Task Group 4 –Nonlinear Design Rules

Claude Faidy EPERC TG4 Chairman info@eperc-aisbl.eu

Minutes of the 1st web-meeting of TG4

Thursday September 2nd, 2021 14,00 – 17,00 CST

1 General introduction

1.1 Participants

Participants	e-mail address	EPERC Member	Country
Andrea Tonti	a.tonti@inail.it	YES-BOD	Italy
Yves Simonet	yves.simonet.ys@outlook.fr	YES	France
Fernando Lidonnici	fernando.lidonnici@fastwebnet.it	YES-BOD	Italy
Roman Satosek	roman.satosek@danfoss.com	NO	Slovenia
Claude Faidy	claude.faidy@gmail.com	YES-BOD	France
Michele Camposaragna	m.camposaragna@enginsoft.com	NO	Italy
Mayur Brijlani	mayur.brijlani@gmx.de	YES	Germany
Luca Gaetani	luca.gaetani@eleo2.eu	YES	Italy
Vincenzo Lasalandra	v.lasalandra@nier.it	NO	Italy
Stefano Milani	milani@enerconsulting.it	YES	Italy
Francesco Iob	francesco.iob@rina.org	NO	Italy
Philippe Rohart	Philippe.Rohart@cetim.fr	NO	France
Andrea Magrì	andrea.magri@lr.org	YES	Italy
Guy Baylac	guy.baylac114@gmail.com	YES-BOD	France

1.2 Chairman General EPERC Introduction

• EPERC Major Objectives

Develop and manage R&D to support, improve and enlarge the scope of Pressure Equipment Construction and Operation Codes & Standards, with International harmonization challenge, if possible…

• EPERC Action plan

- Regular comparison of existing International C &S
- Analysis with Industry and SDOs: gaps and needs
- Proposals of "Recommended Practices" with justification
- R&D programs
- Benchmarking and Examples
- Proposals of "Recommended Practices" with justification
- Code Case proposals
- Knowledge Transfer: Conferences, Workshops, International cooperation, Training

• EPERC "connected" Countries

- All European Countries are "basic members" with registration fees
- UK, Switzerland, Russia, China after BOD agreement
- USA (ASME ST-LLC) Japan (JPVRC), Korea (KEPIC) through dedicated agreement

• Technical General Introduction

- 4 steps for major degradations:

  - Failure modes
  - Degradation mechanisms (generally for cyclic loadings)
  - Flaw tolerance and Reference stress
  - Special Cases
- 4 steps procedures
  - Basic procedure : generally elastic approaches
  - Validation background: theoretical and experimental
  - Complementary R&D program
  - Synthesis – benchmarks- recommended practice-Code Case proposal
  - Knowledge transfer: conferences, workshop, seminar, training…

2 Review of TG4 Technical Program

2.1 Chairman Introduction

- After the International Code review, we will identified Gaps and Needs:
  - in term of Procedure, Material data, Criteria and available justification
  - assure that existing rules covers "innovation" in Pressure Equipment Industries, as: operating conditions, loads and new material;

2.2 WP1: International Codes & Standards comparison

- Updating of existing comparisons for Nuclear, Oil &Gas and other non-nuclear Codes
- Gaps and Needs identification
- Main lines of R&D program

2.3 WP2: Failure Modes

- Plastic collapse
- Plastic Instability (burst)
- Local Failure (de-cohesion)
- Buckling

2.4 WP3: Degradation Mechanisms

- Fatigue: K_e parameter and cycle by cycle strain amplitude evaluation
- Plastic shakedown: simplified rules and cycle by cycle strain amplitude evaluation
- Creep-Fatigue visco-plastic analyses
- Corrosion & Residual Stresses

2.5 WP4: Flaw tolerances

- Reference Stress for J estimation
- Crack growth and crack tip plasticity
- Critical crack size
- Creep consequences: negligible creep and creep-fatigue interaction (with TG1 Tatigue & TG6 creep)
- Local approach of fracture: BEREMIN, GURSSON….

2.6 WP5: Specific cases

- Opening reinforcement
- Elastic Follow Up, in particular in piping systems
- Bolted flange & Sealing & Leak evaluation
- High Dynamic loads: seismic loads and water hammer
- Cumulative Strain Based Criteria
- High Density Polyethylene (HDPE) piping system

2.7 WP6: Material data for all previous WPs

- Stress-strain curves and Young modulus
- Cyclic stress-strain curves
- Fatigue curves & environmental effects
- Crack growth rate
- Toughness
- Negligible creep curves
- Creep-fatigue interaction diagrams
- All needed constitutive equation for cyclic loads

2.8 WP7: Benchmarks on practical Cases

- Later in the project

2.9 WP8: TG's Synthesis

- Later

2.10 WP9: Knowledge transfer

- Later

2.11 WP10: Rod map development and management

- 1st version for next TG4 meeting using TG4 questionnaires from each participant
- Managed by TG4 Chairman

3 Major remarks during the meeting

- Buckling of Heat Exchanger Tubes under external pressure
- Residual stress: distribution, computation, consequences for welding and for forming
- Bolted flange: needs of nonlinear analyses will be defined by EPERC-TG3 and CEN TC74

4 Action List for each potential participant and TG4 members

4.1 Remarks on any Task of the Technical program attached to this minutes from each TG4 member and Potential members

4.2 Fill up attached Questionnaire for each TG4 member and Potential members

4.3 List of proposed contributions to open the Road Map by each TG4 member and Potential members

4.4 First edition of TG4 Road Map by TG4 Chairman

4.5 TG4 next meeting: beginning of December (to be confirmed later by EPERC TG4 Chairman and EPERC BOD

4.6 1st TG4 Workshop beginning of 2022: program and final date to be defined at next TG4 meeting

4.7 Continue to invite international experts and universities in the domain

ANNEXES: TG4 Questionnaire - EPERC TG-4 Potential Technical Program - Status of EPERC development -

EPERC TG4 Questionnaire on Potential Participation

Name	Company	Country	e-mail
1. I'm EPERC member	Yes	No	Potentially: Yes or No
2. I'm interested to be TG4 member	Yes	No	Comments
3. I'm interested to contribute to different reports	Yes	No	Topic
4. I'm interested to develop an Experimental Validation	Yes	No	Topic
5. I'm interested in Benchmark on Practical Cases	Yes	No	Topic
6. I'm interested in a Code Case contribution	Yes	No	Topic
7. I'm interested in other aspect s of the program	If Yes Define it:		
8. Other remarks on the proposed program			

Next TG4 web-meeting : December, 2021 - (to be finalized soon)

Potential participants have to register on EPERC website for Teams-Link

SEND YOUR ANSWERS to: **Claude FAIDY EPERC-BOD-TG4 Chairman** **info@eperc-aisbl.eu**

August 13, 2021 Rev. 2

TG4 - NONLINEAR DESIGN RULES

EPERC TG4 Potential Technical Program

General Introduction

4 major degradations:	failure modes	degradation mechanisms	flaw tolerance	special cases
4 major steps	basic procedure	validation: - theoretical - experimental	complementary R&D program	- synthesis - benchmarks - best practice - Code Case - Knowledge transfer
WP 1: Existing International Codes & Standards	updating of existing review/comparison of International Codes and Rules		gaps & needs, including new needs associated to innovative industries	
WP2: Failure Modes	**Plastic Collapse**	- definition / existing validation - methode1: limit load - methode 2: elastic-plastic - criteria	- recommandation to user - existing tests - complementary R&D program - benchmarks - best practice and Code case	
	Plastic Instability	- definition / existing validation - methode1: limit load - methode 2: elastic-plastic - criteria	- recommandation to user - existing tests - complementary R&D program - benchmarks - best practice and Code case	
	Local failure	- definition / existing validation - analysis rules - criteria	- recommandation to user - existing tests - complementary R&D program - benchmarks - best practice and Code case	
	Buckling	- definition / existing validation - analysis rules (bifurcation…) - criteria - interaction with other degradation mechanisms (progressive deformation, creep…)	- recommandation to user - existing tests - complementary R&D program - benchmarks - best practice and Code case	
WP3: Degradation Mechanisms	**Fatigue**	- cyclic plasticity strain amplification - cycle by cycle approach - criteria	- material constitutive equations and calibration tests - validation tests on small specimenn on real structure - review of existing tests	
	Plastic Shakedown	- simplified elastic perfectly plastic rule - cycle by cycle approach - criteria	- material constitutive equations and calibration tests - validation tests on small specimens and on real structure - review of existing tests	
	Creep consequences	- cyclic viscoplastic method - criteria	- material constitutive equations and calibration tests - validation tests on small specimens and on real structure - review of existing tests	
	Corrosions	- review of major mechanisms - key parameters - surface stress level	- corrosion rate: thinning and crack growth - validation tests on small specimens and on real structure - review of existing tests	
WP4: Flaw Tolerance	**Reference stress method**	- methode presentation - limit load of cracked components	- recommandation to user - existing tests - complementary R&D program - benchmarks - best practice and Code case	
	Crack growth and crack tip cyclic plasticity	- crack tip plasticity - fromΔKcp to ΔJ	- existing tests - complementary R&D program - benchmarks - best practice and Code case	
	Critical crack size	- direct J computation - including ductile tearing - cyclic load consideration	- existing tests - complementary R&D program - benchmarks - best practice and Code case	
	Creep consequences	- C* definition - direct C* computation	- existing tests - complementary R&D program - benchmarks - best practice and Code case	
	Local Approach of Fracture	- review of existing models - associated computation of parameters	- material parameters and calibration tests - validation tests on small specimens and on real structure - review of existing tests	

August 13, 2021 Rev. 2

TG4 - NONLINEAR DESIGN RULES

EPERC TG4 Potential Technical Program

WP5:Specific cases	**Elastic Follow-up**	- defintion - simplified methods - elastic / plastic approaches - criteria: primary/secondary stress	- material parameters - validation tests on on real structure : piping systems - review of existing tests
	Bolted Flange and Leak Evaluation	- selection of typical Bolted Flange - seal properties - leak tests - fugitive emission evaluation	- different seal parameters - review of existing tests - validation tests on on real structure : piping systems - complementary R&D program - benchmarks - best practice and Code case
	Dynamic Loads: seismic and water hammer	- low / high seismic analysis - water hammer analysis	- validation tests on on real structure - complementary R&D program - benchmarks - best practice and Code case
	Cumulative Strain based Criteria	- criteria comparison: on stress / on strain - cyclic cumulation	- complementary R&D program - benchmarks - best practice and Code case
	Opening Reinforcement Rules	- define some reinforced nozzles - comparison elastic stress classification / limit load approach	- complementary R&D program - benchmarks - best practice and Code case
	HDPE Piping	- definition of a visco-plastic models - criteria	- complementary R&D program - benchmarks - best practice and Code case
WP6: Material Properties	**All needed material properties**		- material constitutive equations - local approach mat. properties - da/dN and ΔK to ΔJ - JΔa curves - da/dt - C* - thining rate / corrosion rate - stress-strain curves - thermal ageing consequences - all material data for all the previous WP

WP7: Benchmarks on practical cases	definition	performances	synthesis
WP8: TG4 Synthesis	All task and WP synthesis	**Final Best Practices Report**	**Code Case proposal to European Standards**
WP9: Large Knowledge Transfert	Workshop - Training - International Conferences		
WP10: Road Map management	Regularly up-dated with all TG4 actions		

www.eperc-aisbl.eu

Status of EPERC Development

"European Pressure Equipment Research Council"

www.eperc-aisbl.eu

EPERC Major Objectives:
Develop and manage R&D
to support, improve and enlarge the scope
of Pressure Equipment Construction and
Operation Codes & Standards, with
International harmonization challenge
if possible…

EPERC Action plan::

- Regular comparison of existing International C &S
- Analysis with Industry and SDOs: gaps and needs
- Proposals of "Best Practices" with justification
- R&D programs
- Benchmarking and Examples
- Code Case proposals
- Knowledge Transfer: Conferences, Workshops, International cooperation, Training

Claude FAIDY - EPERC Board Member
Claude.faidy@gmail.com
☏ +33 6 14 10 11 19

EPERC "connected" Countries:
All European Countries (basic members)
UK, Switzerland, Russia, China
USA (ASME ST-LLC) Japan (JPVRC),
Korea (KEPIC)

www.eperc-aisbl.eu

Status on August 2021

Around 20 topics are planned to be considered
Many different Industry C&S are covered
from Nuclear to Oil & Gas or New Energy Plants…

- TG1 Fatigue
- TG2 Alternative to hydro proof tests
- TG3 Bolted Flange
- TG4 Nonlinear Design Rules
- TG5 Additive Manufacturing
- TG6 Creep Design Rules
- TG7 Fitness for Service and Risk Based Decision making
- TG8 Nuclear-Non nuclear bridge
- TG9 EN13445 Background
- TG10 Piping design rules
- TG11 Hydrogen PE
- TG12 Pressure Equipment re-certification
- TG13 Cryogenic Pressure Equipment
- TG14 New Materials /Non Steel Materials
- TG15 New NDE Techniques
- TG16 New Welding Procedure
- TG17 HDPE Piping Rules
- TG18 In-series Pressure Equipment
- TG19 Ultra Super-Critique Power Plants
- TG20 Specific needs for high safety application

- **Any other TG can be proposed by any group of volunteers to EPERC BOD**

www.eperc-aisbl.eu

Status on August 2021 – Active TGs (1/3)

TG1: Fatigue

(draft program available, composition of the Group on-going)

- Detailed Comparison of **last Editions**
  - ASME III and VIII
  - EN 13445 and ASME VIII
  - EN 13480 and ASME B 31
- Fatigue objectives: "small cracks" or "through wall cracks" ?
- Elastic versus Inelastic rules, including K_e
- **Fatigue curves** (mean and design) and cyclic stress-strain curves
- Fatigue reduction factors and uncertainties
- Particular cases of cycle combination, including large seismic event
- Crack like defects and notches: comparison of existing methods
- Environmental Effects: different types as steams, waters… hydrogen…
- Negligible creep rules
- Review of Exemption of fatigue analysis rules
- R&D program: set of tests (standards and specimen) for validation
- Benchmarks
- Best Practice with validation
- Knowledge transfer

Next web-meeting : **TG1 on September 22, 2021**
Open **to all participants** (members or potential members)
by registration on the website for the meeting Agenda and Teams-Link

www.eperc-aisbl.eu

Status on August 2021 – Active TGs (2/3)

TG4: Non-linear Design Rules

(program available, Group under finalization)

- Detailed Comparison of International Codes (lot of modification in last Editions) ASME (III and VIII) – RCCM – EN – API
- Background, Validation, Best Practices on: Plastic collapse, Plastic Instability, Buckling, Tri-axiality limits, Elastic Follow-up, Strain based criteria, Fracture, Fatigue, Plastic Shakedown, Seismic loads…
- R&D program: new validation tests on specimen and components, Material Constitutive Equation for Cyclic Analysis …
- First draft of "Best practices and Validation Report" available and under review

TG7: Fitness for Service - RBI

(draft program available, Group under constitution)

- Detailed Review of International Codes, Standards and Rules on:
  - Excessive def. & Buckling (design)
  - Thinning and pitting
  - Cracks
  - Loss of material properties: ageing
- List of Degradation Mechanisms
- Degradation Rate and Allowable max value
- R&D program for Validation and Material Prop.
- Leak Before Break
- FFS : ASME XI, RSEM/RCC-MRx, R5/R6 / BS7910, API, FITNET, JSME, KEPIC, VERLIFE…
- RBI : RIMAP, ENIQ, API, ASME-RIM & Risk-Informed, TWI…

Next web-meetings :
TG4 on September 2, 2021
TG7 on September 1, 2021
Open **to all participants** (members or potential members)
by registration on the website for the meeting Agenda and Teams-Link

Status on February 2021 – Active TGs (3/3)

TG2: Alternative to Pressure Test
(program available, Group is running)
- Detailed Comparison of European Practices
- Proposal of alternatives based on CND, as Acoustic Emission tests…

TG12: PE Re-certification
(old versus new PE regulation consequences)
- Comparison of European practices
- Best practice proposal

TG3: Bolted Flanges
(draft program under development and Group under constitution)
- Comparison of Codes & Standards
- Standardization of Metallic seal Technology
- Fugitive Emission consideration
- R&D program: leak tests

Status on August 2021 – Other TGs under Preparation

Nuclear and Non-Nuclear	Non-Nuclear
TG5: Additive Manufacturing	TG9: EN 13445 Background- Validation
TG6: Creep Design Rules	TG11: Hydrogen & High Pressure PE
TG10: Piping Design Rules New Needs	TG13: Cryogenic PE
TG14: New Material-Non Steel Mats	TG17: HDPE
TG15: New NDE Techniques	TG18 In-Series PE
TG16: New Welding Procedures	TG19: Ultra-Sup.Critiq. Power Plants

TG8 Nuclear – Non-nuclear C& S Bridge
Comparison of Nuclear versus Non-Nuclear Codes & Standards
Analyses of Differences (except irradiation outside of the comparison)

Welcome to all of you…

Through EPERC website : www.eperc-aisbl.eu

For existing TG's or TG's under development !

For any question or suggestion:

info@eperc-aisbl.eu