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| System Requirements Specification |
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|  | Name | **Role/Title** |
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# Scope

The scope of this document is to describe the system requirements of the Cryomodule and Cryodistribution Control System (C3S). For complete C3S documentation references, consult the System Engineering Management Plan

# Issuing organisation

This document is issued by evopro systems engineering Ltd. commissioned by the ICS Hardware & Integration Group.

# Requirements

## General Requirements

| Id | Text |
| --- | --- |
| C3S.REQ-GR.1010 | The system shall be designed, developed, tested and commissioned according to ESS Engineering Guidelines.  Rationale: See [1] |
| C3S.REQ-GR.1020 | The system shall be designed using ESS Standardised PLC Equipment concerning the automation elements.  Rationale: See [2] |
| C3S.REQ-GR.1030 | The PLC software shall be developed using PLCFactory tool to have ESS-wide unified PLC code blocks.  Rationale: It is easier to operate and maintain a facility built up using unified objects. |
| C3S.REQ-GR.1040 | The C3S shall be designed using Experimental Physics Integrated Control System (EPICS) software platform with its associated applications and services. Graphical user interfaces shall be implemented in Control System Studio. |
| C3S.REQ-GR.1050 | The C3S shall be structured according to the ESS Breakdown Structures (FBS, LBS).  Rationale: See [3] |
| C3S.REQ-GR.1060 | The electrical drawings of C3S shall be made in Eplan P8 design tool according to ESS standards.  Rationale: See <https://confluence.esss.lu.se/display/EIS/ECAD+Workflow> |
| C3S.REQ-GR.1070 | The OPI screens shall be created according to the ESS OPI Development Style Guide. |
| C3S.REQ-GR.1210 | The C3S automation HW shall be designed with at least 30% of reserves of Power consumptions. |
| C3S.REQ-GR.1220 | The C3S automation HW shall be designed with at least 30% of reserves of Computing capacities. |
| C3S.REQ-GR.1230 | The C3S automation HW shall be designed with at least 30% of reserves of Network bandwidth. |
| C3S.REQ-GR.1240 | The C3S automation HW shall be designed with at least 30% of reserves I/O modules. |

## Functional Requirements

### System related functional requirements

| Id | Text |
| --- | --- |
| C3S.REQ-FRS.1010 | C3S will be structured into 44 units, 30 Elliptical (VB+CM), 13 Spoke (VB+CM) and 1 EndBox. |
| C3S.REQ-FRS.1020 | Units of the a section (Ell.,Spk.,EB) shall be unified concerning system design, HW and SW components. |
| C3S.REQ-FRS.1030 | All units of C3S shall operate independently from each other. |
| C3S.REQ-FRS.1040 | All of the units shall have an own, individual control PLC. |

### Hardware related functional requirements

| Id | Text |
| --- | --- |
| C3S.REQ-FRH.1010 | All automation components and front-end electronics shall be fit in the existing electrical (automation) cabinets on Klystron Gallery. |
| C3S.REQ-FRH.1020 | All electrical components of an Elliptical unit (VB+CM) shall be fit in 1 electrical (automation) cabinet. |
| C3S.REQ-FRH.1030 | All electrical components of a Spoke unit (VB+CM) shall be fit in 2 electrical (automation) cabinet. |
| C3S.REQ-FRH.1040 | All electrical components of the EndBox unit shall be fit in 1 electrical (automation) cabinet. |
| C3S.REQ-FRH.1050 | Cables from field devices shall be routed to the automation cabinets through a field distributor box in case of ValveBoxes and EndBox. |
| C3S.REQ-FRH.1060 | Cables from field devices shall be routed to the automation cabinets directly in case of Cryomodules. |
| C3S.REQ-FRH.1070 | All automation cabinets shall have an own, individual power supply. |

Software related functional requirements

| Id | Text |
| --- | --- |
| C3S.REQ-FRS.1010 | C3S PLC programs shall read measurement data of the field devices of the unit. (Analog inputs) |
| C3S.REQ-FRS.1020 | C3S PLC programs shall control the control valve positioners. (Profibus PA) |
| C3S.REQ-FRS.1030 | C3S PLC programs shall read feedback of control valves. (Profibus PA) |
| C3S.REQ-FRS.1040 | C3S PLC programs shall read values of limit switches. (Digital inputs) |
| C3S.REQ-FRS.1050 | C3S PLC programs shall have at least 50 ms cycle time. |
| C3S.REQ-FRS.1110 | C3S PLC programs shall have an Automatic operation mode, in which the control valves are controlled by SW control loops based on measurement data according to the operation specification. Interlocks are allowed. |
| C3S.REQ-FRS.1120 | C3S PLC programs shall have a Manual operation mode, in which the control valves are controlled by operators via OPI. Interlocks are allowed. |
| C3S.REQ-FRS.1130 | C3S PLC programs shall have a Forced operation mode, in which the control valves are controlled by operators via OPI. Interlocks are not allowed. |
| C3S.REQ-FRS.1200 | C3S PLC programs shall handle interlocks according to the interlock specification. (Interlocks are not specified yet!) |
| C3S.REQ-FRS.1300 | C3S PLCs have to synchronize their clock to a common NTP server provided by ESS. |
| C3S.REQ-FRS.2010 | C3S OPI screens shall visualize the system’s operation mode, all of the measurement data, states of all control valves. |
| C3S.REQ-FRS.2020 | C3S OPI visualization shall have a cycle time at least 1 s. All values shall be refreshed within 1 second. |
| C3S.REQ-FRS.2030 | C3S OPI screens shall be structured, every units shall have an individual screen. |
| C3S.REQ-FRS.2040 | C3S OPI visualization shall use block icon and faceplate HMI objects for all measurements and control loops. |
| C3S.REQ-FRS.2050 | C3S OPI screens shall visualize trends of measured values. |
| C3S.REQ-FRS.2060 | C3S OPI shall have a diagnostic screen with information about automation HW components. |
| C3S.REQ-FRS.2070 | C3S OPI shall have a diagnostic screen with alive bit / counter from each PLCs to monitor the connection. |
| C3S.REQ-FRS.3010 | C3S shall handle alarms generated by PLC programs. |
| C3S.REQ-FRS.3020 | C3S shall generate adequate alarm in case of loss of network connection. |
| C3S.REQ-FRS.3030 | C3S shall generate adequate alarm in case of fieldbus failure. |
| C3S.REQ-FRS.3040 | C3S shall generate adequate alarm in case of I/O module failure. |
| C3S.REQ-FRS.3050 | C3S shall generate adequate alarm in case of an interlock event. |
| C3S.REQ-FRS.3060 | C3S shall generate adequate alarm if a measured process value exceeds the HH or LL limit threshold. |
| C3S.REQ-FRS.3070 | C3S shall generate adequate alarm if a control valve does not reach the desired position within the adjusted monitoring time. |
| C3S.REQ-FRS.3080 | C3S shall generate adequate warning if a measured process value exceeds the High or Low limit threshold. |
| C3S.REQ-FRS.3090 | C3S shall generate adequate warning in case of discrepancy between setpoint and process value as soon the adjusted period is expired. |
| C3S.REQ-FRS.4010 | C3S shall provide data for EPICS Archive services. |

## Conventional Safety Requirements

| Id | Text |
| --- | --- |
| C3S.REQ-CSR.1010 | Protective earth shall be used in case of electronic devices. |

## Interface Requirements

| Id | Text |
| --- | --- |
| C3S.REQ-IR.1010 | The system shall provide the He guard pressure values for the PSS. |
| C3S.REQ-IR.2010 | The system shall provide a binary signal value for RF system that turning on RF is enable. |
| C3S.REQ-IR.2020 | The system shall process a binary signal value from RF system that RF is turned on. |
| C3S.REQ-IR.3010 | The system shall process 2 binary signals from Vacuum system that the Beam Vacuum is OK and the Insulation Vacuum is OK. |
| C3S.REQ-IR.4010 | The system shall process a binary signal status value from Water system. |

# Glossary

| Term | | Definition | | |
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| BEAST  C3S  CCDB  CDR  EPICS  ESS  GUI  ICS  IOC  MPS  OPI  ORR  PDR  PLM  PSS  SAR | | Best Ever Alarm System  Cryomodule and Cryodistribution Control System  Controls Configuration Database  Critical Design Review  Experimental Physics and Industrial Controls System  European Spallation Source  Graphical User Interface  Integrated Control System  Input Output Controller  Machine Protection System  OPerator Interface, EPICS based GUI  Operational Readiness Review  Preliminary Design Review  Product Lifecycle Management  Personnel Safety System  System Acceptance Review |
| TIA  TRR  WP | | Totally Integrated Automation, Siemens Programming Platform  Test Readiness Review  Work Package |
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# references

1. ESS HANDBOOK FOR ENGINEERING MANAGEMENT OF CONTROL SYSTEMS -ESS-0054678
2. ESS Standardised PLC Equipment - ESS-0101132
3. ESS Rules for Technical Information Management - ESS-0050017

Document Revision history

| Revision | Reason for and description of change | Author | Date |
| --- | --- | --- | --- |
| 1 | First issue for CDR#1 | Peter Temesvari | 2019-09-16 |
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