Metallic Materials Properties Development and Standardization (MMPDS)

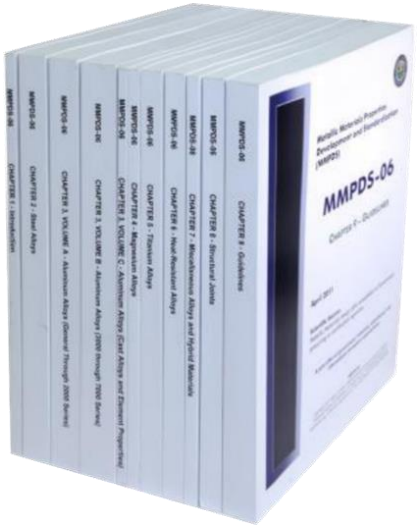
Statistical Analysis for Static Design Allowable Properties

Jana Rubadue
Program Manager

April 2015

MMPDS Bottom Line

- The MMPDS Handbook is the primary source in the United States and many other countries of statistically-based, design allowable properties for metallic materials and fastened joints used by the commercial and military aerospace industries



MMPDS

Battelle
The Business of Innovation

MMPDS Handbook is the primary source of statistically-based, design allowable metallic properties and joints.

Mechanical Properties:
F_{tu}, ksi:
L
LT
ST
F_{ty}, ksi:
L
LT
ST
F_{cy}, ksi:
L
LT
ST
F_{su}, ksi:
L-S
T-S
S-L
F_{bru}^{c}, ksi (e/D = 1.5):
L
LT
ST
F_{bru}^{c}, ksi (e/D = 2.0)
L
LT
ST
F_{bry}^{c}, ksi (e/D = 1.5):
L
LT
ST
F_{bry}^{c}, ksi (e/D = 2.0)
L
LT
ST

Tensile

Compression

Shear

Bearing

Table 3.7.11.0(b_2). Design Mechanical and Physical Properties of 7140 Aluminum Alloy Plate

Specification	AMS 4408								
Form	Plate								
Temper	T7651								
Thickness, in.	4.000-5.000		5.001-6.000		6.001-7.000		7.001-8.000	8.001-9.000	9.001-10.000
Basis	A	B	A	B	A	B	S	S	S
Mechanical Properties:									
F_{tu}, ksi:									
L	74	76	74	75	73	74	72	72	71

Modulus (Typical)

E, 10^3 ksi	10.3
E_c, 10^3 ksi	10.4
G, 10^3 ksi	3.9
μ	0.33

Physical Properties (Typical)

Physical Properties:	
ω, lb/in.^{3}	0.102
C, K, and α	See Figure 3.7.11.0

Considerations for Design Allowables

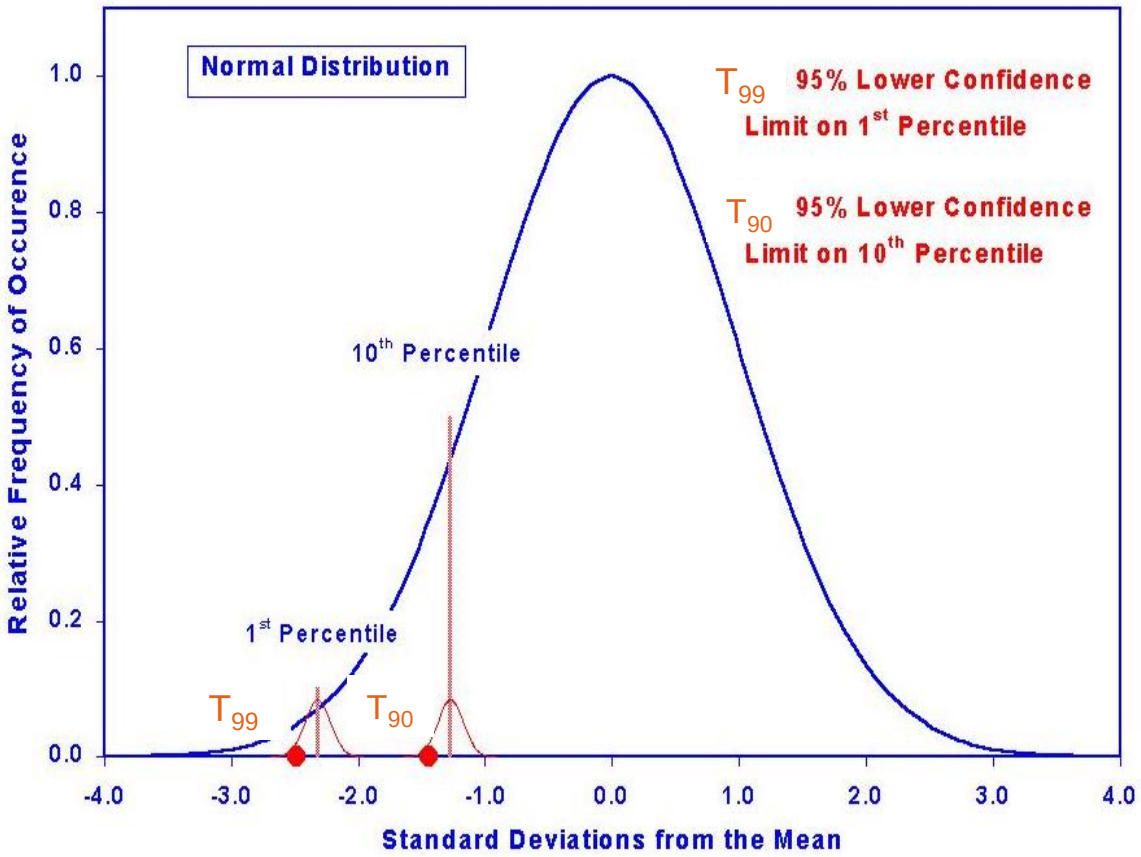
- Public specification (indicates material reflects a standard practice)
- Production Method
- Distribution of material
  - Supplier to Supplier
  - Within single supplier (heats and lots)
  - Materials are not normally distributed
    - Minimum population of 100 is needed to adequately determine skewness for A-basis, if it will fit Pearson or Weibull distribution.
    - Minimum population of 299 is needed for non-parametric A-basis

Property Basis Definitions

- **A-basis:** The lower of either a statistically calculated T99 or specification minimum. T99 is the value at which at least 99% of population is expected to equal or exceed with 95% confidence.
- **B-basis:** Same as T90; at least 90% of population is expected to equal or exceed with 95% confidence.

  NOTE: A- and B-basis for static design properties are based on minimum population of 100
- **S-basis:** Specification minimum, or value based on specification minimum. (recent are based on minimum population of 30 for AMS specs.)

What is a Statistical Design Allowable?



Comparison of Minimum Data Requirements

MMPDS

- Primary tensile properties for A- and B-basis
  - 10 Heats/ 10 Lots
  - 100 tests
  - (or 299 for non-parametric)
- Primary tensile properties for S-basis
  - Same as AMS Specification minimums
- Secondary properties
  - 3 Heats/ 10 Lots
  - 20 tests (paired, prefer 2/lot)

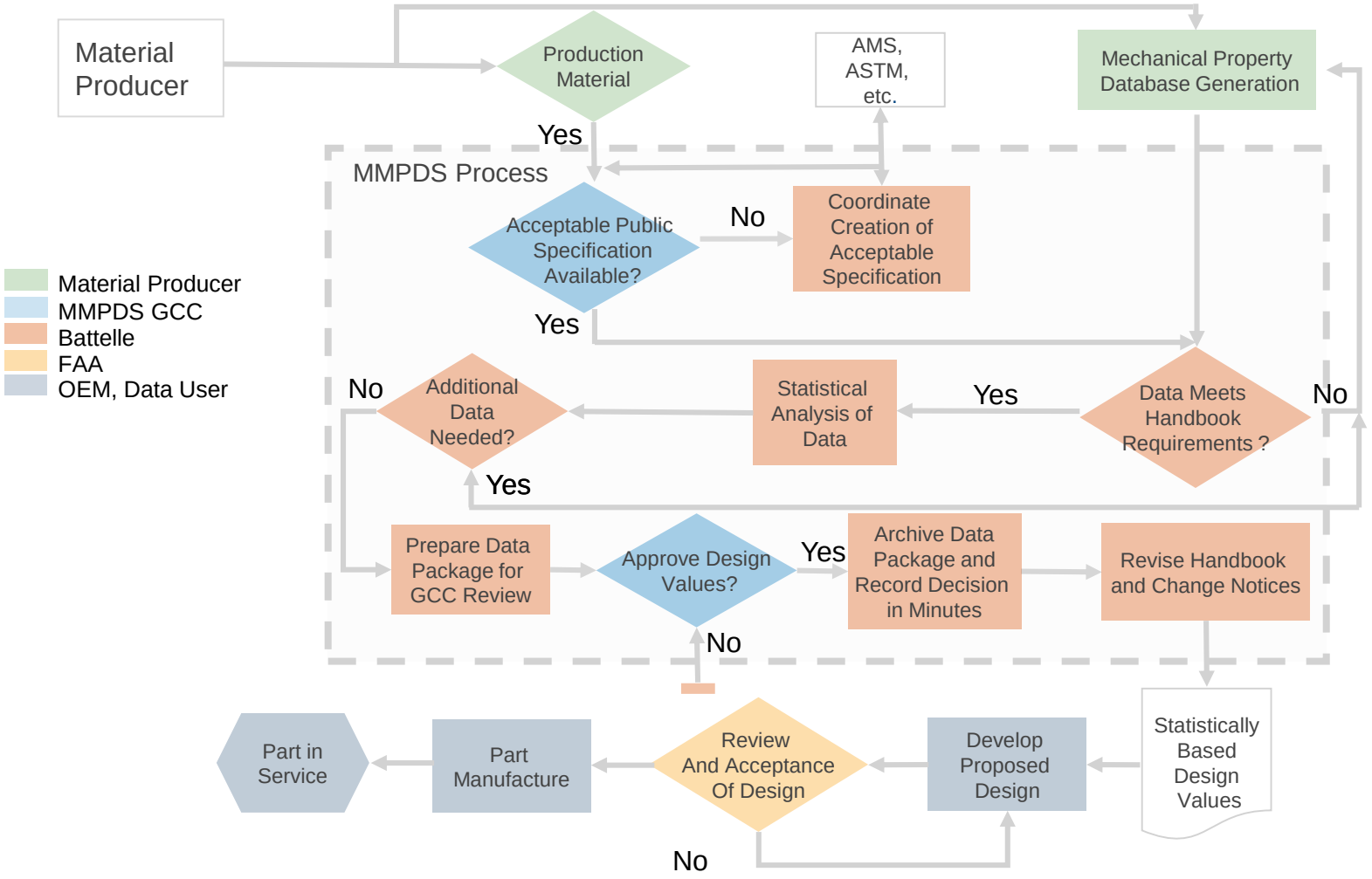
AMS Specification

- S-Basis
- For tensile, compression, elongation, RA, fracture toughness
- 3 Heats, Chemistries
- 30 Tests

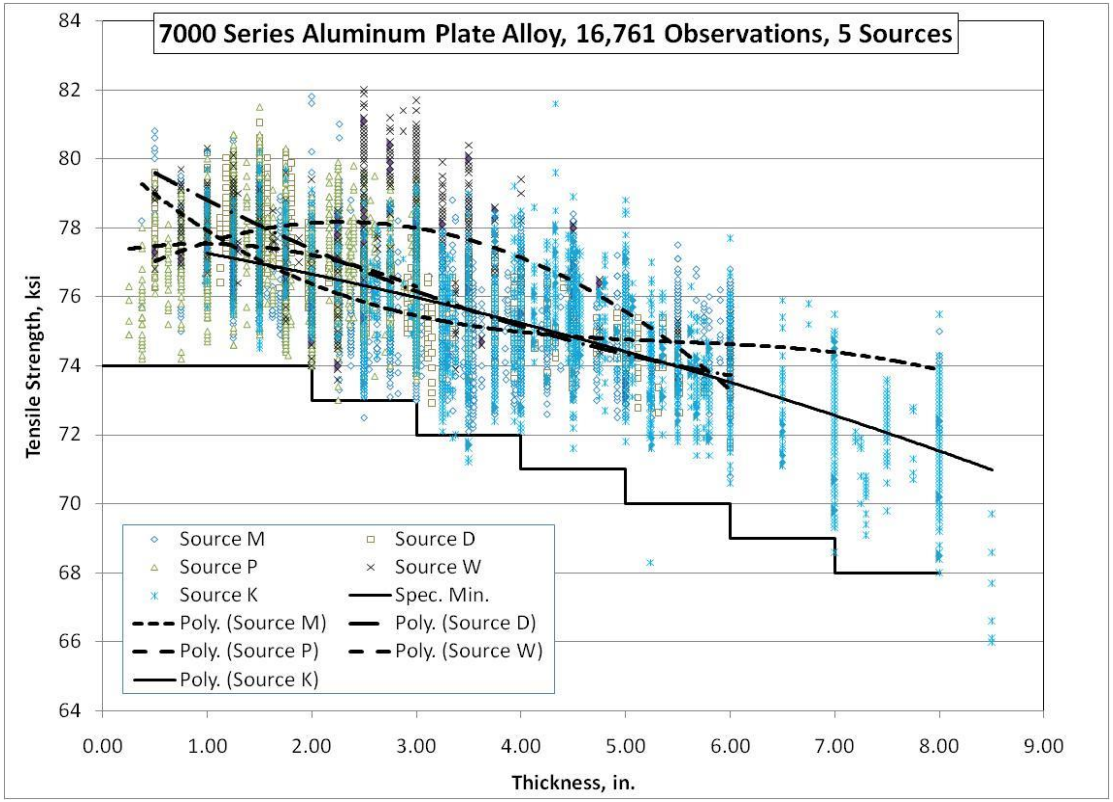
Analysis Methods used by MMPDS

- Direct (minimum of 100 required for A- and B-basis)
  - 3 parameter Weibull
    - Upper tail censoring
    - Upper tail censoring with backoff
  - Pearson type III
    - backoff
  - Non-parametric (minimum of 299)
  - Normal (for small sample sizes <100)
- Indirect using reduced ratios
- Regression; linear or quadratic (used for Direct or Indirect Methods)

Design Value Development Process

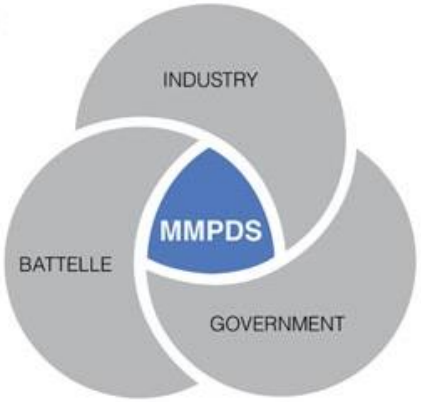


Reality – producer-to-producer variability often significant



Summary

- MMPDS is a long-term, Battelle flagship program built upon a foundation of partnership with FAA, Navy, and other government agencies
- Industry funding support (32 companies from 9 countries) recognizes the key benefits of the program



Questions?

Jana Rubadue

Battelle

rubaduej@battelle.org

(614) 424-5948

www.mmpds.org

Battelle

The Business *of* Innovation

800.201.2011 | solutions@battelle.org | www.battelle.org