System Description Document- Requirements Target Wheel, Drive and Shaft

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1. INTRODUCTION

1.1. Scope of this document

This document presents requirements for the Target Wheel- and Target Drive and Shaft systems in the target station.

Chapter 2 describes identified and defined functions for the system, interfaces and system structure.

Chapter 3 and 0 details requirements, constraints and affordances.

2. SYSTEM CONTEXT AND ALLOCATED FUNCTIONS

2.1. Stakeholders

Relevant speaking partners within ESS.

Division	Group	Remark
Operations, ES & H, QA	Maintenance Personnel	
Operations, ES & H, QA	Operators	
Operations, ES & H, QA	Waste Handling Group	
Operations, ES & H, QA	Remote Handling Personnel	
Operations, ES & H, QA	Radiation Protection Personnel	
Accelerator Division	Vacuum Section	
Engineering and Integration	Survey, Alignment and Metrology Group	
Engineering and Integration	Integration Group	
Engineering and Integration	Design- and Engineering Group	

2.2. Interfaces

2.2.1. Interface Interaction Diagram

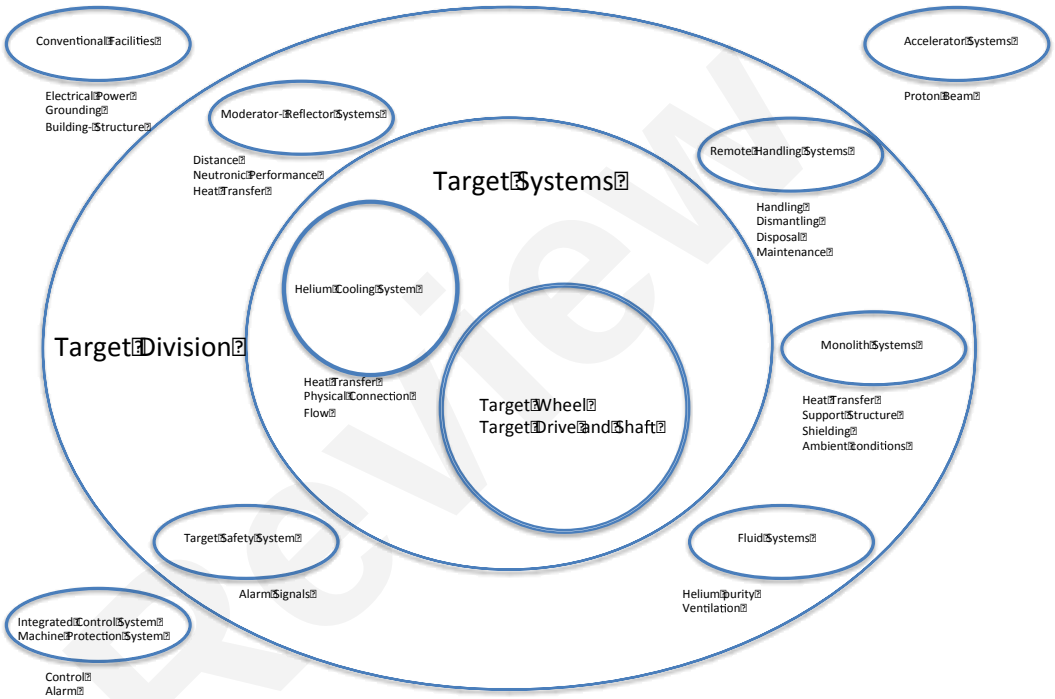


Figure 1: Interface interaction diagram

2.3. Safety functions

2.3.1. Radiation protection and shielding functions

- Limit radiation through internal shielding structures.

2.3.2. Functions related to confinement of radioactive inventory

- Maintain integrity and spallation material geometry.
- Control spallation material temperature through distribution of coolant
- Control Target vessel temperature through distribution of coolant
- Confine radiated and contaminated Helium gas and particles.

2.3.3. Functions related to protection and support of safety functions

- Protect embedded safety related instrumentation belonging to Target Safety System from damage from mechanical, electromagnetic, electrical, temperature, chemical or radiation impact.

2.4. Operational functions

2.5. Functional Analysis of the system

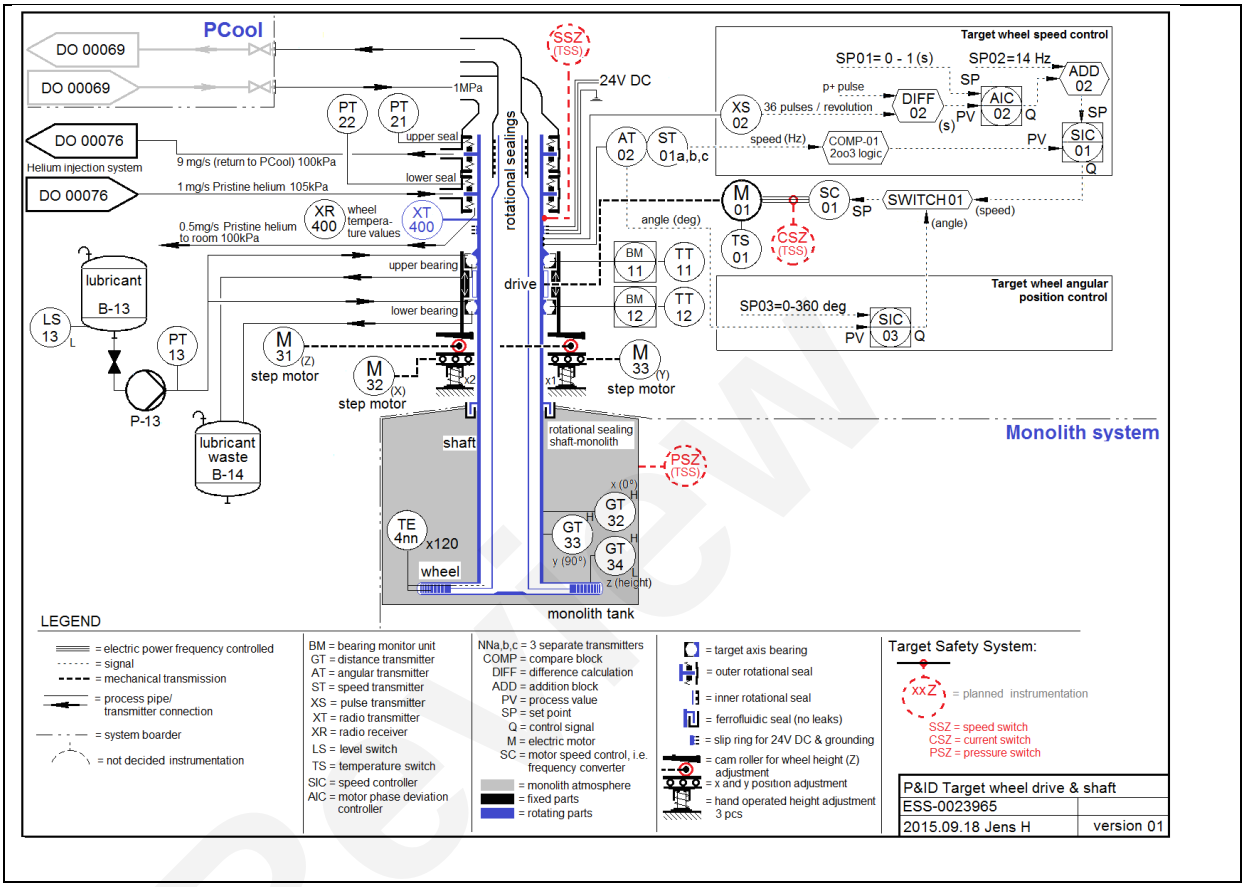
The Target Wheel, Drive and Shaft has the following operational functions and subsystems.

Function	Subsystem	Sub-system, abbreviation
Rotation and speed control	Drive and shaft	Drive system
Friction and position control	Drive and shaft	Bearing system
Helium connection to stationary Helium Cooling System	Drive and shaft	Helium Feedthrough system
Alignment and suspension	Drive and shaft	Static positioning system
Fine vertical adjustment	Drive and shaft	Fine adjustment
Helium transport, rotation and shielding	Drive and shaft	Shaft
Helium distribution and shielding	Wheel	Central part
Wheel structural integrity and tightness	Wheel	Shroud
Spallation material position and temperature control	Wheel	Cassettes
Spallation material	Wheel	Tungsten blocks

2.5.1. Expression of the system need

The Target Wheel Drive and Shaft shall provide a structurally stable suspension, control spallation material temperature and stress, control and distribute coolant and ensure neutronic performance through spallation material configuration.

2.5.2. Process & Instrumentation Diagram (P&ID)



2.5.3. Electrical logic block diagram

To be completed (part of the detail design phase).

2.5.4. Control block diagram

N/A (part of the detail design phase by ICS)

3. REQUIREMENTS

Requirements are defined within one of the 3 main groups:

- Requirements from top level (section 3.1)
- Requirements from system with interface to this system (section 3.2)
- Requirements within this system (section 3.3)

Requirements are labelled according to following principles:

- String: **System-SNN**.
Example: PCool-001 where the system part is the system abbreviation.

- The **System abbreviation** reflects the origin of the requirement
Example: Wheel-001, where the requirement is imposed by system “wheel” and put on another system. This means it is always easy to understand where a requirement comes from.

- **S** is used to divide the number series into groups
Examples: PCool-001 where 0 is used for Top level requirements. PCool-301 where 3 is used for requirements regarding process control.

- **NN** is pure serial number within the S group

3.1. Requirements from ESS top level and authorities

3.1.1. Applicable regulations, codes and standards

Organization	Number	Title
AFCEN	RCC-MrX	Design and Construction Rules for Mechanical Components of Nuclear Installations
ESS	ESS-0016468	ESS rules for identification and classification of safety important components
Strålsäkerhets-myndigheten (SSM)	SSM 2012-131-1	Tillstånd för European Spallation Source ESS AB
Strålsäkerhets-myndigheten (SSM)	SSM 2013-3285	Särskilda villkor till ESS-anläggningen I Lund
ESS	ESS-0000004	General Safety Objectives for ESS
ESS	ESS-0001515	Guideline for Regulations, Codes and Standards
ESS	ESS-2013-001	Technical Design Report
ESS	ESS-0	Vacuum Handbook part 1-4
ESS	ESS-0028465	ESS Target Materials Handbook
ESS	ESS-0002642	Fire protection- Semi Detailed requirements on Radiation safety and protection of Property
ESS	ESS-0004722	Fire & Explosion Safety Program
ESS	ESS-0005857	System Requirement Document Target Station

3.1.2. General requirements related to the Target Station applicable for the system

ID	TWDS-000	Target Station requirements
Requirement	Target Wheel, Drive and Shaft shall comply with applicable Requirements specified in ESS-0005857 . [24]	
Rationale/Reference	In [24] requirements for entire Target Station including Target Wheel, drive and Shaft system are specified.	

3.1.3. Design requirements related to Radiological safety

ID	TWDS-100	Structural verification
Requirement	Parts of the Target Wheel, Drive and shaft fulfils different tasks of importance to radiological safety for the ESS facility. Therefore these shall comply with requirements stated in applicable sections of the RCC- MRx code [25], taking radiation damage mechanisms into account.	
Rationale/Reference	Parts of the structure will be highly affected by radiation and have a limited lifetime.	

3.1.4. Requirements related to fire protection

ID	TWDS-200	Fire Protection
Requirement	Parts of the Target Wheel, Drive and shaft fulfils different tasks of importance to radiological safety for the ESS facility. Therefore these shall comply with requirements stated in ESS-0002642 [xx] in order to mitigate consequences of postulated fire.	
Rationale/Reference	Parts of the structure will be situated in Connection cell and may be affected by fire.	

3.1.5. Requirements related to management of radioactive waste and release

ID	TWDS-300	Radioactive waste and release
Requirement	Low- active waste streams as well as high- active waste streams shall be defined.	
Rationale/Reference	Parts of the Target Wheel, Drive and shaft will be activated and/ or contaminated during operation	

3.1.6. Occupational safety requirements

ID	TWDS-400	Occupational safety
Requirement	Workers must be protected from receiving dangerous radiation dose by access control and design of accessible parts of the system	
Rationale/Reference	Parts of the Target Wheel, Drive and shaft will be activated and/ or contaminated during operation, and will be accessible for maintenance when proton beam is turned off.	

3.1.7. Classification and zone

Safety Classification

In ESS-0016468, ESS principle for Safety Classification is detailed.

The following terminology and principal stance has been adopted in ESS-0016468, which defines the ESS principle for safety classification.

Name	Definition
SSC	Structure, System or Component
SaF	Function whose failure leads to an event and function needed to reach controlled state after event.
SaF (C1-C3)	C1 = High severity, C2 = Medium severity, C3= Low severity (of consequences)
SeF	Service Functions to Safety Functions- protection of Safety Functions
SIC	SSC important to safety
SC (1-3)	ESS Safety class 1 - 3
Redundancy	Redundancy mitigating an active single failure criteria required in Safety Class 1 and 2 but not 3.

Motivations for code class choices

At this point radiation doses to public or workers from different postulated accident scenarios are not known. However, for Target Wheel, Shaft and Drive Unit Code Class N_{2RX} and Code Class N_{3RX} of RCC- MrX is selected, with the caviet that the code does not define a process to account for degradation of materials performance due to radiation damage in a spallation source environment. In this regard, best practice should be applied in lieu of specific RCC- MRx guidance.

3.1.8. Summary table of general parameters

Description	Value or Reference
Proton Beam Averaged Power	5 MW
Proton Beam Pulse repetition rate	14 Hz
Proton Beam Energy	2GeV
Operating days per year	225 Days per year
Target Concept	Rotating
Spallation Material	Tungsten
Coolant	Helium
Number of sectors	36
Operational pressure, Helium	1 MPa
Operational temperatures, Helium inlet	40-60°C
Operational temperatures, Helium outlet	220-240°C

3.2. Requirements related to systems with interface to this system

3.2.1. Accelerator System

The tables below summarises the requirements between the 2 systems.

Req. id nr	Description	Refe-rence
Wheel-901	Beam footprint size encompassing 99% and 99.9% of the beam	[6]
Wheel-902	Beamlet size- size of proton beam that is rastered on target	[6]
Wheel-903	Maximum horizontal and vertical displacement of beam footprint	[6]
Wheel-904	Maximum time-averaged peak current density at target surface	[6]
Wheel-905	Pulse frequency during normal operation	[6]
Wheel-906	Accelerator timing accuracy	[6]
Wheel-907	Beam nominal pulse length	(6)
Wheel-908	Maximum energy per beam pulse	(6)
Wheel- 909	Specification of luminescent coating on Beam Entrance Window	(6)

Interface requirements imposed on the Accelerator system by Target Wheel

Req. id nr	Description	Refe-rence
Acc-951	Beam OK signal to the Accelerator	[6]

Interface requirements imposed on the Target Wheel by the Accelerator system

3.2.2. Target Cooling Systems

The tables below summarises the requirements between the 2 systems.

Req. id nr	Description	Reference
PCool-200	Order signal from Target wheel to PCool to set a fixed cooling power	[10]
PCool-201	Pipe flange with flow to target	[10]
PCool-202	Pipe flange with flow from target	[10]
PCool-203	Pipe flange with seal flow to/from target	[10]
PCool-204	Maximum amount of particles formed	[10]
PCool-205	Total pressure drop over the target	[10]

Interface requirements imposed on Target Wheel by PCool

Req. id nr	Description	Reference
Wheel-200	Heat removal power from the target wheel	[10]
Wheel-201	Cooling media (Helium)	[10]
Wheel-202	Cooling media maximum normal flow	[10]
Wheel-203	Cooling media temperature values (max. diff. and max. temp. out)	[10]
Wheel-204	Maximum operational pressure	[10]
Wheel-205	Minimum operational pressure	[10]
Wheel-206	Pipe connections adapted for plug removal	[10]
Wheel-207	Seal gas mass flow	[10]
Wheel-208	Seal gas maximum temperature	[10]
Wheel-209	Cooling media particulates (>= 5 µm) purity	[10]

Interface requirements imposed on PCool by Target Wheel

3.2.3. Target Safety System

The tables below summarises the requirements between the 2 systems.

Req. id nr	Description	Reference
TSSD-001	Mounting of safety classified instrument	[2]
TSSD-002	Provisions for accurate measurement of Motor Current	[2]
TSSD-003	Provisions for accurate measurement of Rotation Speed	[2]

Interface requirements imposed on Target Wheel by TSS

3.2.4. Moderator and Reflector Systems

The table below summarises the requirements between the 2 systems.

Req. id nr	Description	Refe-rence
Mod-201	Minimum and maximum distance between Moderator and Target Wheel	[4]
Mod-202	Heat flux between Moderator and Target Wheel	[4]
Mod-203	Position of Neutron Peak Flux centre point	[4]

Interface requirements imposed on Target Wheel by the Moderator and Reflector Systems

3.2.5. Ventilation system for activated gases (HVAC)

The table below summarises the requirements between the 2 systems.

Req. id nr	Description	Refe-rence
Shaft-601	Ventilation capacity during normal operation	[20]
Shaft-602	Ventilation capacity and ventilation hoods during maintenance	[20]

Interface requirements imposed on HVAC system by Target wheel systems

3.2.6. Machine Protection System

Req. id nr	Description	Refe-rence
MPS-200	Requirements on instrumentation posed by Machine Protection System	TBD

Interface requirements imposed on Target system by Machine protection system

3.2.7. Remote Handling Systems

The table below summarises the requirements between the 2 systems.

Req. id nr	Description	Refe-rence
ActiveCells1.1	Dimensions requirements	[7]
ActiveCells1.2	Radiation and contamination requirement	[7]
ActiveCells1.3	Condition information requirement	[7]
Casks1.1	Dimensions requirements	[8]
Casks1.2	Dimensions requirements	[8]
Casks1.3	Radiation and contamination requirement	[8]
Casks1.4	Condition information requirement	[8]
Mockup1.1	Dimensional requirement	[9]
Mockup1.2	Functional requirement	[9]
Mockup1.3	Site Acceptance test program	[9]
Mockup1.4	Test Rig instrumentation	[9]

Interface requirements imposed on Target Wheel by the Remote Handling System

3.2.8. Process Control System

The tables below summarises the interface requirements between the 2 systems.

Req. id	Brief description	Reference
N/A	Object signal interfaces	[1]APPENDIX 1
N/A	Control system configuration	[1]
N/A	Controls connection	[1]

Signal interfaces

Req. id nr	Description	Refe-rence
Drv-301	Motor load monitoring	[1]
Drv-302	Motor temperature monitoring	[1]

Interface requirements imposed on Process control system from Target Drive subsystem

Req. id nr	Description	Refe-rence
Pos-301	Motor load monitoring	[1]
Pos-302	Motor temperature monitoring	[1]

Interface requirements imposed on Process control system by Target Positioning subsystem

Req. id nr	Description	Refe-rence
Wheel-301	Tungsten temperature monitoring	[1]
Wheel-302	Wheel Helium temperature monitoring	[1]

Interface requirements imposed on Process control system by Target Tungsten temperature subsystem

Req. id nr	Description	Refe-rence
Feed-302	Sealing pressure monitoring	[1]

Interface requirements imposed on Process control system by Target feedthrough subsystem

Req. id nr	Description	Refe-rence
BearU-301	Lubrication pump timer control	[1]
BearU-302	Lubricant level switch monitoring	[1]
BearU-303	Bearing temperature	[1]
BearU-304	Bearing vibration values	[1]
BearU-305	Lubricant line pressure	[1]

Interface requirements imposed on Process control system by Target Bearings and lubrication subsystem

3.2.9. Monolith Systems

The tables below summarises the requirements between the 2 systems.

Req. id nr	Description	Refe-rence
TW-1.1	Target Monitoring Plug function	[5]
TW-1.2	Target Monitoring Plug function	[5]
TW- 1.3	Target Monitoring Plug Geometrical Interface	[5]
IM-2.1	Irradiation Module Geometrical Interface	[5]
TW-3.1	Neutron Beam Extraction Geometrical Interface	[5]
TGT- 4.1	Shielding geometrical Interface	[5]
TGT-4.2	Heat Flux Distribution to Shielding	[5]
TGT-5.1	Target Wheel support stiffness	[5]
TGT-5.2	Monolith Vessel Geometrical Interface	[5]
MonAtm-6.2	Maximum allowable leak rate	[5]
MonAtm-6.3	Environmental Constraints	[5]

Interface requirements between Monolith Systems and Target Systems

Beam monitoring plug

Req. id nr	Description	Refe-rence
BPlug-201	Luminescent coating applied on Beam Entrance Window	[6]

Interface requirements imposed on Target Wheel by the Beam monitoring plug

3.2.10. Conventional Facilities

The tables below summarises the requirements between the 2 systems.

Req. id nr	Description	Refe-rence
TWDS-401	Electric power; Switchgear total power and distribution	[3]
TWDS-402	Protective earth connections, total number and capacity	[3]
TWDS-403	Electric power; Sockets for tools during e.g. maintenance	[3]
TWDS-404	Lighting; Total capacity, number, locations and capacity	[3]
TWDS-451	Space needed in the monolith during installation & maintenance	[3]
TWDS-452	Space needed in the high bay during installation & maintenance	[3]

Interface requirements imposed on CF by the Target Systems

Req. id nr	Description	Refe-rence
CFSh-001	Internal shielding related to dose rate in surrounding rooms.	[3]

Interface requirements imposed on Target by CF

3.3. Detailed internal system requirements

3.3.1. Function and performance

ID	Wheel-101	Natural frequency
Requirement	First natural frequency of the system shall be higher than 1,8 Hz.	
Rationale/Reference	To avoid self-oscillating	

ID	Wheel-102	Shaft internal shielding
Requirement	The shaft internal shielding shall result in a maximum neutron and gamma flux of 0,1 Gray per hour equivalent dose rate	
Rationale/Reference	For limitation of neutron and gamma flux in connection cell to protect components from radiation damage during operation, and personnel during maintenance and handling.	

ID	Wheel-103	Centre wheel Shielding
Requirement	The Target Wheel shall provide shielding to limit total dose rate at rooms downstream beamline to values acceptable according to Legislation.	
Rationale/Reference	The dose rate behind Target Wheel must be limited to avoid excessive streaming into Utility rooms.	

ID	Wheel-104	Geometrical tolerances
Requirement	The Target Wheel, Drive and Shaft must adhere to certain global tolerance demands.	
Rationale/Reference	ESS-0023776	

Internal Requirements- Target Wheel Cassettes

ID	Wheel-105	Cassettes
Requirement	The fastening of Tungsten into Cassettes must not introduce any unintended stresses into the Tungsten bricks.	
Rationale/Reference	Stress conditions inside Tungsten bricks must be predictable.	

3.3.2. Spallation Material

ID	Wheel-113	Tungsten maximum temperature
Requirement	Tungsten maximum temperature during normal operation shall be below 600 C	
Rationale/Reference	ESS-0009043	

ID	Wheel-114	Tungsten maximum temperature
Requirement	Tungsten maximum temperature during accidents shall be below 700 C	
Rationale/Reference	ESS-0009043	

ID	Wheel-115	Tungsten post-pulse maximum stress
Requirement	Tungsten post-pulse maximum stress shall be below 100 MPa	
Rationale/Reference	ESS-0009043	

ID	Wheel-116	Tungsten post-pulse peak stress
Requirement	Tungsten post- pulse peak stress shall be below 50 MPa	
Rationale/Reference	ESS-0009043	

3.3.3. Bearing Unit

ID	BearU-101	Radial and axial stiffness
Requirement	Complete system stiffness shall be above 10^9 N/m	
Rationale/Reference	Bearings needs a high enough radial and axial stiffness to give a sufficiently high resonance frequency	

ID	BearU-102	Maximum bearings friction
Requirement	Total maximum bearing friction 300 Nm	
Rationale/Reference	Bearing friction determines motor size and speed regulation characteristics	

ID	BearU-103	Internal Radial Clearance
Requirement	Internal radial clearance calculation shall be based on maximum operating temperature difference between bearing shaft and bearing house.	
Rationale/Reference	To avoid loss of clearance	

ID	BearU-104	Bearing life
Requirement	Bearing life time at least 200000 h	
Rationale/Reference	To limit the frequency for replacement of bearings	

ID	BearU-106	Cage Material
Requirement	Bearing Cage Material shall comply with the lubrication conditions	
Rationale/Reference	Cage wear determines bearing life.	

ID	BearU-107	Bearings lubrication media
Requirement	Bearings shall be grease or oil lubricated lubricated	
Rationale/Reference	To secure a long bearing life time	

ID	BearU-108	Lubrication pump capacity
Requirement	The lubricating pump flow capacity shall be up to 5 g/s.	
Rationale/Reference	Bearing lubricating needs.	

ID	BearU-109	Lubrication tank capacity
Requirement	The lubricant storage capability shall last for one year grease consumption	
Rationale/Reference	To limit the frequency of lubrication system refill	

3.3.4. Bearing monitoring Unit

ID	BearU-151	Measuring points
Requirement	Measuring points to be included: 2 accelerometers, one at each bearing.	
Rationale/Reference	Points of interest for Condition Monitoring System	

ID	BearU-155	Envelope capability
Requirement	The system shall be able to measure and trend bearing damage using Envelope Detection Unit.	
Rationale/Reference	A widely used bearing damaged trending system.	

ID	BearU-158	Trend data storage capacity
Requirement	The system shall be able to trend damage from one hour up to 2 years	
Rationale/Reference		

ID	BearU-159	System alarms
Requirement	The system shall be able to send alarm to MPS. Vibration Data related to alarm event shall be stored for Post Mortem analysis. Alarms shall be stored in an Alarm List.	
Rationale/Reference		

ID	BearU-160	User interface
Requirement	It shall be possible to configure bearings with damage frequencies	
Rationale/Reference	Ball- pass frequencies shall be entered in the system.	

ID	BearU-162	FFT capabilities
Requirement	It shall be possible to configure averaging type, filtering type, FFT resolution and other parameters in the FFT analyser	
Rationale/Reference		

3.3.5. Drive Unit

ID	Drv-101	Motor drive torque; inertia
Requirement	The motor, gear/belt drive and the motor drive, i.e. the frequency converter, shall be adapted for a rotor inertia of 4600 kgm2	
Rationale/Reference	To enable fast enough speed changes	

ID	Drv-102	Motor drive torque; friction
Requirement	The motor, gear/belt drive and the motor drive, i.e. the frequency converter, shall be adapted for a target wheel bearing friction of 300 Nm	
Rationale/Reference	To have big enough torque to overcome friction	

ID	Drv-103	Motor drive speed range
Requirement	The motor, and the motor drive, i.e. the frequency converter, shall be adapted for a target wheel maximum speed of 60 rpm, minimum speed of 1 rpm	
Rationale/Reference	To limit maximum speed and to reach a low enough speed used for static positioning.	

ID	Drv-104	Central clock pulse synchronization
Requirement	During operation mode Target Wheel shall run synchronized to central clock pulse so that each wheel sector centreline is hit by the proton beam exactly once in 36/14 seconds (36 sectors/14 Hz = 2.5714 s)	
Rationale/Reference	To fulfil basic functions using 14 Hz frequency for the central clock pulse	

ID	Drv-105	Phase control accuracy
Requirement	During operation mode the wheel speed and phase control accuracy shall correspond to an angular displacement of maximum +/- 2 mm of the beam footprint at Target periphery.	
Rationale/Reference	To fulfil basic functions. The phase error shall be defined as the sum of all errors in the Measuring system, Motor, Frequency Drive and Transmission	

ID	Drv-106	Fixed angular positioning
Requirement	During Studies on Target Mode, Target shall be able to be positioned at any angular position with an angular error of maximum +/- 2 mm at Target periphery.	
Rationale/Reference	To fulfil studies on target basic functions	

ID	Drv-108	Speed measurement redundancy
Requirement	The speed measurement shall be adapted for 2oo3 redundancy	
Rationale/Reference	Target Wheel speed measurement is a crucial part of the drive function	

3.3.6. Helium Feedthrough System

ID	Feed-102	Maximum allowed Process Helium leakage
Requirement	Maximum allowed leakage from the Helium cooling system to Connection Cell Atmosphere is 0,01 mg/s Helium.	
Rationale/Reference	To fulfil requirements for maximum total leakage of Helium	

ID	Feed-103	Maximum allowed buffer gas leakage
Requirement	Maximum allowed leakage from the Helium buffer gas system to Connection Cell Atmosphere is 1 mg/s Helium.	
Rationale/Reference	To fulfil requirements for maximum total leakage of Helium	

ID	Feed-104	Pressures
Requirement	The seal shall operate at an ambient pressure of 10 -100 000 Pa	
Rationale/Reference	The seal isolates the inside helium at approximately 0.7 – 1.1 MPa, from the ambient pressure of between 10 Pa and 100 kPa	

ID	Feed-105	Material
Requirement	Seal materials must be approved by ESS	
Rationale/Reference	Due to ambient conditions and to avoid wear products of certain materials. Tungsten Carbide or Graphite is ok, however, certain binding substances for Graphite is not allowed.	

ID	Feed-106	Run out / shaft movement
Requirement	Feedthrough must be able to accommodate shaft movement or have an internal bearing.	
Rationale/Reference	Stability and reliability.	

3.3.7. Labyrinth seal system

ID	Feed-201	Nominal clearance
Requirement	Nominal clearance in labyrinth at operational temperature shall be 0.2 mm	
Rationale/Reference		

ID	Feed-202	Maximum allowed leakage
Requirement	Maximum allowable leak flow from inlet channel to outlet channel is 30 g/s at normal maximum cooling flow	
Rationale/Reference	To secure maximum bypass flow of less than 1%	

3.3.8. Positioning sub- system

ID	Pos- 101	Wheel vertical positioning span
Requirement	The Zero position of the Target Wheel is defined as a position 1125 mm from the Centre Axis of the Wheel. This point shall be aligned to the origo of the Target Coordinate System (TCS).	
Rationale/Reference	To fulfil basic functions.	

ID	Pos- 102	Wheel vertical positioning span
Requirement	The central process control and monitoring system shall handle adjustments and indicate position of the Target Wheel vertical position span of +/- 5 mm from theoretical zero.	
Rationale/Reference	To adjust for changes in position due to pressure and temperature fluctuation.	

ID	Pos- 103	Wheel vertical parking position
Requirement	The system shall be able to lower Target to a parking position 0 to 15 mm below theoretical zero.	
Rationale/Reference	To fulfil basic functions.	

ID	Pos- 104	Horizontal adjustment range
Requirement	Horizontal adjustment range of the system shall be +/- 25 mm	
Rationale/Reference	To account for deviations in position	

ID	Pos- 105	Angular adjustment resolution
Requirement	Angular adjustment resolution of the system shall be better than 0.1 degrees	
Rationale/Reference	To account for deviations in position	

ID	Pos- 106	Horizontal and vertical resolution
Requirement	Horizontal and vertical resolution shall be 0.1 mm	
Rationale/Reference	To account for deviations in position	

ID	Pos- 107	Horizontal and vertical stiffness
Requirement	Horizontal and vertical stiffness at least 10^9N/m	
Rationale/Reference	To fulfil basic functions	

ID	Pos- 108	Friction
Requirement	Friction shall be constant and predictable for both horizontal and vertical movement	
Rationale/Reference	To fulfil basic functions	

ID	Pos- 109	Material stress
Requirement	Plastic deformation is not allowed	
Rationale/Reference	To fulfil basic functions	

ID	Pos- 110	Allowance for measuring prisms
Requirement	There shall be provisions for holes that can be used for attachment of prisms	
Rationale/Reference	See Report ESS-0012977	

ID	Pos- 111	Vertical speed
Requirement	The vertical speed shall be 0.1 – 0.5 mm/s	
Rationale/Reference	To fulfil basic functions	

ID	Pos- 112	Position stability
Requirement	The system may not drift or have any backlash	
Rationale/Reference	To fulfil basic functions	

4. LIFE-CYCLE DESIGN REQUIREMENTS

4.1. Considerations regarding component lifetime

The following table indicates estimated lifetime of important components.

Component	**Lifetime**
Structural components exposed to radiation damage	5 years
Instrumentation close to wheel, exposed to radiation damage	1- 5 Year
Structural elements not exposed to radiation damage	40 years
Elastomers	1 year
Motors, instrumentation far from wheel	5 years
Bearings, worms, transmission	40 years
Contacting graphite seals	1 year

4.2. Requirements for prototyping

Practical Tests

There is need for practical tests of the following components before final design.

Component	**Test regarding**	**Remark**
Rotating feed through	Leak rate Wear rate	Component test is planned as an Engineering Design Demonstration
Fine adjustment system	Movement accuracy Translation smoothness	Component test will be done during Factory Acceptance Tests
Drive system	Speed – and phase regulation	Component test will be done during factory Acceptance Tests
Target Wheel	Mock-up to qualify welding parameters and qualify Non- destructive testing	Mock-up of sector and complete Target Wheel will be produced.
Target Wheel	Mock-up to qualify coating- and brazing parameters for Tungsten	Tests are planned.
Target Wheel	System with slip rings and wireless transmitters	Component test will be done during Factory Acceptance Tests

Equipment qualification

All sensitive components must be qualified for the environment they will be exposed to. Qualification can be through testing or through relevant experience at similar environments.

4.3. Requirements for commissioning

4.3.1. System and components performance testing

4.3.1.1. Factory Acceptance Test (FAT)

Factory acceptance test will be performed by ESS- Bilbao according to separate instructions.

4.3.1.2. Site Acceptance Test (SAT)

Site acceptance test will be performed by ESS- Lund according to separate instructions.

4.4. Requirements for system in service

4.4.1. Operational waste management

4.4.1.1. Requirements related to management of radioactive spent components

Description	Justification
Handling of highly activated spent components and hazardous waste	Components with high surface dose rate and/ or other complicating factors shall be handled by Remote handling/ Active Cells.
Handling of low active spent components and hazardous waste	Components with low surface dose rate shall be handled by ES & H Operations.

5. CONSTRAINTS

5.1. Environmental constraints

The Design shall be able to deal with three alternative sets of environmental conditions.

Condition	Atmosphere	Ambient Pressure	Ambient Temperature	Ambient Dose Rate
Test	Air	Atmospheric	20^{o}C	Negligible
Vacuum	Air	10 Pa absolute pressure inside Monolith, athmospheric outside Monolith.	40^{o}C	1 Gray per hour equivalent dose rate
Helium	Helium inside Monolith, air outside Monolith.	Atmospheric	40^{o}C	1 Gray per hour equivalent dose rate

5.2. Material constraints

Material constraints according to ESS-0028465. [26]

Constraints on elastomers according to ESS-0023781.[17]

6. GLOSSARY

Term	Definition
Requirement	A “requirement” is a statement of need from a stakeholder, i.e. a user, operator or interfacing system.
Function	A “function” is something that a system or subsystem does or perform in order to fulfil a requirement.
Constraint	A “constraint” is a statement of a restriction that may limit the range of possible solutions.
Affordance	An “affordance” is a requirement that expresses a capability offered to a user, operator or interfacing system. An affordance is only performed upon request from such stakeholders.

7. REFERENCES

1	ESS-0022914	Interface Control Document- Reference Target Wheel and Shaft- Process Control System and Machine Protection System
2	ESS-0022915	Interface Control Document- Reference Target Wheel, Drive and Shaft- Target Safety System
3	ESS-0022916	Interface Control Document- Reference Target Wheel, Drive and Shaft- Site Infrastructure System
4	ESS-0034231	Interface Control Document Target Systems- Moderator Reflector System
5	ESS-0023804	Interface Control Document Target Systems- Monolith Systems
6	ESS-0022919	Interface Control Document- Reference Target Wheel, Drive and Shaft- Accelerator Systems
7	ESS-0030244	Interface Control Document- Reference Target Wheel, Drive and Shaft- Active Cells
8	ESS-0030245	Interface Control Document- Reference Target Wheel, Drive and Shaft- Casks and associated handling devices
9	ESS-0031742	Interface Control Document- Reference Target Wheel, Drive and Shaft- Mockup
10	ESS-0019346	Interface Control Document; Target Wheel, Drive and Shaft - Target Cooling systems
11	ESS-0023773	Target Wheel Balancing
12	ESS-0023776	Target Wheel Global Tolerances, runout and alignment
15	ESS-0023779	Specification for Target Wheel Fine Adjustment System
16	ESS-0023780	Specification for rotating seal for the ESS Target Wheel
17	ESS-0023781	Elastomer seals for the ESS Target Wheel
18	ESS-0023782	Specification for ESS Target Wheel Static Positioning System

20	ESS-0026326	Interface Control Document Reference Target Wheel, Drive and Shaft - Radioactive Gases Emission Control
21	ESS-0026412	Target Wheel, Drive and Shaft System Description Document- Solution
23	ESS-0033258	Radiological Safety Class for Mechanical Equipment
24	ESS-0005857	System requirement Document Target Station
25	RCC-MRx	Rules for the Design of Nuclear Mechanical components
26	ESS-0028465	Target Materials Handbook

DOCUMENT REVISION HISTORY

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1.0	Created	2015-07-29