INTERNATIONAL STANDARD

ISO 19859

First edition
2016-06-15

Gas turbine applications — Requirements for power generation

Applications des turbines à gaz — Exigences relatives à la production d'energie

Reference number
ISO 19859:2016(E)

© ISO 2016



COPYRIGHT PROTECTED DOCUMENT

© ISO 2016, Published in Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

Foreword ..... **xii**
Introduction ..... **xiii**
1 Scope **1**
2 Normative references **2**
3 Terms and definitions **8**
4 Comparative performance assessment at standard reference conditions **12**
4.1 General 12
4.2 Standard reference conditions 13
4.2.1 General 13
4.2.2 Ambient conditions 13
4.2.3 Exhaust conditions 13
4.2.4 Cooling water conditions (if applicable) 13
4.2.5 Working fluid heater or cooler 13
4.2.6 Fuel for comparative performance assessment 13
5 Performance at site conditions **14**
5.1 Site rating 14
5.1.1 Site rated power 14
5.1.2 Site minimum load 14
5.1.3 Site net heat rate 14
5.1.4 Site peak load 14
5.2 Site conditions 14
5.3 Corrections 15
6 Site conditions and utilities **15**
6.1 Air quality 15
6.2 Water quality 16
6.3 Steam quality 16
6.4 Purge media quality 16
6.5 Interface and utility connection points 17
6.6 Gas turbine orientation due to site conditions 17
7 Discharges and emissions to the environment **18**
7.1 General 18
7.2 Design philosophy for prevention of unplanned release of fluids 18
7.3 Noise emissions 18
7.3.1 General 18
7.3.2 Methods for sound measurements and predictions 18
7.3.3 Sound level within the gas turbine enclosure 19
7.4 Exhaust emissions 19
7.4.1 General 19
7.4.2 Responsibilities 19
7.4.3 Reporting emissions 19
7.4.4 Start-up emissions 20
7.5 Post-combustion controls 20
7.6 Emission monitoring 20
7.7 Water, steam and other emissions 20
7.8 Visible plumes 20
8 Contract fuels **21**
8.1 General 21
8.2 Types (gas, liquids and combination) 21
8.3 Fuel composition 21
8.4 Fuel supply requirements 22

© ISO 2016 – All rights reserved

8.5 Alternative fuels (syngas, low calorific value gas, LPG, NGL, Naphtha, LNG, high hydrogen and residual fuel oil) 22

9 Fuel systems and treatment 23
9.1 General requirements 23
9.2 Gas fuel supply 23
9.3 Liquid fuel supply 23
9.4 Fuel filter/separator 24
9.4.1 Gas fuel 24
9.4.2 Liquid fuel 24
9.5 Pre-heating requirements for the dew point control of fuel gas 24
9.6 Pre-heating requirements for liquid fuels approaching their pour point 24
9.7 Alternative fuels – multi-fuel capability 24
9.8 Mixed fuel co-firing 25
9.9 Fuel for igniter 25
9.10 Start-up fuel, main fuel and fuel changeover 25
9.11 Water and steam injection systems 25
9.12 Fuel purge, vents and drains 25
9.13 Fuel system metering 25
9.14 Fuel system pipework and vessels design 26
9.14.1 General 26
9.14.2 Fuel pipes, joints and flanges 26
9.14.3 Flexible pipes 26

10 Regulations, codes and standards 26
10.1 General requirements 26
10.2 Design codes and standards 27
10.3 Verification 27

11 Operating requirements 28
11.1 General requirements 28
11.2 Operating range and limitations 28
11.3 Starts (time to start, number of starts, start restrictions) 28
11.4 Loading/de-loading 29
11.5 Grid operational requirements 29
11.6 Frequency response 30
11.7 Location of controls HMI 30
11.8 Operation documents 30
11.9 Island mode operation and black start 30
11.10 Black start and black grid restoration 31

12 Quality 31
12.1 Quality management system 31
12.1.1 General 31
12.1.2 Project quality manager 31
12.1.3 Project quality plan 31
12.1.4 Quality control plan 32
12.1.5 Inspection and test plan 32
12.2 Quality monitoring and approval 32
12.2.1 Sub-suppliers and supply chain quality monitoring 32
12.2.2 Quality surveillance by the Purchaser 33
12.2.3 Equipment approvals of statutory and coded items 33
12.2.4 Quality control record 33
12.2.5 Control of non-conforming products and services 33
12.2.6 Concessions 33
12.2.7 Project design reviews 34

13 Reliability, availability and maintainability 34
13.1 Basic RAM assessment 34
13.1.1 General 34
13.1.2 Reliability 34

 © ISO 2016 – All rights reserved

13.1.3 Starting reliability 35
13.1.4 Availability 36
13.1.5 Maintainability 36
13.1.6 Spares holding 37
13.1.7 Operating logs 37
13.2 Additional RAM requirements 38
13.2.1 General requirements 38
13.2.2 Forced outage factor and equivalent forced outage factor 38
13.2.3 Equivalent availability factor 39
13.2.4 Equivalent operating hours 41

14 Safety requirements 41
14.1 General 41
14.2 Risk assessment 41
14.3 Fire precautions 41
14.3.1 General 41
14.3.2 Enclosure fire precautions 42
14.3.3 Gas turbine hall fire precautions 42
14.4 Hazardous area classification and explosion prevention and protection 42
14.5 Flammable gas detection 42
14.6 Heat detectors 42
14.7 Smoke detection 42
14.8 Enclosed space access 42
14.9 Containment and rupture 43
14.10 Hydraulically operated safety equipment 43
14.11 Fuel system pressure testing 43
14.12 Clutch 43
14.13 Functional safety 43
14.14 Hazardous material 43
14.15 Overspeed protection system testing 44
14.16 Manual isolation features 44
14.17 Hazard identification and operability studies 44

15 Measurement, language, identification and standardization 45
15.1 Units of measurement 45
15.2 Language 45
15.2.1 General 45
15.2.2 Language for communication 45
15.2.3 Language for documentation 45
15.2.4 Language for HMI display screens 45
15.2.5 Language for labelling and signs 45
15.3 Equipment identification system, nameplates and labels 46
15.4 Standardization and interchangeability 46

16 Corrosion prevention, painting and finishing 47
16.1 General requirements 47
16.2 Painting and coating 47
16.2.1 General 47
16.2.2 Type of exposure 47
16.2.3 Visual assessment of workmanship of surface 48
16.2.4 Preparation of the surface 49
16.2.5 Application procedures 49
16.2.6 Paint materials 49
16.2.7 Galvanized coatings 49
16.2.8 Inspections and tests 50
16.3 Galvanic effects 50

17 Packing and transportation 50
17.1 Preparation 50
17.2 Packing 51

© ISO 2016 – All rights reserved

17.3 Transportation 52

18 Gas turbine core 52
18.1 Design requirements 52
18.1.1 Life (hours and weighted hours, starts, cyclic events) 52
18.1.2 Mechanical design shaft power limitations 53
18.1.3 Radial and axial clearances and control 53
18.1.4 Compressor 53
18.1.5 Turbine 54
18.1.6 Combustor 55
18.1.7 Casings 56
18.1.8 Rotor 56
18.1.9 Rotor standstill corrosion protection 57
18.1.10 Rotor overspeed capability 57
18.1.11 Vibration and dynamics 57
18.2 Vibration acceptance limits 58
18.2.1 General 58
18.2.2 Measurements on rotating shafts 59
18.2.3 Measurements on non-rotating parts 59
18.3 Balance quality 60
18.3.1 Balance planes 60
18.3.2 Balancing general 60
18.3.3 Low speed balancing 60
18.3.4 High speed balancing 60
18.4 Bearings and supports 61
18.5 Modified cycles 61
18.5.1 General 61
18.5.2 External air coolers and direct steam cooling 61

19 Gearboxes and couplings 62
19.1 Load gearbox 62
19.2 Auxiliary gears 62
19.3 Balancing and vibration 62
19.4 Main drive shaft couplings 63
19.4.1 General 63
19.4.2 Main drive flexible couplings – speeds not exceeding 4 000 r/min 63
19.4.3 Main drive flexible couplings – speeds exceeding 4 000 r/min 63
19.4.4 Quill shaft main drive flexible couplings 64
19.4.5 Rigid couplings 64
19.4.6 Over-torque devices 64
19.4.7 Coupling guards 64

20 Air inlet system 65
20.1 General 65
20.2 Air filter 65
20.3 Inlet filter house 66
20.4 Water removal systems 67
20.5 Inlet cooling systems 67
20.6 Inlet ducts and silencer 68
20.7 Resonance of ducts, silencer or turning baffles 68
20.8 Materials, fixings cladding and sealing 69
20.9 Isolation flaps and roller shutters 69
20.10 Anti-icing 70
20.10.1 General 70
20.10.2 Compressor bleed anti-icing heating (static filter) 70
20.10.3 Electric infrared heating (static filter) 70
20.10.4 Inlet coils steam or hot water heating 70
20.10.5 Electrical resistance heating 70
20.10.6 Pulse clean filters 70
20.10.7 Inlet heating fire protection and access limitations 71

 © ISO 2016 – All rights reserved

21 Exhaust system ... **71**
21.1 General ... 71
21.2 Interface between gas turbine and exhaust system ... 72
21.3 Design requirements ... 72
21.4 Mechanical requirements ... 73
21.5 Insulation ... 73
21.6 Noise requirements and silencers ... 73
21.7 Safety requirements ... 73
21.8 Diverter damper ... 74
21.9 Exhaust stack ... 74

22 Civil design and foundation requirements ... **75**
22.1 General ... 75
22.2 Basis of design ... 75
22.2.1 General ... 75
22.2.2 Allowable bearing capacity ... 75
22.2.3 Foundations, settlements and defections ... 75
22.2.4 Levelling datum(s) ... 76

23 Generator design interface requirements ... **76**
23.1 Electrical fault torque ... 76
23.2 Matching of the generator to gas turbine ... 76
23.3 Generator overspeed ... 76
23.4 Starting device ... 77

24 Heat recovery steam generation design interface ... **77**

25 Combined cycle applications ... **78**
25.1 General ... 78
25.2 Gas turbines in combined cycle applications ... 78
25.3 Single-shaft arrangements start restrictions ... 79
25.3.1 General ... 79
25.3.2 Single-shaft rotor train – with clutch ... 79
25.3.3 Single-shaft rotor train – no clutch ... 79

26 Control and instrumentation requirements ... **80**
26.1 Control ... 80
26.1.1 General requirements ... 80
26.1.2 Architecture ... 80
26.1.3 Human machine interfacing (HMI) ... 80
26.1.4 Alarm and annunciation ... 81
26.1.5 Starting ... 81
26.1.6 Sequence control ... 81
26.1.7 Governing and limiting ... 82
26.1.8 Unloading and shutdown ... 83
26.1.9 Automation ... 84
26.2 Instrumentation and associated equipment ... 85
26.2.1 General ... 85
26.2.2 Operability and diagnostics ... 85
26.2.3 Control equipment and instruments ... 85
26.2.4 Gauges ... 86
26.2.5 Solenoid valves ... 86
26.2.6 Vibration monitoring and axial position equipment ... 86
26.2.7 Actuators ... 87
26.2.8 Trace heating ... 87
26.3 Cabling and control panel installation ... 88
26.3.1 General ... 88
26.3.2 Cabling ... 88
26.4 Electrical C&I equipment ... 89
26.4.1 General ... 89
26.4.2 Electrical supplies and other services ... 89

© ISO 2016 – All rights reserved

26.4.3 Spare termination 89
26.5 Power supplies 90
26.5.1 General 90
26.5.2 Power supply sizing 90
26.5.3 Intrinsically safe power supplies 90
26.5.4 Battery systems 91
26.5.5 UPS systems 91
26.6 Electrical/electronic equipment protection 91
26.6.1 Lightning and surge protection 91
26.6.2 Electrostatic discharges (ESD) 91
26.6.3 Electromagnetic compatibility (EMC) 91
26.6.4 Electric arc welding 92
26.6.5 Earthing and bonding 92
26.7 Equipment protection 92
26.7.1 General 92
26.7.2 Protection systems 92
26.7.3 Lubrication system 93
26.7.4 Fuel system 94
26.8 Fire precautions 94
26.8.1 General 94
26.8.2 Fire detection 94
26.8.3 Enclosure fire precautions 94
26.8.4 Gas detection 94
26.8.5 Smoke detection 94
26.9 Emission control 95
26.9.1 General 95
26.9.2 Exhaust emission monitoring 95
26.9.3 Periodic sampling 96
26.10 Hazardous areas and certified equipment 96
26.11 Control and instrumentation – maintenance and spare parts 96
26.11.1 General 96
26.11.2 Equipment access 96
26.12 Data communications 97
26.12.1 General 97
26.12.2 Data acquisition storage system 97
26.13 C&I system commissioning 97

27 Electrical system requirements 98
27.1 General requirements 98
27.2 Design, layout and redundancy 100
27.3 Earthing and lightning protection, equipotential bonding 100
27.4 LV power supply requirements 101
27.5 LV switchgear and control equipment 102
27.6 DC distribution 102
27.7 Battery including battery charger – DC/AC converter 103
27.8 Control system power supply 104
27.9 Conductors, cables and wiring practices general 104
27.10 Conductors, cables and wiring practices outside cabinets 105
27.11 Wiring inside cabinets 105
27.12 Electric motors 105
27.13 Junction boxes and cabinets 106
27.14 Protection against electric shock 106
27.15 Trace heating 106
27.16 Grid codes 106

28 Maintenance requirements 107
28.1 General 107
28.2 Design for maintenance 107
28.3 Maintenance strategy (***in situ*** or at works) 107

 © ISO 2016 – All rights reserved

28.4 Maintenance planning (scheduled maintenance, scheduled inspections) 107
28.5 Parts repairs and replacement 108
28.5.1 Repair 108
28.5.2 Component lives 108
28.6 Tools 108
28.7 Spares 109
28.7.1 General 109
28.7.2 Strategic spares 109
28.8 Training 109
28.9 Outage maintenance 110
28.9.1 Programmed maintenance 110
28.9.2 Degradation after maintenance period 111
28.9.3 Maintenance scope and planning 111
28.10 Maintenance documentation 111

29 Enclosures 112
29.1 General 112
29.2 Construction 113
29.2.1 General 113
29.2.2 Weatherproofing of enclosure 113
29.2.3 Acoustic and heat insulation 113
29.2.4 Ventilation and explosion prevention and protection 114
29.2.5 Internal heating 115
29.2.6 Lighting 115
29.2.7 Enclosure instrumentation 115
29.2.8 Flooring 116
29.2.9 Personnel doorway design (including access panels) 116
29.3 Access and egress 116
29.3.1 General 116
29.3.2 Enclosure roof access 117
29.4 Maintenance within enclosures 117
29.4.1 General 117
29.4.2 Disassembly of enclosure for maintenance 118
29.5 Platforms and access ways 118
29.6 Mechanical handling and cranes 118
29.6.1 General 118
29.6.2 Mobile crane 119
29.6.3 Fixed installed crane 119
29.7 Laydown and storage 119
29.8 Enclosure fire precautions 119

30 Auxiliary equipment 120
30.1 Barring equipment 120
30.1.1 General 120
30.1.2 Gas turbine barring systems 120
30.1.3 Safety and operational requirements 121
30.2 Starting systems 121
30.2.1 Types 121
30.2.2 General and design requirements 122
30.2.3 Power supply for starting systems 122
30.2.4 Start-up restrictions 123
30.3 Lube oil systems 123
30.3.1 General requirements 123
30.3.2 Design requirements 123
30.3.3 Oil reservoirs and storage tanks 125
30.3.4 Temperature control and heating 125
30.3.5 Coolers 125
30.3.6 Filters and contamination 126
30.3.7 Lube oil selection, type and quality 126

© ISO 2016 – All rights reserved

30.3.8 Use of synthetic oil 127
30.3.9 Minimum supervision requirements 127
30.4 Compressor water wash systems 128
30.4.1 General 128
30.4.2 Off-line systems 128
30.4.3 On-line systems 129
30.5 Cooler 129
30.5.1 Interstage cooling 129
30.5.2 Cooling air coolers 129
30.5.3 Water cooling systems 129
30.6 Pipework 130
30.6.1 Piping design code 130
30.6.2 General requirements 130
30.6.3 Testing and certification 130
30.6.4 Hydrostatic testing 130
30.6.5 Non-destructive examination (NDE) 131
30.6.6 Mechanical requirements 131
30.6.7 Joints and connections 131
30.6.8 Corrugated flexible metal hoses and hose assemblies 132
30.6.9 Non-metallic flexible hoses, hose assemblies and end connections 132
30.6.10 Flange connectors 132
30.6.11 Insulation of pipework 132
30.6.12 Trace heating 133
30.6.13 Drains 133
30.6.14 Vents 133
30.6.15 Equipment access 133
30.7 Pressure equipment 134

31 Condition monitoring 134
31.1 General 134
31.2 Vibration monitoring system 134
31.2.1 Introduction and overview 134
31.2.2 On-line vibration analysis systems 134
31.2.3 Off-line vibration analysis system 135
31.3 Data acquisition and trend monitoring 135
31.3.1 General 135
31.3.2 Scope 135
31.3.3 Data-acquisition 135
31.3.4 Trend monitoring system 135

32 Installation and commissioning 136
32.1 Installation 136
32.2 Commissioning 137

33 Verification testing 138
33.1 Scope 138
33.2 Reliability test 138
33.3 Contractual performance tests 139
33.3.1 General 139
33.3.2 Test procedure 139
33.3.3 Measurement uncertainty 140
33.3.4 Tolerances 140
33.3.5 Correction curves 140
33.3.6 Performance degradation 140
33.3.7 ISO TIT values 140
33.4 Noise tests 140
33.5 Emissions test 141

34 Design life 141

35 Technical information and documents 141

 © ISO 2016 – All rights reserved

35.1 General 141
35.2 Instructions for use 142
35.2.1 General 142
35.2.2 Document format 142
35.3 Document submission stages and responsibility 142
35.4 General documentation 142
Annex A (normative) **Use of data sheet requirements and options** **144**
Bibliography **146**

© ISO 2016 – All rights reserved

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*.

© ISO 2016 – All rights reserved

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.

© ISO 2016 – All rights reserved

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.

© ISO 2016 – All rights reserved

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 2016 – All rights reserved

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 2016 – All rights reserved

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 2016 – All rights reserved

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*

© ISO 2016 – All rights reserved

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 (Um = 1,2 kV) up to 30 kV (Um = 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*

 © ISO 2016 – All rights reserved

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*

© ISO 2016 – All rights reserved

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.

© ISO 2016 – All rights reserved

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

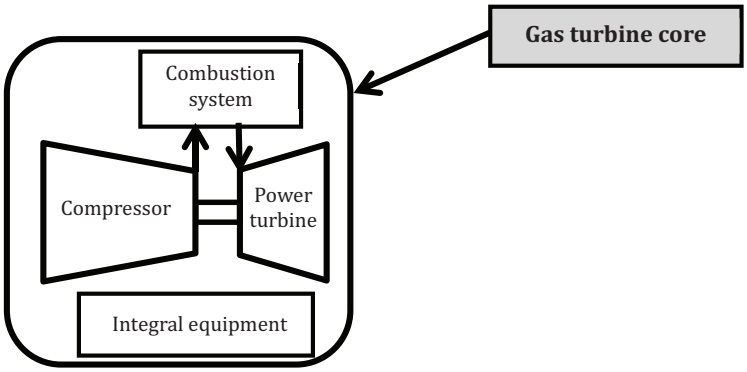


Figure 1 — Gas turbine core

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)

© ISO 2016 – All rights reserved

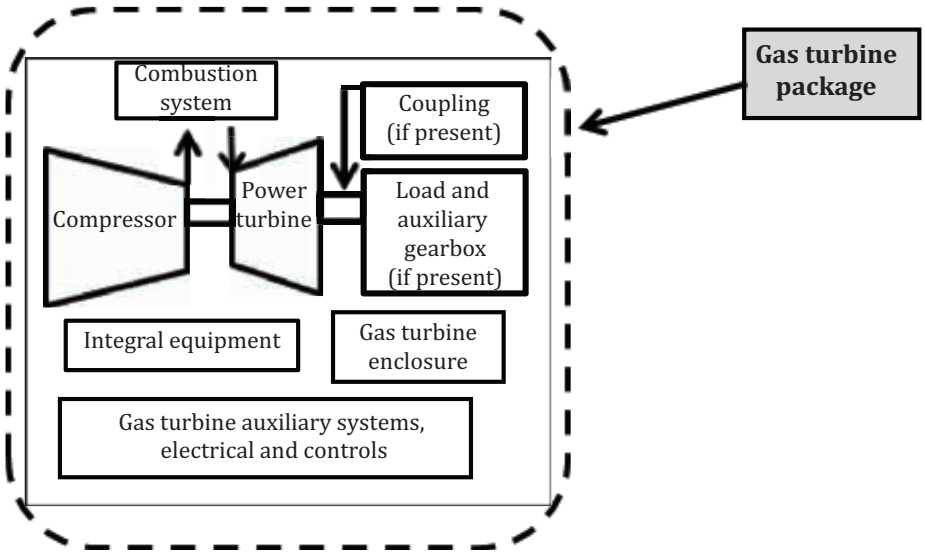


Figure 2 — Gas turbine package

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)

© ISO 2016 – All rights reserved

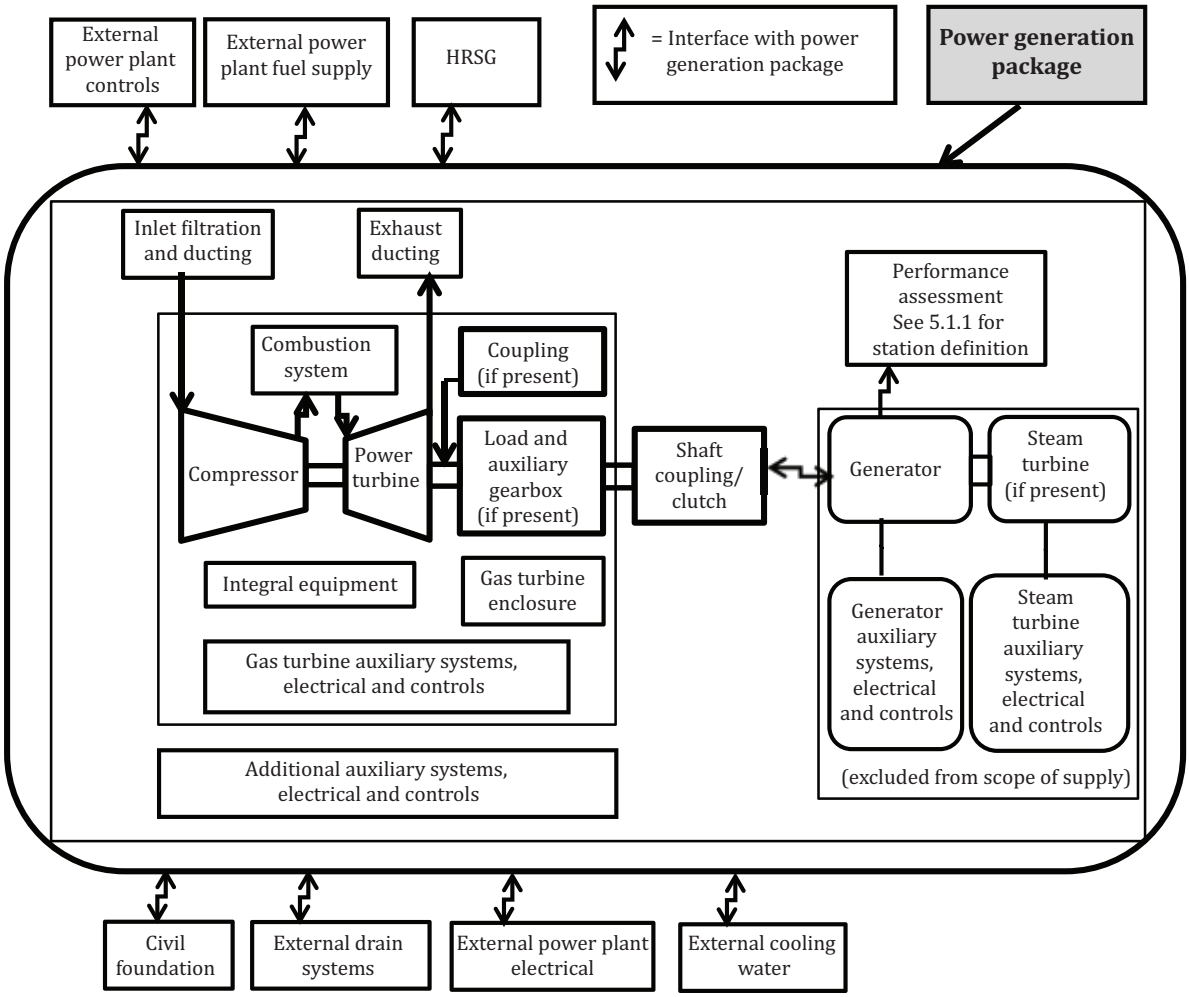


Figure 3 — Power generation package

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]

© ISO 2016 – All rights reserved

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

© ISO 2016 – All rights reserved