










Confidentiality Level	BL - Restricted for internal use	TC ID / Revision	00327964/C
Document Status	Document Released	Document No.	N/A
WBS code	5.1.4 - LUX Beamline		
PBS code	E.E5.LUX.ELE.4.10		
Project branch	Engineering & Scientific documents (E&S)		
Document Type	Specification (SP)		
<p><i>[RSD product category C]</i></p> <p>Matching section for LUIS</p> <p>(Electron beam line)</p> <p>TP22_008</p>  <p>Keywords</p> <p>EM quadrupole magnets, EM quadrupole magnet control, EMQ power supply, electron beam-pipe, support table, alignment table</p>			
	Position	Name	
Responsible person	LUIS project leader	Alexander Molodozhentsev	
Prepared by	LUIS project leader	Alexander Molodozhentsev	

RSS TC ID/revision	RSS - Date of Creation	RSS - Date of Last Modification	Systems Engineer
023565/A.001	22.2.2022	22.2.2022	J. Adamec

Reviewed By

Name (Reviewer)	Position	Date	Signature
Konstantin Kruchinin	Associated Scientist	14.3.2022	
Lucie Kaletusová	Cleanroom Group Leader	16.3.22	
Luboš Nims	Electrical Engineering Group Leader	Via TC	
Lukáš Brabec	Vacuum and Cryogenics Group Leader		
Roman Kuřátko	Head of Department of Building Infrastructure and IT		
Veronika Olšovcová	Group Leader of Safety	9.3.2022	
Adam Pokorný	Group Leader of Installations	3.3.2022	
Viktor Fedosov	Group Leader of Quality and Planning	Via TC	
Radek Toman	Legal Group Leader	14.3.2022	
Martin Laub	Head of department of Construction and Design Support	14.3.2022	

Approved by

Name (Approver)	Position	Date	Signature
Sergei Bulanov	Head of department of Radiation Physics and Electron Acceleration	16.03.2022	

Revision History / Change Log

Change No.	Made by	Date	Change description, Pages, Chapters	TC rev.
1	A.Molodozhentsev	21.02.2022	RSD draft creation	A
2	J. Adamec	23.2.2022	RSD update, version for internal review	B
3	J. Adamec, A.Molodozhentsev	2.3.2022	RSD Final version	C

Table of Content

Table of Content.....	3
1. Introduction.....	4
1.1. Purpose	4
1.2. Scope	4
1.3. Terms, Definitions and Abbreviations.....	4
1.4. Reference documents	5
1.5. List of mentioned standards	5
1.6. References to standards.....	6
2. General system requirement.....	6
3. Functional, Performance and Design requirements.....	7
3.1. General requirements	7
3.2. Matching-Section system requirements.....	8
3.2.1. EMQs requirements	8
3.2.2. EMQ water cooling system.....	9
3.2.3. EMQs alignment table and support frame	9
3.2.4. Power supply systems	10
3.2.5. Vacuum compatibility.....	11
3.2.6. Vacuum leak tests	12
3.2.7. Beam-pipe.....	12
3.2.8. Control units requirements	13
3.2.9. Cable and water tubes requirements.....	13
4. Transportation and Installation requirements	14
5. Safety Requirements.....	16
6. Quality Requirements.....	17
6.1. Documentation and data control	17
6.2. Nonconformity Control System	18
6.3. Specific Quality Requirements.....	18
7. Verification Requirements for the Supplier	19
7.1. General requirements	19
7.2. Verification documentation	20
7.2.1. General requirements	20
7.2.2. Verification reports (VRs)	20
7.2.3. Verification Control Document (VCD)	21
7.3. Phasing of the delivery	21
7.3.1. Conceptual Design of Integrated Setup	22
7.3.2. Technical Design of Integrated Setup.....	22
7.3.3. Manufacturing	23
7.3.4. Delivery and Installation.....	24
7.3.5. Acceptance	24

1. Introduction

1.1. Purpose

This Requirements Specification Document (RSD) lists the technical requirements and constraints on product applying in RA2 program of ELI project. This can lead to the identification of product interfaces with the ELI science-based technology and ELI building facility. This RSD also acts as the parent document for the technical requirements that need to be addressed in lower level design description documents.

1.2. Scope

This RSD contains all of the technical requirements: functional, performance and design, transportation, safety and quality requirements for the following product: **Matching-Section for LUIS** (*tender N^o TP22_008*).

The product is an integral part of the standalone technology "Laser Undulator Illuminating Source (**LUIS**)" and is registered in the PBS software under the following PBS code: E.E5.LUX.ELE.4.10 (*1 pc*). This product will be placed in the E5 hall.

1.3. Terms, Definitions and Abbreviations

For the purpose of this document, the following abbreviated terms are applied:

Abbreviation	Meaning
A	Analysis (as a verification method)
API	Application Programmers Interface
AR	Analysis Report
CA	Contracting Authority (Institute of Physics AV CR, v. v. i.)
CDRR	Critical Design Review Report
DC	Direct current
ELI	Extreme Light Infrastructure
EMQ	Electro Magnetic Quadrupoles
FD	Functional Demonstration (as a verification method)
FTR	Factory Test Report
GFR	Good Field Regions
I	Inspection (as a verification method)
IS	International standard
NCR	Nonconformity Report
R	Review (as a verification method)
RA2	Research activity 2
RD	Reference Documents

Abbreviation	Meaning
RMS	Root Mean Square
RSD	Requirements Specification Document
RU	Rack Unit
STR	on-Site Test Report
T	Test (as a verification method)
UHV	Ultra-High Vacuum
VCD	Verification Control Document
VR	Verification Report

1.4. Reference documents

Number of doc.	TC ID	Title of document / File
RD-01	003277975	RD-01_LUIS-Matching-Section-Setup-Sketch.jpg
RD-02	00327976	RD-02_Assembled setup on the support table (Sketch).jpg
RD-03	00327977	RD-03_Rail mounting system, implemented in the E5-LUIS experimental area
RD-04	00327978	ELI water cooling system - Technical specifications and requirements
RD-05	00327979	RD-05 Edge condition for the support table
RD-06	00327980	VCD - Verification control document

1.5. List of mentioned standards

Number of doc.	Title of document
ČSN EN ISO 2768	General tolerances — Part 1: Tolerances for linear and angular dimensions without individual tolerance indications
ČSN EN ISO 13920	Welding — General tolerances for welded constructions — Dimensions for lengths and angles — Shape and position
ČSN EN ISO 1779	Non-destructive testing. Leak testing. Criteria for method and technique selection
ČSN EN ISO 14644	Cleanrooms and associated controlled environments
ČSN EN ISO 9001	Quality management systems — Requirements
ČSN EN ISO 12944	Paints and varnishes — Corrosion protection of steel structures by protective paint systems
ČSN EN ISO 3834	Quality requirements for fusion welding of metallic materials
ISO/TS 3669-2	Vacuum technology - Bakable flanges: Dimensions of knife-edge flanges

1.6. References to standards

If this document includes references to standards or standardized/standardizing technical documents the CA allows/permits also another equal solution to be offered. If a supplier offers another equal solution the CA shall not reject its bid, once the supplier by appropriate means in the bid proves that the offered supplies, services or works meet in an equivalent manner the requirements including references to standards or technical documents.

2. General system requirement

REQ-033775/A

The Supplier shall deliver the following parts of the Matching-Section system:

- Assembled electromagnetic quadrupoles (EQM8, EQM9, EQM10) in accordance with the setup-sketch (see **RD-01**);
- Beam-pipe, integrated into the assembled setup of the EMQs (see **RD-02**);
- Alignment tables for the individual quadrupole magnet with the common alignment table;
- Support frame for the whole setup;
- Power supply systems for each EQM with power and thermos-switch cables;

Verification method: I – inspection

3. Functional, Performance and Design requirements

3.1. General requirements

REQ-033776/A

The final manufacturing drawings of the integrated Matching-Section system with the beam-pipe, the alignment plates and the common support table shall be made by the Supplier in conformity with the CA conceptual sketch of the **RD-01**.

Verification method: R – review

REQ-033777/A

At any stage of the design or manufacturing, if it is clear to the Supplier that an advantage could be gained by a modification of the original design, the Supplier shall inform the CA.

Verification method: Not To Be Tracked within VCD

REQ-033778/A

To avoid trapped volumes in vacuum spaces which could result in virtual leaks, precautions shall be taken in the design of the vacuum components, and vacuum spaces shall be suitably vented.

Verification method: R – review

REQ-033779/A

Any dimensional/design modifications that may arise as part of detailed manufacturing design shall be consulted with and approved by the CA. Such dimensional/design modifications are possible only if these are advantageous to the CA (e.g. offer more effective solution). The CA shall approve such a modification, if the advantage of doing so is undoubtedly demonstrated to the CA.

Verification method: R – review

REQ-033780/A

The Matching-Section system field quality in the Good Field Regions shall be better than $5e-4$ for each EMQ within the GFR radius for harmonics $n=2\div 10$ for each quadrupole magnet.

The Good Field Region radius for each quadrupole magnet shall be 2 mm.

Verification method: A – analysis, T – test

REQ-033781/A

The evaluation of the field quality of each quadrupole magnet shall be based on the appropriate scaling, if it is not possible to measure the field quality directly. The evaluation of the field quality for the quadrupole magnets shall be discussed with and approved by the CA.

Verification method A – analysis, R – review

REQ-033782/A

The Supplier shall perform the field measurements of each separated quadrupole magnet (see REQ-033786/A and chapter 3.2.1) using the "rotating coil" or/and by the "stretched-wire" technique and shall provide to the CA the results of this tests (see REQ-033851/A) as a part of the technical documentation for each EMQ.

Verification method: T – test, I – inspection, R – review

REQ-033783/A

Each EMQ of the delivered assembled Matching-Section system with the beam-pipe shall have accuracy ± 0.1 % of measured integrated field gradient or better.

Verification method: T – test, R – review

REQ-033784/A

The assembled System shall have alignment precision ± 100 μm or better for the axis of the magnetic field of the each EMQ.

Verification method: T – test, R – review

REQ-033785/A

After the assembling of the whole system at the Supplier site, the Supplier shall make the alignment verification using the 'stretched-wire' technique and include the results in the test report as a part of the technical documentation for the assembled Matching-Section system.

Verification method: R – review, T – test, I – inspection

3.2. Matching-Section system requirements

3.2.1. EMQs requirements

REQ-033786/A

All three EMQs are identical (with the indexes: EMQ8, EMQ9, EMQ10).

All three EMQs shall comply with the following parameters:

- aperture diameter = (25 ± 0.2) mm;
- maximum integrated field along the axis = 0.5 T;
- total length of the magnet including winding ≤ 190 mm.

Verification method: R – review, T – test

3.2.2. EMQ water cooling system

REQ-033787/A

The EMQs water cooling system for all quadrupole magnets shall meet the following requirements:

- Acceptable rise of the cooling water temperature for EMQs < 10 °C at the cooling water inlet temperature 25 °C.

Verification method: R – review, T – test

REQ-033788/A

The requirements on the EMQ water cooling system, determined by the Supplier, shall be compatible with the ELI water cooling system.

*NOTE: For the technical documentation of the ELI water cooling system see **RD-04**.*

Verification method: R – review

3.2.3. EMQs alignment table and support frame

REQ-033789/A

The assembled EMQs setup with individual alignment table for each quadrupole magnet including the integrated beam-pipe shall be mounted on the common alignment table.

Verification method: I – inspection

REQ-033790/A

The geometrical axis of the assembled setup shall be at 1300 mm with additional leveling ± 10 mm from the ground floor (see **RD-02**).

Verification method: R – review, T – test

REQ-033791/A

The support table for the whole assembled setup shall fit transversally the rail system in the experimental hall (see **RD-03**).

Verification method: R – review, T – test

REQ-033792/A

The support frame shall have 4 holes with the inner diameter of **19 mm** for bolting the support frame to the floor in the experimental hall (**RD-03**). The holes shall be positioned 710 mm from the center to the center with tolerances of ± 0.3 mm.

Verification method: R – review, T – test

REQ-033793/A

The frame shall be made of steel 1.0038. The frame shall follow the welding requirements according to the ČSN EN ISO 3834 (equivalent to ISO 3834) or equivalent. The welding tolerances shall follow the standard ČSN EN ISO 13920 AE (equivalent to ISO 13920) or equivalent.

Verification method: R – review

REQ-033794/A

The support frame shall be painted with Clean room ISO 7 compatible non-outgassing paint or equivalent. The frame shall have a color RAL 3003 matt.

Verification method: R – review

REQ-033795/A

The support frame shall have the corrosion resistance according to ČSN EN ISO 12944 (equivalent to ISO 12944) or equivalent. The paint shall have dry film thickness < 200um.

Verification method: R – review

REQ-033796/A

All sharp edges of the support frame shall follow the edge condition (see RD-05). The maximum deflection of the frame caused by the magnets weight shall be below 0.4mm. The assembled setup shall not have any resonant frequencies below 100 Hz.

Verification method: R – review

3.2.4. Power supply systems

REQ-033797/A

The Supplier shall deliver the unipolar DC power supply system for each EMQ, which shall be able to provide the required field parameters (see REQ-033786/A) from the maximum values down to zero.

Verification method: R – review, I – inspection

REQ-033798/A

The power supply systems shall have output power stabilization allowing the EMQs to provide required field quality.

Verification method: R – review

REQ-033799/A

Each power supply system for each individual EMQ shall have the following output power parameters:

- for the EMQ8-EMQ9-EMQ10 < 8 kW.

Verification method: R – review, T – test

REQ-033800/A

The Supplier shall deliver the power supply systems for the EMQs as a compact 19-inch rack mount module, assembled in one standard rack unit compatible with EIA-310.

Verification method: R – review, I – inspection

REQ-033801/A

The Supplier shall deliver the power supply systems for all the EMQs with the RMS current ripple less than ± 0.05 % for the whole range from zero to the maximum parameters.

Verification method: R – review, T – test

REQ-033802/A

The power supply system shall have an air-cooling system.

Verification method: R – review

REQ-033803/A

The total maximum power consumption (i.e. input power consumption) of the Matching-Section system shall not be more than 25 kW. The plug of the power supply system shall have 3 phases (3NPE, 230/400 V, 50 Hz).

NOTE: Final estimation of the Matching-Section system power consumption shall be provided by the Supplier for approval by the CA before completion of the design phase.

Verification method: A – analysis, R – review, T – test

3.2.5. Vacuum compatibility

REQ-033804/A

All the vacuum components of the Matching-Section system (i.e. beam-pipe, flanges etc.) shall be UHV compatible and shall be able to be totally operated under vacuum level up to 10^{-7} mbar.

Verification method: R – review

REQ-033805/A

The cleaning procedure shall remove contaminants been adhered to the surface such as oils, greases, dirt, swarf, corrosion products, or finger prints.

Verification method: R – review

REQ-033806/A

The Supplier shall provide to the CA the description of the vacuum cleaning procedure which will be reviewed and approved by the CA.

Verification method: R - review

REQ-033807/A

Clean components shall be handled wearing clean, dry, lint-free gloves.

Verification method: Not To Be Tracked within VCD

REQ-033808/A

Chemicals used in the cleaning process shall not affect the material properties or cause a color change, corrosion or other damage.

Verification method: R – review

REQ-033809/A

The outgassing of vacuum components shall be free of hydrocarbons and the appropriate proofs shall be performed by Supplier using a sufficiently sensitive residual gas analyzer, usually equipped with a secondary electron multiplier (SEM).

NOTE: Components are considered as hydrocarbon free when the two conditions are fulfilled:

- *the leak-free system reaches a total pressure below 10^{-7} mbar;*
- *Amplitude of all peaks > 44 AMU are not higher than 1/100 of the 44 AMU peak;*
- *Peak at 43 AMU is not higher than 1/10 of the 44 AMU peak.*

Verification method: T – test (RGA report)

3.2.6. Vacuum leak tests

REQ-033810A

The Supplier shall perform a leak test of the beam-pipe and the results of this test shall be provided to the CA (see REQ-033851/A).

NOTE 1: Single leak test (spray test) shall be according to ČSN EN ISO 1779 (equivalent to ISO 1779; method A.3) or equivalent.

NOTE 2: Total leak test shall be according to ČSN EN ISO 1779 (equivalent to ISO 1779; method D2) or equivalent.

Verification method: T – test

REQ-033811/A

The measured single leak rate using calibrated He detector shall be less than **1.0E-9 mbar·l/s**.

Verification method: T – test

REQ-033812/A

The measured total leakage rate shall be better than **5.0E-4 mbar·l/s**.

Verification method: T – test

3.2.7. Beam-pipe

REQ-033813/A

The beam-pipe of the Matching-Section system shall be manufactured using different outer diameter of 22 mm with CF40 flanges at the edges of the beam-pipe (as shown in RD-01). No bellows are required for the beam-pipe.

Verification method: R – review, T – test

REQ-033814/A

The beam-pipe of the Matching-Section system shall be designed and manufactured with the tolerance class **fH** according to ČSN EN ISO 2768 (equivalent to ISO 2768) or equivalent and with the tolerance class **AE** according to ČSN EN ISO 13920 (equivalent to ISO 13920) or equivalent.

The tolerance for the total length of the beam-pipe shall be ± 1 mm. The dimensions of CF flanges shall be according to ISO/TS 3669-2 or equivalent.

Verification method: R – review, T – test

3.2.8. Control units requirements

REQ-033815/A

Each power supply shall be equipped with a serial interface for the remote control operation via following protocols: Ethernet, RS-232 or RS-485.

Verification method: R – review

REQ-033816/A

Supplier shall provide comprehensive communication protocol documentation (commands reference manual) for both power supplies and motion controllers.

Verification method: R – review

3.2.9. Cable and water tubes requirements

REQ-033817/A

All power cables connecting to the EMQs shall be compatible with the power supply systems and the thermos-switch cables shall be delivered by the Supplier.

Note: Power cable connecting the power supply rack to the power socket in the experimental area will be provided by CA.

Verification method: I – inspection, R – review

REQ-033818/A

The length of the power cables interconnecting the power supply systems and the EMQs, including the thermos-switch cables, shall be of 9.0 ± 0.5 meters.

Verification method: R – review

REQ-033819/A

All water tubes for the cooling system shall be assembled for each EMQ and shall be delivered by the Supplier.

Note: The water tubes to connect the magnets water cooling system to water cooling hub in the CA experimental hall will be prepared by CA before the delivery of the items.

Verification method: R – review, I – inspection

REQ-033820/A

The water tube material of the EMQs shall be compatible with the ELI water cooling system.

Verification method: R – review

4. Transportation and Installation requirements

REQ-033821/A

The transportation of the whole assembled setup of the pre-aligned EMQs with the beam-pipe to the final destination (ELI Beamlines experimental hall) and the installation of the whole setup at ELI-Beamline experimental hall shall be conducted by the Supplier.

NOTE: The transportation and installation procedures will be discussed and can be reviewed by the CA's installation officer.

Verification method: R – review

REQ-033822/A

The Matching-Section system shall be delivered in a protective package preventing damage.

Verification method: I – inspection

REQ-033823/A

Before the Delivery the Supplier will provide the instruction for the proper connection of the magnets power supply systems and the magnets water cooling systems to the corresponding hubs in the CA experimental area.

Verification method: R - review

REQ-033824/A

Before the Delivery the Supplier will provide the instruction for the proper installation and final alignment for the Matching-Section setup, including the reference points for the laser tracker.

Verification method: R - review

REQ-033825/A

Connection of the magnets water cooling system to the water cooling hub in the ELI-Beamlines experimental hall will be performed by the CA personal after delivery of the magnets to the CA side. The connection will be based on the instruction, submitted by the Supplier. Verification method: I – inspection

REQ-033826/A

Connection of the rack with the magnets supplies to the electrical power hub in the ELI-Beamlines experimental hall will be performed by the CA personal after delivery of the magnets to the CA side. The connection will be based on the instruction, submitted by the Supplier. Verification method: I – inspection

REQ-033827/A

Final alignment of the assembled setup of the Matching-Section system in the experimental hall shall be performed by the CA and the supervision from the Supplier side. The final installation of the assembled setup will be based on the alignment instruction, submitted by the Supplier.

Verification method: I – inspection

REQ-033828/A

The Supplier shall ensure that the installation of the assembled setup will be performed without contaminating the place of installation unnecessarily. The premises include rooms with normal cleanliness and cleanrooms of class 7 according to ČSN EN ISO 14644 (equivalent to ISO 14644) or equivalent.

Verification method: I – inspection

REQ-033830/A

The Supplier shall check the proper cable and water-cooling connections in the CA experimental area and perform full-power electrical and thermo-test after the final installation of the Matching-Section setup in the CA experimental area.

Verification method: T – test

REQ-033831/A

Before the Delivery, all components of the system shall be cleaned according to a procedure suitable for installation in clean environment of class 7 according to ČSN EN ISO 14644 (equivalent to ISO 14644). *NOTE: The cleaning procedure will be discussed between the Supplier and the CA.*

Verification method: R - review, I – inspection

REQ-033833/A

All transportation and installation tools and equipment entering the clean rooms shall be cleaned and reviewed by the CA's approved methods. The Supplier and the CA shall agree on the cleaning method to clean tools and equipment used at the installation without decreasing their performance or safety.

NOTE: Some tools can be provided by the CA upon agreement.

Verification method: I – inspection

5. Safety Requirements

REQ-033834/A

The Supplier shall supply a Declaration of Conformity for each product type if the appropriate legislation determines the Supplier's obligation to have a Declaration of Conformity for the purposes of a Device sale in the Czech Republic. In such a case the Declaration of Conformity shall comply with:

- Act No. 90/2016 Coll., as amended
- Act No. 22/1997 Coll., as amended
- The equivalent legal regulation of another EU member state so that the conditions for the sale of the product in the Czech Republic are met, and/or
- the relevant EU/EC regulation

NOTE: The compliance with these obligations will be demonstrated by the (EU) Declaration of conformity, other relevant documents and the CE marking if required by the relevant regulations. If a delivered product is not required to assess conformity according to specific legislation, the supplier declares, in written form, by concluding the contract that the product complies with the general safety requirement of EU Directive 2001/95/EC on general product safety and that the Supplier duly complies their obligations under this Regulation.

Verification method: I – inspection

6. Quality Requirements

6.1. Documentation and data control

REQ-033835/A

The Supplier shall provide the **Product User Manual** as part of the delivered system. Completeness of the Manual shall be approved by the CA. The Manual shall include the instructions and descriptions regarding the following procedures:

- transport, handling, storage;
- installation, alignment and cleaning;
- guide for the software and for communication protocol (see REQ-033816/A);
- safe operation and maintenance procedures.

Verification method: R - review, I – inspection

REQ-033836/A

The Supplier shall supply the following relevant manufacturing documents:

- all manufacturing **drawings, 3D models** (if available) and **design supporting documentation** (i.e. technical documentation, see REQ-028610/A) approved by the CA;
- all "**requests for deviation/wavier** from requirements described herein" (see REQ-033840/A) approved by the CA.

Verification method: I – inspection

REQ-033837/A

Documentation shall be supplied in **hardcopy** and **PDF** formats.

Verification method: Not To Be Tracked within VCD

REQ-033838/A

The manufacturing documents shall include the **accuracy of the manufacturing process**. This accuracy shall be also included in the corresponding **test reports** (see REQ-033851/A and REQ-033851/A). *NOTE: The Supplier will specify the maximal difference between specified parameters (in chapter 3) and the parameters of the final Matching-Section system with the beam-pipe.*

Verification method: R – review

REQ-033839/A

The Supplier shall use following data formats:

- *.JPG, *.PNG, *.TIFF, *.PDF/A, *.HTML
- CAD 2D: *.dwg
- CAD 3D: *.stp; *.ste; *.step or other 3D CAD formats agreed with the CA
- text processors: *.doc, *.docx, OpenDocument Format
- spreadsheet processors: *.xls, *.xlsx, OpenDocument Format
- presentations: *.ppt, *.pptx; OpenDocument Format

Verification method: Not To Be Tracked within VCD

6.2. Nonconformity Control System

REQ-033840/A

The Supplier shall establish and maintain a nonconformity control system compatible with ČSN EN ISO 9001 (equivalent to EN ISO 9001) or equivalent.

Verification method: Not To Be Tracked within VCD

6.3. Specific Quality Requirements

REQ-033841/A

In case of a warranty repair of the Matching-Section system with the beam-pipe by the Supplier, the Supplier shall redo necessary parts of the verification procedure (see chapter 7). The results of this process shall be provided to the CA.

Verification method: Not To Be Tracked within VCD

REQ-033842/A

All tests shall be performed by the measuring instruments with valid metrological confirmation.

*NOTE: The CA can request the Supplier to provide the valid **Calibration Certificates**.*

Verification method: Not To Be Tracked within VCD

7. Verification Requirements for the Supplier

The verification process will be performed by the Supplier to demonstrate that the whole system (assembled setup with 3 quadrupole magnets, the beam-pipe, alignment tables and support frame) meets the specified requirements of the CA.

7.1. General requirements

REQ-033843/A

The Supplier shall assign clear responsibility for the implementation of the verification process including the following activities:

1. Verification planning (via VCD, see chapter 7.2.3);
2. Verification execution and reporting (see chapters 7.3, 7.2.2 and 7.2.3);
3. Verification control and close-out (see chapter 7.3.4).

Verification method: R – review

REQ-033844/A

The verification process shall be accomplished by the Supplier through one or more of the following verification methods:

1. **Review**; Verification via Review (**R**) shall consist of using approved records (i.e. design documents and reports, technical descriptions, engineering drawings, manuals and accompanying operation documentation) or evidence unambiguously showing that the requirement has been met.
2. **Inspection**; Verification via Inspection (**I**) shall consist of physical characteristics visual determination including photographs taken by the Supplier and sent to the CA proving that the specific requirements have been met.
3. **Test** (including functional demonstration); Verification via Test (**T**) shall consist of measuring product performance and functions under realistic operating conditions. When the test objectives include the demonstration of qualitative operational performance (functional demonstration), the execution shall be observed and results recorded.
4. **Analysis**; Verification via Analysis (**A**) shall consist of performing theoretical or empirical evaluations (e.g. mathematical models, calculations and etc.).

Verification method: Not To Be Tracked within VCD

7.2. Verification documentation

7.2.1. General requirements

REQ-033845/A

The Supplier shall establish and maintain the system of verification process documentation (see REQ-033846/A and REQ-0033847/A).

Verification method: Not To Be Tracked within VCD

REQ-033846/A

Verification documentation shall consist of following documents:

- **Verification reports** (see chapter 7.2.2);
- **VCD, Verification Control Document** (see chapter 7.2.3).

Verification method: Not To Be Tracked within VCD

REQ-033847/A

The verification report shall be submitted to the CA for the review as agreed with the CA after corresponding verification activity completion, within the time frame agreed with the CA.

NOTE: Verification activity can be design review and/or analysis during the Matching-Section system development, test and inspection during the final Matching-Section system implementation.

Verification method: Not To Be Tracked within VCD

7.2.2. Verification reports (VRs)

REQ-033848/A

The results of the analysis shall be documented in the corresponding **Analysis Report** (further "AR") and tracked in the VCD (see chapter 7.2.3).

Verification method: R – review

REQ-033849/A

The results of a review of design shall be documented in the **Critical Design Review Report** (further "CDRR") and tracked in the VCD (see chapter 7.2.3).

NOTE: The CA can provide to the Supplier the template of CDRR.

Verification method: R – review

REQ-033850/A

The **results of the inspection** shall be tracked in the VCD.

Verification method: R – review

REQ-033851/A

The **results of the tests** shall be documented in the appropriate **Factory Test Report** (further "FTR") or **on-Site Test Report** (further "STR") and tracked in the VCD (see chapter 7.2.3).

Verification method: R – review

7.2.3. Verification Control Document (VCD)

The Verification Control Document (**VCD**) lists the requirements to be verified by the selected methods at the defined stages of the Matching-Section system delivery (see chapter 7.3).

The VCD is a living document which shall be used throughout the entire Contract delivery and its phases (see chapter 7.3). The VCD provides traceability during delivery phases (Qualification of Design, Manufacturing, Delivery & Installation, Acceptance,...). The VCD represents a formal tool of communication between the Supplier and the CA (formal record, reporting tool).

REQ-033852/A

The Supplier shall provide **Verification Control Document** (further "**VCD**") for the reviews as agreed with the CA.

NOTE 1: Guidelines for VCD preparation see in RD-06.

NOTE 2: The form of VCD will be agreed between the CA and the Supplier based on the best commercial praxis used by the Supplier.

Verification method: R – review

REQ-033853/A

In the VCD the Supplier shall specify **HOW** and **WHEN** each requirement is planned to be verified.

Verification method: R – review

REQ-033854/A

The verification approach shall be submitted by the Supplier in the VCD and approved by the CA prior to implementation.

Verification method: Not To Be Tracked within VCD

7.3. Phasing of the delivery

This chapter is intended to briefly summarize basic milestones of the Contract delivery. These milestones represent gates (checkpoints) where the quality of the delivery has to be evaluated.

Delivery shall not proceed past these gates unless their satisfactory accomplishment is approved by the CA.

Delivery lifecycle shall contain at least the following phases (**quality gates**):

- **Conceptual Design of Integrated Setup;**
- **Technical Design of Integrated Setup;**
- **Manufacturing;**
- **Delivery and Installation;**
- **Acceptance** (performed by the CA)

7.3.1. Conceptual Design of Integrated Setup

The goal is to verify the **conceptual design of the integrated setup, including main drawings and design supporting documentation.**

Summary of what shall be provided by the Supplier in terms of documentation (technical documentation including conceptual drawings and design supporting documentation) before starting the technical design of the integrated setup.

Output of this phase is **Qualified Conceptual Design of the Integrated Setup and agreed scope of technical design of the setup.**

REQ-033855/A

Before completion of the Conceptual Design phase the Supplier shall provide following information that shall be agreed by the CA:
structure and content of the verification reports (see chapter 7.2.2);
structure and content of the VCD ready to be implemented (see chapter 7.2.3).

Verification method: R – review

REQ-033856/A

Before completion of the Conceptual Design phase the Supplier and the CA shall agree on:

- conceptual drawings of the integrated setup provided by the Supplier (see REQ-033776/A);
- acceptance results of the conceptual design verification submitted by the Supplier in the corresponding CDRR and AR (see REQ-033848/A and REQ-033849/A);
- detailed procedures related to the testing during Manufacturing and Installation phases (see chapters 7.3.2 and 7.3.3);

Verification method: R – review

7.3.2. Technical Design of Integrated Setup

The goal is to verify the **technical design of the integrated setup, including final drawings for the production and supporting documentation.**

Summary of what shall be provided by the Supplier in terms of documentation (technical documentation including final drawings and supporting documentation) before starting the production of the integrated setup.

Output of this phase is **qualified Technical Design of the Integrated Setup and agreed scope of production of the setup.**

REQ-033857/A

Before completion of the Technical Design phase the Supplier and the CA shall agree on:

- final drawings of the integrated setup provided by the Supplier (see REQ-033776/A);
- acceptance results of the conceptual design verification submitted by the Supplier in the corresponding CDRR and AR (see REQ-033848/A and REQ-033849/A);
- detailed procedures related to the testing during Manufacturing and Installation phases (see chapters 7.3.2 and 7.3.3);

Verification method: R – review

7.3.3. Manufacturing

The goal is to demonstrate that the manufactured and assembled Matching-Section system meets the specified technical requirements (RSD) of the CA.

This quality gate concerns primarily:

- Inspection of assembled System, which includes 3 electromagnetic quadrupole magnets with the integrated beam-pipe, alignment tables and support frame;
- Testing at the Supplier's site (factory testing);
- Cleaning and Packaging.

Output of this phase is the **Verified assembled Matching-Section with the beam-pipe.**

REQ-033858/A

The results of the Manufacturing verification phase shall be recorded by the Supplier in the appropriate FTR (see REQ-033851/A) and overall results (including review of documentation/reports and inspection of assembled Matching-Section system) shall be recorded in the VCD (see chapter 7.2.3).

Verification method: R – review

7.3.4. Delivery and Installation

The goal is to demonstrate that the delivered and installed final Matching-Section system meets all requirements specified herein.

Verification of the final System is executed by the Supplier and the CA together after completion of each stage including delivery, transportation and installation.

This quality gate concerns primarily:

- **Inspection of delivered integrated System and required documentation;**
- **Transportation to the final destination** (ELI Beamlines E5 hall);
- **Inspection and on-site testing of whole installed System.**

Output of this phase is the **Verified delivered and installed Integrated System.**

REQ-033859/A

The results of the verification of delivered and installed Integrated System shall be recorded by the Supplier in the appropriate STR (see REQ-033851/A) and overall results shall be recorded in the VCD (see chapters 7.2.3).

Verification method: R – review

REQ-033860/A

The final issue of the VCD shall be submitted to the CA after the approval of the last report and before starting the Acceptance phase (see chapter 7.3.4).

Verification method: R – review

7.3.5. Acceptance

Acceptance will be carried out by the CA upon verification of the final Integrated System (see chapter 7.3.3). The basis for acceptance will be completed VCD summarizing the overall verification results together with relevant documentation supporting the verification (i.e. VRs, approved manufacturing drawings and 3D model, Product User Manual and etc.).

In case of successful acceptance phase, the CA will provide to the Supplier signed acceptance protocol. In case of unsuccessful acceptance stage, the CA will provide to the Supplier Nonconformity Report (NCR) and ELI nonconformity control process will be applied (see REQ-033840/A).

REQ-033861/A

The Acceptance phase shall demonstrate the following:

- Final Integrated System consisting of the 3 EMQs, the beam-pipe, the alignment tables and support frame has been successfully verified by the Supplier and the results of this process has been documented in an appropriate way through VRs (see chapter 7.2.2) and VCD (see chapter 7.2.3);
- All detected non-conformities have been solved in accordance with REQ-033840/A;
- Final Integrated System is free of fabrication errors and is ready for the intended operational use.

Verification method: Not To Be Tracked within VCD