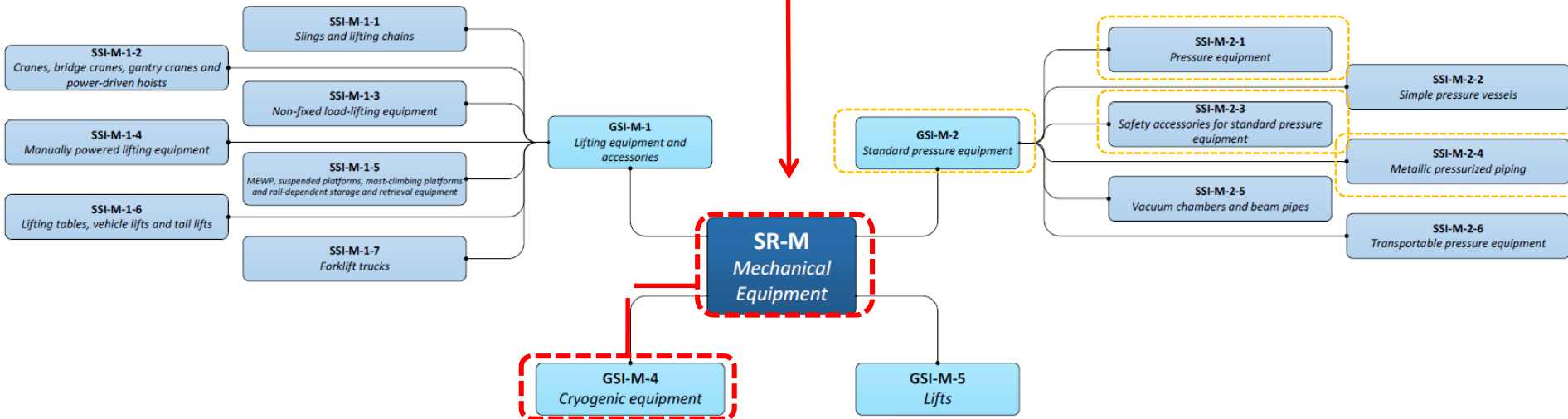


Standards for mechanical systems at CERN (with special focus on pressure and cryogenic equipment)

An equipment installed at CERN
shall comply with CERN rules
cryogenic equipment

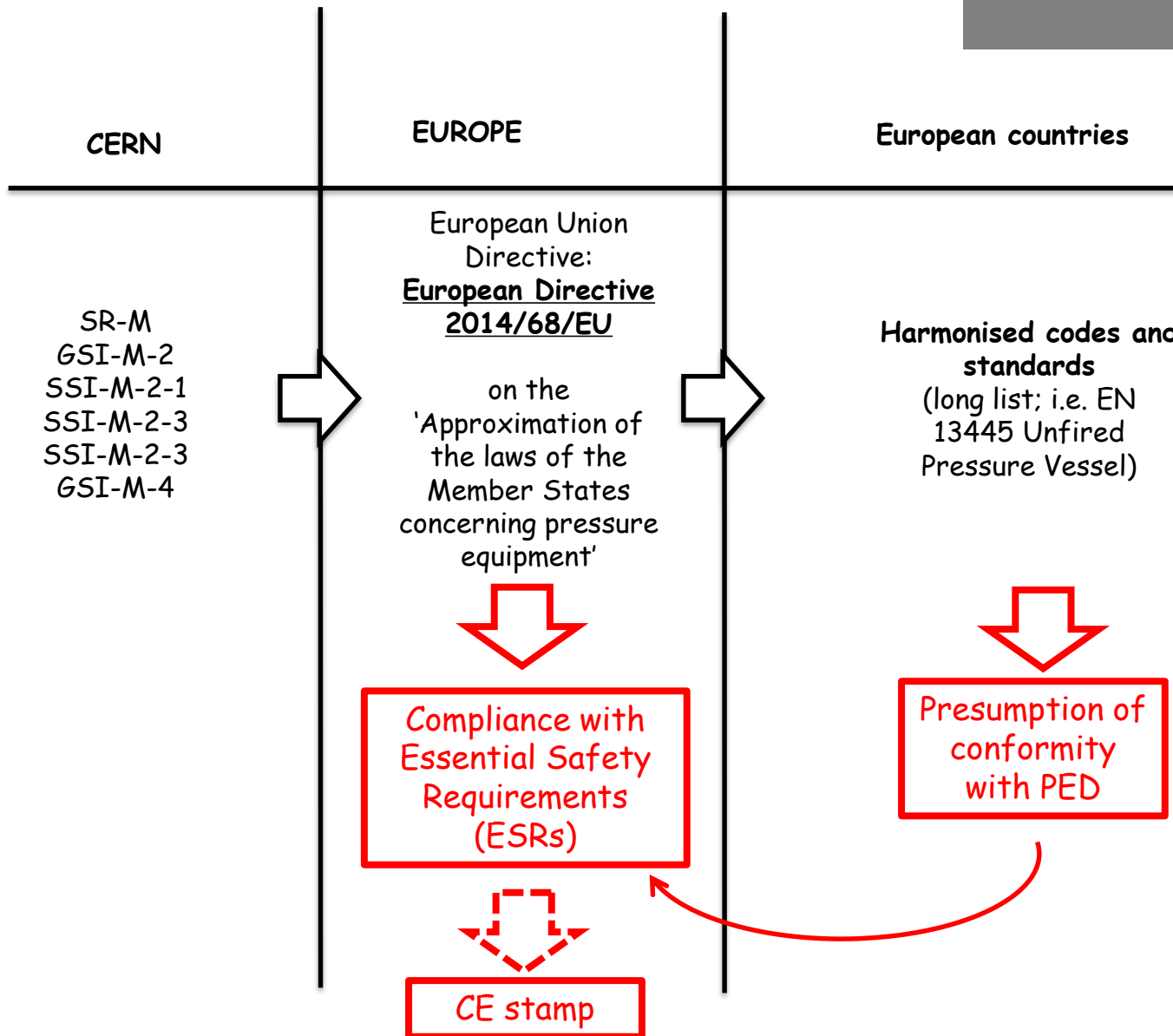
Publication date of the mechanical Safety rules: 9 June 2015



The Safety rules for mechanical equipment at CERN may be found here:
<https://espace.cern.ch/Safety-Rules-Regulations/en/rules/byDomain/Pages/M.aspx>

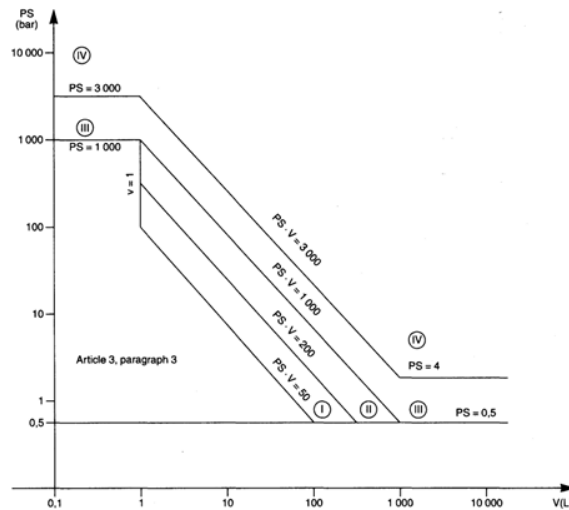
GSI-M-4

- Definitions
- CERN Safety Rules and Laws (framework at CERN + relevant EU laws)
- Minimum Safety Requirements related to the life cycle of the equipment
- Basics for the Safety File



PRESSURE EUROPEAN DIRECTIVE

- Applies to internal pressure > 0.5 bar
- Vessels must be designed, fabricated and tested according to the Essential Safety requirements of Annex I
- Establishes the conformity assessment procedure depending on vessel category
- The category depends on the stored energy (which relates to risks) expressed as Pressure \times Volume in bar \times L



For vessels with non-dangerous gases (cryogenic liquids are treated as gas)

Conformity assessment gets heavier with risk

Cat ory	Conf. assessment module	Comment
SEP	None	The equipment must be designed and manufactured in accordance with sound engineering practice. No CE marking and no involvement of notified body.
I	A	CE marking with no notified body involvement, self-certifying.
II	A1	The notified body will perform unexpected visits and monitor final assessment.
III	B1+F	The notified body is required to approve the design, examine and test the vessel.
IV	G	Even further involvement of the notified body.

8

2 key parameters:

- Service Pressure PS
- Volume V for vessel or Diameter D for pipeline

Category 2 to 4:
Notified body shall be involved

PED Essential Safety Requirements (ESRs): see Annex A

Here some examples

PRELIMINARY OBSERVATIONS

2 - Design

2.2 - Design for adequate strength

2.11 - Safety accessories

3 - Manufacturing

4 - Materials

the pressure equipment manufacturer shall: ... provide in his technical documentation elements relating to compliance with the materials specifications of this Directive in one of the following forms:

- by using materials which comply with harmonised standards,*
- by a particular material appraisal;*

SPECIFIC PRESSURE EQUIPMENT REQUIREMENTS

7 - Specific quantitative requirements for certain pressure equipment

7.1 - Allowable stresses => 7.1.2 permissible general membrane stress

7.2 - Joint coefficient

7.4 - Hydrostatic test pressure

7.5 - Material characteristics => "elongation after rupture is no less than 14 % and its bending rupture energy measured on an ISO V test-piece is no less than 27 J, at a temperature not greater than 20 ° C"

Comprehensive codes:

- EN 13458:2002 Cryogenic vessels - static vacuum insulated vessels (part 1, 2 and 3)
- EN 13445-1:2014 Unfired pressure vessel (part 1, 2, 3, 4, 5 and 8)
- EN 13480-1:2014 Metallic industrial piping (part 1, 2, 3, 4, 5 and 8)

Material codes:

- EN 10028:2007 Flat products made of steel for pressure purposes (part 1, 3 and 7)
- EN 10216-5:2004 Seamless steel tubes for pressure purposes - Technical delivery conditions - part 5: Stainless steel
- EN 10217-7:2005 Welded steel tubes for pressure purposes - Technical delivery conditions - part 7: Stainless steel
- EN 10222:1998 Steel forgings for pressure purposes (part 1 and 5)
- EN 10213:2007 Steel castings for pressure purposes
- EN 10272:2007 - Stainless steel bars for pressure purposes

Codes for components:

Bellows

- EN 14917:2009 Metal bellows expansion joints for pressure applications

Cryogenic vessels

- EN 12434:2000 Cryogenic vessels - Cryogenic flexible hoses
- EN 13371:2001 Cryogenic vessels - Couplings for cryogenic service
- EN 1626:2008 Cryogenic vessels - Valves for cryogenic service

Fittings

- EN 10253-4:1999 Butt-welding pipe fittings. Wrought austenitic and austenitic-ferritic (duplex) stainless steels with specific inspection requirements

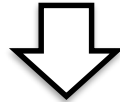
Safety devices (Sizing & selection standards)

- ISO 4126: Safety devices for protection against excessive pressure
 - ISO 4126-1: Safety valves
 - ISO 4126-2: Rupture disks
 - ISO 4126-10 (two-phase flow)
- EN 13648-3: Safety devices for cryogenic equipment
- EN 764-7: Selection of safety systems

not exhaustive lists...

Presumption of conformity
(= compliance with ESRs)

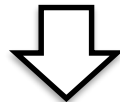
CERN specificity (i.e. exotic materials such as Niobium, Titanium...) => difficulties to comply with laws and standards



From GSI-M2/ GSI-M4 : new definition

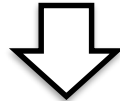
Cryogenic equipment liable to have major Safety implications:

- not compliant with the applicable European directives, or
- of a highly complex design, or
- using reduced safety factors, or
- requiring special conditions of use, or
- using unconventional materials or manufacturing technologies, or
- presenting a high-level hazard for people, the environment or other installations in the event of failure.



Pressurized equipment is by default standard equipment and shall follow classic regulations.

**At CERN the status "liable to have major Safety implications" SHALL BE GRANTED BY HSE.
Even if "liable to have major Safety implications", the EU standard are the reference**



**CE stamp not required for equipment "liable to have major Safety implications"
Demonstration of compliance with Essential Safety Requirements of the PED shall be provided**



compliance with Essential Safety Requirements => use of European harmonised standards

Mandate of the Occupational Health & Safety and Environmental Protection Unit (HSE)

MISSION of CERN's HSE Unit:

- supports the Organization in the implementation and enforcement of its Safety Policy;
- monitors the implementation and accomplishment of Safety objectives aimed at a continuous improvement of safe working and operating conditions as well as environmental protection;
- grants Safety clearance on behalf of the Director-General for special equipment, installations, experiments and projects with major Safety implications

SCOPE OF WORK

I. ... the HSE Unit assists the Organization in defining and monitoring the implementation of its Safety Policy, through:

- assistance in the definition and achievement of Safety objectives at all levels of the Organization;
- advice and relevant expert support on Safety risk assessment, risk reduction and risk control;
- proposals for Safety improvements based, inter alia, on lessons learnt and best practices;
- training, information and awareness-raising in Safety matters;
- assistance in the implementation of CERN's regulatory framework in matters of Safety.

...
IV. The HSE Unit provides Safety clearance for activities, special equipment, installations, experiments and projects with major Safety implications prior to design, operation or dismantling activities.

Source: <https://hse.cern/content/mandate>

Documentation to demonstrate compliance with ESRs => Safety file

From GSI-M-4

The organic unit owning the item of cryogenic equipment shall establish a Safety File and update it. The Safety File shall include the following documents, where they exist:

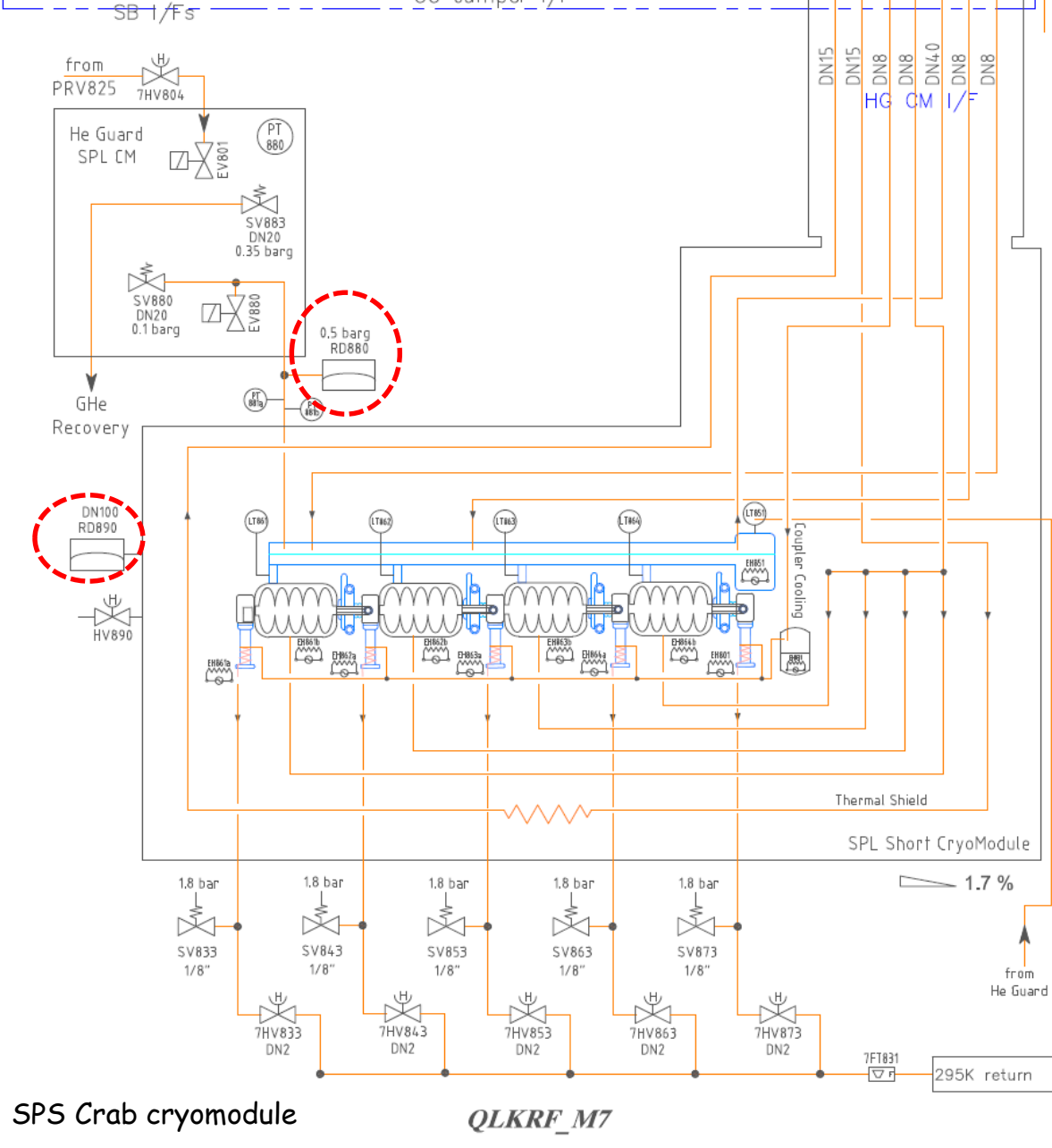
- the risk assessments;
- the technical file:
 - where it is supplied by the manufacturer, or
 - where the item of the cryogenic equipment is manufactured by CERN (in any case);
- the EC or π declarations of conformity or the EU declaration of conformity, including those of Safety accessories (if applicable);
- the instruction manual;
- the test reports;
- the acceptance report;
- the declaration of commissioning;
- the periodic inspection schedule;
- the periodic inspection reports;
- the requalification reports ;
- the maintenance operation schedule;
- the maintenance operation reports;
- the documents relating to the design and performance of any repairs;
- the dismantling instructions;
- the identity of the owning organic unit.

Table 2: Safety file contents for RP-1834 (special equipment)

		Pressure equipment					
		PS≤0.5barg	PS>0.5barg				
			0	I	II	III	IV
Design	Risk assessment	x	x	x	x	x	x
	Result of design calculations	x	x	x	x	x	x
	Design drawings and diagrams of components, circuits...	x	x	x	x	x	x
	Description and explanations necessary to understand the drawings and diagrams	x	x	x	x	x	x
	General assembly and manufacturing drawings	x	x	x	x	x	x
HSE validation (verification of safety files) – Before start of manufacturing							
Manufacturing	Material certificates for base materials and welding consumables	x	x	x	x	x	x
	Welders certificate		x	x	x	x	x
	Welding procedures approval certificates			x	x	x	x
	Welding specifications		x	x	x	x	x
	Non-destructive testing (NDT) personnel certificate			x	x	x	x
	Records of welding inspections		x	x	x	x	x
	Pressure report test		x	x	x	x	x
	Operation and emergency procedures			x	x	x	x
	Maintenance and inspection plan	x	x	x	x	x	x
HSE validation (verification of safety files) – Before start of operation							

The content of the Safety File (= the doc to be produced) is almost independent from the category (= the same except category 0, but...)

Safety devices

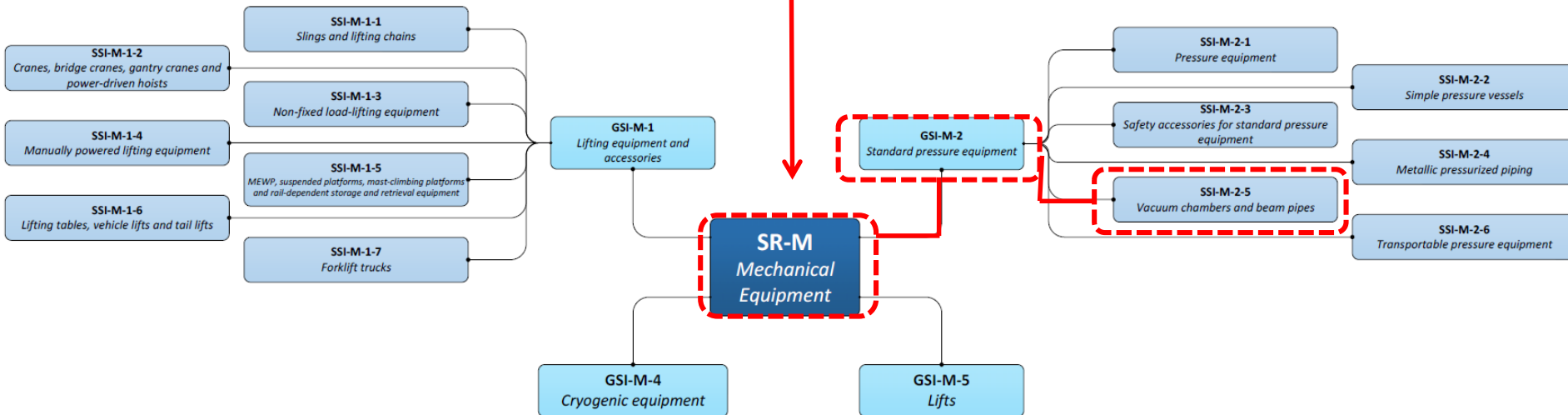


- He cryogenic lines and vacuum insulations volumes shall be protected by safety devices.
- Europeans Standards shall be followed for dimensioning => **presumption of conformity**

An equipment installed at CERN shall comply with CERN rules

Beam pipe

Publication date of the mechanical Safety rules: 9 June 2015



The Safety rules for mechanical equipment at CERN may be found here:
<https://espace.cern.ch/Safety-Rules-Regulations/en/rules/byDomain/Pages/M.aspx>

GSI-M-2

- Definitions
- CERN Safety Rules and Laws (framework at CERN + relevant EU laws)
- Minimum Safety Requirements related to the life cycle of the equipment
- Basics for the Safety File



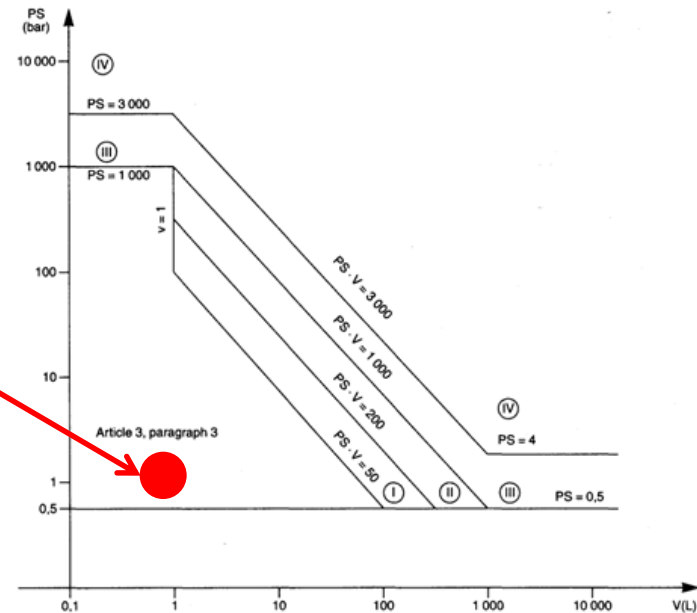
SSI-M-2-5

- Definitions
- CERN Safety Rules and Laws
- Additional Safety Requirements compared to the main GSI

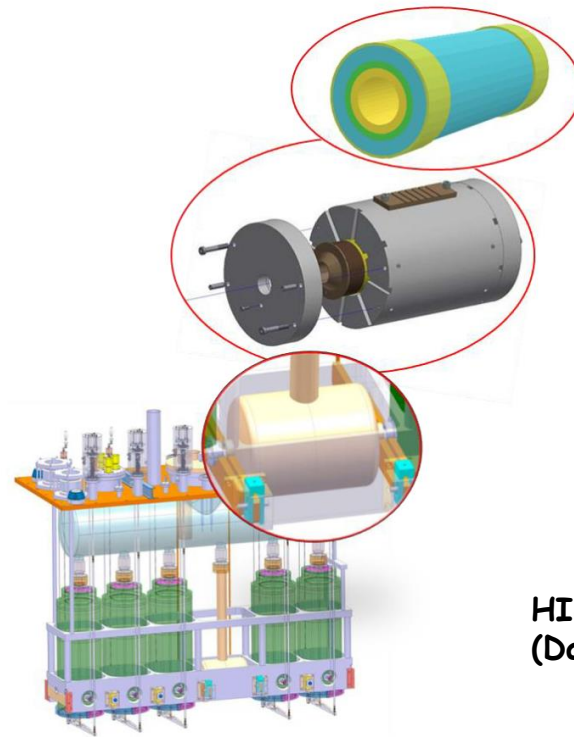
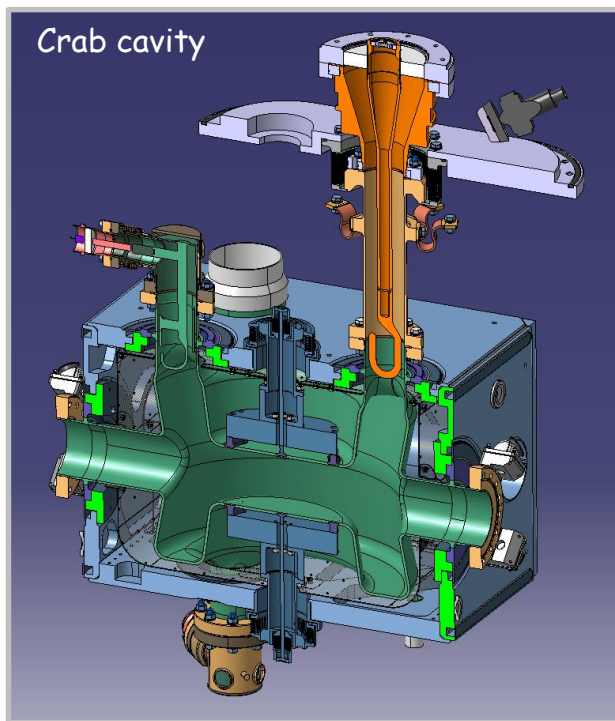
In theory out of the PED scope

At CERN

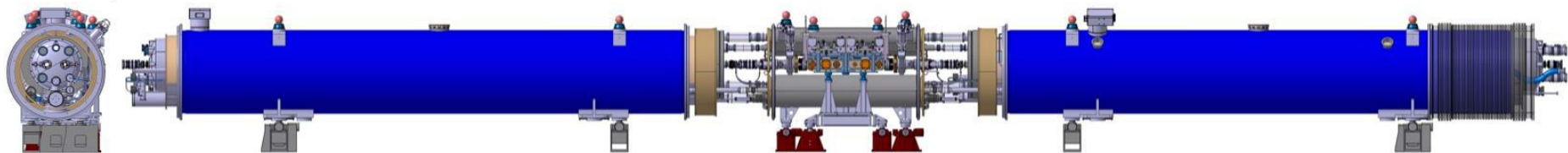
- shall be treated as low risk pressure equipment
- the relevant harmonised standards for the beam vacuum pipe design, manufacturing and testing are listed in the CERN Rules. The most important ones are (not exhaustive list):
 - EN 13445 - Unfired Pressure Vessels
 - EN 14917 - Metal bellows expansion joints for pressure applications



For vessels with non-dangerous gases
(cryogenic liquids are treated as gas)



HIE Isolde magnet
(Danfysik) / CE marked



11T cold mass has been designed according to
PED requirements / not yet manufactured

Superconducting magnets according to PED ?

- PED excludes high voltage equipment (and superconducting magnets are often rated for high voltage).
- So having them CE marked may not be straightforward => agreement with HSE is required
- **however PED/harmonised standards shall be followed for the design, manufacturing and testing => compliance with ESRs**
- often category 2, 3 or 4 : involvement of a Notified Body is required => agreement with HSE is required

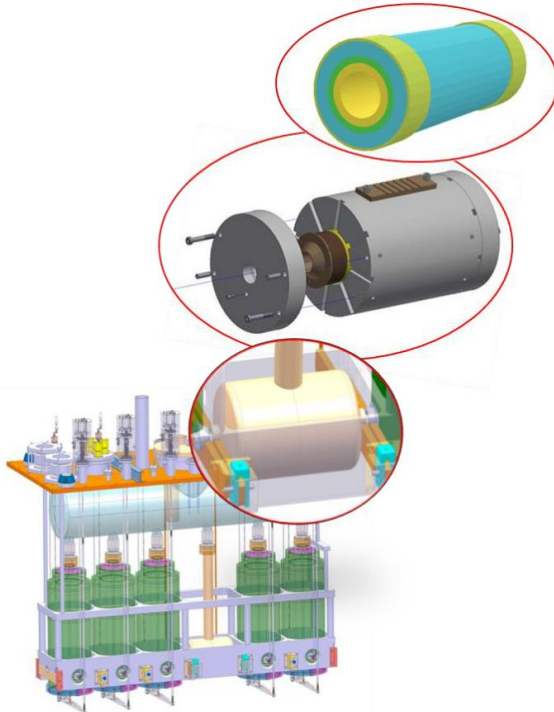
Danfysik A/S
Gregersensvej 8
2630 Taastrup
Att: Leif O. Baandrup

Certificate of conformity, modul F, according to 97/23/EC Pressure equipment – PED

Certificate no.:	TI-14-PED-0938	Revision:	00	File no.:	608821
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Equipment information

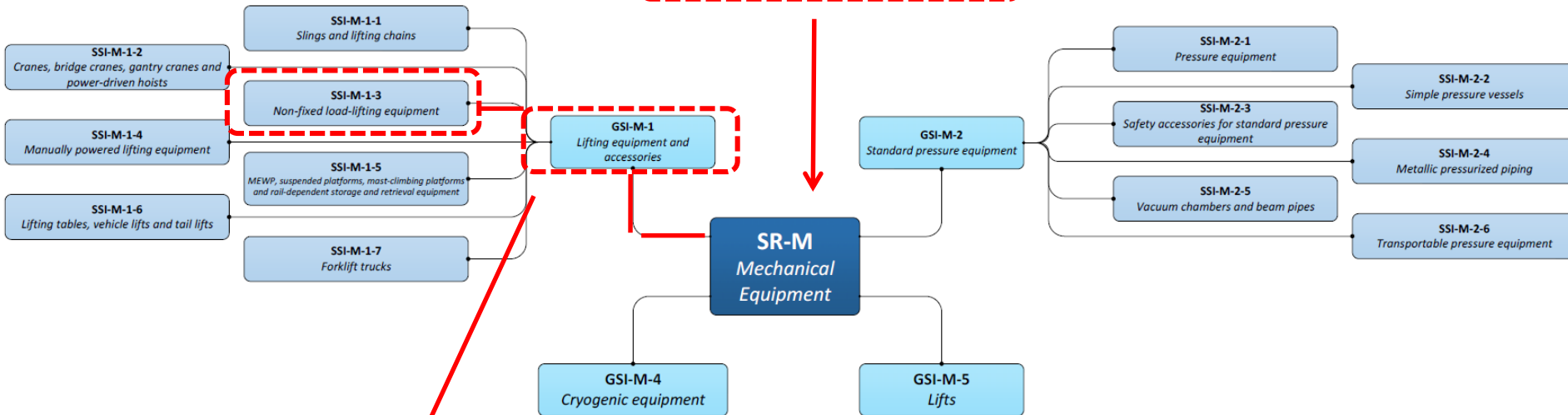
Description:	Solenoid Magnet	Serial No.:	N2713143
Drawing No./rev.:	7103017747, rev. D; 7103017973, rev. C *	Year of manufacture:	2014
Nominal size:	Ø275	Category:	I
Modul B, B1 app.:	TI 0396: TI-13-PED-0847	Designcode:	EN13445
	Vessel	Chamber II	Chamber III
Min /max. Pressure: (PS), Bar(e)	-1/5,5		
Min /max. temperature (TS), °C:	-300/50		
Volume (V), liter:	10,03		
Fluid group:	2		



An equipment installed at CERN shall comply with CERN rules

lifting equipment

Publication date of the mechanical Safety rules: 9 June 2015



The Safety rules for mechanical equipment at CERN may be found here:
<https://espace.cern.ch/Safety-Rules-Regulations/en/rules/byDomain/Pages/M.aspx>

GSI

- Definitions
- CERN Safety Rules and Laws (framework at CERN + relevant EU laws)
- Minimum Safety Requirements related to the life cycle of the equipment
- Basics for the Safety File

SSI

- Definitions
- CERN Safety Rules and Laws
- Additional Safety Requirements compared to the main GSI

Non-fixed load-lifting accessories

SSI-M-1-3

SSI-M-1 Lifting equipment and accessories

SSI-M-1-1 Slings and lifting chains



SSI-M-1-2 Cranes, bridge cranes, gantry cranes and power-driven hoists



SSI-M-1-3 Non-fixed load-lifting accessories



SSI-M-1-4 Manually powered lifting equipment



SSI-M-1-5 MEWP, suspended platforms, mast-climbing platforms and rail-dependent storage and retrieval equipment



SSI-M-1-6 Lifting tables, vehicle lifts and tail lifts



SSI-M-1-7 Forklift trucks



Related European directives:

- Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on **machinery**, and amending Directive 95/16/EC.
- Directive 2009/104/EC of the European Parliament and of the Council of 16 September 2009 concerning the **minimum safety and health requirements for the use of work equipment by workers at work**.

For the complete reference list of regulatory documents applicable please refer to GSI-M-1

Standard Lifting equipment: focus on SSI-M-1-3
Non-fixed load-lifting accessories

- **CE stamp**
- Safety file shall be provided
- Proof test according to French regulations

HSE:

- allocate a CERN identification number;
- draw up an acceptance report which shall be included in the Safety File;
- authorise commissioning.

- CERN norms => European law => European Standards give presumption of conformity / CERN requires to apply European Standards
- Superconducting magnets according to PED?
 - having them CE marked may not be straightforward => this is not the point!
 - relevant harmonised standards shall be used to demonstrate compliance with ESRs
 - agreement with HSE is required, above all about involvement of a Notified Body
- Beam pipes
 - out of PED scope
 - CERN requires to use harmonised standards as per pressure equipment
- Lifting tools: CE stamp according to relevant European directives (i.e. Directive 2006/42/CE for Machinery, ...)

- CERN safety rules (<http://cern.ch/safety-rules>) , Safety Regulation for Mechanical Equipment, SR-M (https://edms.cern.ch/ui/file/875606/LAST_RELEASED/SR-M_EN.pdf)
- GSI-M-2 - Standard pressure equipment (https://edms.cern.ch/ui/file/875610/LAST_RELEASED/GSI-M-2_EN.pdf)
- SSI-M-2-5 - Vacuum chambers and beam pipes (https://edms.cern.ch/ui/file/1453956/LAST_RELEASED/SSI-M-2-5_EN.pdf)
- GSI-M-4 - Cryogenic equipment (https://edms.cern.ch/ui/file/1327191/LAST_RELEASED/GSI-M-4_EN.pdf)
- Directive 2014/68/EU: https://ec.europa.eu/growth/sectors/pressure-gas/pressure-equipment/directive_en
- Guidelines for cryogenic equipment are available in: https://edms.cern.ch/ui/file/1709279/LAST_RELEASED/Safety_Guideline_SG-M-4-0-1_EN.pdf

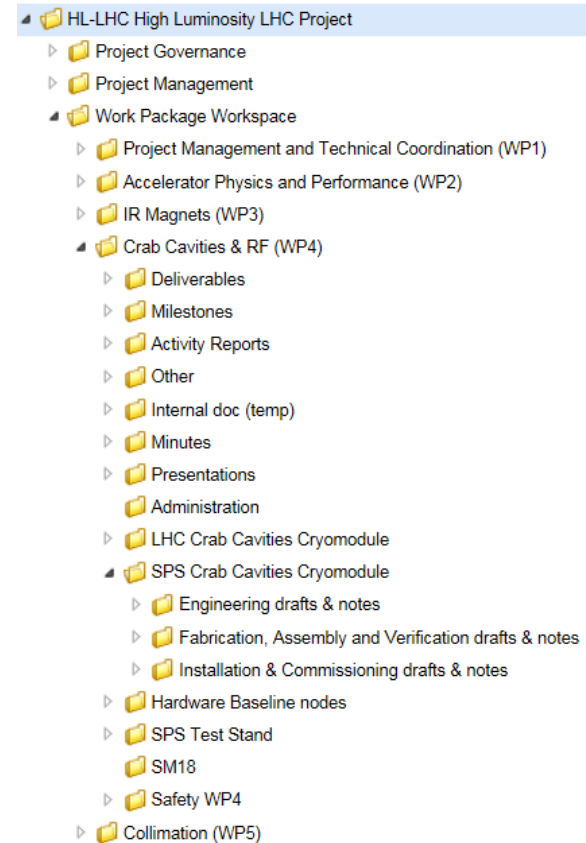
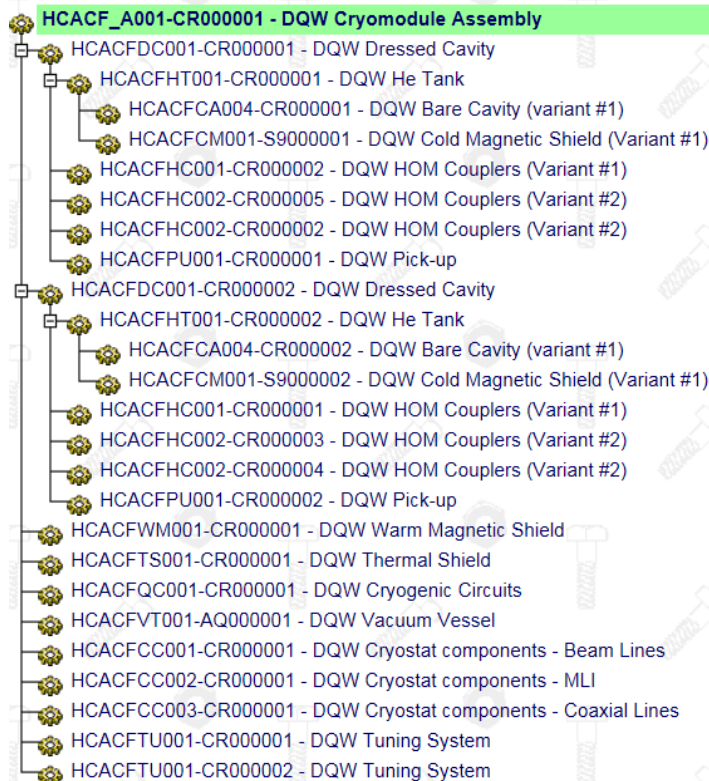
The relevant harmonised standards are (not exhaustive list):

- EN 13445 - Unfired Pressure Vessels
- EN 13458 - Cryogenic vessels - Static vacuum insulated vessels
- EN 13480 - Metallic industrial piping
- EN 14917 – Metal bellows expansion joints for pressure applications

SPARE SLIDES

- "Safety Folder" instead of "Safety File"
- Foresee it since the beginning of the job
- EDMS and MTF (managing assets of the same item) tools are available at CERN for documentation storage

Assembly Tree



Example of Crab SPS cryomodule

Be careful to the choice, even to the choice of the stainless steel!

Harmonized standards :

Useful material standards for cryostats

Plates and sheets	<ul style="list-style-type: none">• EN 10028-1:2007+A1:2009 Flat products made of steels for pressure purposes - Part 1: General requirements• EN 10028-3:2009 Flat products made of steels for pressure purposes - Part 3: Weldable fine grain steels, normalized• EN 10028-7:2007 Flat products made of steels for pressure purposes - Part 7: Stainless steels
Tubes	<ul style="list-style-type: none">• EN 10216-5:2004 Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 5: Stainless steel tubes• EN 10217-7:2005 Welded steel tubes for pressure purposes - Technical delivery conditions - Part 7: Stainless steel tubes
Forged blanks	<ul style="list-style-type: none">• EN 10222-1:1998 Steel forgings for pressure purposes - Part 1: General requirements for open die forgings• EN 10222-5:1999 Steel forgings for pressure purposes - Part 5: Martensitic, austenitic and austenitic-ferritic stainless steels
Castings	<ul style="list-style-type: none">• EN 10213:2007 Steel castings for pressure purposes
Pipe fittings	<ul style="list-style-type: none">• EN 10253-4:2008 Butt-welding pipe fittings - Part 4: Wrought austenitic and austenitic-ferritic (duplex) stainless steels with specific inspection requirement
Bars	<ul style="list-style-type: none">• EN 10272:2007 Stainless steel bars for pressure purposes
Aluminium	<ul style="list-style-type: none">• EN 12392:2000 Aluminium and aluminium alloys - Wrought products - Special requirements for products intended for the production of pressure equipment (choose materials included in the list given in EN 13445-8 section 5.6)

CAS, Superconductivity for accelerators, Erice 2013

10/11

CAS, Superconductivity for accelerators, Erice 2013

101/

Table B.2-11 — Austenitic stainless steels and their lowest minimum metal temperature T_M

Material	Material number	T_M (in °C)
X2CrNi 19-11	1.4306	- 273
X2CrNi 18-9	1.4307	
X2CrNiN 18-10	1.4311	
X1CrNi 25-21	1.4335	
X2CrNiMo 17-12-2	1.4404	
X2CrNiMoN 17-11-2	1.4406	
X2CrNiMoN 17-13-3	1.4429	
X2CrNiMoN 18-12-4	1.4434	
X2CrNiMo 18-14-3	1.4435	
X2CrNiMo 18-15-4	1.4438	
X1CrNiMoN 25-22-2	1.4466	
X6CrNiTi 18-10	1.4541	
X1NiCrMoCu 31-27-4	1.4563	
X6CrNiMoTi 17-12-2	1.4571	
X5CrNi 18-10	1.4301	- 196
X5CrNiMo 17-12-2	1.4401	
X2CrNiMo 17-12-3	1.4432	
X3CrNiMo 17-13-3	1.4436	
X2CrNiMoN 17-13-5	1.4439	
X1NiCrMoCuN 25-20-7	1.4529	
X1CrNiMoCuN 25-25-5	1.4537	
X1NiCrMoCu 25-20-5	1.4539	
X1CrNiMoCuN 20-18-7	1.4547	
X6CrNiNb 18-10	1.4550	
X6CrNiMoNb 17-12-2	1.4580	
GX5CrNi 9-10	1.4308	
GX5CrNiMo 19-11-2	1.4408	
GX2NiCrMo 28-20-2	1.4458	
GX2CrNi 19-11	1.4309	
GX2CrNiMo 19-11-2	1.4409	

During design evaluation, please DON'T use real properties and DON'T use properties you find in the CERN specifications, but properties you find in the harmonized standards.

When a material is not considered in the harmonised standards (see ASME materials) => PMA is required

When you buy a commercial component: be careful to the standard for the material!

Rules for strength assessment are defined in harmonised standards

- Design by formula
 - The most standard approach and easiest to cross check
 - Not always straightforward to understand how the formula was derived
 - Often long and tedious calculation procedures
 - Only deals with pressure loads
 - Rarely enough to calculate a magnet cryostat or a cryomodule (weight, interface loads, particular geometry, etc.)
- Stress analysis (ex: EN 13458-2 Annex A or EN 13445-3 Annex C)
 - Evaluation of stresses using a finite element code
 - Linear elastic analysis
 - Decomposition of stresses in primary, secondary, membrane, bending
 - Comparison with different allowable stresses depending on the load classification
- Design by analysis - Direct route (EN 13445-3 Annex B)
 - Applicable to any component under any action
 - When manufacturing tolerances specified by the code are exceeded
 - Finite element models including material and geometrical non-linearities

* "Design checks" is actually a better term. The verification of the final design **must** be done through one of these routes but it may be practical to use other formulas/methods during the preliminary design phase.

Courtesy of L. Alberty and D. Ramos

CERTIFICAT DE QUALIFICATION / APPROBATION DE SOUDEUR SUIVANT : WELDER QUALIFICATION / APPROVAL TEST CERTIFICATE ACCORDING TO : EN 287-1

Reconduction du certificat N° / Renewal of certificate N°:

Symbolisation / Designation EN 287-1 141 T F SW S 13/3,2 D33,7 H-L045 ml

Reference CMOUS / WPS N° : 2011-15-4F

Certificat N° / Certificate N°

QP - EN - SE - 11 - 4593

Nom du soudeur / Welder's name
Identification
MORGAINDINHO Franck
Identification / designation
S15.175.91.73.06.013
Prénoms
MF
Mail
Date et lieu de naissance
01/01/1975 à CHAMBERY
Employeur
CEFIN

Certification de qualification
Qualification standard
NF EN 287-1 Edition 07/2004 et amendement A2 de 2006

☐ Acceptées / Accepted
☒ Non validées / Not tested

Photographie
Photograph
(si exigée) / if required
ou non fournie / or not supplied

Variables Variables	Détails de l'écoupe pratique Weld test details	Domaine de validité de la qualification Range of qualification
Procédés de la soudure / welding process	141	141
Tôles (P) ou tubes (T) / Plate or pipe	T	T - P
Type de soudure / Joint type	FW	FW
Groupe(s) / Position(s) de base Parent material group		B - 92 - 93 - 10 - 11 - 12 - 13 - 14 - 15 - 16 - 17 - 18 - 19 - 20 - 21 - 22 - 23 - 24 - 25 - 26 - 27 - 28 - 29 - 30 - 31 - 32 - 33 - 34 - 35 - 36 - 37 - 38 - 39 - 40 - 41 - 42 - 43 - 44 - 45 - 46 - 47 - 48 - 49 - 50 - 51 - 52 - 53 - 54 - 55 - 56 - 57 - 58 - 59 - 60 - 61 - 62 - 63 - 64 - 65 - 66 - 67 - 68 - 69 - 70 - 71 - 72 - 73 - 74 - 75 - 76 - 77 - 78 - 79 - 80 - 81 - 82 - 83 - 84 - 85 - 86 - 87 - 88 - 89 - 90 - 91 - 92 - 93 - 94 - 95 - 96 - 97 - 98 - 99 - 100 - 101 - 102 - 103 - 104 - 105 - 106 - 107 - 108 - 109 - 110 - 111 - 112 - 113 - 114 - 115 - 116 - 117 - 118 - 119 - 120 - 121 - 122 - 123 - 124 - 125 - 126 - 127 - 128 - 129 - 130 - 131 - 132 - 133 - 134 - 135 - 136 - 137 - 138 - 139 - 140 - 141 - 142 - 143 - 144 - 145 - 146 - 147 - 148 - 149 - 150 - 151 - 152 - 153 - 154 - 155 - 156 - 157 - 158 - 159 - 160 - 161 - 162 - 163 - 164 - 165 - 166 - 167 - 168 - 169 - 170 - 171 - 172 - 173 - 174 - 175 - 176 - 177 - 178 - 179 - 180 - 181 - 182 - 183 - 184 - 185 - 186 - 187 - 188 - 189 - 190 - 191 - 192 - 193 - 194 - 195 - 196 - 197 - 198 - 199 - 200 - 201 - 202 - 203 - 204 - 205 - 206 - 207 - 208 - 209 - 210 - 211 - 212 - 213 - 214 - 215 - 216 - 217 - 218 - 219 - 220 - 221 - 222 - 223 - 224 - 225 - 226 - 227 - 228 - 229 - 230 - 231 - 232 - 233 - 234 - 235 - 236 - 237 - 238 - 239 - 240 - 241 - 242 - 243 - 244 - 245 - 246 - 247 - 248 - 249 - 250 - 251 - 252 - 253 - 254 - 255 - 256 - 257 - 258 - 259 - 260 - 261 - 262 - 263 - 264 - 265 - 266 - 267 - 268 - 269 - 270 - 271 - 272 - 273 - 274 - 275 - 276 - 277 - 278 - 279 - 280 - 281 - 282 - 283 - 284 - 285 - 286 - 287 - 288 - 289 - 290 - 291 - 292 - 293 - 294 - 295 - 296 - 297 - 298 - 299 - 300 - 301 - 302 - 303 - 304 - 305 - 306 - 307 - 308 - 309 - 310 - 311 - 312 - 313 - 314 - 315 - 316 - 317 - 318 - 319 - 320 - 321 - 322 - 323 - 324 - 325 - 326 - 327 - 328 - 329 - 330 - 331 - 332 - 333 - 334 - 335 - 336 - 337 - 338 - 339 - 340 - 341 - 342 - 343 - 344 - 345 - 346 - 347 - 348 - 349 - 350 - 351 - 352 - 353 - 354 - 355 - 356 - 357 - 358 - 359 - 360 - 361 - 362 - 363 - 364 - 365 - 366 - 367 - 368 - 369 - 370 - 371 - 372 - 373 - 374 - 375 - 376 - 377 - 378 - 379 - 380 - 381 - 382 - 383 - 384 - 385 - 386 - 387 - 388 - 389 - 390 - 391 - 392 - 393 - 394 - 395 - 396 - 397 - 398 - 399 - 400 - 401 - 402 - 403 - 404 - 405 - 406 - 407 - 408 - 409 - 410 - 411 - 412 - 413 - 414 - 415 - 416 - 417 - 418 - 419 - 420 - 421 - 422 - 423 - 424 - 425 - 426 - 427 - 428 - 429 - 430 - 431 - 432 - 433 - 434 - 435 - 436 - 437 - 438 - 439 - 440 - 441 - 442 - 443 - 444 - 445 - 446 - 447 - 448 - 449 - 450 - 451 - 452 - 453 - 454 - 455 - 456 - 457 - 458 - 459 - 460 - 461 - 462 - 463 - 464 - 465 - 466 - 467 - 468 - 469 - 470 - 471 - 472 - 473 - 474 - 475 - 476 - 477 - 478 - 479 - 480 - 481 - 482 - 483 - 484 - 485 - 486 - 487 - 488 - 489 - 490 - 491 - 492 - 493 - 494 - 495 - 496 - 497 - 498 - 499 - 500 - 501 - 502 - 503 - 504 - 505 - 506 - 507 - 508 - 509 - 510 - 511 - 512 - 513 - 514 - 515 - 516 - 517 - 518 - 519 - 520 - 521 - 522 - 523 - 524 - 525 - 526 - 527 - 528 - 529 - 530 - 531 - 532 - 533 - 534 - 535 - 536 - 537 - 538 - 539 - 540 - 541 - 542 - 543 - 544 - 545 - 546 - 547 - 548 - 549 - 550 - 551 - 552 - 553 - 554 - 555 - 556 - 557 - 558 - 559 - 560 - 561 - 562 - 563 - 564 - 565 - 566 - 567 - 568 - 569 - 570 - 571 - 572 - 573 - 574 - 575 - 576 - 577 - 578 - 579 - 580 - 581 - 582 - 583 - 584 - 585 - 586 - 587 - 588 - 589 - 590 - 591 - 592 - 593 - 594 - 595 - 596 - 597 - 598 - 599 - 600 - 601 - 602 - 603 - 604 - 605 - 606 - 607 - 608 - 609 - 610 - 611 - 612 - 613 - 614 - 615 - 616 - 617 - 618 - 619 - 620 - 621 - 622 - 623 - 624 - 625 - 626 - 627 - 628 - 629 - 630 - 631 - 632 - 633 - 634 - 635 - 636 - 637 - 638 - 639 - 640 - 641 - 642 - 643 - 644 - 645 - 646 - 647 - 648 - 649 - 650 - 651 - 652 - 653 - 654 - 655

WQ (Welder Qualification)

Goal

EN 13445-5:2002 (F)
Version 1 (2002-05)

4 Réalisation de l'inspection et des contrôles

4.1 Généralités

Chaque récipient doit être soumis à des inspections pendant la construction et une fois achevé. Des inspections doivent être faites pour s'assurer de la conformité à tous les égards de la conception, des matériaux, de la fabrication et des contrôles avec les exigences de la présente norme. Des preuves documentées doivent être établies pour vérifier la mise en œuvre de cette exigence.

Different tipologies:

- Visual test: **always 100% visual test on EU standards!** Liquid penetrant test
- X-ray test
- Ultrasound test
- Pressure test

Type and extents depend on materials and on joint coefficient (= on the design)

Performed

- by qualified testing personnel
- according to specific European Standards

Remarks

- Brazed joints are not exempted!

