DELISA LTO

DEscription of the extended LIfetime and its influence on the Safety operation and construction materials performance – Long Term Operation with no compromises in the safety

Report summarizing the survey results, containing selected testing and analytical methods and parameters for the experimental program

4. 2

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About DELISA-LTO

The aim of the project is to determine the most affected and threatened components from the point of view of the long-term operation (LTO) and describe the effect of the LTO on the material properties as well as develop a simulation tool able to predict the non-acceptable state of the material. The project is specifically focused on the Water-Water Energetic Reactor (VVER), nevertheless, the approach is to maintain the easy transferability to other light water reactor technologies, as well.

The outputs of the project will lead to the increase of operational safety at the extended lifetime due to the in-time prediction of the potential failure. The basic approach of the project is to combine the development of the simulation tools, experimental work (material analyses), in-service and/or non-destructive inspection techniques to develop the effective "early warning" tool for the assessment of the system integrity for the LTO of the current LWR with a specific focus on the VVER technology.

The project's aim specifically focuses on the thermal aging and swelling of the loaded constructional materials. One of the most affected components from the LTO's point of view are the heat exchanging tubes of steam generators (thermal ageing) and reactor internals (swelling). The experimental material was screened and selected with the main criteria: to support and validate the proposed methods in the most accurate way, and to be "on stock" and available at the expected start of the project, the latest. The experiments are planned to be performed at the available material with clear and well-described operational history as well as the material from the original batch in the "as-received" state to gain the most relevant and valuable information with high impact to the community.

Project information

Project Title	DEscription of the extended LIfetime and its influence on the SAfety operation and construction materials performance – Long Term Operation with no compromises in the safety
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Partners

Dissemination level		
PU	Public	X
SEN	Sensitive, limited under the conditions of the Grant Agreement	
EU-R	EU RESTRICTED under the Commission Decision No2015/444	
EU-C	EU CONFIDENTIAL under the Commission Decision No2015/444	
EU-S	EU SECRET under the Commission Decision No2015/444	

Document information					
Deliverable No.&Name	D4.2 - Report summarizing the survey results, containing selected testing and analytical methods and parameters for the experimental program				
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Work Package No.	4	Work Package Title	Experimental validation and tests		
Work Packed Leader (Institute Acronym)	UJV				
Description of the related task and the deliverable	Report summarizing the survey results, containing selected testing and analytical methods and parameters for the experimental program. Deliverable serves as a basis for the experimental material matrix preparation.				
Comments	–				
Reviewers	–				

V	Date	Author(s)	Description
0	2022.11.30	Radim Kopřiva, Kateřina Rusňáková	**Initial document**

Content

1. Background

The goal of the Deliverable D4.2, realized within the WP4, Task 4.1, is to summarize obtained data from the survey and questionnaires into the experimental testing matrix frame. After evaluation of the collected data, it is possible to create testing material matrix frame that includes priorities, preferences and testing capabilities of all participating laboratories.

This output enables the opportunity of available testing methods and preferred specimen geometries connection with available archive structural materials to develop the detailed system of experimental interlaboratory studies. Due to the very close interconnection of work packages, the obtained data will be utilized within the WP4 – “Experimental validation and tests” as well as WP2 – “Methodology and assessment”.

2. Introduction

The first part of the two-round questionnaires (Deliverable D4.1, WP4) was focused on the collection of information about participating laboratories accreditation and quality assurance system (A1) and used testing methods (A2). After obtaining of the data from the first round of survey, it was possible to prepare more detailed second round of questionnaires.

For every experimental testing method additional more detailed questionnaire (Annex 1) was created. These more comprehensive questionnaires were sent to contributing partners in WP4. Completed questionnaires were subsequently evaluated by the WP4 leader and were summarized in the prepared Experimental matrix frame (Annex 2).

3. Methodology

The first part of the two round questionnaire was divided into two parts - A – “Experimental testing” and B – “Non-destructive testing”. The sub-part A1 includes information about experimental testing accreditation and B1 is focused on non-destructive testing certification and site qualification. The subpart A2 includes experimental testing methods and B2 non-destructive testing methods. The second part of the survey – more detailed questionnaires were sent to contributing partners based on data from Table 1.

Detailed questionnaires were used for the frame of experimental testing matrix preparation (Annex 2). In general, the frame of the experimental matrix combines experimental testing and analytical techniques, participating laboratories, experimental archive material and preferred specimen type of each contributing partner and testing methodology. Specimen types are divided into standard and miniaturized specimen types for the planned comparison of conventional methods with perspective approaches using sub-sized specimens.

Selected experimental and analytical methods will be connected with the available archive material inventory to create the detailed system of experimental interlaboratory studies. Materials were selected within the WP2 from different primary circuit components of the NPP Jaslovske Bohunice (Units 1 and 2) with respect to the structural material state (initial state/number of years in operation) and material type – base metal (BM), weld metal (WM) and heat affective zone (HAZ). Experimental matrix will also serve as a basis for the thermal ageing phenomenon evaluation, thus accelerated thermal ageing in laboratory conditions is also considered.

4. Results / Data summary

The Table 1 summarizes obtained data from first round of the questionnaire. Green cells of the table indicate which testing method is accredited. The table gives an overview about available testing and analytical methodologies in participating laboratories. Based on the results presented in the Table 1, more detailed questionnaires were prepared and distributed to WP4 members (Annex 1).

After the second round of questionnaires collection, evaluated data were used for the preparation of the experimental matrix frame. Experimental matrix will be completed by participating laboratories subsequently to be a fundamental basis for the WP4 inter-laboratory experimental program. Completion of the experimental matrix will be achieved no later than M12 (May 2023, Milestone MS4.1 – "Methods and experimental plans ready").

Table 1 - Obtained data from the first questionnaire (Task 4.1 - Deliverable D4.1)

Experimental equipment and methods matrix

A1 – Experimental testing – Accreditation

Partner	CVR	IPP	STUBA	EK-CER	UJV	VUJE	VTT	BZN
Laboratory accredited	-	-	-	✓	✓	✓	✓	✓
Accreditation standard	-	-	-	ISO 9001 2015	ISO/IEC 17025 2018	ISO/IEC 17025 2017	ISO/IEC 17025 2017	ISO/IEC 17025 2018
Year of the first accreditation	-	-	-	2012	1995	1998	2010	2020

A2 – Experimental testing – Methods

Partner	CVR	IPP	STUBA	EK-CER	UJV	VUJE	VTT	BZN
A2.1 – Impact testing	✓	✓	-	✓	✓	-	✓	✓
A2.2 – Tensile testing	✓	✓	-	✓	✓	-	✓	✓
A2.3 – Static fracture toughness	-	✓	-	✓	✓	-	✓	✓
A2.4 – Hardness	✓	✓	✓	✓	✓	✓	✓	✓
A2.5 – Small Punch Test (SPT)	-	✓	-	-	✓	✓	-	✓
A2.6 – Scanning electron microscopy	✓	-	✓	✓	✓	✓	✓	✓
A2.7 – Optical microscopy	✓	-	✓	✓	-	✓	✓	✓
A2.8 – TEM	✓	-	✓	-	-	-	✓	-

✓ - testing method accredited

5. Conclusions

Within the Task 4.1 the Deliverable D4.2 "Report summarizing the survey results, containing selected testing and analytical methods and parameters for the experimental program" was prepared. Collected data provide basis for subsequent planned activities within the Project. Based on the obtained data, the experimental matrix frame was prepared to serve as the fundamental basis for the WP4 experimental program finalization.

Annex 1

Second round of the questionnaires

DELISA-LTO (WP4) – A2.1 – Impact testing

Laboratory _____

A2.1.1 Testing method – Charpy impact testing

Instrumented testing ◯ Available ◯ Non-available

Standard Charpy–V sample testing ◯ Available (if available complete section A2.1.2) ◯ Non-available

Miniaturized Charpy–V sample testing ◯ Available (if available complete section A2.1.3) ◯ Non-available

A2.1.2 Testing machine - standard

Testing machine (model) _____ **Year of installation** _____

Nominal initial potential energy (J)_____ **Resolution** (J) _____

Striker type ◯ C - type ◯ U – type **Radius of striker** (mm) _____

Max. impact speed (m/s)_____ **Max. angle** (°)_____

Empty swing (J) _____ **Testing temperature range** (°C) _____

Sample positioning and centering method ◯ manual ◯ automatic

Specimen centering method ◯ notch position centering ◯ block centering

Additional information - comments:

A2.1.3 Testing machine - miniaturized

Testing machine (model) _____ **Year of installation** _____

Nominal initial potential energy (J)_____ **Resolution** (J) _____

Striker type ◯ C - type ◯ U – type **Radius of striker** (mm) _____

Max. impact speed (m/s)_____ **Max. angle** (°)_____

Empty swing (J) _____ **Testing temperature range** (°C) _____

Sample positioning and centering method ◯ manual ◯ automatic

Specimen centering method ◯ notch position centering ◯ block centering

Additional information - comments:

A2.1.4 Preferable specimen types and dimensions

Typical (mostly used and preferred) sample geometry – please provide drawing together with completed questionnaire! If you use more typical specimen geometries, please specify other in comments.

☐ Standard - Ch-V (10 x 10 x 55 mm) ☐ Sub-sized - mCh-V (5 x 5 x 27,5 mm)

☐ Sub-sized - mCh-V (3 x 4 x 27 mm) ☐ Other

If other specimen types and geometries (e.g., notch type), please specify (with dimensions):

A2.1.5 Specimen preparation

Equipment for specimen preparation ◯ Available ◯ Non-available
(if non-available, please proceed to the A.2.1.6)

Notch cutting method ☐ Electric discharge (EDM) ☐ Mechanical ☐ Other _____

Specimen reconstitution ◯ Available ◯ Non-available
(if non-available, please proceed to the A.2.1.6)

Reconstitution method (e. g. EBW) _____

Insert dimensions (e. g. 10 x 10 x 14 mm) _____

Please describe the specimen preparation technique:

A2.1.6 Test standards & evaluation

Used standards ☐ ASTM E 23 ☐ ISO 148 ☐ EN 10045

☐ Other (please specify): _____

Additional comments

DELISA-LTO (WP4) – A2.2 – Tensile testing

Laboratory _____

A.2.2.1 Testing machine and specimens

Testing machine (model) _____ Capacity (kN) _____

◯ Servo-hydraulic ◯ Electromechanical Year of installation _____

Load cell capacity (kN) _____

Sensor type ☐ Clip-gage ☐ LVDT ☐ Video extensometer ☐ Laser extensometer

☐ Other (please specify) _____

Testing temperature range (°C) _____

Testing environment ☐ Air ☐ Inert gas (please specify) _____

Typical (mostly used and preferred) sample geometry – please provide drawing together with completed questionnaire! If you use more typical specimen geometries, please specify other in comments.

☐ Cylindrical ☐ Flat

Diameter (mm) _____ Width (mm) _____

Gauge length (mm) _____ Thickness (mm) _____

Total length (mm) _____

Max. diameter (mm) _____

For cylindrical specimens only - Sample alignment (holding)

◯ Threaded (specify, e.g. M12) _____ ◯ Tapered

Additional information - comments:

A.2.2.2 Specimen preparation

Equipment for specimen preparation ◯ Available ◯ Non-available
(if non-available, please proceed to the A.2.2.3)

Finishing method ◯ Grinding ◯ Polishing ◯ Turning

Final surface roughness Ra (μm) _____

Please describe the specimen preparation technique:

A.2.2.3 Data acquisition & test evaluation

Sampling rate (Hz) _____

Used standards ☐ ASTM E8/E8M ☐ ISO 6892-1 ☐ ISO 6892-2

☐ Other (please specify): _____

Additional comments

DELISA-LTO (WP4) – A2.3 – Static fracture toughness

Laboratory _____

A2.3.1 Testing machine

Testing machine (model) _____ **Year of installation** _____

◯ Servo-hydraulic ◯ Electromechanical ◯ Other_____

Capacity (kN) _____ **Load cell capacity** (kN) _____

Sensor type ☐ COD ☐ LVDT ☐ Other_____

Testing temperature range (°C) _____

Additional information - comments:

A2.3.2 Preferable specimen types and dimensions

Typical (mostly used and preferred) sample geometry – please provide drawing together with completed questionnaire! If you use more typical specimen geometries, please specify other in comments.

☐ TPB (10 x 10 x 55 mm) ☐ mTPB (3 x 4 x 27 mm) ☐ CT (0,5T-CT)

☐ CT (1T-CT) ☐ mCT (0,14T-CT) ☐ mCT (0,16T-CT)

☐ RCT ☐ Other

If other specimen types, please specify (with dimensions):

A2.3.3 Specimen preparation

Equipment for specimen preparation ◯ Available ◯ Non-available
(if non-available, please proceed to the A.2.3.4)

Notch cutting method ☐ Electric discharge (EDM) ☐ Mechanical ☐ Other _____

Specimen reconstitution ◯ Available ◯ Non-available
(if non-available, please proceed to the A.2.3.4)

Reconstitution method (e. g. EBW) _____

Insert dimensions (e. g. 10 x 10 x 14 mm) _____

Please describe the specimen preparation technique:

A2.3.4 Test standards & evaluation

Sampling rate (Hz) _____

Used standards
☐ ASTM E399 ☐ ASTM E 1820 ☐ ISO 12737
☐ ISO 12135 ☐ ESIS P2/9D ☐ ASTM E 1921
☐ Other (please specify): _____

Additional comments

DELISA-LTO (WP4) – A2.4 – Hardness

Laboratory _____

A2.4.1 Testing machine

Testing machine (model)_____ **Year of installation** _____

A2.4.2 Testing method - Vickers (HV)

◯ Available ◯ Non-available (if non-available, please proceed to A2.4.3)

HV range (e. g. HV1 – HV 30) _____

Used standards ☐ ASTM E92 ☐ ISO 6507

☐ Other (please specify): _____

A2.4.3 Testing method - Brinell (HB)

◯ Available ◯ Non-available (if non-available, please proceed to A2.4.4)

Indenter ☐ Steel ball ☐ Tungsten carbide ball

Used standards ☐ ASTM E10 ☐ ISO 6506

☐ Other (please specify):_____

A2.4.4 Testing method - Rockwell (HR)

◯ Available ◯ Non-available (if non-available, please proceed to A2.4.5)

Indenter ☐ Diamond cone (HRA/HRC) ☐ Steel Ball (HRB)

Used standards ☐ ASTM E18 ☐ ISO 6508

☐ Other (please specify): _____

A2.4.5 Testing method - Knoop

◯ Available ◯ Non-available (if non-available, please proceed to A2.4.6)

Used standards ☐ ASTM E92 ☐ ISO 4545

☐ Other (please specify): _____

A2.4.6 Specimen preparation

Surface machining (finishing method)

☐ Grinding ☐ Polishing ☐ Other (please specify):_____

Final specimen surface roughness Ra (μm) _____

A2.4.7 Microhardness or nano-hardness

Microhardness or nano-hardness - if available, please specify parameters:

Additional comments

DELISA-LTO (WP4) – A2.5 – Small Punch Test (SPT) Laboratory _____

A2.5.1 Testing machine

Testing machine (model)_____ Capacity (kN) _____

◯ Servo-hydraulic ◯ Electromechanical Year of installation _____

Testing temperature range (°C) _____

A2.5.2 Testing fixture

Receiving hole edge ◯ Chamfer ◯ Radius Nominal dimension (mm) _____

Real dimension (mm) _____

Indenter ◯ Punch ◯ Ball Nominal diameter (mm) _____

Real diameter (mm) _____

A2.5.3 Displacement measurement

☐ Deflection ☐ Punch displacement ☐ Cross-head displacement ☐ Other

If other than deflection, please specify testing apparatus stiffness correction method:

A2.5.4 Specimen preparation

Equipment for specimen preparation ◯ Available ◯ Non-available
(if non-available, please proceed to the A.2.5.5)

Initial cutting method ☐ Electric discharge (EDM) ☐ Mechanical ☐ Other _____

Initial thickness after cutting (mm) _____ Final specimen surface roughness Ra (μm) _____

Please describe the specimen preparation technique and specimen thickness measurement procedure:

A2.5.5 Data acquisition & analysis

Data acquisition – **sampling rate** (Hz) _____

Pre-load used ◯ no ◯ yes - pre-load used (N) _____

F_e and u_e determination ☐ bilinear method ☐ trilinear method ☐ offset t/10 ☐ offset t/100

Yield strength determination ☐ EN 10371 (Annex D) ☐ In-house correlations (i.e., ASTM E3205)

UTS determination ☐ EN 10371 (Annex C) ☐ In-house correlations (i.e., ASTM E3205)

End of the test criterion ☐ $0.8 \cdot F_m$ ☐ Other _____

Please describe the data treatment procedure:

Additional comments

DELISA-LTO (WP4) – A2.6 – SEM

Laboratory _____

A2.6.1 Testing machine

Testing machine (model) _____ **Year of installation** _____

A2.6.2 Detectors

Available Detectors ☐ SE ☐ BSE ☐ EDS ☐ WDS ☐ EBSD ☐ Other

Simultaneous detector analyses ◯ Available ◯ Non-available

If other detectors are available and suitable, please specify:

A2.6.3 Parameters

Used magnification range _____ **Image resolution range** _____

Accelerated voltage operation modes _____

Working distance for analysis (mm) _____

Max. size of analyzed specimen (dimensions) (mm) _____

Low vacuum mode ◯ Available ◯ Non-available

A2.6.4 Specimen preparation

Please, describe specimen preparation procedure (e. g. cleaning – ultrasonic, compressed air; etching):

Additional comments

DELISA-LTO (WP4) – A2.7 – Optical Microscopy

Laboratory _____

A2.7.1 Testing machine

Testing machine (model) _____ **Year of installation** _____

Microscope type (e. g. Stereo, Inverted) _____

A2.7.2 Imaging methods

Bright Field	◯ Available	◯ Non-available
Dark Field	◯ Available	◯ Non-available
Polarizer	◯ Available	◯ Non-available

If other imaging methods are available and suitable, please specify:

A2.7.3 Parameters

Used magnification range _____ **Image resolution range**_____

Lens types _____

Used SW _____

SW tool for image evaluation _____

Image focus in Z-axis	◯ Available	◯ Non-available
Motorized table support	◯ Available	◯ Non-available

A2.7.4 Specimen preparation

Please, describe specimen preparation procedure (e. g. cleaning – ultrasonic, compressed air; etching):

Additional comments

DELISA-LTO (WP4) – A2.8 – TEM

Laboratory _____

A2.8.1 Testing machine

Testing machine (model) _____ **Year of installation**_____

A2.8.2 Additional analytical methods

STEM (Scanning Transmission Electron Microscopy) ◯ Available ◯ Non-available

EELS (Electron Energy Loss Spectrometry) ◯ Available ◯ Non-available

EDS (Energy Dispersive Spectroscopy) ◯ Available ◯ Non-available

In Situ TEM ◯ Available ◯ Non-available

Detector types in STEM ☐ BF ☐ DF ☐ HAADF

Camera **Type** _____ **Resolution range**_____

Video recording ◯ Available ◯ Non-available

Tomography ◯ Available ◯ Non-available

If other additional analytical methods are available and suitable, please specify:

A2.8.3 Parameters

Used magnification range _____ **Image resolution range** _____

Maximum specimen thickness (nm) _____

Accelerated voltage operation modes _____

A2.8.4 Specimen preparation

Please, describe specimen preparation procedure (e. g. cleaning – ultrasonic, compressed air; etching):

Additional comments

Annex 2

Experimental matrix frame

DELISA-LTO – WP2/WP4 Experimental matrix			Experimental Technique		A2.1 - Impact testing											
			Available / Participating Laboratory		CVR		IPP		EK-CER		UJV		VTT		BZN	
Material No.		Material (description)	Material Type	Material state / Specimen geometry	ST	M	ST	M	ST	M	ST	M	ST	M	ST	M
1		**Main circulation piping - 08Ch18N12T -** NPP V1 – initial state	BM	As received												
				Thermal Aged												
2		**Pressurizer surge line - 08Ch18N10T** - NPP EBO3 – initial state	BM	As received												
				Thermal Aged												
3	3a	**Main circulation piping - 08Ch18N12T+WM** - NPP V1 – after 28 years in operation	BM	As received												
				Thermal Aged												
	3b		WM	As received												
				Thermal Aged												
	3c		HAZ	As received												
				Thermal Aged												
4	4a	**Main circulation piping – triple T-junction - 08Ch18N12T+WM** - NPP V1 – after 28 years in operation	BM	As received												
				Thermal Aged												
	4b		WM	As received												
				Thermal Aged												
	4c		HAZ	As received												
				Thermal Aged												
5		**Pressurizer surge line - 08Ch18N10T** - NPP V1 – after 28 years in operation	BM	As received												
				Thermal Aged												
				Specimen type / method	Charpy-V (10x10x55 mm)	mini-Charpy (4x3x27,5 mm)	Charpy-V (10x10x55 mm)	mini-Charpy (4x3x27,5 mm)	Charpy-V (10x10x55 mm)	mini-Charpy (4x3x27,5 mm)	Charpy-V (10x10x55 mm)	mini-Charpy (4x3x27,5 mm)	Charpy-V (10x10x55 mm)	mini-Charpy (4x3x27,5 mm)	Charpy-V (10x10x55 mm)	mini-Charpy (4x3x27,5 mm)

Accredited method
■ Participation in round robin
ST Standard specimen geometry
M Miniturized specimen
BM Base metal
WM Weld metal
HAZ Heat affected zone

DELISA-LTO – WP2/WP4 Experimental matrix			Experimental Technique		A2.2 - Tensile Testing					
			Available / Participating Laboratory		CVR	IPP	EK-CER	UJV	VTT	BZN
Material No.		Material (description)	Material Type	Material state / Specimen geometry	ST	ST	ST	ST	ST	ST
1		**Main circulation piping - 08Ch18N12T -** NPP V1 – initial state	BM	As received						
				Thermal Aged						
2		**Pressurizer surge line - 08Ch18N10T** - NPP EBO3 – initial state	BM	As received						
				Thermal Aged						
3	3a	**Main circulation piping - 08Ch18N12T+WM** - NPP V1 – after 28 years in operation	BM	As received						
				Thermal Aged						
	3b		WM	As received						
				Thermal Aged						
	3c		HAZ	As received						
				Thermal Aged						
4	4a	**Main circulation piping – triple T-junction - 08Ch18N12T+WM** - NPP V1 – after 28 years in operation	BM	As received						
				Thermal Aged						
	4b		WM	As received						
				Thermal Aged						
	4c		HAZ	As received						
				Thermal Aged						
5		**Pressurizer surge line - 08Ch18N10T** - NPP V1 – after 28 years in operation	BM	As received						
				Thermal Aged						
				Specimen type / method	preferred standard geometry of tensile specimens with the diameter 4-8 mm (based on the survey results)					

	Accredited method
■	Participation in round robin
ST	Standard specimen geometry
M	Miniturized specimen
BM	Base metal
WM	Weld metal
HAZ	Heat affected zone

DELISA-LTO – WP2/WP4
Experimental matrix

Material No.		Material (description)	Material Type	Material state / Specimen geometry	A2.3 - Static Fracture Toughness									
				Experimental Technique										
				Available / Participating Laboratory	IPP		EK-CER		UJV		VTT		BZN	
					ST	M	ST	M	ST	M	ST	M	ST	M
1		**Main circulation piping - 08Ch18N12T -** NPP V1 – initial state	BM	As received										
				Thermal Aged										
2		**Pressurizer surge line - 08Ch18N10T** - NPP EBO3 – initial state	BM	As received										
				Thermal Aged										
3	3a	**Main circulation piping - 08Ch18N12T+WM** - NPP V1 – after 28 years in operation	BM	As received										
				Thermal Aged										
	3b		WM	As received										
				Thermal Aged										
	3c		HAZ	As received										
				Thermal Aged										
4	4a	**Main circulation piping – triple T-junction - 08Ch18N12T+WM** - NPP V1 – after 28 years in operation	BM	As received										
				Thermal Aged										
	4b		WM	As received										
				Thermal Aged										
	4c		HAZ	As received										
				Thermal Aged										
5		**Pressurizer surge line - 08Ch18N10T** - NPP V1 – after 28 years in operation	BM	As received										
				Thermal Aged										
				Specimen type / method	TPB (10 x 10 x 55 mm)	mTPB (3 x 4 x 27 mm), mCT (0,16T-CT)	TPB (10 x 10 x 55 mm)	mCT (0,16T-CT)	TPB (10 x 10 x 55 mm), CT (0,5T-CT)	mCT (0,16T-CT)	CT (0,5T-CT)	mCT (0,14T-CT)	TPB (10 x 10 x 55 mm), CT (0,5T-CT)	mTPB (3 x 4 x 27 mm), mCT (0,16T-CT)

Accredited method
■ Participation in round robin
ST Standard specimen geometry
M Miniturized specimen
BM Base metal
WM Weld metal
HAZ Heat affected zone

DELISA-LTO – WP2/WP4
Experimental matrix

Material No.		Material (description)	Material Type	Material state / Specimen geometry	A2.4 - Hardness								
					CVR		IPP	STUBA	EK-CER	UJV	VUJE	VTT	BZN
					ST	M	ST	M	ST	ST	ST	ST	ST
1		**Main circulation piping - 08Ch18N12T -** NPP V1 – initial state	BM	As received									
				Thermal Aged									
2		**Pressurizer surge line - 08Ch18N10T** - NPP EBO3 – initial state	BM	As received									
				Thermal Aged									
3	3a	**Main circulation piping - 08Ch18N12T+WM** - NPP V1 – after 28 years in operation	BM	As received									
				Thermal Aged									
	3b		WM	As received									
				Thermal Aged									
	3c		HAZ	As received									
				Thermal Aged									
4	4a	**Main circulation piping – triple T-junction - 08Ch18N12T+WM** - NPP V1 – after 28 years in operation	BM	As received									
				Thermal Aged									
	4b		WM	As received									
				Thermal Aged									
	4c		HAZ	As received									
				Thermal Aged									
5		**Pressurizer surge line - 08Ch18N10T** - NPP V1 – after 28 years in operation	BM	As received									
				Thermal Aged									
				Specimen type / method	Vickers HV0,01-HV10	Nano-indentation	Vickers HV100-HV1000	Nano-indentation	Vickers HV0,2-HV30	Vickers HV5	Vickers HV0,5-HV120	Vickers HV0,01-HV10	HV0,05-HV20

Accredited method
■ Participation in round robin
ST Standard specimen geometry
M Miniturized specimen
BM Base metal
WM Weld metal
HAZ Heat affected zone

DELISA-LTO – WP2/WP4
Experimental matrix

Material No.		Material (description)	Material Type	Material state / Specimen geometry	Experimental Technique: A2.5 - SPT Available / Participating Laboratory: IPP	UJV	VUJE	BZN
					M	M	M	M
1		**Main circulation piping - 08Ch18N12T -** NPP V1 – initial state	BM	As received				
				Thermal Aged				
2		**Pressurizer surge line - 08Ch18N10T** - NPP EBO3 – initial state	BM	As received				
				Thermal Aged				
3	3a	**Main circulation piping - 08Ch18N12T+WM** - NPP V1 – after 28 years in operation	BM	As received				
				Thermal Aged				
	3b		WM	As received				
				Thermal Aged				
	3c		HAZ	As received				
				Thermal Aged				
4	4a	**Main circulation piping – triple T-junction - 08Ch18N12T+WM** - NPP V1 – after 28 years in operation	BM	As received				
				Thermal Aged				
	4b		WM	As received				
				Thermal Aged				
	4c		HAZ	As received				
				Thermal Aged				
5		**Pressurizer surge line - 08Ch18N10T** - NPP V1 – after 28 years in operation	BM	As received				
				Thermal Aged				
				Specimen type / method	SPT 8 x 0,5 mm, Radius R0,2, Punch	SPT 8 x 0,5 mm, Radius R0,2, Punch	SPT 8 x 0,5 mm, Radius R0,2, Punch	SPT 8 x 0,5 mm, Chamfer 0,2 x 45°, Ball

Accredited method
■ Participation in round robin
ST Standard specimen geometry
M Miniturized specimen
BM Base metal
WM Weld metal
HAZ Heat affected zone

DELISA-LTO – WP2/WP4 Experimental matrix			Experimental Technique		A2.6 - Scanning Electron Microscopy						
			Available / Participating Laboratory		CVR	STUBA	EK-CER	UJV	VUJE	VTT	BZN
Material No.		Material (description)	Material Type	Material state / Specimen geometry	-	-	-	-	-	-	-
1		**Main circulation piping - 08Ch18N12T -** NPP V1 – initial state	BM	As received							
				Thermal Aged							
2		**Pressurizer surge line - 08Ch18N10T** - NPP EBO3 – initial state	BM	As received							
				Thermal Aged							
3	3a	**Main circulation piping - 08Ch18N12T+WM** - NPP V1 – after 28 years in operation	BM	As received							
				Thermal Aged							
	3b		WM	As received							
				Thermal Aged							
	3c		HAZ	As received							
				Thermal Aged							
4	4a	**Main circulation piping – triple T-junction - 08Ch18N12T+WM** - NPP V1 – after 28 years in operation	BM	As received							
				Thermal Aged							
	4b		WM	As received							
				Thermal Aged							
	4c		HAZ	As received							
				Thermal Aged							
5		**Pressurizer surge line - 08Ch18N10T** - NPP V1 – after 28 years in operation	BM	As received							
				Thermal Aged							
				Specimen type / method	SE, BSE, EDS, WDS, EBSD - 2,5 - 300 000x	SE, BSE, EDS, WDS, EBSD - 5 - 1 000 000x	SE, BSE, EDS - 10 - 100 000x	SE - 20 - 2 000x	SE, BSE, EDS - 5 - 300 000x	SE, BSE, EDS, WDS, EBSD - up to 500 000x	SE, BSE, EDS - 10 - 200 000x

Accredited method
■ Participation in round robin
ST Standard specimen geometry
M Miniturized specimen
BM Base metal
WM Weld metal
HAZ Heat affected zone

DELISA-LTO – WP2/WP4
Experimental matrix

Material No.		Material (description)	Material Type	Material state / Specimen geometry	A2.7 - Optical Microscopy						A2.8 - TEM		
				Available / Participating Laboratory	CVR	STUBA	EK-CER	VUJE	VTT	BZN	CVR	STUBA	VTT
					-	-	-	-	-	-	-	-	-
1		**Main circulation piping - 08Ch18N12T -** NPP V1 – initial state	**BM**	As received									
				Thermal Aged									
2		**Pressurizer surge line - 08Ch18N10T** - NPP EBO3 – initial state	**BM**	As received									
				Thermal Aged									
3	3a	**Main circulation piping - 08Ch18N12T+WM** - NPP V1 – after 28 years in operation	**BM**	As received									
				Thermal Aged									
	3b		**WM**	As received									
				Thermal Aged									
	3c		**HAZ**	As received									
				Thermal Aged									
4	4a	**Main circulation piping – triple T-junction - 08Ch18N12T+WM** - NPP V1 – after 28 years in operation	**BM**	As received									
				Thermal Aged									
	4b		**WM**	As received									
				Thermal Aged									
	4c		**HAZ**	As received									
				Thermal Aged									
5		**Pressurizer surge line - 08Ch18N10T** - NPP V1 – after 28 years in operation	**BM**	As received									
				Thermal Aged									
				Specimen type / method	BF, DF, Polarizer - 5 - 100x	BF, DF, Polarizer - 250x, 500x	BF, DF, Polarizer - up to 1 100x	BF, DF, Polarizer - 100 - 2 000x; 4,7 - 120x	BF, DF - 1,25 -100x	BF, DF, Polarizer - 10 - 6 000x	STEM, EELS, EDS, In-situ TEM - 6k - 8 000kx	STEM, EELS, EDS, In-situ TEM - 50 - 2 000kx	STEM, EELS, EDS - 2k - 2 000kx

Accredited method
■ Participation in round robin
ST Standard specimen geometry
M Miniturized specimen
BM Base metal
WM Weld metal
HAZ Heat affected zone

DELISA-LTO – WP2/WP4
Experimental matrix

Material No.		Material (description)	Material Type	Material state / Specimen geometry	Positron annihilation spectroscopy	Mössbauer spectroscopy	Atomic force microscopy	Corrosion tests - Interfacial contact resistance (ICR)	Electrochemical potentiokinetic reactivation (EPR)	Electrochemical potentiokinetic reactivation (EPR)	Replicas	Thermo-electric power measurements (TEP)	Helium and water pycnometry	Acoustic emmission	NDT for thermal ageing evaluation
			Experimental Technique		Other methods										
			Available / Participating Laboratory		STUBA			VUJE		CVR					
1		**Main circulation piping - 08Ch18N12T -** NPP V1 – initial state	BM	As received											
				Thermal Aged											
2		**Pressurizer surge line - 08Ch18N10T** - NPP EBO3 – initial state	BM	As received											
				Thermal Aged											
3	3a	**Main circulation piping - 08Ch18N12T+WM** - NPP V1 – after 28 years in operation	BM	As received											
				Thermal Aged											
	3b		WM	As received											
				Thermal Aged											
	3c		HAZ	As received											
				Thermal Aged											
4	4a	**Main circulation piping – triple T-junction - 08Ch18N12T+WM** - NPP V1 – after 28 years in operation	BM	As received											
				Thermal Aged											
	4b		WM	As received											
				Thermal Aged											
	4c		HAZ	As received											
				Thermal Aged											
5		**Pressurizer surge line - 08Ch18N10T** - NPP V1 – after 28 years in operation	BM	As received											
				Thermal Aged											

Specimen type / method

Accredited method

■ Participation in round robin

ST Standard specimen geometry

M Miniturized specimen

BM Base metal

WM Weld metal

HAZ Heat affected zone