# ISO 21789:2009-02 (E)

## Gas turbine applications - Safety

## Contents

Page


Foreword ..... vii

Introduction ..... viii

1 Scope ..... 1

2 Normative references ..... 1

3 Terms and definitions ..... 4

4 List of significant hazards ..... 5

5 Safety requirements ..... 6
5.1 General ..... 6
5.2 Risk assessment ..... 6
5.3 Modifications and replacement parts ..... 7
5.4 Foreseeable misuse ..... 7
5.5 Lifetime ..... 7
5.6 Hazard combinations ..... 7
5.7 Noise ..... 8
5.8 Mechanical ..... 8
5.8.1 Guarding ..... 8
5.8.2 Accessibility for maintenance ..... 8
5.8.3 Casing design ..... 9
5.8.4 Gas turbine compressor surge ..... 9
5.8.5 Stability and handling ..... 9
5.8.6 Overload of rotating shafts due to torque ..... 9
5.8.7 Vibration ..... 9
5.8.8 Mechanical failure caused by corrosion ..... 10
5.8.9 Design methods and materials ..... 10
5.8.10 Gas turbine temperatures ..... 10
5.8.11 Environmental loads ..... 10
5.8.12 Assembly features ..... 11
5.8.13 Couplings ..... 11
5.8.14 Rotor bearings ..... 11
5.8.15 Rotating part failure ..... 11
5.8.16 Foreign object damage (FOD) screen ..... 12
5.8.17 Gearbox ..... 12
5.8.18 Starting systems ..... 12
5.8.19 Low ambient temperature conditions ..... 13
5.9 Gas turbine compressor air inlet system ..... 13
5.9.1 General ..... 13
5.9.2 Inlet air contamination ..... 13
5.9.3 Icing monitoring and prevention ..... 13
5.9.4 Implosion protection ..... 14
5.9.5 Inlet explosion protection ..... 14
5.9.6 Waste disposal through combustion ..... 14
5.9.7 Recirculation ..... 15
5.9.8 Gas turbine compressor air inlet ducting ..... 15
5.10 Fuel systems ..... 15
5.10.1 General ..... 15
5.10.2 Fuel supply quality and supply conditions ..... 15

5.10.3 Pressure testing ..... 16
5.10.4 Fuel supply heating ..... 16
5.10.5 Gas fuel systems ..... 16
5.10.6 Liquid fuel systems ..... 20
5.10.7 Multi-fuel systems ..... 23
5.10.8 Fuel purging ..... 23
5.10.9 Fuel drainage ..... 24
5.11 Combustion supervision ..... 24
5.11.1 General ..... 24
5.11.2 Requirements for ignition ..... 24
5.11.3 Extinction safety time ..... 25
5.12 Exhaust system ..... 25
5.12.1 Damper controls ..... 25
5.12.2 Flexible joint location ..... 25
5.12.3 Exhaust stack ..... 25
5.12.4 Explosion protection ..... 25
5.13 Enclosures ..... 26
5.13.1 General ..... 26
5.13.2 Enclosure structure ..... 26
5.13.3 Enclosure fire precautions ..... 27
5.13.4 Explosion prevention and protection -- Area classification -- Ventilation ..... 27
5.13.5 Gas detection ..... 27
5.13.6 Enclosure purging ..... 27
5.13.7 Mist detection ..... 27
5.13.8 Access and doors ..... 28
5.13.9 Entrapment ..... 28
5.14 Lighting ..... 28
5.15 Fire precautions ..... 28
5.15.1 General ..... 28
5.15.2 Structural fire risk reduction ..... 28
5.15.3 Hydrocarbon fire risk reduction ..... 29
5.15.4 Fire protection ..... 29
5.15.5 Fire detection ..... 30
5.15.6 Fire extinguishing systems ..... 30
5.15.7 Water mist extinguishant ..... 31
5.15.8 Extinguishing system controls ..... 31
5.15.9 Escape ..... 33
5.15.10 Uncontrolled release of media and loss of propellant pressure ..... 33
5.15.11 Vessel thermal relief (burst disc) ..... 33
5.15.12 Vessel and/or pipe failure ..... 33
5.15.13 Release of extinguishant into gas turbine halls, control rooms, etc ..... 34
5.16 Hazardous area classification and explosion prevention and protection ..... 34
5.16.1 General ..... 34
5.16.2 Area classification ..... 34
5.16.3 Explosion prevention ..... 34
5.16.4 Ignition source control ..... 35
5.16.5 Reduction of explosion effects in an enclosed space ..... 35
5.17 Ventilation ..... 37
5.17.1 General ..... 37
5.17.2 Cooling ..... 37
5.17.3 Heating ..... 37
5.17.4 Hazardous area control ..... 38
5.17.5 Hot surfaces ..... 38
5.17.6 Ventilation inlet location ..... 38
5.17.7 Ventilation inlet filtration ..... 38
5.17.8 Ventilation inlet ducting ..... 38
5.17.9 Ventilation outlet location ..... 39
5.17.10 Flow monitoring -- Artificial ventilation ..... 39
5.18 Fans ..... 39
5.18.1 Fan guards and structural failure ..... 39
5.18.2 Air blast oil coolers ..... 39
5.19 Flammable gas detection ..... 39

5.19.1 General ..... 39
5.19.2 Type/selection principles ..... 39
5.19.3 Location principles ..... 40
5.19.4 Settings ..... 40
5.19.5 Enclosures containing hot surfaces -- Screening tool ..... 40
5.19.6 Maintenance and calibration ..... 40
5.20 Control and automatic protection systems ..... 41
5.20.1 General ..... 41
5.20.2 Environmental suitability ..... 41
5.20.3 Ergonomics ..... 41
5.20.4 Failure ..... 41
5.20.5 Calibration ..... 41
5.20.6 Testing ..... 41
5.20.7 Speed control ..... 42
5.20.8 Gas turbine emergency shut-down system ..... 42
5.20.9 Interlocks ..... 43
5.21 Electrical ..... 43
5.21.1 Design/Installation ..... 43
5.21.2 Isolation and stored energy ..... 43
5.21.3 Electrostatic energy and bonding ..... 44
5.21.4 Water ingress ..... 44
5.21.5 Lightning ..... 44
5.21.6 Electromagnetic compatibility (EMC) ..... 44
5.21.7 Battery installations ..... 45
5.21.8 Electrical overload ..... 45
5.21.9 Electrical power failure ..... 45
5.22 Drains, vents and bleeds ..... 45
5.22.1 General ..... 45
5.22.2 Vents for flammable gases ..... 46
5.22.3 Toxic and hazardous emissions ..... 46
5.22.4 Gas turbine compressor bleeds ..... 46
5.23 Pressure equipment ..... 47
5.23.1 General ..... 47
5.23.2 Design ..... 47
5.23.3 Hazards ..... 47
5.23.4 Misuse ..... 47
5.23.5 Safe handling and operation ..... 47
5.23.6 Isolation, draining and venting ..... 48
5.23.7 Fluid injection ..... 48
5.23.8 Assemblies ..... 48
5.23.9 Safety accessories ..... 49
5.23.10 Flexible piping (and metal hoses) ..... 50
5.23.11 External fire ..... 50
5.23.12 Material embrittlement and corrosion ..... 50
5.23.13 Ultra-violet (UV) resistant pipework ..... 51
5.24 Auxiliary systems ..... 51
5.24.1 Lubrication systems ..... 51
5.24.2 Water systems ..... 51
5.24.3 Hydraulic and pneumatic systems ..... 52
5.24.4 Utility supplies ..... 52
5.25 Installation in a hazardous area ..... 52
5.26 Unenclosed gas turbines in a hall ..... 53
5.27 Decommissioning and disposal ..... 53

6 Compliance verification ..... 53
6.1 Quality assurance ..... 53
6.2 Verification of safety requirements ..... 54

7 Information for use ..... 54
7.1 General ..... 54
7.2 Language ..... 54
7.3 Packaging ..... 54

7.4 Commissioning ..... 54
7.5 Operation ..... 55
7.5.1 General ..... 55
7.5.2 Safety instructions and emergency procedures ..... 56
7.6 Enclosure access ..... 57
7.6.1 General ..... 57
7.6.2 Risk assessment for accessing enclosures ..... 57
7.6.3 Limitations under operational conditions ..... 58
7.6.4 Limitations under non-operational conditions ..... 58
7.6.5 Access during commissioning and re-commissioning ..... 58
7.6.6 Installations in a hazardous area ..... 58
7.7 Maintenance ..... 58
7.7.1 General ..... 58
7.7.2 General maintenance hazards ..... 59
7.7.3 Accessibility, isolation and energy dissipation ..... 59
7.7.4 Pressure equipment ..... 59
7.7.5 Fire protection systems ..... 60
7.7.6 Gas detectors ..... 60
7.7.7 Control systems: maintenance, calibration and testing ..... 60
7.7.8 Hazardous materials ..... 61
7.8 Warning signs and notices ..... 61
7.9 Permit to work (PTW) ..... 62
7.10 Training ..... 62
7.11 Decommissioning and disposal ..... 62

Annex A (informative) List of significant hazards ..... 63

Annex B (normative) Verification of safety requirements and/or measures ..... 71

Bibliography ..... 77

Index ..... 79