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| Magnets D1, Q8 and C8 PDR Charge Document |
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| Preliminary Design Review (PDR)  ESS Dipoles D1, Quadrupoles Q8 and Correctors C8  27 June, 2017, ESS, Lund, Sweden |
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| **Charge for the PDR** |
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Purpose of this PDR

A PDR is the first detailed design review of a component and its functional adjacent systems. It nominally, though not always, marks the transition from conceptual/basic to detailed design. The successful completion of a PDR authorises the commencing of the following activities for the tendering and construction of the components.

The design is reviewed against all design inputs, including technical and interface requirements, according to the level of detail required and available at a PDR stage.

A successful PDR gives confidence that the subsequent detailed design will meet all technical requirements and interface properly with all relevant accelerator subsystems. The completion of a PDR fixes the technology choice of the component being reviewed.

The objective and purpose of this PDR is to confirm that the conceptual design for the magnets D1 (dipole), Q8 (quadrupole) and C8 (corrector) is likely to meet all requirements and is specified in sufficient detail for detailed design and prototyping activities to begin. This includes a check on the status of all interface and performance requirements.

The inputs for conceptual design may include the following, where applicable and agreed by ESS and Elettra:

* The scope of work described in the HoA/In-kind agreement for Magnets technical specifications /appendix.
* Product Breakdown Structure (PBS) requirements for Level 2 (L2) Accelerator, L3 Magnets sections, L4 disciplines and L5 components, including interface requirements applicable for the magnets at various PBS Levels. These requirements are managed in the IBM® Rational® DOORS® database, implemented for ESS products.
* Any specifications agreed as inputs for the conceptual design of the magnets.
* Any inputs provided during previous workshops, or other technical meetings that have been agreed and accepted as applicable input to conceptual design for the magnets.

In general terms, the expected outputs of conceptual design, which should be presented and reviewed in the PDR are:

* Conceptual design CAD models, mock-ups and simulations.
* Specifications and other descriptions resulting from conceptual design activities.
* Reports from calculations, analysis, simulation and other design verification activities.

The specific information, which should be reviewed in the PDR, is listed as Deliverables. See Appendix 1.

**The PDR boundaries and limitations**

The PDR to be performed is dedicated to the dipole magnets D1, quadrupole magnets Q8 and corrector magnets C8 and is limited in its scope. The mechanical supports and alignment system as well as the vacuum chambers are not in the scope of Magnets WU and are provided by STFC Daresbury Laboratory, and therefore are not subject to review in this PDR. The power converters for the magnets are part of a separate contribution from Elettra and therefore are not subject to review in this PDR. However, the interfaces with those and other systems shall be reviewed in this PDR.

**Charge to the Committee**

The Review Committee is composed of the Chairman and members as identified in Appendix 2. This list also shows reviewers, who provide comments and review but are not on the formal committee and presenters.

The Review Committee is asked to:

1. REVIEW: Scrutinize and assess the deliverables listed in Appendix 1, presented through the material presented and discussions, at the PDR. Note that the presentations themselves are means of communication only, and it is the design and design documentation which must be reviewed. “Is the conceptual design and documentation mature enough to commence detailed design”?

2. ANSWER: Answer each question listed in Appendix 3.

3. DECIDE: The Review Committee is to elaborate and deliver at the conclusion of this PDR, a clear recommendation to ESS and to Elettra about continuing with the detailed design along with a list of recommendations for the magnets.

Suggested forms for the decision are:

* Approved, without qualifying comments or further actions.
* Approved, but with recommended actions and or clarifications.
* Not approved, but with recommended actions, for further inputs and activities, and a proposal for a follow-on review.

(If the committee rules for “Approved with recommended actions” or “Not approved” of the PDR, it is of essence that the actions/comments requested are very precise in their formulation and that the fulfilment decision is transferred to Elettra, all this due to time constraints in the schedule).

4. REPORT: The Review Committee is to document in a short report to be delivered as soon as possible after the PDR, its recommendation and any specific actions for Elettra, identifying any further design necessary and other guidance for assisting planning and future success of the Work Unit related to its scope and deliverables.

(If the PDR is “Approved but with recommended actions”, at the PDR, there shall be a summary list of requested actions defined and who is responsible to perform needed work. In order to facilitate the actions, ESS will work with Elettra to accommodate any defined actions in order to meet the schedule constraints. This while awaiting the final report from the PDR review team).

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| Appendix 1  **Scope and Deliverables for Review** |
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Scope for Work Unit MAGNETS

ACCSYS WBS 11.14.4 Work Unit (WU) MAGNETS is led by Davide Castronovo for Elettra and by Edgar Sargsyan for ESS. The WU is part of ACCSYS WBS 11 Work Package (WP) 14 Linac led by Håkan Danared, ESS. The WU for Magnets and essentially all of its scope and deliverables are delivered as In-Kind Contributions (IKC) from Italy to ESS.

The WU is responsible for the following scope relevant for this PDR:

* Analysis and simulations e.g.
  + Optimization of the magnets mechanical, thermal (power dissipation) and electrical parameters
  + Field quality
  + Reliability Availability Maintainability and Inspectability (RAMI) analysis
* Conceptual electromagnetic and mechanical design
* Definition of the interfaces with relevant systems
* Procurement for detailed design and prototyping (if needed)
* Construction and assembly
* Test and measurement of magnet assemblies and associated components to demonstrate their full compliance with the requirements
* Quality assurance and contract follow-up
* Documentation concerning design, construction, tests and measurements

Deliverables for PDR - Information to be reviewed

The information identified below is to be described and communicated through presentation at the PDR, and the source information is to be available to reviewers for reference during the PDR.

Elettra is requested to deliver to the PDR Chairman for distribution to the Review Committee and other reviewers, an agreed subset of the following information for pre-review and comments no later than five (5) working days prior to the CDR.

Reviewers should assess the design, procurement strategy, manufacturing processes and the verification methods, which secure performance, functionality and future operation as defined through the relevant requirements.

**Technical Data Package**

Design and analysis

* Magnets conceptual electromagnetic, thermo-mechanical and mechanical design
* CAD model for magnets and auxiliary systems (to be available on a computer at the PDR and used for live display) as appropriate at the PDR stage.
* Conceptual 2D and 3D magnetic field computations and field maps
* The results of Internal design reviews and quality assurance performed of the design and its results and requested corrective actions

Interfaces

* Design/description of the interfaces with power converters
* Design/description of the interfaces with mechanical support and alignment systems
* Design/description of the interfaces with vacuum system (vacuum chamber)
* Design/description of the interfaces with water-cooling system

Manufacturing and verification

* Procurement strategy
* Manufacturing Data package containing all needed CAD models produced for the conceptual design and for manufacturing contractor. Including manufacturing sequence, quality plans for manufacturing and all needed work and verification procedures.
* Description of planned tests and magnetic measurements
* Detailed schedule for procurement, manufacturing, testing, measurements and delivery
* Preliminary risk analysis with proposed/implemented mitigating actions and expected or verified results

**Safety**

Conventional Hazards

Present on any identified modes of operation or maintenance tasks for magnets, which could expose personnel to conventional hazards (e.g. high voltage hazards, magnetic field hazard, etc.).

**Quality**

Quality Planning

Describe planning for Quality, or provide a Project Quality Plan for magnet systems scope. Use ESS-0037830 as guidance (not mandatory) for the planning of activities for Quality assurance and control.

Standards

List the standards used for engineering design, construction and verification of magnet systems. Note that ESS-0001515 Operating Procedure “Standards & Norms applicable for ESS” identifies radiation protection Standards, namely ICRP, IAEA, Erratum standards, and also more general engineering Standards, such as SIS, CEN and ISO, which ESS considers would be applicable for the design and construction of ESS systems and components. The ESS vacuum handbook also makes specific reference to applicable standards.

**RAMI**

Random failures

List the most frequent failures during normal operation (steady state operation). Related maintenance actions, times to repair and to restart the system should be provided.

Lifetime issues

List the components for which wear-out or degradation to failure will occur within 20 years of operation of the machine. For these components please provide maintenance actions, times-to-repair (hours) and the actions needed for restarting after repair.

Catastrophic events

List the failures with catastrophic consequences in downtime or cost. Please include an estimation of the probabilities, cost and downtime (hours) as well as the mitigation to avoid such failures.

**Integrated Control System (ICS)**

Descriptions or other identification of systems and components – for Integrated Control Systems (ICS) and including Machine Protection Systems (MPS) and Personnel Safety Systems (PSS):

* a list of protection functions required for the local protection system
* a list of the process variables to be monitored in the controls system, archiving rates and alarm limits (when applicable) for the control system and local protection system.
* to assist hazard identification for the Personnel Safety System, please provide a table showing the voltages and estimated current outputs onto each device and identify which devices Elettra considers are hazards for PSS design and other mitigation.

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| Appendix 2  **Review Committee and other Reviewers, Presenters and Observers** |

The PDR Committee conducts this review with the authority of ACCSYS Project Leader, Mats Lindroos, and ESS Director General, John Womersley.

The Committee serves in an advisory capacity to:

* the Work Unit team for MAGNETS and for its parent Elettra,
* the ACCSYS WP 14 Leader, and
* the ACCSYS management team

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| Name | Organisation | Appointment for CDR |
| John Weisend II | ESS, ACCSYS Deputy Project Leader | Chairman of the Review Committee |
| Kent Wigren | ESS, ACCSYS QA | Review Committee member |
| Lali Tchelidze | ESS, ACCSYS Safety Group Leader | Review Committee member |
| Iñigo Alonso | ESS, ACCSYS Linac Integration | Review Committee member |
| Mohammad Eshraqi | ESS, ACCSYS Beam Physics | Review Committee member |
| Carlos Martins | ESS, ACCSYS Power Converters | Review Committee member |
| Thomas Zickler | CERN, Magnet design and measurement expert | Review Committee member |
| Edgar Sargsyan | ESS, ACCSYS Magnets WU Coordinator | Reviewer |
| Fabio Ravelli | ESS, ACCSYS Vacuum Systems | Reviewer |
| Anton Lundmark | ESS, ACCSYS cooling support | Reviewer |
| Frithiof Jensen | ESS, ACCSYS Electrical Support | Reviewer |
| Enric Bargalló | ESS, ICS, Machine Protection and Dependability Analyst | Reviewer |
| Annika Nordt | ESS, ICS, Group Leader for Machine Protection and Personnel Safety systems | Reviewer |
| Alessandro Fabris | Elettra, ESS Project Leader | Presenter |
| Davide Castronovo | Elettra, Magnets Work-Unit Coordinator, magnet designer | Presenter |
| Riccardo Fabris | Elettra, Head of Elettra & FERMI Magnets | Presenter |
| Rodolfo Laghi | Elettra, Project Assistant | Observer from Elettra |
| Mario Maggiore | INFN, Magnets Work-Unit Coordinator | Observer from INFN |
| Paul Aden | STFC Daresbury – LWU IKC Project Manager | Observer from Daresbury |

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| Appendix 3  **PDR Charged Questions** |

1. Has the design and supporting activities for magnets progressed and reached a level of technical maturity in accordance with the activities and milestones for this Work Unit recorded in the ESS ACCSYS Project?
2. Has the design of the magnets been documented appropriately and sufficiently and presented in a suitable format to enable review at this PDR?
3. Have the appropriate design options for the magnets as well as their verification methods been selected and described?
4. Have all or a sufficient coverage of requirements and specifications for the magnets, including for its interfaces with other systems, been identified and documented by ESS, communicated to and understood by the Work Unit team?
5. Does the magnets conceptual design meet these requirements and specifications?
6. Is the magnets conceptual design sufficiently developed for transition to the detailed design?
7. Have safety issues and technical risks been identified and eliminated or otherwise mitigated for in the conceptual design?
8. What quality assurance and quality control activities have been planned and how will these be conducted and documented or reported?
9. Are there sufficient staff resources assigned to the Work Unit team by its parent Elettra to allow to progress with work in accordance with activities, durations and milestone dates shown in the ESS ACCSYS Project plan?
10. Is the conceptual design information and information on procedures required for the operation of the magnets delivered and presented at PDR sufficient? (This includes operational modes and magnet functionality including adjacent systems and interfaces).
11. Are the strategy, policies and regulations for procurement, manufacture and assembly sufficiently identified, defined, documented and understood by the Work Unit team or its parent Elettra, including supplier source(s) and pre-procurement activities and progressed to a sufficient stage?
12. Is the schedule for delivery of materials, components and for the manufacture of magnets sufficiently understood and in accordance with activities, durations and milestone dates shown in the ESS ACCSYS project plan? (This includes the time schedule and technical risk evaluations)
13. Does the Work Unit team or its parent Elettra require additional input from ESS or its other partners, or seek additional review, decision or approval from ESS to proceed with all work planed?
14. Are there any outstanding agreements to be made or other actions necessary to allow the work unit to achieve the Plan?

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| Appendix 4  **Detailed checklist, can be used as guidance for clarification** |

The 5 main question areas for the magnets PDR are:

1. The design:
   1. Is the design documented sufficiently and presented in a suitable format to enable review at this PDR?
   2. Does the design meet the requirements and specifications?
   3. Does the design meet the ESS needs? (Plant integration, testing, operability, maintenance, future changes/upgrades)
   4. Are all or a sufficient coverage of requirements and specifications for the magnets, including its interfaces with other systems, documented, communicated to and understood by the Work Unit team?
   5. Has the design and supporting activity for the magnets progressed and reached a level of technical maturity to start prototyping/manufacturing?
      1. What open technical questions exist?
      2. What is the path forward to clarify the open questions?
   6. Have a proper safety and risk analysis been performed?
      1. What safety issues and technical risks have been identified?
      2. Are they documented?
      3. What mitigations have been implemented? Are they documented? What is the result?
      4. Future actions planed? To eliminated or otherwise mitigated in the detailed design or identified for managing for manufacture, assembly, installation or operation?
   7. Does the Work Unit team or its parent Elettra require additional input from ESS or its other partners, or seek additional review, decision or approval from ESS to proceed with all work planed?
   8. Are there any outstanding agreements to be made or other actions in the work unit necessary to realize the Plan?
2. The manufacturing:
   1. Is there a Manufacturing strategy and sequence?
   2. Are the strategy, policies and regulations for procurement, manufacture and assembly sufficiently identified, defined, documented and understood by the Work Unit team or its parent Elettra, including supplier source(s) and pre-procurement activities and progressed to a sufficient stage?
   3. Are all needed manufacturing procedures and DWG completed? If not what is open?
   4. Are all needed procedures/inspection plans including risk analysis for manufacturing performed including plan for mitigating actions? (E.g. lamination stamping, construction of the coils, overall manufacturing sequence, procedures, etc.)
   5. Is the manufacturer given sufficient time to perform the work?
3. Scope split:
   1. Is the scope split clear between Elettra, ESS and STFC Daresbury Lab?
   2. Are the responsibilities clear and agreed?
   3. Is the requirement verification/validation agreed and understood?
4. Time schedule and critical paths:
   1. Which critical paths exist?
   2. What Top 3 risks are identified and how are they managed?
   3. Is the schedule for delivery of materials, components and for the manufacture of the magnets sufficiently understood and in accordance with activities, durations and milestone dates shown in the ACCSYS project plan?
5. Elettra Resource plan to meet the schedule:
   1. Are all resources named?
   2. Is the schedule resource loaded?
   3. Are all resources available and released by management in due time?
   4. Is there any surplus in the critical areas?
   5. Which bottlenecks exists?