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Guidance on Practice for In Service Inspection and Testing - Common Requirements

GP 32-40

**BP GROUP
ENGINEERING TECHNICAL PRACTICES**

Foreword

This is the first issue of Engineering Technical Practice (ETP) BP GP 32-40. This Guidance on Practice (GP) is based on parts of heritage documents from the merged BP companies as follows:

British Petroleum

RP 32-4

Inspection & Testing of In-Service Civil and Mechanical Plant -
Technical Guidance – Section B1.

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1. Scope

- a. This GP defines requirements for inspection and testing of existing equipment that are common to different classes of equipment.
- b. This GP shall be read and interpreted in conjunction with GP 32-30 and relevant GP 32-4X documents.
- c. GP 32-4X series defines technical recommendations for inspection and testing of existing equipment, as follows:
 1. GP 32-41: Unfired pressure vessels.
 2. GP 32-42: Piping systems.
 3. GP 32-43: Pressure containing envelope of rotating equipment.
 4. GP 32-44: Above ground atmospheric and low pressure storage tanks.
 5. GP 32-45: Fired boilers and heaters.
 6. GP 32-46: Onshore civil/structural facilities.
 7. GP 32-47: Mechanical protective devices.
 8. GP 32-48: Heat exchangers.
 9. GP 32-49: Special and other equipment.

2. Normative references

The following normative documents contain requirements that, through reference in this text, constitute requirements of this technical practice. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this technical practice are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

BP

GN 32-017	Fitness for Service.
GN 32-028	NDE Methods and Techniques.
GP 32-30	Guidance on Practice for In Service Inspection and Testing of Equipment - Management Principles.
GP 32-41	Guidance on Practice for In Service Inspections of Unfired Pressure Vessels.
GP 32-42	Guidance on Practice for In Service Inspection and Testing of Piping Systems.
GP 32-43	Guidance on Practice for In Service Inspection and Testing of Pressure Containing Envelope of Rotating Equipment.
GP 32-44	Guidance on Practice for In Service Inspection and Testing of Above Ground Atmospheric and Low Pressure Storage Tanks.
GP 32-45	Guidance on Practice for In Service Inspection and Testing of Fired Boilers and Heaters.
GP 32-46	Guidance on Practice for In Service Inspection and Testing of Onshore Civil/Structural Facilities.
GP 32-47	Guidance on Practice for In Service Inspection and Testing of Mechanical Protective Devices.



GP 32-48	Guidance on Practice for In Service Inspection and Testing of Heat Exchangers.
GP 32-49	Guidance on Practice for In Service Inspection and Testing of Special and Other Equipment.
GP 43-52	Guidance on Practice for Pipe Wall Inspection, and Analysis of Results (pipelines)

American Petroleum Institute (API)

API 510	Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alteration.
API RP 579	Fitness-for-Service.
API Std 653	Tank Inspection, Repair, Alteration, and Reconstruction.

British Standards Institute (BSI)

BS 7910	Guide on methods for assessing the acceptability of flaws in metallic structures.
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3. Symbols and abbreviations

For the purpose of this GP, the following symbols and abbreviations apply:

DEA	Diethyl amine
DPI	Liquid dye penetrant testing
ET	Eddy current testing
FFS	Fitness for service
FFSA	Fitness for service assessment
HOIS	Harwell Offshore Inspection (R&D) Service
IA	Site Inspection Authority
IKB	Interactive knowledge base
IR	Infrared
MEA	Monoethyl amine
NDE	Non destructive examination
PMI	Positive materials identification
POD	Probability of detection
R&D	Research and development
RT	Radiography testing
TA	Site Technical Authority
UT	Ultrasonic testing



4. Preparation for inspection

- a. Preparation for inspections or examinations shall include, as applicable:
 1. Obtaining necessary work permits with associated job safety assessment (refer to GP 32-30).
 2. Isolation of equipment.
 3. Opening of equipment.
 4. Cleaning and gas freeing for entry.
 5. Provision of facilities for internal and external access (e.g., scaffolding, rope access techniques).
 6. Removing internal fittings or components.
 7. Removing insulation, passive fire protection, and other coverings.
 8. Descaling and surface preparation.

External descaling of heavily corroded equipment under internal pressure is potentially hazardous.
 9. Provision of personnel aids, such as lights or lighting, ropes, gangways, warning signs, breathing apparatus, and other safety equipment.
 10. Provision of utility services.

Preparation requirements for on-stream non invasive inspection differ from offstream invasive inspection. Guidance for on-stream inspections is in [GN 32-010](#).
 11. Provision of test equipment.
- b. Depending on NDE type, IA shall use inspection plan to advise on preparation requirements.
- c. Before inspection, previous reports and other relevant data shall be reviewed for full appreciation of prior condition of equipment and potential areas of deterioration.

Importance of this data gathering and analysis stage cannot be overstated, particularly for equipment types that are inherently difficult to thoroughly inspect because of limited access or visibility (e.g., heat exchanger bundles, boiler tube banks).
- d. Relevant data before inspection shall include the following:
 1. Previous inspection, maintenance, integrity assessment, and failure investigation reports.
 2. Details of operating conditions since previous inspection, particularly if operation has been close to the approved operating boundaries or where the operating boundaries have been violated.
 3. On-stream factors and cyclic operation.
 4. On-stream inspection, condition monitoring, and corrosion monitoring data.
 5. Corrosion control design and operation data (e.g., inhibitor or neutraliser injection, pH control wash water injection, oxygen scavengers, boiler feedwater treatment, fuel oil and gas quality control).
 6. Details of relevant modifications.
 7. Test methods and acceptance criteria.



5. Equipment damage mechanisms

5.1. Introduction

- Important part of integrity management of in service equipment is identification and understanding of occurring or likely to occur damage mechanisms.
- Identification of potential damage mechanisms shall be performed during development and updating of inspection plans such that appropriate inspection techniques can be assigned.
- Potential damage rates for new equipment entering service shall be estimated such that initial inspection frequencies can be determined.

Similarly, FFSA require that damage mechanisms and rates be understood for evaluating remaining service life.

Predicted failure modes are key inputs in determining consequences of failure for risk based inspection (e.g., hole size and "leak before break" criteria).

5.2. Detailed guidance

Many damage mechanisms can affect metallic and non metallic materials in service.

Assistance from materials and corrosion specialists shall be obtained for inspection planning, identification of observed damage types, and failure investigation.

Good overview of generic damage types for process industries is in API RP 571.

Table 1 describes the mechanisms.

Table 1 – Damage Mechanisms (API RP 571)

Mechanical and metallurgical	Aqueous corrosion	High temp corrosion	Environment assisted cracking
Graphitisation	Galvanic corrosion	Oxidation	Chloride stress corrosion cracking
Softening (spheroidisation)	Atmospheric corrosion	Sulphidation	Corrosion fatigue
Temper embrittlement	Corrosion under Insulation	Carburisation	Caustic stress corrosion cracking
Strain aging	Cooling water corrosion	Decarburisation	Ammonia stress corrosion cracking
475 °C (887 °F) embrittlement	Boiler water condensate corrosion	Metal dusting	Liquid metal embrittlement
Sigma phase embrittlement	CO ₂ corrosion	Fuel ash corrosion	Hydrogen embrittlement
Brittle fracture	Flue gas dew point corrosion	Nitriding	
Creep and stress rupture	Microbiologically induced corrosion		
Thermal fatigue	Soil corrosion		
Short term overheating and stress rupture	Caustic corrosion		
Steam blanketing	Dealloying		
Dissimilar metal weld cracking	Graphitic corrosion		
Thermal shock			
Erosion, corrosion			
Cavitation			
Mechanical fatigue			
Vibration induced fatigue			
Refractory degradation			
Reheat cracking			

API RP 571 describes damage mechanisms specifically associated with refining process units. Some of this information is also relevant to oil and gas production facilities (e.g., amine corrosion or stress corrosion cracking, naphthenic acid corrosion, sour water corrosion, wet H₂S damage, titanium hydriding).

VCEDamage Software is an easy to use software reference guide based on API RP 571 for identifying and understanding the potential damage mechanisms. BP has a global licence for this software. Access is available through your Segment Inspection/Integrity network representative.



API RP 580 also provides useful tabulated summary of most common process industry damage mechanisms.

Overviews of damage mechanisms pertaining to specific types of equipment can be found in the following:

- API RP 572: Pressure vessels.
- API RP 573: Fired heaters and boilers.
- API RP 574: Piping components.
- API RP 575: Atmospheric and low pressure storage tanks.
- API RP 576: Pressure relieving devices.
- EEMUA 194 describes various types of internal and external damage mechanisms and methods of rate prediction for subsea oil and gas production facilities. Internal damage mechanisms described are equally applicable to surface (non subsea) facilities.
- RD 32-006 describes the most common drill string failure mechanisms.

BP information and guidance on damage mechanisms and rate estimation is available through ETP website, particularly for corrosion (category 06) and materials selection (category 36), and in RD 32-001 (developed as guide for BP refinery inspectors).

RD 32-001 provides a high level overview of deterioration mechanisms common to refining, appropriate process parameters to control deterioration, and NDE techniques used to locate and monitor deterioration. Information is a quick reference for inspectors and others who need to understand basics of deterioration mechanisms.

Information needed for specialist to judge whether and at what rate degradation is likely to occur is in API RP 579, Table G.1. Table 2 is an example of this information. Individual sites may adapt this to their specific circumstances. The table can be used in management of change (MOC) process for evaluation of effects of change to process or mechanical conditions on types and rates of degradation.

Approval of changes to operating conditions and/or materials of construction assume that the equipment will be operated within defined operating boundaries which should be defined as part of the approval process.

Table 2 – Damage Mechanism Evaluation Checklist

General information						
Unit						
Tag no / Serial Number						
Description						
Item	Existing			New		
Design and operating conditions	Normal	Startup/SD	Upset	Normal	Startup/SD	Upset
Temperature (°C) (°F)						
Pressure (kPa[g]) (psig)						
Flow velocity (m/s) (ft/s)						
Fluid parameters						
Crude fraction sulphur content (%)						
Crude fraction neutral number						
Water content (% & pH) (1)						
H ₂ S (ppm in water)						
NH ₃ (ppm in water)						
NH ₃ (%)						
H ₂ S (%)						



HCl (%)						
Chlorides (%) (1)						
Sulphuric acid (%)						
HF acid (%)						
Amine type (e.g., MEA, DEA) (2)						
Amine (%)						
Amine loading (% H ₂ S)						
Caustic (%)						
H ₂ S partial pressure (kPa abs)						
H ₂ partial pressure (kPa abs)						
Cyanides (%) (1)						
Solid particles (y/n)						
Others:						
Corrosion control						
Water wash injection (y/n)						
Polysulphide injection (y/n)						
Neutralising amine (y/n, type)						
Filming amine (y/n, type)						
Caustic injection (y/n)						
Corrosion monitoring						
Corrosion probes or coupon (y/n)						
Hydrogen probes or coupon (y/n)						
Materials of construction	Existing	New				
Piping, fittings, and flanges						
Bolts, nuts, and fasteners						
Valve internals and trims						
Pump impellers and internals						
Pressure vessel plate						
Internal fittings, trays, bubble caps, Raschig rings, weirs, vortex breakers						
Cladding or lining						
Furnace tubes						
Furnace headers						
Furnace hangers						
Heat exchanger tubesheets						
Heat exchanger tubes						
Heat exchanger baffles						
Tube and header plugs						
Other (specify)						
Reason for change						
Comments						
Responsible Engineer					Date	
Materials and corrosion specialist (3)					Date	

