European standardization activities on safety of liquid helium cryostats

Steffen Grohmann

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

Outline

- Safety of pressure equipment – What is special in LHe cryostats?
- Brief review of a national standardization project (2010 – 2015)
- European standardization project
- Cross-link among projects

Safety of pressure equipment

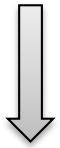
WHAT IS SPECIAL IN LHe CRYOSTATS?

Safety of cryogenic pressure equipment

- Cryogenic installations usually contain **pressure vessels** subject to the European PED 2014/68/EU $\{PS > 0.5\ \mathrm{bar(g)}\}$
  - **Storage containers** [static, transportable, (non-)vacuum insulated]: Dedicated standards such as EN 13458, EN 13648, … (→ H. Barthélémy)
  - **LHe cryostats:** No dedicated safety design standard/rule
- **LHe cryostat** conditions **not covered** by other standards:
  - Necessity of staging multiple safety levels, e.g. for quench recovery
  - Large stored energies, loss of insulating vacuum
  - 3 % rule (inlet piping pressure drop) and 0.6 m rule (heat loads)
  - Thermal acoustic oscillations
  - Two-phase flow
  - Electric arcs
  - Helium discharge in confined spaces
  - …

What is special in LHe cryostats?

- Process dynamics
  - Large heat fluxes of several W/cm^2 during failures
  - Very low latent heat of helium $\rightarrow \left.\frac{\Delta h_v}{\mathrm{L\ liquid}}\right|_{1\mathrm{bar}}$ $(\mathrm{He} : \mathrm{N_2} : \mathrm{H_2O}) = 1 : 62 : 835$



➢ Nearly instantaneous evaporation

➢ Pressure gradients in the range of $(\mathrm{bar}/\mathrm{s})$

Quench test of a sc. solenoid (KATRIN)

What is special in LHe cryostats?

Common pressure equipment	Liquid helium cryostats
• Cryogenic storage containers	• Sc. magnet cryostats, RF cavities
• Protection against disruptive failure ➢ **Extreme** and **rare** failure scenarios	• Protection against disruptive failure ➢ **Extreme** and **rare** failure scenarios
	+ Protection against operation failure ➢ **Expected** and **frequent** failure scenarios (quenches) ➢ Need of **staging** safety levels!
	• Large number *papers*, individual *reports* and *experience* • **BUT** no systematic guideline
• Standardized task (limited complexity)	• Individual and **complex** design task

Examples of typical safety units

LN2 storage tank ($\approx 50.000\ \mathrm{L}$)

- Set pressure p_0 = 17 bar(g)
- Two safety valves $1/2''$ ($d_0 = 7\ \mathrm{mm}$)
- Shuttle valve

Source: Air Liquide

Liquid helium cryostat ($\approx 500\ \mathrm{L}$)

- Safety valve DN25 at p_0 = 2 bar(g)
- Two rupture disks DN65 at p_0 = 3 bar(g)
- Quench gas line DN100

Source: KATRIN

Safety of liquid helium cryostats

NATIONAL STANDARDIZATION PROJECT (2010 – 2015)

Institute of Technical Physics
Institute of Technical Thermodynamics and Refrigeration

Contributions

Industry	
Blum, Lars	Linde Kryotechnik AG
Otte, Wolfgang	Air Liquide Deutschland GmbH
Reinhardt, Matthias	Herose GmbH
Schulenberg, Olaf	Goetze KG Armaturen
Universities and Research Centers	
Grohmann, Steffen	Karlsruhe Institute of Technology
Haberstroh, Christoph	Technical University Dresden
Heidt, Carolin	Karlsruhe Institute of Technology
Raccanelli, Andrea	Research Center Jülich GmbH
Schröder, Claus	GSI Gesellschaft für Schwerionenforschung mbH
Süßer, Manfred	Karlsruhe Institute of Technology
Organization	
Lau, Markus	German Institute for Standardization (DIN)

Workout of a DIN SPEC

- Technical **guideline** rather than a standard
- Can be the basis for a consensus-based standardization process

➢ Publication of the DIN SPEC 4683 in 04/2015

April 2015

DIN SPEC 4683

DIN

ICS 13.240; 23.020.40

Flüssighelium-Kryostate –
Sicherheitseinrichtungen gegen Drucküberschreitung

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

Cryostats pour hélium liquefies –
Dispositifs de sécurité pour protection contre les pressions excessives

Zur Erstellung einer DIN SPEC können verschiedene Verfahrenswelsen herangezogen werden.
Das vorliegende Dokument wurde nach den Verfahrensregeln eines Fachbeirchts erstellt

Gesamtumfang 73 Seiten

DIN-Normenausschuss Druckgasanlagen (NDG)

Safety of liquid helium cryostats

EUROPEAN STANDARDIZATION PROJECT

European standardization project

- Satellite meeting at European Cryogenics Days 2015 (Grenoble)
  - Agreement to advance a **European standardization process**
  - Translation of **DIN SPEC 4683** and **CEA documents**

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)

Present contents of prEN 4683:2015

(1)…(4)	Scope, references, terms…
(5)	Hazard analyses, risk assessment and safety concept
(6)	Scenarios of pressure increase
(7)	Dimensioning of safety relief devices
(8)	Design and operation of safety relief devices and safety units
(9)	Release of the working fluid
(10)	Commissioning, maintenance
(11)	Materials for safety relief devices

+ 10 Annexes = 84 Pages

Presentations in this seminar

→ Thomas Otto, Duy Phan, Gunnar Lindell, Hans Guenter Mueller, Vladislav Benda, Ruggero Pengo, Luca Dassa, Carlos Arregui Rementeria, Stefan Rath

→ Carolin Heidt, Eric Ercolani, Jaroslaw Polinski, Maciej Dziewiecki,

→ Andre Henriques, Sebastian Protz, Jean-Marc Poncet, Eric Ercolani, Christina Weber, Jürgen Schmidt, Quang Dang Le, Ziemowit Malecha

→ Vittorio Parma, Fridolin Holdener

→ Ziemowit Malecha, Thorsten Koettig

→ Simon Marsh

Organizational/strategic talks:

Carlos Arregui Rementeria, Zoe Lawson, Simon Marsh, Hervé Barthélémy

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 international standard** on safety of LHe cryostats

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

Project organization

- 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

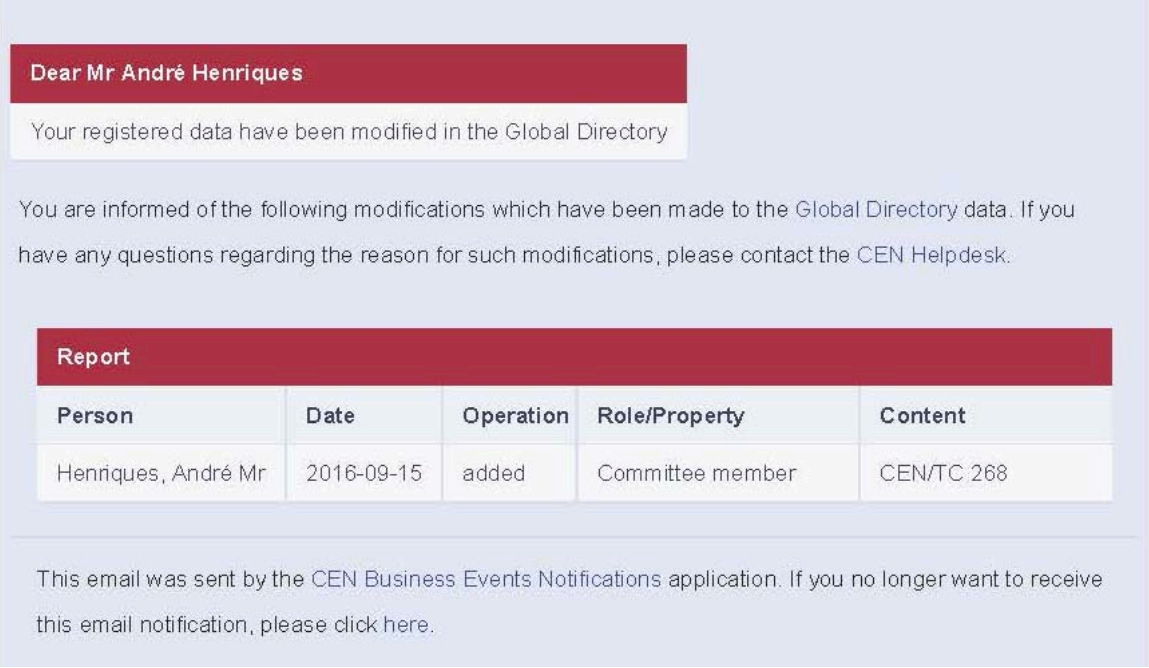
WG 1	Design
WG 2	Compatibility, insulation, accessories
WG 3	Operational requirements
WG 4	Fundamental requirements
WG 5	Specific hydrogen technologies applications
+	
WG 6	**Liquid helium cryostats**

Formal procedure to start the project

- DIN sends **new work item proposal** to CEN/TC 268
- **Secretariat** verifies proposal and **sends inquiry** within **CEN/TC 268**
  - Typical deadline for response 4-6 weeks
- **National Standardization Bodies** contact their experts concerning relevance and participation
  - Some countries have **mirror committees** of CEN/TC 268, some countries don‘t…
  - Make sure you **get registered** at your National Standardization Body as a **participating expert**
  - Your National Standardization Body will **delegate** you later to the new WG
- The National Standardization Bodies **vote** at the end of the deadline
  - For the project approval, **at least 5 participating countries** must indicate active members with their names

Expert registration

- Example for individual registration at the National Standardization Body



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Report

Person	Date	Operation	Role/Property	Content
Henriques, André Mr	2016-09-15	added	Committee member	CEN/TC 268

This email was sent by the CEN Business Events Notifications application. If you no longer want to receive this email notification, please click here.

- If you want to participate, please **register** and **send** me a **confirmation**
  - Contact: steffen.grohmann@kit.edu
  - DIN files the new work item proposal once experts from 5 countries have registered

Project planning

- Project management by WG secretariat at DIN (Berlin)
- Kick-off meeting in early 2017
  - ➢ Doodle poll among participating experts
- Two project meetings/year
- Finalization of the working draft in ≤ 3 years
- Submission to TC chairperson and TC secretary for CEN Enquiry

Safety of liquid helium cryostats

CROSS-LINK AMONG PROJECTS

Horizon 2020 project

- **Approval** of EU project:

  Accelerator and Magnet Infrastructure for Cooperation and Innovation (AMICI)

  - Aim: Knowledge transfer
  - Coordination: CEA Saclay
  - 10 participating organizations

1	CEA	FRANCE
2	CERN	SWITZERLAND
3	DESY	GERMANY
4	INFN	ITALY
5	IFJ PAN	POLAND
6	CNRS	FRANCE
7	STFC	UNITED KINGDOM
8	UPPSALA UNIVERSITET	SWEDEN
9	PSI	SWITZERLAND
10	KIT	GERMANY

- WP5.3: Harmonization – Cryogenic safety procedures
  - KIT, CEA, CERN
  - Cross-link to the new working group at CEN/TC 268

Thank you for your attention!