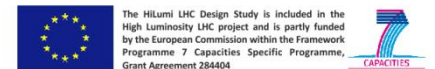


# Selection of technical standards for HL-LHC

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HL-LHC Standards and Best Practices  
Workshop (11-13 June 2014)



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- An example

# Purpose & Rationale

- Technical standards provide a reliable set of technical, quality and, in some cases, safety requirements for different phases of a system life-cycle (concept, development, production, utilization-support, retirement)
- They contribute to an:
  - Increased confidence on the quality of systems, sub-systems, equipment, components,...
  - Increase of reliability and availability
  - Minimization of risks and costs

- A quality guideline has been launched (EDMS: 1376475):
- To guide the different project stakeholders on the choice of codes and standards applicable to HL-LHC systems, sub-systems, equipment and components, as one of the means to meet the HL-LHC system requirements with respect to technical, quality and safety requirements. Maps of standards for different technical fields have been established for this purpose

# Background

- LHC systems have been supported by the use of different technical standards comprising different technical fields

LHC systems	HL-LHC related WPs	Fields																
		M	ME	EE	E	FC	TE	T	IT	ImT	MM	RP	EHS	ChT	MH	ASE	S	G
Magnets	3	X	X	X		X		X	X	X	X	X				X	X	
Radio-frequency	4	X	X	X	X	X	X				X		X					
Collimators	5	X	X	X		X		X										
Powering	6		X					X										
DC powering and quench protection	6&7	X	X			X		X		X							X	
Cryogenics	9	X	X	X	X	X					X		X	X	X		X	X
Vacuum	12	X	X					X									X	
Beam monitoring	13						X	X	X		X							
Transfer lines, injection and beam dumping	14	X	X	X	X	X	X				X		X		X		X	X

## Legend

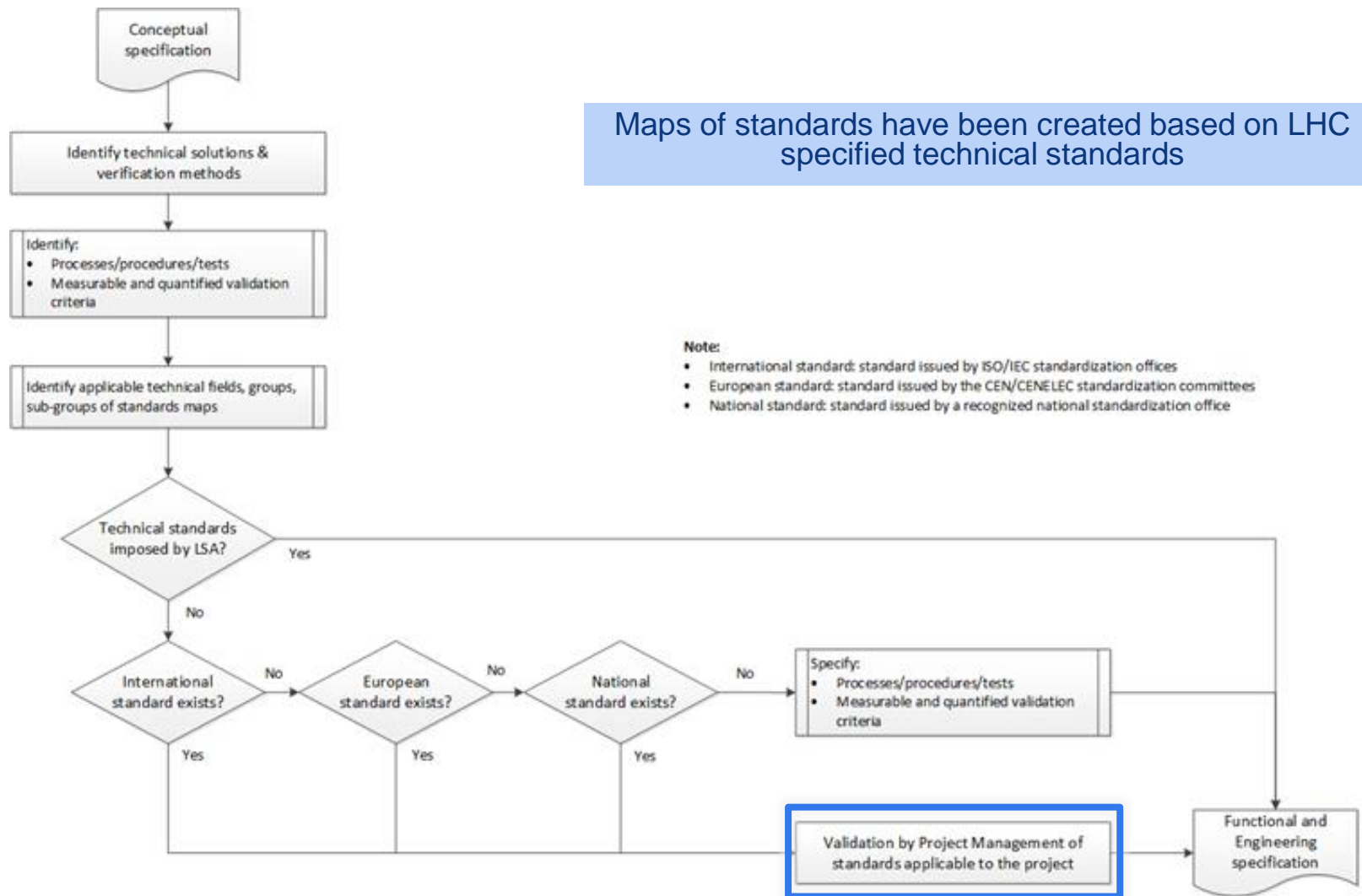
M	Metallurgy	MM	Metrology and measurement. Physical phenomena
ME	Manufacturing engineering	RP	Rubber and plastic industries
EE	Electrical engineering	T	Testing
E	Electronics	EHS	Environment. Health protection. Safety
FC	Fluid systems and components for general use	ChT	Chemical technology
IT	Information technology	MH	Materials handling equipment
TE	Telecommunications engineering	ASE	Aircraft and space vehicle engineering
ImT	Image technology	S	Services. Company organization, management and quality. Administration. Transport. Sociology
		G	Generalities. Terminology. Standardization. Documentation

(source: IT specifications, EDMS - LHC Hardware Baseline)



- The present standardization scenario is very different from the one that existed for the LHC project
- Most of the standards specified for the LHC have been replaced or withdrawn and should not be used for HL-LHC specifications

# Selection process



# Constraints

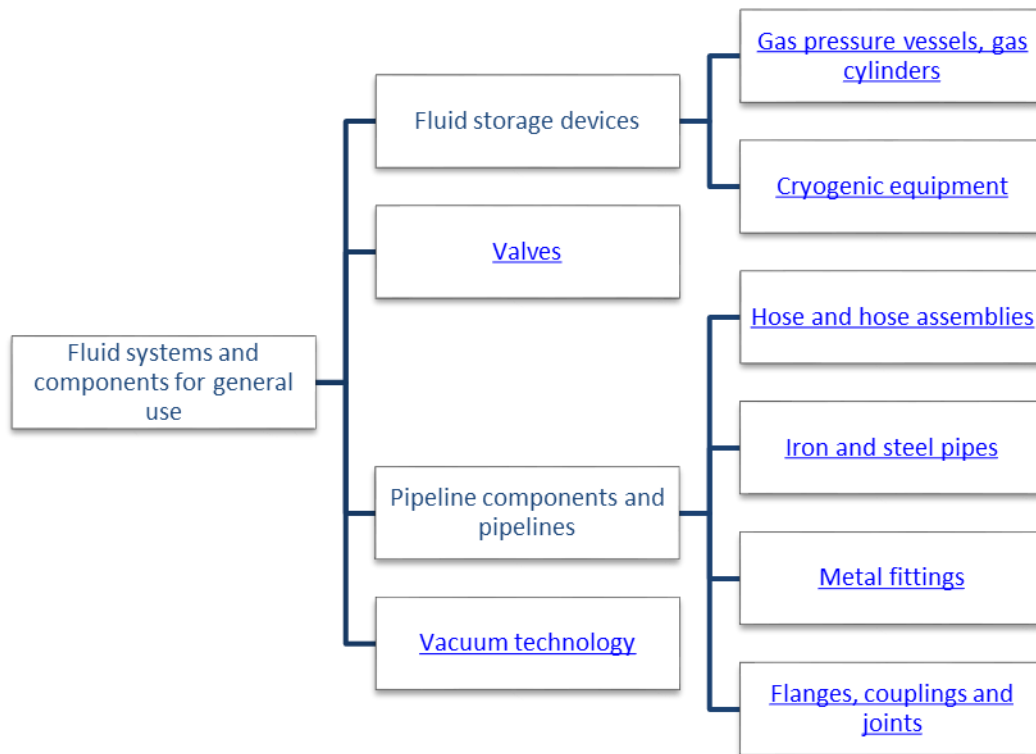


- Codes and standards are only binding constraints, whenever required to:
  - Comply with CERN Safety Rules → *Launch Safety Agreement (LSA)*
  - Guarantee a consistency among all systems, and its interfaces, in critical aspects (risk mitigation) identified in the project

# Structure of technical standards maps (1/2)

Example: Fluid systems and components for general use

Global overview  
EDMS: [1380880](#)



- Based on the International Classification of Standards (ICS) which allows finding among different standardization organizations, standards with similar, or equivalent, scope
- For each technical field, maps have been defined for different groups and sub-groups of standards issued by ISO/IEC/CEN/CENELEC organizations
- For very specific cases National standards (US) have also been included (e.g., non-ferrous materials, pressure vessels)

# Structure of technical standards maps (2/2)

**Unfired pressure equipment**

Guidance on the use of the PED conformity assessment procedures	CR 13445-7	
General requirements	EN 13445-1	
Materials	EN 13445-2	ASME Section II
Design	EN 13445-3	ASME Section VIII
Fabrication	EN 13445-4	ASME Section IX
Inspection & testing	EN 13445-5	ASME Section V
Pressure vessels and pressure parts constructed from spheroidal graphite cast iron	EN 13445-6	
Additional requirements for pressure vessels of aluminium and aluminium alloys	EN 13445-8	
Pressure vessels and pressure parts constructed from cast iron (elongation after fracture $\leq 15\%$ )	EN 15776	
Glass reinforced plastic (GRP) pressure vessels	EN 13923	ASME Section X

**Pressure vessels**

Identification of standards harmonized with EU Directives (→ Safety requirements)

Links to CDS records, whenever existing (valid and superseded)

Legend:

- Harmonized standards: Pressure Equipment Directive (97/23/EC)
- Referenced standards: Transportable Pressure Equipment (2010/35/EU), ADR

**Scope**

**VI: Vacuum insulated**

Vessels		Transportable		Piping
Static	Non-VI	VI	Non-VI	
EN 13458-x	ISO 21009-x	EN 14197	EN 1251-x	EN 13480-x
			EN 13530-x	ASME B31.3
	EN 13445-x	ISO 21029	ISO 20421	
	ASME BPVC			

**Cryogenic equipment**

Identification of standards with "similar" scope

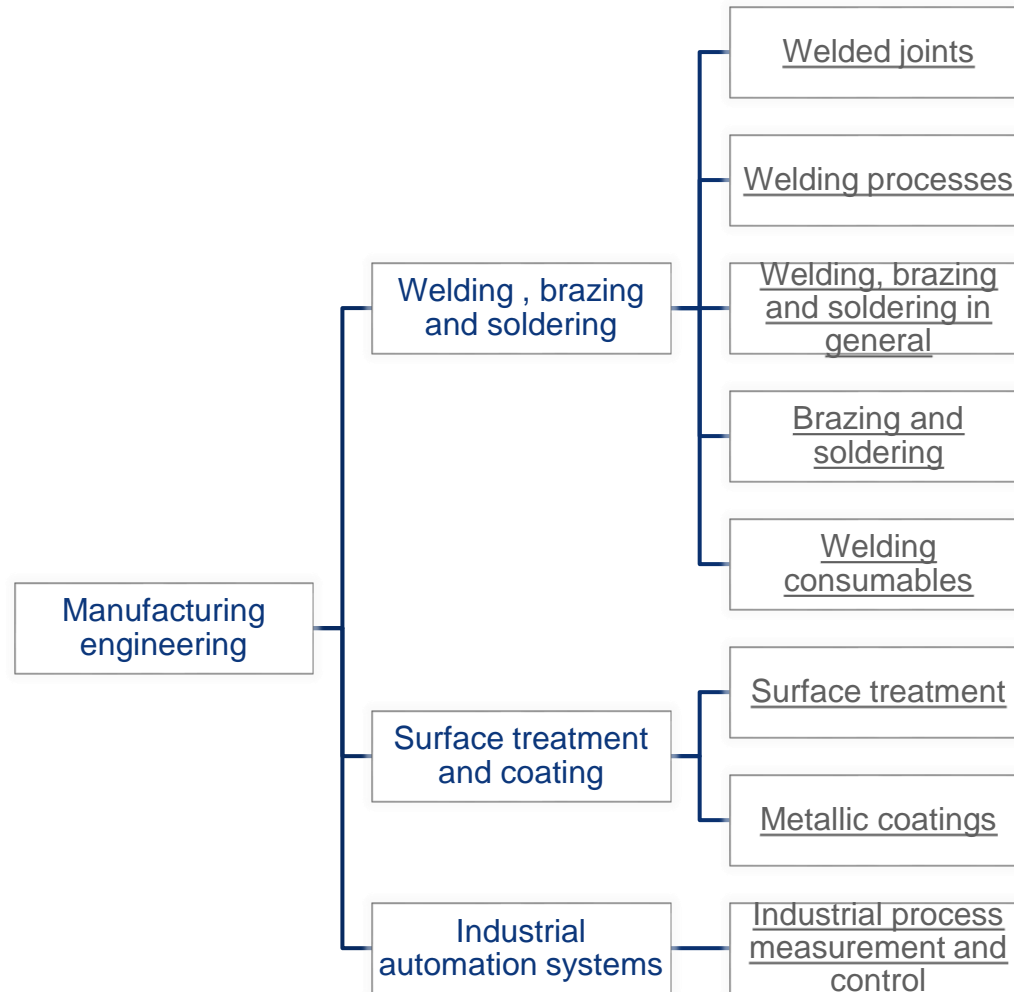
Components				
Metal hoses	Valves	Couplings	Pumps	Expansion joints
EN 12434	ISO 21012	EN 1626	EN 13275	EN 14917
EN 14585-1 CEN/TR 14585-2	ISO 21011		ISO 24490	



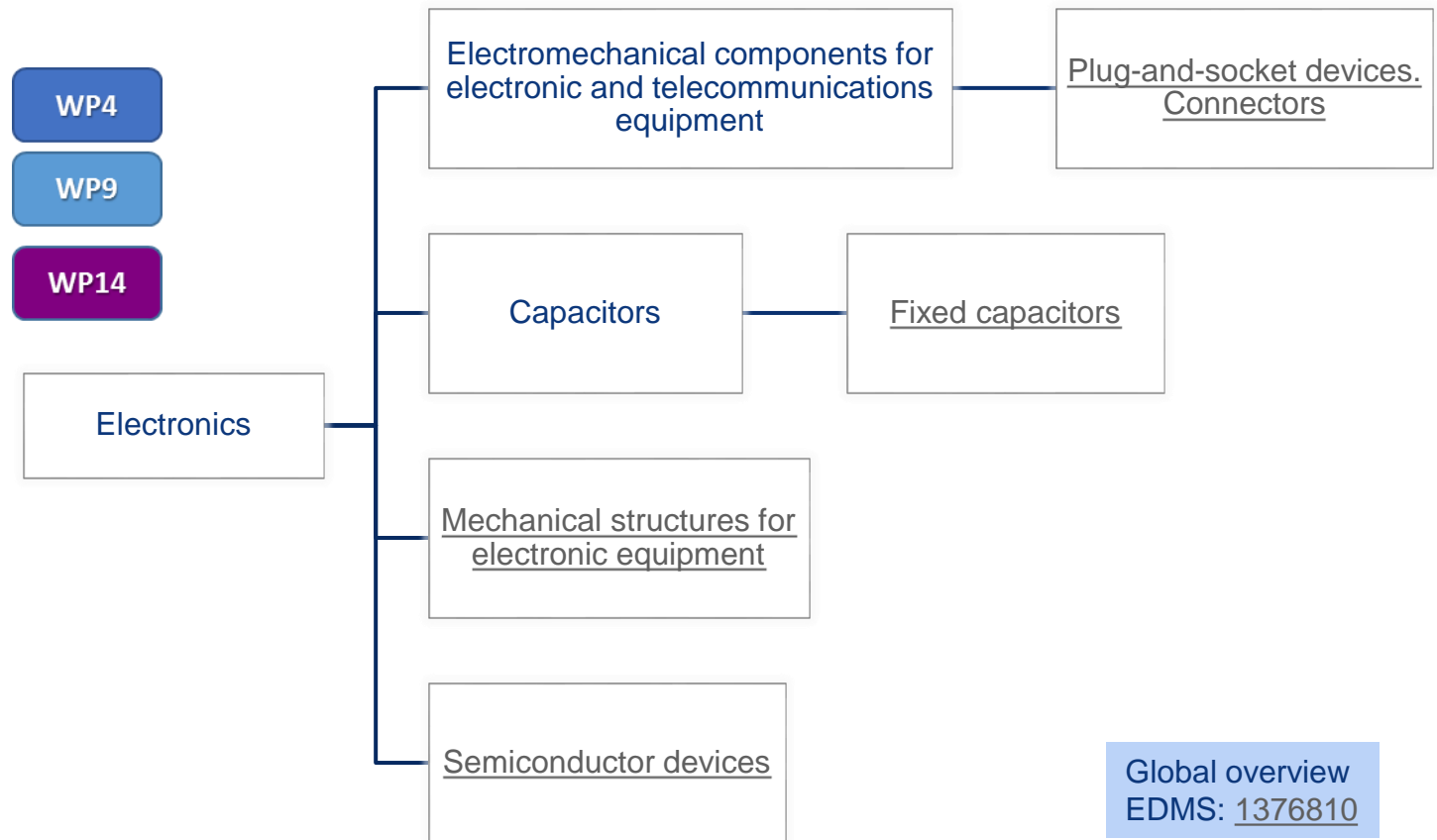
# Manufacturing engineering

Global overview  
EDMS: [1376811](#)

- WP3
- WP4
- WP5
- WP6
- WP6&7
- WP9
- WP12
- WP14



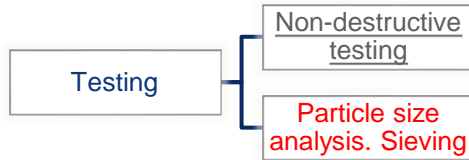
# Electronics



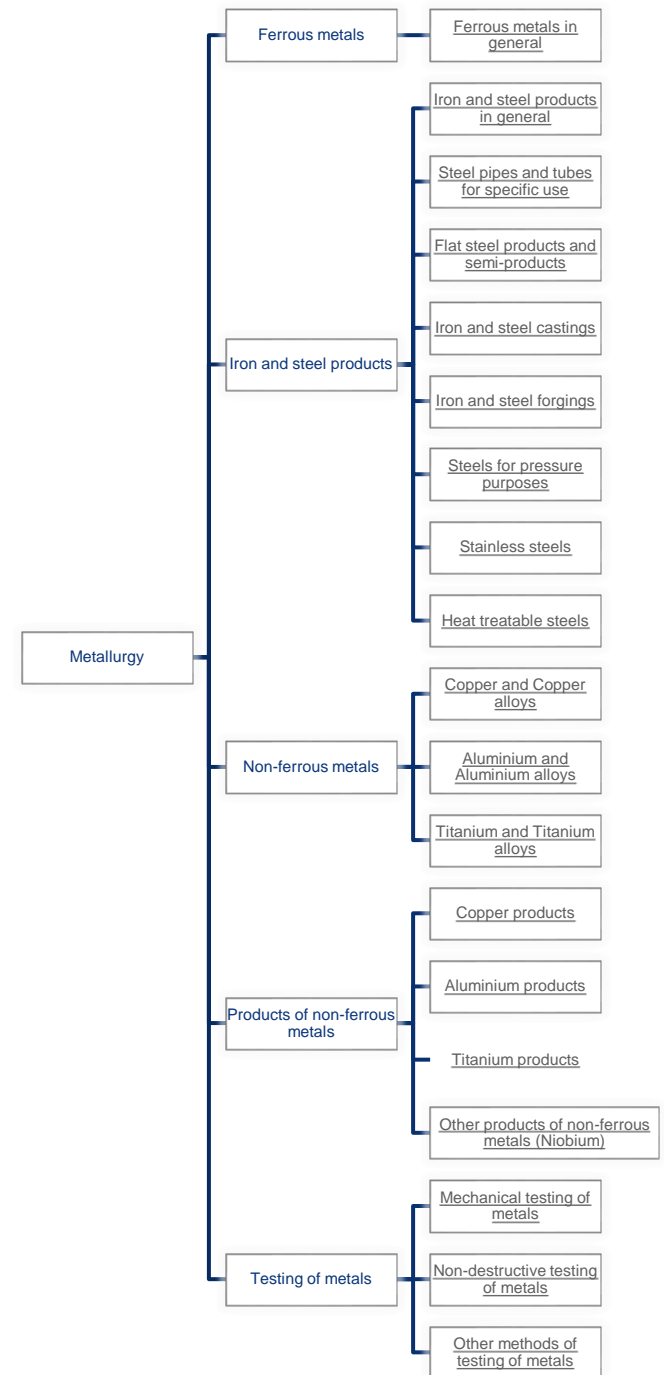
# Metallurgy & Testing

Global overview  
EDMS: [1376801](#)

- WP3
- WP5
- WP6
- WP6&7
- WP12
- WP13

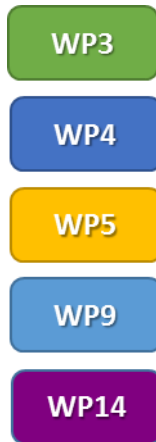


- WP3
- WP4
- WP5
- WP6&7
- WP9
- WP12
- WP14

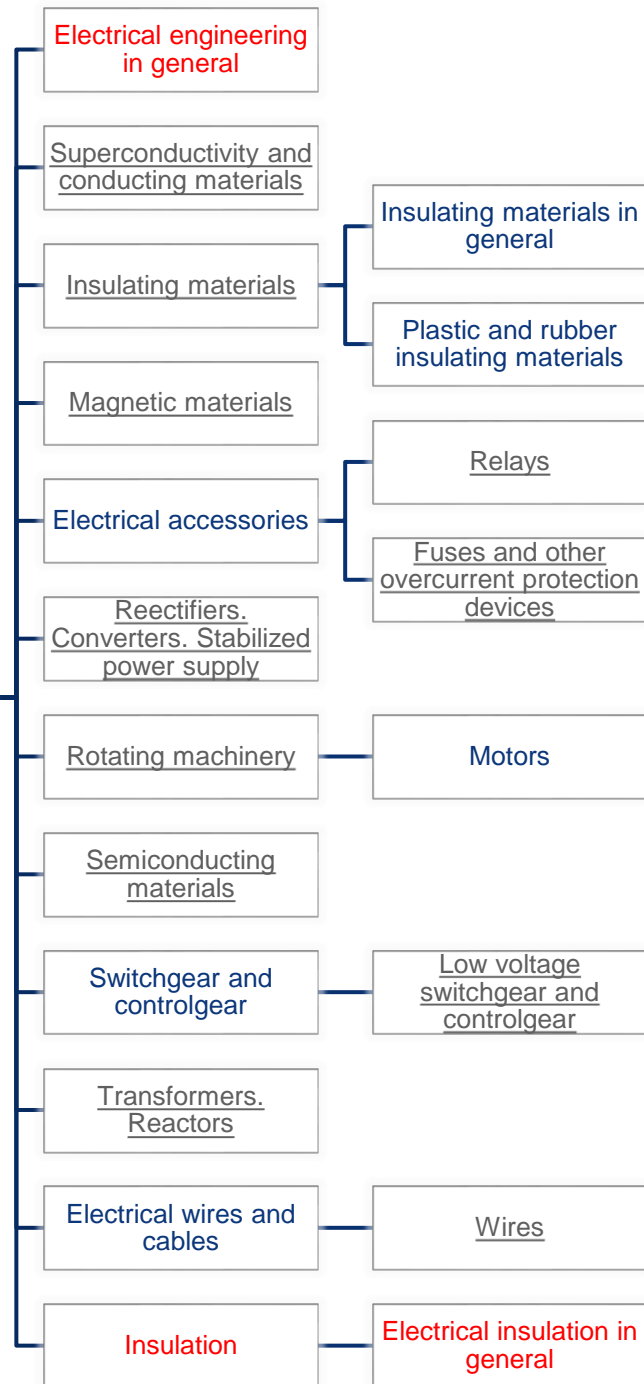


# Electrical engineering

Global overview  
EDMS: [1376809](#)

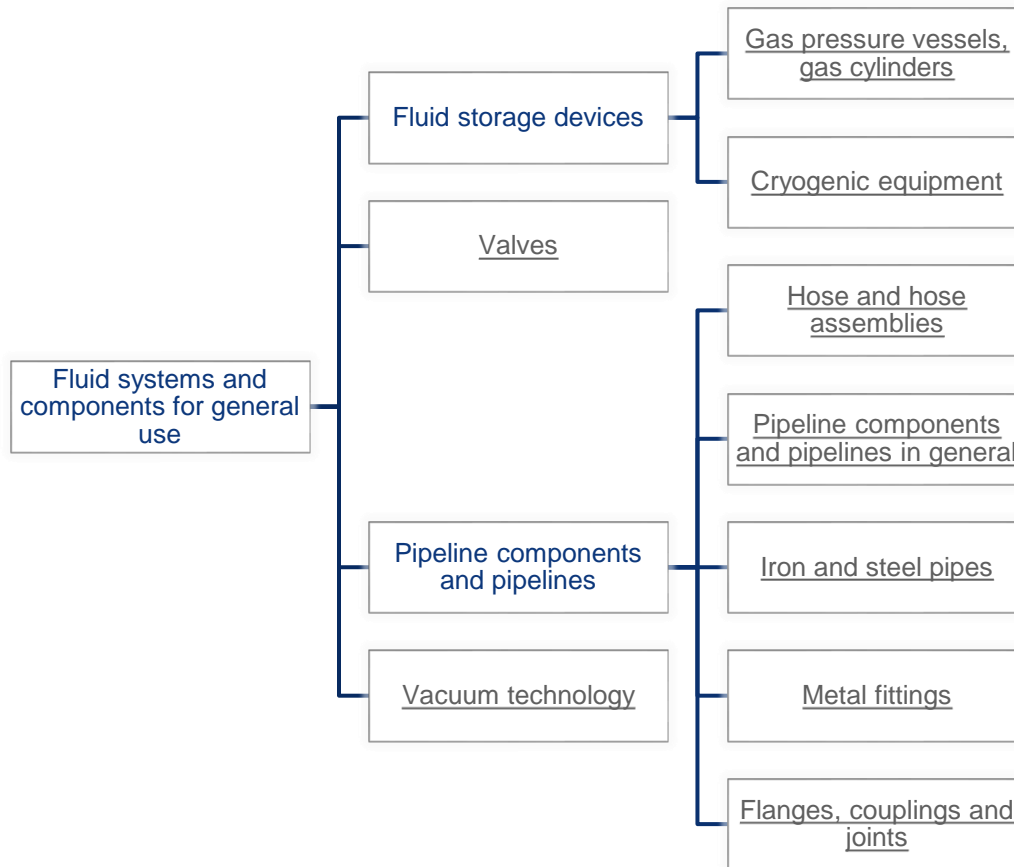


Electrical engineering



# Fluid systems and components for general use

- WP3
- WP4
- WP5
- WP6&7
- WP9
- WP14



Global overview  
EDMS: [1376815](#)

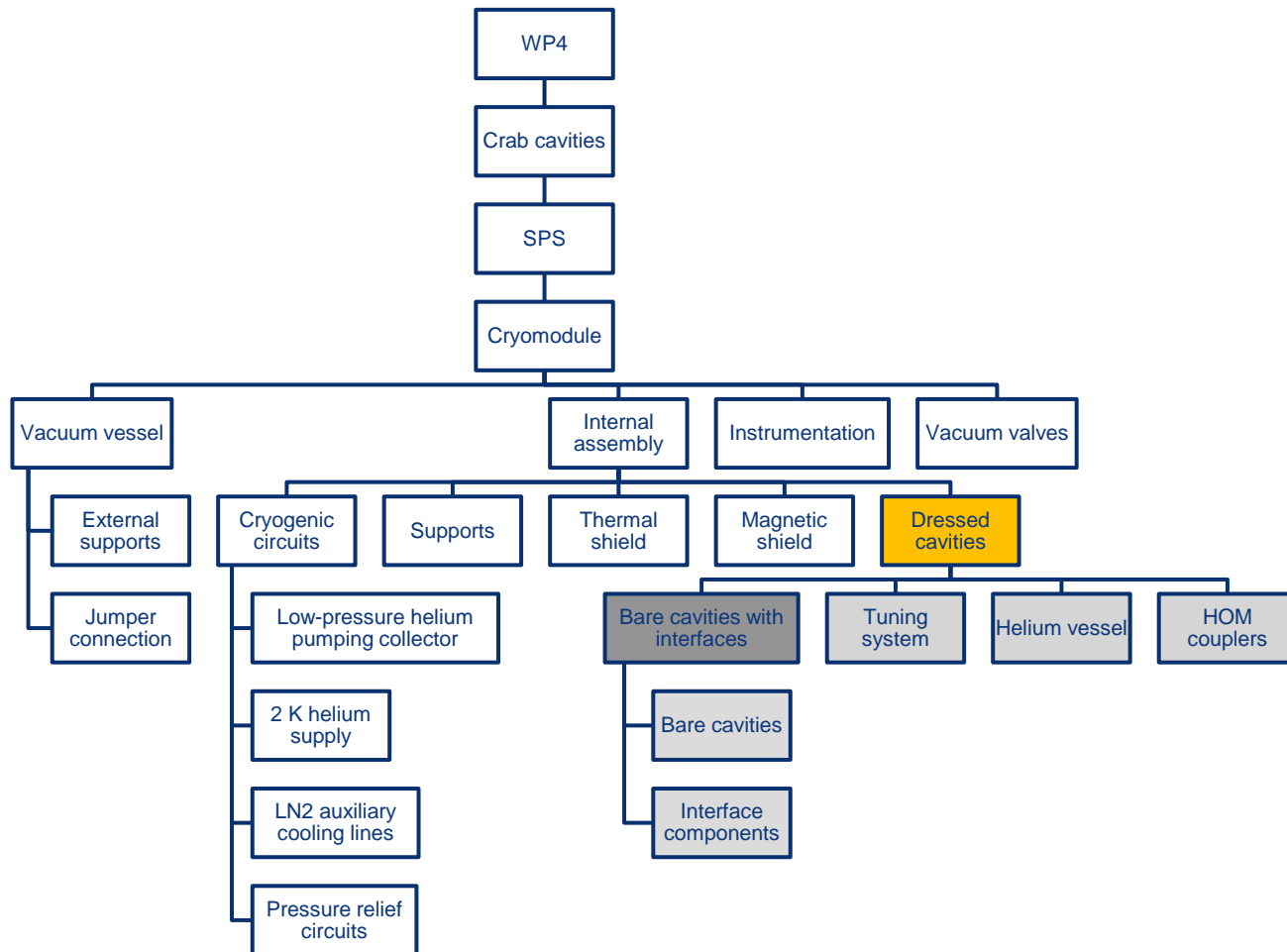
# Into practice (WP4 example)

## CRAB CAVITIES (WP4)

- **Requirement:** correct geometric effects of wider crossing angles from reduced beam sizes
- **Solution:** transverse deflecting cavities (crab cavities)
  - SPS cryomodule (prototype)
  - LHC cryomodule

# Identification of technical solutions

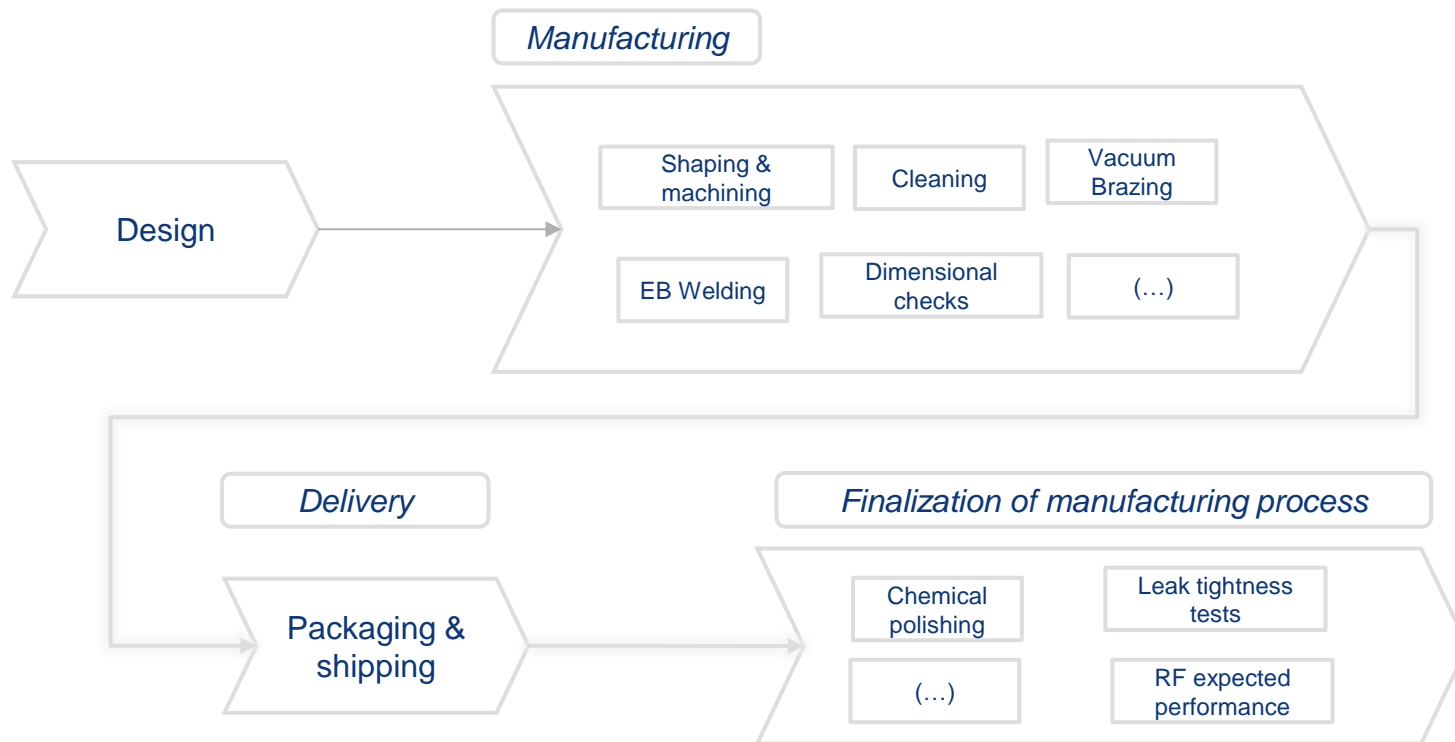
Identification of required equipment, assemblies, parts and components



# Identification of technical processes

To obtain the required “entities”, or products, previously identified

*Simplified processes for **bare cavities (with interfaces)***





# Identification of technical standards

Global overview  
EDMS: [1380880](#)

ICSField	Group	Sub-group	EDMS	Magnets
01.060	Generalities. Terminology. Standardization. Documentation	Quantities and units	<a href="#">1360514</a>	3
01.080.30		Graphical symbols	<a href="#">1360510</a>	
01.100.01		Technical drawings	<a href="#">1360511</a>	
01.100.20			<a href="#">1360512</a>	
01.100.30			<a href="#">1360513</a>	
03.120.10	Services. Company organization, management and quality. Administration. Transport. Sociology	Quality	<a href="#">1360523</a>	X
13.240	Environment. Health protection. Safety	Protection against excessive pressure	<a href="#">1360509</a>	
13.260		Protection against electric shock. Live working	<a href="#">1360508</a>	
13.340.30		Protective equipment	<a href="#">Respiratory protective devices</a> <i>tbd</i>	
17.020	Metrology and measurement. Physical phenomena	Metrology and measurement in general	<a href="#">1360520</a>	X
17.040.20				
17.140.50				
17.160				
17.200.20				
19.100	Testing			
19.120	Fluid systems and components for general use	EB welding		
23.020.30		Visual examination of EB welds		
23.020.40		Pressure vessel		
23.040.01		Niobium – Titanium transition pieces		
23.040.10				
23.040.40				
23.040.60				
23.040.70				
23.060				

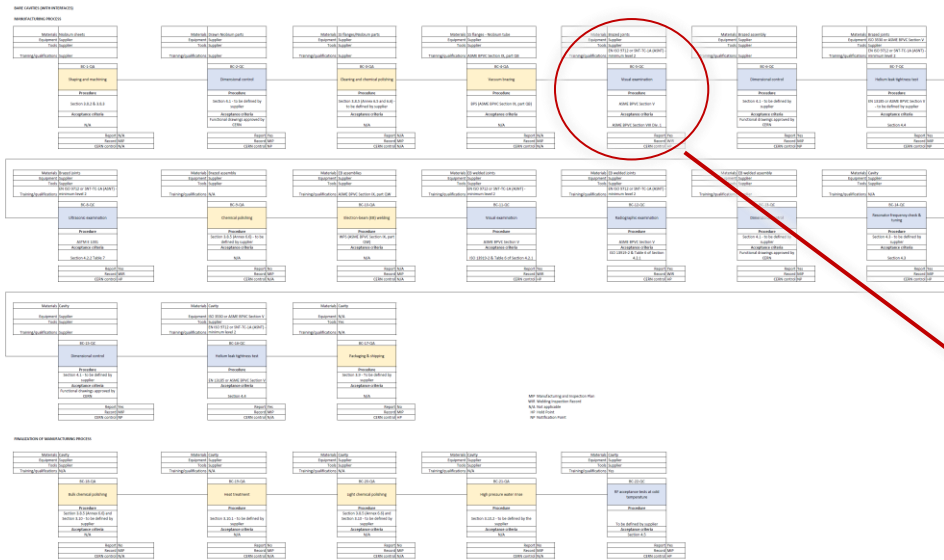
*Non-exhaustive list*

Technical requirements	Standards fields/groups	Selected standards
EB welding	Manufacturing engineering → Welding processes	ASME BPVC Section IX PART- QW
Visual examination of EB welds	Manufacturing engineering → Welded joints	ISO 13919-2
Pressure vessel	Fluid systems and components for general use → Pressure vessels	ASME BPVC
Niobium – Titanium transition pieces	Metallurgy → Other products of non-ferrous metals	ASTM B884-11

Discussed and validated by project management

# Specification of technical processes (1/2)

## Quality assurance and quality controls needed to meet the requirements



Quality control step  
 → supported by validated technical standards

Materials	EB welded joints	
Equipment	Supplier	
Tools	Supplier	
Training/qualifications	EN ISO 9712 or SNT-TC-1A (ASNT) - minimum level 2	
	BC-11-QC	
	Visual examination	
	Procedure	
	ASME BPVC Section V	
	Acceptance criteria	
	ISO 13919-2 & Table 6 of Section 4.2.1	
	Report	Yes
	Record	WIR
	CERN control	HP

# Specification of technical processes (2/2)

Quality assurance steps

→ supported by validated technical standards and/or by CERN best practices

Materials	SS flanges - Niobium tube	
Equipment	Supplier	
Tools	Supplier	
Training/qualifications	ASME BPVC Section IX, part QB	
	BC-4-QA	
	Vacuum brazing	
	<b>Procedure</b>	
	Section 3.8.6 & BPS (ASME BPVC Section IX, part QB)	
	<b>Acceptance criteria</b>	
	N/A	
	Report	N/A
	Record	MIP
	CERN control	N/A

Materials	Brazed assembly	
Equipment	Supplier	
Tools	Supplier	
Training/qualifications	N/A	
	BC-9-QA	
	Chemical polishing	
	<b>Procedure</b>	
	Section 3.8.5 (Annex 6.6) - to be defined by supplier	
	<del>Acceptance criteria</del>	
	N/A	
	Report	No
	Record	MIP
	CERN control	N/A

Other CERN best practices used to support the specification (examples):

- Niobium RRR 300 - Material Technical Specification N° 3300
- Cleaning procedure for stainless steel components

Thank you for your attention !

Questions?