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شرکت ملي گاز ايران

مديريت پژوهش و فنآوري

امورتدوين استانداردها

IGS

دستورالعمل بازرسی

مخازن تحت فشار

Pressure Vessels

شرکت ملی گازایران

دفترمدیرعامل

تاریخ : ۱۳۹۶/۱۱/۲۹
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ابلاغ مصوبه هیأت مدیره

مدیر محترم پژوهش و فناوری

باسلام،

به استحضار می‌رساند در جلسه ۱۷۶۷ مورخ ۱۳۹۶/۱۱/۱۵ هیات مدیره ، نامه شماره گ۹/۱۴۷۹۹۱/۰۰۰ مورخ ۹۶/۱۱/۸ مدیر پژوهش و فناوری درمورد تصویب نهایی استانداردها به شرح زیر مطرح و مورد تصویب قرار گرفت :

۱. مشخصات فنی خرید عمل کننده هیدرولیکی شیرآلات

IGS-M-IN-304(1)

۲. دستورالعمل نگهداری وتعمیرات پوشش خطوط لوله تحت بهره‌برداری

IGS-O-TP-001(0)

۳. دستورالعمل بازرسی‌لیفتراک

IGS-I-GN-008(0)

۴. دستورالعمل نگهداری وتعمیرات برپایه ریسک وطبقه‌بندی پیامدها

IGS-O-MN-002(0)

۵. دستورالعمل بازرسی مخازن تحت فشار در زمان بهره برداری

IGS-I-PM-001(0)

۶. دستورالعمل بازرسی سیستم زمین (Earthing system)

IGS-I-EL-007(0)

این مصوبه به منزله مصوبه مجمع عمومی شرکت‌های تابعه محسوب و برای کلیه شرکت‌های تابعه لازم الاجرا می‌باشد .

الهام ملکی

دبیر هیات مدیره

رونوشت : مدیرعامل محترم شرکت ملی گاز ایران و رییس هیات مدیره
: اعضای محترم هیات مدیره
: مشاور و رییس دفتر محترم مدیر عامل
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: رییس محترم امور مجامع

FOREWORD :

This standard is intended to be mainly used by NIGC and contractors, and has been prepared based on interpretation of recognized standards, technical documents, knowledge, backgrounds and experiences in natural gas industry at national and international levels.
Iranian Gas Standards (IGS) are prepared, reviewed and amended by technical standard committees within NIGC Standardization division and submitted to the NIGC's "STANDARDS COUNCIL" for approval.
IGS Standards are subject to revision, amendment or withdrawal, if required. Thus the latest edition of IGS shall be checked/inquired by NIGC employees and contractors.
This standard must not be modified or altered by NIGC employees or its contractors. Any deviation from normative references and / or well-known manufacturer’s specifications must be reported to Standardization division.
The technical standard committee welcomes comments and feedbacks about this standard, and may revise this document accordingly based on the received feedbacks.

GENERAL DEFINITIONS :

Throughout this standard the following definitions, where applicable, should be followed:
1- "STANDARDIZATION DIV." is organized to deal with all aspects of industry standards in NIGC. Therefore, all enquiries for clarification or amendments are requested to be directed to mentioned division.
2- "COMPANY": refers to National Iranian Gas Company (NIGC).
3- "SUPPLIER": refers to a firm who will supply the service, equipment or material to NIGC whether as the prime producer or manufacturer or a trading firm.
4- "SHALL ": is used where a provision is mandatory.
5- "SHOULD": is used where a provision is advised only.
6- "MAY": is used where a provision is completely discretionary.

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Contents

1. Scope:

This procedure applies to all Company unfired pressure vessels whatever are the type, service and the location (onshore, offshore). It applies to all the steam vessels, associated to the steam generation and to the steam distribution network, such as deaerators, BFW storage tanks, blow down drums. It also applies to all metallic tanks designed and constructed to similar codes and standards as pressure vessels (ASME VIII). It excludes all type of equipment which are mentioned in Annex "A" API 510.

This procedure affects departments and divisions involved in specific activities related to the Inspection:

- Inspection (inspection).
- Maintenance (access, opening, repair, cleaning,...).
- Operation (decommissioning ,isolation, purging, recommissioning,...).
- HSE (safety parameter monitoring, supply of safety equipment, work and entry permit,...).
- Engineering (repairs, modifications,...).

2. References :

All codes and standards are subject to periodic revision, and the most recent revision available should be used.

- **API 510,"** Pressure vessel inspection code "
- **API RP 572,"** Inspection of unfired pressure vessels."
- **API RP 571,"** Damage Mechanisms Affecting Fixed Equipment in the Refining "Industry
- **API RP 576** ," Inspection of pressure –relieving Devices"
- **API RP 577,"** Welding Processes, Inspection, and Metallurgy"
- **API RP 583** ,"Corrosion Under Insulation and Fireproofing"
- **API 579-1/ ASME FFS-1** ,"Fitness For service "
- **API Recommended Practice 580**," Risk-Based Inspection"
- **API Recommended Practice 581**, "Risk-Based Inspection Methodology"
- **API RP 945** ," Avoiding Environmental Cracking in Amine Units"
- **ASME PCC-2**, "Repair of Pressure Equipment and Piping"
- **ASME Pressure Vessel Code Section V Non Destructive Testing**.
- **ASME Pressure Vessel Code Section VIII Div. I and II**.
- **PD 5500 / BS EN.13445** ," Unfired Fusion Welded Pressure Vessels"

3. Terms and Definitions:

3.1.Unfired pressure vessel:
Unfired pressure vessel means, in this procedure, a static vessel submitted to internal or external pressure (pressure limitation as per the pressure vessel code), designed and manufactured under the requirements of a recognised pressure vessel code - ASME section VIII or PD 5500 / BS EN.13445 .
All external attached components/parts, such as supports, access ladders, stairways, platforms, nozzles and piping up to the next isolating valves, lifting and handling gears, electrical and instrument equipment, pipe supports (guide, anchoring, hangers) are included in the definition of unfired pressure vessel for inspection purposes.

3.2.On line inspection (On-Stream Inspection) :
On line inspection means here, in this procedure, an inspection which can be carried out without shutting down the pressure vessel. This inspection includes the visual /or NDE external inspection, any thermographic survey and the foundations and the structure surveys.

3.3.Thorough inspection (Internal Inspection) :
Thorough inspection means, in this procedure, an inspection which requires the shut down and decommissioning of the unfired pressure vessel. This includes an internal visual inspection and any NDT tasks.

3.4.Thorough external inspection (External Inspection) :
Thorough external inspection means, in this procedure, an inspection carried from outside. The external inspection may be done either while the vessel is operating or while the vessel is out-of-service and can be conducted at the same time as an on-stream inspection , using extensively the NDT methods in order to to find conditions that could impact the vessel's
ability to maintain pressure integrity or conditions that compromise the integrity of the supporting structures (e.g. ladders, platforms, supports).

3.5.Corrosion under Insulation (CUI) Inspection :
External corrosion of carbon steel piping, pressure vessels, and structural components resulting from water trapped under insulation. ECSCC of austenitic and duplex stainless steel under insulation is also classified as CUI damage.

3.6.Thickness Inspection :
Thickness measurements are taken to verify the thickness of vessel components. This data is used to determine the corrosion rates and remaining life of the vessel.

3.7.Risk-Based Inspection (RBI) :
A risk assessment and management process that considers both the probability of failure and consequence of failure due to material deterioration and that is focused

on inspection planning for loss of containment of pressurized equipment in processing facilities due to material deterioration. These risks are managed
Primarily through inspection in order to influence the probability of failure but can also is managed through various other methods to control the probability and consequence of failure. RBI assessments should be in compliance with the recommended practices of API 580 & 581.

3.8.Fitness For Service (FFS):
A methodology whereby flaws and other deterioration/damage or operating conditions contained within a pressure vessel are assessed in order to determine the integrity of the vessel for continued service. FFS evaluations, such as those documented in API 579-1/ASME FFS-1, may be used for this evaluation and can be applicable to the specific damage observed.

For more Definitions see section 3 (Terms and Definitions) contained in API 510 .

4. **Objectives**:

The objectives of this procedure are :
- To ensure that the Company unfired pressure vessels are periodically inspected in order to assess their suitability to perform safely their function and to predict their likely behaviour until next inspection, based on the history of the said equipment and/or similar systems.

- To provide the guidelines on the inspection scope and methods.

- To define the reporting system.

5. Limitations:

This procedure shall not be used as a substitute for the original construction requirements governing a pressure vessel before it is placed in-service; but shall it be used in conflict with any prevailing regulatory requirements.

6. Inspection Frequencies and Grades:

As per the result of the RBI study and of the shut-down , an inspection grade associated with a maximum interval have been allocated to each unfired pressure vessel.
Grade 0 applies to the first thorough inspection after commissioning. After completion of the first and subsequent inspections the pre-defined interval and grade allocation will have to be amended, if necessary, in the light of the inspection results by application of the following inspection grade rules:

The relation established between grade and interval is given in the table hereafter for thorough inspection or thorough external inspection.

Table1.Inspection Grade and Maximum interval Relations

Grade / Items	Grade 0	Grade I	Grade II
Critical items	18	36	36
Non critical items	18	36	72

Note: Maximum Interval in months

6.1. Internal Inspection Grades :

Inspection Grade 0 : This is the grade in which all graded equipment should normally be deemed to be, following the pre-commissioning or commissioning inspection and until the first initial thorough inspection is carried out.

Inspection Grade I : This grade should be applied when the conditions of service are such that :

- Deterioration in whole or in part is possible at a relatively rapid rate or at a known mean rate which restricts service life,

or - There is little evidence or knowledge of operational effects on which to predict behaviour in service.

Inspection Grade II : This grade should be applied when the conditions of service are such that :

- Deterioration in whole or in part is possible at a reasonable and predictable rate justifying an inspection interval.

And - Knowledge of facts or actual behaviour in service is sufficiently reliable to justify an increased inspection interval.

Note1: On-stream inspection may be acceptable in lieu of internal inspection for vessels under the specific circumstances and the discretion of the inspector defined in API 510 Sec. 6.5.2.

Note2: Pressure-relieving devices should be inspected, tested, and maintained in accordance with API 576.

Note 3: An alternative method to establish the required inspection interval if an RBI assessment is not performed, the period between internal or on-stream inspections and thickness measurement inspections shall not exceed one-half the remaining life of the vessel or 10 years, whichever is less.
Whenever the remaining life is less than four years, the inspection interval may be the full remaining life up to a maximum of two years.

External Inspection: A maximum 2 year interval is allocated to all the vessels for the on line external inspection.
The on line external Inspection must take place several months prior any thorough internal inspection in order to amend, as required, the inspection and the remedial work scopes.

7. Deferral of Inspection due Dates:

an inspection or pressure relief device servicing interval may be deferred by the inspector, without other approvals, based on a satisfactory review of the equipment history and appropriate risk analysis, when the period of time for which the item is to be deferred does not exceed 10 % of the inspection/servicing interval or six months, whichever is less. The deferral of scheduled inspections should be the occasional
Exception not a frequent occurrence. Deferrals need to be approved by owner/user management and Pressure equipment operated beyond the inspection due date without a documented and approved deferral is not permitted by this procedure. For more details refer to API 510 (part 6.7).

8. Pre-Inspection Activities:

8.1 Preparation of the Inspection Programme

The inspection programme is established taking into account:

- The potential problems identified,
- The inspection task check list (Refer to Appendix 2),
- The time allocated for the inspection.
- Document review(Equipment data sheet ,Inspection History)

8.1.1 Identification of the Potential Problems:

The potential problems have to be identified in order to select the adequate methods of inspection. The major problems which can occur are outlined in the criticality assessment. They could originate from:

8.1.1.1 Effluent Chemistry:

Presence of H_2S, in wet conditions, may lead to SSCC, HIC, and generalised weight loss corrosion.
Presence of CO_2, in wet condition, may lead to pitting, localised corrosion, or general wall thickness reduction. Corrosion rate can be estimated using a computer program by means recorded thickness . CO_2 corrosion is extremely limited when the CO_2 partial pressure is below 0.5 bar. The corrosion rate increases with the partial pressure. It increases also with the temperature to reach a maximum at about 90°C. The corrosion process depends upon operating conditions and upon the relative CO_2 and H_2S contents.
CO_2 and H_2S corrosions can occur only in presence of free water.
Presence of oxygen can lead to pitting, rusting, localised corrosion, general wall thickness reduction. Oxygen is not present in the main stream. It may be a source for corrosion in the utilities, mainly in the steam generation, and in the water / air distribution networks.
Presence of caustic compounds (amines). Depending upon the pH and temperature the presence of caustic compound can entail :
. Caustic embrittlement and cracks.
. Caustic corrosion and localised or general weight loss corrosion.

8.1.1.2 Flow Pattern:

If the flow is too high it could lead to erosion corrosion, destruction of passive layer (it plays an important role in the CO2 corrosion) and to the impossibility to form a protective film with corrosion inhibitor.
If the flow is too low it can lead to deposit build up and localised corrosion, it can also lead to overheating by interfering in the heat transfer.
Vortex can entail degassing and localised corrosion.

8.1.1.3 Working Conditions:

Abnormal working conditions are, in a general manner, an important cause of failure. These abnormal conditions could, for instance lead to overheat, stagnant fluid, or ingress of corrosive species.
Overheating can entail oxidation, scaling, failure of coating and lining, and degradation of effluent compounds into corrosive chemical species.
Stagnant fluid can entail concentration of corrosive species or favour development of bacterial corrosion.
Abnormal conditions can also lead to mechanical failure due to fatigue, overload, and vibration.
Close liaison between Operation and Inspection departments is necessary so that Inspection department can organise its investigations on specific potential anomalies at the next inspection of the equipment involved, when abnormal condition has been reported.

8.1.1.4 Design and Material Selection:

Problems may occur due to a poor design or an inadequate material selection.
The most frequent problems resulting from these causes are corrosion rate higher than expected, galvanic corrosion or mechanical failure due to insufficient sizing (over stressing and fatigue).
The quality of cladding or lining can also be the cause of problems, because, in case of failure, the underneath material is likely not able to resist to the corrosive effluent, when directly exposed. Therefore special attention shall be given to the checking of clad bonding and to any internal lining failure.

8.1.1.5 Environmental Conditions:

The atmospheric condition affects mainly the external corrosion. The atmospheric condition in Onshore and offshore could entail atmospheric corrosion and Presence of chlorides in the air, high temperature, high level of humidity, and possible pollution (in case of shut down of the sulphur plant). Sulphide stress cracking of austenitic stainless steel could be anticipated and special attention shall be given to stainless steel bolts and nuts.

8.1.1.6 Externally Insulated Vessel

The potential problem is the risk of corrosion under insulation. Hot and cold service has to be separately considered.
Hot service:
The risk of external corrosion is negligible for vessel operated above 150 °C. Below this temperature, the risk is decreasing with the temperature from 120 °C to ambient temperature and from 120 °C to 150 °C. The highest corrosion risk is within 70 °C - 120 °C range.

Cold service:
The risk of external corrosion is negligible for vessel operated below -5 °C. There is a risk of external corrosion under insulation above that temperature, and more specifically when the operating temperature is cycling.

Note: For more details refer to API RP 571 (Part 4.3.3.3) and API RP 583.

The potential internal corrosion problems which affect the unfired pressure vessels with regard to their location and the effluent should be summarised in the Corrosion Prevention Policy .

8.1.2 Weak Point Identification

The weak point identification shall be based on the review of the fabrication drawings and of the process conditions.

8.1.2.1 Fabrication Drawings

They give the shape, the size and the material of the components. Thank to a sound judgement, weakness can be identified. Usually the weak points are with the internals: brackets, beams and bed supports, bolted assemblies which can become loose and fall down, impingement plates and their supports, distributors which often break due to fatigue, bubble valves and caps. In a general manner columns and reactors, due to their more complex internals, are more prone to deterioration than the horizontal vessels.

8.1.2.2 Process Conditions

The hottest and coldest parts, as well as the condensing or degassing sections can be identified and, depending upon the effluent composition, they can be more or less exposed to corrosion/erosion.

- Hot parts (60°C to 110°C) are more susceptible to CO_2 corrosion than the coldest.
- Cold parts (below 60°C) are more susceptible to H_2S corrosion than hot parts.
- Stainless steel in hot condition (> 60°C) are more susceptible to chloride stress cracking corrosion than at a lower temperature.
- High velocity and vortex prevent formation of a protective layer, or destroy the protective layer (or the protective film of the corrosion inhibitor).
- Stagnant sections can favour deposit and/or concentration of corrosive species and also favour development of bacterial corrosion.

- Drain nozzles, bottom elbows and boots, are considered as weak points.
- Weld seams and relevant Heat Affected Zones, because of residual stresses, are always considered as weak areas (mainly in sour service or caustic service).

- Claddings by explosion or rolling process are giving more troubles than overlaying.

- Dissimilar materials can bring to localised galvanic corrosion.

- Under lagging corrosion, in cold service, can occur and lead to either generalised corrosion (rusting) or chloride stress cracking of austenitic stainless steel. Signs of moisture/water ingress shall trigger comprehensive additional investigation such as profile flash radiography or Neutron Back Scatter Survey.

8.2 Selection of the Inspection Methods

Inspection methods are selected taking into account:

- The potential problems,
- The accessibility,
- The time allocated for inspection.

8.2.1 Visual Inspection

When ever and everywhere it is feasible, a visual thorough inspection shall be carried out in order to find all the indications of deterioration (corrosion, wear, erosion, cracks, deformation, mechanical failure...).

8.2.2 NDT Inspection

NDT methods are complementary to visual inspection but not a substitute to it. They have to be extensively used for on stream inspection to monitor any anomaly on inner vessel wall and/or when the internal access of the vessel is not possible for operational reasons.

Ultrasonic inspection is recommended for detection of :
- Lamination, blister,
- pitting,
- Non even internal corrosion,
- cladding disbanding.
- Remaining wall thickness measurement.

Dye Penetrant Examination (DPE) and Magnetic Particle Inspection (MPI) are recommended to detect surface flaws (cracking) and surface defects.
Radiography (or gammagraphy) is recommended where ultrasonic (UT) and visual inspection cannot be applied or as a complementary inspection method to UT method.

The selection of the NDT methods can be made by using the following table.

Table2: Selection of NDT methods based on Damage Mechanism Types

Potential problems			**NDT Methods**				
Origin	**Form**	**Mat. affected**	**UT**	**MPI**	**DPE**	**RT**	**Visual**
SSCC (H_2S)	Crack	CS	X	O	X	X	X
CSCC (Cl-)	Crack	SS	X	NA	O	X	X
Caustic embr.	Crack	CS	X	O	X	X	X
HIC (H_2S)	Lamination	CS	O	NR	X	NR	NA
HIC (H_2S)	Blistering	CS	X	NA	NA	NR	O
CO_2, O_2, Cl_2	Pitting	CS/SS	X	NR	NR	X	O
" "	Even corrosion	CS	O	NA	NA	NA	O
" "	Uneven corrosion	CS	X	NA	NA	X	O
" "	Groove	CS, SS	X	NA	NA	X	O
" "	Crevice	SS	X	NA	X	X	O
Galvanic Cell	Uneven	CS, Al.	X	NA	NA	X	O
Fatigue	Crack	CS, SS	X	X	O	X	X
Flow pattern	Corrosion/ erosion	CS, SS	X	NA	NA	X	O
Fabrication process/Service	Clad disbanding	Base Metal	O	NA	NA	X	NA
Fabrication process/Service	Coating defect	Coated mat.	NA	NA	NA	NA	O

O : Recommended NR : Not recommended

X : Suitable NA : Not applicable

CS :CARBON STEEL SS : STAINLESS STEEL

SSCC: Sulfide Stress Corrosion Cracking HIC : Hydrogen Induced Cracking

CSCC : Chloride Stress Corrosion Cracking

Note: DPE, MPI, UT requires direct access the metal surface inspected. They are subject to temperature limitations. UT = 60°C (Special high temperature UT probes for higher temperatures), DPE and MPI up to 180°C with specific products.

In case of defect detection by a NDT method, without possible visual check, the inspection and NDT records of the vessel construction dossier should be reviewed. It is wise to confirm it and its sizing by using a second NDT method.

8.2.3 Corrosion Monitoring

Inspection methods are time consuming and they have to be used according to a pre-established programme. But, on systems severe corrosion problems are suspected, a close corrosion monitoring is required to check the efficiency of the chemical treatment, by using other methods such as coupons, PAIR probes, resistance probes or hydrogen patch probes.

8.3 Selection of Areas for NDT Inspection

Inspection by NDT methods are time consuming. In order to limit the inspection time, NDT are applied to selected areas which are supposed to be the more exposed to corrosion or mechanical damages.
The location of the selected areas and the extent of the surface to be inspected are based on the level of failure risks.
For wall thickness checks, during on line inspection, these areas should be in the range at 0,2% of the total surface for the large vessels (more than 100m² total surface). For smaller vessels the total surface should be in the range of 0.5% of the total surface.
They shall include both heads, each can of the shell and all nozzles (including small bore nozzles for instrumentation). The areas of fluids interface shall be part of the selection.

Weld seams and heat affected zones shall be incorporated in the areas to be inspected.
A map of the selected areas has to be established and incorporated in the inspection documentation package.
In the case of pressurised vessels with high criticality rating like the upstream flare HP K.O. drums, which cannot be decommissioned without full shut down, the NDT selected areas shall be extended for the on line NDT inspection to at least 2% of the surface.

8.4 Inspection Task check list

The inspection task check list is established for each vessel type in order to itemise the standard inspection tasks part of the inspection scope of work. The inspection task check list is part of the Inspection documentation package and it is prepared using the inspection tasks check list form (refer to Appendix 2).

8.5 Inspection Documentation Package

For each vessel to be inspected an inspection documentation package shall be prepared.

The following documents shall be incorporated:

- Equipment Inspection data sheet.
- Assembly/General arrangement drawings.
- Inspection sketch or drawing with indication of the areas selected for NDT examination.
- Inspection task check list
- Preparatory works programme and general planning.
- List of required NDT/inspection equipment.
- Copy of the previous inspection reports.
- Reporting forms.
- Copy of the work permit.

8.6 Preparatory Works

8.6.1 Work Request

As assistance from other Company departments is required, a work request shall be issued by Inspection in due time for preparatory works and assistance during the Inspection.

8.6.2 Preparatory Work Programme and Planning

The preparatory work programme is set up with the involved departments:

- Planning department takes the outlined / detailed plan.
- Operation Department takes the equipment out of service and makes sure that the inspection work can safely be performed.
- Maintenance Department provides all the necessary support services and equipment (access, scaffolding/ladder, portable fans, lighting fixtures, lifting equipment, lagging removal, opening/closure, cleaning as per agreed procedure or manufacturer recommendation, internal dismantlement / removal-refitting, spare parts,...) - and performs the required remedial work (coating, lagging, welding work,...).
- Safety Department makes sure that the safety rules are met (as per standing instructions) before starting the inspection, monitors the safety conditions during the work and provides the required safety equipment (oxygen mask, fire extinguishers,...).

Consequently a joint work programme, with an overall planning, has to be established.

8.6.3 Mobilisation of Equipment/Operators

A list of the equipment required for the inspection shall be established and their availability confirmed for the period planned together with

- The availability of the necessary consumables,
- The availability of the qualified operators.

Subject to the inspection scope, the inspection shall be either performed by Company personnel and equipment, or through contracted services under Company's supervision. Should equipment be provided by Contractor, its list shall established and be part of the contractual documents.

9. Inspection Activities

9.1 Preliminary Inspection checking

Prior to start the inspection activities, the Inspector have to check the following points:

- The completeness of the Inspection documentation package.
- The issue of the work permit(s) and its validity.
- The availability of required inspection equipment, consumables and personnel.
- The completion of the preparatory works.

9.2. ON line Inspection:

9.2.1 Visual External Inspection

- All the items listed in the Inspection task check list have to be carefully and thoroughly examined, in order to detect any sign of general or localised deterioration.
- Each inspected component shall be noted.

- All abnormal conditions shall be reported : poor coating, rusted surface, rusted bolts / nuts, loose bolted assemblies, screws/bolts/nuts missing, rusted weld seams, cracks, distortion, bends, dents, sagging, bulging items, indication of leak, indication of water ingress due to faulty sealing or damaged lagging.
  Special attention shall be given to stainless steel bolting (in low temperature service) where sulphide stress cracking corrosion is a potential risk.

9.2.2 External Insulation Survey

Cold service:

Also external visual survey is the first inspection stage, it is not always reliable to detect areas where moisture has penetrated the vapour barrier. Complementary methods are available.

Thermographic survey allows a rough estimate of the insulation status. It shall be focused on parts where moisture or water ingress is suspected.

In case of indication of insulation defect which can indicate the presence of moisture; the insulation has to be removed at the next opportunity for visual examination of the metal surface.

Neutron backscatter method may be used as a complement of the thermography method to identify the presence of moisture where insulation defects are detected.

Profile radiographic examination, mainly on vessel nozzle, may also be used to detect presence of moisture

Hot service:

Complementary methods to the external visual are required on lagged hot service vessels.

Thermographic survey can identify areas of insulation deficiencies, which should be investigated by local insulation removal for a visual examination of the external vessel surface.

For vessel operated with cycling temperatures, the survey should be performed at high temperature cycle.

As for cold service, profile radiographic examination can be conducted on vessel nozzles.

9.2.3 Foundation and Structure Survey, Plumbness

The plumbness of the vertical columns or drums has to be checked (use of a theodolite for column higher than 20 m).

The concrete foundation slab shall be examined for cracks and evidence of settlement anchor bolts shall be examined for corrosion, crack, and tightness.

Structural frame and support shall be checked for physical defects (bending, denting, lack of squareness, creeping, deformation, etc...)

Still photographs of typical and abnormal conditions shall be used as supports to the visual external inspection report.

9.3 ON- Stream Inspection

On stream inspection, using NDT techniques, mainly ultrasonic wall thickness checks, for detection of internal defects, are carried out at the selected areas (with inspection window in case of insulated vessels).

Selected area co-ordinates have to be reported to fixed marks (reference datum) such as edge of weld seam so that the subsequent inspection can take place exactly at the same place which is necessary to assess the corrosion rate.
If laminations are found, the extend of the defects shall be accurately evaluated and a mapping of the defects shall be drafted out, as reference, in order to assess possible extension and to monitor the evolution. A permanent grid, painted on the surface of the faulty area can help in the monitoring of the defect. The use of corrosion condition computerized system for data recording and trend analysis is to be implemented.
On line Ultrasonic Inspection shall be extensively used for the drums which cannot be taken out of commissioning without entailing a total shut down of the production facilities, the inspection shall include the 100% scanning of the selected areas and additional spot measurements at random.
Radiography/gammagraphy could be used as an alternative or a complementary method to ultrasonic method for nozzles or small diameter parts of the vessel (boot).
NDT scope shall include the weld inspection (MPI/DPE) of lifting/handling equipment attached to the vessel (e.g. manhole davit).

9.4 Thorough Inspection (internal)

The following relates to vessels fitted with manholes, the inspection of which requires an entry permit.
Three phases shall be considered.

- At opening.
- After cleaning.
- At closing.

9.4.1 At the Opening

- Subject to HSE restrictions, an overall internal visual examination shall be carried out and presence of deposits noted with indication of their aspect, colour, quantity and location.
- Samples of deposits, corrosion products shall be taken for further analysis. Samples shall be carefully identified by appropriate label with indication of the sampling location.
- Still photographs shall be taken of typical and abnormal conditions.
- All apparent damages, shall be noted (fallen trays, broken or distorted supports, loose bolted connections, bent beams, torn metal sheets, coating, cladding, refractory failure, etc.).
- Manhole plate inner surface (flange facing) and gasket shall be thoroughly visually examined.
- A preliminary report has to be issued.

9.4.2 After Cleaning

9.4.2.1 Visual Thorough Internal Inspection

All the items of the Inspection tasks check list are thoroughly examined for detection of : pitting, pinhole (stainless steel), cracks, blisters, grooves, crevices and other forms of corrosion, indication of erosion, wear, distortion, bending, sagging or other mechanical failures which have not been noted at the opening time inspection. Particular attention shall be given to weld seams, heat affected zones and stressed parts such as support rings, brackets, beams, etc.
The visual examination shall be completed with a still photograph report of the abnormal findings.

9.4.2.2 NDT thorough Internal Inspection

The purposes of NDT internal inspection are:
- to detect defects which cannot be detected by visual examination such as lamination, small cracks, pinholes or features which are hardly inspectable by external NDT methods.
- to confirm and to evaluate the extend of detected defects by internal visual survey or external BDT inspection (e.g. crack sizes, configuration of a pinhole, etc).

Ultrasonic inspection
It has to be applied at selected areas when no on line NDT inspection is carried out, as a routine inspection, in order to check the vessel wall thickness and to assess any disbanding (if applicable). Ultrasonic wall thickness check shall also apply when metal loss is identified (measurement of remaining thickness and/or on sound surface close to the metal loss).

Dye Penetrant Examination or Magnetic Particle Inspection (CS)

These methods shall be used on internally uncoated vessels to check the soundness of welds. The scope should include the longitudinal/circumferential cross welds, the nozzle welds and any accessible lining welds.

NDT scope shall include other methods to size visually identified anomalies (calipering, profile gauging,...) or to check any metallurgical changes (replicas).

The predefined scope of NDT inspection shall be extended by the inspector subject to the findings.

9.4.3 At Closing

This inspection shall be carried out jointly with Operations and Maintenance department.

Note1:
All repairs and alterations to pressure vessels shall be performed by a repair organization in accordance with the applicable principles of the ASME Code or the applicable construction or repair code and the equipment specific repair plan prepared by the inspector or engineer. Repairs to pressure-relieving devices should be in accordance with API 576 and the approved relief valve QA manual. The repair organization shall follow all applicable safety requirements.

Note2:
Before any repairs , alterations or Re-rating are performed, all proposed methods of design, execution, materials, welding procedures, NDE, and testing shall be approved by the inspector or engineer.
After alterations, major repairs, and temporary repairs, approval by both the inspector and engineer is required.For more details refer to API 510 (Sec.8).
Inspector shall check:

- That the pressure safety valves have been properly inspected / tested / calibrated according to the relevant procedure and that they are properly fitted.
- That the repair works are properly completed with satisfactory quality control results.
- That all dismantled parts are refitted as per design or approved modification.

- That tools, ladders, scaffoldings have been removed and the vessel is tidy.
- That manholes, hand holes and nozzles are correctly closed with new gaskets.

9.5 Internal Inspection of Vessels with Limited Access

The internal inspection is carried out using fibber optic tools in order to assess the internal status. Internal access could be made available by disconnecting a nozzle.

This internal inspection should be considered as complementary to a thorough NDT on line inspection, the scope of which is to be comprehensive to overcome the limitation of access for internal assessment.

Should an hand hole available, an assessment of the inner surface status could be made by hand touching.

10. Reporting :

10.1 Intermediate Reports

In the cases of findings entailing an immediate action such as repair works, replacement, etc... Or entailing an extension of the inspection time, the Inspector shall issue an intermediate report, using the relevant form. In the specific case of the large vessels several intermediate reports can be issued.

10.2 Final Reports

The final report may include:

- A summarised report where appear in brief:

* The status as found of the various parts and works carried out
* The recommendations

- The intermediate reports
- The detailed reports
- The NDT specific inspection report
- Other specific investigation report (replicas, chemical analysis, etc.)
- The photographic report

APPENDIX 1 : INSPECTION TASKS CHECK LIST

SITE:	ONSHORE	UNIT:	SCHEDULING TAG:	
EQUIPMENT TAG:			CATEGORY:	
DESCRIPTION:			LOCATION:	
Shut Down TYPE:			P&ID:	
FREQUENCY:			DATE OF INSPECTION:	
	REASON FOR INSPECTION:		REPORT N°:	
	At opening:			
	ITEM	DESCRIPTION	REMARKS/ RECOMMENDATION	
	MANWAY FLANGE FACING	General condition		
	DEPOSIT	Location/type/quantity/ colour		
	VESSEL SHELL/ENDS	General condition		
	DAMAGED PARTS	Broken/fallen/ bent/ loose		
	INTERNALS	Demister/distributor/ weir/ deflector		
	CLEANING METHOD	Chemical/ mechanical/ water jet		
	GENERAL REMARKS/RECOMMENDATION:			
	AFTER CLEANING:			
	ITEM	DESCRIPTION	REMARKS / RECOMMENDATION	
	MANWAY FLANGE FACING	General condition		
	CLEANING CONDITION	General condition		
	VESSEL SHELL/ ENDS	General condition		
	WELDS	General condition		
	DAMAGED PARTS	Broken/ fallen/ bent/ loose		
	INTERNALS	Demister/ distributor/ weir/ deflector		
	NOZZLES	Inner surface		
	CORROSION SIGN	Location / type		
	COATING/ CLADDING/ LINING	General condition		
	NDT(PT/UT/MT/RT/Other)	Location		
GENERAL REMARKS / RECOMMENDATION: Result:				
	INSPECTED BY		Sign: Date:	
	APPROVED BY		Sign: Date:	

APPENDIX 2: VESSEL BASELINE INTERNAL INSPECTION

SITE :	UNIT :	SCHEDULING TAG :
EQUIPMENT TAG		CATEGORY :
DESCRIPTION		LOCATION :
Shut Down :		P&ID :
FREQUENCY		DATE OF INSPECTION :
REASON FOR INSPECTION: Baseline		REPORT N°:

ITEM	DESCRIPTION	REMARKS / RECOMMENDATIONS
VESSEL SHELL		
VESSEL ENDS/HEADS		
WELDS		
INTERNAL		
INTERNALPLATE SHEET		
FLANGE FACES		
COATING/CLADDING		

GENERAL REMARKS:
RECOMMENDATION:

INSPECTED BY		Sign. Date:	
APPROVED BY		Sign. Date:	

APPENDIX2 :
(Continued) PRESSURE VESSELS VESSEL BASELINE EXTERNAL INSPECTION

SITE:	UNIT:	SCHEDULING TAG:
EQUIPMENT TAG:		CATEGORY:
DESCRIPTION:		LOCATION:
Shut Down TYPE:		P&ID:
FREQUENCY:		DATE OF INSPECTION:
REASON-FOR-NSPECTION:		REPORT N°:

ITEM	DESCRIPTION	REMARKS
HANDHOLE / MANWAY	Check weld between doublers to shell and hand / man way to shell. Check flange face and gasket.	`
NOZZLES	Check the nozzle weld to shell. Check general conditions of nozzles, are gaskets fitted?	
SUPPORTSADDLE LEGS	Check fillet weld between doublers plate and shell. Check general condition. Are earth straps fitted and secure?	
GAUGES/ INSTRUMENTS/ FITTINGS	Check the general condition, any damage?	
VESSELSHELL/ HEADS	Check for dents, distortion, gouges, scratches corrosion and general condition	
WELDED ATTACHMENTS	Check the welds to shell Any sign of excessive force or damage to attachments?	
PSV	Are PSV's installed? Check CSP	
NAME PLATE	Check details of Name Plate	
PAINTING/ COATING INSULATION	Check condition of coating. If insulated check for damaged or unsealed joints	
SUPPORTS/ FOUNDATIONS	Check foundation slab for settlement. Check vessel for plumbness. Check anchor bolts.	

GENERAL REMARKS
RECOMMENDATIONS

INSPECTED BY		Sign: Date:	
APPROVED BY		Sign: Date:	

APPENDIX 3 : VESSEL INTERNAL INSPECTION REPORT

SITE: ONSHORE	UNIT:	SCHEDULING TAG:
EQUIPMENT TAG:	CATEGORY:	
DESCRIPTION:	LOCATION:	
Shut Down TYPE:	P&ID:	
FREQUENCY:	*DATE OF INSPECTION:*	
REASON FOR INSPECTION:	REPORT N°:	
At opening:		
ITEM	DESCRIPTION	REMARKS / RECOMMENDATION
MANWAY FLANGE FACING	General condition	
DEPOSIT	Location/ type/ quantity/ colour	
VESSEL SHELL/ENDS	General condition	
DAMAGED PARTS	Broken/ fallen/ bent/ loose	
INTERNALS	Demister/ distributor/ weir/ deflector	
CLEANING METHOD	Chemical/ mechanical/ water jet	
GENERAL REMARKS/RECOMMENDATION:		
AFTER CLEANING:		
ITEM	DESCRIPTION	REMARKS
MANWAY FLANGE FACING	General condition	
CLEANING CONDITION	General condition	
VESSEL SHELL/ ENDS	General condition	
WELDS	General condition	
DAMAGED PARTS	Broken/ fallen/ bent/ loose	
INTERNALS	Demister/ distributor/ weir/ deflector	
NOZZLES	Inner surface	
CORROSION SIGN	Location / type	
COATING/CLADDING/ LINING	General condition	
NDT(PT/UT/MT/RT/Other)	Location	

INSPECTED BY		Sign: Date:	
APPROVED BY		Sign: Date:	

APPENDIX 3 (Continued) VESSEL EXTERNAL INSPECTION REPORT

SITE:	UNIT:	*SCHEDULING TAG:*
EQUIPMENT TAG:	CATEGORY:	
DESCRIPTION:	LOCATION:	
Shut down TYPE:	P&ID:	
FREQUENCY:	*DATE OF INSPECTION:*	
REASON FOR INSPECTION:	REPORT N°:	
Work Order:		

ITEM	DESCRIPTION	REMARKS
HANDHOLE/ MANWAY	Check weld between doubler to shell and hand / manway to shell. Check flange face and gasket.	
NOZZLES	Check the nozzle weld to shell. Check general conditions of nozzles, are gaskets fitted?	
SUPPORT SADDLE LEGS	Check fillet weld between doubler plate and shell. Check general condition. Are earth straps fitted and secure?	
GAUGES/INSTRUMENTS/ FITTINGS	Check the general condition, any damage?	
VESSEL SHELL / HEADS	Check for dents, distortion, gouges, scratches corrosion and general condition	
WELDED ATTACHMENTS	Check the welds to shell Any sign of excessive force or damage to attachments?	
PSV	Are PSV's installed?	
NAME PLATE	Check details of Name Plate	
PAINTING/ COATING INSULATION	Check condition of coating. If insulated check for damaged or unsealed joints	
SUPPORTS/ FOUNDATIONS	Check foundation slab for settlement. Check for plumbness. Check anchor bolts.	

GENERAL REMARKS:	
RECOMMENDATION:	

INSPECTED BY		Sign: Date:	
APPROVED BY		Sign: Date:	