
System Description Document- Requirements Target Wheel, Drive and Shaft

	Name	Title
Owner	Kristoffer Sjögreen	Work unit leader - Target Wheel, Drive & Shaft
Authors	Kristoffer Sjögreen	Work unit leader - Target Wheel, Drive & Shaft
Reviewer	Ulf Odén Jens Harborn	Lead Engineer - Target Systems Work unit leader - Target Cooling systems
Approver	Mark Anthony	Head of Target division

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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.

1.2. General description

The Target wheel is essential to the fundamental purpose of the ESS facility in that it is the source of the neutrons produced during the spallation process as a result of the interaction with the 2 GeV 5 MW proton beam generated by the ESS linear accelerator.

The wheel and shaft systems are contained within the target monolith, which is located in the Target building at the end of the accelerator-to-target (A2T) area (see Figure 1). The wheel is a disk composed of 36 sectors of tungsten blocks contained within a steel shroud and cooled by flowing helium (see Figure 2). It is located deep within the target monolith (see Figure 3) at the base of a 5 m long shaft that positions the wheel at the level of the incoming proton beam.

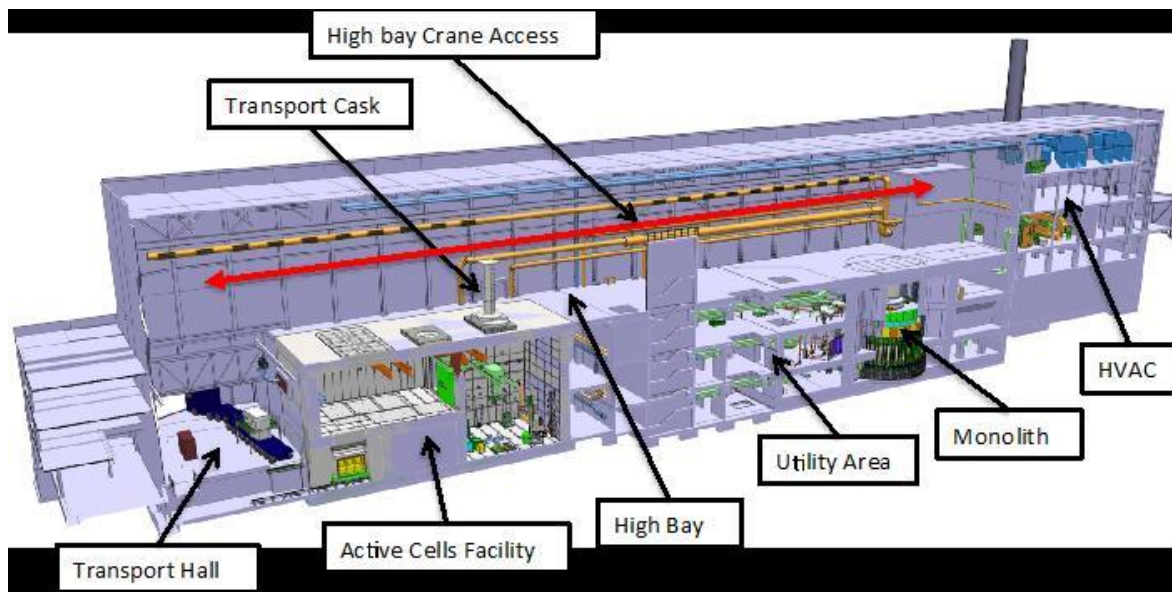


Figure 1 – Target building - Monolith area containing target wheel shown on right

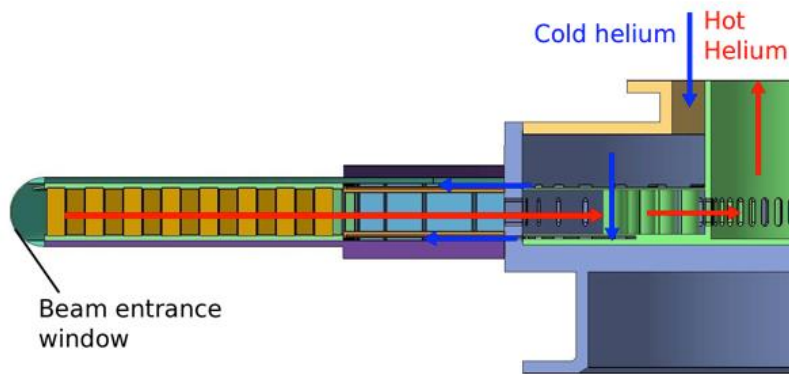


Figure 2 – Principal helium gas coolant flow path through target wheel

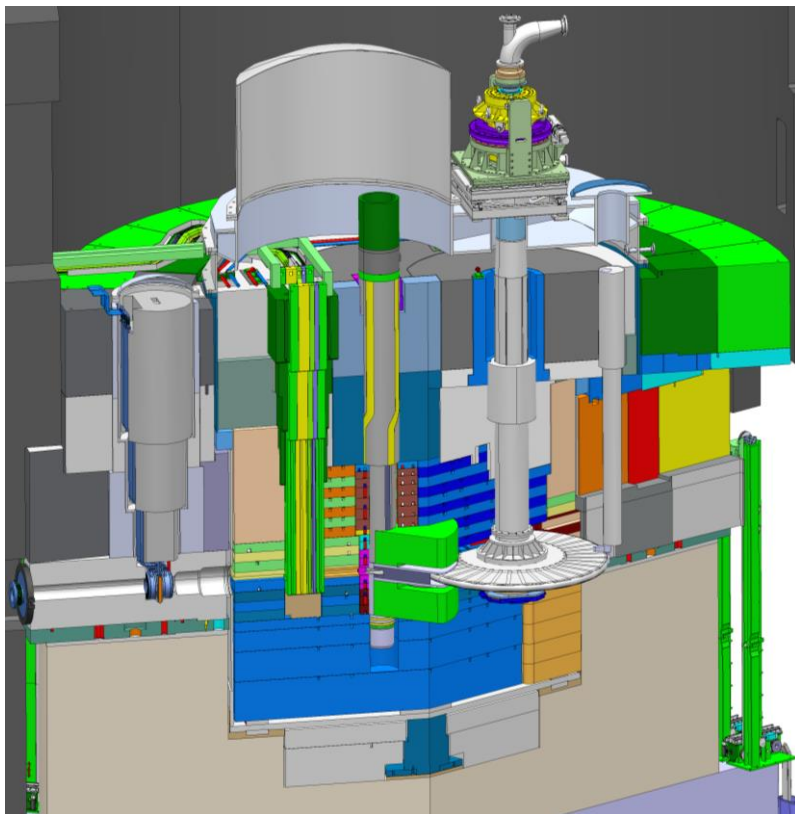


Figure 3 – Cross section of the Target Monolith

During normal operations, the wheel rotates around a vertical axis at a rate of 23 rpm to bring consecutive sectors into alignment with the impact of the proton beam to optimize neutron production. The flowing helium cools the spallation material. The rotation of the wheel is timed with the arrival of the proton beam such that the beam interacts with each sector once every 2.6 seconds.

2. SAFETY FUNCTIONS

2.1. Radiation protection and shielding functions

- Limit radiation through internal shielding structures.

2.2. 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 gas and particles.

2.3. Functions related to protection and support of safety functions

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

3. OPERATIONAL FUNCTIONS

- Ensure that correct amount of spallation material is positioned in the correct position in front of proton beam
- Regulate spallation material temperature
- Rotate target synchronised with accelerator beam pulses

4. 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.

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5. BREAKDOWN STRUCTURE

The Target Wheel, Drive and Shaft has the following functional breakdown.

First level is =ESS.TS.SSS.E01.

2	3	4	5	6	Tag
	Target Wheel system				E01.E01
	Target Wheel rotor				E01.E01.U01
		Upper shaft			E01.E01.U01.WQ01
		Lower shaft			E01.E01.U01.WQ02
		Rotating shielding			E01.E01.U01.F01
		Target vessel			E01.E01.U01.C01
			Spallation material system		E01.E01.U01.C01.E01
				Shell	E01.E01.U01.C01.E01.RQ01
				Cassette 1-36	E01.E01.U01.C01.E01.EU01-EU36
	Helium rotary union				E01.E01.W02
		Ferroseal			E01.E01.W02.R01
		Thrust bearing			E01.E01.W02.UP01
		Radial bearing			E01.E01.W02.UP02
	Vacuum feedthrough				E01.E01.W01
		Ferroseal			E01.E01.W01.R01
		Thrust bearing			E01.E01.W01.UP01
		Radial bearing			E01.E01.W01.UP02
		Bellow			E01.E01.W01.W01
	Target wheel drive unit				E01.E01.M01
		Rotation system			E01.E01.M01.W01
		Bearing system			E01.E01.M01.U01
		XY translation system			E01.E01.M01.W02
		Z- translation system			E01.E01.M01.W03
		Lubrication system			E01.E01.M01.G01
		Target wheel drive control system			E01.E01.M01.K01

Table 1 System parts and breakdown structure

6. REQUIREMENTS

Requirements are defined based on the functional breakdown of the system. This is quite imperative since the system will be produced by several suppliers.

7. SYSTEM 1000- ESS.TS.SSS.E01.E01

ID	E01.E01-1. Target Station requirements
Requirement	Rules and regulations as specified in ESS-0005857 shall be adhered to.
Rationale/Reference	The system shall fulfil SSM special terms and conditions SSM 15-36 and other applicable Swedish and European laws.
ID	E01.E01-2. Safety classification
Requirement	Rules and regulations as specified in ESS-0016468 shall be adhered to.
Rationale/Reference	The system shall fulfil SSM special terms and conditions SSM 15-36 and other applicable Swedish and European laws.
ID	E01.E01-3. Safety classification mechanical
Requirement	Rules and regulations as specified in ESS-0033258 shall be adhered to.
Rationale/Reference	The system shall fulfil SSM special terms and conditions SSM 15-36 and other applicable Swedish and European laws.
ID	E01.E01-4. Safety classification Instrumentation and controls
Requirement	Rules and regulations as specified in ESS-0054158 shall be adhered to.
Rationale/Reference	The system shall fulfil SSM special terms and conditions SSM 15-36 and other applicable Swedish and European laws.
ID	E01.E01-5. Quality
Requirement	Rules and regulations as specified in ESS-0047989 shall be adhered to.
Rationale/Reference	The system shall fulfil SSM special terms and conditions SSM 15-36 and other applicable Swedish and European laws

ID	E01.E01-6. Documentation
Requirement	Rules and regulations as specified in ESS-0097484 shall be adhered to.
Rationale/Reference	Target- specific rules

ID	E01.E01-7. Approval of controlled documentation
Requirement	Rules and regulations as specified in ESS-0025516 shall be adhered to.
Rationale/Reference	ESS Rules

ID	E01.E01-8. ESS rules for owners, reviewers and approvers of engineering documentation
Requirement	Rules and regulations as specified in ESS-0107602 shall be adhered to.
Rationale/Reference	ESS Rules

ID	E01.E01-9. Required submittals for mechanical systems
Requirement	Rules and regulations as specified in ESS-0091757 shall be adhered to.
Rationale/Reference	ESS Rules

ID	E01.E01-10. Marking and labelling
Requirement	Rules and regulations as specified in ESS-0094091 shall be adhered to.
Rationale/Reference	ESS Rules

ID	E01.E01-11. Naming and tagging
Requirement	Rules and regulations as specified in ESS-0094090 shall be adhered to.
Rationale/Reference	ESS Rules

ID	E01.E01-12. Approved RDS letter codes
Requirement	Rules and regulations as specified in ESS-0057106 shall be adhered to.
Rationale/Reference	ESS Rules

D	E01.E01-13. Technical requirements for mechanical equipment
Requirement	Rules and regulations as specified in ESS-0039311 shall be adhered to.
Rationale/Reference	ESS Rules
ID	E01.E01-14. Materials selection and requirements
Requirement	Rules and regulations as specified in ESS-0028465 shall be adhered to.
Rationale/Reference	ESS Rules
ID	E01.E01-15. FAT and SAT
Requirement	Rules and regulations as specified in ESS-0094204 shall be adhered to.
Rationale/Reference	ESS Rules
ID	E01.E01-16. FAT
Requirement	Rules and regulations as specified in ESS-01137104 shall be adhered to.
Rationale/Reference	ESS Rules
ID	E01.E01-17. Availability
Requirement	Availability requirements according to ESS-0008886 shall be followed.
Rationale/Reference	To fulfil ESS availability requirements
ID	E01.E01-18. Operational limits
Requirement	Operational limits according to ESS-0060625 shall be used.
Rationale/Reference	The system shall fulfil SSM special terms and conditions SSM 15-36 and other applicable Swedish and European laws

ID	E01.E01-19.Radiation safety
Requirement	The Target shall comply with the terms specified in the ESS General Safety Objectives.
Rationale/Reference	E01.E01-1

ID	E01.E01-20.Target concept- tungsten
Requirement	The Target shall use tungsten as spallation material such that the neutronic performance will sustain the required brightness while the technical risk will be residual thanks to the available experience using this material.
Rationale/Reference	E01.E01-1

ID	E01.E01-21.Target concept- rotational speed
Requirement	The rotational speed of the Target wheel shall be equal to the proton beam pulse repetition rate divided by the number of sectors in the wheel such that the heat will be repetitively deposited in accordance to the structural arrangement of the wheel.
Rationale/Reference	E01.E01-1

ID	E01.E01-22.Target concept temperature
Requirement	In order to assure a stable oxide coating on the tungsten, the surface temperature of the tungsten during normal operation shall be limited to 500°C.
Rationale/Reference	E01.E01-1

ID	E01.E01-23.Target concept helium coolant
Requirement	The Target shall use helium as a coolant based on its benign interaction with tungsten and the expectation that it will have low levels of entrained radioactivity.
Rationale/Reference	E01.E01-1

ID	E01.E01-24.Target concept 316L
Requirement	The Target shall use 316L stainless steel as target wheel vessel material such that the neutronic performance will sustain the required brightness while the technical risk will be residual thanks to the available experience using this material.
Rationale/Reference	E01.E01-1

ID	E01.E01-25.Availability no trips
Requirement	Target Wheel, drive and shaft shall be designed and maintained with such margins, that no stops outside planned maintenance periods can be foreseen.
Rationale/Reference	E01.E01-17

ID	E01.E01-26.Availability lifetime
Requirement	The Target shall be operational until 2065.
Rationale/Reference	E01.E01-1

ID	E01.E01-27.Availability yearly operation
Requirement	The Target shall be designed to operate at least 5392 hours per year.
Rationale/Reference	E01.E01-1

ID	E01.E01-28.Availability component lifetime
Requirement	Expected lifetime for all components in target shall be more than 5 years with 99% probability.
Rationale/Reference	E01.E01-17

ID	E01.E01-29.Design verification seismic
Requirement	The Target shall comply with the seismic requirements specified in ESS-0001424.
Rationale/Reference	E01.E01-1

ID	E01.E01-30.Code for 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 taking radiation damage mechanisms into account.
Rationale/Reference	E01.E01-5

ID	E01.E01-31.Occupational safety during maintenance
Requirement	Workers must be protected from receiving dangerous radiation dose by access control and design of accessible parts of the system
Rationale/Reference	E01.E01-2

ID	E01.E01-32.Target breakdown in Facility breakdown structures at ESS
Requirement	Rules and regulations as specified in ESS-0320880 shall be adhered to.
Rationale/Reference	E01.E01-11

ID	E01.E01-33.Routine for approval of manufacturing and control documentation
Requirement	Routine as specified in ESS-0102039 shall be adhered to.
Rationale/Reference	E01.E01-5

ID	E01.E01-34.Design basis
Requirement	The system shall be structurally verified according to ESS-0060792.
Rationale/Reference	E01.E01-5

ID	E01.E01-35.Design specification- mechanical
Requirement	Testing and manufacturing shall be done as specified in ESS-0123178.
Rationale/Reference	E01.E01-5

ID	E01.E01-36.Ambient conditions outside monolith
Interface	Ambient conditions outside monolith are <ul style="list-style-type: none"> • Temperature: 10°C min 40°C max • Humidity levels: 10% and 100% E01.E01-50

ID	E01.E01-37.Maximum allowed internal bypass leakage
Requirement	Total internal bypass leak flow, including all bypass positions in the complete Target wheel, drive and shaft system, shall be included in the calculation of tungsten operational temperature.
Rationale/Reference	E01.E01-94

ID	E01.E01-38.Target- Accelerator ICD
Requirement	Rules according to ESS-0005734 shall be adhered to.
Rationale/Reference	Interface to accelerator

ID	E01.E01-39.Proton beam frequency
Requirement	The nominal operational repetition rate of accelerator acceleration cycles shall be 14 Hertz.
Rationale/Reference	E01.E01-38

ID	E01.E01-40.Proton beam pulse length
Requirement	The nominal operational beam pulse length shall be 2.86 milli-Seconds.
Rationale/Reference	E01.E01-38

ID	E01.E01-41.Proton beam peak beam power
Requirement	The nominal peak beam power delivered to Target Station averaged over a period of 200 micro-Seconds shall not vary more than 5 percent from the peak beam power delivered to Target Station averaged over the nominal macro pulse length.
Rationale/Reference	E01.E01-38

ID	E01.E01-42. Proton beam time average beam power variation
Requirement	The time averaged beam power delivered to the Target Station shall not vary more than 5 percent pulse to pulse.
Rationale/Reference	E01.E01-38

ID	E01.E01-43. Proton beam time averaged beam power precision
Requirement	The time averaged beam power delivered to the Target Station shall be able to be varied in steps to its nominal value of 5 mega-Watts with a maximum step size of 500 kilo-Watts and with a precision of 125 kilo-Watts
Rationale/Reference	E01.E01-38

ID	E01.E01-44. Proton beam parameters
Requirement	Target shall receive proton beam from accelerator in accordance to beam parameters described in the tables below.
Rationale/Reference	E01.E01-38

Parameter	Minimum	Nominal	Maximum
Time averaged beam power (MW)	0	5	5.25
Beam energy (GeV)	0.55	2	2.5
Average beam current during the pulse (mA)	0		62.5
Pulse length (ms)	19.8/7	20/7	20.2/7
Time averaged pulse length (ms)	19.98/7	20/7	20.02/7
Beam energy per pulse (kJ)	0	357.1	375
Beam footprint on interface (PBW) enclosing > 97,5% beam fraction (mm²)	-	-	160 H x 60 V
Beam footprint on interface (PBW) enclosing > 99,9% beam fraction (mm²)	-	-	180 H x 62 V
Pulse repetition rate (Hz)		14	14
Maximum displacement of footprint (mm)	-5 H ; -2 V	0 ; 0	+5 H ; +2 V

Table 2 Beam on target parameters

ID	E01.E01-45. Monitoring system
Requirement	Target wheel, drive and shaft shall fulfil requirements according to ESS-0124062
Rationale/Reference	Interface to target monitoring system

ID	E01.E01-46.Cooling system
Requirement	Target wheel, drive and shaft shall fulfil requirements according to ESS-0019346
Rationale/Reference	Interface to target helium cooling system

ID	E01.E01-47.Monolith vessel system
Requirement	Target wheel, drive and shaft shall fulfil requirements according to ESS-0079166
Rationale/Reference	Interface to target monolith vessel

ID	E01.E01-48.Mockup system
Requirement	Target wheel, drive and shaft shall fulfil requirements according to ESS-0031742
Rationale/Reference	Interface to Mockup

ID	E01.E01-49.Waste system
Requirement	Target wheel, drive and shaft shall fulfil requirements according to ESS-0366897
Rationale/Reference	Interface to Waste management

ID	E01.E01-50.HVAC system
Requirement	Target wheel, drive and shaft shall fulfil requirements according to ESS-0034721
Rationale/Reference	Interface to HVAC

ID	E01.E01-51.Survey- and alignment group
Requirement	Target wheel, drive and shaft shall fulfil requirements according to ESS-0012977
Rationale/Reference	Interface to Survey- and alignment group

7.1. Target wheel rotor E01.E01.U01

ID	E01.E01-52. Atmosphere system
Requirement	Target wheel, drive and shaft shall fulfil requirements according to ESS-0135169
Rationale/Reference	Interface to Monolith rough vacuum system

Interface ID	E01.E01-53. Atmosphere inside monolith
Interface	The Target Wheel Drive & Shaft System must withstand a rough vacuum < 100 Pa consisting of an uncontrolled residual composition.
Rationale/Reference	E01.E01-52

ID	E01.E01-54. Shielding system
Requirement	Target wheel, drive and shaft shall fulfil requirements according to ESS-0096589
Rationale/Reference	Interface to inner shielding

ID	E01.E01-55. Moderator system
Requirement	Target wheel, drive and shaft shall fulfil requirements according to ESS-0034232
Rationale/Reference	Interface to moderator

ID	E01.E01-56. Active cells system
Requirement	Target wheel, drive and shaft shall fulfil requirements according to ESS-0030244 and ESS-0095924
Rationale/Reference	Interface to Active cells

ID	E01.E01-57. Casks system
Requirement	Target wheel, drive and shaft shall fulfil requirements according to ESS-0030245
Rationale/Reference	Interface to Casks

ID		E01.E01-58.Vacuum testing
Requirement	Rules and regulations as specified in ESS-0155385 shall be adhered to.	
Rationale/Reference	ESS Rules	

ID		E01.E01-59.Surface finishing for vacuum
Requirement	Rules and regulations as specified in ESS-0122675 shall be adhered to.	
Rationale/Reference	ESS Rules	

ID		E01.E01-60.Monolith in- vessel vacuum rules
Requirement	Rules and regulations as specified in ESS-0057844 shall be adhered to.	
Rationale/Reference	ESS Rules	

ID		E01.E01-61.Cleaning procedure for components in vacuum
Requirement	Rules and regulations as specified in ESS-0122647 shall be adhered to.	
Rationale/Reference	ESS Rules	

ID		E01.E01-62.Vacuum design part 1
Requirement	Rules and regulations as specified in ESS-0012894 shall be adhered to.	
Rationale/Reference	ESS Rules	

ID		E01.E01-63.Vacuum design part 2
Requirement	Rules and regulations as specified in ESS-0012895 shall be adhered to.	
Rationale/Reference	ESS Rules	

ID		E01.E01-64.Vacuum design part 3
Requirement	Rules and regulations as specified in ESS-0012896 shall be adhered to.	
Rationale/Reference	ESS Rules	

ID	E01.E01-65.Natural frequency
Requirement	First natural frequency of the system shall be higher than 1,8 Hz.
Rationale/Reference	E01.E01-34

ID	E01.E01-66.Geometrical tolerances
Requirement	The Target Wheel, Drive and Shaft must adhere to certain global tolerance demands as defined in ESS-0023776.
Rationale/Reference	E01.E01-18

Interface ID	E01.E01-67.Laser distance measurement surface properties
Interface	Surfaces used for laser distance measurement should have a maximum surface roughness of Ra 0.8
Rationale/Reference	E01.E01-45

7.1.1. Upper shaft E01.E01.U01.WQ01

ID	E01.E01-68.Principles for in- service inspections
Requirement	Rules and regulations as specified in ESS-0053218 shall be adhered to.
Rationale/Reference	ESS Rules

ID	E01.E01-69.Handling, assembly and disassembly of top shaft
Requirement	Target assembly will be handled by CASKS with the top shaft dismantled both at loading and unloading.
Rationale/Reference	E01.E01-57

ID	E01.E01-70.Upper shaft interface to Helium rotational feedthrough
Requirement	Upper shaft interface to helium rotational feedthrough shall be defined through an interface drawing.
Rationale/Reference	Function

ID	E01.E01-71.Upper shaft interface to Drive unit
Requirement	Upper shaft interface to Drive unit shall be defined through an interface drawing.
Rationale/Reference	Function

7.1.2. Lower shaft E01.E01.U01.WQ01

ID	E01.E01-72.Target rotor parking position
Interface	The TWDS shall be positioned in a “designated parking position” with a defined angle which simplifies the orientation of the CASKS lifting tools.
Rationale/Reference	E01.E01-57

ID	E01.E01-73.Sealing of lower shaft top end during maintenance
Requirement	During the disassembly of the Drive Unit, the top of the TS shaft must be designed so it is sealed, meaning that risk for contamination is excluded in order to not affect the work procedures by personnel around the Monolith Vessel. In addition, this shall not affect CASKS opportunity to grab the Target Wheel.
Rationale/Reference	E01.E01-57

ID	E01.E01-74.Handling of target rotor
Requirement	The top of the lower shaft must be designed with an interface for the Cask gripping tools, and allowing for a margin of +/- 5 mm for gripping in all directions.
Rationale/Reference	E01.E01-57

ID	E01.E01-75.Shaft internal shielding
Requirement	The shaft and monolith vessel cover together shall have an internal shielding that results in a dose rate in connection cell that is so low that the expected functional span of neodymium magnets will be at least 10 years.
Rationale/Reference	E01.E01-28

7.1.3. Rotating shielding

ID	E01.E01-76.Handling of rotating shielding block
Requirement	TWDS lower shaft shielding block must be designed so that no cumbersome situations occur during assembly/disassembly.
Rationale/Reference	E01.E01-57

ID	E01.E01-77.Handling of rotating shielding block
Requirement	Target shall provide a designated lifting tool for assembly/ disassembly of rotating shielding block.
Rationale/Reference	E01.E01-57

ID	E01.E01-78.X/Y measurement surfaces height
Requirement	The x/y measurement surfaces shall be at a minimum 30 mm long in the z-direction.
Rationale/Reference	E01.E01-45

ID	E01.E01-79.X/Y measurement surfaces concentricity deviation
Requirement	The maximum concentricity relative to the shaft center should be defined according to later agreement and predictable for the measurement surfaces.
Rationale/Reference	E01.E01-45

Interface ID	E01.E01-80.X/Y measurement surfaces properties
Interface	Surfaces used for laser distance measurement should have a maximum surface roughness of Ra 0.8
Rationale/Reference	E01.E01-45

7.1.4. Target vessel E01.E01.C01.C01

ID	E01.E01-81.Design verification
Requirement	Target vessel lifetime shall be more than 5 years taking proton irradiation into account.
Rationale/Reference	E01.E01-17

ID	E01.E01-82.Requirements on stress and temperature in tungsten
Requirement	Rules and regulations as specified in ESS-0009043 shall be adhered to.
Rationale/Reference	ESS Rules

ID	E01.E01-83.Beam Instrumentation system
Requirement	Target wheel, drive and shaft shall fulfil requirements according to ESS-0156859
Rationale/Reference	Interface to Beam instrumentation system

ID	E01.E01-84.Shielding of used target during handling
Requirement	TWDS must be designed so that the upper section of Wheel Disc can handle a lead blanket of 5 tons during removal after use.
Rationale/Reference	E01.E01-57

Interface ID	E01.E01-85.IR measurement target location, emissivity and size
Interface	Target Wheel, drive and shaft shall provide an interface specified according to Target Monitoring System requirements so that local outlet helium and shroud temperature measurements can be performed.
Rationale/Reference	E01.E01-45

ID	E01.E01-86.Helium outlet measurement cups
Requirement	Helium outlet measurement 36 measurement cups shall be placed at the distance of 580 mm from the wheel centre and in each tungsten sector centre line. The cup bottom shall be located in the middle of the outlet helium stream
Rationale/Reference	E01.E01-45

ID	E01.E01-87.Surface requirements- IR
Requirement	The IR-target surface should have a minimum emissivity of 0.25.
Rationale/Reference	E01.E01-45

ID	E01.E01-88.Inner diameter of measuring cups
Requirement	The measurement surface, ie the inner diameter of the measurement cup, shall be minimum 42 mm.
Rationale/Reference	E01.E01-45

ID	E01.E01-89.Position of IR shroud temperature measurement
Requirement	Shroud temperature measurement. The position of the IR temperature measurement shall be on top of shroud above first row of bricks (the first row hit by proton beam).
Rationale/Reference	E01.E01-45

ID	E01.E01-90.Retroreflectors for z-position measurement
Requirement	A minimum of 6 retroreflectors with a a minimum size 22 mm radial and 3 mm width shall be placed on the target wheel at a radius of 730 +/- 1 mm.
Rationale/Reference	E01.E01-45

Interface ID	E01.E01-91.Beam entrance window heat treatment
Interface	Beam entrance window shall go through a solution annealing heat treatment process after cold forming as defined in ESS-0111453.
Rationale/Reference	Function

Interface ID	E01.E01-92.Beam entrance window surface roughness.
Interface	Beam entrance window surface roughness will be normal for a pipe of standard quality, and have a surface roughness of maximum Ra=3,2 um.
Rationale/Reference	E01.E01-83

Interface ID	E01.E01-93.Welding method
Interface	Target shall be welded using mechanical welding Narrow- gap TIG except for welds in beam entrance window where manual TIG can be used due to its thin structure.
Rationale/Reference	Function

ID	E01.E01-94.Spallation material surface temperature
Requirement	Temperature on tungsten surface shall be lower than 500 C during operation and expected incidents.
Rationale/Reference	E01.E01-82

ID	E01.E01-95.Spallation material surface temperature
Requirement	Temperature on tungsten surface shall be below 700 C during accidents where confinement is lost and tungsten is exposed to air.
Rationale/Reference	E01.E01-82

ID	E01.E01-96.Spallation material post pulse maximum stress
Requirement	Tungsten post pulse maximum stress shall be lower than 100 MPa.
Rationale/Reference	E01.E01-82

ID	E01.E01-97.Spallation material interface
Requirement	The fastening of Tungsten into Cassettes must not introduce any unintended stresses into the Tungsten bricks.
Rationale/Reference	E01.E01-82

ID	E01.E01-98.Proton beam for design calculation
Requirement	Beam characteristics shall be modelled based on ESS-0034495
Rationale/Reference	To ensure a common definition of proton beam

7.2. Helium rotary union E01.E01.W01

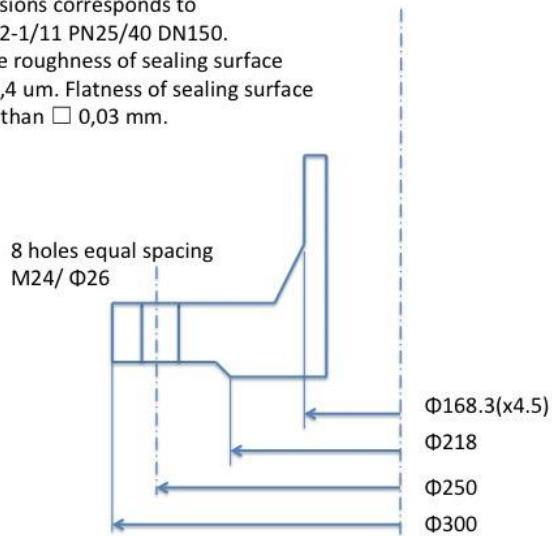
ID	E01.E01-99. Maximum allowed process helium leakage
Requirement	Maximum allowed leakage from the Helium cooling system to Connection Cell Atmosphere is 0,01 mg/s Helium.
Rationale/Reference	E01.E01-46

ID	E01.E01-100. Maximum allowed buffer gas leakage
Requirement	Maximum allowed leakage from the Helium buffer gas system to Connection Cell Atmosphere is 0.01 mg/s Helium.
Rationale/Reference	E01.E01-46

ID	E01.E01-101. Material qualification
Requirement	Seal materials must be approved by ESS and qualified for the environment.
Rationale/Reference	Due to ambient conditions and to avoid wear products of certain materials.

ID	E01.E01-102. Interface to Helium cooling system
Requirement	Interface connections to helium cooling system shall be according to sketch below.
Rationale/Reference	E01.E01-46

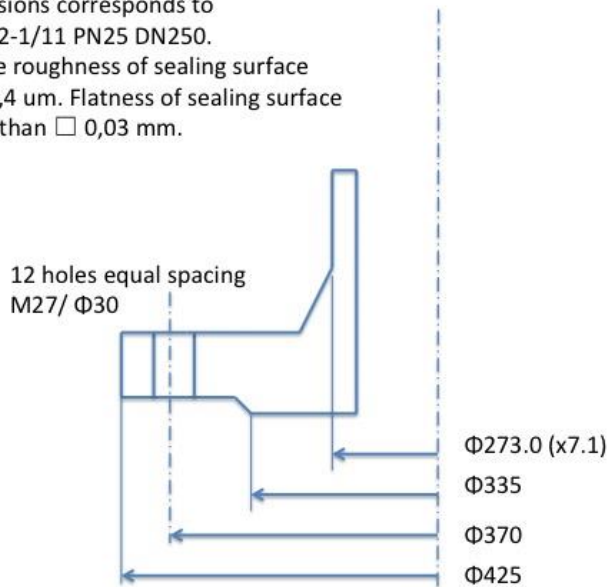
Flange on connecting pipe- inlet.
 Dimensions corresponds to
 EN1092-1/11 PN25/40 DN150.
 Surface roughness of sealing surface
 3,2—6,4 μm . Flatness of sealing surface
 better than \square 0,03 mm.



2

Figure 4 Inlet flange connection

Flange on connecting pipe- outlet.
 Dimensions corresponds to
 EN1092-1/11 PN25 DN250.
 Surface roughness of sealing surface
 3,2—6,4 μm . Flatness of sealing surface
 better than \square 0,03 mm.



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Figure 5 Outlet flange connection

ID	E01.E01-103.	Vibration measurement target monitoring system
Requirement	Measuring points to be included: 2 accelerometers, one at each main bearing.	
Rationale/Reference	E01.E01-45	

ID	E01.E01-104.	Vibration measurement target monitoring system
Requirement	The accelerometers shall measure vibration in x/y direction according to Target coordinate system.	
Rationale/Reference	E01.E01-45	

ID	E01.E01-105.	Temperature measurement target monitoring system
Requirement	Measuring points to be included: 2 temperature sensors, one at each main bearing and one temperature sensor measuring first stage ferrofluid temperature. Operational limits defined in ESS-0060625.	
Rationale/Reference	E01.E01-45	

ID	E01.E01-106.	Temperature measurement target monitoring system
Requirement	The temperature sensors shall be standard 4- wire RTD (PT-100)	
Rationale/Reference	E01.E01-45	

ID	E01.E01-107.	Temperature measurement target monitoring system
Requirement	The bearing temperature sensors shall be installed with direct contact to the bearing outer ring.	
Rationale/Reference	E01.E01-45	

ID	E01.E01-108.	Run out / shaft movement
Requirement	Feedthrough must be able to accommodate shaft movement or have an internal bearing.	
Rationale/Reference	Design requirement	

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ID	E01.E01-109.	Internal clearance in bearings and labyrinths
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	E01.E01-110.	Bearing life L10h
Requirement	Bearing life time shall be at least 120000 h	
Rationale/Reference	E01.E01-28	

7.3. Vacuum feedthrough

Interface ID	E01.E01-111.	Atmosphere inside monolith
Interface	The Target Wheel Drive & Shaft System must withstand a rough vacuum < 100 Pa consisting of an uncontrolled residual composition.	
Rationale/Reference	E01.E01-52	

ID	E01.E01-112.	Ambient conditions outside monolith
Interface	Ambient conditions outside monolith are <ul style="list-style-type: none"> • Temperature: 10°C min 40°C max • Humidity levels: 10% and 100% 	
	E01.E01-50	

ID	E01.E01-113.	Vibration measurement target monitoring system
Requirement	Measuring points to be included: 2 accelerometers, one at each main bearing.	
Rationale/Reference	E01.E01-45	

ID	E01.E01-114.	Vibration measurement target monitoring system
Requirement	The accelerometers shall measure vibration in x/y direction according to Target coordinate system.	
Rationale/Reference	E01.E01-45	

ID	E01.E01-115.	Temperature measurement target monitoring system
Requirement	Measuring points to be included: 2 temperature sensors, one at each main bearing.	
Rationale/Reference	E01.E01-45	

ID	E01.E01-116.	Temperature measurement target monitoring system
Requirement	The bearing temperature sensors shall be standard 4- wire RTD (PT-100)	
Rationale/Reference	E01.E01-45	

ID	E01.E01-117.	Temperature measurement target monitoring system
Requirement	The bearing temperature sensors shall be installed with direct contact to the bearing outer ring.	
Rationale/Reference	E01.E01-45	

ID	E01.E01-118.	Run out / shaft movement
Requirement	Feedthrough must be able to accommodate shaft movement or have an internal bearing.	
Rationale/Reference	Design requirement	

ID	E01.E01-119.	Internal clearance in bearings and labyrinths
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	E01.E01-120.	Bearing life L10h
Requirement	Bearing life time shall be at least 120000 h	
Rationale/Reference	E01.E01-28	

7.4. Target wheel drive unit E01.E01.M01

ID	E01.E01-121.	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 in order to mitigate consequences of postulated fire.	
Rationale/Reference	ESS Rules	
ID	E01.E01-122.	CE-marking
Requirement	Rules and regulations as specified in ESS-0127031 shall be adhered to.	
Rationale/Reference	The system shall fulfil SSM special terms and conditions SSM 15-36 and other applicable Swedish and European laws	
ID	E01.E01-123.	Electrical safety
Requirement	Rules and regulations as specified in ESS-0012721 shall be adhered to.	
Rationale/Reference	The system shall fulfil SSM special terms and conditions SSM 15-36 and other applicable Swedish and European laws.	
ID	E01.E01-124.	Safety classification Instrumentation and controls
Requirement	Rules and regulations as specified in ESS-0054158 shall be adhered to.	
Rationale/Reference	The system shall fulfil SSM special terms and conditions SSM 15-36 and other applicable Swedish and European laws.	
ID	E01.E01-125.	Qualification of electrical and instrumentation and control equipment
Requirement	Rules and regulations as specified in ESS-0118082 shall be adhered to.	
Rationale/Reference	ESS Rules	

ID	E01.E01-126.	Protection class
Requirement	Electrical equipment shall comply with minimum IPX3 where applicable.	
Rationale/Reference	Connection cell will have water sprinkler	

ID	E01.E01-127.	Electrical design
Requirement	Rules and regulations as specified in ESS-0015433 shall be adhered to.	
Rationale/Reference	ESS Rules	

ID	E01.E01-128.	Use of UPS power
Requirement	Rules and regulations as specified in ESS-0016586 shall be adhered to.	
Rationale/Reference	ESS Rules	

ID	E01.E01-129.	Instrument power and grounding
Requirement	Rules and regulations as specified in ESS-0147271 shall be adhered to.	
Rationale/Reference	ESS Rules	

ID	E01.E01-130.	Grounding
Requirement	Target rotor shall be grounded to the monolith vessel, by means of a slipring assembly	
Rationale/Reference	Function	

ID	E01.E01-131.	Electrical systems
Requirement	Rules and regulations as specified in ESS-0127285 shall be adhered to.	
Rationale/Reference	ESS Rules	

ID	E01.E01-132.	Selection of materials in cables
Requirement	Rules and regulations as specified in ESS-0034035 shall be adhered to.	
Rationale/Reference	ESS Rules	

ID	E01.E01-133.	Using ePlan at ESS
Requirement	Rules and regulations as specified in ESS-0028698 shall be adhered to.	
Rationale/Reference	ESS Rules	

ID	E01.E01-134.	ESS Procedures for electrical design
Requirement	Rules and regulations as specified in ESS-0024652 shall be adhered to.	
Rationale/Reference	ESS Rules	

ID	E01.E01-135.	Motion control standard
Requirement	Motion control components shall be in accordance with ESS-0037290	
Rationale/Reference	ESS Rules	

ID	E01.E01-136.	Motion control concept
Requirement	Motion control of target shall be in accordance with ESS-0052796	
Rationale/Reference	ESS Rules	

ID	E01.E01-137.	Cabling
Requirement	Cables should be radiation resistant according to CEI 60544-2 and 4, and ISO R527. Radiation Index in relation to application. Recommended RI > 5,7".	
Rationale/Reference	E01.E01-132	

ID	E01.E01-138.	Cables
Requirement	Splicing cable shall be avoided	
Rationale/Reference	E01.E01-121	

ID	E01.E01-139.	Cabinets
Requirement	Electrical cabinets shall have a drain hole in the bottom and be placed on a pedestal high enough to keep the electronics above the drainage curbing of the specific area and to allow any water that gets inside the cabinet to drain	
Rationale/Reference	E01.E01-121	

ID	E01.E01-140.	Verification of installed electrical equipment
Requirement	Rules and regulations as specified in ESS-0145259 shall be adhered to.	
Rationale/Reference	ESS Rules	

ID	E01.E01-141.	Decontamination of painted surfaces
Requirement	Painted surfaces shall be possible to decontaminate. This shall be documented in accordance with ISO 8690 or equivalent. Supplier shall provide specification of painting system for review.	
Rationale/Reference	E01.E01-49	

ID	E01.E01-142.	Surface treatment
Requirement	Where carbon steel components are used, the rules set out in 'TBY-Technical regulations for surface protection' apply. The applicable treatment types from those specified in 'Approved systems for TBY, edition 2' are generally S4 and by exception S12 where permitted in tables 6-2 and 6-3.	
Rationale/Reference	E01.E01-49	

ID	E01.E01-143.	Horizontal and vertical stiffness
Requirement	Horizontal and vertical stiffness at least 10 ⁹ N/m	
Rationale/Reference	To fulfil basic functions	

ID	E01.E01-144.	Elastomers
Requirement	EPDM are preferred in radiation field, but should not be used in contact with mineral oil.	
Rationale/Reference	E01.E01-14	

ID	E01.E01-145.	Internal clearance in bearings and labyrinths
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	E01.E01-146.	Bearing life L10h
Requirement	Bearing life time shall be at least 120000 h	
Rationale/Reference	E01.E01-28	

ID	E01.E01-147.	Measuring prisms
Requirement	There shall be provisions for holes that can be used for attachment of prisms	
Rationale/Reference	E01.E01-51	

ID	E01.E01-148.	Maintenance
Requirement	The system shall be designed for hands- on maintenance	
Rationale/Reference	System protection	

ID	E01.E01-149.	Maintenance
Requirement	The system shall be designed so that there is a planned major service, including replacement of moving parts, at a suitable interval, between 5-10 years.	
Rationale/Reference	System protection	

ID	E01.E01-150.	Maintenance
Requirement	There shall be covers for rotating parts to protect injury to workers in maintenance when drive unit is rotating.	
Rationale/Reference	System protection	

7.4.1. Drive unit rotation system E01.E01.M01.W01

ID	E01.E01-151.	Ramp
Requirement	Start- up and stop- ramp time shall be 20 minutes.	
Rationale/Reference	Function	

ID	E01.E01-152.	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	E01.E01-21	

ID	E01.E01-153.	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	E01.E01-18	

ID	E01.E01-154.	Positioning accuracy
Requirement	The drive system shall be able to position the rotor with a sector in front of Target monitoring plug or in front of Beam instrumentation system. Positioning accuracy shall be +/- 2 mm measured on Beam Entrance Window circumference.	
Rationale/Reference	E01.E01-18	

ID	E01.E01-155.	Phase control
Requirement	Speed and phase shall be controlled based on allowable phase angle deviation between theoretical position based on the 14 Hz clock pulse from ICS Central Clock and the actual value from each Target sector.	
Rationale/Reference	E01.E01-136	

ID	E01.E01-156.	Phase control
Requirement	The speed and phase control solution requires measuring teeth or holes around shaft circumference that in combination with a digital proximity sensor will give a pulse train output of 14Hz when in nominal speed. There shall be exactly 36 teeth or holes, one for each sector.	
	E01.E01-136	
ID	E01.E01-157.	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 kgm ²	
Rationale/Reference	Function	
ID	E01.E01-158.	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	Function	
ID	E01.E01-159.	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 28 rpm, minimum speed of 1 rpm	
Rationale/Reference	Function	
ID	E01.E01-160.	Motor temperature monitoring
Requirement	It shall be possible to monitor and limit stator temperature.	
Rationale/Reference	Function	
ID	E01.E01-161.	Angular feedback sensor
Requirement	The speed and phase control solution, requires an angular feedback sensor to enable absolute angular measurements and for commutation of the motor.	
Rationale/Reference	E01.E01-136	

ID	E01.E01-162.	Digital sensor
Requirement	The speed and phase control solution, requires one digital sensor to enable measurement of phase error relative ESS central clock pulse.	
Rationale/Reference	E01.E01-136	

ID	E01.E01-163.	Homing sensor
Requirement	The speed and phase control solution, requires one digital sensor to define zero, homing signal	
Rationale/Reference	E01.E01-136	

ID	E01.E01-164.	Notch wheel
Requirement	The speed and phase control solution, requires one notch wheel to give discrete signals for measurement of phase error. This wheel shall be the same for Control system, MPS and TSS sensors.	
Rationale/Reference	E01.E01-136	

ID	E01.E01-165.	Sensor resolution
Requirement	Sensors chosen for measuring position or angle shall have at least 2 times higher resolution than the defined sensor accuracy.	
Rationale/Reference	Function	

ID	E01.E01-166.	TSS system
Requirement	Target wheel, drive and shaft shall fulfil requirements according to ESS-0022915	
Rationale/Reference	Interface to TSS	

ID	E01.E01-167.	MPS system
Requirement	Target wheel, drive and shaft shall fulfil requirements according to ESS-0372661	
Rationale/Reference	Interface to MPS	

ID	E01.E01-168.	Control system
Requirement	Target wheel, drive and shaft shall fulfil requirements according to ESS-0022914	
Rationale/Reference	Interface to ICS	

ID	E01.E01-169.	Machine protection sensors scope
Requirement	In addition to the sensors above, there shall be three extra digital sensors belonging to Machine protection system, designed to measure phase error relative ESS central timing system.	
Rationale/Reference	E01.E01-167	

ID	E01.E01-170.	Machine protection sensors suspension
Requirement	The sensors shall be provided by MPS, but Target (System E01.E01) shall provide suspension for the sensors.	
Rationale/Reference	E01.E01-167	

ID	E01.E01-171.	Machine protection sensors type
Requirement	System E01.E01 shall design suspension for three sensors of the type EPRO PR6423 RAD as defined in Appendix.	
Rationale/Reference	E01.E01-167	

ID	E01.E01-172.	Machine protection sensors division
Requirement	There shall be three MPS sensors, placed with a division of 120 degrees.	
Rationale/Reference	E01.E01-167	

ID	E01.E01-173.	Machine protection sensors approval
Requirement	MPS representatives shall approve of the design of the sensor suspension.	
Rationale/Reference	E01.E01-167	

ID	E01.E01-174.	Machine protection sensors position
Requirement	After disassembly the position shall be repeatable within +/- 1 mm.	
Rationale/Reference	E01.E01-167	

ID	E01.E01-175.	Machine protection sensors principle
Requirement	The sensors shall be mounted to provide discrete signals when passing over holes in a steel structure as shown in appendix.	
Rationale/Reference	E01.E01-167	

ID	E01.E01-176.	Machine protection sensors magnetic structure
Requirement	The steel structure must be magnetic.	
Rationale/Reference	E01.E01-167	

ID	E01.E01-177.	Machine protection sensors angular tolerance
Requirement	The holes in the structure shall be placed with a angular tolerance of +/- 0,5 degrees or better.	
Rationale/Reference	E01.E01-167	

ID	E01.E01-178.	Machine protection sensors cable removal
Requirement	The mechanical structure shall allow easy dismantle and mounting of cables at wall of connection cell when maintenance is performed	
Rationale/Reference	E01.E01-167	

ID	E01.E01-179.	Target safety system speed sensors
Requirement	In addition to the speed- and phase measurement system described above, space shall be claimed for three extra speed sensors, belonging to the Target Safety System.	
Rationale/Reference	E01.E01-166	

ID	E01.E01-180.	Target safety system sensor type
Requirement	System E01.E01 shall design suspension for three sensors of the type EPRO PR6423 RAD as defined in Appendix.	
Rationale/Reference	E01.E01-166	

ID	E01.E01-181.	Target safety system sensors numbers
Requirement	There shall be three TSS sensors, placed with a division of 120 degrees.	
Rationale/Reference	E01.E01-166	

ID	E01.E01-182.	Target safety system sensors approval
Requirement	System 1080 representatives shall approve of the design of the sensor suspension.	
Rationale/Reference	E01.E01-166	

ID	E01.E01-183.	Target safety system sensors repeatability
Requirement	After disassembly the position shall be repeatable within +/- 1 mm.	
Rationale/Reference	E01.E01-166	

ID	E01.E01-184.	Target safety system sensors structure
Requirement	The sensors shall be mounted to provide discrete signals when passing over holes in a steel structure as shown in appendix.	
Rationale/Reference	E01.E01-166	

ID	E01.E01-185.	Target safety system sensors magnetic
Requirement	The steel structure must be magnetic.	
Rationale/Reference	E01.E01-166	

ID	E01.E01-186.	Target safety system sensors tolerance
Requirement	The holes in the structure shall be placed with a angular tolerance of +/- 0,5 degrees or better.	
Rationale/Reference	E01.E01-166	

ID	E01.E01-187.	Target safety system sensors maintainability
Requirement	The mechanical structure shall allow easy dismantle and mounting of cables at wall of connection cell when maintenance is performed	
Rationale/Reference	E01.E01-166	

ID	E01.E01-188.	Vibration measurement target monitoring system
Requirement	Measuring points to be included: 4 accelerometers, 2 at each main bearing.	
Rationale/Reference	E01.E01-45	

ID	E01.E01-189.	Vibration measurement target monitoring system
Requirement	The accelerometers shall measure vibration in x/y direction according to Target coordinate system.	
Rationale/Reference	E01.E01-45	

ID	E01.E01-190.	Temperature measurement target monitoring system
Requirement	Measuring points to be included: 2 temperature sensors, one at each main bearing.	
Rationale/Reference	E01.E01-45	

ID	E01.E01-191.	Temperature measurement target monitoring system
Requirement	The bearing temperature sensors shall be standard 4- wire RTD (PT-100)	
Rationale/Reference	E01.E01-45	

ID	E01.E01-192.	Temperature measurement target monitoring system
Requirement	The bearing temperature sensors shall be installed with direct contact to the bearing outer ring.	
Rationale/Reference	E01.E01-45	

7.4.2. Drive unit z- positioning system E01.E01.M01.W02 and Drive unit xy- positioning system E01.E01.M01.W03

ID	E01.E01-193.	Friction
Requirement	Friction shall be constant and predictable for both horizontal and vertical movement	
Rationale/Reference	To fulfil basic functions	

ID	E01.E01-194.	Positioning accuracy
Requirement	Horizontal and vertical accuracy shall be 0,1 mm	
Rationale/Reference	Function	

ID	E01.E01-195.	Vertical positioning interlock
Requirement	Vertical position adjustment shall be interlocked when Target rotor is in mode 'synchronised'.	
Rationale/Reference	Function	

ID	E01.E01-196.	Horizontal positioning interlock
Requirement	Horizontal position adjustment shall be interlocked when Target rotor is in operation.	
Rationale/Reference	Function	

ID	E01.E01-197.	Position stability
Requirement	The system may not drift or have any backlash	
Rationale/Reference	To fulfil basic functions	

ID	E01.E01-198.	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	E01.E01-199.	Sensor accuracy
Requirement	Sensors chosen for measuring position shall be at least 10 times more accurate than the stated position accuracy requirement.	
Rationale/Reference	Function	

ID	E01.E01-200.	Sensor accuracy
Requirement	Sensors chosen for measuring position shall have at least 2 times higher resolution than the defined sensor accuracy.	
Rationale/Reference	Function	

ID	E01.E01-201.	Measurement principle
Requirement	Measurements of the position for each positioning axis shall be measured absolute.	
Rationale/Reference	Function	

ID	E01.E01-202.	Movement limitation
Requirement	Each positioning axis shall be equipped with limit switches with limits as defined in ESS-0060625	
Rationale/Reference	E01.E01-18	

ID	E01.E01-203.	Stepper motor referencing
Requirement	Each positioning axis shall be equipped with at least one reference switch	
Rationale/Reference	E01.E01-136	

ID	E01.E01-204.	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	E01.E01-18	

ID	E01.E01-205.	Positioning limits
Requirement	Vertical and horizontal adjustment range shall be according to ESS-0060625	
Rationale/Reference	E01.E01-18	

ID	E01.E01-206.	Movement accuracy
Requirement	Horizontal and vertical accuracy shall be 0,1 mm	
Rationale/Reference	Function	

ID	E01.E01-207.	Vertical speed
Requirement	The vertical speed shall be 0.1 – 0.5 mm/s	
Rationale/Reference	Function	

ID	E01.E01-208.	Sensor accuracy
Requirement	Sensors chosen for measuring position shall be at least 10 times more accurate than the stated position accuracy requirement.	
Rationale/Reference	Function	

ID	E01.E01-209.	Sensor accuracy
Requirement	Sensors chosen for measuring position shall have at least 2 times higher resolution than the defined sensor accuracy.	
Rationale/Reference	Function	

ID	E01.E01-210.	Measurement principle
Requirement	Measurements of the position for each positioning axis shall be measured absolute.	
Rationale/Reference	Function	

ID	E01.E01-211.	Movement limitation
Requirement	Each positioning axis shall be equipped with limit switches.	
Rationale/Reference	Function	

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ID	E01.E01-212.	Stepper motor referencing
Requirement	Each positioning axis shall be equipped with at least one reference switch	
Rationale/Reference	Function	

ID	E01.E01-213.	Stepper motors temperature measurement
Requirement	Stepper motors shall have provision for motor temperature measurement and trending	
Rationale/Reference	Function	

7.4.3. Drive unit lubrication system E01.E01.M01.G01

ID	E01.E01-214.	Radiation qualification of lubricants
Requirement	Lubricants should be qualified for operation up to 1 MGy and in a mixed radiation field (Neutrons and gamma)	
Rationale/Reference	Function	

ID	E01.E01-215.	Lubricant requirements
Requirement	Lubricants shall fulfill requirements according to ESS-0087609	
Rationale/Reference	Function	

ID	E01.E01-216.	Preferred lubricants
Requirement	Preferred lubricants are Kluber Petamo GHY 135 or Kluberlub BE 41-542.	
Rationale/Reference	Function	

ID	E01.E01-217.	Collecting used grease
Requirement	There shall be provisions to collect used grease	
Rationale/Reference	Function	

ID	E01.E01-218.	Lubrication pump interlock
Requirement	Lubrication shall be interlocked when system is not rotating	
Rationale/Reference	To prevent overlubrication	

ID	E01.E01-219.	Lubrication pump low-level alarm
Requirement	Container for lubricants shall have low- level alarm	
Rationale/Reference	To ensure lubrication	

ID	E01.E01-220.	Lubrication pump flow
Requirement	The lubricating pump flow capacity shall be up to 5 g/s.	
Rationale/Reference	Bearing lubricating needs.	

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ID	E01.E01-221.	Lubricant tank volume
Requirement	The lubricant storage capability shall last for one year grease consumption	
Rationale/Reference	To limit the frequency of lubrication system refill	

7.4.4. Drive unit control system E01.E01.M01.K01

ID	E01.E01-222.	Controller phase shift
Requirement	During the calibration phase the control unit shall be able to shift the phase of the target wheel by a constant amount of maximal one sector.	
Rationale/Reference	Function	

ID	E01.E01-223.	Controller phase shift resolution
Requirement	The fixed phase shift shall have a resolution 20 to 50 times better than the precision of the target wheel phase control	
Rationale/Reference	Function	

ID	E01.E01-224.	Controller range
Requirement	The regulating accuracy as defined above shall be achievable for a rotor speed between 0 and 28 rpm.	
Rationale/Reference	Function	

ID	E01.E01-225.	Controller compatibility
Requirement	The controller shall be compatible with the chosen drive and preferably of the same supplier/architecture as the ESS standard motion control unit.	
Rationale/Reference	Function	

ID	E01.E01-226.	Controller digital sensor compatibility
Requirement	The controller shall be able to interface the signal from the digital sensor to perform the phase control loop.	
Rationale/Reference	Function	

ID	E01.E01-227.	Controller temperature sensor compatibility
Requirement	The controller shall be able to interface directly the signal from the temperature sensor of the motor in case it cannot be read by the drive.	
Rationale/Reference	Function	

ID	E01.E01-228.	Controller drive interface
Requirement	The controller shall be able to connect to the driver with a fast real time interface (e.g. EtherCAT) to perform the phase control loop and the position control loop if needed.	
Rationale/Reference	Function	

ID	E01.E01-229.	Drive brake configuration
Requirement	The Variable Frequency Drive shall be set up to brake the rotor to enable positioning according to above.	
Rationale/Reference	Function	

ID	E01.E01-230.	Drive position control loop
Requirement	The drive shall have a local current control and velocity control loop, preferably also position control loop.	
Rationale/Reference	Function	

ID	E01.E01-231.	Drive phasing and parking
R,requirement	The drive shall have the needed performance to achieve the required accuracy for phasing and parking.	
Rationale/Reference	Function	

ID	E01.E01-232.	Drive interface
Requirement	The drive shall support interfacing of the chosen components: motor and sensors.	
Rationale/Reference	Function	

ID	E01.E01-233.	Drive controller interface
Requirement	The drive shall have a fast real-time interface (e.g. EtherCAT) to the controller to perform the phase control loop over that interface.	
Rationale/Reference	Function	

ID	E01.E01-234.	Drive position feedback sensor
Requirement	The drive should be able to transfer in real time the absolute position information of the feedback sensor in case the position control loop is done in the controller.	
Rationale/Reference	Function	

ID	E01.E01-235.	Drive interface temperature sensor
Requirement	The drive should be able to interface the motor temperature sensor and transfer the information to the controller	
Rationale/Reference	Function	

ID	E01.E01-236.	Drive torque monitoring
Requirement	It shall be possible to monitor and limit torque output from the Drive	
Rationale/Reference	Function	

ID	E01.E01-237.	Controller
Requirement	Drive unit control system shall be able to interface signals from the ESS timing system.	
Rationale/Reference	Function	

ID	E01.E01-238.	Power supply, cabling and grounding
Requirement	Drive unit control system shall interface electrical infrastructure as defined in xx	
Rationale/Reference	Function	

ID	E01.E01-239.	Interface target monitoring system
Requirement	The target wheel x, y and z position from Target Motion Control System should be available for the system 1063 data processing.	
Rationale/Reference	To enable comparison between adjustment of the x position and the measured movement of the shaft.	

ID	E01.E01-240. Accelerometers interface target monitoring system
Requirement	Accelerometer vibration signals from the main bearing x/y accelerometers shall be available for the system 1063 data processing.
Rationale/Reference	To enable vibration analysis and bearing vibration monitoring of the drive unit main bearings.

ID	E01.E01-241. Phase signal target monitoring system
Requirement	The target wheel phase signal should be available for the system 1063 data processing.
Rationale/Reference	To enable phase angle dependent compensation of the measured position

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DOCUMENT REVISION HISTORY

Version	Reason for revision	Date
1.0	Created for PDR	2015-07-29
2.0	Revised with ICD	2016-07-30
3.0	Revised for spallation material CDR	2016-10-28
4.0	Revised after Drive Unit CDR	2018-08-24