EUROfusion

IFMIF DONES

Small specimen test techniques activities within IFMIF/DONES

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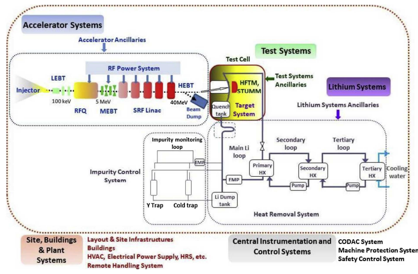
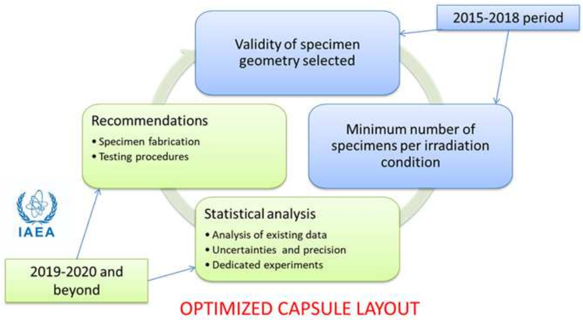
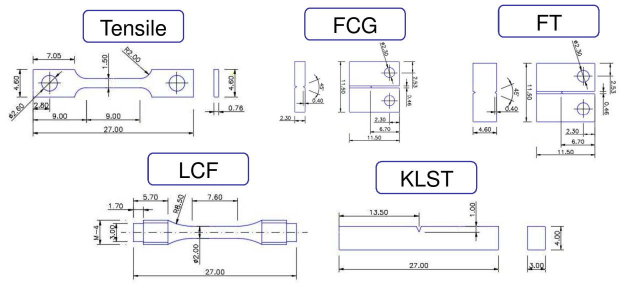
- **The International Fusion Materials Irradiation Facility - Demo Oriented NEutron Source (IFMIF-DONES) is a single-sited novel Research Infrastructure for**
  - ✓ (1) generation of materials irradiation test data for design, licensing, construction and safe operation of the fusion demonstration power reactor (DEMO) and
  - ✓ (2) generation of data base for benchmarking of radiation responses of materials hand in hand with computational material science.
- **The irradiation capsule of the High Flux Test Module (HFTM) developed during IFMIF/EVEDA is now being adapted to the situation in IFMIF-DONES in the frame of the EUROfusion Early Neutron Source work package (WPENS). Due to limited extension of the neutron flux field, the use of small specimens is mandatory .**

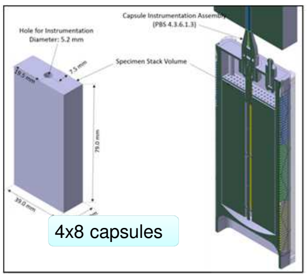


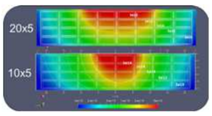
IFMIF-DONES Plant configuration.
D. Bernardi, et al, Fusion Engineering and Design, 2019,

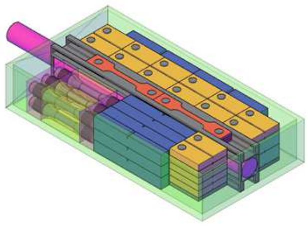




Types and sizes of the specimens proposed by Möslang et al.







- ✓ The neutron flux= 5 × 10^{14} n/cm²/s.
- ✓ Dose: 12–25 dpa/fpy -> 306 cm³ of usable specimen volume -> corresponding to about 850 specimens.
- ✓ Helium production rate=13 appm He / dpa
- ✓ Hydrogen production rate = 53 appm H / dpa.

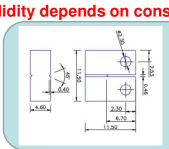
- Tensile test — Minimum number per irradiation condition = 8-12 specimens
- Impact test — Minimum number per irradiation condition = 6-8 specimens
- Fracture toughness — Minimum number per irradiation condition = 12 specimens
- Fatigue crack growth — Minimum number per irradiation condition = 4 specimens
- Fatigue — Minimum number per irradiation condition = 6-8 specimens

Fracture toughness validity (Eurofer97)

$$K_{Jc\,Limit} \leq \sqrt{\frac{E(W-a_0)R_{p0.2}}{30(1-\mu^2)}} \qquad J_{max} \leq B\frac{R_{p0.2}+R_m}{20}$$

Validity depends on constraint level

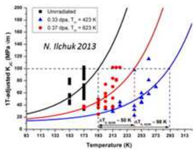
Room Tª	E399	E1820
	ISO 12135	ISO 12135
dpa	KIC max MPa√m	Jmax (kJ/m2)
0	23	279
5	36	380
10	39	417
15	41	435
20	42	445



ASTM E1820
ASTM E1921

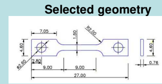
B=4.6 mm
W-a0=b0

	E1921
T	$K_{JC\,Limit}$ MPa√m
-150	162.6
-100	154.5
-50	148.0
0	142.9



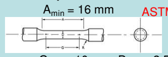
Tensile validity

Selected geometry



Smaller specimen standardized

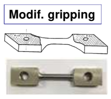
A_{min} = 16 mm ASTM E8



G_{min} = 10 mm D_{min} = 2.5 mm

Validity depends on Specimen geometry

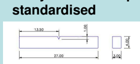
Modif. gripping



Impact validity

Selected geometry → Smaller specimen standardised

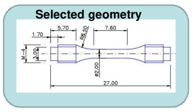
ASTM: E2248
ISO:14556



Need correlation procedures to compare with the standard specimens data.

Low Cycle Fatigue Validity

Selected geometry



ASTM: E2368
ISO 12111

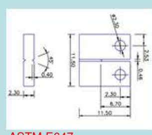
Validity depends on Specimen geometry

Not valid according existing standard
Minimum diameter 5 mm

Fatigue Crack Growth Validity

$$(W-a) \geq \frac{4}{\pi}\left[\frac{K_{max}}{\sigma_{YS}}\right]^2 \rightarrow \sqrt{(W-a)\pi/4} * \sigma_{YS} \geq Kmax$$

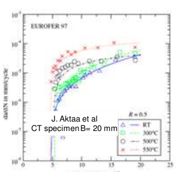
$$Kmax = \frac{\Delta K}{1-R} \rightarrow \sqrt{(W-a)\pi/4} * \sigma_{YS}(1-R) \geq \Delta K$$



ASTM E647
ISO 12108

Validity depends on constraint level

dpa	ΔK_{max} MPa√m
0	16.8
5	25.1
10	27.5
15	28.6
20	29.2



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