Annual Work Plan WPMAT-2019

Call for Post Irradiation Experiments (PIE) and Materials Data

Explanation

- This call is for post irradiation experiments of irradiated Cu(CrZr)-W/V/Ta and tungsten samples.
- The objective of each "Lot" is briefly summarized.
- PIE: The properties to be tested, the test methods and further details are given in Appendix C.
- For offers the formation of "Joint Proposals" is an option, where "Joint" indicates a proposal from more than one consortium member, see Appendix D.

Objectives

Two high priority irradiation topics, i.e. the screening of CuCrZr and tungsten materials have been launched in 2017 (AWP-2017) and implemented under WPMAT WBS 6.7. and 6.8., respectively.

This Call is for respective PIE of specimens irradiated under AWP-2017 as Lot-A & Lot-B.

Abbreviations

Lot-A	*Irradiation campaign: Screening of mechanical properties of advanced Cu alloys*
Lot-A-PIE	*PIE to be performed on specimens irradiated under Lot-A*
Lot-B	*Irradiation campaign of advanced W alloys (mechanical properties & selected fracture mechanics)*
Lot-B-PIE	*PIE to be performed on specimens irradiated under Lot-B*
Wf/W	*Fiber reinforced W composites*
DIC	*Digital Image correlation*
PIM	*Powder injection molding production route*
FEM	*Finite element model*
TEM	*Transmission electron microscope*

Background

Definition of Lot-A und Lot-B and Materials used

The AWP-2017 WPMAT programme included irradiation campaigns on Cu(CrZr)-W/V/Ta (Lot-A) tungsten-based (Lot-B) materials. It was called as "AWP17_Call_N-Irradiation" by letter of the EUROfusion Programme Manager TD-EG-1744, May 8th 2017, and implemented as WBS MAT 6.7. and 6.8., respectively. The major scope of the irradiation was the establishment of mechanical and microstructural properties of the samples irradiated. The full details are given in **Appendix A.**

Irradiations campaigns (Lot-A und Lot-B)

The irradiation campaigns have been started April 2018 in BR-2, Mol, Belgium and are now about to be finished. Details on the implementation, irradiation conditions and specimen irradiated (e.g. drawings, number) are given in **Appendix B**.

Overview of Services requested and Requirements

The aim of the call is PIE on samples irradiated as Lot-A and Lot-B, i.e.

- ***Lot-A-PIE**, tensile test of CuCrZr grade irradiated material*
- ***Lot-B-PIE**, bending and fracture toughness test on different tungsten grade irradiated material.*

Details are specified in **Appendix C.**

Offers

Offers should indicate the costs for PIE, and if needed transport, for the lots Lot-A-PIE & Lot-B-PIE, separately (see Appendix D).
Offers shall be split into "technical" and "financial" offers to allow for independent assessment of both parts.

Evaluation

The offers will be assessed and evaluated taking into account their suitability to meet the objectives and schedule. PIE shall be finished by end of 2020.
Primary assessment criteria for the offers are:

- The matching of the offer with the technical requirements of the call.
- Costs.

Required Information

Information shall be provided (*separate for each partner in the case of "Joint Proposal" offers*). All information required for the submission of the proposals and the eligibility and awarding criteria are detailed in **Annex 2** and **Annex 3** to the present document.

Structure of Annexes

ANNEX 1: Technical Specifications and Requirements

APPENDIX A: Definition of Lot-A and Lot-B and Materials
APPENDIX B: Implementation of Irradiation Campaigns Lot-A/B
APPENDIX C: Technical Content of the Proposal for PIE & Overview of Services and requirements

ANNEX 2: Content of the Proposal – to be submitted

APPENDIX D: Legal Requirements and Documents to be submitted with the Proposals

- Selected Legal Requirements
- Submission of Proposals and Eligibility
- Technical Content of the Proposal (offers)

ANNEX 3: Evaluation and Awarding

APPENDIX E: Awarding Criteria &Awarding Procedure

APPENDIX A: Definition of Lot-A und Lot-B and Materials

The AWP-2017 WPMAT programme included irradiation campaigns on Cu(CrZr)-W/V/Ta (Lot-A) and tungsten-based (Lot-B) materials. It was called as "AWP17_Call_N-Irradiation" by letter of the EUROfusion Programme Manager TD-EG-1744, May 8th 2017, and implemented as WBS MAT 6.7. and 6.8., respectively. The major scope of the irradiation was the establishment of mechanical and microstructural properties of the samples irradiated

Lot-A (copper materials): up to 2.5 dpa (equivalent in Cu) in a temperature range 150, 350, 450 °C (**Objective**: determination of tensile strength for an evaluation of advanced heat sink materials (screening for down-selection).

- **Rationale**: The irradiation softening behaviour of CuCrZr is well known. For screening experiments, about 2.5 dpa (Cu) is sufficient to assess the candidate materials. The relevant lower temperature for water-cooling is 150 °C. The new materials are supposed to extend the application temperature beyond 350 °C. Therefore, 450°C was selected additional to the lower and upper operation temperature window.
- **Materials:** 5 advanced heat sink materials in the condition as delivered: CuCrZr-W(fiber) composite, CuCrZr-W(particle) composite, CuCrZr-W laminate, CuCrZrV (SAcwA), ODS Cu-Y2O3
- **Specimen type:** Miniaturized flat tensile samples (16 mm x 4.2 x 1 mm, gauge 5.2 mm x 1.6 mm x 1 mm)
- **In total 60 irradiated samples:** 5 materials x 3 irradiation temperatures x 4 samples (plus spare for reference tests).

Lot-B (tungsten materials): up to 1 dpa[1] (equivalent in W) 600, 1000, 1100 °C (for W).

- **Objective**: determination of basic properties for an evaluation of baseline and advanced armour materials (screening for down-selection).
- **Rationale** Significant irradiation hardening in tungsten is observed already below 1 dpa (W equivalent dose. It is assumed that irradiation hardening does not vary significantly between 400°C and 800°C (to be verified by LOT III). Therefore, the number of irradiation temperatures was reduced to targets as of 600°C, 1000°C and 1100°C.
- **Scope:** Static or dynamic bending tests provide data to characterize hardening and DBTT behaviour.
- **Specimen type:** mini (3/4)-point-bend-bars (1 x 1 x 12 mm) and mini-Charpy/KLST (3 x 4 x 27 mm).
- **Materials:** 8 advanced armour materials in the condition as delivered:
  - W (ITER type) – "reference"
    Fibre (two)
    - W(long fiber)-W composite
    - W(short fiber)-W composite
      Advanced W options (five)
    - PIM W-Y2O3
    - PIM W-TiC
    - W-K doped plate 7 mm, Tohoku Univ.
    - W3%Re-K doped plate 7 mm, Tohoku Univ.
    - W-K doped plate 1 mm, KIT

Properties to be addressed and specimen used

a) For "advanced tungsten options" (non-fibre)
"Matchstick" samples (miniaturized "bars") are irradiated for, optionally use in three or four-point bending.

[1] Note: There is a minor deviation between "scope" (1dpa) and "achieved" (~0.7-0.8dpa) as referenced in Appendix B/C.

In total 120 bars are irradiated for 6 materials and at 3 irradiation temperatures. A break-down is given, in Table A1.

b) For fibre tungsten material
Mini-Charpy (KLST) specimen geometry is used for both W-fiber reinforced materials.
In total 24 samples were irradiated: 3 materials x 2 temperatures (600/1000C) x 4 samples, each.

c) In addition, pure W (PLANSEE) is used as reference to compare both geometries.

Table A1: Miniaturized "bars" for three/four point bend.

	mini (3)4P bend bars	
	unirr. for reference	***irradiated***
PIM W-Y2O3	10	21
PIM W-TiC	10	24
W plate K-doped, 1 mm	10	15
W plate K-doped, 7 mm	10	15
W3%Re plate K-doped, 7 mm	10	15
W reference (PLANSEE)	10	30
Σ		**120**

The irradiation have been performed in Mol, BR2 reactor, Belgium and the campaigns are about to be finished and specimens ready for post irradiation tests (number and types summarized in Table A2).

Number and types of tests			
	Lot-A	Lot-B	Lot-B Wf/W
# samples, tensile tests	60		
# samples 3/4PB tests (for tensile properties)		120	
# samples fracture toughness tests			24

Table A2: Summary of irradiated material and samples to be tested.

Additional technical details on the 2017-call, its implementation, the material (properties0 and samples (geometry/drawings) can be found in **Appendix B.**

Appendix B: Implementation of Irradiation Campaigns Lot-A/B

(Description of the Irradiation campaigns Lot-A, Lot-B, Specimen Drawings)

The technical requirements of the AWP-2017 call vs. the actual implementation are summarized in Tables App-B1 and B2 at the end of the Appendix

LOT-A: Screening of CuCrZr-W Composites and Cu Alloys

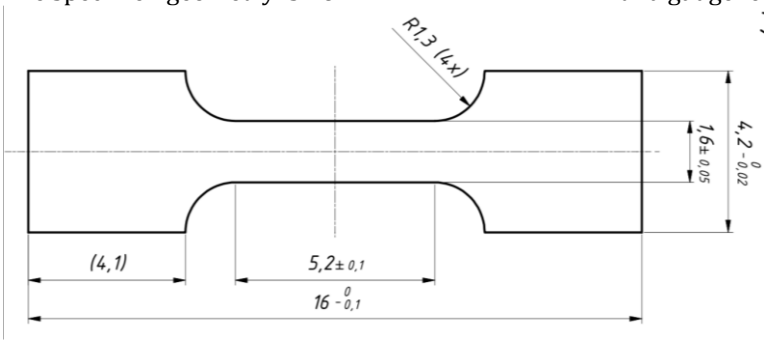
Objective: determination of tensile strength for an evaluation of advanced heat sink materials (screening for down-selection).
Dose: Target of 2.5 dpa (Cu).
Temperature: Irradiation temperatures 150, 350, 450 °C.

START of IRRADIATION: APRIL 2018

Materials (5)	1. CuCrZr-W(fiber) composite 2. CuCrZr-W(particle) composite 3. CuCrZr-W laminate 4. CuCrZrV 5. ODS Cu-Y2O3
Irrad. Doses	2.5 dpa (in Cu)
Irrad. Temperatures	150, 350, 450 °C
Specimen type	mini-tensile (16 mm x 4.2 x 1 mm, gauge length 5.2 mm)
PIE properties	tensile properties, fractography, TEM
Reactor	BR-2, Mol, Belgium
PIE Schedule	**Scheduled 2019/2020 – *Objective of this call***

1. Irradiation/Test-Matrix

Tensile properties shall be determined.
The specimen geometry is 16 mm x 4.2 mm x 1 mm with a gauge length of 5.2 mm:



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	1dpa 150 °C	**1 dpa 350 °C**	**1 dpa 450 °C**
mini tensile 16 mm x 4.2 x 1 mm, gauge length 5.2 mm	• CuCrZr-W_p • CuCrZr-W_f • W-CuCrZr laminate • CuCrZr-V • ODS Cu-Y2O3	• CuCrZr-W_p • CuCrZr-W_f • W-CuCrZr laminate • CuCrZr-V • ODS Cu-Y2O3	• CuCrZr-W_p • CuCrZr-W_f • W-CuCrZr laminate • CuCrZr-V • ODS Cu-Y2O3

2. Specimen: Type, Suppliers, Total Numbers, Identification

	mini tensile	RU	ID-Code
CuCrZr-W_p	22	IPP	P1, P2, ..., P22
CuCrZr-W_f	22	IPP	F1, F2, ..., F22
W-CuCrZr laminate	22	KIT	L1, L2, ..., L22
CuCrZr-V	22	KIT	V1, V2, ..., V22
ODS Cu-Y2O3	22	KIT	Y1, Y2, ..., Y22

Four mini tensile specimens are required for each irradiation temperature plus additional 10 specimens for unirradiated testing and as backup, that is, 4*3 + 10 = 22 mini tensile specimens per material.
Total number of samples irradiated is 4 samples * 3 temperatures * 5 materials = 60 samples

3. Materials Data – indicative composition and physical properties

CuCrZr-W_p
Composition: W-30%CuCrZr (wt.%)
Density: 14.29 g/cm^3
Thermal conductivity: 243 W/m.K
Microstructure: homogeneous / isotropic

CuCrZr-W_f
Composition: W – 46%CuCrZr (wt.%)
Density: 12.55 g/cm^3
Thermal conductivity: 267 W/m.K (parallel), 258 W/m.K (perpendicular)
Microstructure: infiltrated W-fiber fabric with main fiber orientation parallel to tensile loading – minor contribution by woven fibers in perpendicular direction

W-CuCrZr laminate
Composition: W-27%CuCrZr (wt.%)
Density: 14.6 g/cm^3
Thermal conductivity: 255 W/m.K (parallel), 223 W/m.K (perpendicular)
Microstructure: orientation of single rolled W-sheets parallel to tensile loading

CuCrZr-V
Composition: Cu-0.922%Cr-0.041%Zr-0.221%V (wt.%)
Density: ~8.90 g/cm^3
Thermal conductivity: ~300-350 W/m.K (estimate)
Microstructure: homogeneous / isotropic

ODS-Cu
Composition: Cu-Y_2O_3 (heat # C3/40-Y)
Density: ~8.90 g/cm^3
Thermal conductivity: (to be determined) – assumption: 300-350 W/m.K
Microstructure: homogeneous / isotropic

LOT B: Screening of Tungsten Materials

Objective: determination of basic properties for an evaluation of baseline and advanced armour materials (screening for down-selection).
Dose: *Target* 1 dpa (W)
Tests: Static or dynamic bending tests provide data to characterise hardening and DBTT behaviour.

Materials (8)	1. W (ITER-type, reference) 2. W(long fiber)-W composite 3. W(short fiber)-W composite 4. PIM W-Y2O3 5. PIM W-TiC 6. W-K doped plate 7 mm, Tohoku Univ. 7. W3%Re-K doped plate 7 mm, Tohoku Univ. 8. W-K doped plate 1 mm, KIT
Irrad. Doses	0.7-0.8 dpa (in W), shielding to reduce Re transmutation
Irrad. Temperatures	600, 1000, 1100 °C
Specimen type	mini 4P-bend-bars (1 x 1 x 12 mm) / mini-Charpy (3 x 4 x 27 mm)
PIE properties	DBTT, ductility
Reactor	BR-2, Mol, Belgium
PIE Schedule	**Scheduled 2019/2020 – *Objective of this call***

1. Irradiation/Test-Matrix

START of IRRADIATION: APRIL 2018
Note: Actual dose will be lower than 1 dpa (~0.7-0.8 dpa) .

	0.7-0.8 dpa 600 °C	**0.7-0.8 dpa 1000 °C**	**0.7-0.8 dpa 1100 °C**
mini 4P bend bars 1 mm x 1 mm x 12 mm	• W-K doped plate 1 mm • W-K doped plate 7 mm • W3%Re-K doped plate 7 mm • PIM W-Y2O3 • PIM W-TiC • W (reference)	• W-K doped plate 1 mm • W-K doped plate 7 mm • W3%Re-K doped plate 7 mm • PIM W-Y2O3 • PIM W-TiC • W (reference)	• W-K doped plate 1 mm • W-K doped plate 7 mm • W3%Re-K doped plate 7 mm • PIM W-Y2O3 • PIM W-TiC • W (reference)
KLST 3 mm x 4 mm x 27 mm	• W(short fiber)-W • W(long fiber)-W • W (reference)	• W(short fiber)-W • W(long fiber)-W • W (reference)	

2. Specimen Preparation, Total Numbers & Identification

	mini 3/4P bend bars		KLST			RU	ID-Code
	unirr.	***irr.***	*unirr.*	***Irr.***			
W(short fiber)-W			10	12	S1, S2, ..., S22	FZJ	L1, L2, ..., L22
W(long fiber)-W			10	12	L1, L2, ..., L22	IPP	Y1, Y2, ..., Y31
PIM W-Y2O3	10	21			Y1, Y2, ..., Y31	KIT	T1, T2, ..., T34
PIM W-TiC	10	24			T1, T2, ..., T34	KIT	P1, P2, ..., P25
W plate K-doped, 1 mm	10	15			P1, P2, ..., P25	KIT	K-01, K-02, ..., K-25
W plate K-doped, 7 mm	10	15			K-01, K-02, ..., K-25	Tohoku Univ.	KR-01, KR-02, ..., KR-25
W3%Re plate K-doped, 7 mm	10	15			KR-01, KR-02, ..., KR-25	Tohoku Univ.	L1, L2, ..., L22
W reference (PLANSEE)	10	30	10	8	SCK.CEN decision	SCK.CEN	-
∑		**120**		**32**			

3. Materials – Details & Irradiation Temperature

3.1. W(long fibre)-W composite

	unirradiated & backup	0.7-0.8 dpa 600 °C	0.7-0.8 dpa 1000 °C
KLST 3 mm x 4 mm x 27 mm	10	6	6

3.2. W(short fibre)-W composite

	unirradiated & backup	0.7-0.8 dpa 600 °C	0.7-0.8 dpa 1000 °C
KLST 3 mm x 4 mm x 27 mm	10	6	6

3.3. PIM W-Y2O3

	unirradiated & backup	0.7-0.8 dpa 600 °C	0.7-0.8 dpa 1000 °C	0.7-0.8 dpa 1100 °C
mini 4P bend bars 1 mm x 1 mm x 12 mm	10	7	7	7

3.4. PIM W-TiC

	unirradiated & backup	0.7-0.8 dpa 600 °C	0.7-0.8 dpa 1000 °C	0.7-0.8 dpa 1100 °C
mini 4P bend bars 1 mm x 1 mm x 12 mm	10	8	8	8

3.5. W plate K-doped, 1 mm

	unirradiated & backup	0.7-0.8 dpa 600 °C	0.7-0.8 dpa 1000 °C	0.7-0.8 dpa 1100 °C
mini 4P bend bars 1 mm x 1 mm x 12 mm	10	5	5	5

3.6. W plate K-doped, 7 mm

	unirradiated & backup	0.7-0.8 dpa 600 °C	0.7-0.8 dpa 1000 °C	0.7-0.8 dpa 1100 °C
mini 4P bend bars 1 mm x 1 mm x 12 mm	10	5	5	5

3.7. W-3%Re plate K-doped, 7 mm

	unirradiated & backup	0.7-0.8 dpa 600 °C	0.7-0.8 dpa 1000 °C	0.7-0.8 dpa 1100 °C
mini 4P bend bars 1 mm x 1 mm x 12 mm	10	5	5	5

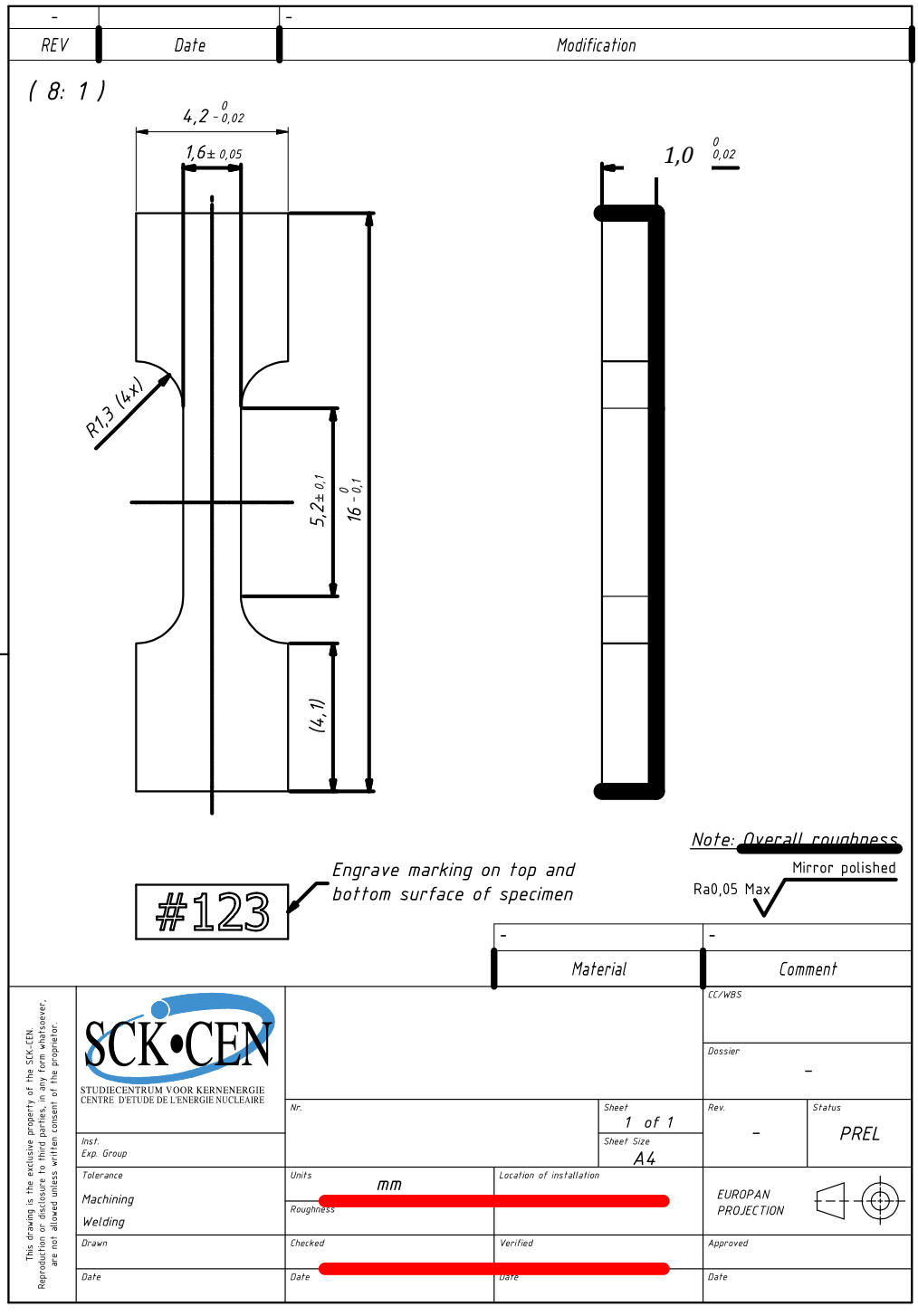
3.8. W reference (PLANSEE, LOT-III), “ITER-type W”

	unirradiated & backup	0.7-0.8 dpa 600 °C	0.7-0.8 dpa 1000 °C	0.7-0.8 dpa 1100 °C
mini 4P bend bars 1 mm x 1 mm x 12 mm	10	10	10	10
KLST 3 mm x 4 mm x 27 mm	10	4	4	

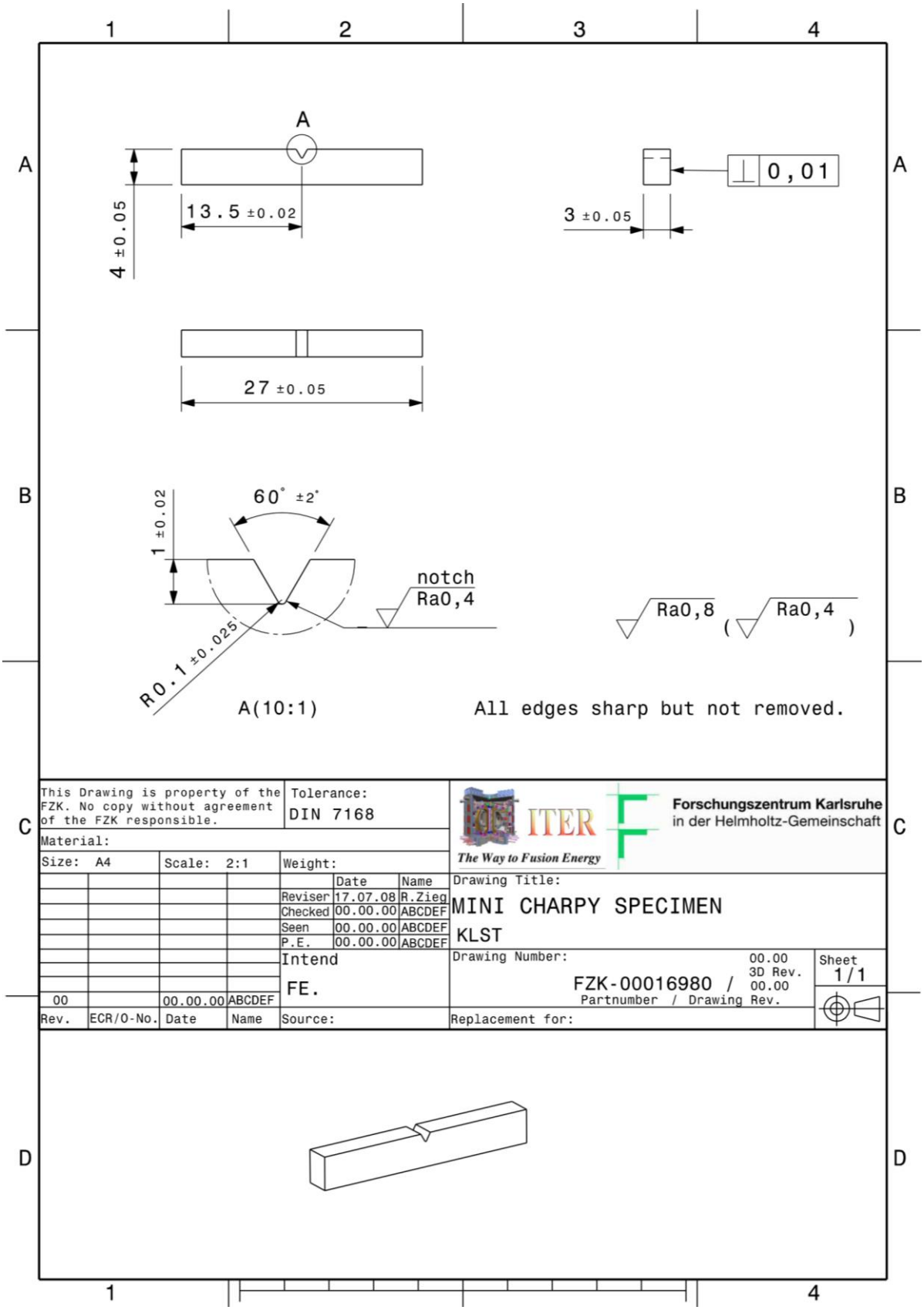
Specimen Geometries

Mini tensile (Lot-A)

Specimen thickness: 1,0 mm (+/- 0.01 mm)
Surfaces polished

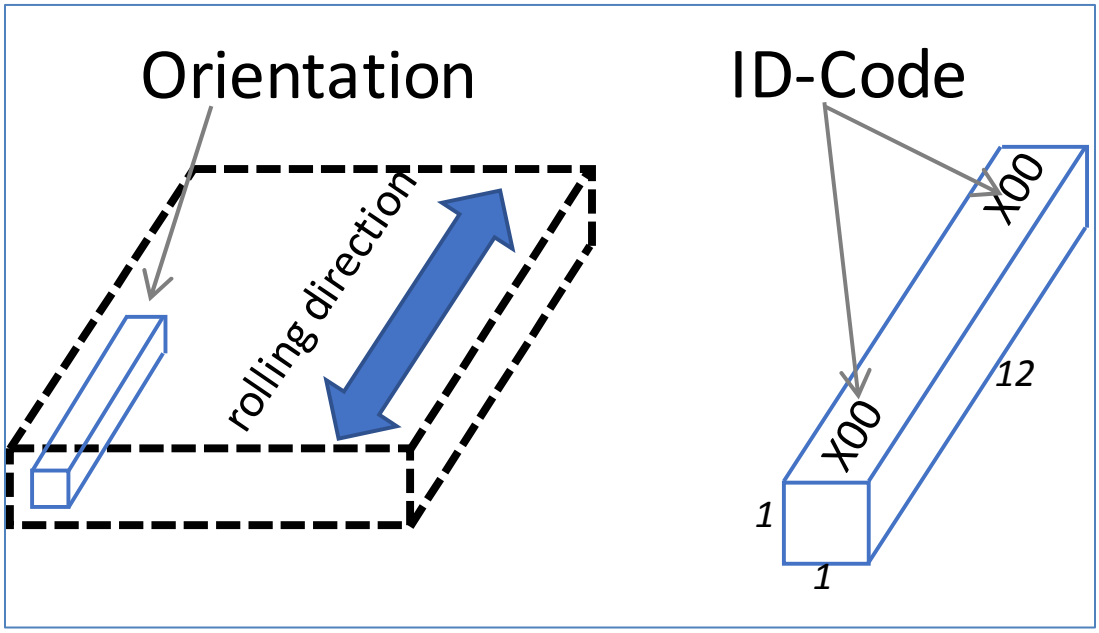


KLST (Lot-B, fibre options)



Mini (3)4P bend bar (Lot-B)

Length: 12 mm (+/- 0.1 mm)
Cross-section: 1 mm x 1 mm (+/- 0.005 mm)
Surfaces polished



Mini tensile (Lot-A)

Specimen thickness: 1,0 mm (+/- 0.01 mm)
Surfaces polished

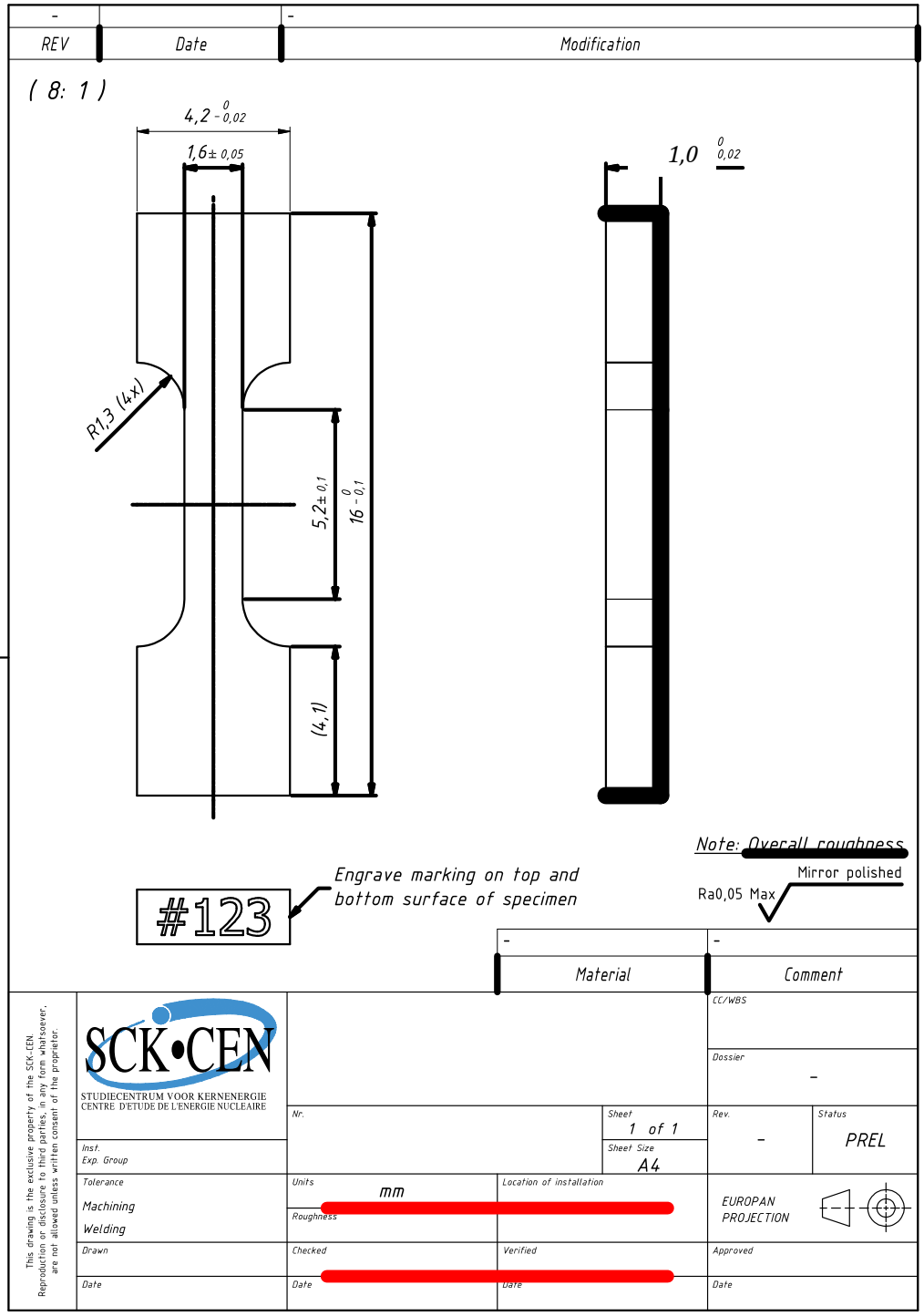


Table App-B 1: Lot A – Call and Implementation in BR2 (main elements)

Irradiation	Call	Offer
irrad. temperature target range (°C)	150	150
target dose (dpa)	2.5	2.5 dpa (5 cycles)
dose accuracy (IR1)	±15%	±10-15%
fast neutron (E>0.1 MeV) fluence (10** m^{-2})	Not specified	3.62E+25
fast neutron (E>0.1 MeV) flux (10** m^{-2} s^{-1})	Not specified	3.99E+18
any further information		See Technical Note below
dose rate for CuCrZr	Not specified	2.5×10^{-7} dpa/sec
temp. accuracy over time (IR2)	±20	±15 K
spatial temperature accuracy (IR3)	±20	±5 K
Irradiation	**Call**	**Offer**
irrad. temperature target range (°C)	350	350
target dose (dpa)	2.5	2.5 dpa (5 cycles)
dose accuracy (IR1)	±15%	±10-15%
fast neutron (E>0.1 MeV) fluence (10** m^{-2})	Not specified	3.62E+25
fast neutron (E>0.1 MeV) flux (10** m^{-2} s^{-1})	Not specified	3.99E+18
any further information		See Technical Note below
dose rate for CuCrZr	Not specified	2.5×10^{-7} dpa/sec
temp. accuracy over time (IR2)	±15	±15 K
spatial temperature accuracy (IR3)	±10	±5 K
Irradiation	**Call**	**Offer**
irrad. temperature target range (°C)	450	450
target dose (dpa)	2.5	2.5 (5 cycles)
dose accuracy (IR1)	±15%	±10-15%
fast neutron (E>0.1 MeV) fluence (10** m^{-2})	Not specified	3.62E+25
fast neutron (E>0.1 MeV) flux (10** m^{-2} s^{-1})	Not specified	3.99E+18
any further information		See Technical Note below
dose rate for CuCrZr	Not specified	2.5×10^{-7} dpa/sec
temp. accuracy over time (IR2)	±25	±20 K
spatial temperature accuracy (IR3)	±20	±10 K

Table App-B 2: Lot B – Call and Implementation in BR2 (main elements)

Irradiation	Call	Offer
irrad. temperature target range (°C)	600	600
target dose (dpa)	1	1 dpa (5 cycles)
dose accuracy (IR1)	±15%	±10-15%
fast neutron (E>0.1 MeV) fluence (10** m^{-2})	Not specified	3.62E+25
fast neutron (E>0.1 MeV) flux (10** $m^{-2}\,s^{-1}$)	Not specified	3.99E+18
any further information		See Technical Note below
dose rate for Tungsten	Not specified	9.5×10^{-8} dpa/sec
temp. accuracy over time (IR2)	±25	±20 K
spatial temperature accuracy (IR3)	±25	±10 K
Irradiation	**Call**	**Offer**
irrad. temperature target range (°C)	1000	1000
target dose (dpa)	1	1 (5 cycles)
dose accuracy (IR1)	±15%	±10-15%
fast neutron (E>0.1 MeV) fluence (10** m^{-2})	Not specified	3.62E+25
fast neutron (E>0.1 MeV) flux (10** $m^{-2}\,s^{-1}$)	Not specified	3.99E+18
any further information		See Technical Note below
dose rate for Tungsten	Not specified	9.5×10^{-8} dpa/sec
temp. accuracy over time (IR2)	±15	±15 K
spatial temperature accuracy (IR3)	±15	±10 K
Irradiation	**Call**	**Offer**
irrad. temperature target range (°C)	1100	1100
target dose (dpa)	1	1 (5 cycles)
dose accuracy (IR1)	±15%	±10-15%
fast neutron (E>0.1 MeV) fluence (10** m^{-2})	Not specified	3.62E+25
fast neutron (E>0.1 MeV) flux (10** $m^{-2}\,s^{-1}$)	Not specified	3.99E+18
any further information		See Technical Note below
dose rate for Tungsten	Not specified	9.5×10^{-8} dpa/sec
temp. accuracy over time (IR2)	±25	±25 K
spatial temperature accuracy (IR3)	±25	±15 K

Appendix C: Technical Content of the Proposal for PIE & Overview of Services and requirements

Lot-A-PIE und Lot-B-PIE - Technical specification

Lot-A-PIE: Mechanical Tests - Tensile Properties – CuCrZr grades

The tensile tests have to be performed to measure properties required for material data base and a proper down-selection:

- yield stress
- tensile stress
- uniform elongation (measured in a uniform gauge length)
- total elongation (measured in a uniform gauge length)
- stress-strain curves
- relevant fracture mechanism depending on irradiation temperature

Tensile test requirements - 60 samples	
	• vacuum furnace (< 10-4 mbar) • temperature controlled (Indicate max. deviation ± x °C) • direct strain measurement by optical or attached extensometer • strain rate controlled tests (x-y 1/s)
Required result	• yield stress • tensile stress • uniform elongation (measured in a uniform gauge length) • total elongation (measured in a uniform gauge length) • stress-strain curves
Recording	• applied force • displacement (strain rate) • *video recording & DIC (optional)* • location of failure
Microstructure Fracture surface	• Microstructure: SEM analyses (target: ~15-20 samples) • *Optional: Fracture surface analyses & TEM analyses*
Standards	• Tests to be performed as per ASTM E8M norm (or equivalent)
Temperature	• Two valid tests shall be performed a irradiation temperature • Two tests at 150°C

Table App-C1: Summary of technical specifications

The analyses shall comprise sufficient microstructural characterization by TEM techniques and by SEM on fracture surface (target ~15 TEM/20 SEM samples), minimum one for each condition (material/irradiation temperature).

Lot-B-PIE: Tungsten grades tensile and fracture properties

The PIE tests have to be performed to measure properties required for a proper down-selection.
All tests shall be performed in L-S orientation to determine respective appropriate properties.

Two different type of PIE test shall be performed for the different material options.

a) "Advanced tungsten options" (non-fibre)

Specifications for bending tests

- vacuum furnace (< 10^{-4} mbar), temperature controlled
- FEM simulation support to determine true-stress-true-strain curve
- strain rate controlled tests (x-y 1/s)
- *direct strain measurement by optical or attached extensometer (optional)*

Required results

- Ductile-Brittle Transition Temperature (DBTT) from test series
- Yield strength
- Flexural strength
- yield stress (verified by FEM)
- tensile stress (verified by FEM)
- load-deflection curves
- strain at maximum stress and fracture
- relevant fracture mechanisms depending on irradiation temperature

Test temperature shall be the irradiation temperature and a variation of test temperatures according to the observed fracture behavior. Target: determination of DBTT.

Microstructure Fracture surface

The analyses shall be complemented by microstructural characterization by TEM techniques and by SEM on fracture surface (target ~30-40 TEM/SEM samples).

"Matchstick" (miniaturized "bars") shall be tested as bend bars, optionally used in three or four-point bending.

The final objective, however, is to determine DBTT and tensile properties, such as by applying some "inverse" methodology and respective FEM simulations.

As these tests are "non-standard", some brief description on the methodology proposed (to extract tensile properties from 3/4 bending) shall be included with the proposal and if applicable a reference where the tenderer has applied the approach in a similar task for fusion / fission material characterization shall be provided.
Prior to application to PIE/hot-cell: The methodology shall be validated for non-irradiated samples, e.g. for W-material where tensile properties are available for comparison and verification.

A total 120 bars are irradiated for 6 materials and at 3 irradiation temperatures (600/1000/1100°C). A break-down is given, in Table App-C2.
Table App-C2: Miniaturized "bars" for three/four point bend.

	mini (3)4P bend bars	
	unirr. for reference	***irradiated***
PIM W-Y2O3	10	21
PIM W-TiC	10	24
W plate K-doped, 1 mm	10	15
W plate K-doped, 7 mm	10	15
W3%Re plate K-doped, 7 mm	10	15
W reference (PLANSEE)	10	30
Σ		**120**

b) "<u>Fibre tungsten material</u>"

Mini-Charpy (KLST) specimen geometry is used.

In total 32 samples were irradiated (at two temperatures 600/1000C) and shall be tested to determine fracture toughness properties.

Specifications for 3/4PB Tests - Static Toughness

- vacuum furnace (< 10^{-4} mbar), temperature controlled
- strain rate controlled bending tests (x-y 1/s)

Required Results

- Fracture toughness for individual specimens
- Ductile-Brittle Transition Temperature (DBTT) from test series

Fracture Surface Analysis & Interface Analysis

The analyses shall be complemented by microstructural characterization by SEM on fracture surface to determine the fracture/failure mode/mechanism (target ~24 SEM samples)

APPENDIX D: Legal Requirements and Documents to be submitted with the Proposals

- **Selected Legal Requirements**
- **Submission of Proposals and Eligibility**
- **Technical Content of the Proposal (offers)**

(1) Selected Legal Requirements

- ### Preamble

This Call and the implementation of the activities are subject to the rules and procedures of the EUROFUSION Consortium and Grant Agreement.

- ### LANGUAGE

Documentation provided shall be in English or accompanied by a translation of the relevant parts. Failure to comply with this requirement shall lead to the exclusion of the tenderer from the tender procedure. Moreover, all correspondence, all input and output documentation relevant for and as result of the contract shall be in English.

- ### JOINT PROPOSALS

Proposals can be submitted jointly by two or more Consortium members.

However, the proposal should indicate the "leading" Beneficiary that will be the contact for any questions and requirements during the selection and awarding process. *(Note: Cost and price statements – as detailed below need to be provided, both, as a total price offer and break-down into the level of beneficiaries).*

- ### SUBCONTRACTING

Tasks and services provided may be entrusted to subcontractors, but the Beneficiary retains full liability for performance of the contract as a whole. In particular, any communication and contact during the evaluation shall be with the Beneficiary.

(2) Submission of Proposals and Eligibility

- ### Offer Submission

The Offer shall contain separate proposals for the two PIE campaigns (Lot-A-PIE and Lot-B-PIE).

Offers must be submitted not later than **mid-night 10th September 2019** through the IMS-system. The link to use is: https://ims.euro-fusion.org.

The Technical proposal shall detail all the information required in APPENDIX C to the present document.

The financial proposals, in Euros, shall detail the cost as detailed in APPENDIX D, below.

In both cases, the technical and the financial parts for each LOT shall be separately submitted to allow for independent evaluation.

- ### Questions for Clarification

Question for clarification of the technical part of Call for Proposal are possible and will be answered, if posted before August 29th 2019. The contact address is the PMU RO:

eberhard.diegele@euro-fusion.org.

The questions posed will be made anonymous (i.e. the name of Beneficiary asking is not released) and a list of question posed together with the answers will be distributed to all Beneficiaries by the Programme Manager Tony Donné by Email.

• Eligibility

Offers are eligible if they are submitted by a GA member within the deadline set in the present call. In case of joint proposal the offer shall be submitted by the Head of the leading Beneficiary and he/she will be responsible for obtaining the agreement from the respective Head of Research Unit regarding the joint content of the proposal.

Only offers that include "complete" information, i.e. technical and financial details as required will be considered for the evaluation.

• Evaluation and awarding

The proposals shall be awarded under a best-value-for-money procedure and evaluated on the basis of the price and of the technical quality criteria explained below.

The technical assessment of the proposals will be done by the WPMAT PL and RO. In case of potential conflict of interest, the EUROfusion Programme Manager, Tony Donné, will take a decision.

The evaluating group may ask for additional information/clarification in view of finalizing its assessment of the proposals.

(3) Technical Content of the Proposal (offers)

• Offer - Required Information

Information shall be provided, both, as a complete offer to be evaluated- and separate for each partner (for the case of joint proposals).

• CALL for PIE - schedule

Due to the current time limitation for re-imbursements under the provisions of the current Grant Agreement, i.e. any activities shall, preferably be finished before Dec 31st 2020. Any deviation in schedule shall be justifies.

• Offer Technical Part

The information to be provided needs to be sufficient in detail and comprehensive to address any of the details required in the technical specification (Appendix C).

In particular:

- **For Lot-A-PIE:** The compliance with the requirements as of Table App-C1 shall be addressed.
- **Lot-B-PIE:** The proposal shall in particular describe the test method (option three vs four point bending) and the methodology applied to determine by inverse method and FEM analyses the (equivalent) tensile properties from bending tests.
- **Time / Planning:**

The proposal should include a detailed planning, summarized, preferably in a GANTT chart, or, optional in Excel format.

The offer has to define a detailed schedule for each element of the campaign. Periods to indicate include:

- Lead times and/or times for transport to the tenderers facilities
- Preparation time
- Usage of hot cells.

• Offer Financial Part

The financial proposals, in Euros, shall detail the cost as described below.

The financial part of the offer should include a break-down of any costs that will be declared by the proponent. In particular, **cost shall be split according to the internal funding categories**.

In any case, information on schedule, hardware, human resources (ppy) has to be indicated separately.

For each LOT, the proponent's proposal shall include information that clearly indicates:

- Total and detailed costs per specified campaign.

The cost break down must include

- The total costs
- Cost for Manpower
- Cost for Equipment and other goods and services

Note: Joint Proposals:

As mentioned above, in case of Joint Proposals the financial offer shall include:

- *The total prices of the proposal for the evaluation and awarding.*
- *A detailed break-down of the costs for the individual members, eg for future potential implementation phase.*

APPENDIX E: Evaluation and Awarding

- **TECHNICAL Evaluation CRITERIA and POINTS**

Note for the neutrality of the technical assessment: The assignment of technical points is completely independent from the financial evaluation.

The technical evaluation will consider the merit of the proposal to ensure and verify the quality and technical value of the services to be implemented with respect to the technical information provided and as detailed below.

Firstly, the Evaluation panel checks the "technical completeness" of the documents to be provided as required in Appendix C&D ("Offer Technical Part"). Only proposals where the set of documents as requested are complete will be further considered and evaluated.

For the technical evaluation the key elements include

- the experience of the proponents in conducting post irradiation examination
- the general understanding of activity to be carried out,
- In particular, addressing elements needed and deliberately not being completely described in the technical requirements (e.g. as of different methods, test standards etc. applied by different RUs)

The quality of the proposal will be evaluated for 100 technical points.

Minimum threshold not to be disqualified: 60 points out of 100.

The evaluation panel will assess:

Topic	Criteria	Points
Overall experience in performing PIE tasks on fusion materials	Experience and competence of the proponents in conduction of post irradiation examination Quality of Hot Cell equipment	40
Compliance with the technical requirements	Alignment of the proposal with the technical specification on the tests and quality of data (mechanical properties & microstructural analyses)	50
Quality of data for down-selection and additional elements	In addition to tests labeled "mandatory" data additional some indication on "optional" evaluation are provided	10

- **FINANCIAL Evaluation**

The Financial evaluation shall only applied to proposals that are technically compliant, i.e. that meet the threshold for technical assessment in the previous step.

As a next step: The "financial completeness" of the documents to be provided as required in Appendix D ("Offer Financial Part") will be checked. Only proposals, where the set of documents as requested, are complete, shall be further considered and evaluated.

The proposal will be evaluated for maximum 100 price points (financial award points).

Final awarding of the LOTs:

- For each LOT, the best proposal will be selected.