24 Plant Sampling Systems

24.1 Functions, Basic Configuration, and Interfaces

24.1.1 Functions

The function of the plant sampling systems is to collect and evaluate the chemical and radiological attributes of key plant systems samples. The plant sampling system is designed to perform analysis of the samples (chemical and radiological) and provide supporting information and rationale for the process systems chemical specifications of ITER plant.

24.1.2 Basic Configuration

24.1.2.1 General

Samples will be obtained using a grab sample technique, wherein workers will periodically collect samples and deliver them to laboratories. For samples taken within the tokamak core buildings (tokamak, tritium, hot cell, radwaste, and personnel buildings), where there is a possibility of radioactive contamination, the "hot" laboratory, located in the radwaste building, will be used for analyses. Samples taken outside these buildings will normally be analyzed in the "cold" laboratory, located in the site services building, unless those samples require radioactive analysis, in which case they will be taken to the "hot laboratory". Plant sampling system equipment is located in each of these laboratories. All samples taken to the radioactive laboratory will be discarded to either radwaste or hazardous waste systems unless they qualify for unrestricted release.

The two separate laboratory analysis sub-systems within the plant sampling system, are located in separate facilities to avoid cross contamination. The first sub-system, "hot" laboratory analysis, will be capable of handling radioactive samples in solid, liquid or gaseous form. The second sub-system, "cold" laboratory analysis will handle non-radioactive samples including potentially hazardous chemicals in solid, liquid or gaseous form.

Both sub-systems are designed to be available on demand such that no maintenance or operations activity will be delayed beyond the minimum practical sample processing time. Routine samples that may be safely contracted to outside laboratories will be routed to the off-site laboratories only if such action is cost effective and does not interfere with priority samples.

The chemical and radiological control program impacts on the performance of ITER plant in the areas of safety, environment emissions, reliability and cost. The plant sampling system is important to the operating performance of virtually all parts of ITER plant. The expected sample throughput is shown in Table 24-1.

Table 24-1 Expected Sample Throughput

System WBS #	Sample Type	No. of Samples per Lot	Max Sampling Frequency	Remarks
2.3.H Dust Removal	Dust material composition	4	2 lots/yr	Hot analysis
	Dust ^3H concentration	included	included	Hot analysis
	Dust isotopic composition & activity	included	included	Hot analysis
WBS 2.4.E VV Pressure Suppression Tank	Coolant ^3H concentration	1	1 lot/week	Hot analysis
	Coolant ACP concentration, species, and activity	included	included	Hot analysis
	Coolant chemistry	included	included	Hot analysis
WBS 2.6.A PFW/BLK PHTS Primary Loops	Coolant ^3H concentration	10	3 lots/day	Hot analysis
	Coolant ACP concentration, species, and activity	included	included	Hot analysis
	Coolant chemistry	included	included	Hot analysis
WBS 2.6.D DIV/LIM PHTS Loops	Coolant ^3H concentration	4	3 lots/day	Hot analysis
	Coolant ACP concentration, species, and activity	included	included	Hot analysis
	Coolant chemistry	included	included	Hot analysis

System WBS #	Sample Type	No. of Samples per Lot	Max Sampling Frequency	Remarks
WBS 2.6.E VV PHTS Primary Loops	Coolant ^{3}H concentration Coolant ACP concentration, species, and activity Coolant chemistry	2 included included	1 lot/day included included	Hot analysis Hot analysis Hot analysis
WBS 2.6.F NBI-LV PHTS Loops	Coolant ^{3}H concentration Coolant ACP concentration, species, and activity Coolant chemistry	1 included included	1 lot/day included included	Hot analysis Hot analysis Hot analysis
WBS 2.6.F NBI-HV PHTS Loops	Coolant ^{3}H concentration Coolant ACP concentration, species, and activity Coolant chemistry	1 included included	1 lot/day included included	Hot analysis Hot analysis Hot analysis
WBS 3.2.F ADS Effluent	Output Stream ^{3}H concentration Input stream impurity analysis	4 included	3 lots/day included	Hot analysis Hot analysis
WBS 2.6.L Water Circulation System	Coolant ^{3}H concentration Coolant ACP concentration, species, and activity	18 included	3 lots/day included	Hot analysis Hot analysis
WBS 2.6.M Cooling tower system	Coolant ^{3}H concentration Coolant ACP concentration, species, and activity Coolant chemistry	1 included 1	1 lot/day included 1 lot/day	Hot analysis Hot analysis Cold analysis

System WBS #	Sample Type	No. of Samples per Lot	Max Sampling Frequency	Remarks
WBS 2.6.M Blowdown line	Coolant ^3H concentration Coolant ACP concentration, species, and activity Coolant chemistry	1 included 1	1 lot/day included 1 lot/day	Hot analysis Hot analysis Cold analysis
WBS 6.1.W Site Environment	Vegetation radioisotope composition & activity	4	2 lots/yr	Hot analysis
WBS 6.3.A ^3H Removal Effluent	^3H concentration	1	2 lots/day	Hot analysis
WBS 6.3.A Dust Removal	Dust material Composition Dust ^3H concentration Dust isotopic composition & activity	1 included included	2 lots/day included included	Hot analysis Hot analysis Hot analysis
WBS 6.3.B High Level Waste Process	Waste material composition Waste isotopic composition & activity	1 included	1 lot/day included	Hot analysis Hot analysis
WBS 6.3.C High Level Waste Process	Sample material composition Sample isotopic composition & activity	1 included	2 lots/day included	Hot analysis Hot analysis
WBS 6.3.D Clean Liquid Batch Feed	Liquid ^3H concentration Liquid isotopic concentration & activity	1 included	2 lots/day included	Hot analysis
WBS 6.3.D Clean Liquid Effluent	Liquid ^3H concentration Liquid radio-isotope concentration and activity Liquid impurity analysis	1 included included	2 lots/day included included	Hot analysis Hot analysis Hot analysis

System WBS #	Sample Type	No. of Samples per Lot	Max Sampling Frequency	Remarks
WBS 6.3.D Dirty Liquid Batch Feed	Liquid ^{3}H concentration Liquid radio-isotope concentration and activity Liquid impurity analysis	1 included included	1 lot/day included included	Hot analysis Hot analysis Hot analysis
WBS 6.3.D Dirty Liquid Effluent	Liquid ^{3}H concentration Liquid radio-isotope concentration and activity Liquid impurity analysis	1 included included	1 lot/day included included	Hot analysis Hot analysis Hot analysis
WBS 6.3.D Soapy Liquid Batch Feed	Liquid ^{3}H concentration Liquid radio-isotope concentration and activity Liquid impurity analysis	1 included included	2 lots/day included included	Hot analysis Hot analysis Hot analysis
WBS 6.3.D Soapy Liquid Effluent	Liquid ^{3}H concentration Liquid radio-isotope concentration and activity Liquid impurity analysis	1 included included	2 lots/day included included	Hot analysis Hot analysis Hot analysis
WBS 6.3.D Low Level Solid Waste	Waste material Composition Waste radioisotope concentration & activity	1 included	2 lots/day included	Hot analysis Hot analysis
WBS 6.3.F Hazardous Waste	Waste material Composition	1	1 lot/day	Cold analysis
WBS 2.6.O Component Cooling Water	Coolant chemistry	10	1 lot/week	Cold analysis
WBS 2.6.P Chilled Water	Coolant chemistry	9	1 lot/week	Cold analysis
WBS 6.5.C Fire Water	Coolant chemistry	5	1 lot/month	Cold analysis

System WBS #	Sample Type	No. of Samples per Lot	Max Sampling Frequency	Remarks
WBS 6.5.D Sanitary Waste	Selected waste Impurities Radioisotope concentration & activity	1 1	1 lot/day 1 lot/day	Cold analysis Hot analysis
WBS 6.5.D Industrial Waste	Selected waste Impurities Radioisotope concentration & activity	1 1	1 lot/day 1 lot/day	Cold analysis Hot analysis
WBS 6.5.E Steam Condensate	Coolant chemistry	1	1 lot/week	Cold analysis
WBS 6.5.E Demin Water	Coolant chemistry	1	1 lot/week	Cold analysis

24.1.2.2 Beryllium

Special attention is required for the handling and the control of materials containing beryllium (Be). Components with Be surfaces, such as blanket modules, will be first handled in the hot cell area during machine assembly. These Be containing components will be received in the hot cell area and a temporary Be analysis laboratory will be set up close to the hot cell building, or in a separate area of the hot cell building, so as to avoid cross-contamination, to analyze samples from smears and from sample air filters to determine the presence of air-borne Be. This laboratory analysis subsystem is part of the assembly arrangements (see chapter 7). The permanent Be analysis function will be combined with the hot laboratory functions in the radwaste building once that portion of the radwaste facility is available.

24.1.3 Interfaces

1.8.A Pellet Fuelling System
2.3.H Dust Removal
2.4.E Vacuum Vessel Pressure Suppression System
2.6.A Primary First Wall and Blanket PHTS
2.6.D Divertor and Limiter PHTS
2.6.E Vacuum Vessel PHTS
2.6.F Additional Heating PHTS
2.6.G Test Blanket Modules PHTS
2.6.J Draining, Refilling, and Drying Systems
2.6.K Chemical Volume Control System (CVCSs)
2.6.L Circulating Water System
2.6.M Cooling Tower System
2.6.O Component Cooling Water System
2.6.P Chilled Water System
3.2.F Atmosphere Detritiation
6.2.A Tokamak Buildings
6.2.B Hot Cell Building
6.2.E Auxiliary Buildings
6.2.G Radwaste and Personnel Buildings
6.2.H Laboratory Office Building
6.2.J Cryoplant Buildings
6.2.K Control Building
6.2.L Emergency Power Supply Building
6.2.M Site Services Building
6.2.S Utility Tunnels & Site Improvements
6.3.A Hot Cell Docking and Storage
6.3.B Hot Cell Waste Processing and Storage
6.3.C Hot Cell Component Repair (Hot Cell Maintenance)
6.3.D Low Level Waste Processing
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

24.2 Design Requirements

24.2.1 Specific

24.2.1.1 Reliability

The plant sampling system shall be designed so that the probability of a laboratory equipment failures which could contribute more than 8 hours delay to the ITER maintenance or operations schedule is less than 10^{-2} per year.

24.2.1.2 Hot Laboratory Analysis Processing Capability

The hot laboratory analysis sub-system shall have the capability to identify and make total radioactivity and radioactivity concentration determinations for samples emitting beta and/or gamma radiation with half-lives greater than 30 minutes.

24.2.1.3 Hot Laboratory Analysis Equipment Layout

The hot laboratory analysis functions and equipment shall be located in the radwaste building. The functions and equipment shall be in a separate area from the cold laboratory analysis equipment to avoid cross-contamination.

24.2.1.4 Cold Laboratory Analysis Processing Capability

The cold laboratory analysis sub-system shall be capable of identification and quantitative analysis for a wide variety of chemicals, hazardous and non-hazardous. All chemicals must be below the threshold for treatment as low-level radwaste as defined in the GSSR annex to the PDD.

24.2.1.5 Cold Laboratory Analysis Equipment Layout

The cold laboratory analysis functions and equipment shall be located in the site services building, separate from the hot laboratory to avoid cross-contamination.

24.2.1.6 Be Analysis

The permanent Be analysis functions and equipment will be located in a separate area of the hot laboratory to be able to deal with Be-containing samples that may also contain radioactive species. This function may be augmented in the machine assembly phase by a temporary Be laboratory situated close to the hot cell area until the hot laboratory is available.

24.2.2 General

24.2.2.1 Vacuum

The plant sampling system shall be capable of providing and maintaining a vacuum for evacuating gaseous sample bottles for both hot and cold laboratory analysis.

24.2.2.2 Mechanical

The plant sampling system equipment design shall accommodate normal ("hands-on") maintenance and operation. Specifically, all sample containers shall be standardized as much as possible to the interfacing sample drawing points for liquids, for gases, and for special fluids on the ITER plant equipment.

24.2.2.3 Electrical

AC power shall be provided from class IV power electrical sockets;
Electrical Supply: Voltage 120 V/ 240 AC
Frequency: 50 - 60 Hz

24.2.2.4 Seismic

The plant sampling system shall be seismic class 0.

24.2.2.5 Instrumentation and Control

24.2.2.5.1 General

The plant sampling system shall be designed to include all necessary instrumentation and controls. Automated controllers shall be implemented for high throughput sample systems or where precision requirements preclude manual control.

24.2.2.5.2 Sampling Identification, Scheduling and Reporting

All scheduled samples shall be drawn at uniquely identified sample points within the time interval scheduled. This information shall be encoded directly on the sampled container and read by equipment at the laboratories and entered into a sample information database. Reports shall be generated by the database to a standard distribution list on a standard schedule.

24.2.2.5.3 CODAC Interface

The plant sampling system shall conform to all signal and command protocol standards established by CODAC. The plant sampling system shall provide status reporting signals to CODAC. These signals can then be used by supervisory staff to augment their knowledge of the status of various systems.

24.2.2.6 Materials

24.2.2.6.1 Mechanical

All sampling systems shall be constructed of 316 SS or better quality materials (depending on compatibility with sampled fluid), and shall be small bore pipe or tubing (10 mm).

24.2.2.6.2 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 24-2 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

24.2.2.7 HVAC

The hot laboratory analysis activities shall be conducted in a B access zone. Therefore, room pressure will nominally controlled to -10mm H_2O gauge. Volatile radioactive sample analysis shall be performed in a glovebox or hood.

24.2.3 Surveillance and Inspection

All instruments are to be calibrated on a regular basis as determined from regulatory requirements, manufacturer's recommendations and good laboratory practice. Calibration samples are to be maintained in the laboratories where practical.

24.2.4 Quality Assurance (QA)

The sampling system components are safety importance class 4. Therefore, only industrial product level QA is required from the vendors and constructors who provide the equipment.

24.3 Codes and Standards

Equipment, implementation and testing procedures shall conform to local regulatory requirements and the relevant sections of the standard specifications listed below:

- Standard requirements for instrumentation equipment
- General requirements for electrical/electronic component assemblies and systems
- General requirements for radiation measurement equipment/component assemblies and systems.

The American national standards institute:

- N 13.1: Guide to sampling radioactive material in nuclear facilities
- N 13.10: Specification and performance of on-site instrumentation for continuous sampling radioactive samples.