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| Manufacture Spec 1010-V001 |
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# INTRODUCTION

## Background

This document provides the mechanical design, manufacturing and installation requirements for the circulator in Target primary cooling, system 1010 at ESS.

According to Swedish Radiation Safety Authority (SSM) document “Specific Requirements for the ESS Facility in Lund” [2], each mechanical component shall have a specific safety and quality classification. This gives the design requirements and quality assurance measures for the design, manufacture and installation as well as repair of components intended for use in the facility.

The procedure for defining the classifications shall follow the guideline in [4]. The design and construction rules for mechanical components of the main circulator in system 1010 are consistent with the RCC-MRx 2012 Edition [6] code since the design pressure is 13 bar(g) and the design temperature is 250C, and the system has moderate ionization radiation according to the dose calculation report [17].

## Purpose and use of this document

The main purpose of this document is to set design and manufacturing rules including requirements for the circulator in system 1010 in order to comply with the regulatory requirements. The circulator functionality is NOT included here since only the confinement is subject to qualification.

## Applications

The regulations apply to design and manufacturing of pressurized mechanical components;

* The circulator
* Connection flanges
* Pipe system to connected equipment in the main loop
* Connected equipment, e.g. lubricant filter system

## System Requirements and Description

For an overall detailed design description of the cooling system refer to [1] and for technical details for the circulator refer to [5].

## Definitions and Abbreviations

| Abbreviation | Definition |
| --- | --- |
| ASTM | American Society for Testing and Material |
| DCRMC | Design and Construction Rules for Mechanical Components |
| EN | European Norm |
| ETA | European Technical Approval |
| ETAG | European Technical Approval Guidelines |
| MQC3 | Safety Classified Components (Component with quality class MQC3 are subjected to regulatory requirements) |
| MQC4 | Non-Safety Classified Component (Component with quality class MQC4 are not subjected to regulatory requirements) |
| N3RX | RCC-MRx Class 3 of mechanical components |
| NDT | Non-Destructive Testing |
| PT | Penetrant testing |
| QA | Quality Assurance |
| QC | Quality Control |
| RCC-MRx | Design and Construction Rules for Mechanical Components of Nuclear Installations |
| SSM | Strålsäkerhetsmyndigheten (Swedish Radiation Safety Authority) |
| SS | Swedish Standard |
| SWEDAC | Swedish Board for Accreditation and Conformity Assessment |
| VT | Visual testing |
| WPS | Welding Procedure Specification |
| WPQR | Welding Procedure Qualification Record |
| SDD | System description document |

Also refer to ESS Glossary [8].

## Design of mechanical components under regulatory requirements

The requirements for the design of mechanical components that are a part of a safety function and whose failure or malfunction can cause radioactive emissions is described in chapter 5 of the Specific Requirements for the ESS Facility in Lund [2].

Mechanical components has different classifications, which gives design requirements and quality assurance measures applicable for the design, manufacture and installation as well as repair of the component. A classified mechanical component can only be used for the first time when the Certificate of Conformity according to chapter 5, in [2] is approved.

## Classification

The classifications shall follow the document Guideline- Identification and ranking criteria for ESS Safety Functions and Safety Important Components [4]. Safety class and quality class for the circulator is specified in [5].

### Safety Classes

Mechanical components can have different safety classes. The quality of mechanical components must correspond to the requirements of the safety related functions.

### Quality Class

The mechanical components in process systems at ESS has two different quality classes defined as:

* Components with quality class *MQC3* has a radiation shielding/confinement safety function and are safety important components must fulfil regulatory requirements for the design and construction rules for components. The regulatory requirements are based on the RCC-MRx class N3RX, where the design approach is based on Eurocode standards.
* Components with quality class *MQC4* that does not have any radiation shielding/confinement safety functions shall follow design and construction rules strictly based on Eurocode and ISO standards.

# GENERAL PROVISION

## Quality Assurance

The entire supply is subjected to generic quality requirements in accordance with SS-EN ISO 9001. In addition, according to RCC-MRx 2012 Edition [6], all suppliers exercising any activity that might affect the radiological safety function of a component, must identify and implement the processes of the Management System that meets the requirements of the SS-EN ISO 9000 and SS-EN ISO 9001 standards as stipulated and completed in the paragraphs below:

* **§7.3.5 of SS-EN ISO 9001: design verification**

Individuals other than those who perform the design tasks shall perform design verification.

* **§7.3.2 and 7.3.3 of SS-EN ISO 9001: document and data control**

Individuals other than those who established the document or data, before they are distributed shall perform documents and data verification.

* **§7.4.1 of SS-EN ISO 9001: purchasing data**

Regardless of its position in the supply chain, the Supplier shall take necessary provisions to ensure that any purchasing data they issue contains suitable provision for ensuring that the subcontractor fulfills the client’s contractual requirements. All tests and verification results shall be recorded.

* **§7.5.3 of SS-EN ISO 9001: product identification and traceability**

All documents required by this Design Specification Document or stipulated in the purchase order shall be clearly identified and related unambiguously to the products concerned.

* **§7.6 of SS-EN ISO 9001: inspection and testing – general**

Individuals performing inspections required either by this Design Specification Document or the purchase order, shall be different than those performing the activity to be inspected.

* **§8.3 of SS-EN ISO 9001: control of non-conforming product**

Supplier arrangements regarding the processing of non-conformities shall be in accordance with the requirements of section 1.10 in this Document.

Following information must be documented independently of the defined quality class:

1. Organization chart and senior staff responsible for each part of the execution
2. The applicable procedures, methods and work instructions
3. Inspection plan specific to the design
4. The procedure for handling of changes
5. The procedure for handling deviations, requesting authorization and contradictions in the documents
6. Specified milestones or requirements for witnessing of inspections or tests, and any access requirements

## Accreditation

### General

An Accredited Inspection Body according to [2] shall issue a Certificate of Compliance (Operational Readiness) for quality classed mechanical components, summarized in section 1.6 and 8 of this document.

### Requirements for Accredited Inspection Body and Certification Body in the position of third party

The Inspection Body that performs inspection and issues Certificate of Conformance according to requirements in [2], shall be accredited by SWEDAC (or similar national accreditation body) to fulfill Specific Requirements for the ESS-facility in Lund and the requirements in SS-EN ISO/IEC 17011. Accredited Certification Bodies performing services such as certification of quality systems, certification of personnel for joining of material and testing, shall at least fulfil the requirements in SS-EN-ISO/IEC 17021-1/17024.

### Requirements for Accredited Laboratories in the position of third party

SWEDAC (or similar national accreditation body) shall accredit testing Laboratories performing prescribed NDT and services at material laboratories in accordance to SS-EN ISO/IEC 17025.

## Non-Conformance Report

The manufacturer shall obtain FROM the purchasers written approval of any deviations from DCRMC or Equipment Specification.The content of this report shall provide the following information:

* Identification of the component and technical document concerned
* Description of the non-conformance and comparison with the specified criteria
* The solution adopted by the Manufacturer, - corrective action envisaged

There are two types of non-conformance that may be distinguished as follows:

1. In the case where the suppliers own requirements are not followed, the sole responsibility of this non-conformance is the suppliers and must be recorded in writing.
2. In the case where the supplier does not follow the requirements in the DCRMC, the non-conformance shall be remedied as for case 1. As for case 1, the sole responsibility of this non-conformance is with the supplier.

After the review and possible approval of the non-conformance, the purchaser applies for any disposition that may be required by authorities and the Accredited Inspection Body.

## Deviation Report

All deviations shall be processed, corrected and approved before the relevant work operations are finalized.

The Deviation Report allows the non-conformance to be dealt with in accordance with the cases described in section 1.10. In addition to the information provided by the corresponding non-conformance report, the deviation report shall include at least the solution adopted by the supplier.

# DOCUMENTATION AND DOCUMENTATION REQUIREMENTS

## General requirements

Documents directly related to manufacturing, e.g. drawings, may be written in any language if not, in special cases, English or Swedish is required by ESS. All other types of documents shall be written in English.

## Applicable documents

### Equipment Specification Documents

The Equipment Specification documents are a set of documents that presents the essential data for a specific equipment or mechanical component, i.e. design data, operational data, safety class, quality class, cleanness class, dimensions etc. The Equipment Specification documents are together with the Design and Construction Rules for Mechanical Components Document mandatory in the design process.

Equipment Specifications for main circulator in system 1010:

* Circulator Housing
* Main pipe connections
* Pipe connection to filter unit if applicable
* Filter unit housing if applicable
* Anchor plates and anchor bolts
* Embedded cable routing and junction boxes

## Review and Approval Procedure of Documents

The documents must be submitted to ESS for review and approval. All documents must indicate the current revision and status and any changes or modifications made in the documents must be clearly stated in the revision index. The documents are approved once all changes and additions have been entered and may then be used as a basis for manufacture and inspection.

## Required documentation for Standard Components

Required Documents for Components defined as “from catalogue”, i.e. standard components shall have the following documentation prepared:

* **Component Reference File**

This file completely identifies a component and shall contain not only the component description and nomenclature, but also the procurement, manufacture, control and test conditions for the component.

* **Acceptance test report**
* **Validation File** comprising the test program that includes the target results and the validation test report.
* **The sizing report**, if specified in the purchase order
* **The certificate of compliance** in particular certifying compliance with the Component Reference File.

## Required documents for components of mechanical quality class MQC3 & -4

The list of documents that are applicable for components of the mechanical quality class *MQC3* and *MQC4* are listed in Table 1. The contract or a detailed Inspection Plan shall specify which documents that needs to be handed over to the relevant parties.

Note that this section is about components that are NOT an integrated part of an assembly defined as “from catalogue”, i.e. standard component such as a complete compressor or pump, that is described in section 2.2 above.

|  |  |
| --- | --- |
| **REQUIRED DOCUMENTS** | **DEFINITION AND DESCRIPTION** |
| **Design, procurement and manufacturing documents** |  |
| Comprehensive layout and referencing documents | Section 2.6.2 |
| Component parts list | Section 2.6.8 |
| Design and calculation reports | Section 2.6.10 |
| Technical Part and Product Manufacturing Programme | Section 2.6.5 |
| Material Procurement Specification | Section 2.6.6 |
| Description of fabrication shops | Section 2.6.3 |
| Welding data package | Section 2.6.4 |
| Welding inspection and Traceability Document | section 2.6.9 |
| Examination procedures or instructions | Section 7 |
| Examination reports  Information regarding visual and penetrant testing examinations can be stated in the examination reports. | All elements according to template in [15] |
| Non-conformance report and deviation report | section 1.10 respective section 1.11 |
| Test specification, test report and test certificate | Section 7 |
| Certificate of compliance after manufacturing | section 2.6.11 |
| End-of-Design and Manufacturing Report | section 2.6.12 |
| End-of-Installation Report | section 2.6.13 |
| Certificate of compliance after installation | section 2.6.14 |
| **Inspection Plan Documents** |  |
| Inspection plan documents (Before/During Manufacturing) | section 2.4.1 |
| Inspection plan documents (Before/During Installation) |

Table 1 - Required documents for components of quality class MQC3 and MQC4

## Definition and description of required documentation

### Inspection Plan Documents

For all design, manufacturing, assembly and testing activities, it shall be possible to demonstrate that the required level of quality has been adequately defined, that the activities have been performed in a satisfactory manner and that the required degree of quality has been reached. Inspection plan documents go through two successive phases:

* **Before/During Manufacturing (phase 1)**: In this phase, the Inspection Plan document contains a chronological list of the requirements for contractor, expected design, procurement, manufacturing, examination and testing operations for the component before release to ESS. Documents for this phase has been entirely completed and consigned to the End-of-Design and Manufacturing Report, defined in section 2.4.12.
* **Before/During Installation (phase 2)**: In this phase, the Inspection Plan document contains a chronological list of the requirements for contractor for site installation, procurement, installation work, examination and testing operations for the component before installation acceptance. The installation is finalized once the End-of-Installation Report is signed, defined in section 2.4.13.

For components of mechanical quality class *MQC3* and *MQC4*, every operation must have a space provided to mark the operations of which the Manufacturer must notify the ESS representatives and/or the Surveillance Agent. There are three types of "notification points":

1. **A witness point**. This point is marked with the letter "**W**", and is used to designate an operation that the Surveillance Agent or ESS representatives wishes to be notified about.
2. **A hold point**. This point is marked with a letter "**H**" and is used to designate an operation that the Manufacturer is not allowed to perform or begin without the Surveillance Agent's or ESS permission.
3. **A review point**. For each operation important to ensure that the agreed requirements are fulfilled, a space shall be provided to mark with a letter "**R**" the operations of which the ESS representatives or Surveillance Agent must review.

Other four interventions are “designation points”:

1. **Quality Assurance Department Sign-off.** This point is marked with abbreviation "**Q**", and is used to indicate an important checkpoint where the ESS Quality Control Department must sign, in order to proceed further with the project.
2. **Project Manager Sign-off**. This point is marked with letter "**M**", and is used to indicate an important checkpoint where the ESS project manager must sign, in order to proceed further with the project.
3. **Performer**. This point indicates the performer of the task and is marked with letter "**P**" and that the internal review is carried out by appropriate department.
4. **Accredited Laboratory.** This point is marked with letter "**L**", and is used to indicate an important checkpoint where the Accredited Laboratory must perform the testing and then sign, in order to proceed further with the project.

These interventions are applicable for all defined quality classes. The main differences in Inspection Plan documents between the different quality classes are the requirements for operations in which the third-party inspectors are notified and/or present. The required surveillance and review level for mechanical quality classes *MQC3* and *MQC4* are specified in this document, see section 7.1 for more information.

The Inspection Plan documents covering quality control of manufacturing and installation work are described in Figure 1 – Figure 2. The phase before/during manufacturing is covered by Inspection Plan sections IP100 - IP400, while phase before/during installation is covered by sections IP100, IP200, IP500 and IP600. Templates for these two Inspection Plan phases can be found in [21] respectively [22] and shall be used for all the defined quality classes in order to demonstrate that the required level of quality is achieved.

#### Inspection Plan IP100-IP400: Before/During Manufacturing

|  |
| --- |
| Inspection Plan: Before/During Manufacturing  **Inspection prior to manufacturing**  **Inspection of base material**  **Inspection during manufacturing**  **Inspection of completed equipment or sub-assemblies** |

Figure 1 - Inspection Plan before/during manufacturing

The Inspection Plan IP100 covers checkpoints in order to ensure the quality of the manufacturers and design documents.

#### Inspection Plan IP100-IP200, IP500-IP600: Before/During Installation

The Inspection Plan document applicable for installation phase, covers all the necessary quality control checkpoints for the installation work on site.

|  |
| --- |
| Inspection Plan: Before/During Installation  **Inspection prior installation**  **Inspection of base material**  **Inspection during installation**  **Inspection of**  **completed installation** |

Figure 2 - Inspection Plan before/during installation

### Comprehensive layout and referencing documents

The scope is to provide an overall description of a component or a major component part. They shall determine geometrical characteristics and give a comprehensive description of the interconnection of parts from the fabrication and installation point of view.

Documents must contain all necessary information for review and approval that at least consists of:

* System identification, Mechanical Component identification
* Design data in SI-units
* Classification
* Material identification, material standard and the type of material certificate
* WPS and WPQR reference
* Inspection Plan documents reference
* Pressure and Tightness test data
* Calculation Report(s)

### Description of fabrication shops

The document shall consist of at least the following information:

* Purpose and background information
* Work instructions (Laser and water jet cutting, bending, rolling, cutting, turning, milling, drilling, welding, grinding, etc.)
* Welding manual
* Specific project quality plan (Responsibility, purchasing, planning, preparation, inspections etc.)

### Welding Data Package

The content of the Welding Data Package document must include following elements:

1. Reference to an overall or outline drawing
2. A schedule showing welding sequences for the parts of the component
3. A catalogue of all joints used in the component
4. WPS and WPQR

The Welding Procedure Specification (WPS) and Welding Procedure Qualification Record (WPQR) shall contain all necessary data according to SS-EN ISO 15609-1 and requirements specified in SS-EN ISO 15614-1.

### Technical Part and Product Manufacturing Program

Technical Part and Product Manufacturing Program is a document that specifies the main phases in the manufacture and examination of a part or product, so as to demonstrate that the applicable requirements have been met.

### Material Procurement Specification

This document describes the requirements for materials allowed in components with quality class *MQC3 and MQC4.* The materials must follow the requirements specified in section 5 and the corresponding Equipment Specification.

The raw material procurement specification shall include at least the following items:

* Chosen standard incl. used options
* Chemical composition and restrictions
* Mechanical properties and restrictions
* Certifications required
* Name of supplier
* Procurements and procurement follow-up of all materials/product forms

### Filler materials acceptance specification

The filler materials acceptance specification is as a part of the manufacturers Material Procurement Specification document.

The template for Material Overview List [18] is required to be used. The part list should contain at least the following information:

* Item number
* Quantity of the parts
* Designation of the parts
* Main dimension of the parts
* Material of the parts (Material number, respectively material identification)
* Weight
* The type of the Material Certificate according to SS-EN 10204

In addition to the part list, a Material Overview List is required in order to keep record of the received material, see also Figure 3. Components with quality class *MQC3* requires full traceability, i.e. each material received shall have a material certificate.

For *MQC4* components however, the Material Overview List shall only contain a list of all materials related to a specific component with its associated certificates (2.1/2.2 certificate acc. to EN 10204).

|  |
| --- |
| **Material Overview List**  Receiving Inspections, part = 1  **Comprehensive layout**  **FULL MATERIAL TRACEABILITY**  Receiving Inspections, part = 2  Receiving Inspections, part = n  **.**  **.**  **.** |

Figure 3 - Flow-chart - Full material traceability of Confinement quality class components

### Welding inspection and Traceability Document

Manufacturer must prepare a document for Welding Inspection Methods that describes the examination procedures of a component’s welds.

Mechanical components with quality class *MQC3* requires a weld traceability document in order to track each weld specified in the components drawings and the Welding Data Package in section 2.4.4. This documents records the results of each weld that is subject to a specific examination method. The template “Weld Record and Inspection List” [19] or equivalent, shall be used.

Mechanical components with quality class *MQC4* does not require weld traceability but a welding work report is needed containing the applicable WPS numbers and welder sign-off for the performed check of required NDT levels.

#### Welding inspection methods – Requirements for VT

All visual examinations shall be performed in accordance with the requirements specified in section 7.3.1.

#### Welding inspection methods – Requirements for PT

All liquid penetrant examinations shall be performed in accordance with the requirements specified in section 7.3.2. The Liquid Penetrant Examinations methods descriptions shall comply with a minimum extent of information as specified in section 9 of SS-EN ISO 3452-1.

### Design and calculation reports

The design and calculation reports of mechanical components must be done in accordance with the component’s requirements stated in the Equipment Specification and requirements stated in section 4.5 of this document. The calculation report must contain information about loads, calculation methods, applicable drawings, as well as calculation software qualification and other information necessary for verification of the results.

The typical organization of these Design and Calculation Reports is as follows:

* Introduction
* Basic data: description of the geometry of the structures, data at the interfaces and loadings with, where possible, explanatory diagrams.
* Materials
* Specified criteria: summary of the rules and criteria required by the Equipment Specification
* Calculations: this paragraph primarily comprises:
  + - Justification of the modelling used for the geometry and loading calculations,
    - Description and justification of the calculation methods used, calculation results.
* Analysis of the results: this primarily comprises:
  + - Presentation of the analysis method where applicable
    - Transformation of the calculation results and classification of stresses needed to proceed to the comparison with the acceptance criteria
    - Stress concentration factor and justification
    - Comparison of stresses and deformations with allowable values
    - Validity of results, subsequent work of modelling and simplifications
* Conclusions

### Certificate of Compliance after manufacturing

The certificate shall contain at least the following details:

* Supplier's name and address
* Identification of the component concerned; designation, reference, type
* Reference to the technical requirements stipulated in the contract and, where these have not been met, a list of non-conformance and deviation reports stipulated in section 1.10 & 1.11
* In the case of qualified components, the certificate of compliance shall mention both the reference of the Reference File and the revision number in force

### End-of-Design and Manufacturing Report

The End-of-Design and Manufacturing Report shall comprise at least the following according to the Inspection Plan:

1. The certificate(s) of compliance
2. Inspection Plan documents during manufacturing phase
3. The following documents:
4. Examination and test results
5. Welding Inspection and Traceability Document [19]
6. Heat treatment records if applicable
7. Non-conformance reports and deviation reports acc. to section 1.10
8. Documents relating to procurement
9. Material Overview List acc. to section 2.4.8
10. The welding data package acc. to section 2.4.4
11. Filler Material Acceptance Specification acc. to section 2.4.7
12. Manufacturing procedures or instructions acc. to section 2.4.3
13. The as-built drawings

### End-of-Installation Report

The report must contain all documents according to the Inspection Plan incl. Non-Conformance reports and Deviation Reports acc. to section 1.10 respective section 1.11, in order to demonstrate that the final quality of the final assembly that is required by this DCRMC and the applicable The Final Quality Control documentation shall use applicable Inspection Plan as an index.

### Certificate of Compliance after installation

Certificate of Compliance after installation is to certify that the supply complies with the technical and quality requirements stipulated in the detailed inspection plan. This document shall be presented by the installation company in accordance with the requirements depending of the quality class (*MQC3*= SSM [2] and *MQC4* = SS-EN ISO/IEC 17050-1).

For quality class *MQC3*, the Certificate of Compliance shall be issued by an Accredited Inspection Body as described in section 1.9. The company performing the installation work shall issue the certificate for components in quality class MQC4.

# APPLICABLE STANDARDS

## Swedish Regulatory Requirements

Swedish Radiation Safety Authority’s document SSM 15-36 [2] gives the specific requirements for ESS Facility. For more information about the importance of SSM 15-36 [2], see section 1.1.

## Design and construction standards

Design, material selection, manufacturing, inspection and testing of the mechanical components must be fulfilled by requirements of the Standards mentioned in this Mechanical Design Specification. These standards have been carefully chosen in order to cope with the RCC-MRx 2012 Edition [6] design and construction code for Nuclear Installations.

The appropriate versions of the standards referenced in this Mechanical Design Specification are listed in section 3.3 of this document.

## List of applicable standards

|  |  |  |
| --- | --- | --- |
| **QUALITY MANAGEMENT AND QUALITY ASSURANCE** | | |
| **Standards and norms** | **Date** | **Titles** |
| SS-EN ISO 9000 | 2005 | Quality management systems - Fundamentals and vocabulary |
| SS-EN ISO 9001 | 2009 | Quality Management Systems - Requirements |
| SS-EN ISO/IEC 17050-1 | 2010 | Conformity assessment - Supplier's declaration of conformity - Part 1: General requirements |
| SS-EN ISO/IEC 17011 | 2005 | Conformity assessment - General requirements for accreditation bodies accrediting conformity assessment bodies |
| SS-EN-ISO/IEC 17021-1 | 2015 | Conformity assessment - Requirements for bodies providing audit and certification of management systems - Part 1: Requirements |
| SS-EN-ISO/IEC 17024 | 2012 | Conformity assessment - General requirements for bodies operating certification of persons |
| SS-EN-ISO/IEC 17025 | 2005 | General requirements for the competence of testing and calibration laboratories |
| **DESIGN RULES** | | |
| **Standards and norms** | **Date** | **Titles** |
| RCC-MRx | 2012 | Design and construction rules for mechanical components of nuclear installations |
| EN-13445 |  |  |
| SS-EN 1993 (Eurocode 3) | - | Eurocode 3: Design of steel structures  (All applicable parts of Eurocode 3) |
| SS-EN 13480 | 2014 | Metallic industrial piping- Part 1: General  Metallic industrial piping- Part 2: Materials  Metallic industrial piping- Part 3: Design and calculation  Metallic industrial piping- Part 4: Fabrication and installation  Metallic industrial piping- Part 5: Inspection and testing |
| SS-EN 13155 | 2009 | Cranes -Safety - Non-fixed load lifting attachments |
| SIS-CEN/TS 1992-4-1 | 2010 | Design of fastenings for use in concrete - Part 4-1: General |
| SIS-CEN/TS 1992-4-2 | 2010 | Design of fastenings for use in concrete - Part 4-2: Headed Fasteners |
| ETAG 001 | 2013 | Guideline for European Technical Approval  of metal anchors for use in concrete |
| **WELDING OPERATIONS AND INSPECTIONS** | | |
| **Standards and norms** | **Date** | **Titles** |
| SS-EN ISO 15609-1 | 2004 | Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 1: Arc welding |
| SS-EN ISO 15613 | 2004 | Specification and qualification of welding procedures for metallic materials - Qualification based on pre-production welding test |
| SS-EN ISO 3834-2 | 2005 | Quality requirements for fusion welding of metallic materials - Part 2: Comprehensive quality requirements |
| SS-EN ISO 3834-3 | 2005 | Quality requirements for fusion welding of metallic materials - Part 3: Standard quality requirements |
| SS-EN ISO 15614-1 | 2012 | Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys |
| SS-EN ISO 9606-1 | 2013 | Qualification testing of welders - Fusion welding - Part 1: Steels |
| SS-EN ISO 14732 | 2013 | Welding personnel - Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials |
| SS-EN ISO 9712 | 2012 | Non-destructive testing - Qualification and certification of NDT personnel |
| SS-EN 13018 | 2004 | Non-destructive testing - Visual testing - General principles |
| SS-EN ISO 17637 | 2011 | Non-destructive testing of welds – Visual testing of fusion-welded joints (ISO 17637:2003) |
| SS-EN ISO 3452-1 | 2013 | Non-destructive testing - Penetrant testing - Part 1: General principles |
| SS-EN ISO 3651-2 | 1998 | Determination of resistance to intergranular corrosion of stainless steels - Part 1: Austenitic and ferritic-austenitic (duplex) stainless steels - Corrosion test in media containing sulfuric acid |
| SS-EN ISO 23777 | 2015 | Non-destructive testing of welds - Penetrant testing - Acceptance levels (ISO 23277:2015) |
| SS-EN ISO 5817 | 2014 | Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections (ISO 5817:2014) |
| **MATERIALS** | | |
| **Standards and norms** | **Date** | **Titles** |
| SS-EN 10204 | 2005 | Metallic products - Types of inspection documents |
| SS-EN 10028-7 | 2007 | Flat products made of steels for pressure purposes - Part 7: Stainless steels |
| SS-EN 10088-2 | 2014 | Stainless steels - Part 2: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes |
| SS-EN 10088-3 | 2014 | Stainless steels - Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes |
| SS-EN 10088-4 | 2009 | Stainless steels - Part 4: Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for construction purposes |
| SS-EN 10088-5 | 2009 | Stainless steels - Part 5: Technical delivery conditions for bars, rods, wire, sections and bright products of corrosion resisting steels for construction purposes |
| SS-EN 10272 | 2007 | Stainless steel bars for pressure purposes |
| SS-EN 10294-2 | 2012 | Hollow bars for machining - Technical delivery conditions - Part 2: Stainless steels with specified machinability properties |
| SS-EN 10216-5 | 2013 | Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 5: Stainless steel tubes |
| SS-EN 10217-7 | 2014 | Welded steel tubes for pressure purposes - Technical delivery conditions - Part 7: Stainless steel tubes |
| SS-EN 10296-2 | 2007 | Welded circular steel tubes for mechanical and general engineering purposes - Technical delivery conditions - Part 2: Stainless steel |
| SS-EN 10297-2 | 2005 | Seamless steel tubes for mechanical and general engineering purposes - Technical delivery conditions - Part 2: Stainless steel |
| SS-EN 10222-5 | 2000 | Steel forgings for pressure purposes - Part 5: Martensitic, austenitic and austenitic-ferritic stainless steels |
| SS-EN 10250-4 | 1999 | Open die steel forgings for general engineering purposes - Part 4: Stainless steels |
| SS-EN 10213 | 2008 | Steel castings for pressure purposes |
| SS-EN 10283 | 2010 | Corrosion resistant steel castings |
| SS-EN 10269 | 2008 | Steels and nickel alloys for fasteners with specified elevated and/or low temperature properties |

Table 2 - List of applicable standards

# DESIGN CRITERIA

The design procedure of the circulator mechanical components shall follow sound engineering practice.

## Requirements

Refer to [1] SDD-req Target helium cooling systems and [5] for the circulator.

## Code requirements

* Standard components that are subjected to CE mark requirements shall comply with the European Directive for machinery safety in addition to this DCRMC
* In addition to the requirements of this DCRMC, manufactured structural steel components shall comply with the European standards appropriate for the design, i.e. SS-EN 1993 series for steel structures, SS-EN 13480 for industrial steel pipes

The procedure for design approach of mechanical components is defined in Figure 4. The component’s Equipment Specification for both *MQC3* and *MQC4* quality class shall specify the applicable code that must be considered during the design process.



Figure 4 - Design approach for mechanical components

## Requirements for Fabrication

All mechanical work has to be performed in a professional workmanship and due care shall be exercised. The Following shall be taken into consideration:

* Corners, edges and transitions must be smooth
* The number of welds shall be minimized
* Welds shall be located such as to consider accessibility during welding (taking preheating into account) and minimization of weld residual stresses. Further on, they shall be carried out in a way that they can be cleaned and decontaminated easily
* Lifting lugs and other components that are necessary for transportation or lifting of equipment, shall comply with SS-EN 13155

## Maintenance and Service Inspection Requirements

Mechanical components must be designed in such a way that it should be easy to perform maintenance, inspection and decontamination. Parts intended for continuous maintenance and repairs must be designed so that they are easily removable and fixable.

## Structural verification

All loads (static and dynamic) that are expected to occur over the facility lifetime or that are associated with postulated design basis accidents should be identified and grouped according to their probability of occurrence. For mechanical components with quality class *MQC4*, structural verification shall be made in accordance to the rules specified in the applicable Equipment Specification.

All calculations made to check the rules contained in the Design Basis [5] and/or Equipment Specification, shall be written up in Design Calculation Reports.

# MATERIAL REQUIREMENT

## General

Materials shall be selected appropriately for the intended purpose and condition. The proper material shape (plates, forgings etc.) has to be selected for the corresponding loads.

Selection and procurement of the material shall be made according to Table 3 in section 5.4 to the maximum extent possible. For any other materials, not belonging to the austenitic stainless steel group, a procurement and elaboration concept must be sent to ESS for validation.

The use of different materials within a component shall be minimized to the necessary extend. When choosing an appropriate material, all kinds of corrosion attacks, like e.g. crevice corrosion, pitting corrosion, atmospheric corrosion, intergranular corrosion, galvanic effects and stress corrosion have to be considered. In case different materials are used together, the different thermal expansions have to be considered concerning their effect due to stresses, deformations, pre-stressing and changes of clearances.

## Material procurement

ESS general document for procurement of materials of classified and non-safety classified mechanical components [12], defines the conditions for procurement of metal products or parts (castings, forgings, plates, tubes, laminated bars, etc.) based on the Standards referenced in Table 3 of section 5.4. The Equipment Specification defines the type of products and the grades selected. The material procurement must be done in accordance with the requirements in this section.

Before the procurement of materials starts, a Material Procurement Specification Document must be produced in accordance with the requirements in section 5.2. This document is subjected for review and ESS approval before the procurement is started.

## Steel material selection

The table below shows some examples of preferred steel qualities to be used.

|  |  |
| --- | --- |
| **Product shape** | **Applicable material standards** |
| Plates | SS-EN 10028-7  SS-EN 10088-2  SS-EN 10088-4 |
| Bars | SS-EN 10272  SS-EN 10088-3  SS-EN 10088-5  SS-EN 10294-2 |
| Tubes, pipes | SS-EN 10216-5  SS-EN 10217-7  SS-EN 10296-2  SS-EN 10297-2 |
| Forging | SS-EN 10222-5  SS-EN 10250-4 |
| Casting | SS-EN 10213  SS-EN 10283 |
| Studs, screws, threaded rods and nuts | SS-EN 10269 |

Table 3 - Matrix of standards for stainless steel

### Surface examination – Surface defects

Material surfaces shall be thoroughly examined during all phases of production and machining to check the soundness of the metal. The part shall be sound and free of scale, strings, tears, nicks or other defects.

A visual examination shall be performed on all parts and this may be followed by a liquid penetrant examination if specified in the Equipment Specification or in the Inspection Plan. The examinations are performed in accordance with the Examination Methods defined in the ESS general document for procurement of materials of classified and non-safety classified mechanical components [12].

## Material certificates and declaration of performance

Materials must be ordered with a specific control and delivered with a certificate according to SS-EN 10204. Post-installed anchor bolts shall be ordered with declaration of performance in accordance to the specific ETA on the basis of ETAG 001.

Any deviation from the requirements in this section shall be specifically listed in the applicable Equipment Specification.

### Material certificate – Type 3.1

Mechanical components with quality class *MQC3* requires a type 3.1 material certificate acc. to SS-EN 10204, regardless if it is a critical load bearing component or not.

For non-safety classified components *(MQC4)*, the type 3.1 certificate is only required for critical load bearing elements. The calculation study of the design or the applicable Equipment Specification shall identify these elements.

### Material certificate – Type 2.1/2.2

Mechanical components with quality class *MQC4*, not identified as critical load bearing component, shall be supplied with type 2.1 certificates acc. to SS-EN 10204.

Mass-produced mechanical components which are not to be machined after purchase, such as fasteners, shall be supplied with type 2.1 certificate.

Some mechanical components which consist of electrical parts, i.e. sensors and other measuring devices, shall be supplied with test report type 2.2 acc. to SS-EN 10204.

## Polymers material selection

The overall service life of polymers is dependent upon the total amount of radiation absorbed. PEEK, PI, EPDM and other polymers with aromatic molecules are more resistant than polymers with aliphatic molecules. When choosing polymer materials, it should be considered to choose a material with highest radiation resistance possible in order to lower the need of exchange.

## Lubricants

The lubricants used must be classified, approved and registered in chemical data-base of the ESS plant before implementation.

# MANUFACTURING OPERATIONS

The manufacture of mechanical components can only commence after conclusion of review and approval of the documents necessary for manufacturing. For the list of required documents, see section 2.

## General requirements

This chapter states the minimum requirements for manufacturing, installation and welding of components with quality class *MQC3* and *MQC4.* Companies manufacturing safety classified mechanical components, shall establish and use manufacturing documentation approved by the licensee. The manufacturing documents shall comply with the requirements in section 2 and the codes and standards listed in this section.

## Welding requirements

The general requirements for quality assurance of welding operations based on the mechanical quality class as specified in the corresponding Equipment Specification is as follow:

* **Components with quality class MQC3:**

The manufacturer is expected to be qualified acc. to SS-EN ISO 3834-2: Comprehensive Quality Requirements.

* **Components with quality class MQC4:**

The manufacturer is expected to be qualified acc. to SS-EN ISO 3834-3: Standard Quality Requirements.

The Welding Operations of a component must comply with the requirements stated in this section, based on the Environmental conditions and the components mechanical quality class as defined in the corresponding Equipment Specification.

### Qualification of welders and weld operators

The qualification of welders, welding procedures controls and Non Destructive Testing personnel are specified in Table 4.

|  |  |  |
| --- | --- | --- |
| **Title** | **Standard** | **Notes / Requirement level** |
| Welding Procedure Control | SS-EN ISO 15614-1 | This standard is applicable for specification and qualification of welding procedures for metallic materials. |
| Welding Testing Outcome | SS-EN ISO 15613 | This standard is applicable for specification and qualification of welding procedures for metallic materials. |
| Welders Qualification | SS-EN ISO 9606-1 | This standard specifies the requirements for qualification testing of welders for fusion welding of steels. |
| Qualification testing of welding operators and weld setters | SS-EN ISO 14732 | This standard specifies requirements for approval of welding operators for fusion welding and resistance weld setters for fully mechanized and automatic welding processes of metallic materials. |
| NDT Personnel | SS-EN ISO 9712 | NDT Personnel must be qualified and certified according to standard SS-EN ISO 9712, Level 2. |

Table 4 - Qualification of welders and weld operators

## Heat treatment

Heat treatment shall be carried out by companies with the necessary technical resources and by staff that have training, practice, experience and technical knowledge of the tasks. Companies performing heat treatment of welding and material shall work under a quality system SS-EN ISO 3834-2. For material manufacturers, heat treatment shall be part of the certified quality system. Heat treatments of manufactured materials must comply with the requirements for corresponding material standard as defined in Table 3.

## Processing of Austenitic Material

During storage of the materials, before and during the production of the component, austenitic and ferritic materials must be distinctly separated. This also applies to the appropriate tools and equipment required for the component production. Stainless steel welds must be cleaned with stainless steel wire brushes and iron-free abrasive discs that are not used on carbon steel material. All cleaners and solvents used on stainless steel shall be free of halogen. Depending on the component cleanness class which is defined in the corresponding Equipment Specification, additional requirements coming from the cleaning specification, defined in section 7.5 shall be fulfilled.

## Surface Conditions

The surface of the semi-finished products shall be free of scale, oxides, dirt, rust, oil, grease or other foreign materials.

# INSPECTIONS AND TESTING

## Required surveillance and review level

The Inspection Plan Documents, as described in section 2.4.1, defines the requirements for manufacturer qualification, material procurement, fabrication, inspection and testing.

The required surveillance and review level by third party for mechanical quality classes *MQC3* and *MQC4* are specified in Table 5. This information can also be seen in the complete Inspection Plan document templates for manufacturing/installation phase in ESS-0044705 [21] respective ESS-0044705 [22].

|  |  |  |
| --- | --- | --- |
| **INSPECTIONS (performed by third party)** | **Mechanical Quality Class** | |
| MQC3 | MQC4 |
| Quality assurance requirements for welding | AIB | - |
| Qualification of welding procedures | AIB | - |
| Qualification of welders and weld operators | AIB | - |
| General arrangement drawings / Detailed drawings | AIB | - |
| Calculation reports | AIB | - |
| Inspection Plan documents | AIB | - |
| Weld inspection and traceability | AIB | - |
| Visual tests and dimensional inspections of welds | AIB | - |
| Penetrant tests of welds | AL | AL |
| Extent of additional NDT inspections (if applicable) | AL | AL |
| Dimensional inspection | AIB | - |
| Marking of components and material identification (if applicable) | AIB | - |
| Leak testing (if applicable) | AIB | - |
| End of manufacturing report | AIB | - |
| End of Installation Report | AIB | - |
| Certificate of Compliance (Operational readiness) | AIB | - |

AIB: Accredited Inspection Body

AL: Accredited Laboratory

Table 5 - Inspections and involvement of third-party

## Inspection of welding

Inspection of welds before/during/after welding work shall be performed in accordance to the requirements specified in SS-EN ISO 3834-2/3, depending on the mechanical quality class of the component.

## Non-Destructive Testing (NDT)

Personnel performing non-destructive testing, must be qualified according to standard SS-EN ISO 9712. Outside Europe, certification granted by an independent organization, following an equivalent standard could be used once approved by the ESS.

### Visual Testing (VT)

Visual testing (VT) of welds shall be performed in accordance with the requirements in SS-EN ISO 17637. Personnel responsible for visual examinations shall be chosen either from non-destructive test operators or from personnel familiar with the manufacture and fabrication processes for items under examination. In accordance with standard SS-EN ISO 9712, examination personnel shall provide proof that their eyesight is satisfactory. The visual acuity shall be proven annually by a certificate.

### Penetration Testing (PT)

Personnel performing liquid penetrant examination of welds, must be qualified according to requirements specified in section 7.3. The examination procedure described in standard SS-EN ISO 3452-1 shall be applied.

### Acceptance criteria and extent of non-destructive testing

The acceptance criteria for the performed welding operations are based on the functional requirements according to [1], i.e. leak rate requirements, long service life requirements, long maintenance intervals requirements, load bearing sections etc. Table 6 specifies the required quality level, acceptance level and extent of NDT for the two identified quality classes *MQC3* and *MQC4*. If a mechanical component specifically requires higher quality than the stated levels in Table 6, it shall be clearly specified in the applicable Equipment Specification.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Quality Class** | | **Visual Testing (VT)** | | **Penetrant Testing (PT)** | |
| Quality level acc. to  SS-EN ISO 5817 | Extent of VT1 | Acceptance level acc. to SS-EN 23277 | Extent of PT1 |
| *MQC3* | | Quality level C | 100% | Level 1 | 100% |
| *MQC4* | Sections with special requirements2 | Quality level C | 100% | Level 2 | 10% |
| Other sections | Quality level D | 100% | - | - |

1: Percentage in the table refers to the aggregate weld length of all the component’s welds

2: Leak rate requirements, long service life requirements, long maintenance intervals requirements, load bearing sections etc.

Table 6 - Acceptance criteria for NDT

## Leak testing

The circulator shall be leak tested in accordance with the SS-ISO 10648-2 standard, where constant pressure method shall be chosen.

## Cleanliness inspection

### General

The cleanliness requirements defined in this section follows the requirements in RCC-MRx SECTION III - Tome 5 – RF 6000.

### Cleanliness classification and definition

Following shall be considered during both manufacturing and installation phase:

* Welds shall always be cleaned to restore corrosion resistance.
* Reduce the likelihood of pitting by removing weld splatter, brushing with a stainless steel wire brush or pickling the stainless steel to remove unwanted welding products (Strongly oxidizing chloride-containing reagents such as ferric chloride should be avoided. Instead, a pickling bath or a pickling paste, both containing a mixture of nitric acid and hydrofluoric acid should be used).
* After pickling thorough rinsing with water should be carried out.
* Weld NDT liquid shall be properly removed
* All wiping should be done with clean white lint-free rags of cotton
* Use workshop areas and tools that are dedicated to stainless steel (avoiding pick-up of carbon steel particles, copper, zinc, lead and other heavy metals).

## Marking of components and material identification

The marking of mechanical components with defined quality class *MQC3* shall be performed with clearly visible data and with appropriated methods. All parts of a component shall be marked with ESS unique number as specified in the general ESS part marking document ESS-0011947 [9]. The marking information shall be specified on the component drawing or the purchase order.

The marking of Mechanical Components with defined quality class MQC4 shall be performed in order to maintain the installation traceability. The design engineer determines the extent of the component’s marking. The marking shall be clearly visible and performed with appropriated methods in acc. to the ESS-0011947 [9]. It shall be specified on the component drawing or the purchase order.

## Factory Acceptance Test

The FAT shall demonstrate that the component and all related auxiliary systems fulfill the required and specified properties in the Equipment Specification and in this DCRMC document.

The manufacturer is responsible to prepare a detailed test procedure and to demonstrate that the component meets the requirements that are set in accordance with the ESS generic document for Factory and Site Acceptance Tests [16].

## Packing, transportation and storage

The packing, transportation and storage of components must comply with the requirements of ESS generic document [10].

## Site Acceptance Test

After installation, SAT shall demonstrate that the component and all related auxiliary systems are installed properly at site and interfaces with other systems and peripherals in its working environment. SAT could also be a part of the incoming inspection in order to ensure that no damage has occur during the transportation.

The manufacturer is responsible to prepare a detailed test procedure in accordance with the ESS generic document for Factory and Site Acceptance Tests [16].

## ESS personnel training

ESS operators shall receive proper training of the equipment. This shall be specified in the contract for each mechanical component included in the main circulator in system 1010.

# CRITERIA FOR OPERATIONAL READINESS

According to Swedish Radiation Safety Authority (SSM) document “Specific Requirements for the ESS Facility in Lund” [2], section 1, E3b following is applicable before the operational readiness for safety classified components:

The verification of the operational readiness for the design, redesign, manufacturing, installation or repair consists of approved operational test programs, approved installation inspection certificate and approved installation inspection. Functional testing should reflect the conditions expected to prevail when the affected safety function is exploited. If the full functionality check is not possible or reasonable, there should be an analysis before the commissioning is performed that shows that the adequate verification of the safety function exists, despite the limited possibility to check them.

# PROCESS AND INSTRUMENT DRAWINGS (P&ID)

Process and instrumentation drawings are specified below with their specific document number:

* ESS-0040854 P&ID Target primary cooling
* ESS-0040855 PFD Target helium cooling systems overview

# REFERENCES

[1] ESS-0012524 SDD-req Target helium cooling systems (requirements)

[2] Swedish Radiation Safety Authority, Document no.: 15-36 Specific Requirements for the ESS-Facility in Lund, 2015-07-01

[4] ESS-0016468 Guideline- Identification and ranking criteria for ESS Safety Functions and Safety Important Components

[5] ESS-0051820 Procurement specification Technical description Target primary cooling loop circulator

[6] RCC-MRx 2012 Edition, Design and construction rules for mechanical components of nuclear installations

[7] ESS-0012527 SDD-sol Target helium cooling systems (system description)

[8] ESS-0000385 ESS Glossary

[9] ESS-0011947 STD Parts Marking

[10] ESS-0025721 STD Packing, Transportation and Storage

[11] ESS-0007476 ESS Technical Design Report

[12] ESS General Material Procurement Specification for safety classified and non-safety classified mechanical components

[13] ESS General Welding Specifications for safety classified and non-safety classified mechanical components

[14] ESS General Manufacturing Operations Specifications for safety classified and non-safety classified mechanical components

[15] ESS General Examination Methods Specification for safety classified and non-safety classified mechanical components

[16] ESS-0000465 Factory and Site Acceptance Tests

[17] ESS-0036141 Dose calculation report for Target cooling systems

*[18]* *ESS-0026632 Material Overview List [TEMPLATE]*

*[19]* *ESS-0026633 Weld Record and Inspection List [TEMPLATE]*

*[20] ESS-0026586 End-of-Installation Report [TEMPLATE]*

*[21]* *ESS-0044705 Inspection Plan IP100-IP400: Before/During Manufacturing TEMPLATE]*

*[22] ESS-0044706 Inspection Plan IP100, IP500-IP600: Before/During Installation [TEMPLATE]*