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SCHEDULE NIK 3.7 – LABORATOIRE LEON BRILLOUIN (LLB)'S CONTRIBUTION REGARDING THE DESIGN, PROCUREMENT, MANUFACTURING, AND DELIVERY OF HIGH-PRESSURE SAMPLE ENVIRONMENT SYSTEMS TO THE IN-KIND CONTRIBUTION AGREEMENT SIGNED BETWEEN EUROPEAN SPALLATION SOURCE ERIC (ESS) AND COMMISSARIAT A L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES (CEA) AND CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE (CNRS) ON DATE

ANNEX TO THE IN-KIND CONTRIBUTION AGREEMENT BETWEEN EUROPEAN SPALLATION SOURCE ERIC (ESS) AND THE COMMISSARIAT A L'ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES (CEA) AND THE CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE (CNRS) ON DECEMBER 2019

1. SCOPE

This document describes the Scope of Work (SoW) required to complete the High-Pressure Sample Environment Systems contribution to the ESS programme by LLB (represented by CEA and CNRS). It is an integral part of the In-Kind Contribution Agreement and is agreed upon by all undersigning Parties. The SoW contains an appropriate level of detail so all parties clearly understand what work is required, the duration of the work involved, the deliverables and the conditions of acceptance.

2. RELATED DOCUMENTS

2.1 Applicable Documents

[CCP] ESS-0001879 Procedure of Change Control of ESS Facility, 27 Feb 2017, Rev.5 Released

[CMP] ESS-0003688 Configuration Management Plan, 16 May 2016, Rev.2 Released

[DRP] ESS-0008910 Design Review Standard Operating Procedure, 2 Mar 2016, Rev.1 Released

[ESM] ESS-0013139 EV-Schedule-Milestone Template and Instructions, 2 Mar 2016, Rev.2 Released

[LOG] ESS-0042559 ESS Logistics Guidelines, 14 Dec 2015, Rev.1 Released

[PQP] ESS-0037830 ESS Template for Project Quality Plan, 22 Sep 2015, Rev.1 Released

[RMP] ESS-0000263 Risk Management Process, 16 May 2016, Rev. 4 Released

[SEM] ESS-0002908 System Engineering Management Plan, 15 Mar 2016, Rev. 2 Released

[IPD] ESS-0177972 Use and Inspection of Pressurised Devices Released (English translation of original Swedish legal controls on pressurised devices: ESS-0177971 “Användning och kontroll av trycksatta anordningar (AFS 2017:3), föreskrifter.

[MII] ESS-0038078 Scientific Activities Division Mechanical Interfaces for Instruments Reference Document

[USR] ESS-0038163 Scientific Activities Division Utilities Supplies Reference Document

[SCS] ESS-0038165 ESS Sample environment control system reference document

[PED] 2014/68/EU European Pressure Directive.

[EQP] ESS-0000126, Revision 3 ESS Quality Policy

2.2 Reference documents

[PSOMM] ESS-1419285. PREMP Systems Operation and Maintenance Manual).

[PDD] ESS-1545382 High-pressure sample environment systems – gas, liquid, clamp and PE type – preliminary design documents

3. TERMS AND DEFINITIONS

BP	Burst Pressure
CDR	Critical Design Review
CE	Conformité Européenne
CHESS	ESS Data Management Software
CoDR	Conceptual Design Review
DAP Incoterms	Delivered at Place. ESS is responsible for any import costs and applicable taxes.
EPICS	Experimental Physics and Industrial Control System
EV	Earned Value, the value of the work completed.
Facility element	This item corresponds to the product contribution of the partner. It is an element of the ESS Product Breakdown Structure.
FEA	Finite Element Analysis
GLC	Gas Liquid or Clamp system
GPa	Giga Pascal, unit of pressure equivalent to 10,000 bar
HP	High Pressure (here implies pressure in excess of 0.1 GPa = 1,000 bar)

IKC	In-Kind Contribution
MESI	Mechatronics and Software Integration
PED	2014/68/EU European Pressure Directive.
PS	Maximum allowable pressure at 20°C (following definition in PED
P&ID	Piping and Instrumentation Drawings
PE	Paris-Edinburgh
PEGL	PE Gas Loader
QENS	Quasi-Elastic Neutron Scattering
RSM	Regular Status Meeting
RSR	Regular Status Report
SAR	System Acceptance Review
SAT	Site Acceptance Test
SEE	Sample Environment Equipment
SES	Sample Environment System
WU	Work Unit
ATEX	ATmosphere EXplosible according to EU directive 2014/34/EC

Table of Contents

4. PROJECT DEFINITION

4.1 Motivation & Benefits

The motivation for this project is to meet the requirement for specific sample-environment systems (SES) to subject experimental samples to conditions of extremely high-pressure during neutron measurements on ESS beamlines. The systems delivered through this agreement will include established technologies, in regular operational use at existing neutron facilities, which may be either commercial or non-commercially available. The devices covered include those of gas, liquid and clamp cell types. They also include "Paris-Edinburgh" (PE) type devices and important subsystems to operate these. An integral component of this agreement is the transfer of sufficient experience from the Partner to the ESS to enable the continued safe operation and maintenance of the systems delivered.

The benefit of this project arises from the possibility to work with experienced partners at the LLB neutron facility and to use their decades of practical experience of neutron operations to guide establishment of the ESS's own in-house expertise. In addition, the specialised nature of the application means that many of the envisaged systems are not commercially available. We also note here that some specialised items of equipment may not comply with requirements of legislation, such as the PED. Therefore, we will work with our LLB partners (and sub-contractors) to design, fabricate, document and test these systems and sub-systems.

The focus of this project *is only the needs of the first 8 instruments* as given in Table 1

Table 1. Reference table of first 8 instruments projected to enter operation at the ESS. At the time of writing, the three instruments with their names in bold font are those prioritised to be delivered first. Required sample environment systems provided in this agreement are indicated using the following acronyms: GLC (gas liquid or clamp systems) and PE (Paris-Edinburgh Cell systems). Bold text is used to indicate cases where SES are critical for early scientific success on a given instrument. The hot-commissioning dates for relevant instruments have been used to define delivery schedules for the various SES, reflecting a requirement that systems must be fully commissioned within the first 6 months of hot-commissioning.

Instrument	Class	Projected hot commissioning date	Relevant SES
ODIN	Imaging	2022/Q3	GLC, PE
ESTIA	Reflectometry	2022/Q3	
DREAM	Diffraction (powder)	2023/Q1	**GLC**, **PE**
LOKI	SANS	2023/Q3	**GLC**
CSPEC	Spectroscopy	2022/Q3	**GLC**, **PE**
MAGIC	Diffraction (single-crystal)	2022/Q3	**GLC**, **PE**
BEER	Engineering	2022/Q3	**GLC**, PE
BIFROST	Spectroscopy	2022/Q3	**GLC**, **PE**

4.2 Overview and structure of project

The Partner shall provide its contributions in accordance with the following time schedule:

Start date: [20 Apr 2020] TO BE DEFINED IN A KICK OFF MEETING

End date: [30 July 2022]

This project is broken down into Tasks and Subtasks, as documented in Table 2

Table 2. Summary of tasks comprising the work covered by this collaborative agreement

Task/Sub-task no.	Name	Reference	Deliverables	Delivery Deadline / Deliv-ery MS(s)
1.0	Gas, liquid and clamp systems	§4.3	• A suite of high-pressure sample environment devices according to defined specifications. • A system to generate and control high-pressure He gas up to 1.0 GPa • Training in operation and maintenance of suite of devices covered by this agreement • Documentation Package as defined	July 2022/ MS1-7
2.1	Paris-Edin-burgh (PE) cell suite	§4.4	• Procurement of Paris-Edinburgh presses (PE) according to defined specifications • Documentation Package as defined	May 2021/ MS2.1-3
2.2	HP gas-loading system for PE cells	§4.6	• Design and manufacture of a complete gas loading system compatible with standard PE anvil assemblies and operable with H2 gas with a maxium allowable pressure at 20°C (PS) of 0.3 GPa. • Documentation Package as defined	June 2022/ MS2.2-6
2.3	Cryogenic system for PE cells	§4.7	• Design and manufacture of a cryogenic system compatible with the PE devices provided in Task 2.1 • Documentation Package as defined	July 2022/ MS2.3-6

This overall contribution is set to the ESS Cost Book value of €$_{2013}$**694,513(EUR)** and each of the delivery milestones is also part of the Earned Value tracking (Section 5.1).

Each Task described in Table 2 is described in more detail in subsequent sections as indicated in the Ta-ble. Included in these sections are descriptions of:

- Overall activities and responsibilities of partners in the Task
- Project stages definition
- Project schedules and key milestones
- Description of data and document deliverables

Following these sections, the general terms and activities applicable to all project Tasks and Subtasks will be outlined.

4.3 Detailed description Task 1.0: Gas, liquid and clamp systems

4.3.1 Overview of Task:

Gas, liquid and clamp cells are distinct types of sample-environment systems that have been used at neutron facilities for many decades. Both gas and liquid cells are very similar in design being essentially high-pressure chambers that are driven by external compressors. They normally have defined windows for neutron beams to enter and exit. In clamp cells, pressure is generated by direct application of force, typically via an offline hydraulic press, provided by the ESS, which is then locked in with a clamping mechanism.

This Task is intended to deliver a basic suite of both pressure vessel types, to cover the basic needs of the first 8 instruments. These devices will closely match existing devices in use at LLB, with small modifications to match other ESS instrumentation. Also included is provision of a semi-automated He-gas compatible pressure generating unit. The PS of the He system shall be between 0.7 and 1.0 GPa, with the exact value to be decided by ESS during Intermediate Design Review IDR-1.

In addition to this hardware, knowledge transfer, in the form of training, is also an important deliverable ensuring that, in the future, ESS staff will be able to independently design, operate and maintain the devices provided through this agreement. After training, the partner shall assess the competence of the ESS staff.

Lastly, the Task includes requirements focused on ensuring compliance with European law [PED] and related Swedish regulations [IPD] on the manufacture and operations of high-pressure equipment where these are applicable. These requirements are explicitly detailed in the Deliverables sections below with further explanatory text in §5.7.

Planned budget of subtask of Task: 207,778 €$_{2013}$ **(EUR)**

Min. Duration of Task: 30 months

4.3.2 Deliverable Item definitions:

This Task entails the following distinct deliverables. Each deliverable having a number indicating the Task and providing an index for the specific deliverable.

4.3.2.1 Deliverable D1.1: Suite of high-pressure gas, liquid and clamp cells

The deliverable includes the provision of a suite of HP gas, liquid and clamp cells manufactured from various materials and dimensions, closely following the preliminary design document [PDD ESS-1545382]. These devices will be based on existing cylindrical designs that have been used previously in operational scenarios at the Partner's institution. The detailed technical specification of the suite is given in Table 3.

Table 3. Detailed specification of gas, liquid and clamp cell suite to be delivered according to this Agreement

Cell class	Body material	Inner diameter (mm)	Sample vol. (cc)	Max. Operating Pressure, PS (GPa)	Number of cells
Gas	TiZr*	7	1.0	0.5	1

Gas	TiZr*	5	0.5	0.5	1
Gas	Al	7	1.0	0.4	1
Gas	Al	5	0.5	0.4	1
Gas	CuBe	7	1.0	0.7	1
Liquid	TiZr*	7	1.0	0.5	1
Liquid	TiZr*	5	0.5	0.5	1
Liquid	Al	7	1.0	0.4	1
Liquid	Al	5	0.5	0.4	1
Clamp	CuBe	TBD	0.3	1.5	1

*TiZr material shall be provided by ESS and Partner is not responsible for deviation of material properties from specification.

Additional requirements:

- All devices shall be manufactured according to sound engineering practice and, where applicable, explicit provisions in European law [PED] relating to pressure equipment.
- Specific grades of material and processing (such as heat treatment) are to be chosen by the Partner to ensure best performance and safety. Certifications must be provided for all material processing (comprising deliverable D1.4 below).
- Connecting fittings shall be defined by LLB Partner to be compatible with relevant media and pressure requirements.
- Each of the devices listed in Table 3 shall be accorded a unique serial number, allowing explicit association with the documentation and data deliverables described below and comprising Deliverable 1.4.
- Each device shall include permanent marking, in a convenient position, not to interfere with the entering or exiting neutron beam, recording the following information:
  - Permanent serial number
- Provided equipment shall be compliant with ESS CE-marking requirements if possible and, if not, a written note detailing reasons shall be supplied (see §5.7)

This deliverable has associated documentation and data comprising Deliverable 1.4, described in detail below.

4.3.2.2 Deliverable D1.2: A system to control He gas pressure up to 1.0 GPa

A system capable of safely generating and controlling He gas pressures with a PS of 0.7 to 1.0 GPa [to be finalised during intermediate design review (IDR 1) shall be specified and procured from a commercial supplier and delivered to the ESS. The system shall have provision for semi-automatic pressure control comparable to state-of-the-art capability at other neutron facilities. The function of the system is expected to follow closely existing devices at ILL and PSI and to have comparable specifications, e.g. on pressure rates and stroke volume. It shall include the possibility for automatic pressure control to a set point.

Other required elements of the specification are:

- The entire system shall be fabricated within a portable structure, a wheeled frame is envisaged, to facilitate easy transportation between laboratories and instruments.
- The system shall be compatible with relevant documents defining ESS standard utilities (ESS-0038163) and the interface with ESS instruments (ESS-0038078) (e.g. European standard power connections).
- The system shall be compatible with a standard He gas cylinder as the source of media.
- It shall be possible to control the device both locally and remotely. The ESS MESI team shall advise on the control interface to ensure compatibility with ESS (EPIC's based) control systems and compliance with ESS policies [SCS].
- Full system shall be delivered assembled to Lund with operation demonstrated as part of SAT 1.2.
- Provided equipment shall be compliant with ESS CE-marking requirements (see §5.7)

This deliverable has associated documentation and data comprising Deliverable 1.4, described in detail below.

4.3.2.3 Deliverable D1.3: Training of ESS personnel in the design, manufacture, maintenance and operation of devices comprising Deliverables 1.1 and 1.2

This deliverable is to provide training to enable ESS technical staff to understand the details of the devices in provided through this agreement as deliverables 1.1 and 1.2. This training shall be provided to such a level that skilled and experienced ESS technical staff will afterwards be able to:

- Safely design similar devices to those provided in Deliverable 1.1. This is to include instruction on performing basic safety calculations on cylindrical pressure chambers, sharing of experience on materials issues relating to both mechanical and neutronic performance.
- Conduct appropriate modification of similar devices to those provided in Deliverable 1.1, using appropriate machine tools, to ensure safe and reliable operation of such devices.
- Safely operate the HP He gas system comprising Deliverable 1.2.

The deliverable is to include hands-on instruction and training of up to three ESS technicians at the Partner's Facility. The expected duration is around 1 week, however, the Partner can request a longer period if deemed necessary. In addition, the Partner is expected to provide follow-up training remotely (via either phone, email or video-conference) to supplement the on-site training if deemed necessary.

In addition to the practical training provided through this deliverable, the Partner shall also provide instruction in the form of operating manuals and maintenance schedules as detailed below in the description of Deliverable 1.4.

4.3.2.4 Deliverable D1.4: Documentation and Data Package associated with deliverables D1.1, D1.2 and D1.3 described above

A summary of the technical documentation comprising Deliverable D1.4 is contained Table 4. Also, in this table, specific sub-elements of main D1.4 have been given individual numbers to generate an associated ID number.

Table 4. Details of documentation and data deliverables associated with Task 1

Deliverable name (and ID)	Associated Systems	Documentation Deliverable	Data Deliverable
Gas, liquid, clamp design documentation (D1.4.1)	All gas, liquid and clamp cells comprising D1.1	Design Documentation including: • Detailed specification for each provided device including defined PS. • A risk analysis for each device highlighting design features implemented to negate or minimise risk. • Full technical drawings and 3D models of all delivered devices. • Report detailing calculations reflecting key safety elements in design including wall ratio determination and, where necessary, FEA for all delivered devices.	
Gas, liquid, clamp operational documentation (D1.4.2)	All gas, clamp and liquid cells in D1.1	• Maintenance schedule for all delivered devices. • A risk assessment covering operation and maintenance of all delivered devices under the conditions specified. • Material reports detailing the mechanical properties of metals used, particularly where these relate to safety calculations. • Heat treatment documentation.	• Physical data collected from materials according to EN 10204/3.1. • Physical data collected from pressure tests that shall be conducted in a way that is consistent with the material properties
HP He gas system design documentation (D1.4.3)	HP He gas system D1.2	• Detailed specification of device giving full operating parameters, including volumes of components. • A detailed P&ID for the entire system. • Schematic drawings	
HP He gas system operational documentation (D1.4.4)	HP He gas system D1.2	• A full operating manual suitable for a skilled operator to perform all operational and maintenance tasks and including a maintenance schedule for all delivered devices. • Calibration reports for any pressure transducers or pressure-limiting safety devices. • Reports detailing pressure tests and proof tests conducted at Partner facility.	• Physical data collected from pressure tests of devices up to at least PS x 1.25 (see §5.7.3 on CE marking) • Physical data collected from materials including hardness

			testing or other physical properties measurements.

Further clarifying details:

- Instruction manuals: The required manuals are not intended to be sufficient for an unskilled novice (e.g. a new neutron user), rather they are intended as tools to allow correct operation by skilled and knowledgeable ESS staff who have a background in high-pressure neutron research. Manuals should be consistent with any provided training given as part of D1.3.

- Requested documentation is designed to comply with the PED specifically the Essential Safety Requirements detailed in 2014/68/EU Annex I and, where relevant, the Conformity Assessment Procedures described in 2014/68/EU Annex III (Module A). It shall be provided with sufficient detail compatible with descriptions in that document. [PED]. In the case where compliance with the PED is not possible (see §5.7.3), equivalent documentation is still required.

4.3.3 Task definitions (including phase definitions, reviews, milestones definitions and schedule):

The distinct Task phases and associated activities occurring in these are described in this section. In addition, the projected schedule for the whole task is given. Normally, the transition from one phase to another phase requires a review which will be associated with a specific project Milestone. Additionally, realisation of a deliverable may also be associated with a milestone. As per §5.3.5 achievement of a milestone is associated with a weight from 1-100% indicating progress towards task completion. Detailed description of requirements and processes for both meetings and reviews are described in §5.2.

4.3.3.1 *Task Phase Definition: Phase 1-1 (Detailed Design Phase)*

Phase 1-1 of the contribution is a design study, which shall define the detailed elements of the gas, liquid and clamp cells (D1.1) and the technical specification for the He compressor (D1.2). This includes, but is not necessarily limited to:

1. Partner shall complete a detailed analysis of all aspects of design of gas, liquid and clamp cells relating to safety in compliance with the [PED], Annex I §2. If compliance with PED is not possible, then this shall be documented as described in §5.7.3. Independent of whether devices are compliant with the PED, safety-critical aspects of design shall be documented, to a level of detail comparable to PED requirements.
2. For Deliverable D1.1 Partner shall complete a detailed technical design of all devices to a level of detail adequate for subsequent procurement or manufacture. Activities include, but are not limited to, specifications such as: seals design, wall thicknesses, sample volumes and materials specification and treatment considerations.
3. For Deliverable D1.2 Partner shall assess commercial options for both price and performance and ESS shall make a final decision on PS (which shall be between 0.7 and 1.0 GPa). In addition, the Partner shall prepare a full design specification for the system to a level to allow a subsequent tender process. This specification for tender shall be reviewed by the ESS during a Call for Tender Verification (CTR1)
4. Partner shall complete and submit to the ESS documentation associated with (1) and (2) above and comprising deliverables D1.4.1. These deliverables are to be provided to CDR board at least 4 weeks in advance of the CDR.

Phase 1-1 starts upon the sign off of the parties of this SoW and the Kick-off meeting. Phase 1-1 ends with the successful completion of the Critical Design Review for Task 1 (CDR1)

4.3.3.2 *Task Phase Definition: Phase 1-2 (Procurement and Manufacturing)*

Phase 1-2 is where the designs for gas liquid and clamp cells derived in Phase 1-1 are realised as physical components and where a successful tender process for the He compressor leads to a completed device. These activities include but are not necessarily limited to:

1. Partner shall manage the procurement process for the He compressor.
2. Partner shall participate in any necessary intermediate verifications during the fabrication, e.g. inspection of material certificates, part dimensions, etc.
3. Partner shall communicate with suppliers to ensure timely delivery of components.
4. Partner shall conduct any necessary Factory Acceptance Testing (FAT) to ensure components are within specification and are suitable for the intended purpose and to guarantee safety.
5. Where necessary, the Partner shall assemble delivered or manufactured components to complete full systems comprising D1.1 and D1.2.
6. Partner shall test complete systems to ensure functionality and to optimise operational parameters.
7. Partner shall ensure completion and submission of all materials comprising D1.4.2 and D1.4.4.
8. Partner shall deliver D1.1 and D1.2 to Lund.
9. ESS Staff will conduct local assembly of any dismantled systems shipped to Lund. Where necessary instruction and or training of ESS staff by the Partner is necessary to correctly assemble equipment, this shall be provided
10. ESS Staff will perform initial testing of systems delivered to confirm compliance with agreed specification via a Site Acceptance Test (SAT).

Phase 1-2 starts upon successful completion of CDR1. Phase 1-2 ends with SAT (relating to D1.1 and D1.2) at ESS premises in Lund.

4.3.3.3 *Task Phase Definition: Phase 1-3 (Installation, Integration and Commissioning)*

Phase 1-3 is the final phase of the Task and comprises the installation of delivered systems in Lund, integration of these systems into local utilities and control systems and demonstration of functionality within specification. These activities include:

1. ESS staff shall integrate system controls with ESS computer systems.
2. ESS staff shall complete of pressure testing to meet ESS requirements on HP systems [PSOMM].
3. ESS staff (with support from Partner and, relevant commercial suppliers) shall integrate of systems with ESS SEE mechanical interface [MII].

Phase 1-3 begins with a successful SAT at ESS site in Lund. After devices are fully integrated and commissioned a Site Acceptance Review (SAR-1) will be conducted. Phase 1-3 will end with successful completion of SAR-1 and the task will be considered complete after submission of the Final Report §5.1.2].

4.3.3.4 *Milestone descriptions*

Milestone ID	**Short description**	**Planned/Baseline date**	**Responsible and actions**	**Percentage of task completion [%]**

MS-1-0	Project start	*Start*	ESS: provide framework and requirements to Partners.	0
MS-1-1	Intermediate design Report	*Start*+4 months	Partners: Present status of initial designs relating to D1.1 and D1.2, operating pressure of He compressor will be decided by ESS.	20
MS-1-2	Critical Design Review and CTR	*Start*+7 months	ESS: review and validate Designs comprising D1.1 Full specification for and tender documents for D1.2 to be verified	40
MS-1-3	ESS staff training complete	*Start*+10 months	Partners: completion of agreed upon training of ESS staff	50
MS-1-4	Site Acceptance Tests passed	*Start*+14 months	ESS: completion of agreed tests to confirm specification of D1.1 and D1.2 has been met Partners: successfully address any encountered problems	70
MS-1-5	Interim milestone	*Start* + 17 months	ESS: provides partners with update on installation and commissioning BOTH: formulate plans to address any issues arising during commissioning.	80

MS-1-6	Systems fully commissioned at ESS	*Start*+21 months	ESS: complete installation and commissioning of systems	90
MS-1-7	Final site acceptance review successfully completed	*Start*+22 months	ESS and PARTNER: conduct review and reach mutual agreement that task is successfully completed	100

4.3.3.5 *Meeting/Review locations*

Meeting/Review	**Location**
Kick-off meeting	LLB
Regular status meetings	Video conference
Critical Design Review and CTV	Video conference
Site Acceptance Review	ESS

4.4 Overview of Task 2: Paris-Edinburgh Systems

The Paris-Edinburgh (PE) Press was developed in the early 1990's and its several variants are in routine use at various neutron facilities around the World. PE devices have been used for a broad variety of neutron techniques including diffraction, phonons spectroscopy, QENS and imaging and are able to reach pressures approaching 25 GPa. PE devices are perceived to be critically important to support early operations at the ESS. In addition to the presses themselves, two additional systems are considered critical: a gas loading system and a cryogenic system. The provision of these PE Systems has been broken down into the three Subtasks, each with their own value and Subtask summarised in Table 5.

Table 5. Subtasks comprising Task 2

Number and name of Subtask	**Min. Duration**	**Relevant Section**	**Budget of subtasks**
Paris-Edinburgh Press Suite	15 months	§4.5	€123.405
Paris-Edinburgh Gas Loading System	28 months	§4.6	€144,430
Cryostat for PE presses	29 months	§4.7	€218,900
		Total	**€486,513**

4.5 Detailed description of Subtask 2.1: Paris-Edinburgh Press Suite

Subtask 2.1 will define deliver the initial complement of PE presses to the ESS

4.5.1 Overview of Subtask:

The goal of this task is to supply the ESS with an initial suite of PE cells, chosen to match the needs of the first few instruments. In order to define the initial suite, a Preliminary Design Study has been conducted [PDD ESS-1545382], supplemented with a series of meetings between ESS Scientific Activities Division and ESS Instrument Scientists and by broader consultation with the HP scientific community.

This Subtask focuses on the PE press itself and *excluded* are items including:

- Hydraulic driving and control systems
- Anvils
- The mechanical interface between PE press and ESS instrumentation

All of which are related to this Subtask, but are being developed separately by ESS.

Planned budget of subtask: 118,655 €$_{2013}$ (EUR)

Min. Duration: 15 months

4.5.2 Deliverable item definitions:

4.5.2.1 *Deliverable D2.1.1: Suite of PE presses with the following specification*

Item	**Material**	**No. of pieces to be delivered**
VX5/6 with low temperature piston	AW819	1
Seats for VX6 standard design	WC	2
Backing discs for VX6	Steel	2
Sets of centring rings for VX6 seats and backing discs	Al	2
VX1 with low temperature piston	CuBe with appropriate heat treatment - cell body shall be non-magnetic	2
Room temperature seals for both press designs	Rubber	15 (5 for each press)

Additional requirements:

- All PE presses delivered shall be given a unique serial number, which shall be permanently marked.
- All PE presses shall have date of manufacture and maximum operating pressure PS (of the press) permanently marked on the press body.
- Heat treatment is to be specified by the Partner to ensure safe and efficient operation of the pressures. Certificate of heat treatment shall be supplied (as per D2.1.2 below).
- Provided equipment shall be compliant with ESS CE-marking requirements (see §5.7)

4.5.2.2 *Deliverable D2.1.2: Data and documentation for PE presses*

In addition to the PE presses comprising D2.1.1 associated data and documentation will be provided, this shall include:

- Detailed specification for each provided device in D1.2.1. including defined PS.
- Full technical drawings and 3D models of all delivered presses and sub-components such as seats and centring rings.
- Report detailing calculations reflecting key safety elements in the PE press design. In particular, calculations and or experimental tests demonstrating expected burst pressure (BP) of the device.

- Data collected during proof testing of the presses to a pressure of 130 tonnes for the vx5/6 and 50 tonnes for the VX1.
- Recommended maintenance schedule for PE press.
- Material reports and certification on all materials used to fabricate the press.
- Certificates of any heat treatments or other materials processing used.

Further clarifying details:

- Requested documentation is designed to comply with the European regulations [PED], specifically the Essential Safety Requirements detailed in [PED] Annex I and, where relevant, the Conformity Assessment Procedures described in Annex III (Module A). It shall be provided with sufficient detail compatible with descriptions in the PED. If compliance with PED is not possible, then this shall be documented as described in §5.7.3. Independent of whether devices are compliant with the PED, safety-critical aspects of design shall be documented, to a level of detail comparable to PED requirements (i.e. matching the bullet points above).

4.5.3 Subtask definitions (including phase definitions, reviews, milestone definitions and schedule).

The distinct Subtask phases and associated activities occurring in these are described in this section. Normally, the transition from one phase to another phase requires a review which will often be associated with a specific project Milestone. Additionally, realisation of a deliverable may also be associated with a milestone. As per §5.3.5 achievement of a milestone is associated with a weight from 1-100% indicating progress towards task completion. Detailed description of requirements and processes both meetings and reviews are described in §5.2.

4.5.3.1 *Subtask phase definition: Phase 2.1-1 (Detailed Design Phase)*

Although the design of the PE press is well established, a small amount of detailed design may be necessary to fine tune specification of sub components (for example which piston design to use). Both ESS Staff and Partner will participate in this short phase, which will end once final details of the specification are agreed upon and CDR2.1 is complete.

4.5.3.2 *Subtask phase definition: Phase 2.1-2 (Procurement and Manufacturing)*

During this phase, the Partner will complete the procurement process for the PE press (D2.1.1) and create all necessary documentation comprising D2.1.2.

The Partner will conduct any necessary verifications and/or assembly of devices at their own facilities and will then deliver all components to ESS site.

ESS Staff will perform any required on-site assemblies at ESS site and will conduct Site Acceptance Tests (SAT) to demonstrate compliance with specifications and ESS rules on pressure equipment [PSOMM ESS-1419285].

Phase 2.1-2 will begin with CDR2.1 and end with a successful Site Acceptance Test (SAT2.1) conducted in Lund.

4.5.3.3 *Milestone descriptions*

Milestone ID	**Short description**	**Planned/Baseline date**	**Responsible and actions**	**Percentage of task completion [%]**

MS1-0*	Kick-off meeting	*Start*		0
MS2.1-1	Critical Design Review	*Start* + 2 months	Partner and ESS review finalized design. Design approved by ESS	10
MS2.1-2	D2.1.1 & D2.1.2 arrive in Lund	*Start* + 11 months	Partner delivers items to ESS HQ.	90
MS2.1-3	Site acceptance test successful	*Start* + 12 months	ESS conducts on-site acceptance tests.	100

4.5.3.4 Meeting/Review locations

Meeting/Review	**Location**
Kick-off meeting	LLB
Regular status meetings	Video conference

4.6 Detailed description Subtask 2.2: High-pressure Paris-Edinburgh Gas Loading (PEGL) System

4.6.1 Overview of Subtask:

Gas loading is seen as a critical component of PE press operation. It necessary to ensure hydrostatic conditions above ~ 7-8 GPa for all solid samples. It also must be employed when the sample itself is gaseous under ambient conditions (and cryogenic loadings are not possible).

The goal of this Subtask is to deliver a functional and safe gas-loading system that is compatible with PE-presses comprising D2.1.1. Due to the importance of hydrogen and deuterium for neutron science, the system is to be compatible with both: this implies both hydrogen compatibility (with respect to construction materials) and a sufficient PS to provide adequate pre-compression of the gas.

The system supplied must be compliant with European Law (in particular provisions relating to systems falling under the purview of Article 4a(i) first indent in the PED [PED]) and ESS requirements on CE-marking (see §5.7)] If compliance with PED is not possible, then this shall be documented as described in §5.7.3.

Planned budget of subtask: 144,430 €$_{2013}$ **(EUR)**

Min. Duration: 29 months

4.6.2 Deliverable Item definitions:

4.6.2.1 Deliverable D2.2.1: Detailed design of HP PEGL system

The design of the PE gas loader (PEGL) will closely follow existing prototypes such as those operating at the ISIS and ILL Facilities. As such, minimal design work is expected including a reduction of inner diameter for compatibility with smaller standard anvils of 54 mm diameter and re-visiting of the design in light of experience with the existing prototypes. A final detailed design comprises the first deliverable of this task.

Specific elements of the deliverable include:

- A confirmation by ESS of the detailed specification of the system after consultation with the Partner.
- Detailed specification of device giving full operating parameters, including volumes of components based on preceding bullet point.
- A full risk analysis of the system that highlights elements of design to ensure safe operation.
- A detailed P&ID for the entire system
- Full technical drawings and 3D models of system and sub-systems (including anvil assembly)
- Report detailing calculations reflecting key safety elements in design and, where necessary, FEA.
- Conduct a specific risk assessment relating to ATEX risks and reflect this in the design. In particular ensuring all potential ignition sources including all electrical equipment or sources of static build up (e.g. wheels) have been considered and mitigated to category 3 explosion group IIC and temperature class T1 (Zone 2 hydrogen).
- ESS will perform a subsequent risk analysis prior to operation of device on ESS premises and the Partner agrees to participate and provide remote support in this process if necessary.

4.6.2.2 Deliverable D2.2.2: The PEGL system

This deliverable includes fabrication and testing of the physical PEGL system and sub-systems and its delivery to Lund.

The system is envisaged to closely follow the existing system existing at the ILL (Figure 1). The main specification of the system is given here. Any changes to the specification given here that arise as a result of design work relating to D2.2.1 shall be agreed upon in writing by both Partner and ESS as a formal Change Request.

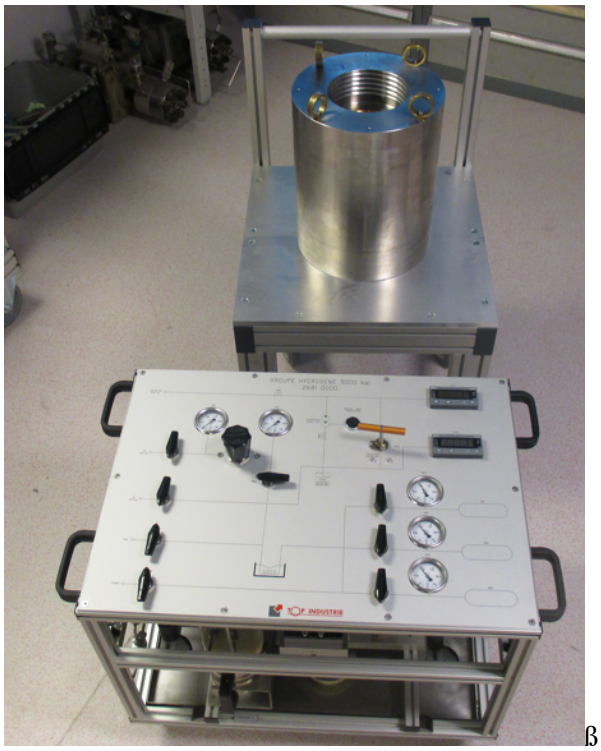 ß

Figure 1 ILL PEGL System at top of image, the cylindrical vesses is the gas-loading chamber at the bottom of the image is the compressor and gas handling system.

- The system shall have a PS of 0.3 GPa.
- The full system shall be compatible with hydrogen gas at full PS.
- The inner diameter of the chamber shall be defined to accommodate anvil insers for 54mm standard anvils (see also §4.6.2.3). the length of the chamber must be at least 100mm.
- The main pressure chamber must have a volume of less than 0.1 L when used in operation with anvil assembly (D2.2.3) and appropriate space-filling components.
- Space-filling components shall be provided to allow compliance with the preceding point.
- The system shall be easily portable and built into a self-contained frame(s).
- The system shall feature a pre-compression system of input gas supply, or use of a double-stage compressor allowing operation with partially full gas cylinders.
- The system shall feature a post-loading recovery system allowing the capturing of waste gas. The total volume of stored gas will not exceed 200 bar pressure and 1 L volume.
- The system shall be permanently marked with its PS and the statement “hydrogen compatible”.
- Provided equipment shall be compliant with ESS CE-marking requirements (see §5.7)

4.6.2.3 Deliverable D2.2.3 Anvil inserts for PEGL system

The anvil insert is the device that seals the pressurized gas generated within the PEGL into the sample chamber of PE anvils. As such, the insert is a clamping device that must provide adequate load to form a seal between the anvils and the used gasket (~7 met. tonnes). In addition to the PEGL, the Partner will deliver a set of 3 anvil inserts to be compatible with “Los Alamos” profile single-toroid, Ø54 mm PE anvils (Figure 2).

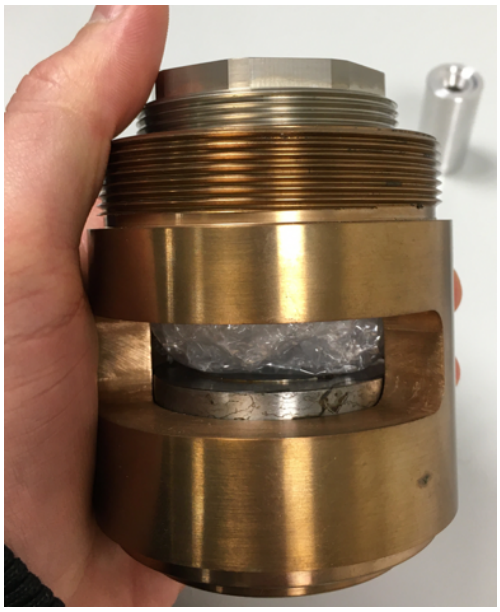

Figure 2 Example BeCu anvil insert used at the ILL

- Anvil inserts compatible with “Los Alamos” profile single-toroid PE anvils with the smaller size of binding ring (Ø54 mm) for the VX6 press (D2.1.1) and with the PEGL shall be provided (although anvils are excluded). These inserts shall be able to maintain the loading gas pressure of 0.3 GPa.
- Anvil inserts are to be compatible with H_2 loadings.

4.6.2.4 Deliverable D2.2.4: Data and documentation deliverables related to D2.2.2 and D2.2.3

Supplementing the hardware described above, this deliverable also contains data and documentation elements that support safe operation of the device. The data and documentation deliverables apply to both the PEGL itself (D2.2.2) and to the anvil inserts (D2.2.3). Individual items are listed here:

- The Partner shall create a full operating manual enabling safe operation of the system, the manual shall include any required training schedules for operators. ESS staff shall be responsible for ensuring compliance with local Swedish Law relating to HP devices.
- The Partner shall collate and provide any test and calibration reports for all safety-critical components of the system including (where relevant) pressure transducers calibrations and pressure-vessel manufacturing materials reports.
- The Partner shall provide a test report and all associated data relating to proof testing of the system and sub-systems.
- The Partner shall provide a detailed maintenance schedule supporting safe operation of the device.
- The Partner shall provide a full P&ID for the System
- The Partner shall provide a full set of drawings and 3D models for the System.
- The Partner shall provide certificates for any materials processing employed in manufacturing such as welding or heat treatments.
- Documentation relating to ESS CE-marking requirements (§5.7.3) shall be provided
- Documentation relating to Risk assessment of ATEX considerations and mitigations included in design.

4.6.3 Subtask definitions (including phase definitions, reviews, milestone definitions and schedule).

The distinct Subtask phases and associated activities occurring in these are described in this section. In addition, the projected schedule for the whole task is given. Normally, the transition from one phase to another phase requires a review which will often be associated with a specific project Milestone. Additionally, realisation of a deliverable may also be associated with a Milestone. As per §5.3.5 achievement of a milestone is associated with a weight from 1-100% indicating progress towards task completion. Detailed description of requirements and processes both meetings and reviews are described in §5.2.

4.6.3.1 *Subtask Phase Definition: Phase 2.2-1 (Detailed Design Phase)*

Phase 2.2-1 of the contribution is a design study, which will revisit the existing design for the HPGL and apply any appropriate modification necessary to optimise the device for operations at the ESS. This phase will consider experience of prototype devices in operation at other facilities and envisages a principal modification to be the reduction of the inner diameter (relative to existing devices) to match the 54 mm standard anvil size.. The output of this phase is a set of full designs suitable for manufacturing.

1. The Partner and ESS Staff shall together complete a detailed analysis of all aspects of design relating to safety in compliance with the PED Annex I §2.
2. The Partner shall complete a detailed technical design of all devices comprising D2.2.2 and D2.2.3 to a level of detail adequate for subsequent procurement or manufacture.
3. The Partner shall complete and submit all documentation associated with (1) and (2) above and comprising D2.2.1
4. The partner shall prepare any materials necessary for procurement tenders should these be deemed necessary.

Phase 2.2-1 starts upon the sign off of the parties of this SoW and the Kick-off meeting. Phase 2.1-1 ends with the successful completion of the Critical Design Review for Task 2.2 (CDR-2.2)

4.6.3.2 *Subtask Phase Definition: Phase 2.2-2 (Procurement and Manufacturing)*

Phase 2.2-2 is where the designs derived in Phase 2.2-1 are realised as physical components through either in-house manufacturing by the Partner or through commercial procurements. These activities include but are not necessarily limited to:

1. The Partner shall conduct appropriate surveying of potential suppliers, including discussions to determine optimal technical solutions to deliver specification.
2. The Partner shall conduct any necessary intermediate verifications during the fabrication, e.g. inspection of material certificates, part dimensions, etc.
3. The Partner shall communicate with suppliers to ensure timely delivery of components.
4. The Partner shall conduct any necessary testing to ensure components are delivered within specification and are suitable for the intended purpose and to guarantee safety.
5. The Partner shall assemble delivered or manufactured components to complete full systems comprising D2.1.2 and D2.1.3.
6. The Partner shall test full systems to ensure functionality and to optimise operational parameters.
7. The Partner shall complete and submit to the ESS all materials comprising D2.2.4
8. The Partner shall deliver of D2.2.2 and D2.2.3 to Lund.

Phase 2.2-2 starts upon successful completion of CDR-2.2. Phase 2.2-2 ends with delivery of physical systems (comprising D2.2.2 and D2.2.3) to ESS premises in Lund and successful completion of Site Acceptance Test (SAT-2.2) using standard test conditions applicable to the vessel.

4.6.3.3 *Subtask Phase Definition: Phase 2.2-3 (Installation, Integration and Commissioning)*

Phase 2.2-3 is the final stage of the project and comprises the installation of delivered systems in Lund, integration of these systems into local utilities, demonstration of functionality within specification and compliance with ESS safety/quality rules. These activities include:

1. ESS Staff shall provide local assembly of any dismantled systems shipped to Lund.
2. ESS Staff shall conduct initial testing of systems delivered to confirm compliance with agreed specification (Site Acceptance Test SAT2.2).
3. ESS Staff shall complete pressure testing to meet ESS requirements on HP systems [PSOMM].

Phase 2.2-3 begins with a successful SAT at ESS site in Lund. After devices are fully integrated and commissioned a Site Acceptance Review (SAR2.2) will be conducted. Phase 2.2-3 will end with successful completion of SAR2.2 and the task will be considered complete after submission of the Final Report §5.1.2].

4.6.3.4 *Milestone descriptions*

Milestone ID	**Short description**	**Planned/Baseline date**	**Responsible and actions**	**Percentage of task completion [%]**
MS-1-0	Kick-Off meeting	*Start*	ESS: provide framework and requirements to Partners.	0
MS-2.2-1	Interim milestone A	*Start* + 5 months	ESS: provide feedback to Partner on Design to date.	15
MS-2.2-2	Critical Design Review	*Start* + 8 months	ESS: review and validate Designs comprising D2.2.2 and D2.2.3.	30
MS-2.2-3	Interim milestone B	*Start* + 12 months	Partner: initial procurements arrive at Partner site.	45
MS-2.2-4	Site Acceptance Tests passed	*Start* + 16 months	ESS: completion of agreed tests to confirm specification of D2.2.2 and D2.2.3 has been met Partners: successfully address any	80

			encountered problems	

4.6.3.5 *Meeting/Review locations*

Meeting/Review	**Location**
Kick-off meeting	LLB
Regular status meetings	Video conference
Critical Design Review	Video conference
Site Acceptance Review	ESS

4.7 Detailed description Subtask 2.3: Cryostat for PE presses

Combining high-pressures with low temperatures is essential for high-impact early science at the ESS. In particular, magnetic studies on CSPEC, BIFROST, DREAM, LOKI, SKADI and MAGIC will all demand low temperature capability for pressure cells. The range of PE presses that are compatible with the envisaged cryostat system will be determined in an initial conceptual design phase.

At the present point in time, closed-cycle refrigerators (CCR) or combined CCR-liquid designs are in use at various other facilities. This task includes a preliminary design phase which will take as a starting point the existing CCR design at the ILL, and iterate this with the preliminary specification given [PDD ESS-1545382] below to create an initial design concept. Subsequently, a detailed design phase will conduct the full design work necessary to develop a technical realisation of a final design. Successive phases of manufacturing and assembly, followed by commissioning phase at the ESS, will deliver a system ready for operation.

4.7.1 Overview of Subtask:

Planned budget of subtask: 218,900 €$_{2013}$ (EUR)

Min. Duration: 36 months

4.7.2 Deliverable Item definitions:

4.7.2.1 Deliverable D2.3.1: A detailed design for a cryostat for PE presses

A detailed design will be developed for a device to enable cryogenic operation of a sub-set of PE press designs. This device will closely resemble existing devices at the ILL which employ pre-cooling with liquid N2, followed by subsequent cooling using a CCR (Fig 3).

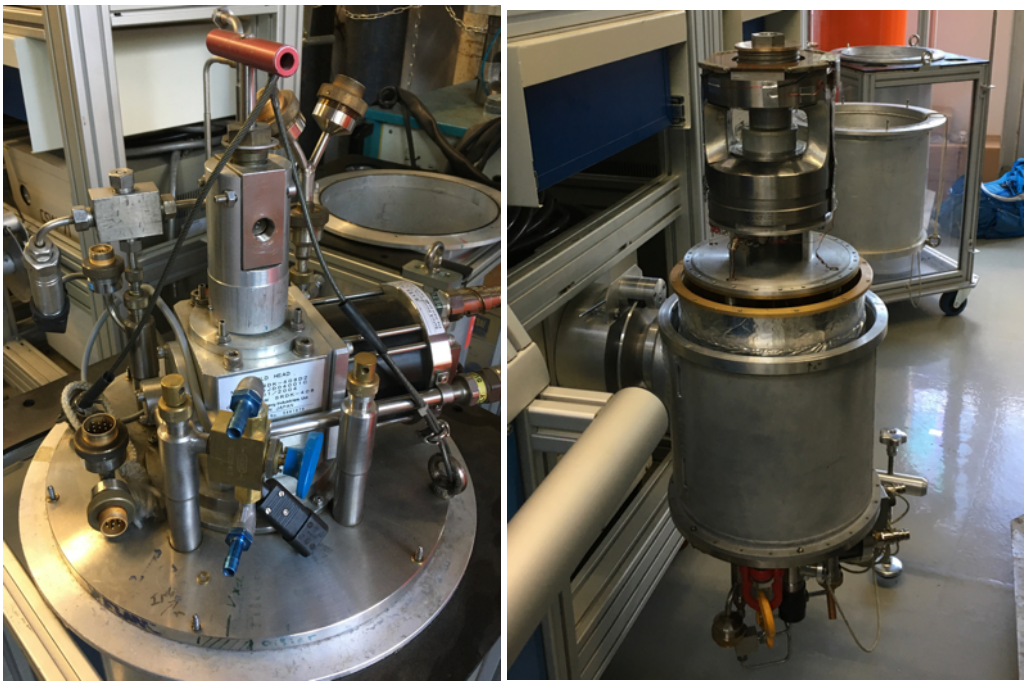

Figure 3 ILL CCR system for PE presses

The specification above will be chosen to optimize interoperability between early instruments at the ESS as defined in §4.1 and Table 1, and to maximise scientific output.

Design elements to be included are:

- PE press compatibility (e.g. with the VX1 and VX6 standards).
- Geometry: shall have the press axis positioned vertically, with the CCR head attached to the piston end of the PE load frame (as in the ILL system).
- Minimum acceptable operating temperature (expected to match the ILL system)
- Minimum acceptable cooling rate (expected to be consistent with ILL system, but possibly faster if more powerful CCR can be accommodated.
- Maximum physical dimensions and mass of cryostat combined with PE press (to be compatible with ESS mechanical interface requirements [MII] and to include a definition of specific mounting levels therein for both “floor” and “flange” mount instrument types.
- Necessary utility connections and their specification (e.g. vacuum, power for heaters, thermocouple connections and gas/hydraulic feedthroughs) [USR].
- A solution for transporting the cryostat from laboratory to instrument. It is not intended to have active control of the cryostat during transportation i.e. it is permissible to power down all electronic systems and for the cryostat to naturally warm during the period of transport.
- A solution to allow inversion of the cell for loading and subsequent transfer into cryostat vacuum tanks
- A vacuum vessel with an interface suitable for both floor and flange mount possibilities at the ESS (according to ESS-0038078) and with suitable windows for the neutron beam.
- A mount that enables PE press to be installed in the cryostat system.
- An electronic temperature controller (e.g. Lakeshore) with full compatibility to ESS control software that is compliant with ESS requirements [SCS].

- The entire system shall be non-magnetic
- Provided equipment shall be compliant with ESS CE-marking requirements (see §5.7)

This deliverable includes the following specific items:

- The partner shall prepare full detailed drawings and 3D models produced to a level suitable for manufacture and assembly.
- The partner shall prepare full P&ID for the system.
- The partner and ESS Staff shall together create a written risk assessment. The Partner shall detail specific design elements provided to mitigate any envisaged risks.
- The Partner shall provide a full concept of operations including envisaged maintenance requirements.
- The Partner will provide a report detailing calculations reflecting key operational and safety elements in design including, where necessary, FEA.

4.7.2.2 Deliverable D2.3.2: A cryostat for PE presses

This deliverable includes the physical realization of the detailed design defined in D2.3.1. Included in this deliverable are all the design features and specifications defined in D2.3.1. It is seen to be beneficial for all parties if ESS staff participate in the assembly of the device t the partners facility.

The final physical product is to be shipped to ESS site in Lund.

4.7.2.3 Deliverable D2.3.4: Operational documentation and data package

In addition to the physical hardware provided by D2.3.2, a documentation and data package shall be provided that includes the following:

- A risk assessment covering operation and maintenance of all delivered devices under the conditions specified.
- Material reports detailing the mechanical properties of metals used, particularly where these relate to safety calculations. To be included are certificates of any material processing such as welding or heat treatment.
- A manual for operation that ensures that a competent and experienced sample-environment technician is able to safely operate the device. The manual shall include a maintenance schedule.
- Data detailing any Factory Acceptance Tests, for example, cooling curves as a function of time that demonstrate achievement of specification.

4.7.3 Subtask definitions (including phase definitions, reviews, milestone definitions and schedule).

The distinct Subtask phases and associated activities occurring in these are described in this section. In addition, the projected schedule for the whole task is given. Normally, the transition from one phase to another phase requires a review which will often be associated with a specific project Milestone. Additionally, realisation of a deliverable may also be associated with a milestone. As per §5.3.5 achievement of a milestone is associated with a weight from 1-100% indicating progress towards task completion. Detailed description of requirements and processes both meetings and reviews are described in §5.2.

4.7.3.1 *Subtask phase definition: Phase 2.3-1 (Detailed Design Phase)*

. Technical solutions will be developed that meet or exceed the defined specifications. A full 3D engineering model and bill of materials will be developed to an adequate standard to support a call for tender in subsequent phases.

This phase will begin with a successful CoDR and will end with a Critical Design Review (CDR)

4.7.3.2 *Subtask phase definition: Phase 2.3-2 (Procurement and Manufacturing)*

In this phase, a call for tender will be prepared and bids from suppliers assessed. After a successful procurement process, some further assembly is expected at the Partner facility in order to create a finished product. It is agreed that it benefits both parties that this assembly be conducted by ESS and Partner staff together to allows for valuable knowledge transfer and to reduce the human resource requirements on the partner. After assembly, Factory Acceptance Tests will be conducted to ensure that the device performs adequately in relation to the define specifications (D2.3.1). For the purposes of this testing, it is *not* necessary to use an ESS owned PE device, but the device should be tested with a comparable PE press to confirm performance. After these, the system will be transported to ESS in Lund, where a Site Acceptance Test (SAT2.3) will be conducted.

This phase begins with a successful CDR and ends with a successful SAT.

Phase 2.3-2 is where the designs derived in Phase 2.3-1 are realised as physical components through either in house manufacturing by the Partner or through commercial procurements. These activities include but are not necessarily limited to:

1. Partner shall conduct appropriate surveying of potential suppliers, including discussions to determine optimal technical solutions to deliver specification.
2. Partner shall participate in any necessary intermediate verifications during the fabrication, e.g. inspection of material certificates, part dimensions, etc.,
3. Partner shall communicate with suppliers to ensure timely delivery of components.
4. Partner together with ESS staff shall assemble delivered or manufactured components to complete full systems comprising D2.3.3.
5. Partner shall conduct any necessary Factory Acceptance Testing to ensure components are within specification and are suitable for the intended purpose and to guarantee safety.
6. Partner and ESS staff shall test complete systems to ensure functionality and to optimise operational parameters.
7. Partners shall ensure completion and submission of all materials comprising D2.3.4.
8. Partners shall deliver D2.3.3 to Lund.
9. ESS Staff will conduct local assembly of any dismantled systems shipped to Lund.
10. ESS Staff will perform initial testing of systems delivered to confirm compliance with agreed specification via a Site Acceptance Test (SAT2.3).

This phase begins with a successful CDR2.3 and ends with a successful SAT2.3.

4.7.3.3 *Subtask phase definition: Phase 2.3-3 (Installation, Integration and Commissioning)*

During this Subtask phase ESS staff will integrate the system into local ESS systems including utility supplies, mechanical mounting standards and EPICS software controls in compliance with [MII], [USR], and [SCS].

Where the integration process identifies issues related to design or implementation of D2.3.3, the Partner will assist ESS staff in identifying and realising technical solutions.

This phase begins with a successful SAT and ends with Site Acceptance Review (SAR2.3), which will confirm the system is ready for operation at ESS.

4.7.3.4 *Milestone descriptions*

Milestone ID	**Short description**	**Planned/Baseline date**	**Responsible and actions**	**EV [%]**
MS-1-0	Kick-Off meeting	*Start*	ESS: provide framework and requirements to Partners.	0
MS2.3-1	Interim A	*Start* + 5 months	Partner: completes detailed design of vacuum tank	15
MS2.3-2	Critical Design Review	*Start*+9 months	ESS: review and validate detailed designs comprising D2.3.2	50
MS2.3-3	Interim B	*Start* +14 months	Partner: initial procurements arrive at Partner site	60
MS2.3-4	Site Acceptance Test passed	*Start* +19 months	ESS: completion of agreed tests of D2.3.3 to confirm specification of D2.3.1 and D2.3.2 has been met Partners: successfully address any encountered problems	80
MS2.3-5	Interim C	*Start* +24 months	ESS demonstrates first cooling run of cryostat	90
MS2.3-6	Site Acceptance Review passed	*Start*+28 months		100

4.7.3.5 *Meeting/Review locations*

Meeting/Review	**Location**
Kick-off meeting	LLB
Regular status meetings	Video conference

Conceptual Design Review	Video conference
Critical Design Review	Video conference
Site Acceptance Review	ESS

5. TASKS APPLICABLE TO ALL PROJECT PHASES

5.1 Project reporting

5.1.1 Regular Status Reports

During the execution of the SoW, the Partners shall submit to the European Spallation Source ERIC status reports containing (as according Annex 5 to the In-Kind Contribution Agreement: Status Report) at least every three months:

1. The status of the SoW since the preceding report;
2. The progress expected to be made in the next following period and any other pertinent issues related to the Project Results;
3. Updated Milestone Tracking Table;
4. Desired changes to existing baseline;
5. Risk Management;
6. Updated electronic versions of the Partners plans.

The regular status reports follow the same 3 monthly schedule of the Regular Status Meetings and shall be submitted 1 week in advance of the associated Status Meeting, to the content can be discussed during the meeting.

During the execution of the SoW, the Partners shall submit to the European Spallation Source ERIC status reports containing (as according Annex 5 to the In-Kind Contribution Agreement: Status Report) at least every three months:

5.1.2 Final Reports

The Partner shall issue a final written report to the European Spallation Source ERIC for each Task and Subtask undertake (that is four separate reports for Tasks 1,2.1,2.2 and 2.3). Each report shall include a comprehensive summary of the contributions made, works and services undertaken and Project Results achieved for that particular Task. Final Reports shall be submitted 1 month after the Site Acceptance Review that completes the Task.

5.2 Meeting and Review Definitions, Requirements, Roles and Responsibilities

Several distinct meetings and/or reviews are required as intrinsic parts of this agreement and their completion is an important part of the defined tasks. Similarly, the regular status meetings (§5.2.2) are expected to provide updates on all ongoing tasks.

5.2.1 Kick-Off Meeting

The main objective of the kick-off meeting is to confirm the mutual understanding of the Scope of Work specified herein, including the applicable specifications.

In particular the partners shall:

- Present and review the project plan, schedule and details of expected deliverables (comprising the baseline project),
- Introduce the key resources and team members,
- Complete the milestone definition list with weightings (if not present in the TA),
- Make a technical presentation of proposed solutions,
- Present management plans as applicable.

The participants shall take the minutes of the meeting and record the action items.

5.2.2 Regular Status Meetings

A Regular Status Meeting (RSM) shall be held every 3 months during the whole duration of the project. Status meetings may be held at the ESS or partner's premises or over the telephone/video conferencing facilities available.

The purpose with the meeting is to review progress, risks, review/decide on change requests and discuss upcoming activities and potential challenges.

The Partner is responsible for carrying out the SoW in a timely manner, fully in accordance with the time schedule referred to above for each specific Task.

The Partner shall provide a written Regular Status Report (RSR) every 3 months. The RSR shall be submitted at least 1 week in advance of the date of the RSM in a given month so that the content of the RSR may be discussed in the RSM.

The Parties shall take the minutes of the meeting and record the action items.

The purpose of the meeting is to review progress, risks, discuss/decide on change requests provided that it does not lead to exceeding the validated Partners IKC, and without prejudice of the provisions of the articles 6 (Organization) and 8 (Variations) of the IKCA, and discuss upcoming activities and potential challenges.

5.2.3 Conceptual Design Reviews

A conceptual Design Review (CoDR) concludes a Preliminary Design Phase. The CoDR assesses that the preliminary design is consistent with initial goals of the related task.

Deliverables related to the CoDR, such as a related data package from that Task shall be established at a minimum 2 weeks before the review.

The review shall be conducted in a meeting between Partner and ESS, whereby the documentation deliverables provided are discussed and a consensus reached. This consensus shall be recorded in the meeting minutes.

No detailed schedule of a review meeting is requested but for planning purposes it can be expected that a review may last 0.5 working day.

5.2.4 Call for Tender Review (CTR)

The CTR applies to components which detailed design, and not only the manufacturing, will be outsourced. For the procurement verification ESS requires the tender/contract document(s).

The tendering is the responsibility of the Partners. ESS holds the responsibility to verify various project aspects:

- The involved ESS Reviewer Group reviews the technical content of the tender and provides feedback to the Partners.
- The technical specification should comply with the requirements established by the relevant ESS Reviewer Team.
- ESS will evaluate if the planning is compatible with NSS schedule, as well as global resource plan of the instrument suite

The parts of the contract/tender relevant for the requirements above shall be translated to English.

If the ESS completeness requirements are not compatible with the Partners institutes rules, then the specific issue has to be discussed and addressed by a common agreement. If the components schedule or resource plan is conflicting with NSS project planning, then the issue has to be discussed between ESS and the Partners and the consequences have to be evaluated according to the main IKCA agreement.

ESS aims to respond (approval or request for further details) within 7 working days after receiving all the document(s).

ESS shall be notified if there are changes in the tendering conditions after the call for tender before signing the contract.

5.2.5 Critical Design Reviews

The Critical Design Review (CDR) concludes a Detailed Design Phase. The CDR assesses if the design meets all facility element requirements with acceptable risk and within the cost and schedule constraints.

The CDR demonstrates that the maturity of the design is appropriate to support proceeding with full-scale fabrication, assembly, integration, test, and future operation and decommissioning.

The contents of the associated CDR data package shall be established as a minimum 4 weeks before the review. Where a deliverable is necessary for the CDR, this is noted in its detailed description.

The review board shall review the documentation provided and submit written comments to the ESS and Partner no less than 2 working weeks before the review meeting. The Partner shall consolidate the comments and provide written answers to the board no less than 1 working week before the review meeting.

The agenda of the review meeting shall be communicated to the Parties no less than 1 week before the review meeting. The review meeting may include in depth presentations by the Partner of the work undertaken and responses to the review findings.

No detailed schedule of a review meeting is requested but for planning purposes it can be expected that a review may last 0.5 working day.

5.2.6 System Acceptance Review

A System Acceptance Review (SAR) examines any physical products and associated documentation and data packages. The SAR ensures that all system requirements have been satisfied.

The review shall be organized by European Spallation Source ERIC and will involve program members of the partner, as well as any other stakeholders at the discretion of the review chairman. The chair of the review board is appointed by European Spallation Source ERIC. The membership of the board is communicated to the review participants at the earliest possible time.

The contents of the SAR data and documentation package, including, for example, explicit data and document deliverables (as noted in deliverable descriptions and project phase descriptions) and reports or data related to any relevant Site Acceptance Tests relevant to the review shall be established and distributed at a minimum 4 weeks before the review itself.

The review board shall review the documentation provided and submit written comments no less than 2 working weeks before the review meeting. The Partner shall consolidate the comments and provide written answers to the board no less than 1 working week before the review meeting.

The agenda of the review meeting shall be communicated to the review participants no less than 1 week before the review meeting. The review meeting may include in depth presentations by the partner of the work undertaken and responses to the review findings.

No detailed schedule of a review meeting is requested but for planning purposes it can be expected that a review may last 1 working day.

The successful completion of a System Acceptance Review is a prerequisite for crediting values to the Partner.

5.3 **Project management and control**

ESS is mandated to use Earned Value Management as a tool for managing progress and performance. This translates into a requirement for tracking deliverables from partners. This includes, requirements concerning scheduling below and progress reporting (§5.1). Templates and instructions for managing the milestone schedule, including the associated earn value basis are found within the Applicable documents.

5.3.1 Use of a Planning Tool

The partner should use a planning tool (MS Project, Oracle Primavera, Deltek Open Plan or similar). The purpose with this requirement is to enforce a systematic approach to planning, both creating and maintaining the plan.

As part of the 3-monthly status report, the current schedule should be made available for ESS (electronic format).

5.3.2 Delivery Milestones

Each distinct delivery should have a milestone with a date. This also includes part or incremental deliveries.

5.3.3 Milestone Definition List

Each Milestone should have a number, name and a definition (captured in a Milestone Definition List). The definition should both explain the content and fulfilment of the milestone and delivery.

5.3.4 Interim Milestones

If the duration of the project work producing the deliverable is more than 6 months, the plan should also contain interim milestones. The purpose with interim milestones is to measure progress and to be used for signalling issues in the fulfilment of the delivery (in the interest of both parties).

5.3.5 EV – Weighted MS value

Each milestone, both interim and delivery milestones, should be associated with a weight (percentage between 0-100). The aggregated fulfilment of all milestones should result in 100%.

5.3.6 Monthly Forecasting

In conjunction with the status reporting, the partner should also provide an updated forecast for the upcoming milestones, as well as the final delivery milestone.

5.4 **Risk Management**

ESS uses Risk Management as one of the Project Management tools to assist the execution of the Programme. The Partner's contribution in this field is vital and shall therefore form a part of ESS Risk Management Process.

The contribution shall be characterized by risk awareness and open communication regarding risks. The common view of risks and uncertainties are utilized as a stepping-stone to the identification and exploitation of opportunities.

5.4.1 ESS Risk Management Process

Risk Management shall be incorporated as a part of the day-to-day work with the contribution. The partner shall work according to ESS Risk Management Process, including:

- Plan Risk Management,
- Identify risk,
- Analyse risk,
- Risk treatment, and
- Monitor and control risk.

5.4.2 ESS risk criteria

When analysing risk, ESS' risk criteria shall be used. Using ESS' criteria for likelihood and consequence enables partner and ESS to analyse risks in a uniformed way.

The ESS acceptance criteria clarify what risk level that ESS accepts, and when risk treatments are required. All combinations of likelihoods and consequences correspond to a risk level, either being high, medium or low. This is graphically presented in the ESS risk matrix.

Risk treatments are the measures being taken in order to treat the risk to an acceptable level. High-level risks can never be accepted and require treatment. Medium-level risks can be accepted without treatment if

the treatment is not proportional to the gained improvements. Low-level risks can be accepted without treatments.

5.4.3 Risk register

The risk register shall contain the gathered knowledge of identified risks, including the assessed risk exposure. The register shall show identified risks in order of priority, including risk treatment plans.

The Partner should preferably use ESS Risk Management software system, used for systematic documentation of risk registers. If not, the partner risk register format shall be according to ESS' requirements.

5.4.4 Risk status report

Risk status reports shall include summary describing news and relevant changes to the risk exposure, including on-going Risk Management activities. It shall furthermore contain an updated risk register including risk treatment status.

5.5 Configuration management

The ESS programme participants shall develop the baseline of the facility elements and may redefine the architecture of the facility elements. Full and part delivery milestones should be under change control. This means that the parties need to agree on changes to the milestones in accordance with the article 8 (Variations) of the IKCA. Each baseline change shall be documented as defined in the Change Control Process [ESS-0001879].

The ESS programme participants shall follow the principles of configuration management as laid down in the ESS configuration management plan [CMP], or equivalent best practices. In particular:

1. The ESS programme participants shall identify each document, drawing, subsystem or part, establishing the item configuration and relation to the hardware and software at any time in the study.
2. The ESS programme participants shall apply the change control process [CCP], in agreement with best practices.
3. The ESS programme participants shall ensure that all personnel that use or generate information can easily access in the tools implemented to ensure configuration control. European Spallation Source ERIC shall provide a central repository for all information and that this repository is properly backed up.

5.6 Organization

The persons nominated as the Work-Unit Coordinator according to Article 6 of the In-Kind Contribution Agreement [IKCA] are:

For the Partners (local coordinator): [ANNIGHOFER Burkhard]

For European Spallation Source ERIC: [GUTHRIE Malcolm]

The following personnel of the Partner will take part in the provision of the works and services: Francois MAIGNEN (LLB engineer), Stefan KLOTZ (Professor at Sorbonne University), ADD NAMES

5.7 Product & Quality assurance, safety and CE-marking

5.7.1 Applicable law, legislation and standards

All national safety laws and legislation applicable to the design, development, manufacturing, installation, testing and operation of the supply shall be followed and fulfilled.

All operator national safety laws and legislation applicable to the design, development, manufacturing, installation, testing and operation of the supply shall be followed and fulfilled as defined in the requirement document for the facility element by European Spallation Source ERIC. We note that, due to the specialised nature of the requirements, some equipment covered by this TA cannot comply with EU directives. Where this exception occurs this shall be documented as per §5.7.3

The Parties shall implement and maintain throughout the Project a quality assurance and safety approach that covers all relevant aspects of ISO9001 with respect to the scope of the IKC delivery and all specified reliability, quality assurance and safety requirements.

5.7.2 Quality Plan

The partner shall prepare a consistent and comprehensive Quality plan (based on the [PQP] template] for its contribution and submit it to approval by the ESS WU Coordinator on [date TBD] the latest. The Quality plan shall generally comply with the recommendations of the ISO 10005:2005 Standard.

The documentation required might be principally generated from the Partner's Quality Management System when applying a system manual with defined procedures. However, a Quality plan does not replace such a quality management system, but may complement to the issues of the cooperation.

5.7.3 CE-marking

The ESS normally requires that all equipment and systems provided by Partners be CE-marked. Where CE marking is not relevant, the Partner must provide an analysis and appropriate documentation to verify this. Further, if CE marking is not provided by the Partner this must be agreed with the ESS in writing for the equipment to which the exception applies, the Partner also agrees to assist the ESS by providing all necessary and reasonable documentation to meet ESS safety requirements. This could include, for example, heat treatment certificates or material conformity documentation.

For equipment that cannot comply with the requirements of the applicable directive (e.g. due to technical matters), these requirements shall be defined and the technical solutions used to ensure that a sufficient level of safety is achieved be documented.

6. DOCUMENTATION FORMAT

All documentation and correspondence shall be in English.

All office documents shall be in a MS Word and PDF format.

The electrical drawings shall be in a commonly use format, such as STP, which can be readily included in ESS standard Catia models.

Drawings shall be also provided in PDF.

7. TRANSPORTATION AND DELIVERY

All tangible deliverables shall be delivered DAP 2010 Incoterms, delivered at the final destination of European Spallation Source ERIC, Odarslövsvägen 113, 225 92 Lund, Sweden.

8. WARRANTY

8.1 Systems, sub systems, devices and components procured from commercial suppliers

For items procured by the Partners from commercial suppliers (the "**Procured Components**"), the Partners shall acquire (and maintain) industry standard warranties, which are commercially available and applicable to such components.

For clarity, the Partners shall be responsible for ensuring that the warranty period for all Procured Components is the same as the warranty period the Partners would negotiate and secure in case of components procured for its own use.

The Partner shall provide a copy of all warranty terms applicable to Procured Components to the ESS ERIC WU Coordinator for information, as soon as reasonably possible after such details become known to the Partner.

The Partners shall be responsible for handling and managing any warranty claims (directly with its suppliers or manufacturers) related to Procured Components, which may arise during the warranty period.

8.2 Systems, sub systems, devices and components procured from commercial suppliers

Where a system, subsystem or device is manufactured by the Partner (the "manufactured components"), the partner agrees to provide any modifications or adjustments necessary to deliver original specification during integration phases up to final Site Acceptance Review (SAR). In addition, the Partner agrees to support any failure of manufactured components due to faulty construction or design errors for a period of two years from the date of the relevant SAR.

9. EXCLUDED BACKGROUND

The Partner excludes the following Background in accordance with paragraphs 13.3.1.2 and 13.3.2.2 of the Agreement:

IN WITNESS WHEREOF, the Agreement has been executed in two (2) originals, of which the Parties have received one (1) each.

European Spallation Source ERIC

_____	_____
Date	
_____	_____
Signature	
_____	_____
Name (in block letters)	
_____	_____
Position	

CNRS

_____
Date

_____
Signature

_____
Name (in block letters)

_____
Position

CEA

_____
Date

_____
Signature

_____
Name (in block letters)

_____
Position