DM--SD-TBSIDD----SI Process.docx

	Name
Owner	*Martin Hansson, System Owner*
Reviewer	*Martin Hansson, System Owner*
Approver	*Fredrik Österberg, Base Line Lead*

TABLE OF CONTENT

1. INTRODUCTION

1.1. Purpose of the document

This document describes the system Process for Site Infrastructure. It will describe the overall Site-wide design, as well as standard solution for design and interfaces.

1.2. Definitions, acronyms and abbreviations

Abbreviation	Explanation of abbreviation
CWL	Cooling Water Low temp
CWM	Cooling Water Mid temp
CWH	Cooling Water High temp
DH	District heating (Kraftringen)
DHL	District heating Low temp (ESS)
IAR	Instrument Air
DIW	De-ionized Water
N2G	Nitrogen gas
ARG	Argon gas
CF	Conventional Facilities (division responsible for SI)
SI	Site infrastructure
ES&H	Environment, Safety & Health Division
CUB	Central Utilities Building
HVAC	Heating, Ventilation & Air conditioning

2. REFERENCES

[1] ”ESS-0039311, ESS Rules for Plants & Process Design”.

[2] ”ESS-0007857, CF Design Manual Technical systems”.

[3] ”ESS-0030239, Process Design Instructions”.

[4] ”ESS-0031401, CF Sustainability Requirements”.

[5] ”ESS-0045937, ESS BREEAM design quality assurance”.

[6] ”ESS-0031412, BREEAM introduction”.

[7] ”ESS-0001786, Definition of Supervised and Controlled Radiation Areas”.

[8] ”ESS-0057090, Zoning Map for G-buildings”.

[9] ”ESS-0057612, Zoning Map for D- and E-buildings”.

[10] ”ESS-0001761, Energy Design Report”.

[11] ”ESS-0061161, CF Energy Strategy”.

[12] ”ESS-0012603, Part judgement from the Environmental Court”.

[13] ”ESS-0006406, General review of Acoustic design”.

3. GENERAL DESCRIPTION

3.1. Purpose

Main feature of the Process system is to provide fluid utilities with specified quality to stakeholders across the site.

3.2. Context & interfacing systems

Design and construction of the ESS Process systems are organized within several Building projects. (See figure 1) Each Building project will issue a separate Process System description describing the separate sub- system in more details.

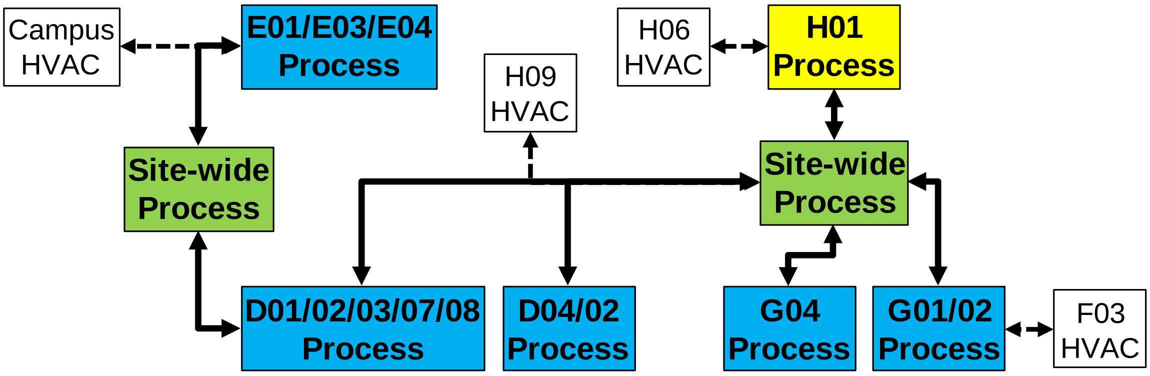

Figure 1: Process projects

All Process sub-projects must define conditions to Stakeholders within each sub-project, as well as to interfacing Process systems.

3.3. Standards and norms

Design shall be in accordance with ESS Rules for Plants & Process Design [1], CF Design Manual Technical systems [2] and Process Design Instructions [3]

3.4. CF Process System – Radiological classification

In general CF Process system is not subject to SSM (Swedish Radiation Safety Authority) related requirements. However, CF is to verify process systems by assessing them against SSM requirement if those are relevant. When connecting to CF Process systems it is within the responsibility of the connecting party to establish safety critical barriers when needed.

For installations in radiological exposed areas the aluminium pipe class AL13A shall be avoided. Use EAS16A instead. *(Example: IAR piping in G01 tunnel)*

3.5. Maintenance concept

Most Process systems are in continuous operation. Major maintenance actions should generally be planned for periods when Accelerator is shut downed and stakeholders are less sensitive to disturbances.

Maintenance actions and modification on control system must generally be done while Process systems are in operation.

Rotating equipment shall generally be equipped with standby units. Exceptions are possible if equipment failures not will interfere with Accelerator, Target or NSS operation.

Failure of heat exchangers is very rare and standby units are not required. Planned cleaning must however be possible at least once per year.

Critical field instrumentation and control valves must be accessible for maintenance action while Process systems are in operation.

3.6. Control & Monitoring

The majority of Process C&M functionality is for systems in the Central Utility Building (H01). In other buildings there are mainly monitoring functions required for overall system monitoring and fault handling. There are also some control features for local sub-systems required.

Performance of the Control & Monitoring system (C&M) will have a great impact on the ESS operating economy, especially for the cooling water operating cost and the upgraded heat product value. The loss per year can be considerable depending how close to optimum operating conditions the system can operate at.

The C&M system must support following features:

- Continuous operation for a minimum of 5 years
- Very high reliability and availability (quantification TBD)
- On-line tuning of controllers
- On-line reconfiguration of control schemes
- Extension/modification of connected hardware while C&M system in operation
- Support a very wide operating range, basically from "0" to 100% of full capacity. (example: variable gain PID)
- Include Process systems in all buildings into a single HMI view.
- Possible to have site-wide control schemes
- Extensive long term data logging

3.7. Constraints to the system

- Process systems shall in general be designed for requirements up to 2025 (22 running instruments and a 5 MW proton beam). Unless specifically stated no preparations are made for future requirements/expansion.

3.8. Risk management

Risk analyses of Process systems, HAZOP or similar, shall be carried out in Detailed Design. Identified risks and performed actions shall be part of Detail design delivery package.

3.9. Environmental, Safety and Health

The ES&H division is responsible at ESS for the coordination with the Swedish authorities and defining safety, security and environmental requirements on ESS. The CF organisation has advisors to support analysing and interpreting the overall ESS strategies and requirements, defining requirements on the SI system including Process systems.

Below supporting and controlling documents affecting the design of SI Process systems are listed.

3.9.1. Material Selection

See CF Design manual Technical systems [2]

3.9.2. BREEAM and sustainability

BREEAM (Building Research Establishment Environmental Assessment Methodology) is a methodology chosen by ESS Conventional Facilities (CF) for assessing, rating, and certifying the sustainability of buildings. ESS shall achieve a BREEAM certification for all buildings containing continuously occupied workspaces. The following buildings shall be BREEAM certified:

- G02 Gallery building
- All D buildings
- All E buildings
- F03 Logistic Centre
- F04 Guard House
- H09 Waste building
- B01 Campus office building
- B02 Campus laboratory building

<u>Related reference documents</u>

CF Sustainability requirements (ESS-0031401) [4]	Listing all sustainability requirements, including BREEAM requirements. Use sorting function to single out applicable requirements.

ESS BREEAM design quality assurance (ESS-0045937) [5]	Design quality assurance supporting the incorporation of BREEAM requirements into the design process.
BREEAM introduction (ESS-0031412) [6]	Introduction to BREEAM

3.9.3. Radiological safety

To be defined by Systems engineering

3.9.4. Radiological zoning

The radiological zoning affects water systems due to different level of contamination and to prevent releasing of nuclides. The zoning is different between “Beam on” and “Beam off”. Sometimes “Beam off” is the design case due to access for maintenance. Different parts of the facility have its own documentation according to below. Some of the zoning is currently under development.

Definition of supervised and controlled radiation areas (ESS-0001786) [7]	Describes the definitions and thresholds for different radiological zones.
Zoning map for G-buildings (ESS-0057090) [8]	Describes which rooms have which radiological zoning class in G-buildings.
Zoning map for D- and E-buildings (ESS-0057612) [9]	Describes which rooms have which radiological zoning class in D- and E-buildings.

3.9.5. Energy

ESS has made a commitment to apply an Energy Management Strategy "in order to minimize costs, lower the environmental impact and factor out the variability in energy" (ESS Scandinavia Secretariat 2008). The strategy had three pillars, called Responsible, Renewable and Recyclable, each with a specific goal.

There is an Energy Design Report for the entire ESS project that was released in 2012.

Responsible, Renewable and Recyclable impacts the Process design with high demands on energy recycling and minimization of energy use. For detailed system requirements see system characteristics for each system.

Energy simulations must be carried out in cooperation with CF Energy advisor.

<u>Related reference documents</u>

Energy Design Report (ESS-0001761) [10]	A report which is the basis for requirements and design.

CF Energy strategy (ESS-0061161) [11]	A report which specifies the energy performance requirements for ESS buildings and systems designed by ESS CF, and how to verify these requirements.

3.9.6. Acoustics

Acoustics coordinate requirements from Swedish laws and the Part judgement from the Environmental Court.

The Part judgement from the Environmental Court limits the noise egress from the ESS facility.

Each building is investigated by an acoustician, recommendations and requirements related to acoustics are shared in an acoustics report. The requirements include but are not limited to:

- Airborne Sound Insulation
- Impact Noise
- Reverberation Times
- Noise Egress
- Noise Ingress
- Building Services Noise

Related reference documents

Part judgement from the Environmental Court (ESS-0012603) [12]	Including Criteria for noise egress from the entire ESS-facility.
General Review of Acoustic Design (ESS-0006406) [13]	General Review of Acoustic Design

3.9.7. Waste handling

Non-hazardous waste shall be handled according to existing waste legislation. In addition, ESS is obliged to follow decisions in the part judgment from the environmental court regarding handling of hazardous waste.

Related reference documents

Part judgment from the environmental court (ESS-0012603) [12]	See Condition 2 regarding handling of chemical products and hazardous waste.
CF Sustainability requirements (ESS-0031401) [4]	Listing all sustainability requirements.

4. MEDIA DESCRIPTIONS

4.1. Cooling Water (CW)

4.1.1. Purpose

- Production of CW for stakeholder requirements
- Distribution of CW from H01 to consumers
- Energy recovery according to ESS sustainability commitment

4.1.2. System stakeholders

- Accelerator Division (via WP16)
- Target division
- Science Directorate (via AD WP16)
- SI HVAC
- ICS division

4.1.3. Operational Scenarios

The system shall be designed for continuous operation without any need for planned full system shutdowns. The cooling load will vary from very low to maximum depending on Accelerator operation and HVAC needs.

The cooling water system shall during start-up and shutdown of the Accelerator be able to maintain temperature and pressure requirements within specified limits.

The system shall be able to supply CW cooling from 0-100% of design load.

The system shall be able to handle a wide range of return temperatures from CW consumers, while maintaining CW supply temperatures. The operational limits are however depending on the actual cooling loads and several design criteria.

The system shall be able to handle large variations in temperature of incoming DH and DHL, while maintaining CW supply temperatures.

The system is only required to supply basic requirements of CW if there is a major failure in DH connection to Kraftringen (No Accelerator operation possible).

4.1.4. Conceptual design and requirements

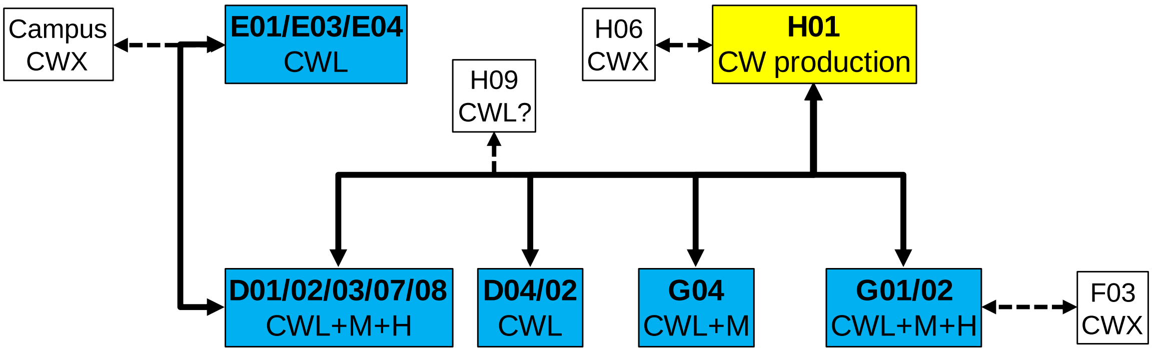

Figure 2: CW Schematic for ESS

- Three independent main systems working at different temperature levels
  - *Low-temp (CWL)*
    +8°C +/- 1°C (Lowest stakeholder requirement = HVAC)
  - *High-temp (CWH)*
    +50°C +/- 1°C (Cooling without need of heat pumps = Incoming DH +45°C)
  - *Mid-temp (CWM)*
    +25°C +/- 1°C (Optimum for best operating economy)
- Local sub-systems where needed. (CWX) Examples:
  - *Shunt-loop where independent temperature control is required*
  - *Subsystem where equipment cannot have low conductivity water*
- Water quality for CWM and CWH systems
  - Conductivity 1µS/cm *(AD requirement)*
  - Oxygen content <15 ppb *(reduce corrosion)*
  - pH > 7 *(reduce corrosion)*
- Water quality for CWL
  - *(No specific requirements)*
- CW supplies from H01 shall have 100% of flow filtered at 1000µ
- CW supplies from H01 shall have a slip stream (1-5% of flow) filtered at 100µ
- DIW shall be used for make-up to CW systems from H01 to reduce fouling
- Return line pressure in CUB at 4 bar g (+/- 0.2 bar)
- Differential pressure between return and supply in CUB at 3 bar (+/- 0.2 bar)
- Set-point for differential pressure shall be controllable in the range 2-4 bar
- Design pressure 10 bar g
- Temperature or pressure outside specification more than 1 min < 10 times/year
- 100% capacity available > 8000 hours/year
- <50% capacity for < 10 hours/year
- For stable Accelerator operation and future ESS flexibility, pressure drop in pipelines headers shall be low. For headers a line velocity <1.5 m/s is recommended. For short pipelines and/or less sensitive consumers up to 2.5 m/s can be acceptable.
- Piping material according to design manual pipe class EAS16A (1.4432)

- For other equipment 1.4404 or similar should be used. Other materials shall be confirmed with BLT Process.

Forbidden materials and substances in CWM and CWH (and indirectly DIW) systems:

- Silicon oils
- Silicon materials
- Silicon lubricants
- Oils
- Greases
- Carbon steel
- Cast iron
- Galvanized iron
- Aluminium
- Bronze
- Teflon (tape)
- Zinc alloys
- Brass

NOTE! Design and installation of sub-systems required to avoid contamination of CF main systems are not part of CF scope.

4.2. District Heating Low-temp (DHL)

4.2.1. Purpose

- Production of DHL for use in ESS buildings
- Prepare for production of DHL for future external use
- Distribution of DHL from H01 to consumers

4.2.2. System stakeholders

- SI HVAC
- Target division

4.2.3. Operational Scenarios

The system shall be designed for continuous operation without any need for planned full system shutdowns. During periods with low heating demand, the system can however be shut-down for planned service. Short planned shutdowns are possible also during periods of cold weather.

The system shall be able to supply heating from 0-100% of design load.

The system shall be able to handle a wide range of supply and return temperatures. The operational limits are however depending on the actual heating load, available waste heat and several design criteria.

4.2.4. Conceptual design and requirements

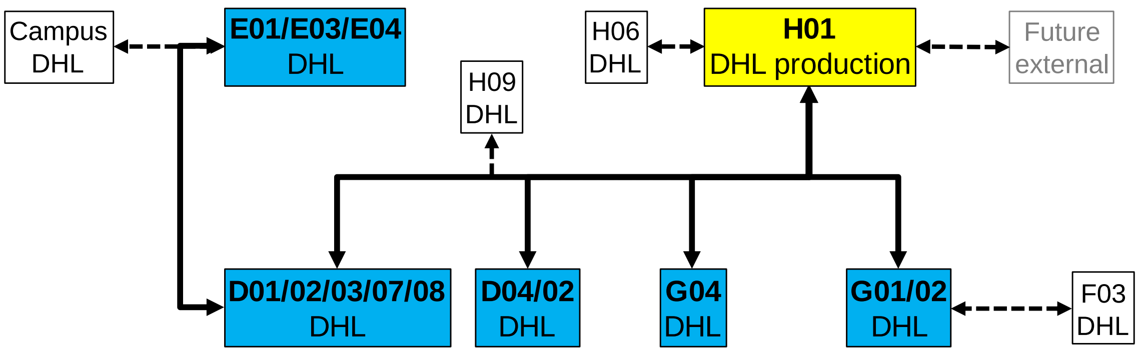

Figure 3: DHL schematics for ESS

- Supply temperature can vary depending on seasonal conditions at +35 - +55°C. +55°C applies when outdoor temperature is -18°C (design case).
- "Normal "district heating water quality.
- DHL return line pressure in CUB TBD in future CUB design
- Differential pressure between return and supply in CUB at 2 bar (+/- 0.5 bar).
- Set-point for differential pressure shall be controllable in the range 1-3 bar
- Design pressure 10 bar g
- Temperature or pressure outside specification more than 10 min < 5 times/year
- 100% capacity available > 7000 hours/year
- <50% capacity for < 150 hours/year
- For headers a line velocity <2.0 m/s is recommended. For short pipelines and/or less sensitive consumers up to 2.5 m/s can be acceptable.
- Piping material according to design manual pipe class DCS16A (P235GH)

4.3. District Heating (DH)

4.3.1. Purpose

- Production of DH for sale to external customer

4.3.2. System stakeholders

- Kraftringen

4.3.3. Operational Scenarios

The system shall be designed for continuous operation without any need for planned full system shutdowns. During Accelerator shutdowns it is however possible to shut down the DH system temporarily by dispatching the CW heat in air coolers. CW temperature requirements can however not be maintained in full without DH system in operation.

The system shall be able to handle waste heat loads from 0-100% of design load.

4.3.4. Conceptual design and requirements

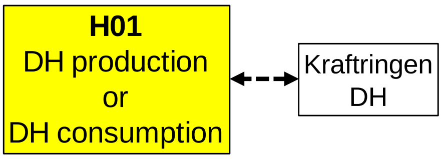

Figure 4: DH schematics for ESS

- Two operational modes:
  - *Heat export when ESS produce excess heat*
    - *ESS gets ~45°C (30-65°C) water from Kraftringen at 0-4 bar g.*
    - *ESS delivers 80-82°C water to Kraftringen at 7-11 bar g*
  - *Heat import when ESS internal consumption higher then production*
    - *ESS gets 70-100°C water from Kraftringen at 6-7 bar g*
    - *ESS delivers 30-50°C water to Kraftringen at 4-5 bar g*
- "Normal "district heating water quality.
- Pressure in "cold line" and "hot line" determined by Kraftringen and pressure drop in piping to/from ESS.
- Design pressure 12 bar g
- Temperature or pressure outside specification more than 10 min < 5 times/year
- 100% capacity available > 7000 hours/year
- <50% capacity for < 150 hours/year
- For headers a line velocity <2,0 m/s is recommended. For short pipelines and/or less sensitive consumers up to 2,5 m/s can be acceptable.
- Piping material according to design manual pipe class DCS16A (P235GH)

4.4. Instrument Air (IAR)

4.4.1. Purpose

- Production of high quality instrument air
- Distribution of instrument air from H01 to consumers

4.4.2. System stakeholders

- Accelerator division
- Target division
- Science directorate

4.4.3. Operational Scenarios

The system shall be designed for continuous operation without any need for planned full system shutdowns. It is however possible to shutdown isolated sections by supplying local rental compressors/driers.

The system shall be able to manage air consumption from 0-100% of design flow rate.

4.4.4. Conceptual design and requirements

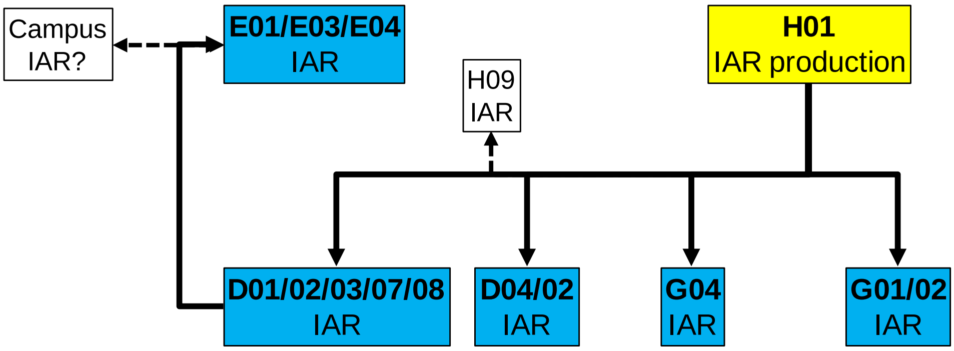

Figure 5: IAR schematics for ESS

- Solids : ISO 8573 class 1
- Dew point : ISO 8573 class 2 (-40°C)
- Oil : ISO 8573 class 0 (oil free)
- Operating pressure 6-7 bar g (the pressure level is adjustable)
- For headers a line velocity <15 m/s is recommended. For short pipelines and/or less sensitive consumers up to 25 m/s can be acceptable.
- Design pressure 10 bar g
- Pressure outside specification more than 1 min < 5 times/year
- 100% capacity available > 8000 hours/year
- <50% capacity for < 150 hours/year
- Piping material according to design manual pipe class AL13A (Aluminium)
- For system exposed to radiation, pipe class EAS16A should be used. (1.4432)

4.5. De-ionized water (DIW)

4.5.1. Purpose

- Production of DIW for stakeholder requirements
- Distribution of DIW from H01 to consumers

4.5.2. System stakeholders

- Accelerator division
- Target division
- Science directorate

4.5.3. Operational Scenarios

The system shall be designed for continuous operation without any need for planned full system shutdowns. The production unit before the buffer tank can however be temporarily shut down, while using up the buffer volume.

The system shall be able to handle DIW consumption from 0-100% of design flow rate.

4.5.4. Conceptual design and requirements

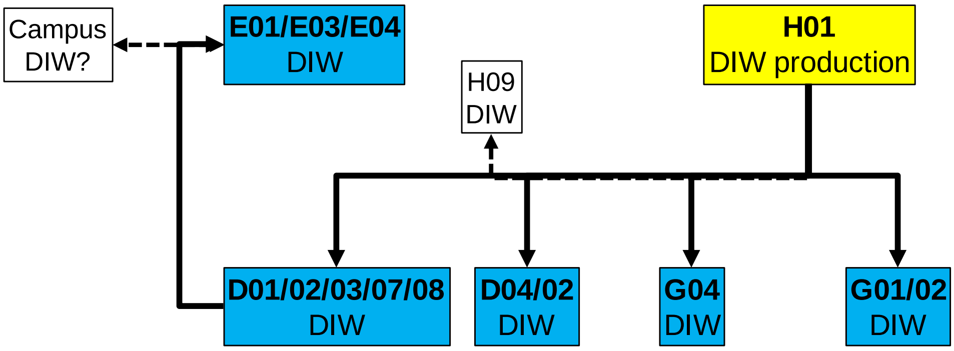

Figure 6: DIW schematics for ESS

- Conductivity : <0,1 µS/cm
- No biological contamination
- Oxygen < 15 ppb
- Operating pressure 8 bar g
- For headers a line velocity <1,5 m/s is recommended. For short pipelines and/or less sensitive consumers up to 2,5 m/s can be acceptable.
- Design pressure 10 bar g
- Pressure outside specification more than 1 min < 5 times/year
- 100% capacity available > 8000 hours/year
- <50% capacity for < 150 hours/year
- Piping material according to design manual pipe class EAS16A. (1.4432)

<u>Forbidden materials and substances in DIW system:</u>

- See chapter 3.1.4

4.6. Nitrogen gas (N2G)

4.6.1. Purpose

- Distribution of N2G from evaporators to consumers
- (Evaporators provided by others)

4.6.2. System stakeholders

- Target division
- Science directorate

4.6.3. Operational Scenarios

The system shall be designed for continuous operation without any need for planned full system shutdowns.

4.6.4. Conceptual design and requirements

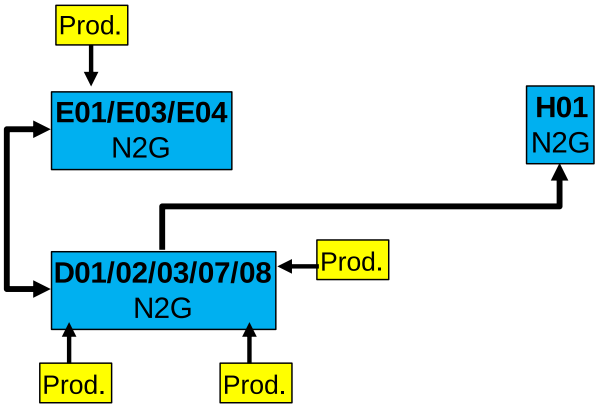

Figure 7: N2G schematics for ESS

Nitrogen gas will be produced from four liquid nitrogen storages (supplied by others) located outside the Experimental Halls. CF will install piping system to supply consumers.

- Design pressure: 13 bar g
- Operational pressure: 10 bar g
- Piping material according to design manual pipe class AL13A. (Aluminium)

4.7. Laboratory gases and Detector gases

4.7.1. Purpose

- Distribution of Laboratory gases and Detector gases from gas bottles (provided by NSS) to consumers in lab buildings.

4.7.2. System stakeholders

- Science directorate

4.7.3. Operational Scenarios

The system shall be designed for continuous operation without any need for planned full system shutdowns.

4.7.4. Conceptual design and requirements

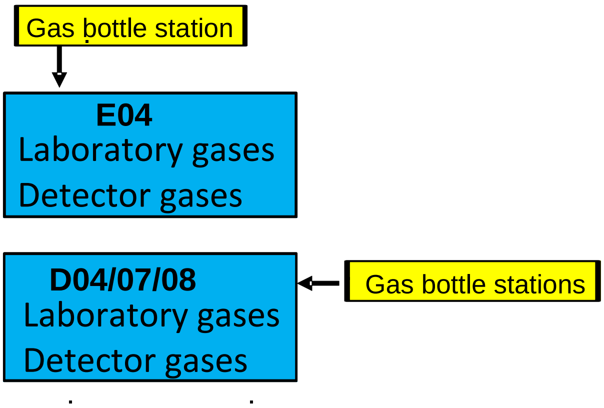

Figure 8: Laboratory gases and Detector gases schematics for ESS

Laboratory gases and Detector gases shall be supplied from gas bottle stations (supplied by NSS) located in a specified area at the laboratory buildings D04, D07, D08 and E04. CF will install piping system to supply consumers.
This is local systems limited to each building where Laboratory gases and Detector gases are needed.

- Operational pressure: 10 bar g
- Material: Stainless steel
- Piping/tubing: Swagelok or similar

4.8. Moderator hydrogen

4.8.1. Purpose

- Installation of transfer line for hydrogen from swap containers to Hydrogen room

4.8.2. System stakeholders

- Target division

4.8.3. Operational Scenarios

The system is only needed for short periods during moderator fill-up.

4.8.4. Conceptual design and requirements

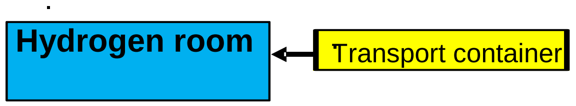

Figure 9: Hydrogen gas schematics for ESS

Local system for first-fill of moderator hydrogen.

- Design pressure: 13 bar g
- Operational pressure: 10 bar g
- Piping material according to design manual pipe class EAS16A. (1.4432)

4.9. Radiological waste water and risk waste water

4.9.1. Purpose

- Installation of transfer lines for radiological waste water from D02 and D08 Radiological lab, Target entrance building and Target utility room to H09 Waste Building for further treatment.
- Installation of transfer lines for risk waste water from other laboratories to Waste Building for checking.

4.9.2. System stakeholders

- Target division
- Science directorate
- ES&H (H09 Waste Building)

4.9.3. Operational Scenarios

The system is operated intermittently when pumping waste water from storage tanks in D and E buildings to H09 waste building.

4.9.4. Conceptual design and requirements

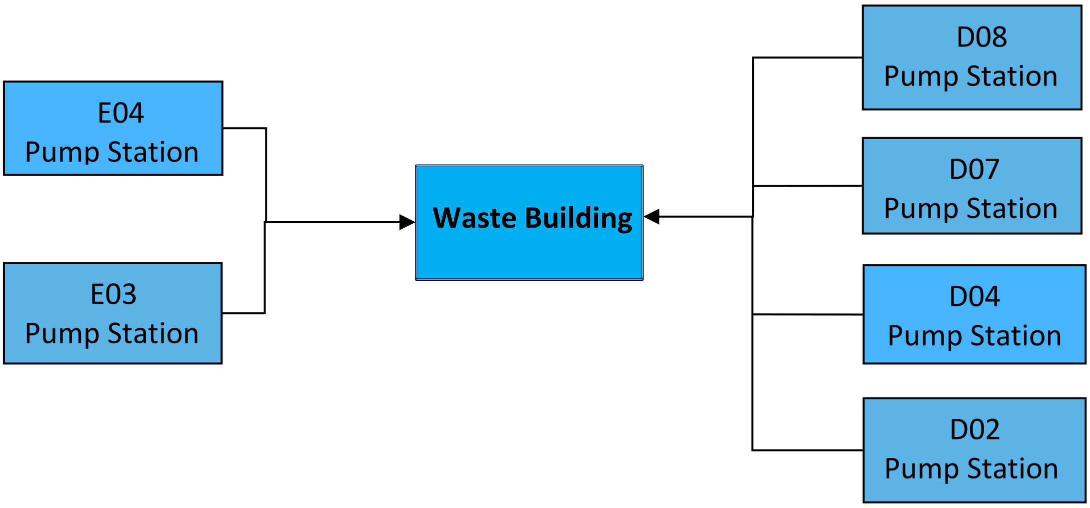

Figure 10: Radiological waste water and risk waste water schematics for ESS

CF Process will only provide piping system for transfer to Waste Building. The system will most likely be subject to SSM regulation due to risk of radioactive contamination from Target water system and Laboratories. Documentation and risk analysis of the system shall comply with ESS rules and procedures according to SSM permit.

- Operating pressure: 5 bar g
- Piping material according to design manual pipe class EAS16A. (1.4432)

DOCUMENT REVISION HISTORY

Version	Reason for revision	Date
1.0	New document	2016-04-26
2.0	Added chapters regarding ES&H plus adjustments/corrections	2016-07-04
3.0	Added reference to ESS-0039311 and clarified statement about SSM requirements in section 3.3 and 3.4	2017-06-08