

23 (6.6.D) SF₆ and Other Special Gases

23.1 Functions, Basic Configuration, and Interfaces

23.1.1 Functions

The primary function performed by the SF₆ and other special gases system is to provide SF₆ and other special gases for equipment and other plant needs.

23.1.2 Basic Configuration

The function is accomplished by storage cylinders and other equipment needed to meet the requirements detailed in this document. An important feature of the SF₆ and other special gases system is that it covers needs for these gases for the entire ITER plant. The SF₆ gas makeup in the power supply areas will be provided by high pressure cylinders. The SF₆, deuterium, hydrogen, neon, argon, ultra-pure nitrogen and other special gases equipment are located in the areas and buildings where the gas is needed and the gases are delivered to the users by a building distribution system. The principal users are located in the tokamak, tritium and hot cell buildings and the NB H&CD system power supply area.

Currently, all needs for special gases are small, such that a central distribution system is not economical. Rather, the special gas system will consist of primarily "multi-bottle stations" located near the point of use. The stations have regulators and pressure monitors to assure safe and reliable delivery to the user.

23.1.3 Interfaces

The SF₆ and other special gases system interfaces with the following WBS elements:

23.1.3.1 Tokamak Building

WBS Title

5.3 Neutral Beam Heating and Current Drive (H&CD) System

23.1.3.2 Steady State Power Supply

WBS Title

4.3.A Steady State HV Substation

23.1.3.3 Auxiliary Building Subsystem

WBS Title

4.1.B High Voltage Substation & AC Power Distribution

4.2.C NB H&CD System Power Supplies

6.2.E Auxiliary Buildings

23.2.1.2 Deuterium Gas

The detailed needs (including purity) for deuterium gas are listed in Appendix A. The resulting deuterium gas bottle stations and their characteristics are given in Table 23 (6.6.D)-2.

Table 23 (6.6.D) -2 Deuterium Gas Bottle Stations

| Building name | Systems | Number of standard bottles/station | Bottle consumption (# per month) |
|----------------------|----------------|-------------------------------------------|-----------------------------------------|
| Tritium | Fuelling | 2 banks of 12 | 0.5 |

23.2.1.3 Hydrogen Gas

The detailed needs (including purity) for hydrogen gas are listed in Appendix A. The resulting hydrogen gas bottle stations and their characteristics are given in Table 23 (6.6.D)-3.

Table 23 (6.6.D) -3 Hydrogen Gas Bottle Stations

| Building name | Systems | Number of standard bottles/station | Bottle consumption (# per month) |
|----------------------|-------------------------------|-------------------------------------------|-----------------------------------------|
| Tokamak | TBM | 1 bank of 12 | 0.5 |
| Tritium | Fuelling in the tritium plant | 1 bank of 12 | 2 |

23.2.1.4 Argon Gas

The detailed needs (including purity) for argon gas are listed in Appendix A. The resulting argon gas bottle stations and their characteristics are given in Table 23 (6.6.D)-4.

Table 23 (6.6.D) -4 Argon Gas Bottle Stations

| Building name | Systems | Number of standard bottles/station | Bottle consumption (# per month) |
|----------------------|----------------|-------------------------------------------|-----------------------------------------|
| Tritium | Fuelling | 2 banks of 12 | 1 |

23.2.1.5 Neon Gas

The detailed needs (including purity) for neon gas are listed in Appendix A. The resulting neon gas bottle stations and their characteristics are given in Table 23 (6.6.D)-5.

Table 23 (6.6.D) -5 Neon Gas Bottle Stations

| Building name | Systems | Number of standard bottles/station | Bottle consumption (# per month) |
|----------------------|----------------|-------------------------------------------|-----------------------------------------|
| Tritium | Fuelling | 2 banks of 12 | 1 |

23.2.1.6 Pure Nitrogen Gas

The detailed needs (including purity) for pure nitrogen gas are listed in Appendix A. The resulting pure nitrogen gas bottle stations and their characteristics are given in Table 23 (6.6.D)-6.

Table 23 (6.6.D) -6 Pure Nitrogen Gas Bottle Stations

| Building name | Systems | Number of standard bottles/station | Bottle consumption (# per month) |
|----------------------|----------------|-------------------------------------------|-----------------------------------------|
| Tritium | Fuelling | 2 banks of 12 | .05 |

Note: Pure nitrogen gas needs are distinguished from bulk industrial quality nitrogen gas needs, which is within the scope of the nitrogen, helium system (chapter 23 (6.6.C)).

23.2.1.7 Pure Helium Gas

The detailed needs (including purity) for pure helium gas are listed in Appendix A. The resulting pure helium gas bottle stations and their characteristics are given in Table 23 (6.6.D) -7.

Table 23 (6.6.D) -7 Pure Helium Gas Bottle Stations

| Building name | Systems | Number of standard bottles/station | Bottle consumption (# per month) |
|----------------------|----------------|-------------------------------------------|-----------------------------------------|
| Tritium | Fuelling | 2 banks of 12 | .05 |

23.2.1.8 Pure Helium/Oxygen Gas

The detailed needs (including purity) for pure helium/oxygen gas are listed in Appendix A. The resulting pure helium/oxygen gas bottle stations and their characteristics are given in Table 23 (6.6.D) -8.

Table 23 (6.6.D) -8 Pure Helium/Oxygen Gas Bottle Stations

| Building name | Systems | Number of standard bottles/station | Bottle consumption (# per month) |
|----------------------|----------------|-------------------------------------------|-----------------------------------------|
| Tritium | Fuelling | 2 banks of 12 | .05 |

23.2.1.9 Gas Bottle Stations

Bottle stations shall consist of two to twelve, or more if required, standard laboratory or industrial gas bottles for each type of specialty gas. Each type of specialty gas supply will be equipped with its own regulators, pressure monitors and automatic bottle switching. The stations shall be located outside the buildings which they serve. Distribution lines shall interface with the system supply line at the building boundary. Flammable or explosive gas bottles shall be further protected by concrete barriers.

23.2.1.10 Standard Gas Bottles

Standard laboratory gas bottles shall have a capacity of 8.5 Nm³ at 15.5 MPa(g).

23.2.1.11 Check Valves

All specialty gas bottle stations shall have check valves that will isolate the station from the distribution system if gas pressure in the distribution system is greater than the station pressure. The SF₆ recovery unit is an exception to this requirement.

23.2.1.12 Capacity Margin

All gas bottle stations shall have storage capacity equal to 2 months of use.

23.2.2 **General**

23.2.2.1 Mechanical

23.2.2.1.1 Storage Pressure

The storage pressure for specialty gases shall be nominally 15.5 MPa(g). The SF₆ low pressure storage tank shall be 2 MPa(g).

23.2.2.1.2 Distribution Pressure

Unless otherwise specified all specialty gas distribution systems shall be regulated to provide gas at a minimum of 590 kPa and a maximum of 865 kPa.

23.2.2.1.3 Safety Relief Devices

All gas systems shall have safety relief devices for overpressure protection in accordance with local site regulations. This requirement does not apply to gas storage bottles, which are self-relieving.

23.2.2.1.4 Security

All bottle stations shall be designed to hold the gas bottles securely, so as to prevent them from falling or being knocked over, thus guarding against them breaking while under pressure, which could cause portions of the bottles to become missiles.

23.2.2.2 Electrical

All electrical components (pumps, etc.) shall operate at standard IEC nominal voltages. In order to limit the number of step-down transformers, preference shall be given to 11 kV for large equipment (> 500 kW) and to 3.3 kV for (100-500 kW).

23.2.2.3 Seismic

The SF₆ and other special gas system shall be seismic class 0.

23.2.2.4 Instrumentation and Control

23.2.2.4.1 Pressure Monitoring

Unless otherwise specified, all subsystems shall provide local pressure instrumentation as appropriate for the service delivered. Pressure gauges shall be provided upstream and downstream of the pressure regulating valve. A pressure switch, set at 865 kPa(g) (or at the maximum pressure for the connected system) shall be provided on the supply line to be used by others to activate their interlocks.

23.2.2.4.2 Flow Monitoring

Unless otherwise specified, all subsystems shall provide local flow instrumentation as appropriate for the service delivered.

23.2.2.4.3 SF₆ & Other Special Gases Quality Monitoring

Unless otherwise specified, all distribution systems shall provide local gas quality instrumentation as appropriate for the service delivered.

23.2.2.4.4 Control Panels

System pressure regulation shall be from local control panels at the supply stations. System pressure, flow and gas quality data shall be available both locally and remotely.

23.2.2.5 Grounding/Insulation

All major equipment piping shall be firmly grounded to the site ground grid.

23.2.2.6 Materials

23.2.2.6.1 Pipes and Vessels

Unless otherwise specified, all subsystems shall use Class HB (red brass, extra strong piping ASTM B43) for high pressure circuits. For low pressure circuit class ATB (copper piping ASTM B88) shall be used. SF₆ receivers, valves and supply lines shall be 316 SS.

23.2.2.6.2 Electrical

All cables will be made with copper and should have the 15 kV, 6 kV and 0.6 kV rated

insulation voltage for 11 kV, . Cable insulation should meet the following requirements:

- insulation material XLPE preferred, PVC not accepted;
- max. permissible temperature of conductor:
 - continuous 90°C,
 - under short circuit conditions 250°C;
- acid gas content zero halogen, according to IEC-754;
- fire retardancy according to IEC-332

Table 23 (6.6.D) -9 IEC Relevant Material

| IEC # | Technical Committee | Title |
|------------|---------------------|--------------------------------------------------------------|
| 332-1 to 3 | SC 20C | Test on electric cables under fire conditions |
| 728 | SC 12G | Cable distribution systems |
| 754 | SC 20C | Tests on gases involved during combustion of electric cables |
| 840 | SC 20A | Test on electric cables 30 kV to 150 kV |

23.2.3 Operation and Maintenance

The operations and maintenance (O&M) requirements for the SF₆ and other special gases system are derived from DRG1 and the functions of the gas distribution system. The following are the O&M requirements of the system.

23.2.3.1 Accessibility

All gas distribution systems shall be designed such that operations and maintenance personnel are able to perform their duties with reasonable accessibility to the equipment.

23.2.3.2 Operability

SF₆ and other special gases, at or above the minimum specifications, shall be available for at least 10 minutes following the loss of electrical power.

23.2.4 Surveillance and In-Service Inspection

23.2.4.1 Visual Inspection

All gas distribution components shall provide visual inspection access for surface corrosion, cracks and other signs of degradation on the outer surfaces of components.

23.2.4.2 Corrosion Control

Components which are vulnerable and exposed to corrosive conditions shall have features which control corrosion or make allowances for corrosion over the expected life of the component.

23.2.5 Quality Assurance (QA)

The SF₆ and other special gases system quality assurance specifications shall be consistent with local building codes, ITER plant quality assurance requirements for safety importance classification (SIC) systems and quality levels for standard industrial equipment.

23.3 Codes and Standards

The design, construction and operation of the system and components shall conform to the following standards and code:

- All piping shall be in accordance with ANSI piping code B31.1.
- All pressure vessels shall conform with section VIII, ASME boiler and pressure vessel code.
- Materials shall conform to:
 - ASTM B43 for high pressure piping.
 - ASTM B88 for low pressure piping.

Appendix A Detailed List of Specialty Gas Requirements

| WBS Item | Application | Location: - Bldg. Number and Name | Initial Fill Nm ³ [@ kPa(g)] | Continuous Supply Nm ³ /day [@ kPa(g)] | Gas Quality |
|----------------------------------------------------|----------------------------------|-----------------------------------------|---------------------------------------------------|-------------------------------------------------------------|-----------------------|
| <i>SF₆</i> | | | | | |
| 4.2.C NB H&CD System Power Supplies | HV line insulation | 37 NB Power Supply Area | 5,520 | | Industrial |
| | HV power equipment | 11 Tokamak Building | 1,240 | | Industrial |
| 4.2.C NB H&CD System Power Supplies | HV Transmission line N1 | 21 Hot Cell Building | 80 | | Industrial |
| 4.1 Coil Power Supply and Distribution | Switchyard HV equipment | 35 Switchyard Grade level | From supplier | None | Supplier specified |
| 4.3 Steady State Electrical Power Network | Switchyard HV equipment | 42 Switchyard Grade level | From supplier | None | Supplier specified |
| <i>Neon</i> | | | | | |
| 1.8 Fuelling and Wall Conditioning | Radiative divertor | 14 Tritium | Not applicable | 0.2/plasma pulse @ 101 kPa(g) 10 pulses per day | Laboratory grade |
| <i>Argon</i> | | | | | |
| 1.8 Fuelling and Wall Conditioning | Radiative divertor | 14 Tritium | Not applicable | 0.2/plasma pulse @ 101 kPa(g) 10 pulses per day | Laboratory grade |
| <i>Deuterium</i> | | | | | |
| 1.8 Fuelling and Wall Conditioning | NB ion source fuelling | 14 Tritium | | 33 MW @ 1 Mev for 3,600 s pulses | Ultra-high purity |
| 1.8 Fuelling and Wall Conditioning | VV glow discharge cleaning | 14 Tritium | 25 @ 101 kPa(g) | | Ultra-high purity |
| <i>Hydrogen</i> | | | | | |
| 1.8 Fuelling and Wall Conditioning | NB ion source fuelling | 14 Tritium | | 33 MW @ 1 Mev for 3,600 s pulses | Ultra-high purity |
| 3.2 Tritium Plant | ISS* and VPCE** | 14 Tritium | 25 @ 101 kPa(g) | | Laboratory grade |
| 5.6 Test Blankets | TBM+ purge | Tokamak, equatorial port | | 0.1-1% of 50 liter/min during pulse campaign | Laboratory grade |
| <i>Ultra-Pure Nitrogen</i> | | | | | |
| 1.8 Fuelling and Wall Conditioning | Radiative divertor | 14 Tritium | Not applicable | 0.2/ plasma pulse @ 101 kPa(g) 10 pulses per day | Ultra-high purity |
| <i>Ultra-Pure Helium</i> | | | | | |
| 1.8 Fuelling and Wall Conditioning | Radiative divertor | 14 Tritium | Not applicable | 0.2/ plasma pulse @ 101 kPa(g) 10 pulses per day | Ultra-high purity |

| WBS Item | Application | Location: - Bldg. Number and Name | Initial Fill Nm ³ [@ kPa(g)] | Continuous Supply Nm ³ /day [@ kPa(g)] | Gas Quality |
|------------------------------------------|-----------------------|-----------------------------------------|-----------------------------------------------|---------------------------------------------------------|----------------------|
| <i>Ultra-Pure Helium/Oxygen</i> | | | | | |
| 1.8 Fuelling and Wall Conditioning | Radiative divertor | 14 Tritium | Not applicable | 0.2/ plasma pulse @ 101 kPa(g) 10 pulses per day | Ultra-high purity |

- * isotope separation system
- ** vapour phase catalytic exchange (for detritiation)
- *** maintenance detritiation system
- + test blanket module