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Gas turbine applications — Requirements for power generation

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National foreword

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Gas turbine applications — Requirements for power generation

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#).

The committee responsible for this document is ISO/TC 192, *Gas turbines*.

Introduction

This International Standard provides technical information to be used for the procurement of gas turbines and the associated gas turbine systems for power generation by a Purchaser from a Contractor.

It provides a basis for the submission of tenders in line with the different environmental and safety requirements. It also specifies, wherever possible, criteria to establish whether these are met.

It defines a standard framework for dealing with questions of fuel and other matters, such as the minimum information to be provided by both the Purchaser and the Contractor. It does not, however, purport to include all necessary information for a contract and each gas turbine installation should be considered in its entirety. Attention is drawn to the need for technical consultation between the Purchaser and the Contractor to ensure compatibility of equipment being supplied, particularly where the responsibility for supply may be divided.

Because of the very widely varying operating modes for gas turbines in practice, distinct categories of operating modes are specified with which a “standard” rating can be associated. These ratings are made on the basis of the ISO standard ambient reference conditions.

Gas turbine applications — Requirements for power generation

1 Scope

This International Standard specifies the minimum technical and documentation requirements for the evaluation and procurement of gas turbine systems for electrical power generation.

It applies to simple cycle and combined cycle gas turbines for both onshore and offshore applications, where applicable. It also applies to gas turbines used in cogeneration (see ISO 11086:1996, Annex B). Testing of the gas turbine in combination with a generator is included in the scope.

It is not applicable to gas turbines used for all types of propulsion including aircraft, mobile barges, floating production vessels and marine propulsion applications and microturbines.

This International Standard defines the requirements for gas turbine power generation from an international perspective based on the content of existing, recognized ISO and IEC standards to the greatest extent practical. Nonetheless, it is recognized that within the industry other codes or standards are used, some of which are included in the text of this International Standard. The use of other such codes and standards is permissible provided an appropriate and acceptable level of requirements, functional design and safety is achieved and agreement has been reached for their use between the Purchaser and Contractor and such use is suitably documented.

Consideration should be given to applying/using standards in the following hierarchical order: international; regional; national; local.

This International Standard identifies the requirements for both the Purchaser and Contractor attributable to the design and procurement of a gas turbine power generation package.

The defined requirements apply to the scope of supply, except where excluded, encompassing the following equipment and the associated selected options, located within the power generation package, (see [3.14](#)), listed below:

- gas turbine package;
- load shaft coupling and clutch, as applicable;
- air inlet system;
- exhaust system;
- fuel equipment;
- control equipment;
- electrical equipment;
- additional auxiliary systems, including starting, lubrication, barring, compressor wash, pipework, drains and vents;
- fire and gas protection;
- cooling water equipment.

Where applicable to the integrity of the gas turbine package, the interface and applicable design requirements are included for equipment, utilities and supplies that interface with the power generation package.

The following equipment is excluded from the scope of supply, but references are included where required for interface or performance measurement:

- generator and auxiliary systems, except the module control option;
- steam turbine and auxiliary systems;
- equipment external to the power generation package.

Data sheets in [Annex A](#) of this International Standard are provided for defining requirements and exchanging information between the Purchaser and the Contractor.

The Purchaser fills in the data sheets for the tender and forwards them to the Contractor. The Contractor responds by completing the applicable data sheets for their tender.

[Annex A](#) identifies the different types of data sheets and how they are to be used.

Where the Contractor does not comply with a selected requirement of this International Standard, this is detailed as an exception, referencing the applicable clause and describing the deviation and any alternatives available in a document listing all the exceptions taken.

Where the text in this International Standard requests procedures and operating, maintenance and commissioning manual information or equipment that would require the disclosure/supply of proprietary information/equipment which the Contractor is not prepared to release, such exceptions are listed. Where this situation exists, the Contractor will be prepared to release appropriate personnel and equipment to undertake all the tasks that otherwise would be undertaken by the Purchaser.

A bullet • at the beginning of a paragraph in the text of this International Standard indicates an optional requirement (see [A.3](#)).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 128-1, *Technical drawings — General principles of presentation — Part 1: Introduction and index*

ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods*

ISO 1940-1:2003, *Mechanical vibration — Balance quality requirements for rotors in a constant (rigid) state — Part 1: Specification and verification of balance tolerances*

ISO 2314:2009, *Gas turbines — Acceptance tests*

ISO 2409, *Paints and varnishes — Cross-cut test*

ISO 2533, *Standard Atmosphere*

ISO 2592, *Determination of flash and fire points — Cleveland open cup method*

ISO 2909, *Petroleum products — Calculation of viscosity index from kinematic viscosity*

ISO 2954, *Mechanical vibration of rotating and reciprocating machinery — Requirements for instruments for measuring vibration severity*

ISO 3016, *Petroleum products — Determination of pour point*

ISO 3104, *Petroleum products — Transparent and opaque liquids — Determination of kinematic viscosity and calculation of dynamic viscosity*

ISO 3448, *Industrial liquid lubricants — ISO viscosity classification*

ISO 3675, *Crude petroleum and liquid petroleum products — Laboratory determination of density — Hydrometer method*

ISO 3746, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane*

ISO 3977-1, *Gas turbines — Procurement — Part 1: General introduction and definitions*

ISO 3977-3:2004, *Gas turbines — Procurement — Part 3: Design requirements*

ISO 3977-4:2002, *Gas turbines — Procurement — Part 4: Fuels and environment*

ISO 3977-8, *Gas turbines — Procurement — Part 8: Inspection, testing, installation and commissioning*

ISO 3977-9:1999, *Gas turbines — Procurement — Part 9: Reliability, availability, maintainability and safety*

ISO 4261, *Petroleum products — Fuels (class F) — Specifications of gas turbine fuels for industrial and marine applications*

ISO 4263-1, *Petroleum and related products — Determination of the ageing behaviour of inhibited oils and fluids — TOST test — Part 1: Procedure for mineral oils*

ISO 4406, *Hydraulic fluid power — Fluids — Method for coding the level of contamination by solid particles*

ISO 4407, *Hydraulic fluid power — Fluid contamination — Determination of particulate contamination by the counting method using an optical microscope*

ISO 5167-1, *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full — Part 1: General principles and requirements*

ISO 6247, *Petroleum products — Determination of foaming characteristics of lubricating oils*

ISO 6336-1, *Calculation of load capacity of spur and helical gears — Part 1: Basic principles, introduction and general influence factors*

ISO 6743-5, *Lubricants, industrial oils and related products (class L) — Classification — Part 5: Family T (Turbines)*

ISO 6976, *Natural Gas — Calculation of Calorific Values, Density, and Relative Density and Wobbe Index from Composition*

ISO 7919-4:2009, *Mechanical vibration — Evaluation of machine vibration by measurements on rotating shafts — Part 4: Gas turbine sets with fluid-film bearings*

ISO 8501-1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

ISO 8501-2, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 2: Preparation grades of previously coated steel substrates after localized removal of previous coatings*

ISO 8501-3, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 3: Preparation grades of welds, edges and other areas with surface imperfections*

ISO 8502 (all parts), *Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness*

ISO 8504-1, *Preparation of steel substrates before application of paints and related products — Surface preparation methods — Part 1: General principles*

ISO 9120, *Petroleum and related products — Determination of air-release properties of steam turbine and other oils — Impinger method*

ISO 9223, *Corrosion of metals and alloys — Corrosivity of atmospheres — Classification, determination and estimation*

ISO 9614-1, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 1: Measurement at discrete points*

ISO 9614-2, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 2: Measurement by scanning*

ISO 9951, *Measurement of gas flow in closed conduits — Turbine meters*

ISO 10380, *Pipework — Corrugated metal hoses and hose assemblies*

ISO 10396, *Stationary source emissions — Sampling for the automated determination of gas emission concentrations for permanently-installed monitoring systems*

ISO 10441:2007, *Petroleum, petrochemical and natural gas industries — Flexible couplings for mechanical power transmission — Special-purpose applications*

ISO 10494, *Gas turbines and gas turbine sets — Measurement of emitted airborne noise — Engineering/survey method*

ISO 10816-2, *Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 2: Land-based steam turbines and generators in excess of 50 MW with normal operating speeds of 1 500 r/min, 1 800 r/min, 3 000 r/min and 3 600 r/min*

ISO 10816-3, *Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured in situ*

ISO 10816-4:2009, *Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 4: Gas turbine sets with fluid-film bearings*

ISO 10817-1, *Rotating shaft vibration measuring systems — Part 1: Relative and absolute sensing of radial vibration*

ISO 11042-1, *Gas turbines — Exhaust gas emission — Part 1: Measurement and evaluation*

ISO 11042-2, *Gas turbines — Exhaust gas emission — Part 2: Automated emission monitoring*

ISO 11086:1996, *Gas turbines — Vocabulary*

ISO 11204, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions applying accurate environmental corrections*

ISO 11342:1998, *Mechanical vibration — Methods and criteria for the mechanical balancing of flexible rotors*

ISO 12100, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 12151-1, *Connections for hydraulic fluid power and general use — Hose fittings — Part 1: Hose fittings with ISO 8434-3 O-ring face seal ends*

ISO 12151-2, *Connections for hydraulic fluid power and general use — Hose fittings — Part 2: Hose fittings with ISO 8434-1 and ISO 8434-4 24° cone connector ends with O-rings*

ISO 12944-1, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 1: General introduction*

ISO 12944-2:1998, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 2: Classification of environments*

ISO 12944-4, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 4: Types of surface and surface preparation*

ISO 13691, *Petroleum and natural gas industries — High-speed special-purpose gear units*

ISO 13938-1, *Textiles — Bursting properties of fabrics — Part 1: Hydraulic method for determination of bursting strength and bursting distension*

ISO 14122-1, *Safety of machinery — Permanent means of access to machinery — Part 1: Choice of fixed means of access between two levels*

ISO 14122-2:2001, *Safety of machinery — Permanent means of access to machinery — Part 2: Working platforms and walkways*

ISO 14122-3, *Safety of Machinery — Permanent Means of Access to Machinery — Part 3: Stairs, Stepladders and Guard-Rails*

ISO 14122-4, *Safety of machinery — Permanent means of access to machinery — Part 4: Fixed ladders*

ISO 14123-1, *Safety of machinery — Reduction of risks to health from hazardous substances emitted by machinery — Part 1: Principles and specifications for machinery manufacturers*

ISO 14691, *Petroleum, petrochemical and natural gas industries — Flexible couplings for mechanical power transmission — General-purpose applications*

ISO 14713-2, *Zinc coatings — Guidelines and recommendations for the protection against corrosion of iron and steel in structures — Part 2: Hot dip galvanizing*

ISO 15649, *Petroleum and natural gas industries — Piping*

ISO 16276-2, *Corrosion protection of steel structures by protective paint systems — Assessment of, and acceptance criteria for, the adhesion/cohesion (fracture strength) of a coating — Part 2: Cross-cut testing and X-cut testing*

ISO 18752, *Rubber hoses and hose assemblies — Wire- or textile-reinforced single-pressure types for hydraulic applications — Specification*

ISO 19840, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Measurement of, and acceptance criteria for, the thickness of dry films on rough surfaces*

ISO 19860:2005, *Gas turbines — Data acquisition and trend monitoring system requirements for gas turbine installations*

ISO 21789:2009, *Gas turbine applications — Safety*

ISO 21940-13, *Mechanical vibration — Rotor balancing — Part 13: Criteria and safeguards for the in-situ balancing of medium and large rotors*

ISO 21940-31, *Mechanical vibration — Rotor balancing — Part 31: Susceptibility and sensitivity of machines to unbalance*

ISO 21940-32, *Mechanical vibration — Rotor balancing — Part 32: Shaft and fitment key convention*

ISO 22266-1, *Mechanical vibration — Torsional vibration of rotating machinery — Part 1: Land-based steam and gas turbine generator sets in excess of 50 MW*

ISO 80000-1, *Quantities and units — Part 1: General*

IEC 60034-1, *Rotating electrical machines — Part 1 — General requirements*

IEC 60034-3:2010, *Rotating electrical machines — Part 3: Specific requirements for synchronous generators driven by steam turbines or combustion gas turbines*

IEC 60034-5, *Rotating electrical machines — Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) — Classification — Edition 4.1; Consolidated Reprint*

IEC 60038:2009, *EC standard voltages*

IEC 60079-10-1, *Explosive atmospheres — Part 10-1: Classification of areas — Explosive gas atmospheres*

IEC 60079-11, *Explosive atmospheres — Part 10-1: Classification of areas — Explosive gas atmospheres*

IEC 60079-14:2013, *Electrical installations in hazardous areas (other than mines)*

IEC 60146-1, *Semiconductor converters — General requirements and line commutated converters — Part 1-1: Specification of basic requirements*

IEC 60204-1:2009, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*

IEC 60204-11, *Safety of machinery — Electrical equipment of machines — Part 11: Requirements for HV equipment for voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV*

IEC 60304, *Standard Colours for Insulation for Low-Frequency Cables and Wires*

IEC 60332, *Tests on electric and optical fibre cables under fire conditions: Relevant Part*

IEC 60364-1, *Low-voltage electrical installations — Part 1: Fundamental principles, assessment of general characteristics, definitions*

IEC 60364-4-41, *Low-voltage electrical installations — Part 4-41: Protection for safety — Protection against electric shock*

IEC 60417, *Graphical symbols for use on equipment*

IEC 60439, *Low-Voltage Switchgear and Control gear Assemblies: Relevant parts*

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification — Identification of equipment terminals, conductor terminations and conductor*

IEC 60502, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV ($U_m = 1,2$ kV) up to 30 kV ($U_m = 36$ kV): Relevant Parts*

IEC 60529:2013, *Degrees of Protection Provided by Enclosures (IP Code)*

IEC 60757, *Basic and safety principles for man-machine interface, marking and identification — Identification of equipment terminals, conductor terminations and conductor*

IEC 60896, *Stationary lead-acid batteries: Relevant Parts*

IEC 60947, *Low-voltage switchgear and control gear — Relevant parts*

IEC 60947-7-1, *Low-voltage switchgear and control gear — Part 7-1: Ancillary equipment — Terminal blocks for copper conductors*

IEC 61000-2-2, *Electromagnetic Compatibility (EMC) Part 2-2: Environment — Compatibility Levels for Low-Frequency Conducted Disturbances and Signaling in Public Low-Voltage Power Supply Systems*

IEC 61000-2-4:2002, *Electromagnetic compatibility (EMC) Part 2-4: Environment Compatibility levels in industrial plants for low-frequency conducted disturbances*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) — Part 4-2: Testing and measurement techniques — Electrostatic discharge immunity test*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) — Part 6-2: Generic standards — Immunity for industrial environments*

IEC 61000-6-3, *Electromagnetic compatibility (EMC) — Part 6-3: Generic standards — Emission standard for residential, commercial and light-industrial environments*

IEC 61000-6-4, *Electromagnetic compatibility (EMC) — Part 6-4: Generic standards — Emission standard for industrial environments*

IEC/TR 61000-5-1, *Protection against lightning — Part 1: General principles*

IEC/TR 61000-5-2, *Electromagnetic Compatibility (EMC) — Part 5: Installation and Mitigation Guidelines — Section 2: Earthing and Cabling*

IEC 61140, *Protection against electric shock — Common aspects for installation and equipment*

IEC 61643-12, *Low-voltage surge protective devices — Part 12: Surge protective devices connected to low-voltage power distribution systems — Selection and application principles*

IEC 61672-1, *Electroacoustics — Sound Level Meters — Part 1: Specifications*

IEC 61786, *Measurement of Low-Frequency Magnetic and Electric Fields with Regard to Exposure of Human Beings — Special Requirements for Instruments and Guidance for Measurements*

IEC 61918, *Industrial communication networks — Installation of communication networks in industrial premises*

IEC 61936-1, *Power installations exceeding 1 kV a.c. — Part 1: Common rule*

IEC 62040-1, *Uninterruptible power systems (UPS) — Part 1: General and safety requirements for UPS*

IEC 62040-2, *Uninterruptible power systems (UPS) — Part 2: Electromagnetic compatibility (EMC) requirements*

IEC 62305-1, *Protection against lightning — Part 1: General principles*

IEC 62305-4, *Protection against lightning — Part 4: Electrical and electronic systems within structures*

IEC 82079-1, *Preparation of instructions for use — Structuring, content and presentation — Part 1: General principles and detailed requirements*

EN 779, *Particulate air filters for general ventilation — Determination of the filtration performance*

EN 1822-1, *High efficiency air filters (EPA, HEPA and ULPA) — Part 1: Classification, performance testing, marking*

EN 1822-5, *High efficiency air filters (EPA, HEPA and ULPA) — Part 5: Determining the efficiency of filter elements*

EN 1837, *Safety of machinery — Integral lighting of machines*

EN 1838, *Lighting Applications — Emergency Lighting*

EN 1997-1, *Eurocode 7: Geotechnical design — Part 1: General rules*

EN 13284-1:2001, *Stationary Source Emissions — Determination of Low Range Mass Concentration of Dust — Part 1: Manual Gravimetric Method*

EN 13480-1, *Metallic industrial piping — Part 1: General*

EN 15259-1:2007, *Air quality — Measurement of stationary source emissions — Requirements for measurement sections and sites and for the measurement objective, plan and report*

EN 50160, *Voltage characteristics of electricity supplied by public electricity networks*

EN 50272-2, *Safety Requirements for Secondary Batteries and Battery Installations Part 2: Stationary Batteries*

EN 50522, *Earthing of power installations exceeding 1 kV a.c*

IEEE C50.13, *Cylindrical-Rotor 50 Hz and 60 Hz Synchronous Generators Rated 10 MVA and Above*

IEEE C95.3, *IEEE Recommended Practice for Measurements and Computations of Radio Frequency Electromagnetic Fields With Respect to Human Exposure to Such Fields, 100 kHz–300 GHz*

IEEE 762:2006, *Standard Definitions for Use in Reporting Electric Generating Unit Reliability, Availability, and Productivity*

AGMA 6011-I03, *Specification for High Speed Helical Gear Units*

AGMA 6011-J14, *Specification for High Speed Helical Gear Units*

AGMA 6123-B06, *Design Manual for Enclosed Epicyclic Gear Drives*

ASHRAE 52.2, *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*

API 613, *Special Purpose Gear Units for Petroleum, Chemical, and Gas Industry Services*

API 670, *Machinery Protection Systems*

ASME B31.1, *Power Piping*

ASME B31.3, *Process Piping*

ASME PTC 22, *Performance Test Code on Gas Turbines*

ASTM D3786, *Standard Test Method for Bursting Strength of Textile Fabrics—Diaphragm Bursting Strength Tester Method*

NAS 1638, *Cleanliness requirements of parts used in hydraulic systems*

NEMA MG1, *Motors and Generators*

NFPA 70, *National Electrical Code*

NFPA 85:2015, *Boiler and Combustion Systems Hazards Code*

SAE AS 4059E, *Aerospace Fluid Power — Cleanliness Classification for Hydraulic Fluids*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3977-1, ISO 3977-3, ISO 3977-4:2002, ISO 3977-8, ISO 3977-9:1999, ISO 11086:1996 and the following apply.

3.1 auxiliary systems

interconnected electrical, control and mechanical equipment with specific functions relating to main items of equipment such as lubricating oil system, fuel system, controls and their external interconnections

3.2 combined cycle

thermodynamic cycle employing the combination of a gas turbine cycle with a steam or other fluid Rankine cycle

Note 1 to entry: In a common example, the gas turbine exhaust heat is used to generate steam for the Rankine cycle.

Note 2 to entry: The superior thermal performance of this cycle is due to a combination of the best thermodynamic attributes of each cycle, namely the addition of thermal energy at higher temperatures in the gas turbine cycle and the rejection of thermal energy at lower temperatures in the Rankine cycle.

[SOURCE: ISO 11086:1996, 1.12]

3.3

Contractor

organization for the supply of goods and/or services applicable to the specific clause(s) of this International Standard

3.4

enclosure

structure enveloping/enclosing sections of equipment for the applicable requirements of

- weather protection (all applicable types),
- noise attenuation,
- ventilation for removal of hazardous gases and vapours,
- ventilation for temperature control,
- control of radiated heat, and
- contamination due to local environment conditions.

3.5

gas turbine core

assembly that includes the gas turbine compressor, combustion system, power turbine and integral equipment

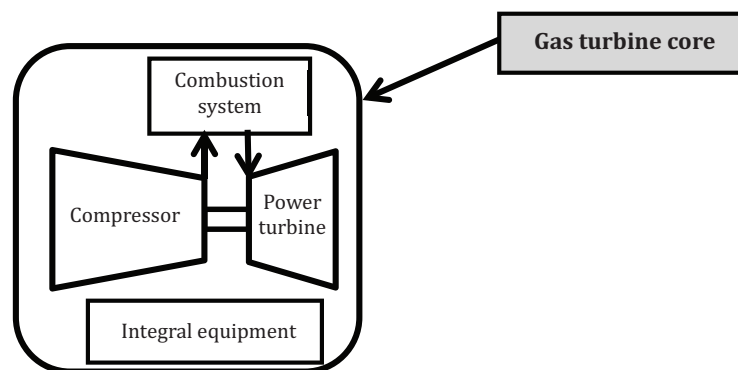


Figure 1 — Gas turbine core

3.6

gas turbine enclosure

local *enclosure* (3.4) covering a single gas turbine

3.7

gas turbine hall

large structure that may enclose one or more gas turbine packages, each of which may have their own local *enclosure(s)* (3.4)

3.8

gas turbine package

assembly that includes the *gas turbine core* (3.5), gas turbine load and auxiliary gearboxes, core integral equipment, applicable auxiliary systems and *enclosure* (3.4)

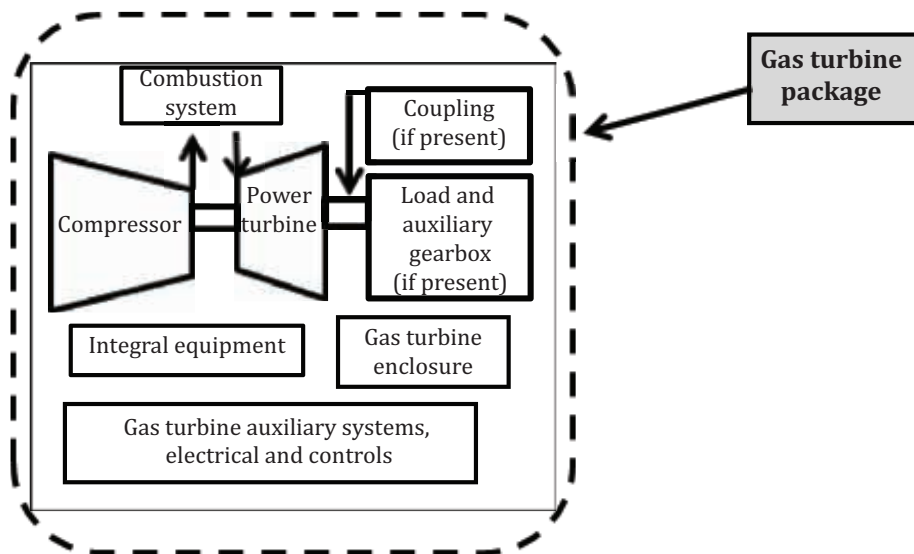


Figure 2 — Gas turbine package

3.9

Island mode

operation of one or more power generation packages operating independently when a local grid connection fails or is disconnected or as a standalone grid with one or more power generation packages supplying the local loads

3.10

lifed component

any component within the *gas turbine core* (3.5) with a shorter finite useable life than the design life of the gas turbine in terms of permitted starts, operating hours or weighted operating hours before action (e.g. inspection, repair or scrapping) is required

3.11

MCR

maximum continuous rating

maximum continuous electrical output for the power generation package with the *gas turbine package* (3.8) operating at its maximum reference turbine control temperature [exhaust temperature, *TIT* (3.27) or *RIT* (3.20)] and its inlet guide vanes (where fitted) fully open

3.12

MCO

minimum continuous rating

minimum continuous electrical output for the *power generation package* (3.14) without meeting emission limits and environmental constraints

3.13

MEL

minimum environmental load

minimum continuous electrical output for the *power generation package* (3.14) while meeting all emission limits and environmental constraints

3.14

power generation package

assembly that includes the *gas turbine package* (3.8), generator, steam turbine (if on the same shaft), inlet system, exhaust system as applicable, fuel system, controls and electrical equipment, auxiliaries and *enclosures* (3.4)

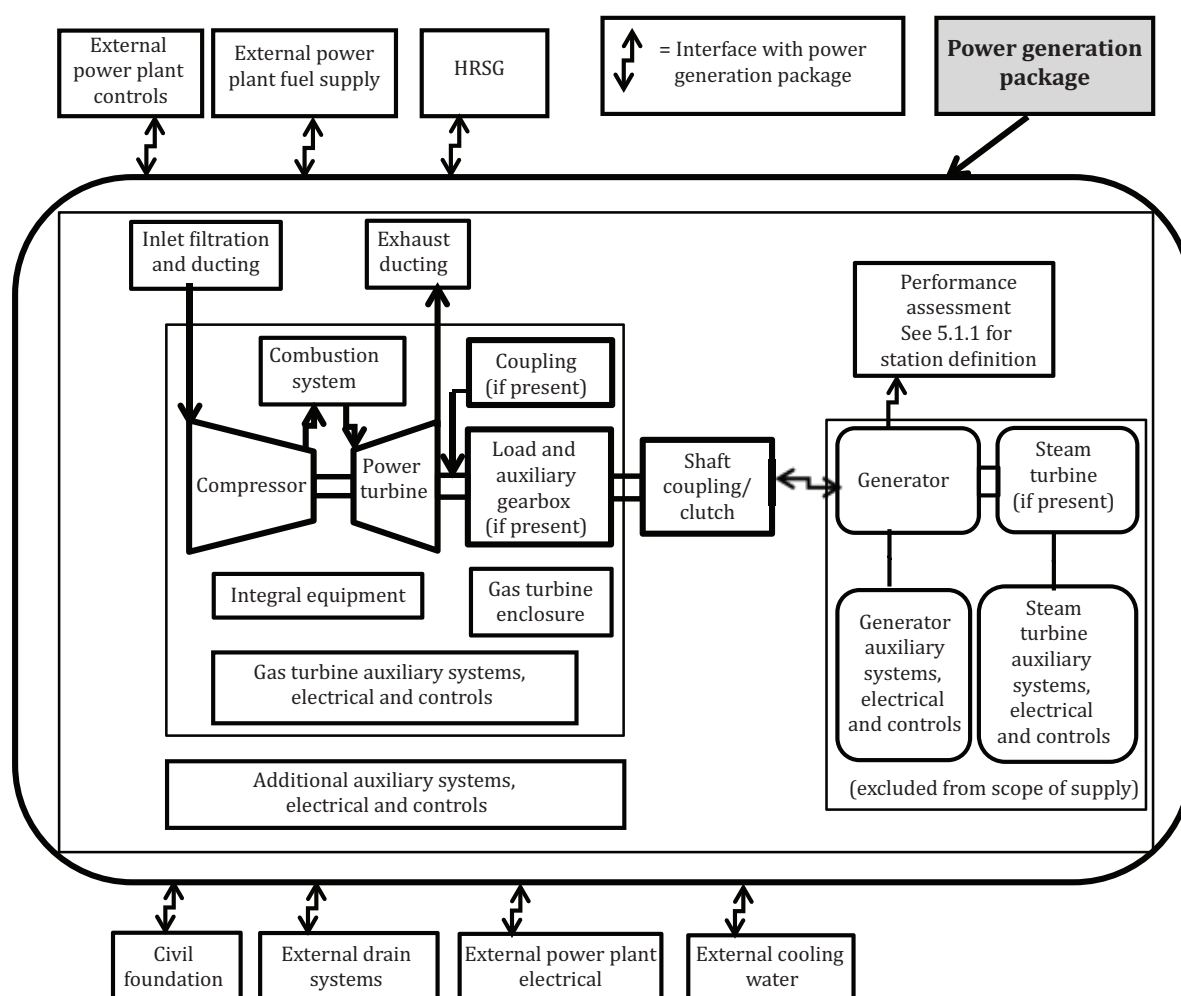


Figure 3 — Power generation package

3.15

power plant

all main equipment and auxiliary equipment employed in producing electrical power at a *site* (3.23) and may include one or more *power generation packages* (3.14)

3.16

power rating

net electrical power developed by the gas turbine when it is operated at a defined reference turbine control temperature [exhaust temperature, *TIT* (3.27) or *RIT* (3.20)] and standard reference conditions

3.17

project

general term for all the works and equipment for the construction of the concerned *power plant* (3.15)

3.18

Purchaser

person or company having authority to specify and to buy the equipment, who has a contract(s) with the *Contractor(s)* (3.3) and is considered to be the owner and operator of the *power plant* (3.15)

[SOURCE: ISO 21789:2009, 3.11, modified]

3.19

rated speed

speed expressed in revolutions per minute of the *gas turbine core* (3.5) output shaft required for generator synchronous speed

3.20

RIT

rotor inlet temperature

flow weighted mean total temperature of the working fluid relative to a stationary plane immediately upstream of the first rotating row of turbine blades

Note 1 to entry: Also known as the firing temperature.

3.21

sequential combustion

process created by a gas turbine that typically consists of two combustors, a high pressure combustor followed by a high pressure turbine and a low pressure combustor followed by a low pressure turbine

3.22

simple cycle

thermodynamic cycle consisting only of successive compression, combustion and expansion

[SOURCE: ISO 11086:1996, 1.8]

3.23

site

geographical location of the *power plant* (3.15)

3.24

site rated power

net electrical output developed by the gas turbine when it is operated at the applicable site reference turbine control temperature [exhaust temperature, *TIT* (3.27) or *RIT* (3.20)] at site rated conditions of speed, inlet temperature, inlet pressure, exhaust pressure and normal fuel composition

3.25

specification

Purchaser's (3.18) requirements in conjunction with the complete or fractional requirements of this International Standard

3.26

tender

document containing the contractual offer for the supply and installation of a *power plant* (3.15) provided by a *Contractor* (3.3) when requested by a *Purchaser* (3.18) during the procurement phase

3.27

TIT

turbine inlet temperature

mean temperature of the working fluid upstream of the first stage turbine stator blades

[SOURCE: ISO 2314:2009, 3.15, modified]

4 Comparative performance assessment at standard reference conditions

4.1 General

The power rating (see 3.16), heat rate and exhaust emissions required and fuel consumption shall be supplied at MEL, 50 % MCR and MCR for comparative performance assessment purposes at the initial enquiry stage. Ratings shall be based on the standard reference condition and given fuel values specified in 4.2.6, neglecting pressure drops at the inlet and exhaust systems and generator excitation

energy. The details shall be supplied on the information data sheet by the Contractor for the fuel(s) selected thereon by the Purchaser.

Exhaust emissions [NO_x , CO, unburned hydrocarbons (UHC)] shall be quoted as gas/vapour emission concentrations reported on a dry basis (corrected to 15 % oxygen) for operation on fuels specified in 4.2.6. Sulfur emissions are solely a function of the sulfur present in the incoming air and fuel flows. Sulfur emissions are not to be stated since the gas turbine(s) has no influence on them.

4.2 Standard reference conditions

4.2.1 General

The standard reference conditions on which ISO power, efficiency, heat rate and specific fuel consumption are based are as specified in 4.2.2 to 4.2.5.

4.2.2 Ambient conditions

For the intake air at the compressor flange (alternatively, the compressor intake flare), in accordance with ISO 2533, the conditions shall be as follows:

- a total pressure of 101,325 kPa;
- a total temperature of 15 °C;
- a relative humidity of 60 %.

4.2.3 Exhaust conditions

For the exhaust at the turbine exhaust flange (or regenerator outlet, if a regenerative cycle is used), the static pressure shall be 101,325 kPa.

4.2.4 Cooling water conditions (if applicable)

Where a heater or a cooler is used that uses cooling water, the standard reference conditions for the temperature of the cooling water shall be 15 °C.

4.2.5 Working fluid heater or cooler

Where a heater or a cooler is used that uses ambient air, the standard reference conditions for the ambient air shall be 15 °C and 101,325 kPa.

4.2.6 Fuel for comparative performance assessment

For a comparative performance assessment, fuel details shall be based on the following:

- turbines intended for use on gaseous fuel: Natural gas 100 % methane – 50 035 kJ/kg;
- turbines intended for use on liquid fuel: No. 2 Distillate – 42 600 kJ/kg and a carbon to hydrogen weight ratio of 6 to 1.

The lower heating value (LHV) at constant pressure of the fuel(s), whether liquid or gaseous, is based on a pressure of 101,325 kPa and a temperature of 15 °C.

5 Performance at site conditions

5.1 Site rating

5.1.1 Site rated power

The contractual site rated power (see [3.24](#)), fuel consumption and exhaust emissions shall be supplied (at the tender stage) at the MCR required as described in [4.1](#) based on the following conditions and requirements.

- The station definition in ISO 2314:2009, 6.4.5.1 Table 5 9.1a unless otherwise specified on the information data sheet.
- The specific site conditions as described in [5.2](#), including fuel details as described in [Clause 8](#).
- Air inlet losses shall be based upon air inlet filters at new and clean values but using air velocities specific to the design of the air inlet house.
- Exhaust losses shall be based on the complete exhaust system whether for simple cycle or combined cycle or cogeneration plant.
- A new and clean gas turbine core. New is defined as the gas turbine core having nominally less than 200 fired operating hours. A clean gas turbine is defined as where the gas turbine core has operated nominally less than 25 h since an offline water wash.
- Emissions shall be quoted for NO_x, CO and UHC.

The output shall not include any degradation or ageing as defined by ISO 2314:2009, 3.1.

5.1.2 Site minimum load

The contractual site rated power at minimum load based on the applicable conditions defined for site rated power in [5.1.1](#) shall be specified for

- MEL, taking into account any emission controls downstream of the exhaust outlet flange, and
- MCO.

5.1.3 Site net heat rate

The contractual site net heat rate shall be specified based on the applicable conditions in [5.1.1](#) and computed in accordance with ISO 2314:2009, 8.1.3 for

- the site rated power at MCR as [5.1.1](#), and
- the site rated power at MEL as [5.1.2](#).

5.1.4 Site peak load

- If requested by the Purchaser, the peak load capability (as defined in ISO 3977-3:2004, 3.35) on the information data sheet and any implications shall be defined in accordance with the document data sheet.

5.2 Site conditions

The performance shall be quoted at the following site parameters and operating conditions, where applicable.

The site rated power shall be quoted at the following applicable site parameters and operating conditions, defined by the Purchaser.

- Ambient temperature (°C).
- Barometric pressure [Pa and (bar)].
- Ambient relative humidity (%).
- Contract gas fuel details (see [Clause 8](#)).
- Contract liquid fuel details (see [Clause 8](#)).
- Load gearbox efficiency, where applicable and supplied by the Purchaser.
- Generator efficiency where supplied by the Purchaser, taking into account all losses, at each load condition, and cooling media requirements/conditions.
- Generator speed at nominal grid frequency.
- Generator voltage.
- Generator nominal power factor, leading or lagging, at the grid frequency, where supplied by the Purchaser.
- Inlet conditioning, where applicable and supplied by the Purchaser.
- Exhaust back pressure, where applicable (see [21.7](#)).

5.3 Corrections

Corrections from the Contractor's design values to the contractual ratings shall follow the guidance in ISO 2314:2009 or as otherwise specified by the Purchaser in accordance with the document data sheet.

6 Site conditions and utilities

6.1 Air quality

The Purchaser shall provide the following information on the information data sheet.

- Sufficient information to determine the local air quality to enable the Contractor to properly design the air inlet filtration system and determine the impact of the air quality on the lifetime of the gas turbine package equipment.
- Where potentially significant air contamination is present, data of specific measurements of the local air quality over a sufficient period of time by air sampling to establish representative information of dust, dirt and other contaminants of the combustion air.
- Classification of the corrosivity of the atmosphere in accordance with ISO 9223.
- Details of any rural, agricultural, commercial, urban, light and heavy industrial local sources of airborne emissions.
- Sources of dust emissions such as adjacent coal storage, gypsum or similar manufacturing plants, construction and quarrying activities.

The Purchaser shall provide the following information on the document data sheet:

- Site map and the typical wind direction commonly issued as a wind rose showing direction velocity and direction likelihood.
- Details of conditions where hot, dust bearing winds may be present (e.g. Sirocco or equivalent).

Sampling shall be supplemented by analysis of the composition of materials to identify contaminants. This also helps to identify sources of contaminants such as salt and fouling sources such as road/rail transport.

Due consideration should be taken by the Purchaser of any known future plans that could impact air quality.

The predominant soil type composition may have a specific impact on air quality and air filter type and grade. The gas turbine hot gas path Thermal Barrier Coatings (TBC) can be affected by contamination by basic elements within soils such as Ca, Mg, Al and SiO₂ and is collectively referred to as CMAS contamination. This contamination results in the premature spalling of this coating with impacts on component life and repair yield. Hot, dry climates are at greater risk of having higher dust concentrations in the air.

6.2 Water quality

The Purchaser shall define the following:

- potable water quality available;
- potable water flow capacity;
- water quality available for cooling water;
- cooling water supply pressure, temperature and flow capacity and any limitations on the return flows;
- quality of demineralized water available;
- demineralized water supply pressure, temperature and flow capacity.

The Contractor shall document the water requirement (supply pressure, temperature and flow) against each applicable usage and the required water quality for all water types in accordance with the document data sheet.

6.3 Steam quality

The Purchaser shall define the following:

- steam quality available;
- steam pressure, temperature and flow capacity available.

The Contractor shall document the steam requirement (supply pressure, temperature and flow and return flow if any) against each applicable usage and the required steam quality in accordance with the document data sheet.

6.4 Purge media quality

The Purchaser shall define the following:

- plant and instrument air pressure and flow capacity available;
- nitrogen supply pressure and storage capacity.

The Contractor shall document the purge media requirement (media type, supply pressure, temperature and flow) against each applicable usage for each start-up and shutdown cycle and the required purge media quality in accordance with the document data sheet.

6.5 Interface and utility connection points

The Purchaser shall document, in accordance with the document data sheet, the interface, termination and utility connection details and locations in a qualitative and quantitative manner for all applicable interfaces between the proposed power generation package location and connecting equipment or utilities. Connecting equipment is listed in the Scope ([Clause 1](#)) and utilities that may be applicable include, but are not limited to, the following:

- fuel supply termination point(s);
- junction box(es) for control and instrumentation (C&I) signals to/from the gas inlet location/reception compound and generating unit control room;
- electrical supply termination(s) in a distribution board located outside the gas inlet location/reception compound boundary fence;
- access road to gas inlet location/reception compound;
- isolating valve for local municipal authority or potable water supplier;
- cooling water or process water source and any existing structure for take-off;
- demineralized water supply;
- steam supply;
- plant air supply;
- instrument air supply;
- nitrogen purge supply;
- isolating valve for local municipal authority or water supplier responsible for foul water removal;
- surface water drainage destination and any existing structure for collection;
- oily water drainage destination and any existing structures for collection;
- generator connection to the grid organization's busbars;
- voltage transformers (VT) and current transformers (CTs) connected to outgoing terminals of interface termination cubicle;
- earth pillar location for each connection;
- nearest existing access road – general traffic;
- nearest existing access road – construction traffic;
- location of telephone company lines.

The Purchaser is responsible for the organization, coordination and information exchange methodologies between Contractors supplying equipment to the site.

The Contractor shall document the location and details of all the applicable interface connection points listed above in the Contractor's scope of supply in accordance with the document data sheet.

6.6 Gas turbine orientation due to site conditions

The Contractor shall arrange, following the receipt of the project information (including the prevailing wind direction), for the gas turbine package and its air intake to be orientated within the constraints of the available plot so that the gas turbine package's exposure to airborne contaminants is minimized and the impact of other equipment is considered.

The Purchaser shall advise the location of any existing or proposed cooling towers or other known equipment that may impact gas turbine package performance or air quality in accordance with the document data sheet.

7 Discharges and emissions to the environment

7.1 General

Environmental issues primarily include emissions during start-up, shutdown and general operation. Typical emissions of interest are noise (acoustic), combustion-generated emissions, waste fluids, mists, vents and thermal emissions. These topics are described in [7.2](#) to [7.8](#).

Toxic and/or hazardous emissions shall be prevented in accordance with ISO 21789:2009, 5.22.3.

7.2 Design philosophy for prevention of unplanned release of fluids

The Contractor shall document the full inventory of fluids within the gas turbine package and its auxiliary systems and containment methods that would prevent unacceptable release of these fluids in accordance with the document data sheet. The Contractor shall design these containment systems to prevent a release to the environment based upon credible failure scenarios for storage and pipework systems. The Contractor shall provide functional requirements for detailed design of containment systems (e.g. bunding) not included in the Contractor's scope of supply in accordance with the document data sheet.

7.3 Noise emissions

7.3.1 General

The Purchaser shall specify on the information data sheet the allowable sound pressure level acceptable for major equipment, blow offs and vents that generate a significant noise level, where applicable, including, but not limited to, the following:

- gas turbine air inlet;
- gas turbine enclosure;
- gas turbine exhaust;
- reduction gearboxes.

- If requested by the Purchaser, the Contractor shall provide the predicted or measured sound pressure and sound power level noise spectrum for the said equipment and the peak predicted or measured sound levels from blow offs and vents (see [33.4](#)).

- If requested by the Purchaser, near field noise levels shall be measured by the Contractor.

For personnel protection the requirements of ISO 21789:2009, 5.7 shall be applied.

7.3.2 Methods for sound measurements and predictions

Sound pressure levels shall be measured in accordance with ISO 10494 and ISO 11204 for workstations.

- If requested by the Purchaser, sound power levels shall be measured in accordance with ISO 9614-1 or ISO 9614-2.

Nominal far field noise predictions may be undertaken in accordance with ISO 9613-2 utilizing information provided under [7.3.1](#).

7.3.3 Sound level within the gas turbine enclosure

- If requested by the Purchaser, the Contractor shall provide estimated sound levels inside the gas turbine enclosure. Where measurements have been undertaken, these shall be made in accordance with ISO 3746. If the enclosure is not accessible during running, this requirement may be waived.

7.4 Exhaust emissions

7.4.1 General

The height of exhaust outlets, where applicable, shall be sufficient to provide adequate dispersion of all emissions and the design shall take into account the potential, under reasonably foreseeable operating conditions, for large amounts of oxygen depleted air, carbon monoxide or other hazardous air pollutants being emitted that can cause the asphyxiation of personnel in the area of an inadequately dispersed exhaust. The emissions shall not cause a danger to nearby persons or property.

NOTE Regional, national or local regulations can govern stack heights.

7.4.2 Responsibilities

The Purchaser shall specify the specific emission levels to be achieved over the required load range and any relevant environmental regulations and restrictions existing or being developed that are applicable to the project for a specific fuel composition in accordance with the document data sheet.

The Contractor shall be responsible for the gas turbine package performing according to the exhaust emission levels defined by the Purchaser. The exhaust gas emission levels apply for gas turbine operation with the specific fuel and specified air quality at the specific site ambient conditions (pressure, temperature and relative humidity) as advised by the Purchaser.

See also [Clause 8](#) for contract fuels.

7.4.3 Reporting emissions

The Contractor shall provide emission levels information, at MCR for applicable fuels, for the following:

- NO_x;
- CO.

- If requested by the Purchaser, the Contractor shall provide emission levels information, at MCR, for the following:

- unburned hydrocarbons (UHC);
- volatile organic compounds (VOC) (gas);
- smoke opacity or visibility;
- particulates (total including condensable).

- If requested by the Purchaser, the Contractor shall provide the same emission levels information as provided at MCR for the following load conditions:

- MCO;
- MEL;
- other values as specified by the Purchaser.

The definition of UHC and VOC shall be in accordance with ISO 11042-1. Additionally, the composition of the exhaust gases (such as CO₂, H₂O, O₂, N₂, argon) shall be known (both on a volumetric and mass basis) since this information may be required for any post-combustion equipment.

The methods used for the measurement, analysis and evaluation shall be in accordance with ISO 11042-1 or ISO 11042-2, or applicable regional, national or local regulatory authority requirements or standards. Reporting values and particulate details are described in ISO 3977-4:2002, 6.3.3 and 6.3.5. When reporting emissions on a density basis, the reference temperature and pressure shall be clearly specified.

7.4.4 Start-up emissions

- If requested by the Purchaser, the Contractor shall provide a prediction of the start-up emissions from ignition to full load for NO_x and CO for all start conditions (cold, warm and hot starts as applicable) and fuels.

7.5 Post-combustion controls

The impact of post-combustion controls on all emissions is important. For example, oxidation catalysts shall oxidize fuel sulfur to SO₃, and may potentially increase the total particulate emission. Selective catalyst reducers (SCR) can further increase particulate emissions via the formation of ammonium sulfates and ammonia slip. The Purchaser shall be aware of the interaction between any proposed post-combustion controls technology and gas turbine package emission levels. It is the responsibility of the Purchaser to evaluate the impact of all post-combustion control technologies on the exhaust emission signature.

7.6 Emission monitoring

- If requested by the Purchaser, the Contractor shall supply equipment for continuous monitoring of exhaust emissions according to the requirements specified in [26.9.2.1](#).

In some cases, it is possible to encounter emission requirements more stringent than the pre-existing ambient air quality. The Contractor assumes all exhaust emissions are net emissions, above those pre-existing in the ambient air background quality.

7.7 Water, steam and other emissions

The Purchaser shall specify the existing constraints on other emissions (which are specified in regional, national or local regulations) on the information data sheet. Such emissions may include, but are not limited to, the following:

- water discharge to streams, rivers or lakes;
- water discharge to foul water or sewage systems;
- emissions of hot saturated air or steam;
- lube oil vapour emissions;
- gas fuel venting;
- thermal emissions.

7.8 Visible plumes

- If requested by the Purchaser, a specific requirement relating to the visibility of exhaust stack and oil demister vent plumes during normal operation shall be provided on the document data sheet. The Contractor shall state on the document data sheet whether they can predict by analysis and/or measure site plumes. Where the risk of plumes endangers a road or railway in the proximity of the equipment,

the Contractor shall deliver information about that plume formation to allow the Purchaser to evaluate the risk.

8 Contract fuels

8.1 General

The Purchaser shall provide detailed fuel properties, including composition, lower heating value and density derived in accordance with ISO 6976, and all known contaminant levels, limits of variability and the supply pressure and temperature to the Contractor for gas or liquid fuel(s) as selected in the information data sheet (see 4.1). Besides design condition fuel, the minimum and maximum values shall be made available. Refer to ISO 3977-4:2002, 5.2 for further information. It is the Purchaser's responsibility to ensure that the contract fuels supplied meet the fuel specifications.

8.2 Types (gas, liquids and combination)

Gas turbines may operate with gas, liquid or a combination of both primary fuels or mixed co-firing with liquid and gas fuels.

The gas turbine package shall be capable of running on either a single gas or single liquid fuel or as dual fuel with operation on either gas or liquid fuel and changeover between fuels at load as applicable with the Purchaser's requirements. The maximum load at which fuel changeover may take place shall be documented on the information data sheet.

- If requested by the Purchaser, the gas turbine package shall be capable of running on both gas or liquid fuels with on load fuel changeover (in both directions).
- If requested by the Purchaser, the Contractor shall advise on the capability to provide mixed co-fired fuel operation (and specifically the range of percentage of each fuel specified by the Purchaser), the specific maintenance penalties and any operating restrictions or additional maintenance inspections for the range of fuel mix combinations. Details shall be provided in accordance with the document data sheet.

8.3 Fuel composition

The Contractor shall define the fuel types and ranges of fuel qualities acceptable for the gas turbine application and use ISO 4261 or equivalent regional or national standards as applicable for both fuel gas and liquid fuel oil. Details shall be provided in accordance with the document data sheet. For general guidance on fuel chemical and physical properties refer to ISO 3977-4:2002, 5.4 for gaseous fuel and ISO 3977-4:2002, 5.5 for liquid fuel. Where specific fuel limitations exist relative to specific gas turbine models, such as the Wobbe index, these shall be explicitly stated. In the case of the Wobbe index, the calculation method used by the Contractor shall be stated. Measured values for composition or specific properties shall quote the associated preferred test or calculation standard. These may include liquid and gaseous fuels; fuel emulsions may also be considered.

The Contractor's fuel specification shall ensure the reliability, availability, maintainability and durability of the turbine and associated systems. The specifications shall address the fuel qualities needed to support reliable combustion including supply temperature and margins, table of allowable contamination levels and allowable carryover from upstream equipment and additional factors, where applicable. Examples of additional factors include the allowable content of hydrogen, sulfur, hydrogen sulfide and the viscosity and heating values, which may lead to degradation of the combustion process, turbine hot-section, and fuel control system, as well as compromise the safety of the turbine operation.

For the project fuel(s) the Contractor shall ensure that requirements are correctly identified and suitable measures taken for the proper operation of its scope-of-supply equipment.

The Purchaser shall provide the maximum dew point temperature for the contract gaseous fuel on the information data sheet. The Contractor shall check the dew point value against the constituents and provide a margin to this temperature on the information data sheet.

- If requested by the Purchaser, where a fuel composition that meets the Contractor's fuel requirements is unavailable, the Contractor shall define in accordance with the document data sheet, where possible, details of technical measures to upgrade the combustor, hot gas path components or fuel supply system (see [Clause 9](#)) to cope with the out-of-specification fuel and advise on the possibility for fuel treatments (such as washing or dosing) to reduce the impact of fuel contamination.

The Contractor shall advise, based upon the information provided by the Purchaser, details of the economic impact of out-of-specification fuels in terms of reduced maintenance intervals in accordance with the document data sheet. The Contractor shall identify the components at risk, the possible degradation mechanism (such as hot corrosion) that may apply and the impact on component life.

8.4 Fuel supply requirements

The Contractor shall document the fuel supply requirements in accordance with the document data sheet. Fuel supply condition requirements shall include the minimum and maximum pressure, the limits for temperature and the minimum flow rate(s) stated at the Contractor's terminal point.

Also quoted shall be the maximum allowable rate of change of supply conditions to meet all operating conditions.

- If requested by the Purchaser, where the Contractor's fuel supply requirements cannot be met, the Contractor shall document in accordance with the document data sheet, where possible, technical measures to meet the delivery conditions (see [Clause 9](#)).

8.5 Alternative fuels (syngas, low calorific value gas, LPG, NGL, Naphtha, LNG, high hydrogen and residual fuel oil)

- If requested by the Purchaser that operation on a non-standard fuel is required, including, but not limited to, syngas, low calorific value gas, liquid petroleum gas (LPG), natural gas liquids (NGL), naphtha, liquefied natural gas (LNG), high hydrogen and residual fuel oil, the Purchaser shall provide composition and supply condition details for the fuel document in accordance with the document data sheet. The Contractor shall document the fleet experience with the applicable fuel and the expected impact on maintenance intervals, performance, component integrity and any modifications required to the gas turbine core or the fuel system including any potential corrosion, flame temperature and toxicity conditions that require special attention in accordance with the document data sheet.

- If requested by the Purchaser, the Contractor shall provide resources to carry out a specific hazard and operability (HAZOP) study for a non-standard fuel that may entail special precautions due to low ignition temperature or toxicity.

Where the auto ignition temperature of the fuel is such that uncontrolled ignition may occur due to hot internal temperatures of the gas turbine core, leading to dangerous overpressure conditions or uncontained component failure, an alternative start-up fuel shall be used which mitigates these risks. The applicable fuel system details shall be documented by the Contractor in accordance with the document data sheet.

Where low energy fuels are to be used, the Contractor shall propose and document a start-up fuel system, if required. Low energy value fuel gases have many specific complications associated with their properties and composition. The Contractor shall advise the Purchaser on the necessity for a start-up fuel if fuel vaporization or other problems are predicted. Details shall be provided in accordance with the document data sheet.

The Contractor shall document any limits for high levels of inert gases to avoid problems with low flame temperatures such as blow out and emissions in accordance with the document data sheet.

Low energy gases require a very high volume flow rate to achieve adequate output power. This may require a modified fuel supply system, fuel manifolds and even changes to the fuel burners. The Contractor shall advise the full scope of any modifications to the standard gas turbine, fuel system and auxiliary systems to operate with the specified low energy fuels. Specifically, the fuel compression systems and their configuration and works power demands required shall be identified and documented.

procurement phase as these requirements may be significant. Low energy fuel gases may have specific contaminants that may or may not be listed in the Contractor's standard fuel specification. Any limits specific to these gases shall be identified early in the procurement phase to allow the Purchaser to assess the economic impact of any maintenance constraints such as from hot corrosion of gas path components, ash formation or even sulfide/sulfate corrosion of carbon steel burners. Details of any modifications required and fuel limitations shall be documented in accordance with the document data sheet.

Fuels which have high hydrogen content are generally suitable from a combustion standpoint, if the fast reaction rate and high flame temperatures are provided for. Also, hydrogen's low volumetric heating value results in higher flow volumes compared to natural gas. The safe handling of high-hydrogen fuels is important as their low molecular weight allows them to rapidly diffuse in air and pass through gasket materials and joints that are generally impervious to natural gas. Hydrogen is a highly flammable gas with much wider limits of flammability than natural gas. It can also be absorbed into metals and cause a general loss of ductility or hydrogen embrittlement that can readily occur at ambient temperatures. In addition, high-hydrogen fuels may affect emissions and increase component maintenance intervals. Special gas detectors are typically required to sense hydrogen.

Other fuels such as naphtha have low lubricity and may impact the life of a fuel supply system by affecting pumps and fuel flow distribution equipment (flow dividers).

9 Fuel systems and treatment

9.1 General requirements

The gas turbine package fuel system shall comply with the requirements for equipment and safety defined in ISO 21789:2009.

9.2 Gas fuel supply

- If requested by the Purchaser, a pressure regulator shall be supplied for the gas fuel supply system set to regulate the gas fuel supply to the gas turbine package fuel system maximum allowed pressure. This may be located on the gas turbine package or in the fuel supply line.
- If requested by the Purchaser, a gas compression skid shall be supplied with a gas compressor and associated accessories and controls to boost the gas fuel supply pressure to the gas turbine package fuel system to the minimum pressure required. This skid will typically be located in the fuel supply line. Where an oil injected screw compressor is utilized, a demister oil eliminator shall be supplied that is designed to achieve the flow conditions while removing oil droplets, mists and vapour from the gas fuel supply to the level that complies with the Contractor's fuel specification. Details including type of compressor configuration, flow rate, discharge pressure and power consumption shall be documented in accordance with the document data sheet.

9.3 Liquid fuel supply

Where the head from the liquid fuel storage or pipeline supply does not supply the fuel at the minimum pressure required for the gas turbine package fuel system, a suitably sized liquid fuel pump (skid) shall be required. The location available for the pump shall be advised by the Purchaser.

- If requested by the Purchaser, a pressure regulator shall be supplied for the liquid fuel supply system set to regulate the liquid fuel supply pressure to the gas turbine package fuel system maximum allowed pressure. This may be located on the gas turbine package or in the fuel supply line.
- If requested by the Purchaser, a liquid fuel forwarding skid shall be supplied with a low pressure liquid fuel pump and associated accessories to provide the liquid fuel at the minimum supply pressure to the gas turbine package fuel system. This skid may be located on the gas turbine package or in the fuel supply line.

9.4 Fuel filter/separator

9.4.1 Gas fuel

Service experience has found that liquid entrainment in fuel gas may occur despite installed fuel separation equipment. Entrained liquids would typically be hydrocarbon drop-out, which is a potential source of combustion problems in the gas turbine.

- If requested by the Purchaser, a combined gas fuel filter/liquid separator shall be supplied by the Contractor to eliminate the risk from off-specification fuels. The filter/liquid separator should be installed as close to or on the gas turbine package, to eliminate the risk of liquid drop-out from the gas fuel supply.

9.4.2 Liquid fuel

- If requested by the Purchaser, a liquid fuel filter shall be supplied by the Contractor, installed as close to or on the gas turbine package, to eliminate the risk from off-specification fuels of unacceptable solid particles in the liquid fuel supply.

9.5 Pre-heating requirements for the dew point control of fuel gas

The Purchaser shall ensure that, where applicable, measures shall be taken to ensure the temperature of the gas is kept above its dew point by implementing appropriate heating in the fuel gas supply according to the Contractor's fuel requirements. This facility may be placed at the entrance of the fuel pipeline to the site. The facility shall include isolation, separation, dew point heating and filtration in sequence of flow. It may also include metering and pressure control. The separator shall always be placed ahead of the dew point control. The temperature shall be maintained at an acceptable margin above its dew point downstream of the control by suitable heating of equipment and piping within the supply to and on the gas turbine package. The margin above dew point, where applicable, shall be specified on the information data sheet.

Where required, the Contractor shall provide trace heating to maintain the temperature of the gas fuel on the gas turbine package.

9.6 Pre-heating requirements for liquid fuels approaching their pour point

The Contractor shall identify all the heating requirements prior to pumping and the recommended heating source for fuels that might approach their pour point while not in operation and during operation in accordance with the document data sheet. Where failure of the heating source would result in solidification or difficult to remove fuel residues, measures, e.g. redundant heating systems, shall be proposed by the Contractor. The margin above pour point, where applicable, shall be specified on the information data sheet.

Piping and associated equipment shall be trace heated to maintain the supply temperature and prevent formation of contaminants leading to blockage. Winter grade fuel shall be used where possible to minimize the potential for pour point problems.

9.7 Alternative fuels – multi-fuel capability

Where the Purchaser requires the gas turbine to run with more than two primary fuels (see [8.2](#)) the Contractor shall identify the specific modifications to equipment and the control systems to ensure stable and reliable operation of the gas turbine combustion system during alternative fuel running in accordance with the document data sheet. All safety, operational and maintenance considerations shall be identified and necessary modifications implemented. Specifically, any unique hazards associated with alternative fuels shall be identified and assessed using the guidance provided in ISO 21789:2009.

9.8 Mixed fuel co-firing

Where the Purchaser requires the gas turbine to run with mixed fuel co-firing operation (see 8.2), the Contractor shall advise if a mixed co-firing fuel operation can be achieved with the fuels stated by the Purchaser. The Contractor shall provide the permissible flow splits utilizing these fuels and shall identify the specific modifications to equipment and control systems required to ensure stable and reliable operation of the gas turbine combustion system during the mixed co-firing operation. Details shall be specified in accordance with the document data sheet.

All safety, operational and maintenance considerations shall be identified and necessary modifications implemented. Specifically, any unique hazards associated with co-firing shall be identified and assessed using the guidance provided in ISO 21789:2009.

9.9 Fuel for igniter

For some gas turbines an alternative fuel is required in support of the igniter.

Where applicable, the Contractor shall identify and document the igniter fuel type, pressure and flow (e.g. natural gas or propane) and the storage capacity required in accordance with the document data sheet.

9.10 Start-up fuel, main fuel and fuel changeover

When the turbine's main or primary fuel is natural gas or liquid fuel, the turbine shall start, run and shutdown on these fuels without the need for changeover. For some gas turbines an alternative fuel for start-up, ignition only, run-up to full speed at no load or a specific part load, fuel changeover or for unloading and shutdown may be required.

Where applicable, the Contractor shall document in accordance with the document data sheet the alternative fuel type, pressure and flow (e.g. natural gas, propane or liquid fuel), operational requirements and the storage capacity required.

9.11 Water and steam injection systems

Where water or steam injection is required for NO_x emissions control or power augmentation, the Contractor shall advise the Purchaser in accordance with the document data sheet and shall provide the water or steam delivery and control system as part of the gas turbine package. The maintenance plans, including outage schedules and component lives, as required in 28.4, specific to a water or steam injected gas turbine core shall be supplied by the Contractor. (See [Clause 6](#) for water and steam details.)

9.12 Fuel purge, vents and drains

Gas turbines utilizing liquid fuels, either as the sole fuel or as part of a multiple-fuel application, typically require purge systems to remove residual liquid fuel from the injectors following a fuel transfer or gas turbine shutdown or to prevent fuel and combustor gases from entering inactive fuel or air passages. Typical fluids used as purge media include air, nitrogen, water and gas fuel. Fuel purge systems shall be designed in accordance with ISO 21789:2009. The purge delivery and control system shall be part of the gas turbine package. Where an external purge media (such as nitrogen) system is required, the Contractor shall provide purge media requirements including purge media type, quality and consumption rate for a start-up and shut down cycle in accordance with the document data sheet (see [Clause 6](#)).

Vents and drains shall comply with the requirements of ISO 21789:2009.

9.13 Fuel system metering

- If requested by the Purchaser, a fuel flow meter shall be supplied in the main and back-up (where installed) fuel system(s) to monitor the total volumetric fuel flow to the gas turbine. Turbine meter and orifice plate flow measurement devices shall comply with ISO 9951 and ISO 5167-1 respectively. The

Contractor shall install a flow computer to allow volumetric flow (from the main and back-up fuel) to be calculated from the meter(s) raw data and supplied to the control system. The Contractor shall advise, on the information data sheet, the type of flow meter(s) employed, the applicable standard(s) for the meter(s) and which fuel gas flow units are employed.

- If requested by the Purchaser, on-line component analysis of the fuel gas by chromatography shall be installed on the fuel supply at a suitable location. The chromatograph shall supply this data to either a dedicated flow computer or the gas turbine control system to calculate compressibility, density and fuel mass flow. The system shall also provide lower calorific value. The Contractor shall supply the details of the systems, the standards applicable to calculation of compressibility, density and calorific value and the outputs available to the gas turbine control system in accordance with the document data sheet.

9.14 Fuel system pipework and vessels design

9.14.1 General

Fuel gas and liquid pipework shall be implemented in accordance with [30.6](#) and [30.7](#).

9.14.2 Fuel pipes, joints and flanges

Fuel gas and liquid pipework downstream of the fuel filter(s) shall be constructed from corrosion-resistant materials suitable for the application.

Fuel gas pipe spools shall be constructed from welded pipe components jointed by full penetration welds. Components using slip-on style flanges do not require full penetration welds, however, all welds shall be manufactured and volumetric inspection carried out in accordance with the design and inspection codes.

9.14.3 Flexible pipes

The design, manufacture and test of corrugated flexible metal hoses and hose assemblies for use in the fuel delivery shall comply with ISO 10380. The design shall take into account operating pressures, temperatures, installation bend radius and the magnitude and direction of vibration. The Contractor shall provide a finite life for the flexible pipes based upon the design calculations on the information data sheet.

The installation of flexible fuel pipes shall avoid kinks, twisting and the possibility of abrasion from contact with other objects. The Contractor shall provide procedures for the removal and fitting of the flexible pipes during maintenance. Guidance shall be provided for the nature and frequency of inspections and testing to ensure pipe integrity during service operation.

Where specialized non-metallic flexible hoses are used on liquid fuel lines, the Contractor shall provide the Purchaser with the detailed hose specification for their approval in accordance with the document data sheet.

10 Regulations, codes and standards

10.1 General requirements

Where international, regional (e.g. EN), national and local regulations exist for the safe reliable operation of the power plant and the control of discharges, the equipment shall be designed to comply, control and monitor as applicable for compliance as specified by the Purchaser as well as complying with the content of [Clause 14](#).

The Contractor shall comply with applicable regulations and legislation relating to the equipment supplied in the country where the equipment is installed. The Purchaser shall provide details of all the applicable regulations and legislation in accordance with the document data sheet.

This may include, but not be limited to, applicable regulations and legislation that apply to the following.

- Pressure equipment and systems covering pressure vessels, pressure equipment, pressure systems and transportable pressure vessels.
- Equipment in explosive atmospheres.
- Electrical equipment, covering disposal, electromagnetic compatibility, voltage, batteries.
- Equipment markings and identification.
- Emissions, including air contamination (arsenic, benzene, carbon monoxide cadmium, lead, mercury, nickel, nitrogen dioxide, ozone, polycyclic aromatic hydrocarbons, sulfur dioxide, nitrogen) and combustion exhaust outlets.
- Safety, covering machinery, construction products, personnel protection, materials.
- Pollution, covering noise, water intakes/discharges, batteries, soil, waste management.
- Fuel, covering contamination, content (sulfur, hydrogen sulfide).
- Firefighting equipment.
- Hazardous area classification.

The Contractor's obligations under these regulations include, but are not necessarily limited to, the roles of designing, manufacturing, construction and commissioning.

10.2 Design codes and standards

The Contractor shall provide equipment designed, manufactured/constructed and tested in accordance with internationally recognized design and engineering standards appropriate to the duty, operational requirements, safety requirements and environmental conditions that are applicable.

It shall be demonstrated that the design and construction complies with good engineering practice and that all equipment and materials are fit for purpose and compliant in all respects with the proposed duty.

The tender shall include a list of major standards, in accordance with the document data sheet, with which the Contractor proposes to comply.

Where regulations or directives given by authorities mention particular design or engineering standards as methods of compliance, the Contractor shall give preference to applying these standards in the design, manufacture and construction of the relevant parts of the power plant. If the Contractor proposes to employ an alternative standard, this shall be brought to the attention of the Purchaser for approval. When seeking such approval, it shall be the Contractor's responsibility to provide the appropriate documentation for comparison.

Consideration shall also be given to the implication of changes and amendments to applicable codes and standards issued before the contract is signed.

The Contractor shall be consistent in their application of the specified standards in this document. If an alternative international or national standard is normally used by the Contractor such use shall require approval by the Purchaser.

10.3 Verification

Before the contract is placed, there shall be agreement over the conformity assessment procedures to be used, and provision for the Purchaser to comment.

- If requested by the Purchaser that independent assessment of the design and/or construction processes or written schemes of examination are required for compliance with regulations and legislation, the Contractor shall document the proposed method/format of such verification schemes.

The Purchaser shall document any variations required or an alternative system required such that the Contractor may integrate these activities into their own systems for compliance. Documentation shall be in accordance with the document data sheet.

The Contractor shall supply information and documentation that is necessary to allow the Purchaser to fulfil their obligations with respect to the applicable regulations and directives.

Where written verification schemes of examination are prepared by the Contractor they shall

- be approved as required by applicable regulations,
- identify the scope of the initial examination performed by the Contractor as initial purchaser of the equipment and systems, and
- be delivered to the Purchaser in advance of commissioning of the equipment and systems to which they apply.

The Contractor shall be responsible for ensuring that the examination of the power plant is carried out, in accordance with the applicable regulations and directives, before the power plant is brought into service.

For any in-service examination of the power plant in accordance with the written verification schemes required by the applicable regulations or directives (subsequent to takeover), the appointment of an engineering inspection organization fulfilling the role of competent person shall be the responsibility of the Purchaser, unless otherwise defined by the Purchaser in accordance with the document data sheet.

11 Operating requirements

11.1 General requirements

The Purchaser shall specify at the tender stage in the information data sheet the total annual number of starts per fuel (hot, warm and cold: see [11.3](#) for definitions), and the total annual operating hours per fuel.

11.2 Operating range and limitations

The minimum output of a gas turbine package shall be taken to be a unit [with the steam turbine and the gas turbine(s) in service in case of combined cycle gas turbine (CCGT)] operating at a fraction of maximum output and meeting all environmental constraints as specified for a continuous operation. The output range between MCR and MEL shall be the nominal operating range of the gas turbine package and this shall be confirmed by the Contractor. The Contractor shall advise any operating restrictions for extended operation between MEL and MCR in accordance with the document data sheet.

A higher output or peak load as defined in [5.1.4](#) is a higher net output than maximum nominal output that may be selected and may be achieved by a higher TIT, water or steam injection or inlet cooling. The Contractor shall advise any operating restrictions for extended operation at peak load in accordance with the document data sheet. The Contractor shall define any operating and technical limitations that apply from operating for extended periods at MEL.

11.3 Starts (time to start, number of starts, start restrictions)

The start-up time is defined as the elapsed time between the instant when start-up is initiated and power is available to the grid connection at MCR for the gas turbine package. The start-up time may vary according to the technology involved.

The Contractor shall state the constraints on the number of repeated starts (in the event of failed starts) on the gas turbine and the reason for the constraint in accordance with the document data sheet. The Contractor shall further declare whether the constraint on repeated starts relates to a specific thermal state (hot or warm start) and provide the reason for the constraint. The waiting time before restart shall be quoted by the Contractor in cases where the maximum number of starts are reached.

The Contractor shall provide specific advice (including barring requirements) for repeated starts in the operating manual.

Start times shall be provided for hot, warm and cold starts in minutes. The following definitions are made to allow comparison between Contractors.

- Shutdown refers to the point at which the unit shutdown is initiated by the operator via the control system.
- A start-up refers to the point at which the unit start is initiated by the operator via the control system.
- A hot start shall be defined as < 4 h from the shutdown of the unit.
- A warm start shall be defined as between 4 h and 40 h after shutdown.
- A cold start shall be defined as > 40 h from the shutdown of the unit.

NOTE The start times above are typical but will vary depending on the size and structure of the gas turbine.

Where start times are modified based upon the thermal condition of the steam side (in a combined cycle) and where a stack damper is available (to reduce thermal siphoning losses through the stack) these shall be quoted instead of a standard combined cycle start time.

The Contractor shall provide the time (included in a start) for exhaust (and heat recovery steam generator, if installed) purge to comply with the requirements of ISO 21789:2009.

- If requested by the Purchaser, the Contractor shall provide a fast start option (with a higher loading ramp rate than normal) covering hot, warm or cold start conditions and the corresponding start times (in minutes). The Purchaser shall supply their preferred fast hot, warm and cold start times on the information data sheet.

11.4 Loading/de-loading

The loading and de-loading shall be automatic. Where applicable, the target load is entered manually by the operator. The Contractor shall provide details of loading and de-loading ramp rates and loading conditions for hot, warm and cold starts. The ramp rate for loading from synchronization to MCR and de-loading from MCR to de-synchronization shall be provided as MW/min or % of MCR/min on the document data sheet. Differences between gas turbine package loading rate and CCGT loading rate shall also be provided.

The Purchaser shall provide any required loading rate in the information data sheet.

The Contractor shall ensure that the gas turbine package is emission compliant when loading and de-loading between MEL and MCR.

During a fast load ramp there is the possibility that the demanded load and the corresponding exhaust gas emission is temporarily exceeded with the risk to the operator of having to report non-compliance to the regulatory authorities.

- If requested by the Purchaser, the Contractor shall state the expected load/emission overshoots during ramping in a document provided in accordance with the document data sheet.

The Contractor shall state any limitations from load cycling between MCR and MEL and between synchronization and MCR.

11.5 Grid operational requirements

The gas turbine package shall be capable of operation in accordance with the grid code or technical constraints of an electrical network or system where required. This shall include continued operation within the stated grid frequency range. The Purchaser shall identify and document the applicable grid

code in accordance with the document data sheet. The Contractor shall document any restrictions to the grid code requirements caused by physical limitations in accordance with the document data sheet.

The gas turbine package shall be capable of being synchronized on a stabilized grid within a specified range around the nominal frequency.

11.6 Frequency response

- If requested by the Purchaser, the gas turbine package shall be capable of providing automatic changes in load to assist grid frequency changes in a proportional response as required by the grid code. This requirement is typically called frequency response. The frequency sensitive mode or limited frequency sensitive mode shall be capable of being selected and enabled manually. This feature shall be selected in the options data sheets by the Purchaser. The control system requirements for this capability are given in [26.1.7](#).

11.7 Location of controls HMI

- The location of the local controls human machine interfacing (HMI) for the power generation package shall be located as defined by the Purchaser either being located on or adjacent to the gas turbine package/power generation package, in an adjacent control room or a control room remote from the power generation package but within the power plant.
- If requested by the Purchaser, an offsite remote control function shall be provided. The level of control and method of access required shall be documented by the Purchaser in accordance with the document data sheet. The functions supplied and the reliability, integrity and security for communications between the remote and local control systems shall be considered and demonstrated by the Contractor to the Purchaser to achieve an equivalent safety integrity level as achieved for the local controls.

11.8 Operation documents

The Contractor shall provide an operating manual with the operating modes of the gas turbine package and any constraints this places on gas turbine operation. The manual shall describe all steady-state and transient operations such as starting, synchronisation, loading, de-loading, de-synchronisation and shutdown. It shall also describe any optional modes selected by the Purchaser such as peak firing, part load operation, frequency response and fast starts, and any foreseeable abnormal events and the recommended actions for the operator. Alarms and protections shall be described in the C&I documentation (see [Clause 26](#)).

An operating manual shall be supplied prior to the initial commissioning of the unit at site.

11.9 Island mode operation and black start

- If required by the Purchaser, the power generation package may be required to operate in Island mode. Therefore, the gas turbine package control system shall have to manage voltage regulation and frequency control. The Purchaser shall advise the nature of the network and identify who is responsible for network control in accordance with the document data sheet. It should be noted that small grids with several producers may require a special controls concept.

Black start is defined as the ability to start the gas turbine package without connection to the electricity grid. This typically requires power supplied by a dedicated auxiliary diesel package.

- If requested by the Purchaser that black start is a requirement, the auxiliary start package shall be supplied and sized to allow sufficient power for gas turbine auxiliary systems and for the gas turbine starting system. Where more than one gas turbine package is installed on site, there shall be sufficient interconnection for one unit to supply power for the other units to start. The black start capability shall be compliant with the local grid code and shall be capable of not less than three successive black starts (see [30.2.3](#)).

11.10 Black start and black grid restoration

Black grid restoration is defined as the ability to energize part of the grid or, if appropriate, the host distribution system, followed by the capability to accept instantaneous loading of demand blocks of a defined size and controlling frequency and voltage levels within acceptable limits during the block loading process.

- If requested by the Purchaser that black grid restoration is required, the details of the grid restoration procedure, including size of required load steps, overall demanded load, applicable fuel, details of local transmission and distribution system, shall be provided by the Purchaser for development of a basic concept in accordance with the document data sheet.

12 Quality

12.1 Quality management system

12.1.1 General

The Contractor and its major subcontractors shall operate a quality management system (QMS), e.g. ISO 9001, or any corresponding regional or national standard that complies with its elements.

The scope of the QMS shall be directly relevant to the full projected scope of work to be undertaken, including both works and site activities. The QMS shall be available for review on the Purchaser's request.

Where the development, supply and maintenance of computer software is required as part of the project (or could affect the quality of the delivered product), the Contractor shall implement a QMS adapted to software (e.g. ISO/IEC 90003).

The project quality activities shall be defined clearly by the Contractor in a project quality plan (PQP). The PQP shall cover all stages of the project and be applicable to all major subcontracts. The PQP should follow the guidance given in ISO 10005.

12.1.2 Project quality manager

The Contractor shall appoint a qualified quality assurance manager who shall be responsible for the management and implementation of the quality assurance arrangements for the project and serve as the direct coordination interface with the Purchaser.

12.1.3 Project quality plan

At an early stage in the contract the Contractor shall submit a PQP in accordance with the document data sheet. The PQP shall define the programme of quality control and inspection activities that shall be implemented by the Contractor to ensure that the design, procurement, manufacture and completion of the materials and equipment comply with the specified requirements. The Purchaser shall document any variations required on the submitted plan in accordance with the document data sheet.

The PQP shall include the name of major manufacturers and major subcontractors. The PQP will be revised to include further details during the course of project execution.

The PQP shall cover all aspects, as far as applicable, according to the QMS.

The PQP shall define the following:

- project organization for all activities during all stages of the project;
- duties and responsibilities for the key roles within the project;
- organizational interfaces, internal and external;

- communication links between all parties in terms of scope, extent, periods and participants, including reporting and follow-up of action items.

12.1.4 Quality control plan

The Contractor shall prepare as required, in accordance with the document data sheet, and maintain quality control plans (QCP) that detail the controls that are to be used in managing quality throughout the project phases (design, procurement, manufacture, erection, commissioning, inspection, testing and take over) with respect to work undertaken directly by and subcontracted by the Contractor.

The QCP(s) shall typically include

- reference to controlling standards, specifications, drawings, instruction references, etc.,
- inspections and tests to be carried out (including frequency), and
- quality records and documents to be produced specific to the activity, which shall be used to ensure compliance with the contract requirements.

The QCP(s) shall be formatted to allow the Purchaser to identify those specific activities that are to be included within their own programme of verification. The QCP(s) shall be submitted to the Purchaser in advance of the activity to which they relate to enable the Purchaser to establish their surveillance intention. The QCP(s) shall be uniquely identified with a specific reference number, which shall be defined on each page of the document, along with the page numbers.

The Contractor shall mark-up each QCP, prior to submission to the Purchaser, to indicate specific inspection and verification stages and frequency of control checks carried out.

Upon completion of the package inspection, the signed QCP shall be part of the Final Quality Dossiers (Manufacturing Record Book).

12.1.5 Inspection and test plan

The Inspection and test plan (ITP) defined in accordance with the document data sheet shall detail all test and inspections that are performed during fabrication of the equipment in the workshop. The ITP shall identify the material and components with article numbers or project numbers in order to ensure that the issued test reports are traceable with the production order or article/project number.

The Contractor shall prepare, maintain and provide an ITP.

The Purchaser shall document the witness points required in accordance with the document data sheet. The Contractor shall document any variations required to the Purchaser's requirements, including the reason for the variation.

The ITP shall also identify the acceptance criteria, procedures or standards for the test and inspections. Procedures written for local labour may be written in local language when referring to an international standard.

12.2 Quality monitoring and approval

12.2.1 Sub-suppliers and supply chain quality monitoring

The Contractor shall provide details, in accordance with the document data sheet, of major sub-suppliers and shall not replace any listed major sub-suppliers previously authorized in the contract without the prior written agreement of the Purchaser. The Contractor shall monitor their sub-suppliers in a programme of surveillance, inspection, reviews and audit.

12.2.2 Quality surveillance by the Purchaser

The Purchaser shall be permitted on request to review and monitor the Contractor's proposals and their execution of all aspects of the project. Within the respect of intellectual property rights (IPR) in agreement with the Contractor and upon the signature of a non-disclosure agreement, the Purchaser or the Purchaser's representative shall have access to all locations and, at reasonable times, where activities are performed as listed within the IPR.

A corrective action programme shall be defined by the Contractor to correct deficiencies revealed by the monitoring. The programme shall be approved by the Purchaser.

12.2.3 Equipment approvals of statutory and coded items

- If independent inspection is required, the Purchaser shall provide the Contractor with details of the inspecting authority or organization who they propose to appoint to survey the design, construction, inspection and verification of compliance to the stated standards and regulations in accordance with the document data sheet.

12.2.4 Quality control record

Following each visit to perform a quality control activity, the Purchaser or the Purchaser's nominated representative shall complete a quality control record (QCR).

The QCR shall

- identify the item inspected, the stage of manufacture, and the nature of the quality control carried out, and
- list all points that require remedial action by the Contractor, before the subject item can be released.

Once all actions from QCR have been closed, the Purchaser and Contractor shall co-sign the QCR to indicate that there are no more non-conformities pending identified by the Purchaser. The completed QCR shall be documented in accordance with the document data sheet.

12.2.5 Control of non-conforming products and services

The PQP shall include or reference the procedures concerning handling and control of all non-conformances and corrective measures, including those affecting subcontractors and contractors.

The Contractor shall keep records of all non-conforming items identified throughout the duration of the project. This shall reflect evidence of notification of the non-conformance to the relevant party and the suggested course of action or an instruction issued to rectify the situation where necessary. The Purchaser shall have the right to review these reports.

12.2.6 Concessions

The Contractor shall advise the Purchaser of any intention to seek a concession with respect to any permanent deviation from the terms and conditions of the project requirements in any of the following areas.

- Effects to terminal points where the mating item or system is outside of the Contractor's scope of supply.
- Deviations from the Purchaser's work specification.
- Deviations from the Contractor's submissions which have been accepted by the Purchaser.
- Deviations which reduce safety margins or allowances.
- Non-standard items which reduce the capability to interchange power plant items or components and/or increase the cost of replacements.

The Contractor shall maintain a record of concession types as defined above throughout the duration of the project. This shall reflect evidence of notification of the concession to the relevant party and the suggested course of action or an instruction issued to rectify the situation where necessary.

12.2.7 Project design reviews

A process of design reviews shall be implemented by the Contractor and the Purchaser to ensure that the specific provisions of the project are being met, in particular to ensure that design information relating to interfaces between different project areas is implemented in accordance with the project.

Project design reviews shall include such items as

- layout/interfaces,
- constructability,
- hazard area classification,
- environmental management,
- health and safety, and
- maintainability.

The design reviews shall be reported in accordance with the document data sheet.

13 Reliability, availability and maintainability

13.1 Basic RAM assessment

13.1.1 General

The following information covering reliability, starting reliability, availability and maintainability (RAM) shall be documented, in accordance with the document data sheet, by the Contractor in accordance with this clause based on the definitions and formula in ISO 3977-9:1999 for reliability and availability and supplemented by IEEE 762:2006 for maintainability. The scope of the assessment shall be the gas turbine package. The Purchaser shall provide targets for these requirements on the information data sheet.

For comparison purposes the measurements should be based on data representative of a specific operation, of a fleet period of at least 150 000 running hours and a fleet sample size of 3 units. The period shall include 2 basic maintenance and inspection periods and 1 major maintenance and inspection period for each unit. Where these values are not available the values used shall be defined with the RAM assessment data.

13.1.2 Reliability

Reliability is the probability of an item operating for a given amount of time without failure when used under specified conditions. More generally, reliability is the capability of parts, components, equipment, products and systems to perform their required functions for desired periods of time without failure, in specified environments and with a desired confidence.

Mean time between failures for the gas turbine package, based on ISO 3977-9:1999, 3.67, shall be used as a nominal measure of reliability, as shown in [Formula \(1\)](#):