KFM 1067 AND 1076 - COVERS, PENETRATIONS & MONOLITH VESSEL AND PROTON BEAM WINDOW PORT BLOCK AND VESSEL

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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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1. SYSTEM DESCRIPTION

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

1.1. P&ID

See P&ID for system 1076 [3].

1.2. 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].

2. 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.

3. 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.

4. LOADS & OPERATING CONDITIONS

4.1. 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.

4.2. 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.

4.3. 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.

4.4. 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.

4.5. 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].

Table 5. Loads at SF2 operating conditions.

[1] By scaling H2/H4 bedrock spectra in [17].

4.6. 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]. 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.

4.7. 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.

[2] By scaling H2/H4 bedrock spectra in [17].

5. LOAD COMBINATIONS

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

5.1. 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

5.2. 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

5.3. 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

5.4. 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

5.5. 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

5.6. 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

5.7. 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

5.8. 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

6. 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.

7. 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

8. 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].

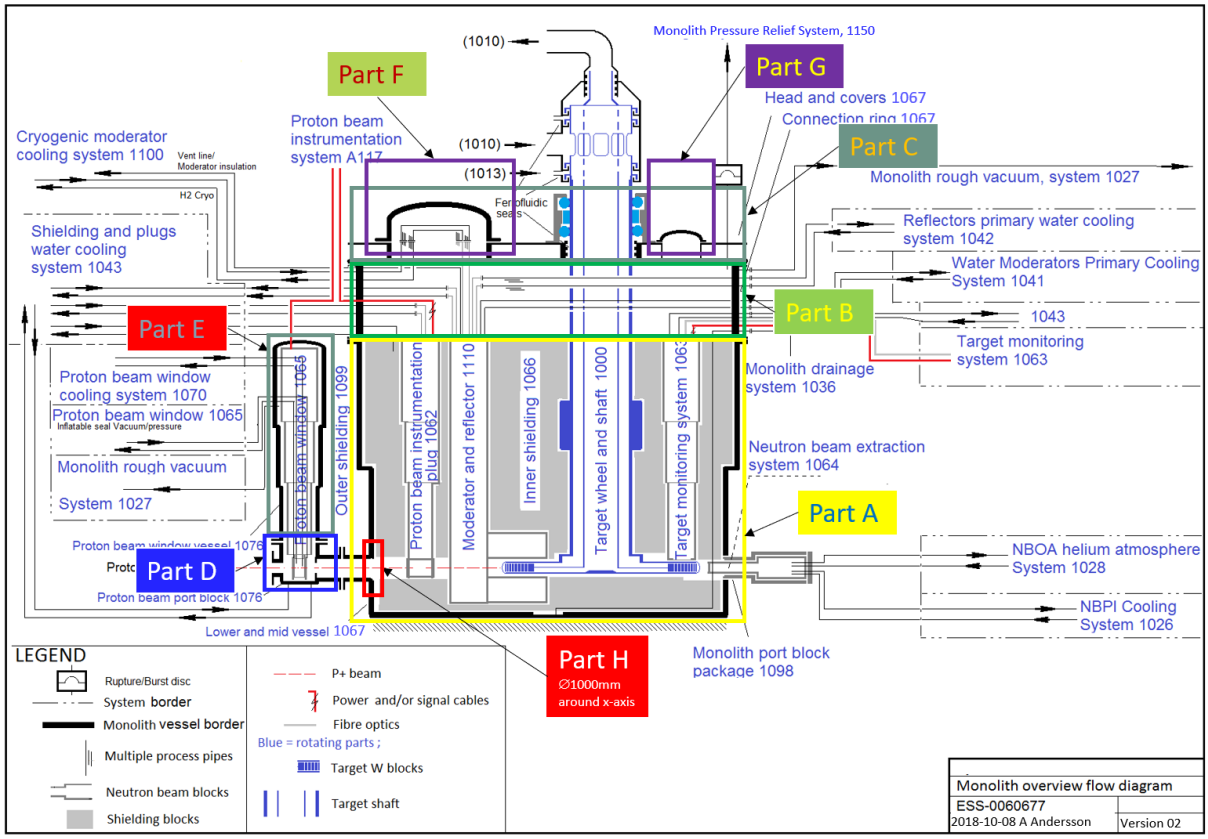

Figure 1 System 1067 and 1076 PFD

9. 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