

ISO 19859:2016-06 (E)

Gas turbine applications - Requirements for power generation

| 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 |
| 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 |
| 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 |
| 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 |
| 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 deflections | 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 |
| 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 |

| | | |
|--------|---|-----|
| 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 |
| 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 |
| 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