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|  | Name | **Role/Title** |
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INTRODUCTION

An Equipment Specification (or corresponding type of specification) consists of a Design Basis Mechanical (Swedish: Konstruktionsförutsättningar för Mekaniska anordningar, KFM) and a Design Specification Mechanical (Swedish: Konstruktionsspecifikation för Mekaniska anordningar, KSmek).

This document constitutes the Design Basis for system 1067, *Covers, Penetrations and Monolith Vessel and system 1076, Proton Beam Window Port Block and Vessel*.  
The information given herein constitutes the input required for the structural assessment of the system or component.

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# System Description

For detailed description see reference to System description and/or project specific description/specification, see [1] and [2].

## P&ID

See P&ID for system 1076 [3].

## System parts

The systems are divided into a number of parts according to Appendix A.

* System part A: Lower and Medium Vessel (LMV)
* System part B: Connection Ring (CC)
* System Part C: Vessel Head (Head)
* System Part D: Proton Beam Window Port Block (PBWPB)
* System Part E: Proton Beam Window Vessel (PBWV)
* System Part F: Moderator Cap, including flange (MCF)
* System Part G: Target Monitoring Cap, including flange (TMC)
* System Part H: Area around the connection between the Connection pipe and the Monolith Vessel (CA)

APPENDIX A SYSTEM PARTS only reports current system limitations and should not be considered complete as a Piping and Instrumentation Diagram (P&ID). For current version see P&ID [3] or the Process Flow Diagram (PFD) [4].

# LEVEL OF IRRADIATION

Calculation of irradiation for the system is found in [5], section 6.3.2.

Irradiation for all parts (System parts A-G) of system 1067 and 1076 is considered negligible according to RCC-MRx [6], Subsection Z, Appendix A3.3S.33.

# APPLICABLE CODE & CLASSIFICATION

The design work started in accordance to the code framework for safety classified mechanical components (MQC1-3), i.e. RCC-MRx, [6]. However, in the final stage of detail design, the classification was changed to MQC4 [7], [8] and [9].

As a result, EN 13445 and harmonized standards apply for the following stages (installation and operation.)

Since the system parts, described in 1.2, are manufactured in accordance with EN13445, it needs to be demonstrated that the design fulfils the analysis requirements of EN13445-3. If a complete analysis according to RCC-MRx has been conducted, a delta-analysis is sufficient to demonstrate compliance with EN 13445-3.

# LOADS & OPERATING CONDITIONS

## Design pressure and design temperature

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **System part** | **PD (bar(g))** | **TD (°C)** | **Ref.** | **Remarks** |
| A – LMV | 1 / Vacuum | 80 | [10], [11], [12] |  |
| B – CC | 1 / Vacuum | 80 | [10] , [11], [12] |  |
| C – Head | 1 / Vacuum | 80 | [10] , [11], [12] |  |
| D – PBWPB | 1 / Vacuum | 80 | [10] , [11], [12] | PD for cooling channels = 6 bar(a) |
| E – PBWV | 1 / Vacuum | 80 | [10] , [11], [12] |  |
| F – MCF | 1 / Vacuum | 80 | [10] , [11], [12] |  |
| G – TMC | 1 / Vacuum | 80 | [10] , [11], [12] |  |
| H – CA | 1 / Vacuum | 200 | [10] , [11], [12] | Preliminary value |

**Table 1. Design pressure and temperature.**

## Operating pressure and operating temperature

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **System part** | **PO (bar(g))** | **TO (°C)** | **Ref.** | **Remarks** |
| A – LMV | Vacuum | 50 |  |  |
| B – CC | Vacuum | 50 |  |  |
| C – Head | Vacuum | 50 |  |  |
| D – PBWPB | Vacuum | 50 |  |  |
| E – PBWV | Vacuum | 50 |  |  |
| F – MCF | Vacuum | 50 |  |  |
| G – TMF | Vacuum | 50 |  |  |
| H – CA | Vacuum | 150 |  | Preliminary value |

**Table 2. Operating pressure and temperature.**

## Maintenance pressure and maintenance temperature

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **System part** | **PM (bar(g))** | **TM (°C)** | **Ref.** | **Remarks** |
| A – LMV | 0 | 35 |  | Max temperature guaranteed by HVAC |
| B – CC | 0 | 35 |  | Max temperature guaranteed by HVAC |
| C – Head | 0 | 35 |  | Max temperature guaranteed by HVAC |
| D – PBWPB | 0 | 35 |  | Max temperature guaranteed by HVAC |
| E – PBWV | 0 | 35 |  | Max temperature guaranteed by HVAC |
| F – MCF | 0 | 35 |  | Max temperature guaranteed by HVAC |
| G – TMF | 0 | 35 |  | Max temperature guaranteed by HVAC |
| H – CA | 0 | 35 |  | Max temperature guaranteed by HVAC |

**Table 3. Maintenance pressure and temperature.**

## Loads at SF1 operating conditions

SF1 operating conditions are normal operating conditions.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Load** | **Description** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **Ref.** | **Remarks** |
| PO | Operating Pressure | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | [1] |  |
| TO | Operating Temperature | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | [1] |  |
| DW | Dead Weight | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |  | Loads associated with masses of mechanical devices. Refer to drawings for systems 1067 and 1076. |
| SF1\_NL | Nozzle loads |  | ✓ | ✓ | ✓ | ✓ |  |  | ✓ | Pipe support analysis, not available today | Demonstrating that nozzle is stronger than connecting pipe is acceptable as an alternative to formal stress analysis. |

**Table 4. Loads at SF1 operating conditions.**

## Normal operating incidents- loads at SF2 operating conditions

SF2 operating conditions are normal operating incidents, including maintenance.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Load** | **Description** | **A** | **B** | **C** | **D** | **E** | | **F** | **G** | **H** | **Ref.** | **Remarks** |
| SF2\_ML | Normal Maintenance Loads | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | [14] | Loads from equipment, Lifting actions, Machinery actions, Placement actions, Heavy transports, Exchange of heavy components, Process related actions. |
| SF2\_NL | Nozzle loads |  | ✓ | ✓ | ✓ | | ✓ |  |  | ✓ | Pipe support analysis, not available today | Demonstrating that nozzle is stronger than connecting pipe is acceptable as an alternative to formal stress analysis. |
| SF2\_EQ | Expected Seismic event, H2 | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | [16] | Ref [16] reports H4 seismic spectra. The H2 seismic spectra may be taken 5 % of the H4 spectra[[1]](#footnote-1). |

**Table 5. Loads at SF2 operating conditions.**

## Loads at SF3 operating conditions

There is not a demand for SF3 verification due to radiological aspects or governmental requirements, however due to economical and operational demands the design shall withstand a H3 event.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Load** | **Description** | **A** | | **B** | | **C** | | **D** | | | **E** | | **F** | **G** | **H** | **Ref.** | **Remarks** |
| SF3\_NL | Nozzle loads |  | ✓ | | ✓ | | ✓ | | | ✓ | | |  |  | ✓ | Pipe support analysis, not available today | Demonstrating that nozzle is stronger than connecting pipe is acceptable as an alternative to formal stress analysis |
| SF3\_EQ | Seismic event | ✓ | | ✓ | | ✓ | | ✓ | | | ✓ | | ✓ | ✓ | ✓ | [16] | Ref [16] reports H4 seismic spectra. The H3 seismic spectra may be taken 20 % of the H4 spectra[[2]](#footnote-2). N.B. This is not a formal requirement but an additional requirement. |
| SF3\_TB | Confined System break, release of inventory | ✓ | ✓ | | ✓ | | ✓ | | ✓ | | | ✓ | | ✓ | ✓ | [11] |  | |

**Table 6. Loads at SF3 operating conditions.**

## Loads at SF4 operating conditions

There is not a demand for SF4 verification due to radiological aspects or governmental, economical or operational requirements. The SF4 shall be simulated but with no demands on integrity.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Load** | **Description** | **A** | **B** | **C** | **D** | **E** | | **F** | **G** | **H** | **Ref.** | **Remarks** |
| SF4\_NL | Nozzle loads |  | ✓ | ✓ | ✓ | ✓ |  | |  | ✓ | Pipe support analysis, not available today | Demonstrating that nozzle is stronger than connecting pipe is acceptable as an alternative to formal stress analysis. |
| SF4\_EQ | Seismic event, H4 | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | [16] | The design does not have to withstand this load. However, it shall be analysed. |

**Table 7. Loads at SF4 operating conditions.**

# LOAD COMBINATIONS

The sum of the normal operating load group shall be combined with each transient load.

## Load combinations system part A

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Combination** | **Rule for combination** | **Event class** | **Criteria level** | **Remarks** |
| A01 | (PD+TD+DW) | SF1 | A |  |
| A02 | (PO+TO+DW) | SF1 | A |  |
| A03 | (PO+TO+DW) + SF2\_EQ | SF2 | A |  |
| A04 | (PM+TM+DW) +SF2\_ML | SF2 | A |  |
| A05 | (PO+TO+DW) +SF3\_EQ | SF3 | C |  |
| A06 | (PO+TO+DW) +SF3\_EQ + SF3\_TB | SF3 | C |  |
| A07 | (PO+TO+DW) +SF3\_TB | SF3 | C |  |
| A08 | (PO+TO+DW) +SF4\_EQ | SF4 | D |  |

**Table 8. Load combinations for system part A**

## Load combinations system part B

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Combination** | **Rule for combination** | **Event class** | **Criteria level** | **Remarks** |
| B01 | (PD+TD+DW) | SF1 | A |  |
| B02 | (PO+TO+DW+SF1\_NL) | SF1 | A |  |
| B03 | (PO+TO+DW+SF2\_NL) | SF2 | A |  |
| B04 | (PO+TO+DW+SF2\_NL) + SF2\_EQ | SF2 | A |  |
| B05 | (PM+TM+DW) +SF2\_ML | SF2 | A |  |
| B06 | (PO+TO+DW+SF3\_NL) + SF3\_TB | SF3 | C |  |
| B07 | (PO+TO+DW+ SF3\_NL) +SF3\_EQ + SF3\_TB | SF3 | C |  |
| B08 | (PO+TO+DW+ SF4\_NL) | SF4 | D |  |
| B09 | (PO+TO+DW+ SF4\_NL) +SF4\_EQ | SF4 | D |  |

**Table 9. Load combinations for system part B**

## Load combinations system part C

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Combination** | **Rule for combination** | **Event class** | **Criteria level** | **Remarks** |
| C01 | (PD+TD+DW) | SF1 | A |  |
| C02 | (PO+TO+DW+SF1\_NL) | SF1 | A |  |
| C03 | (PO+TO+DW+SF2\_NL) | SF2 | A |  |
| C04 | (PO+TO+DW+SF2\_NL) + SF2\_EQ | SF2 | A |  |
| C05 | (PM+TM+DW) +SF2\_ML | SF2 | A |  |
| C06 | (PO+TO+DW+SF3\_NL) + SF3\_TB | SF3 | C |  |
| C07 | (PO+TO+DW+ SF3\_NL) +SF3\_EQ + SF3\_TB | SF3 | C |  |
| C08 | (PO+TO+DW+ SF4\_NL) | SF4 | D |  |
| C09 | (PO+TO+DW+ SF4\_NL) +SF4\_EQ | SF4 | D |  |

**Table 10. Load combinations for system part C**

## Load combinations system part D

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Combination** | **Rule for combination** | **Event class** | | | **Criteria level** | **Remarks** |
| D01 | (PD+TD+DW) | | SF1 | A | |  |
| D02 | (PO+TO+DW+SF1\_NL) | | SF1 | A | |  |
| D03 | (PO+TO+DW+SF2\_NL) | | SF2 | A | |  |
| D04 | (PO+TO+DW+SF2\_NL) + SF2\_EQ | | SF2 | A | |  |
| D05 | (PM+TM+DW) +SF2\_ML | | SF2 | A | |  |
| D06 | (PO+TO+DW+SF3\_NL) + SF3\_TB | | SF3 | C | |  |
| D07 | (PO+TO+DW+ SF3\_NL) +SF3\_EQ + SF3\_TB | | SF3 | C | |  |
| D08 | (PO+TO+DW+ SF4\_NL) | | SF4 | D | |  |
| D09 | (PO+TO+DW+ SF4\_NL) +SF4\_EQ | | SF4 | D | |  |

**Table 11. Load combinations for system part D**

## Load combinations system part E

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Combination** | **Rule for combination** | **Event class** | | **Criteria level** | **Remarks** | |
| E01 | (PD+TD+DW) | | SF1 | A | |  |
| E02 | (PO+TO+DW+SF1\_NL) | | SF1 | A | |  |
| E03 | (PO+TO+DW+SF2\_NL) | | SF2 | A | |  |
| E04 | (PO+TO+DW+SF2\_NL) + SF2\_EQ | | SF2 | A | |  |
| E05 | (PM+TM+DW) +SF2\_ML | | SF2 | A | |  |
| E06 | (PO+TO+DW+SF3\_NL) + SF3\_TB | | SF3 | C | |  |
| E07 | (PO+TO+DW+ SF3\_NL) +SF3\_EQ + SF3\_TB | | SF3 | C | |  |
| E08 | (PO+TO+DW+ SF4\_NL) | | SF4 | D | |  |
| E09 | (PO+TO+DW+ SF4\_NL) +SF4\_EQ | | SF4 | D | |  |

**Table 12. Load combinations for system part E**

## Load combinations system part F

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Combination** | **Rule for combination** | **Event class** | | | **Criteria level** | | **Remarks** |
| F01 | (PD+TD+DW) | | SF1 | A | |  | |
| F02 | (PO+TO+DW) | | SF1 | A | |  | |
| F03 | (PO+TO+DW) + SF2\_EQ | | SF2 | A | |  | |
| F04 | (PM+TM+DW) +SF2\_ML | | SF2 | A | |  | |
| F05 | (PO+TO+DW) +SF3\_EQ | | SF3 | C | |  | |
| F06 | (PO+TO+DW) +SF3\_EQ + SF3\_TB | | SF3 | C | |  | |
| F07 | (PO+TO+DW) +SF3\_TB | | SF3 | C | |  | |
| F08 | (PO+TO+DW) +SF4\_EQ | | SF4 | D | |  | |

**Table 13. Load combinations for system part F**

## Load combinations system part G

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Combination** | **Rule for combination** | **Event class** | **Criteria level** | **Remarks** |
| G01 | (PD+TD+DW) | SF1 | A |  |
| G02 | (PO+TO+DW) | SF1 | A |  |
| G03 | (PO+TO+DW) + SF2\_EQ | SF2 | A |  |
| G04 | (PM+TM+DW) +SF2\_ML | SF2 | A |  |
| G05 | (PO+TO+DW) +SF3\_EQ | SF3 | C |  |
| G06 | (PO+TO+DW) +SF3\_EQ + SF3\_TB | SF3 | C |  |
| G07 | (PO+TO+DW) +SF3\_TB | SF3 | C |  |
| G08 | (PO+TO+DW) +SF4\_EQ | SF4 | D |  |

**Table 14. Load combinations for system part G**

## Load combinations system part H

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Combination** | **Rule for combination** | **Event class** | **Criteria level** | **Remarks** |
| H01 | (PD+TD+DW) | SF1 | A |  |
| H02 | (PO+TO+DW+SF1\_NL) | SF1 | A |  |
| H03 | (PO+TO+DW+SF2\_NL) | SF2 | A |  |
| H04 | (PO+TO+DW+SF2\_NL) + SF2\_EQ | SF2 | A |  |
| H05 | (PM+TM+DW) +SF2\_ML | SF2 | A |  |
| H06 | (PO+TO+DW+SF3\_NL) + SF3\_TB | SF3 | C |  |
| H07 | (PO+TO+DW+SF3\_NL) +SF3\_EQ + SF3\_TB | SF3 | C |  |
| H08 | (PO+TO+DW+ SF4\_NL) | SF4 | D |  |
| H09 | (PO+TO+DW+ SF4\_NL) +SF4\_EQ | SF4 | D |  |

**Table 15. Load combinations for system part H**

# Glossary

| Term | Definition |
| --- | --- |
| SSM | Swedish Radiation Safety Authority |
| P&ID | Piping and Instrument Diagram |
| PFD | Process Flow Diagram |
| PD | Design Pressure |
| TD | Design Temperature |
|  |  |

See also the official ESS Glossary [15] for further information.

# references

1. ESS-0042429 – SDD-Sol, System 1067
2. ESS-0040693 – SDD-Req, System 1067
3. ESS-0145028 – P&ID System 1076
4. ESS-0060677 – PFD Monolith Vessel overview
5. ESS-0028465 – ESS Target Materials Guide
6. RCC-MRx – Design and Construction Rules for mechanical components of nuclear installations: high-temperature, research and fusion reactors. Ed 2012
7. ESS-0491827 – 2018-12-06 CCB Minutes of Meeting
8. ESS-0047989 – Rules for Quality Regulation – Mechanical Equipment
9. ESS-0099097 –Classification Report System 1067
10. ESS-0129228 - Thermal and structural analysis of the PB Port Block
11. ESS-0390039 – REPORT - teknisk-not-p201804-not017
12. ESS-1104434 – Design pressure and design temperature of Monolith Vessel
13. ESS-0093301 – Drawings, Lower and Mid Vessel
14. ESS-0147192 – Maintenance loads
15. ESS Glossary: <https://access.esss.lu.se/glossary>
16. Scanscot PM scte\_pid13416\_Preliminary\_Monolith\_ISRS\_150820.pdf
17. ESS-0006207 Seismic Ground Motion Hazard rev 2

# APPENDIX A SYSTEM PARTS

System parts shown below are for information purpose only, to identify system parts.  
Before use of Process flow diagram below, please verify its validity in CHESS, see [4].

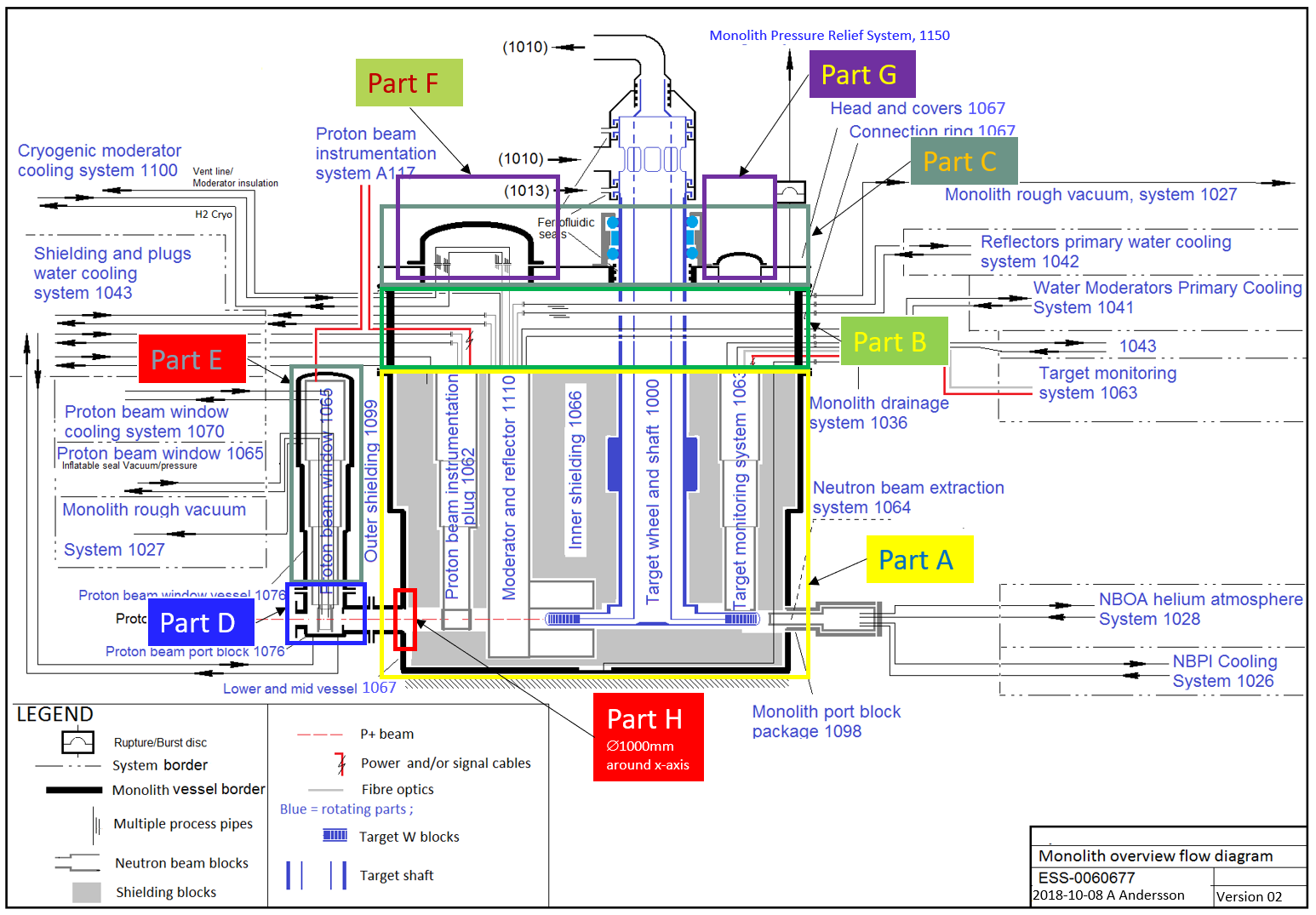


Figure 1 System 1067 and 1076 PFD

# Document Revision history

| Revision | Reason for and description of change | Author | Date |
| --- | --- | --- | --- |
| 1 | First issue | Markus Andersson | 2018-05-25 |
| 2 | Update of system numbers and references. Change from MQC3 to MQC4.  PD changed from 2 bar(g) to 1 bar(g).  System part H added with a local TD of 200°C.  Notes added to sections 4.2, 4.5, 4.6 and 4.7. | Anders Andersson | 2019-05-14 |
|  |  |  |  |

1. By scaling H2/H4 bedrock spectra in [17]. [↑](#footnote-ref-1)
2. By scaling H2/H4 bedrock spectra in [17]. [↑](#footnote-ref-2)