
System Requirements Specification for the Common Shielding System

	Name	Role/Title
Owner	Mark Ridgley	Technical Documentation Coordinator – Common Shielding Project
Reviewer	Zvonko Lazic Phillip Bentley	Project Leader – Common Shielding Project Group Leader Neutron Optics
Approver	Ken Andersen	Head of Neutron Instruments Division

TABLE OF CONTENTS

1.	SCOPE.....	4
2.	ISSUING ORGANISATION	4
3.	HIGH-LEVEL SYSTEM REQUIREMENTS CATEGORIZATION	4
4.	SYSTEM REQUIREMENTS	5
4.1.	Functional Requirements	5
4.2.	Constraint Requirements.....	6
4.3.	Radiation Safety Requirements	8
4.4.	Conventional Safety Requirements	11
4.5.	Environmental Requirements.....	12
4.6.	Interface Requirements.....	12
5.	HIGH-LEVEL SYSTEM REQUIREMENTS TRACEABILITY MATRIX	15
6.	GLOSSARY.....	16
7.	LIST OF ACRONYMS	16
8.	REFERENCES	17
	DOCUMENT REVISION HISTORY	18

LIST OF TABLES

Table 1.	High-level System Requirements Categorization Matrix.....	4
Table 2.	Functional Requirements with Traceability.....	5
Table 3.	Constraint Requirements with Traceability.....	6
Table 4.	Radiation Safety Requirements with Traceability.	8
Table 5.	Conventional Safety Requirements with Traceability.	11
Table 6.	Environmental Requirements with Traceability.....	12
Table 7.	Interface Requirements with Traceability.	12
Table 8.	High-level SyR Traceability Matrix.	15

Document Title System Requirements Specification for the Common Shielding System
Document Number ESS-0472974
Date Jan 15, 2019
Revision 1 (1)
State Review
Confidentiality Level Internal

LIST OF FIGURES

Figure 1. Illustration of 10-fold rule for chicane design. 10

Review

1. SCOPE

This document specifies and describes the system requirements for the Common Shielding System (CSS), a subsystem of the Shielding & Safety System (S&SS), which will provide a common shielding design for the participating instrument systems. Each shielding system provides attenuation down to a safe level of the radiation emanating from the respective instrument system's elements along the sector between the bunker wall interface through to the respective instrument system cave interface.

The system requirements described in this document are applied to the requirements driven development of the system design and form the basis for the verification of the system. They are derived from the high-level requirements allocated by the parent system and the information presented in the Concept of Operations (ConOps) for the Common Shielding System (CSS) [1] as well as feedback from the evolving design development of the system and its system interfaces.

2. ISSUING ORGANISATION

European Spallation Source ERIC, Science Directorate.

3. HIGH-LEVEL SYSTEM REQUIREMENTS CATEGORIZATION

The high-level system requirements identified in the ConOps for the CSS [1] are categorized for breakdown as required into system requirements for the Common Shielding System as shown in Table 1.

Table 1. High-level System Requirements Categorization Matrix.

	S&SS.SyR-03	S&SS.SyR-05	S&SS.SyR-06	S&SS.SyR-08	S&SS.SyR-15	S&SS.SyR-16	S&SS.SyR-17	S&SS.SyR-18	S&SS.SyR-19	S&SS.SyR-20	S&SS.SyR-21	S&SS.SyR-30	S&SS.SyR-32	S&SS.SyR-33	S&SS.SyR-137
Constraint	↙	↙	↙									↙			
Radiation safety				↙	↙	↙	↙	↙	↙	↙	↙		↙		
Conventional safety														↙	
Environmental															↙

4. SYSTEM REQUIREMENTS

The system requirements of the Common Shielding System (CSS.SyR) are defined according to the different categories and each system requirement is uniquely identified.

4.1. Functional Requirements

Functional requirements applicable to the Common Shielding System are specified in Table 2.

Table 2. Functional Requirements with Traceability.

ID	Description	CHES ID
CSS.SyR-01	<p>Title: Safe restricted access for installation/removal.</p> <p>Statement: CSS shall provide safe restricted access for the installation/removal of Instrument System (InS) elements and associated equipment.</p> <p>Rationale: The CSS design shall be modular in design to allow for varying partial openings of sections of that suit the size for the handling of InS elements and associated equipment that need to be removed or re-installed or removed and replaced.</p> <p>Traceability: ConOps [1].</p> <p>Verification: Inspection.</p>	
CSS.SyR-02	<p>Title: Safe restricted access for maintenance.</p> <p>Statement: CSS shall provide safe restricted access to the InS elements and associated equipment within.</p> <p>Rationale: Personnel will require restricted safe access into the CSS to access InS elements and associated equipment within for maintenance, inspection, etc., so the design shall be modular to allow for varying partial openings of the CSS to suit.</p> <p>Traceability: ConOps [1].</p> <p>Verification: Inspection.</p>	

Document Title	System Requirements Specification for the Common Shielding System
Document Number	ESS-0472974
Date	Jan 15, 2019
Revision	1 (1)
State	Review
Confidentiality Level	Internal

4.2. Constraint Requirements

Constraint requirements applicable to the Common Shielding System are specified in Table 3.

Table 3. Constraint Requirements with Traceability.

ID	Description	CHES ID
CSS.SyR-03	<p>Title: Design to allow minimal suite of 22 Instrument Systems.</p> <p>Statement: CSS shall be designed to allow for allocating volumes, with defined envelopes, for a minimal suite of 22 Instrument Systems that are to be located along 22 defined and allocated beam-port central axes.</p> <p>Rationale: From ESS stakeholder requirement, it is expected that ESS shall provide experimentation services for each user with a minimal suite of 22 neutron instruments.</p> <p>Traceability: ConOps (S&SS.SyR-05) [1].</p> <p>Verification: Inspection.</p>	
CSS.SyR-04	<p>Title: Programme plan delivery.</p> <p>Statement: CSS design shall support NSS delivery of initial suite of instruments being operational in accordance with the NSS programme plan.</p> <p>Rationale: NSS delivery for initial suite of instruments are to be operational in accordance with the NSS programme plan without compromising future expansion to minimal suite of 22.</p> <p>Traceability: ConOps (S&SS.SyR-03, 06, 30) [1].</p> <p>Verification: Inspection.</p>	

Document Title	System Requirements Specification for the Common Shielding System
Document Number	ESS-0472974
Date	Jan 15, 2019
Revision	1 (1)
State	Review
Confidentiality Level	Internal

ID	Description	CHESS ID
CSS.SyR-05	<p>Title: Future expansion of instrument suite.</p> <p>Statement: CSS design shall not impede upon reserve volumes along currently unassigned designated beam-port central axes in preparation for future installation of as yet undefined Instrument Systems whose envelopes will be constrained by said reserved volumes.</p> <p>Rationale: Future expansion of the suite of instruments is planned and as yet undefined Instrument Systems will, during the operational life of the ESS facility, be installed along currently unassigned and unpopulated designated beam-port central axes.</p> <p>Volume is to be reserved along these beam-port central axes to allow for future definition of currently undefined Instrument Systems which will be constrained by the reserved volume.</p> <p>Therefore, CSS design shall be accommodating for future expansion.</p> <p>Traceability: ConOps [1].</p> <p>Verification: Inspection.</p>	
CSS.SyR-06	<p>Title: Maximum load for primary lifting devices.</p> <p>Statement: The maximum mass of CSS modular elements that will be serviced by the primary lifting devices shall be less than or equal to (\leq) 5 t.</p> <p>Rationale: Design loading capacity of primary lifting devices servicing the CSS must be observed.</p> <p>Traceability: ConOps [1].</p> <p>Verification: Analysis and inspection.</p>	
CSS.SyR-07	<p>Title: Maximum dimensions for primary lifting devices.</p> <p>Statement: The maximum dimensions of CSS modular elements that will be serviced by the primary lifting devices shall be less than or equal to (\leq) 3000 mm x 1500 mm x 1500 mm.</p> <p>Rationale: Design dimensioning capacity of primary lifting devices servicing the CSS must be observed.</p> <p>Traceability: ConOps [1].</p> <p>Verification: Inspection.</p>	

Document Title	System Requirements Specification for the Common Shielding System
Document Number	ESS-0472974
Date	Jan 15, 2019
Revision	1 (1)
State	Review
Confidentiality Level	Internal

ID	Description	CHES ID
CSS.SyR-08	<p>Title: CSS modular element identification.</p> <p>Statement: CSS modular elements shall have permanent markings with a unique identification and location in the installation.</p> <p>Rationale: CSS will be modular in design allowing removal and re-installing of modular elements, therefore, permanent markings with unique identification and location in the installation will be required.</p> <p>Traceability: ConOps [1].</p> <p>Verification: Inspection.</p>	

4.3. Radiation Safety Requirements

Radiation safety requirements applicable to the Common Shielding System are specified in Table 4.

Table 4. Radiation Safety Requirements with Traceability.

ID	Description	CHES ID
CSS.SyR-09	<p>Title: Maximum radiation level in the freely accessible areas of the experimental halls and guide hall.</p> <p>Statement: Maximum radiation level measured in the freely accessible areas of the experimental halls and guide hall during ESS facility normal full beam operation shall be less than or equal to (\leq) 3 μSv/h.</p> <p>Rationale: The experimental halls and guide hall, external to CSS, have defined freely accessible areas as per “NSS zoning document, part I (safety)” [4] which comply with the supervised area classification defined in “Definition of Supervised and Controlled Radiation Areas” [8]. The radiation level (dose limit) in the defined freely accessible areas of the experimental halls are therefore required to be less than or equal to (\leq) 3 μSv/h during ESS facility normal full beam operation.</p> <p>Traceability: ConOps (S&SS.SyR-17) [1].</p> <p>Verification: Analysis and Inspection. The compliance of CSS shielding design with the zoning requirements will be verified following the rules stated in “ESS Procedure for designing shielding for safety” [9]. After beam on target the predicted levels will be verified through measurement by the appropriate/assigned team.</p>	

Document Title	System Requirements Specification for the Common Shielding System
Document Number	ESS-0472974
Date	Jan 15, 2019
Revision	1 (1)
State	Review
Confidentiality Level	Internal

ID	Description	CHESS ID
CSS.SyR-10	<p>Title: Dose contribution from CSS to NSS dose budget.</p> <p>Statement: The total dose from NSS sources during normal full beam operation, including the dose contribution from CSS, shall comply with GSO allocated NSS dose budget.</p> <p>Rationale: The attenuated radiation from within CSS (dose from CSS) during normal full beam operation contributes to the total dose from NSS sources which shall comply with dose budget allocated by the ESS General Safety Objectives [10].</p> <p>Traceability: ConOps (S&SS.SyR-08, 17) [1].</p> <p>Verification: Analysis and Inspection. The performance of CSS shielding design will be verified following the rules stated in “ESS Procedure for designing shielding for safety” [9]. The total dose from NSS sources, including the dose contribution from CSS, will be assessed through analysis to verify compliance with the GSO allocated NSS dose budget [10]. After beam on target the predicted levels will be verified through measurement by the appropriate/assigned team.</p>	

ID	Description	CHESS ID
CSS.SyR-11	<p>Title: Reduction of radiation leakage through shielding.</p> <p>Statement: No line of sight from the experimental halls and guide hall to sources of radiation within CSS is allowed. The “10-fold rule” shall apply for all planes emanating from the radiation sources.</p> <p>Rationale: The “10-fold rule” is an accepted method for ensuring the radiation leakage is kept to a minimum (refer to Figure 1.).</p>	
<p>Figure 1. Illustration of 10-fold rule for chicane design.</p> <p>Traceability: ConOps (S&SS.SyR-17) [1].</p> <p>Verification: Analysis and inspection. Simulation of CSS shielding performance in attenuation of radiological hazards emanating from within during full beam operations. Measurement of the radiation level external to CSS at specified proximities and time intervals set by the appropriate/assigned team after installation and during commissioning of the ESS facility.</p>		

Document Title	System Requirements Specification for the Common Shielding System
Document Number	ESS-0472974
Date	Jan 15, 2019
Revision	1 (1)
State	Review
Confidentiality Level	Internal

ID	Description	CHESS ID
CSS.SyR-12	<p>Title: CSS access restriction.</p> <p>Statement: Opening of CSS shall be restricted by a Personnel Safety System (PSS) linked to proton beam operation.</p> <p>Rationale: Within the CSS is an area of high radiation which is an access exclusion zone until it is positively ascertained that it is safe to access the area. CSS shall not be open whilst proton beam is operational and proton beam shall not operate whilst CSS is open.</p> <p>Traceability: ConOps (S&SS.SyR-32) [1].</p> <p>Verification: Inspection and test.</p>	
CSS.SyR-13	<p>Title: Surface coating of concrete surfaces.</p> <p>Statement: All concrete surfaces of the CSS shall have surface coating to minimise dust contamination. Surface coating shall be flame retardant and comply at minimum to B-s1, d0.</p> <p>Rationale: Concrete dust can become irradiated, so its production shall be minimised using appropriate surface coating on all concrete surfaces. The flame retardancy of the surface coating shall comply with at minimum B-s1, d0.</p> <p>Traceability: ConOps (S&SS.SyR-21) [1].</p> <p>Verification: Inspection.</p>	

4.4. Conventional Safety Requirements

Conventional safety requirements applicable to the Common Shielding System are specified in Table 6.

Table 5. Conventional Safety Requirements with Traceability.

ID	Description	CHESS ID
CSS.SyR-14	<p>Title: Conventional safety barriers.</p> <p>Statement: CSS shall provide conventional safety barriers to restrict freedom of movement of personnel into unsafe areas.</p> <p>Rationale: Personnel will where defined necessary be restricted form access to unsafe areas of the CSS with conventional safety barriers.</p> <p>Traceability: ConOps (S&SS.SyR-33) [1].</p> <p>Verification: Inspection.</p>	

Document Title	System Requirements Specification for the Common Shielding System
Document Number	ESS-0472974
Date	Jan 15, 2019
Revision	1 (1)
State	Review
Confidentiality Level	Internal

4.5. Environmental Requirements

Environmental requirements applicable to the Common Shielding System are specified in Table 6.

Table 6. Environmental Requirements with Traceability.

ID	Description	CHESS ID
CSS.SyR-15	<p>Title: Environmental court verdict.</p> <p>Statement: CSS radioactive waste shall be limited so NSS overall handles and stores no more than 550 ton of radioactive waste at a time, pending shipment to final disposal.</p> <p>Rationale: CSS radioactive waste contributes to the overall radioactive waste of NSS and NSS shall handle and store no more than 550 ton of radioactive waste at a time, pending shipment to final disposal.</p> <p>Traceability: ConOps (S&SS.SyR-137) [1].</p> <p>Verification: Inspection.</p>	

4.6. Interface Requirements

Interface requirements applicable to the Common Shielding System are specified in Table 7.

Table 7. Interface Requirements with Traceability.

ID	Description	CHESS ID
CSS.SyR-16	<p>Title: Provision for safe routing of utilities.</p> <p>Statement: CSS shall be designed to allow the safe routing of required utilities for InS elements installed within the CSS.</p> <p>Rationale: InS elements located within CSS require various utilities that are essential for system functionality to be routed safely from outside of CSS.</p> <p>Traceability: ConOps [1].</p> <p>Verification: Inspection.</p>	

Document Title	System Requirements Specification for the Common Shielding System
Document Number	ESS-0472974
Date	Jan 15, 2019
Revision	1 (1)
State	Review
Confidentiality Level	Internal

ID	Description	CHESS ID
CSS.SyR-17	<p>Title: Load on D01 floor.</p> <p>Statement: CSS elements combined with all other systems elements loading the floor in D-building D01 shall not exert more than 14 t/m² load on average over the whole area of this floor.</p> <p>Rationale: D01 floor is designed for a maximum loading of 14 t/m² on average over the whole area.</p> <p>Traceability: NSS-CF-133 [5]; ESS-0057699 [12].</p> <p>Verification: Analysis.</p>	
CSS.SyR-18	<p>Title: Load on D03 floor.</p> <p>Statement: CSS elements combined with all other systems elements loading the floor in D-building D03 shall not exert more than 14 t/m² load on average over the whole area of this floor except in region from inside face of D03/E02 wall to 3 m inwards where they shall not exert more than 10 t/m² on average.</p> <p>Rationale: D03 floor is designed for a maximum loading as specified.</p> <p>Traceability: NSS-CF-133 [5]; ESS-0057699 [12].</p> <p>Verification: Analysis.</p>	
CSS.SyR-19	<p>Title: Load on E02 floor.</p> <p>Statement: CSS elements combined with all other systems elements loading the floor in E-building E02 shall not exert more than 20 t/m² load on average over the whole area of this floor (Constraint: maximum gathered load shall not to exceed 80 t/4m².) and 5 ton/m² on large areas.</p> <p>Rationale: E02 floor is designed for a maximum loading as specified.</p> <p>Traceability: NSS-CF-139 [5]; ESS-0057699 [12].</p> <p>Verification: Analysis.</p>	

Document Title	System Requirements Specification for the Common Shielding System
Document Number	ESS-0472974
Date	Jan 15, 2019
Revision	1 (1)
State	Review
Confidentiality Level	Internal

ID	Description	CHESS ID
CSS.SyR-20	<p>Title: D03/E02 floor dilatation joint.</p> <p>Statement: CSS installation shall not impede upon nor hinder the D03/E02 floor dilatation joint.</p> <p>Rationale: The D03/E02 floor dilatation joint allows for interference free movement/settlement of D-building D03 relative to the E-building E02. CSS must not interfere with the performance of the D03/E02 floor dilatation joint.</p> <p>Traceability: ConOps [1].</p> <p>Verification: Inspection.</p>	
CSS.SyR-21	<p>Title: E01/E02 floor dilatation joint.</p> <p>Statement: CSS installation shall not impede upon nor hinder the E01/E02 floor dilatation joint.</p> <p>Rationale: The E01/E02 floor dilatation joint allows for interference free movement/settlement of E-building E01 relative to the E-building E02. CSS must not interfere with the performance of the E01/E02 floor dilatation joint.</p> <p>Traceability: ConOps [1].</p> <p>Verification: Inspection.</p>	

5. HIGH-LEVEL SYSTEM REQUIREMENTS TRACEABILITY MATRIX

Traceability of system requirements derived from high-level system requirements are shown in Table 8.

Table 8. High-level SyR Traceability Matrix.

	S&SS.SyR-03	S&SS.SyR-05	S&SS.SyR-06	S&SS.SyR-08	S&SS.SyR-15	S&SS.SyR-16	S&SS.SyR-17	S&SS.SyR-18	S&SS.SyR-19	S&SS.SyR-20	S&SS.SyR-21	S&SS.SyR-30	S&SS.SyR-32	S&SS.SyR-33	S&SS.SyR-137
CSS.SyR-03		↙													
CSS.SyR-04	↙		↙									↙			
CSS.SyR-09							↙								
CSS.SyR-10				↙			↙								
CSS.SyR-11							↙								
CSS.SyR-12													↙		
CSS.SyR-13											↙				
CSS.SyR-14														↙	
CSS.SyR-15															↙

6. GLOSSARY

Term	Definition
10-fold rule	The “10-fold rule” mentioned in this document refers to relationship of expected gap versus the length of the possible streaming path through shielding as shown in Figure 1.
Beam-port central axis	Centre-line axis of the notional straight beam-line emitting outward from the respective beam-port at target monolith.
Beam-port coordinate system	Defines each one of the neutron beam-ports inserts within the target monolith. There is a total of 42 neutron beam-port inserts each one with a beam-port central axis and a BPCS. [11]
Shall requirement	System requirement statements using the word “shall” (a shall requirement) express a strict mandatory requirement that must be fulfilled.
Should requirement	System requirement statements using the word “should” (a should requirement) express a non-mandatory requirement; “nice to have”. Should is used to set a goal which if fulfilled would increase the performance or functionality of the system but is subject to prioritization, achievability and impact (mainly to cost and schedule but also with respect to e.g. future upgrade possibilities etc.)
Target centre	$x=0, y=0, z=0$ in the target coordinate system.
Target centre plane	$z=0$ plane in the target coordinate system
Target coordinate system	Primary coordinate system at ESS. The origin is in the centre of the target monolith defined as the intersection of the proton beam with common vertical axis of the two moderators. [11]

7. LIST OF ACRONYMS

Acronym	Definition
BPCS	Beam-Port Coordinate System
BS	Bunker System
CF	Conventional Facilities
CHESS	Collaboration Home at ESS
ConOps	Concept of Operations
CSS	Common Shielding System
ERIC	European Research Infrastructure Consortium
ES&H	Environment Safety & Health
ESS	European Spallation Source

Document Title	System Requirements Specification for the Common Shielding System
Document Number	ESS-0472974
Date	Jan 15, 2019
Revision	1 (1)
State	Review
Confidentiality Level	Internal

Acronym	Definition
GSO	General Safety Objectives
I	Infrastructure
ICD	Interface Control Document
ICS	Integrated Control Systems
ID	Identification
InS	Instrument Systems
NSS	Neutron Scattering Systems
PSS	Personnel Safety Systems
RMH	Radioactive Material Handling
RMHF	Radioactive Material Handling Facility
S&SS	Shielding & Safety Systems
SAD	System Architecture Description
SI	Site Infrastructure
SRS	System Requirements Specification
SSM	Swedish Radiation Safety Authority (Strålsäkerhetsmyndigheten)
SyR	System Requirement
TCS	Target Coordinate System
TS	Target Systems

8. REFERENCES

- [1] ESS-0123251, ConOps for the CSS
- [2] ESS-0108886, SRS for the S&SS
- [3] ESS-0185913, SAD for the S&SS
- [4] ESS-0149510, ICD - InS and S&SS
- [5] NSS-CF-Interface Requirements Rev 1 in CHESS
- [6] ESS-0051603, NSS zoning document, part I (safety)
- [7] ESS-0050516, NSS zoning document - part II (security /protection classes)
- [8] ESS-0001786, Definition of Supervised and Controlled Radiation Areas
- [9] ESS-0019931, ESS Procedure for designing shielding for safety
- [10] ESS-0000004, General Safety objectives
- [11] ESS-0035090, Main Coordinate Systems at the ESS
- [12] ESS-0057699, DM--ID-TBSIGDIN--Interface Control Document D01 D03 E01 E02 Building

Document Title System Requirements Specification for the Common Shielding System
Document Number ESS-0472974
Date Jan 15, 2019
Revision 1 (1)
State Review
Confidentiality Level Internal

DOCUMENT REVISION HISTORY

Revision	Reason for and description of change	Author	Date
1	First issue	Mark Ridgley	2019-01-14

Review