

PROFILE 1

Engineering support for Neutral Beam Beamline components design, ESP(N) classification and assembly procedure for Neutral Beam Injector

Technical Specifications

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	<i>Name</i>	<i>Affiliation</i>
<i>Author</i>	J Graceffa	CHD/HCD/NB
<i>Reviewers</i>	D Boilson	CHD/HCD/NB
<i>Approver</i>	P Thomas	CHD/HCD

Table of Contents

1	Abstract	3
2	Background and Objectives	3
3	Scope of Work.....	4
4	Estimated Duration.....	5
5	Work Description	5
6	Responsibilities (including customs and other logistics)	6
7	List of deliverables and due dates (proposed or required by ITER).....	6
8	Acceptance Criteria (including rules and criteria).....	7
9	Specific requirements and conditions.....	7
10	Work Monitoring / Meeting Schedule	7
11	Payment schedule / Cost and delivery time breakdown.....	8
12	Quality Assurance (QA) requirement	8
13	References / Terminology and Acronyms	9

Abstract

This document describes technical needs of Neutral Beam Heating and Current Drive (NB H&CD) section in engineering support to design the Neutral Beam Injectors (NBI) including design activities and follow-up of activities.

Background and Objectives

The Neutral Beam (NB) Heating & Current Drive (H&CD) system is designed to:

- Help in accessing the H-mode and heating the ITER plasma at $Q > 10$,
- Provide steady state current drive capability (on-axis, off-axis) for DT, D, H and He plasmas,
- Modify current density and q profile,
- Provide plasma rotation,
- Provide power to sustain the density during shutdown and allow for controlled transition from H to L-mode at the end of burn.

The H&CD NB system consists of two injectors (see below a view of one injector). Space is available in the building and on the tokamak for a third system. Each H&CD injector will deliver an atomic deuterium beam of 16.5 MW, with an energy of 1 MeV, and will be able to operate for long pulses (up to 3,600 s for “steady state” operation). A system based on negative (D^-) ions is used.

In addition to H&CD, plasma rotation is also provided by the NB H&CD injectors.

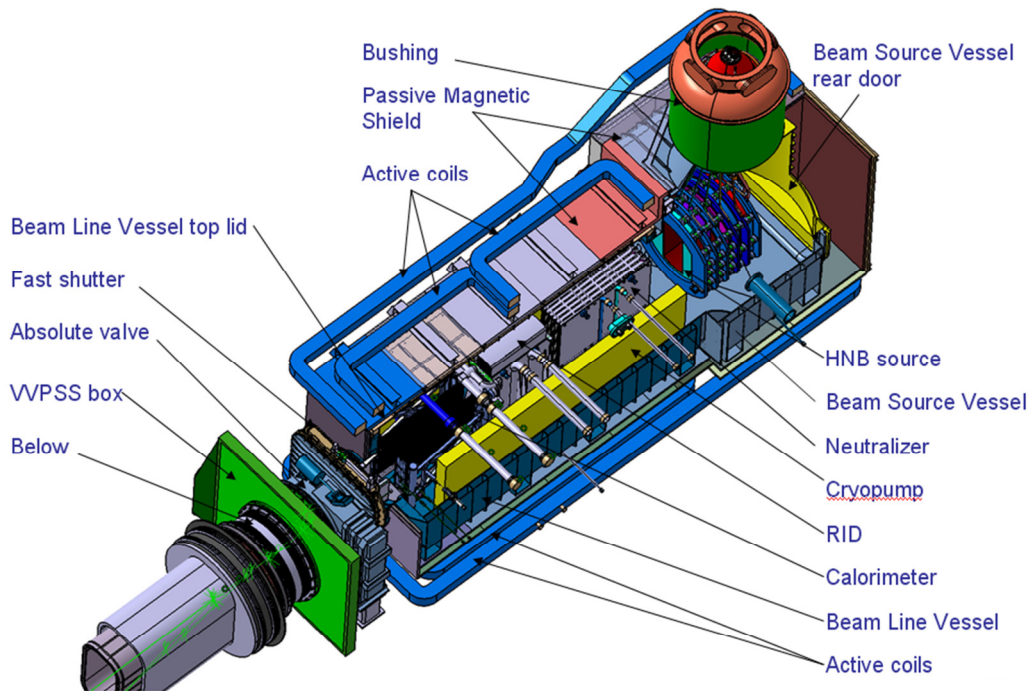
For the H - He operation phase of ITER, the H&CD injectors can be operated in hydrogen, with beam energy ≤ 0.87 MeV and neutral beam power ≤ 16.5 MW per injector to the ITER plasma.

Table NB Heating and Current Drive Parameters

		H - He	D & DT	Upgrade ⁽¹⁾
NB H&CD injection power	MW	≤ 33	≤ 33	≤ 50
Number of heating neutral beam injectors		2	2	3
Injected species		H^0	H^0 or D^0	H^0 or D^0
NBCD beam energy	MeV	0.87	0.87 or 1.0	0.87 or 1.0
NB H&CD - number of allocated equatorial ports		2	2	3
NB tangency radius ⁽¹⁾	m	5.31	5.31	5.31
NB lowest beam axis level at the tangency point	mm	417	417	417
NB highest beam axis level at the tangency point ⁽¹⁾	mm	+156	+156	+156
Approximate NB e-folding length of beam profile at the tangency point in vertical direction, B ⁽²⁾	m	≈ 0.32	≈ 0.32	≈ 0.32
Approximate NB e-folding length of beam profile at the tangency point in horizontal direction, A ⁽²⁾	m	≈ 0.22	≈ 0.22	≈ 0.22

⁽¹⁾Upgrading the H&CD system to 3 injectors is one of 4 upgrade scenarios proposed for the heating systems.

⁽²⁾Beam profile at tangency point described approximately as $P(x,y) = Ce^{-\left[\left(\frac{x}{A}\right)^2 + \left(\frac{y}{B}\right)^2\right]}$



3D view of Heating Neutral Beam injector

Scope of Work

The objective of this engineering contract is to support the NB H&CD team in the:

- Follow-up of design activities related to the following HNB components: High Voltage Bushing, Beam Source, Neutralizer, RID, Calorimeter and Exit Scraper. Liaising with EU suppliers and JADA for the follow-up of these components, writing and reviewing of related documentation,
- Study of NBIs misalignment and define the assembly procedure,
- Make and follow-up the ESP(N) classification of the HNB components,
- Prepare load specifications of HNB Beam Line Components.

Estimated Duration

The duration shall be 1 year (220 working days) from the starting date of the contract. 3 to 4 trips within the Europe area are foreseen.

Work Description

Description of the tasks to perform:

Subtask 1: Follow-up of HNB components design and exit scraper and HV bushing:

The vessels and Beamline components of the ITER heating neutral beam injectors (HNB) are to be supplied by the EU. Because of the lack of manpower within the IO, the drawings will also be supplied by the EU under an ITA (ITER task agreement) with Fusion for Energy. A mechanical engineer is needed to oversee the design of the components and the production of the drawings; cross check all design details, to ensure correct interfaces between the components and the HNB vessels, ensure correct interfaces with services in the NB cell and to oversee the integration into ENOVIA. The engineer will have to liaise with the different partners, to coordinate all the design exchanges and evolutions and write and/or review all the related technical documentation.

Subtask 2: NBIs misalignment studies and assembly procedure:

The injectors will be located outside the cryostat inside a common enclosure, the NB cell, on north side of the tokamak building. As they are directly coupled to the ITER vacuum vessel, the injectors are extensions of the primary confinement barrier of radioactive materials coming from the vacuum vessel. The NB cell will form the secondary confinement. Due to the long distance between NB injection point and ITER vacuum vessel (>25m) a small angular misalignment of the components could have a strong impact on NBIs installation and interaction with the NB cell.

The goal of this task is to complete the work already started on this topic and to ensure it is updated as necessary due to the detailed design and implementation of the NBIs. It consists of an assessment of potential misalignment and following up of any possible interaction with building design and requested modifications, updates of existing drawings and design recommendations. This will lead to the definition of the assembly of the NBIs, taking into account the possible misalignments previously estimated and proposing solutions to reduce them through the assembly procedure.

Subtask 3: ESPN classification:

Due to high power deposition on BLCs due to direct interception of the high power neutral beam by the beamline components, they must be actively water cooled. The beamline component cooling circuits in ITER have been designed with a certain internal pressure and their classification under ESP(N) rules must be examined and assessed. First studies and classifications have been run; the aim is to follow-up their classification in accordance with the design evolution, the regulator and the IO Safety group.

Subtask 4: Load specifications:

In order to design the beamline components, the loads which will be applied in ITER must be taken into account. Some documents summarizing the loads must be written, and the engineer in charge of the work will have strong interactions with people in charge of load

definitions. This information will be necessary for the technical specifications of the components.

The engineer will work under the direct responsibility of IO management.

Other objectives which are common to all tasks described here above must be ensured. They are:

- Check of deliverables (technical specifications, drawings, analysis report, and documentation) and ensure traceability of modifications,
- Ensuring tasks schedule compliance with NBIs design main milestones,
- Organize necessary meeting/discussion between ITER, organization and other involved parties when necessary and ensure traceability of the discussions/choices made (Writing of minutes, memo and storage in IDM of all relevant documents),
- Organize design review meeting and ensure traceability of the discussions/choices made (Writing of minutes, memo and storage in IDM of all relevant documents),
- Ensure compliance with ITER needs and requirements and constraints (design choices done at ITER, codes and standards, maintenance scheme foreseen),
- Ensure quality of deliverables as defined by ITER and maintain it all along the progress of the task,
- Report activities progress to section leader and interact with NB team.

Responsibilities

The engineer will work under IO neutral beam section member responsibility.

List of deliverables and due dates

Subtask	Deliverables	Dates
Overall	Report of on-going activities during each NB section's progress meeting.	Each two weeks
Overall	Report listing all documents/study performed within the contract.	End of the contract
Overall	Any presentations/documents requested by IO to support NB section	When needed by IO
1	Reports/comments on deliverables regarding mechanical design of Beam Line Components and exit scraper and HV bushing	At each delivery steps of on-going ITAs
2	Report on misalignment analysis and design recommendation	When needed by IO
3	Report on PED/ESPN	At each design review/end of

	classification of Beam line components and results (dwg/3D models) of necessary modifications	the contract
4	Load specifications of Beam line components and exit scraper and HV bushing	Each design review/End of the contract

Written reports discussed each two weeks during NB section progress meeting.

Acceptance Criteria

The selection will be done taking into account the following criteria:

- | | |
|--------------|-----|
| 1) Expert CV | 60% |
| 2) Price | 40% |

Specific requirements and conditions

The required resource is a mechanical engineer (master degree) at least 3 years of working experience in mechanical design.

The engineer shall have experience in the following activities:

- English fluent (written and spoken),
- Catia V5 (mechanical design software used in ITER),
- Mechanical analysis (knowledge of ANSYS 11 is an advantage),
- Knowledge in hydraulic analysis and thermo mechanical analysis,
- Experience in design activities follow up,
- Experience in design of component in vacuum environment is an advantage,
- Experience in welding processes (EB welding, brazing...) is an advantage,
- Knowledge of international and French codes and standards,
- Written of technical specification and documentation

Work Monitoring / Meeting Schedule

Final Reports should be self-contained, and relevant documentation, such as drawings, should be supplied together with it in electronic form. Deviations from the Task Order Specifications, approved by the ITER Organization, shall be recorded in a specific chapter of the relevant final report.

Meetings and progress reports

The work will be managed by means of Progress Meetings and/or formal exchange of documents transmitted by emails which provide detailed progress. Progress Meetings will be called by the ITER Organization, to review the progress of the work, the technical problems, the interfaces and the planning.

A progress meeting is organized by H&CD NB section each week. The engineer will have to report every two weeks in the progress meeting dedicated to mechanical activities.

The main purpose of the Progress Meetings is to allow the ITER Organization/H&CD NB section and the Contractor Technical Responsible Officers to:

- a) Allow early detection and correction of issues that may cause delays;
- b) Review the completed and planned activities and assess the progress made;
- c) Permit fast and consensual resolution of unexpected problems;
- d) Clarify doubts and prevent misinterpretations of the specifications.

In addition to the Progress Meetings, if necessary, the ITER Organization and/or the Contractor may request additional meetings to address specific issues to be resolved.

For all Progress Meetings, a document describing tasks done, results obtained, blocking points must be written by the engineer. Each report will be stored in the ITER IDM in order to ensure traceability of the work performed.

Every 3 months, the Contractor shall submit to ITER Organization a Progress Report to be issued five working days before the each Progress Meeting so that the report can be reviewed prior to, and discussed at, that Meeting.

The quarterly Progress Report shall illustrate the progress against the baseline work plan and indicate variances that should be used for trending. Performance indicators suitable to measure the progress of the work as compared to the approved work plan shall also be reported in the Monthly Progress Report.

Experts from the Domestic Agencies may be invited by ITER Organization to participate in the meetings or other involved parties.

Payment schedule / Cost and delivery time breakdown

Interim payment after approval of quarterly reports and final report final acceptance.

Quality Assurance (QA) requirement

The organisation conducting these activities should have an ITER approved QA Program or an ISO 9001 accredited quality system.

The general requirements are detailed in ITER document [ITER Procurement Quality Requirements \(22MFG4\)](#)

Prior to commencement of the task, a Quality Plan [Quality Plan \(22MFMW\)](#) must be submitted for IO approval giving evidence of the above and describing the organisation for this task; the skill of workers involved in the study; any anticipated sub-contractors; and giving details of who will be the independent checker of the activities.

Prior to commencement of any manufacturing, a Manufacturing & Inspection Plan [Manufacturing and Inspection Plan \(22MDZD\)](#) must be approved by ITER who will mark up any planned interventions.

Deviations and Non-conformities will follow the procedure detailed in IO document [MQP Deviations and Non Conformities \(22F53X\)](#)

Prior to delivery of any manufactured items to the IO Site, a Release Note must be signed [MQP Contractors Release Note \(22F52F\)](#).

Documentation developed as the result of this task shall be retained by the performer of the task or the DA organization for a minimum of 5 years and then may be discarded at the direction of the IO. The use of

computer software to perform a safety basis task activity such as analysis and/or modelling, etc shall be reviewed and approved by the IO prior to its use, it should fulfil IO document on Quality Assurance for ITER Safety Codes [Quality Assurance for ITER Safety Codes \(258LKL\)](#).

References / Terminology and Acronyms

- BLC: Beam Line Component
- EB: Electron Beam
- ESP(N): Equipement Sous Pression (Nucléaire) = (Nuclear) Pressurized Equipment
- H&CD: Heating & Current Drive
- HNB: Heating Neutral Beam
- IDM: ITER Document Management
- NB: Neutral Beam
- NBI: Neutral Beam Injector
- RID: Residual Ion Dump