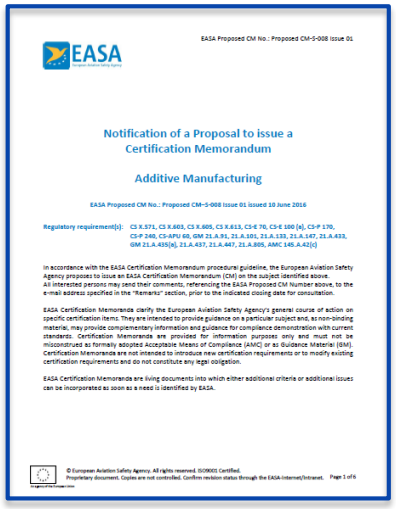
Establishing the Building Blocks

Imagination at work.

Export Classification: NLR
(DoC Jurisdiction, 9E991)



EASA Proposed CM No.: Proposed CM-S-008 Issue 01

EASA

Notification of a Proposal to issue a Certification Memorandum

Additive Manufacturing

EASA Proposed CM No.: Proposed CM-S-008 Issue 01 issued 10 June 2016

Regulatory requirement(s): CS X.571, CS X.603, CS X.605, CS X.613, CS-E 70, CS-E 100 (a), CS-P 170, CS-P 240, CS-APU 60, GM 21.A.91, 21.A.101, 21.A.133, 21.A.147, 21.A.433, GM 21.A.435(a), 21.A.437, 21.A.447, 21.A.805, AMC 145.A.42(c)

In accordance with the EASA Certification Memorandum procedural guideline, the European Aviation Safety Agency proposes to issue an EASA Certification Memorandum (CM) on the subject identified above. All interested persons may send their comments, referencing the EASA Proposed CM Number above, to the e-mail address specified in the "Remarks" section, prior to the indicated closing date for consultation.

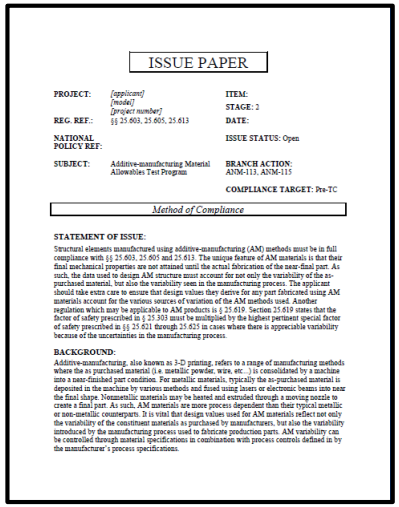
EASA Certification Memoranda clarify the European Aviation Safety Agency's general course of action on specific certification items. They are intended to provide guidance on a particular subject and, as non-binding material, may provide complementary information and guidance for compliance demonstration with current standards. Certification Memoranda are provided for information purposes only and must not be misconstrued as formally adopted Acceptable Means of Compliance (AMC) or as Guidance Material (GM). Certification Memoranda are not intended to introduce new certification requirements or to modify existing certification requirements and do not constitute any legal obligation.

EASA Certification Memoranda are living documents into which either additional criteria or additional issues can be incorporated as soon as a need is identified by EASA.

© European Aviation Safety Agency. All rights reserved. ISO9001 Certified.
Proprietary document. Copies are not controlled. Confirm revision status through the EASA-Internet/Intranet. Page 1 of 6

"The **unique feature** of AM materials is that their **final mechanical properties are obtained during the fabrication process**. As such, the data used to design AM parts must account for not only the typical variability of the as-purchased material, but also for the variability seen in the manufacturing process."

EASA Proposed CM No.: CM-S-008 Issue 01



ISSUE PAPER

PROJECT: [applicant] [model] [project number]
REG. REF.: §§ 25.603, 25.605, 25.613
ITEM:
STAGE: 2
DATE:
NATIONAL POLICY REF:
ISSUE STATUS: Open
SUBJECT: Additive-manufacturing Material Allowables Test Program
BRANCH ACTION: ANM-113, ASNE-115
COMPLIANCE TARGET: Pre-TC

Method of Compliance

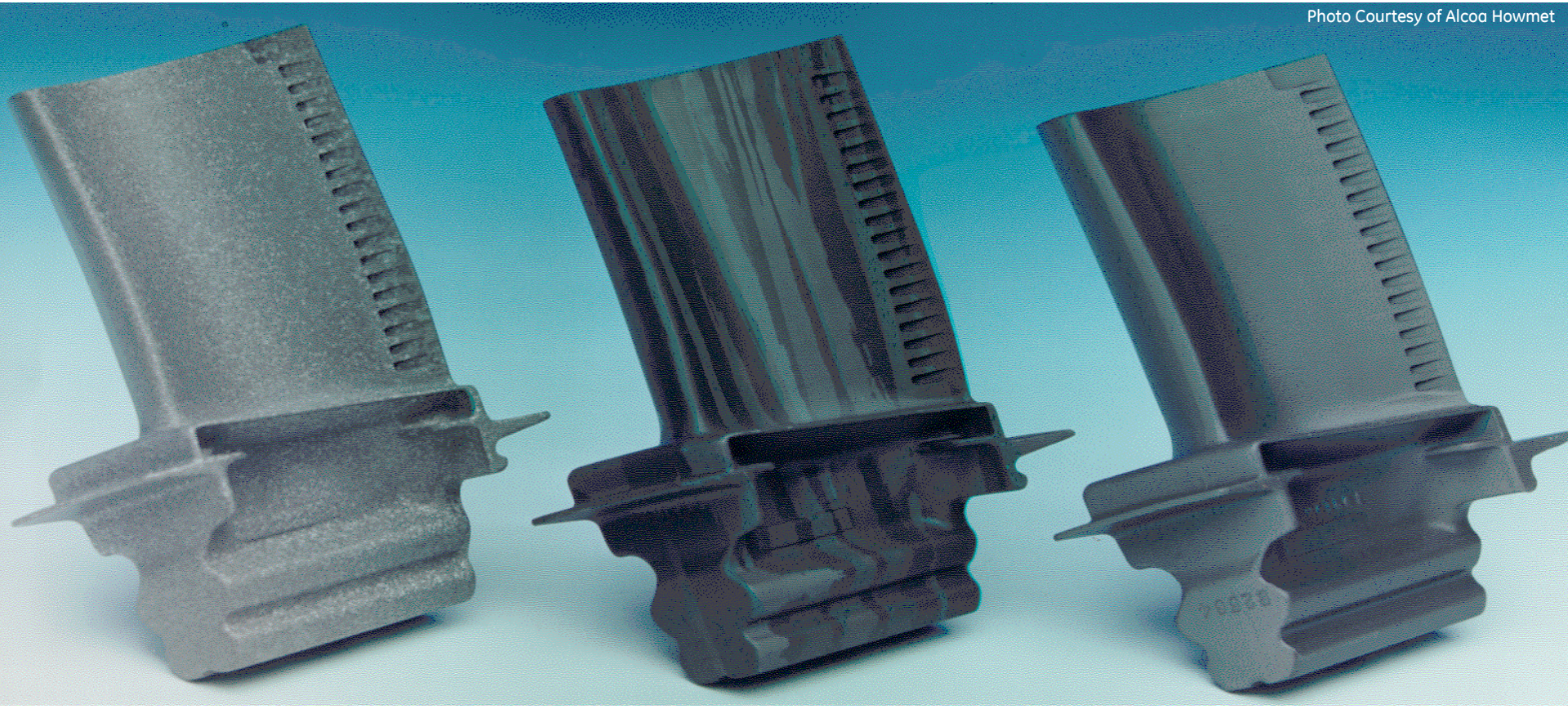
STATEMENT OF ISSUE:
Structural elements manufactured using additive-manufacturing (AM) methods must be in full compliance with §§ 25.603, 25.605 and 25.613. The unique feature of AM materials is that their final mechanical properties are not attained until the actual fabrication of the near-final part. As such, the data used to design AM structure must account for not only the variability of the as-purchased material, but also the variability seen in the manufacturing process. The applicant should take extra care to ensure that design values they derive for any part fabricated using AM materials account for the various sources of variation of the AM methods used. Another regulation which may be applicable to AM products is § 25.619. Section 25.619 states that the factor of safety prescribed in § 25.303 must be multiplied by the highest pertinent special factor of safety prescribed in §§ 25.621 through 25.625 in cases where there is appreciable variability because of the uncertainties in the manufacturing process.

BACKGROUND:
Additive-manufacturing, also known as 3-D printing, refers to a range of manufacturing methods where the as purchased material (i.e. metallic powder, wire, etc...) is consolidated by a machine into a near-finished part condition. For metallic materials, typically the as-purchased material is deposited in the machine by various methods and fused using lasers or electronic beams into near the final shape. Nonmetallic materials may be heated and extruded through a moving nozzle to create a final part. As such, AM materials are more process dependent than their typical metallic or non-metallic counterparts. It is vital that design values used for AM materials reflect not only the variability of the constituent materials as purchased by manufacturers, but also the variability introduced by the manufacturing process used to fabricate production parts. AM variability can be controlled through material specifications in combination with process controls defined in by the manufacturer's process specifications.

"The **unique feature** of AM materials is that their **final mechanical properties are not attained until the actual fabrication of the near-final part**. As such, the data used to design AM structure must account for not only the variability of the as-purchased material, but also the variability seen in the manufacturing process."

FAA Issue Paper Additive-manufacturing Material Allowables Test Program (DRAFT)

Processing **always** determines properties

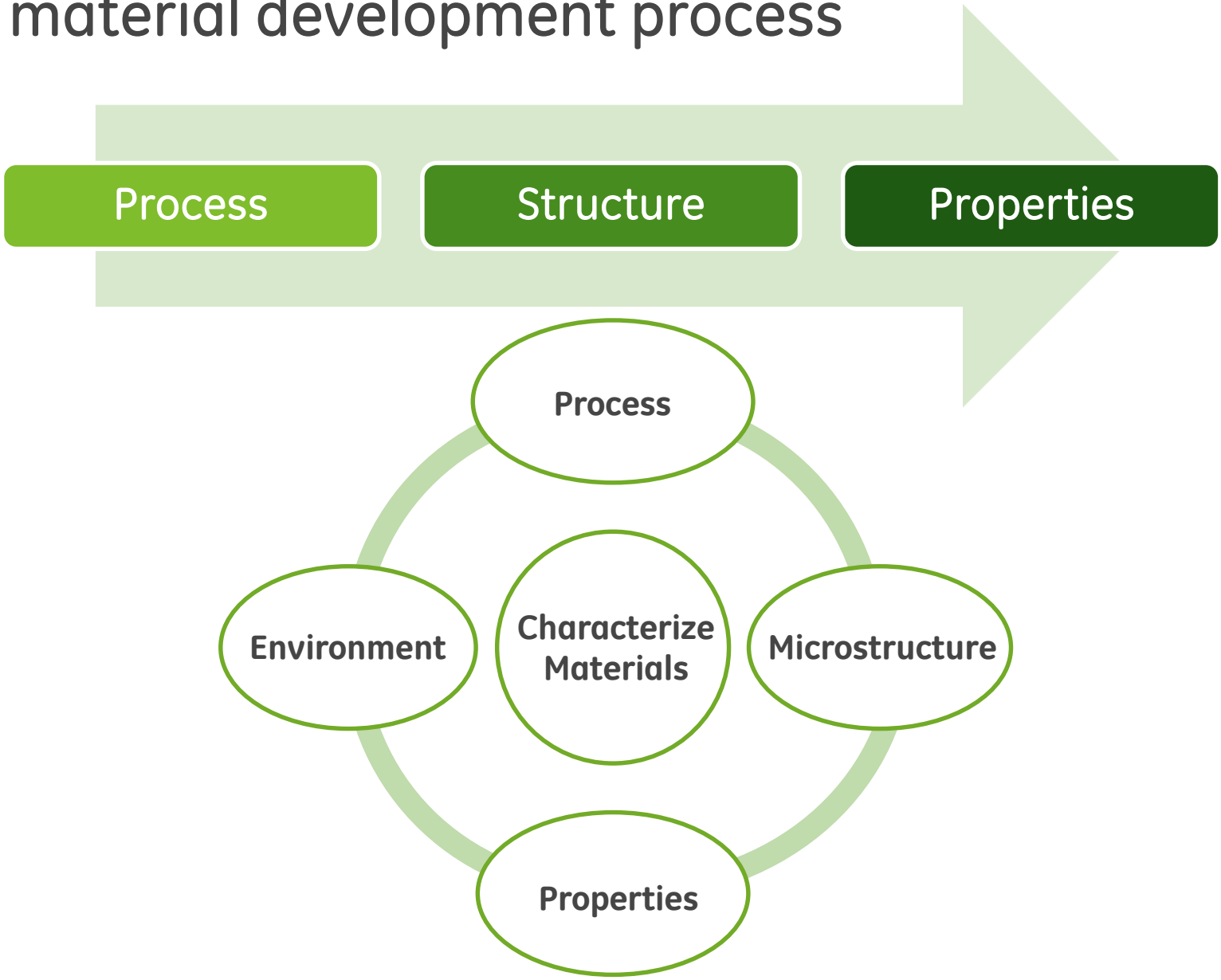


Equiaxed
(multiple grains)

Directionally Solidified
(oriented grains)

Single Crystal
(one grain)

GE material development process



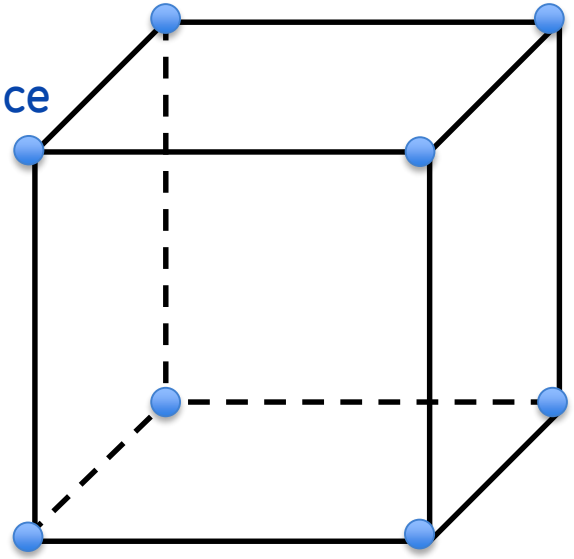
Additive Manufacturing development process

100+ Laser & Machine Parameters

Powder Specification
- Powder Source
- Powder Size
- Powder Composition
- Powder Reuse Procedures

Laser Parameters
- Spot Size
- Laser Power
- Laser Travel Speed
- Laser Dwell Time

Calibration & Maintenance
- Preventative Maintenance
- Pre-build Calibration
- Factory Environment Controls



Hatch Strategy
- Contour Pass
- Sky Writing
- Line Spacing & Overlap

Post Processing
- Mechanical Finishing
- Thermal Exposures

Recoat Parameters
- Layer Thickness
- Recoater Arm Design

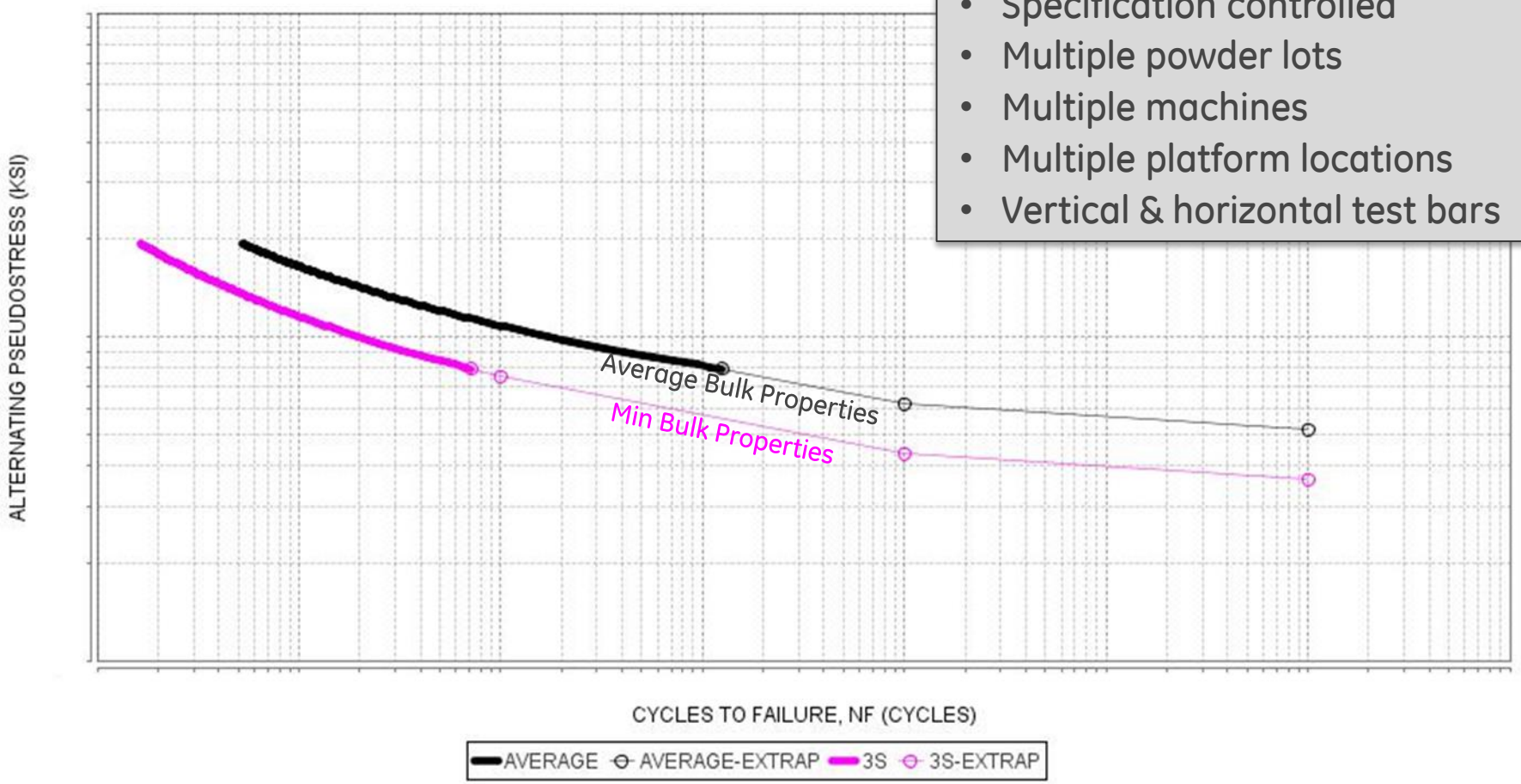
Thermal Processes
- HIP Cycle Parameters
- Heat Treat Atmosphere
- Braze HT Parameters
- Solution Temperature

Build Chamber
- Build Atmosphere
- Purge Gas
- Airflow
- Preheat Temp

Properties: Establishing Design Limits

Production Representative Environment

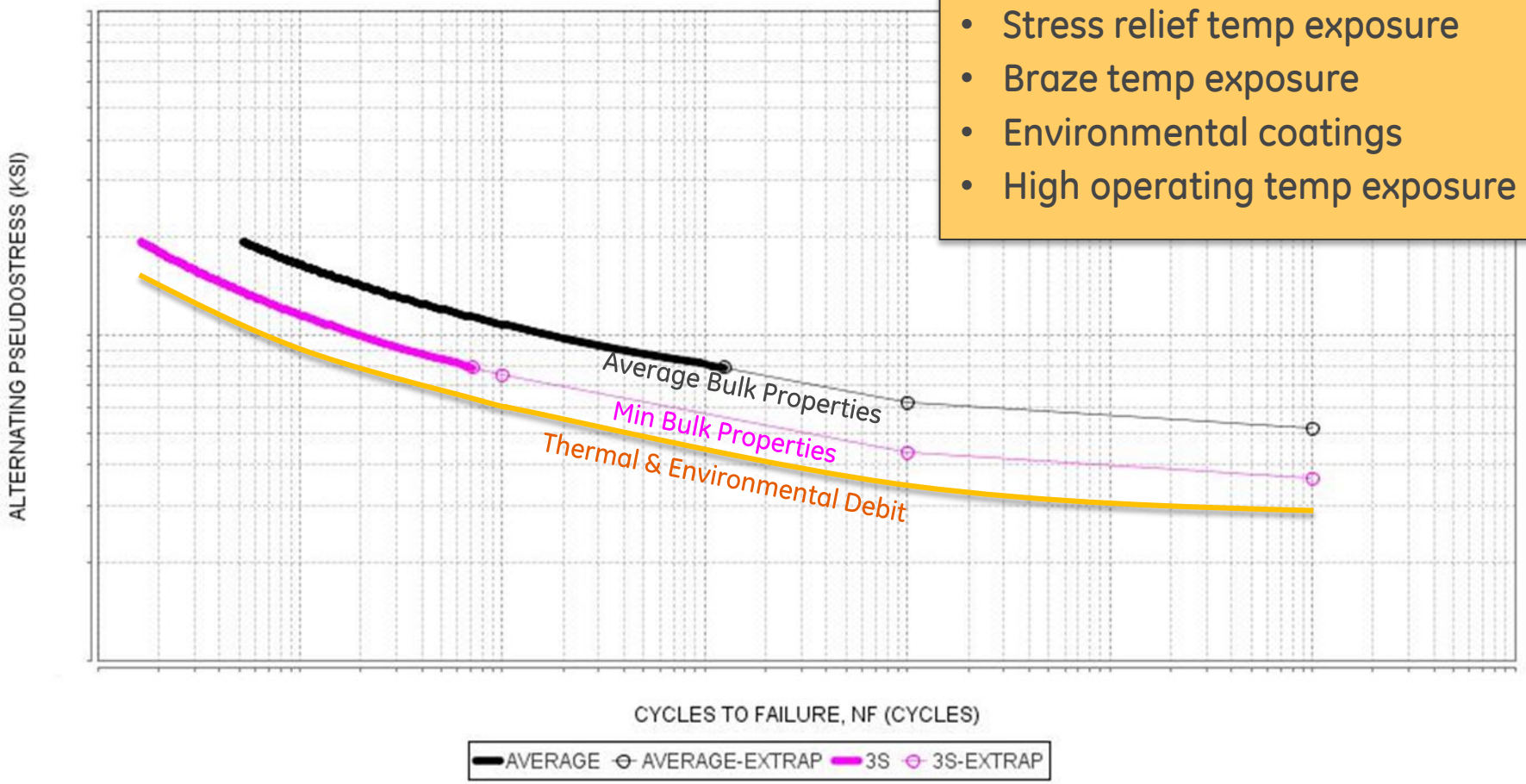
- Specification controlled
- Multiple powder lots
- Multiple machines
- Multiple platform locations
- Vertical & horizontal test bars



Properties: Establishing Design Limits

Accounting for Thermal and Environmental Effects

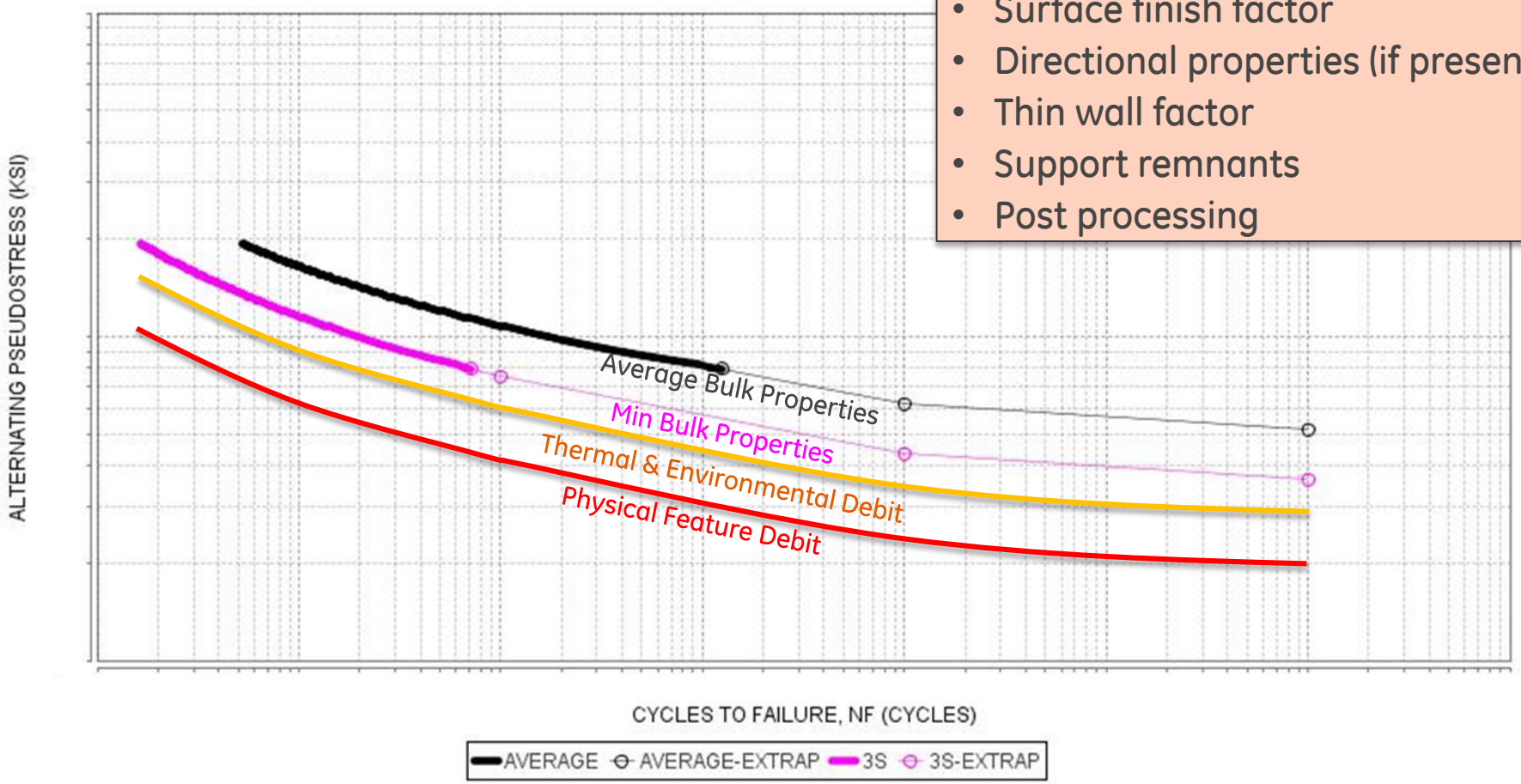
- Stress relief temp exposure
- Braze temp exposure
- Environmental coatings
- High operating temp exposure



Properties: Establishing Design Limits

Accounting for Physical Effects

- Surface finish factor
- Directional properties (if present)
- Thin wall factor
- Support remnants
- Post processing



Production Qualification Overview

Current Approach: *6 months per machine*

Every Machine is a "Foundry"

Material Qualification

Raw Material Specification

✓ ***Qualify incoming material***

Process Specification

✓ ***Manufacturing process controls***

Finish Material Specification

✓ ***Metallographic structure***

✓ ***Material properties***

GE Aviation Additive Technology Center