GAS-COOLED REACTOR

ADVANCED REACTOR TECHNOLOGIES PROGRAM

ASME Code Development: Design Rules

Activities July 2023 – June 2024

U.S. DEPARTMENT OF ENERGY

ASME BPVC HHA-3000

SUBSECTION HH
CLASS SN NONMETALLIC CORE COMPONENTS

SUBPART A
GRAPHITE MATERIALS

ASME BPVC.III.5-2023

ARTICLE HHA-3000
DESIGN

HHA-3100 GENERAL DESIGN

Rules for the design of Graphite Core Components and Graphite Core Assemblies are described in this Article.

Design of Graphite Core Components is addressed in HHA-3200. Provisions are made for three alternative approaches to the design. These are

(a) Design of Graphite Core Components to meet the reliability targets based on stress limits derived from the material reliability curve (HHA-3220). This is referred to as a simplified assessment.

(b) Design of Graphite Core Components to meet the reliability targets based on calculated reliability values derived from the distribution of stress in the Graphite Core Component and the material reliability curve (HHA-3230). This is referred to as a full assessment.

(c) Design of Graphite Core Components to meet the reliability targets based on experimental proof of Graphite Core Component performance with margins derived from the material reliability curve (HHA-3240). This is referred to as design by test.

HHA-3300 provides requirements for the design of the Graphite Core Assembly.

The design approach selected is semiprobabilistic, based on the variability in the strength data of the graphite grade. Due to the nature of the material, it is not possible to ensure absolute reliability, expressed as an absence of cracks, of Graphite Core Components. This is reflected in the setting of Probability of Failure (POF) targets. Also note that due to the complex nature of the loadings of graphite components in a reactor combined with the possibility of disparate failures of material due to undetectable manufacturing defects, the Probability of Failure values used as design targets may not be precisely accurate predictions of the rate of cracking of components in service. The Designer is required to evaluate the effects of cracking of individual Graphite Core Components in the course of the design of the Graphite Core Assembly and ensure that the assembly is damage tolerant.

HHA-3110 GRAPHITE CORE COMPONENTS

HHA-3111 Classification of Graphite Core Components

Graphite Core Components shall be assigned to one of the following Structural Reliability Classes in the Design Specification:

(a) SRC-1: The Structural Reliability of components in this class is important to safety. These parts may be subject to environmental degradation.

(b) SRC-2: The Structural Reliability of components in this class is not important to safety. These parts are subject to environmental degradation during life.

(c) SRC-3: The Structural Reliability of components in this class is not important to safety. These parts are not subject to environmental degradation during life.

The Structural Reliability Class defines the graded level of reliability that the Graphite Core Component is designed to meet. Generally, a lower class (SRC-3) signifies a lower mechanical reliability than a higher class (SRC-1).

The allocation of Graphite Core Components to these Structural Reliability Classes is the responsibility of the Owner and shall be justified in the system safety criteria for the nuclear power system. The classes are to be indicated in the Design Specification. Interfaces between components of different classes shall be designed to ensure that any failure in a component classified in a lower class will not propagate to a component in a higher class.

HHA-3112 Enveloping Graphite Core Components

A Graphite Core Assembly may consist of many hundreds of Graphite Core Components. These Graphite Core Components may have minor geometric differences and be exposed to variations in loading. It is acceptable to subdivide the Graphite Core Assembly into groups of components and then to assess Graphite Core Components that see the highest utilization. The grouping of components shall be based on similar function, geometry, and environmental conditions.

Design analyses are to be completed for the Graphite Core Components of each group subject to the highest utilization (which is defined as the ratio of applied loads, both internal and external, to the load to failure). The Designer shall show the acceptability of the Graphite Core Components subject to highest utilization with respect to the requirements in this Subpart. The responsibility for identifying and justifying the enveloping Graphite Core Components is allocated to the Designer.

ASME BPVC HHA-3000: CALCULATES COMPONENT STRESS LIMITS AND RELIABILITY VALUES BASED ON MATERIAL RELIABILITY TARGETS

- Used extensively in the traffic engineering field, the *85th percentile speed* is based on the premise that the majority of drivers choose reasonable speeds for given road conditions and should be accommodated.

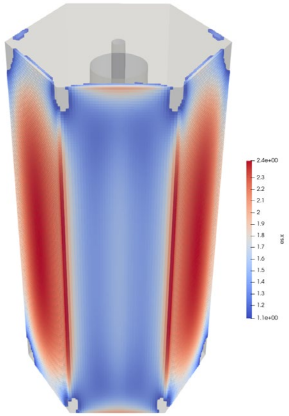


Table HHA-3221-1
Design Allowable Probability of Failure

SRC	Design	Service Limit Level A	Service Limit Level B	Service Limit Level C	Service Limit Level D
SRC-1	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-3}
SRC-2 [Note (1)]	10^{-4} (10^{-3})	10^{-4} (10^{-3})	10^{-4} (10^{-3})	5×10^{-2}	5×10^{-2}
SRC-3	10^{-2}	10^{-2}	10^{-2}	5×10^{-2}	5×10^{-2}

NOTE:
(1) This applies to the SRC-2 Design as well as Service Level A and B limits. The change in limits is to indicate that this Article allows for the degradation of Graphite Core Components (or increase in stresses) caused by irradiation during service. The difference between the initial allowable stress value and the allowable stress value in parentheses makes sure that there is margin for material degradation or increase of stresses in service.

DESIGN BY ANALYSIS

INPUTS

1. Graphite material reliability curve and grain size

FORM MDS-1 MATERIAL DATA SHEET (SI UNITS)

Grade Designation

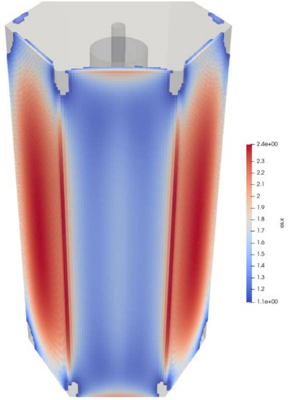
Material Grade ① ____ Material spec. ID ② ____ ASTM spec. ③ ____

Max. grain size (mm) ④ ____ Designation ⑤ ____

Design Strength and Material Reliability Curve Values

Ratio of compressive to tensile strength (R_{tc}) ⑰	Ratio of flexural to tensile strength (R_{tf}) ⑱	$S_{c_{0.05}}$ MPa ⑲	$m_{0.05}$ ⑳
	S' MPa ㉑	$S_{c'_{0.05}}$ MPa ㉒	$m'_{0.05}$ ㉓
$S_g(10^{-4})$ MPa ㉔	$S_g(10^{-3})$ MPa ㉕	$S_g(10^{-2})$ MPa ㉖	$S_g(5 \times 10^{-2})$ MPa ㉗

2. Component stress distribution



3. Component SRC limit

Table HHA-3221-1
Design Allowable Probability of Failure

SRC	Design	Service Limit Level A	Level B	Level C	Level D
SRC-1	10^{-4}	10^{-4}	10^{-4}	10^{-4}	10^{-3}
SRC-2 [Note (1)]	10^{-4} (10^{-2})	10^{-4} (10^{-2})	10^{-4} (10^{-2})	5×10^{-2}	5×10^{-2}
SRC-3	10^{-2}	10^{-2}	10^{-2}	5×10^{-2}	5×10^{-2}

Full Assessment

OR

Simplified Assessment

OUTPUTS

Component reliability value (POF) compared to SRC reliability target (design allowable POF)

1. Component membrane stresses compared to allowable tensile stress limit
2. Component peak stress compared to allowable flexural stress limit, based on SRC

Task Group on Graphite Design Analysis, meeting/collaborating since 2022, official in 2023

The Graphite Design task group will correct, clarify, and modify to function as intended the Design Code rules for the use of graphite core components within a nuclear application, specifically within the article HHA-3000: Design. The Graphite Design Task Group will not write new Code. Specific strategic objectives include evaluating and modifying the Full and Simplified Assessment methodology along with the supporting sub-articles necessary to accurately complete the Design rules.

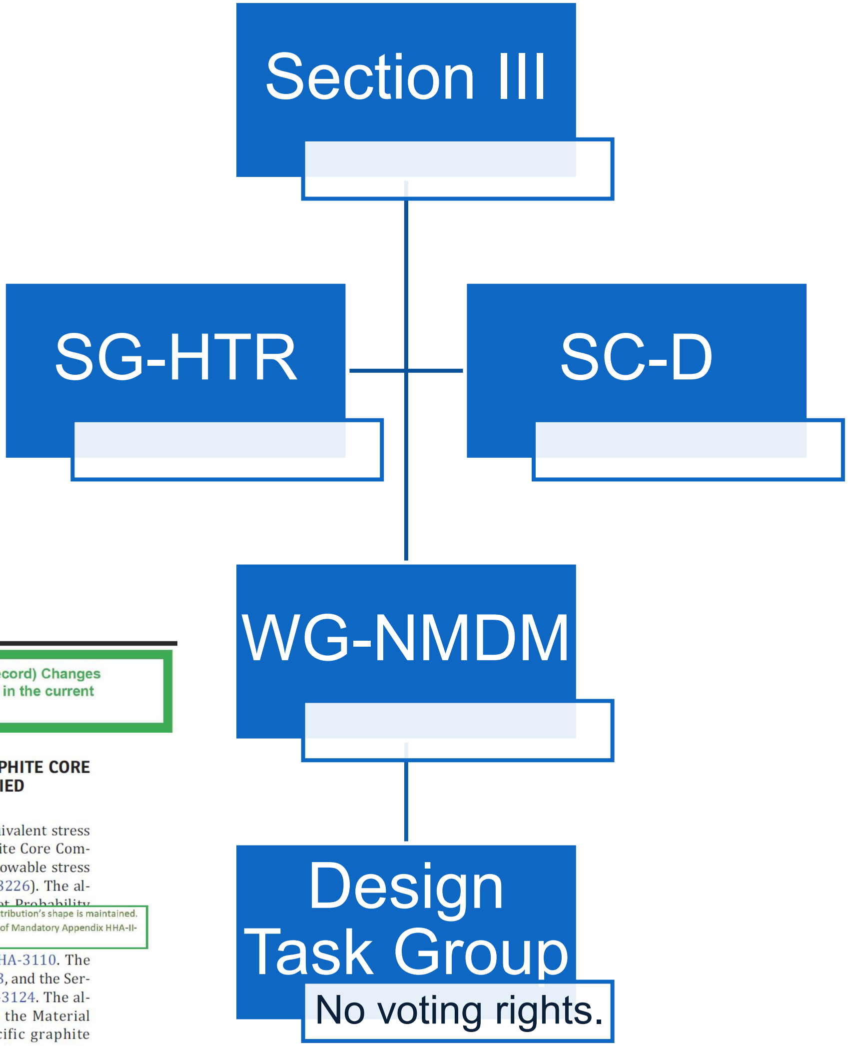
Design Task Group Members

Andrea Mack (Chair)
Adam Walker, Westinghouse
Gwennael Beirnaert, MPR
Jarryd Potgieter, USNC
Jesse Quick, USNC
Joseph Bass, NRC
Michael Saitta, MPR
Owen Booler, formerly Jacobs
Pierre-Alexandre Juan, Kairos
Sam Baylis, X-Energy

The task group will sunset once its strategic objectives are met.

How to modify existing Code: Hierarchy of ballot voting process

To make Code changes, a proposal file and background documents are submitted to the voting committees.



Record 21-1581

Background Document

SUMMARY

Record 21-1581 adds the requirement of updating the shape parameter when the threshold parameter is updated in the full assessment for qualifying graphite core components, outlined in HHA-3217.

The Code currently includes both simplified and full assessments for qualifying nuclear graphite core components. HHA-3217 (full assessment) utilizes the 3-parameter Weibull distribution, characterized by the threshold, shape and scale parameters. Both the shape and scale parameters depend on the threshold parameter. Currently, the full assessment requires a threshold parameter reduction when the component stress distribution is too far from the material tensile strength lower bound distribution. The scale parameter is implicitly updated with the threshold update as HHA-3217 is currently written. However, HHA-3217 does not currently require implicit nor explicit update of the shape parameter when the threshold is updated. The effect of not updating the shape parameter is that the 3-parameter Weibull distribution produces probability of failures that are more conservative than the 2-parameter (0-threshold) Weibull distribution used in the simplified assessment, around the Code-defined structural reliability class limits.

Instruction: Replace text to that shown in the respective green text boxes.

Red indicates changes approved in Record #20-1308 that will be incorporated in the 2023 Code version. Red changes are NOT being voted on in the current record. Only vote on green revisions.

ASME BPVC.III.5-2021

Record #21-1581 (current record) Changes in green are being voted on in the current record.

S'' ~~S'_0~~ $=$ ~~S_0~~ S'

and $m''_{0.05} = m'_{0.05}$

If the maximum equivalent stress is less than the value of ~~$S_{c095\%}$~~, then ~~S'_0~~ S'' is recalculated as follows:

$$S'' \; S'_0 = \frac{\sigma_{max}}{S_{c095\%} \; S'_{c0.05}} S_0 \; S'$$

where σ_{max} is the highest equivalent stress occurring in the component.

The shape parameter is recalculated correspondingly, such that the distribution's shape is maintained. The designer may modify the shape parameter by using the equations of Mandatory Appendix HHA-II-3200 by setting $\mu = S''$.

Truncate the list of integration points to those where the point equivalent stress is greater than the threshold stress (S'_0).

(3) For the integration point, calculate and store

$$X_i = \left[\frac{\sigma_{vi} - S'_0 \; (S'')}{S_{c095\%} \; (S'_{c0.05}) - S'_0 \; (S'')}\right]^{m_{095\%} \; (m'_{0.05}) \; (m''_{0.05})}$$

(4) Group the integration volumes into groups (designated by the index I, II, III,...), starting with the point of highest stress. The allocation to groups is based on

HHA-3220 STRESS LIMITS FOR GRAPHITE CORE COMPONENT — SIMPLIFIED ASSESSMENT

As a simplified assessment, the peak equivalent stress (see HHA-3214.2) calculated for the Graphite Core Component shall be compared directly to an allowable stress value (calculated in accordance with HHA-3226). The allowable stress value depends on the target Probability [...] Level of the load. The SRC is defined in HHA-3110. The Design Loadings are as defined in HHA-3123, and the Service Level Loadings are as defined in HHA-3124. The allowable stress values are retrieved from the Material Data Sheet (see HHA-2200) for the specific graphite grade.

This assessment is conservative, and not meeting the prescribed limit does not mean that the Graphite Core Component is not acceptable. A full assessment (HHA-3230) or design by test (HHA-3240) may be completed to accept the Graphite Core Component

Meetings and Conferences

- PVP 2023
- Aug 2023 Code Week
- INGSM 2023
- Nov. 2023 Code Week
- Feb. 2024 Code Week
- May 2024 Code Week
- PVP 2024

Design Task Group Papers, Presentations, and Memorandums

Papers and presentations

[1] Mack, A., Hoffman, W., Bass, J., & Windes, W. 2023. Finite element model mesh refinement effects on qualification of nuclear grade graphite components, Proceedings of the ASME 2023 Pressure Vessels & Piping Conference, PVP2023-107369.

[2] Mack, A., Hoffman, W., Quick, J., & Windes, W. 2023. Qualifying nuclear graphite components using ASME guidelines, International Graphite Specialists Meeting 2023.

[3] Mack, A. & Hoffman, W. 2024. Understanding the semi-probabilistic approaches in structural reliability used to set design reliability targets for graphite components using ASME BPVC methods, Proceedings of the ASME 2024 Pressure Vessels & Piping Conference, PVP2024-123395.

[4] Walker, A. & Mack, A. & Hoffman, W. 2024. Evaluation of the simplified assessment peak equivalent stress design limit probability of failure, Proceedings of the ASME 2024 Pressure Vessels & Piping Conference, PVP2024-123465.

[5] Saitta, M. & Beirnaert, G. 2023. Simplified Method for Adjusting the Shape and Characteristic Strength Parameters of the Weibull Strength Distribution of Graphite Materials, Proceedings of the ASME 2023 Pressure Vessels & Piping Conference, PVP2023-105207

Memos

03/16/2023 Conservatism of full and simplified assessments. Memorandum to William Windes answering the NRC inquiry from January 2022, from Andrea Mack.

06/07/2023. Request for additional testing to complete the tuning Vm and delta subtask. Memorandum to William Windes and Wilna Geringer from Andrea Mack.

09/07/2023. WG-NMD: Design Task Group Internal Memo or Stress Delta from Jarryd Potgieter.

10/25/2023. Supporting information for R23-2066. Memorandum to Gerhard Strydom from William Hoffman.

12/08/2023. Theoretical Vm for R23-2066. Memorandum to Michael Saitta from Andrea Mack.

12/29/2023. Background information on the procedure for the calculation of probability of failure (HHA-3217) in the ASME Boiler & Pressure Vessel Code (BPVC), Section III, Division 5. Memorandum to the ASME Working Group on Nonmentallic Design and Materials from Gwennael Beirnaert.

01/30/2024. Interpretations of the full and simplified assessments in ASME BPVC. Memorandum to ASME WG-NMDM from the ASME Design Task Group.

02/30/2024. Evaluating the effects on margin from updating the threshold and shape parameters in the full assessment (HHA-3217, ASME BPVC Section III Div. 5). Memorandum to ASME WG-NMDM from Andrea Mack.

Design Task Group Records

Record Title	Record Number	Project Manager	Status
Modify notation and definitions	R20-1308	Andrea Mack (INL)	Approved
Update shape parameter in the full assessment	**R21-1581**	**Andrea Mack (INL)**	**In-process**
Correct notation and equations in HHA-II-3200	R23-170	Andrea Mack (INL)	Approved
Stress terminology in the simplified assessment	R23-473	Pierre-Alexandre Juan (Kairos Power)	In-process
Full assessment flow chart	R23-1349	Gwennael Beirnaert	Approved
Modify Vm	R23-2066	Michael Saitta (MPR)	In-process
Assessment interpretations: POF vs. POCI	**R24-432**	**Andrea Mack (INL)**	**In-process**

R24-432: Assessment Interpretations

*Information copied from: *Interpretations of the full and simplified assessments in ASME BPVC*

Component Failure Modes

Degradation: corrosion and irradiation

Tensile failure

Bending failure

Compressive failure

Shear failure

ASME BPVC HHA-3000

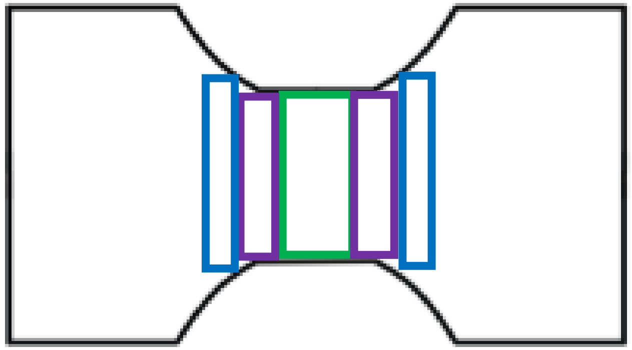
Why does the Code only consider tensile failure in design of graphite core components?

It is the most conservative.

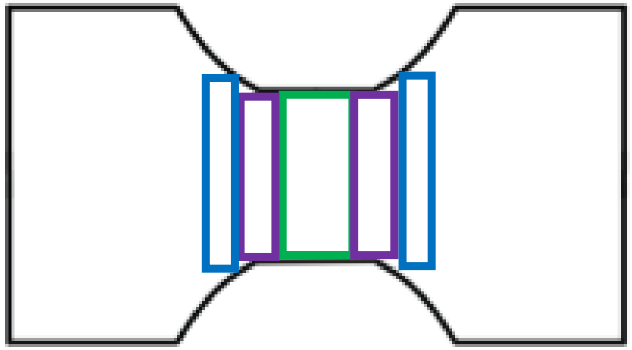
WHY DOES ASSESSMENT INTERPRETATION MATTER?

- Interpretation matters to ensure proper use of the assessment output. For example, if crack initiation is different from full tensile fracture (failure), then theoretically, the POCI would be “plugged” in to further calculate a component POF. That is NOT the intended use of the assessment outputs and is NOT recommended.

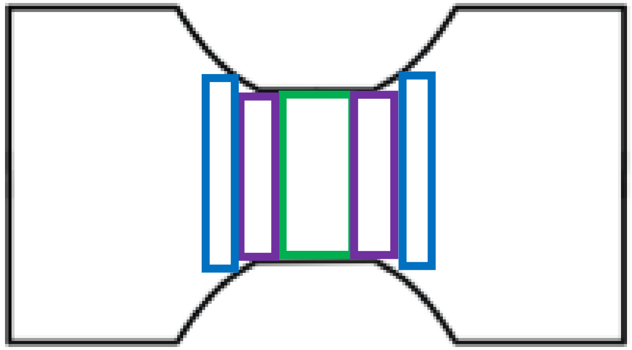
WHAT IS MOST CONSERVATIVE?



CRACK INITIATION



CRACK PROPAGATION



TENSILE FRACTURE/ FULL CRACKING

DOES CRACKING LEAD TO LOSS OF SAFETY FUNCTIONALITY?

EXPERIENCE SAYS, IT DEPENDS. IT IS CONSERVATIVE TO SAY CRACKING DOES LEAD TO LOSS OF SAFETY FUNCTIONALY, OR ENGINEERING FAILURE.

While R22-486 claimed that some of the UK AGR bricks have cracked into two separate pieces and have still been able to perform their safety function (i.e. no engineering failure occurred), it is important to consider the effect of cracking in the AGR bricks in more detail. The UK AGR brick cracking highlights a number of potential issues (there are also others):

- Singly cracked brick opening: with further irradiation, a cylindrical brick with a full-height axial crack opens up in a 'C' shape, pushing against nearby components. This may cause core distortion.

- Induced cracking: when one brick cracks, it may apply loads to neighbors (particularly via the keying system), which can cause further cracks in those bricks. Initiation of a single crack in a channel may rapidly lead to several other cracks in a chain, or it may accelerate cracking after some further irradiation.

- Double cracking: if a brick splits in two, the halves are free to move, adding 'slack' to the core and potentially leading to larger displacements in a seismic event

- Fragments and debris: small parts may break off a cracked brick (often associated with the keying system); the potential effects of these on coolant flow need to be evaluated (in particular: can debris block a fuel assembly). There is also potential for debris to prevent fuel movement by jamming between the fuel and the fuel channel wall.

- Keying system disengagement due to large displacements: wide enough cracks or large movement of cracked brick parts could allow keys to move out of place. This would make it difficult to evaluate the structural integrity of the core.

- Cracking of the graphite fuel sleeve (a part of the fuel assembly that forms the coolant flow path over the fuel) could starve the fuel of coolant and lead to fuel failure. This would not be acceptable. 100% proof testing of fuel sleeves is used to eliminate weak outliers.

In modern HTGRs, an additional concern is the effect of cracking on passive heat removal through graphite by conduction. The AGRs do not make this claim.

Pre-existing ASME interpretations

The design approach selected is semiprobabilistic, based on the variability in the strength data of the graphite grade. Due to the nature of the material, it is not possible to ensure absolute reliability, expressed as an absence of cracks, of Graphite Core Components. This is reflected in the setting of Probability of Failure (POF) targets. Also note that due to the complex nature of the loadings of graphite components in a reactor combined with the possibility of disparate failures of material due to undetectable manufacturing defects, the Probability of Failure values used as design targets may not be precisely accurate predictions of the rate of cracking of components in service. The Designer is required to evaluate the effects of cracking of individual Graphite Core Components in the course of the design of the Graphite Core Assembly and ensure that the assembly is damage tolerant.

Figure 1: Snippet from HHA-3100

- Semi-probabilistic
- It is not possible to ensure absolute reliability, defined as the absence of cracks
- The probability of failure values used as design targets may not be precisely accurate predictions of the rate of cracking of components in service
- The Designer is required to evaluate the effects of cracking … and ensure the assembly is damage tolerant

FURTHER CLARIFICATIONS & SUMMARY

- **Simplified assessment**
  - **There are TWO limits and checks in the simplified assessment**
  - **If the membrane stress exceeds the tensile stress limit and the peak equivalent stress exceeds the flexural stress limit, it does NOT mean a crack initiated. It means the stresses exceeded our reliability limits.**
- **Full assessment**
  - **The full assessment provides a conservative estimate of the probability of cracking.**
- The Design Task Group's consensus is that the methods do not allow claims that a crack will only initiate and will not propagate. Conclusions about severity nor location of cracking cannot be determined from the assessments.
- **The failure mode assessed in both assessments is tensile fracture or cracking.**
- **While some cracks may initiate and arrest before through wall cracking in some components, a general statement cannot guarantee this will always happen. It is conservative to assume full cracking.**
- Full cracking or partial cracking may result in loss of component functionality, depending on the design.
- **The assessments are not meant to predict where or how cracks occur in graphite. The Design by Analysis methods make simplifying and conservative assumptions to determine whether component reliability targets are met.**

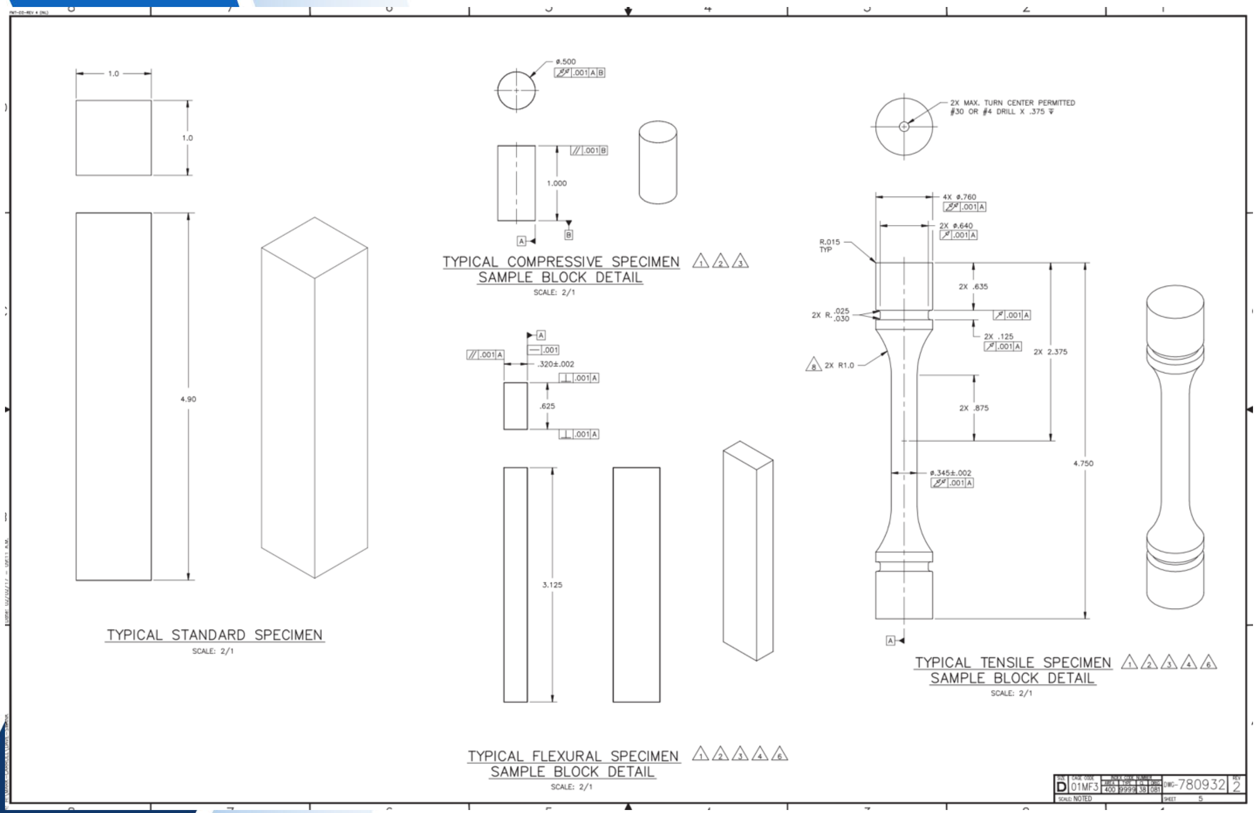
- The modified weakest link method used in the full assessment makes no distinction between crack initiation and through wall cracking. Both crack initiation and through wall cracking are treated as failure of the component to meet the reliability targets in the full assessment. Therefore, the parts of R22-486 that changed interpretations of probability of failure to probability of crack initiation are inaccurate and should be removed.
- The full assessment provides a conservative estimate of the probability of cracking.
- Experience tells us that cracking may or may not affect a component's ability to perform its function. Depending on the design and loading configuration, cracking may or may not result in component failure as defined in an engineering sense.
- A POF is not calculated in the simplified assessment. Practical implications of stress limit exceedance in the simplified assessment is design and loading configuration dependent.
- As HHA-3100 already states, it is up to the Designer to ensure the assembly is damage tolerant and the individual components meet the full/simplified assessment criteria.
- As HHA-3100 already states, the assessments do not provide accurate probabilities of cracking.

R21-1581:
Update the shape parameter in the full assessment

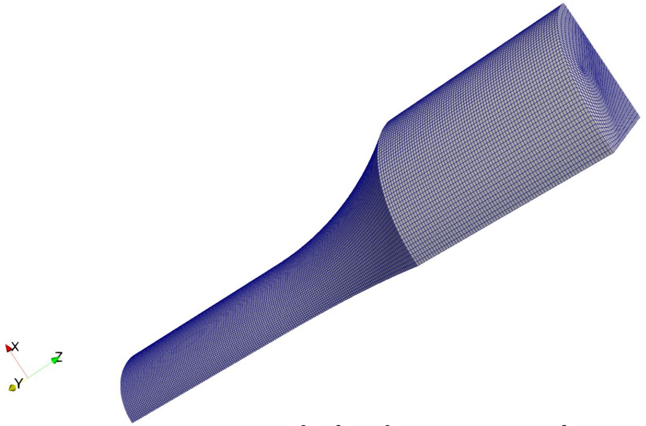
*Information copied from: *Evaluating the effects on margin from updating the threshold and shape parameters in the full assessment (HHA-3217, ASME BPVC Section III Div. 5)*

Update shape parameter in the full assessment
R21-1581

FEA MODELING

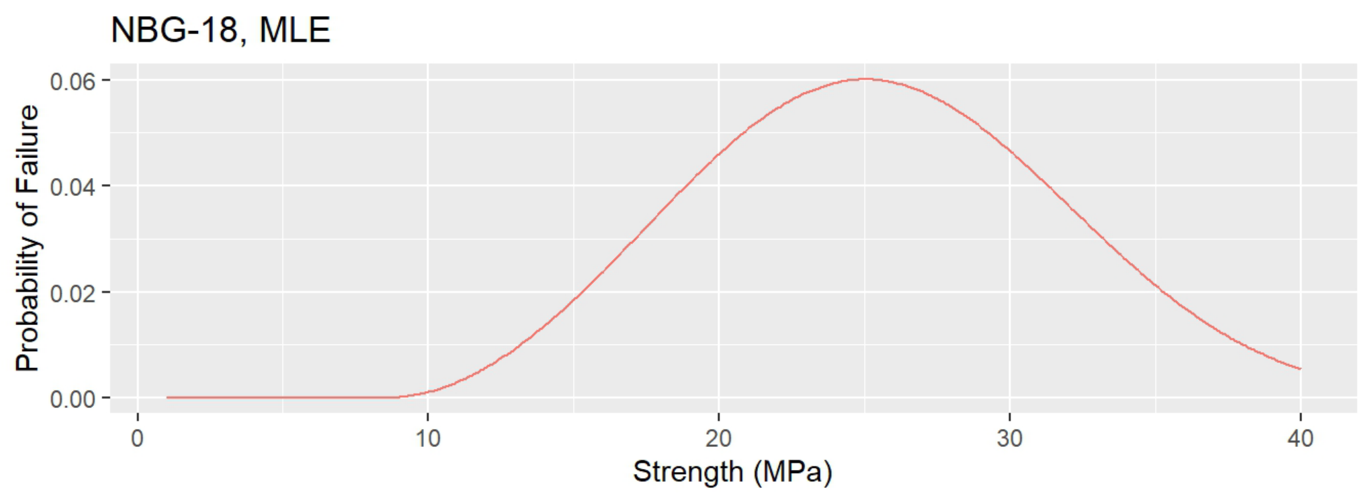


Grade	Young's modulus (GPa)	Poisson's Ratio
NBG-18	14.93	0.230
NBG-17	13.71	0.230
IG-110	11.00	0.209
2114	10.72	0.204
PCEA	13.05	0.178



Dogbone tensile specimen modeled using 8th symmetry.

Threshold reduction step changes the strength distribution



N=508

Update shape/scale parameters if threshold updated

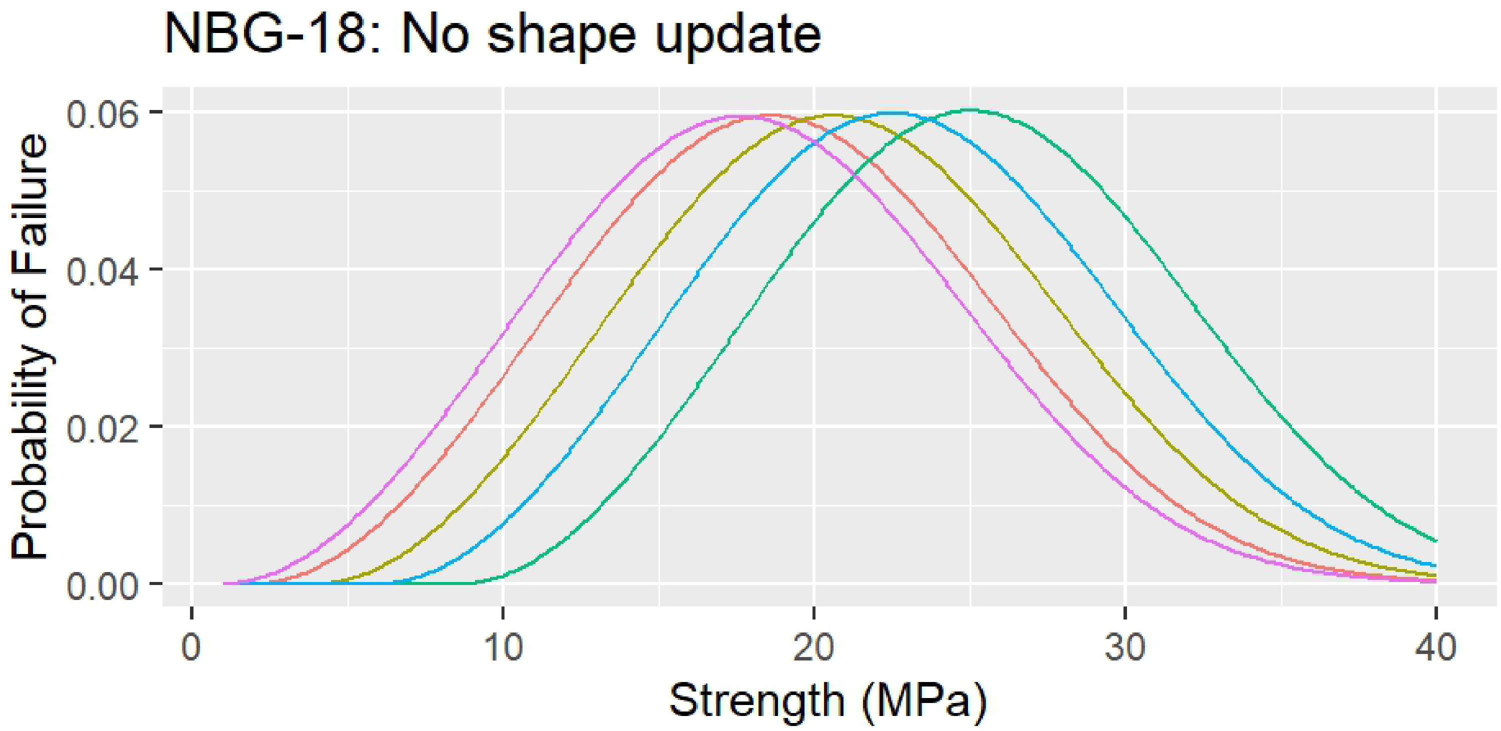
- Current: This step is not currently in the code. It will be inserted after the step (2) where the threshold is updated.
- Revision: Update the shape ($m'_{0_{0.05}}$) and scale ($S'_{c0_{0.05}}$) lower bounds using the reduced threshold. If the threshold was not reduced, set $m'_{0_{0.05}} = m_{0_{0.05}}$ and $S'_{c0_{0.05}} = S_{c0_{0.05}}$.
- Justification: Shape/scale parameters are dependent on the threshold.

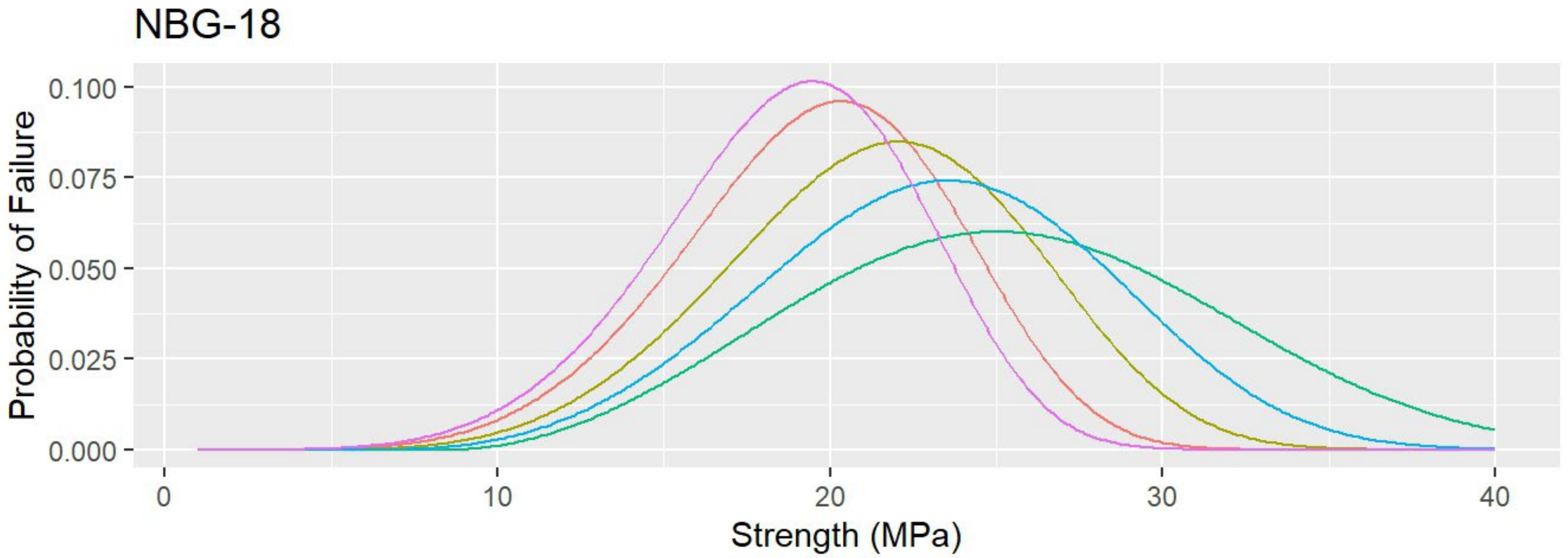
Given a sample of independent and identically distrib
uted observations $X_1, X_2, \ldots, X_n$ having a common PD
[eq. (10)], the maximum likelihood estimates $\hat{\alpha}$, $\hat{\beta}$, an
$\hat{\mu}$ of the parameters α, β, and μ satisfy the following thre
equations:

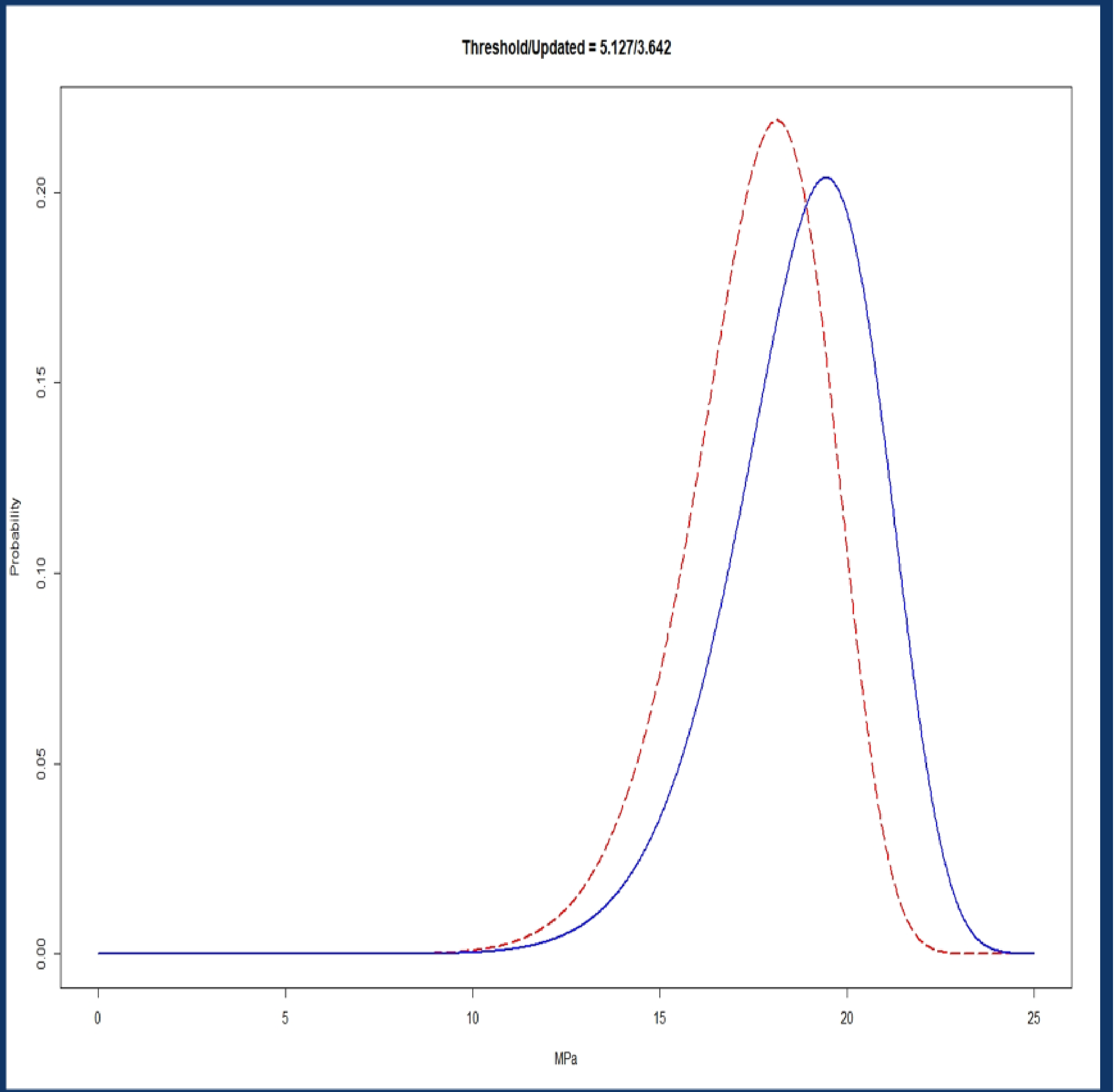
$$\hat{\beta} = \left(\frac{1}{n}\sum_{i=1}^{n}(X_i - \hat{\mu})^{\hat{\alpha}}\right)^{\frac{1}{\hat{\alpha}}} \qquad (1$$

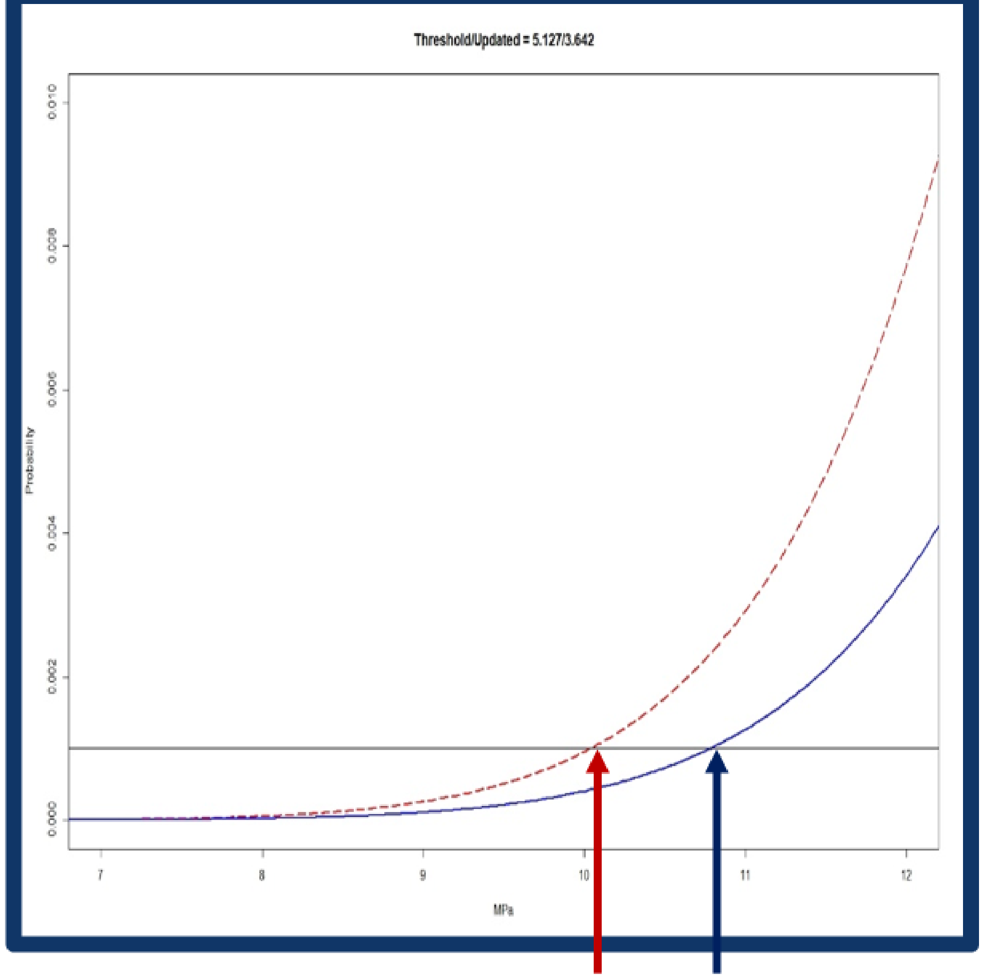
$$\hat{\alpha} = \left[\frac{\left(\sum_{i=1}^{n}(X_i - \mu)^{\hat{\alpha}}\ln(X_i - \hat{\mu})\right)}{\left(\sum_{i=1}^{n}(X_i - \hat{\mu})^{\hat{\alpha}}\right) - \left(\frac{1}{n}\sum_{i=1}^{n}\ln(X_i - \hat{\mu})\right)}\right]^{-1} \qquad (13)$$

$$(\hat{\alpha} - 1)\sum_{i=1}^{n}(X_i - \hat{\mu})^{-1} = \frac{\hat{\alpha}}{\hat{\beta}^{\hat{\alpha}}}\sum_{i=1}^{n}(X_i - \hat{\mu})^{\hat{\alpha} - 1} \qquad (14)$$


NBG-18: No shape update
Probability of Failure
0.06
0.04
0.02
0.00
0
10
20
30
40
Strength (MPa)


NBG-18
Probability of Failure
0.100
0.075
0.050
0.025
0.000
0
10
20
30
40
Strength (MPa)


Threshold/Updated = 5.127/3.642
Probability
0.00
0.05
0.10
0.15
0.20
0
5
10
15
20
25
MPa


Threshold/Updated = 5.127/3.642
Probability
0.000
0.002
0.004
0.006
0.008
0.010
7
8
9
10
11
12
MPa

METHODS

Margin is assessed in reference to the load factor (L_f), define below:

$$L_f = \frac{L_{allowable}}{L_{experimental\ median}}$$

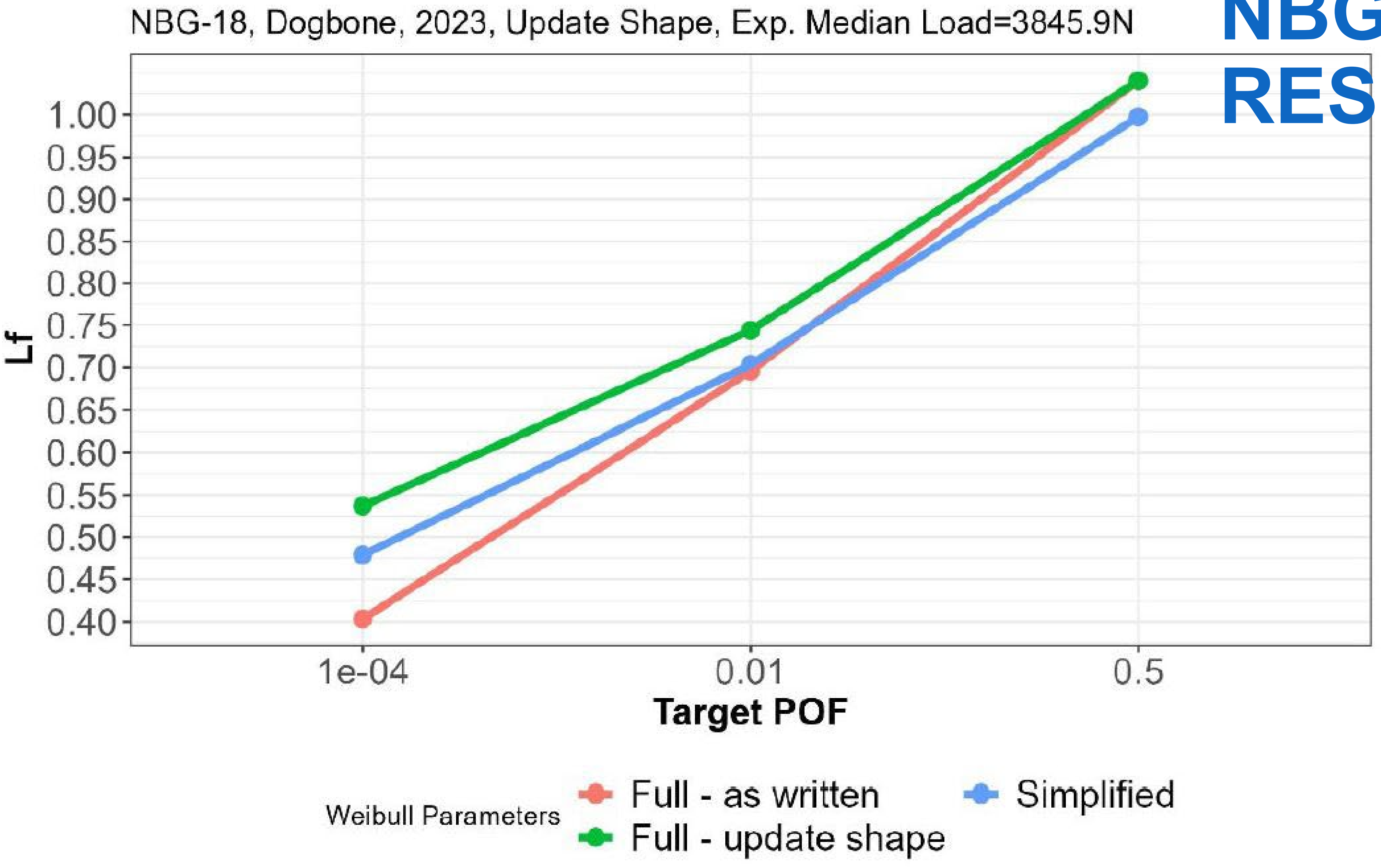
Where:

$L_{allowabale}$: the allowable load at the target POF, given the graphite grade, component, and assessment

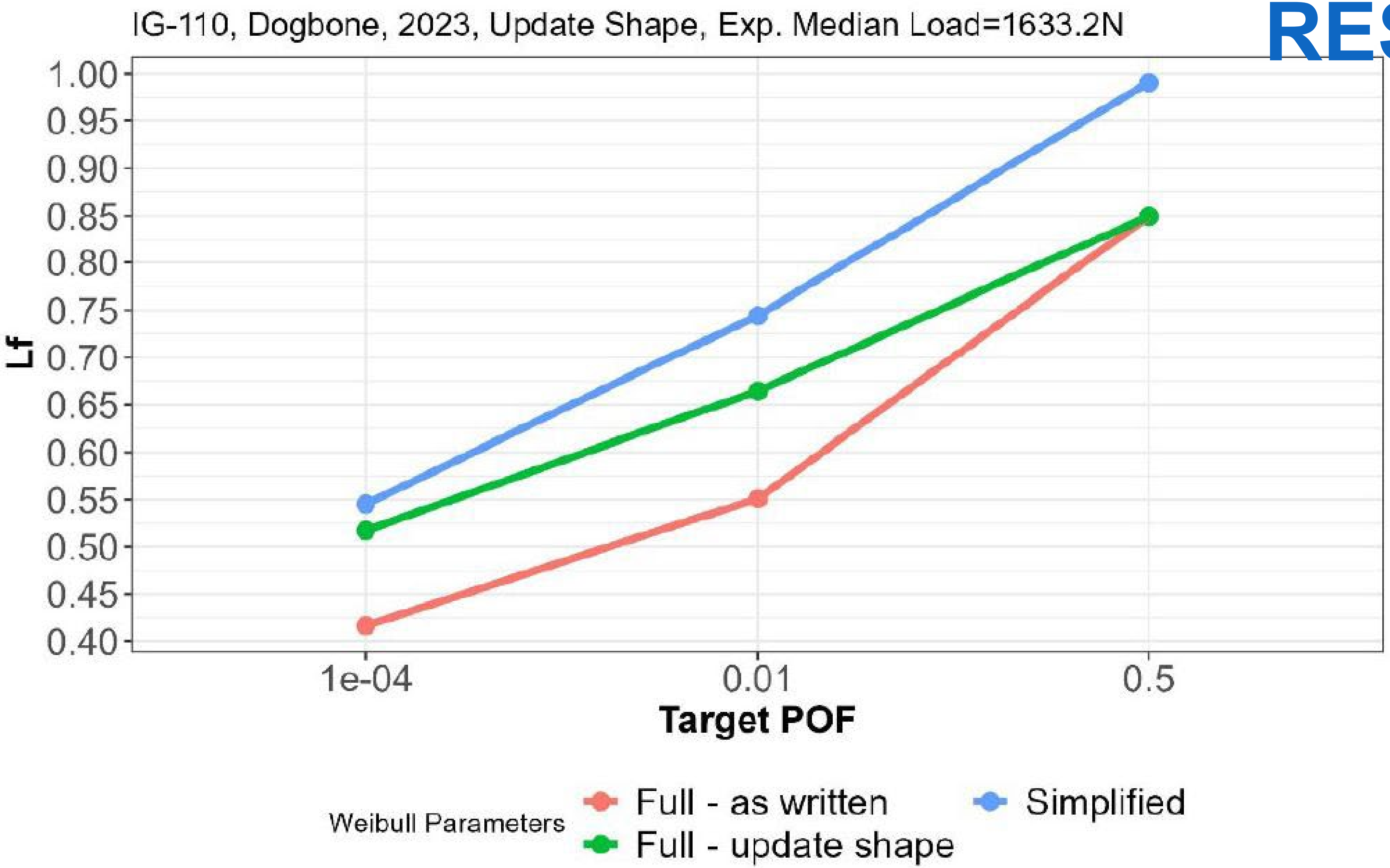
$L_{experimental\ median}$: the median experimental load for the graphite grade

The only components considered in the analysis are the dogbone geometries, based on the dogbone specimens to estimate the Weibull distributions. The assessments are run for SRC-1, SRC-2 (10^{-4}, 10^{-2}) and the median (0.5) target failure probabilities. If the assessments work perfectly, the $L_f = 1$ when the target failure probability is 0.5. $L_f < 1$ indicates the assessment is conservative relative to the experimental median load. The smaller the L_f, the more conservative the assessment relative to the experimental median load.

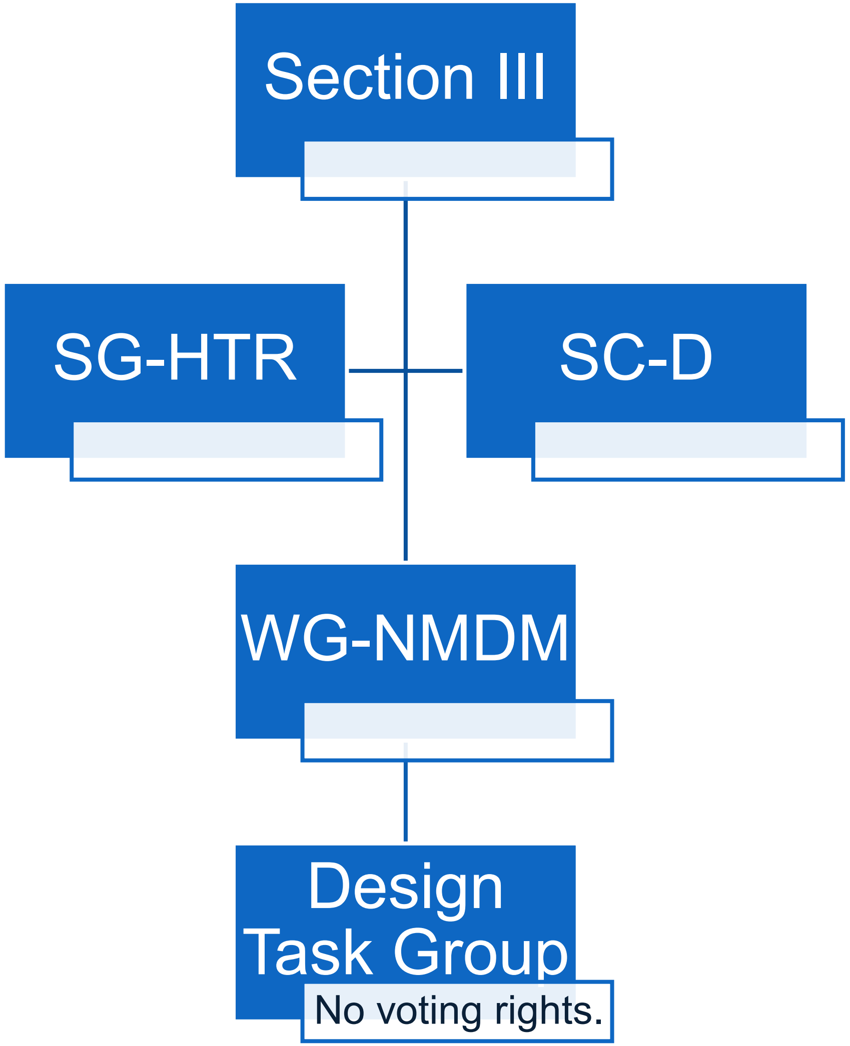
NBG-18 RESULTS



IG-110 RESULTS



Record Title	Record Number	Project Manager	Status
~~Modify notation and definitions~~	~~R20-1308~~	~~Andrea Mack (INL)~~	~~Approved~~
Update shape parameter in the full assessment	R21-1581	Andrea Mack (INL)	In-process
~~Correct notation and equations in HHA-II-3200~~	~~R23-170~~	~~Andrea Mack (INL)~~	~~Approved~~
Stress terminology in the simplified assessment	R23-473	Pierre-Alexandre Juan (Kairos Power)	In-process
~~Full assessment flow chart~~	~~R23-1349~~	~~Gwennael Beirnaert~~	~~Approved~~
Modify Vm	R23-2066	Michael Saitta (MPR)	In-process
Assessment interpretations: POF vs. POCI	R24-432	Andrea Mack (INL)	In-process



GAS-COOLED REACTOR

ADVANCED REACTOR TECHNOLOGIES PROGRAM

U.S. DEPARTMENT OF ENERGY

The American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME BPVC)

CODE	STANDARD	SPECIFICATION
Enforceable by law or by contract	Globally accepted "how to instruction"	Must meet requirements by contracts
Written by government or government approved body	Written by public organization or by a government body	Written by organization
Guidelines for design, fabrication, construction and installation	Set of technical definitions and guidelines for manufacturing	Additional requirements, beyond code & standard
ASME,BS,DIN	ASTM,SAE,ISO	SHELL DEP, EIL SPEC.

https://www.linkedin.com/pulse/codes-standards-specifications-abhishek-singh/

GENERAL ASSESSMENT PHILOSOPHIES

- Methods don't have to be perfectly accurate
  - Methods do not perfectly predict failure
  - Modifications are made to the Weibull analysis
- Methods should be
  - Relatively easy to implement
  - Conservative