



Exploration & Production

GENERAL SPECIFICATION

FIELD OPERATION

GS EP EXP 201

**Operations preparation during project -
Maintainability & Inspectability criteria**

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Contents

1. Scope	3
2. Application.....	3
3. Reference documents.....	3
4. Terminology.....	4
5. Generalities.....	5
5.1 Specification purpose	5
5.2 Nature of maintainability and inspectability criteria.....	5
6. General design studies.....	6
6.1 Project design	7
6.2 Redundancy, spare capacity, modularity.....	7
6.3 Standardisation.....	8
6.4 Items selection.....	8
6.5 Accessibility	9
6.6 Handling.....	9
6.7 Monitoring and testing equipment.....	11
6.8 Equipment identification.....	12
7. Specific design criteria.....	12
7.1 Pipelines, structure	13
7.2 Piping, valves and vessels.....	14
7.3 Electrical equipment	16
7.4 Instrumentation equipment	17
7.5 Mechanical equipment.....	17
7.6 Domestic equipment.....	18
Appendix 1 Material selection comparison table.....	19

1. Scope

The availability of industrial facilities is directly affected by the downtime associated with their maintenance and inspection activities. This may vary significantly depending upon the complexity of the plants, its maintainability, its inspectability, and the statutory requirements.

In order to achieve the required performance it is necessary to anticipate the maintenance and inspection requirements at project phase, and to ensure suitable maintainability and inspectability of the concerned plant.

This specification aims at defining maintainability and inspectability criteria, both technical and organisational, necessary to ensure the installations' integrity throughout their life, that shall be assessed throughout the pre-project and project phases. These requirements complement as necessary those provided in other Company General Specifications.

2. Application

This General Specification is applicable to all construction projects including the erection of new facilities, or the modifications of existing ones, whether implemented by integrated project groups or by the modification/construction or maintenance teams of the affiliates; it concerns all facilities operated by the Company.

3. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Standards

Reference	Title
EN 13306	Maintenance Terminology
ISO 14224	Petroleum and natural gas industries – Collection and exchange of reliability and maintenance data for equipment

Professional Documents

Reference	Title
Not applicable	

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS EP EXP 203	Maintenance and Inspection documentation preparation during project phase
GS EP EXP 205	Requirements to MIEC Contractor for spare parts
GS EP EXP 311	Plant Integrity. Minimum Inspection requirements
GS EP ECP 103	Process sizing criteria
GS EP SAF 261	Emergency shut-down and emergency De-Pressurisation (ESD & EDP)
GS EP STR 002	Cranes for fixed offshore installations
GS EP MEC 290	Rotating machines packages
GS EP ELE 001	Electrical design criteria
GS EP ELE 364	Electrical installations
GS EP PVV 107	Piping stress analysis

4. Terminology

Maintainability	Ability of an item under given conditions of use, to be retained in, or restored to, a state in which it can perform a required function, when maintenance is performed under given conditions and using stated procedures and resources. (EN 13306) Note: In the above definition, and in the context of the present General Specification, the term maintainability is understood to also include the ability to permit inspection of equipment, named by extension inspectability.
Vital	Equipment whose failure immediately decreases the level of safety, affects the environment, or impairs export or production.
Critical	Equipment necessary for health and general welfare of the personnel, or whose failure may affect the environment, or impair export or production.
Secondary	Equipment whose failure neither affects safety, nor the environment, nor production.

Shutdown strategy The strategy applicable for the planned shutdowns states the intent to either proceed to regular total shutdowns like in the refinery sector and applied generally in the LNG plants, or alternatively to perform the maintenance and inspection works independently unit by unit, or to adopt an intermediate policy (partial shutdowns).

5. Generalities

During the course of a project Maintenance and Inspection Engineering is performed, consisting of several simultaneous activities:

- Maintainability and Inspectability studies **GS EP EXP 201**
- Documentation management **GS EP EXP 203**
- Spare-parts selection **GS EP EXP 205**

5.1 Specification purpose

The purpose of the present specification is to define the maintainability and inspectability criteria that shall be considered throughout the project process by all parties involved in or in charge of:

- The project design, coordination or supervision,
- The engineering, the specification, selection or purchase of materials and equipment, the construction, the installation, or the commissioning,
- The supply of equipment or services (vendors),
- The operations preparation including the maintenance engineering, the inspection engineering, the baseline surveys and the start-up of the facilities.
- The maintenance and Inspection engineering QA/QC.

It ultimately aims to ensure that the maintainability and inspectability criteria are met thus ensuring the required availability and integrity of the facilities throughout their operational life.

5.2 Nature of maintainability and inspectability criteria

The maintainability and inspectability criteria cover various aspects, of both an organisational and technical nature which may be intrinsic (only related to item) or extrinsic (context dependant). They cover preventive and corrective maintenance requirements, major overhaul, revamping and inspection works. They are established in light of various obligations and of economic considerations.

They include but are not restricted to:

- Consistency between the design, the maintenance and inspection strategies resulting from the operating philosophy, and the applicable standards and rules: legal requirements, Company HSE standards,
- Consistency of equipment and associated maintenance/inspection philosophy with the maintenance and inspection resources that can be mobilised, and with the industrial environment, context of after sales services, available logistic support,

- Consistency with the shutdown strategy: process by-pass, amount of spare parts and capital spares, tools sets, working space around packages, accommodation facilities, lifting and storage facilities, maintenance and inspection staff, etc.
- Spare capacity, redundancy of items (hot or cold stand-by),
- Standardisation of equipment (other similar equipment already installed, or subject to installation),
- Modularity (possibility of partial exchange by module, possibility of alternative running modes involving equipments from different units or trains,
- Equipment and item environment: access, physical constraints (temperature, smoke, gases, etc.), others,
- Handling facilities (possibilities for installation or removal),
- Dismantling/tooling (convenient dismantling possibilities, availability of standard or special tools),
- Internal access (convenient access to internals),
- Potential hazard constraints (e.g. corrosive or contaminated products, stress level, etc.),
- Standardisation of components (components suitability to various equipment),
- Equipment condition monitoring (possibility of on-line or off-line monitoring, of sampling, availability of measurement points), facilities for defect analysis and for efficient diagnosis,
- Availability and usefulness of required documentation,
- Availability of the necessary supporting means: workshops, warehouse, stock, support contracts, etc.

6. General design studies

Specific maintainability and inspectability related studies shall be carried out during the course of the project. They shall first be taken into account to validate the equipment lay-out, and the main project options, and shall be followed up along the project to ensure consistency of the final delivered installations.

These studies include but are not restricted to:

- Validation studies on certification or inspection matters, as defined in chapter 5.1,
- Reliability and risk assessment studies, as defined in chapter 5.2,
- Accessibility study, as defined in chapter 5.5,
- Handling – lifting studies, as defined in chapter 5.6,
- Complementary maintainability and inspectability reviews, as necessary.
Such studies shall typically be carried out for the packages and other equipment of high value, subject to heavy maintenance, and with critical impact on operations. This includes but is not limited to: the power generation systems (main and emergency units), the gas lift, or gas injection or gas export compression packages, the water injection packages, the water treatment units, the oil export systems, and the export metering systems.

In such cases the maintainability reviews shall detail the expected performance (availability, reliability, etc...), the main maintenance/inspection operations and schedules, etc.

- Other specific studies as necessary, like inspection reviews aiming at assessing the inspection plan. Such reviews may be initiated to evaluate for instance the internal corrosion then define the corrosion prevention and monitoring means, or to investigate and validate certification aspects, or for other purpose.

All these studies shall be supported by adequate reports that shall be inserted in the final project documentation.

6.1 Project design

From the conceptual studies until finalisation of the design, the following criteria shall be taken into account and assessed in accordance with the expected performance (availability and reliability).

The equipment design and associated operating philosophy, including the maintenance and inspection strategies, shall be consistent with:

- The applicable statutory requirements (e.g. ensuring that the design is such that the inspection requirements are taken into account in the availability figures defined at design stage, eventually proceeding with a RBI review).
- The HSE standards, both those issued by external bodies and by Company (e.g.: ensuring that the design is such that the associated maintenance operations can be carried-out in compliance with the Company HSE standards).
- The applicable certification obligations associated to product delivery (e.g.: ensuring that the gas metering systems are designed and certified in accordance with the export gas sales agreement, and the contractual calibration procedure).
- The necessary resources (manpower, vendors, external support or services, etc.) and means (workshops, tools, logistic facilities, external means, spare parts, etc.), that can be economically developed or mobilised in due time (e.g. ensuring compatibility of selected technology with the industrial environment).

6.2 Redundancy, spare capacity, modularity

From the conceptual studies until finalisation of the design, the equipment redundancy shall be evaluated in front of the performance expectations (availability and reliability), taking all maintainability aspects into account.

This evaluation shall be based on equipment Vital, Critical or Secondary rating (as defined in chapter 4), and on the results of inspectability studies, and shall lead to specify:

- The modularity requirements on the redundant systems (typically process trains running in parallel), in order to minimise the effects of partial shutdown with an optimized number of units (1 x 100 %, or 2 x 50 %, or 3 x 33 %, or other).
- The needs for active redundancy (hot installed spares; i.e. running in normal mode).
- The needs for passive redundancy (cold installed spares; i.e. in stand-by in normal mode).
- The needs for spare units (capital items) kept on board, or in remote locations, or subject to ad-hoc service contracts.

The needs for spares or redundancy shall be clearly identified for each vital and critical equipment item.

The benefit of selecting equipment with modular design shall be identified and taken into account in the project specifications.

6.3 Standardisation

Standardization shall be the rule whenever feasible, in particular for items or components already operated in the same facilities or site or asset.

The following rules shall be observed during the course of equipment selection:

- The equipment and components of the same design and similar duties shall be standardised.
- For new equipment or facilities to be installed within an existing operating Company, the standardisation review shall take into account the design of the existing facilities, the existing stock of spare parts, the skills and capabilities already developed by the staff, and as the case may be, the existing support contracts.
- For existing installations extension, except when justified by documented technical or economic studies approved by the Company, the high value items or packages shall be standardized. It concerns, but is not limited to, the long lead items: gas turbines, generators, compressors and other engines, offshore cranes, DCS, ESD and F&G systems, LV and HV electrical switchboards.

6.4 Items selection

During the course of equipment selection, the equipment and consequently the vendors and the items shall be selected with due consideration for the following maintainability and inspectability criteria:

- Field proven equipment,
- Equipment belonging to the Company approved materials' lists,
- Minimum maintenance over the life of the facilities,
- Life cycle cost. For the major items with high maintenance costs such as rotating machines or cranes or control systems, the bids commercial evaluation shall be made considering the life cycle cost. It shall take into account, over a sufficient period of time i.e. generally 10 years, all the costs associated with the maintenance and inspection requirements and shall include the manpower, the spare parts, the support contracts and other associated costs. It shall in particular include as necessary the replacement costs (purchasing, rental) associated to the refurbishment of major components subject to long turn around time (rotors, engine components, crane components, etc.), or to the replacement made necessary for obsolescence reasons (DCS and other control systems),
- The after sales services that may or may not be offered by the vendor and / or other contractors, as sole supplier or in competitive bids,
- All usual criteria establishing the quality of the offer and of the vendor: ISO certifications, references, etc.

Appendix 1 presents a comparison table which may be used to rank the offers of high value equipment. Depending on the equipment, the selected criteria will be attributed different weights.

6.5 Accessibility

On a systematic basis, an accessibility study taking into account the inspection and maintenance requirements shall be carried out for all the projects in order to ensure that the design is satisfactory and matches with the performance expectations.

The following rules shall be observed for the equipment located in open areas, as well as the arrangement / content of the packages.

- The access to equipment shall be evaluated in light of the Company HSE standards and rules, in particular about working at height, working in hazardous situations, working with specific protective equipment, evacuation requirements, etc.
- The equipment shall be installed in a convenient and accessible manner, preferably from a watch walkway.
- The lay-out of the equipment shall be designed in such a way that its access can be made without prior dismantling of any other equipment located in its vicinity.
- The plant layout and equipment package design shall allow for the inspection of the facilities, including provision for the access of necessary additional equipment: mobile units, cranes, trucks, inerting gas racks, etc.
- As far as practicable, the equipment supposed to be used from time to time shall be made removable so that they can be kept in protected area when not in use, and maintained off site, such as chain blocks, trolleys, etc.
- The facilities shall be designed in order to efficiently isolate, drain and inert individually the equipment whenever necessary.

6.6 Handling

6.6.1 General principles

Particular attention shall be given to the handling and rigging facilities. This aspect includes the identification and specification of:

- The lifting means, fixed or mobile, permanent or temporary, fully or partially equipped, removable as necessary,
- The transfer routes (roads, bridges, ways), the lay down areas and the storage areas permanent or designed for particular works (turbo-machines overhauls for instance).

The lifting / handling requirements are applicable for the handling of loads exceeding twenty kilogram (20 kg), and cover the equipment installed in open areas as well as inside the packages.

Attention shall be given to the maintainability of the lifting devices. They must not be multiplied excessively, and must remain accessible for maintenance or inspection. Easy access for installation and/or removal shall be considered for the units like the chain blocks that are normally not permanently in place.

The transfer routes, lay-down areas, and storage areas shall be clearly identified, and the maximum acceptable loads shall be indicated.

All the equipment or components which may have to be lifted shall be provided with certified, identified and marked lifting points.

6.6.2 Handling study

6.6.2.1 Scope of study

For each project a handling study shall be performed. It shall be used at project design stage to define the handling philosophy and to specify the needs for the major lifting equipment (pedestal cranes, overhead cranes, etc.), the transfer routes, and the storage / lay-down areas. It shall then be developed during the project course to ensure that all the lifting, handling and rigging requirements are taken into account safely, in accordance with the Company standards.

It shall specify the requirements for handling facilities depending on:

- The concerned loads, (weight, and as necessary volume and height under the hook).
- The frequency of use, based on the preventive and corrective (estimated) maintenance and the inspection needs,
- The urgency of the interventions, subject to criticality and redundancy.
- Other requirements such as for example the need for low clearance operations (e.g. dismantling or rebuilding of mechanical equipment in situ, or installation of mechanical components with tight adjustment: exchanger bundle, rotating equipment rotor, etc.).
- Safety considerations with regards to the risk of dropped object, to safety protection for personnel against load rocking (on floating units in particular), to hazardous areas (e.g.: choice of fixed electrical overhead cranes -Eex type- against mobile diesel cranes for onshore facilities).

This study shall specifically address, in dedicated chapters the cases of equipment subject to frequent or occasional maintenance / inspection operations: turbo-machines (driving and driven components), submersible pumps, cranes, heat exchangers, valves, PSV, filters, HVAC equipment, transformers, electrical heaters, flare tips, telecom equipment, wells (for wire line equipment handling), other.

It shall address the dismantling, transfer and storage of equipment and components as well as the transfer and storage consumable materials, chemicals, and temporary means: lubricants, methanol, TEG, MEA, MDEA, nitrogen racks, welding sets, special tools, etc.

6.6.2.2 Handling matrix

As a general principle, and unless otherwise specified by Company, the requirements for the handling facilities to be associated to the equipment shall be specified on the basis of the figure 1, which requirements may be adjusted as follows:

- For the onshore facilities, depending on the availability and accessibility of mobile cranes, and on the needs for suitability to hazardous areas
- To prefer powered units rather than manual ones when the maintenance operations are infrequent but involve multiple lifting operations or operations over high heights (e.g. typically for the submersible pumps), or operations related to vital equipment which downtime must be absolutely optimised.
- To prefer mobile units, whenever possible (accessibility) and if fully safe for use, rather than fixed ones..

A matrix similar to the following one shall be systematically issued.

Handling & Lifting requirements - Typical offshore case

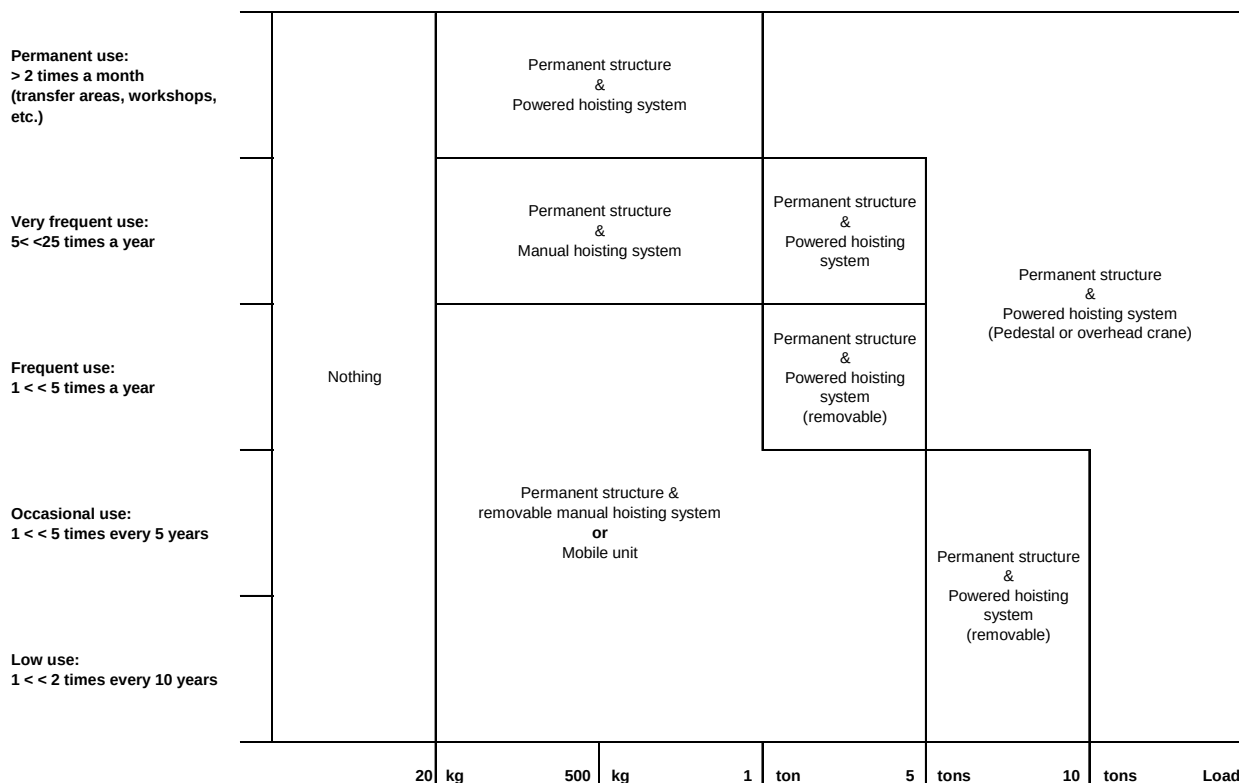


Figure 1

6.6.2.3 Transfer

The study shall also include the analysis of the transfer requirements. The study shall not be limited to the installed equipment or components but shall also consider the specific items that may have to be brought at site; e.g. coiled tubing, intelligent pig, remote operated vehicle (ROV) spread, lubricants and chemicals, consumables, etc.

For each item subject to a possible transfer the study shall indicate:

- The selected route for the transfer,
- The means to be used for the transfer (e.g. wheel trolley, powered or un-powered).

The tools and mobile units necessary for the transfers shall be provided as part of the project equipment. This may include wheel trolleys, tracks trolleys, and any other item.

The routes shall be properly designed and identified (on location and on the drawings), with regard to load capacity, in order to safely accommodate the transfers.

6.7 Monitoring and testing equipment

At each of the successive stages, from the basic engineering until the final selection and construction of equipment, the requirements for monitoring and testing equipment shall be evaluated.

It includes a review of means allowing to properly evaluating the soundness of the facilities, with minimum operations disruptions, in line with the continuous objective of mastering the equipment integrity.

This review shall assess the need for complementary accessories, devices or systems, and shall concern but not be restricted to the following devices:

- The corrosion monitoring systems (probes, coupons) to be installed on piping and pipelines sections or other process equipment,
- The vibrations and displacement monitoring systems associated to the rotating machines,
- The sampling points on process systems (associated or not to on-line analysers) or on utility equipment (e.g. on the hydraulic systems, to monitor the condition of the pumps and motor),
- Measuring points and adequate instruments (Flow, Pressure, Temperature, Current, etc.) allowing to evaluate or calculate the efficiency or capacity of a given equipment or process (e.g. fire pump, gas turbine, electrical batteries, etc.),
- Enhanced facilities aiming at minimizing the adverse effects of the tests made on the safety systems, on either safety (for instance when the tested system is unavailable during the test), or on production (such as shutdown of facilities), or on maintenance/inspection organization (for the fire and gas detection tests which are manpower consuming). Requirements for such enhanced facilities are further described in **GS EP SAF 261**.

6.8 Equipment identification

6.8.1 Functional identification

For safety reasons as well as for maintenance and inspection purpose, the equipment, the vessels, the lines, the instruments, the pipes, the cables, and generally all the independent items shall be properly identified, tagged and marked.

This requirement equally applies to the mechanical, electrical, instrumentation, telecommunication, structural, or process items, associated to a given function.

The tag marks shall be indelible, of an appropriate size, and fitted in a visible place. They shall not be fitted on the item itself, in particular when it refers to equipment which may be frequently removed for calibration or reconditioning purpose and later reinstalled in another location.

6.8.2 Physical identification

The equipment subject to movements from one functional location to another shall be identifiable, usually by a manufacturer serial number, unless specified otherwise.

For the lifting devices, each non-captive item shall be given a specific individual identification code or number, which will be used for certification purpose from the initial manufacturing stage, and then for the subsequent inspection and re-certification campaigns.

7. Specific design criteria

The following chapter indicates maintainability and inspectability criteria specific to particular equipment, depending on their nature or duty. They specify design requirements that shall be enforced.

7.1 Pipelines, structure

7.1.1 Pipelines

All requirements related to pipelines are part of the **GS EP EXP 311**.

7.1.2 Structure

7.1.2.1 Offshore jackets

The jacket shall be fitted with referenced marks to ease the subsea inspections; permanent markers shall be installed or, in the case of painted jackets, light paint colour shall be selected.

The design of the jacket, down to the second level below the sea level shall allow the installation of mechanical marine growth preventers or cleaning devices. The appropriate needs shall be identified and provided at project stage; they shall cover at least the requirements for non obstruction of the cleaning devices and for the resistance of the coating to abrasion.

Project schedules shall allow for a baseline inspection of the jacket to be undertaken in the construction yard prior to load out.

The facilities shall be provided with an appropriate system to record the environmental oceanometeo forces; these data being necessary for the recertification of the platforms.

7.1.2.2 Topsides

Provision shall be made for the temporary installation of equipment in relation with the maintenance and inspection operations. These requirements shall be taken into account in the handling study (refer also to the chapter 5.6). They may concern the following items:

- Spare components (for turbine gas generator, compressor, rotors, generators, heat exchangers, etc.) brought on board for major overhauls,
- Consumables of high consumption or which may be heavy or of large volume (lubricants, chemicals, filter cartridges, etc.),
- Intelligent pig,
- ROV (remote operated vehicle) spread.

The topside steel structures shall be designed in such a way that access to all structure components shall be possible for inspection purpose.

Project schedules should allow for a baseline inspection of the topsides to be undertaken in the construction yard prior to load out.

7.1.3 Cranes and lifting / transfer devices

The following rules complement the Company general specification **GS EP STR 002**.

7.1.3.1 General

All the various parts of the permanent lifting facilities shall be made accessible for the purpose of inspection or maintenance.

All the components subject to regular maintenance (jib, pulley, block, sensors, etc.) shall be accessible without the need for specific scaffolding or similar temporary access facilities, unless specific devices are installed in order to reduce the maintenance frequency (e.g. central greasing system avoiding physical intervention for greasing).

In open marine areas where external corrosion is a concern, the lifting devices subject to infrequent operations shall be provided with weather protective covers (fibreglass made for instance), fixed or easily removable / installable without specific means.

The conditions for performing the maintenance and inspection activities on the lifting equipment shall be studied during the project. Suitable means shall then be added to the design as deemed necessary by Company.

7.1.3.2 Cranes

The pedestal internal shall be accessible for inspection.

Adequate facilities shall be made for the inspection/replacement of the crane slewing ring. That may include supports or saddles of suitable capacity to jack-up the upper crane equipment. The installation of non-intrusive slew ring monitoring devices shall, as necessary, be considered as complementary mean for condition assessment.

For the large cranes essential to the operations, the conditions for their major maintenance and inspection operations shall be taken into consideration at project stage. These studies, to be provided as part of the maintenance and inspection manual, shall address the downtime associated to the major inspections and maintenance works, and the removal/replacement possibilities for the concerned components: slewing ring, engine or motor, boom, cylinders (if any), pulleys, etc. On that basis, the project manager shall consider the most appropriate options: crane standardisation (to make economical the purchase of complete components), addition of lifting jibs or suitable structure for components handling purpose, or other.

For the major offshore cranes, the load monitoring device shall incorporate a recording function.

Access shall be made for grease sampling and rocking play measurement on the cranes slew ring.

7.2 Piping, valves and vessels

7.2.1 General

7.2.1.1 Process isolation

The process equipment shall be provided with appropriate isolation means and drainage/venting facilities in order to allow safe isolations, achievable in a reasonable period of time.

7.2.1.2 Insulation

The insulation of the pipework and vessels shall be minimised and, as far as possible, limited to that required for process and acoustic reasons.

To prevent as much as possible the under lagging corrosion, the insulation proposed for the purpose of personnel protection shall preferably be made with the use of guards, or other similar means, other than insulation.

Special attention shall be given by the construction supervisors to the quality of the insulation works and to satisfactory compliance to the following requirements:

- The insulation sections shall generally be removable and reusable.

- For all the items subject to possible dismantling such as the valves and the instruments, the insulation shall be fitted with clamps so that it can be removed and reinstalled several times without damage.
- The use of pop rivets shall be banned and self-tapping screws shall be preferred.
- “Windows” shall be made with removable insulation material in order to control equipment condition in specified areas (located at 6 o'clock).
- At construction stage, the valves shall not be boxed-in until leak testing has been completed.
- Attention shall be given to the hand operated valves, to the valves equipped with partial stroking facilities and generally to the instruments with visible indications so that no specific function is affected by the insulation.

7.2.2 Piping

In addition to the requirements set forth in **GS EP PVV 107**, the piping shall be designed and built with due consideration for the following aspects:

- Suppression of the abrasion and corrosion risks on the pipe supports,
- Alignment; the project management shall in particular ensure proper supervision at the time of PSV or rotating machines installation, in order to guarantee that they are not installed with excessive stress, possibly detrimental to their safe operation.
- Lines flexibility allowing the dismantling of the valves and piping sections in reasonable conditions, or the spading,
- Preservation of flange gap and bolting against corrosion (e.g. by use of grease and tape),
- Dead legs which shall be avoided,
- Sufficient spacing between the piping and the adjacent walls (e.g. deck floor) allowing access to properly inspect and paint the piping.

All the fittings associated to the piping and which require access from time to time shall be made accessible. This includes:

- The corrosion monitoring fittings,
- The flame arrestors,
- Other instruments, fittings and accessories.

7.2.3 Valves

7.2.3.1 General

The valves requiring regular greasing which need to be insulated shall be equipped with extended grease nipples so that lubrication can be carried out without dismantling the insulation material.

All the valves (ESDV – SDV - BDV, control valves, isolation valves and PSV's) shall be positioned so as to be accessible from deck level or from permanent access platform.

7.2.3.2 PSV's

PSV's general design criteria are defined by **GS EP ECP 103**.

Unless it is not feasible, the PSV shall be systematically tested after transportation, and before installation in place. As a consequence, a PSV test bench shall be provided and installed in the workshop of the remote facilities (offshore and for isolated onshore plants). Adequate transportation baskets shall be considered.

7.2.3.3 Control valves

Single control valves shall be preferred to multiple valves arrangements unless required by specific operating conditions.

The provision of means allowing the valves maintenance with limited process disruption shall be considered on a case by case basis, depending on valve criticality, size or repair time. These means may include hand wheel or valve by-pass.

7.2.4 Vessels and process equipment

7.2.4.1 Vessels

The vessels shall be installed in appropriate location, with sufficient space around to allow access for external inspection while in operation, and also for recoating (50 cm from adjacent walls, floor, roof).

The vessel internals shall be removable for the purpose of vessel internal examination.

Weep and teel tales shall be fitted with sealant compound.

7.2.4.2 Filters

Except if they can be isolated without affecting safety, environment or production (equivalent to secondary equipment, as per chapter 3 definitions), the filters shall be duplicated, with a spare unit installed and with appropriate interlocking means, so that the operations are not interrupted when a filter is under maintenance or inspection. Filters packages shall be installed with appropriate change-over facilities when a continuous filtered flow is to be maintained.

All the filters which necessitate being monitored either for heavy equipment protection or for maintenance optimization shall be equipped with differential pressure measurement, isolation valves and by-passes.

7.3 Electrical equipment

For general electrical maintainability and inspectability criteria, refer to **GS EP ELE 001**.

When the manufacturer does not provide a guaranty on the terminations tightening in LV switchgear, the design will be such that thermographical inspection of the busbars is possible.

7.3.1 Lighting

For general lighting maintainability and inspectability criteria, refer to **GS EP ELE 364**.

The light poles shall preferably be of hinged type.

7.4 Instrumentation equipment

7.4.1 Equipment selection

7.4.1.1 General

The instrumentation systems and components shall be selected with due consideration for field proven materials, and minimum impact of maintenance on the process function. They shall be standardised as far as possible.

Complementarily, the selection shall also take into account the following criteria:

- The flow transmitters shall be equipped on a case by case basis with integral digital readout local display,
- The number of the various types of instrument shall be optimised to a minimum number of body ratings and materials,

7.4.2 Fire and gas detection systems

The fire and gas detection systems shall be selected and designed with the best technology to provide the most reliable functions and the lowest maintenance requirements.

In particular, the following shall be selected:

- Gas detectors with filters that are easily removable,
- Systems equipped with faults monitoring facilities.

The detectors shall be in all cases accessible for the purpose of easy and quick functional / calibration tests.

The detectors located in inaccessible places (height, hot surface, rotating machines packages, etc.) shall be fitted with adequate pipework to allow the injection of the test medium from accessible place. Alternatively, they may be fitted on hinged arms or on rails, so as to perform the test without equipment function interruption.

7.4.3 Bulk materials

The compression fittings shall be:

- Selected in accordance with the operator, who may have already decided the standardisation to a particular fittings manufacturer on the facilities.
- Standard for the whole concerned project, packages included: metric or US, of a specific brand, which shall be common to all materials suppliers.

7.5 Mechanical equipment

General maintainability requirements are stated in [GS EP MEC 290](#).

Specific attention shall be paid to the accessibility around the units so as to ensure maintenance in acceptable conditions.

7.5.1 Condition monitoring facilities

The mechanical equipment shall be provided with minimum monitoring equipment aiming at identifying efficiently the soundness of the unit, thus optimizing the preventive and corrective maintenance.

It shall include, depending on criticality of equipment, the following devices:

- Hour meters, for all rotating equipment,
- Vibration and shaft displacement monitoring,
- Torque-meters (for large turbo compressor and turbo pump units),
- Suitable sensors for data collection and monitoring of the main gas turbine parameters: P0-T0, P1-T1, P2-T2, etc..., so that the turbine performance can be calculated,
- Computerised performance monitoring systems associated to the control system of the main turbo-machines, whenever proposed by vendor and proved reliable,
- Differential pressure manometers on the filters (air, oil, other),
- Oil sampling point for oil analysis,

The vital and critical equipment shall be provided with suitable alarm and trip devices to prevent failures.

7.6 Domestic equipment

Attention shall be given to the domestic equipment and components to be installed in the buildings and within the accommodations such as:

- Galley equipment
- Electrical fittings
- Plumbing fittings
- Doors and associated fittings, air-locks tightness,
- Floor, ceiling and wall covering
- Furniture

These items shall be procured from reputable makers, specialised in industrial and heavy duty equipment only, with established after sales services dedicated to the supply of spare parts.

A provision of spare items shall be ordered and handed over as spare parts stock at the start-up time; it shall include about five per cent (5%) of the installed quantities of plumbing and electrical fittings, locks and door hinges, floor, ceiling and wall elements, plus other items as deemed necessary.

Appendix 1 Material selection comparison table

For the purpose of the final equipment selection, a comparison table shall be made to rank the offers; it shall be designed on the basis of criteria, such as the following ones, each one being given an appropriate weight factor:

- Environmental impact (thermal efficiency, waste, etc.)
- Performance expectations (Availability, reliability, mean time between failures, mean repair time),
- Purchasing cost (including capital items),
- Spare parts cost, service costs,
- Life cycle cost (limited to about 10 years), including all OPEX and CAPEX expenditures,
- Redundancy, spare capacity,
- Standardisation of equipment,
- Modularity,
- Equipment environment and access, ,
- Handling facilities,
- Dismantling possibilities,
- Internal access
- Components standardisation,
- Facilities for monitoring, for curative maintenance (diagnosis),
- Other specific maintainability and inspectability aspects,
- Quality of tender documents
- Technical documentation,
- QA/QC manuals and references,
- Suitability – quality of after sales service, local support
- Possibility of support contract, vendors commitments, warranties
- Management of obsolescence by manufacturer,