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| System Requirement Specification for the ESS Test Beamline |
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# Scope

The scope of the ESS Test Beamline, of which the requirements are presented in this document, is defined in accordance with the instrument system originally proposed, ref [1]. The scope is defined for the system to fulfil the high level scientific requirements. The functional requirements will be structured according to the high level functional grouping of the PBS.

# Issuing organisation

ESS Neutron Scattering Systems (NSS)

# Requirements

## Background and guidelines for generation of requirements

This entire section should be regarded as a brief background on how to read the system requirements.

### Requirements Categories

ESS has organized system requirements in three categories. Ideally they can be separated as follows:

* Functional requirements – generally answering to the “what” is performed by the system
* Constraint requirements (or non-functional requirements) – generally answering to the “how” a function is performed by the system
* Performance requirements – generally answering to the “how well” a function has to perform or “to what extent” a constraint affects the system design

In reality it is often difficult to differentiate between what is a functional and what is a constraint requirement. Performance requirements are in principle either functional or constraint requirements with limiting statements quantifying the satisfaction level.

To clarify: In principle, constraint requirements do not impact on the functionality of the instrument. They will however have a lesser or greater impact on the design choices of the instrument in order to achieve the intended functionality. They could also have an impact on the performance of the instrument.

Figure 1: TBL PBS

### Requirements pre-requisites

When creating requirements the following principles should be respected:

* each requirement is necessary, unique and verifiable
* attempt to address each phase of the life cycle, as completely as possible, incl. decommissioning,

### Requirement wording

Requirements are written in statements using shall or should, where the former implies a mandatory statement and the latter is a non-mandatory one. Should is used to set a goal which if fulfilled would increase the performance or functionality of the system. It can trigger discussions of prioritizing and how they can be achieved and at what impact (mainly to cost but also with respect to e.g. future upgrade possibilities etc.).

## Operational Requirements

1. Characterization of the top moderator (time structure, spatial distribution, energy dependence etc.)
2. Simple tests of key neutron technologies (such as optical components, shielding devices, choppers and detector systems)
3. The instrument shall use energy sensitive pinhole imaging (ESPI) technique according to the BrightnESS document

## Functional Requirements

The following sections breakdown the Operational Requirements to requirements that the major subsystems need to fulfil.

### Beam Transport and Conditioning System (BTCS)

| Id | Text | Trace up to |
| --- | --- | --- |
| 1 | Wavelength Transportation – Range  The Beam Transfer and Conditioning System (BTCS) shall be optimised to transport neutrons with wavelength from 0.5 Å (?) to 20 Å (?) from the thermal and cold moderator surfaces | 3.2-1 |
| 2 | Wavelength Resolution and Selection – Wavelength Range  The BTCS shall be able to provide various selectable wavelength resolutions from smaller than 0.2% to bigger than 4%. | 3.2-1 |
| 3 | Field of View - Aperture  The system shall be able to project the full image of the top moderator and the pre-moderator surfaces (300mmx38mm) to the plane of the detector. | 3.2-1 |
| 4 | Beam Collimation  Pinhole Size, fixed The BTCS shall have settings of the pinhole size less than 3 mm. | 3.2-1 |
| 6 | Background  Noise to Signal ratio better than 10% (High energy neutron background and gamma radiation divided by cold and thermal neutrons) | 3.2-1 |

### Sample Exposure System (SES)

| Id | Text | Trace up to |
| --- | --- | --- |
| 8 | SES - Alignment  The future experiments are not designed yet, but it is defined in in the Operational requirements that these experiments should be simple, we require only an empty space between the detector and the Bunker Wall for sample placement, don’t have specific requirements for sample environment. We are going to make provision for a 3 axis future sample stage in the control system | 3.2-2 |

### Scattering Characterization System (SCS)

| Id | Text | Trace up to |
| --- | --- | --- |
| 9 | Detector Area  The SCS shall be able to record an image of the complete moderator. | 3.2-1 |
| 10 | Spatial resolution  The SCS shall provide effective resolutions of down to at least 1mm. | 3.2-1 |
| 11 | Time resolution  The SCS shall provide detector time resolutions down to ? | 3.2-1 |
| 11 | Efficiency – Lower acceptable limit  The SCS shall provide detector time resolutions down to ? | 3.2-1 |
| 11 | Count rate – Limitation and Decay  ? | 3.2-1 |
| 11 | Beam Stop – Attenuation  The beam stop of the SCS shall be able to attenuate a direct beam to a level below 3 µSv/hr outside the Experimental Cave | 3.2-1 |

### Experimental Cave (EC)

| Id | Text | Trace up to |
| --- | --- | --- |
| 9 | The Experimental Cave – access  The Experimental Cave shall provide access to all components downstream the bunker wall | 3.2-1 |
| 9 | The Experimental Cave – design  The cave should be designed to allow easy extension of the beamline in case of future needs. | 3.2-1 |
| 9 | Biological shielding, Experimental Cave – Access to SES during irradiation  Experimental Cave shall prevent access to the SES while sample irradiation is occurring or the safety monitor is triggered. | 3.2-1 |
| 9 | Biological Shielding, Experimental Cave – dose attenuation  The maximum dose rate on the outer surface of the cave shall be less than 3 µSv/h during a sample irradiation , i.e shutter open, in accordance with ESS-0001786 & ESS- 0051603, | 3.2-1 |
| 9 | Experimental Cave – Beam access height The Experimental Cave shall have a floor to beam axis height of 1.25±0.1 m along beam for manual manipulations. | 3.2-1 |
| 9 | Experimental Cave – Object accommodation  Entry to the Experimental cave shall allow for the movement of apparatus up to 1m wide × 0.8m thick × 1m tall. | 3.2-1 |
| 9 | The Experimental Cave – utilities  We need to design the cave to have the provisions for the standard sample environment feed-trough, but only one 230V power line will be installed. | 3.2-1 |

### Control Hutch (CH)

| Id | Text | Trace up to |
| --- | --- | --- |
| 9 | Control Hutch – Instrument control terminal(s)  The control hutch shall allow the user to remotely control the technical components from dedicated computer terminals | 3.2-1 |
| 9 | Control Hutch – Detector terminals  The control hutch shall allow the user to remotely control detector systems from dedicated computer terminals and view live streams of detectors and CCTV. | 3.2-1 |
| 9 | Control Hutch – Data reduction terminal  The control hutch shall allow the user to process the neutron data | 3.2-1 |
| 9 | Control Hutch – Comfort  The control hutch should be a comfortable working environment for up to 2 users. ISO 11064-6 provides good guidelines for defining comfort and should be followed where possible. | 3.2-1 |

### Integration Control and monitoring (IC&M)

| Id | Text | Trace up to |
| --- | --- | --- |
| 9 | IC&M – Instrument Control and Automation  All motorized axes and electronic driven systems shall be remotely controllable with the instruments computer system | 3.2-1 |
| 9 | IC&M – Monitoring  All viable systems shall be monitored electronically and feed back into the control system | 3.2-1 |
| 9 | IC&M – Source pulse synchronizing  A signal, (ideally NIM) synchronized with the source pulse, shall be available to the system | 3.2-1 |
| 9 | IC&M – Personal Safety System (PSS)  The PSS shall be fully integrated into the Instrument control such that the Instrument can be operated safely. | 3.2-1 |

## Constraint Requirements

### Operational constraint requirements

| Id | Text | Trace up to |
| --- | --- | --- |
| 9 | The pinhole shall be remotely adjustable in Y-Z direction and manually in X direction to fine tune the image. Moving it in X direction the Imaging Ratio of BTCS shall be adjustable by 10%. | 3.2-1 |
| 9 | The system shall be designed to accommodate to the limitations of the chosen detector (decrease the beam intensity with different pinhole sizes, additional attenuators, changing the slit size for the choppers). | 3.2-1 |
| 9 | The Detector and the support structure shall allow the imaging of the whole moderator image without manual intervention. (Either by having a large detector, or a motion stage for scanning.) | 3.2-1 |

### Reliability, Availability, Maintainability & Inspectability (RAMI) requirements

| Id | Text | Trace up to |
| --- | --- | --- |
| 9 | Operation Schedule  The system shall be operational according to the schedule of the ESS source and the set availability goals of NSS RAMI Handbook | 3.2-1 |
| 9 | Maintainability  The system shall be maintainable in a way fulfilling the Operation Schedule requirement (above). | 3.2-1 |
| 9 | Access  Instrument components shall be accessible for all maintenance and repair activities needed to fulfil the Operation Schedule and Maintenance requirements (above). | 3.2-1 |
| 9 | Reliability – MTBF (Mean Time Between Failure)  Instrument components and sub-systems shall meet MTBF requirements (as specified elsewhere in detail) that enable to meet the Operation Schedule requirement (above). | 3.2-1 |
| 9 | Availability – MTTR (Mean Time To Repair)  Instrument components and sub-systems shall meet MTTR requirements (as specified elsewhere in detail for critical subsystems) that enable to meet the Operation Schedule requirement. | 3.2-1 |
| 9 | Internal Interfaces (physical connection)  Instrument sub-systems shall be connected and integrated such to enable to meet the functional and other RAMI requirements. | 3.2-1 |
| 9 | Design Robustness  The overall system design shall enable to meet the Operation Schedule requirements through robustness against single subsystem failure. | 3.2-1 |
| 9 | Spares  The system shall include spares critical to meet OS requirement, where reasonably possible. | 3.2-1 |

### Environmental Requirements

| Id | Text | Trace up to |
| --- | --- | --- |
| 9 | Shielding  The radiological shielding of the system shall satisfy all applicable legal regulations incorporated in ESS procedures, guidelines, handbooks etc. to guarantee safe operation concerning radiation hazards. | 3.2-1 |
| 9 | Activation  The Activation of system components shall comply with ALARA criteria, corresponding ESS procedures, guidelines, handbook, etc. incorporating applicable legal regulations, in particular also with respect to disposal. | 3.2-1 |
| 9 | Sample handling  The system shall allow for sample handling procedures complying with ESS environmental policies and legal regulations incorporated in ESS procedures, guidelines, handbooks etc., in order not to pose an environmental risk. | 3.2-1 |
| 9 | Materials  The materials used in the system shall avoid environmental hazards and comply with all applicable legal regulations incorporated in ESS procedures, guidelines, handbooks etc. | 3.2-1 |

### Conventional Safety Requirements

| Id | Text | Trace up to |
| --- | --- | --- |
| 9 | Safety  The system and all required operational procedures shall comply with ESS safety procedures, guidelines, handbooks etc. and legal regulations, incorporated in the former. | 3.2-1 |

### Radiation Safety Requirements

| Id | Text | Trace up to |
| --- | --- | --- |
| 9 | Activation  The Activation of system components shall comply with ALARA criteria, corresponding ESS procedures, guidelines, handbook, etc. incorporating applicable legal regulations, in particular also with respect to disposal. | 3.2-1 |
| 9 | Sample handling  The system shall allow for sample handling procedures complying with ESS environmental policies and legal regulations incorporated in ESS procedures, guidelines, handbooks etc., in order not to pose an environmental risk. | 3.2-1 |
| 9 | Materials  The materials used in the system shall avoid environmental hazards and comply with all applicable legal regulations incorporated in ESS procedures, guidelines, handbooks etc. | 3.2-1 |
| 9 | PSS  The system shall feature a PSS complying with ESS regulations and policies that enables radiological safety for the access to sub-systems. | 3.2-1 |

### External Interface Requirements

| Id | Text | Trace up to |
| --- | --- | --- |
| 9 | CF environment  The system shall fit within and profit from the boundary conditions set through CF. | 3.2-1 |
| 9 | Neighbouring Systems  The system shall comply with the physical requirements of neighbouring systems and its design shall take into account needs of potential future neighbours. (E.g. modular FOC 5 pit to allow integration with potential shielding for a future S1 instrument) | 3.2-1 |
| 9 | ICS  The system shall connect to the ICS to allow for monitoring and control with respect to all viable functions through ICS. | 3.2-1 |
| 9 | Data Streaming  The system together with ICS shall enable to stream all recorded data through ICS to central data storage and back to instrument control/data computers. | 3.2-1 |
| 9 | Remote Control Software  The system shall interface with control software to satisfy all remote control requirements for operation, testing, maintenance and meta-data production for users and operators. A specification of which components and operations require remote control is provided elsewhere in the instrument documentation [9]. | 3.2-1 |
| 9 | Data Reduction Software  The entirety of TBL operational modes shall be the basis for the specification of all required data reduction and visualisation through a GUI and through command line interface, suitable for use by users with only minor training requirements. Detailed requirements for the reduction software constitute the major part of the interface with DMSC/Data Reduction and are in a process of development. | 3.2-1 |
| 9 | Data Analyses Software  The entirety of TBL operational modes shall be the basis for the specification of all required data analyses and corresponding visualisation through a GUI and through command line interface, suitable for use by users with only minor training requirements. Detailed requirements for the analyses software constitute the mayor part of the interface with DMSC/Data Analyses and are in a process of development available. | 3.2-1 |
| 9 | Monitoring  The system shall enable monitoring with regards to radiological data, safety functions, operational conditions of sub-systems, vacuum, smoke, heat, specific gases etc. as required for safe operations by other sub-systems, systems and policies and regulations. | 3.2-1 |
| 9 | The system shall comply with the bunker design. | 3.2-1 |

# Glossary

| Term | Definition |
| --- | --- |
| <<Sample term>> | <<Sample explanation >> |
|  |  |
|  |  |

# references

1. <<Sample reference to CHESS document: ESS Document (ESS-00XXXXX)>>

Document Revision history

| Revision | Reason for and description of change | Author | Date |
| --- | --- | --- | --- |
| 1 | First issue | <<Name>> | <<YYYY-MM-DD>> |
|  | <<Keep only full number revisions when approving document>> |  |  |
|  |  |  |  |