

23 (6.6.C) Nitrogen, Helium System

23.1 Functions, Basic Configuration, and Interfaces

23.1.1 Functions

The primary function performed by the nitrogen, helium gas system is to provide nitrogen, helium and other gases for equipment and other plant needs.

23.1.2 Basic Configuration

The function is accomplished by storage tanks and other equipment needed to meet the requirements detailed in this document.

An important feature of the nitrogen, helium gas system is that it covers needs for these gases for the entire ITER plant. For the very large volumes of helium in the cryoplant, dedicated storage tanks and distribution lines are provided by the cryoplant distribution system (WBS 3.4). However, most ITER systems have small volumetric needs for these gases and local banks of bottled gas with a localized distribution system is cost effective. The nitrogen, helium gas system equipment is located in the site services building or adjacent to other ITER buildings and the gases are delivered to the users by a local pipe distribution system. The principal users are located in the tokamak, tritium and hot cell buildings.

Currently only nitrogen and helium are specified for this system, but additional gases will be added if equipment designers develop needs for significant volumes of other gases.

An important limitation to this system is that it can supply the gases at standard industrial qualities. If higher quality standards are required, they can be met by including the gas in the special gas list for the WBS that covers SF₆ and special gases (WBS 6.6.D).

23.1.3 Interfaces

The gas distribution systems have interfaces with the following WBS elements:

Subsystem	WBS Elements	
Tokamak Building	1.8	Fuelling and Wall Conditioning
	2.6.D	Divertor PHTS
	2.6.E	Vacuum Vessel PHTS
	2.6.F	Additional Heating PHTS
	2.6.G	Test Blanket Modules PHTS
	3.1	Vacuum Pumping & Leak Detection Systems
	3.2.A	Tokamak Exhaust Processing
	5.1	IC H&CD System
	5.2	EC H&CD System
	5.3.B	NB Injector
	5.3.D	Neutral Beam Cell
	5.3.E	Neutral Beam Services
	5.5	Diagnostics
	6.2.A	Tokamak Buildings
Tritium Building	1.8	Fuelling and Wall Conditioning
	3.1	Vacuum Pumping & Leak Detection Systems
	3.2.A	Tokamak Exhaust Processing
	3.2.B	HDT Isotope Separation
	3.2.C	Fuel Storage and Delivery
	3.2.E	Water Detritiation
	3.2.F	Atmosphere Detritiation
	3.2.G	Tritium Recovery from PFC Materials
	3.2.H	Tritium Plant Analytical Facilities
	3.2.J	Tritium Plant Control Systems
	3.2.K	Tritium Extraction from Breeding Blanket Test Modules
	5.1	IC H&CD System
	5.2	EC H&CD System
	6.2.A.02	Tritium Building
Hot Cell Building Subsystem	6.2.B	Hot Cell Building
	6.2.G	Radwaste and Personnel Building
	6.3.A	Hot Cell Docking and Storage
	6.3.B	Hot Cell Waste Processing and Storage
	6.3.C	Hot Cell Component Repair
	6.3.D	Low Level Waste Processing
Cryoplant Building Subsystem	3.4.A	Cryoplant
	3.4.B	Cryodistribution
	4.3.C	Steady-State Electrical Power Distribution
	6.2.J	Cryoplant Buildings
Emergency Power Supply Building Subsystem	4.3.A	Steady-State HV Switchyard
	4.3.C	Steady-State Electrical Power Distribution
	6.2.L	Emergency Power Supply Building
Auxiliary Building Subsystem	4.1	Coil Power Supply and Distribution
	4.2.A	IC H&CD System Power Supplies
	4.2.B	EC H&CD System Power Supplies
	4.2.C	NB H&CD System Power Supplies
	6.2.E	Auxiliary Buildings
Site Services Building Subsystem	2.6.L	Circulating Water System
	2.6.M	Cooling Tower System
	2.6.O	Component Cooling System
	2.6.P	Chilled Water Systems
	6.2.M	Site Services Building
	6.3.F	Non-Radioactive Waste Systems
	6.5.C	Potable & Fire Water
	6.5.D	Sewage (Sanitary & Industrial)
6.5.E	Steam/Condensate/Demineralized Water	

23.2 Design Requirements

The requirements for the nitrogen, helium gas system are derived from DRG1 and the ITER plant gas needs.

The design requirements listed below, design parameters and other criteria are used for the system sizing, layout, determination of system reliability and the selection of major components for the nitrogen, helium gas system. It is expected that the following sections identify the requirements which control the overall configuration and general design concept of the nitrogen, helium gas system.

Appendix A gives a list of nitrogen and helium gas requirement for the ITER client systems for both initial fill and continuous use conditions. This data is used to size the storage and flow components.

23.2.1 Specific

23.2.1.1 Gaseous Nitrogen Demand

Gaseous nitrogen shall be supplied in a distributed system from a number of pressurized storage tanks and liquid nitrogen tanks with vaporizers (depending on purity requirements). The gaseous nitrogen use profile, purity and total calculated consumption is given in Appendix A. The max/avg. monthly consumption is 195,000/89,000 Nm³ for all purity levels.

Nitrogen gas shall be supplied through a distribution system with a connection to the following buildings:

- tokamak building
- tritium building
- hot cell building
- radwaste building
- auxiliary building
- site services building

23.2.1.2 Gaseous Nitrogen Storage Capacity

The gaseous nitrogen storage capacity shall be equal to the average monthly consumption. The storage pressure shall be in pressurized gas storage tanks @15.5 MPa(g) for impurity levels > 0.1% by volume. For lower impurity levels, the storage shall be in the form of liquid nitrogen tanks with vaporizers.

23.2.1.3 Gaseous Nitrogen Purity

Gaseous nitrogen shall be supplied at two purity levels depending on user requirements. Systems which require impurity levels of < 1% shall be supplied by N₂ with an impurity level of ~ 0.1%. Systems which require impurity levels of < 0.1% shall be supplied by N₂ with an impurity level of ~ 0.01%. All gas shall be "ultra-dry" with a dew-point of < -40°C.

23.2.1.4 Liquid Nitrogen Demand

Liquid nitrogen shall be supplied through a site distribution system from cryogenic storage tanks. The cryogenic storage tank unit will have a vaporizer to convert liquid into gas at maximum flow of 200 ℓ/s to meet high purity nitrogen gas demands. The average monthly consumption is ~ 57 m³. The storage tank shall be provided with a connection for liquid nitrogen withdrawal. The liquid nitrogen lines shall be insulated. The liquid nitrogen shall be supplied to the following systems:

- TCWS
- water detritiation system

23.2.1.5 Liquid Nitrogen Storage Capacity

The liquid nitrogen is stored in a ~ 114 m³ capacity storage tank. The gaseous equivalent capacity of the storage tank is ~ 94,000 Nm³.

23.2.1.6 Liquid Nitrogen Purity

The liquid nitrogen shall be industrial grade "ultra-dry" with a dew-point of < -179°C.

23.2.1.7 Nitrogen & Helium Cylinders

A number of single high pressure nitrogen and helium cylinders shall be provided as "gas bottle stations" to supply systems which are small users of nitrogen or helium gas. The cylinders shall be standard "laboratory cylinders" with a capacity of 8.5 Nm³ at 15.5 MPa(g) storage pressure. The supply pressure shall be regulated to meet system required pressure.

23.2.1.8 Gaseous Helium Demand

The demand for bulk helium gas is estimated at the average rate of 20,000 Nm³/month at the delivery point. The maximum delivery rate is assumed to be 40,000 Nm³/month. Helium gas shall be supplied through a distribution system with a connection to the following buildings at varying flows:

- tokamak building
- tritium building
- hot cell building
- radwaste and personnel buildings
- auxiliary buildings
- site services building

23.2.1.9 Gaseous Helium Storage Capacity

The gaseous helium storage capacity shall be equal to the average monthly consumption of 20,000 Nm³. The storage pressure shall be 15.5 MPa(g).

23.2.1.10 Helium Purity

The gaseous helium shall be standard industrial grade.

23.2.1.11 Capacity Margin

All gas supply and distribution systems shall have their components specified (sized) to provide the maximum daily supply as identified in Appendix A.

23.2.2 **General**

23.2.2.1 Mechanical

23.2.2.1.1 Storage Pressure

The storage pressure for nitrogen and helium gas shall be nominally 15.5 MPa(g).

23.2.2.1.2 Distribution Pressure

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

23.2.2.1.3 Gas Taps

All gas taps on the distribution systems shall have check valves that will isolate the tap from the distribution system if gas pressure is applied to the tap greater than the distribution pressure at the tap.

23.2.2.1.4 Pressure Relief Devices

All gas distribution systems shall be provided with safety relief devices which meet local design and safety codes for the ITER site.

23.2.2.1.5 Security

All gas 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 nitrogen, helium gas system shall be seismic class 0.

23.2.2.4 Construction

Dry nitrogen will be required for piping and vessel lay-up during construction. An evaluation of construction needs should be carried out to determine whether early construction of this system is mandated or whether construction needs can be satisfied by temporary supply of

dry nitrogen.

23.2.2.5 Instrumentation and Control

23.2.2.5.1 Pressure Regulation

The system pressure shall be regulated from the storage pressure to 865 kPa(g) by pressure regulators upstream of the main supply header. Control to lower pressure will be provided at the user tap as required.

23.2.2.5.2 Pressure Monitoring

Unless otherwise specified, all subsystems shall provide pressure instrumentation for storage tanks, supply headers and distribution lines.

23.2.2.5.3 Flow Monitoring

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

23.2.2.5.4 Gas Quality Monitoring

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

23.2.2.5.5 Local Control Panel

System pressure regulation shall be from a local control panel in the site services building system pressure, flow and gas quality data shall be available both locally and at the control panel.

23.2.2.5.6 Annunciation

The following printout messages shall be provided in the main control room:

- (a) "High" nitrogen/helium supply pressure low" will be brought in when the pressure in the high pressure helium header drops as sensed by pressure switch located in the supply header in the local control cabinet.
- (b) "Low" nitrogen/helium supply pressure low" will be brought in when the pressure in the high pressure helium header drops as sensed by pressure switch located in the supply header in the local control cabinet.
- (c) Level gauge and pressure gauge shall be provided to give indication of the level and pressure of liquid nitrogen in the storage tank respectively.

23.2.2.5.7 CODAC

The control panel in the site services building shall interface with CODAC to make system pressure data available in the main control room.

23.2.2.6 Grounding/Insulation

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

23.2.2.7 Materials

23.2.2.7.1 Pipes and Vessels

Unless otherwise specified all subsystems shall use class HB (red brass, extra strong piping ASTM B43) for high pressure circuit. For low pressure circuit class ATB (copper piping ASTM B88) shall be used.

23.2.2.7.2 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.C) -1 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 **Operations and Maintenance**

The operations and maintenance (O&M) requirements for the nitrogen, helium gas system are derived from DRG1 and the functions of the gas distribution 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

Storage tanks and related equipment shall be designed to provide compressed gas, at or above the minimum specifications, for at least 10 minutes following loss of electrical power.

23.2.4 Surveillance & 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 nitrogen, helium gas system quality assurance specifications shall be consistent with local building codes, ITER plant quality assurance requirements for non-safety class systems, the ITER QA manual, and quality levels for standard industrial equipment.

23.2.6 Environmental

The nitrogen gas and liquid storage tanks shall be located outdoors and shall be subjected to atmospheric conditions.

23.2.7 Reliability Assurance

Due to infrequent demand and the use of industry standard equipment, a backup system shall not be provided.

23.2.8 Maintainability

Sufficient pressure gauges shall be provided to facilitate locating faults so that maintenance may be initiated as soon as possible.

23.2.9 Other

For ease of hose disconnection, all flexible hoses shall be equipped with quick connect/disconnect couplings.

23.3 Codes and Standards

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

- All piping shall be in accordance with ANSI piping code B31.1.
- All pressure vessels shall be 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 N₂ and Helium Needs

A.1 Analysis of Nitrogen Requirements

	NB Cell	HC PFC Port	IVT Cells (2)	Tritium Plant Glove Boxes	Gen. Trans- port Cask	Hot Cell Cutting Station	VV
INPUT							
Required number of months storage inventory	1	1	1	1	1	1	1
O ₂ impurity limit, %	1.0	1.0	0.1	1.0	0.1	1.0	0.1
Initial O ₂ impurity	21.0	21.0	21.0	21.0	1.0	21.0	0.0
No. of purge/fills per maintenance day	1	2	1	1	2	1	1
No. of purge/fills per maintenance month	1	40	1	1	55	4	1
No. of purge/fills per year	1	180	1	1	240	40	1
Fraction time inerted during maintenance	.5	.95	1.0	1.0	1.0	1.0	1.0
Fraction time inerted during operation	1.0	0.0	1.0	1.0	0.0	1.0	0.0
Maximum maintenance period, months	6	6	6	1	6	12	6
Room volume, m ³	0	884	500	750	100	350	3400
Room leak rate, % vol./day	10	10	10	25	10	50	0
Purge/fill line diameter, m	0.1	0.05	0.1	0.1	0.03	0.1	0.1
Purge/fill line velocity, m/s	20	20	20	20	20	20	20
Purge/fill line pressure, kPa	865	865	865	865	865	865	865

	NB Cell	HC PFC Port	IVT Cells (2)	Tritium Plant Glove Boxes	Gen. Trans- port Cask	Hot Cell Cutting Station	VV
CALCULATION							
1. Purge volumes and times:							
Purge/fill line flow rate, m ³ /s	.157	.039	.157	.157	.014	.157	.157
Required purge/fill volume, m ³	0	2691	500	750	230	1066	3400
Required volume turnover	3.04	3.04	1.0	1.0	2.30	3.04	1.0
Required purge/fill time, s	0	8002	372	558	1902	792	2527
Required purge/fill time, h	0.0	2.22	0.10	0.15	0.53	0.22	0.70
Required daily makeup for leakage, m ³ /d	0	88	50	188	10	175	0
2. Maximum daily consumption							
During maintenance							
Purge/fill flow, Nm ³	0	5467	550	938	471	1241	3400
Leakage makeup flow, Nm ³	0	84	50	188	10	175	0
Total	0	5551	600	1125	481	1416	3400
During operation							
Purge/fill flow, Nm ³	0	0	0	0	0	0	0
Leakage makeup flow, Nm ³	0	0	50	188	0	175	0
3. Maximum monthly consumption							
During maintenance							
Purge/fill flow, Nm ³	0	107, 654	500	750	12,664	4,262	3400
Leakage makeup flow, Nm ³	0	2519	1500	5625	300	5250	0
Total	0	110, 174	2000	6375	12,964	9512	3400

	NB Cell	HC PFC Port	IVT Cells (2)	Tritium Plant Glove Boxes	Gen. Trans- port Cask	Hot Cell Cutting Station	VV
During operation							
Purge/fill flow, Nm ³	0	0	0	0	0	0	0
Leakage makeup flow, Nm ³	0	0	1500	5625	0	5250	0
Total	0	0	1500	5625	0	5250	0
4. Yearly consumption							
During maintenance							
Purge/fill flow, kNm ³	0	484	.5	.75	55.2	42.6	3.4
Leakage makeup flow, kNm ³	0	15.3	9.1	5.7	1.825	63.9	0
Total, kNm ³	0	500	9.6	6.5	57.0	106.5	3400
During operation							
Purge/fill flow, Nm ³	0	0	0	0	0	0	0
Leakage makeup flow, kNm ³	0	0	9.125	62.7	0	0	0
Total, kNm ³	0	0	9.1	62.7	0	0	0
5. Total Annual consumption, kNm³	0	500	18.7	69.2	57.1	106.4	3.4
6. Average consumption							
Daily, Nm ³	0	1369	51	190	156	292	9
Monthly, kNm ³	0	41.1	1.5	5.7	4.7	8.8	.28
Max total consumption							
Daily, kNm ³	16.7						
Monthly, kNm ³	195						
Average total consumption							
Daily, kNm ³	3						
Monthly, kNm ³	89						
Pressurized gas trailer tank consumption							
Max tanks per day	0	1.66	0.18	0.34	0.14	0.42	1.02
Max tanks per month	0	33	0.6	1.91	3.9	2.8	1.02
Tanks consumed per year	0	149	5.6	20.7	17.1	31.8	1.02

	NB Cell	HC PFC Port	IVT Cells (2)	Tritium Plant Glove Boxes	Gen. Transport Cask	Hot Cell Cutting Station	VV
Equivalent liquid nitrogen tank consumption							
Max tanks per day	0	0.08	0.01	0.02	0.01	0.02	0.05
Max tanks per month	0	1.55	0.03	0.09	0.18	0.13	0.05
Tanks consumed per year	5						
Max daily tank consumption, Nm ³	5						
Max monthly tank consumption, Nm ³	58						
Total yearly tank consumption, Nm ³	323						
Average Monthly Consumption, Nm ³	26.9						

A.2 Analysis of Helium Requirements

WBS - System	Application	Location: - Building	Initial Fill Nm³ [@ kPa(g)]	Continuous Supply Nm³/time [@ kPa(g)]
Industrial Grade Helium				
1.8 Fueling	Glow discharge cleaning	Tokamak; Vacuum Vessel	3400@101	TBD
5.6 Test Blanket Module (TBM)	Helium TBM coolant fill and makeup	Tokamak; Equatorial port	TBD	TBD