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Rapporto preliminare "Engineering Validation and Engineering Design Activities" Contratto ENEA-RFX del 02/08/2013

Giuseppe Pruneri (Consorzio RFX)

CONSORZIO RFX
Ricerca Formazione Innovazione

Report RdS/2013/284

RAPPORTO PRELIMINARE "ENGINEERING VALIDATION AND ENGINEERING DESIGN ACTIVITIES"

CONTRATTO ENEA-RFX DEL 02/08/2013

Giuseppe Pruneri (Consorzio RFX)

Settembre 2013

Report Ricerca di Sistema Elettrico

Accordo di Programma Ministero dello Sviluppo Economico - ENEA
Piano Annuale di Realizzazione 2012
Area: Produzione di energia elettrica e protezione dell'ambiente
Progetto: Attività di fisica della fusione complementari a ITER
Obiettivo: b1. *Campagna sperimentale dei sistemi di monitoring online per la misura delle impurezze in litio e per i fenomeni di cavitazione per l'impianto EVEDA di Oarai (Giappone) e costruzione del bersaglio a baionetta*
Responsabile del Progetto: Ing. Aldo Pizzuto, ENEA

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INTERMEDIATE ENGINEERING DESIGN REPORT

IFMIF

Design Description Document
For the
Electrical Power System (EPS)
PBS 5.3.2

Design Description Document
For the
Electrical Power System (EPS)
PBS 5.3.2

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Abstract: **This document describes the Electrical Power System (EPS) considered as a system belonging to the Conventional Facilities. Key functions of the system are here presented, as well as interfaces with bounding facilities/systems, main design assumptions and input data necessary for the design of the system.**

TABLE OF CONTENT

ACRONYMS

AF	Accelerator Facility
AC	Alternating Current
ACSS	Access Control & Security System
BFD	Block Flow Diagram
CC&CI	Central Control & Common Instrumentation
CDA	IFMIF Conceptual Design Activity
CDR	IFMIF Comprehensive Design Report
CF	Conventional Facilities
CVCF	Constant Voltage Constant Frequency
DC	Direct Current
DDD	Design Description Document
DVT	Data Validation Table
EPS	Electrical Power System
FPS	Fire Protection System
HV	High Voltage
HVAC	Heating Ventilation Air Conditioning
HRS	Heart Rejection System
EVEDA	Engineering Validation & Engineering Design Activities
IFMIF	International Fusion Materials Irradiation Facility
LF	Lithium Target Facility
LV	Low Voltage
MCC	Motor Control Centre
MV	Medium Voltage
OLD	One Line Diagram
PBS	Plant Breakdown Structure
PIEF	Post Irradiation Examination Facility
PT	Project Team
RAMI	Reliability, Availability, Maintainability, Inspectability
RAMSES	Radiation Monitoring System for Environment & Safety
RWTS	Radioactive Waste Treatment System
SGS	Service Gas System
SIC	Safety Important Component
SWGR	Switchgear
SWS	Service Water System
UPS	Uninterruptible Power Supply
TF	Test Facility
WBS	Work Breakdown Structure

LIST OF EXHIBITS

Tables

Figures

1. System Functions and Basic Configuration

1.1 System Functions

The Electrical Power System (EPS) has the following main functions:

- It receives the AC power from the commercial transmission grid, transforms it to appropriate voltage levels and distributes it to the IFMIF Facilities / systems requiring steady state electric power. The total power of all connected loads is estimated to be approximately 90 MVA.
- In the event of loss of off-site power loop, the EPS incorporates on-site emergency power sources (diesel generators, uninterruptible power supply systems and DC batteries) to supply the loads classified as Safety Important Components.
- It compensates the reactive power consumed by the systems / components supplied by the EPS.
- It provides monitoring, control, and protection of electric power sources and distribution including functions of start-up; recovery from interruptions, load prioritization, sequencing, fault protection and fault isolation.
- It provides control and protection of its own components and provides on / off control of electrical power flow to the loads, but do not provide control or protection of the loads themselves, which will be the responsibility of the corresponding systems / components.

To accomplish the above-mentioned functions the EPS is composed by the following three (3) subsystems: (I) Power System Substation; (II) Emergency Power System; and (III) Electric Distribution System.

1.2 System Basic Configuration

The following Table 1-1 presents the broken down of the systems into its subsystems (PBS L4).

PBS Number					PBS Item
1	**2**	**3**	**4**	**5**	
5	**0**	**0**	**0**	**0**	**Conventional Facilities**
	3	0	0	0	Plant Services
		2	*0*	*0*	*Electrical Power System*
			1	*0*	*Power System Substation*
			2	*0*	*Emergency Power System*
			3	*0*	*Electric Distribution System*

Table 1-1: EPS PBS Location

1.2.1 **Power System Substation (PBS: 5.3.2.1.0)**

Power System Substation is the system related to power receiving from commercial grid. Under normal operating condition, IFMIF is fed through the commercial grid by two (2) lines of redundant 66 kV (HV: High Voltage) electrical power; 100% × 2. The receiving voltage is step-downed to 6.6 kV (MV: Medium Voltage) via HV/MV power transformers, then being distributed to medium voltage switchgears (MV SWGRs) which feed power to MV SWGRs of Emergency Power System and Electric Distribution System. All the equipment related to this system is installed in the dedicated Electrical Switchyard Building.
The system is further broken down as per the following Table 1-2,

Equipment List (Electrical Power System) Doc.No. S-1226-031 RI

Building	No.	Equipment No.	Equipment Name	Size (WxDxH) (mm)	Q'ty	SUBSYSTEM
Electrical Switchyard Building	H01	GIS-01	66kV SF6 Gas Insulated Switchgear	x x	1 Set	Power System Substation
	H02	MTR-01	66kV/6.6kV Main Transformer 30MVA ONAN	x x	1 Set	〃
	H03	MTR-02	66kV/6.6kV Main Transformer 30MVA ONAN	x x	1 Set	〃
	H04	MTR-03	66kV/6.6kV Main Transformer 30MVA ONAN	x x	1 Set	〃
	H05	MC-01	6.6kV 3ph-3W Switchgear	x x	1 Set	〃
	H06	MC-02	6.6kV 3ph-3W Switchgear	x x	1 Set	〃
	H07	MC-03	6.6kV 3ph-3W Switchgear	x x	1 Set	〃
	H08	TR-01A	6.6kV/0.4-0.23kV Transformer 150kVA Dry	x x	1 Set	〃
	H09	LDP-01	0.4-0.23kV LV Distribution Panel	x x	1 Set	〃
Emergency Power Building-1	G11	EG-1A	6.6kV 3ph-3W Emergency Generator 4000kVA(Diesel)	x x	1 Set	Emergency Power System
	G12	EG-1B	6.6kV 3ph-3W Emergency Generator 4000kVA(Diesel)	x x	1 Set	〃
	G13	MC-EG1M	6.6kV 3ph-3W Switchgear (With Syncro. Panel)	x x	3 Panel	〃
	G14	MC-EG1	6.6kV 3ph-3W Switchgear	x x	4 Panel	〃
Emergency Power Building-2	G21	EG-2A	6.6kV 3ph-3W Emergency Generator 4000kVA(Diesel)	x x	1 Set	Emergency Power System
	G22	EG-2B	6.6kV 3ph-3W Emergency Generator 4000kVA(Diesel)	x x	1 Set	〃
	G23	MC-EG2M	6.6kV 3ph-3W Switchgear (With Syncro. Panel)	x x	3 Panel	〃
	G24	MC-EG2	6.6kV 3ph-3W Switchgear	x x	4 Panel	〃

Table 1-2: Equipment List for Electric Power System 1/3

1.2.2 **Emergency Power System (PBS: 5.3.2.2.0)**

Emergency Power System is the system related to emergency power generation. In case of grid power failure, emergency generators will be started and will feed electric power to the loads classified as SIC-1 and SIC-2. Emergency Generators are provided as a redundant system (50% x 2+2). Diesel engine is selected as the driver. The fuel is diesel oil. Each generator and relevant equipment is installed in dedicated buildings, namely: Emergency Power Building 1 and Emergency Power Building 2.
The system is further broken down as per previous Table 1-2.

1.2.3 **Electric Distribution System (PBS: 5.3.2.3.0)**

Electric Distribution Systems covers power distribution within the IFMIF. All electrical equipment / components excluding the ones under PBS 5.3.2.1 and PBS 5.3.2.2 are within the scope of this system.
The system is classified based on Safety Important Class (Ref. [1]) into three (3) groups based upon the loads served:

- SR/Non-SIC loads : Single Power System
- SIC-2 loads : Power System + Emergency Power System
- SIC-1 loads : Redundancy Power System + Emergency Power System

However, the load connected to Emergency Power System also exists by the requirement of each facility besides the above.
Uninterruptible Power Supply (UPS), Direct Current (DC) Battery and Constant Voltage Constant Frequency (CVCF) are needed with each facility are scope of each facility.
UPSs, DC Batteries and CVCFs indicated here are only for Conventional Facility (CF).
The system is further broken down as per the following Table 1-3 and Table 1-4:

Equipment List (Electrical Power System)

Doc.No. S-1226-031 RI

Building		No.	Equipment No.	Equipment Name	Size (WxDxH) (mm)	Q'ty	SUBSYSTEM
Main Building	R301-1 Elect. Power Receiving Area-1	M11	MC-011	6.6kV 3ph-3W Switchgear	800 x 2000 x 2350	15 Panel	For HVAC-SR
		M12	MC-012	6.6kV 3ph-3W Switchgear	800 x 2000 x 2350	7 Panel	For HRS,SMS,EGDS-SR
		M13	MC-021	6.6kV 3ph-3W Switchgear	800 x 2000 x 2350	7 Panel	For SGS,EGDS-SIC-1(A)
		M14	SC-011	6.6kV Power Capacitor	900 x 1400 x 2100	4 Panel	For HVAC-SR
		M15	SC-012	6.6kV Power Capacitor	900 x 1400 x 2100	3 Panel	For HRS,SMS,EGDS-SR
		M16	SC-021	6.6kV Power Capacitor	900 x 1400 x 2100	3 Panel	For SGS,EGDS-SIC-1(A)
	R302-1 UPS Room-1	U11	UPS-A1	AC Uninterrupted Power System-3 ϕ 400V 200kVA	7800 x 1000 x 1950	1 Set	Electric Distribution System
		U12	UPS-A2	AC Uninterrupted Power System-3 ϕ 400V 200kVA	7800 x 1000 x 1950	1 Set	〃
		U13	DC-A1	DC Battery & Charger-100V 100Ah	1400 x 1000 x 1950	1 Set	〃
		U14	DC-A2	DC Battery & Charger-100V 100Ah	1400 x 1000 x 1950	1 Set	〃
	R303-1 LV Elect. Power Supply Area-1	T11	TR-011	6.6kV/0.4-0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1 Set	For HVAC-SR
		T12	TR-012	6.6kV/0.4-0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1 Set	For HVAC-SR
		T13	TR-013	6.6kV/0.4-0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1 Set	For HRS,SMS,EGDS-SR
		T14	TR-014	6.6kV/0.4-0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1 Set	For HRS,SMS,EGDS-SR
		T15	TR-015	6.6kV/0.4-0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1 Set	For Building Utility etc-SR.
		T16	TR-021A	6.6kV/0.4-0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1 Set	For SGS,EGDS-SIC-1(A)
		T17	TR-022A	6.6kV/0.4-0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1 Set	For SGS,EGDS-SIC-1(A)
		P11	PC-011	0.4-0.23kV 3ph-4W LV Switchgear	900 x 1800 x 2350	4 Panel	For HVAC-SR
		P12	PC-012	0.4-0.23kV 3ph-4W LV Switchgear	900 x 1800 x 2350	4 Panel	For HVAC-SR
		P13	PC-013	0.4-0.23kV 3ph-4W LV Switchgear	900 x 1800 x 2350	8 Panel	For HRS,SMS,EGDS-SR
		P14	PC-014	0.4-0.23kV 3ph-4W LV Switchgear	900 x 1800 x 2350	8 Panel	For HRS,SMS,EGDS-SR
		P15	PC-015	0.4-0.23kV 3ph-4W LV Switchgear	900 x 1800 x 2350	3 Panel	For Building Utility etc-SR.
		P16	PC-021	0.4-0.23kV 3ph-4W LV Switchgear	900 x 1800 x 2350	8 Panel	For SGS,EGDS-SIC-1(A)
		C11	MCC-011	0.4-0.23kV Motor Control Center	850 x 600 x 2350	10 Panel	For HVAC-SR
		C12	MCC-012	0.4-0.23kV Motor Control Center	850 x 600 x 2350	10 Panel	For HVAC-SR
		C13	MCC-013	0.4-0.23kV Motor Control Center	850 x 600 x 2350	6 Panel	For HRS,SMS,EGDS-SR
		C14	MCC-014	0.4-0.23kV Motor Control Center	850 x 600 x 2350	6 Panel	For HRS,SMS,EGDS-SR
		C15	MLP-015	0.4-0.23kV Main Loading Panel	1400 x 600 x 2350	4 Panel	For Building Utility etc-SR.
		C16	MCC-021	0.4-0.23kV Motor Control Center	850 x 600 x 2350	8 Panel	For SGS,EGDS-SIC-1(A)

Table 1-3: Equipment List for Electric Power System 2/3

Equipment List (Electrical Power System) Doc.No. S-1226-031 RI

Building		No.	Equipment No.	Equipment Name	Size (WxDxH) (mm)	Q'ty	SUBSYSTEM
Main Building	R301-2 Elect. Power Receiving Area-2	M21	MC-013	6.6kV 3ph-3W Switchgear	800 x 2000 x 2350	3 Panel	For L.F, T.F, P.I.E-SR
		M22	MC-022	6.6kV 3ph-3W Switchgear	800 x 2000 x 2350	7 Panel	For SGS,EGDS-SIC-1(B)
		M23	MC-023	6.6kV 3ph-3W Switchgear	800 x 2000 x 2350	7 Panel	For SGS,EGDS,LWTF,FPS-SIC-2
		M24	SC-022	6.6kV Power Capacitor	900 x 1400 x 2100	3 Panel	For SGS,EGDS-SIC-1(B)
		M25	SC-023	6.6kV Power Capacitor	900 x 1400 x 2100	3 Panel	For SGS,EGDS,LWTF,FPS-SIC-2
	R302-2 UPS Room-2	U21	UPS-B1	AC Uninterrupted Power System-3ϕ400V 200kVA	7800 x 1000 x 1950	1 Set	Electric Distribution System
		U22	UPS-B2	AC Uninterrupted Power System-3ϕ400V 200kVA	7800 x 1000 x 1950	1 Set	〃
		U23	DC-B1	DC Battery & Charger-100V 100Ah	1400 x 1000 x 1950	1 Set	〃
		U24	DC-B2	DC Battery & Charger-100V 100Ah	1400 x 1000 x 1950	1 Set	〃
	R303-2 LV Elect. Power Supply Area-2	T21	TR-021B	6.6kV/0.4-0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1 Set	For SGS,EGDS-SIC-1(B)
		T22	TR-022B	6.6kV/0.4-0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1 Set	For SGS,EGDS-SIC-1(B)
		T23	TR-023	6.6kV/0.4-0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1 Set	For SGS,EGDS,LWTF,FPS-SIC-2
		T24	TR-024	6.6kV/0.4-0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1 Set	For SGS,EGDS,LWTF,FPS-SIC-2
		T25	TR-025	6.6kV/0.4-0.23kV Transformer 750kVA Dry	2200 x 1500 x 2350	1 Set	For FPS,Building Utility-SIC-2
		P21	PC-022	0.4-0.23kV 3ph-4W LV Switchgear	900 x 1800 x 2350	8 Panel	For SGS,EGDS-SIC-1(B)
		P22	PC-023	0.4-0.23kV 3ph-4W LV Switchgear	900 x 1800 x 2350	4 Panel	For SGS,EGDS,LWTF,FPS-SIC-2
		P23	PC-024	0.4-0.23kV 3ph-4W LV Switchgear	900 x 1800 x 2350	4 Panel	For SGS,EGDS,LWTF,FPS-SIC-2
		P24	PC-025	0.4-0.23kV 3ph-4W LV Switchgear	900 x 1800 x 2350	3 Panel	For FPS,Building Utility-SIC-2
		C21	MCC-022	0.4-0.23kV Motor Control Center	850 x 600 x 2350	8 Panel	For SGS,EGDS-SIC-1(B)
		C22	MCC-023	0.4-0.23kV Motor Control Center	850 x 600 x 2350	14 Panel	For SGS,EGDS,LWTF,FPS-SIC-2
		C23	MCC-024	0.4-0.23kV Motor Control Center	850 x 600 x 2350	14 Panel	For SGS,EGDS,LWTF,FPS-SIC-2
		C24	MLP-025	0.4-0.23kV Main Loading Panel	1400 x 600 x 2350	4 Panel	For FPS,Building Utility-SIC-2

Table 1-4: Equipment List for Electric Power System 3/3

2. Interfaces (Boundaries)

PBS 5.3.2.1.0 Power System Substation

The coverage by the Power System Substation is from the 66 kV (HV) grid power-connecting terminals to 6.6 kV (MV) switchgears (SWGRs) terminal end in Electrical Switchyard Building.

Thus, the Power System Substation has to feed 6.6 kV (MV) power to the following MV SWGRs:

1) Accelerator Facility
2) Emergency Power System
3) Electric Distribution System

PBS 5.3.2.2.0 Emergency Power System

Emergency Power System receives power from MV SWGRs of the Power System Substation and feed power to MV SIC SWGRs of Electric Distribution System which feeds power to SIC-1 and SIC-2 loads.

PBS 5.3.2.3.0 Electric Distribution System

Other electrical apparatus excluding PBS 5.3.2.1.0 & 5.3.2.2.0 are within Electrical Distribution System scope. Electric Distribution System has to feed power to the following Electric Power Board or sub system of Conventional Facility:

1) Lithium Target Facility : 6.6 kV (MV)
2) Test Facility : 6.6 kV (MV)
3) PIE Facility : 6.6 kV (MV)
4) Conventional Facility : 6.6 kV (MV) / 400V(LV) / 230V(LV)
   - Heating, Ventilation and Air Conditioning (HVAC) System
   - Heat Rejection System (HRS)
   - Service Water System (SWS)
   - Service Gas System (SGS)
   - Radioactive Waste Treatment System (RWTS)
   - Fire Protection System (FPS)
   - Central Control & Common Instrumentation (CC&CI)

- Access Control & Security Systems (ACSS)
- Radiation Monitoring for Environment & Safety (RAMSES)

Interface Tables		
System A	**System B**	**Title**
Accelerator Facility	Power System Substation	Power System Substation has to feed power to Electric Board of Accelerator Facility 6.6 KV (MV)
Lithium Target Facility	Electric Distribution System	Electric Distribution System has to feed power to Electric Board of Lithium Target Facility 6.6 KV (MV)
Test Facility	Electric Distribution System	Electric Distribution System has to feed power to Electric Board of Test Facility 6.6 KV (MV)
PIE Facility	Electric Distribution System	Electric Distribution System has to feed power to Electric Board of PIE Facility 6.6 KV (MV)
Conventional Facility	Electric Distribution System	Electric System has to feed power to each sub system of Conventional Facility 6.6 KV (MV)/400 V(LV)/230 (LV)

Table 2-1: Interface Table

2.1 EPS vs. Accelerator Facility (AF)

EPS supply 6.6kV power to Accelerator Facility through the:

- MV Electric Power Board for Accelerator Facility
- LV Electric Power Board for Accelerator Facility

The boundary between EPS and AF is set at the terminal of the MV Electric Power Board for Accelerator Facility.
The Power Board for Accelerator Facility including connecting terminal and all the afterwards equipment are within the scope of the Accelerator Facility.

2.2 EPS vs. Lithium Target Facility (LF)

EPS supply 6.6kV power to the Lithium Target Facility through the:

- Electric Power Board for Lithium Target Facility

The boundary between EPS and LF is set at the terminal of the Electric Power Board for Lithium Target Facility.
The Power Board for Lithium Target Facility including connecting terminal and all the afterwards equipment are within the scope of the Lithium Target Facility.

2.3 EPS vs. Test Facility (TF)

EPS supply 6.6kV power to Test Facility through the:

- Power Board for Test Facility

The boundary between EPS and TF is set at the terminal of the Power Board for Test Facility.
The Power Board for Test Facility including connecting terminal and all the afterwards equipment are within the scope of the Test Facility.

2.4 EPS vs. Post Irradiation Examination Facility (PIEF)

EPS supply 6.6kV power to Post Irradiation Examination Facility through the:

- Power Board for Post Irradiation Examination

The boundary between EPS and Post Irradiation Examination Facility is set at the terminal of the Power Board for Post Irradiation Examination Facility.
The Power Board for Post Irradiation Examination Facility including connecting terminal and all the afterwards equipment are within the scope of the Post Irradiation Examination Facility.

2.5 EPS vs. Conventional Facility (CF)

EPS supply 6.6 KV (MV)/400 V (LV)/230 V (LV) power to Conventional Facility through the:

- HV Electric Power Board for Conventional Facility
- LV Electric Power Board for Conventional Facility

3. System Design requirements

3.1 General Requirements

Input Data Requirements are identified as the data necessary to be defined in order to enable a system design that respects all the needs of the interfacing components.
Currently a draft set of data has been proposed. This list is have been prepared and assessed by the PT on the base of the current references, of the outcomes of the Engineering Validation Engineering Design Activities (i.e. Accelerator prototypes) and on the standard engineering practice.
Parameters identified as Input Data Requirements for EPS are, for each interfacing component:

- Electric Load (Rated Power) : kW or kVA
- Power Supply Voltage : kV or V
- Load Efficiency : %
- Power Factor : 0-1(value)
- Operation Status : Normal / Emergency / Maintenance
- Emergency Power System : Necessary / Not Necessary
- UPS or DC Battery : Necessary / Not Necessary
- Heat Dissipation : W

Heat Dissipation is important for design of HVAC, in this DDD, we have indicated the rated electric load while for the HVAC proper value of electrical heating dissipation (when available) have been considered, in the other cases when not available proper assumptions have been taken.(based on the HVAC engineering practice)

3.2 Engineering Requirements

3.2.1 Accelerator Facility (AF)

Table 3-1, Table 3-2, Table 3-3, Table 3-4 and Table 3-5 show Electric Load List for Accelerator Facility, created based on its requirements.

The required electric power for Accelerator Facility is:

- For Rated Power : 52887 kVA
- For Emergency Power : 411 kVA
- For UPS : 411 kVA

Electric Load List for Accelerator Facility

PBS No.	ITEM No.	Service	Rated Power 6.6 kV (kW)	Rated Power 400V (kW)	Efficiency %	Power Factor %	SIC	Redundancy	Normal Operation	Emergency Generator	UPS	Remarks
4.1.1.0.0.0		Injector-A		130	90	85	SIC-1		○			
4.1.1.0.0.0		Injector-A Instrumentation		2.5	90	85	SIC-1		○	○	○	
4.9.1.0.0.0		Injector-A Water Cooling Box		20	90	85	No		○			
4.6.1.0.0.0		RF HVPS for RFQ-A-1 (8 X 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for RFQ-A-2 (8 X 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for RFQ-A-3 (8 X 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for RFQ-A-4 (8 X 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for RFQ-A-5 (8 X 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for RFQ-A-6 (8 X 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for RFQ-A-7 (8 X 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for RFQ-A-8 (8 X 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.2.1.0.0.0		RFQ-A		85	90	85	No		○			
4.9.1.0.0.0		RFQ-A Water Cooling Box		115	90	85	No		○			
4.6.1.0.0.0		RF HVPS for MS-A (2 x 16kW RF Chains)	70		90	85	No		○			
4.3.1.0.0.0		MEBT-A		70	90	85	No		○			
4.3.1.0.0.0		MEBT-A Instrumentation		2.5	90	85	No		○			
4.9.1.0.0.0		MEBT-A Water Cooling Box		16	90	85	No		○			
4.6.1.0.0.0		RF HVPS for SRF Linac-A-1-1 (8 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-1-2 (8 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-1-3 (8 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-1-4 (8 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-2-1 (10 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-2-2 (10 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-2-3 (10 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-2-4 (10 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-2-5 (10 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-3-1 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-3-2 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-3-3 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-3-4 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-3-5 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-3-6 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-3-7 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-3-8 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-3-9 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-3-10 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-3-11 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-3-12 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-4-1 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-4-2 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-4-3 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-4-4 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-4-5 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-4-6 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-4-7 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-4-8 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-4-9 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-4-10 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-4-11 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.1.0.0.0		RF HVPS for SRF Linac-A-4-12 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.4.1.0.0.0		SRF Linac-A (100 kW solenoid LVPS + 50 kW other)		150	90	85	No		○			
4.5.1.0.0.0		HEBT-A + Beam Dump-A		500	90	85	No		○			

Table 3-1: Electric Load List for Accelerator Facility 1/5

Electric Load List for Accelerator Facility

PBS No.	ITEM No.	Service	Rated Power 6.6 kV (kW)	Rated Power 400V (kW)	Efficiency %	Power Factor %	SIC	Redundancy	Normal Operation	Emergency Generator	UPS	Remarks
4.9.1.0.0.0		HEBT-A Water Cooling Box		50	90	85	No		○			
4.9.1.0.0.0		Beam Dump-A Water Cooling Box		60	90	85	SR		○			
4.9.1.0.0.0		He Compressor-A		600	90	85	No		○			
4.4.1.0.0.0		Cold Box-A		40	90	85	No		○			
4.4.1.0.0.0		Cryo Plant-A (10 kW x 4 = 40 kW)		40	90	85	No		○			
4.6.1.0.0.0		LV for RF SET 1 RFQ		81.855	90	85	No		○			LV for RF module
		LV for RF SET 1 RFQ for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 2 RFQ		81.855	90	85	No		○			LV for RF module
		LV for RF SET 2 RFQ for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 3 RFQ		81.855	90	85	No		○			LV for RF module
		LV for RF SET 3 RFQ for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 4 RFQ		81.855	90	85	No		○			LV for RF module
		LV for RF SET 4 RFQ for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 5 MEBT		62.73	90	85	No		○			LV for RF module
		LV for RF SET 5 MEBT for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 6 Cryo module 1		62.73	90	85	No		○			LV for RF module
		LV for RF SET 6 Cryo module 1 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 7 Cryo module 1		62.73	90	85	No		○			LV for RF module
		LV for RF SET 7 Cryo module 1 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 8 Cryo module 1		62.73	90	85	No		○			LV for RF module
		LV for RF SET 8 Cryo module 1 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 9 Cryo module 1		62.73	90	85	No		○			LV for RF module
		LV for RF SET 9 Cryo module 1 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 10 Cryo module 2		62.73	90	85	No		○			LV for RF module
		LV for RF SET 10 Cryo module 2 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 11 Cryo module 2		62.73	90	85	No		○			LV for RF module
		LV for RF SET 11 Cryo module 2 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 12 Cryo module 2		62.73	90	85	No		○			LV for RF module
		LV for RF SET 12 Cryo module 2 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 13 Cryo module 2		62.73	90	85	No		○			LV for RF module
		LV for RF SET 13 Cryo module 2 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 14 Cryo module 2		81.855	90	85	No		○			LV for RF module
		LV for RF SET 14 Cryo module 2 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 15 Cryo module 3		81.855	90	85	No		○			LV for RF module
		LV for RF SET 15 Cryo module 3 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 16 Cryo module 3		81.855	90	85	No		○			LV for RF module
		LV for RF SET 16 Cryo module 3 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 17 Cryo module 3		81.855	90	85	No		○			LV for RF module
		LV for RF SET 17 Cryo module 3 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 18 Cryo module 3		81.855	90	85	No		○			LV for RF module
		LV for RF SET 18 Cryo module 3 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 19 Cryo module 3		81.855	90	85	No		○			LV for RF module
		LV for RF SET 19 Cryo module 3 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 20 Cryo module 3		81.855	90	85	No		○			LV for RF module
		LV for RF SET 20 Cryo module 3 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 21 Cryo module 4		81.855	90	85	No		○			LV for RF module
		LV for RF SET 21 Cryo module 4 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 22 Cryo module 4		81.855	90	85	No		○			LV for RF module
		LV for RF SET 22 Cryo module 4 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 23 Cryo module 4		81.855	90	85	No		○			LV for RF module
		LV for RF SET 23 Cryo module 4 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 24 Cryo module 4		81.855	90	85	No		○			LV for RF module

Table 3-2: Electric Load List for Accelerator Facility 2/5

Electric Load List for Accelerator Facility

PBS No.	ITEM No.	Service	Rated Power		Efficiency	Power Factor	SIC	Redundancy	Normal Operation	Emergency Generator	UPS	Remarks
			6.6 kV (kW)	400V (kW)	%	%						
		LV for RF SET 24 Cryo module 4 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 25 Cryo module 4		81.855	90	85	No		○			LV for RF module
		LV for RF SET 25 Cryo module 4 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 26 Cryo module 4		81.855	90	85	No		○			LV for RF module
		LV for RF SET 26 Cryo module 4 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.9.1.0.0.0		RF Water Cooling-A (150 kW x 8.4/2.6= 485 kW)		485	90	85	No		○			9 RF moduled = 150 kW
4.9.1.0.0.0		Instrumentation-A		15	90	85	SR		○	○	○	
4.9.1.0.0.0		PC Box-A		50	90	85	No		○	○	○	
4.1.2.0.0.0		Injector-B		130	90	85	SIC-1		○			
4.1.2.0.0.0		Injector-B Instrumentation		2.5	90	85	SIC-1		○	○	○	
4.9.2.0.0.0		Injector-B Water Cooling Box		20	90	85	No		○			
4.6.2.0.0.0		RF HVPS for RFQ-B-1 (8 X 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for RFQ-B-2 (8 X 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for RFQ-B-3 (8 X 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for RFQ-B-4 (8 X 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for RFQ-B-5 (8 X 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for RFQ-B-6 (8 X 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for RFQ-B-7 (8 X 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for RFQ-B-8 (8 X 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.2.2.0.0.0		RFQ-B		85	90	85	No		○			
4.9.2.0.0.0		RFQ-B Water Cooling Box		115	90	85	No		○			
4.6.2.0.0.0		RF HVPS for MS-B (2 x 16kW RF Chains)	70		90	85	No		○			
4.3.2.0.0.0		MEBT-B		70	90	85	No		○			
4.3.2.0.0.0		MEBT-B Instrumentation		2.5	90	85	No		○			
4.9.2.0.0.0		MEBT-B Water Cooling Box		16	90	85	No		○			
4.6.2.0.0.0		RF HVPS for SRF Linac-A-1-1 (8 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-1-2 (8 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-1-3 (8 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-1-4 (8 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-2-1 (10 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-2-2 (10 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-2-3 (10 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-2-4 (10 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-2-5 (10 x 105kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-3-1 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-3-2 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-3-3 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-3-4 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-3-5 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-3-6 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-3-7 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-3-8 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-3-9 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-3-10 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-3-11 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-3-12 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-4-1 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-4-2 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-4-3 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-4-4 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-4-5 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)

Table 3-3: Electric Load List for Accelerator Facility 3/5

Electric Load List for Accelerator Facility

PBS No.	ITEM No.	Service	Rated Power 6.6 kV (kW)	Rated Power 400V (kW)	Efficiency %	Power Factor %	SIC	Redundancy	Normal Operation	Emergency Generator	UPS	Remarks
4.6.2.0.0.0		RF HVPS for SRF Linac-A-4-6 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-4-7 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-4-8 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-4-9 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-4-10 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-4-11 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.6.2.0.0.0		RF HVPS for SRF Linac-A-4-12 (12 x 200kW RF Chains)	400		90	88.889	No		○			400kW HVPS (500 kVA)
4.4.2.0.0.0		SRF Linac-B (100 kW solenoid LVPS + 50 kW other)		150	90	85	No		○			
4.5.1.0.0.0		HEBT-B + Beam Dump-B		500	90	85	No		○			
4.9.2.0.0.0		HEBT-B Water Cooling Box		50	90	85	No		○			
4.9.2.0.0.0		Beam Dump-B Water Cooling Box		60	90	85	SR		○			
4.9.2.0.0.0		He Compressor-B		600	90	85	No		○			
4.4.2.0.0.0		Cold Box-B		40	90	85	No		○			
4.4.2.0.0.0		Cryo Plant-B (10 kW x 4 = 40 kW)		40	90	85	No		○			
4.6.1.0.0.0		LV for RF SET 1 RFQ		81.855	90	85	No		○			LV for RF module
		LV for RF SET 1 RFQ for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 2 RFQ		81.855	90	85	No		○			LV for RF module
		LV for RF SET 2 RFQ for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 3 RFQ		81.855	90	85	No		○			LV for RF module
		LV for RF SET 3 RFQ for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 4 RFQ		81.855	90	85	No		○			LV for RF module
		LV for RF SET 4 RFQ for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 5 MEBT		62.73	90	85	No		○			LV for RF module
		LV for RF SET 5 MEBT for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 6 Cryo module 1		62.73	90	85	No		○			LV for RF module
		LV for RF SET 6 Cryo module 1 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 7 Cryo module 1		62.73	90	85	No		○			LV for RF module
		LV for RF SET 7 Cryo module 1 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 8 Cryo module 1		62.73	90	85	No		○			LV for RF module
		LV for RF SET 8 Cryo module 1 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 9 Cryo module 1		62.73	90	85	No		○			LV for RF module
		LV for RF SET 9 Cryo module 1 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 10 Cryo module 2		62.73	90	85	No		○			LV for RF module
		LV for RF SET 10 Cryo module 2 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 11 Cryo module 2		62.73	90	85	No		○			LV for RF module
		LV for RF SET 11 Cryo module 2 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 12 Cryo module 2		62.73	90	85	No		○			LV for RF module
		LV for RF SET 12 Cryo module 2 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 13 Cryo module 2		62.73	90	85	No		○			LV for RF module
		LV for RF SET 13 Cryo module 2 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 14 Cryo module 2		81.855	90	85	No		○			LV for RF module
		LV for RF SET 14 Cryo module 2 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 15 Cryo module 3		81.855	90	85	No		○			LV for RF module
		LV for RF SET 15 Cryo module 3 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 16 Cryo module 3		81.855	90	85	No		○			LV for RF module
		LV for RF SET 16 Cryo module 3 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 17 Cryo module 3		81.855	90	85	No		○			LV for RF module
		LV for RF SET 17 Cryo module 3 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 18 Cryo module 3		81.855	90	85	No		○			LV for RF module
		LV for RF SET 18 Cryo module 3 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 19 Cryo module 3		81.855	90	85	No		○			LV for RF module
		LV for RF SET 19 Cryo module 3 for emergency		3.06	90	85	No		○	○	○	LV for RF module

Table 3-4: Electric Load List for Accelerator Facility 4/5

Electric Load List for Accelerator Facility

PBS No.	ITEM No.	Service	Rated Power 6.6 kV (kW)	Rated Power 400V (kW)	Efficiency %	Power Factor %	SIC	Redundancy	Normal Operation	Emergency Generator	UPS	Remarks
4.6.1.0.0.0		LV for RF SET 20 Cryo module 3		81.855	90	85	No		○			LV for RF module
		LV for RF SET 20 Cryo module 3 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 21 Cryo module 4		81.855	90	85	No		○			LV for RF module
		LV for RF SET 21 Cryo module 4 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 22 Cryo module 4		81.855	90	85	No		○			LV for RF module
		LV for RF SET 22 Cryo module 4 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 23 Cryo module 4		81.855	90	85	No		○			LV for RF module
		LV for RF SET 23 Cryo module 4 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 24 Cryo module 4		81.855	90	85	No		○			LV for RF module
		LV for RF SET 24 Cryo module 4 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 25 Cryo module 4		81.855	90	85	No		○			LV for RF module
		LV for RF SET 25 Cryo module 4 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.6.1.0.0.0		LV for RF SET 26 Cryo module 4		81.855	90	85	No		○			LV for RF module
		LV for RF SET 26 Cryo module 4 for emergency		3.06	90	85	No		○	○	○	LV for RF module
4.9.2.0.0.0		RF Water Cooling-B (150 kW x 8.4/2.6= 485 kW)		485	90	85	No		○			9 RF moduled = 150 kW
4.9.2.0.0.0		Instrumentation-B		15	90	85	SR		○	○	○	
4.9.2.0.0.0		PC Box-B		50	90	85	No		○	○	○	
4.9.1.0.0.0		AF Control System-A		10	90	85	SIC-2		○	○	○	
4.9.2.0.0.0		AF Control System-B		10	90	85	SIC-2		○	○	○	
		Total	32940	8953.33								

Table 3-5: Electric Load List for Accelerator Facility 5/5

3.2.2 **Lithium Target Facility (LF)**

Table 3-6 and Table 3-7 show Electric Load List for Lithium Target Facility which was created based on requirements from Lithium Target Facility.
The required electric powers for Lithium Target Facility are:

- For Rated Power : 2595 kVA
- For Emergency Power : 823 kVA
- For UPS : 167 kVA

Electric Load List for Lithium Target Facility

ITEM No.	ITEM No.	Service	Rated Power		Efficiency	Power Factor	SIC	Redundancy	Normal Operation	Emergency Generator	UPS	Remarks
			6.6 kV (kW)	400V (kW)	%	%						
3.2.1.0.0.0		Heater for Dump Tank		115	100	100	SIC-1		○			
3.2.1.0.0.0		Heater for Quench Tank		54	100	100	SIC-1		○			
3.2.1.0.0.0		Heater for Surge Tank		38	100	100	SIC-1		○			
3.3.2.0.0.0		Heater for Cold Trap-A		40	100	100	SIC-2		○	○		
3.3.2.0.0.0		Heater for Cold Trap-B		40	100	100	SIC-2			○		
3.3.2.0.0.0		Economizer Heater for Cold Trap-A		6	100	100	SIC-2		○	○		
3.3.2.0.0.0		Economizer Heater for Cold Trap-B		6	100	100	SIC-2			○		
3.3.2.0.0.0		Heater for N-Hot Trap-A		80	100	100	SIC-2		○			
3.3.2.0.0.0		Heater for N-Hot Trap-B		80	100	100	SIC-2					
3.3.2.0.0.0		Economizer Heater for N-Hot Trap-A		12	100	100	SIC-2		○			
3.3.2.0.0.0		Economizer Heater for N-Hot Trap-B		12	100	100	SIC-2					
3.3.2.0.0.0		Heater for H-Hot Trap-A		80	100	100	SIC-2		○			
3.3.2.0.0.0		Heater for H-Hot Trap-B		80	100	100	SIC-2					
3.5.1.0.0.0		Heater for No.1 Mist Trap		8	100	100	SR		○			
3.5.1.0.0.0		Heater for No.2 Mist Trap		8	100	100	SR		○			
3.5.1.0.0.0		Heater for No.3 Mist Trap		8	100	100	SR		○			
3.5.1.0.0.0		Heater for No.4 Mist Trap		8	100	100	SR		○			
3.5.1.0.0.0		Heater for No.1 Vapor Trap		8	100	100	SR		○			
3.5.1.0.0.0		Heater for No.2 Vapor Trap		8	100	100	SR		○			
3.5.1.0.0.0		Heater for No.3 Vapor Trap		8	100	100	SR		○			
3.3.3.0.0.0		Heater for Li Sampling Unit		3	100	100	SIC-2		○	○		
3.2.1.0.0.0		Heater for Main Loop		234	100	100	SIC-1		○			
3.2.1.0.0.0		Heater for Vacuum Line		107	100	100	SIC-1		○			
3.3.2.0.0.0		No.1 Heater for Purification Loop		20	100	100	SIC-2		○			
3.3.2.0.0.0		No.2 Heater for Purification Loop		10	100	100	SIC-2		○			
3.3.3.0.0.0		Heater for Impurity Monitoring Loop		10	100	100	SIC-2		○			
3.2.1.0.0.0		Heater for Motor Valve		95	100	100	SIC-1		○	○		
						100						
3.2.2.0.0.0		Heater for Organic Oil Loop		330	100	100	SIC-1		○	○		
3.2.3.0.0.0		Heater for Intermediate Water Loop		315	100	100	SIC-1		○			
3.3.2.0.0.0		Blower for Cold Trap (INV)		7.5	75	75	SIC-2		○	○		
3.2.1.0.0.0		Blower for Dump Tank Pit Ventilation		2.7	75	75	SIC-2		○	○		
3.2.1.0.0.0		Blower for Li Outlet Channel Plug Cooling	45		90	85	SIC-2		○	○		
3.2.1.0.0.0		Blower for Li Inlet Pipe Plug Cooling	45		90	85	SIC-2		○	○		
3.1.5.0.0.0		Vacuum Pump Unit for Beam Duct-1		1.224	90	85	SR		○			
3.1.5.0.0.0		Vacuum Pump Unit for Beam Duct-2		1.224	90	85	SR		○			
3.1.5.0.0.0		Vacuum Pump Unit for Beam Duct-3		1.224	90	85	SR		○			
3.1.5.0.0.0		Vacuum Pump Unit for Beam Duct-4		1.224	90	85	SR		○			
3.1.5.0.0.0		Vacuum Pump Unit for Beam Duct-5		1.224	90	85	SR		○			
3.1.5.0.0.0		Vacuum Pump Unit for Beam Duct-6		1.224	90	85	SR		○			
3.1.5.0.0.0		Booster Pump for Vacuum Pump Unit -1		0.4	90	85	SR		○			
3.1.5.0.0.0		Booster Pump for Vacuum Pump Unit -2		0.4	90	85	SR		○			
3.1.5.0.0.0		Booster Pump for Vacuum Pump Unit -3		0.4	90	85	SR		○			
3.1.5.0.0.0		Booster Pump for Vacuum Pump Unit -4		0.4	90	85	SR		○			
3.1.5.0.0.0		Booster Pump for Vacuum Pump Unit -5		0.4	90	85	SR		○			
3.1.5.0.0.0		Booster Pump for Vacuum Pump Unit -6		0.4	90	85	SR		○			
3.5.2.0.0.0		Vacuum Pump Unit for Quenchi Tank		3.7	100	75	SR		○			
3.5.2.0.0.0		Vacuum Pump Unit for Surge Tank		3.7	100	75	SR		○			
3.5.2.0.0.0		Vacuum Pump Unit for Dump Tank		5.5	100	75	SR		○			
3.2.1.0.0.0		Eectric Magnet Pump for Main Loop	260		90	62.222	SIC-1		○			

Table 3-6: Electric Load List for Lithium Target Facility 1/2

Electric Load List for Lithium Target Facility

ITEM No.	ITEM No.	Service	Rated Power 6.6 kV (kW)	Rated Power 400V (kW)	Efficiency %	Power Factor %	SIC	Redundancy	Normal Operation	Emergency Generator	UPS	Remarks
3.3.1.0.0.0		Eectric Magnet Pump for Purification Loop		14	90	62.222	SIC-2		○			
3.5.2.0.0.0		Pressure Relief Valve for Argon Gas		0.55	60	60	SIC-1		○	○	○	
3.5.2.0.0.0		No.1 Valve for DPI Between QT & DT		0.55	60	60	SIC-1		○	○	○	
3.5.2.0.0.0		No.2 Valve for DPI Between QT & DT		0.55	60	60	SIC-1		○	○	○	
3.5.2.0.0.0		Valve for Argon Gas Inlet of Li Leak Drain Collecting Tank		0.02	60	60	SIC-1		○	○	○	
3.5.2.0.0.0		Valve for Cooling Air Inlet of Cold Trap		0.025	60	60	SR		○	○	○	
3.2.1.0.0.0		Valve for Quench Tank Outlet		0.9	60	60	SIC-1		○	○	○	
3.2.1.0.0.0		Valve for Inlet of Main Loop		0.69	60	60	SIC-1		○	○	○	
3.2.1.0.0.0		Vent Valve for Main Loop		0.23	60	60	SIC-1		○	○	○	
3.3.2.0.0.0		No.1 Injection Valve for Purification Loop		0.23	60	60	SIC-2		○	○	○	
3.3.2.0.0.0		No.2 Injection Valve for Purification Loop		0.23	60	60	SIC-2		○	○	○	
3.3.2.0.0.0		Valve for Purification Loop Inlet		0.23	60	60	SIC-2		○	○	○	
3.3.2.0.0.0		Vent Valve for Purification Loop		0.23	60	60	SIC-2		○	○	○	
3.3.2.0.0.0		Valve for Purification Loop Outlet		0.23	60	60	SIC-2		○	○	○	
3.2.1.0.0.0		Valve for Quench Tank Over-Flow		0.23	60	60	SIC-1		○	○	○	
3.2.1.0.0.0		Valve for Surge Tank Outlet		0.23	60	60	SIC-1		○	○	○	
3.2.1.0.0.0		Valve for Main Loop Returm		0.23	60	60	SIC-1		○	○	○	
3.3.1.0.0.0		Drain Valve for Purification Loop		0.23	60	60	SIC-2		○	○	○	
3.3.2.0.0.0		Drain Valve for Cold Trap-A		0.23	60	60	SIC-2		○	○	○	
3.3.2.0.0.0		Drain Valve for Cold Trap-B		0.23	60	60	SIC-2			○	○	
3.3.2.0.0.0		Drain Valve for H Hot Trap-A		0.23	60	60	SIC-2		○	○	○	
3.3.2.0.0.0		Drain Valve for H Hot Trap-B		0.23	60	60	SIC-2			○	○	
3.3.2.0.0.0		Drain Valve for N Hot Trap-A		0.23	60	60	SIC-2		○	○	○	
3.3.2.0.0.0		Drain Valve for N Hot Trap-B		0.23	60	60	SIC-2			○	○	
3.3.3.0.0.0		Valve for Impurity Monitoring Loop Inlet		0.23	60	60	SIC-2		○	○	○	
3.3.3.0.0.0		Vent Valve for Impurity Monitoring Loop		0.23	60	60	SIC-2		○	○	○	
3.3.3.0.0.0		Valve for Impurity Monitoring Loop Outlet		0.23	60	60	SIC-2		○	○	○	
3.5.2.0.0.0		Communication Valve Between DT & QT		0.5	60	60	SR		○	○	○	
3.5.2.0.0.0		Communication Valve Between DT & ST		0.5	60	60	SR		○	○	○	
3.5.2.0.0.0		Valve for Argon Gas Inlet of Quench Tank		0.55	60	60	SIC-1		○	○	○	
3.5.2.0.0.0		Valve for Argon Gas Inlet of Surge Tank		0.55	60	60	SIC-1		○	○	○	
3.5.2.0.0.0		Valve for Argon Gas Inlet of Dump Tank		0.55	60	60	SIC-1		○	○	○	
3.2.1.0.0.0		Solenoid Valve for Target Assembly Inlet (100V)		0.01	100	100	SIC-1		○	○	○	
3.2.1.0.0.0		Solenoid Valve for Target Assembly Bypass (100V)		0.01	100	100	SIC-1		○	○	○	
3.5.1.0.0.0		Control Board (100V)		7.6	100	100	SIC-1		○	○	○	
3.5.1.0.0.0		Control System (100V)		8.3	100	100	SIC-1		○	○	○	
3.5.1.0.0.0		Instrument (100V)		2.4	100	100	SIC-1		○	○	○	
3.2.2.0.0.0		Organic Oil Loop Circulation Pump	160		100	75	SR		○			
3.2.3.0.0.0		Intermediate Water Loop Circulation Pump	90		100	75	SR		○	○	○	
3.4.0.0.0.0		Laser Oscillator for Welding & Cutting		5	90	85	SR					
3.4.0.0.0.0		Drive Unit for Laser Head		0.4	90	85	SR					
		Total	600	1903.869								

Table 3-7: Electric Load List for Lithium Target Facility 2/2

3.2.3 **Test Facility (TF)**

Table 3-8 show Electric Load List for Test Facility which was created based on requirements from Test Facility.
The required electric power for Test Facility are:

- For Rated Power : 3689 kVA
- For Emergency Power : 238 kVA
- For UPS : 67 kVA

NOTE:

For the next step of EPS engineering design and regarding to the Helium compressors for TF system we noted that its power supply could be most probably 400V rather that 6.6 KV as indicated on present DDD (this point was not clearly defined by the TF system since the TF engineering study was not synchronised with the present EPS DDD). However, this issue needs probably revision during engineering construction design.

In other words, and to be more clear, the interface point between CF and TF has been identified at the delivery point of 6.6 KV, hence He compressor 400 V power supply is downstream to the CF interface point and will be managed by TF by means of TF dedicated transformers and related LV power boards.

Electric Load List for Test Facility

PBS No.	ITEM No.	Service	Rated Power		Efficiency	Power Factor	SIC	Redundancy	Normal Operation	Emergency Generator	UPS	Remarks
			6.6 kV (kW)	400V (kW)	%	%						
2.7.1.1.0.0		TC diagnostics and control system		5	90	85	SIC-2		○	○	○	
2.7.1.2.1.0		Fast evacuation system		15	90	85	SR		○			
2.7.1.2.2.0		Continous evacuation system		1	90	85	SR		○			
2.7.1.3.1.0		TC GIMS high pressure compressor system (w/ buffer)		30	90	85	SR		○			
2.7.1.4.1.0		TC atmosphere circulation blower		11	90	85	SIC-2		○	○		
2.7.1.4.5.0		TC atmosphere gas analysis system		5	90	85	SIC-2		○	○		
2.7.1.5.1.0		TC-WCS Water circulation pump		7.5	90	85	SIC-2		○	○		
2.7.1.5.6.0		Water conditioning system		1	90	85	SR		○			
2.7.1.5.8.0		Piping sections, valves and fittings		1	90	85	SR		○	○	○	
2.7.1.5.9.0		Instrumentation and local control system		5	90	85	SIC-2		○	○	○	
2.7.1.6.1.0		Helium compressor array 2 parallel machines	700		90	85	SR		○			
		Helium compressor for Emergency (It is a part of above.)	35		90	85	SR			○		5% of Helium compressor
2.7.1.6.4.0		Instrumentation		1	90	85	SIC-2		○	○	○	
2.7.1.7.0.0		VIT loading&transport system		5	90	85	SR		○			
2.7.1.8.0.0		TC RH control system		5	90	85	SR		○			
2.7.2.1.1.0		Helium compressor array, 5 parallel machines	1446.5		90	85	SR		○			
		Helium compressor for Emergency (It is a part of above.)	73		90	85	SIC-2			○		5% of Helium compressor
2.7.2.1.4.0		Instrumentation		1	90	85	SIC-2		○	○	○	
2.7.2.1.9.0		Feed helium purification system (Oil(?) and air, water removal)		30	90	85	SR		○			
2.7.2.1.11.0		TM inlet gas conditioning equipment (heaters, valves, instrumentation)		150	90	85	SR		○			
2.7.2.3.0.0		TRTM&LBVM tritium analysis station (TM-TAS)		5	90	85	SR		○	○	○	
2.7.3.1.0.0		TM Experiments User Interface (TM-UI)		5	90	85	SR		○	○	○	
2.7.3.2.0.0		HFTM Control System (HFTM-CS) : Heater		108	90	85	SR		○			Heater : 108 kW
		HFTM Control System (HFTM-CS) : Control System		5	90	85	SR		○	○	○	Control System : 5kW
2.7.3.3.0.0		CFTM Control System (CFTM-CS) : Heater		10	90	85	SR		○			Heater : 10 kW
		CFTM Control System (CFTM-CS) : Control System		5	90	85	SR		○	○	○	Control System : 5kW
2.7.3.4.0.0		TRTM Control System (TRTM-CS) : Heater		8	90	85	SR		○			Heater : 8 kW
		TRTM Control System (TRTM-CS) : Control System		5	90	85	SR		○	○	○	Control System : 5kW
2.7.3.5.0.0		LBVM Control System (TRTM-CS) : Heater		10	90	85	SR		○			Heater : 10 kW
		LBVM Control System (TRTM-CS) : Control System		5	90	85	SR		○	○	○	Control System : 5kW
2.7.3.6.0.0		LFTM Control System (LFTM-CS) : Heater		20	90	85	SR		○			Heater : 20 kW
		LFTM Control System (LFTM-CS) : Control System		5	90	85	SR		○	○	○	Control System : 5kW
2.7.3.7.0.0		Test Cell User Interface (TC-UI)		1	90	85	SR		○	○	○	
2.7.3.8.0.0		Access Cell User Interface (AC-UI)		2	90	85	SR		○	○	○	
2.6.1.1.0.0		Heavy Rope Overhead Crane (HROC)		30	90	85	SR					50 ton Crane
2.6.1.2.0.0		Access Cell Mast Crane (ACMC)		5	90	85	SR					Auxiliary Hoist (3 ton)
2.6.2.0.0.0		Small Universl Robot System (SURS)		4	90	85	SR					Auxiliary Small Hoist (2 ton)
		Others		61	90	85	SR					
		Total	2254.5	567.5								

Table 3-8: Electric Load List for Test Facility

3.2.4 **Post Irradiation Examination Facility (PIEF)**

Table 3-9 show Electric Load List for Post Irradiation Examination Facility that was created based on requirements from Post Irradiation Examination Facility.
The required electric powers for Post Irradiation Examination Facility are:

- For Rated Power : 1013 kVA
- For Emergency Power : 13 kVA
- For UPS : 13 kVA

Electric Load List for Post Irradiation Examination Facility

PBS No.	ITEM No.	Service	Rated Power 6.6 kV (kW)	Rated Power 400V (kW)	Efficiency %	Power Factor %	SIC	Redundancy	Normal Operation	Emergency Generator	UPS	Remarks
6.0.0.0.0.0		Manippulator			100	100						
6.0.0.0.0.0		Crane			100	100						
6.0.0.0.0.0		Transfer System			100	100						
6.0.0.0.0.0		Testing Equipment for Tensile			100	100						
6.0.0.0.0.0		Testing Equipment for Fracture Toughness			100	100						
6.0.0.0.0.0		Testing Equipment for Charpy Impact			100	100						
6.0.0.0.0.0		Testing Equipment for Fatiuge			100	100						
6.0.0.0.0.0		Testing Equipment for Creep Deformation			100	100						
6.0.0.0.0.0		Testing Equipment for Creep Rupture			100	100						
6.0.0.0.0.0		Testing Equipment for Crack Growth Measurement			100	100						
6.0.0.0.0.0		Testing Equipment for SSRT/SCC			100	100						
6.0.0.0.0.0		Testing Equipment for Compression			100	100						
6.0.0.0.0.0		Testing Equipment for Small Punch			100	100						
6.0.0.0.0.0		Testing Equipment for Hardness			100	100						
6.0.0.0.0.0		Testing Equipment for Micro-Vickers			100	100						
6.0.0.0.0.0		Testing Equipment for Nano-Indentaion			100	100						
6.0.0.0.0.0		Testing Equipment for Microstructure Observation			100	100						
6.0.0.0.0.0		Testing Equipment for Aoutmatic Radiography & Micro Gamma Scanning			100	100						
6.0.0.0.0.0		Testing Equipment for Chemical Analysis (Gas Element Analysis)			100	100						
6.0.0.0.0.0		Testing Equipment for Chemical Analysis (Materials Analysis)			100	100						
6.0.0.0.0.0		Cutting Instrument			100	100						
6.0.0.0.0.0		Griding & Etching Instruments			100	100						
6.0.0.0.0.0		Electrolytic Polishing Equipment			100	100						
6.0.0.0.0.0		Extraction Residue Device			100	100						
6.0.0.0.0.0		Testing Equipment for X-Ray Radiography			100	100						
6.0.0.0.0.0		Testing Equipment for Micro Gamma-Scanning			100	100						
6.0.0.0.0.0		Testing Equipment for Eddy Current			100	100						
6.0.0.0.0.0		Leak Detector			100	100						
6.0.0.0.0.0		Mass Spectrometer			100	100						
6.0.0.0.0.0		Dessity Mesurment Equipment			100	100						
6.0.0.0.0.0		Testing Equipment for Magnectic Property			100	100						
6.0.0.0.0.0		Testing Equipment for Electromagnetic Induction Method			100	100						
6.0.0.0.0.0		Testing Equipment for Liquid Penetrant			100	100						
6.0.0.0.0.0		Testing Equipment for Electron Conductivity			100	100						
					100	100						
6.0.0.0.0.0		PIE Control System		10	90	85			○	○	○	
6.0.0.0.0.0		Others			100	100						
		Total	0	1010								

Table 3-9: Electric Load List for Post Irradiation Examination Facility

3.2.5 **Conventional Facility (CF)**

Table 3-10, Table 3-11, Table 3-12, Table 3-13, Table 3-14 and Table 3-15 show Electric Load List for Conventional Facility which was created based on requirements from Conventional Facility.
The required electric powers for Conventional Facility are:

- For Rated Power : 24697 kVA
- For Emergency Power : 4992 kVA
- For UPS : 359 kVA

Electric Load List for Conventional Facility

PBS No.	ITEM No.	Service	Rated Power 6.6 kV (kW)	Rated Power 400V (kW)	Efficiency %	Power Factor %	SIC	Redundancy	Normal Operation	Emergency Generator	UPS	Remarks
5.3.1.1.0	5.3.1.1.0-A-001A(1)	Air Handling Unit for Nuclear HVAC	250		90	85	SR	100% x 2	○			In Industrial HVAC Room-2
5.3.1.1.0	5.3.1.1.0-A-001A(2)	Air Handling Unit for Nuclear HVAC	250		90	85	SR					〃
5.3.1.1.0	5.3.1.1.0-A-001B(1)	Air Handling Unit for Nuclear HVAC	250		90	85	SR	100% x 2	○			〃
5.3.1.1.0	5.3.1.1.0-A-001B(2)	Air Handling Unit for Nuclear HVAC	250		90	85	SR					〃
5.3.1.2.0	5.3.1.2.0-A-001A	Air Handling Unit for PIE Nuclear HVAC	250		90	85	SR	100% x 2	○			In Industrial HVAC Room-1
5.3.1.2.0	5.3.1.2.0-A-001B	Air Handling Unit for PIE Nuclear HVAC	250		90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-A-001A	Air Handling Unit for Industrial HVAC		110	90	85	SR	100% x 2	○			〃
5.3.1.3.0	5.3.1.3.0-A-001B	Air Handling Unit for Industrial HVAC		110	90	85	SR					〃
5.3.1.1.0	5.3.1.1.0-K-001A	Exhaust Fan for Nuclear HVAC "C1"		110	90	85	SIC-1	100% x 2	○	○		In HVAC Blower Room
5.3.1.1.0	5.3.1.1.0-K-001B	Exhaust Fan for Nuclear HVAC "C1"		110	90	85	SIC-1					〃
5.3.1.1.0	5.3.1.1.0-K-002A	Exhaust Fan for Nuclear HVAC "C2"	200		90	85	SIC-1	50% x 4	○	○		〃
5.3.1.1.0	5.3.1.1.0-K-002B	Exhaust Fan for Nuclear HVAC "C2"	200		90	85	SIC-1					〃
5.3.1.1.0	5.3.1.1.0-K-002C	Exhaust Fan for Nuclear HVAC "C2"	200		90	85	SIC-1		○	○		〃
5.3.1.1.0	5.3.1.1.0-K-002D	Exhaust Fan for Nuclear HVAC "C2"	200		90	85	SIC-1					〃
5.3.1.1.0	5.3.1.1.0-K-003A	Exhaust Fan for Nuclear HVAC "C3"	132		90	85	SIC-1	100% x 2	○	○		〃
5.3.1.1.0	5.3.1.1.0-K-003B	Exhaust Fan for Nuclear HVAC "C3"	132		90	85	SIC-1					〃
5.3.1.1.0	5.3.1.1.0-K-004A	Exhaust Fan for Nuclear HVAC "C4"		18.5	90	85	SIC-1	100% x 2	○	○		〃
5.3.1.1.0	5.3.1.1.0-K-004B	Exhaust Fan for Nuclear HVAC "C4"		18.5	90	85	SIC-1					〃
5.3.1.1.0	5.3.1.1.0-K-005A	Circulation Fan for Accelerator Area		37	90	85	SIC-1	50% x 4	○	○		In Vault Recirculation Blower Room-1
5.3.1.1.0	5.3.1.1.0-K-005B	Circulation Fan for Accelerator Area		37	90	85	SIC-1					〃
5.3.1.1.0	5.3.1.1.0-K-005C	Circulation Fan for Accelerator Area		37	90	85	SIC-1		○	○		〃
5.3.1.1.0	5.3.1.1.0-K-005D	Circulation Fan for Accelerator Area		37	90	85	SIC-1					〃
5.3.1.1.0	5.3.1.1.0-K-006A	Exhaust Fan for Accelerator Area		18.5	90	85	SIC-1	50% x 4	○	○		In Vault Recirculation Blower Room-2
5.3.1.1.0	5.3.1.1.0-K-006B	Exhaust Fan for Accelerator Area		18.5	90	85	SIC-1					〃
5.3.1.1.0	5.3.1.1.0-K-006C	Exhaust Fan for Accelerator Area		18.5	90	85	SIC-1		○	○		〃
5.3.1.1.0	5.3.1.1.0-K-006D	Exhaust Fan for Accelerator Area		18.5	90	85	SIC-1					〃
5.3.1.2.0	5.3.1.2.0-K-001A	Exhaust Fan for PIE Nuclear HVAC "C1"		11	90	85	SIC-1	100% x 2	○	○		In HVAC Blower Room
5.3.1.2.0	5.3.1.2.0-K-001B	Exhaust Fan for PIE Nuclear HVAC "C1"		11	90	85	SIC-1					〃
5.3.1.2.0	5.3.1.2.0-K-002A	Exhaust Fan for PIE Nuclear HVAC "C2"		18.5	90	85	SIC-1	100% x 2	○	○		〃
5.3.121.0	5.3.121.0-K-002B	Exhaust Fan for PIE Nuclear HVAC "C2"		18.5	90	85	SIC-1					〃
5.3.1.2.0	5.3.1.2.0-K-003A	Exhaust Fan for PIE Nuclear HVAC "C3"		18.5	90	85	SIC-1	100% x 2	○	○		〃
5.3.1.2.0	5.3.1.2.0-K-003B	Exhaust Fan for PIE Nuclear HVAC "C3"		18.5	90	85	SIC-1					〃
5.3.1.2.0	5.3.1.2.0-K-004A	Exhaust Fan for PIE Nuclear HVAC "C4"		90	90	85	SIC-1	100% x 2	○	○		〃
5.3.1.2.0	5.3.1.2.0-K-004B	Exhaust Fan for PIE Nuclear HVAC "C4"		90	90	85	SIC-1					〃
5.3.1.3.0	5.3.1.3.0-K-001A	Exhaust Fan for Industrial HVAC	132		90	85	SR	100% x 2	○	○		In Industrial HVAC Room-1
5.3.1.3.0	5.3.1.3.0-K-001B	Exhaust Fan for Industrial HVAC	132		90	85	SR					〃
5.3.1.4.0	5.3.1.4.0-HC-001A	Chiller for Cooling / Heating	300		90	85	SR		○			Outside on Ground
5.3.1.4.0	5.3.1.4.0-HC-001B	Chiller for Cooling / Heating	300		90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-HC-001C	Chiller for Cooling / Heating	300		90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-HC-001D	Chiller for Cooling / Heating	300		90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-HC-001E	Chiller for Cooling / Heating	300		90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-HC-001F	Chiller for Cooling / Heating	300		90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-HC-001G	Chiller for Cooling / Heating	300		90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-HC-001H	Chiller for Cooling / Heating	300		90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-HC-001I	Chiller for Cooling / Heating	300		90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-HC-001J	Chiller for Cooling / Heating	300		90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-HC-001K	Chiller for Cooling / Heating	300		90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-HC-001L	Chiller for Cooling / Heating	300		90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-HC-001M	Chiller for Cooling / Heating	300		90	85	SR	(Spare)				〃

Table 3-10: Electric Load List for Conventional Facility 1/6

Electric Load List for Conventional Facility

PBS No.	ITEM No.	Service	Rated Power 6.6 kV (kW)	Rated Power 400V (kW)	Efficiency %	Power Factor %	SIC	Redundancy	Normal Operation	Emergency Generator	UPS	Remarks
5.3.1.4.0	5.3.1.4.0-HC-002A	Chiller for Heating	210		90	85	SR	100% x 2	○			Outside on Ground
5.3.1.4.0	5.3.1.4.0-HC-002B	Chiller for Heating	210		90	85	SR					〃
5.3.1.4.0	5.3.1.4.0-P-001A	Cooling / Hot Water Pump		45	90	85	SR		○			Outside on Ground
5.3.1.4.0	5.3.1.4.0-P-001B	Cooling / Hot Water Pump		45	90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-P-001C	Cooling / Hot Water Pump		45	90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-P-001D	Cooling / Hot Water Pump		45	90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-P-001E	Cooling / Hot Water Pump		45	90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-P-001F	Cooling / Hot Water Pump		45	90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-P-001G	Cooling / Hot Water Pump		45	90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-P-001H	Cooling / Hot Water Pump		45	90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-P-001I	Cooling / Hot Water Pump		45	90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-P-001J	Cooling / Hot Water Pump		45	90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-P-001K	Cooling / Hot Water Pump		45	90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-P-001L	Cooling / Hot Water Pump		45	90	85	SR		○			〃
5.3.1.4.0	5.3.1.4.0-P-001M	Cooling / Hot Water Pump		45	90	85	SR	(Spare)				〃
5.3.1.4.0	5.3.1.4.0-P-002A	Hot Water Pump		22	90	85	SR	100% x 2	○			〃
5.3.1.4.0	5.3.1.4.0-P-002B	Hot Water Pump		22	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-001A	Packaged Air Conditioner (For HP Panel Room)		0.88	90	85	SR	100% x 2	○			Outside on Roof
5.3.1.3.0	5.3.1.3.0-PAC-001B	Packaged Air Conditioner (For HP Panel Room)		0.88	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-002A	Packaged Air Conditioner (For Contol Room)		1.51	90	85	SR	100% x 2	○			〃
5.3.1.3.0	5.3.1.3.0-PAC-002B	Packaged Air Conditioner (For Contol Room)		1.51	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-003A	Packaged Air Conditioner (For LV E.P Supply Area-1)		11.88	90	85	SR	50% x 4	○			〃
5.3.1.3.0	5.3.1.3.0-PAC-003B	Packaged Air Conditioner (For LV E.P Supply Area-1)		11.88	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-003C	Packaged Air Conditioner (For LV E.P Supply Area-1)		11.88	90	85	SR		○			〃
5.3.1.3.0	5.3.1.3.0-PAC-003D	Packaged Air Conditioner (For LV E.P Supply Area-1)		11.88	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-004A	Packaged Air Conditioner (For LV E.P Supply Area-2)		11.88	90	85	SR	50% x 4	○			〃
5.3.1.3.0	5.3.1.3.0-PAC-004B	Packaged Air Conditioner (For LV E.P Supply Area-2)		11.88	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-004C	Packaged Air Conditioner (For LV E.P Supply Area-2)		11.88	90	85	SR		○			〃
5.3.1.3.0	5.3.1.3.0-PAC-004D	Packaged Air Conditioner (For LV E.P Supply Area-2)		11.88	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-005A	Packaged Air Conditioner (For Control Room)		6.01	90	85	SR	100% x 2	○			〃
5.3.1.3.0	5.3.1.3.0-PAC-005B	Packaged Air Conditioner (For Control Room)		6.01	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-006A	Packaged Air Conditioner (For Power Receiving Area-1)		6.01	90	85	SR	50% x 4	○			〃
5.3.1.3.0	5.3.1.3.0-PAC-006B	Packaged Air Conditioner (For Power Receiving Area-1)		6.01	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-006C	Packaged Air Conditioner (For Power Receiving Area-1)		6.01	90	85	SR		○			〃
5.3.1.3.0	5.3.1.3.0-PAC-006D	Packaged Air Conditioner (For Power Receiving Area-1)		6.01	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-007A	Packaged Air Conditioner (For Power Receiving Area-2)		6.01	90	85	SR	50% x 4	○			〃
5.3.1.3.0	5.3.1.3.0-PAC-007B	Packaged Air Conditioner (For Power Receiving Area-2)		6.01	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-007C	Packaged Air Conditioner (For Power Receiving Area-2)		6.01	90	85	SR		○			〃
5.3.1.3.0	5.3.1.3.0-PAC-007D	Packaged Air Conditioner (For Power Receiving Area-2)		6.01	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-008A	Packaged Air Conditioner (For UPS Room-1)		6.01	90	85	SR	100% x 2	○			〃
5.3.1.3.0	5.3.1.3.0-PAC-008B	Packaged Air Conditioner (For UPS Room-1)		6.01	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-009A	Packaged Air Conditioner (For UPS Room-2)		6.01	90	85	SR	100% x 2	○			〃
5.3.1.3.0	5.3.1.3.0-PAC-009B	Packaged Air Conditioner (For UPS Room-2)		6.01	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-010A	Packaged Air Conditioner (For Utilities)		6.01	90	85	SR	50% x 4	○			〃
5.3.1.3.0	5.3.1.3.0-PAC-010B	Packaged Air Conditioner (For Utilities)		6.01	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-010C	Packaged Air Conditioner (For Utilities)		6.01	90	85	SR		○			〃
5.3.1.3.0	5.3.1.3.0-PAC-010D	Packaged Air Conditioner (For Utilities)		6.01	90	85	SR					〃

Table 3-11: Electric Load List for Conventional Facility 2/6

Electric Load List for Conventional Facility

PBS No.	ITEM No.	Service	Rated Power 6.6 kV (kW)	Rated Power 400V (kW)	Efficiency %	Power Factor %	SIC	Redundancy	Normal Operation	Emergency Generator	UPS	Remarks
5.3.1.3.0	5.3.1.3.0-PAC-011A	Packaged Air Conditioner (For Local Control Rack-1)		16.1	90	85	SR	50% x 4	○			Outside on Roof
5.3.1.3.0	5.3.1.3.0-PAC-011B	Packaged Air Conditioner (For Local Control Rack-1)		16.1	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-011C	Packaged Air Conditioner (For Local Control Rack-1)		16.1	90	85	SR		○			〃
5.3.1.3.0	5.3.1.3.0-PAC-011D	Packaged Air Conditioner (For Local Control Rack-1)		16.1	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-012A	Packaged Air Conditioner (For Local Control Rack-2)		16.1	90	85	SR	50% x 4	○			〃
5.3.1.3.0	5.3.1.3.0-PAC-012B	Packaged Air Conditioner (For Local Control Rack-2)		16.1	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-012C	Packaged Air Conditioner (For Local Control Rack-2)		16.1	90	85	SR		○			〃
5.3.1.3.0	5.3.1.3.0-PAC-012D	Packaged Air Conditioner (For Local Control Rack-2)		16.1	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-013A	Packaged Air Conditioner (For HV E.P Supply Area-1)		11.88	90	85	SR	33% x 6	○			〃
5.3.1.3.0	5.3.1.3.0-PAC-013B	Packaged Air Conditioner (For HV E.P Supply Area-1)		11.88	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-013C	Packaged Air Conditioner (For HV E.P Supply Area-1)		11.88	90	85	SR		○			〃
5.3.1.3.0	5.3.1.3.0-PAC-013D	Packaged Air Conditioner (For HV E.P Supply Area-1)		11.88	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-013E	Packaged Air Conditioner (For HV E.P Supply Area-1)		11.88	90	85	SR		○			〃
5.3.1.3.0	5.3.1.3.0-PAC-013F	Packaged Air Conditioner (For HV E.P Supply Area-1)		11.88	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-014A	Packaged Air Conditioner (For HV E.P Supply Area-2)		11.88	90	85	SR	33% x 6	○			〃
5.3.1.3.0	5.3.1.3.0-PAC-014B	Packaged Air Conditioner (For HV E.P Supply Area-2)		11.88	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-014C	Packaged Air Conditioner (For HV E.P Supply Area-2)		11.88	90	85	SR		○			〃
5.3.1.3.0	5.3.1.3.0-PAC-014D	Packaged Air Conditioner (For HV E.P Supply Area-2)		11.88	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-014E	Packaged Air Conditioner (For HV E.P Supply Area-2)		11.88	90	85	SR		○			〃
5.3.1.3.0	5.3.1.3.0-PAC-014F	Packaged Air Conditioner (For HV E.P Supply Area-2)		11.88	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-015A	Packaged Air Conditioner (For Non-Radi. Cooling Machine Room-1)		6.01	90	85	SR	100% x 2	○			〃
5.3.1.3.0	5.3.1.3.0-PAC-015B	Packaged Air Conditioner (For Non-Radi. Cooling Machine Room-1)		6.01	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-016A	Packaged Air Conditioner (For Non-Radi. Cooling Machine Room-2)		6.01	90	85	SR	100% x 2	○			〃
5.3.1.3.0	5.3.1.3.0-PAC-016B	Packaged Air Conditioner (For Non-Radi. Cooling Machine Room-2)		6.01	90	85	SR					〃
5.3.1.3.0	5.3.1.3.0-PAC-017A	Packaged Air Conditioner (For Computer Room)		1.51	90	85	SR	100% x 2	○			〃
5.3.1.3.0	5.3.1.3.0-PAC-017B	Packaged Air Conditioner (For Computer Room)		1.51	90	85	SR					〃
5.3.3.0.0	5.3.3.0.0-HT-001A	Cooling Tower		111	90	85	SR		○			37 kW x 3
5.3.3.0.0	5.3.3.0.0-HT-001B	Cooling Tower		111	90	85	SR		○			37 kW x 3
5.3.3.0.0	5.3.3.0.0-HT-001C	Cooling Tower		111	90	85	SR		○			37 kW x 3
5.3.3.0.0	5.3.3.0.0-HT-001D	Cooling Tower		111	90	85	SR		○			37 kW x 3
5.3.3.0.0	5.3.3.0.0-HT-001E	Cooling Tower		111	90	85	SR		○			37 kW x 3
5.3.3.0.0	5.3.3.0.0-HT-101A	Cooling Tower		111	90	85	SR		○			37 kW x 3
5.3.3.0.0	5.3.3.0.0-HT-101B	Cooling Tower		111	90	85	SR		○			37 kW x 3
5.3.3.0.0	5.3.3.0.0-HT-101C	Cooling Tower		111	90	85	SR		○			37 kW x 3
5.3.3.0.0	5.3.3.0.0-HT-102A	Cooling Tower (2nd Phase)		111	90	85	SR		○			37 kW x 3
5.3.3.0.0	5.3.3.0.0-HT-102B	Cooling Tower (2nd Phase)		111	90	85	SR		○			37 kW x 3
5.3.3.0.0	5.3.3.0.0-HT-201A	Cooling Tower		44	90	85	SR		○			22 kW x 2
5.3.3.0.0	5.3.3.0.0-HT-201B	Cooling Tower		44	90	85	SR		○			22 kW x 2
5.3.3.0.0	5.3.3.0.0-HT-202	Cooling Tower (2nd Phase)		44	90	85	SR		○			22 kW x 2
5.3.3.0.0	5.3.3.0.0-HT-301A	Cooling Tower		74	90	85	SR		○			37 kW x 2
5.3.3.0.0	5.3.3.0.0-HT-301B	Cooling Tower		74	90	85	SR		○			37 kW x 2
5.3.3.0.0	5.3.3.0.0-HT-302	Cooling Tower (2nd Phase)		74	90	85	SR		○			37 kW x 2
5.3.3.0.0	5.3.3.0.0-HC-021A	Primary ChW Chiller	398		90	85	SR	100% x 2	○			
5.3.3.0.0	5.3.3.0.0-HC-021B	Primary ChW Chiller	398		90	85	SR					
5.3.3.0.0	5.3.3.0.0-HC-211A	Secondary ChW Chiller	460		90	85	SR	100% x 2	○			
5.3.3.0.0	5.3.3.0.0-HC-211B	Secondary ChW Chiller	460		90	85	SR					

Table 3-12: Electric Load List for Conventional Facility 3/6

Electric Load List for Conventional Facility

PBS No.	ITEM No.	Service	Rated Power 6.6 kV (kW)	Rated Power 400V (kW)	Efficiency %	Power Factor %	SIC	Redundancy	Normal Operation	Emergency Generator	UPS	Remarks
5.3.3.0.0	5.3.3.0.0-P-001A	Secondary CW Pump	400		90	85	SR	100% x 2	○			
5.3.3.0.0	5.3.3.0.0-P-001B	Secondary CW Pump	400		90	85	SR					
5.3.3.0.0	5.3.3.0.0-P-111A	Secondary CW Pump	185		90	85	SR	100% x 2	○			
5.3.3.0.0	5.3.3.0.0-P-111B	Secondary CW Pump	185		90	85	SR					
5.3.3.0.0	5.3.3.0.0-P-201A	Secondary CW Pump		110	90	85	SR	100% x 2	○			
5.3.3.0.0	5.3.3.0.0-P-201B	Secondary CW Pump		110	90	85	SR					
5.3.3.0.0	5.3.3.0.0-P-211A	Secondary ChW Pump		90	90	85	SR	100% x 2	○			
5.3.3.0.0	5.3.3.0.0-P-211B	Secondary ChW Pump		90	90	85	SR					
5.3.3.0.0	5.3.3.0.0-P-011A	Primary CW Pump		120	90	85	SR	100% x 2	○			
5.3.3.0.0	5.3.3.0.0-P-011B	Primary CW Pump		120	90	85	SR					
5.3.3.0.0	5.3.3.0.0-P-021A	Primary ChW Pump		90	90	85	SR	100% x 2	○			
5.3.3.0.0	5.3.3.0.0-P-021B	Primary ChW Pump		90	90	85	SR					
5.3.3.0.0	5.3.3.0.0-P-301A	Tertiary CW Pump		75	90	85	SR	100% x 2	○			
5.3.3.0.0	5.3.3.0.0-P-301B	Tertiary CW Pump		75	90	85	SR					
5.3.3.0.0	5.3.3.0.0-P-311A	Secondary CW Pump		75	90	85	SR	100% x 2	○			
5.3.3.0.0	5.3.3.0.0-P-311B	Secondary CW Pump		75	90	85	SR					
5.3.4.1.0	5.3.4.1.0-U-001	Portable Water Supply Unit (200V)		3	90	85	SR		○			1.5 kW x 2
5.3.4.2.0	5.3.4.2.0-P-021	Demineralized Water Supply Unit (200V)		3	90	85	SR		○			1.5 kW x 2
5.3.4.2.0	5.3.4.2.0-P-031A	Industrial Water Pump		37	90	85	SR	100% x 2	○			
5.3.4.2.0	5.3.4.2.0-P-031B	Industrial Water Pump		37	90	85	SR					
5.3.5.1.0	5.3.5.1.0-U-003	Argon Purification System		65	90	85	SIC-2		○	○		
5.3.5.1.0	5.3.5.1.0-K-004A	Argon Recirculation Blower		45	90	85	SIC-2	100% x 2	○	○		
5.3.5.1.0	5.3.5.1.0-K-004B	Argon Recirculation Blower		45	90	85	SIC-2					
5.3.5.3.0	5.3.5.3.0-K-201A	Instrumentation Air Compressor		28.1	90	85	SIC-1	100% x 2	○	○		
5.3.5.3.0	5.3.5.3.0-K-201B	Instrumentation Air Compressor		28.1	90	85	SIC-1					
5.3.5.3.0	5.3.5.3.0-U-211A	Breathable Air Supply Unit		15	90	85	SIC-1	100% x 2	○	○		
5.3.5.3.0	5.3.5.3.0-U-211B	Breathable Air Supply Unit		15	90	85	SIC-1					
5.3.6.1.0	5.3.6.1.0-U-002A	VDS Electrolysis Cell		0.4	90	85	SIC-1	100% x 2	○	○		
5.3.6.1.0	5.3.6.1.0-U-002B	VDS Electrolysis Cell		0.4	90	85	SIC-1					
5.3.6.1.0	5.3.6.1.0-HE-003	VDS Electric Heater-1		0.2	100	100	SIC-1		○	○		
5.3.6.1.0	5.3.6.1.0-K-007A	VDS Blower-1		0.14	90	85	SIC-1	100% x 2	○	○		
5.3.6.1.0	5.3.6.1.0-K-007B	VDS Blower-1		0.14	90	85	SIC-1					
5.3.6.1.0	5.3.6.1.0-HE-012	VDS Electric Heater-2		23	100	100	SIC-1		○	○		
5.3.6.1.0	5.3.6.1.0-K-016A	VDS Blower-2		12	90	85	SIC-1	100% x 2	○	○		
5.3.6.1.0	5.3.6.1.0-K-016B	VDS Blower-2		12	90	85	SIC-1					
5.3.6.1.0	5.3.6.1.0-HE-017	VDS Regeneration Electric Heater		44	100	100	SIC-1		○	○		
5.3.6.1.0	5.3.6.1.0-K-019A	VDS Regeneration Blower		12	90	85	SIC-1	100% x 2	○	○		
5.3.6.1.0	5.3.6.1.0-K-019B	VDS Regeneration Blower		12	90	85	SIC-1					
5.3.6.1.0	5.3.6.1.0-P-022A	VDS Tritiated Water Transfer Pump		0.75	90	85	SR	100% x 2	○			
5.3.6.1.0	5.3.6.1.0-P-022B	VDS Tritiated Water Transfer Pump		0.75	90	85	SR					
5.3.6.1.0	5.3.6.1.0-U-023A	VDS Chilled Water Supply Unit		0.8	90	85	SR	100% x 2	○			
5.3.6.1.0	5.3.6.1.0-U-023B	VDS Chilled Water Supply Unit		0.8	90	85	SR					

Table 3-13: Electric Load List for Conventional Facility 4/6

Electric Load List for Conventional Facility

PBS No.	ITEM No.	Service	Rated Power 6.6 kV (kW)	Rated Power 400V (kW)	Efficiency %	Power Factor %	SIC	Redundancy	Normal Operation	Emergency Generator	UPS	Remarks
5.3.6.1.0	5.3.6.1.0-HE-101	EDS Electric Heater		28	100	100	SIC-1		○	○		
5.3.6.1.0	5.3.6.1.0-K-105A	EDS Blower		25	90	85	SIC-1	100% x 2	○	○		
5.3.6.1.0	5.3.6.1.0-K-105B	EDS Blower		25	90	85	SIC-1					
5.3.6.1.0	5.3.6.1.0-K-106A	EDS Vent Blower		0.4	90	85	SIC-1	100% x 2	○	○		
5.3.6.1.0	5.3.6.1.0-K-106B	EDS Vent Blower		0.4	90	85	SIC-1					
5.3.6.1.0	5.3.6.1.0-K-109A	EDS Regeneration Blower		25	90	85	SIC-1	100% x 2	○	○		
5.3.6.1.0	5.3.6.1.0-K-109B	EDS Regeneration Blower		25	90	85	SIC-1					
5.3.6.1.0	5.3.6.1.0-HE-107	EDS Regeneration Electric Heater		52	100	100	SIC-1		○	○		
5.3.6.1.0	5.3.6.1.0-P-112A	EDS Tritiated Water Transfer Pump		0.75	90	85	SIC-1	100% x 2	○	○		
5.3.6.1.0	5.3.6.1.0-P-112B	EDS Tritiated Water Transfer Pump		0.75	90	85	SIC-1					
5.3.6.1.0	5.3.6.1.0-P-116A	EDS ChW Pump		2.5	90	85	SIC-1	100% x 2	○	○		
5.3.6.1.0	5.3.6.1.0-P-116B	EDS ChW Pump		2.5	90	85	SIC-1					
5.3.6.1.0	5.3.6.1.0-HE-201	GDS Electric Heater		35	100	100	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-K-207	GDS Blower		25	90	85	SIC-2		○	○		VSD
5.3.6.1.0	5.3.6.1.0-K-208	GDS Vent Blower		0.23	90	85	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-HE-209	GDS Regeneration Electric Heater-1		130	100	100	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-K-211	GDS Regeneration Blower-1		25	90	85	SIC-2		○	○		VSD
5.3.6.1.0	5.3.6.1.0-HE-214	GDS Regeneration Electric Heater-2		5	100	100	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-K-216	GDS Regeneration Blower-2		5	90	85	SIC-2		○	○		VSD
5.3.6.1.0	5.3.6.1.0-P-217	GDS Tritiated Water Transfer Pump		0.5	90	85	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-U-221A	GDS Electrolysis Cell		2.5	90	85	SIC-2	500% x 2	○	○		
5.3.6.1.0	5.3.6.1.0-U-221B	GDS Electrolysis Cell		2.5	90	85	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-HE-301	HDS-1 Electric Heater		173	100	100	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-K-305	HDS-1 Blower		55	90	85	SIC-2		○	○		VSD
5.3.6.1.0	5.3.6.1.0-K-306	HDS-1 Vent Blower		0.14	90	85	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-HE-307	HDS-1 Regeneration Electric Heater		327	100	100	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-K-309	HDS-1 Regeneration Blower		55	90	85	SIC-2		○	○		VSD
5.3.6.1.0	5.3.6.1.0-P-312	HDS-1 Tritiated Water Transfer Pump		0.5	90	85	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-HE-401	HDS-2 Electric Heater		173	100	100	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-K-405	HDS-2 Blower		55	90	85	SIC-2		○	○		VSD
5.3.6.1.0	5.3.6.1.0-K-406	HDS-2 Vent Blower		0.14	90	85	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-HE-407	HDS-2 Regeneration Electric Heater		327	100	100	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-K-409	HDS-2 Regeneration Blower		55	90	85	SIC-2		○	○		VSD
5.3.6.1.0	5.3.6.1.0-P-412	HDS-2 Tritiated Water Transfer Pump		0.5	90	85	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-HE-501	HDS-3 Electric Heater		104	100	100	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-K-505	HDS-3 Blower		55	90	85	SIC-2		○	○		VSD
5.3.6.1.0	5.3.6.1.0-K-506	HDS-3 Vent Blower		0.23	90	85	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-HE-507	HDS-3 Regeneration Electric Heater		196	100	100	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-K-509	HDS-3 Regeneration Blower		55	90	85	SIC-2		○	○		VSD
5.3.6.1.0	5.3.6.1.0-P-512	HDS-3 Tritiated Water Transfer Pump		0.5	90	85	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-HE-601	GDS-V Electric Heater		35	100	100	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-K-605	GDS-V Blower		25	90	85	SIC-2		○	○		VSD
5.3.6.1.0	5.3.6.1.0-K-606	GDS-V Vent Blower		0.23	90	85	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-HE-607	GDS-V Regeneration Electric Heater		65	100	100	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-K-609	GDS-V Regeneration Blower		25	90	85	SIC-2		○	○		VSD
5.3.6.1.0	5.3.6.1.0-P-612	GDS-V Tritiated Water Transfer Pump		0.5	90	85	SIC-2		○	○		

Table 3-14: Electric Load List for Conventional Facility 5/6

Electric Load List for Conventional Facility

PBS No.	ITEM No.	Service	Rated Power 6.6 kV (kW)	Rated Power 400V (kW)	Efficiency %	Power Factor %	SIC	Redundancy	Normal Operation	Emergency Generator	UPS	Remarks
5.3.6.1.0	5.3.6.1.0-HE-701	GDS-E Electric Heater		12	100	100	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-K-705	GDS-E Blower		25	90	85	SIC-2		○	○		VSD
5.3.6.1.0	5.3.6.1.0-K-706	GDS-E Vent Blower		0.14	90	85	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-HE-707	GDS-E Regeneration Electric Heater		25	100	100	SIC-2		○	○		
5.3.6.1.0	5.3.6.1.0-K-709	GDS-E Regeneration Blower		25	90	85	SIC-2		○	○		VSD
5.3.6.1.0	5.3.6.1.0-P-712	GDS-E Tritiated Water Transfer Pump		0.5	90	85	SIC-2		○	○		
5.3.6.2.0	5.3.6.2.0-P-002A	Activated Cooling Water Pump		7.5	90	85	SIC-2	100% x 2	○	○		
5.3.6.2.0	5.3.6.2.0-P-002B	Activated Cooling Water Pump		7.5	90	85	SIC-2					
5.3.6.2.0	5.3.6.2.0-P-012A	Tritiated Water Transfer Pump		0.75	90	85	SIC-2	100% x 2	○	○		
5.3.6.2.0	5.3.6.2.0-P-012B	Tritiated Water Transfer Pump		0.75	90	85	SIC-2					
5.3.6.2.0	5.3.6.2.0-P-022A	Liquid Waste Transfer Pump		5.5	90	85	SIC-2	100% x 2	○	○		
5.3.6.2.0	5.3.6.2.0-P-022B	Liquid Waste Transfer Pump		5.5	90	85	SIC-2					
5.3.6.2.0	5.3.6.2.0-P-032A	Chemical Waste Water Transfer Pump		0.75	90	85	SIC-2	100% x 2	○	○		
5.3.6.2.0	5.3.6.2.0-P-032B	Chemical Waste Water Transfer Pump		0.75	90	85	SIC-2					
5.3.6.2.0	5.3.6.2.0-P-042A	Non-aqueous Liquid Waste Transfer Pump		0.75	90	85	SIC-2	100% x 2	○	○		
5.3.6.2.0	5.3.6.2.0-P-042B	Non-aqueous Liquid Waste Transfer Pump		0.75	90	85	SIC-2					
5.3.7.1.0	5.3.7.1.0-P-001A	Firewater Jokey Pump		11	90	85	SIC-2	100% x 2		○		Skid Mounted
5.3.7.1.0	5.3.7.1.0-P-001B	Firewater Jokey Pump		11	90	85	SIC-2					"B" is a spare
5.3.7.1.0	5.3.7.1.0-P-002	Motor Driven Firewater Pump	150		90	85	SIC-2			○		UL Approval / FM Listed
5.3.7.1.0	5.3.7.1.0-P-003	Diesel Driven Firewater Pump					SIC-2					Diesel Engine Pump
		Fire Protection System		20	90	85	SIC-2		○	○		
		Central Control System		100	90	85	SR		○			
		Central Control System for Emergency		50	90	85	SIC-1		○	○	○	
		Instrumentation		50	90	85	SR		○			
		Instrumentation for Emergency		25	90	85	SIC-1		○	○	○	
		Monitoring and Security Camera		50	90	85	SIC-1		○	○	○	
		Access Control & Security System		50	90	85	SIC-1		○	○	○	
		RAMSES		100	90	85	SIC-1		○	○	○	
		Handling System (Crane, Telemanipulators, etc)		400	90	85	SR		○			
		Building Utility (Lights, Sokets, etc.)		400	90	85	SR		○			
		Building Utility (Lights, Sokets, etc.) for Emergency		400	90	85	SIC-2		○	○		
		Total	10184	9120.91								

Table 3-15: Electric Load List for Conventional Facility 6/6

3.2.6 **IFMIF Total Electric Load**

Table 3-16 show Total Electric Load for IFMIF.

- For Rated Power : 84880 kVA
- For Emergency Power : 6478 kVA
- For UPS : 1017 kVA

Sybsystem	Total Rated Power				Normal Operation Power				Emergency Generator				UPS			
	6.6 kV (kW)	400V (kW)	6.6 kV (kVA)	400V (kVA)	6.6 kV (kW)	400V (kW)	6.6 kV (kVA)	400V (kVA)	6.6 kV (kW)	400V (kW)	6.6 kV (kVA)	400V (kVA)	6.6 kV (kW)	400V (kW)	6.6 kV (kVA)	400V (kVA)
Accelerator facility	32940	8953	41183	11704	32940	8953	41183	11704	0	314	0	411	0	314	0	411
Lithium Target Facility	600	1904	915	1680	600	1680	915	1723	180	559	238	585	90	29	120	47
Test Facility	2255	707	2947	742	2147	468	2806	611	108	75	141	97	0	51	0	67
Post Irrsdiation Facility	0	1010	0	1013	0	1010	0	1013	0	10	0	13	0	10	0	13
Conventional Facility	10184	9121	13313	11384	6667	7511	8715	9280	664	3567	868	4124	0	275	0	359
Total	**45979**	**21695**	**58358**	**26523**	**42354**	**19622**	**53619**	**24331**	**952**	**4525**	**1247**	**5230**	**90**	**679**	**120**	**897**

Table 3-16: Total Electric Load of IFMIF

3.3 **Safety Design Requirements**

The general Safety approach for the design execution of EPS is based on the general Safety specification for the Engineering Design Activities of IFMIF.

- The IFMIF Safety objectives, principles and criteria.
- The Hazard evaluation techniques, have been implemented on RAMI and EFMECA analysis.

The entire document is uploaded on DMS: Safety Specifications (Ref. [2]) and following updating. At the present time the Engineering Design for EPS follow the Safety approach mentioned on the guideline document, nevertheless it can be subject to some deviation or weaves according the final IFMIF site selection. As well as the safety authority could gives some further requirements.

3.4 **Operation and Maintenance**

3.4.1 **Operation**

Operation of Electric Power System is usually automatically controlled and performed from IFMIF Central Control Room. Grid change in an emergency and starting of the emergency generator are also automatically performed from Central Control Room.
The operational status of Electric Power System, voltage values, and current values are monitored and recorded in IFMF Central Control Room.
In addition, the operational status of Electric Power System, voltage values, and current values are shown on the front panel of each electric power board.
At an emergency or the time of maintenance, the manual operative method can be carried out from each electric power board.
HV and MV electric power board
From safety point of view, HV and MV electric power board should be considered so that people may not come close during operation.

3.4.2 **Maintenance**

Integrative maintenance plan is not yet described on this DDD. It shall be defined clearly and in detailed after having selected all the components for Electric Power System, preferable the maintenance plan shall be prepared by the suppliers, as well as regulatory maintenance requirements must properly identified.
Minimum information required within the maintenance plan here listed:

- Scheduled Operation
- Controls
- Checks
- Adjustments
- Calibrations
- Overhauls
- Replacements

Information provided from safety specification (Ref.[2]), and of course will be implemented and identified as necessary by the supplier in order to ensure the best operation of Electric Power System within its intended operational scenario.
That may impact IFMIF availability and become essential to evaluate and to introduce an additional important support of recommended spare parts list, (provided by the suppliers) procedures, training, tools and test equipments, infrastructures.
The design of Electric Power System shall accommodate long-term maintenance activities required to support IFMIF plant operation. For maintainability and inspectability, Electric Power System shall be designed in such a way that it can

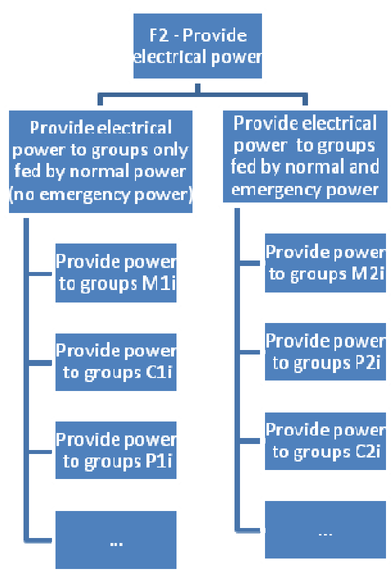
facilitate maintenance and, in case of failure, easy diagnostics safe repair or replacement and re-calibration. The maintenance of Electric Power System must be an ongoing endeavor. Any lapses in regular maintenance can result in system degradation and obvious loss of efficiency, which could arose to serious health issue.
Maintenance requirement for Electric Power System and equipments mast be conform to the maintenance period defined for the IFMIF plant (particularly for the facilities that are not reachable during operation period)

3.5 RAMI requirements

Electric Power System have been designed for all modes of IFMIF plant operation, as well as shut down period. Electric Power System should be reliable for continuous operation, easily accessible for the purpose of operation and maintenance. The EPS have been designed in a way that; maintained and operated will meet the reliability and availability requirements, in a preliminary way identified on the conventional facility safety report. RAMI specification guide documents Ref. to doc.22HA3G from J.M. Arroyo Feb.2012 [3]and further preliminary study presented during the DDII RAMI status for CF availability was 98 % ref. BA_D_229V7H [6]
Further detailed RAMI analysis has been performed by Tractebel, dedicated to the EPS, ref. doc. [7] dividing into different load groups to which the IFMIF system are associated:

- Groups M11, M12, M21, M22, M23
- Groups P11 to P14 and P21 to P24
- Groups C11 to C14 and C21 to C24
- Ungrouped users (Accelerators, I&C, TF, LF …)

The EPS model is structured following these EPS groups:



These groups are located on the normal power systems or on the emergency power systems. All these items are written on the P&IDs.

The detailed list of these functions and their associated criticality group/recovery time is provided in the following table 22 (Only the functions having an impact on IFMIF availability are listed on table 22)

Table 17: List of functions

Normal /Emergency	Electrical Load Group	Criticality Group	Systems supplied
Normal	Group C11	E2	CF HVAC-SR
Normal	Group C12	E2	CF HVAC-SR
Normal	Group C13	A3	CF HRS-SWS-EGDS - SR
Normal	Group C14	A3	CF HRS-SWS-EGDS - SR
Normal	Group M11	E2	CF HVAC-SR
Normal	Group M12	A3	CF HRS-SWS-EGDS - SR
Normal	Group P11	E2	CF HVAC-SR
Normal	Group P12	E2	CF HVAC-SR
Normal	Group P13	A3	CF HRS-SWS-EGDS - SR
Normal	Group P14	A3	CF HRS-SWS-EGDS - SR
Normal	I&C SR	E2	CF I&C-SR
Normal	LF SR	T1	LF SR equipments
Normal	Power to Accelerator 1 unavailable A3	A3	Power to Accelerator 1
Normal	Power to Accelerator 2 unavailable A3	A3	Power to Accelerator 2
Normal	TF SR	E2	TF SR equipments
Emergency	FPS	E3	Fire Protection System
Emergency	Group C21	E5	CF SGS-EGDS – SIC1
Emergency	Group C22	E5	CF SGS-EGDS – SIC1
Emergency	Group C23	E5	CF SGS-EGDS-LWTS-SIC2

Normal /Emergency	Electrical Load Group	Criticality Group	Systems supplied
Emergency	Group C24	E5	CF SGS-EGDS-LWTS-SIC2
Emergency	Group M21 SIC1	E5	LF/TF SIC1
Emergency	Group M22 SIC1	E5	LF/TF SIC1
Emergency	Group M23 SIC2	E5	LF/TF SIC2
Emergency	Group P21	E5	CF SGS-EGDS – SIC1
Emergency	Group P22	E5	CF SGS-EGDS – SIC1
Emergency	Group P23	E5	CF SGS-EGDS-LWTS-SIC2
Emergency	Group P24	E5	CF SGS-EGDS-LWTS-SIC2
Emergency	LF SIC1	T3	LF SIC1
Emergency	LF SIC2	T3	LF SIC1
Emergency	TF SIC1	E5	TF SIC1
Emergency	TF SIC2	E5	TF SIC1
Emergency	UPS load	E5	IFMIF equipments for safe shutdown

3.5.1 **Recovery time**

A recovery time of the IFMIF facility has been added to the MTTR of each EPS components. Logically, a recovery time should be associated to a loss of an EPS function. However, it is not possible to directly allocate a recovery time to a function in Risk spectrum. In the model, the recovery time associated with a function has been introduced in the MTTR of all the components that are used to fulfil the function. In case a component is used in different EPS functions with different associated recovery times, the longest time is used. The component recovery time considered is coded in its name.

3.5.2 **Specific model assumptions**

The generic model assumptions are discussed in the folio 0 of this note. The additional assumptions specific to the EPS model are hereunder listed:

- The electrical cables have been neglected in the model since the exact information is not available. However, the cable connectors that have a higher failure rate than the cables themselves are included in the model.
- The protection systems of the EPS are not considered in the model. Such protection systems (for example overvoltage protection, differential protection …) can produce some unavailability if they fail. It is assumed that this failure mode is included in the reliability data of the electrical component (transformers, switchgears …).

- The reparation time of some electrical equipment can be very long or very short, depending on the failure considered. For example, a small failure in a transformer can induce a very short down time, whereas a major short circuit can result in the total destruction of the transformer and a huge down time since there are in general no spare parts for such components. For that reason, for the high voltage transformer and the high voltage switchgear a long failure and short failure have been considered in the model.
- It is assumed that the diesel generators are safeguards and that failure of a diesel generator cannot induce IFMIF unavailability. However, these components have been taken into account in the model in order to increase the availability seen by the consumers, thanks to the emergency system.
- Based on the FMECA, the emergency power system towards the SIC-1 consumers is fully redundant. Practically, it means that
    - The MC-EG1/2 switchgear are powered by normal power or by both emergency generators group 1 or 2;
    - The 6.6 kV SIC-1 consumers are connected on both MC-021 and MC-022 switchgear that can be powered by both MC-EG-1 and MC-EG2 switchgear;
    - The 0.4kV SIC-1 consumers are connected on both PC-021 and PC-022 switchgear that can be powered by both MC-021 and MC-022;
    - The UPS SIC-1 consumers are connected on both UPS-A and UPS-B that can be powered by both PC-021 and PC-022.
- The availability of the external grid is assumed as 100% since external events are not considered in the first RAMI iteration.
- A diesel generator can deliver 50% of the emergency load.

3.5.3 Results

This case considers that the equipments associated with a long recovery time (>A3/E3) are supplied by the emergency power similarly to any SIC1 or SIC2 equipments.

The availability results are described in the following table:

RiskSpectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability %
CEP-0-GENERAL	**EPS**	**3.76E-03**	**99.624**
CEP-1-EMERGENCY	Provide electrical power to groups fed by normal and emergency power	3.24E-03	**99.685**
CEP-1-NORMAL	Provide electrical power to groups only fed by normal power (no emergency power)	1.28E-03	99.883

The results related to the EPS sub-groups normal and emergency are informative since these sub-groups are not independent.

In this case, the EPS availability is higher than the general CF availability requirement equally allocated among the CF systems (99.6%) thanks to the high redundancy of the emergency distribution system. It should also be noted that the external event (i.e. external grid power supply) is not considered in the first RAMI iteration. It means that the availability of the external power supply is 100%, limiting the difference between the availability of the normal and emergency power supply.

3.5.4 Components and parameters susceptible to be problematic

From the minimal cut set list, it can be seen that the critical equipments are those required to fulfil the functions linked with the SIC2 equipments since these equipments combine the lowest redundancy with the highest recovery time:

- Group M23 – E5
- Groups P23 and P24 – E5
- Groups C23 and C24 – E5
- Lithium facility SIC2 – T3
- Test facility SIC2 – E5

It was indeed assumed that the loss of power to these SIC2 load groups could lead to the highest recovery time, and that these equipments are not powered by the UPS.

The transformers are the critical equipments among the equipments required to supply these SIC2 groups since transformers have the highest unavailability. About 50% of the EPS unavailability is generated by the unavailability of the following transformers:

- MTR-01 supplying indirectly the group M23
- TR-023 supplying the groups P23 and C23
- TR-024 supplying the groups P24 and C24

Based on the importance analysis results, it is obvious that the failure rate and mean down time of these components are critical for the availability calculation. A variation of these parameters will lead to a significant improvement or degradation of the availability.

These components should consequently be carefully designed to ensure a high availability of the EPS systems.

3.5.5 Sensitivity and Degraded cases

In order to assess the model and challenge some uncertainties, different sensitivity cases have been computed.

3.5.6 No recovery times

In order to assess the availability of the EPS as a stand-alone system, the FTA model was run after removing all IFMIF recovery times in the components' MTTR/MDT.

The availability results for the stand-alone system are given in the following table:

RiskSpectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Stand Alone Availability %
CEP-0-GENERAL	EPS	4.88E-04	**99.9512**

3.5.7 Transformer reliability parameters

The transformer failure rate is an important parameter in the model. In order to assess its sensitivity, two cases have been analysed with some variation of the failure rate:

1. Transformer failure rate multiplied by 10

RiskSpectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability %
CEP-0-GENERAL	EPS	2.14E-02	97.86

2. Transformer failure rate divided by 10

RiskSpectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability %
CEP-0-GENERAL	EPS	1.97E-03	99.803

These components are very important for the IFMIF availability and should consequently be carefully designed and maintained to ensure a high availability of the EPS systems.

3.5.8 Critical equipments supplied by normal power

This case considers that the equipments associated with a long recovery time (>A3/E3) are supplied by the normal power: these equipments are powered by the MC-012 or MC-013 switchgears.

The availability results are described in the following table:

RiskSpectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability %
CEP-0-GENERAL	EPS	3.56E-03	99.644
CEP-1-EMERGENCY	Provide electrical power to groups fed by normal and emergency power	2.59E-03	99.741

CEP-1-NORMAL	Provide electrical power to groups only fed by normal power (no emergency power)	9.74E-04	99.903

Compared to the first results, the difference is negligible since the external events are not considered in this first iteration (i.e. the external power supply is 100% available). This assumption is not conservative since the external power supply should be a model component with one of the worst failure rate.

By considering the unavailability of the power supply, the normal power availability figures of this case would be negatively impacted. For instance, for one external grid failure per 5 year lasting more than 3 hours (leading to a high criticality), the availability figure would be the following:

RiskSpectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability %
CEP-0-GENERAL	EPS	3.56E-02	96.44
CEP-1-EMERGENCY	Provide electrical power to groups fed by normal and emergency power	7.68E-03	99.232
CEP-1-NORMAL	Provide electrical power to groups only fed by normal power (no emergency power)	3.31E-02	96.69

If we add the sensitivity of the transformer failure rate, we obtain the following availabilities:

1. Transformer failure rate multiplied by 10

RiskSpectrum Fault Tree	Description	Time Dependent Unavailability	Availability %

		(TD Mean)	
CEP-0-GENERAL	EPS	5.42E-02	94.58

2. Transformer failure rate divided by 10

RiskSpectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability %
CEP-0-GENERAL	EPS	3.37E-02	96.63

For the emergency power, the availability is maintained thanks to the redundancy brought by the diesel power supplies. In such configuration, the availability of the diesel generators is important to ensure a high EPS availability.

3.6 Applicable Codes and Standards

Applicable Codes and Standards for EPS as follows,

1) International Electro-technical Commission (IEC)
2) European Standards (EN)
3) ANSI/EE Standards
4) IFMIF safety specification for EDA : BA_D_22AB9R
5) Electrical Power supply needs from the nuclear safety point of view : BA_D_22GZSB
6) RAMI Specifications : BA_D_22HA3G

4. System Design Description

4.1 Design Summary

Electric Power System is designed based on the requirements (Sec.3.), IFMIF specifications, codes and standards. Result of design is shown Sec.1 and Key One Line Diagram.
The Electric Power System supplies electric power to facilities, sub systems and equipments in IFMIF. It has to be taken into account safety requirements, receiving power conditions, safety margin, SIC specifications, etc.

4.2 Safety

Refer to Safety specifications for the Engineering design Activities of IFMIF (Ref. [2]), Safety Important Class – SIC Methodology (Ref.[1]) and Electrical Power supply needs from the nuclear safety point of view (Ref.[4]).

4.3 Assumptions

Receiving Power Conditions from commercial grid are assumed as follows,

Current Type	:	Alternating Current
Cabling System	:	Three - Phase Three Wire
Feeding System	:	2 Feeding System (Primary and Secondary)
Incoming Voltage	:	66 kV
Voltage Permissible Range	:	± 7 %
Supply System	:	Steel Tower with OverHead Cables
Frequency	:	50 Hz
Frequency Permissible Range	:	± 2 Hz
Supply Voltage Stop (<10sec,)	:	Less than 1 per year
Supply Voltage Drop (<20 %,< 1sec)	:	Less than 5 per year
Supply Voltage Generation Type (Ideal)	:	Coal Thermal or Gas Thermal or Nuclear
Harmonic current (in feeding wire)	:	as lower as possible
Grid Shortcut Intensity	:	kA
Max. Reactive Power/Active Power	:	Coefficient (By the Power supply Company)
Min. kW/kVA	:	kW/kVA

4.4 Detailed Design Description

4.4.1 Power Supply Voltage Classification

International Standard IEC 60038 defines a set of standard voltages for use in low voltage and high voltage electricity supply systems.
The definition of voltage level is as follows:

1) Alternating Current (AC)
- High Voltage (HV) : > 1000 Vrms
- Low Voltage (LV) : 25-1000 Vrms
- Extra Low Voltage (ELV) : < 25 V rms

2) Direct Current (DC)
- High Voltage (HV) : > 1500 V
- Low Voltage (LV) : 60-1500 V
- Extra Low Voltage (ELV) : < 60 V

In IFMIF, AC Power Supply Voltage is defined as follows,

- High Voltage (HV) : > 66000 Vrms
- Medium Voltage (MV) : 6600 Vrms
- Low Voltage (LV): 230-400 Vrms

4.4.2 Equipment Margin and specifications

A safety margin for the EPS equipment has been assumed according to the standard engineering practice.
In general a margin in the design has to be assumed in order to allow some flexibility to the system.
In particular:

- For all equipment except circuit breaker, margin takes into account +10 to 20 % of the rated power.
- For circuit breaker, margin does not take into account. But it is selected according to the electric load capacity of the equipment connected downstream.
- A shortcut circuit calculation shall be taken into consideration to define circuit breaker KA (Icu max) peak capacity to prevent permanent damage to these protection equipment in the event of a short-circuit.

4.4.3 **SIC Classification**

According to the classification proposed in Safety Specifications (Ref.[2]) and Safety Important Class-SIC, Methodology, Classification & Requirements (Ref. [1]).
But, SIC is not specified when it thinks Electric Power System independent.
However, Electric Power System have to be designed according to the SIC class of facilities, sub systems and equipments connected to it.

4.4.4 **Redundant Equipment**

Redundancy of the equipment should contribute to the target availability value of the Conventional Facilities (stated into 99.7 % as mentioned in CDR (Ref.[5]).but was not possible to reach such high level of reliability due to the complexity of the systems.
According to the new assessment by J.M. Arroyo, availability of CF is now 98%, ref. BA_D_229V7H (Ref. [6]). At this stage of the project a complete RAMI Analysis have been performed and confirmed the value of 98% for the CF availability, while for the present EPS the availability stated on the latest RAMI analysis results 99.624%, based on Tractebel RAMI analysis (Ref.[7]) and well described on RAMI requirements chapter 3.5.
Accordingly, from view point of availability, following measures shall be taken.

- Redundant Emergency Generators (50% × 2 × 2) shall be installed.

4.4.5 **Power System Substation (PBS: 5.3.2.1.0)**

Power System Substation was designed based on Electric Load List (Sec.3.2)
The power supply capacity required from each facility is as follows:

- AF : 52.9 MVA
- LF : 2.6 MVA
- TF : 3.7 MVA
- PIEF : 1.0 MVA
- CF : 24.7 MVA

Total : 84.9 MVA

From the result of above, 30MVA x 3 transformer (66kV/6.6kV) were installed.
In consideration of the stole of the external commercial grid, two-line power receiving of the commercial external grid was adopted.

4.4.6 **Emergency Power System (PBS: 5.3.2.2.0)**

Emergency Power System was designed based on Electric Load List (Sec.3.2)
The emergency power supply capacity required from each apparatus is as follows:

- AF : 411 kVA
- LF : 823 kVA
- TF : 238 kVA
- PIEF : 13 kVA
- CF : 4992 kVA

Total : 6478 kVA

From the result of above, 4000 kVA × 2 emergency power generators were installed and 4000kVA × 2 emergency power generators were prepared as full back-up.
The reason 4000 kVA emergency generator was chosen is flexible as commercial products. Emergency power is supplied through Electric Distribution System to equipments which classified SIC-1 and SIC-2.

4.4.7 **Electric Distribution System (PBS: 5.3.2.3.0)**

Electric Distribution System was designed by requirements of SIC classification as follows:

- SR/Non-SIC loads : Single Power System
- SIC-2 loads : Power System + Emergency Power System
- SIC-1 loads : Redundancy Power System + Emergency Power System

4.5 **System Performance Requirements**

Not applicable at this engineering stage, anyhow the system performance basic functions are indicated on Key One Line Diagram as follows:

- Figure 6-1 : Key One Line Diagram 1/2
- Figure 6-2 : Key One Line Diagram 2/2

4.6 **System Arrangement**

4.6.1 **Equipment Arrangement Drawings**

Equipments arrangement for EPS is as follows:

- Electric Power Boards for LT, TF and CF are installed in same room of "R303-2 LV Elect. Power Supply Area-2".
- UPS and DC Batteries for LT, TF and CF are installed in same room of "R302-1/2 UPS Room-1/2".
- Electric Power Boards including UPSs, DC Batteries and CVCF for PIE F are installed "R162 PIE-Electric Room".
- For AF, Transformers for RF HVPS are installed on the roof of the IFMIF building. Electric Power Boards including UPSs, DC Batteries and CVCF for AF are installed "R201-A1-1/2 High Voltage Electric Power Supply Area-1/2".

Equipments arrangement drawings for EPS is as follows:

- Figure 6-3 : IFMIF Outdoor Overall View, Switchyard, Emergency Generators
- Figure 6-4 : Equipment Layout for Electric Power System 1/6
- Figure 6-5 : Equipment Layout for Electric Power System 2/6
- Figure 6-6 : Equipment Layout for Electric Power System 3/6
- Figure 6-7 : Equipment Layout for Electric Power System 4/6
- Figure 6-8 : Equipment Layout for Electric Power System 5/6
- Figure 6-9 : Equipment Layout for Electric Power System 6/6

4.6.2 **Equipment Lists (Parts/Components)**

Refer to Sec.1.2 System Basic Configuration.

5. List of Reference

5.1 **List of Reference**

[1] Y.Le Tonqueze, Safety Important Class - SIC Methodology, classification & requirements. BA_D_228V5Q.
[2] Y.Le Tonqueze, Safety Specification for the EDA of IFMIF. BA_D_224X48.
[3] J. Arroyo, RAMI Specifications. BA_D_22HA3G.

[4] Y.Le Tonqueze, Electrical Power supply needs from the nuclear safety point of view. BA_D_22GZSB.
[5] IEA, IFMIF Comprehensive Design Report.
[6] J.M. Arroyo, Availability of CF is 98%, ref. BA_D_229V7H
[7] RAMI analysis EPS 99.624 %, Tractebel Ref. IFMIF/4NT/276784/002/01

6. Appendices

6.1 List of Documents

Figure 6-1: Key One Line Diagram 1/2

Figure 6-2: Key One Line Diagram 2/2
Figure 6-3: IFMIF Outdoor Overall View, Switchyard, Emergency Generators
Figure 6-4: Equipment Layout for Electric Power System 1/6
Figure 6-5: Equipment Layout for Electric Power System 2/6
Figure 6-6: Equipment Layout for Electric Power System 3/6
Figure 6-7: Equipment Layout for Electric Power System 4/6
Figure 6-8: Equipment Layout for Electric Power System 5/6
Figure 6-9: Equipment Layout for Electric Power System 6/6

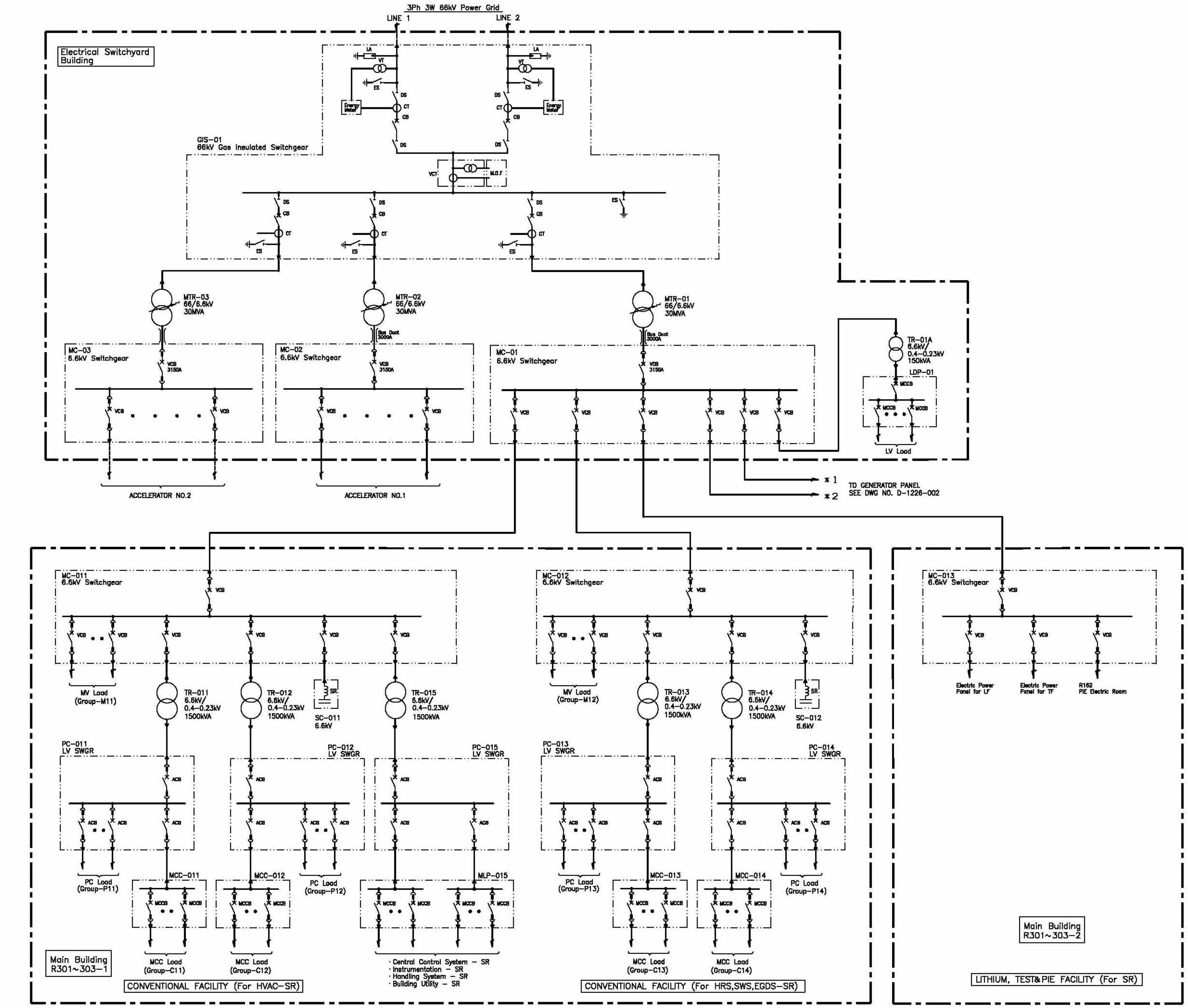


Figure 6-1: Key One Line Diagram 1/2

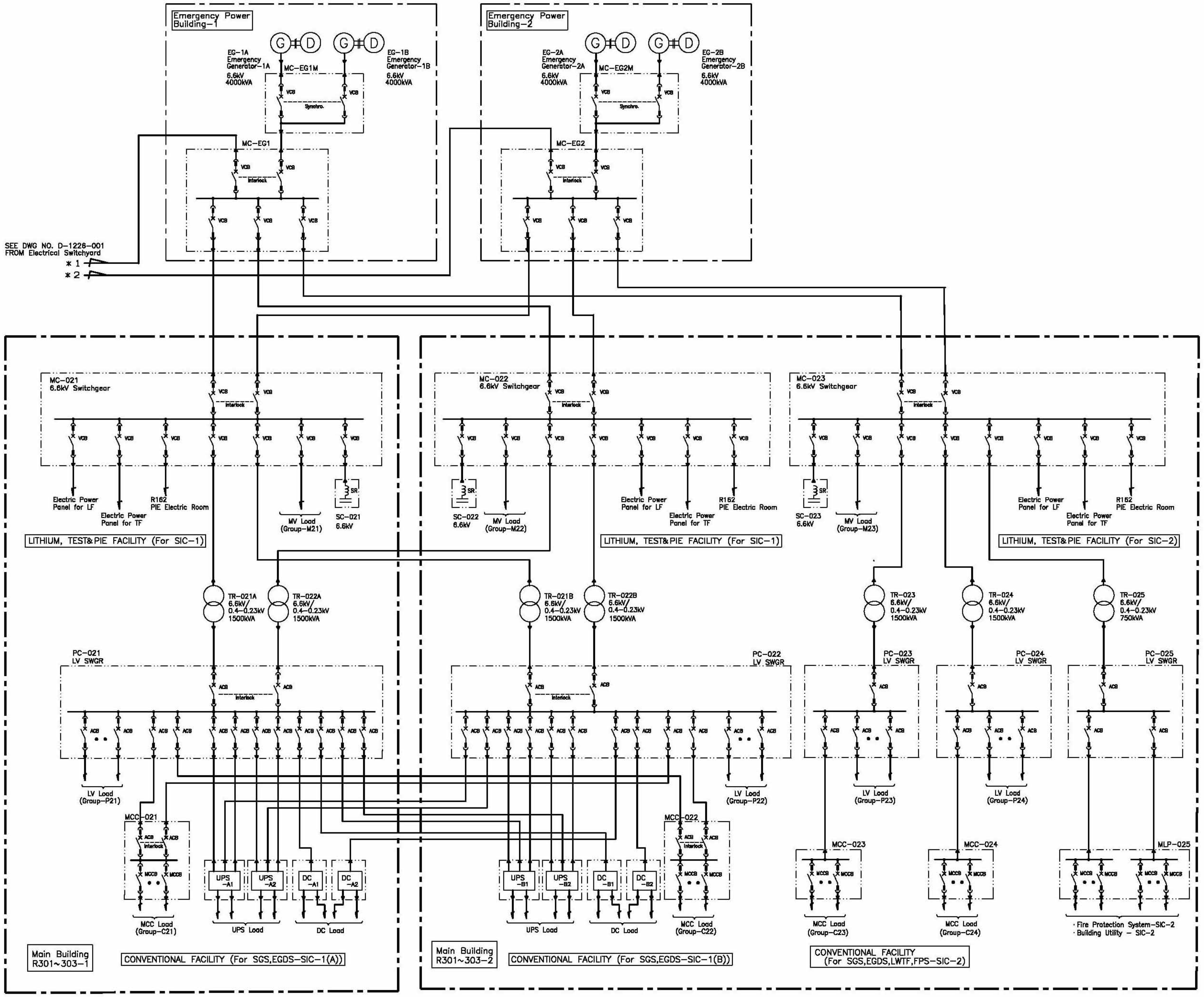
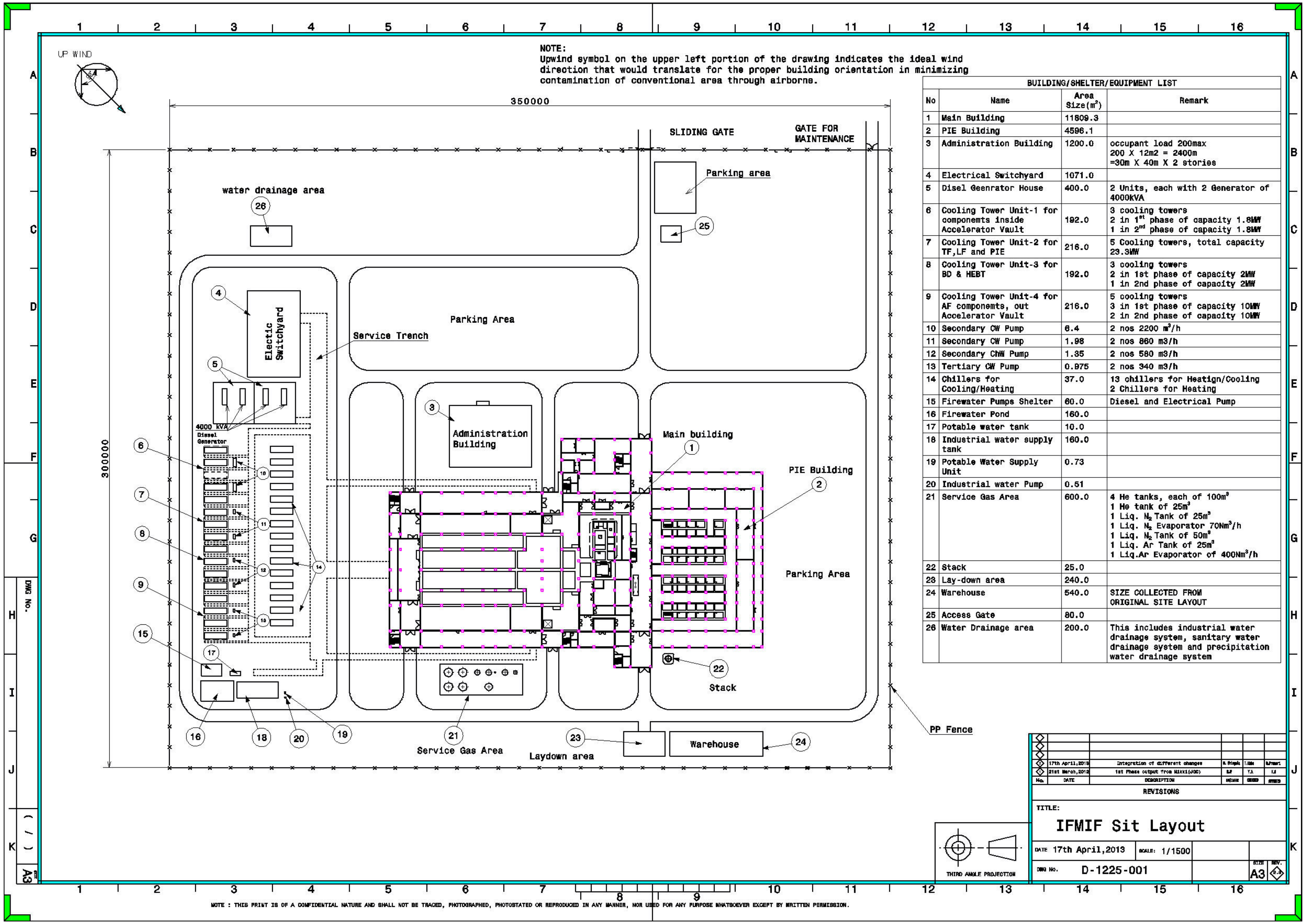


Figure 6-2: Key One Line Diagram 2/2



BUILDING/SHELTER/EQUIPMENT LIST

No	Name	Area Size(m^2)	Remark
1	Main Building	11809.3	
2	PIE Building	4596.1	
3	Administration Building	1200.0	occupant load 200max 200 X 12m2 = 2400m =30m X 40m X 2 stories
4	Electrical Switchyard	1071.0	
5	Disel Geenrator House	400.0	2 Units, each with 2 Generator of 4000kVA
6	Cooling Tower Unit-1 for componemts inside Accelerator Vault	192.0	3 cooling towers 2 in 1st phase of capacity 1.8MW 1 in 2nd phase of capacity 1.8MW
7	Cooling Tower Unit-2 for TF,LF and PIE	216.0	5 Cooling towers, total capacity 23.3MW
8	Cooling Tower Unit-3 for BD & HEBT	192.0	3 cooling towers 2 in 1st phase of capacity 2MW 1 in 2nd phase of capacity 2MW
9	Cooling Tower Unit-4 for AF componemts, out Accelerator Vault	216.0	5 cooling towers 3 in 1st phase of capacity 10MW 2 in 2nd phase of capacity 10MW
10	Secondary CW Pump	6.4	2 nos 2200 m^3/h
11	Secondary CW Pump	1.98	2 nos 860 m3/h
12	Secondary ChW Pump	1.35	2 nos 580 m3/h
13	Tertiary CW Pump	0.975	2 nos 340 m3/h
14	Chillers for Cooling/Heating	37.0	13 chillers for Heatign/Cooling 2 Chillers for Heating
15	Firewater Pumps Shelter	60.0	Diesel and Electrical Pump
16	Firewater Pond	160.0	
17	Potable water tank	10.0	
18	Industrial water supply tank	160.0	
19	Potable Water Supply Unit	0.73	
20	Industrial water Pump	0.51	
21	Service Gas Area	600.0	4 He tanks, each of 100m^3 1 He tank of 25m^3 1 Liq. N_2 Tank of 25m^3 1 Liq. N_2 Evaporator 70Nm^3/h 1 Liq. N_2 Tank of 50m^3 1 Liq. Ar Tank of 25m^3 1 Liq.Ar Evaporator of 400Nm^3/h
22	Stack	25.0	
23	Lay-down area	240.0	
24	Warehouse	540.0	SIZE COLLECTED FROM ORIGINAL SITE LAYOUT
25	Access Gate	80.0	
26	Water Drainage area	200.0	This includes industrial water drainage system, sanitary water drainage system and precipitation water drainage system

Figure 6-3: IFMIF Outdoor Overall View, Switchyard, Emergency Generators

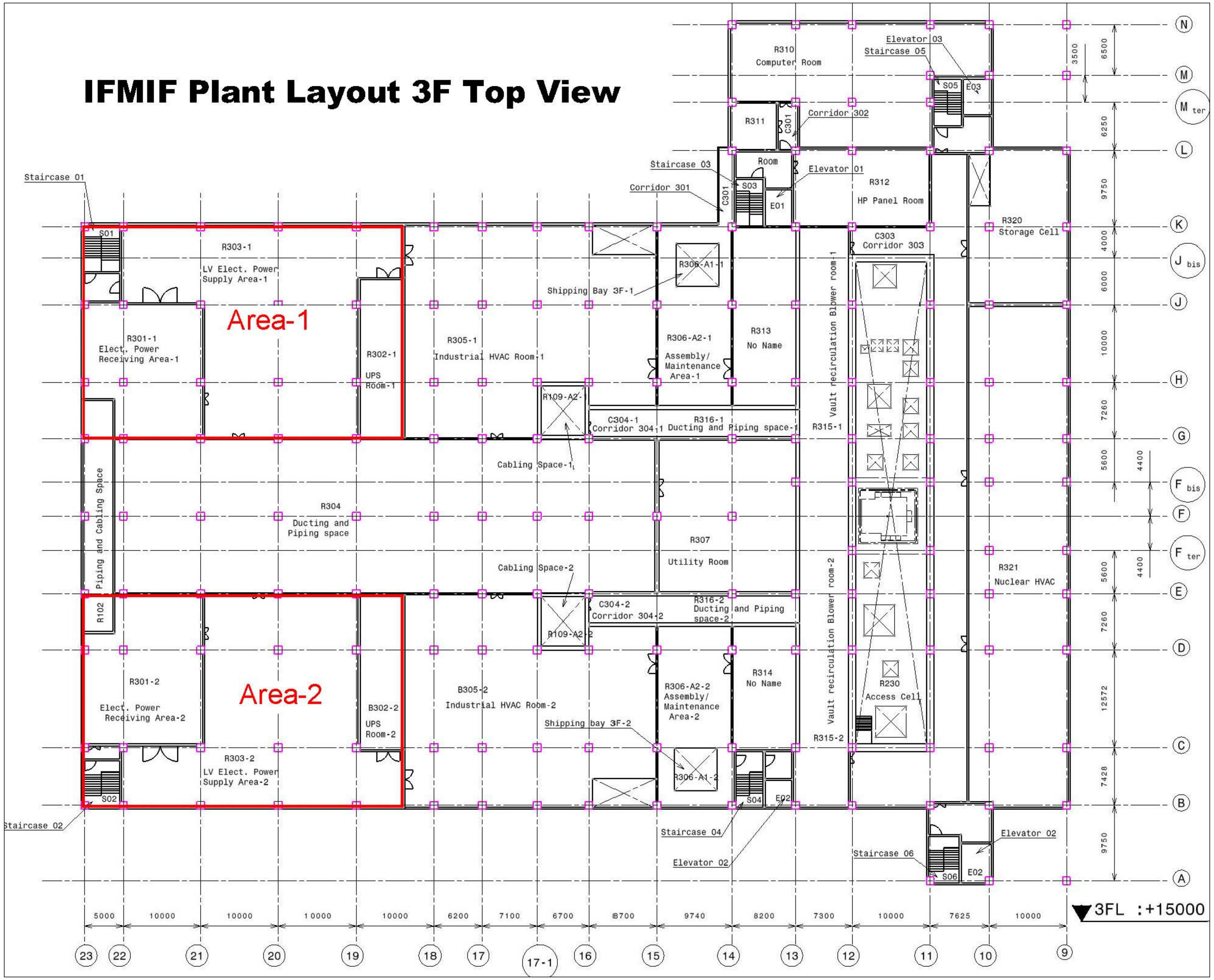
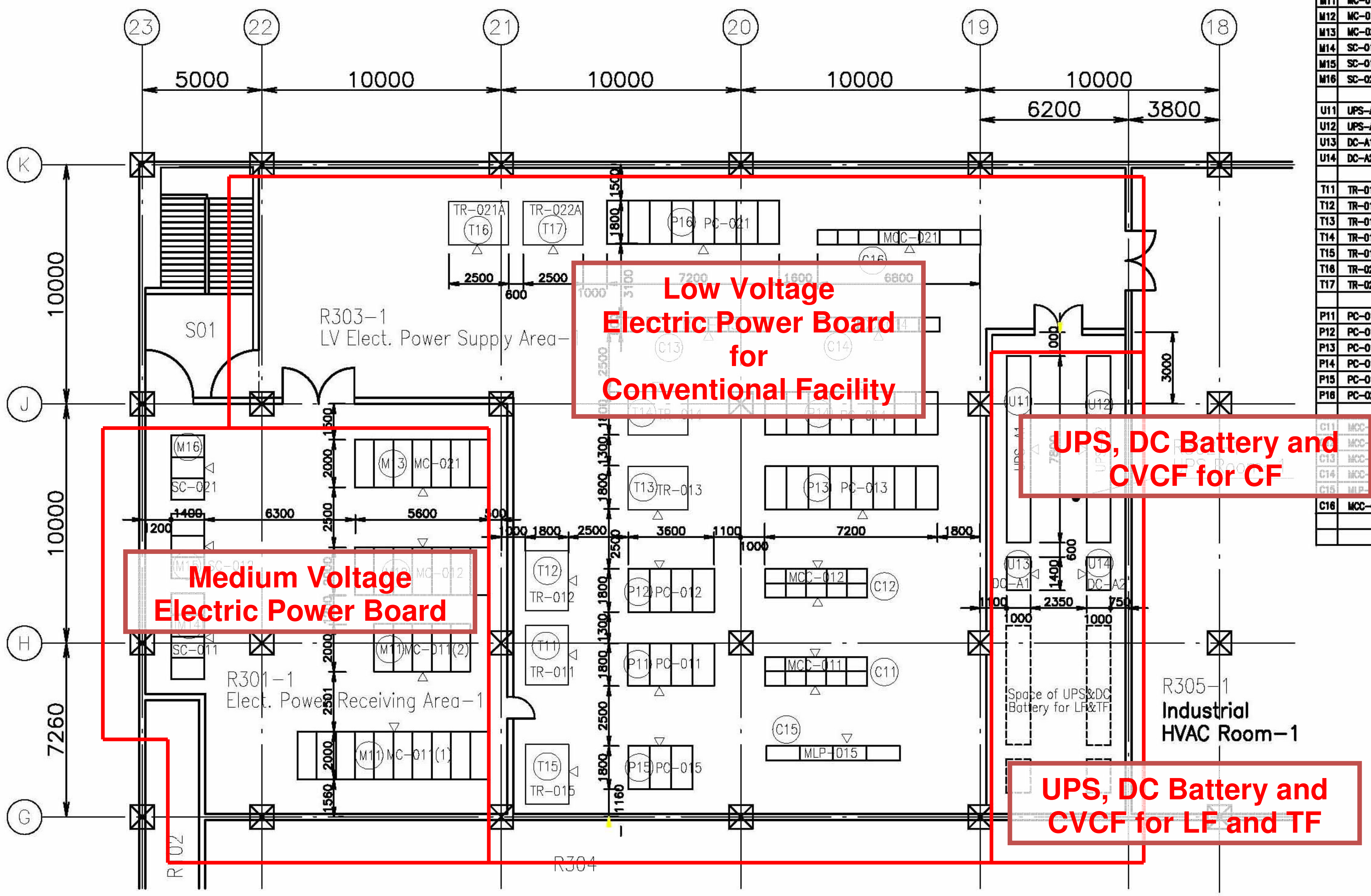


Figure 6-4: Equipment Layout for Electric Power System 1/6

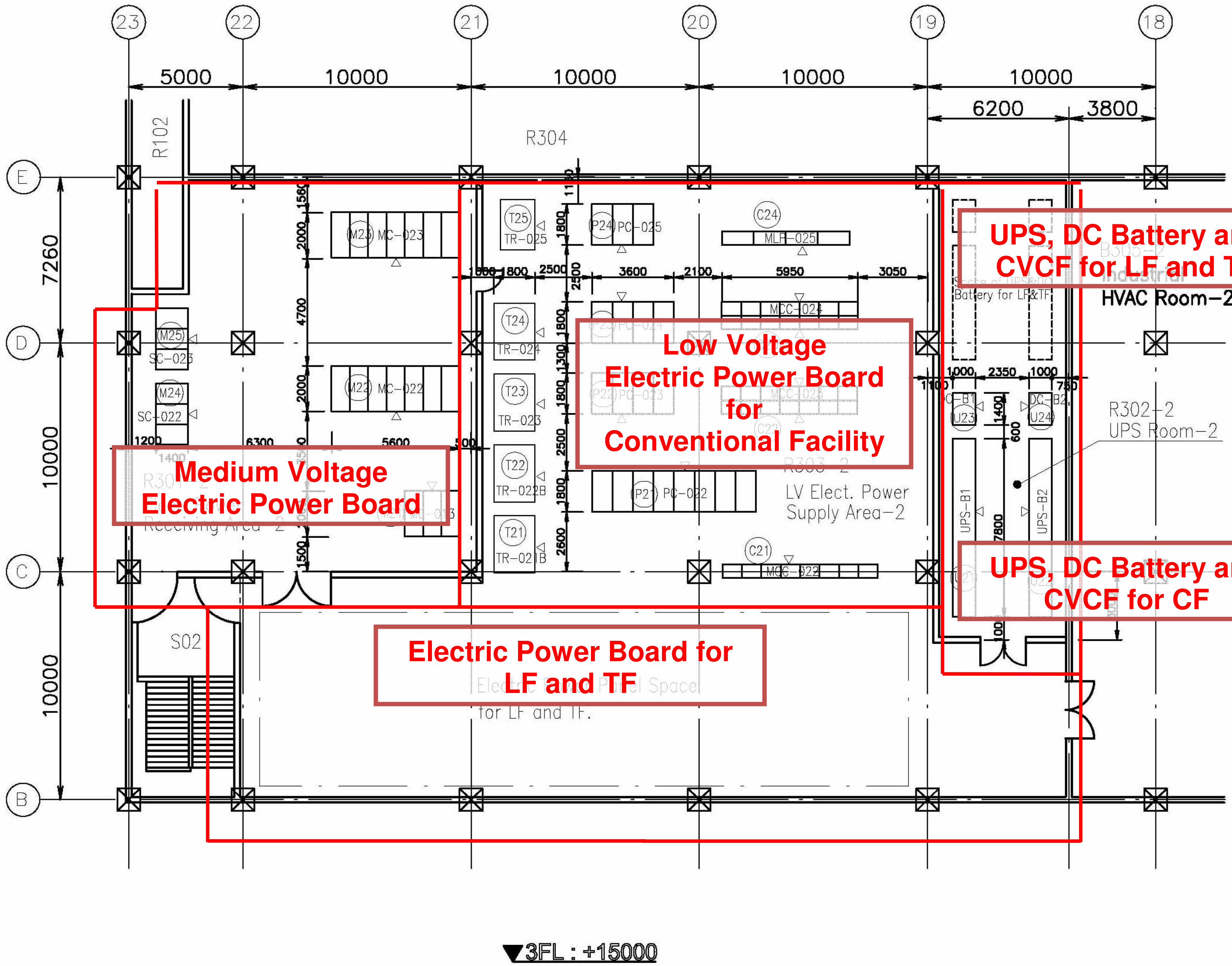


EQUIPMENT LIST (ELECTRICAL)

No.	EQUIPMENT No.	EQUIPMENT NAME	SIZE (WxDxH) (mm)	Q'TY	REMARKS
M11	MC–011	6.6kV 3ph–3W, Switchgear	800 x 2000 x 2350	15	
M12	MC–012	6.6kV 3ph–3W, Switchgear	800 x 2000 x 2350	7	
M13	MC–021	6.6kV 3ph–3W, Switchgear	800 x 2000 x 2350	7	
M14	SC–011	6.6kV Power Capacitor	900 x 1400 x 2100	4	
M15	SC–012	6.6kV Power Capacitor	900 x 1400 x 2100	3	
M16	SC–021	6.6kV Power Capacitor	900 x 1400 x 2100	3	
U11	UPS–A1	AC Uninterrupted Power System–3ϕ 400V 200kVA	7800 x 1000 x 1950	1 Set	
U12	UPS–A2	AC Uninterrupted Power System–3ϕ 400V 200kVA	7800 x 1000 x 1950	1 Set	
U13	DC–A1	DC Battery & Charger–100V 100Ah	1400 x 1000 x 1950	1 Set	
U14	DC–A2	DC Battery & Charger–100V 100Ah	1400 x 1000 x 1950	1 Set	
T11	TR–011	6.6/0.4–0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1	
T12	TR–012	6.6/0.4–0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1	
T13	TR–013	6.6/0.4–0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1	
T14	TR–014	6.6/0.4–0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1	
T15	TR–015	6.6/0.4–0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1	
T16	TR–021A	6.6/0.4–0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1	
T17	TR–022A	6.6/0.4–0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1	
P11	PC–011	0.4–0.23kV, 3ph–4W, LV Switchgear	900 x 1800 x 2350	4	
P12	PC–012	0.4–0.23kV, 3ph–4W, LV Switchgear	900 x 1800 x 2350	4	
P13	PC–013	0.4–0.23kV, 3ph–4W, LV Switchgear	900 x 1800 x 2350	8	
P14	PC–014	0.4–0.23kV, 3ph–4W, LV Switchgear	900 x 1800 x 2350	8	
P15	PC–015	0.4–0.23kV, 3ph–4W, LV Switchgear	900 x 1800 x 2350	3	
P16	PC–021	0.4–0.23kV, 3ph–4W, LV Switchgear	900 x 1800 x 2350	8	
C11	MCC–011	0.4–0.23kV, Motor Control Center	850 x 600 x 2350	10	
C12	MCC–012	0.4–0.23kV, Motor Control Center	850 x 600 x 2350	10	
C13	MCC–013	0.4–0.23kV, Motor Control Center	850 x 600 x 2350	6	
C14	MCC–014	0.4–0.23kV, Motor Control Center	850 x 600 x 2350	6	
C15	MLP–015	0.4–0.23kV, Main Loading Panel	1400 x 600 x 2350	4	
C16	MCC–021	0.4–0.23kV, Motor Control Center	850 x 600 x 2350	8	

▼3FL : +15000

Figure 6-5: Equipment Layout for Electric Power System 2/6



EQUIPMENT LIST (ELECTRICAL)

No.	EQUIPMENT No.	EQUIPMENT NAME	SIZE (WxDxH) (mm)	Q'TY	REMARKS
M21	MC−013	6.6kV 3ph−3W, Switchgear	800 x 2000 x 2350	3	
M22	MC−022	6.6kV 3ph−3W, Switchgear	800 x 2000 x 2350	7	
M23	MC−023	6.6kV 3ph−3W, Switchgear	800 x 2000 x 2350	7	
M24	SC−022	6.6kV Power Capacitor	900 x 1400 x 2100	3	
M25	SC−023	6.6kV Power Capacitor	900 x 1400 x 2100	3	
U21	UPS−B1	AC Uninterrupted Power System−3ϕ 400V 200kVA	7800 x 1000 x 1950	1 Set	
U22	UPS−B2	AC Uninterrupted Power System−3ϕ 400V 200kVA	7800 x 1000 x 1950	1 Set	
U23	DC−B1	DC Battery & Charger−100V 100Ah	1400 x 1000 x 1950	1 Set	
U24	DC−B2	DC Battery & Charger−100V 100Ah	1400 x 1000 x 1950	1 Set	
T21	TR−021B	6.6/0.4−0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1	
T22	TR−022B	6.6/0.4−0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1	
T23	TR−023	6.6/0.4−0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1	
T24	TR−024	6.6/0.4−0.23kV Transformer 1500kVA Dry	2500 x 1800 x 2350	1	
T25	TR−025	6.6/0.4−0.23kV Transformer 750kVA Dry	2200 x 1500 x 2350	1	
P21	PC−022	0.4−0.23kV, 3ph−4W, LV Switchgear	900 x 1800 x 2350	8	
P22	PC−023	0.4−0.23kV, 3ph−4W, LV Switchgear	900 x 1800 x 2350	4	
P23	PC−024	0.4−0.23kV, 3ph−4W, LV Switchgear	900 x 1800 x 2350	4	
P24	PC−025	0.4−0.23kV, 3ph−4W, LV Switchgear	900 x 1800 x 2350	3	
C12	MCC−022	0.4−0.23kV, Motor Control Center	850 x 600 x 2350	8	
C22	MCC−023	0.4−0.23kV, Motor Control Center	850 x 600 x 2350	14	
C23	MCC−024	0.4−0.23kV, Motor Control Center	850 x 600 x 2350	14	
C24	MLP−025	0.4−0.23kV, Main Loading Panel	1400 x 600 x 2350	4	

Figure 6-6: Equipment Layout for Electric Power System 3/6

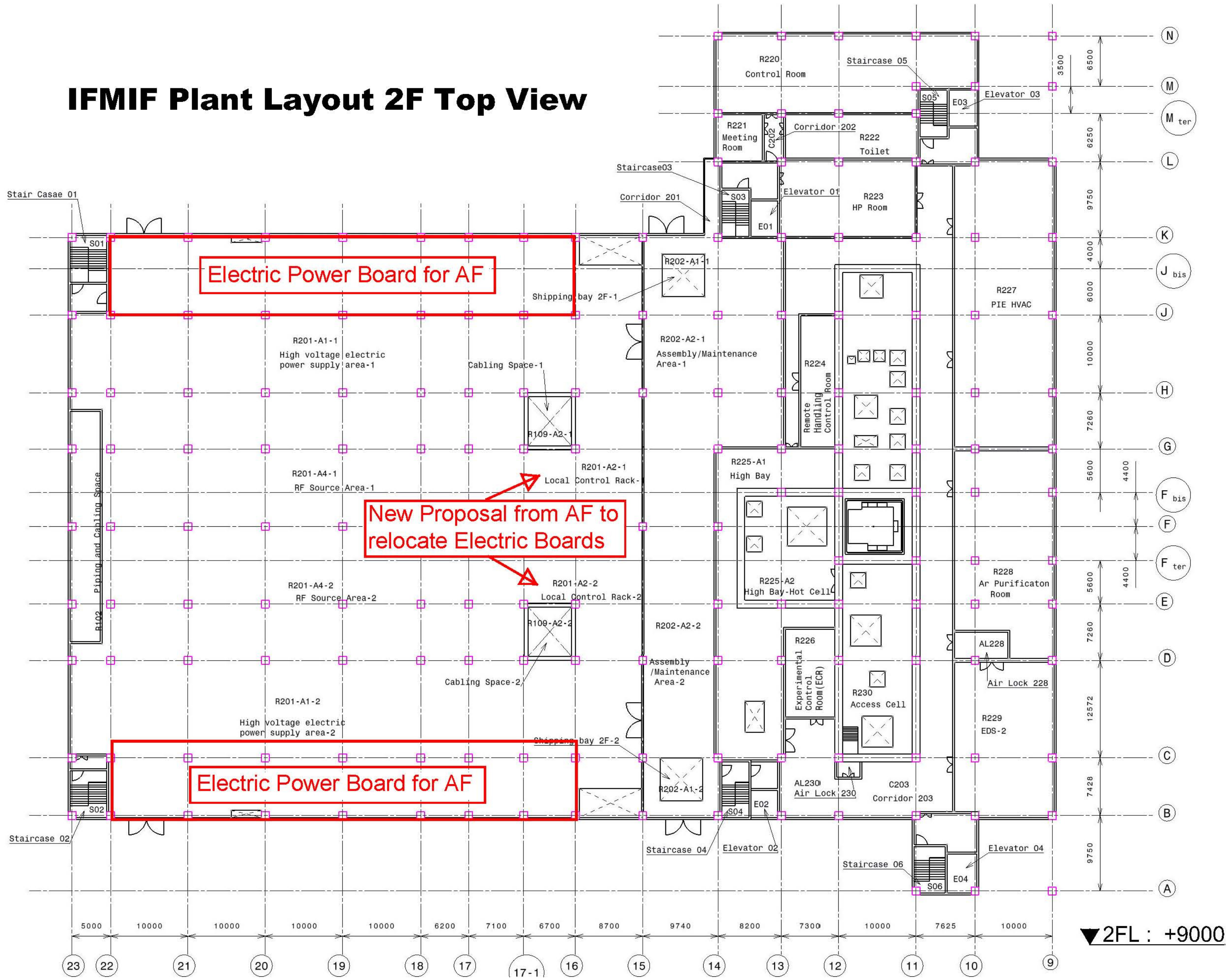


Figure 6-7: Equipment Layout for Electric Power System 4/6

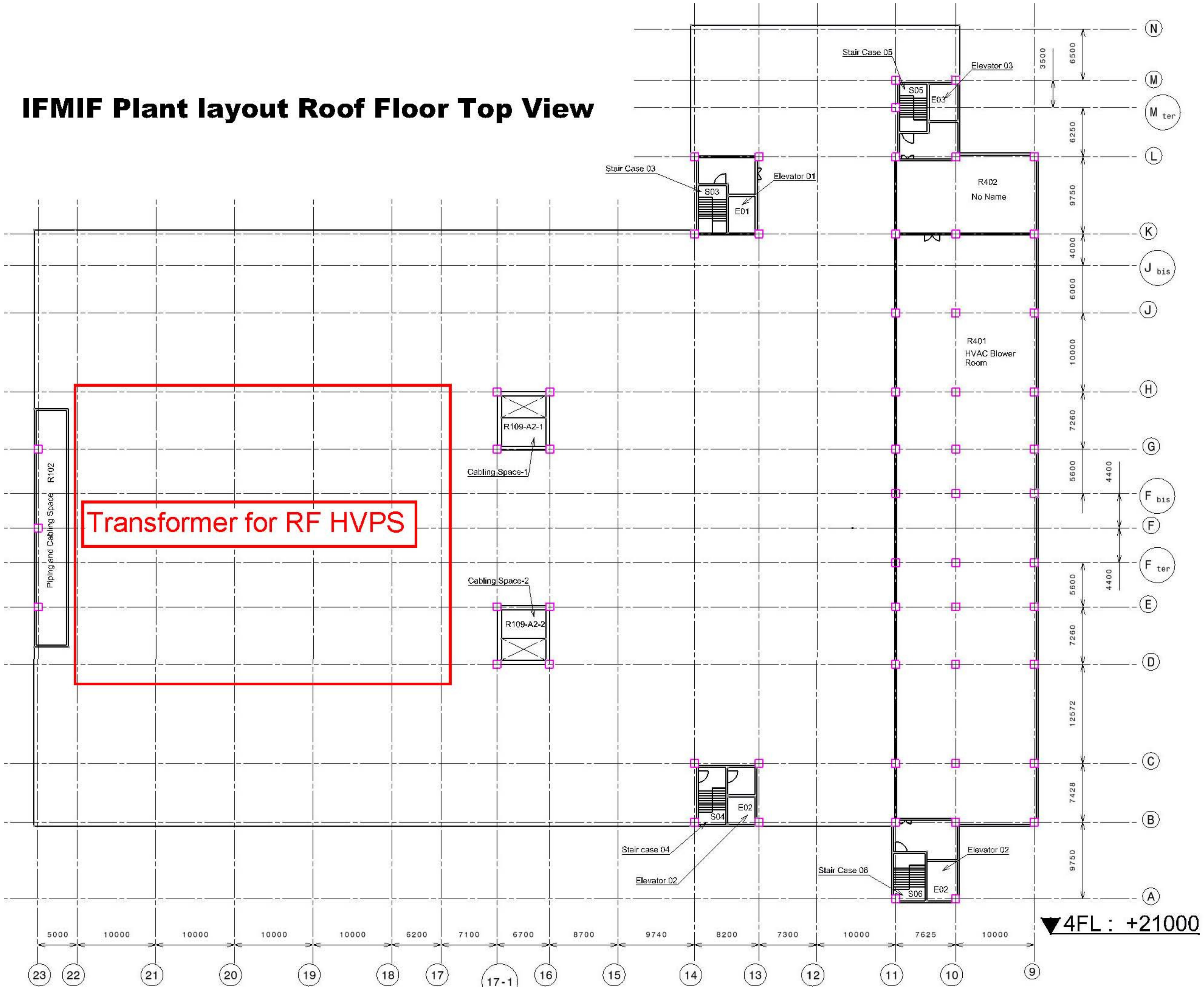


Figure 6-8: Equipment Layout for Electric Power System 5/6

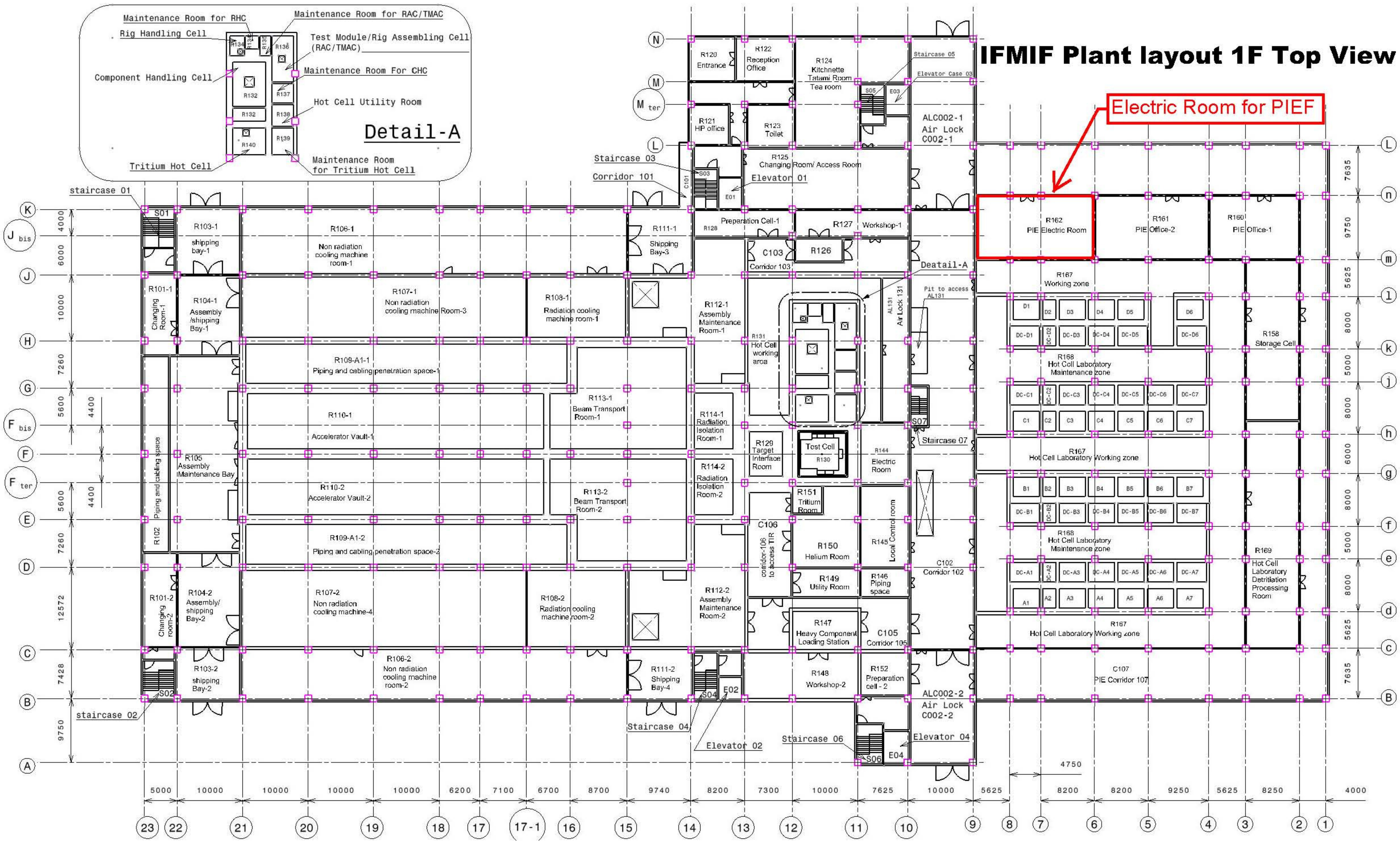


Figure 6-9: Equipment Layout for Electric Power System 6/6

INTERMEDIATE ENGINEERING DESIGN REPORT

Design Description Document

For the

Heat Rejection System (HRS)

PPS 5.3.3

IFMIF/EVEDA Integrated Project Team

Issued in the framework of the EU-Japan Fusion Broader Approach Agreement

Design Description Document
For the
Heat Rejection System (HRS)
PPS 5.3.3

Prepared by: G. Pruneri[a]

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Abstract: **This document describes the Heat Rejection System (HRS) considered belonging to the Conventional Facilities. Key functions of the system as well as: interfaces with other facilities/systems, PFD, P&ID's, equipment layout, equipment list, flow diagrams, piping layout and input data requirement for the design of the system.**

TABLE OF CONTENTS

ACRONYMS

AF	Accelerator Facility
CCS	Central Control System
CF	Conventional Facilities
CODA	Construction Operation and Decommissioning Activities
DDD	Design Description Document
DVT	Data Validation table
EDS	Emergency Detritiation System
EVEDA	Engineering Validation & Engineering Design Activities
GDS	Glove boxes Detritiation System
HDS	Hot cells Detritiation System
HRS	Heat Rejection System
HVAC	Heating Ventilation Air Conditioning
IFMIF	International Fusion Materials Irradiation Facility
LF	Lithium target Facility
MPS	Machine Protection System
PBS	Plant Breakdown Structure
PFD	Process Flow Diagram
P&ID	Piping& Instrumentation Diagram
PIE	Post Irradiation Examination
PT	Project Team
RAMI	Reliability, Availability, Maintainability, Inspectability
RF	Radio Frequency
RFQ	Radio Frequency Quadrupole
SIC	Safety Important Component
TF	Test Facility
VDS	Vent gas Detritiation System
WBS	Work Breakdown Structure

LIST OF EXHIBITS

Tables

Figures

1. System Functions and Basic Configuration

The main function of the Heat Rejection System (HRS) is to be capable of transferring heat from the Cooling water System of the different components of the process facilities. The HRS is thus designed to perform the following key functions:

- Prepare and supply coolant to the primary and secondary cooled and chilled loops.
- Transfer the heat generated in the different systems / components of the process facilities to the coolant.
- Maintains coolant temperatures, pressures and flow rates to ensure component temperatures and thermal margins are maintained during the operating campaign.
- Provide the capability to drain and refill the HRS components for maintenance, The HRS is designed as an open system consisting of cooling towers, circulation water pumps, heat exchangers, chillers, valves and instruments including sensors and interconnected piping.

HRS is an important system for IFMIF project, its fault or low efficiency could compromise the all IFMIF process system, for these reasons, HRS system have been designed with enough margins in terms of heat sinks. The components characteristics and the solution of series parallel configuration have been adopted in order to allow an easily maintenance even when the plant process are in operation.

The main components as pumps and cooling towers are redundant and several by-pass on piping configuration allow the HRS operation even during scheduled maintenance. Figure 1-1: HRS PFD (Heat Rejection System, Process Flow Diagram).

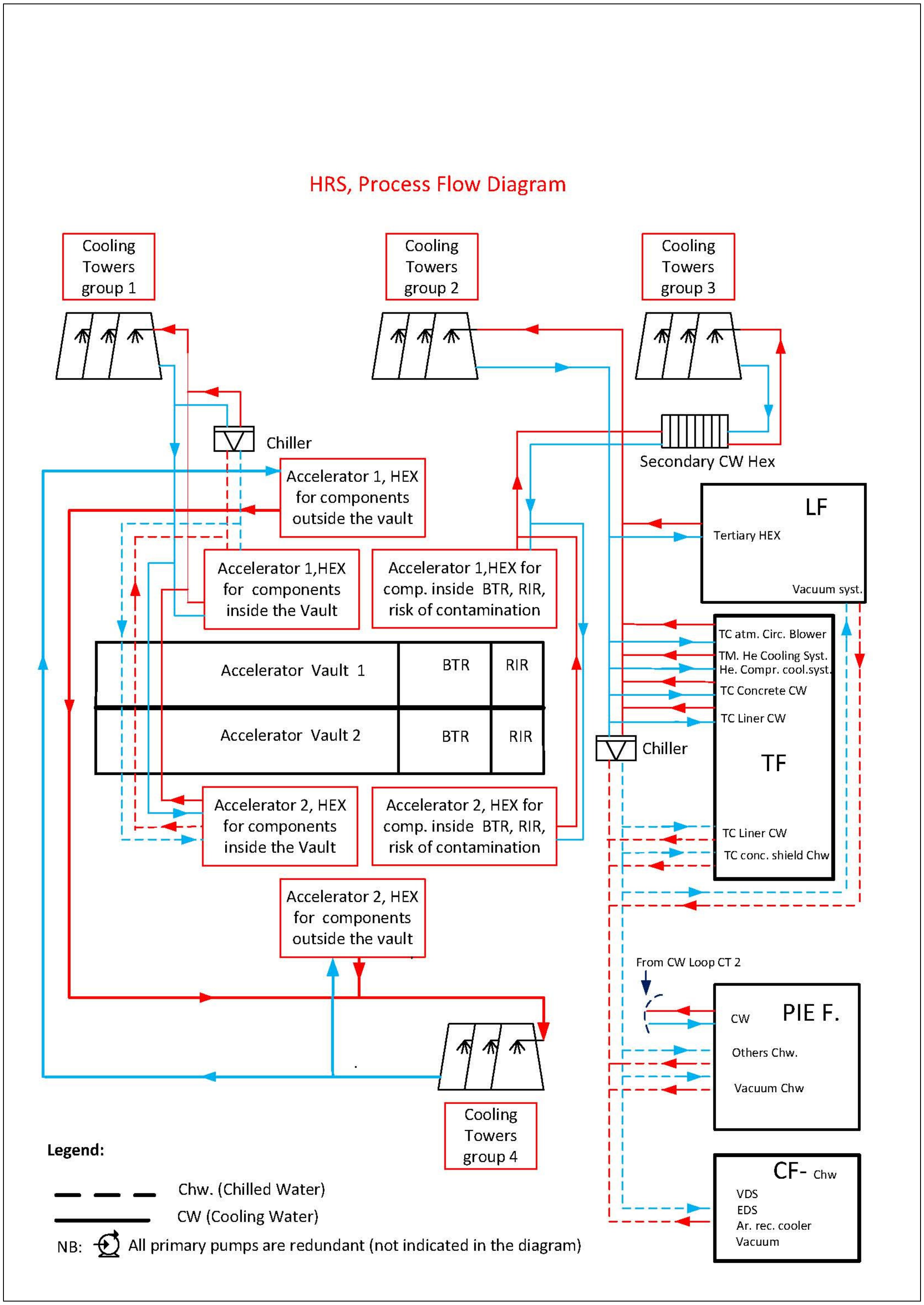


Figure 1-1: HRS PFD (Heat Rejection System, Process Flow Diagram)

1.1 System Functions

The HRS is thus designed to perform the following key functions:

- Prepare and supply coolant to primary and secondary cooled and chilled loops;
- Transfer the heat generated in the different systems/components of the process facilities to the coolant;
- Maintain coolant temperatures, pressures, and flow rate to ensure components temperatures and thermal margins maintained during the operation campaign;
- Provide the capability to drain and refill the HRS components for maintenance.

The HRS is designed as an open system consisting of cooling towers, circulation water pumps, heat exchangers, chillers, valves, water storage tank and instruments, including sensors and interconnected piping.

The HRS comprised the following four (4) groups of cooling water towers here below described and shown on Figure 8-1: Overall View, outdoor cooling Tower main configuration. :

1) **The Water cooling Towers Group 1** serves cooling water for accelerator 1 and 2, to the secondary water cooling loop for heat exchangers of all components inside the Vault. This loop is shown on PFD (cfr. Ref. Figure 8-8: D-1223-D-013-Process Flow Diagram HRS (Accelerator Facility) 3/4
2) **The Water cooling Towers Group 2** serves cooling water to the secondary water cooling loop for the heat exchangers of: TF (Test Facility), LF (Lithium Facility), PIE (Post Irradiation Examination facility) and CF (Conventional facility) the loop is shown on PFD (Process Flow Diagram) (cfr. Ref. D-1223-011-Figure 8-6: D-1223-011, Process Flow Diagram HRS (TF-LF-PIE-CF))
3) **The Water cooling Towers Group 3** serves cooling water tower to the secondary water cooling loop for the heat exchanges of the 2 Accelerator’s components inside the vault with potential risk of water activation, i.e. Beam Dump and HEBT**.** This loop is shown on PFD (cfr.Ref. Figure 8-9: D-1223-D-014- Process Flow Diagram HRS (Accelerator facility) 4/4
4) **The Water cooling Towers Group 4** serves cooling water tower to the secondary water cooling loop for the heat exchanges of the components outside the Vault. This loop is dedicated for: RF chain plus HVPS, He compressors for Cry plant common cooling skid (for Cold box, Injector LVPS, HEBT LVPS, RFQ cryo compressors, HEBT compressors and vacuum system). It is shown on PFD (cfr.Ref. Figure 8-7: D-123-012- Process Flow Diagram HRS (Accelerator Facility) 2/4

The circulation water pumps shall be used to pump water from the Cooling Tower to the Heat exchanges for the subsystem to cool down. The cooling Tower basin acts as a first buffer to meet the heat load fluctuations.

The hot water return to the C.T. spray header that is located near the top of the Cooling Tower. The ancillary system include blow down system, make-up water system, water storage reserve tank, (1000 m^3) suitable filtration system and chemical dosing arrangement. The chemical dosing system shall be capable to prevent the corrosion, (since due to the huge consume of water for evaporation we selected industrial water and not demineralized water) scaling and biological growth (including legionella) by adding anti-corrosive, anti-scaling chemical, pH control additives and biocides in the Cooling tower basin water.

1.2 System Basic Configuration

Here below summarized in Table 1, HRS PBS.

PBS Number						PBS Item
1	**2**	**3**	**4**	**5**	**6**	
5	**0**	**0**	**0**	**0**	**0**	**Conventional Facilities**
	3	0	0	0	0	Plant Services
		3	0	0	0	Heat Rejection System (HRS)
			1	***0***	***0***	***Accelerator Facility***
			2	***0***	***0***	***Test Facility***
			3	***0***	***0***	***PIE Facility***
			4	***0***	***0***	***Conventional Facility***
			5	***0***	***0***	***Piping layout***

Table 1: HRS PBS (Project breakdown structure)

2. Interfaces (boundaries)

The interfaces with other systems may be physical and functional or both. Additional information about HRS interfaces is provided in Systems Interface (Ref. Table 2 : Interface table) Characteristics of the components for the HRS is indicated on the Equipment List (cfr.Ref. Table 11: S-1224-001- HRS Equipment List) There is a multiple interface between HRS, Facilities (hosted mainly in the Heat Exchanger rooms) and Building. A generic multiple interface was defined to overcome this issue. HRS system interfaces at the same time with Conventional Facilities (in the sense of the Building) and with the equipment hosted in the rooms (that can be part of the Accelerator, Lithium, Test, PIE and/or of the Conventional Facilities themselves). The sharing of responsibilities will be clarified case by case, but at list this general triple interface includes all the requirements that HRS needs in order to proceed with the design, here below are summarized (at first level) the interfaces related to the HRS .

Interface Table HRS (Heat Rejection System)		
System A	**System B**	**Title**
Test Facility	Heat Rejection System	Heat Rejection System has to provide secondary cooling water to: Test Facility
PIE Facility	Heat Rejection System	Heat rejection System has to provide primary cooling water to: PIE Facility.
Lithium Target Facility	Heat Rejection System	Heat Rejection System has to provide secondary cooling water to: Lithium Target Facility
Accelerator Facility	Heat Rejection System	Heat Rejection System has to provide secondary cooling and chilled water to: Accelerator Facility
Main Building	Heat Rejection System	Main building has to accommodate heat exchangers, chillers, piping and pumps of: Heat Rejection System and water storage tank (1000 m^3)
Cooling Tower Area	Heat Rejection System	Cooling Tower area has to be accommodate cooling towers and pumps of: Heat Rejection System
Electrical Power System	Heat Rejection System	Electric Power Supply has to provide electric power to: Heat Rejection System
Service Water System	Heat Rejection System	Service Water System has to provide demineralized and industrial water to: Heat Rejection System
Service Gas System	Heat Rejection System	Service Gas System has to provide instrumentation air and nitrogen gas to: Heat Rejection System Heat Rejection System has to provide primary chilled water to: Service Gas System
Exhaust Gas Processing System	Heat Rejection System	Heat Rejection System has to provide primary chilled water to: • VDS (Vent Gas Detritiation System) • GDS-V(GDS for 1st stage VDS) • EDS (Emergency Detritiation System) • GDS-E (GDS for EDS) • HDS (Hot cell Detritiation System) • GDS (Glove box Detritiation System) of Exhaust Gas Processing System
Liquid waste Treatment System	Heat Rejection System	When contamination in water of primary cooling and chilled water loop of Heat Rejection System is detected, the waste water has to be sent to: Liquid waste Treatment System

Table 2 : Interface table

2.1 HRS System vs. Lithium Facility

The boundary between HRS and LF is set at the interception flanges of the Tertiary Heat Exchanger, interception valves and all the downstream components are within the scope of the Lithium Target Facility.

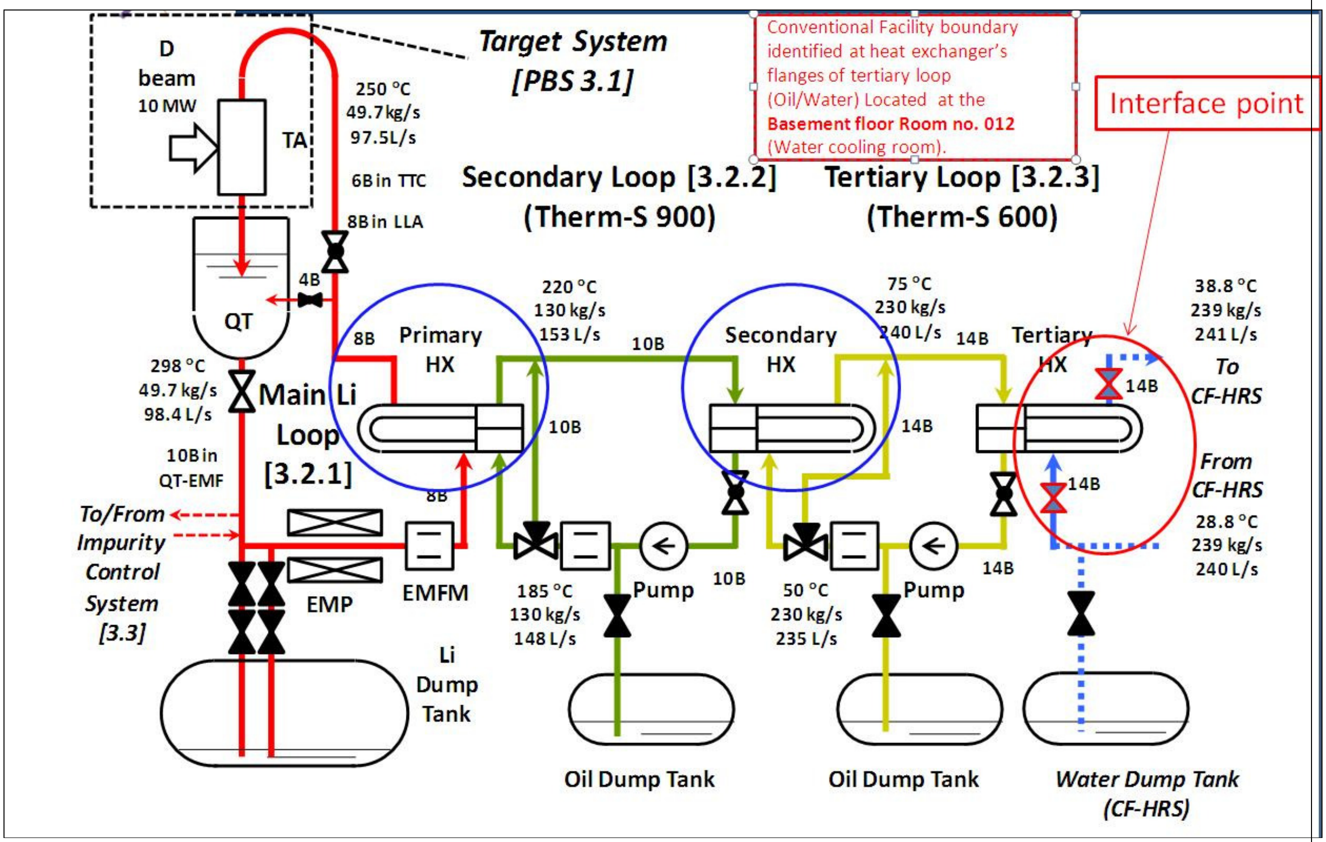


Figure 2-1: Heat mass balance of Heat removal (Extracted from LF.DDD)

2.2 HRS System vs. Accelerator facility[1]

HRS will serve the Accelerator Facility through the:

- RFQ chiller skid
- RF & Auxiliary cooling skid (Out Vault Equipment)
- In Vault Equipment cooling skid
- Beam Dump Scrapper & HEBT-BTR-RIR cooling skid

Ref. to Figure 2-2: Accelerator Heat loads scheme (cfr. Ref. [6])

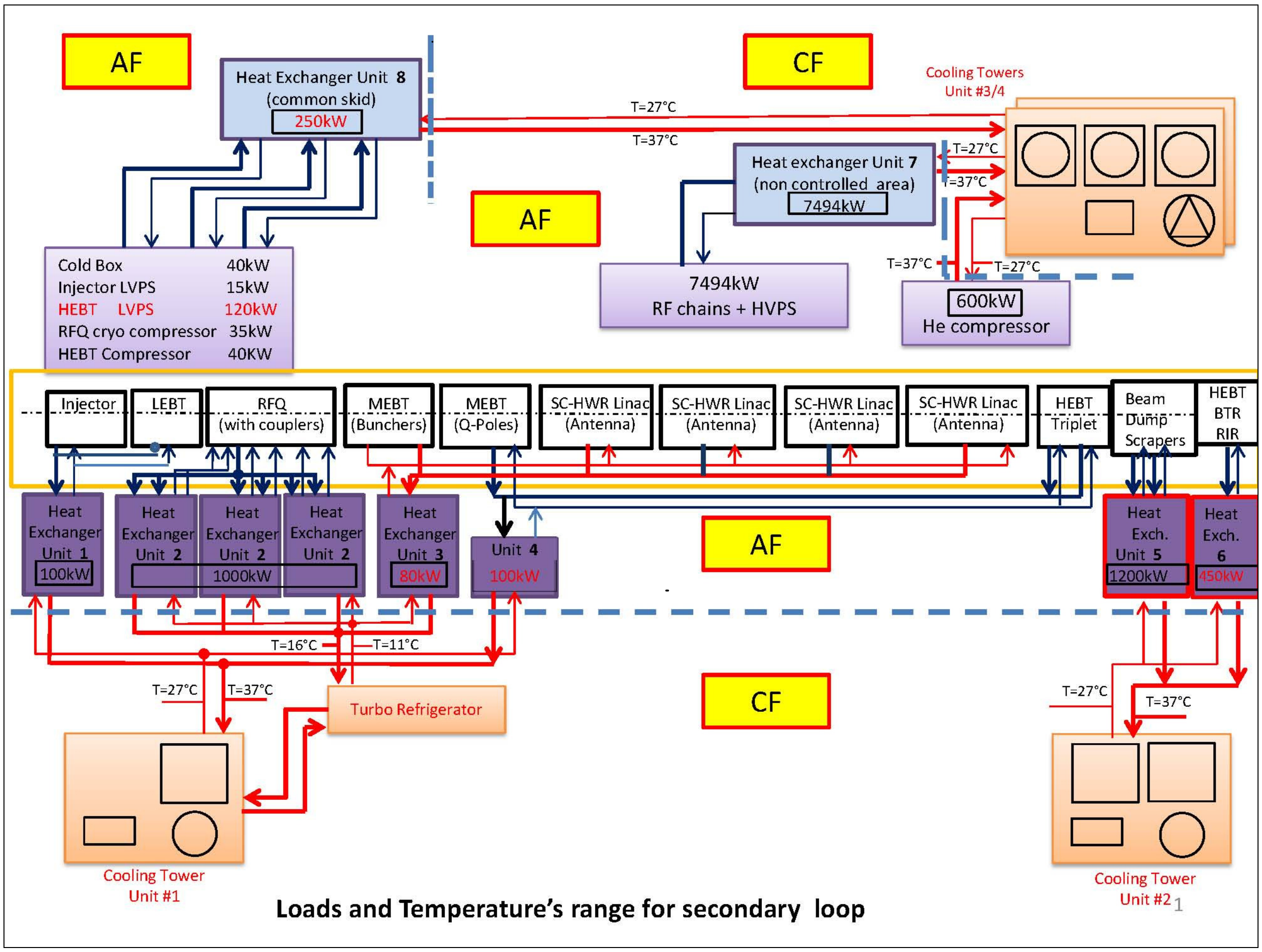


Figure 2-2: Accelerator Heat loads scheme

[1] According to the same approach used in the Accelerator prototype it has been considered that the primary cooling loop (the ones in direct contact with the Accelerator's components) of the Accelerators belong to the Accelerator facility.

2.3 HRS System vs. Test Facility

HRS shall serve the Test facility through the:

- Test cell water exchanger for to cool the concrete shield wall
- Test cell Helium exchangers for to cool the test module.
- Test cell argon and Helium exchangers for to cool TC atmosphere argon/helium blower.
- Test cell water exchanger for to cool TC liner (cooled by water, new concept progress of DDD I concept with Helium cooling system)

The boundary between HRS and TF is set at the interception valves of the cooling exchanger's interception valves and all the afterwards equipments are within the scope of Test Facility (Ref. to Figure 2-3 : Test Facility HRS, (Extracted from PFD-D-1223-011).

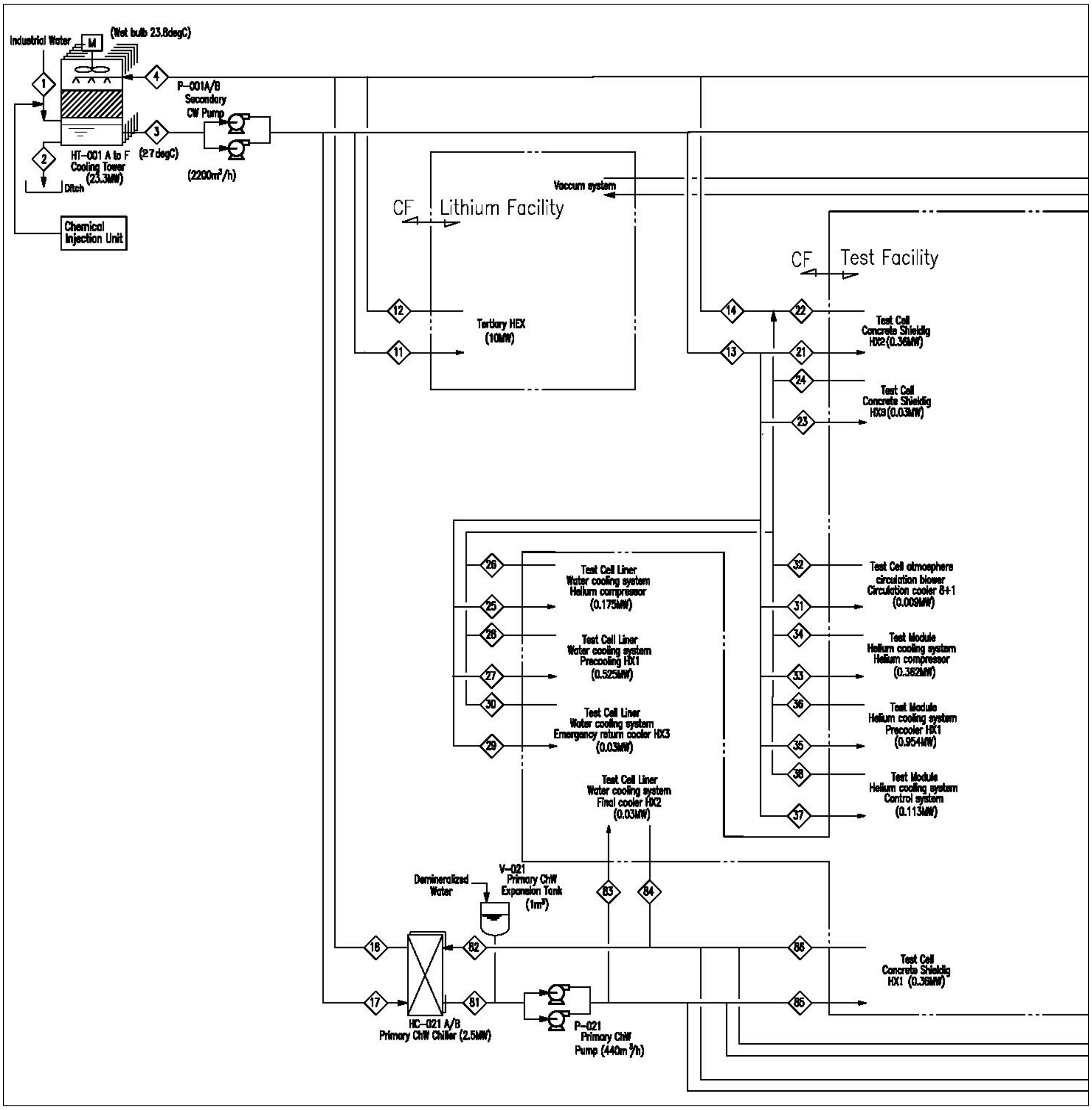


Figure 2-3 : Test Facility HRS, (Extracted from PFD-D-1223-011)

2.4 HRS System vs. Post Irradiation Examination Facility

(Ref. Figure: 2-4: PIE Facility, HRS (Extracted from HRS PDF-D- 1223-011) Extract from PFD, D-1223-011.

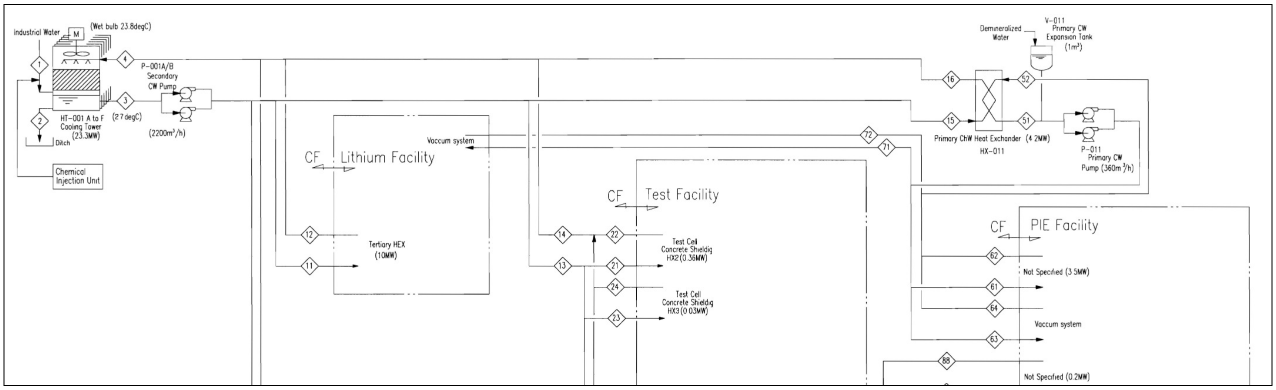


Figure: 2-4: PIE Facility, HRS (Extracted from HRS PDF-D- 1223-011)

2.5 HRS System vs. Conventional Facilities

Heat Rejection System has to provide primary chilled water to:

- VDS (Vent Gas Detritiation System)
- GDS-V(GDS for 1st stage VDS)
- EDS (Emergency Detritiation System)
- GDS-E (GDS for EDS)
- HDS (Hot cell Detritiation System)
- GDS (Glove boxe Detritiation System) of Exhaust Gas Processing System

(Ref. Figure 2-5: Conventional Facility HRS (Extracted from HRS-PDF D-1223-011),

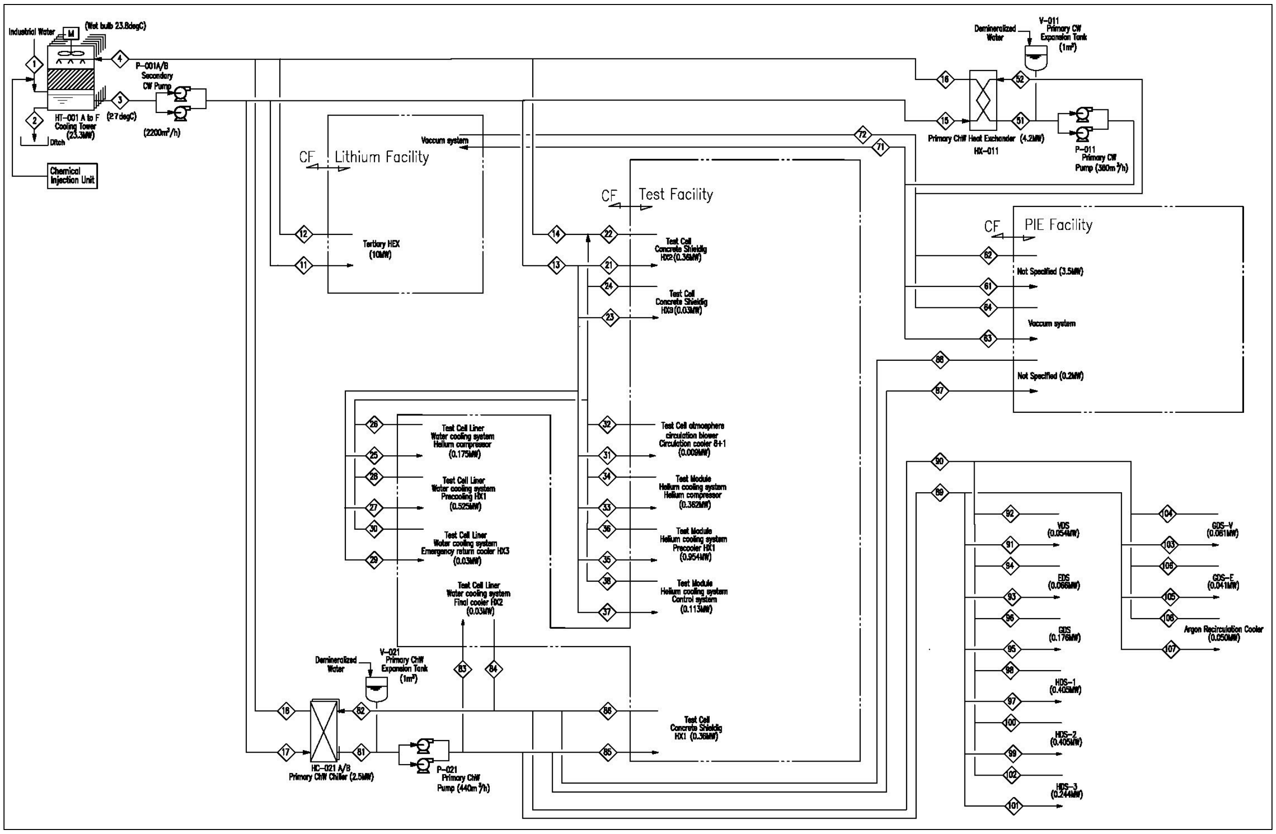


Figure 2-5: Conventional Facility HRS (Extracted from HRS-PDF D-1223-011)

3. System Design Requirements

3.1 General requirements

Input Data Requirements are defined as the data necessary to be defined in order to enable a system design that respects all the needs of the interfacing components.

Currently a draft set of data has been proposed. This list is partially complete and assessed by the PT on the base of the current references, of the outcomes of the Engineering Validation activities (i.e. prototypes) and on the standard engineering practice.

Parameters to be defined as *Input Data Requirements* for the HRS are, for each interfacing component:

- Heat load to be removed: (MW);
- Cooling media: (chilled/cooled water);
- Inlet water temperature: (°C);
- Temperature tolerance: (±°C);
- ΔT= (outlet temp) – (inlet temp): (°C);
- Supply water pressure: (MPa);

- Water Pressure drop after the passage in the skid: (MPa);
- Coolant Flow[2]: (m^3/h).

The following sections describe in detail the logic that brought to the selection by the PT of the current set of parameters.

Here below are listed the *Input Data Requirements:*

- Figure 3-1: Input data requirements for LF Heat Loads
- Figure 2-2: Accelerator Heat loads scheme
- **Error! Reference source not found.**
- Table 5: Input Data Requirement for PIE Facility Heat Loads.
- Table 6: Input Data Requirement for Conventional Facility Heat Loads.

3.2 Engineering Requirements

3.2.1 Lithium Facility

The current status of LT Facility input data requirement are indicated on the Ref. Figure 3-1: Input data requirements for LF Heat Loads, the value has been assessed by the Project Team according to:

- Facility Description of CDR (ref. [3])
- Standard engineer practice
- LF DDD III, HRS Heat mass balance of Heat removal (Extracted from DDD III, IFMIF LF Ref. BA_D_22QUE –v 1.1) [12]

[2] Coolant flow is a consequences of the definition of following parameters:

1. Cooling media
2. Heat loads
3. ΔT

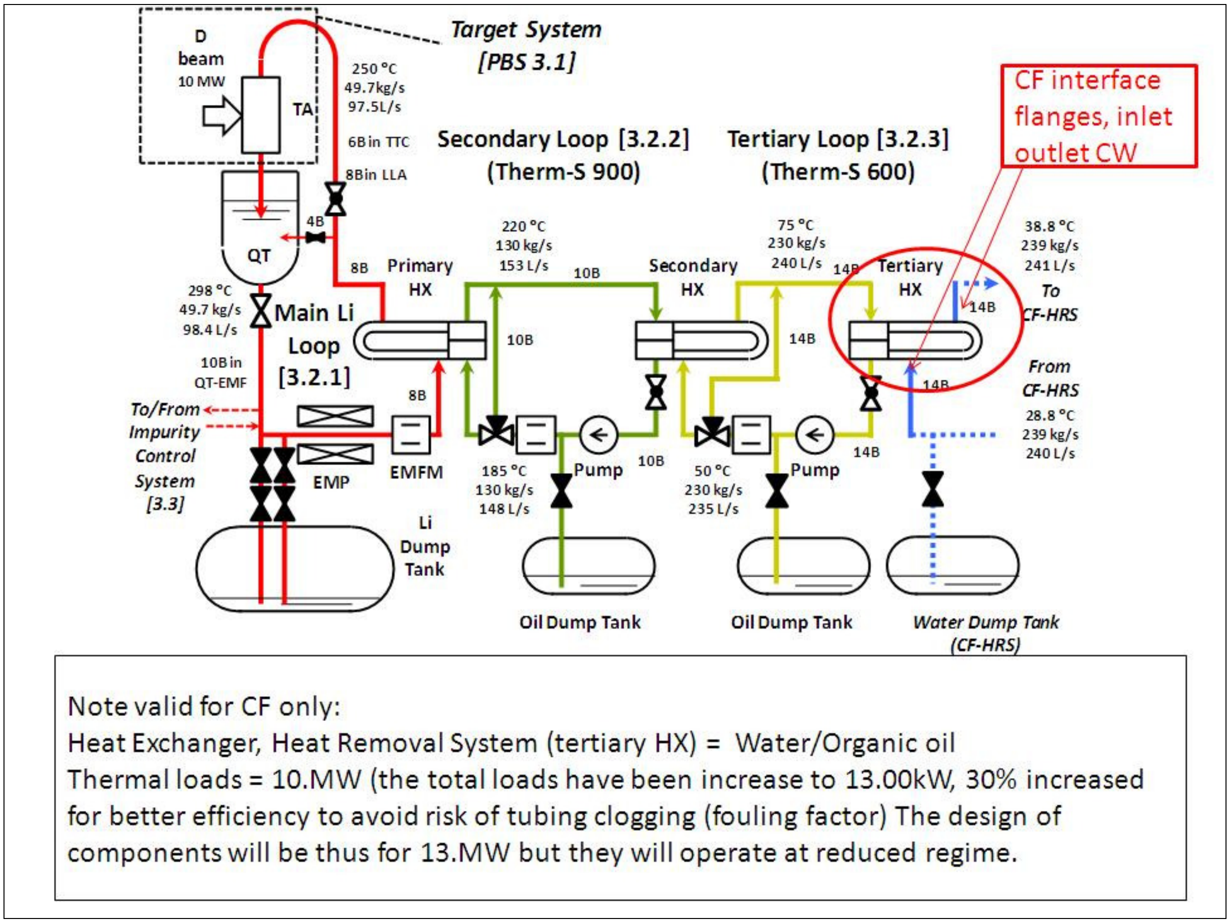


Figure 3-1: Input data requirements for LF Heat Loads

3.2.2 **Accelerator Facility**

The current status of both Accelerators Facility input data requirement are indicated on the Ref. Table: 3 (The values indicated on the Table are referred to one Accelerator only) the values have been assessed by the Project Team according to:

- Facility Description of CDR (ref. [3])
- Standard engineer practice.
- Heat loads scheme (Ref. to Figure 8-2: Accelerator's Heat Loads scheme. [6])
- Accelerator Facility heat Loads (Ref.[4])
  - Sect. 4.3.2.6.(cfr. Ref.[4]) RF Power System- Water Cooling System
  - Sect. 4.3.2.9.1.8. (cfr. Ref. [4]) LHe Cryogenic System
  - Sect.4.3.2.9.2.8.(cfr.Ref.[4]) Cryoplant

Item	Component	Reference	Unitary Heat Load	Quantity	To Load	From Load	Heat Load	Water Flow Rate	Comments and Assumptions
	Accelerator #1 "In Vault-Components" Heat Loads								
					Secondary loops Water Conditions (from Heat Exchanger to Cooling System)				Heat loads and Water temperatures considered here are the one belonging to the "secondary loop'.
					Water temperatures				
1	Injector + LBET		100 kW	1	27°C	37°C	100 kW	9 m^3/h	Same Heat Load and Temperature of the Prototype
2	RFQ		1000 kW	1	11°C	16°C	1000 kW	172 m^3/h	Same Heat Load and Temperature of the Prototype
3	MEBT Bouncher		**20 kW**	**2**	11°C	16°C	**40 kW**	**6.9 m^3/h**	Same Heat Load and Temperature of the Prototype **(new design of buncher -> 20 kW/buncher)**
4	MEBT Quadrupoles		**3 kW**	**5**	**27°C**	**37°C**	**15 kW**	**1.3 m^3/h**	Same Heat Load and Temperature of the Prototype (5 Quadrupoles cooling, **3 kW/Qpole**)
5	SRF LINAC #1 antenna (5 to 9 MeV)		3 kW	8	11°C	16°C	24 kW	4 m^3/h	Same Heat Load and Temperature of the Prototype (each antenna needs a 3 kW cooling)
6	SRF LINAC #2 antenna (9 to 14.5 MeV)		3 kW	10	11°C	16°C	30 kW	5 m^3/h	Each antenna needs a 3 kW cooling. The number of antennas comes from the "Superconducting HWR alternative.pdf" document discussed with Accelerator facility people
7	SRF LINAC #3 antenna (14.5 to 26 MeV)		3 kW	12	11°C	16°C	36 kW	6 m^3/h	Each antenna needs a 3 kW cooling. The number of antennas comes from the "Superconducting HWR alternative.pdf" document discussed with Accelerator facility people
8	SRF LINAC #4 antenna (14 to 40 MeV)		3 kW	12	11°C	16°C	36 kW	6 m^3/h	Each antenna needs a 3 kW cooling. The number of antennas comes from the "Superconducting HWR alternative.pdf" document discussed with Accelerator facility people
9	HEBT Focusing/Shaping Elements		500 kW	1	27°C	37°C	500 kW	43 m^3/h	The Heat value comes from discussion with Accelerator facility people. **Probably a bit overestimated but as I do not have any magnet power value today, it is wise to let like this. We will update for the**
	Beam Dump	Acc Prototype	1200 kW	1	27°C	37°C	1200 kW	103 m^3/h	CDR considers a Beam dump Capable of 5 MW (in order to stop all the beam), but nowadays the IFMIF beam dump will be dimensioned on the given value of 1200 kW (discussion with Accelerator Facility People) Beam Dump use will be limited to beam start-up periods, so a dedicated cooling scheme for this item seems a resonable solution. It has to be considered also that the limited power of this item forces the accelerator to work at a reduced duty factor (pulsed working regime). **Even 1200 kW is probably overestimated. We will probably use the beam dump with duty cycles lower than 10-2 but today it is not formally decided. It is thus preferable to let like this. It will be updated later.**
	Total Heat Loads in Vault components						**2981 kW**		

Item	Component	Reference	Support to	Unitary Heat	Quantity	To Load	From Load	Heat Load	Water Flow Rate	Comments and Assumptions
	Accelerator #1 "Out-Vault Components" Heat Loads									
						Secondary loops Water Conditions (from Heat Exchanger to Cooling System)				Heat loads and Water temperatures considered here are the one belonging to the "secondary loop', whereas the "Primary Loop" .
						Water temperatures				
10	Injector LVPS	Acc Prototype	Injector	15 kW	1	27°C	37°C	15 kW	1 m^3/h	Part of the commun skid
11	RFQ Cryo Compressor	Acc Prototype	RFQ	35 kW	1	27°C	37°C	35 kW	3 m^3/h	Part of the commun skid
12	Cold box	Acc Prototype	Cry plant	40 kW	1	27°C	37°C	40 kW	3m^3/h	Part of the commun skid (considered 4 times bigger than LIPAc)
13	HEBT Compressor	Acc Prototype	HEBT	40 kW	1	27°C	37°C	40 kW	3 m^3/h	Part of the commun skid (considered double than LIPAc)
14	He Compressor	Acc Prototype	Cryoplant	150 kW	4	27°C	37°C	600 kW	52 m^3/h	LIPAc 150 KW (we considered al least 4 times bigger 60 0 KW) probably we will need only
15	RF Chains	Acc Prototype	RFQ-MEBT-SRF Linac	6674 kW	1	27°C	37°C	6674 kW	573 m^3/h	RFQ = RF Chains: 350kW x 0,8 x 8 Chains = 1400kW. MEBT RF Chains: 24kW x 0,5 x2 chains =24KW . Cryomodule 1 RF Chains : 170kW x 0,5 x 8 Chains = 680 kW Cryomodule 2 RF Chains : 170kW x 0,5 x 10 Chains = 850 kW Cryomodule 3 RF Chains : 310kW x 0,5 x 12 Chains = 1860 kW Cryomodule 4 RF Chains : 310kW x 0,5 x 12 Chains = 1860 kW
16	HVPS	Acc Prototype	RFQ-MEBT-SRF Linac	820 kW	1	27°C	37°C	820 kW	70 m^3/h	Thermal power to be dissipated for each source is around 20kW x 41 for each Linac =820 kw.
	Total Heat Loads out Vault components							**8224 kW**		
	Grand total for each accelerator (Heat Loads)							**11205 kW**	**~ 11,3MW**	

Table 3: Input data requirements, Accelerator Heat Load

3.2.3 **Test Facility**

The current status of the Test Facility input data requirement are indicated on the Table 4, the values have been assessed by the Project Team according to:

- Facility Description of CDR (ref. [3])
- Standard engineer practice.
- Heat loads scheme Figure 3-2(Ref [7])
- Test Facility Utility Room DDD III (Ref. [7])

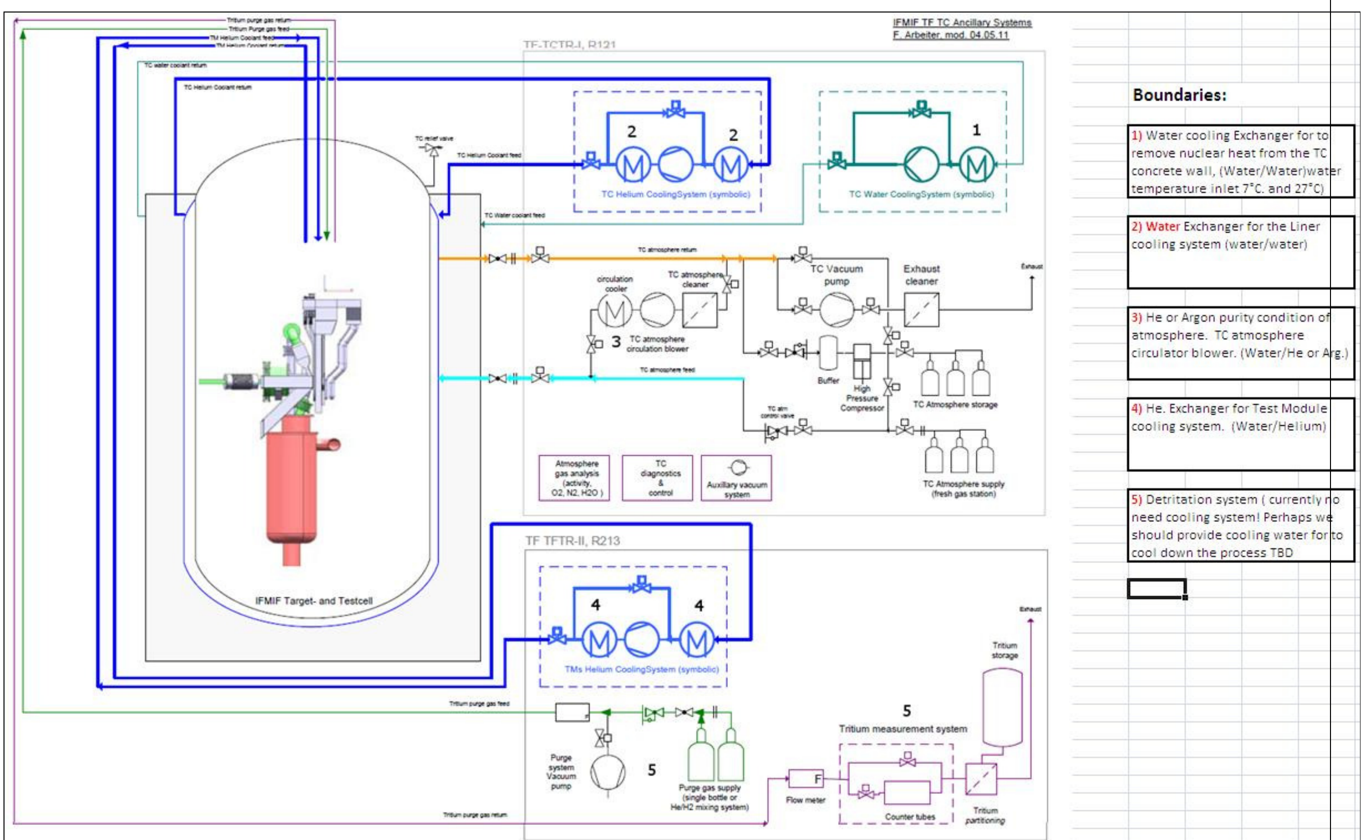


Figure 3-2: TF Cooling scheme

Test Facility Input Data Requirements (HRS)												
					Prymary loop			Secondary Water loops				
Item	Cooling system	Reference (KIT scheme)	Unitary Heat Load	Quantity	To Load	From Load	Type of fluid or gases	To Load	From Load	Type of fluid or gases	Heat Load	Water Flow Rate
1	**Test Cell . Concrete shielding** , Water cooling system (to remove from the concrete nuclear heat generated) **HX 1**	**KIT - DDD I (1) Attachment 2**	360 kW	1	40°C	80°C	Water	7°C	12°C	Cooled water	360 kW	62 m^3/h
2	**Test Cell . Concrete shielding** , Water cooling system (to remove from the concrete nuclear heat generated) **HX 2 (use 0,00274)**	**KIT - DDD I (1) Attachment 2**	360 kW	1	40°C	80°C	Water	27°C	37°C	Cooled water	360 kW	31 m^3/h
3	**Test Cell . Concrete shielding** , Water cooling system (to remove from the concrete nuclear heat generated) **HX 3 (use 0,0137)**	**KIT - DDD I (1) Attachment 2**	30 kW	1	40°C	80°C	Water	27°C	37°C	Cooled water	30 kW	3 m^3/h
4	**Test C ell Liner** **Water** cooling system. Helium compressor (2 parallele machine)	**KIT - DDD I (2) Attachment 3**	175 kW	1			**Water**	27°C	37°C	Cooled water	175 kW	15 m^3/h
5	**Test C ell Liner** **Water** cooling system. **Precooling HX 1** (compressoion heat removal)	**KIT - DDD I (2) Attachment 3**	525 kW	1			**Water**	27°C	37°C	Cooled water	525 kW	45 m^3/h
6	**Test C ell. Liner** Helium cooling system. **Final cooler HX 2**	**KIT - DDD I (2) Attachment 3**	30 kW	**1**			**Water**	7°C	12°C	Chilled water	30 kW	5.2 m^3/h
7	Test C ell Liner **water** cooling system. **Emergency return cooler HX 3** (protect compressor for excess T1) use 0,0137	**KIT - DDD I (2) Attachment 3**	30 kW	**1**			**Water**	27°C	37°C	Cooled water	30 kW	2.6 m^3/h
8	**Test Cell atmosphere circulation blower** (Supply inert gas (Ar.) for a protective "curtain" to prevent ingress/accumulationof reactive gases inside TC, when the TC is opened to the AC. Supply of He when test cell is closed, after proper purge of all Ar. gas **(Circulation cooler 8+1)**	**KIT - DDD I (3) Attachment 1**	9 kW	1	30°C	25°C	Argon or helium	27°C	37°C	Cooed water	9 kW	1 m^3/h
9	**Test Module helium cooling system** (Helium compressor 5 parallele machines)	**KIT - DDD I (4) Attachment 4**	362 kW	1			Helium	27°C	37°C	Cooled water	362 kW	31 m^3/h
10	**Test Module helium cooling system (pre-cooler HX1** (compression heat removal)	**KIT - DDD I (4) Attachment 4**	954 kW	1			Helium	27°C	37°C	Cooled water	954 kW	82 m^3/h
11	**Test Module helium cooling system (control system)**	**KIT - DDD I (4) Attachment 4**	113 kW	1			Helium	27°C	37°C	Cooled water	113 kW	10 m^3/h
Discrepances between Conventional Facility and Tractebel: **Conventional Facility have to consider:** **To increase 185 KW heat loads for Chiller water.** **Reduce 808 kW heat loads for Cooled water**							**Discrepance**	→	**185 kW**	**Chilled water**	**390 kW**	**575 kW**
							Discrepance	→	**-807 kW**	**Cooled water**	**2558 kW**	**1751 kW**

Table 4: Input Data Requirement TF Heat Loads

3.2.4 **Post Irradiation Examination Facility (PIE)**

The current status of PIE Facility input data requirement are indicated on the Table 5: Input Data Requirement for PIE Facility Heat Loads. The values have been assessed by the Project Team according to:

- Facility Description of CDR (ref. [3])
- Standard engineer practice.

For the PIE facility a proper value was not available, since now PIE function requirements and layout arrangement (for optimization) is still under study, nevertheless an assumption have been made and the value of Heat load have been summarized on the Table 5: Input Data Requirement for PIE Facility Heat Loads. Represented on PDF ref. Figure 8-6: D-1223-011, Process Flow Diagram HRS (TF-LF-PIE-CF)

Input Data Requirements (HRS)										
Item	Component	References/assessment/assumptions	Heat load (max/MW)	Cooling media	Inlet temperature (°C)	Temperature tolerance (±°C)	ΔT (°C)	Supply water pressure (MPa [G])	Water pressure drop (MPa)	Coolant flow (m^3/h)
1	PIE cooling system	Heat Loads assumption	3.5	Cooled water	37.0°C		10°C	0.35MPa		0.3 m3/h
1	PIE cooling system	Assumption	0.2	Chilled water	7.0°C		5°C	0.35MPa		0.03 m3/h

Table 5: Input Data Requirement for PIE Facility Heat Loads.

3.2.5 **Conventional Facility (CF)**

The current status of Conventional Facility input data requirement are indicated on the Ref. Table 6: Input Data Requirement for Conventional Facility Heat Loads. These values have been assessed by the Project Team according to:

- Facility Description of CDR (ref. [3])
- Standard engineer practice.
- Heat loads scheme (Ref to Table 6: Input Data Requirement for Conventional Facility Heat Loads. and Figure 2-5: Conventional Facility HRS (Extracted from HRS-PDF D-1223-011)

HRS for CF is referred to the following systems:

- Exhaust Gas Detritiation System
- Service Gas System (Argon/Helium heat exchanger's cooling)
- Central Vacuum System

Input Data Requirements (HRS)											
Item	Component	References/assessment/ assumptions	Heat load (max/MW)	Cooling media	Inlet temperature (°C)	Temperature tolerance (±°C)	ΔT (°C)	Supply water pressure (MPa [G])	Water pressure drop (MPa)	Coolant flow (m^3/h)	Special requirements
1	Exhaust Gas Detritiation System**	- Water flows selected according to the Exhaust Gas Detritiation System design**	0.276 MW	Chilled Water	7.0°C		5°C	0.35MPa		Water Flows: VDS-1= 7.9 m^3/h VDS-2= 10.5 m^3/h EDS= 11.3 * 2=22.6 m^3/h HDS= 20.9 m^3/h GDS= 7.5 m^3/h TOTAL= 69.4 m^3/h	
2	Service Gas System	- Heat Load selected according to the Service Gas System (Ar Supply System) design.	0.05 MW	Chilled Water	7.0°C		5°C	0.35MPa		8.6 m3/h	
3	Central Vacuum System	- Coolant flow selected according to the Central Vacuum design	0.0111 MW	Cooled Water	37.0°C		10°C	0.35MPa		Water Flows/unit= 0.004 m^3/(min*unit) no. of units= 8 units TOTAL= 1.92 m^3/h	

Table 6: Input Data Requirement for Conventional Facility Heat Loads.

3.3 Safety Design Requirements

The general Safety approach for the design execution of HRS is based on the general Safety specification for the Engineering Design Activities of IFMIF

- The IFMIF's Safety objectives, principles and criteria.
- The Hazard evaluation techniques, to be implemented on the next design phase

The entire document is uploaded on DMS: Safety Specifications Ref. doc. BA_D_224X48 Ver.4.0 (cfr. Ref. [2]) and following updating. At the present time the Engineering Design for HRS follow the Safety approach mentioned on the guideline document, nevertheless it can be subject to some deviation or weaves according the final IFMIF site selection. As well as the safety authority could gives some further requirements.

3.4 Operation and Maintenance

Integrative maintenance plan is not yet described on this DDD , shall be defined clearly after having selected all the components for the HRS plant, preferable the maintenance plan shall be prepared by the suppliers, as well as regulatory maintenance requirements must be identified.

Minimum information required within the maintenance plan is listed below:

- Scheduled operation:
    - Controls
    - Checks
    - Adjustments
    - Calibrations
    - Overhauls
    - Replacements, etc.

Information provided from safety specification, Ref. doc. BA_D_224X48 Ver.4.0 (cfr. Ref. [2]) and of course will be implemented and identified as necessary by the supplier in order to ensure the best operation of the HRS system within its intended operational scenario.

- Critical unscheduled operations:
    - Replacements repair etc.

That may impact IFMIF availability and become essential to evaluate and to introduce an additional important support of recommended spare parts list, (provided by the suppliers) procedures, training, tools and test equipments, infrastructures.

The design of HRS shall accommodate long-term maintenance activities required to support IFMIF plant operation. For maintainability and inspectability, HRS system shall be designed in such a way that it can facilitate maintenance and, in case of failure, easy diagnostics safe repair or replacement and re-calibration. The HRS' maintenance must be an ongoing endeavor. Any lapses in regular maintenance can result in system degradation and obvious loss of efficiency which could arose to serious health issue.

Maintenance requirement for HRS system and equipments mast be conform to the maintenance period defined for the IFMIF plant (particularly for the facilities that are not reachable during operation period)

3.5 RAMI Requirements

RAMI Specifications guide documents Ref. to doc. 22HA3G from J. Arroyo Feb. 2012 (cfr. Ref.[10]) and the updating analysis from J.M. Arroyo showed availability of CF 98%, ref. BA_D_229V7H (cfr. Ref. [9]). The HRS system have been designed to operate during all modes of IFMIF plant operation as well as shut down period HRS should be reliable for continuous operation, easily accessible for the purpose of operation and maintenance. Detailed RAMI analysis devoted to HRS has been performed by Tractebel (cfr. Ref. [11]) the results are here below described, the same values of 98% availability for the general CF system have been archived.

The HRS model is structured following the HRS system functions, the CF HRS model is based on the P&IDs D-1225-011 to D-1225-020.

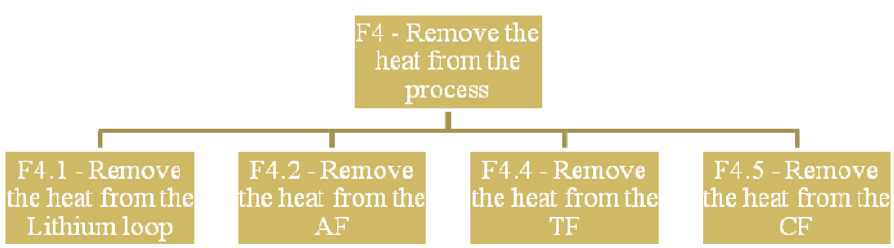


Table 7: List of Functions

Function ID	Function	Criticality group
4	Remove the heat from the process	
4.1	Remove the heat from Lithium Loop	
4.1.1	Remove the heat form the Li vacuum system	T2
4.1.2	Remove the heat form the Li tertiary Hx	T2
4.2	Remove the heat from the Accelerator Facility	
4.2.1	Remove the heat from the AF HE compressor	A5
4.2.10	Remove the heat from AF1 RFQ	A2
4.2.11	Remove the heat from AF2 RFQ	A2
4.2.16	Remove the heat from AF1 MEBT (buncher) SC-HWR linac	A2
4.2.17	Remove the heat from AF2 MEBT (buncher) SC-HWR linac	A2
4.2.18	Remove the heat from AF1 beam dump + scrapers	A2
4.2.19	Remove the heat from AF2 beam dump + scrapers	A2
4.2.2	Remove the heat from the RF chains + HVPS (Accelerator 1)	A1
4.2.20	Remove the heat from AF1 HEBT, BTR, RIR	A2
4.2.21	Remove the heat from AF2 HEBT, BTR, RIR	A2
4.2.22	Remove the heat from AF1 vacuum system	A2

4.2.23	Remove the heat from AF2 vacuum system	A2
4.2.3	Remove the heat from the RF chains + HVPS (Accelerator 2)	A1
4.2.4	Remove the heat from (Acc 1): Cold Box/HEBT LVPS injector PFQ cryo compressor HEBT compressor	A2
4.2.5	Remove the heat from (Acc 2): Cold Box/HEBT LVPS injector PFQ cryo compressor HEBT compressor	A2
4.2.6	Remove the heat form AF1 injector LEBT	A2
4.2.7	Remove the heat form AF2 injector LEBT	A2
4.2.8	Remove the heat from AF1 MEBT/HEBT Q poles/triplet	A2
4.2.9	Remove the heat from AF2 MEBT/HEBT Q poles/triplet	A2
4.4	Remove heat from Test facility	
4.4.1	Remove heat from TF: test cell concrete shilding HX2	E5
4.4.10	Remove heat from TF: test cell liner water cooling system HX2	E1
4.4.11	Remove heat from TF: test cell concrete shielding HX1	E1
4.4.2	Remove heat from TF: test cell concrete shilding HX3	E5
4.4.3	Remove heat from TF: test cell liner water cooling system (HX1)	E5
4.4.4	Remove heat from TF:test cell liner water cooling system (HX3)	E5

4.4.5	Remove heat from TF: test cell liner HE cooling system (compressor)	E5
4.4.6	Remove heat from TF: test cell atmosphere circulation blower	E5
4.4.7	Remove heat from TF: test module liner HE cooling system (HX1)	E5
4.4.8	Remove heat from TF: test module HE cooling system (compressor)	E5
4.5	Remove heat from Conventional facility	
4.5.1	Remove heat from CF VDS	A2
4.5.4	Remove heat from CF GDS-V	A2

3.5.1 Recovery time

A recovery time of the IFMIF facility has been added to the MTTR of each HRS components. Logically, a recovery time should be associated to a loss of an HRS function. However, it is not possible to directly allocate a recovery time to a function in Risk spectrum. In the model, the recovery time associated with a function has been introduced in the MTTR of all the components that are used to fulfill the functions. In case a component is used in different HRS functions with different associated recovery times, the longest time is used. The component recovery time considered is coded in its name.

3.5.2 Specific model assumptions

The generic model assumptions are discussed in the folio 0 of this note. The additional assumptions specific to the HRS model are hereunder listed:

- For every HRS cooling loop, one cooling tower group is considered as a spare. At minimum two cooling towers must be unavailable in order to lose the heat removal function.
- The distance between the cooling towers and the client facility is considered as ~200m of piping.
- Some valves were assumed pneumatic: the valves at outlet of the cooling tower, and the valves at the interface between the CF HRS and the "client" facility or system.
- For the manual valves, only the leakage failure mode has been considered. An error of position configuration after maintenance or an erroneous actuation by an operator is not considered. The MTTR of such operator errors would also be very low.
- The check valves are not supposed to fail.

- If the MTTR of a component is lower than 5h, it is assumed that the inertia of the cooling system will limit the recovery time. The "short" recovery time is used in these cases (i.e. one category lower compared to the "long" recovery time). The 5h time threshold has been discussed with the designer during the FMECA session. The generic short/long thresholds defined in the folio 0 are consequently not applied for this HRS system.

3.5.3 Results

The availability results are described in the following table:

RiskSpectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability %
CHR-0-GENERAL	HRS	3.90E-02	96.1
CHR-4.1	HRS for LF	9.97E-03	99.003
CHR-4.2	HRS for AF	1.09E-02	98.91
CHR-4.4	HRS for TF	2.77E-02	97.23
CHR-4.5	HRS for CF	9.97E-03	99.003

The results related to the HRS functions 4.1, 4.2, 4.4 and 4.5 are informative since these functions are not independent.

With this first model, even the general CF availability requirement (98%) is not fulfilled.

This result is conservative since it does not consider the potential degraded case with one accelerator available and the other one unavailable; resulting in a 50% availability of IFMIF (0% availability is considered in case of failure of one AF). Since both AF are cooled by the same loops, most of the failure will lead to the loss of both AF. Analyzing the 50% availability degraded case will consequently not improve significantly the results.

3.5.4 Components and parameters susceptible to be problematic

From the minimal cut set list, it can be seen that the critical equipments are those required to fulfil the functions with a highest recovery time:

- Remove heat from the TF TC (liner, concrete shielding, …) - E5 (function identified as critical in FMECA)
- Remove heat from the TF TM (helium, …) - E5

- Remove the heat from the AF HE compressor - A5

The loss of these functions have been identified as critical for IFMIF recovery since the unavailability can cause damage to the TF or a heating up of the AF.

More than 70% of the HRS unavailability is generated by single event cut sets linked to these functions. The main single event cut sets are:

- The basic events associated with the 200m water pipes of the HRS loop that supports the above critical functions (FR = 9.84E-9 /h/m = 3.94E-6/h for ~400m of pipe)
- The motorized butterfly valves at the interface between the CF HRS and the supported facility or system (FR = 4E-6 /h).

The failure of one of these components that have a relative high failure rate will directly lead to a long period of unavailability due to the associated recovery time.

Based on the importance analysis results, it is obvious that the failure rate and mean down time of these components are critical for the availability calculation. A variation of these parameters will lead to a significant improvement or degradation of the availability. The reliability parameters of the cooling towers are also important with the advantage that there is a spare cooling tower in every HRS cooling loop.

These components should consequently be carefully designed to ensure a high availability of the HRS systems.

3.5.5 Sensitivity and Degraded cases

In order to assess the model and challenge some uncertainties, different sensitivity cases have been computed.

3.5.6 No recovery times

In order to assess the availability of the HRS as a stand-alone system, the FTA model was run after removing all IFMIF recovery times in the components' MTTR/MDT.

The availability results for the stand-alone system are given in the following table:

RiskSpectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability %
CHR-0-GENERAL	HRS	1.2E-03	99.88
CHR-4.1	HRS for LF	1.27E-04	99.99
CHR-4.2	HRS for AF	6.83E-04	99.93

CHR-4.4	HRS for TF	3.74E-04	99.96
CHR-4.5	HRS for CF	1.86E-04	99.98

3.5.7 Failure rate of critical components

As explained, the pipe and motorized valve failure rate is an important parameter in the model. In order to assess its sensitivity, two cases have been analyzed with some variation of the failure rate:

Failure rates of pipe multiplied by 10

Risk Spectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability %
CHR-0-GENERAL	HRS	2.06E-01	79.4

Failure rates of pipe divided by 10

Risk Spectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability %
CHR-0-GENERAL	HRS	2.24E-02	97.76

Failure rates of motorized valve multiplied by 10

Risk Spectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability %
CHR-0-GENERAL	HRS	1.63E-01	83.7

Failure rates of motorized valve divided by 10

Risk Spectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability %

CHR-0-GENERAL	HRS	3.41E-02	97.36

3.5.8 **TF Test Cell cooling loops success criteria**

There are six interfaces between the HRS and the test cell cooling system (3 for the concrete shielding and 3 for the liner cooling) corresponding to the different test cell heat exchangers. During the FMECA, it was not defined how many of these exchanger are required to ensure the TC cooling in normal operation. The first model described above assumes that every of these interfaces should be available to ensure sufficient cooling of the TC.

If we assume a 2 out of 3 redundancy of these cooling systems, meaning that the loss of one interface on 3 is acceptable, the availability figure becomes:

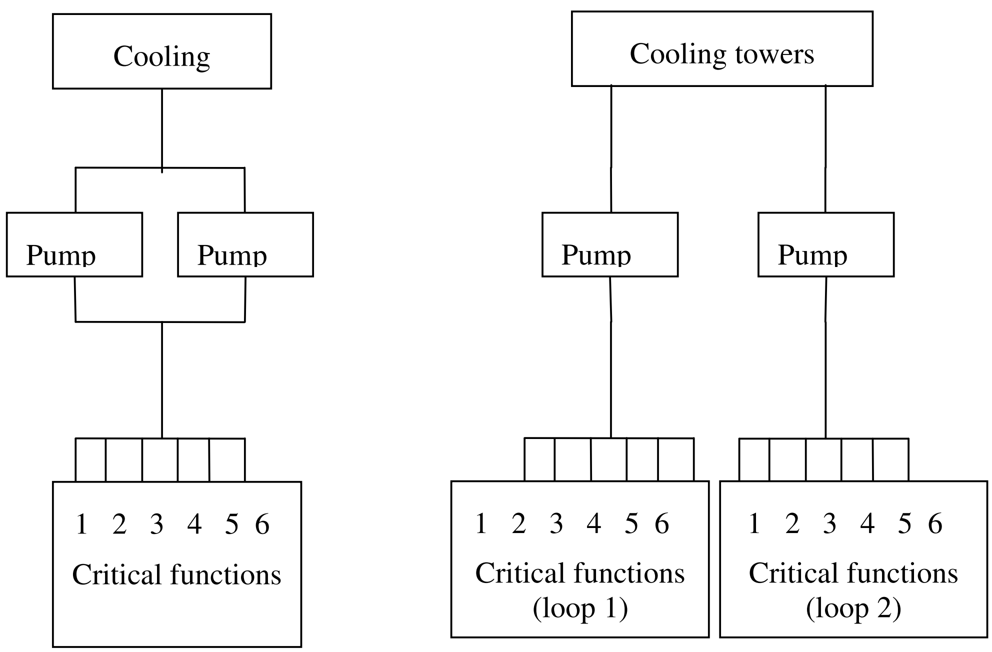
RiskSpectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability %
CHR-0-GENERAL_D-1	Remove heat (degraded case/ redundancy)	2.61E-02	**96.89**
CHR-4.1	HRS for LF	8.26E-03	99.003
CHR-4.2	HRS for AF	8.46E-03	98.91
CHR-4.4_D	Remove heat from TF degraded case/ redundancy	1.72E-02	**98.02**
CHR-4.5	HRS for CF	8.25E-03	99.003

3.5.9 **Redundancy of the cooling loops**

In the DDD II (Reference document for RAMI analysis) design, some components of a cooling loop are redundant (for example the circulation pumps or the chillers unit) but other components of the loop are not (for example the water pipes, the valves at the interface between the HRS and the other IFMIF facilities …).

In order to determine the availability improvement potential of more redundant cooling loops for the cooling of the critical functions, a case has been simulated in Risk spectrum that simulates two independent cooling loops for the critical functions. This case does not consider the previous sensitivity regarding the success criteria.

The figure below schematically shows the current design configuration for the TF concrete and liner cooling (P&IDs D-1225-011 and D-1225-012), and the redundant configuration model for this sensitivity analysis case. In the redundant case, the critical functions are cooled by two independent lines, excepted for the cooling towers. This model case corresponds to a situation where the critical equipment is cooled by two independent cooling loops. The interface between the HRS and the critical systems are consequently redundant.



Current design

Redundant design

Compared to the first results, the availability figure becomes:

	Description			Time Dependent Unavailability (TD Mean)	Availability %
CHR-0-GENERAL	HRS			1.13E-02	**98.57**
CHR-4.1	HRS for LF			8.26E-03	99.003
CHR-4.2	HRS for AF			8.46E-03	98.91
CHR-4.4 (redundant)	Remove heat from TF facility			2.45E-03	**99.681**
CHR-4.5	HRS for CF			8.25E-03	99.003

The increase of the HRS availability is significant. By applying the same design for the cooling loop to the AF Helium compressor (criticality = A5), the unavailability of the AF cooling could also decrease.

3.5.10 Applicable Codes and Standard Requirements

International standards have been selected for the design of the HRS in particular:

- The equipment for (HRS) shall be designed according to safety specification for the engineer design activities IFMIF ref. BA_D_224x48 (Le Tonqueze Y.[2]) in accordance with the pressure equipment directive (PED) 97/23Ec. and following the most restrictive directive adopted in EU and in Japan.
- Code and standards for HRS mechanical components shall follow the general IFMIF specification: Applicable Codes and standards for the CF design, in addition the following codes and standards shall be applied:
  - ASME/ANSI B16.34-Valves, flanges, threaded and welding end.
  - ASME B31.3- process piping.
  - ASME/ANSI B.16.25- Pipes, valves, fittings and flanges butt weld ends.
  - ISO 4427 and DIN 8074-HDPE pipes.
  - ASME B73.2M-Vertical in-line pumps.
  - CTI standard-Cooling Towers.
  - ASME section IX- welding and brazing qualification.
  - ASME section V- non destructive examination.

- API 510- testing of valves.
- EN 13445 – Pressurized Vessels design;
- EN 13480 – Metallic Piping;

4. System Design Description

4.1 Design Summary

For this section you can refer to the System Functions and Basic configuration (cfr. Sect. 0-1.1)

4.2 Safety

Refer to Safety specifications for the Engineering design Activities of IFMIF ref. doc. BA_D_224X48 Ver. 4.0 and following updating (cfr. Ref. [2])

4.3 Assumptions

4.3.1 Reference Outdoor Conditions

The design of a Heat Rejection System is related to the outdoor summer conditions that indeed have strong influence on the selection of the equipment to reject the removed heat in the environment (cooling towers)

The most constraining summer conditions were taken from ASHRAE Handbook (cfr. ref [1]):

- ✓Summer Dry Bulb Temperature: 30.2°C;
- ✓Summer Wet Bulb Temperature: 23.8°C;
- ✓Time during the year exceeding the above conditions: 0.4%

4.3.2 Equipment Margin

A safety margin for the HRS equipment has been assumed according to the standard engineering practice; generally, the design has to be assumed in order to allow some flexibility to the system.

In particular:

- ✓For pumps, margin takes into account the heat generated by the pumps themselves. This has been quantified in a +10% of the flow rate;
- ✓For heat exchange equipment, margin takes into account the partial clogging up of the heat exchange surfaces (pipes and/or plates). This has been quantified in a +10% of the exchanged heat.

4.3.3 Environment-Water Heat Exchangers Main Features

The main characteristics of the equipment designated to transfer heat from the cooling media to the environment have been selected according to the standard engineering practice and considering the reference outdoor conditions (cfr. Sect.4.3.1)

In particular main assumptions are referred to the:

- Equipment typology:
  - Open circuit Cooling Tower

- Equipment configuration:
  - Modular Layout of Cooling System (Cooling Towers in Parallel (cfr.Ref: **Error! Reference source not found.**) mainly divided into 4 (four) main loops as follows:

  a) Loop 1 Accelerator (components inside Vault) **Cooling Towers 1**, capacity 1.8 MW referred to the first phase only for 1 accelerator.

  b) Loop 2 for LF-TF-PIE-CF **Cooling Towers 2**, capacity 22.1 MW one phase only)

  c) Loop 3 for Accelerator's Beam Dump & scrapers and HEBT-BTR-RIR (risk of contamination) **Cooling Towers 3**, capacity of 2.0 MW referred to the first phase only, for 1 accelerator.

  d) Loop 4 for Accelerator auxiliaries (i.e. He. compressor, RF& HVRS and common skid) **Cooling Towers 4**, capacity of 10.0MW referred to phase one only, for 1 accelerator.

  e)

4.3.4 Water Chillers Main Features

The main characteristics of the equipment designated to supply chilled cooling media to the different components have been selected according to the standard engineering practice.

In particular main assumptions are referred to the:

- Equipment typology: Water Condensed Chillers.
- Chiller compressor type:
  - Centrifugal ≥700 kW
  - Reciprocal ≤500 kW

4.3.5 **Water/Water Heat Exchangers main characteristics**

The main characteristics of the equipment designated to transfer heat from one heat removal loop to another one has been selected according to the standard engineering practice.

In particular main assumptions are referred to the:

- Equipment typology;
  - Plate Heat Exchanger

4.3.6 **Accelerator Heat Removal Skids**

The different heat exchange stations that supply the Accelerator Facility has been selected following the same approach that is characteristic of the accelerator prototype.

In general, the current design considers that there are different heat removal skids for the different part of the accelerator. The main reasons of this choice are:

- to respect the differences in the cooling parameters of each accelerator component
- To isolate the potentially activated loops from the ones that do not present water activation hazard.

According to the above statements, the following skids have been considered:

- RFQ Chilling skid: Radio Frequency Quadrupole (this needs a very precise supply temperature and accuracy);
- RF & He C. &Auxiliaries cooling skid: RF Chains and all the auxiliaries located outside the vault;
- In Vault Equipment Cooling skid: all the equipment located inside the vault that doesn't need a precise water temperature and/or accuracy;
- Beam Dump and HEBT Cooling skid: Separate skids for High risk of contamination.

4.3.7 **SIC Classification**

According to the classification proposed in Safety Specifications (cfr. ref [2]) and Safety Important Class-SIC, Methodology, Classification & Requirements (cfr. Ref. to Doc. BA_D_228V5Q Version 1.2 ref [8]

The system has been classified as SR/ non- SIC

4.3.8 **Redundant Equipment**

Redundancy of the equipment should contribute to the target availability value of the Conventional Facilities stated into 98% (cfr. Ref.Tractebel report RAMI analysis 98%

ref, IFMIF/4NT/276784/000/01[11]). The following assumptions have been made based of RAMI analysis and the standard engineering practice.

Simple redundancy to components that can cover 100% of the requirements ;(100% × 2).

Multiple redundancy is considered when requirements can be fulfilled by a set of components (*n* components) working together ([100%/*n*] × [*n*+1]).

4.4 Detailed Design description

According to the classification proposed in CDR (cfr. Ref. [3]) a further HRS System subdivision has been proposed with slightly changes to meet the safety regulations and system flexibility:

The HRS has been selected into two main category of cooling tower's Loops:

- **Potential risk of water contamination**
  - **Beam Dump scrapers cooling skid, HEBT-BTR-BTR-RIR cooling skid**. For these cooling skid and intermediate Heat exchanger was necessary in order to avoid the possibility of water cooling contamination due to accidental leakages (due to foreseen height activation of these primary cooling water loop) Intermediate heat exchanger will act as effective new safety barrier to prevent such situation of water contamination.(see drawing Figure 8-9: D-1223-D-014- Process Flow Diagram HRS (Accelerator facility) 4/4)
  - **Lithium Facility**, Tertiary water exchanger. This exchanger is not part of the HRS, HRS have the interface point to the inlet out let valves of the heat exchanger (Tertiary Heat Exchanger), nevertheless the contamination protection is ensured since the tertiary heat exchanger for the cooling Lithium loop use water as coolant fluid into close circuit and the heat is extracted from the oil loop which in turn the oil extract heat from liquid metal Lithium by means of another heat exchanger Ref. to Figure 8-6: D-1223-011, Process Flow Diagram HRS (TF-LF-PIE-CF)) and the Figure 3-1: Input data requirements for LF Heat Loads
- **Low risk of water contamination**
  - Accelerator's components cooling skids Inside the vault: Injector, RFQ, MEBT (Bunchers) SRF Linac antennas and Accelerator's components cooling skids outside the vault: Helium compressors, RF chain &HVPS, Cold box, Injector's LVPS, HEBT, LVPS, RFQ and HEBT Cryo compressors, Vacuum system, Ref. Figure 8-8: D-1223-D-013-Process Flow Diagram HRS (Accelerator Facility) 3/4 and Figure 8-7: D-123-012- Process Flow Diagram HRS (Accelerator Facility) 2/4

4.5 System Performance Requirements

Not applicable at this engineering stage, anyhow the system performance basic functions are indicated on the P&ID's of HRS designs Ref:

- Figure 8-10: D-1225-011- P&ID HRS 1/10
- Figure 8-11: D-1225-012-P&ID HRS 2/10
- Figure 8-12: D-1225-013-P&ID HRS 3/10
- Figure 8-13: D-1225-014-P&ID HRS 4/10
- Figure 8-14: D-1225-015- P&ID HRS 5/10
- Figure 8-15: D-1225-016- P&ID HRS 6/10
- Figure 8-16: D-1225-017-P&ID HRS 7/10
- Figure 8-17: D-1225-018-P&ID HRS 8/10
- Figure 8-18: D-1225-019-P&ID HRS 9/10
- Figure 8-19: D-1225-020 P&ID HRS 10/10

4.6 System Arrangement

4.6.1 Equipment arrangement Drawings

Refer to the next (Ref. Sect.4.7) Component Design Description

4.7 Component Design Description

For this purpose we have detailed the list of the HRS components necessary for the all HRS system of IFMIF plant, the information are integrated on the document called Equipment List HRS system referred to PBS 5.3.3.3 Ref. Table 11: S-1224-001- HRS Equipment List. The Equipment List represents all the HRS components, on the list following detailed information are provided:

- Item NO
- Service
- QTY
- Material type
- Type of component
- Specification
- Main Dimension
- Electrical output rate (kW)
- Location on the IFMIF Building (Area/room's number)

4.8 Instrumentation and Control

HRS Central Control System (CCS) shall be conforming to standards, specifications and interfaces as documented in the CC&CI – DDD document ref. BA_D_23RU2B.

CC&CI will ensure the integrated supervision control of overall IFMIF plant and plant system operation. These functions will be available in master control room HRS shall have its own plant control system (PCS) (MPS) machine protection system that shall integrate the individuals control system of each of the HRS subsystems.

Information from the data is available in the HRS local control system (MPS) shall be transferred to CC&CI to allow a complete and reliable operation of the HRS. The instrumentation and control components shall include all Computers hardware and software required to control the HRS plant system, including input/output (I/O) interfaces and plant system interlocks. These requirements shall be established based on the preliminary design of the HRS. Sufficient instruments shall be included in HRS plant system to monitor components performance within the design envelope and to alarm plant operators on the onset of operation outside design margin (particularly for the water leakages detection and water quality conditions). Instrumentations shall include pressure and temperature flow sensor to measure/monitor performance and allow independent control of components for the system. Also, instruments shall be installed to monitor water chemistry, temperature of blow down and the Cooling Tower basin, the instrumentations indicated is descriptive but not limited, specific instrumentations and control requirements for HRS system shall be established on due course. We can refer to the HRS P&ID (Ref. documents D-1225- 011 to 019 Figures: 6:10 to 6:19)

4.9 Status of R&D activities and future plans

Not applicable for this system.

5. List of references

5.1 References

[1] *2009 ASHRAE Handbook Fundamental*s
[2] Y. Le Tonqueze, *Safety Specifications for the EDA of IFMIF*, BA_D_224X48
[3] IEA, *IFMIF Comprehensive Design Report*
[4] Accelerator System Group, Ref. BA_D_22NF7C v1.0
[5] G. Pruneri Heat Loads Input data In Vault components.
[6] G. Pruneri /Pierre-Yves Beauvais: Accelerator Heat Rejection System Scheme
[7] F.Arbeiter Test Facility Utility Room DDD doc. BA_D_22BWBP rev. 4.0
[8] Y. Le Tonqueze, Safety Important Class-SIC Ref. BA_D_228V5Q rev. 1.2
[9] .M. Arroyo, Availability of CF is 98%, ref. BA_D_229V7H
[10] RAMI Specifications guide documents Ref. to doc. 22HA3G from J.M. Arroyo Feb. 2012
[11] Tractebel report RAMI analysis 98% ref, IFMIF/4NT/276784/000/01
[12] HRS Heat mass balance of Heat removal (Extracted from DDD III, IFMIF LF Ref. BA_D_22QUE –v 1.1)

6. Appendices

6.1 List of Documents

6.1.1 Drawings (PFD's, P&ID's 2D drawings & Excel file)

6.1.2 Layout Plan for HRS

This section reports the preliminary HRS layout, main components outdoor Cooling Towers. The layout is divided by floor and is represented the overall dimensions of the HRS's piping and equipment. These layouts enable the Building designer to validate the size of the technical shafts, corridors, HRS's technical rooms and all the area where are foreseen heat exchangers and HRS component's installation.

These drawings together with CF piping layout should help to have a clear picture of the components that take part in the system definition and of the main interactions among them.
Layout Plan for HRS is considered as a preliminary document for the system design, could be slightly modified by an updating in the input data or IFMIF layout changes. Ref. to Figure 8-1: Overall View, outdoor cooling Tower main configuration.

6.1.3 HRS's Heat Loads scheme.

In the Figure 6-1 to 6-5 are shown the different configurations selected for each HRS based upon the engineering design have been developed.

6.1.4 Process Flow Diagram (PFD)

Ref to Figure 6-6 to 6-9

6.1.5 Equipment List HRS System

Identified on Table 11: S-1224-001- HRS Equipment List

6.1.6 HRS P&ID

The basic design for the major HRS components is identified on these drawings. The components have been checked and confirmed their dimensions based on the performance and availability on the HRS commercial market. The Basic design of HRS's Equipment layout is identified from (Figure 6-10 to 6-19) Figure 8-10, Figure 8-11**,** Figure 8-12**,** Figure 8-13**,** Figure 8-14**,** Figure 8-15**,** Figure 8-16**,** Figure 8-17**,** Figure 8-18 and Figure 8-19**.**

6.1.7 Equipment Layout, displaced on Conventional room.

These Figure 8-20, Figure 8-21, Figure 8-22, Figure 8-23, Figure 8-24, Figure 8-25, Figure 8-26 and Figure 8-27, show various components of HRS i.e. located in a different technical rooms of IFMIF plant, mainly Heat exchangers, pumps etc. that are also clearly identified by type on the List of Equipment and are belong to the HRS, some of them as part of the Detritiation system but still served by HRS System . (Ref.

to: Figure 8-20, Figure 8-21, Figure 8-22, Figure 8-23, Figure 8-24, Figure 8-25, Figure 8-26 and Figure 8-27.)

6.1.8 Layout Plan for main piping of Conventional Facility

(Ref. Figure 2-1, Figure 8-29, Figure 8-30, Figure 8-31)

6.2 List of Computer Programs

Not applicable

7. Others

Not applicable

8. Note, IFMIF configuration

The following tables Table 8, Table 9 and Table 10 are necessary to explain that the evolution of the FMIF design has brought to some changes on room characteristics and its layout configuration. In the following tables; 8-9 and 10 you can identify these changes that will have to be considered at the final construction engineering phase of IFMIF. Nevertheless the HRS concept configuration and preliminary calculation analysis included on this DDD are in line with the IFMIF HRS heat loads calculations and components allocation.

Changes not implemented in the report compared with Room Characteristic table and 3D CAD Model								
Floor	Room Number	Room Name	Changes					Reason
			Room Added	Room Deleted	Name change			
					From	To		
General Changes : √ New PIE Design based on HFTM only √ Access Cell shifted by 1.25m towards Accelerator √ Access Cell floor lowered by 2m √ TMHC floor lowered by 1m √ To elongate Accelerator Vault whole building elongated by 10m at back side								
B1F	R009	Lithium Trap Cell	√					Requirement from LF
B1F	R106ter	Pit for Electro Magnetic Pump	√					Requirement from LF
1F	C103	Corridor 103		√				Access to TIR only from one side
1F	ALC102-1	Air LockC102-1	√					Realization of airlock for corridor C102
1F	ALC102-2	Air LockC102-2	√					Realization of airlock for corridor C103
1F	R137	Maintenance Room for CHC			Hot cell utility room	Maintenance Room for CHC		Correction of mistake
1F	R138	Hot cell utility room			Maintenance Room for CHC	Hot cell utility room		Correction of mistake
1F	R141	Cooling/Storage Pit-1		√				Based on discussion and agreement at IPT Level
1F	R142	Cooling/Storage Pit-2		√				
1F	R143	Cooling/Storage Pit-3		√				
1F	AL163	Air Lock 163		√				New PIE Design
1F	R163	Glove Box Laboratory		√				
1F	AL163	Air Lock 163		√				
1F	R163	Glove Box Laboratory		√				
1F	R164	Glove box laboratory detritiation process room		√				
1F		Iron cells		√				
1F	R165	Iron Cell Maintenance zone		√				
1F	R166	Iron cells working zone		√				

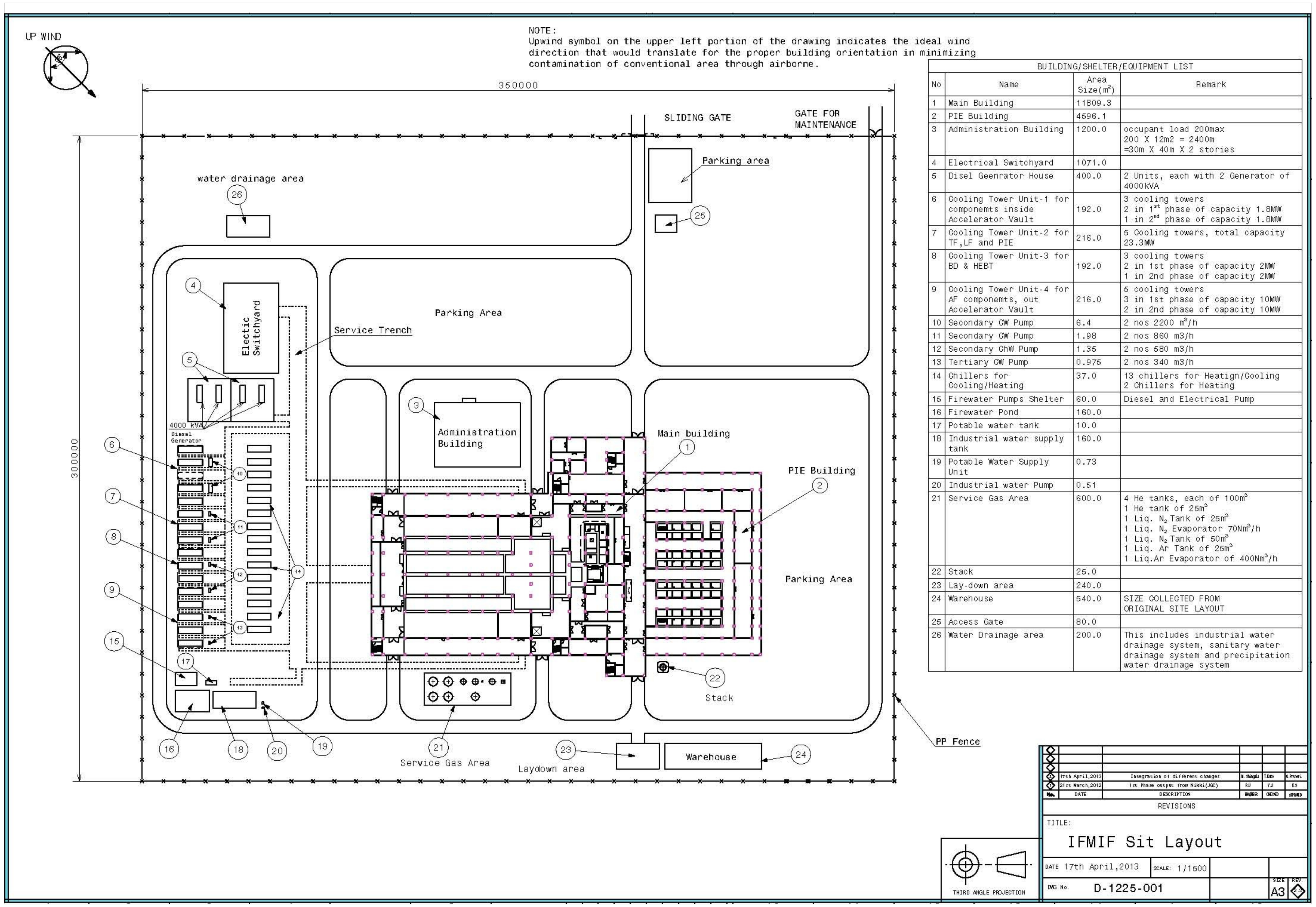
Table 8: List of changes, room’s characteristics

Changes not implemented in the report compared with Room Characteristic table and 3D CAD Model								
Floor	Room Number	Room Name	Changes					Reason
			Room Added	Room Deleted	Name change			
					From	To		
1F	AL166	Air Lock 166		√				New PIE Design
1F	R167	Conventional Hot Cell Laboratory working zone		√	Conventional Hot Cell Laboratory working zone	Hot Cell Laboratory working zone		
1F	AL167	Air Lock 167		√				
1F	R168	Conventional Hot Cell Laboratory Maintenance zone		√	Conventional Hot Cell Laboratory Maintenance zone	Hot Cell Laboratory Maintenance zone		
1F	R169	Conventional Hot cell Laboratory Detrition Process room		√	Conventional Hot cell Laboratory Detrition Process room	Hot cell Laboratory Detrition Process room		
1F	R170-1 ~R170-5	Conventional Hot Cell -1~-5		√				
1F	R171-1~R170-5	Conventional Hot Cell Maintenance cell-1~-5		√				
1F	R172	Tritium Laboratory Maintenance zone		√				
1F	R173	Tritium Laboratory working zone		√				
1F	AL173	Air Lock 173		√				
1F	R174	Tritium Laboratory Detrition Process Room		√				
1F	R176-1~R176-5	Tritium Hot cell-1~-5		√				
1F	R175-1~R175-5	Tritium Hot cell maintenance Cell-1~-5		√				
1F	R177	Electron microscope working zone		√				
1F	AL177	Air Lock 177		√				
1F	R178	Electron Microscope Maintenance Zone		√				
1F	R179	Electron Microscope Detritiation process room		√				

Table 9: List of changes, room's characteristics

Changes not implemented in the report compared with Room Characteristic table and 3D CAD Model								
Floor	Room Number	Room Name	Changes					Reason
			Room Added	Room Deleted	Name change			
					From	To		
1F	R180-1~R180-3	Electron Microscope Preparation Hot cell-1~-3		√				New PIE Design
1F	R181-1~R181-3	Electron Microscope Hot cell Maintenance Cell-1~-3		√				
1F	A1~A7	Hot Cell A1~Hot Cell A7	√					
1F	DC-A1~DC-A7	Decontamination Cell-A1~ Decontamination Cell- A7	√					
1F	B1~B7	Hot Cell B1~Hot Cell B7	√					
1F	DC-B1~DC-B7	Decontamination Cell-B1~ Decontamination Cell- B7	√					
1F	C1~C7	Hot Cell C1~Hot Cell C7	√					
1F	DC-C1~DC-C7	Decontamination Cell-C1~ Decontamination Cell- C7	√					
1F	D1~D6	Hot Cell D1~Hot Cell D6	√					
1F	DC-D1~DC-D6	Decontamination Cell-D1~ Decontamination Cell- D6	√					
2F	R201-A3-1	Corridor and Piping Space-1		√				RF power supply layout requirement
2F	R201-A3-2	Corridor and Piping Space-2		√				
2F	R225-A1	High Bay			R225	R225-A1		Addition of Hot Cell
2F	R225-A2	High Bay- Hot cell	√					
3F	R304	Ducting and Piping Space			Ducting and piping space-1 and Ducting and piping space-2	Ducting and Piping Space		Merged in one
3F	R109-A3-1	Cabling space-1		√				Merged with R109-A2-1 and R109-A2-2
3F	R109-A3-2	Cabling space-2		√				
3F	R310	Computer room			Control Room	Computer Room		Correction of mistake
3F	R313	No name			Computer room	No name		Correction of mistake

Table 10: List of changes, room's characteristics



BUILDING/SHELTER/EQUIPMENT LIST

No	Name	Area Size(m^2)	Remark
1	Main Building	11809.3	
2	PIE Building	4596.1	
3	Administration Building	1200.0	occupant load 200max 200 X 12m2 = 2400m =30m X 40m X 2 stories
4	Electrical Switchyard	1071.0	
5	Disel Geenrator House	400.0	2 Units, each with 2 Generator of 4000KVA
6	Cooling Tower Unit-1 for componemts inside Accelerator Vault	192.0	3 cooling towers 2 in 1st phase of capacity 1.8MW 1 in 2nd phase of capacity 1.8MW
7	Cooling Tower Unit-2 for TF,LF and PIE	216.0	5 Cooling towers, total capacity 23.3MW
8	Cooling Tower Unit-3 for BD & HEBT	192.0	3 cooling towers 2 in 1st phase of capacity 2MW 1 in 2nd phase of capacity 2MW
9	Cooling Tower Unit-4 for AF componemts, out Accelerator Vault	216.0	5 cooling towers 3 in 1st phase of capacity 10MW 2 in 2nd phase of capacity 10MW
10	Secondary CW Pump	6.4	2 nos 2200 m^3/h
11	Secondary CW Pump	1.98	2 nos 860 m3/h
12	Secondary ChW Pump	1.35	2 nos 580 m3/h
13	Tertiary CW Pump	0.975	2 nos 340 m3/h
14	Chillers for Cooling/Heating	37.0	13 chillers for Heatign/Cooling 2 Chillers for Heating
15	Firewater Pumps Shelter	60.0	Diesel and Electrical Pump
16	Firewater Pond	160.0	
17	Potable water tank	10.0	
18	Industrial water supply tank	160.0	
19	Potable Water Supply Unit	0.73	
20	Industrial water Pump	0.51	
21	Service Gas Area	600.0	4 He tanks, each of 100m^3 1 He tank of 25m^3 1 Liq. N_2 Tank of 25m^3 1 Liq. N_2 Evaporator 70Nm^3/h 1 Liq. N_2 Tank of 50m^3 1 Liq. Ar Tank of 25m^3 1 Liq.Ar Evaporator of 400Nm^3/h
22	Stack	25.0	
23	Lay-down area	240.0	
24	Warehouse	540.0	SIZE COLLECTED FROM ORIGINAL SITE LAYOUT
25	Access Gate	80.0	
26	Water Drainage area	200.0	This includes industrial water drainage system, sanitary water drainage system and precipitation water drainage system

Figure 8-1: Overall View, outdoor cooling Tower main configuration.

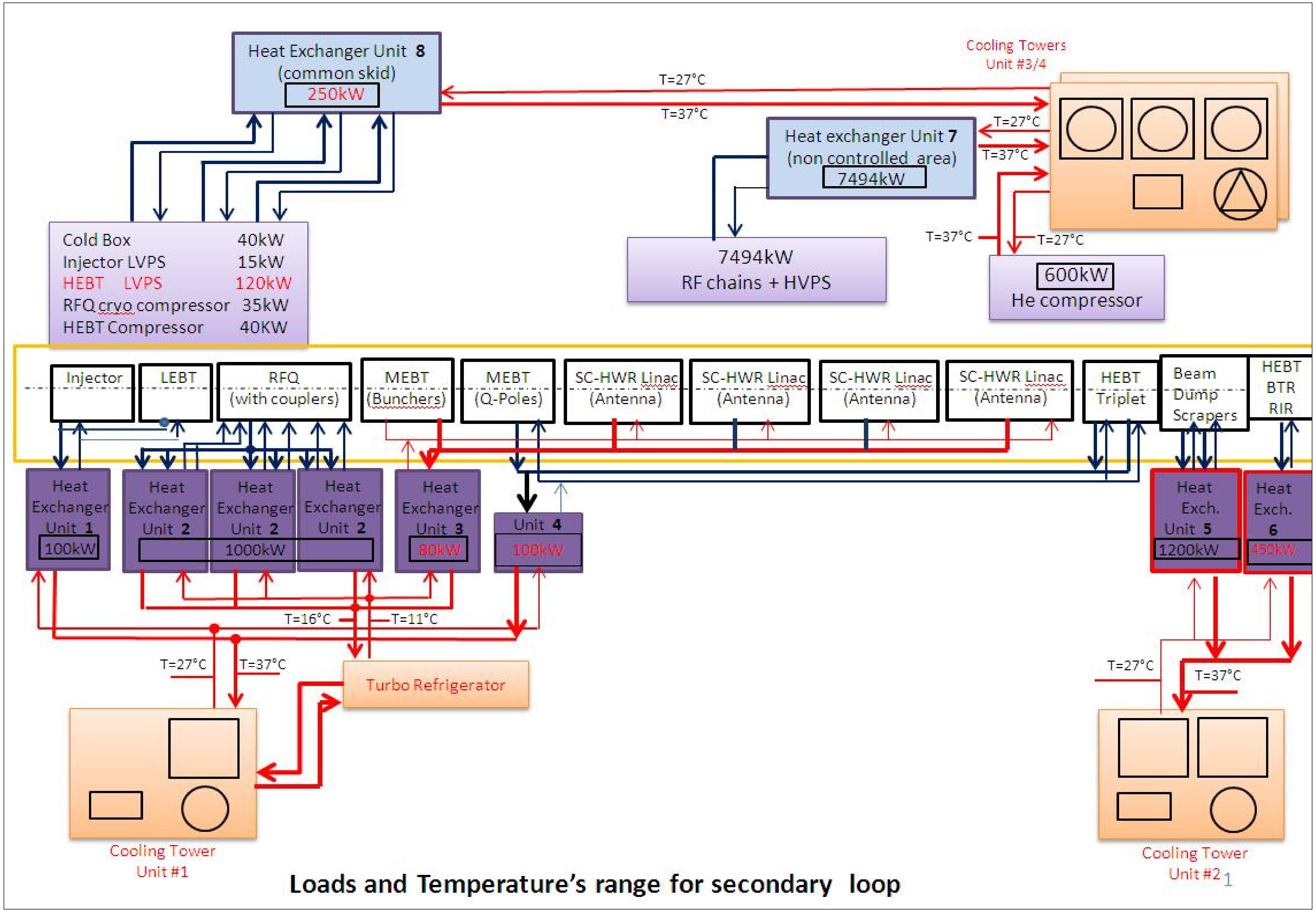


Figure 8-2: Accelerator's Heat Loads scheme.

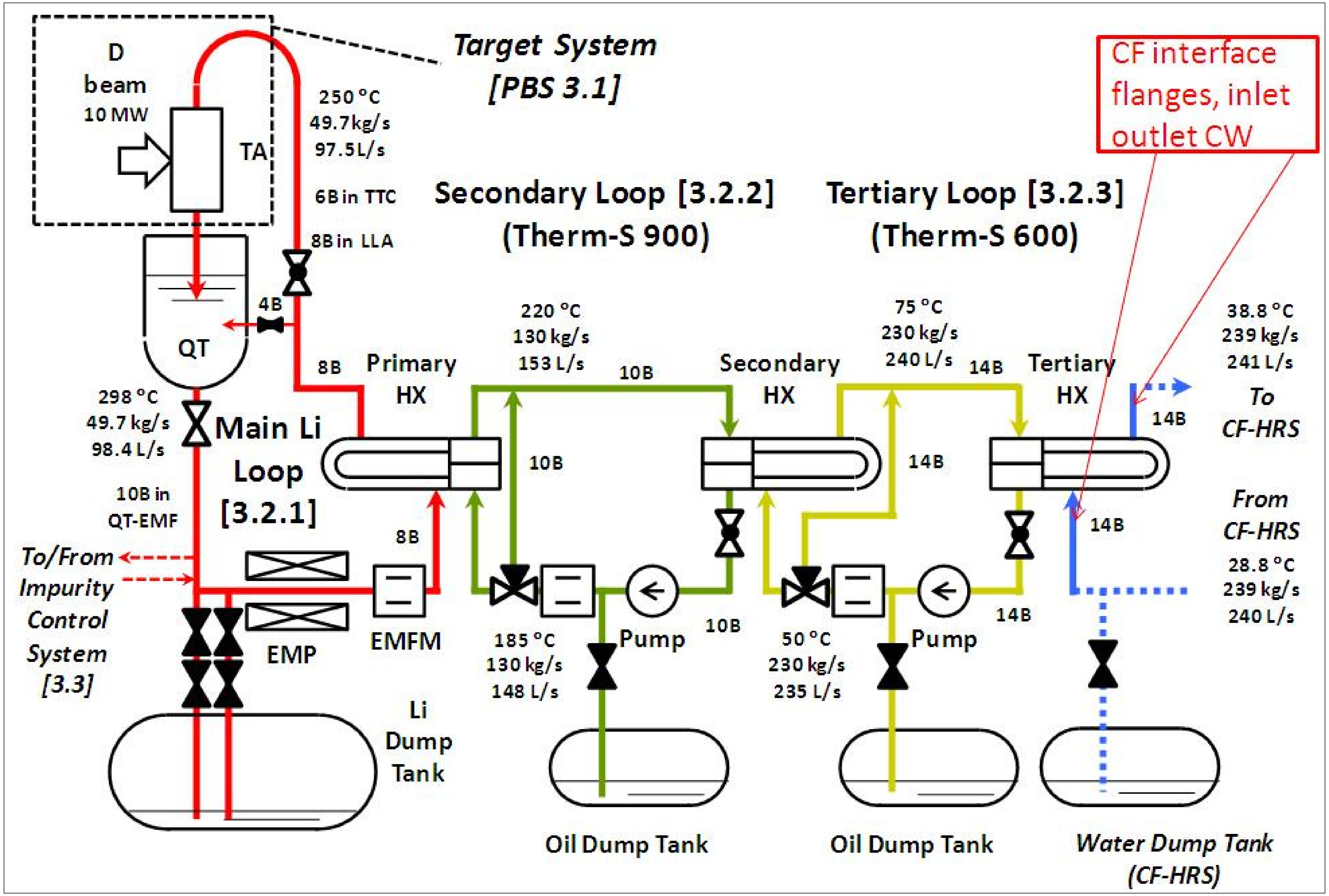


Figure 8-3: LF Flow Diagram of Heat Removal System.

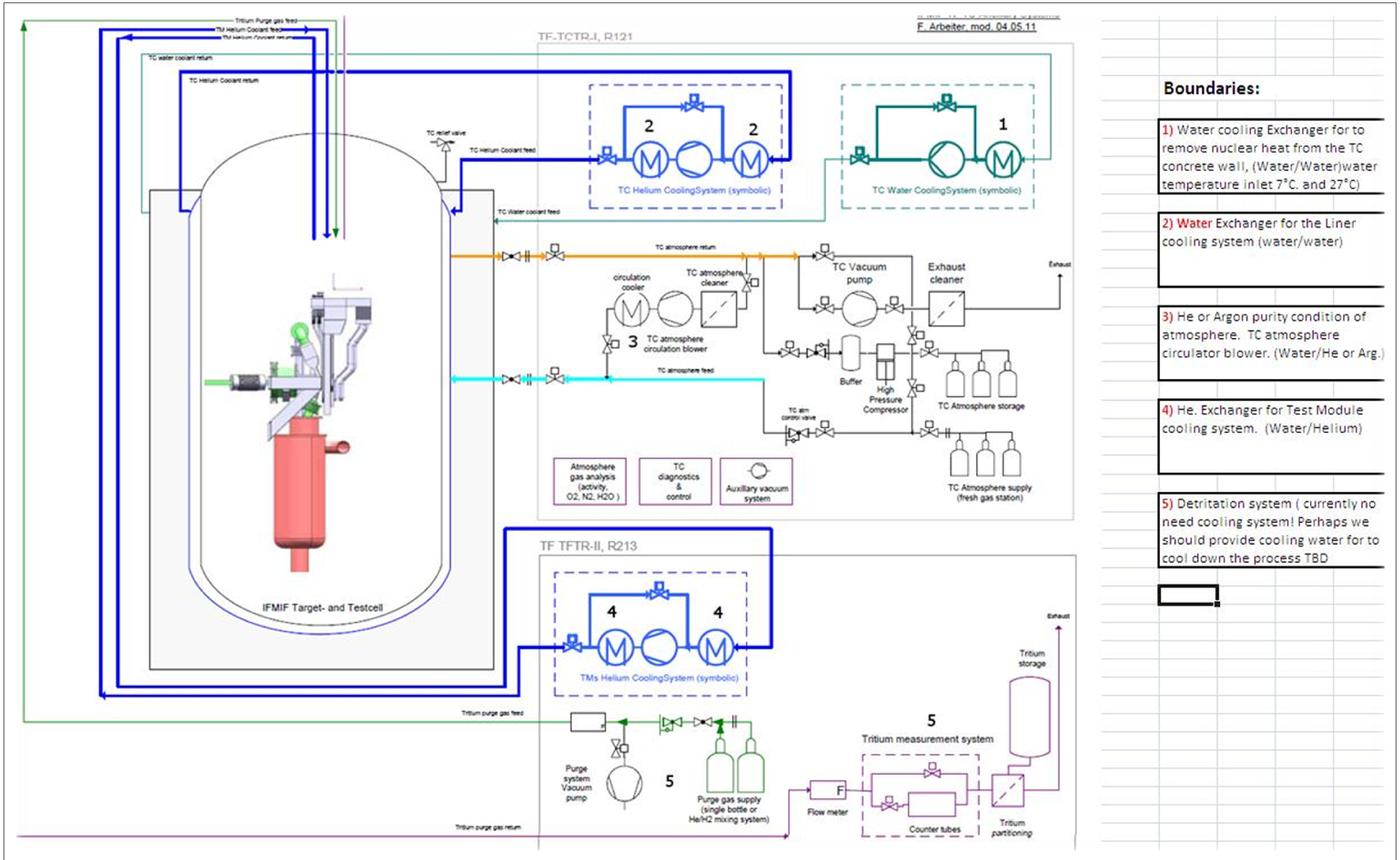


Figure 8-4: TF, HRS scheme.

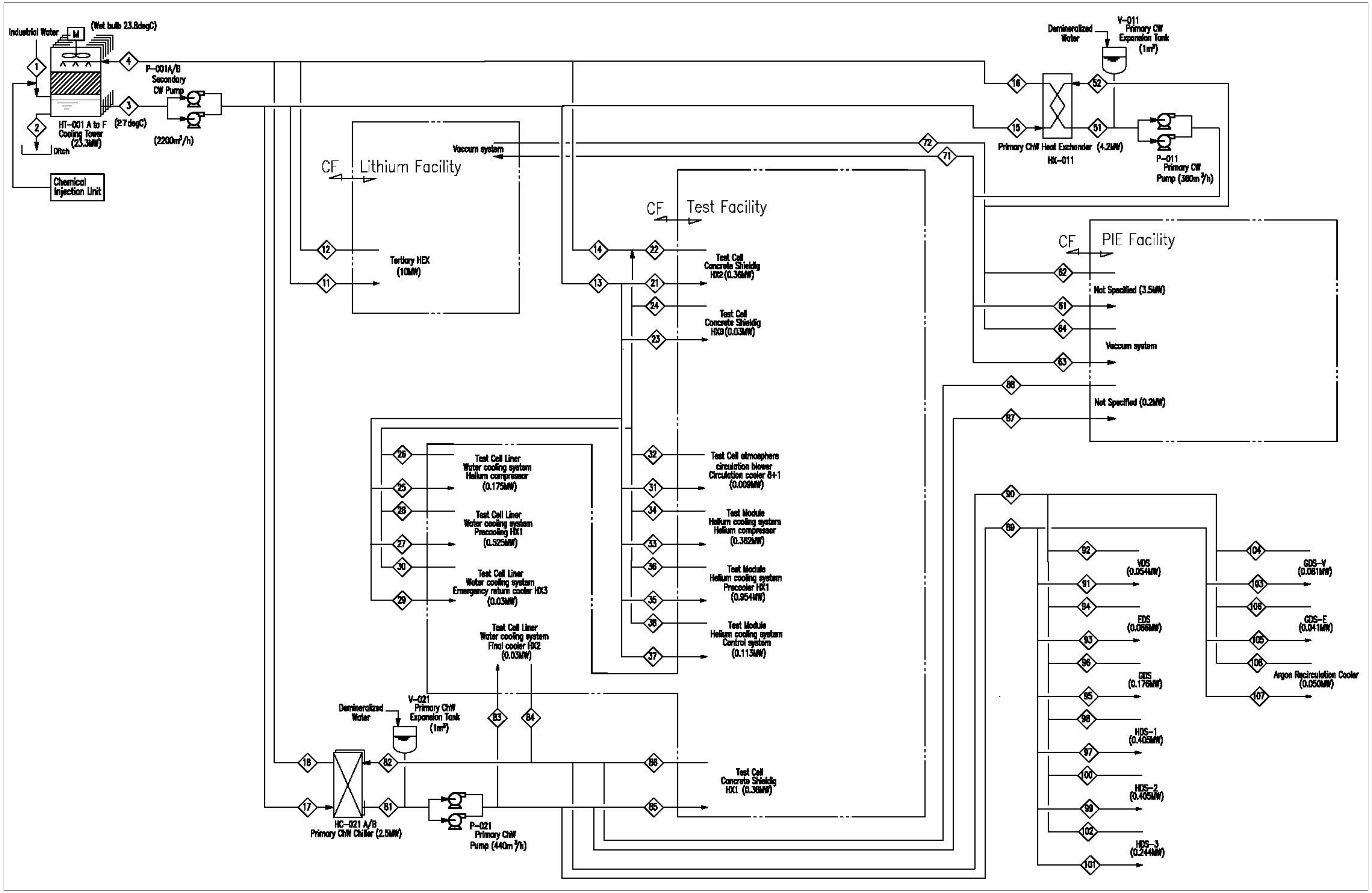


Figure 8-5: CF Heat Loads scheme

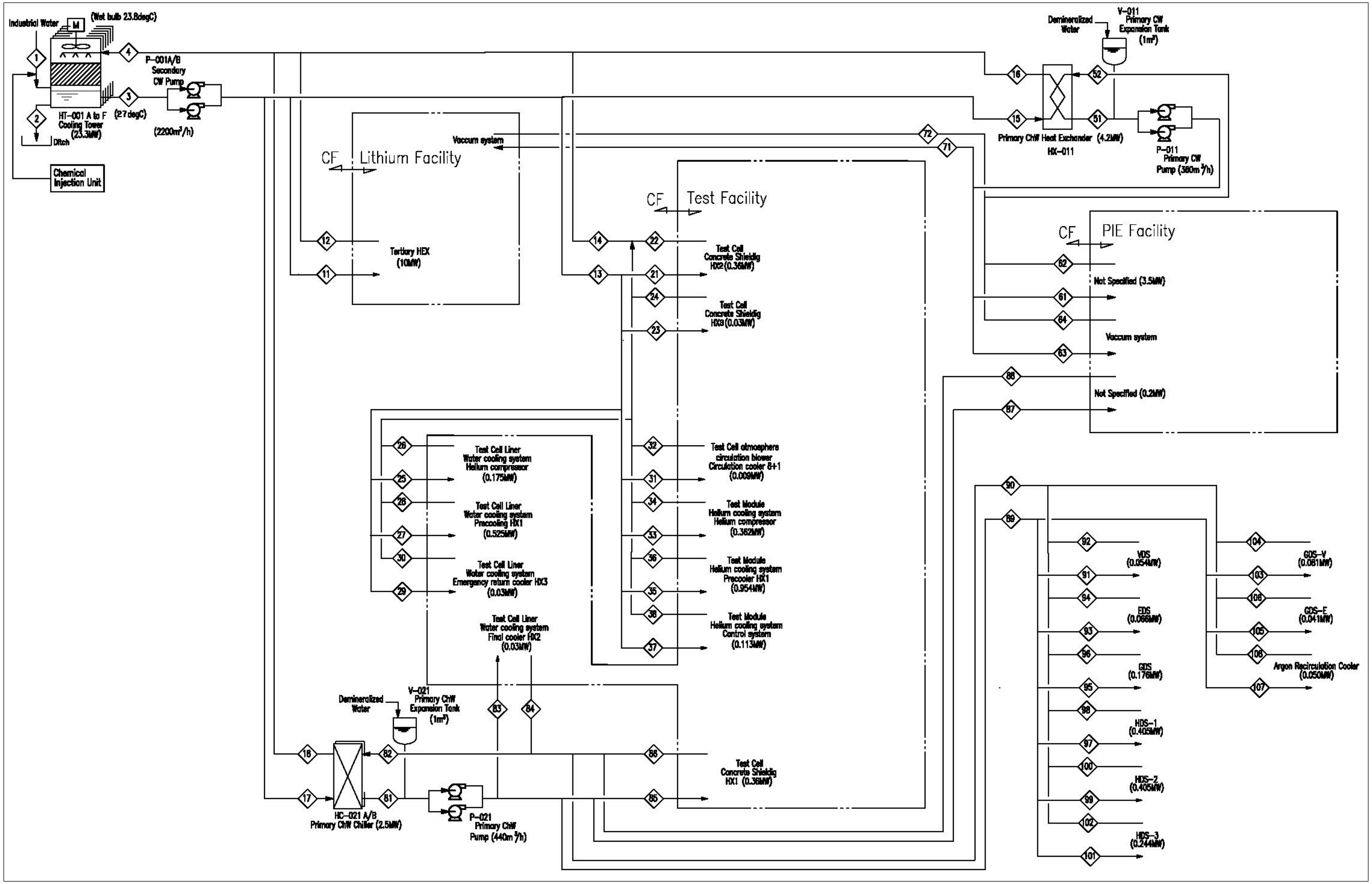
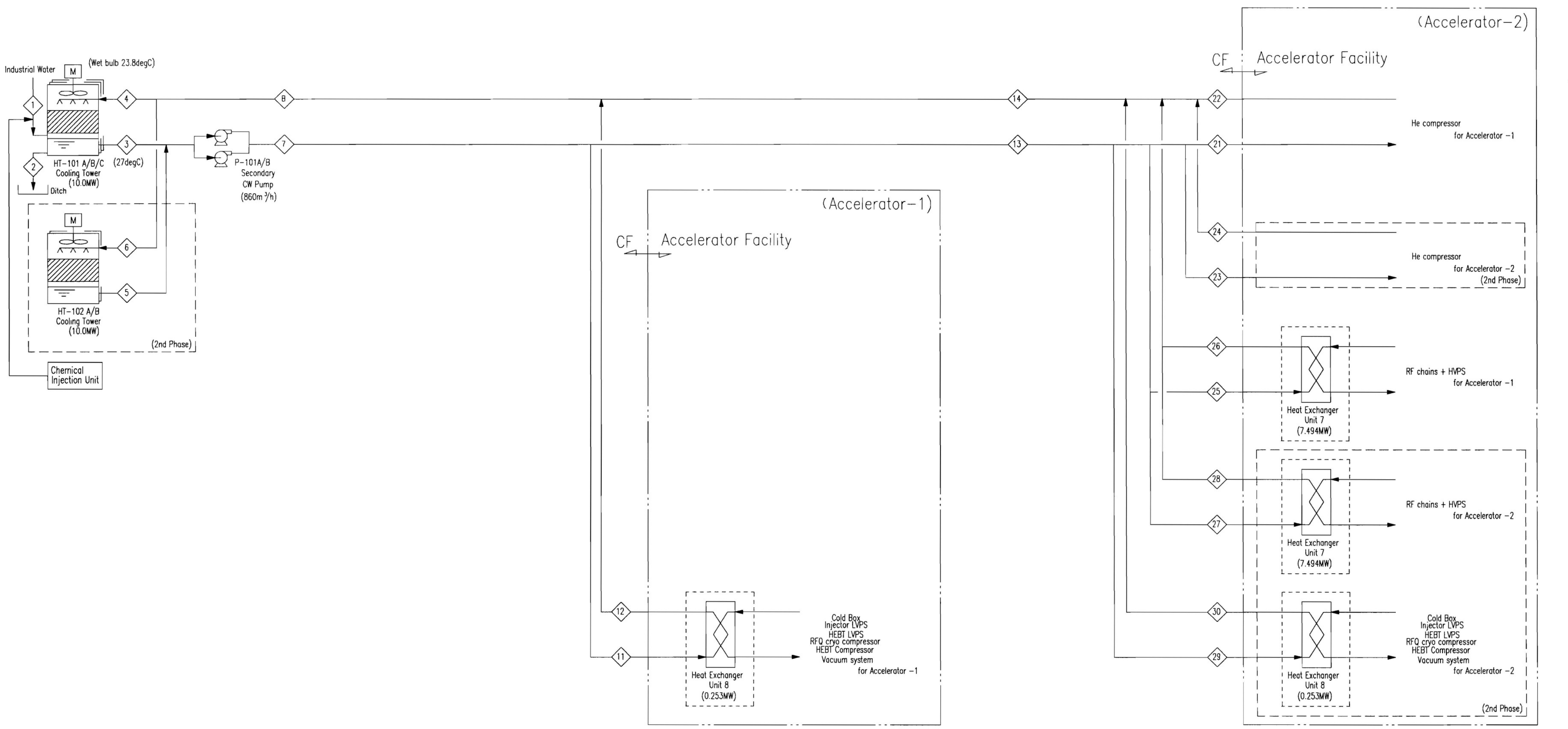


Figure 8-6: D-1223-011, Process Flow Diagram HRS (TF-LF-PIE-CF) 1/4(CT-2)



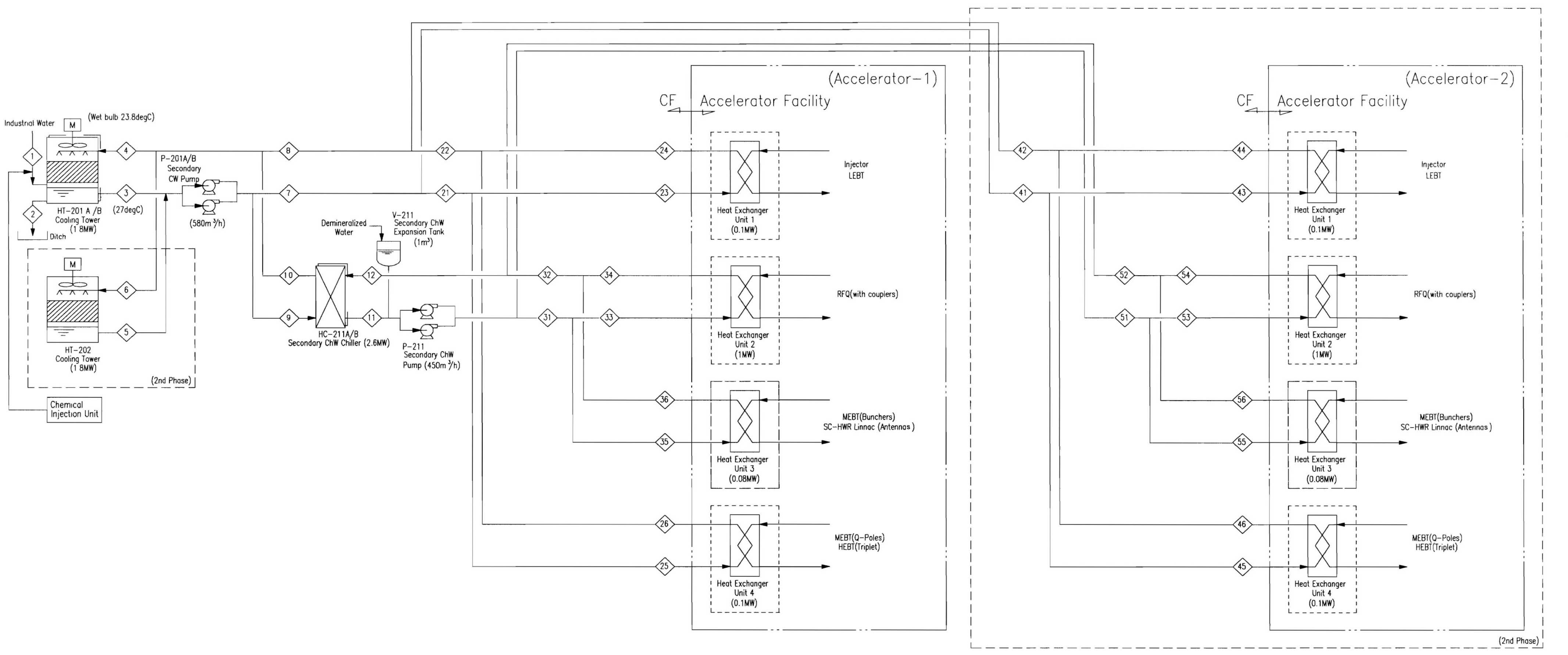
Flow Number		1	2	3	4	5	6	7	8
Fluid		Industrial Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water
Water Flow	m^3/h	33.0	8.2	718	718	718	718	1436	1436
Temperature	℃	AMB	27 *1	27	37	27	37	27	37
Pressure	MPa	–		0.5		0.5		0.5	
Remarks			Conc. Ratio 4 –	8.347 MW		8.347 MW		16.694 MW	

*1 Wey Bulb 23.8℃, Approach 3.2℃

Flow Number		11	12	13	14
Fluid		Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water
Water Flow	m^3/h	21.7	21.7	1413.9	1413.9
Temperature	℃	27	37	27	37
Pressure	MPa			0.5	
Remarks		0.253 MW		16.441 MW	

21	22	23	24	25	26	27	28	29	30
Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water
51.6	51.6	51.6	51.6	644.5	644.5	644.5	644.5	21.7	21.7
27	37	27	37	27	37	27	37	27	37
0.5		0.5				0		0	
0.6 MW		0.6 MW		7.494 MW		7.494 MW		0.253 MW	

Figure 8-7: D-123-012- Process Flow Diagram HRS (Accelerator Facility) 2/4 (CT 4)



Flow Number		1	2	3	4	5	6	7	8	9	10	11	12
Fluid		Industrial Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Chilled Water	Secondary Chilled Water
Water Flow	m^3/h	5.9	1.5	240	240	240	240	34	34	446	446	372	372
Temperature	℃	AMB	27 *1	27	32.4	27	32.4	27	37	27	32	11	16
Pressure	MPa	–		0.5		0.5		0.5		0.5		0.5	
Remarks			Conc. Ratio 4 –	1.496 MW		1.496 MW		0.4 MW		2.59 MW 5 *2		2.16 MW	

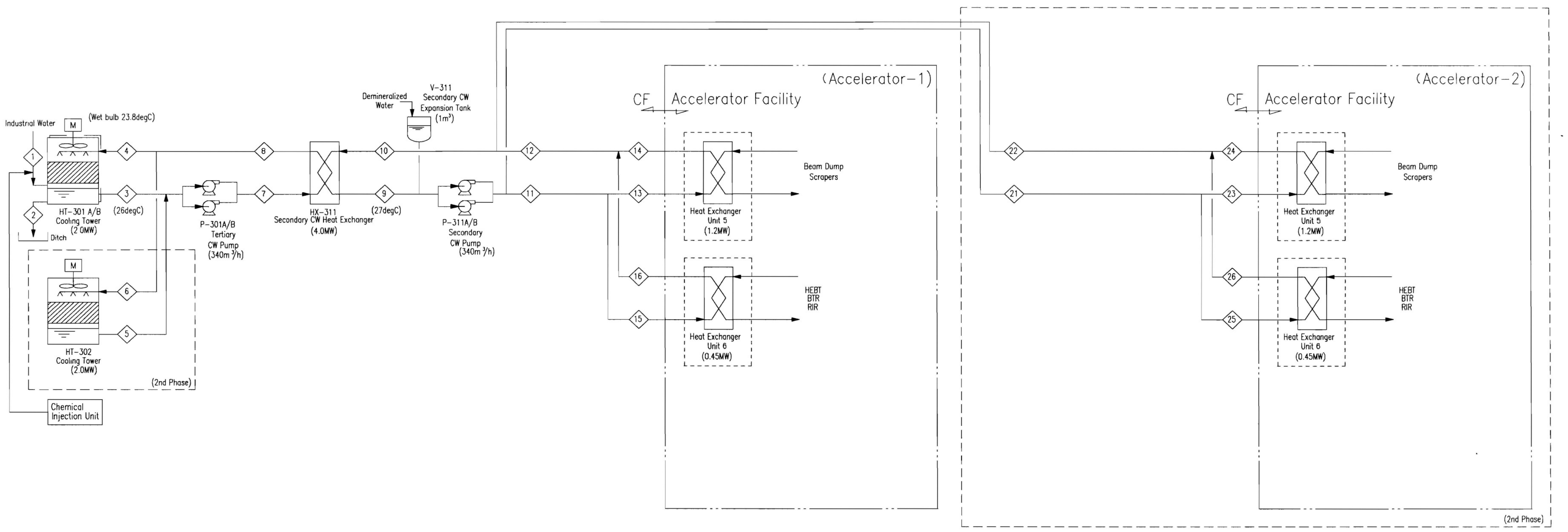
Flow Number		21	22	23	24	25	26
Fluid		Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water
Water Flow	m^3/h	17.2	17.2	8.6	8.6	8.6	8.6
Temperature	℃	27	37	27	37	27	37
Pressure	MPa	0.5		0.5			
Remarks		0.2 MW		0.1 MW		0 1 MW	

Flow Number		31	32	33	34	35	36	41	42	43	44	45	46
Fluid		Secondary Chilled Water	Secondary Chilled Water	Secondary Chilled Water	Secondary Chilled Water	Secondary Chilled Water	Secondary Chilled Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water
Water Flow	m^3/h	185.8	185.8	172.0	172.0	13.8	13.8	17.2	17.2	8.6	8 6	8 6	8 6
Temperature	℃	11	16	11	16	11	16	27	37	27	37	27	37
Pressure	MPa			0.5		0.5		0.5		0.5		0	
Remarks		1.08 MW		1 MW		0.08 MW		0.2 MW		0.1 MW		0 1 MW	

Flow Number		51	52	53	54	55	56
Fluid		Secondary Chilled Water	Secondary Chilled Water	Secondary Chilled Water	Secondary Chilled Water	Secondary Chilled Water	Secondary Chilled Water
Water Flow	m^3/h	185.8	185.8	172.0	172.0	13.8	13 8
Temperature	℃	372	16	11	16	11	16
Pressure	MPa	0		0.5		0.5	
Remarks		1.08 MW		1 MW		0.08 MW	

*1 Wey Bulb 23.8℃, Approach 3 2℃
*2 COP of chillers

Figure 8-8: D-1223-D-013-Process Flow Diagram HRS (Accelerator Facility) 3/4 (CT 1)



Flow Number		1	2	3	4	5	6	7	8	9	10
Fluid		Industrial Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water
Water Flow	m^3/h	6.5	1.6	142	142	142	142	284	284	284	284
Temperature	°C	AMB	26 *1	26	36	26	36	26	36	27	37
Pressure	MPa	–		0.5		0.5		0.5		0.5	
Remarks			Conc. Ratio 4 –	1.65 MW		1.65 MW		3.3 MW dT 1 °C		3.3 MW	

*1 Wey Bulb 23.8°C, Approach 3.2°C

Flow Number		11	12	13	14	15	16
Fluid		Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water
Water Flow	m^3/h	141.9	141.9	103.2	103.2	38.7	38.7
Temperature	°C	27	37	27	37	27	37
Pressure	MPa	0.5		0.5			
Remarks		1.65 MW		1.2 MW		0.45 MW	

21	22	23	24	25	26
Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water	Secondary Cooling Water
141.9	141.9	103.2	103.2	38.7	38.7
27	37	27	37	27	37
0.5		0.5		0	
1.65 MW		1.2 MW		0.45 MW	

Figure 8-9: D-1223-D-014- Process Flow Diagram HRS (Accelerator facility) 4/4 (CT 3)

Equipment List for **5.3.3.0.0.** 7333.333333

No.	ITEM No.	SERVICE	QTY	MAT'L	TYPE	SPECIFICATION	MAIN DEMENSION	RATED OUTPUT	ACCESSORIES	Installation ROOM No.	REMARKS
1	5. 3. 3. 0. 0. - HT - 001 A to E	Cooling Tower	5	Carbon Steel	Open	Exchanged heat quantity: 23.3MW Secondary CW Flow rate: 2200m3/h Temperature: 35.8→27℃ 20%X5+1	W11000XL3000XH5000	FAN 37kW x 3/Unit (400V)	-	Outdoor	Wet bulbe 23.8℃ BAC's VXT-1200
2	5. 3. 3. 0. 0. - P - 001 A/B	Secondary CW Pump	2	Carbon Steel	Centrifugal	2200m3/h, 50m, 100%X2	W1600XL4000XH1700	400kW (6.6kV)	-	Outdoor	-
3	5. 3. 3. 0. 0. - HX - 011	Primary CW Heat Exchanger	1	Stainless Steel	Plate	Exchanged heat quantity: 4.2MW Secondary CW Flow rate: 360m3/h Temperature: 27→37℃ Primary CW Flow rate: 360m3/h Temperature: 30→40℃ Area of heat transfer surface: 470m2	W780XL3900XH2300	-	-	R106-1	ALFA LAVAL's T20
4	5. 3. 3. 0. 0. - P - 011 A/B	Primary CW Pump	2	Stainless Steel	Centrifugal	440m3/h, 50m, 100%X2	W780XL1650XH1180	132kW (400V)	-	R106-1	-
5	5. 3. 3. 0. 0. - V - 011	Primary CW Expansion Tank	1	Stainless Steel	-	1m3	Φ1000XH2000 t6	-	-	R307	-
6	5. 3. 3. 0. 0. - HC - 021 A/B	Primary ChW Chiller	2	Cu, Carbon Steel	Centrifugal	Exchanged heat quantity: 2.5MW Secondary CW Flow rate: 520m3/h Temperature: 27→32℃ Primary ChW Flow rate: 440m3/h Temperature: 12→7℃ 100%X2	W2330XL4380XH2640	460kW (6.6kV)	-	R106-1	DAIKIN's HT800MB
7	5. 3. 3. 0. 0. - P - 021 A/B	Primary ChW Pump	2	Stainless Steel	Centrifugal	270m3/h, 50m, 100%X2	W750XL1400XH1000	90kW (400V)	-	R106-1	-
8	5. 3. 3. 0. 0. - V - 021	Primary ChW Expansion Tank	1	Stainless Steel	-	1m3	Φ1000XH2000 t6	-	-	R307	-
9	5. 3. 3. 0. 0. - HT - 101 A/B/C	Cooling Tower	3	Carbon Steel	Open	Exchanged heat quantity: 10.0MW Secondary CW Flow rate: 860m3/h Temperature: 37→27℃ 25%X2+1	W11000XL3000XH5000	FAN 37kW x 3/Unit (400V)	-		Wet bulbe 23.8℃ BAC's VXT-1200
10	5. 3. 3. 0. 0. - HT - 102 A/B	Cooling Tower (2nd Phase)	2	Carbon Steel	Open	Exchanged heat quantity: 10.0MW Secondary CW Flow rate: 860m3/h Temperature: 37→27℃ 25%X2	W11000XL3000XH5000	FAN 37kW x 3/Unit (400V)	-	Outdoor	Wet bulbe 23.8℃ BAC's VXT-1200
11	5. 3. 3. 0. 0. - P - 101 A/B	Secondary CW Pump	2	Carbon Steel	Centrifugal	860m3/h, 50m, 100%X2	W900XL2200XH1100	185kW (6.6kV)	-	Outdoor	-
12	5. 3. 3. 0. 0. - HT - 201 A/B	Cooling Tower	2	Carbon Steel	Open	Exchanged heat quantity: 1.8MW Secondary CW Flow rate: 290m3/h Temperature: 32.4→27℃ 50%X1+1	W5500XL3000XH5000	FAN 22kW x 2/Unit (400V)	-	Outdoor	Wet bulbe 23.8℃ BAC's VXT-560
13	5. 3. 3. 0. 0. - HT - 202	Cooling Tower (2nd Phase)	1	Carbon Steel	Open	Exchanged heat quantity: 1.8MW Secondary CW Flow rate: 290m3/h Temperature: 32.4→27℃ 50%X1	W5500XL3000XH5000	FAN 22kW x 2/Unit (400V)	-	Outdoor	Wet bulbe 23.8℃ BAC's VXT-560
14	5. 3. 3. 0. 0. - P - 201 A/B	Secondary CW Pump	2	Carbon Steel	Centrifugal	580m3/h, 50m, 100% X2	W750XL1800XH950 X2	110kW (400V)	-	Outdoor	-
15	5. 3. 3. 0. 0. - HC - 211 A/B	Secondary ChW Chiller	2	Cu, Carbon Steel	Centrifugal	Exchanged heat quantity: 2.6MW Secondary CW Flow rate: 540m3/h Temperature: 27→32℃ Secondary ChW Flow rate: 450m3/h Temperature: 11→16℃ 100%X2	W2330XL4380XH2640	460kW (6.6kV)	-	R106-1	DAIKIN's HT800MB
16	5. 3. 3. 0. 0. - P - 211 A/B	Secondary ChW Pump	2	Stainless Steel	Centrifugal	450m3/h, 50m, 100%X2	W700XL1600XH900	90kW (400V)	-	R106-1	-
17	5. 3. 3. 0. 0. - V - 211	Secondary ChW Expansion Tank	1	Stainless Steel	-	1m3	Φ1000XH2000 t6	-	-	R307	-
18	5. 3. 3. 0. 0. - HT - 301 A/B	Cooling Tower	2	Carbon Steel	Open	Exchanged heat quantity: 2.0MW Secondary CW Flow rate: 170m3/h Temperature: 36→26℃ 50%X1+1	W74000XL3000XH5000	FAN 37kW x 2/Unit (400V)	-	Outdoor	Wet bulbe 23.8℃ BAC's VXI-800
19	5. 3. 3. 0. 0. - HT - 302	Cooling Tower (2nd Phase)	1	Carbon Steel	Open	Exchanged heat quantity: 2.0MW Secondary CW Flow rate: 170m3/h Temperature: 36→26℃ 50%X1	W74000XL3000XH5000	FAN 37kW x 2/Unit (400V)	-	Outdoor	Wet bulbe 23.8℃ BAC's VXI-800
20	5. 3. 3. 0. 0. - P - 301 A/B	Tertiary CW Pump	2	Carbon Steel	Centrifugal	340m3/h, 50m, 100%X2	W650XL1500XH750	75kW (400V)	-	Outdoor	-
21	5. 3. 3. 0. 0. - HX - 311	Secondary CW Heat Exchanger	1	Stainless Steel	Plate	Exchanged heat quantity: 4.0MW Secondary CW Flow rate: 340m3/h Temperature: 26→36℃ Secondary CW Flow rate: 340m3/h Temperature: 37→27℃ Area of heat transfer surface: 1330m2	W1150XL5200XH3100	-	-	R106-1	ALFA LAVAL's M30
22	5. 3. 3. 0. 0. - P - 311 A/B	Secondary CW Pump	2	Stainless Steel	Centrifugal	340m3/h, 30m, 100%X2	W800XL1400XH1200	75kW (400V)	-	R106-1	-
23	5. 3. 3. 0. 0. - V - 311	Secondary CW Expansion Tank	1	Stainless Steel	-	1m3	Φ1000XH2000 t6	-	-	R307	-
24											
25											

Table 11: S-1224-001- HRS Equipment List

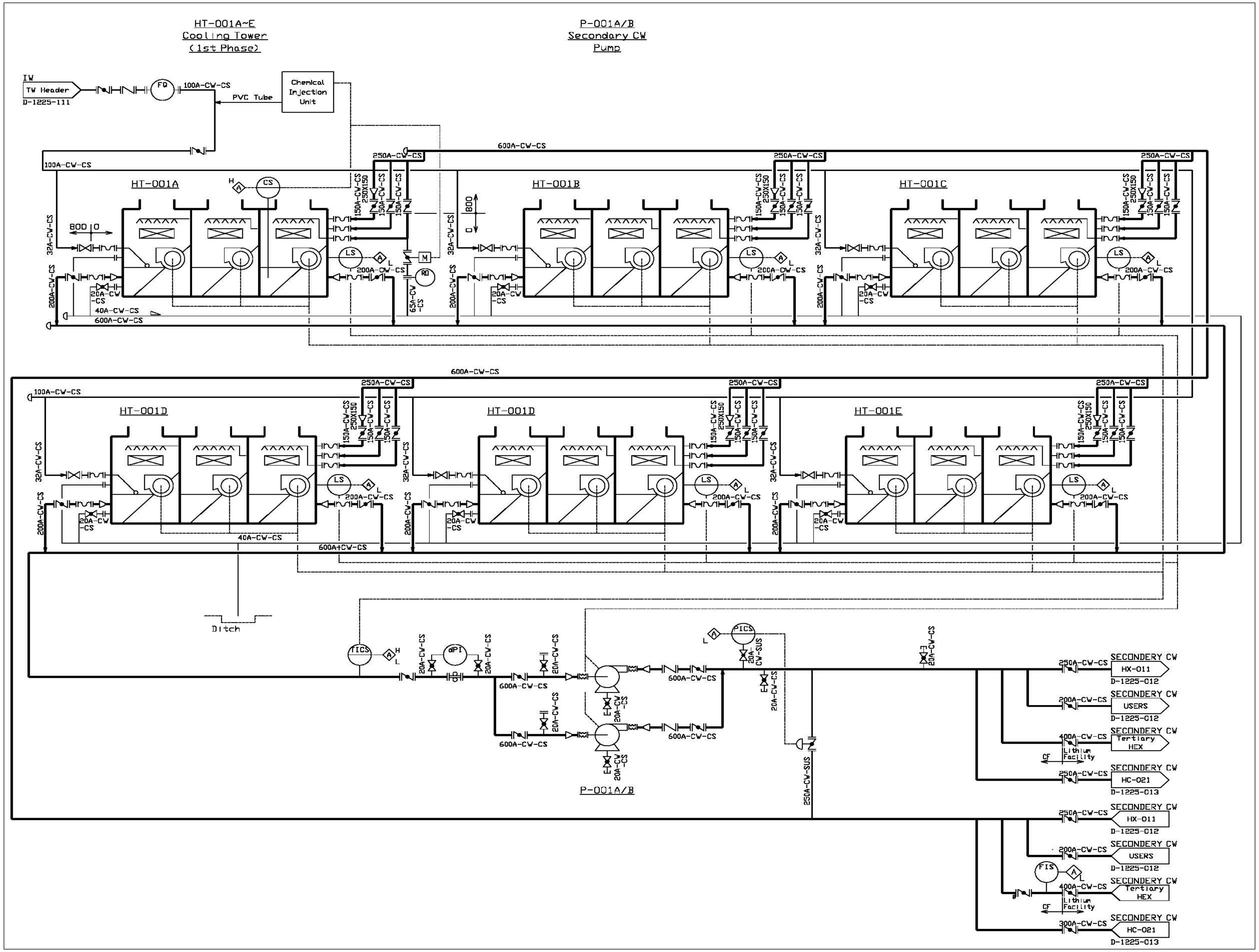


Figure 8-10: D-1225-011- P&ID HRS 1/10

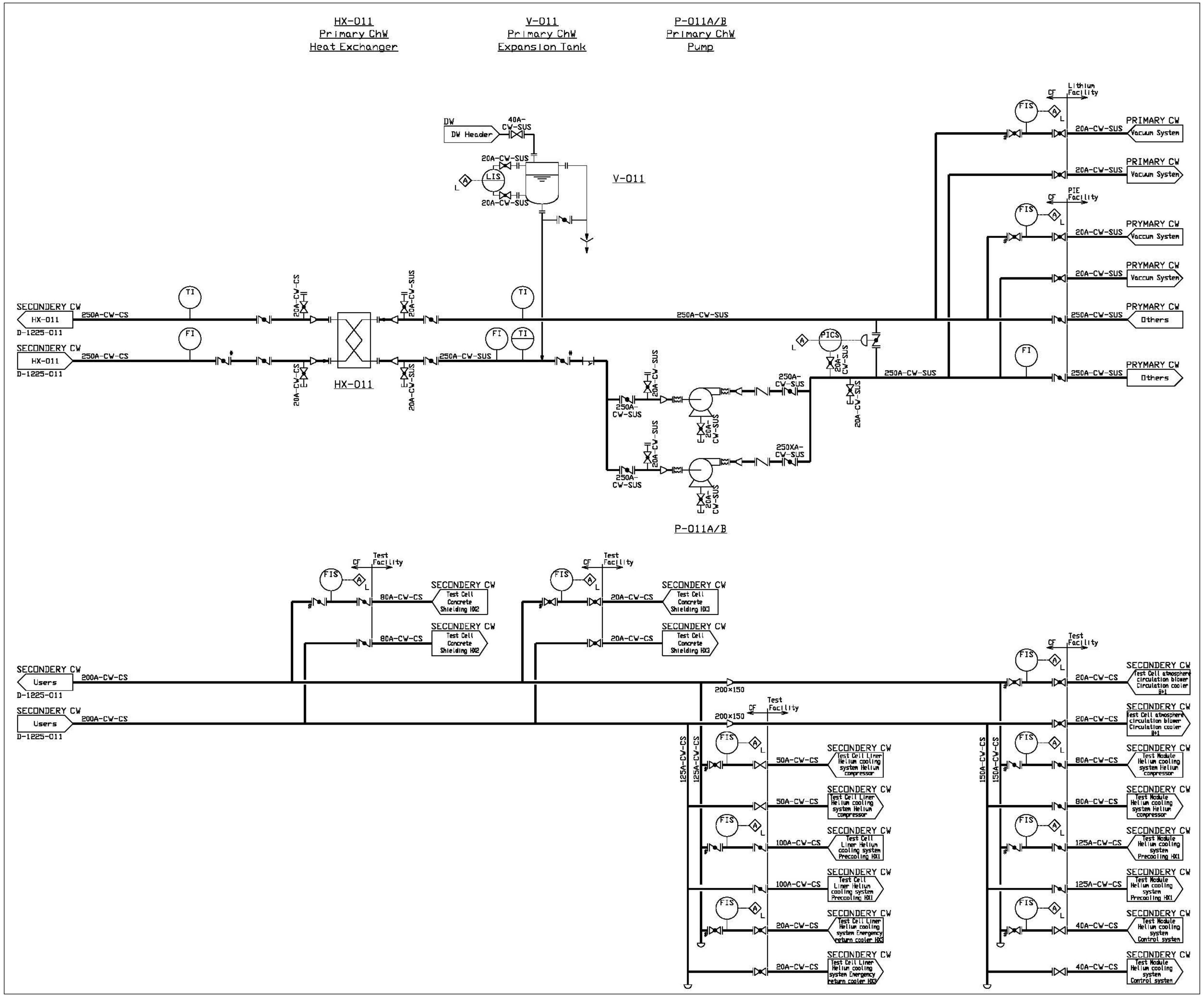


Figure 8-11: D-1225-012-P&ID HRS 2/10

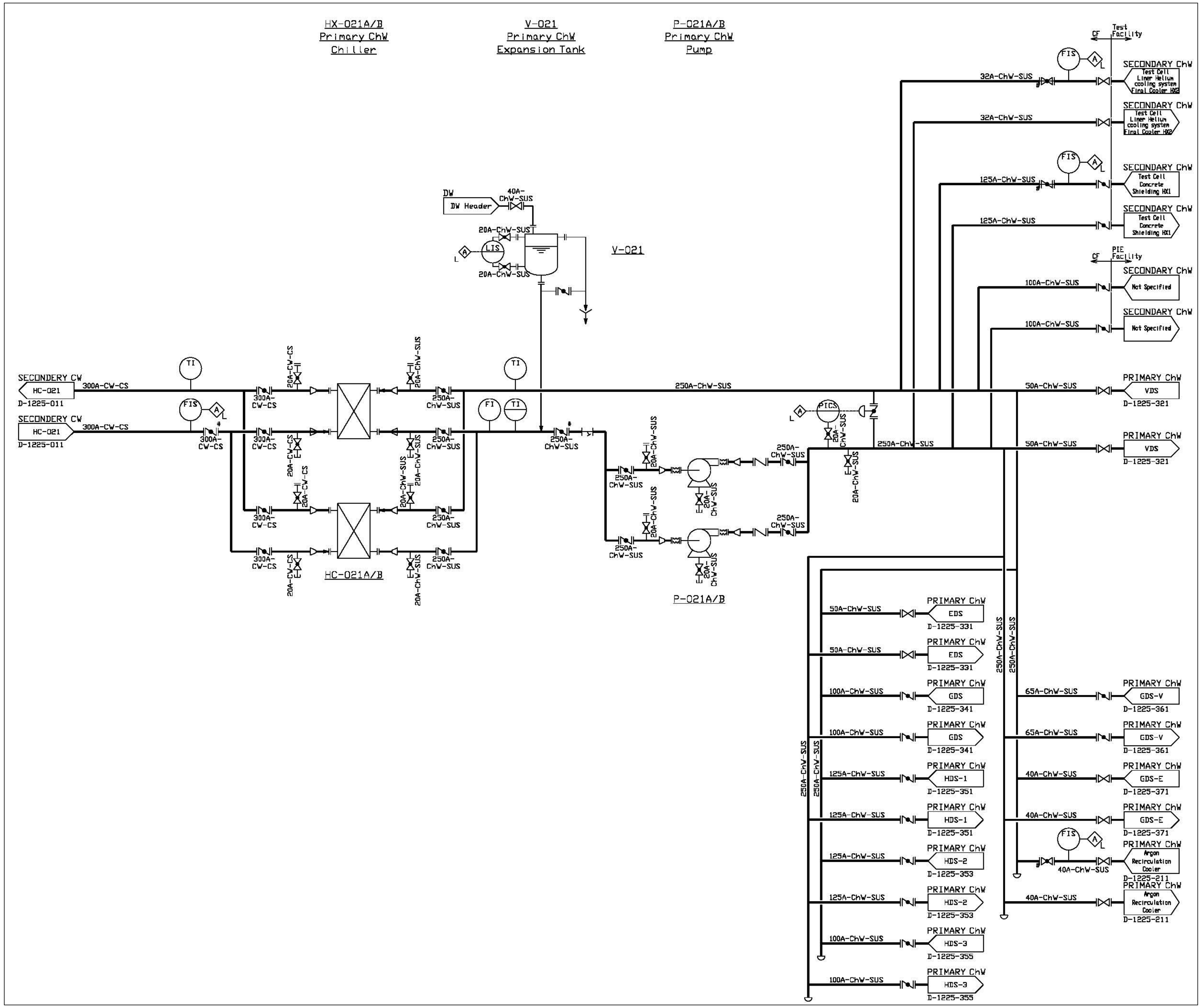


Figure 8-12: D-1225-013-P&ID HRS 3/10

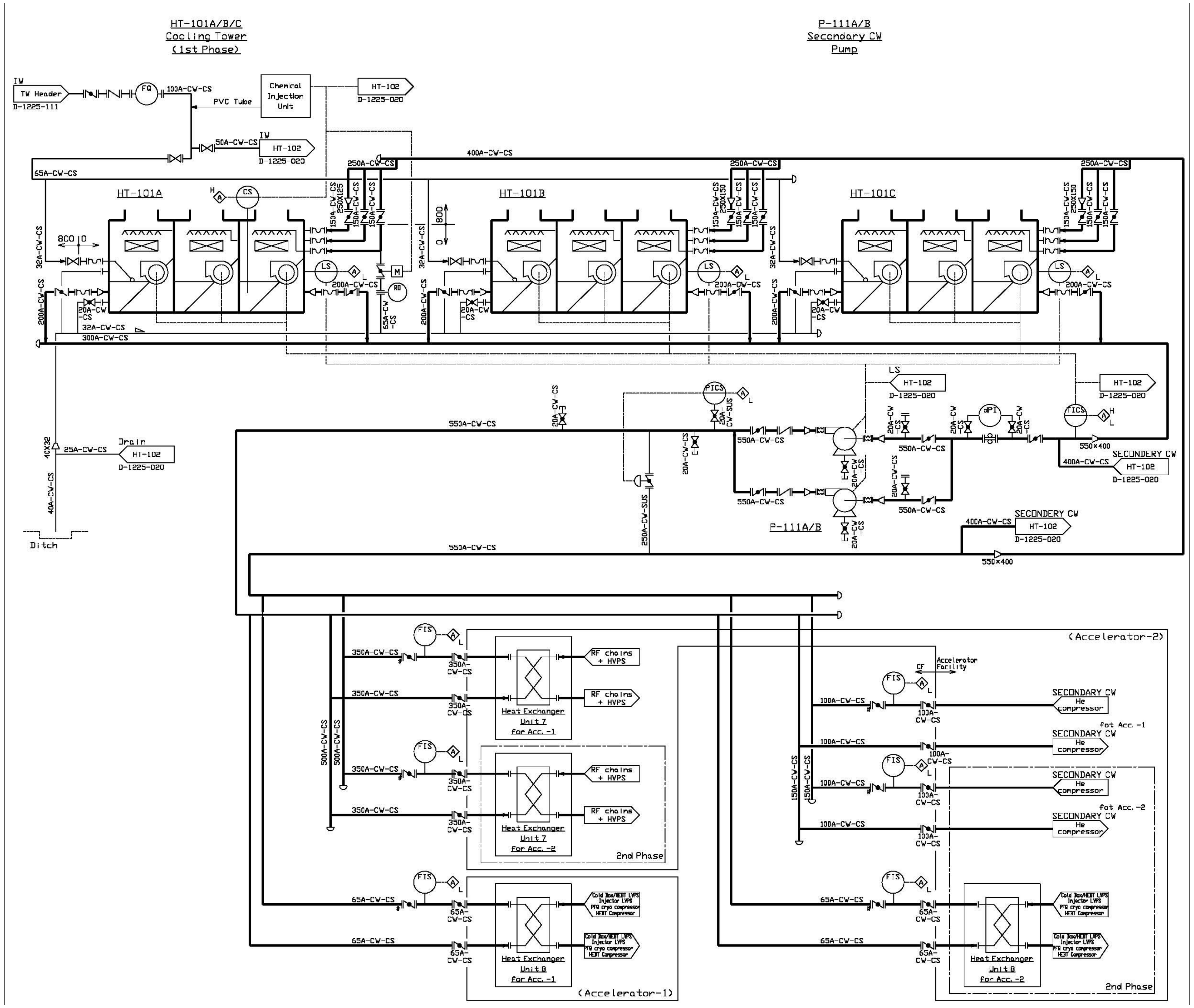


Figure 8-13: D-1225-014-P&ID HRS 4/10

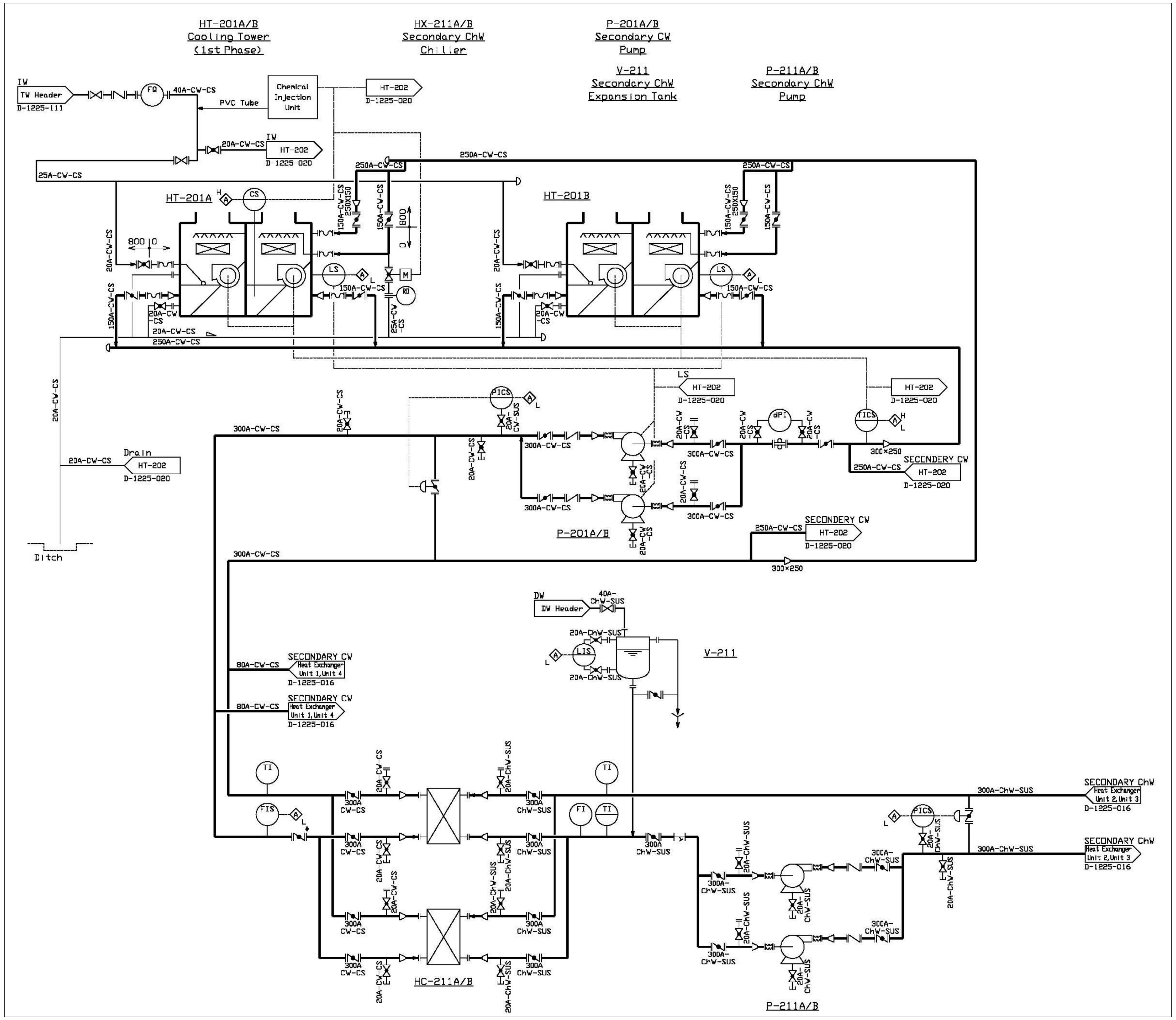


Figure 8-14: D-1225-015- P&ID HRS 5/10

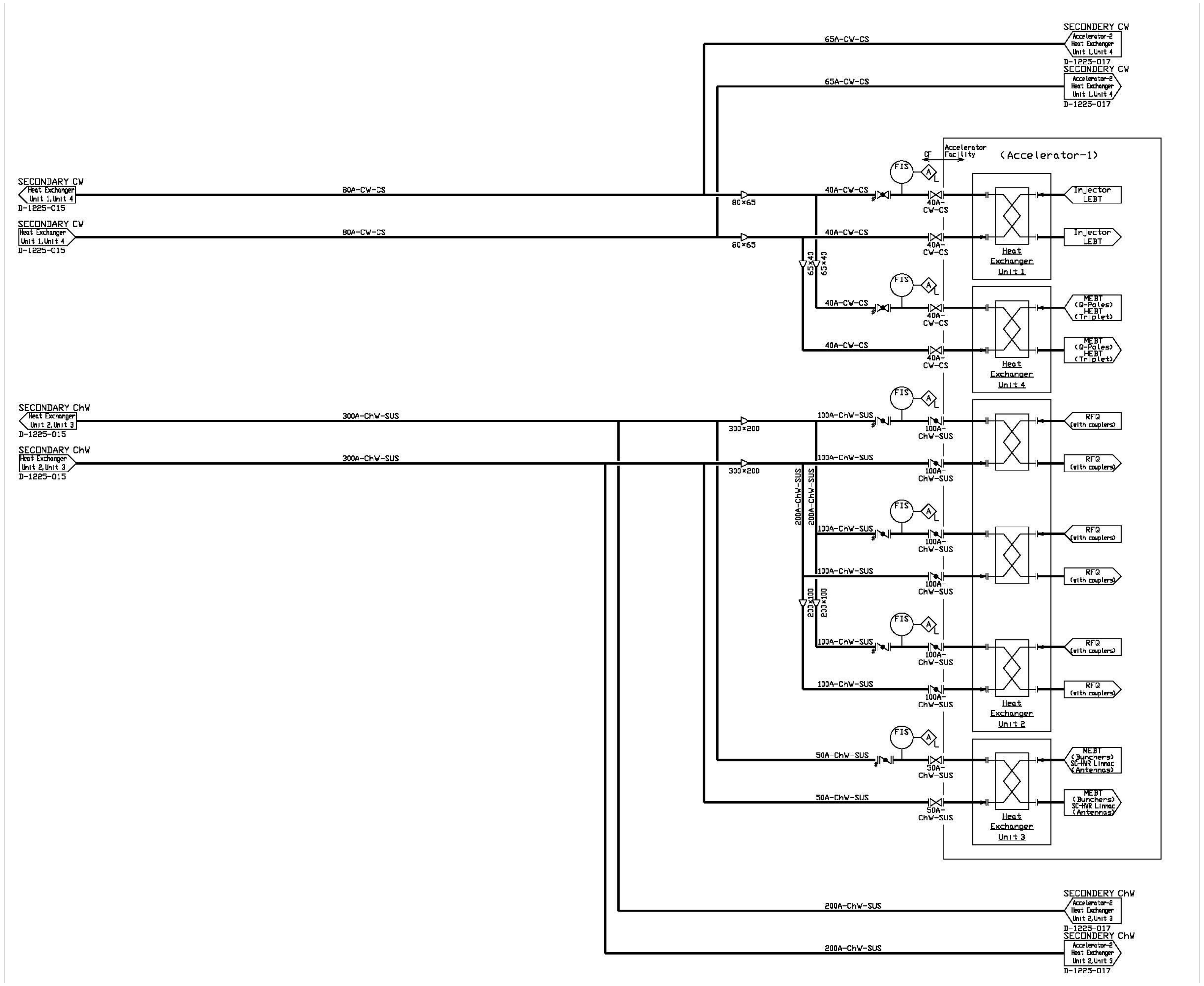


Figure 8-15: D-1225-016- P&ID HRS 6/10

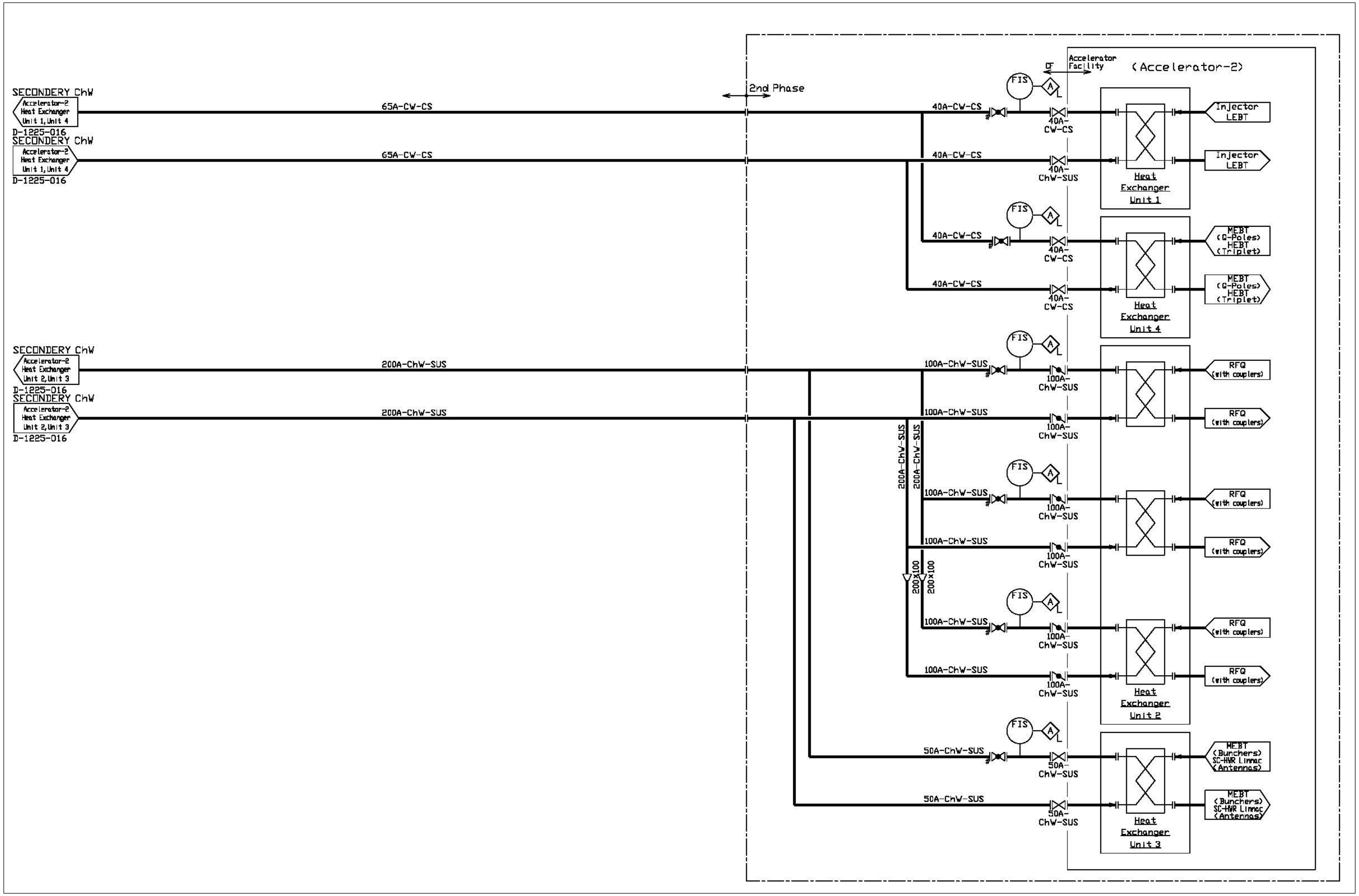


Figure 8-16: D-1225-017-P&ID HRS 7/10

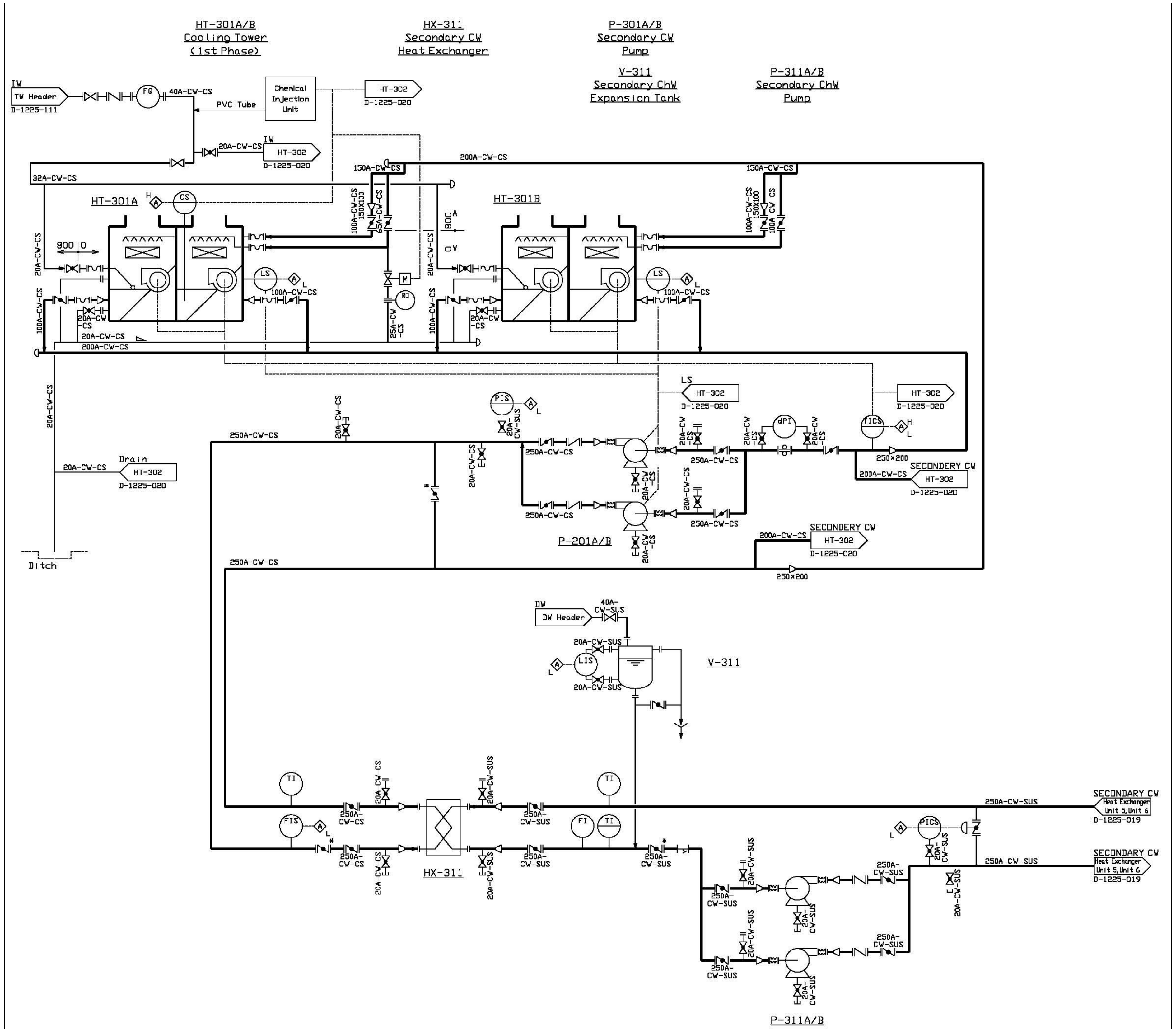


Figure 8-17: D-1225-018-P&ID HRS 8/10

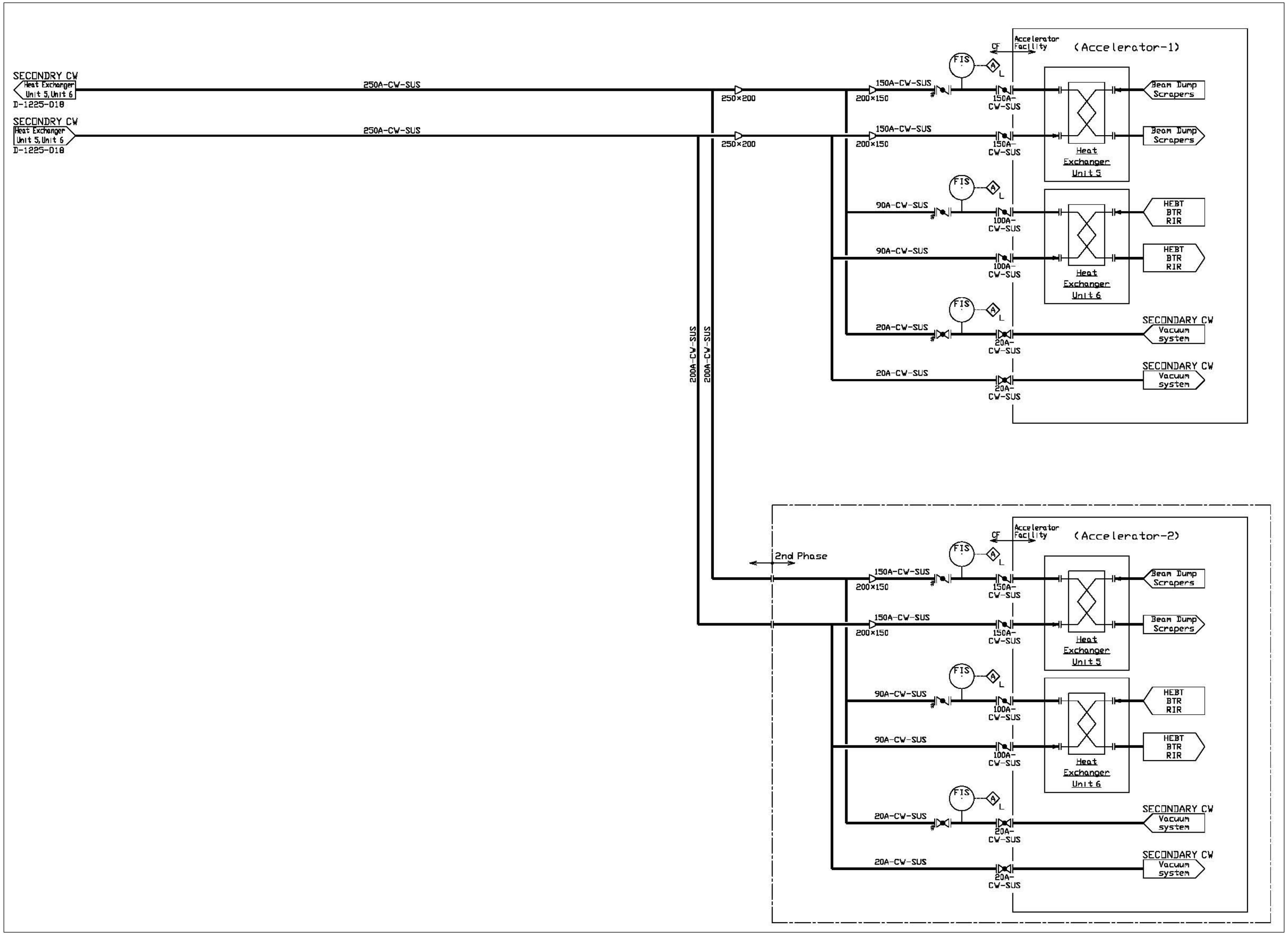


Figure 8-18: D-1225-019-P&ID HRS 9/10

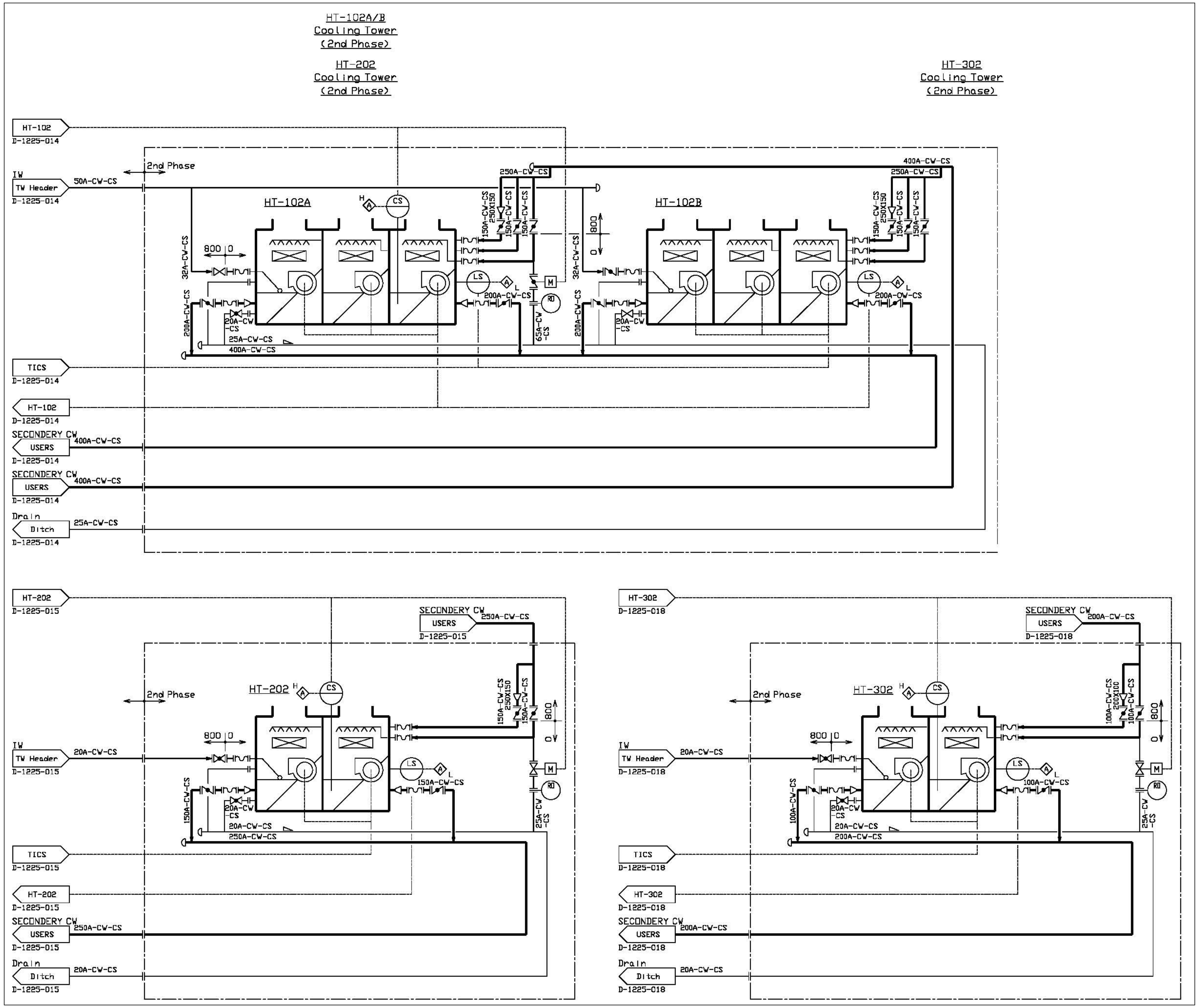


Figure 8-19: D-1225-020 P&ID HRS 10/10

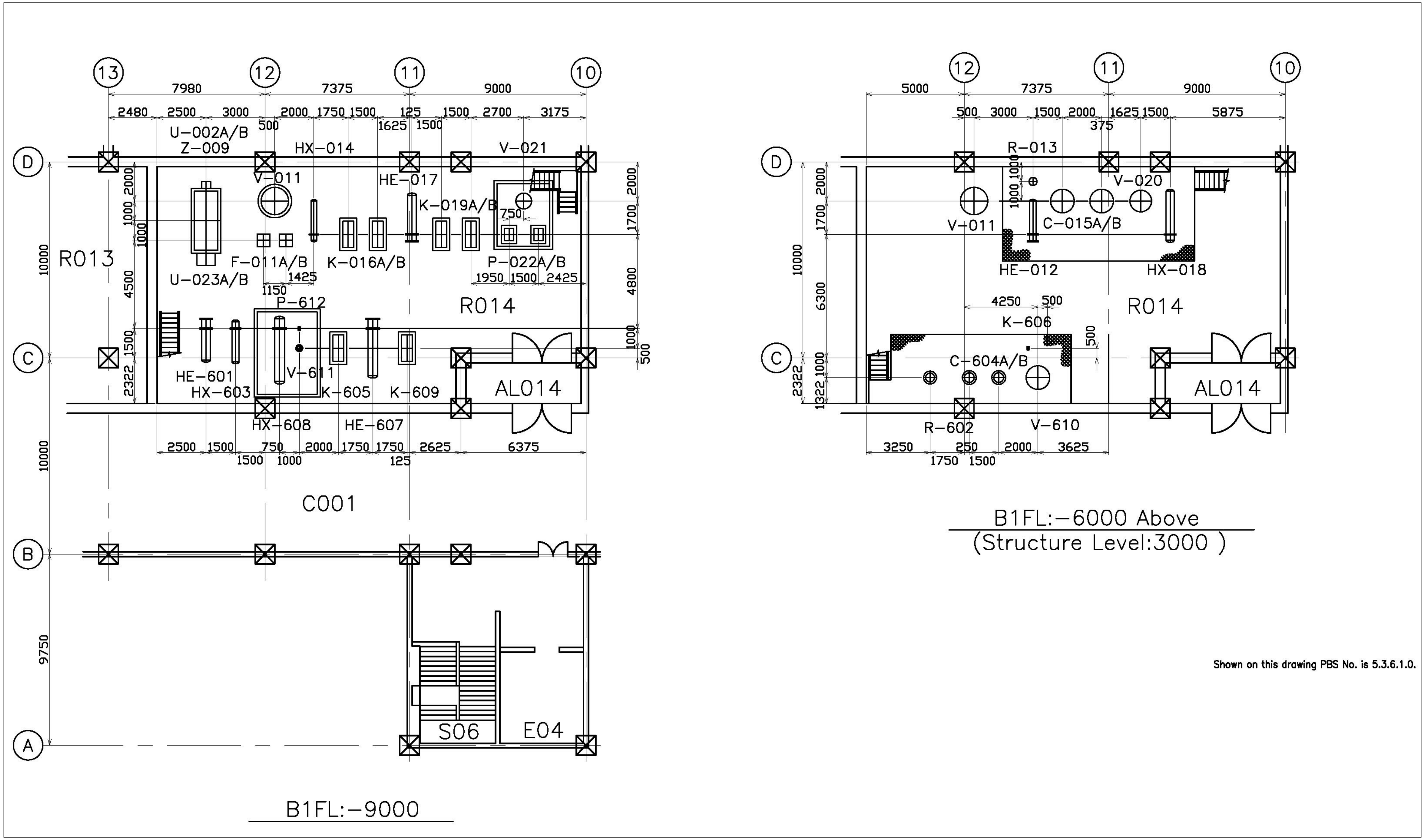


Figure 8-20: D-1225-053-HRS Equipment Layout (room R014)

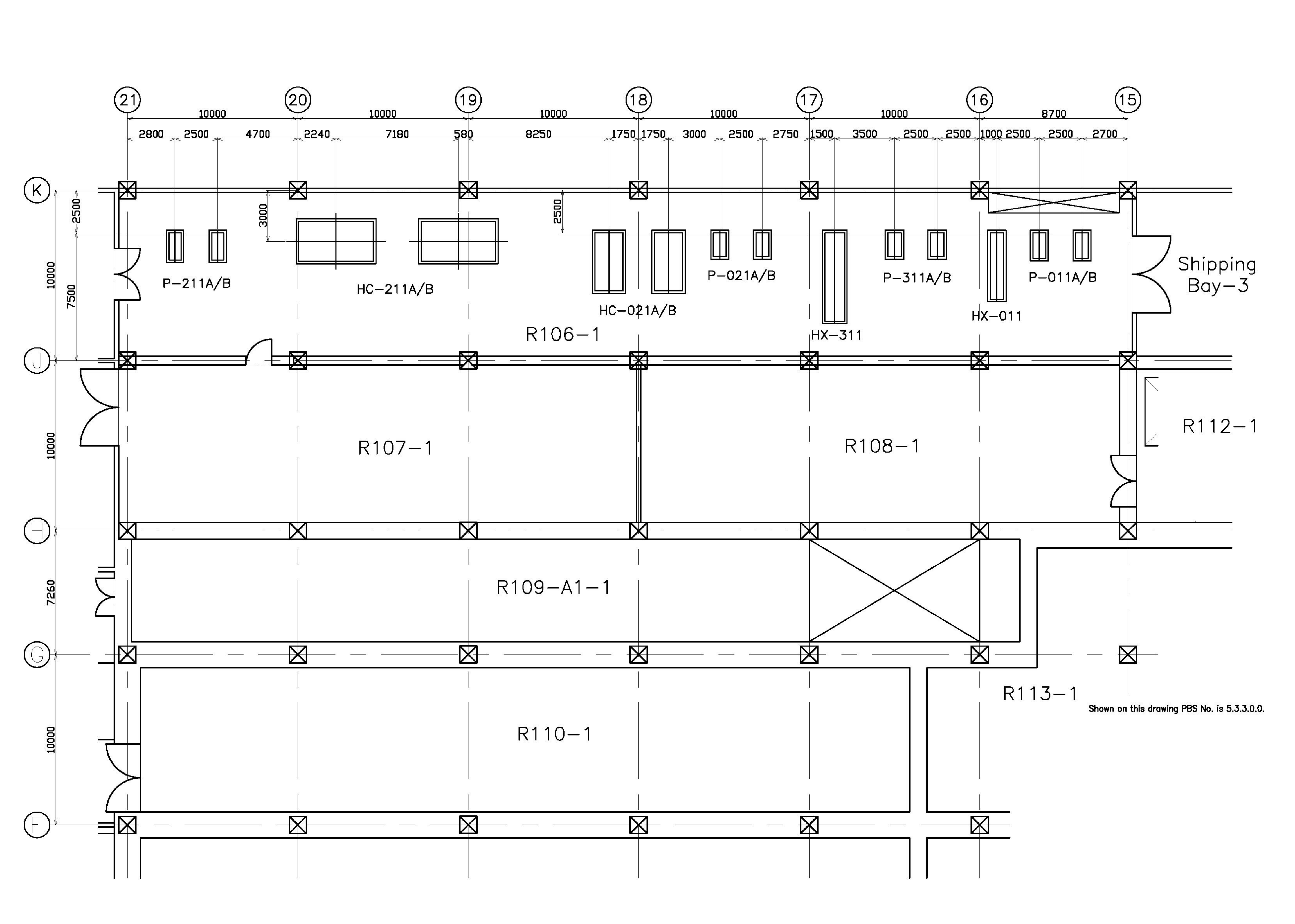


Figure 8-21: D-1225-054- HRS Equipment Layout (room R106-1)

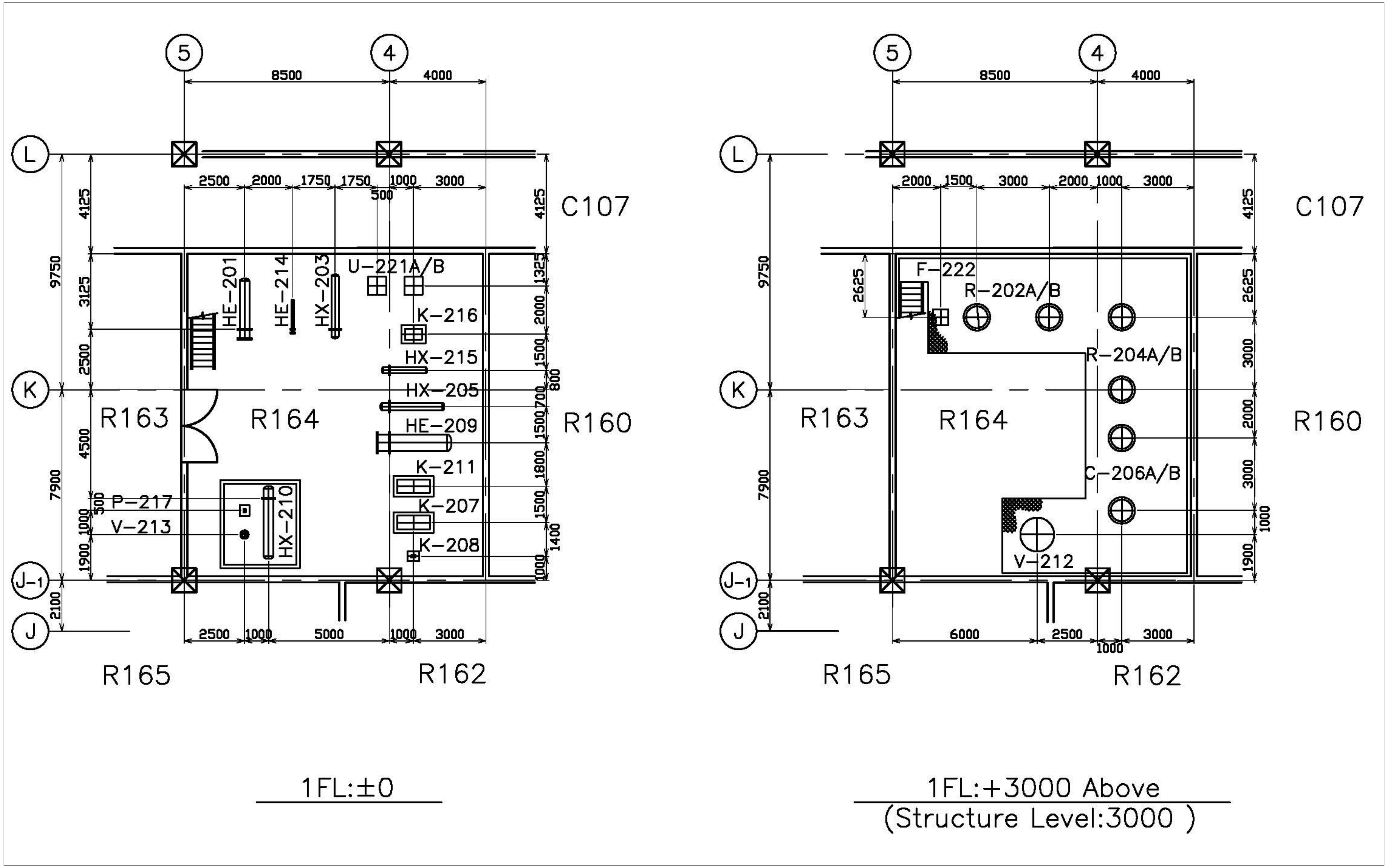


Figure 8-22: D-1225-056 Equipment Layout HRS (room R164)

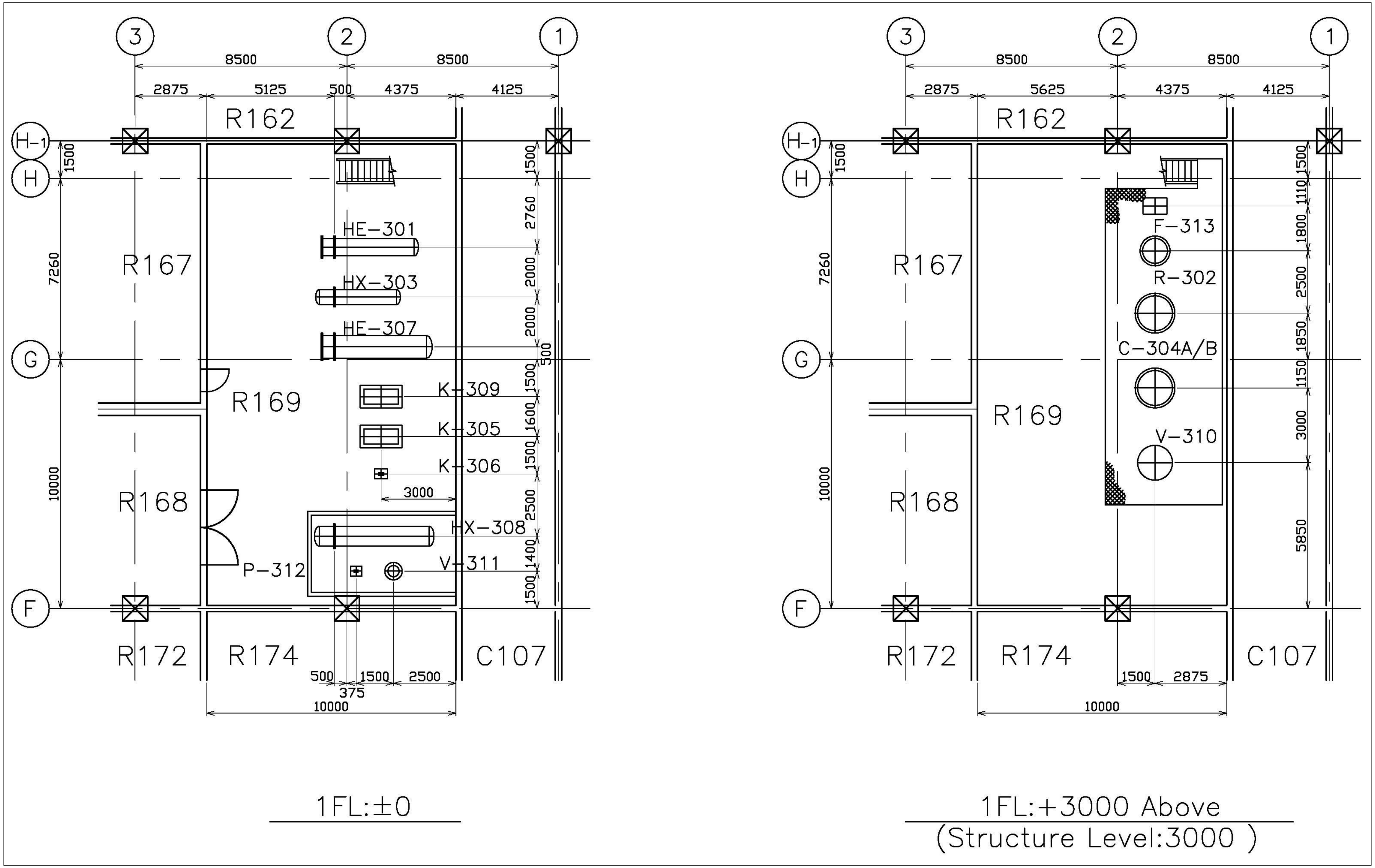


Figure 8-23: D-1225-057- Equipment Layout HRS (room R169)

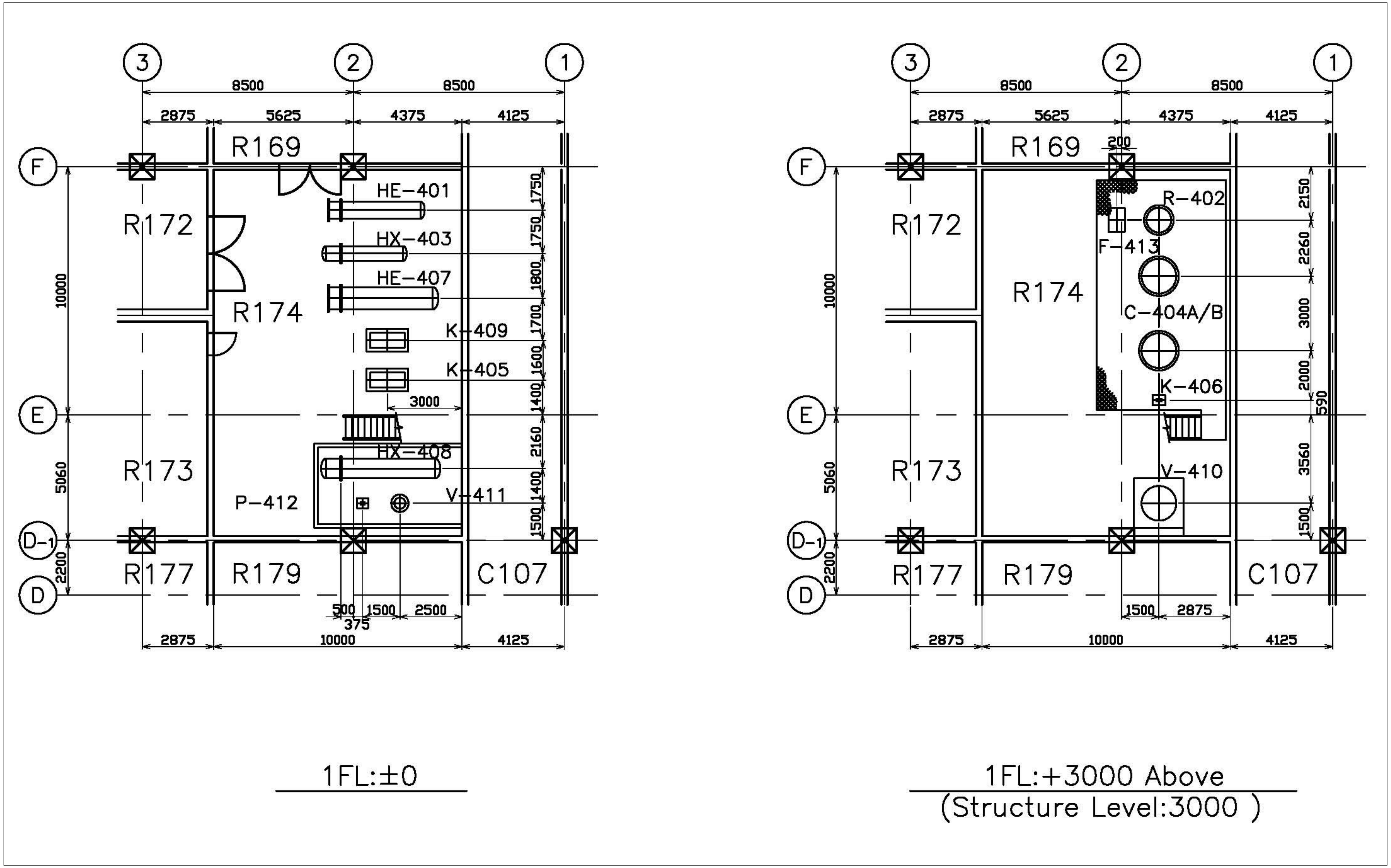


Figure 8-24: D-1225-058- Equipment Layout HRS (room R174)

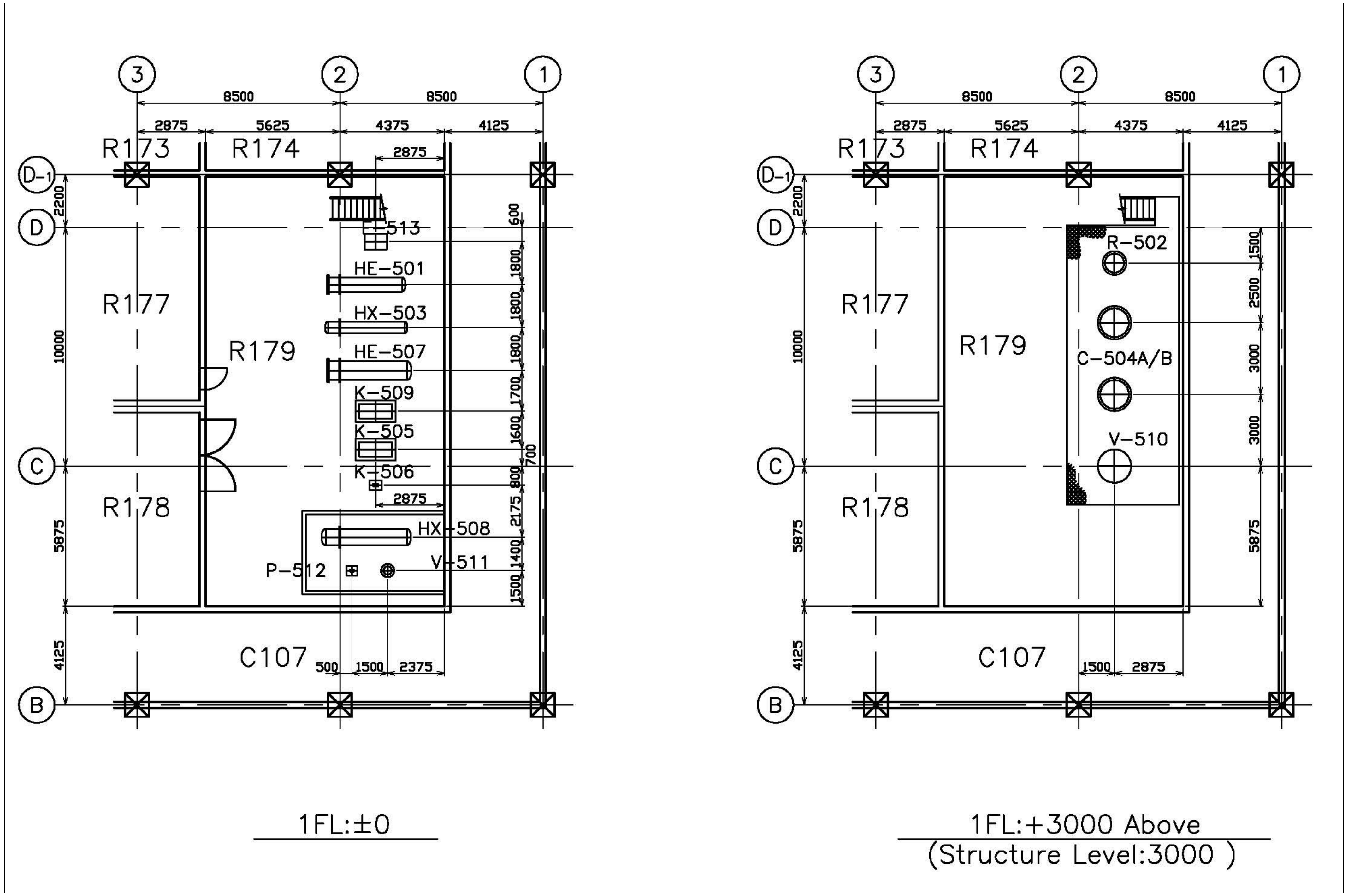


Figure 8-25: D-1225-059- Equipment Layout HRS (room R179)

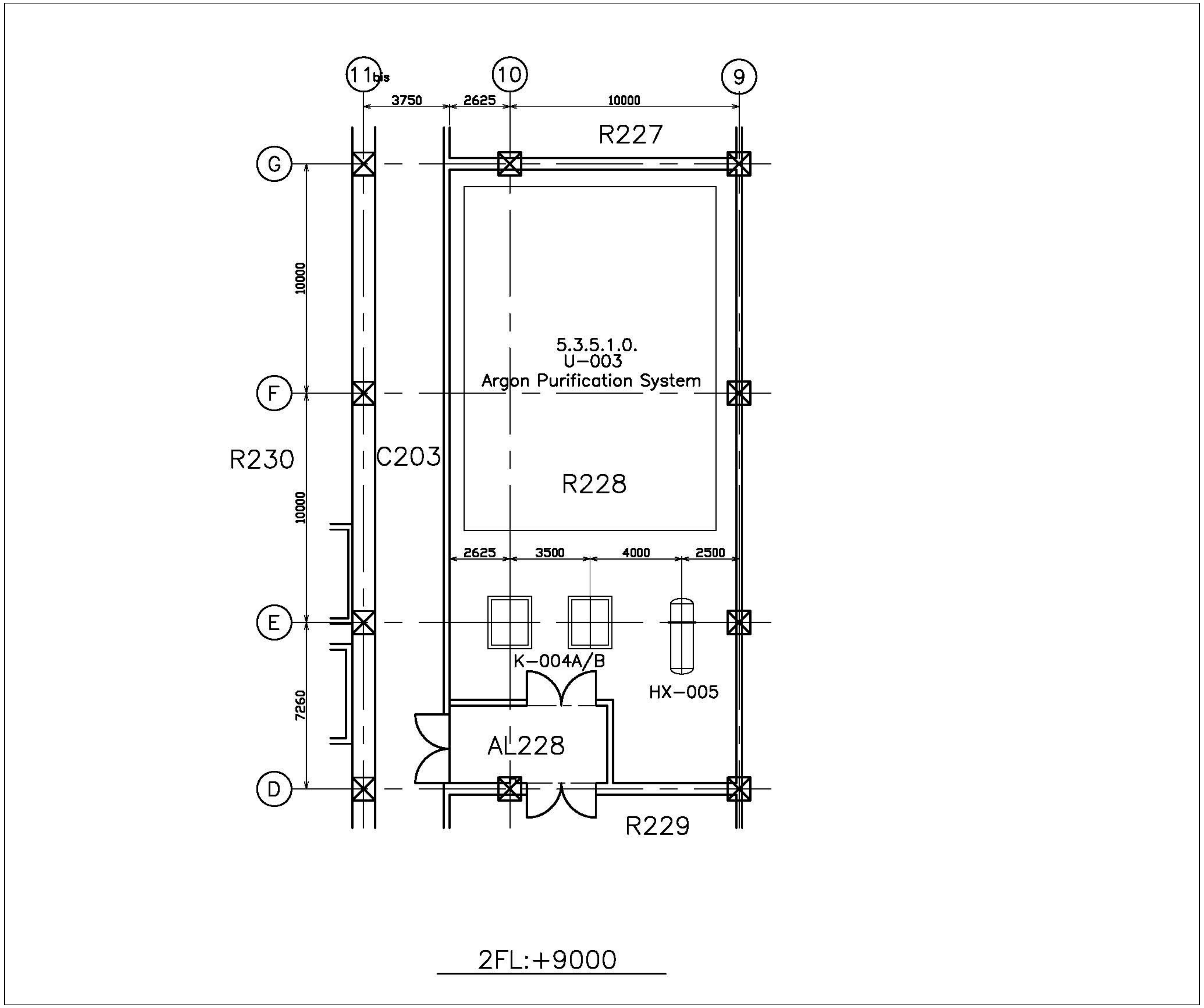


Figure 8-26: D-1125-060- Equipment Layout HRS (room R228)

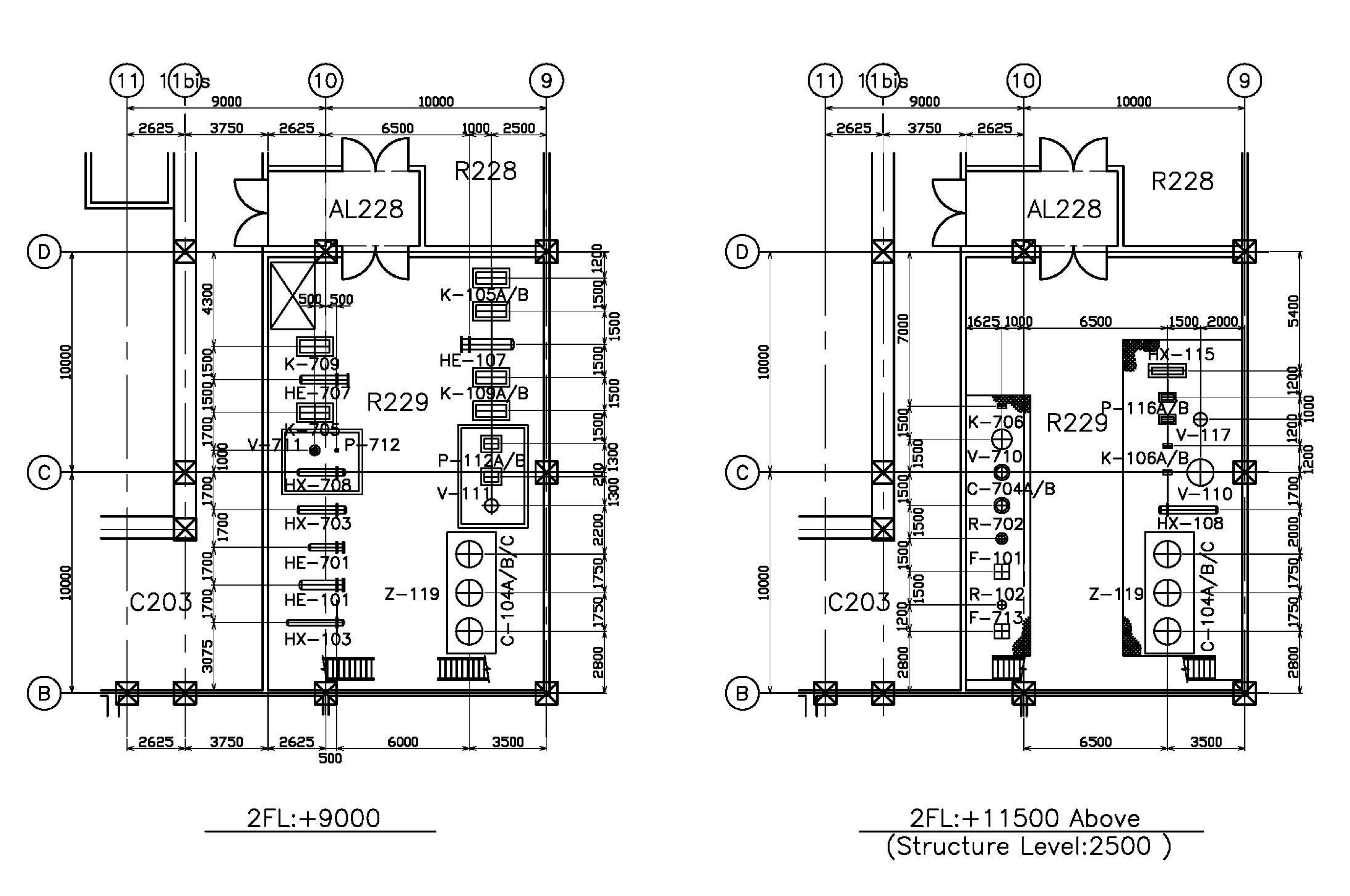


Figure 8-27: D-1225-061- Equipment Layout HRS (room R229)

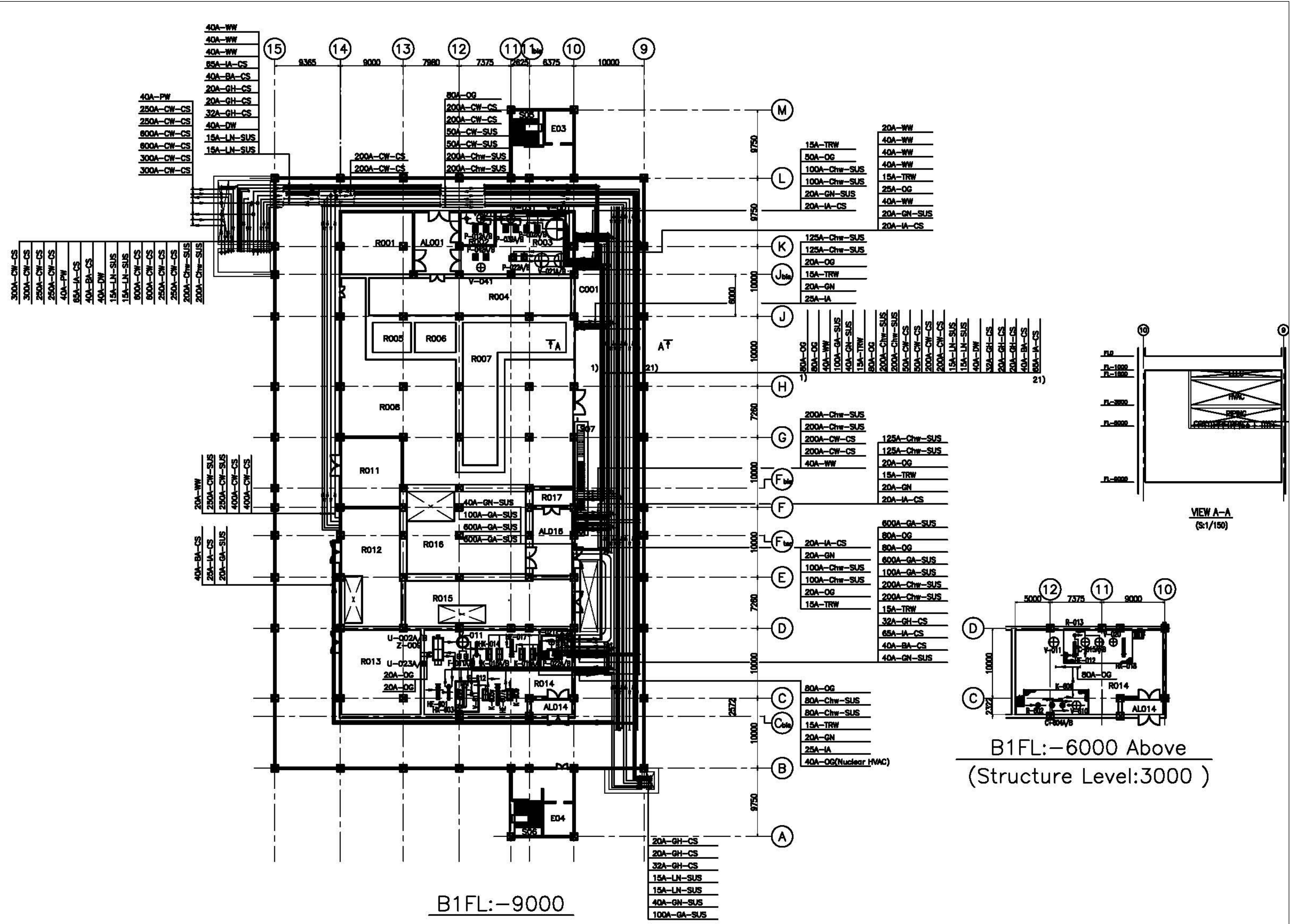


Figure 8-28: D-1226-501- Layout Plan for Main Piping (HRS Basement Floor)

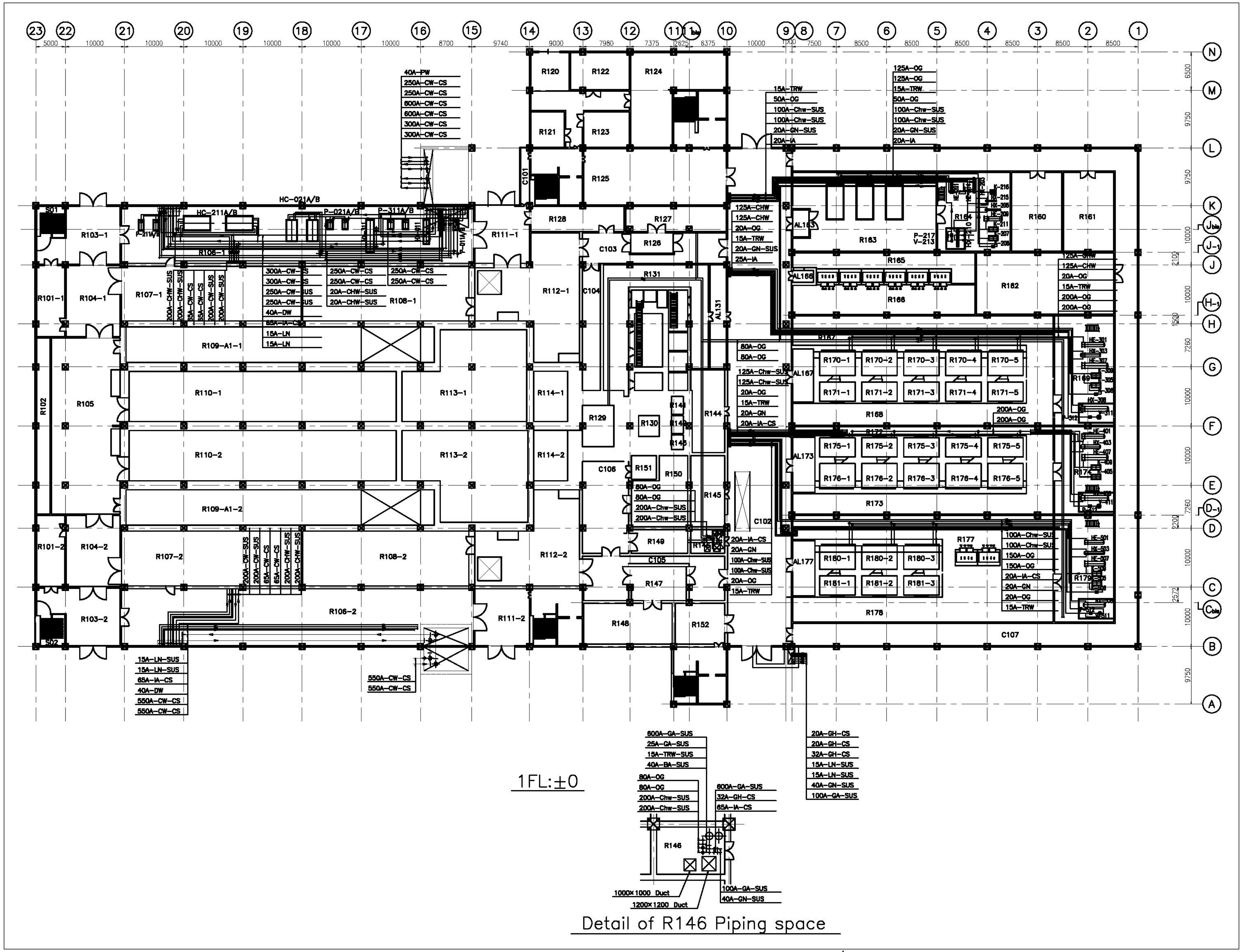


Figure 8-29: D-1226-502- Layout Plan for Main Piping (HRS 1st Floor)

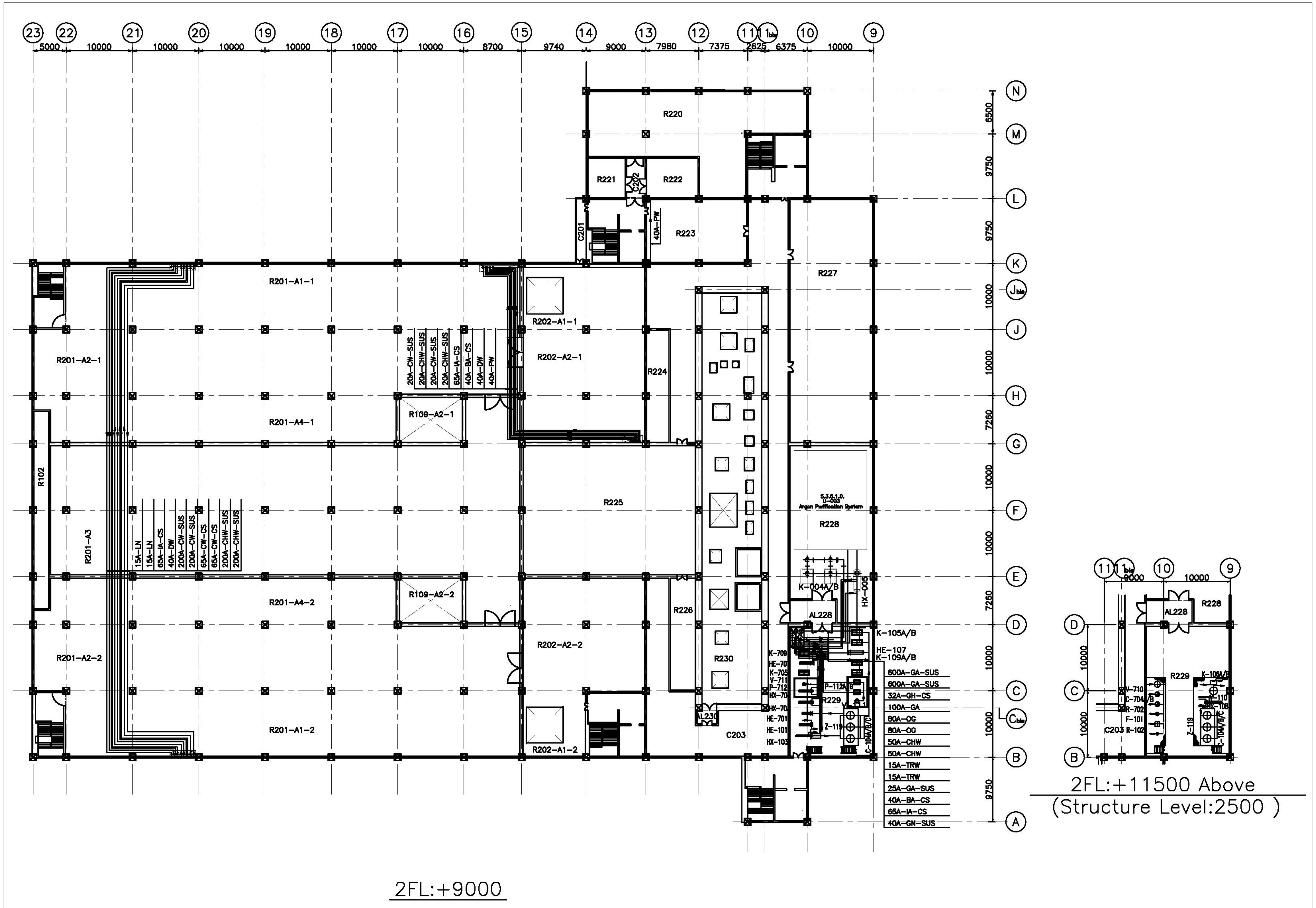


Figure 8-30: D-1226-503- Layout Plan for Main Piping (HRS 2nd Floor)

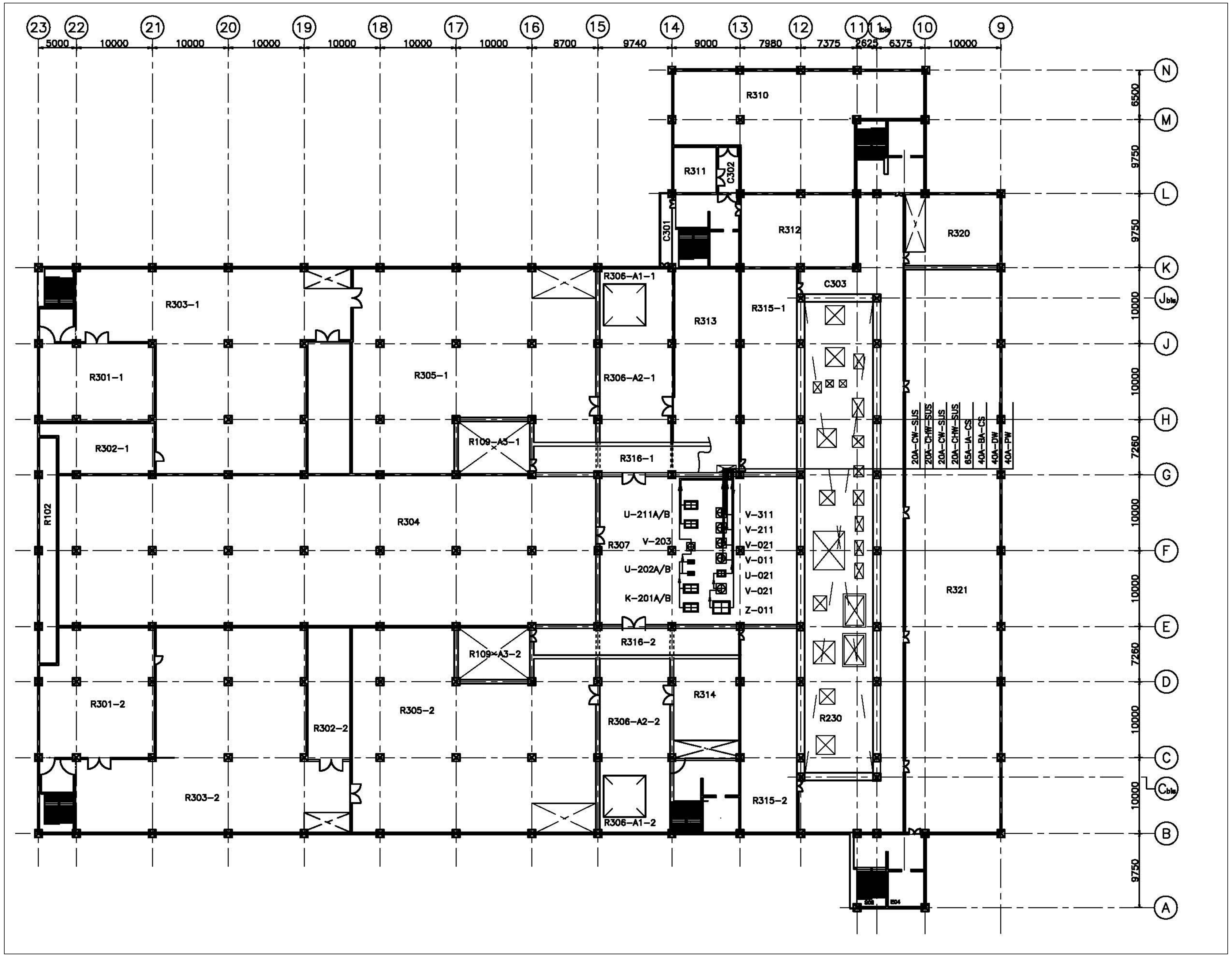


Figure 8-31: D-1226-504- Layout Plan for Main Piping (HRS 3rd Floor)

INTERMEDIATE ENGINEERING DESIGN REPORT

Design Description Document For the Service Gas System (SGS) PBS 5.3.5

IFMIF/EVEDA Integrated Project Team

Issued in the framework of the EU-Japan Fusion Broader Approach Agreement

Design Description Document For the Service Gas System (SGS) PBS 5.3.5

Prepared by: G. Pruneri[a]

Contributors: A. Polato[a]; T.Kato[b]

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Abstract: **This document describes the Service Gas System (SGS) considered belonging to the Conventional Facilities. Key functions of the system as well as: interfaces with other facilities/systems, PFD, P&ID's, equipment layout, equipment list, flow diagrams, piping layout and input data requirement for the design of the system.**

TABLE OF CONTENTS

ACRONYMS

AF	Accelerator Facility
Ar.S	Argon System
BAS	Breathable Air System
CAS	Compressed Air Supply System
CF	Conventional Facilities
CHC	Component Handling Cell
CODA	Construction Operation and Decommissioning Activities
DDD	Design Description Document
DVT	Data Validation table
EDS	Emergency Detritiation System
EVEDA	Engineering Validation & Engineering Design Activities
GDS	Glove boxes Detritiation System
HDS	Hot cells Detritiation System
He.S	Helium Supply System
HRS	Heat Rejection System
HRWTC	Irradiation Radiation Waste treatment Cell
HVAC	Heating Ventilation Air Conditioning
IFMIF	International Fusion Materials Irradiation Facility
LF	Lithium target Facility
LSP	Lower Shielding Plug
N S	Liquid Nitrogen System
ORS	Oil removal System
P&ID	Piping& Instrumentation Diagram
PBS	Plant Breakdown Structure
PFD	Process Flow Diagram
PIE	Post Irradiation Examination
PT	Project Team
RAC	Rig Assembling Cell
RAMI	Reliability, Availability, Maintainability, Inspectability
RF	Radio Frequency
RFQ	Radio Frequency Quadrupole
RHC	Rig Handling Cell
SIC	Safety Important Component
TF	Test Facility
TMHCs	Test Module Handling Cells
VDS	Vent gas Detritiation System
WBS	Work Breakdown Structure

LIST OF EXHIBITS

Tables

Figures

1. System Functions and Basic Configuration

1.1 System Functions

1.2 System Basic Configuration

The Service Gas System (SGS) stores, supplies and distributes service gases in sufficient quality, quantity, and at sufficient pressure to client's systems which required such supply within IFMIF Site.

To accomplish the above mentioned functions the SGS is composed by the following main four (4) subsystems:

- Argon Supply System (Ar.)
- Helium Supply System (He.)
- Compressed Air Supply System (Included; Breathable Air and Compressed Air)
- Nitrogen Supply System (N)

PBS, proposed for the plant, and summarized in Table 1: SGS PBS location, locates the SGS System within the Conventional Facilities/ Plant services.

PBS Number						PBS Item
1	**2**	**3**	**4**	**5**	**6**	
5	**0**	**0**	**0**	**0**	**0**	**Conventional Facilities**
	3	0	0	0	0	Plant Services
		5	0	0	0	Service Gas System (SGS) (Ar, He, Air, N)
			1	0	0	Argon Supply system
				1	0	Storage Tanks
				2	0	Evaporators
				3	0	Fans and Blowers
				4	0	Coolers
				5	0	Purification Equipment
				6	0	Valves & Piping
				7	0	Instruments & sensors
			2	0	0	Helium Supply System
			3	0	0	Compressed Air Supply System
			4	0	0	Breathable Air Supply System
			5	0	0	Nitrogen Supply System

Table 1: SGS PBS location

1.2.1 System Basic Configuration Argon System (Ar. S)

Argon supply System stores, supplies and distributes Argon in sufficient quantity, quality, and at sufficient pressure to client systems which require such supply within the IFMIF Site in order to create the corresponding fire risk free atmospheres. The function is accomplished by a liquid Argon storage system (tank), a recirculation and cooling system, and a purification system.

- Liquid Storage and Gas Supply System: Fluid Argon is transported by a truck to a liquid Argon tank with vacuum insulation. Charged into gaseous form by an air heating evaporator, the Argon is supplied to the following components:
  - Ar. filled cells: Lithium loop Cell; Lithium Trap Cell; Air Lock chamber for HRWTC, Target Interface Room, Li. Impurity monitoring room for gloves boxes, Li. Sampler, plugging meter and organic loop room for cold trap cooling circuit.
  - Vacuum Cell (Test Cell)
  - Argon curtain for Access Cell in correspondence to the Test cell Plug during maintenance while the plug is removed.
  - PIE facility
  - (**TF responsibility**) The Argon filling of CHC (in case of failure (e.g. broken capsule of HFTM)), in that case, Argon is also needed to remove decay heat from HFTM-capsules; RHC (regularly to blow out the Nak from the capsule), RAC (regularly during filling the capsule with NaK, Argon curtain is needed)
  -

Before operation the argon is supplied to replace the atmosphere of the Ar.-filled cells from air to Argon. During operation and to hedge a fire risk at Lithium leakage, fresh Argon is supplied to keep an impurity concentration of the atmosphere below a defined value cfr. Ref. Table 17-Table 18 and Table 19.

Argon recirculation and cooling system for atmosphere of Ar. filled cells; to maintain temperature below a defined value, atmosphere of the cells is re-circulated and cooled by chilled water.

Argon purification system for atmosphere of Ar.-filled cells, Impurity concentration can be maintained only by continually supplying fresh argon, the Argon consumption would be very high under one-through configuration. Therefore a fraction of the Argon atmosphere cooled by chilled water and purified by argon purification system is recycled.

1.2.2 System Basic Configuration Helium Supply System (He. S)

Helium supply System stores, supplies and distributes Helium in sufficient quantity, quality, and at sufficient pressure to those client systems which require such supply within the IFMIF Site. The function is accomplished by one or several gas bottles (indoor) and storage tank outdoor (buffer tanks for Accelerator Cryoplant) the system includes related distribution system, piping, valves, instrumentations, etc. (until the subsystem; Accelerator Helium compressor station, Test Cell storage tank for Tritium release module, test cell atmosphere and test modules cooling system.
Helium gas is transported by a tank truck and filled to the helium storage tanks located outdoor the IFMIF Building, one tank dedicated to the Test facility (one × 25 m³) and the other storage tanks dedicated to the Cryoplant for the accelerators (buffer storage tank 4 × 100m³) He in the buffer tanks is stored from the high pressure pure Helium of the cycle compressor. The pressure is varying depending on the quantity of He. being

stored or sent back to the loop. For IFMIF Cryoplant, the maximal compressor pressure would be 16 bars, and usually pure helium buffer are calculated to hold 20 bars.
The helium gas is supplied to:

- TRTM (Tritium Release Test Module) in the test Cell technology room during operation.
- Test Cell Atmosphere during operation
- Test Module Cooling System.
- Test Cell Lower Shielding plug
- PIE Laboratory
- Accelerators Cryo plant
- Li. Loop area for plug cooling
- TC for target assembly structure cooling
- LBVM

1.2.3 System Basic Configuration Compressed Air Supply System & Breathable Air Supply System (CAS) & (BAS)

1.2.3.1 Instrumentation Air Supply System

Instrumentation air supply system supplies and distributes clean, dry and oil free instrument air to client systems throughout the IFMIF Site. Compressors and dryers are provided to make instrumentation air. The air is supplied through a buffer tank for various instrumentation purposes (e.g. be among others for pneumatics actuators controls or insulation valves as well as switches and circuit breakers operations or maintenance purpose for flushing or drying)

1.2.3.2 Breathing Air System

Breathing Air System supplies and distributes “Breathing quality” compressed air to a number of consumers throughout the IFMIF Site, to enable personnel wearing pressurized suits or respirators to enter and work in contaminated areas. Breathing air is used also by workers bearing respirators when entering enclosed work locations having inadequate ventilation. This function is accomplished by compressors, air receivers, air-dryers, air distribution, filters, accumulator and air quality devices and other control instrumentations.

1.2.4 System Basic Configuration Nitrogen Gas System (N2S)

Nitrogen Supply System supplies and distributes nitrogen to those client systems which require such supply within the IFMIF Site. Liquid Nitrogen is transported by a tank truck to a liquid nitrogen tank with vacuum insulation. Nitrogen Supply System provides:

- Liquid Nitrogen:

- Cold Boxes for the Accelerator's system cold box Helium pre-cooling and for LN2 thermal shield cooling for the Cryostats (SRF Linac Accelerator's modules)
- A liquid nitrogen trap of the Accelerator vacuum line of the vacuum system
- Oil Removal System (ORS) liquid nitrogen is required once in a year, to perform the charcoal pot drying during its annual maintenance period.(system belong to Accelerator's Cryoplant) CF will deliver the liquid nitrogen till the valves of oil removal system (ORS)

- Gaseous Nitrogen:
  - Glove Boxes for the Laboratory: to change atmosphere from air to nitrogen
  - Glove Boxes Detritiation System: to regenerate a CU Catalyst
  - Target Interface Room
  - Dry Pump of each vacuum system for all facilities to purge shaft sealing devices.
  - Buffer tanks of primary cooling water loops of the accelerators to seal the tanks off from the air; prevent oxygen from dissolving into the primary cooling water; and to retard depletion of in-exchange resin cartridges by easing corrosion environment
  - Used along the Accelerator and the HEBT for venting to atmosphere the beam pipes or cavities prior to make maintenance or repair. Nitrogen has to fill the accelerator by means of a pipe following the same route than the compressed air distribution

2. Interfaces (boundaries)

The interfaces with other systems may be physical and functional or both. Additional information about SGS interfaces is provided in Systems Interface (Ref. Table 2: Interface table Characteristics of the components for the SGS is indicated on the Equipment List (Ref. Table 16)there is a multiple interface between SGS Facilities (hosted mainly in Lithium loop and TF room) and Building. A generic multiple interface was defined to overcome this issue. SGS system interfaces at the same time with Conventional Facilities (in the sense of the Building) and with the equipment hosted in the rooms (that can be part of the Accelerator, Lithium, Test, PIE and/or of the Conventional Facilities themselves). The sharing of responsibilities will be clarified case by case, but at list this general triple interface includes all the requirements that SGS needs in order to proceed with the design, here below are summarized (at first level) the interfaces related to the SGS.

Interface Table SGS (Service Gas System)		
System A	**System B**	**Title**

Test Cell	Service Gas System	Argon with high purity (grade G3) shall be provided to: Test Cell, Test Module Handling Cells
Tritium Release Module	Service Gas System	Helium shall be provided to: Tritium Release Module
Helium Cooling System	Service Gas System	Helium shall be provided to: Helium Cooling System of Test Facility
Vacuum System	Service Gas System	Nitrogen gas shall be provided to: Vacuum System of Test Facility
PIE Facility	Service Gas System	Argon with high purity (grade G3) shall be provided to: PIE Facility
Glove Boxes	Service Gas System	Nitrogen gas shall be provided to: Glove Boxes of PIE Facility
Vacuum System	Service Gas System	Nitrogen gas shall be provided to: Vacuum System of PIE Facility
Lithium System	Service Gas System	Argon with high purity (grade G3) shall be provided to: Lithium System, also for LF pneumatics valves (instead of Compressed air)
Cooling System	Service Gas System	Nitrogen gas shall be provided to: Cooling System
Vacuum System	Service Gas System	Nitrogen gas shall be provided to: Vacuum System of Accelerators
Cryoplant	Service Gas System	Liquid Nitrogen and Helium shall be provided to: Accelerator's Cryoplant
Main Building	Service Gas System	Main Building has to accommodate compressors, blowers, and etc. of: Service Gas System
Lithium loop Cell	Service Gas System	Argon with high purity (grade G3) shall be provided to: R016, Lithium Loop Cell
Lithium Trap Cell	Service Gas System	Argon with high purity (grade G3) shall be provided to: Lithium Trap Cell adjacent to room R016 (Lithium Loop cell) and Li. Impurity monitoring system
Air Lock Chamber for HRWTC	Service Gas System	Argon with high purity (grade G3) shall be provided to: Irradiation Radiation Waste Treatment Cell (HRWTC)R007

Table 2: Interface table

2.1 Argon Supply System, Interface description

2.1.1 Ar. S vs. Lithium Target Facility

Ar. S will serve the Lithium Target Facility rooms:

- *Lithium Loop Cell R016-016bis(Electromagnetic pump &Dump tank)*
- *Lithium Trap Cell plus Li. Impurity monitoring system*
- *Air Lock Chamber for HRWTC R007*

- All the pneumatic valves and other pneumatic devices located on the Lithium loop and in the area where there is lithium are served by Argon gas instead of common Compressed air.

The boundary between Ar S and LF rooms is set at the internal part of the room walls. Inlet/outlet grilles and backward equipment are within the scope of the Argon System.
ArS. Shall provide its service also to the:

- *Lithium Loop(for maintenance purpose)*

The boundary between Ar S and LF is set at the Argon feed and extraction plugs. Connection flanges and afterward equipment are considered within the scope of the Lithium Facility.

- *Target Interface Room R129*

The boundary between Ar S and Target Interface Room (TF) is set at the internal part of the room walls. Inlet/outlet grilles and backward equipment for Ar. supply are within the scope of the LF

2.1.2 Ar S vs. Test Facility

Ar S will serve:

- *Test Cell R130*

The boundary between Ar. S and TF is set at the Argon feed and extraction plugs. Connection flanges and downstream equipment are considered within the scope of the Test Facility.

2.1.3 Ar S vs. Post Irradiation Examinations Facility

Ar S will serve the Post Irradiation Examination Facility
The boundary between Ar S and PIEF rooms is set at the internal part of the room walls, backward equipment are within the scope of the PIE Facility.

2.1.4 Ar S vs. Conventional Facilities

Ar S will serve some rooms of the IFMIF plant and eventually process enclosures hosted in the rooms.
The boundary between Ar S and CF rooms is set at the internal part of the room walls. Inlet and outlet grilles and backward equipment are within the scope of the HVAC System.
The boundary between Ar S and CF enclosures is set at the external wall of hot cells/glove boxes. Connection flanges and afterward equipment are considered within the scope of the PIE Facility.

2.2 Helium Supply System Interface description

2.2.1 He Gas S vs. Lithium Facility

Not Applicable.

2.2.2 He Gas S vs. Accelerator Facility

He Gas will serve the Accelerator Facility Cryoplant trough the He compressor

The boundary between He and AF enclosures is set inside the Helium compressor room Connection flanges and afterward equipment are considered within the scope of the Accelerator Facility.

2.2.3 He Gas S vs. Test facility

He gas will serve the TF Helium room for the tritium release test module system, Test Cell atmosphere control during irradiation campaign and Test Module cooling System.

The boundary between He and TF room's enclosures is set inside the Helium room of the TF. Connection flanges and afterward equipment are considered within the scope of the Test Facility and Test Cell: Lower Shielding Plug (LSP).

2.2.4 He Gas S vs. PIE Facility

He gas will serve the PIEF for the laboratory use.

The boundary between He and PIE Facility enclosures is set at the internal part of the room walls. Connection flanges and afterward equipment are considered within the scope of the PIE Facility.

2.2.5 He Gas S vs. Conventional Facility

He gas system will serve the CF dry pumps for the IFMIF vacuum system.

The boundary between He and CF Vacuum systems are set inside the CF vacuum rooms. Connection flanges and afterward equipment are considered within the scope of the CF.

2.3 Compressed Air Supply System, Interface description

2.3.1 CAS vs. Lithium Target Facility

CAS will serve the Lithium Target Facility (LF) rooms, only the area that is not involved with Lithium metal liquid to avoid the possible reaction if occur a direct contact of Lithium with air (In case of leakages or other circumstances) which may contain unacceptable humidity level; Argon gas shall be provided in such areas.

The boundary between CAS and LF is set at the internal part of the room walls. The equipment downstream of connection point is considered within the scope of the LF.

2.3.2 CAS vs. Accelerator Facility

CAS will serve the Accelerator Facility (AF) rooms.

The boundary between CAS and AF is set at the internal part of the room walls. The equipment downstream of connection point is considered within the scope of the AF.

2.3.3 CAS vs. Test Facility

CAS will serve the Test Facility (TF) rooms.

The boundary between CAS and TF is set at the internal part of the room walls. Connections and the equipment downstream of connection point are considered within the scope of the TF.

2.3.4 CAS vs. Post Irradiation Examination Facility

CAS will serve the Post Irradiation Examination Facility (PIEF) rooms.

The boundary between CAS and PIEF is set at the internal part of the room walls. Connections and the equipments downstream of connection point are considered within the scope of the PIEF.

2.3.5 CAS vs. Conventional Facility

CAS will serve the Conventional Facility (CF) rooms.

The boundary between CAS and CF is set at the internal part of the room walls. Connections and the equipment downstream of connection point are considered within the scope of the CF.

2.4 Nitrogen Supply System Interface description

2.4.1 N Gas S vs. Lithium Facility

Not Applicable.

2.4.2 N Gas S vs. Accelerator Facility

Nitrogen Liquid (LN2) will serve the Accelerator facility Cold box and a trap of the accelerator vacuum line of the vacuum system.

Nitrogen gas (N) will serve the Buffer tanks of the primary cooling water loops of the Accelerators to seal the tanks off from the air.

Nitrogen gas will serve the dry pumps for each vacuum system of the AF to purge shaft sealing devices.

Nitrogen gas will be supply along the Accelerator and the HEBT for venting to atmosphere the beam pipes or cavities prior to make maintenance or repair.

The boundary between N-LN2 and AF is set at the internal part of the room wall. The equipment downstream of connection points are considered within the scope of AF.

2.4.3 N Gas S vs. Test Facility

Nitrogen Gas (N) will serve the Test facility R110 Target interface room dry pumps for vacuum.

Nitrogen gas (N) will serve Utility room/ helium room of the TF.

Nitrogen gas (N) will serve the Buffer tanks of the primary cooling water loops of the TF to seal the tanks off from the air.

The boundary between N and TF is set at the internal part of the room wall. The equipment downstream of connection points are considered within the scope of TF.

2.4.4 N Gas S vs. PIE Facility

Nitrogen gas (N) will serve the PIE Facility globe box, to change the atmosphere from air to nitrogen.

The boundary between N and PIEF is set at the internal part of the room wall. The equipment downstream of connection points are considered within the scope of PIEF.

2.4.5 N Gas S vs. Conventional facility

Nitrogen gas (N) will serve the CF globe box detritiation system to regenerate a Cu catalyst.

Nitrogen gas (N) will serve the CF vacuum system dry pumps.

The boundary between N and CF is set at the internal part of the room wall. The equipment downstream of connection points are considered within the scope of CF Exhaust Gas Processing System.

3. System Design Requirements

3.1 General requirements

Input Data Requirements are defined as the data necessary to be defined in order to enable a system design that respects all the needs of the interfacing components.

Currently a draft set of data has been proposed. This list is partially complete and assessed by the PT on the base of the current references, of the outcomes of the Engineering Validation activities (i.e. prototypes) and on the standard engineering practice.

Parameters to be defined as *Input Data Requirements* for the SGS are, for each interfacing component:

- Argon grade (G3)
    - Purity (>99.999%)
    - O2 (<0.2 ppm)
    - Dew point (<-70 °C)
- Cooling media: (chilled/cooled water)

- Temperature: (°C)
- Temperature tolerance: (±°C)
- ΔT= (outlet temp) – (inlet temp): (°C)
- Supply Gas pressure: (MPa)
- Flow: (Nm^3/h)
- Change rate (Vol./h)

The following sections describe in detail the logic that brought to the selection by the PT of the current set of parameters.
Here below are listed the *Input Data Requirements:*

- cfr. Ref.Table 8: Argon Input Data Requirements 1/4
- cfr. Ref.Table 9: Argon Input Data Requirements 2/4
- cfr. Ref.
- Table 10: Argon Input Data Requirements 3/4
- cfr. Ref.Table 11: Argon Input Data Requirements 4/4
- cfr. Ref.Table 12: Helium Input Data Requirements
- The IFMIF Safety objectives, principles and criteria.
- The Hazard evaluation techniques, to be implemented on the next design phase

The entire document is uploaded on DMS: Safety Specifications Ref.doc BA_D_224X48 Ver.4.0 (cfr. Ref. [1]) and following updating. At the present time the Engineering Design for SGS follow the Safety approach mentioned on the guideline document, nevertheless it can be subject to some deviation or waves according the final IFMIF site selection. As well as the safety authority could give some further requirements.

3.2 Operation and Maintenance

Integrative maintenance plan is not yet described on this DDD, shall be defined clearly after having selected all the components for the SGS plant, preferable the maintenance plan shall be prepared by the suppliers, as well as regulatory maintenance requirements must be identified.
Minimum information required within the maintenance plan is listed below:

- Scheduled operation:
  - Controls
  - Checks
  - Adjustments
  - Calibrations
  - Overhauls
  - Replacements, etc.

Information provided from safety specification, Ref. doc. BA_D_224X48 Ver.4.0 (cfr. Ref. [1]) and of course will be implemented and identified as necessary by the supplier in order to ensure the best operation of the SGS system within its intended operational scenario.

- Critical unscheduled operations:
  - Replacements repair etc.

That may impact IFMIF availability and become essential to evaluate and to introduce an additional important support of recommended spare parts list, (provided by the suppliers) procedures, training, tools and test equipments, infrastructures.
The design of SGS shall accommodate long-term maintenance activities required to support IFMIF plant operation. For maintainability and inspectability, SGS system shall be designed in such a way that it can facilitate maintenance and, in case of failure, easy diagnostics safe repair or replacement and re-calibration. The SGS maintenance must be an ongoing endeavor. Any lapses in regular maintenance can result in system degradation and obvious loss of efficiency which could arose to serious health issue.
Maintenance requirement for SGS system and equipments mast be conform to the maintenance period defined for the IFMIF plant (particularly for the facilities that are not reachable during operation period)

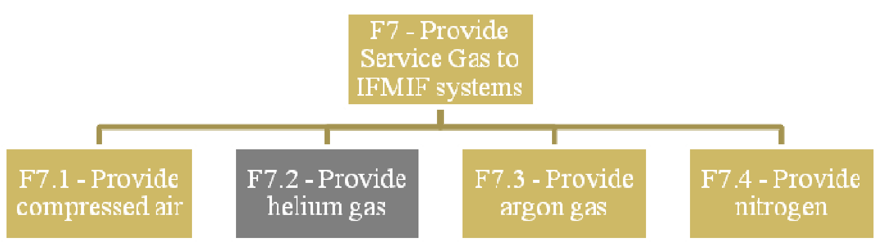
3.3 RAMI Requirements

Service Gas System have been designed for all modes IFMIF plant as well as shut down period. SGS should be realized for continuous operation, easily accessible for the purpose of operation and maintenance. The SGS have been designed in a way that; maintained and operated will meet the reliability and availability requirements, in a preliminary way identified on the conventional facility safety report. RAMI specification guide documents Ref. to doc. 22HA3G from J. M. Arroyo Feb. 2012 [6]and further preliminary study presented during former preparative version for RAMI status for CF, availability was 98% ref. BA_D_229V7H [2]

Detailed RAMI analysis devoted to SGS has been performed by Tractebel (ref. doc.[7]) dividing into different load groups to which the IFMIF system are associated.

The CF SGS model is based on the P&IDs D-1225-211 to D-1225-220 (ref to Figure 6-6 to Figure 6-9)

The SGS model is structured following the SGS system functions:



Only the functions having an impact on IFMIF availability are listed below Table 3:

Table 3: List of Functions

Function ID	Function	Criticality group
F1.7	Provide the other fluids	
F1.7.1	Provide compressed air	
F1.7.1.2	Provide compressed air to accelerator facility	A5
F1.7.1.4	Provide compressed air to test facility, conventional facility, etc	E0
F1.7.2	Provide Helium Gas	N/A
F.1.7.3	Provide Argon gas	
F1.7.3.1	Provide argon gas to R016bis (pit for electromagnetic pump and dump tank)	T3
F1.7.3.2	Provide argon gas to R016 Lithium loop cell	T3
F1.7.4	Provide Nitrogen	
F1.7.4.2	Provide liquid Nitrogen to Cryo plant and cold boxes for accelerator 1	A2
F1.7.4.3	Provide liquid Nitrogen to Cryo plant and cold boxes for accelerator 2	A2

The FMECA analysis established that unavailability of the CF Helium gas system would not impact on IFMIF availability. AF and TF have their own Helium source. It was discussed during FMECA that the CF Helium system was a backup for the other Helium systems. Therefore the CF Helium gas system has not been included in the RAMI analysis.

The detailed list of functions included in the model and their associated criticality group/recovery time is provided in the Table 3

3.3.1 Recovery time

A recovery time of the IFMIF facility has been added to the MTTR of each SGS components. Logically, a recovery time should be associated to a loss of an SGS function. However, it is not possible to directly allocate a recovery time to a function in Risk spectrum. In the model, the recovery time associated with a function has been introduced in the MTTR of all the components that are used to fulfill the function. In case a component is used in different SGS functions with different associated recovery times, the longest time is used. The component recovery time considered is coded in its name .

The choice of the recovery time is detailed hereafter:

- Compressed air supply system:
    - Compressed air to AF is essential because it is assumed that it supports cryogenic function for AF. Without compressed air it is conservatively assumed that AF stops in safe shutdown, with a significant restart time. Therefore components having a repair time longer than 3 hours have been assigned a recovery time A5 (1800 hours). When the repair time is shorter, a recovery time A3 (24 hours) has been assigned.
    - Compressed air is supplied to other users (TF, CF, etc) for pressure operated components. In this case it is assumed that loss of compressed air supply would not lead to any IFMIF recovery time, after repair of the component has been completed. A recovery time E0 has been assigned, i.e. 0 hours.

- Argon supply system: The argon constitutes the atmosphere of the rooms R016 (Lithium loop cell) and R016bis (pit for electromagnetic pump and dump tank), and is used to ensure also the negative pressure of these rooms. The highest criticality T3 has been chosen for the components which failure can cause damage due to ingress of air in the system. It is assumed that this air will react with the Lithium and damage the installations.
- Nitrogen supply system: in normal operation nitrogen is supplied continuously to the cryogenic plant and cold boxes for accelerator 1 & 2, to compensate evaporation. It is assumed that in case of loss of nitrogen supply IFMIF recovery time would be minimal, with recovery times A1 (1 hour) and A2 (4 hours) assigned (for a component repair time less or equal to 3 hours, and more than 3 hours respectively).

3.3.2 Specific model assumptions

The generic model assumptions are here below described. The additional assumptions specific to the SGS model are hereunder listed:

- Compressed air:

  - One instrument air compressor K-201A/B, plus its associated instrument air dryer U-202A/B and butterfly valve is considered as one item in the model, called an air supply unit. The 2 air supply units have a 2 x 100% capacity.
  - The pressure safety valve on air vessel V-203 is considered as a safeguard, and not included in availability study.
  - The same failure rate and MTTR values are used for globe valves and butterfly valves.
  - The common supply line from the air vessel V-203 to users is assumed to measure 200m.
  - Both pipes from the common line to AF and to other users are assumed to measure 30m.
  - The end cap on the main gas line has been modeled as a gas pipe connector/flange, with the corresponding failure rate and MTTR listed in the FEEL original database.
- Argon supply system:
  - The model is limited to the loop providing argon gas to the rooms R016 (Lithium loop cell) and R016bis (Pit for electromagnetic pump). The liquid argon supply part has not been considered as continuously required for the IFMIF normal operation.
  - The design of the Argon purification system U-003 is not known. It has been assumed that the argon purification system has the same global failure rate and time to repair as a gas filter.
  - The argon purification system U-003 and the connection to the VDS are continuously required in order to maintain the negative pressure of these rooms.
  - The lithium pneumatic instrumentation use argon instead of air. However, this function is not present on the P&ID and the design is not known. This function of the argon supply system has not been considered in the model.
- Nitrogen:
  - Pressure safety valves and check valves are considered as safeguards, and not included in the availability study.
  - The length of the common liquid nitrogen pipe is assumed to be 30m.
  - Both pipes from the common nitrogen pipe to cryo plant and cold boxes for accelerator 1 and 2 are assumed to measure 200m.

3.3.3 Results

The availability results are described in the following table:

Risk Spectrum Fault Tree	Description	Time Dependent	Availability %

		Unavailability (TD Mean)	
CSG-0-GENERAL	**SGS**	**2.57E-02**	**97.43**
CSG-7.1	SGS – compressed air	1.73E-02	98.27
CSG-7.3	SGS – argon gas	8.40E-03	99.16
CSG-7.4	SGS – nitrogen	1.22E-06	99.99988

In this case the three SGS functions 7.1, 7.3 and 7.4 are independent and the overall availability is the product of each function's availability.

3.3.4 Components and parameters susceptible to be problematic

3.3.5 Overall service gas system

The overall minimal cut set list shows that, in the current model, the two air supply units in the compressed air system are the most critical items in the overall SGS, with failure of both units simultaneously accounting for 71.5% of overall unavailability, due to the resulting long period of recovery for IFMIF of 2.5 months. This long recovery time is due to the fact that in case of compressed air failure, cryogenic function will stop and the accelerators will shut down. This in turn requires a long procedure to restart the accelerators.

The next critical items are the argon system motor valves to and from HVAC (see below), with 8.8% each (considering both failure modes: fail to control and leakage).

3.3.6 Compressed air supply system

In the current model 98% unavailability of the compressed air supply system comes from failure of both air supply units simultaneously. They have been modeled as compressors in parallel with 2 x 100% capacity, with a failure rate of 1.00E-04 per hour, a basic MTTR of 10 hours, a detection/access time of 1 hour, and a significant IFMIF recovery time of 1800 hours (A5).

Despite redundancy in the system, these components are shown to be critical for operation in the current model. This is believed to be due to the conservative modeling of 'AND' gate in Risk Spectrum, which is investigated in a sensitivity study (Ref. section 3.3.9

3.3.7 Argon supply system

From the minimal cut set list, it can be seen that the critical equipments are the valves in interface between the Argon supply system and the HVAC. Indeed, any failure of these valves (spurious opening or internal leak) will lead to ingress of air and potential damage to the lithium facility.

More than 90% of the Argon supply system unavailability is generated by the failures of these valves in interface between the Argon supply system and the HVAC. The failure of one of these valves that have a relative high failure rate will directly lead to a long period of unavailability due to the associated recovery time.

Based on the importance analysis results, it is obvious that the failure rate and mean down time of these components are critical for the availability calculation. A variation of these parameters will lead to a significant improvement or degradation of the availability.

3.3.8 Nitrogen supply system

The largest contributor to unavailability of the nitrogen supply system is the liquid nitrogen tank V-311, with 8.2% contribution. The next contributors are the twelve globe valves, with 7.3% contribution each.

3.3.9 Sensitivity and Degraded cases

In order to assess the model and challenge some uncertainties, different sensitivity cases have been computed.

3.3.10 Overall service gas system

In order to assess the availability of the SGS as a stand-alone system, the FTA model was run after removing all IFMIF recovery times in the components' MTTR/MDT.

The availability results for the stand-alone system are given in the following table:

Risk Spectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Stand Alone Availability %
CSG-0-GENERAL	SGS	9.05E-05	99.99095
CSG-7.1	SGS – compressed air	4.37E-06	99.99956
CSG-7.3	SGS – argon gas	8.54E-05	99.99146
CSG-7.4	SGS – nitrogen	6.97E-07	99.99993

An examination of the minimal cut set list shows that in this case the components with the highest impact on SGS availability are the argon system motor valves to and from HVAC, with 22.1% each (considering both failure modes: fail to control and leakage). The next item is the Argon purification system U-003 with 17.9%. Together the three Argon system motor valves and the Argon purification system make 84.3% of total SGS unavailability in the stand-alone mode.

3.3.11 Compressed air system

The compressed air supply units' failure rate is an important parameter in the model. In order to assess its sensitivity, two cases have been analyzed with some variation of the failure rate:

1. Air supply units' failure rate multiplied by 10 (i.e. failure rate of 1.00E-03 per hour)

Risk Spectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability % (air unit FR increased)
CSG-7.1	SGS – compressed air	3.22E-01	67.8

2. Air supply units' failure rate divided by 10 (i.e. failure rate of 1.00E-05 per hour)

Risk Spectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability % (air unit FR decreased)
CSG-7.1	SGS – compressed air	4.09E-04	99.9591

Instead of having two air supply units in parallel (2 x 100%), increase redundancy with three air supply units in parallel has been analyzed (3 x 100%). The results are shown below:

Risk Spectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability % (3 x 100% capacity)
CSG-7.1	SGS – compressed air	1.75E-03	99.825

Due to the significant impact on IFMIF with large recovery times, it is recommended to improve the availability of the compressed air system (and therefore the availability of the overall SGS) by either acquiring reliable air supply units (with a FR of 1.00E-05 per hour) or increasing the redundancy of the air supply to 3 x 100% capacity

3.3.12 Argon supply system

A sensitivity case that considers two valves in series for each interface between the argon supply system and the HVAC has been performed. The availability figure of the argon supply system becomes:

Risk Spectrum Fault Tree	Description	Time Dependent Unavailability (TD Mean)	Availability %
CSG-7.3	SGS - Provide argon gas	4.81E-04	99.952

The interface valves between the argon supply system and the HVAC should be redundant in order to avoid any spurious ingress of air in the argon system and to guarantee high argon supply system availability.

3.3.13 Nitrogen supply system

No sensitivity analysis was performed on the nitrogen supply system, as its overall availability of 99.999 is already excellent.

3.4 Applicable Codes and Standard Requirements

International standards have been selected for the design of the SGS in particular:

- The equipment for (SGS) shall be designed according to safety specification for the engineer design activities IFMIF ref. BA_D_224x48 (Le Tonqueze Y.[1]) in accordance with the pressure equipment directive (PED) 97/23Ec.
- Code and standards for SGS mechanical components shall follow the general IFMIF specification: Applicable Codes and standards for the CF design, in addition the following codes and standards shall be applied:
  - API 510- testing of valves.
  - ASME B31.3- process piping.
  - ASME B73.2M-Vertical in-line pumps.
  - ASME section IX- welding and brazing qualification.
  - ASME section V- nondestructive examination.
  - ASME/ANSI B.16.25- Pipes, valves, fittings and flanges butt weld ends.
  - ASME/ANSI B16.34-Valves, flanges, threaded and welding end.
  - EN 13445 – Pressurized Vessels design
  - EN 13480 – Metallic Piping

– ISO 10648: Containment Enclosure:
  - 10648-1:1997: Design Principle
  - 10648-2:1994: Classification according to leak tightness and associated checking methods.

– ISO 4427 and DIN 8074-HDPE pipes.

4. System Design Description

4.1 Design Summary

For this section you can refer to the System Functions and Basic configuration (cfr. Ref. Section;1)

4.2 Safety

Refer to Safety specifications for the Engineering design Activities of IFMIF ref. doc. BA_D_224X48 Ver. 4.0 and following updating (cfr. Ref. [1])

4.3 Assumptions

General assumptions / requirements have been considered as per the following:

4.3.1 Argon Supply System PBS - 5.3.5.1

- Supplying Frequency

  The supplying frequency of liquid argon to the main Argon Tank (25m³) have been assumed at once replacement with interval of 4 weeks or less times except for rare cases.

- Supplying Conditions

  Pressure 0,8 MPa (G)
  Temperature Ambient (AMB)

- Degree of Purity
  Argon will be provided Grade 3 for the two purposes:
  - General purpose
  - High purity

As per the following table:

	Grade 3	Remarks
Purity	> 99.999%	

N_2	-	
O_2	< 0.2ppm	
Dew Point	≦ -70℃	
H_2O	-	

Table 4: Argon Grade 3, characteristics

In accordance with IFMIF Safety Specifications nitrogen; oxygen; and water vapors is to be held under 5 ppm respectively.

- Enclosure Leak Tightness; in accordance with ISO 10648-2 (see below table) Class 1 Leak Tightness is applied to Argon filled cells and glove boxes.
- Impurity concentration of the atmosphere of the Argon filled cells; in accordance with IFMIF Safety Specifications the relative humidity is to be maintained at 2% or lower at 21 ºC.

4.3.2 Helium Supply System PBS - 5.3.5.2

- Supplying Frequency
    - We have two Helium storage tanks: one for the Accelerator Cryo-plan composed of 4 Helium storage tanks each of 100 m³ and the second He tank of 25 m³ for to supply helium to the Test Cell and PIE Laboratory. Helium storage tanks for the Accelerator have the function of buffer tank, there is no a real consumption for these tanks. The He large capacity are necessary for to recover all the purge He gas in case of the machine with a general warming-up (all the liquid He is boiled off and transferred in these tanks) Generally, for this type of He closed loop, a periodically re-filling could be set every 6 months to compensate the small leak (compressors, temporary purging for regeneration of Cold Box absorbers and so on) with an amount of approximately 500 liters of liquid. The supply frequency of helium for the other He tanks of 25m³ is assumed every two-three weeks, hence approximately 20m³ per month or less except for rare cases.

- Supplying Conditions
    - Pressure 14.7 MPa (G) (stored in the tanks)

- Supply to the system at 0.8 MPa. (G)
- Temperature Ambient (AMB)

Degree of Purity

	General Purpose	Remarks
Purity	≧ 99.995%	
N_2	≦ 20ppm	
O_2	≦ 5ppm	
Dew Point	≦ -60℃	
H_2O	(≦ 5.3ppm)	

Table 5 – Degree of Purity of Helium.

4.3.3 Compressed Air Supply System PBS - 5.3.5.3& Breathable Air System PBS - 5.3.5.4

- Supplying Pressure
  - The assumed supplying pressure is 0.69 MPa (G) or higher.
- Supplying Conditions
  - Pressure 0.69 MPa (G)
  - Temperature Ambient (AMB)
  - Flow rate 200 Nm^3/h (for instrumentations)

- Flow rate 60 Nm³/h (Breathable air Supply 0.085m³/min.pr person, considered 10 at once)

Note: The breathable air distribution is independent and provided with efficient filter for to ensure the high level of quality suitable for to be breathed. Details for the components and its installation are shown on Table 16: S-1224-201- SGS Equipment List - PBS 5.3.5.0.0.And Figure 6-11: Compressed Air technical room, R307

Degree of Purity:

	Instrumental Air	**Breathable Air**	**Remarks**
Oil Content	Oil free	-	
Dew Point	≦ -40°C	5°Cat 0.69MPa(G)	
CO_2	-	≦ 1000ppm	
CO	-	≦ 5ppm	
Odor	-	Not recognized	

Table 6: Degree of Purity of Compressed Air

4.3.4 Nitrogen Supply System PBS - 5.3.5.4

Supplying Frequency

The supplying frequency of liquid nitrogen is assumed interval of 6 days for one accelerator and 3 days for two accelerators (Considering the short term frequency filling the tanks i.e. 3 days, could be analyzed the possibility to produce the nitrogen on site) we have two tanks one of 50m³ for the accelerators without nitrogen evaporator and the second one of 25m³ for the PIE facility (cold boxes, GDS) Conventional facility and for the primary cooling system buffer tank's seal. For the accelerators consumption of LN2 are not well known for the moment. It depends on the cryostats and cold box consumptions. Nevertheless, a rough estimation leads to a maximum of 300 l/h (including 2 × 130 l/h for He. refrigerator plus various utilities) Hence assumption of two or three days of refilling the tank of 50m³.

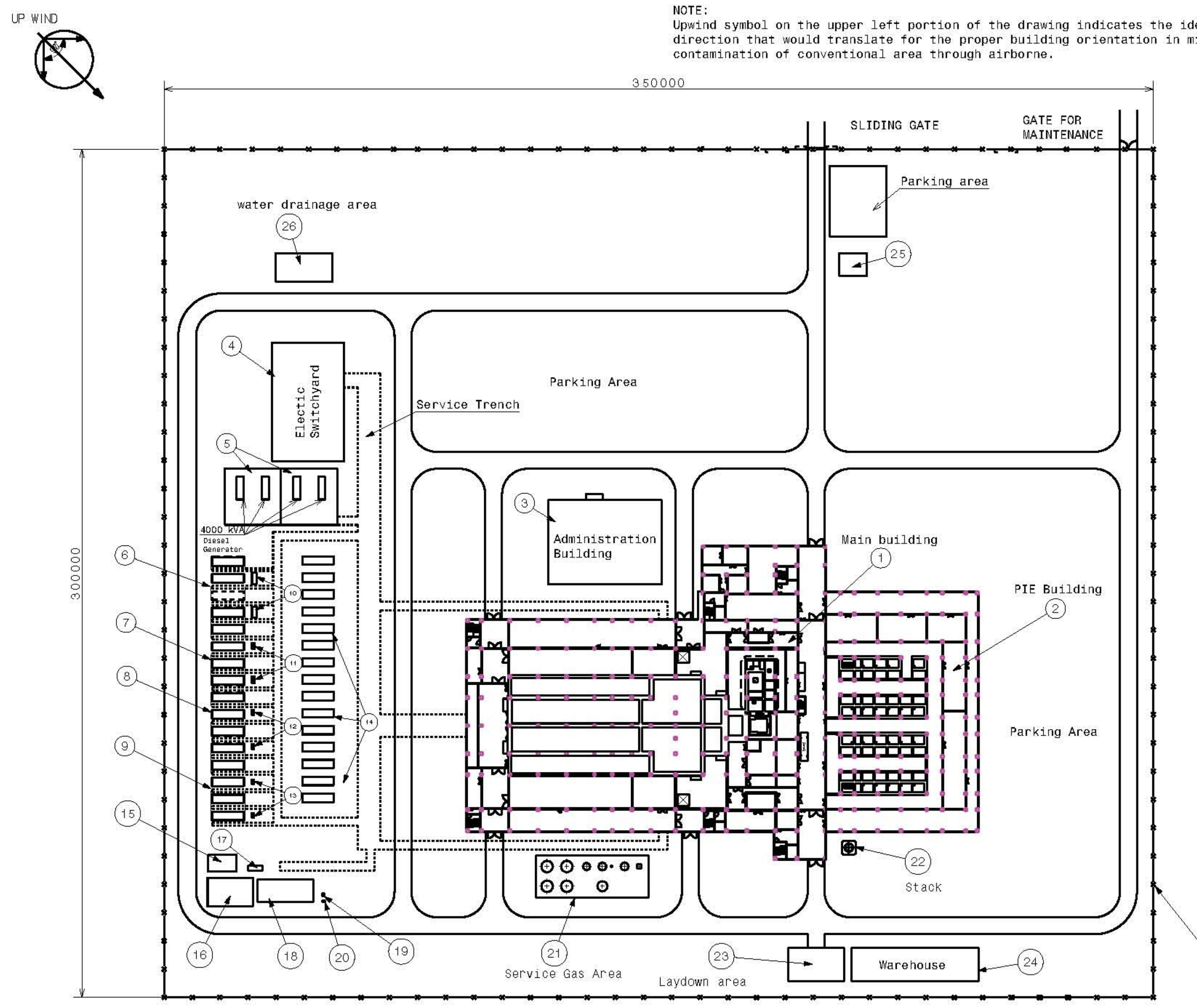
For the other LN2 storage tank of 25 m³ we assume to refill with a frequency of one month.

- Supplying Conditions:
  - Pressure 0.8 MPa (G)
  - Temperature Ambient(AMB)

Degree of Purity;

	General Purpose	Remarks
Purity	≧ 99.995%	
O_2	≦ 50ppm	
Dew Point	≦ -60℃	

Table 7: LN2 degree of purity



BUILDING/SHELTER/EQUIPMENT LIST			
No	Name	Area Size(m^2)	Remark
1	Main Building	11053.8	
2	PIE Building	4596.1	
3	Administration Building	1200.0	occupant load 200max 200 X 12m2 = 2400m =30m X 40m X 2 stories
4	Electrical Switchyard	1071.0	
5	Disel Geenrator House	400.0	2 Units, each with 2 Generator of 4000kVA
6	Cooling Tower Unit-1 for componemts inside Accelerator Vault	192.0	3 cooling towers 2 in 1^{st} phase of capacity 1.8MW 1 in 2^{nd} phase of capacity 1.8MW
7	Cooling Tower Unit-2 for TF,LF and PIE	216.0	5 Cooling towers, total capacity 23.3MW
8	Cooling Tower Unit-3 for BD & HEBT	192.0	3 cooling towers 2 in 1st phase of capacity 2MW 1 in 2nd phase of capacity 2MW
9	Cooling Tower Unit-4 for AF componemts, out Accelerator Vault	216.0	5 cooling towers 3 in 1st phase of capacity 10MW 2 in 2nd phase of capacity 10MW
10	Secondary CW Pump	6.4	2 nos 2200 m^3/h
11	Secondary CW Pump	1.98	2 nos 860 m3/h
12	Secondary ChW Pump	1.35	2 nos 580 m3/h
13	Tertiary CW Pump	0.975	2 nos 340 m3/h
14	Chillers for Cooling/Heating	37.0	13 chillers for Heatign/Cooling 2 Chillers for Heating
15	Firewater Pumps Shelter	60.0	Diesel and Electrical Pump
16	Firewater Pond	160.0	
17	Potable water tank	10.0	
18	Industrial water supply tank	160.0	
19	Potable Water Supply Unit	0.73	
20	Industrial water Pump	0.51	
21	Service Gas Area	600.0	4 He tanks, each of 100m^3 1 He tank of 25m^3 1 Liq. N_2 Tank of 25m^3 1 Liq. N_2 Evaporator 70Nm^3/h 1 Liq. N_2 Tank of 50m^3 1 Liq. Ar Tank of 25m^3 1 Liq.Ar Evaporator of 400Nm^3/h
22	Stack	25.0	
23	Lay-down area	240.0	
24	Warehouse	540.0	SIZE COLLECTED FROM ORIGINAL SITE LAYOUT
25	Access Gate	80.0	
26	Water Drainage area	200.0	This includes industrial water drainage system, sanitary water drainage system and precipitation water drainage system

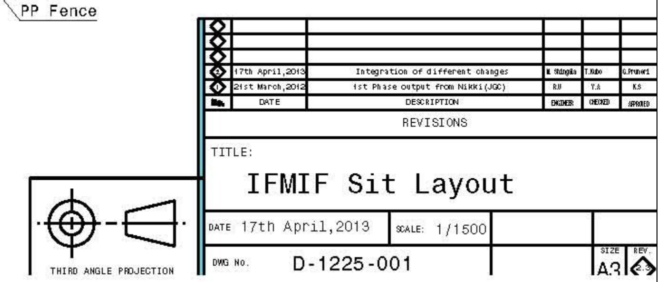


Figure 4-1: IFMIF overall view, outdoor SGS He-LN2 and LAr storage tanks configuration.

4.3.5 SIC Classification

According to the classification proposed in Safety Specifications (cfr. ref [1]) and Safety Important Class-SIC, Methodology, Classification & Requirements (cfr. Ref. to Doc. BA_D_228V5Q Version 1.2 ref [4] ;
The system has been classified as follows:

- SIC-1 for **Argon Supply System**. On former preparative version, we had two type of Ar. Gas: General purpose and High purity (for the maintenance) for the present DDD we have selected one type of Ar. gas belong to grade 3 that can satisfy both application for the case of LF (High purity Argon System and General Purpose Argon) for this reasons we kept the SIC classification as SIC-1, hence considered conservative solution to avoid any possible risk that, Lithium may have a contact with an atmosphere not suitable.

- The characteristics of Ar.; **<u>Grade 3</u>** are here below described:
  - Argon grade (G3)
  - Purity (>99.999%)
  - O2 (<0.2 ppm)
  - Dew point (<-70 °C)

- SIC- SR/non-SIC for **Helium Supply System**
- SIC-1 for **Compressed Air Supply System**
- SIC-1 for **Breathable Air supply System**
- SIC-SR/non-SIC for **Nitrogen Supply System**

4.3.6 Redundant Equipment

Redundancy of the equipment should contribute to the target availability value of the Conventional Facilities (J.M. Arroyo, Availability of CF is 98%), ref. BA_D_229V7H (cfr Ref. [2]). At this stage of the project a complete RAMI Analysis has not been performed (due to the high variability of the parameters, such a procedure has not been considered worthwhile) (Ref. to Sect. 3.3). By the way some assumptions have been made on the base of the standard engineering practice.
Simple redundancy is addressed to components that can cover 100% of the requirements (100% × 2).
Multiple redundancy is considered when requirements can be fulfilled by a set of components (*n* components) working together ([100%/*n*] × [*n*+1]).

4.4 Detailed Design description

According to the classification proposed in CDR (cfr. Ref. [5]) a further SGS System subdivision has been proposed with slightly changes to meet the safety regulations and system flexibility:

4.5 System Performance Requirements

The system performance basic functions are indicated on the P&ID's of SGS (cfr. Ref. Figure 6-6, Figure 6-7, Figure 6-8 and Figure 6-9

4.6 System Arrangement

4.6.1 Equipment arrangement Drawings

Refer to the next (Ref. Sect.4.7) Component Design Description

4.7 Component Design Description

For this purpose we have detailed the list of the SGS components necessary for the all SGS system of IFMIF plant, the information are integrated on the document called Equipment List SGS system (Ref. Table 16: S-1224-201- SGS Equipment List - PBS 5.3.5.0.0.) The Equipment List represents all the SGS components, on the list following detailed information are provided:

- Item NO
- Service
- QTY
- Material type
- Type of component
- Specification
- Main Dimension
- Electrical output rate (kW)
- Location on the IFMIF Building (Area/room's number)

4.8 Instrumentation and Control

SGS Central Control System (CCS) shall be conforming to standards, specifications and interfaces as documented in the CC&CI - DDD document ref. BA_D_23RU2B.
CC&CI will ensure the integrated supervision control of overall IFMIF plant and plant system operation. These functions will be available in master control room SGS shall have its own plant control system (PCS) that will allow to know the status of the reserve storage tanks, flow, pressure, purity conditions of the distributed gases (gaseous or liquid conditions) SGS -PCS shall integrate the individuals control system of each of the SGS and served IFMIF subsystems in the various facilities of the plant.
Information from the data is available in the SGS local control system (PCS) shall be transferred to CC&CI to allow a complete and reliable operation of the SGS. The instrumentation and control components shall include all Computers hardware and software required to control the SGS plant system, including input/output (I/O) interfaces and plant system interlocks. These requirements shall be established based on the preliminary design of the SGS. Sufficient instruments shall be included in SGS plant

system to monitor components performance within the design envelope and to alarm plant operators on the onset of operation outside design margin (particularly for the Gas leakages detection, leak tightness for the cells (in the case of Argon and helium) flow rate, pressure rate, humidity level, purification efficiency, etc. Instrumentations shall include: pressure and temperature flow sensor to measure/monitor performance and allow independent control of components for the system. In addition, instruments shall be installed to monitor all necessary parameters useful for the regular and safety functionality of the SGS, the instrumentations indicated is descriptive but not limited, specific instrumentations and control requirements for SGS system shall be established on the next step of this document; now we can refer to the SGS P&ID (cfr. Ref. Figure 6-6, Figure 6-7, Figure 6-8 and Figure 6-9)

4.9 Status of R&D activities and future plans

Not applicable for this system.

5. List of References

5.1 References

[1] Y. Le Tonqueze, *Safety Specifications for the EDA of IFMIF*, BA_D_224X48
[2] J.M. Arroyo, Availability of CF is 98%, ref. BA_D_229V7H .0
[3] F. Arbeiter Test Facility Utility Room DDD III doc. BA_D_22XRTP
[4] Y. Le Tonqueze, Safety Important Class-SIC Ref. BA_D_228V5Q rev. 1.2
[5] IEA, IFMIF Comprehensive Design Report
[6] RAMI Specifications guide documents Ref. to doc. 22HA3G from J.M. Arroyo Feb. 2012
[7] RAMI analysis SGS 97.43 %, Tractebel Ref. IFMIF/4NT/276784/005/01

6. Appendices

6.1 List of Documents

6.1.1 Drawings (PFD's, P&ID's 2D drawings & Excel file)

6.1.2 Layout Plan for SGS

This section reports the preliminary SGS layout, main components and outdoor Storage tanks. The layout is divided by floor whenever the SGS components present and is represented the overall dimensions of the SGS's equipment (whenever considered necessary) these layouts enable the Building designer to validate the size of the components for SGS technical rooms and all the area where are foreseen SGS component's installation.
These drawings together with CF piping layout should help to have a clear picture of the components that take part in the system definition and of the main interactions among them.

Layout Plan for SGS is considered as a preliminary document for the system design, could be slightly modified by a updating in the input data or IFMIF layout changes.
(Ref. to Figure 4-1: IFMIF overall view, outdoor SGS He-LN2 and LAr storage tanks configuration).

6.1.3 SGS's Input data requirements.

Table 8, Table 9,
Table 10, Table 11, Table 12, Table 13, Table 14 and Table 15, are shown values assumed for the elaboration of engineering design.

6.1.4 Process Flow Diagram SGS (PFD)

Ref to: Figure 6-1, Figure 6-2, Figure 6-3, Figure 6-4

6.1.5 Equipment List SGS System

Identified on; Table 16: S-1224-201- SGS Equipment List - PBS 5.3.5.0.0.

6.1.6 Equipment Layout, installed on the Conventional rooms.

These Figure shown various components for SGS i.e. mainly storage tanks, evaporators, fans and blowers, coolers, purification equipments etc. that are clearly identified by type on the List of Equipment and are belong to the SGS (Ref. to Figure 6-10: Argon Purification System, Room 228 and Figure 6-11: Compressed Air technical room, R307)

6.2 List of Computer Programs

Not applicable

6.3 Others

General consideration:

Compressed air (instrumentation) Nitrogen and Argon should be available in all working areas as standard equipments except in those where a gas is specifically excluded, it is cheaper to install the piping during construction than being requested to do it during operation.

IFMIF operational state	Cells to be served	Cell name	References/assessment/ assumptions	Cell volume (m^3)	Ar atmosphere change rate (vol/h)	Ar flowrate (Nm^3/h)	Leak tightness of the cells (h^{-1})	Leak rate of air (m^3/h)	Maximum relative humidity tolerable* (%)	Ar flow necessary to respect the relative humidity in the cell (Nm^3/h)	Argon purification system efficiency (%)	Recovered argon flow (Nm^3/h)	Fresh Ar consumption due to the Ar purification system (Nm^3/h)	Special requirements
Operation		Pit for Electro magnetic pump and dump tank	- During operation a continuous Ar athmosphere is required - Leak tightness and leak rate derived from ISO 10648 classification (see assumptions) - Ar Atmosphere change rate assumed tentatively according to the standard engineering practice - Maximum RH assumed in accordance with " *Safety Specifications for EDA of IFMIF* " - Ar flow necessary to respect the cell atmosphere derived from the maximum relative humidity admissibile inside Ar-filled cells - Fresh Ar consumption derived considering the efficiency of the Ar purification system		1-5/h		5.0E-04 h-1		2%	Nm3/h	70%	0. Nm3/h	Nm3/h	
Operation		Lithium loop cell	**As pe above**		1-5/h	--	5.0E-04 h-1		2%	Nm3/h	70%	--	--	
Operaton		Lithium trap cell	**As pe above**		5-10/h	--	5.0E-04 h-1		2%	--	70%	--		
Operation		PIE Facility	- Argon Flow should be an outcome of the PIE Facility design - During operation a continuous Ar athmosphere is required - Value tentatively assumed		TBD	--	?		2%	--	70%	--		
IFMIF operational state	**Cells to be served**	**Cell name**	**References/assessment/ assumptions**	**Cell volume (m^3)**	Air atmoshere	**Ar flowrate (Nm^3/h)**	**Leak tightness of the cells (h^{-1})**	**Leak rate of air (m^3/h)**	**Maximum relative humidity tolerable***	**Ar flow necessary to respect the relative**	**Argon purification system efficiency**	**Recovered argon flow (Nm^3/h)**	**Fresh Ar consumption due to the Ar purification**	**Special requirements**
Maintenance		Pit for Electro magnetic pump and dump tank	- During maintenance Li Loop is not working. The cell will be ventilated with air, so Ar Supply System is not in charge of the service		1-5/h	--	--	--	--	--	--	--	--	
Maintenance		Lithium loop cell	- During maintenance Li Loop is not working. The cell will be ventilated with air, so Ar Supply System is not in charge of the service		1-5/h	--	--	--	--	--	--	--	--	

Table 8: Argon Input Data Requirements 1/4

Maintenance		Lithium trap cell	- During maintenance Li Loop is not working. The cell will be ventilated with air, so Ar Supply System is not in charge of the service		5-10/h	--	--	--	--	--	--	--	--	
Maintenance		PIE Facility	- It has been assumed that during maintenance, no argon is supplied		TBD	--	--	--	--	--	--	--	--	
Maintenance		Test Cell	- Argon Flow should be an outcome of the Test Facility design - During maintenance a continuous Ar supply is assumed to be required - Flow tentatively assumed		--	--	--	--	--	--	--	--		Durin maintenance, when open the TC plug, argon flow curtain is required to be ensure keeping the separation from TC - Access cell
IFMIF operational state	**Cells to be served**	**Cell name**	**References/assessment/ assumptions**	**Cell volume (m^3)**	**Maximum air concentration after atmosphere change (vol%)**	**Number of atmosphere changes required to change atmosphere**	**Maximum time required to change atmosphere (days)**	**Argon supply required (Nm^3/h for 2 days)*****	**Special Requirements**					
Atmosphere change from Air to Argon		Pit for Electro magnetic pump and dump tank	- Maximum air concentration assumed - maximum time required to change atmosphere tentatively assumed standard engineering practice		1 vol %	5	2 d							
Atmosphere change from Air to Argon		Lithium loop cell	- Maximum air concentration assumed - maximum time required to change atmosphere tentatively assumed standard engineering practice		1 vol %	5	2 d							
Atmosphere change from Air to Argon		Lithium trap cell	- Maximum air concentration assumed - maximum time required to change atmosphere tentatively assumed standard engineering practice		1 vol %	5	2 d							
Atmosphere change from Air to Argon		PIE Facility	- The assumption is that this room does not take part in the atmosphere change		1 vol %	5	2 d							
Atmosphere change from Helium to Argon		Test Cell			1 vol %	--								During TC experiment test modules replacement
IFMIF operational state	**Cells to be served**	**Cell name**	**References/assessment/ assumptions**	**Cell volume (m^3)**	**Hazzard Material**	**Number of atmosphere changes required to change atmosphere**	**Maximum time required to change atmosphere (days)**	**Argon Supply**	**Special Requirements**					

Table 9: Argon Input Data Requirements 2/4

Operation and maintenance		Cooling/Storage Pit-1	To extinguish the fire in case of accident, mainly caused by Metal Liquid handling (we need to provide Argon gas to the cell with an automatic sprinkler in case of fire detection.(the Ar. Supply should be studied according to Fire protection analysis's, may be independent with dedicated Ar. gas cylinders or centralized with sprinkler net)		Metal liquid handling	NA	NA		To select the system; Local, dedicated or centralized.	
Operation and maintenance		Cooling/Storage Pit-2	To extinguish the fire in case of accident, mainly caused by Metal Liquid handling (we need to provide Argon gas to the cell with an automatic sprinkler in case of fire detection.(the Ar. Supply should be studied according to Fire protection analysis's, may be independent with dedicated Ar. gas cylinders or centralized with sprinkler net)		Metal liquid handling	NA	NA		To select the system; Local, dedicated or centralized.	
Operation and maintenance		Cooling/Storage Pit-3	To extinguish the fire in case of accident, mainly caused by Metal Liquid handling (we need to provide Argon gas to the cell with an automatic sprinkler in case of fire detection.(the Ar. Supply should be studied according to Fire protection analysis's, may be independent with dedicated Ar. gas cylinders or centralized with sprinkler		Metal liquid handling	NA	NA		To select the system; Local, dedicated or centralized.	
Operation and maintenance		Tr. Hot Cell	To extinguish the fire in case of accident, mainly caused by Metal Liquid handling (we need to provide Argon gas to the cell with an automatic sprinkler in case of fire detection.(the Ar. Supply should be studied according to Fire protection analysis's, may be independent with dedicated Ar. gas cylinders or centralized with sprinkler		Metal liquid handling	NA	NA		To select the system; Local, dedicated or centralized.	
Operation and maintenance		Component handling Cell	To extinguish the fire in case of accident, mainly caused by Metal Liquid handling (we need to provide Argon gas to the cell with an automatic sprinkler in case of fire detection.(the Ar. Supply should be studied according to Fire protection analysis's, may be independent with dedicated Ar. gas cylinders or centralized with sprinkler		Metal liquid handling	NA	NA		To select the system; Local, dedicated or centralized.	

Table 10: Argon Input Data Requirements 3/4

Operation and maintenance		Rig Handling Cell (RHC)	To extinguish the fire in case of accident, mainly caused by Metal Liquid handling (we need to provide Argon gas to the cell with an automatic sprinkler in case of fire detection.(the Ar. Supply should be studied according to Fire protection analysis's, may be independent with dedicated Ar. gas cylinders or centralized with sprinkler		Metal liquid handling	NA	NA		To select the system; Local, dedicated or centralized.			
Operation and maintenance		Test Module/Rig Assembling cell (RAC/TMAC)	To extinguish the fire in case of accident, mainly caused by Metal Liquid handling (we need to provide Argon gas to the cell with an automatic sprinkler in case of fire detection.(the Ar. Supply should be studied according to Fire protection analysis's, may be independent with dedicated Ar. gas cylinders or centralized with sprinkler net)		Metal liquid handling	NA	NA		To select the system; Local, dedicated or centralized.			
Operation and maintenance		Access Cell	To extinguish the fire in case of accident, mainly caused by Metal Liquid handling (we need to provide Argon gas to the cell with an automatic sprinkler in case of fire detection.(the Ar. Supply should be studied according to Fire protection analysis's, may be independent with dedicated Ar. gas cylinders or centralized with sprinkler net)		Metal liquid handling	NA	NA		To select the system; Local, dedicated or centralized.			

Table 11: Argon Input Data Requirements 4/4

Input Data Requirements SGS (He)							
Facility	IFMIF operational state	Equipment to be supplied	References/assessment/assumptions	Helium consumption (m^3/h)	Centralize storage tank	He consumed in the supplying interval (m^3)	Special requirements
Test Facility	Operation	Tritium Release Test Modules (TRM)	- Helium Flow should be an outcome of the the Test Facility design	TBC	Yes/local	TBC	8 bar. to the TF
Test Facility	Operation	Test cell atmosphere	- Helium Flow should be an outcome of the the Test Facility design	60m³/h 100% 1 year plus 10% montly integration	Yes/local	60m³/h 100% 1 year plus 10% montly integration	8 bar. to the TF
Test Facility	Operation	Test module cooling system	- Helium Flow should be an outcome of the the Test Facility design	16m³/h 100% 1 year plus 10% montly integration	Yes/local	16m³/h 100% 1 year plus 10% montly integration	8 bar. to the TF
Acceler. Facility	Operation	Cryo plant	- Helium Flow should be an outcome of the the Accelerator Facility design	TBC	Yes/local	400 m³ Storage	
PIE	Operation	Laboratory use	- Helium Flow should be an outcome of the the PIE Facility design	TBC	Yes/local	TBC	8 bar. to the TF
Facility	IFMIF operational state	Equipment to be supplied	References/assessment/assumptions	Volume to be supplied with Helium (m^3)	Special requirements		
Test Facility	Maintenance	Tritium Release Test Modules (TRM)		NO supply			
Test Facility	Maintenance	Cooling of the liner		NO supply			
Test Facility	Maintenance	Test cell atmosphere		NO supply			
Test Facility	Maintenance	Test module cooling system		NO supply			
Acceler. Facility	Maintenance	Cryo plant		NO supply			
PIE	Maintenance	Laboratory use		NO supply			

Table 12: Helium Input Data Requirements

Reference Assesment /assumption; Value tentatively assumed for the whole plant according to a first assessment based to the standard engineering practice					
Breathable air System		Criteria	Maximum number of people to be supplied with Breathable Air	Air required for each person (m^3/min)	Breathable air system capacity (Nm^3/h)
		Utilities to be served assumed according to the standard engineering practice	10	0.085 Nm3/min	51 Nm3/h
Instrument air system	**Instrument air flow (Nm^3/h)**	**Instrument device's location**	**Breathable air system capacity (Nm^3/h)**	**Breathable air device's location**	
PIE Facility	35. m3/h	TBD	51. m3/h	TBD	
Accelerators	80. m3/h	TBD		TBD	
Other (TC -CF-etc.)	25. m3/h	TBD		TBD	
Total (Nm^3/h)	140 **m3/h**		**51. m3/h**		

Table 13: Compressed Air Input Data Requirements

Liquid Nitrogen Supply System Main Requirements/Assumptions Table						
Facility	Equipment to be supplied	References/assessment/assumptions	Cold Box volume (m^3/cold box)	Number of Cold Boxes/accelerator	Cold Boxes heat loss (%vol of N_2 evaporated per day)	Special requirements
AF	Accelerator DTL cold boxes	- Cold Boxes capacity should be an outcome of the Accelerator Facility design - Cold Boxes volume assumed on the base of JGC experience - It is assumed here that the volume of the cold boxes includes all the DTL stages for each accelerator - Heat loss due to N2 evaporation and nitrogen circulating equipment assumed according to the standard engineering practice - circulating compressors are assumed to be one for each accelerator	5 m3	2	0.5 %vol/d	

Table 14: Liquid Nitrogen (LN2) Input Data Requirements

Gaseous Nitrogen Supply System Main Requirements/Assumptions Table								
Facility	**Equipment to be supplied**	**References/assessment/assumptions**	**Glove boxes volume (m^3)**	**Number of glove boxes**	**Maximum oxygen concentration tolerable in the glove boxes (%vol)**	**Time required to change the atmosphere in the glove boxes (h)**	**Gaseous nitrogen consumption (Nm^3/h)**	**Special requirements**
PIEF	R-136: Glove Box Laboratory	- Number & capacity of the glove boxes should be an outcome of the PIE Facility design - Glove Boxes Volume Assumed according to JGC experience - Number of Glove Boxes Assumed according to JGC experience - Maximum Oxygen Concentration assumed according to JGC experience - Time required to change atmosphere tentatively assumed	20 m3	3	0.2 %vol	6 h	50 Nm3/h	
Facility	**Equipment to be supplied**	**References/assessment/assumptions**	**Time required for regenration (h)**	**Gaseous nitrogen supply required (Nm^3/h)**	**Special requirements**			
CF	Glove Boxes Detritiation System Catalyst regeneration	- Time required to change atmosphere tentatively assumed according to JGC experience - N2 flow selected according to the Exhaust Gas detritiation System design	?	?				
Facility	**Equipment to be supplied**	**References/assessment/assumptions**	**Nitrogen consumption of each pump (Nm^3/h)**	**Number of pumps**	**Gaseous nitrogen consumption (Nm^3/h)**	**Special requirements**		
CF	Dry Pumps for Central Vacuum system. Nitrogen necessary to purge shaft sealing devices	- Nitrogen consumption of each pump assumed according to JGC experience - Number of pumps selected according to the Central Vacuum System design	2.25 Nm3/h	8	18 Nm3/h			
Facility	**Equipment to be supplied**	**References/assessment/assumptions**	**Buffer tanks capacity (m^3)**		**Ratio of empty portion inside each buffer tank (%)**	**Daily temperature fluctuation (°C/d)**	**Nitrogen consumption (Nm^3/d)**	**Special requirements**
AF	Seal gas for buffer tanks of primary cooling water loop of accelerator	- Buffer Tanks capacities should be an outcome of the Accelerator Facility design; - Buffer Tanks capacity assumed according to JGC experience and according to the actual design of the accelerator prototype - Empty portion of the buffer tanks assumed according to JGC experience	RFQ Buffer Tank (m^3)	?	30%	20.0°C	?	

Table 15: Gaseous Nitrogen (N) Input Data requirements

Equipment List for 5.3.5.0.0.

No.	ITEM No.	SERVICE	QTY	MAT'L	TYPE	SPECIFICATION	MAIN DEMENSION	RATED OUTPUT	ACCESSORIES	Installation ROOM No.	REMARKS
1	5. 3. 5. 1. 0. - V - 001	Liquid Argon Tank	1	Stainless Steel	Vacuum Flask	25m3	Φ2700XH8000	-	-	Outdoor	-
2	5. 3. 5. 1. 0. - HA - 002	Liquid Argon Evaporator	1	-	Air Heating	400Nm3/h	W1540XL1540XH3026	-	-	Outdoor	Nikkaki's CAV-400-N
3	5. 3. 5. 1. 0. - U - 003	Argon Purification System	1	-	PSA/TSA	80Nm3/h. 100%X2 for Compressor and Chiller Unit Only	W11000XL15000XH5500	65kW	-	R228	-
4	5. 3. 5. 1. 0. - K - 004 A/B	Argon Recirculation Blower	2	Stainless Steel	Centrifugal	14000Nm3/h, 6kPa, 100%X2	W1600XL2000XH1200	45kW	-	R228	-
5	5. 3. 5. 1. 0. - HX - 005	Argon Recirculation Cooler	1	Stainless Steel	Shell & Tube	Duty: 50kW	φ1000XL2000	-	-	R228	-
6	5. 3. 5. 2. 0. - V - 101	Helium Tank	1	Carbon Steel	-	25m3	φ2500XH5000	-	-	Outdoor	-
6	5. 3. 5. 2. 0. - V - 111 A~D	Helium Tank	4	Carbon Steel	-	100m3 x4	φ4000XH8000	-	-	Outdoor	-
7	5. 3. 5. 3. 0. - K - 201 A/B	Instrumentation Air Compressor	2	-	Screw	200Nm3/h. 0.69MPa, 100%X2	W1650XL900XH1500	27.7+0.4=28.1kW	-	R307	KOBELCO's FE370W-5/6
8	5. 3. 5. 3. 0. - U - 202 A/B	Instrumentation Air Dryer	2	-	PSA	Outlet 160Nm3/h, 100%X2	W220XL570XH1600	-	-	R307	KOBELCO's KE060
9	5. 3. 5. 3. 0. - V - 203	Instrumentation Air Tank	1	Stainless Steel	-	3.5m3	Φ1400XH2800	-	-	R307	-
10	5. 3. 5. 3. 0. - U - 211 A/B	Breathable Air Supply Unit	2	-	-	60Nm3/h. 0.69MPa, 100%X2	W830XL1480XH1520	15KW	-	R307	BAUER's V150-15-5
11	5. 3. 5. 4. 0. - V - 301	Liquid Nitrogen Tank	1	Stainless Steel	Vacuum Flask	25m3	Φ2700XH8000	-	-	Outdoor	-
12	5. 3. 5. 4. 0. - HA - 302	Liquid Nitrogen Evaporator	1	-	Air Heating	70Nm3/h	W574XL574XH2346	-	-	Outdoor	Nikkaki's CAV-80
13	5. 3. 5. 4. 0. - V - 311	Liquid Nitrogen Tank	1	Stainless Steel	Vacuum Flask	50m3	Φ3500XH10000	-	-	Outdoor	-
14											
15											
16											
17											
18											
19											
20											

Table 16: S-1224-201- SGS Equipment List - PBS 5.3.5.0.0.

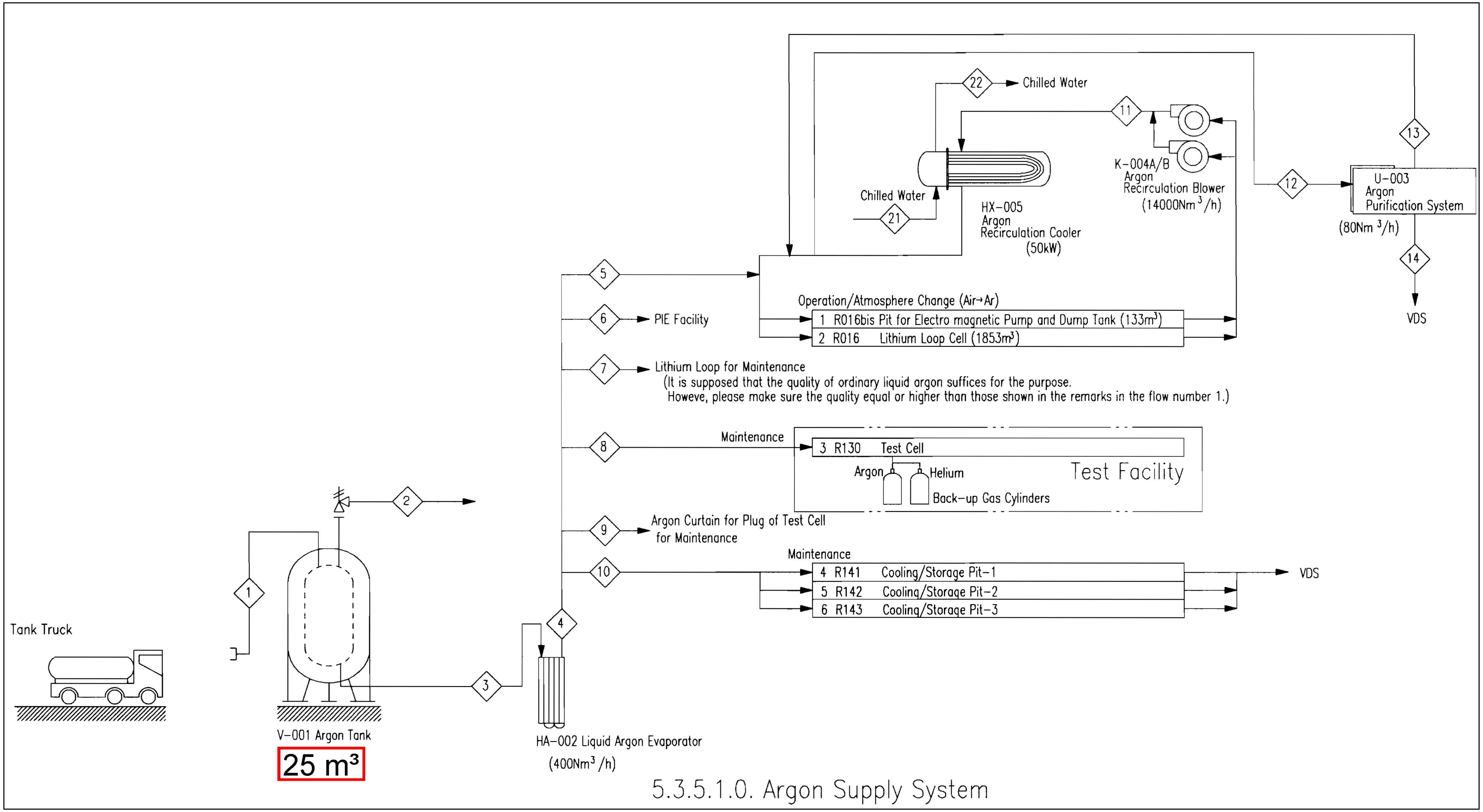


Figure 6-1: Argon Supply System, PFD

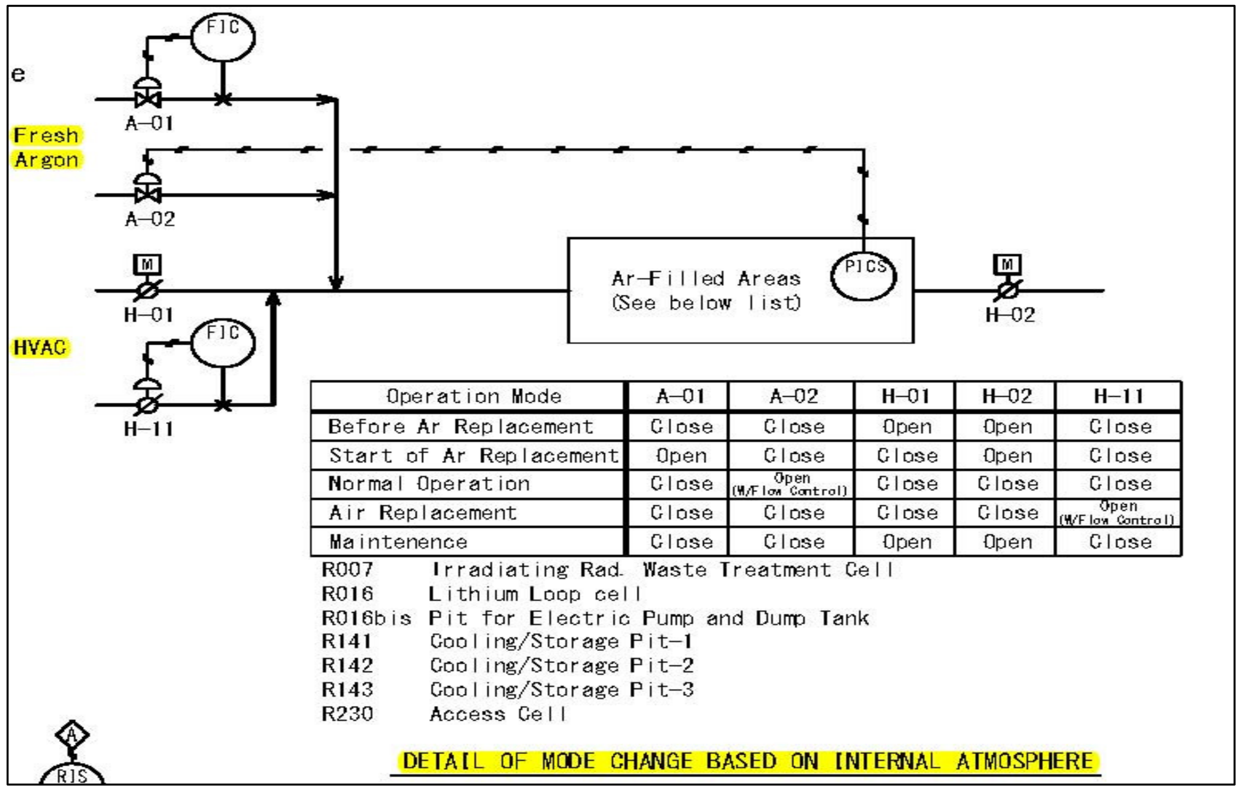
Operation

Flow Number			1	2	3	4	5	6	7	8	9	10	11	12	13	14
Fluid			Liquid Argon	Relieved Argon Gas	Liquid Argon	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Recirculated Ar to Ar-filled Cells	Exhaust from Ar-filled Cells	Purified Argon Gas	Vent Gas
Flow		Nm^3/h	6.1 m^3/week	97 Nm^3/d	0.031 m^3/h	24.00	24	TBD	-	-	-	-	14000	80.00	55.03	24.97
Composition	Ar	Nm^3/h					24							78.92	54.92	24.00
	N2	Nm^3/h												0.85	0.09	0.77
	O2	Nm^3/h												0.23	0.02	0.20
	H2O	Nm^3/h												0.03	0.00	0.02
	H2	Nm^3/h												-	-	-
Main Inpurities	O2	ppm												2825	411	8147
	H2O	ppm												327	48	944
Activity	HT,DT	Bq/h												3.1E+06	2.1E+06	9.6E+05
	HTO,DTO	Bq/h												-	-	-
	HT,DT	Bq/cm^3												3.8E-02	3.8E-02	3.8E-02
	HTO,DTO	Bq/cm^3												-	-	-
Temperature		℃	-186	AMB	-186	AMB	AMB	AMB					30	20	AMB	AMB
Pressure		MPa	0.8	0.8	0.8	0.8	0.8	0.8					-	-	0.3	-
Remarks			Grade G3 Purity >99.999 % O_2 <0.2 ppm Dew Point <-70 ℃ Replenisment Interval 4 week	LAr Tank 25 m^3 Evap. rate 0.5 %/d No. of Tanks 1			Argon Purification Capacity 80 Nm^3/h Recovery rate 70 %						Volume of cells 1986 m^3 Change rate 7.0 Vol/h	Volume of cells 1986 m^3 Leak rate 5.E-04 /h		

Table 17: Argon Supply System, Operation conditions

Maintenance

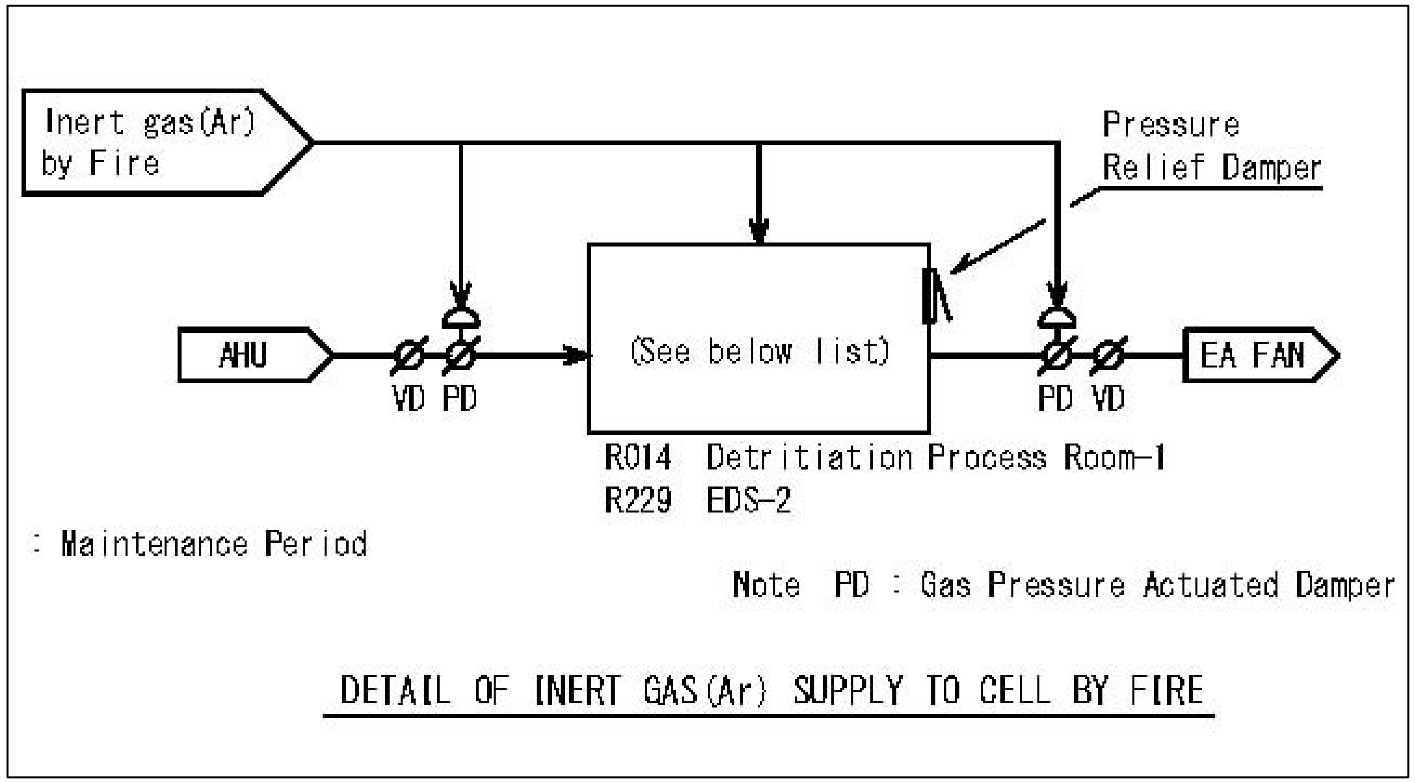
Flow Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Fluid		Liquid Argon	Relieved Argon Gas	Liquid Argon	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Recirculated Ar to Ar-filled Cells	Exhaust from Ar-filled Cells	Purified Argon Gas	Vent Gas
Flow	Nm^3/h	3.5 m^3/month	97 Nm^3/d	0.03854 m^3/h	30.0	-	TBD	30	TBD	TBD	TBD	-	-	-	-
Temperature	°C	-186	AMB	-186	AMB	AMB	AMB	AMB	AMB	AMB	AMB	-	-	-	-
Pressure	MPa	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	-	-	-	-
Remarks		Replenisment Interval 7 month						$3m^3/B$							



Operation Mode	A-01	A-02	H-01	H-02	H-11
Before Ar Replacement	Close	Close	Open	Open	Close
Start of Ar Replacement	Open	Close	Close	Open	Close
Normal Operation	Close	Open (W/Flow Control)	Close	Close	Close
Air Replacement	Close	Close	Close	Close	Open (W/Flow Control)
Maintenence	Close	Close	Open	Open	Close

R007 Irradiating Rad. Waste Treatment Cell
R016 Lithium Loop cell
R016bis Pit for Electric Pump and Dump Tank
R141 Cooling/Storage Pit-1
R142 Cooling/Storage Pit-2
R143 Cooling/Storage Pit-3
R230 Access Cell

DETAIL OF MODE CHANGE BASED ON INTERNAL ATMOSPHERE



R014 Detritiation Process Room-1
R229 EDS-2

: Maintenance Period

Note PD : Gas Pressure Actuated Damper

DETAIL OF INERT GAS(Ar) SUPPLY TO CELL BY FIRE

Table 18: Argon Supply System, Maintenance conditions and change-over mode to fresh air

Atmosphere Change (Air → Argon)

Flow Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Fluid		Liquid Argon	Relieved Argon Gas	Liquid Argon	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Recirculated Ar to Ar-filled Cells	Exhaust from Ar-filled Cells	Purified Argon Gas	Vent Gas
Flow	Nm^3/h	9.4 m^3/d	97 Nm^3/d	0.39 m3/h	300	300	–	–	–	–	–	14000	–	–	–
Temperature	°C	-186	AMB	-186	AMB	AMB	AMB					30	–	–	–
Pressure	MPa	0.8	0.8	0.8	0.8	0.8	0.8					–	–	–	–
Remarks		Replenisment Interval 2 day Duration 1.4 days				Atm. Change of cells Volume 1986 m^3 No. of change 5 - Duration 1.4 d									

Table 19: Argon Supply System. Atmosphere change (Air - Argon)

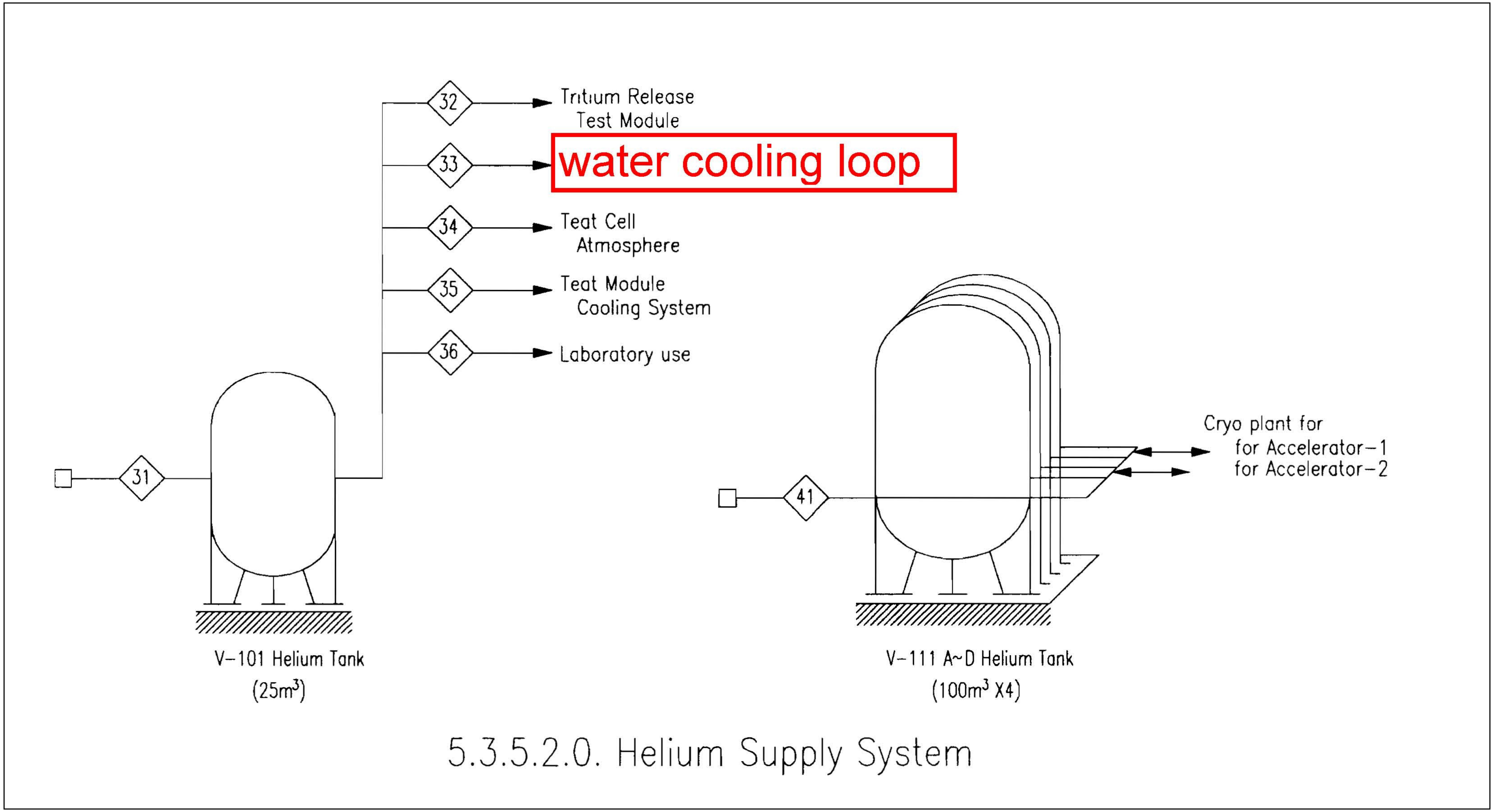


Figure 6-2: Helium Supply System, PFD

Operation

Flow Number		31	32	33	34	35	36
Fluid		Helium Gas	Helium Gas	Helium Gas	Helium Gas	Helium Gas	Helium Gas
Flow Rate	Nm^3/h	10.1 Nm^3/week	1.44 Nm^3/d	16	60	16	TBD
Temperature	°C	AMB	AMB	AMB	AMB	AMB	AMB
Pressure	MPa	0.8	0.8	0.8	0.8	0.8	0.8
Remarks		Replenishment Interval 2 week Consumption 20 Nm^3 3 Cylinder		Inventory TBD Nm^3 Replenishment TBD %/month	Inventory TBD Nm^3 Replenishment TBD %/month	Inventory TBD Nm^3 Replenishment TBD TBD	

Table 20: Helium Gas Supply system (Operation conditions)

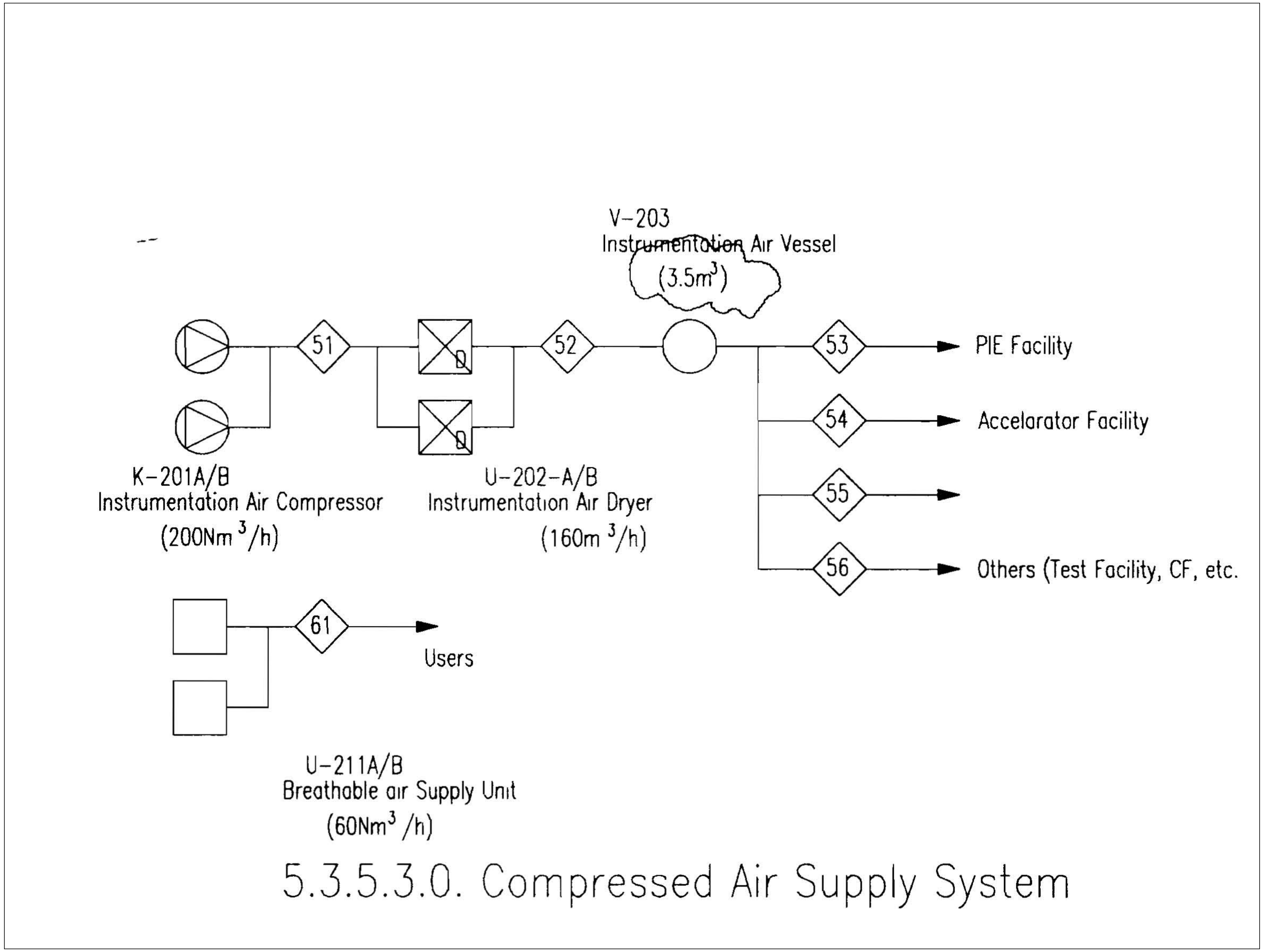


Figure 6-3: Compressed Air Supply System & Breathable Air, PFD

Flow Number		51	52	53	54	55	56
Fluid		Compressed Air	Instrumentation Air	Instrumentation Air	Instrumentation Air		Instrumentation Air
Flow Rate	Nm^3/h	200	160	35	80		25
Temperature	°C	AMB	AMB	AMB	AMB		AMB
Pressure	MPa	0.69	0.69	0.69	0.69		0.69
Remarks		140	Dew Point -40 °C Buffer Vessel (1min) 0.52→0.44MPa				

Table 21: Compressed Air supply system (for Instrumentation) Operation conditions.

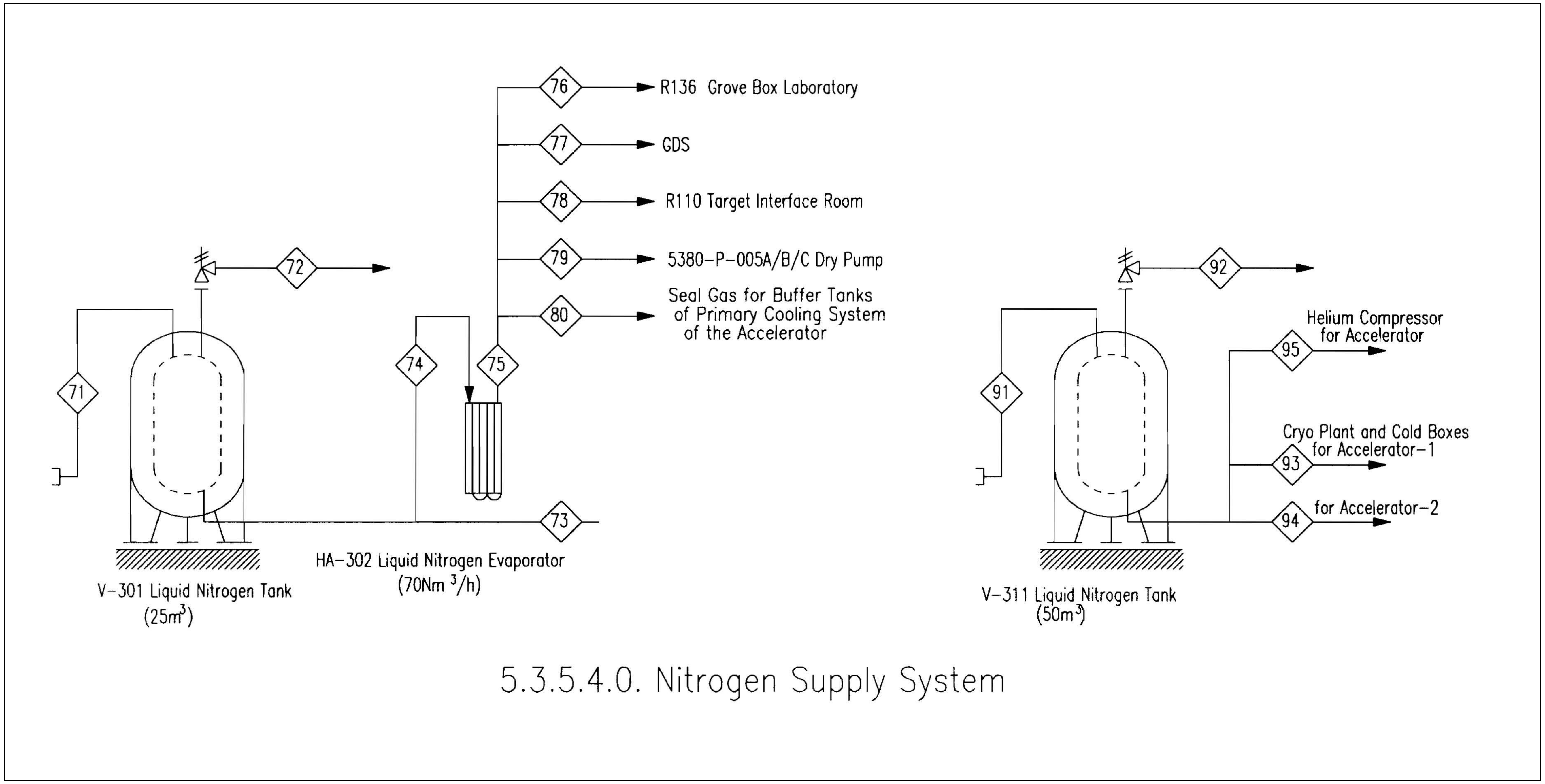


Figure 6-4: Nitrogen Supply System, PFD

Flow Number		71	72	73	74	75	76	77	78	79	80
Fluid		Liquid Nitrogen	Relieved Nitrogen Gas		Liquid Nitrogen	Nitrogen Gas	Nitrogen Gas	Nitrogen Gas	Nitrogen Gas	Nitrogen Gas	Nitrogen Gas
Flow Rate	Nm^3/h	5.6 m^3/week	81 Nm^3/d		0.669 m^3/d	433 Nm^3/d	50	21.3	–	18	1.4 Nm^3/d
Temperature	℃	-186	AMB		-186	AMB	AMB	AMB	AMB	AMB	AMB
Pressure	MPa	0.8	0.8		0.8	0.8	0.8	0.8	0.8	0.8	0.8
Remarks		Replenisment Interval 4 week	LN2 Tank 25 m^3 Evap. rate 0.5 %/d No of Tanks 1			Max. 70 Nm^3/h	Atm. Change of GB Volume 60 m^3 No. of Change 5 – Duration 6 h Frequency 1 /y	Regeneration of Cu and CuO Catalyst For 6h every 180d		N2 for a pump 3 Nm^3/h No. of pumps 6	Buffer Tank 70 m^3 Empty Volume 30 % Temp. Fluctuation 20 ℃

Table 22: Nitrogen Gas Supply Conditions

91	92	93	94
Liquid Nitrogen for an Accelarator	Relieved Nitrogen Gas	Liquid Nitrogen	Liquid Nitrogen
0.3 m^3. h	162 Nm^3/d	TBD m^3/d	TBD m^3/d
-186	AMB	-186	-186
0.8	0.8	0.8	0.8
Replenishment Interval 6 days for an Accelerator 3 days for two Accelerators	LN2 Tank 50 m^3 Evap. rate 0.5 %/d No. of Tanks 1		

Table 23: Liquid Nitrogen (LN2) Operation conditions

Operation

Flow Number			1	2	3	4	5	6	7	8	9	10	11	12	13	14
Fluid			Liquid Argon	Relieved Argon Gas	Liquid Argon	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Recirculated Ar to Ar-filled Cells	Exhaust from Ar-filled Cells	Purified Argon Gas	Vent Gas
Flow		Nm^3/h	6.1 m^3/week	97 Nm^3/d	0.031 m^3/h	24.00	24	TBD	–	–	–	–	14000	80.00	55.03	24.97
Composition	Ar	Nm^3/h					24							78.92	54.92	24.00
	N2	Nm^3/h												0.85	0.09	0.77
	O2	Nm^3/h												0.23	0.02	0.20
	H2O	Nm^3/h												0.03	0.00	0.02
	H2	Nm^3/h												–	–	–
Main Inpurities	O2	ppm												2825	411	8147
	H2O	ppm												327	48	944
Activity	HT,DT	Bq/h												3.1E+06	2.1E+06	9.6E+05
	HTO,DTO	Bq/h												–	–	–
	HT,DT	Bq/cm^3												3.8E-02	3.8E-02	3.8E-02
	HTO,DTO	Bq/cm^3												–	–	–
Temperature		℃	-186	AMB	-186	AMB	AMB	AMB					30	20	AMB	AMB
Pressure		MPa	0.8	0.8	0.8	0.8	0.8	0.8					–	–	0.3	–
Remarks			Grade G3 Purity >99.999 % O_2 <0.2 ppm Dew Point <-70 ℃ Replenisment Interval 4 week	LAr Tank 25 m^3 Evap. rate 0.5 %/d No. of Tanks 1			Argon Purification Capacity 80 Nm^3/h Recovery rate 70 %						Volume of cells 1986 m^3 Change rate 7.0 Vol/h	Volume of cells 1986 m^3 Leak rate 5.E-04 /h		

Flow Number		21	22
Fluid		Chilled Water	Chilled Water
Flow	m^3/h	8.4	8.4
Temperature	℃	7	12
Pressure	MPa	0.35	0.35
Remarks			

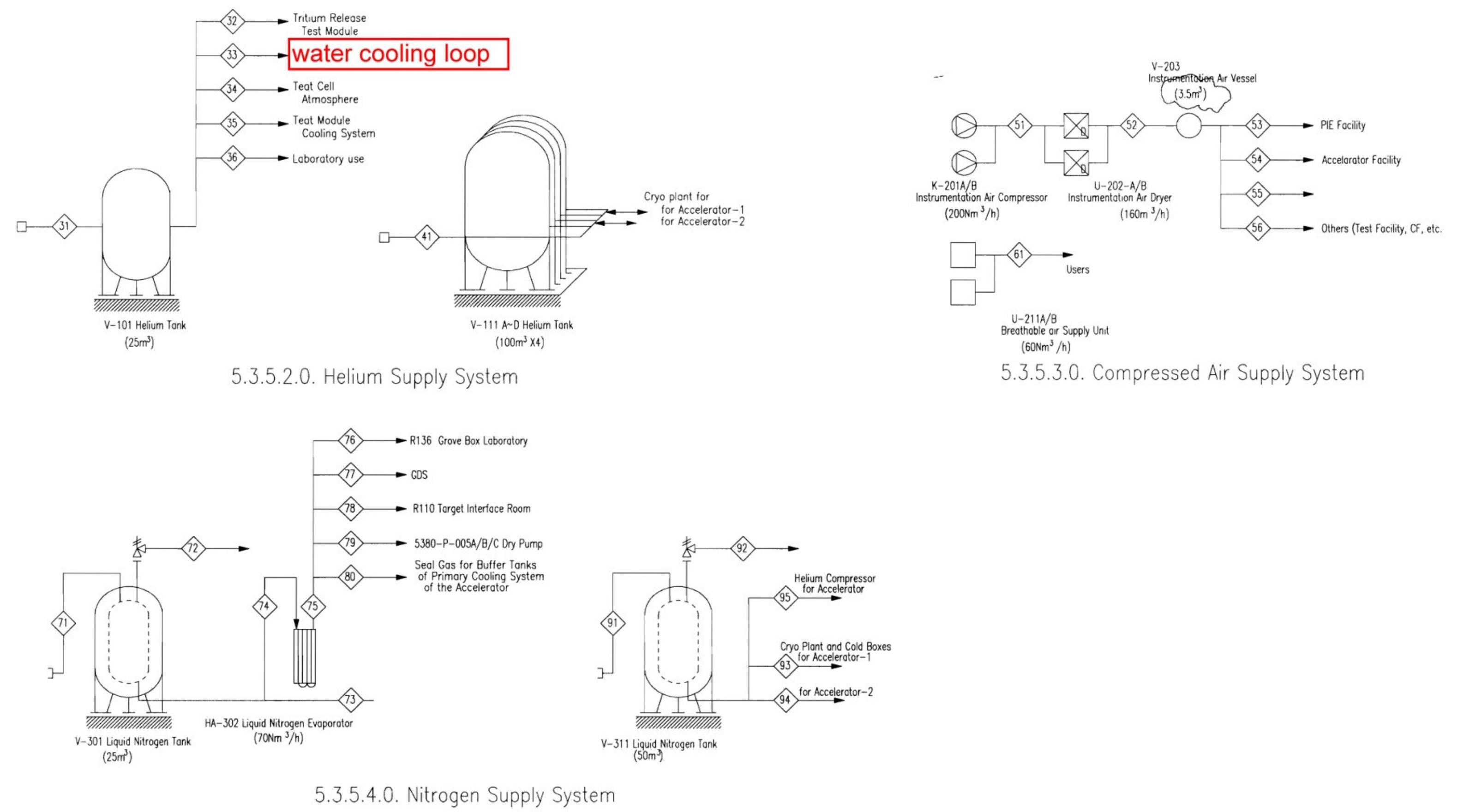
Maintenance

Flow Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Fluid		Liquid Argon	Relieved Argon Gas	Liquid Argon	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Recirculated Ar to Ar-filled Cells	Exhaust from Ar-filled Cells	Purified Argon Gas	Vent Gas
Flow	Nm^3/h	3.5 m^3/month	97 Nm^3/d	0.03854 m^3/h	30.0	–	TBD	30	TBD	TBD	TBD	–	–	–	–
Temperature	℃	-186	AMB	-186	AMB	AMB	AMB	AMB	AMB	AMB	AMB	–	–	–	–
Pressure	MPa	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	–	–	–	–
Remarks		Replenisment Interval 7 month						$3m^3$/B							

Atmosphere Change (Air → Argon)

Flow Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Fluid		Liquid Argon	Relieved Argon Gas	Liquid Argon	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Argon Gas	Recirculated Ar to Ar-filled Cells	Exhaust from Ar-filled Cells	Purified Argon Gas	Vent Gas
Flow	Nm^3/h	9.4 m^3/d	97 Nm^3/d	0.39 m3/h	300	300	–	–	–	–	–	14000	–	–	–
Temperature	℃	-186	AMB	-186	AMB	AMB	AMB					30	–	–	–
Pressure	MPa	0.8	0.8	0.8	0.8	0.8	0.8					–	–	–	–
Remarks		Replenisment Interval 2 day Duration 1.4 days				Atm. Change of cells Volume 1986 m^3 No. of change 5 - Duration 1.4 d									

Table 24: Argon supply system description table



Operation

Flow Number		31	32	33	34	35	36
Fluid		Helium Gas	Helium Gas		Helium Gas	Helium Gas	Helium Gas
Flow Rate	Nm^3/h	10.1 Nm^3/week	1.44 Nm^3/d		60	16	TBD
Temperature	℃	AMB	AMB		AMB	AMB	AMB
Pressure	MPa	0.8	0.8		0.8	0.8	0.8
Remarks		Replenishment Interval 2 week Consumption 20 Nm^3 3 Cylinder			Inventory TBD Nm^3 Replenishment TBD %/month	Inventory TBD Nm^3 Replenishment TBD TBD	

Flow Number	41
Fluid	Helium Gas
Flow Rate	1.0 Nm^3/y
Temperature	AMB
Pressure	
Remarks	Replenisment Interval 6 month Consumption 0.5 Nm^3 1 Cylinder

Flow Number		51	52	53	54	55	56
Fluid		Compressed Air	Instrumentation Air	Instrumentation Air	Instrumentation Air		Instrumentation Air
Flow Rate	Nm^3/h	200	160	35	60		25
Temperature	℃	AMB	AMB	AMB	AMB		AMB
Pressure	MPa	0.69	0.69	0.69	0.69		0.69
Remarks		140 (red annotation)	Dew Point -40 ℃ Buffer Vessel (1min) 0.52→0.44MPa				

Flow Number	61
Fluid	Breathable Air
Flow Rate	60
Temperature	AMB
Pressure	0.69
Remarks	Air required 0.085 m^3/min/person 10 person

Flow Number		71	72	73	74	75	76	77	78	79	80
Fluid		Liquid Nitrogen	Relieved Nitrogen Gas		Liquid Nitrogen	Nitrogen Gas	Nitrogen Gas	Nitrogen Gas	Nitrogen Gas	Nitrogen Gas	Nitrogen Gas
Flow Rate	Nm^3/h	5.6 m^3/week	81 Nm^3/d		0.669 m^3/d	433 Nm^3/d	50	21.3	-	18	1.4 Nm^3/d
Temperature	℃	-186	AMB		-186	AMB	AMB	AMB	AMB	AMB	AMB
Pressure	MPa	0.8	0.8		0.8	0.8	0.8	0.8	0.8	0.8	0.8
Remarks		Replenisment Interval 4 week	LN2 Tank 25 m^3 Evap. rate 0.5 %/d No. of Tanks 1			Max. 70 Nm^3/h	Atm. Change of GB Volume 60 m^3 No. of Change 5 - Duration 6 h Frequency 1 /y	Regeneration of Cu and CuO Catalyst For 6h every 180d		N2 for a pump 3 Nm^3/h No. of pumps 6	Buffer Tank 70 m^3 Empty Volume 30 % Temp. Fluctuation 20 ℃

Flow Number	91	92	93	94
Fluid	Liquid Nitrogen for an Accelarator	Relieved Nitrogen Gas	Liquid Nitrogen	Liquid Nitrogen
Flow Rate	0.3 m^3/h	162 Nm^3/d	TBD m^3/d	TBD m^3/d
Temperature	-186	AMB	-186	-186
Pressure	0.8	0.8	0.8	0.8
Remarks	Replenishment Interval 6 days for an Accelerator 3 days for two Accelerators	LN2 Tank 50 m^3 Evap. rate 0.5 %/d No. of Tanks 1		

Maintenance

Flow Number	95
Fluid	Liquid Nitrogen
Flow Rate	TBD m^3/d
Temperature	-186
Pressure	0.8
Remarks	

Figure 6-5: Helium- Nitrogen and Compressed Air, PFD with tables.

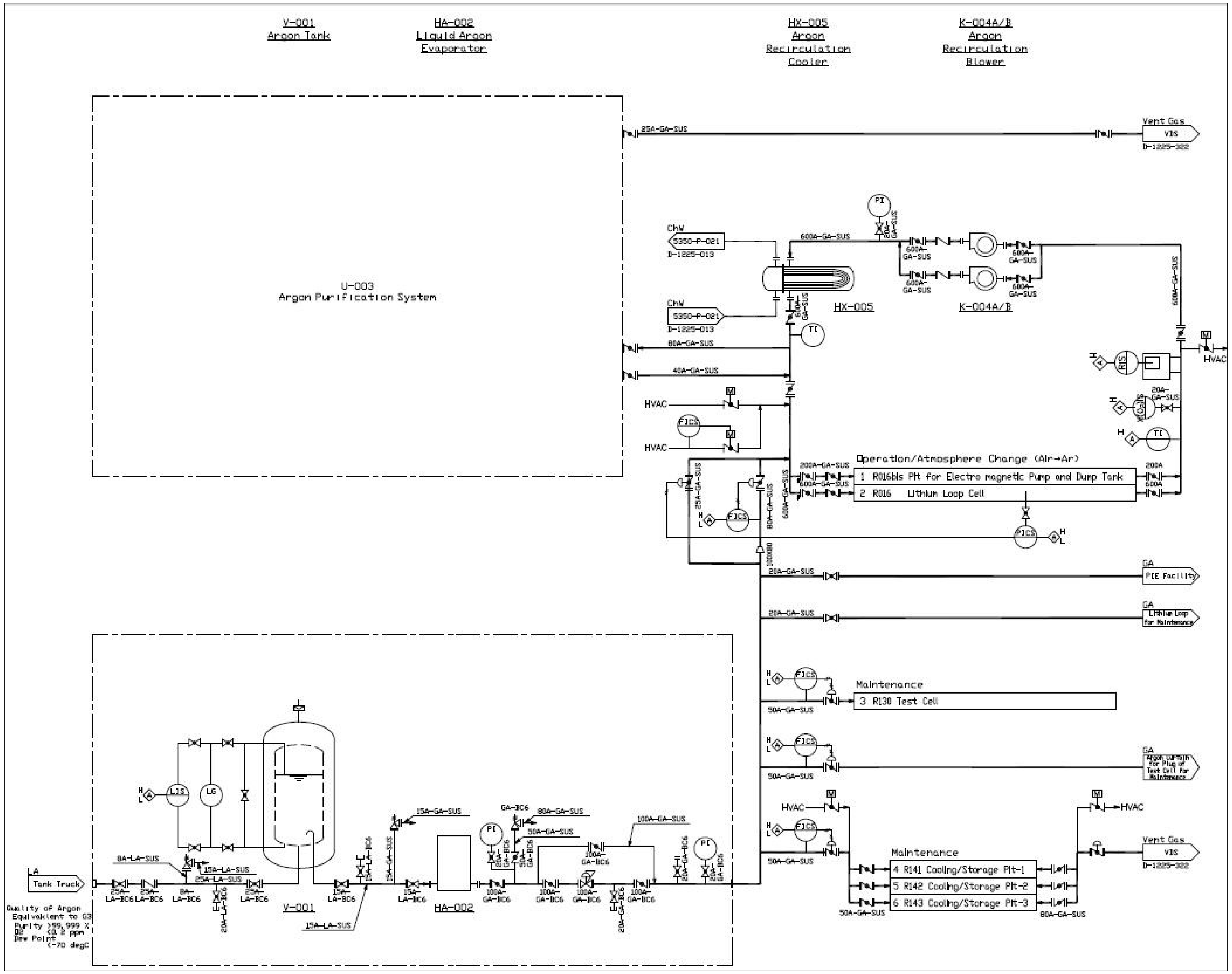


Figure 6-6: D-1225-211- Argon Supply System - P&ID

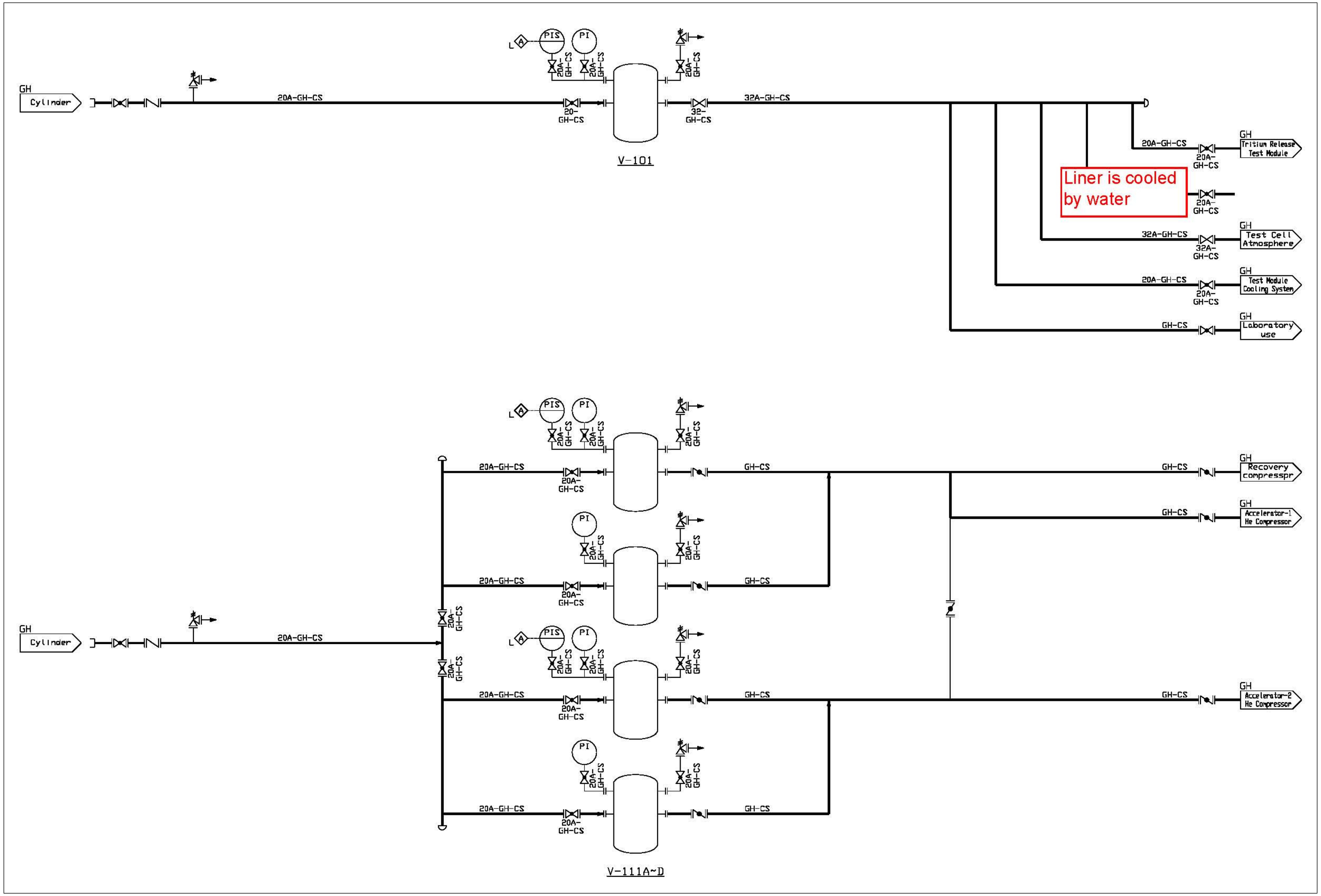


Figure 6-7: D-1225-212-Helium Supply System, P&ID

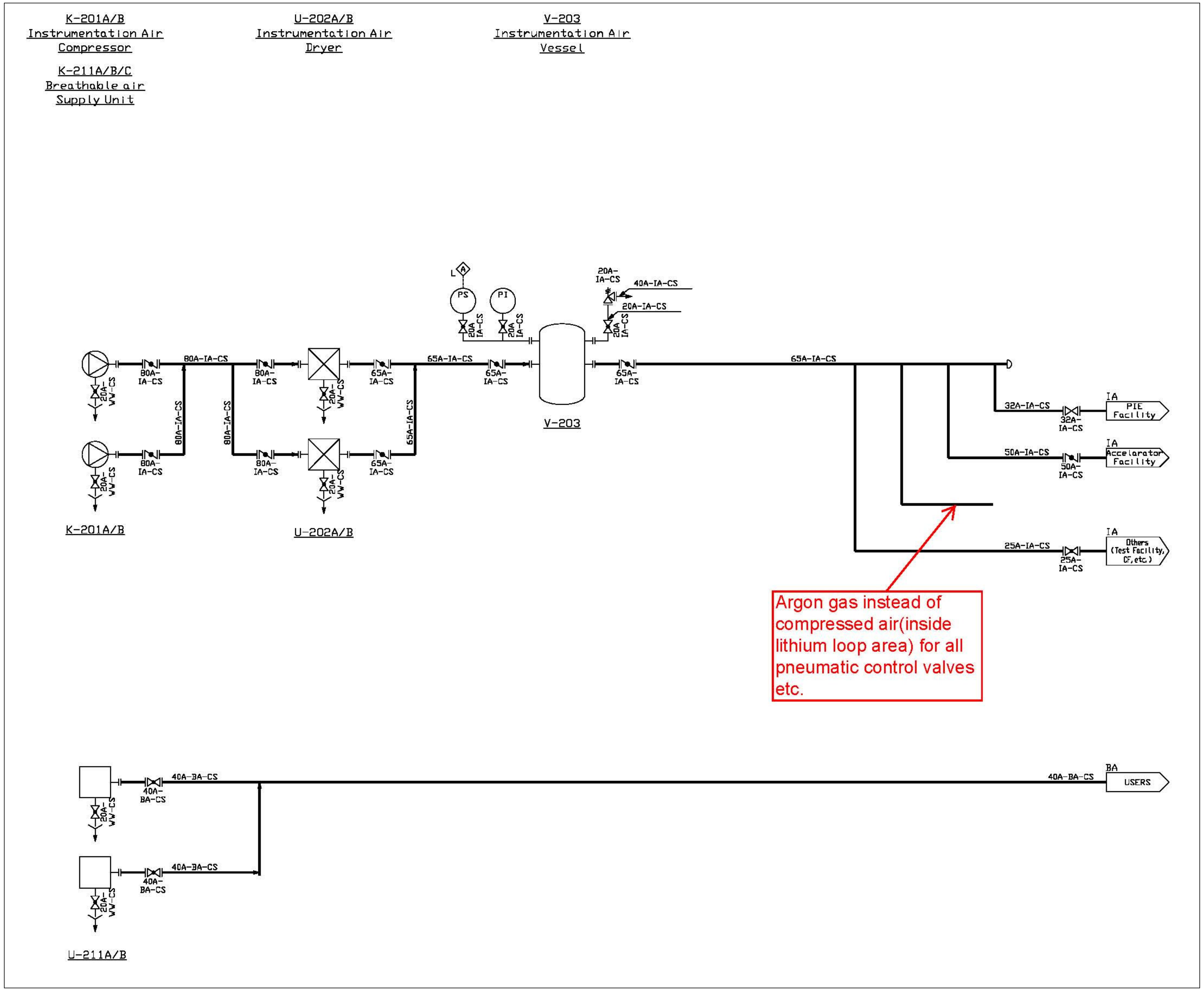


Figure 6-8: D-1225-213-Compressed Air Supply System, P&ID

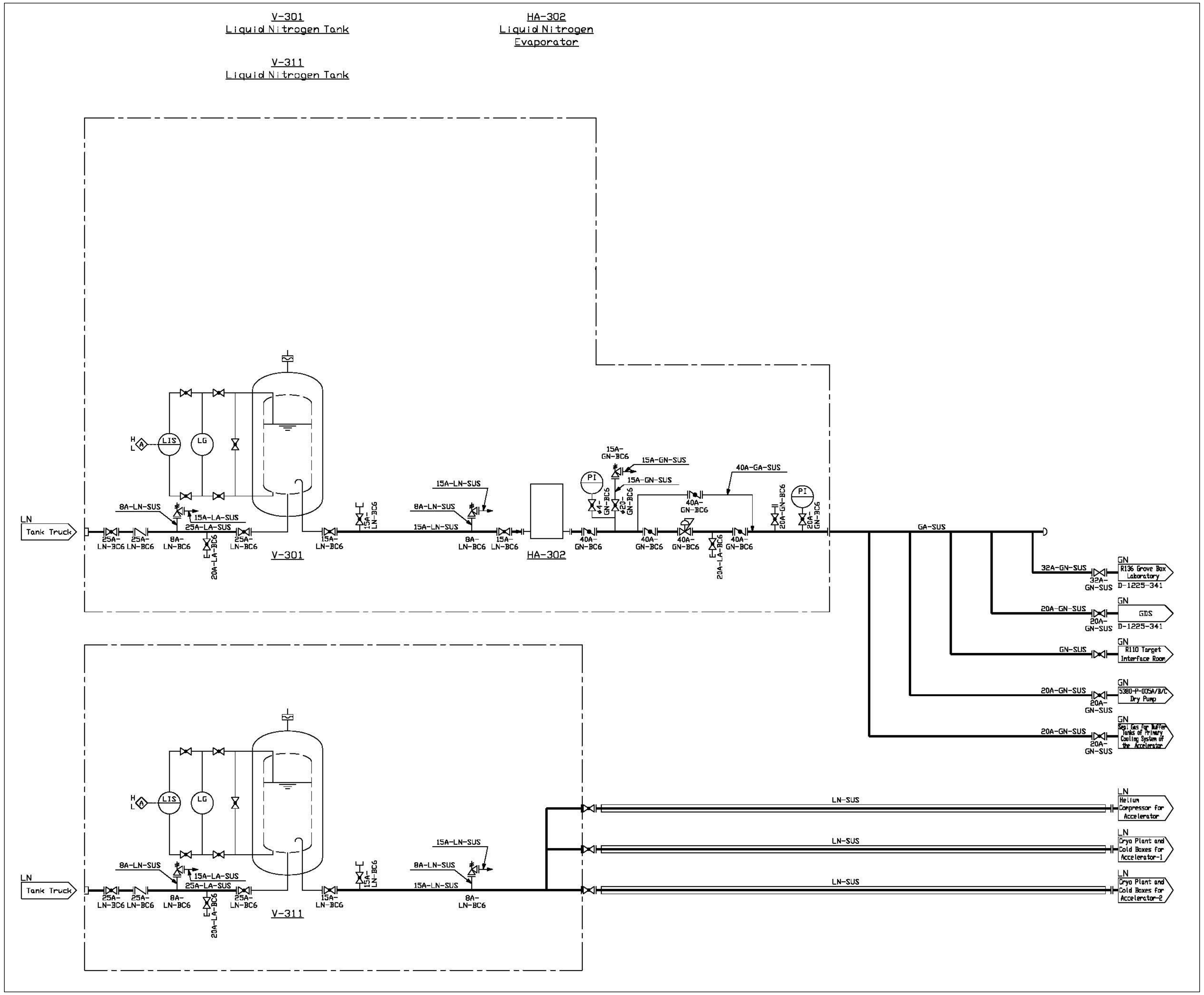


Figure 6-9: D-1225-214- Nitrogen Supply System, P&ID

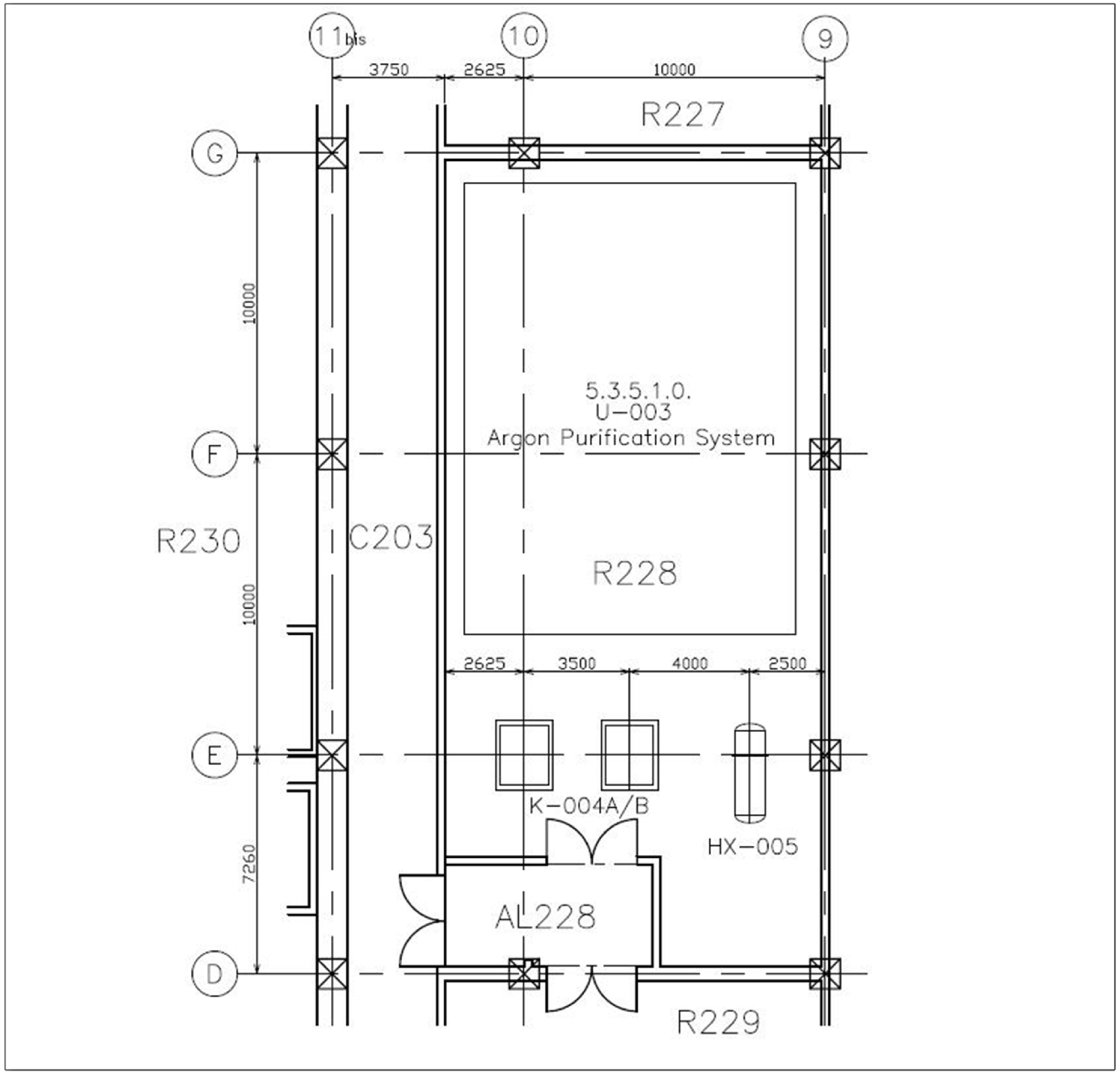


Figure 6-10: Argon Purification System, Room 228

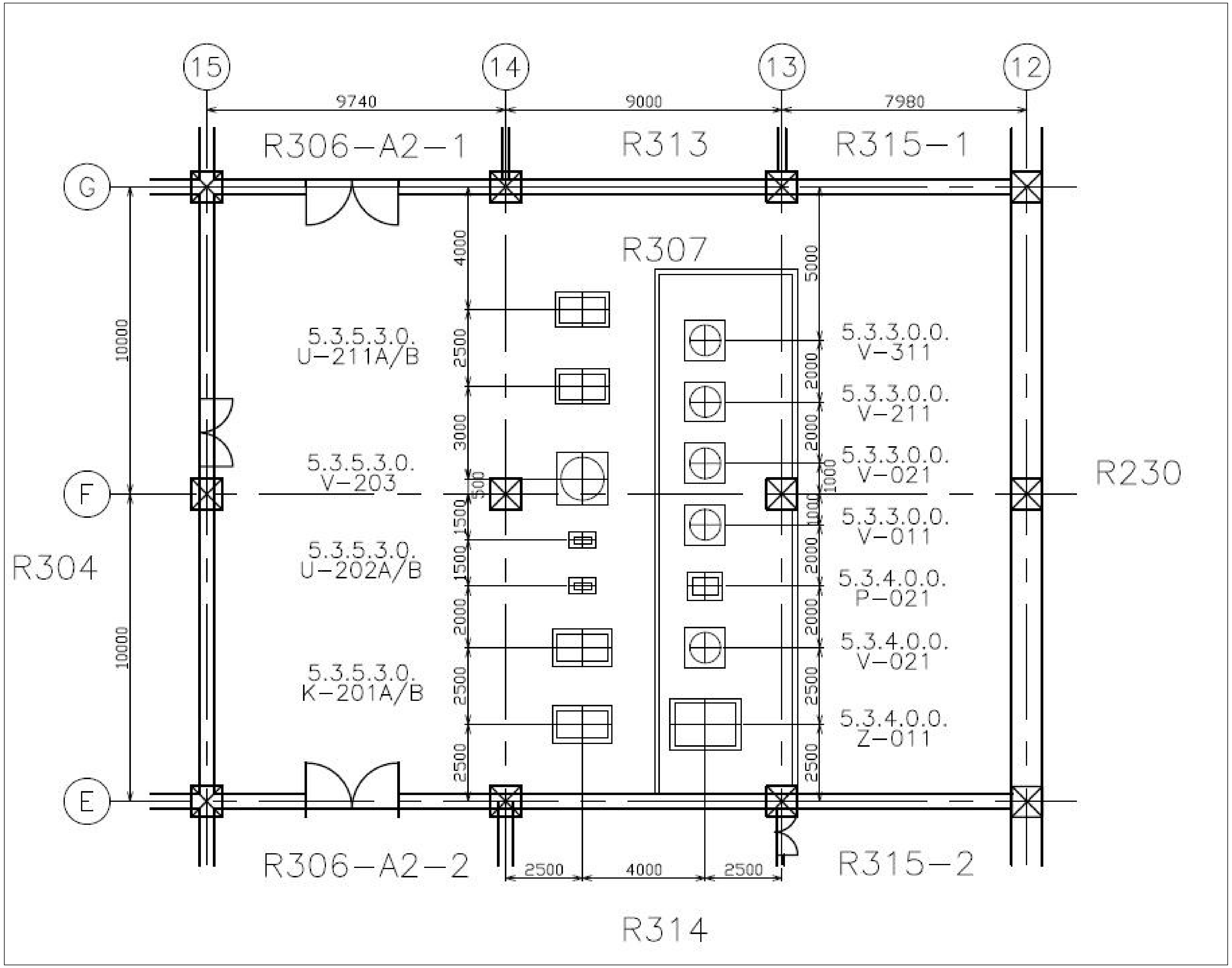


Figure 6-11: Compressed Air technical room, R307

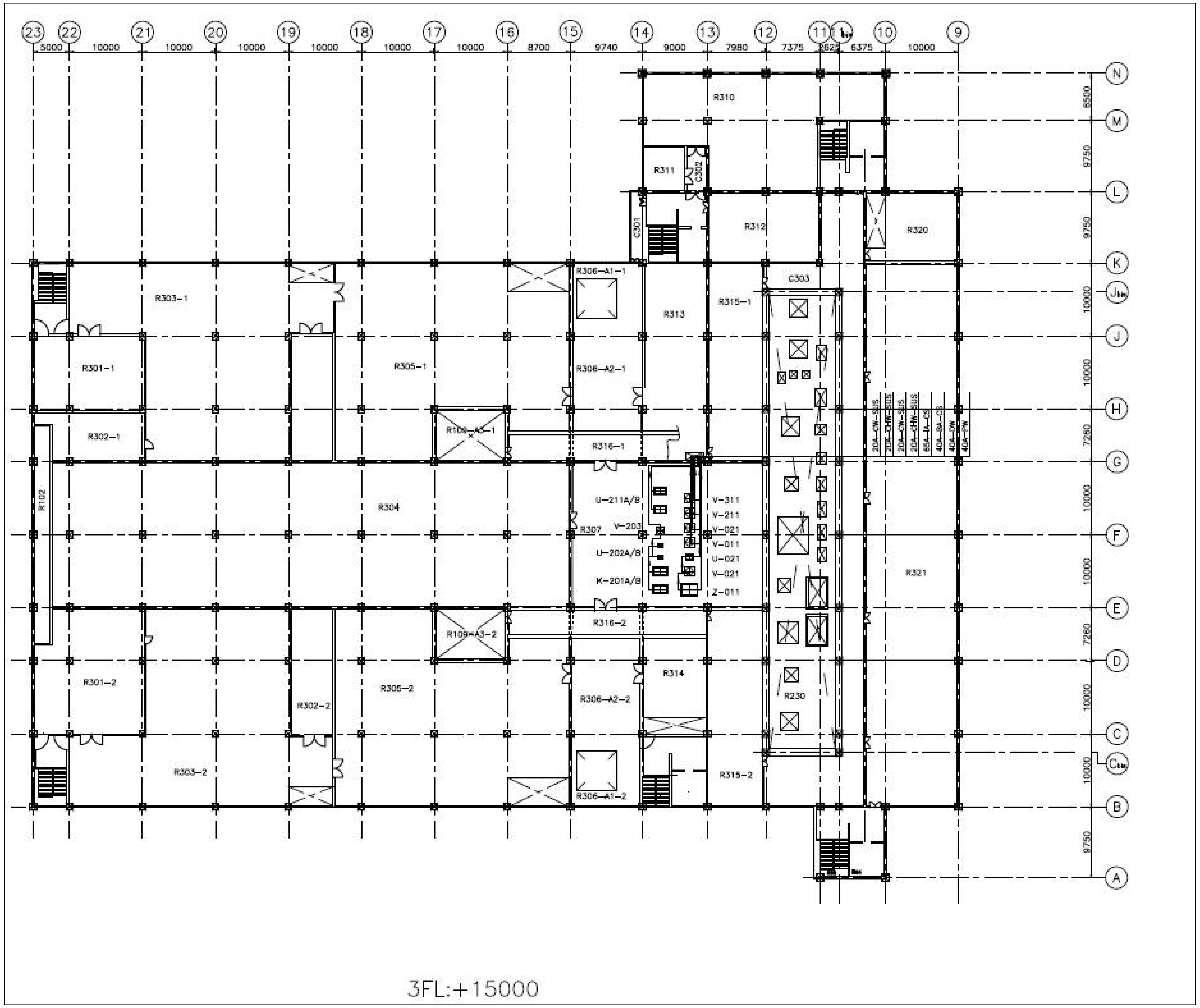


Figure 6-12: Compressed Air piping's layout.