MMPDS & Additive Metals

NIST-ASM International Additive Manufacturing Data Management Workshop
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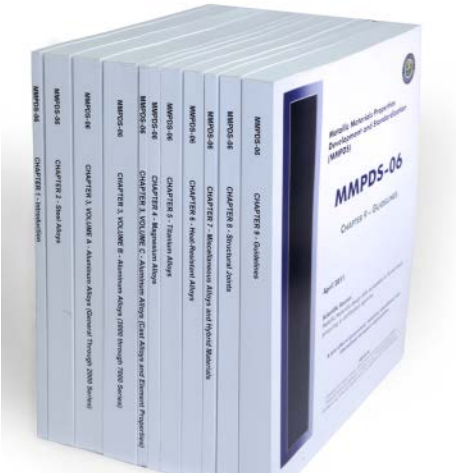
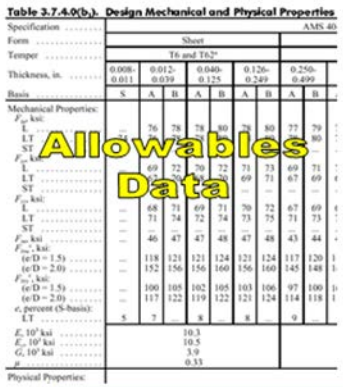
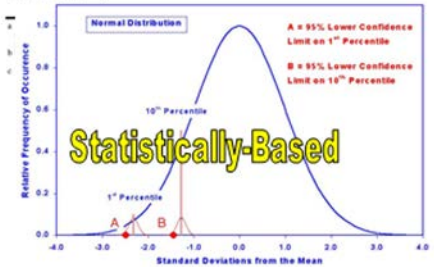
Metallic Materials Properties Development and Standardization







History

- ANC5 (1937-1954), MIL-HDBK-5 (USAF: 1954 – 2003), MMPDS (FAA: 2003-today)
- Battelle Memorial Institute - program Secretariat since 1956.
- MMPDS Handbook is the primary source of statistically-based design allowable properties for metallic materials and fasteners used in many different commercial and military weapon systems around the world.
- The MMPDS General Coordinating Committee is a collaboration between government agencies, aerospace companies, testing and data service companies, and metallic material producers.
- Biannual meetings to review and approve statistical analyses and guidelines.

Scope

- The Handbook currently contains 600+ A/B-Basis and 1000+ S-Basis entries, 400+ unique metal specifications.
- Two to five new alloys are added each year.
- For more information visit www.mmpds.org

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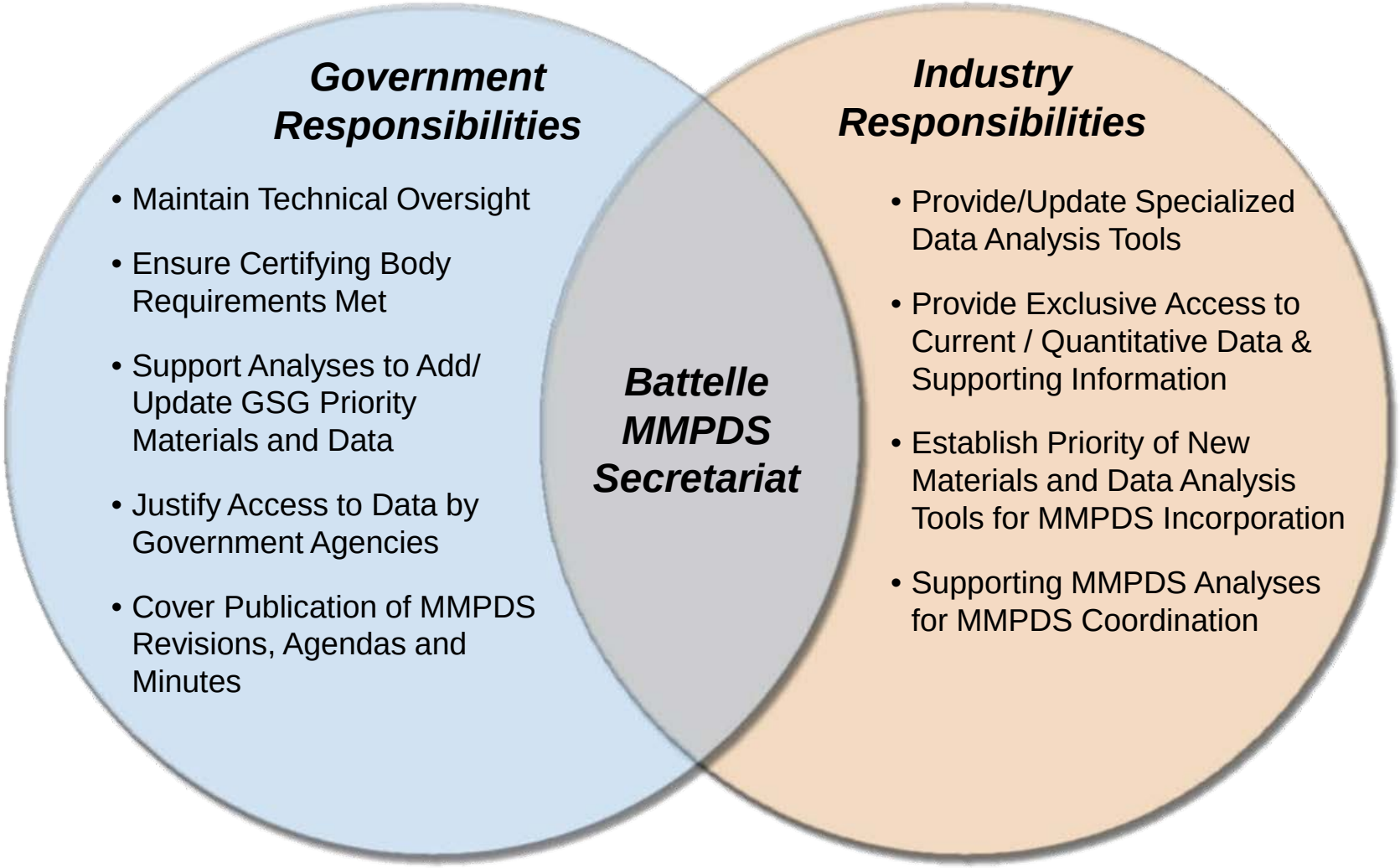
MMPDS General Coordinating Committee

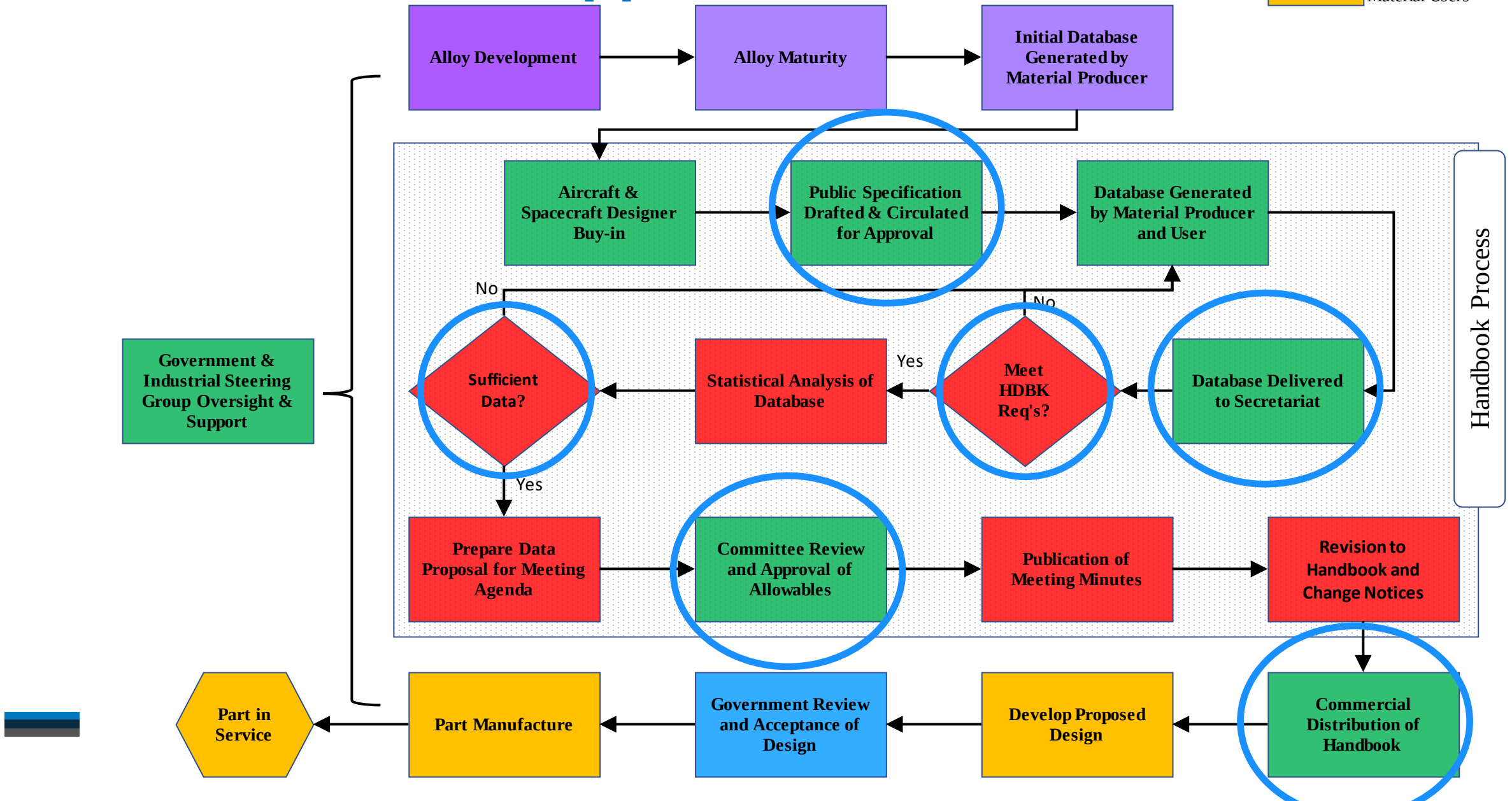


Task Groups:
GTG – approve **all** guidelines
MTG – approve materials (Ch. 2-7)
FTG – approve fasteners (Ch. 8)
ETTG – approve V2 content

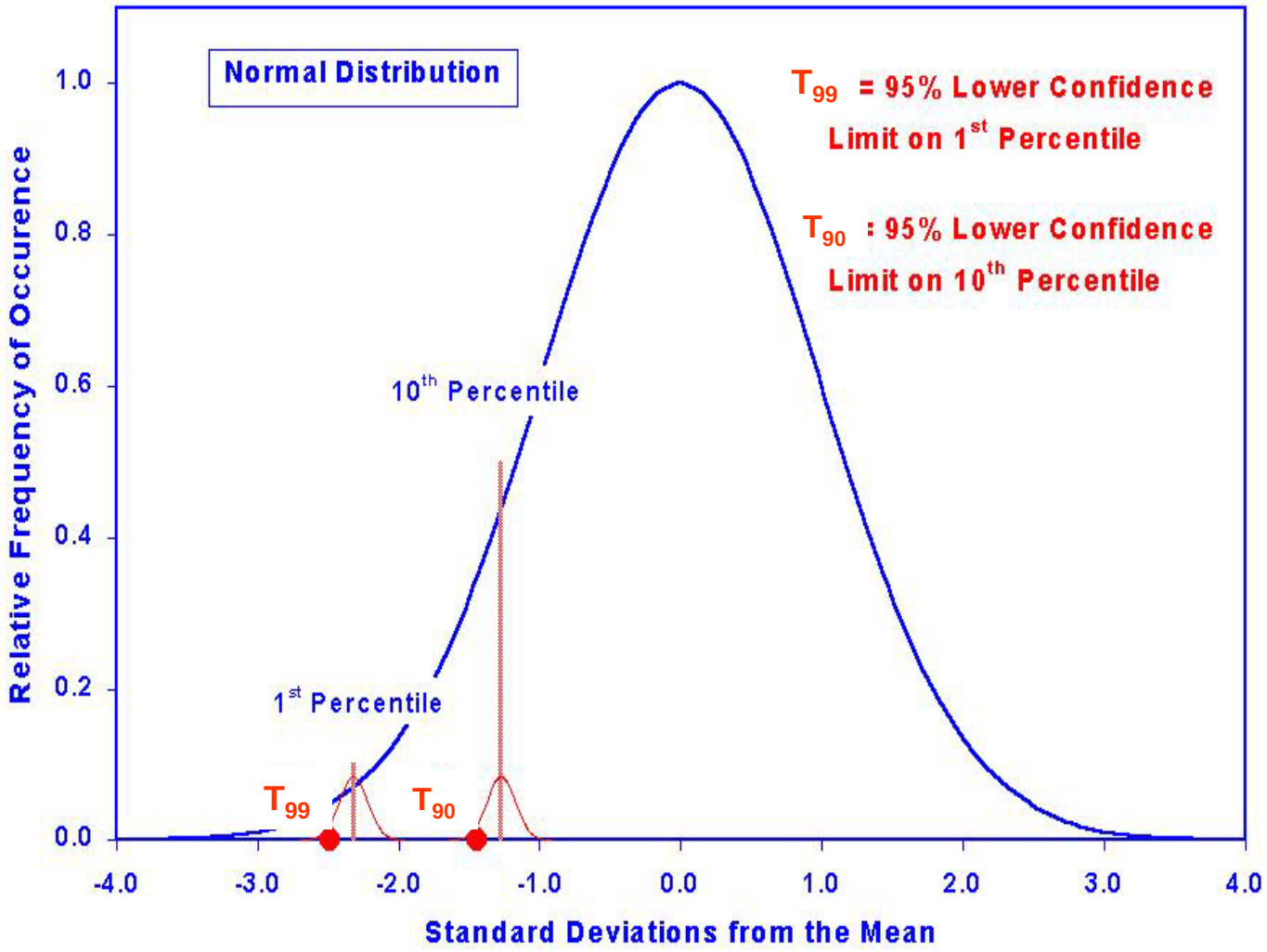
Steering Groups:
Get industry sector inputs
ASG, MATSSG, PSG

Working Groups:
Technical input from industry
FatWG, SWG, WWG
V2WG – develop V2 tech details

MMPDS Review & Approval Process



Volume I A-Basis, B-Basis, S-Basis: Material Allowables



T_{99} and T_{90} are one-sided lower tolerance bounds. Both are calculated from data.

S-Basis = is a T_{99} that does not meet A-Basis requirements for sample size or distribution fit.

A-Basis is the lower of the specification minimum or T_{99} value.

B-Basis = is the T_{90}. It is not related to the spec minimum.

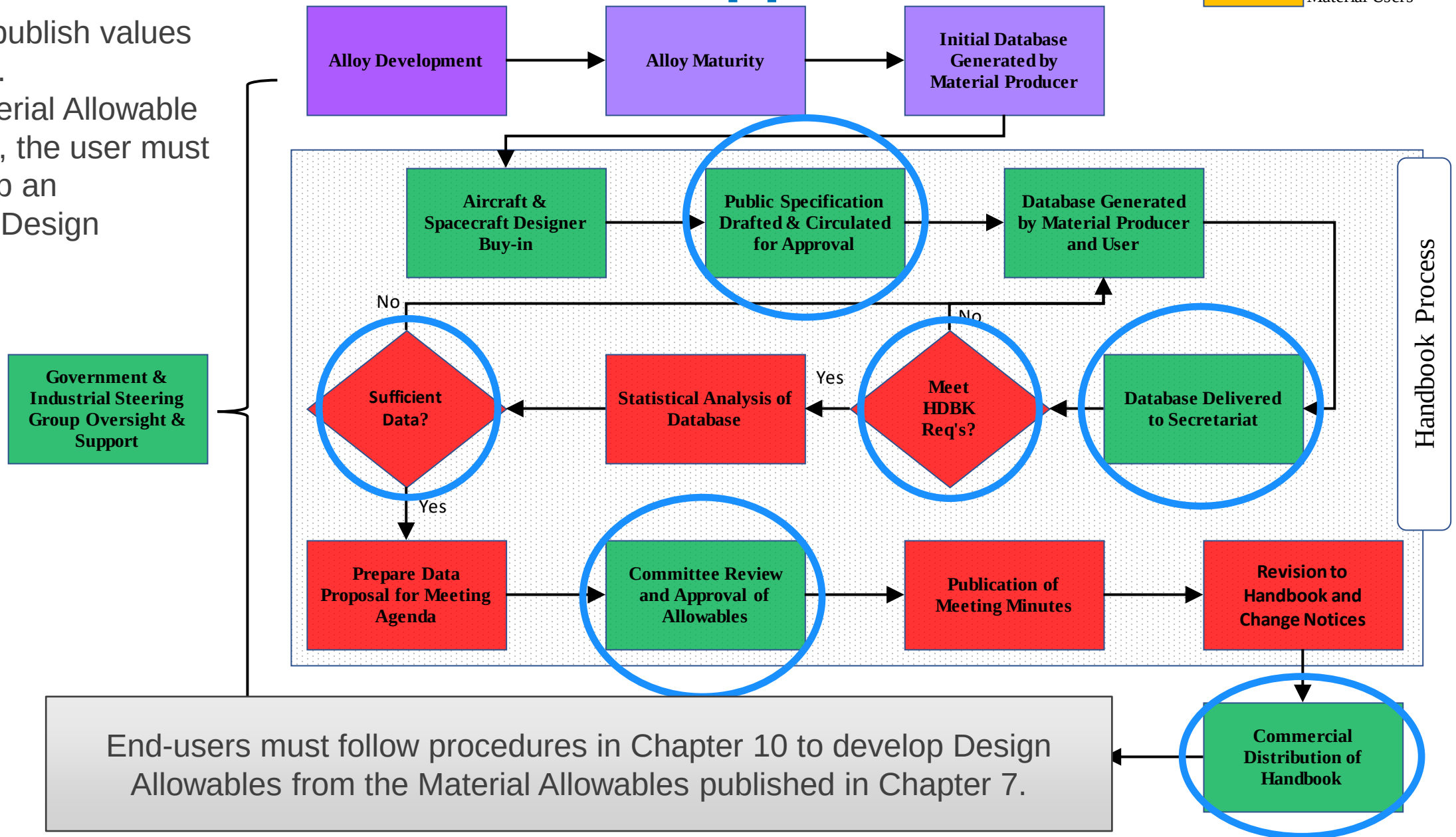
Metallic A-/B-Basis are values published in MMPDS or approved by the FAA "with further showing." A large sample is required.

MIDAS and FastenerCalc calculate T99 and T90 values in accordance with the requirements of MMPDS Chapter 9. A-/B-/S-Basis design allowables generated internally require further showing for certification.

Task 1.5 Volume II Review & Approval DRAFT

Material Producers
Collaboration
Secretariat
Government
Material Users

Process to publish values in Volume II.
Once a Material Allowable is published, the user must then develop an appropriate Design Allowable.

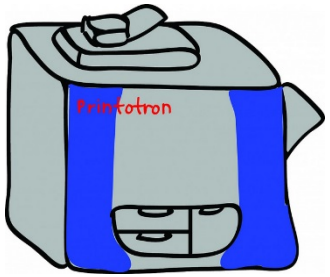


End-users must follow procedures in Chapter 10 to develop Design Allowables from the Material Allowables published in Chapter 7.

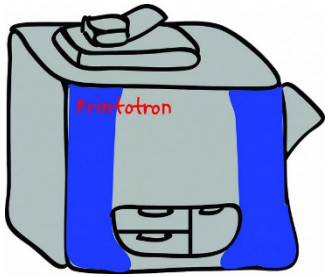
Test Matrix – Sponsor a Public Specification

- Use the draft specification to make material meeting the SDO's requirements for establishing specification minimum values. The cartoon is consistent with current AMS AM Data Submission Guidelines.

Ser. No. 1001
Draft Specification
Establish baseline
N=x1
y1 heats/lots/batches



Ser. No. 1002
Draft Specification
Establish baseline
N=x2
y2 heats/lots/batches



Ser. No. 1003
Draft Specification
Establish baseline
N=x3
y3 heats/lots/batches

$x1 + x2 + x3 \geq 30$
$y1 + y2 + y3 \geq 3$ feedstock/mfg. lots
3+ different machines

Item 19-17: Minimum Specification Content Requirements for Public Specifications – Volume II

was approved by the MMPDS GCC at the 36th MMPDS CCM

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Minimum Content Requirements for Public Specs

- Section 9.2.2 Specification Requirements
  - Qualify controls to ensure stable statistically valid mechanical properties.
  - “These controls shall include, but not limited to, lot-release acceptance criteria for composition and mechanical properties, control of thermal-mechanical processing, sampling and testing methodologies, and internal soundness/qualify.”
- Subsections to define addition requirements unique to AM
  - 9.2.2.1 Material Properties - data to meet S-Basis requirements for properties in the Spec
  - 9.2.2.2 Manufacturing and/or Processing
  - 9.2.2.3 Feedstock
  - 9.2.2.4 Recycling
  - 9.2.2.5 Machine Qualification

Test Matrix – Bulk Material Allowables

- Build specimens per the public specification using qualified machines and all other necessary monitoring processes. Details are still being debated.

Ser. No. A
N1

Ser. No. B
N2

Ser. No. C
N3

Ser. No. D
Nn-1

Ser. No. E
Nn

N1 + N2 + N3 + . . . + Nn-1 + Nn ≥ TBD
Industry experts recommend at least three machines, maybe more.
Mandatory, strongly recommended, and recommended properties, sample sizes, heats, lots, builds is TBD.
Current TBD depends on which property. Ftu requires 100 to 299 points from 10+ heats/lots.

Item 19-20: Data Requirements for Volume II

19-20: Data Requirements for Volume II (Task 1.2)

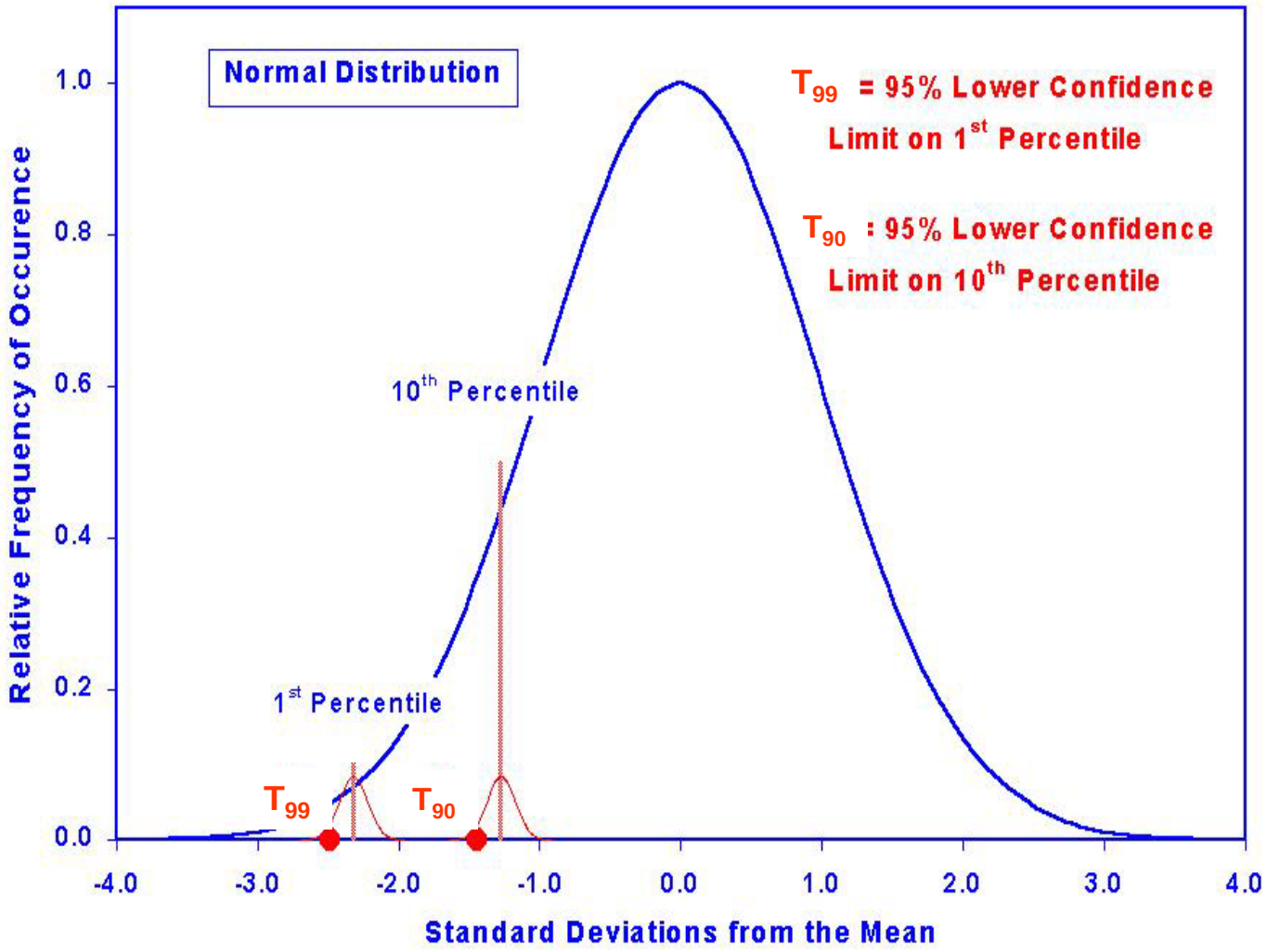
Mechanical or Physical Property	Customary Statistical Basis	Relative Importance in MMPDS Volume II	Extenuating Circumstances for Special Material Usage Requirements	Minimum Data Requirements				
				Sample Size	No. of Heats[f]	No. of Mfg. Lo	Machines[f]	Build Cycles
Bearing Yield and Ultimate Strength	S-Basis	Mandatory	Except for elevated temperature applications	30	3	3	3	3
Compression Yield Strength[a] (Derived)	Same as Tensile Properties	Mandatory		30	3	3	3	3
Density	Typical	Mandatory		3	3	3	3	3
Elastic Modulus - Tension Elastic Modulus - Compression Elastic Modulus - Dynamic Elastic Modulus - Shear	Typical	Mandatory Ma Rec mmended Rec mmended	Dynamic modulus is strongly r mmended some engine pl tions	9	3	3	3	3
Elastic Modulus (T, C, D) - Elevated Temperatures	Typical	Ma latory	For an ipated erature range	9	3	3	3	3
Elongation	S-Basis	Ma latory	Two-incl age ngth preferred	30	3	3	3	3
Shear Ultimate Strength[a]	S-Basis	Mandatory	Except for elevated temperature applications	30	3	3	3	3
Stress/Strain Curves (To Yield) Tension and Compression	Typical	Mandatory	Desirable to have accurate plastic strain offsets from 10^{-6} to 3×10^{-2}	6	3	6	3	3
Stress/Strain Curves (Full Range) Tension	Typical	Mandatory		6	3	6	3	3
Tension Yield and Ultimate Strength	S-Basis	Mandatory		30	3	3	3	3

Item 19-20 has not been approved by the MMPDS GCC

19-20: Data Requirements for Volume II (Task 1.2)

Mechanical or Physical Property	Customary Statistical Basis	Relative Importance in MMPDS Volume II	Extenuating Circumstances for Special Material Usage Requirements	Minimum Data Requirements				
				Sample Size	No. of Heats	No. of Mfg. Lo	Machines[f]	Build Cycles
Coefficient of Thermal Expansion	Typical	Strongly recommended	For anticipated usage temperature range	6	3	3	3	3
Poisson's Ratio	Typical	Strongly recommended		6	3	3	3	3
Specific Heat	Typical	Strongly recommended	For anticipated usage temperature range	6	3	3	3	3
Tension Yield and Ultimate Strength	D-Basis	Strongly recommended	Especially for strength critical applications; a parametric representation of data is possible	100	10	10	5	10
Tension Yield and Ultimate Strength	C-Basis	Strongly recommended	Especially for strength critical applications; a parametric representation of data is possible	100	10	20	5	20
Tension Yield and Ultimate Strength	C-Basis & D-Basis	Strongly recommended	Especially for strength critical applications; a parametric representation of data is not possible	299	10	20	5	20
Thermal Conductivity	Typical	Strongly recommended	For anticipated usage temperature range	6	3	3	3	3

Volume II C-Basis, D-Basis, S-Basis: Material Allowables



T_{99} and T_{90} are one-sided lower tolerance bounds. Both are calculated from data.

C-Basis is the lower of the specification minimum or T_{99} value.

D-Basis = is the T_{90}. It is not related to the spec minimum.

S-Basis = is a T_{99} that does not meet C-Basis requirements for sample size or distribution fit.

Metallic C-/D-/S-Basis published in MMPDS Volume II require “further showing.”

Definitions for A-/B-C-/D-/S-Basis have not been approved for AM Metals by the MMPDS Coordinating Committee. Do Not Use those labels.

Dependent upon Items 19-17, 19-20, *et.al.*

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FAIR & MMPDS

- Findable
  - Data is retrieved by referencing an archival index.
- Accessible
  - Paper and electronic files are accessible to a short list of authorized users.
- Interoperable
  - Data is organized for our single purpose in a format consistent with the last time it was analyzed.
- Reusable
  - MMPDS has a legacy alloy review process.
  - Archived data is reviewed when new data is received and prioritized for re-analysis.

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It can be done

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