Report

Summary

Report-No.: **Rp-2234-1030-0** rev.: **0**
Date/Datum: **16. Oct. 2017** Pages/Seiten: **7**

Verfasser/Autor: TWA ______________

Freigabe/Release: WDI ______________

Summary of conceptual design for the ESTIA 'In-Bunker Beam Extraction System' to be build at ESS

Project/Projekt: **P1030**

Distribution/Verteiler

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internal: WDI, JMA, TWA

Revisions/Historie

rev.	Sec./Abschnitt	Changes/Änderungen	Date Datum	Sign Kürzel
0	All	First issue	16.10.17	twa

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Content

1 General

This document is a summary of the up to now performed design work as part of the development for the full design of the work package 'in-bunker beam extraction system' for the ESTIA project to be realized at the ESS in Lund, Sweden. This report shall document the current status of the design which reflects the conceptual design. Based on this and on the review held on Oct. 9th 2017 at PSI the design will be continued to reach the final design state which will be the base for manufacturing drawings to realize and build the system later on.

The CDR review meeting took place at PSI on Oct. 9th from 12:30-14:30 with the following participants:

- A. Glavic (PSI)
- S. Schütz (PSI)
- P. Keller (PSI)
- E. Maslowski (PSI)
- M. Ferreira (ESS)
- L. Page (ESS)
- W. Diete (AAT)
- T. Waterstradt (Axilon)

Later that afternoon an auxiliary meeting was held together with C. Schütz and C. Lozza (both SwissNeutronics AG) to detail the interface design of the neutron guide elements themselves.

2 Design description

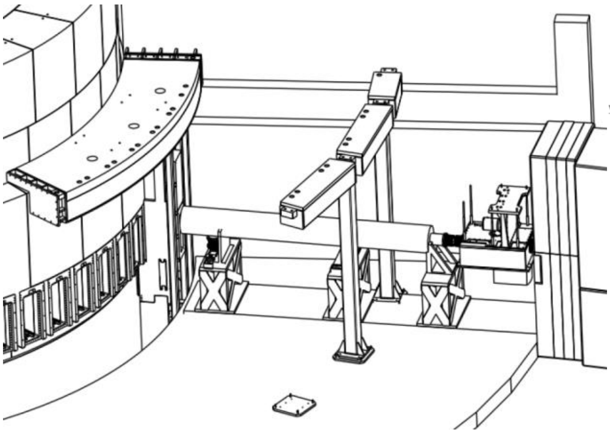
The in-bunker beam extraction system consists of two beam-paths of planar-elliptical Selene guides. The aim of the Beam Extraction System is to refocus the neutron beam at 11m distance to the moderator where the final size of the beam is defined with a slit-aperture.

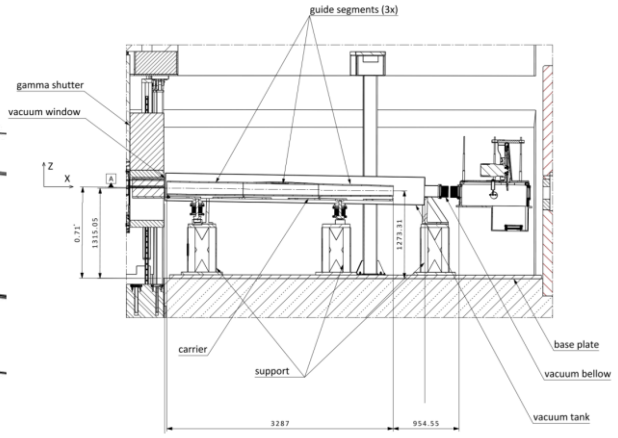
The here discussed work package (WP) contains the in-bunker beam extraction system (IBES), beginning after the gamma-shutter and ending at the flange on which the length compensation of the Beam Extraction System is fixed to the chopper-pit

The IBES consists of three guide segments to which apply higher precision demands relatively to each other compared to the complete unit with respect to the beam. Thus, in the here followed design concept the three guide segments are mounted and pre-aligned on a common carrier, which then is placed on a kinematic mount decoupled from a surrounding vacuum-tank and aligned with remote handling tools from the bunker roof during maintenance cycles if necessary.

2.1 References

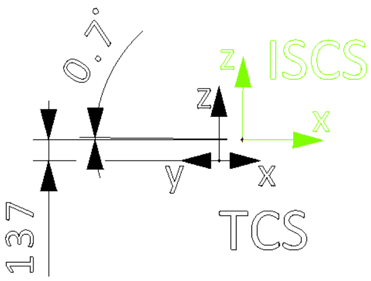
The design is oriented along the fundamental requirements, ideas and concepts as described and given with the documents provided by PSI ([1], [2], [3], [4]). I.e. a segmented neutron guide aligned and supported by an in-vacuum carrier. The carrier is mounted to in-air adjustment units decoupled from the vacuum chamber by means of bellows. The upstream end is defined by a minimum gap to the gamma shutter and comprises a vacuum window (aluminum). The downstream end is connected via a bellows to the consecutive chopper pitch (covered in a separate work package). Following pictures illustrate the starting ideas and concepts:

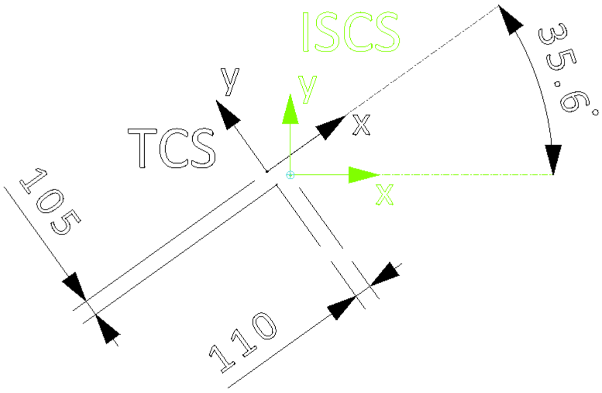




2.1.1 Coordinates

We follow the given, right handed coordinate system of the ESTIA beam (i.e. 'ISCS', green) as given within [4]. This means '*x*' follows the neutron beam axis, positive for downstream direction; '*y*' is oriented in the horizontal plane, perpendicular to the beam axis and counting positive to the left (when looking from the source to the experiment); '*z*' is vertical, pointing upwards for positive directions.

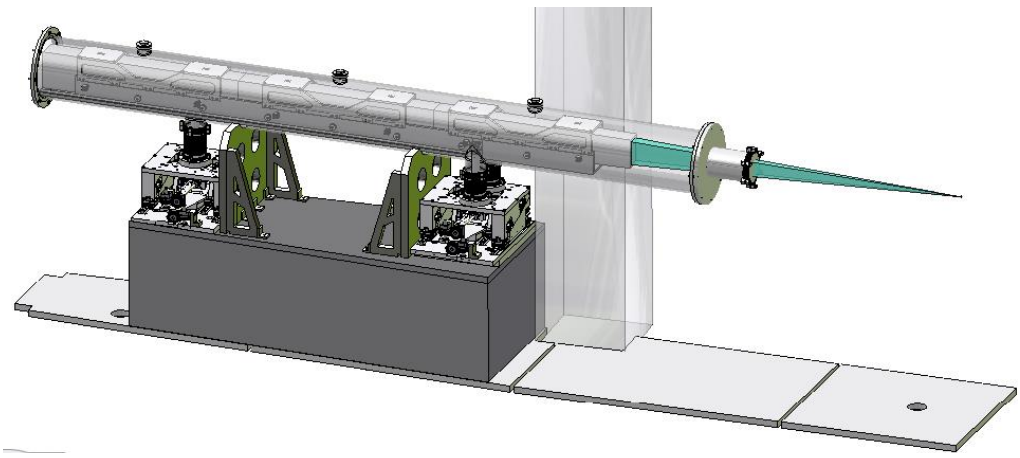




3 Design Status

3.1 Design Concept

The current design concept and all aspects have been presented and discussed during the meeting. For reference please also refer to the corresponding PowerPoint presentation file as given in [5].



The whole neutron guide will be placed inside a vacuum chamber made from Aluminium. The current design assumes a vacuum chamber of Ø300 inner clearance and approx. 10mm wall thickness. The entrance and exit flanges will follow ISO-K standards. The entrance to the vacuum chamber will comprise a window flange machined from aluminium. The aperture of the window will be sized to the entrance aperture of the neutron guide plus the specified stroke of the adjustment stages (i.e. ±5mm in *y* and ±7mm in *x*). The downstream end will be connected via a bellows to the consecutive chopper pitch. The exit flange is designed to be a DN150 ISO-K.

The neutron guide segments are assumed to three pieces each 1093mm long segments, each different in curvature and cross section. The material of the guides is assumed to be aluminium and the design allows for a wall thickness of the guides of approx. 15mm.

These three segments are placed inside a carrier, each segment rests on its Bessel points and is fixed laterally. The segments are precisely pre-adjusted inside the carrier resting outside of the vacuum chamber on its dedicated kinematic mount. This pre-alignment is accomplished outside the final installation point. After pre-alignment of the segments the chamber is placed back to the setup and the neutron guide carrier is rolled into the chamber from the entrance flange and put back to its kinematic support points. Flanges on top of the chamber allow no to verify the correct alignment of the guide and to reference the guide to the beam. These flanges will be realized to be easily opened by remote handling tools from the bunker top, similar to the adjustment stages of the in vacuum guide.

The adjustment stages allowing the neutron guide to be positioned in horizontal and vertical plane are realized by dedicated in-air stages (a special AXILON design based on wedges). Two of these units (each allowing for a horizontal stroke of ±5mm and a vertical stroke of ±7mm) are located on a common concrete support block. The spindle driven linear stages can be manipulated from the bunker top via remote handling tools.

The whole system can be lifted as one and installed to the final bunker position. The concrete support will be rigidly fixed by steel brackets to the foreseen grouting plates. Additional fixation wholes are needed to the current design of these plates.

3.2 Issues

The main open issues and questions have been addressed and marked in [5]. Most important aspects and discussions will be listed in the following:

- Space constraints: Not all aspects of the given boundary conditions were fully clear up to now. One important aspect with regards to the insertion/removal of the whole unit to/from the bunker is the fact that the system can't be lifted straight upwards. An interfering installation upstream close to the bunker roof is obstructing the straight clearance, hence the device needs to be shifted downstream by approx.. 65.5mm
- A new (possible) requirement of design considerations had been mentioned early before and during the meeting but is not yet clear if and how it might have to be observed and covered. It seems that the design needs to demonstrate capabilities of 2g accelerations in case of earthquakes. The design has not covered such aspects up to know and it needs to be clearly communicated in case it has to.

- For the initial installation one has to access the bunker in order to connect the downstream bellow and to position and to fix the concrete support to the base plates. In that task also the unhinging from the crane will be performed
- Materials is an ongoing point where specifications and final usability is not fully defined yet. There is a list of allowed materials (refer to [6], latest version supplied on Oct. 2nd 2017) which we try to observe and to follow. Additionally during the meeting the complex of problems regarding lubrication came up. This aspect has not been covered yet and my affect the design of the linear stage (slides and bearings).
- Within this subject, it was discussed and agreed to skip the up to know foreseen EPDM seal at the entrance flange and replace it with a full metal solution. Reference was given with an example presented at the last ICON meeting at the ESS ([7]). For the aluminium wire seal a reference from Goodfellow was mentioned during the meeting
- Regarding the direct interfacing of neutron guide segments to the common carrier and the guide segments design itself all aspects were discussed and covered within the auxiliary meeting. It was agreed to:
    - maintain the current assumption of 15mm guide wall thickness, whereas the realisation will most likely be a 8-9mm thick aluminium guide and a 6mm thick MirroBor shielding compound around it
    - use three segments, each 1093mm long resulting in a total guide of 3280mm length (with 0.5mm gap between the segments)
    - each segment will rest on 4 points located along the segments in the corresponding Bessel points. The distance of the two points on each end will be such that each contact point is central to a vertical wall. No 'bridge' underneath the guide needed, no forces on guide walls.
    - for locking the position of each segment spring loaded ball tips will be positioned on the top of each segment, directly above the four support points as well as four contacts at the sides, acting on the height of the bottom part of each guide segment (two fix ball contacts on one side, two spring loaded pushing against on the other side)
    - the segments will be made from aluminium, for designing and predicting the gravitational sag of the carrier one should assume the guides to be made from copper.
- Thickness of entrance window: the thickness should be as small as possible regarding neutron absorption and scattering but as thick as possible from the point of safety. Up to now we have foreseen to realize a thickness of 0.5mm, this has to be analysed and verified with FEA in the ongoing design process. From the operational point of view it would be necessary to define clear requirements from acceptable absorption and stringent safety regulation. It is expected that this window falls under the rule of ESS (i.e. "a thin window is what bends more than its thickness").
- The chamber shall comprise additional flanges for pumping and vacuum monitoring. It was agreed to add one ISO-KF DN40 flanges for monitoring and one ISO-K DN60 for pumping. Flanges will be located close to the downstream chamber end, pointing upwards

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4 Summary and Outlook

This reports summarizes and closes the conceptual design phase as defined in the project. Based on this conceptual design and the findings and agreements of the meeting the final design will be prepared and realized. A final design review will be conducted and is currently expected to happen in participation with ESS experts. After that final design review manufacturing drawings will be supplied. The current schedule was to close this project with all manufacturing drawings in December. However, this schedule might be revised according to statements from A. Glavic during this meeting.

5 Acknowledgment

By approval of this report the preliminary design phase is formally accepted and closed. The project will be continued as defined in the contract with the final design phase.

______________________________ ______________________________

A. Glavic (PSI) T. Waterstradt (AXILON)

6 References

[1] Requirement document "WP_02.2 In-Bunker - Beam Extraction System" as given with *WP_02.2+In-Bunker+-+Beam+Extraction+System.pdf*, dated April 12th 2017

[2] Drawing ESS-0105739.3, rev. 1.0 "frozen" as given with *ESS-0105739 .pdf*, dated April 12th 2017

[3] 3D model in *.step format as given with *Estia_Bunker_Feeder.stp*, dated August 8th 2017

[4] Drawing ESS-0050413.3, rev. 1.0 "preliminary" as given with *Estia In-Bunker Feeder Geometry Definition-ESS-0050413.3.pdf* and *Estia In-Bunker Feeder Geometry Definition-ESS-0050413.3.dxf*, dated April 12th 2017

[5] PowerPoint presentation from CDR meeting as given in *ESTIA_bunkerFeeder_CDR_ppt_v3_2017-10-09_twa.pdf*

[6] Guideline of material usage in neutron environment as given in *NOSG-220725475-021017-0820-4.pdf*

[7] Example on full aluminum flange connection given in *Loki_Ikon_13.pdf*