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| G02 RF Gallery Cooling System Description |
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|  | Name | **Role/Title** |
| --- | --- | --- |
| **Owner** | Anton Lundmark | Cooling system engineer |
| **Reviewer** | Akif Coku | WP16 project engineer |
| **Approver** | Anton Lundmark | Cooling system engineer |

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# Introduction

## General description

The ESS accelerator is a long pulsed superconducting linac that accelerates a 62.5 mA proton beam current to the energy of 2 GeV. Peak beam power to the target will be 125 MW. The layout of the accelerator is shown in Figure 1.

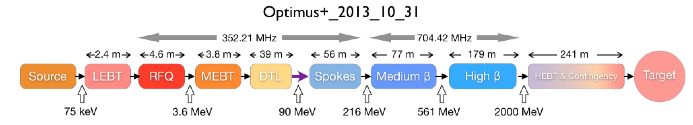


Figure 1. Layout of the ESS accelerator. The blue parts indicate the superconducting part of the linac whereas the other colours indicate room temperature elements.

The accelerator comprise of a number of different subsystems, primarily divided into a warm section (room temperature) and a superconducting section. The last part of the accelerator consists of quadrapole magnets and beam instrumentation that guides the proton beam to the target station (HEBT). The HEBT section may also be used as future upgrade space.

The warm section consists of ion source, Low Energy Beam Transport (LEBT), Radio Frequency Quadrapole (RFQ), Medium Energy Beam Transport (MEBT), and Drift Tube Linac (DTL).

The superconducting section Spokes, Medium Beta, and High Beta. The acceleration in this section is performed via 2 K helium cooled niobium cavitites.

The protons are accelerated by means of RF power at two principal frequencies (approx. 352 MHz and 704 MHz) shown in Figure 1.

The MEBT buncher cavitites are powered by solid state RF amplifiers.

The RFQ is powered by a 3MW (peak) klystron.

The DTL is powered by 5 3MW (peak) klystrons.

The spoke section is powered by 52 tetrodes

The medium and high beta sections are powered by 36 + 84 1.5 MW (peak) klystrons[[1]](#footnote-1).

All RF circuits include protective devices such as circulators and RF loads.

# Design criteria

## Applicable standards and norms

Table 1 presents the applicable design rules and guidelines.

| Table 1 Design standards | |
| --- | --- |
| Parameter | Description |
| Applicable directives | European Pressure Directive (2014/68/EU) |
|  | Low Voltage Directive (2006/95/EC) |
|  | EMC directive ([2004/108/EC](http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32004L0108&locale=en)) |
| Applicable standards | ISO and EN standards, primarily harmonized standards and its normative references |
| Piping material | Stainless Steel EN 1.4404 or similar |
| ESS internal rules | ESS rules for plant and process, reference [1] |

## General design prerequisites for LINAC systems

| Table 2 Design prerequisites | |  |
| --- | --- | --- |
| Parameter | Value | Comment |
| Nominal operating pressure | 7 bar(g) | Spoke CWH system supplies water at 4 bar(g) due to tetrode anodes maximum allowed pressure of 5 bar(g) |
| Design pressure | 10 bar(g) |  |
| Allowed pressure drop between supply and return headers | 3 bar |  |
| CWL operating temperature | 8 °C |  |
| CWM operating temperature | 25 °C |  |
| CWH operating temperature | 50 °C |  |
| Nominal operating temperature | 20 °C |  |

## Heat loads and flow rate requirements

Heat loads for each RF gallery section is provided in reference [3].

## Radiological safety

G02 RF Gallery process systems are not radiological safety systems. The klystrons generate X-rays, which are shielded locally, and does not contaminate the cooling water.

## Risk assessment

See reference [2] for hazop protocol.

# Interfacing systems

## General description of interfacing systems

The RF gallery cooling systems interface on one end with the conventional facilities cooling systems and on the other end with RF equipment, modulators, and rack coolers, i.e. LINAC systems.

Conventional facilities produce deionized water at three different temperature levels (CWL, CWM, and CWH) in the central utilities building. From there the water is distributed to all relevant buildings process substations. G02 has three process substations designated low beta substation, medium beta substation, and high beta substation.

The LINAC systems are directly supplied from CUB, i.e. there are no isolated subsystems in the substations. The CWH circuit has a set of shunt pumps, which are used to recirculate the water and increase temperature. This is done in order improve heat recovery.

The CWM, and CWH water is supplied via piping located inside of the roof trusses. CWL is supplied via piping located on the south wall. CWL supplies water to the rack coolers.

CWH is used for klystron collectors, tetrode anodes, and RF loads (except spoke RF loads). CWM is used for the rest of the circuits.

## CF system description

Conventional facilities process systems are described in documents listed in Table 3.

| Table 3 CF documentation | |
| --- | --- |
| Name | Type |
| PS0155---8-G-----002 | P&ID |
| PS0155---8-G-----003 | P&ID |
| PS0155---8-G-----004 | P&ID |
| PS0155---8-G-----005 | P&ID |
| PS0155---8-G-----006 | P&ID |
| PS0155---8-G-----007 | P&ID |
| PS0155---8-G-----008 | P&ID |
| PS0155---8-G-----009 | P&ID |
| PS0155---8-G-----010 | P&ID |
| PS0155---8-G-----011 | P&ID |
| ESS-0039348, DM--SD-TBSIDDG02- System Description G02 Process | System description |
| ESS-0043566, DM--SD-TBSIDD----SI Process | System description |
| PS0055---8-G-----201 | PFD cooling water |
| PS0055---8-G-----202 | PFD instrument air |
| PS0055---8-G-----203 | PFD deionized water |
| DM--ID-TBSIDDG02-ACC-SI G02 Process | CF/ACCSYS agreed baseline design |
|  |  |

## LINAC (RF) system description

The RF system is described in detail in reference [4].

## WP16 (local cooling) system description

Table 4 contains the list of P&IDs within the scope of the local cooling system (scope of WP16). Design data are as per Table 2 and CF baseline documentation, Table 3.

| Table 4 WP16 P&IDs | |
| --- | --- |
| Name | Type |
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# References

1. ESS rules for plant and process
2. Hazop protocol
3. ESS-0027146 - WP16 water cooling systems
4. ESS-0021791 G02

# Glossary

| Term | Definition |
| --- | --- |
| CWL | Cooling Water Low, 8 °C |
| CWM | Cooling Water Medium, 25 °C |
| CWS | Cooling Water System |
| LEBT | Low Energy Beam Transport |
| MEBT | Medium Energy Beam Transport |
| HEBT | High Energy Beam Transport |
| A2T | Accelerator to Target (last part of accelerator before target station) |

Document Revision history

| Revision | Reason for and description of change | Author | Date |
| --- | --- | --- | --- |
| 1 | First issue | Anton Lundmark | 2016-11-16 |
|  |  |  |  |
|  |  |  |  |

1. The high beta section baseline are multi beam IOTs but the cooling system design is conservatively based on klystrons. [↑](#footnote-ref-1)