

FABEST in LCF



A Flagship Initiative of FABER COST Action (CA23109)

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OFFICIAL CLARIFICATIONS & TECHNICAL Q&A

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1. Young's Modulus for Category A and Dynamic Modulus Definition for Category B

- The supplied material contains several different Young's modulus values. The monotonic tensile characterization gives approximately 206 GPa, a value of 210 GPa is used in the ϵ -N and plastic-work post-processing, while the individual specimen protocols report separately evaluated moduli (e.g., 212.9 GPa for Exp_1_8 and 213.1 GPa for Exp_1_7L). Could you please clarify whether a specific Young's modulus is expected for the Category A constitutive model, or whether we are free to select one global modulus or experiment-specific moduli?

You are free to select a single global Young's modulus (e.g., in the range of 206–210 GPa) for your constitutive model. In line with the spirit of the benchmark, we recommend using a single global elastic modulus for all simulation cases rather than tuning it on a per-specimen basis.

(Note: If your constitutive formulation incorporates continuum damage mechanics or unilateral microcrack closure effects where the effective modulus evolves differently in tension and compression, such advanced theories are fully welcome—in that case, only the initial undamaged modulus E_0 needs to be anchored to the monotonic/initial cyclic response).

- How are the specimen-specific “Young modulus E / Evaluated E” values determined? Are these intended to represent the elastic stiffness for constitutive modelling or are they primarily post-processed experimental quantities?

The individual values in the test protocols (e.g., ~213 GPa) are post-processed experimental values determined via linear regression on the initial quasi-elastic loading branch of each individual specimen. They are provided as diagnostic/informational data, not as mandatory input constants.

- For Category B, could you clarify how the reported $E_{dyn_tension}$ and $E_{dyn_compression}$ are evaluated, particularly in relation to the dynamic-modulus reduction used to define the experimental fatigue life N_f ?

E_{dyn}^{ten} and E_{dyn}^{com} are determined for each cycle from the linear portion of the unloading/reloading branches of the hysteresis loop (linear regression in the range depicted in the protocol as „El. region size“). As stated in Section 5.2 of the rules, the experimental life N_f^{exp} is defined strictly as a 10% decrease in the compressive dynamic modulus (E_{dyn}^{comp}), evaluated as a 10% drop relative to the linear regression baseline established in the steady-state interval $\langle N1, N2 \rangle$.

2. Meaning of a “Single Material Parameter Set”

- I understand that the same material description should be used for all calibration and validation cases. Would a constitutive model containing state-dependent material functions, for example $C_k(p)$ or $\gamma_k(p)$, still satisfy the “single material parameter set” requirement if the parameters defining these functions are calibrated once from Cases 1–3 and then kept completely fixed for Cases 4–5?

Yes, this is fully permitted and complies with the rules.

(A "single material parameter set" means that the governing constitutive equations and the underlying constants/coefficients defining those functions (e.g., saturation rates, initial and asymptotic parameters, hardening/softening evolution laws) are calibrated once using the Calibration Set (Cases 1–3) and held strictly constant for all simulations (Cases 1–5). Internal state variables and state-dependent material functions that evolve during the simulation according to these fixed laws are a natural and welcome part of advanced cyclic plasticity modeling.)

- Or is the intention that quantities such as C_k and γ_k themselves must remain constant scalar values throughout the simulations?

No.

3. Category B Fatigue-Life Definition and Use of Category A Histories

- For Category B, should the predicted fatigue life N_f correspond specifically to the same failure criterion used to determine N_f in the experimental protocols, rather than to final fracture or another definition of fatigue life?

From a physical standpoint, the experimental failure criterion (a 10% drop in E_{dyn}^{comp}) corresponds to engineering crack initiation—i.e., the presence and growth of a significant macroscopic crack leading to measurable cross-sectional stiffness loss, rather than complete catastrophic separation/rupture of the specimen. For the competition evaluation, your predicted fatigue life N_f^{pred} should target this engineering

life (N_f^{exp}), as the benchmark metric (E_B) directly compares submissions against reference lives defined by this 10% modulus reduction (or the corresponding best-fit curves for Cases 4 & 5).

- Also, is it acceptable for the Category B fatigue model to use the stress/strain histories calculated by our Category A constitutive model as its input?

Yes, absolutely. Utilizing the simulated cyclic stress–strain histories, stabilized hysteresis loops, or accumulated energy/plastic work from your Category A constitutive model as inputs to your Category B fatigue model is standard practice and highly encouraged.

4. Endurance-Limit Parameters for Category B

- Some fatigue models, including the Tveit/Ottosen-type model I am considering, contain an endurance-limit parameter. The supplied Cases 1–3 appear to consist of finite-life LCF tests rather than true endurance/runout experiments. If such an endurance parameter is required, is the use of external or publicly available fatigue-limit data for 42CrMo4+QT permitted, or should all Category B material parameters be identified exclusively from the supplied calibration experiments?

The 42CrMo4+QT steel investigated in this benchmark comes from the exact same heat/batch as the material tested in the companion FABEST in HCF benchmark campaign. If your fatigue model (e.g., Ottosen/Tveit-type criterion) requires a true endurance/fatigue limit parameter, you are fully welcome and encouraged to utilize the uniaxial fatigue limit / HCF data from the FABEST in HCF dataset.

Alternatively, using well-documented literature values for this steel grade is also acceptable. Please simply document the source and value used in your 2-page Category B summary report.

5. Category A Mean-Response Error Normalisation

- In the Category A error definition, the mean-response error appears to be normalised by the corresponding experimental mean value. For fully reversed cases, however, the experimental mean stress or strain may be small or close to zero. Could you please clarify how this term is treated in such cases?

Please note that X represents the response quantity (stress in strain-controlled tests; strain in stress-controlled tests).

To ensure numerical stability and prevent artificial singularities when the experimental initial mean response is close to zero (e.g., initial mean stress in fully reversed strain

control $R_e = -1$), the evaluation code applies a minimum lower-bound threshold (clamping floor) in the denominator:

$$\text{Denominator} = \max(|X_{m,1}^{exp}|, X_{\text{threshold}})$$

where:

$X_{\text{threshold}} = 5 \text{ MPa}$ for strain-controlled experiments (Cases 1, 2, 4, where the response quantity is stress),

$X_{\text{threshold}} = 0.0005$ (i.e., 0.05% strain) for stress-controlled experiments (Cases 3, 5, where the response quantity is strain).

- In particular, is the denominator used directly as written, taken in absolute value, or regularised when the experimental mean is close to zero?

The denominator is always evaluated in absolute terms, i.e., $|X_{m,1}^{exp}|$ and $X_{a,1}^{exp}$.

6. Evaluation of the summation in the Category A metric

The metric is defined as a sum over every cycle, $\sum_{j=1}^{N_f}$, normalised by N_f . Submissions, however, contain only the twelve logarithmic cycles (1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, and 5000), truncated at the prescribed maximum cycle number N , which is by construction lower than N_f . Could you clarify how the evaluation code bridges this? Specifically:

- is the error averaged over the submitted rows only, or are the submitted values interpolated onto every cycle before the sum is formed;
- if they are interpolated, is the interpolation linear in the cycle number or in its logarithm;
- does the sum run to N or to N_f , and if to N_f , how is the interval between N and N_f treated?

Discrete evaluation points & Normalization: The evaluation code compares predictions and experimental data directly at the specified logarithmic cycles (i.e., 1,2,5,10,20,50, ..., N) reported in your CSV submission. No interpolation onto every continuous cycle is performed.

Summation divisor: The inner sum is averaged over the number of evaluated discrete cycle points (N_{eval}) present up to the specified maximum cycle number N for each experiment (e.g., $N_{\text{eval}} = 12$ points for tests running up to $N = 5000$; $N_{\text{eval}} = 7$ points for $N = 100$). The symbol N_f in the general formula simply represents this evaluated subset in the evaluation code.

Correct formulae:

$$E_A = \frac{1}{n} \sum_{i=1}^n \left[\frac{1}{N_{eval}} \sum_{j=1}^{N_{eval}} \left(0.6 \cdot \frac{|X_{m,j}^{pred} - X_{m,j}^{exp}|}{|X_{m,1}^{exp}|} + 0.4 \cdot \frac{|X_{a,j}^{pred} - X_{a,j}^{exp}|}{X_{a,1}^{exp}} \right) \right]$$

(Note: The denominator $|X_{m,1}^{exp}|$ is regularised using the threshold floor defined in Section 5).

7. Conversion of the reported quantities to true measures (Category A only)

- The Category A format notes require all submitted predictions to be in true stress and true strain, while the calibration protocols are in engineering measures. Since Eps_A, Eps_M, Sig_A and Sig_M are quantities derived from the two extremes of the loop rather than pointwise values, the conversion is not unique unless the order of operations is fixed. My assumption is that each extreme is converted individually and the amplitude and mean are then re-formed from the converted extremes, that is

$$\sigma_{m,true} = \sigma_m (1 + \varepsilon_m) + \sigma_a \varepsilon_a$$

$$\sigma_{a,true} = \sigma_a (1 + \varepsilon_m) + \sigma_m \varepsilon_a$$

$$\varepsilon_{m,true} = (1/2) * \ln[(1 + \varepsilon_m + \varepsilon_a)(1 + \varepsilon_m - \varepsilon_a)]$$

$$\varepsilon_{a,true} = (1/2) * \ln[(1 + \varepsilon_m + \varepsilon_a) / (1 + \varepsilon_m - \varepsilon_a)]$$

Could you confirm that this is the convention used to prepare the reference values? The cross-term $\sigma_a \varepsilon_a$ is not negligible for the strain-controlled cases: it is of the order of 13 MPa at 1.25 % strain amplitude and remains comparable to the first-cycle mean stress itself at 0.4 %, so the choice of convention has a visible effect on the normalised mean error.

In our evaluation protocols and data post-processing, the extreme peak and valley points of the cyclic hysteresis loop (σ_{max} , ε_{max}) and (σ_{min} , ε_{min}) are converted to true measures individually, and the true amplitude and mean values are subsequently re-formed from these converted extremes. Your explicit formulation directly matches the convention used in our reference datasets.

8. Final loading levels for Cases 4 and 5

- The Rules note that the strain and stress amplitudes of the validation cases "may be slightly revised/adjusted during the tests". Will the final values be communicated to participants before the submission deadline, or should predictions be prepared for the nominal levels given in Table 1 (0.4 / 0.6 / 0.85 / 1.25 % and 700 / 750 / 800 / 850 MPa)?

All participants must prepare their models and simulations strictly for the nominal loading levels given in Table 1 (0.4%, 0.6%, 0.85%, 1.25% for Case 4; 700, 750, 800, 850 MPa for Case 5). As this is a true blind benchmark, no adjusted values will be issued before the submission deadline—the nominal values are the definitive target inputs for all simulations.