Landbased derricks and permanent attachment to be examined every 48 months.
- C- Every crane, crab or winch shall also be tested every 48 months.
- D- 7 day interval for the examination of:-
 - (i) Those parts of a lifting appliance wire lines are liable to suffer wear or other deterioration (Sch. 1 Part 1).
 - (ii) Lifting appliance safety load indications and alarms (Sch. 1 part II).
- E- There is a continuing obligation to maintain these items in a safe condition which, therefore, requires regular inspection / maintenance while in use examinations.
- F- The term 'examination' has been used to cover all frequencies of examination and competency whereas other regulations use examination and inspection.

Reference should be made to the appropriate Para.of the relevant Act, Regulation or Order for a full understanding of the requirements.

PART C - REGIONAL ANNEX - UK STATUTORY INSPECTION REQUIREMENTS

SECTION C.6 HEAT EXCHANGERS

C.6.1 Introduction

Pressure containing parts will be considered as pressure vessels, and where they contain or are liable to contain a relevant fluid will be subject to the provisions of [SI 2169](#), The Pressure Systems and Transportable Gas Containers Regulations 1989.

C.6.2 Definitions

Refer to para C.3.2

C.6.3 Inspection Frequency

Refer to para C.3.3

C.6.4 Inspection Requirements

Refer to para C.3.4

Inspection of heat exchangers should generally be carried out in accordance with the guidance set out in Section B6 of this RP.

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SECTION C.7 PIPING SYSTEMS

C.7.1 General

[SI 2169](#) (1989) has provisions for the inspection of 'pipework' and 'pipelines' (see below for definitions). Excluded from these provisions by exemption are:-

- (a) all pipework and pipelines not carrying a relevant fluid.
- (b) all pipework carrying a relevant fluid (but excluding steam) at a pressure not exceeding 0.5 bar above atmospheric pressure.
- (c) all pipelines carrying a relevant fluid at a pressure not exceeding 2.0 bar above atmospheric pressure (2.7 bar under relief conditions).

C.7.2 Definitions

pipeline	a pipe or system of pipes used for the conveyance of relevant fluid across the boundaries of the centre, together with any apparatus for inducing or facilitating the flow of fluid through, or through part of, the pipe system, and any valves, valve chambers, pumps, compressors and similar works which are annexed to, or incorporated in the course of, the pipe or system (also see Sections B.16 and C.16 of the RP).
pipework	a pipe or system of pipes together with associated valves, pumps, compressors and other pressure containing components and includes a hose or bellows but does not include a pipeline or any protective devices.

C.7.3 Additional Remarks

- C.7.3.1 In practice only a small percentage of piping will be included in 'schemes of examination' for pressure systems although all pipework in a pressure system must conform to the regulations on design, marking, installation, and operation. In particular it shall be noted that the term 'relevant fluid' only covers steam, gases and pressurised liquids which will turn to gas if the pressure is released. This excludes from the Regulations piping for water below 100°C, lubricating oil and some finished products.



C.7.3.2 Regulation 8 sub-section (3)

This Regulation (Regulation 8) shall only require pipework to be included in the scheme of examination to the extent that it is necessary to include it to prevent danger.

The Code of Practice for Pressure Systems interprets this as:-

Pipework, which is widely defined to include pipes, associated valves, pumps, compressors, hoses, bellows and other pressure containing components, will only need to be covered in the scheme if:-

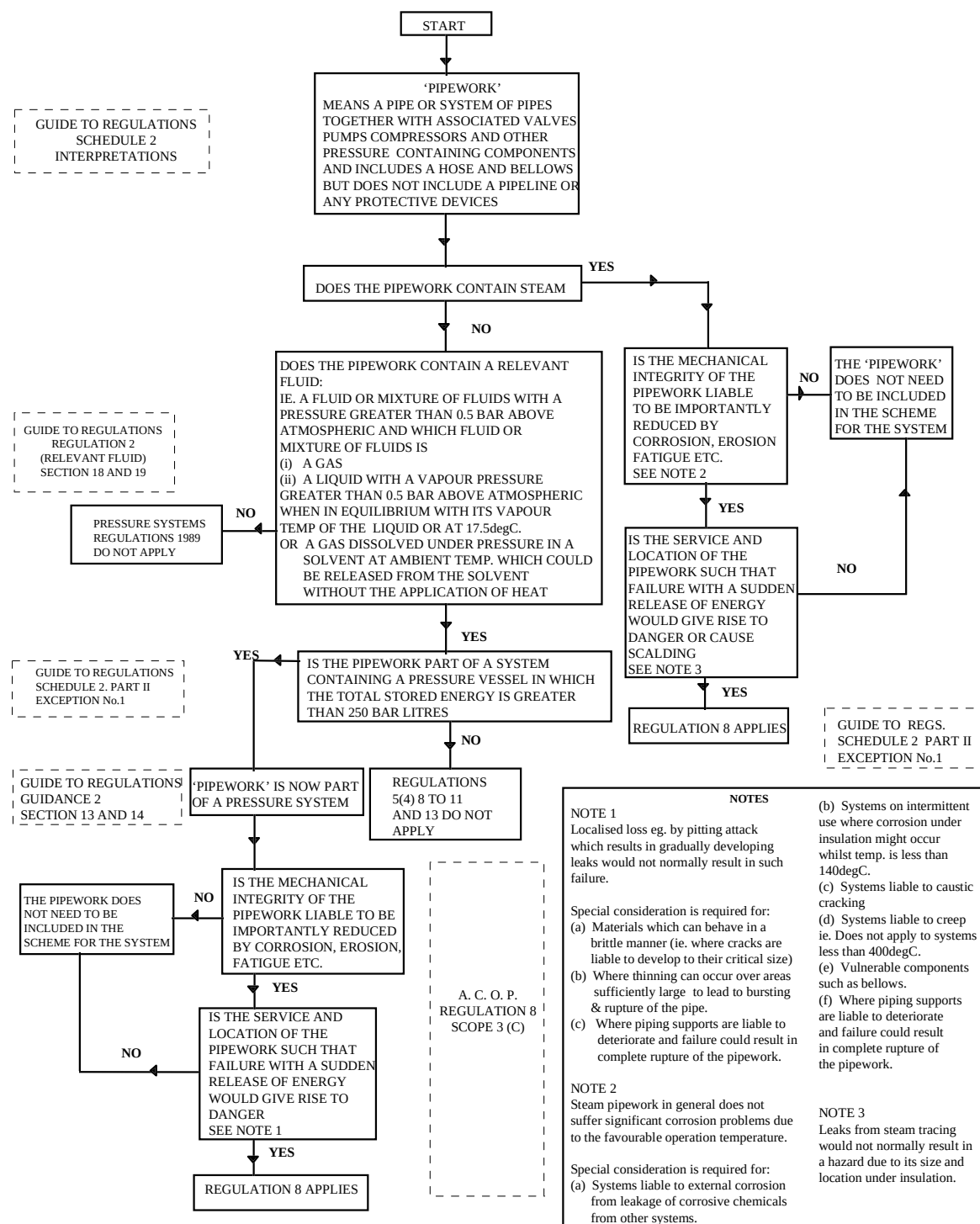
- (i) it is subject to a duty such that its mechanical integrity is liable to be seriously reduced by corrosion, erosion, fatigue or any other factors; and
- (ii) it is in such service and location that failure with the sudden release of stored energy would give rise to danger.

C.7.3.3 Inspection of pipework and pipelines should generally be in accordance with the guidance set out in Sections B.7 and B.16 of this RP.

C.7.4 EEMUA/CUI Interpretation

Appendix C.7 summarises the EEMUA/CUI interpretation of the requirements for registration of pipework under Regulation 8 of [SI 2169](#). Reference should be made to the EEMUA Guide for a more complete interpretation.

ANNEX 3
EEMUA/CUI INTERPRETATION OF THE PRESSURE SYSTEMS AND
TRANSPORTABLE GAS CONTAINERS REGULATIONS 1989
REQUIREMENT FOR REGISTRATION OF PIPEWORK UNDER REGULATION 8



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PART C - REGIONAL ANNEX - UK STATUTORY INSPECTION REQUIREMENTS

SECTION C.8 FIRED HEATERS

C.8.1 General

The fired heater does not normally have an integral pressure vessel and would be treated as pipework under the Regulations. Pipework without a pressure vessel does not comprise a pressure system, so a fired heater considered in isolation would not attract the Regulations. However, heaters are invariably operated as part of a larger system with one or more pressure vessels and will therefore be covered by the Regulations. The pressure system includes protective devices which will be a prominent part of heater inspection.

Non-pressure containing parts such as refractory linings, casing, and structural steelwork will not be part of the scheme of examination except in so far as they may be essential for the protection of pressure containing parts, or where their removal is necessary to gain access for examination.

C.8.2 Inspection

Inspection of fired heaters should generally be in accordance with guidance set out in Section B.8 of this RP.



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SECTION C.9 PROTECTIVE DEVICES

C.9.1 General

[SI 2169](#) (1989) defines Protective Devices as those devices designed to protect the Pressure System against system failure and devices designed to give warning that system failure might occur. Bursting discs are included.

The HSE document Guidance on the Regulations (page 10) explains clearly that the definition of Protective Device does not include every device which has a control or measuring function. Rather, it includes any protective control or measuring equipment which is essential to prevent a dangerous situation from arising. Instrument and control equipment should be considered as a protective device subject to the Regulation where it has to function correctly in order to prevent the safe operating limits being exceeded where no other protective device is provided.

Table C.9 offer examples of devices which may be considered as essential to prevent system failure and which therefore should be included in Schemes of Examination. It must be stressed that the examples given in the Table are for the purpose of illustration and should not be regarded as definitive.

There are other devices that are used to prevent physical damage to equipment. These are not necessary to prevent a sudden discharge of pressure energy that may cause danger to persons because either there is a backup device to prevent overpressure or the subject components are non-pressure containing - such devices therefore do not come within the scope of the Regulations.

The decision to apply the Regulation to a device is dependent upon whether or not the correct operation of that device is essential for the pressure integrity of the system. In general, normal operating parameter monitoring devices such as pressure gauges and temperature indications would not be included in a Scheme of Examination.

C.9.2 Inspection and Testing

Inspection and testing of protective devices should generally follow the guidance set out in Section B.9 of this RP.



Description of Function	Typical Examples	Possible Consequence of Device Failing to operate
Devices to relieve excess pressure	Relief Valves Bursting Discs	Failure due to over-pressurisation
Devices to prevent a predetermined temperature level from being exceeded	(a) High temp trips (b) Low Temp Trips	(a) Failure due to loss of strength as a result of exposure (b) Loss of Ductility at low temperature
Warning devices	(a) Fusible Plugs (b) Pressure gauge or alarm that indicated when space between bursting disc and safety valves assembly is pressurised	(a) Failure due to loss of strength as a result of exposure to high temperature (b) Pin-holing of disc would not be identified and over-pressurisation could result
Rapid isolation of excessive pressure source	Slam shut valves	Failure due to over-pressurisation
Restriction device to limit the flow rate from a high pressure source	(a) Restriction Orifice plate (b) Control Valve Trim	Failure due to over-pressurisation
Device to indicate low level of water in boiler	Level gauge	Failure due to over-heating of boiler

TABLE C.9
EXAMPLES OF PROTECTIVE DEVICES TO BE CONSIDERED FOR
INCLUSION IN A SCHEME OF EXAMINATION

PART C - REGIONAL ANNEX - UK STATUTORY INSPECTION REQUIREMENTS

SECTION C.14 FLEXIBLE HOSES

C.14.1 [SI 2169](#) (1989)

Hoses are specifically mentioned in [SI 2169](#) (1989) as part of the definition of pipework. Amongst the hoses which could, if carrying a relevant fluid, be included in a pressure system are:-

- (a) Loading hoses (e.g. jetty, roadcar and railcar).
- (b) Flexible hose connections in process streams.
- (c) Flexible hose connections to temporary systems.

C.14.2 **Inspection and Testing**

Inspection and testing of flexible hoses should generally follow the guidance set out in Section B.14 of this RP.

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SECTION C.15 GAS CYLINDERS

C.15.1 General

SI 2169 (1989) defines 'transportable gas container' as:-

a container, including any permanent fitting of such a container, which is used, or is intended to be used, to contain a relevant fluid and is -

- (a) designed to be transportable for the purposes of refilling and has an internal volume of at least 0.5 litres and not greater than 3000 litres;
- (b) a non-refillable container having an internal volume of at least 1.4 litres and not greater than 5 litres; or
- (c) in the case of Regulation 17.(3) only, a non-refillable container.

C.15.2 Examination of containers

C.15.2.1 The owner of a transportable gas container shall, for the purposes of determining whether it is safe, ensure that the container is properly examined at appropriate intervals by a competent person.

C.15.2.2 Where a competent person is requested to carry out an examination for the purposes of paragraph C.15.2.1, (s)he shall carry out that examination properly, and if on completing the examination (s)he is satisfied that the container is safe, (s)he shall ensure that there is affixed to the container a mark showing the date of the examination.

C.15.2.3 No person other than the competent person or person authorised by the competent person shall affix to a transportable gas container the mark referred to in paragraph C.15.2.2 or a mark liable to be confused with it.

C.15.3 Additional Remarks

C.15.3.1 The main impact of the Regulations on transportable gas containers concerns the supply and filling of containers.

Many of the transportable gas containers in use at BP's UK centres are hired from gas suppliers. These centres, as users, have obligations under the Regulations concerning modification, repair work and records.



- C.15.3.2 Exempted from the Regulations are portable fire extinguishers except those which are in effect gas cylinders used as extinguishers, such as carbon dioxide and halon types.
- C.15.3.3 Inspection of gas cylinders under the Regulations will generally be carried out according to the procedures set out in Section B.15 of this RP.
- C.15.3.4 A transportable gas container becomes a pressure system when connected to pipework and a relief device (see C.1.4.1).

The HSE has indicated that self-contained breathing apparatus sets come within the Scope of the Regulations, but that cutting and welding regulators, hoses and equipment etc. do not.



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SECTION C.16 TRANSMISSION PIPELINES

C.16.1 Pipelines Act 1962

Covers all aspects relating to the approval, construction, use, safety and inspection of cross-country pipelines. In particular, Section 23 refers to the Safety Notice issued by the Department of Energy (DEn) for each new pipeline which lays down the requirements for inspection and the maximum intervals between inspections.

C.16.2 Pipelines Act 1962 (Repeals and Modifications) Regulations 1974

These regulations align the Act of 1962 with the requirements and enforcement provisions of the Health and Safety at Work Act.

C.16.3 Petroleum and Submarine Pipelines Act 1975

Covers all aspects relating to the approval, use, safety and inspection of pipelines in UK territorial and continental waters. The Submarine Pipelines Guidance Notes issued by the DEn explain the procedures whereby submarine pipelines are certified in accordance with the Act.

C.16.4 Submarine Pipelines Safety Regulations 1982 [SI No 1513](#)

These regulations require that an inspection scheme for each submarine pipeline is in force and requires that the reports of such surveys be submitted to the Health & Safety Executive.

C.16.5 Submarine Pipelines (Inspectors, etc.) Regulations 1977 [SI No 835](#)

C.16.6 The Pressure Systems and Transportable Gas Containers Regulations 1989 [SI No 2169](#).

Pipelines (as defined in Section C.7 paragraph C.7.2 of this Code) are treated as pressure systems if carrying a relevant fluid.

Where the provisions of The Pipelines Act 1962 apply also to the pipeline, compliance with that act will be deemed to satisfy the provisions of the Regulations. Schemes approved under The Pipelines Act will be gradually amended and updated to reflect this. Inspection arrangements under The Pipelines Act will remain unchanged.



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SECTION C.18 CRYOGENIC EQUIPMENT

C.18.1 General

[SI 2169](#) (1989) covers cryogenic equipment when handling a relevant fluid. The equipment (or parts thereof) may form all or part of a pressure system.

C.18.2 Additional Remarks

Inspection of cryogenic equipment should generally be carried out in accordance with the procedures set out in Section B.18 of this RP.



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SECTION C.20 OFFSHORE INSTALLATIONS

C.20.1 General

Within UK areas, all offshore work and equipment is subject to statutory control under the provisions of the Mineral Workings (Offshore Installations) Act 1971 and the subsequent legislation emanating from that Act which is principally the Offshore Installations (Construction and Survey) Regulations, 1974. These Regulations have been reinforced by the Offshore Installations: Guidance on Design and Construction, issued by the Department of Energy in May, 1974 and a subsequent document entitled 'Instruction to Certifying Authorities' dated June, 1974, issued by the same Department; the former document is subject to frequent amendments and hence this should be noted in its interpretation.

However, other Regulations do apply to which inspection schemes will require to be prepared. These are:-

- (a) The Offshore Installations (operational Safety, Health and Welfare) Regulations 1976 - [SI 1019](#).
- (b) The Offshore Installations (Life Saving Appliances) Regulations 1977 - [SI 486](#) and Guidance on Life Saving Appliances 1978.

C.20.2 Certificate of Fitness

The Regulation which has the greatest impact on an offshore installation is the Construction and Survey Regulations [SI 289](#) (1974) which leads to the following circumstances:-

- C.20.2.1 From the 31st August, 1975, all offshore installations operating on the UK sector of the Continental Shelf are required to have a valid Certificate of Fitness.

This Certificate of Fitness can be obtained only from one of the following approved bodies (Certifying Authorities):-

- Lloyds Register of Shipping
- American Bureau of Shipping
- Bureau Veritas
- Det Norske Veritas
- Germanischer Lloyd
- Offshore Certification Bureau

The Certificate of Fitness will encompass all parts of the structure and the equipment on that structure.



C.20.2.2 The Certifying Authority need not itself carry out the examination of those items on which it has little or no detailed expertise but may delegate this work to other independent parties subject to the Certifying Authority being satisfied with the quality of the work and the competency of the persons carrying out the work.

BP inspection personnel are not excluded from this role but must, presumably, be acceptable to the Certifying Authority.

C.20.2.3 Although the acquisition and retention of a Certificate of Fitness must be the prime consideration, the inspection work associated with process-oriented equipment on the platform will require work from BP inspection staff at times and for purposes other than the acquisition of a Certificate of Fitness.

C.20.2.4 The Guidance Notes currently suggest that the Certifying Authority shall be the arbiter of intervals between inspections of equipment on the platform but this is not a mandatory requirement and must not be construed as being so.

C.20.2.5 The Certifying Authority will require surveys to be made of the structure over the 5 year Certificate of Fitness period. They may also require additional inspections following annual surveys which would normally be agreed with the operator.

C.20.2.6 For equipment other than the structure, the Regulations and Instructions clearly state that inspection by bodies other than the Certifying Authority is permissible subject to their general competency in specialised fields and the submission of detailed information on the condition of the equipment being made available to the Certifying Authority for their ratification and incorporation in the final Certificate.

The principle to be adopted should be that BP inspection services are competent to examine and report on all processing and production equipment installed on the platform. Lifting equipment which is governed by the Offshore Installation (Operational Safety, Health and Welfare) Regulations must be inspected by an independent outside body and hence BP normally employs specialist organisations.

