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CRITICAL DESIGN REVIEW #1 FOR MEDIUM BETA CAVITY CRYOMODULES

3-4 APRIL 2017

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CRYOMODULE LICENSING PLAN

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VINCENT HENNION

LICENSING CONFORMANCE

•V2 update with Ps=1,04barg on 02 Oct15

B. Elliptical Cryomodules, WP5

Specification: IPN document No. EDMS I-036902, dated 03.03.2015 and email from Mr Bosland, dated 15.06.2015

Equipment is specified in 9 different sections:

- C1-C8 with PS 1,04 barg
- LP1-LP33 with PS 1,04 barg
- JLP1-JLP12 with PS 1,04 barg
- JSK1-JSK5 with PS 6 barg
- CC1-CC6 with PS 6 barg
- CD1-CD8 with PS 6 barg
- CP1-CP7 with PS 6 barg
- JTS1-JTS2 with PS 25 barg
- TS1-TS25 with PS 25 barg

•Extract from ESS-0033356_v4 TÜV Nord

•07 Oct15

Classification according to figure 2 (pressure vessels) or figure 7 (piping) in PED, appendix 2, was checked. Due to small equipment (volume not above 49,9 litres and DN not above 960 mms for 1,04 barg, not above 8,33 litres and 200 mms for 6 barg and not above 2 litres and 40 mms for 25 barg) all pressure equipment is classified according to PED, article 3.3.

This equipment *"must be designed and manufactured in accordance with the sound engineering practice of a Member State in order to ensure safe use. Pressure equipment and/or assemblies must be accompanied by adequate instructions for use and must bear markings to permit identification of the manufacturer or of his authorized representative established within the*

Cryomodules

As presented before, all equipment is classified according to PED, article 3.3.

HYDROSTATIC TEST PRESSURE (1/3)

PED ANNEX I Section	Sub-Section	Essential Safety Requirements
	7.4	**Hydrostatic test pressure**
		For pressure vessels, the hydrostatic test pressure to be not less than; - maximum loading to which the pressure equipment may be subject to in service, taking into account its maximum allowable pressure and its maximum allowable temperature, multiplied by the coefficient 1.25, or - the maximum allowable pressure multiplied by the coefficient 1.43, whichever is the greater

- PS = MAWP (Maximum Allowed Working Pressure)

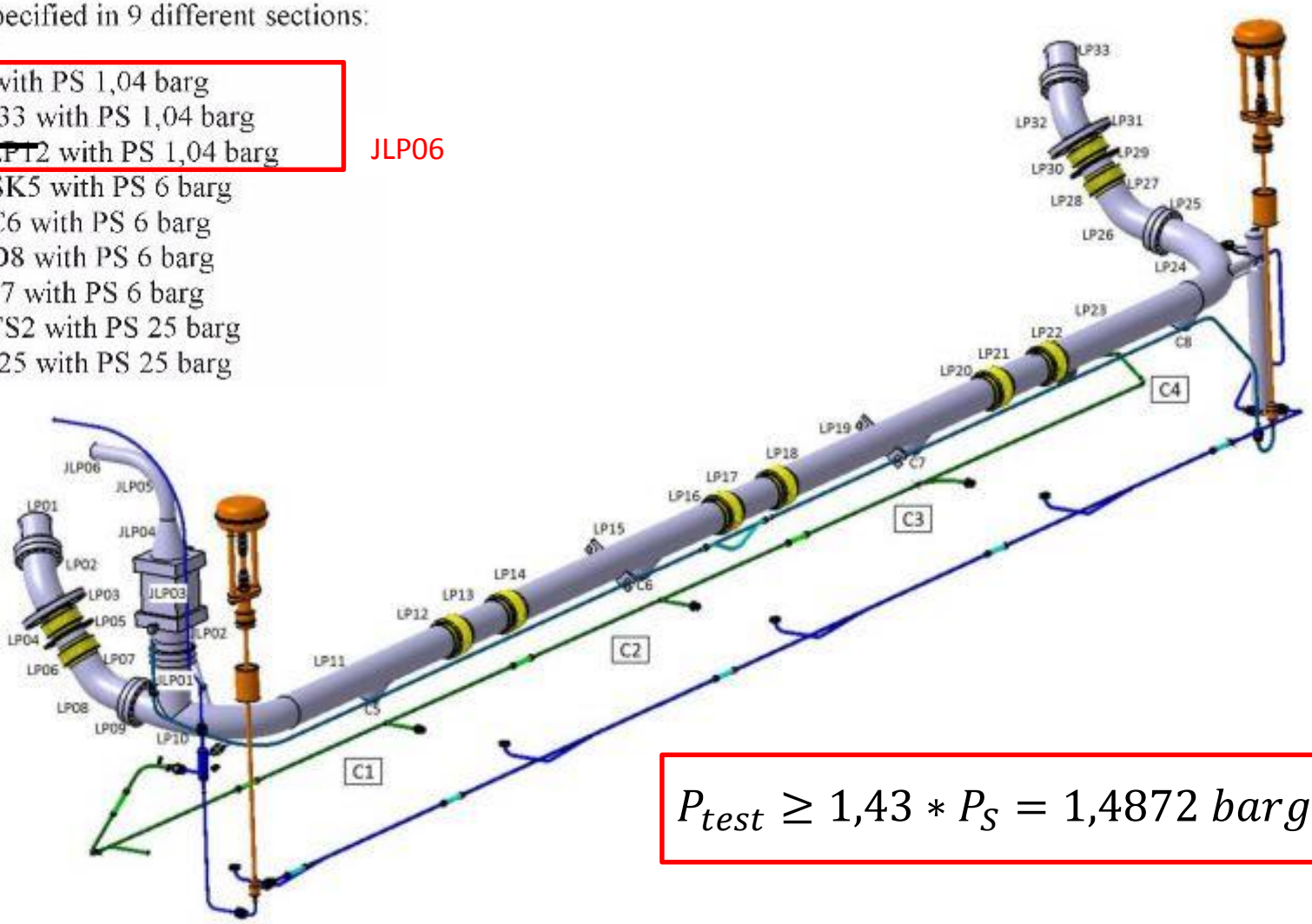
HYDROSTATIC TEST PRESSURE (2/3)

4 BREAKDOWN OF THE LOW PRESSURE CIRCUIT

Equipment is specified in 9 different sections:

- C1-C8 with PS 1,04 barg
- LP1-LP33 with PS 1,04 barg
- JLP1-JLP12 with PS 1,04 barg
- JSK1-JSK5 with PS 6 barg
- CC1-CC6 with PS 6 barg
- CD1-CD8 with PS 6 barg
- CP1-CP7 with PS 6 barg
- JTS1-JTS2 with PS 25 barg
- TS1-TS25 with PS 25 barg

JLP06



$$P_{test} \geq 1{,}43 * P_S = 1{,}4872\ barg$$

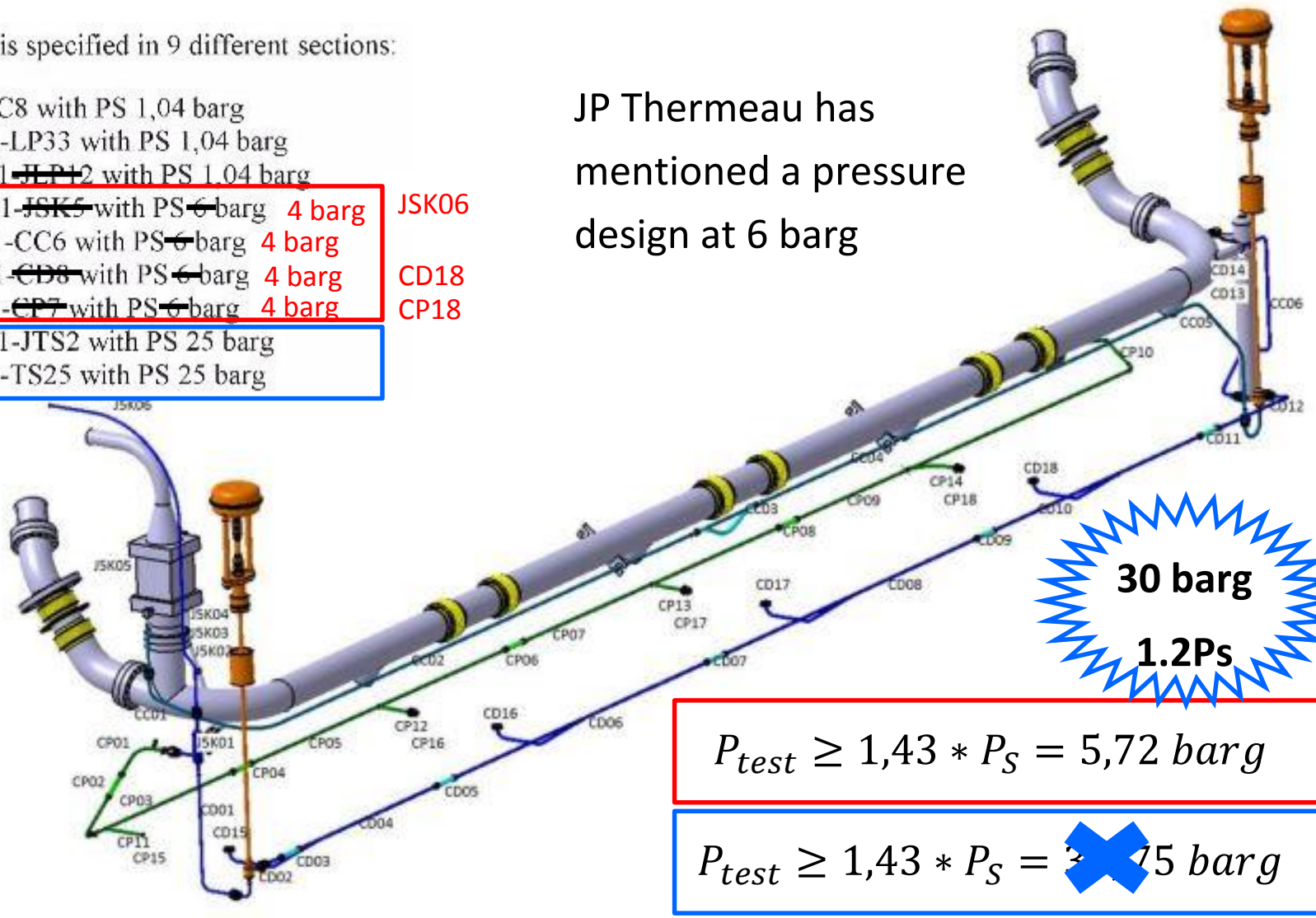
HYDROSTATIC TEST PRESSURE (3/3)

5 BREAKDOWN OF THE HIGH PRESSURE CIRCUIT

Equipment is specified in 9 different sections:

- C1-C8 with PS 1,04 barg
- LP1-LP33 with PS 1,04 barg
- JLP1-~~JLP12~~ with PS 1,04 barg
- JSK1-~~JSK5~~ with PS ~~6~~ barg 4 barg — JSK06
- CC1-CC6 with PS ~~6~~ barg 4 barg
- CD1-~~CD8~~ with PS ~~6~~ barg 4 barg — CD18
- CP1-~~CP7~~ with PS ~~6~~ barg 4 barg — CP18
- JTS1-JTS2 with PS 25 barg
- TS1-TS25 with PS 25 barg

JP Thermeau has mentioned a pressure design at 6 barg



30 barg

1.2Ps

$$P_{test} \geq 1{,}43 * P_S = 5{,}72\ barg$$

$$P_{test} \geq 1{,}43 * P_S = \text{[illegible]}\ barg$$

MATERIALS

- **Answer**:

- At the moment, there are no requirements at ESS regarding the use of specific materials for the equipment to be installed in the Accelerator Tunnel, except for electrical cables (ESS-0034035). However, a combination of various recommendations apply when selecting materials in order to reduce the impact on fire safety, radioprotection as well as to the environment. The details and relevant documentation per domain are listed below:

- **Fire Safety [1]**

- Purpose**:** mitigate the consequences of a potential fire on the Safety of personnel and equipment by prohibiting the use of halogenated plastics that emit carbon monoxide (CO) as well as dense, toxic and corrosive smokes during their combustion.
- The selection of plastics and non-metallic materials to be used in the Accelerator Tunnel should be done according to the table in Annex 1 of the present document [1].

- **Sustainability [2]**

- Purpose: replace, as far as possible, hazardous substances that can have an impact on safety and on the environment by alternatives materials should be selected according to Appendix 1 of ESS-0011452 [2].

- **Radiation resistance [3], [4] and [5]**

- Purpose: provide guidance on the selection of rad-hard materials to be used in the accelerator tunnel in order to reduce beam down-time periods and a list of a materials to be avoided due to their high radiological hazard.
- ESS-0007659 [3] can be used as a guideline for the selection of materials with respect to radiation resistance. In addition, a complementary document (ESS-0060280) [4] provides operational and accidental absorbed dose values in various locations of the accelerator tunnel and at various beam energy ranges. Finally, Annex 2 [5] provides a list of materials to be avoided as far as possible due to their high radiological risk.
- In the event of ambiguity or contradiction between the above-mentioned recommendations and documentation, these should apply in decreasing order of priority, starting from the top.

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- **Documents related to the answer:**

- [1] *CERN Safety Instruction 41 – The use of plastics and other non-metallic materials at CERN with respect to fire safety and radiation resistance,* EDMS 335806
- [2] *ESS Procedure for sustainable selection of materialsSustainable Selection of Materials,* ESS-0011452
- [3] *Material classification to radiation resistance in the ESS linac tunnel,* ESS-0007659
- [4] *A Guideline to Operational and Accidental Absorbed Dose Rates in the ESS Accelerator Tunnel,* ESS-0060208
- [5] *Radiological hazard classification of material in CERN's accelerators,* EDMS 1184236

From: Lali Tchelidze <lali.tchelidze@esss.se>

Date: onsdag 12 oktober 2016 14:46

MATERIALS

List of materials considered as highly critical due to their high radiological hazard [5]

Critical elements
Antimony
Cadmium
Cesium
Cobalt
Europium
Gold
Hafnium
Iridium
Lithium
Scandium
Silver
Strontium-90
Tantalum
Terbium
Thorium
Uranium
Xenon

- No issue for Cryomodule

MATERIALS

- List of materials with respect to fire safety

	Epoxy resin	EP
	Ethyl acrylate rubber	EAR
	Ethylene propylene diene	EPDM
	Ethylene propylene rubber	EPR
	Ethylene vinyl acetate	EVA
	High density polyethylene	HDPE
	Low density polyethylene	LDPE
	Polyamide	PA
Suitable only with incorporation of fire retardant NOT containing halogen, sulphur and phosphorus	Polyaryl amide	PAA
	Polybutylene	PB
	Polybutylene terephthalate	PBT
	Polycarbonate	PC
	Polyethylene terephthalate	PET (PETP)
	Polyiscocyanurate	PIR
	Polyphenylene ether	PPE
	Polyphenylene oxide	PPO
	Polypropylene	PP
	Polyurethane	PU
	Polyvinyl acetate	PVAC
	Polyvinyl alcohol	PVA
	Silicones	SI

- No issue for Cryomodule with prohibited materials
- Use of many standard EPDM seals for vacuum vessel ports

CONCLUSION

•ESS Elliptical Cryomodule design is compliant with ESS licensing requirements

•Procured components will be tested under hydrostatic test pressure at 1,43*PS for FAT (industrial premises) at least once.

•The assembled cryomodule will be tested at Saclay at PS prior shipment to Lund

Thank you

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