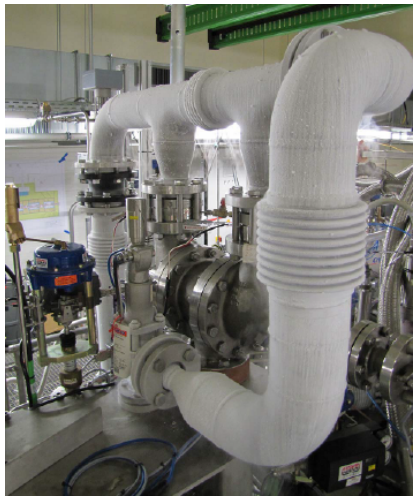
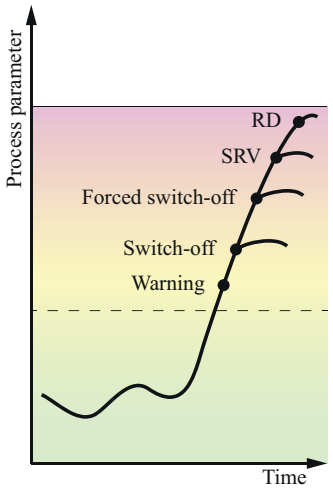
WP5.3:
Harmonisation – Cryogenic Safety Procedures

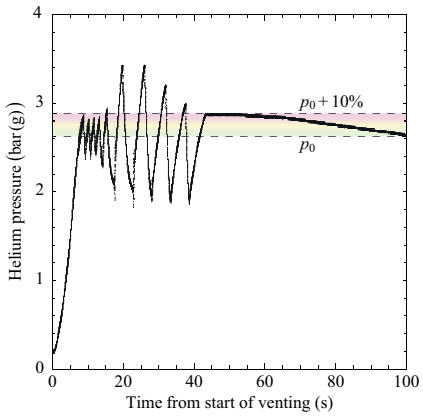
Steffen Grohmann

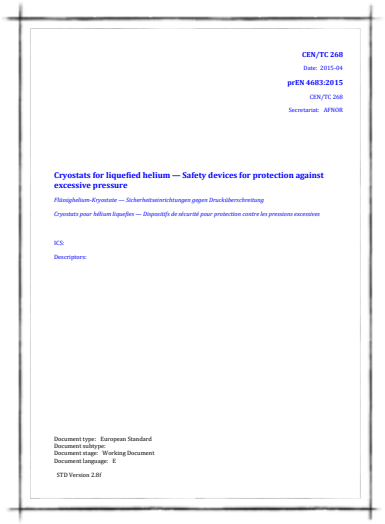
AMICI Kick-off Meeting, Paris, January 17-19, 2017

INSTITUTE OF TECHNICAL PHYSICS (ITEP)
INSTITUTE OF TECHNICAL THERMODYNAMICS AND REFRIGERATION (ITTK)








CEN/TC 268
Date: 2015-04
prEN 4683:2015
CEN/TC 268
Secretariat: AFNOR

Cryostats for liquefied helium — Safety devices for protection against excessive pressure

Flüssighelium-Kryostate — Sicherheitseinrichtungen gegen Drucküberschreitung

Cryostats pour helium liquefies — Dispositifs de sécurité pour protection contre les pressions excessives

ICS:

Descriptors:

Document type: European Standard
Document subtype:
Document stage: Working Document
Document language: E

STD Version 2.0f

Outline

- Introduction – Relevant existing standards
- Motivation – What is special in LHe cryostats?
- Status of the European standardization project
- Objectives within WP5.3 of the AMICI project

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RELEVANT EXISTING STANDARDS

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General standards for pressure equipment

- **Legal basis** for pressure equipment with a *maximum allowable pressure* of $\mathrm{PS} > 0.5\ \mathrm{bar(g)}$: European **PED 2014/68/EU**
- Generally applicable **harmonised** standards
  - EN 13445 (Unfired pressure vessels)
  - EN 13480 (Metallic industrial piping)
  - EN ISO 4126 (Safety devices for protection against excessive pressure)
- Generally applicable **national** standards
  - AD 2000
  - British Standard
  - CODAP
  - …

storage

Particular standards for *cryogenic vessels*

- Basic requirements, calculation, manufacturing, testing, operation

DIN EN ISO 21029 DIN EN 1251	Transportable vacuum insulated vessels of not more than 1.000 liters volume
DIN EN ISO 20421 DIN EN 13530	Large transportable vacuum insulated vessels
DIN EN 14398	Large transportable non-vacuum insulated vessels
DIN EN ISO 21009 DIN EN 13458	Static vacuum insulated vessels
DIN EN 14197	Static non-vacuum insulated vessels

- Further cryogenic standards for individual *components*, *materials*, *thermal insulation* and *cleanliness*

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WHAT IS SPECIAL IN LHe CRYOSTATS?

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What is special in LHe cryostats?

- Process dynamics
  - Large heat fluxes up to $\dot{q} \approx 40\,\mathrm{kW/m^2}$ during system failures
  - Very low latent heat of helium $\rightarrow \left.\frac{\Delta h_\mathrm{v}}{\mathrm{L\ liquid}}\right|_{1\mathrm{bar}}$ $(\mathrm{He} : \mathrm{N_2} : \mathrm{H_2O}) = 1 : 62 : 835$

  - ➢ Nearly instantaneous evaporation
  - ➢ Rates of pressure raise $\mathrm{d}p/\mathrm{d}\tau > 1\,\mathrm{bar/s}$
    - Limit wrt. EN ISO 4126-10 $\mathrm{d}p/\mathrm{d}\tau < 0.2\,\mathrm{bar/s}$!

Quench test of a sc. solenoid (KATRIN)

Rupture of a 70 L liquid nitrogen dewar

Accident in a laboratory (09/2005)

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What is special in LHe cryostats?

Common pressure equipment	Liquid helium cryostats
• Cryogenic storage containers	• Sc. magnet cryostats, RF cavities

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Examples of typical safety units

LN2 storage tank ($\approx 50.000\ \mathrm{L}$)	Liquid helium cryostat ($\approx 500\ \mathrm{L}$)

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Liquid helium cryostats

- Nomenclature
  - Cryostat ≠ storage vessel/container!
  - LHe cryostats involve **active components** such as superconducting magnets and cavities, heaters, pumps, valves etc.
- LHe cryostat conditions **not covered** by other standards
  - Staging of multiple safety levels, e.g. for quench recovery
  - Large stored energies, loss of insulating vacuum, thermal acoustic oscillations, electric arcs
  - Rates of pressure raise (out of scope wrt. EN ISO 4126-10)
  - Two-phase flow (discharge functions out of scope wrt. EN ISO 4126-10)
  - Incompatible design constraints (e.g. 3 % rule for inlet piping pressure drop; 0.6 m rule for heat load)
  - Helium recovery and discharge in confined spaces
  - …

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EUROPEAN STANDARDISATION PROJECT

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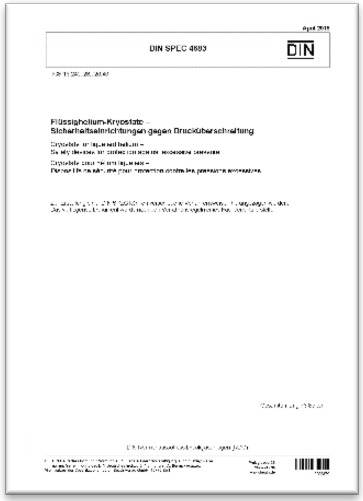
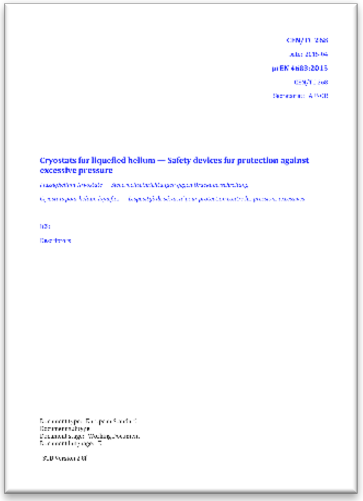
European standardisation project

- Satellite meeting at European Cryogenics Days 2015 (Grenoble)
  - Agreement to advance a **European standardisation process**
  - Baseline documents: Translations of DIN SPEC 4683 and CEA documents, CERN standards + any other contribution





prEN 4683:2015

Working document (07/2016)

- Inconsistent **nomenclature** in different standards
- **Different definitions** of **set pressure** in ISO 4126 (2013), API 520 (2014) and ASME PTC 25 (2014)

Aim of the European standard

- **Collect**, **structure** and **harmonize** state-of-the-art **rules**, **procedures** and **know-how** from labs, institutes and companies in Europe
- Provide a **comprehensive overview** on all major aspects of **safe design and operation** of liquid helium cryostats
- **Solve conflicts** with other standards by the indication of **alternative options**
- Provide the **first multi-national standard** on safety of LHe cryostats for our community

➢ European standards are produced by **all interested parties** through a **transparent**, **open** and **consensus based** process

Project organisation

- Establishment of a **new working group** at CEN/TC 268 – *Cryogenic vessels and specific hydrogen technologies applications*
  - Chairperson: Dr. Hervé Barthélémy, Air Liquide
  - Link: CEN/TC 268

WG 1	Design
WG 2	Compatibility, insulation, accessories
WG 3	Operational requirements
WG 4	Fundamental requirements
WG 5	Specific hydrogen technologies applications
+	
WG 6	**Liquid helium cryostats**

CERN Cryogenic Safety Seminar 09/2016

- First dedicated seminar with 120 participating experts
  - 36 talks and intense discussions
  - General support for the European standardization project

Participating experts (Status 01/2017)

- CEN requirement: Min. **5 participating countries** must indicate active members

Country	Name	Surname	Affiliation	National Registration Status		
				No feedback	Ongoing	Confirmed
France	Ercolani	Eric	CEA	☐	☐	☐
	Fauchon	Arnaud	Air Liquide (F)	☐	☐	☑
	Poncet	Jean-Marc	CEA	☐	☐	☐
Germany	Blum	Lars	Linde Kryotechnik	☐	☐	☑
	Grohmann	Steffen	KIT	☐	☐	☑
	Otte	Wolfgang	Air Liquide (D)	☐	☐	☑
	Reinhardt	Matthias	Herose	☐	☐	☑
	Sarosiek	Karol	DIN	☐	☐	☑
	Weber	Christina	KIT	☐	☐	☑
Italy	Parma	Vittorio	CERN	☐	☑	☐
	Pengo	Ruggero	INFN	☐	☑	☐
Netherlands	Bremer	Johan	CERN	☐	☑	☐
Poland	Polinski	Jaroslaw	Wroclaw University	☐	☐	☑
Portugal	Henriques	Andre	CERN	☐	☐	☑
Switzerland	Heidt	Carolin	PSI	☐	☑	☐
United Kingdom	Down	Richard	Rutherford Lab	☐	☐	☑

European standardisation project schedule

- Project management by WG secretariat at DIN, Berlin
  - Coverage of administrative cost
- Kick-off meeting in early 2017
  - Discussion at CEN/TC 268 secretariat on **January 19, 2017**
  - Doodle poll among participating experts
- Two project meetings/year
- Finalisation of the working draft in ≤ 3 years
  - Submission to TC chairperson and TC secretary for CEN Enquiry

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OBJECTIVES WITHIN WP5.3 OF AMICI

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Objectives within WP5.3 of AMICI

- *"Under the EU regulations, this task will organise the **exchange of knowledge and procedures** in order to obtain a common methodology used by labs and industry for the design and fabrication of cryogenic equipment. This will be achieved by **organising and coordinating a working group at the European Committee for Standardization (CEN)**, where additional experts from Universities, research labs and industry will participate. Its aim is to **compose a draft European standard on safety of cryogenic equipment**, merging and harmonising state-of-the-art rules and codes from various labs and organisations. The compliance of the new standard with the PED and other standards will be assured by the established procedures in such process."*

➢ More precisely: **Safety of liquid helium cryostats** (no change of existing codes for standardized equipment!)

➢ Focus on **particular accelerator expertise**

Objectives within WP5.3 of AMICI

- *"Beyond the actual state-of-the art, this task will **collect and assess** available **modelling codes**, which are able to consider and analyse the **process dynamics** of cryogenic incidents. In addition, the task will **define the scope of future experiments and model developments** required to consolidate and evolve the proposed common methodologies. This concern specifically the **experimental basis** required **for the implementation of dynamic models** in a common standard, as well as performance data of pressure relief devices under cryogenic conditions."*

- Scope **beyond** the European standardization project (which will reflect the *state-of-the-art*)

  - Definition of the **roadmap / pre-conditions** for a **future upgrade of methodologies** in the new European standard on safety of liquid helium cryostats

Milestones and deliverables

Milestones

- **M5.1:** List of safety scenarios in liquid helium cryostats **(M12)**

Deliverables

- **D5.3:** General harmonised guidelines for the safety of cryogenic equipment **(M28)**
  - ➢ Working draft produced by the new CEN/TC 268 WG