

 	<h1>EPERC TG 4</h1> <p>European Pressure Equipment Research Council</p>	<p>TG4 Program sheet</p> <p>Number: December 15, 2019 Rev. 4</p>
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NONLINEAR DESIGN RULES

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1. Scope and Objectives of TG4

After a detailed existing Codes and Standards comparison [1], it was concluded that many Pressure Equipment Code have a Chapter on Nonlinear Analysis with limited information to perform the analyses and limited validation documents of their proposals. 2 particular Codes has been considered with particular attention: ASME BPV Code – Section VIII – Division 2 and AFCEN - RCC-MRx Code. Since this review a new Appendix has been proposed in AFCEN RCC-M Appendix ZC.

The major objectives of this Group are to review all the nonlinear rules used to design Pressure Equipment in different international Codes and the R&D State of the Art in order to propose:

- a "recommended practice document" based on existing knowledge
- a "complementary experimental R&D program", developed with the support of EPERC and the European Commission, with a regular update if necessary of the previous document,
- a "set of benchmarks" to assure usability of the proposed rules and that can be used as a set of typical applications

The "recommended practice document" will contain the different rules applicable, their detailed application, the material data required, the basic criteria, the Quality management required and all the associated validation (theoretical, engineering approaches and experimental validation).

Major failure modes and degradation mechanisms of Pressure Equipment will be considered:

- **Under monotonic loads:** plastic collapse, plastic instability, local failure, buckling
- **Under cyclic loads:** fatigue, shakedown
- **Consequences of potential crack** in a pressure equipment: failure assessment diagram and reference stress approach, local approaches of rupture and "Master Curve Approach", leak before break...
- **Particular cases of specific nonlinear analyses:** openings and reinforced nozzle, elastic follow-up in piping system, seismic design, bolted flanges, bellows...

Creep conditions will not be considered in this first phase of this Project.

2. TG4 Potential Members

<i>Status</i>	<i>Name</i>	<i>Company</i>	<i>Country</i>	<i>email</i>
- Chairman	Claude FAIDY	CF Integrity	France	claude.faidy@gmail.com
- Company	TBD*	RINA	Italy	
- Company	TBD*	Rolls Royce	UK	
- University	TBD*	Strathclyde	UK	
- Association	TBD*	WNA-CORDEL-CSTF	UK	
- Company	TBD*	AMEC	UK	
- Others	TBD*	

TG4 Potential Guests

- Company	TBD*	ROSATOM	Russia
- Association	TBD*	JPVRC	Japan
- Company	TBD*	KEPIC	Korea
- Association	TBD*	ASME STLLC	USA

A list of members will be developed and formalized beginning of 2020, with EPERC membership rules (refer to EPERC website) to assure large representability of European countries and International expert Groups, Industry, Code Organizations and Universities

* TBD : to be defined

3. TG4 Roadmap

List of potential tasks that will be periodically updated are attached.

Task 1: Existing International Codes comparisons

The corresponding WNA-CORDEL-CSTF report is available [1]

Task 2: Recommended Practice Document

- Scope:
 - o Review all available methods: limit load and elastic-plastic analyses
 - o Precise all the details of their application: methods, criteria, material properties...
 - o Collect and Synthetized all the existing validation
 - o Identified Gaps and Needs
- Schedule:
 - o On-going report "Table of Content" is available [2]
 - o Draft report for International review → January 2020
 - o First full draft report: → June 2020
- Actors:
 - o Report : C. FAIDY CF Integrity France EPERC TG4 Chairman
 - o Reviews: extremely large toward EPERC TG4 members and International experts on the topic

Task 2: Performance of benchmarks

- 2.1 A first set of benchmarks are available and will be considered to improve the rules in collaboration with WNA-CORDEL-CSTF [3]
- 2.2 The result are under analyses
 - o 1st Benchmark lessons learned is available [4]
- 2.2 A second set of benchmarks will be developed in accordance with the experimental program of Task 3
- Schedule:
 - o Task 2.1: end of 2019
 - o Task 2.2: to be defined with the experimental program
- Actors:
 - o WNA-CORDEL-CSTF for 1st Benchmark lessons learned [4]
 - o RINA for 2nd set of Benchmarks definition from Experimental Program
 - o EPERC TG 3 members

Task 3: Complementary Experimental Program

- Under definition by RINA – Italy around a preliminary proposal [5]
- Will be partly support by EC through an EPERC TG4 proposal

Task 4: Code Case Proposal

A dedicated Report will be produced in "Code language" with all the details, step by step procedure, material properties and criteria.

All the standard Development Organization (some CEN Technical Committees, some European Nuclear Codes and some other International Codes) will be free to consider totally or partially the document for their own use.

- 4.1: for monotonic loads
- 4.2: for cyclic loads
- 4.3: for consequences of cracks
- 4.4: for particular cases

Task 5: Reference Cases Analyzes Examples

- To be defined in accordance with the Benchmarks and Needs of Industry by TG4

Task 6: Training Courses

- To be defined by TG3 and proposed to BOD and different international training will be proposed

Task 7: Publication in Conferences or Workshops

- 7.1: an EPERC Seminar on the topic will be proposed by TG4 beginning of 2020 (Milan EPERC Task Force)
- 7.2: Key international conferences on the subject (PVP, ICONE, ICPVT, ESOPe...)
 - o EPERC presentations
 - o Interesting papers selection in the TG4 Scope
- 7.3: 2020 detailed program of TG4 participations will be finalized before end of January 2020 (take care with Abstract deadlines...)

4. TG4 Report Management

4.1. Introduction

All EPERC-TG4 reports will be associated to information for release: TG4 members, EPERC members, International Experts on the TG4 topic, Public, at different stages:

- Draft
- Reviewers results
- Different versions
- Final Version approved by TG4 members and schedule
- Submitted finally to EPERC BOD for publication

(To be finalized, for numeration and common format of EPERC Reports from all TGs)

4.2. Status

The 1st report on Code Comparison has been developed with WNA-CORDEL-CSTF and is available

The "Benchmarks definition and final data presentation has been developed by WNA-CORDEL-CSTF and are available

The preliminary benchmark result analyses have been done by WNA-CORDEL-CSTF and are available

The final benchmark analyses will be done in cooperation between WNA-CORDEL-CSTF and EPERC-TG4 beginning of 2020

The "Nonlinear Design Rule recommended practices document" is under preparation in EPERC TG4 to be issued beginning of 2020

The draft "Code Case" proposal will be issued mid of 2020 by EPERC-TG4.

All the other TG4 Tasks will be issued on Draft phases before end of 2020.

All the Tasks associated to experimental Programs need a dedicated planning and requests for EC support with corresponding procedure.

5. TG4 Meeting Management

In order to assure transparency to all members and potential new members, different documents will be developed and released by TG4 Chairman, with all the major actions accessible to all interesting parties (members and/or non-members) and all the technical reports only to TG4 members freely. A possible fee for "Final Report" have to be re-discussed with the EPERC BOD

- 1. **TG4 Program Sheet** (this document), last Revision
 - o With regular update and Revision increment
- 2. **List of TG4 meetings** with:
 - o Organizer, Date, Place (or web-conference),
 - o Agenda and Attachments
 - o Minutes and Presentations used during the meeting

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- 3. [List of EPERC Technical Seminars & Workshop](#) with:
 - o Organizer, Date, Place
 - o Agenda and Attachments
 - o Minutes and Presentation (or Seminar Proceeding) used during the Seminar
 - 4. [Final List of TG4 Documents](#)
 - o List of Documents produced by TG4
 - o List of Interesting Documents from different sources with Public access

All these reports will be associated to a clear position on accessibility for TG4 non-member
All these documents have to be regularly updated and shortly download on EPERC website

6. TG4 Key References

1. C. Faidy, "Non-linear Analysis Design Rules – Part 1 : Codes Comparison", World Nuclear Association, Report No. 2017/002, February 2017
(<https://www.google.fr/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=2ahUKewjXu7jy7YzIAhWJmBQKHArKCxAQFjABegQIARAI&url=https%3A%2F%2Fwww.world-nuclear.org%2Four-association%2Fpublications%2Fonline-reports%2Fnon-linear-analysis-design-rules-part-1-code-comp.aspx&usg=AOvVaw1mfgY3pO75TC61M8AdOtPY>)
2. C. Faidy, "Non-linear Analysis Design Rules – Part 2 : Recommended Practice", EPERC TG4 Report Table of Content
3. C. Faidy, "Non-linear Analysis Design Rules – Part 3 : Benchmarks Definition", World Nuclear Association, CSTF Report (www.world-nuclear.org)
4. N. Prinja, M. Rababah, "Non-linear Analysis Design Rules – Part 3 Benchmarks- Pre-assessment of NL Benchmark Results", WNA-CORDEL-CSTF
5. T. Coppola, E. Mecozzi, "Non Linear Design Rules for Pressure Vessels and Piping (NOLDER-PVP)- Preliminary program definition", RINA-CSM-RFCS Research project, Italy (www.rina.org)

This list will be periodically supplemented....

7. TG4 Document Management and EPERC website Document Folder

A dedicated folder is under preparation for TG4 members in order to have access to all the TG4 Reports and Public References on the TG4 topic.