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ESS Vacuum Handbook
Part 1 – General Requirements for the ESS Technical Vacuum System

	Name	Date
Author	Laurence Page Vacuum System Group, STS	
Reviewer	Fabio Ravelli Vacuum System Group, STS	
Approver	Marcelo Juni Ferreira Vacuum Systems Section Leader, STS	

Document Revision History

Version	Reason for revision	Date
0.	New Document	2013-05-23
0.1	Updated procurement policy	2019-01-11

Table of Contents

Abbreviations:

ESS	European Spallation Source
HV	High Vacuum
IKC	In Kind Contributor
LINAC	Linear Accelerator
RV	Rough Vacuum
NE	Nitrogen Equivalent
UHV	Ultra-High Vacuum
VG	Vacuum Group
VH	Vacuum Handbook
VGL	Vacuum Group Section Leader

1. INTRODUCTION

The European Spallation Source (ESS) is an accelerator-driven neutron spallation source. The linear accelerator (LINAC) of which is a critical component. The role of the accelerator is to create protons at the ion source, accelerates them to an appropriate energy, and steers them onto the target to create neutrons via the spallation process for use by a suite of research instruments.

2. SCOPE

The ESS Vacuum Handbook comprises four (4) parts:

ESS Vacuum Handbook Part 1 – General Requirements for the ESS Technical Vacuum Systems,

ESS Vacuum Handbook Part 2 – Vacuum Equipment Standardization,

ESS Vacuum Handbook Part 3 – Vacuum Design & Fabrication, and

ESS Vacuum Handbook Part 4 – Vacuum Test Manual

This Vacuum Handbook (VH) part 1 provides guidelines, and imposes requirements where necessary, for the definition of equipment and processes associated with the vacuum systems of the Accelerator, Target and Neutron Instruments. The VH is applicable to all vacuum components and systems exposed to a technical vacuum environment.

This VH, a level 2 requirement, is to ensure that consistent standards are employed throughout all the accelerator, target and neutron instrument vacuum systems and hardware.

This VH will be periodically updated throughout the life of the ESS project. Queries or additional information concerning the contents of this VHB should be addressed to the ESS Vacuum Group Section Leader (VGL).

3. REPONSABILITIES

The ESS vacuum team has overall responsibility for all technical vacuum systems used on the Accelerator, Target and Neutron Scattering Instrument Systems and has the responsibility to provide guidance and on-going support and oversight to ensure the implementation of compatible vacuum designs for e.g. vacuum chambers, components and other equipment exposed to a technical vacuum environment. This responsibility extends to supporting these systems during commissioning and operations.

4. PROCUREMENT POLICY

Please refer to tender documents for information regarding procurement.

5. CLASSIFICATION OF PRESSURE RANGES

In the VH the following classes of vacuum level have been assigned to the following pressure ranges:

- Rough vacuum (RV): From atmosphere to 0.1 Pa (10^{-3} mbar)
- High vacuum (HV): 0.1 to 10^{-5} Pa (10^{-3} to 10^{-7} mbar)
- Ultra-High Vacuum (UHV): 10^{-5} to 10^{-8} Pa (10^{-7} to 10^{-10} mbar)

5.1 Operating Pressures

5.1.1 Accelerator

Typical vacuum levels in the accelerator, except for the front-end systems, will be in the 10^{-6} Pa (10^{-8} mbar) Nitrogen equivalent (NE) range. While the pressure required to minimize interaction of the proton beam with the rest gas will be in the 0.1 Pa (10^{-3} mbar) range, the operational pressure is driven by the long-term operation requirements of the ion pumps which requires pressures below 10^{-4} Pa (10^{-6} mbar) to achieve > 60.000 hours of operation. In addition, gas flow into the cryomodules must be minimized in order to limit the mono-molecule build-up of residual gases in the cavities.

5.1.2 Target

The pressure requirements for target systems are currently undefined.

5.1.3 Neutron Scattering Instruments

5.1.3.1 Detectors Vessels

Vacuum levels required for the various detectors will vary depending on the science to be performed but will typically be in the 1 to 10^{-4} Pa (10^{-2} to 10^{-6} mbar) range. The Instrument Division will specify, on a case-by-case basis, the specific vacuum requirements for each detector vessel.

5.1.3.2 Neutron Guides

Neutron guides will be designed to operate in the 0.1 to 10^{-2} Pa (10^{-3} to 10^{-4} mbar) range to minimize the neutron beam interaction with the rest gas.

5.1.3.3 Choppers

Choppers will be designed to operate in the 0.1 to 10^{-2} Pa (10^{-3} to 10^{-4} mbar) range to minimize the neutron beam interaction with the rest gas and minimize windage losses.

6. VACUUM WORK FLOW

The following workflow is to be implemented, with applicable documents sent to the ESS vacuum group (VG) for review and/or approval.

A technical contact person shall be nominated by each group/ system/ IKC as the point of contact with the ESS VG.

Vacuum related activities will include but not limited to:

1) Review of technical documents, e.g. pressure simulations, drawings, manufacturing plans, test procedures and reports, etc.
2) The review and approval of formal requests for use of Unlisted Materials, section 8 of the VH.
3) Conducting of on-site inspection of vacuum related components and equipment.
4) Witnessing of tests on vacuum components and systems on an as required basis.

7. HEALTH AND SAFETY CONSIDERATIONS

Many of the chemicals and processes described in this document are subject to control and regulation under various parts of the European Agency for Safety and Health at Work or other judicial authorities. Any persons or companies using chemicals and processes must ensure that they are conversant with the requirements for the implementation of all applicable Legislation and/or Regulations.

7.1 Pressure Rating of Vacuum Vessels and Components

A vacuum system consists of a vessel and its associated piping and components evacuated below atmospheric pressure. Pressurization above the design rating can occur as the result of a failure of a containment boundary releasing e.g. gas or cryogens entering into the vacuum envelope or the venting of the vacuum volume with gas from an external source. Under normal circumstances it desirable to limit by design or engineering controls the vacuum vessel to vacuum service only. This avoids the complication involved in rating the vacuum vessel as a pressure vessel together with the additional costs involved. The guidelines for the rating of vacuum vessels will be determined by the categories describes below:

Category I Vacuum Vessels in which the differential operating pressure across the vacuum boundary can never exceed 1 bar. This would be the case for a vacuum vessel that is always vented to air at atmospheric pressure.

Category II Vacuum Vessels that those are protected from credible failures that could create a pressurization exceeding 1 bar through the use of engineering controls such as pressure relief devices. In general, this will be the situation for most of the vacuum vessels installed and operated at ESS. It is desirable in most cases to keep the vessel dry, avoiding moisture in the vessel that would occur if the vessel were to vented to atmosphere. This is especially important for the accelerator. When venting is from a pressurized gas source, pressure relive devices must be installed both at the source and also at the vacuum vessel. Since the gas source will be pressure regulated, the pressure relief device must be suitably sized to protect the vacuum vessel in the case of failure of this device.

Category III Vacuum Vessels are such that they are not or cannot be protected from credible failures that could create pressurization exceeding 1 bar. In this case these vessels will need to be designed as a pressure vessels in accordance with applicable codes.

8. GENERAL GUIDE TO THE SELECTION OF MATERIALS

8.1 Ultra High Vacuum Applications

In general, the term UHV applies to any vacuum applications where the pressure requirement is <10^{-5} Pa (<10^{-7} mbar).

Materials used for ALL vacuum systems and components of the accelerator and other systems exposed to vacuum and operating at <10^{-5} Pa (<10^{-7} mbar) shall be selected from the approved list of materials for UHV applications UNLESS specific approval is given in writing by the ESS VGL.

It is important to ensure that the correct fabrication techniques (e.g. only the use of water-soluble machining lubricants for manufacture,) handling and cleaning procedures are used so as not to compromise the vacuum performance of the selected material.

Approved UHV Materials List:

- Stainless Steel ASTM type 304 & 316 series or ISO equivalent
- Copper OFHC (phosphorous de-oxidized grade shall not be used)
- Aluminium and its alloys. Do not use cast components.
- Gold
- Silver
- Titanium
- Molybdenum
- Platinum
- Beryllium Copper
- Ceramic (as Al_2O_3) >90%
- Machinable glass (Macor)

Prohibited Materials List:

- Brass
- Soft Solder
- Standard Hard Solder
- Electrical Solder
- All Plastics
- ASTM type 303, free cutting stainless steel
- All Glues
- Greases
- Silicon or sulphur based machining lubricants when machining any components (only water-soluble machining lubricants are permitted)
- GE Varnish
- Anodized surfaces or any mechanically polished components
- Any material containing: Zinc, Cadmium, Phosphorus, Sodium, Selenium, Potassium or Magnesium

8.2 High and Rough Vacuum Applications

Materials approved for UHV applications are also suitable for high vacuum use. In addition, some of the materials specifically prohibited from use for UHV applications maybe suitable for the high vacuum use. Contact the ESS VG for assistance in the selection of alternate materials.

8.3 Unlisted Materials

The material list provided above is not extensive and a request can be made to the VGL to use an unlisted material. A requested shall be submitted, using the "Approval of Unlisted Material" form attached as Appendix A, to the ESS VGL for consideration and approval. Out-gassing measurements studies may need to be conducted to establish if the material being considered is suitable for vacuum service in the application proposed. Some materials will not be provided with blanket approval, e.g. insulated cable, which, in general, is procured on a batch-to-batch basis. In this case approval will be given, subjected to satisfactory out-gassing test measurements on the tested sample, for the use on that batch of material only.

9. APPLICABLE DOCUMENTS

In the case of conflict, with the requirements stated in this VH, the VH shall take precedence. If the requirements of the VH are in conflict with Legislation and/or Regulations then these conflicts are to be brought to the attention of the VGL for resolution.

10. APPENDIX

ESS Unlisted Material approval

Part 1

Date: ____________

Institution: _________________________ Requester: ___________________________________

Materials name: ____

Material Composition: ____

____

Hazard:

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Part 2

Application: ____

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Vacuum requirements: ____

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Part 3

Test Responsible Person (print name): ______________________ Date: ___________________

System Identification: ____

Sample and test description: ____

____

____

Calibration Pre-Test:

Standard sample:________________________ Outgassing Rate:________________________

Outgassing Test:

Gauges Pressure during test:____

Sample preparation description:____

____

____

____

Baking temperature and time: ___________ C _________________________hours.

RGA scan Assessment:

Any unusual mass peak ? (No/Yes):_______________________

Describe:____

Any deformation noted after process? (No/Ye): ______________________________
Describe:____
____
____
____

Part 4
Certification:
Test Responsible Person (signature):____
Witness: (print name)_______________________(signature)____________________________

Notes/Comments:____
____
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