Alternatives to the hydro testing for in-service pressure equipment

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1. Introduction

1.1. European Regulation (PED) and consequences

The essential safety requirements laid down in this Directive [1] are **mandatory**. The obligations following from those essential safety requirements apply only if the corresponding hazard exists for the pressure equipment in question when it is used under conditions which are "reasonably foreseeable" by the manufacturer.
The manufacturer is under an obligation to analyze the hazards and risks in order to identify those which apply to his equipment on account of pressure; he shall then design and construct it taking account of his risk analysis
Pressure Equipment shall be designed for adequate strength associated to pressure loads and for loadings appropriate to its intended use and other reasonably foreseeable operating conditions. In particular, different degradation mechanisms shall be taken into account, as: fatigue, creep-fatigue, corrosion and erosion…
Consequently:

- some margins have to be justified in front of the basic pressure equipment failure modes, as: plastic collapse, plastic instability, local failure without crack, buckling, creep…
- potential degradation that can affect the pressure boundary has to be considered at the design stage: no thinning, no loss of material properties (material strength and toughness), no cracks, associated to different degradation mechanisms, as fatigue, plastic shakedown, corrosions or thermal ageing….
- in some cases, the "flaw tolerance" of the pressure equipment has to be evaluated at design level to assure safe operation life of the equipment

1.2. Needs of EN standards

- assure "easy to use" Standards, sufficiently explain, justified, at the state of the art technical level
- assure "competitiveness" with similar international standard to assure relevance of the European pressure equipment designs: safetyand cost of Construction (Design, Fabrication, Protection, Tests)
- anticipate "specific or future needs" of European Pressure Equipment industry on the future Clean Energy market and other innovative Pressure Equipment application.

2. Potential EU Research Support

A dedicated Report has been proposed by CEN-CENELEC:

- "How to Link Standardization with EU research projects" [2] can be found on www.cencenelec.eu/research .
- "Horizon 2020" December 2019 [3] on https://ec.europa.eu/programmes/horizon2020/en/background-material
- "Strategic Plan" December 2019 [4] on https://ec.europa.eu/info/files/strategic-planning-process-and-strategic-plan_en
- "Different CEN cooperation working products": ES, TS, TR, Gu, CWA [5] https://www.cen.eu/work/products/cwa/pages/default.aspx

3. EPERC TG2- Detailed Proposed Working Program

3.1. Project Introduction

The in-service inspection to requalify pressure equipment after a certain period of operation comprises a set of different tests and inspections. In many European countries the specification of the testing and inspection scope lies within the responsibility of the respective national authority. Therefore, the requalification process to be initiated by the owner/operator of the pressure equipment varies substantially across Europe. It may consist of a pressure test, an internal and external inspection as well as a leak test. Internal and external inspections are usually carried out visually by an authorised inspector and may be complemented by suitable non-destructive tests in order to assess particular sections of the pressure equipment in more detail (e.g. testing of weld seams or wall thickness measurements of areas affected by corrosion).

The pressure test is usually conducted as a hydrostatic test. This practice has been widely established in Europe for several reasons. In the course of the industrialisation more than 150 years ago, hydrostatic testing was an effective measure to raise the operational safety of steam boilers and pressure vessels to an

acceptable level. Due to this success, it became an essential part of the inspection routine and it still is till to date. Hydrostatic testing is generally considered to be a rather low risk activity compared to the performance of a pneumatic test, which needs quite a high effort to obtain the permit and then finally to conduct the test itself under stringent safety precautions.

3.2. Hydrostatic test limitations and alternatives

Beside the merits described above, many owners/operators in Europe have identified general issues connected to the application of hydrostatic testing. Some of them are listed below:

- Overdesign of the foundation and the supports to bear the water weight just for the test
- Preparation procedure (e.g. emptying, isolation from the connecting pipe system etc.)
- Disposal of waste water and drying procedure for the internal shell
- Residual humidity and consequently the risk of product contamination
- Long down time due to preparation, performance and post-test treatment
- Limited outcome of the test (binary test result yes/no in terms of plastic deformation)
- Hydro testing of pressure equipment in very old plants can lead to initiation of cracks in aged components thus reducing their lifespan and increasing risk.

3.3. Alternative solutions

Alternative solutions to the traditional hydrostatic testing are already available. Performing a pneumatic test is one option among others. In order to reduce the potential risk connected to its application, it is possible to combine it with an acoustic emission test or to replace it by an acoustic emission test at all. The technical requirement on an alternative solution is in any case that it provides at least an equivalent level of safety compared to the hydrostatic testing. The legal environment given at the site of installation finally rules which kind of alternatives may be applied in the course of pressure equipment requalification. The regulations addressing the operation of pressure equipment for owners/operators in Europe are quite different and depend strongly from the national or even regional experiences. Consequently, isolated solutions are the common practice in Europe. This calls for a European approach to harmonise the boundary conditions for the operation of pressure equipmentList of Work Packages and Tasks covered in the Project.

In general, it's strongly recommended to implement a combination of tests based on "static" and "dynamic" method.

Sole "static" ones – meant as those technique applied at "static condition" (visual inspections, thickness measurement, PT, MT, UT, RT, etc.) where there is no dynamic load applied to the pressure equipment – should be avoided or limited where not applicable.

To find a suitable combination of tests, being also low invasive respect the service availability of the equipment and the shutdown costs, is the challenge of industry and of this TG too.

3.3.1. Work Package 1: Regulation background of EU countries

- Task 1.1: Analysis of survey results per country
- Task 1.2: Update of survey according to recent changes and new TG members participation

3.3.2. Work Package 2: Analysis of available known NDT techniques

- Task 2.1: NDT technique description, scope and possible application
- Task 2.2: Setup a matrix of possible application per test object

3.3.3. Work Package 3: "Normal" Pressure equipment (PE)

- Task 3.1: Listing PE operating in normal service conditions
- Task 3.2: Setup of a suitable "kit" combination of static & dynamic – preferable noninvasive -tests
- Task 3.3: Prepare a "in service inspection guideline / best practice

3.3.4. Work Package 4: "Special" Pressure equipment (PE)

- Task 4.1: Listing PE operating in harsh environment of special conditions
- Task 4.2: Setup of a suitable "kit" combination of static & dynamic – preferable noninvasive -tests
- Task 4.3: Prepare a "in service inspection guideline / best practice

3.3.5. Work Package 5: CEN Standardization & PED directive

- Task 5.1: Cooperate for introducing such best practice into relevant standards and PED directive

3.4. Management, Synthesis and Conclusion of the Project

- Chairman and list of members
- Detailed program of each task
- Periodic updated Planning and Roadmap review
- Report: review by Project members and selected International Key Actors of the domain
- All the documents of each Work Package will be released to: all the sponsors and EPERC TG4 members

4. Work Package 1: Regulation background of EU countries

4.1. Task 1.1: Analysis of survey results per country

Analyze and compare different national practices for in-service hydrostatic testing with focus on European countries. Structured information from selected countries regarding their national legal environment for the operation of pressure equipment have been collected.

4.2. Task 1.2: Update of survey according to recent changes and new TG members participation

Last survey finished in late 2017. From that period, recent changes have been in several countries. Moreover, some comments and remarks came during last TG meeting in Milan, that suggest to update such survey result and/or enlarge it to the new TG members for their response and acknowledgement.

5. Work Package 2: Analysis of available known NDT techniques

5.1. Task 2.1: NDT technique description, scope and possible application

This TG needs the participation of a large number of experts especially in order to identify, classify and assess the most relevant NDT techniques available on the market. NDT experts (namely Lev 3 ISO 9712) should build up suitable NDT form where lists best applications, advantages and results of known technique.

5.2. Task 2.2: Setup a matrix of possible application per test object

From any NDT form prepared, a matrix indicating possible or best application of this or that technique should be prepared. Particular emphasis, in order to simplify the discussion, should be given to the targeted object to test/inspect.

6. Work Package 3: “Normal” Pressure equipment (PE)

6.1. Task 3.1: Listing PE operating in normal service conditions

In such task, the aim is to classify relevant pressure equipment working into “normal” service conditions, that is environmental temperature or in not extreme range of temperature according to the contained/ processed fluid. As well should be taken out, PE designed and working with very high pressure.

6.2. Task 3.2: Setup of a suitable “kit” combination of static & dynamic – preferable noninvasive -tests

According with results of previous tasks aimed to identify and classify potential NDT to be used, the output of this task is to build up a possible suitable “NDT KIT”, made by a combination of static and dynamic techniques being so low invasive or even noninvasive as possible.

6.3. Task 3.3: Prepare a “in service inspection guideline / best practice

Starting from the results of previous tasks, a suitable guideline or best practice report shall be prepared and disclosed.

7. Work Package 4: "Special" Pressure equipment (PE)

7.1. Task 4.1: Listing PE operating in harsh environment of special conditions

In such task, the aim is to classify relevant pressure equipment working into "special" service conditions, that is harsh environment or at very high or very low temperature according to the contained/processed fluid or for special applications (nuclear plants).

7.2. Task 4.2: Setup of a suitable "kit" combination of static & dynamic – preferable noninvasive -tests

According with results of previous tasks aimed to identify and classify potential NDT to be used, the output of this task is to build up a possible suitable "NDT KIT", made by a combination of static and dynamic techniques being so low invasive or even noninvasive as possible.

7.3. Task 4.3: Prepare a "in service inspection guideline / best practice

Starting from the results of previous tasks, a suitable guideline or best practice report shall be prepared and disclosed.

8. Work Package 5: CEN Standardization & PED directive

8.1. Task 5.1: Cooperate for introducing such best practice into relevant standards and PED directive

According with the just activated contacts between EPERC and CEN secretary as well as UE commission, the aim of this task and relevant work package is to make aware to all parties (stakeholders) to the achieved results (guideline / best practice reports).
These detailed description of the Work Package have to be filled up with TG2 members (or potential members) to prepare a CEN Committee proposal for a ES (European Standards), TS (Technical Specification), TR (Technical Reports), Gu (Guides) or CWA (CEN Workshop Agreement)
(https://www.cen.eu/work/products/guides/Pages/default.aspx)
Moreover, could be tried to "insert" those into and PED directive update and possibly into a national laws adoption.

8.2. Deliverables, planning and meetings

To be defined later with TG Chairman and Work Package Leaders…
A first SKYPE meeting with volunteers will take place before end of June 2020

8.3. Meetings and Preliminary Budget

8.3.1. TG2 Project Meetings

- To be defined later with Chairman and Work Package Leaders…
- **Max of web-meetings: SKYPE or ZOOM video conference**
  - At WP level
  - At TG2 Project level with TG2 Chairman and WP Leaders
  - 1 EPERC workshop per year

8.3.2. TG2 Budget

- To be defined later with Chairman and Work Package Leaders…

9. References

1. DIRECTIVE 2014/68/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 May 2014 on the harmonization of the laws of the Member States relating to the "making available on the market of pressure equipment"

2. "How to Link Standardization with EU research projects" can be found on www.cencenelec.eu/research and https://www.cen.eu/work/products/cwa/pages/default.aspx
3. "Horizon 2020" December 2019 on https://ec.europa.eu/programmes/horizon2020/en/background-material
4. "Strategic Plan" December 2019 on https://ec.europa.eu/info/files/strategic-planning-process-and-strategic-plan_en
5. "Different CEN cooperation working products": ES, TS, TR, Gu, CWA https://www.cen.eu/work/products/cwa/pages/default.aspx