

# Metallic Materials Properties Development and Standardization (MMPDS)

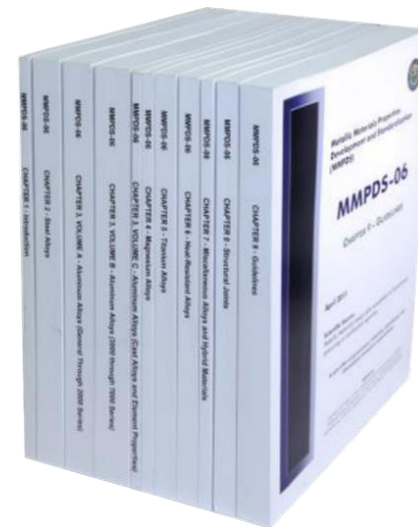
Statistical Analysis for Static Design Allowable Properties

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

**Mechanical Properties:**

$F_u$ , ksi:  
L  
LT  
ST

$F_y$ , ksi:  
L  
LT  
ST

$F_{cu}$ , ksi:  
L  
LT  
ST

$F_{su}$ , ksi:  
L-S  
T-S  
S-L

$F_{br}^c$ , ksi (e/D = 1.5):  
L  
LT  
ST

$F_{br}^c$ , ksi (e/D = 2.0)  
L  
LT  
ST

$F_{br}^c$ , ksi (e/D = 1.5):  
L  
LT  
ST

$F_{br}^c$ , ksi (e/D = 2.0)  
L  
LT  
ST

Tensile  
Compression  
Shear  
Bearing

Table 3.7.11.0(b<sub>2</sub>). Design Mechanical and Physical Properties of 7140 Aluminum Alloy Plate

Table 3.7.11.0(b <sub>2</sub> ). 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
	A	B	A	B	A	B	S	S	S
<b>Mechanical Properties:</b>									
$F_u$ , ksi:	74	76	74	75	73	74	72	72	71
L	74	76	74	75	73	74	72	72	71
LT	76	77	74	75	73	74	72	72	71
ST	73	74	74	75	73	74	72	72	71
$F_y$ , ksi:	70	71	70	71	70	71	70	70	70
L	69	70	70	71	69	70	69	69	69
LT	63	65	63	64	63	64	63	63	63
ST	63	65	63	64	63	64	63	63	63
$F_{cu}$ , ksi:	68	69	67	69	67	68	66	64	63
L-S	72	73	71	73	72	73	71	69	68
T-S	70	71	71	71	69	70	68	66	65
S-L	48	49	48	49	48	48	47	46	45
L	47	48	46	48	46	47	46	45	44
LT	38	38	38	39	39	40	39	39	39
ST	38	38	38	39	39	40	39	39	39
$F_{br}^c$ , ksi (e/D = 1.5):	120	122	119	122	119	120	117	116	112
L	122	123	120	123	120	122	119	117	114
LT	156	158	154	158	154	156	152	150	146
ST	158	160	156	160	156	158	154	152	146
$F_{br}^c$ , ksi (e/D = 2.0)	101	103	100	103	100	101	100	100	100
L	101	103	100	103	100	101	100	100	100
LT	119	121	118	121	118	119	117	115	111
ST	112	122	118	122	118	119	117	115	111
$e$ , percent (S-Basis):	7	...	...	7	...	6	5	5	...
L	6	...	4	...	3	3	3	3	...
LT	3	...	3	...	3	3	3	3	...
ST	3	...	3	...	3	3	3	3	...
$E$ , 10 <sup>3</sup> ksi	10.3								
$E$ , 10 <sup>4</sup> ksi	10.4								
$G$ , 10 <sup>3</sup> ksi	3.9								
$\mu$	0.33								
<b>Physical Properties:</b>									
$\omega$ , lb/in. <sup>3</sup>	0.102								
C, K, and $\alpha$	See Figure 3.7.11.0								

Modulus (Typical)

Physical Properties (Typical)

Issued: Apr. 2009, MMPDS-04CN1, Item 07-43  
 a Specification minimum. The rounded  $T_u$  for  $F_u$ , LT = 76 ksi.  
 b Specification minimum. The rounded  $T_u$  for  $F_y$ , ST = 63 ksi.  
 c Bearing values are "dry pin" values per Section 1.4.7.1.



# 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

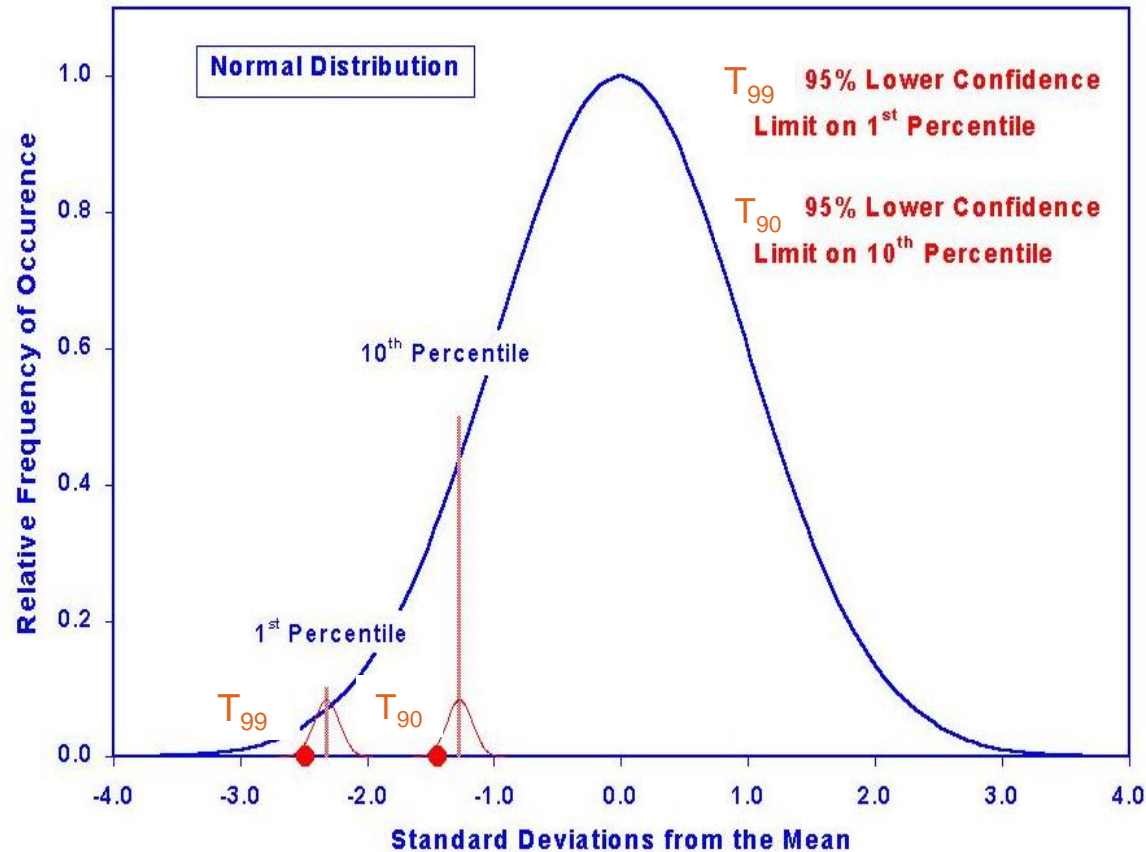
# Property Basis Definitions

- **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

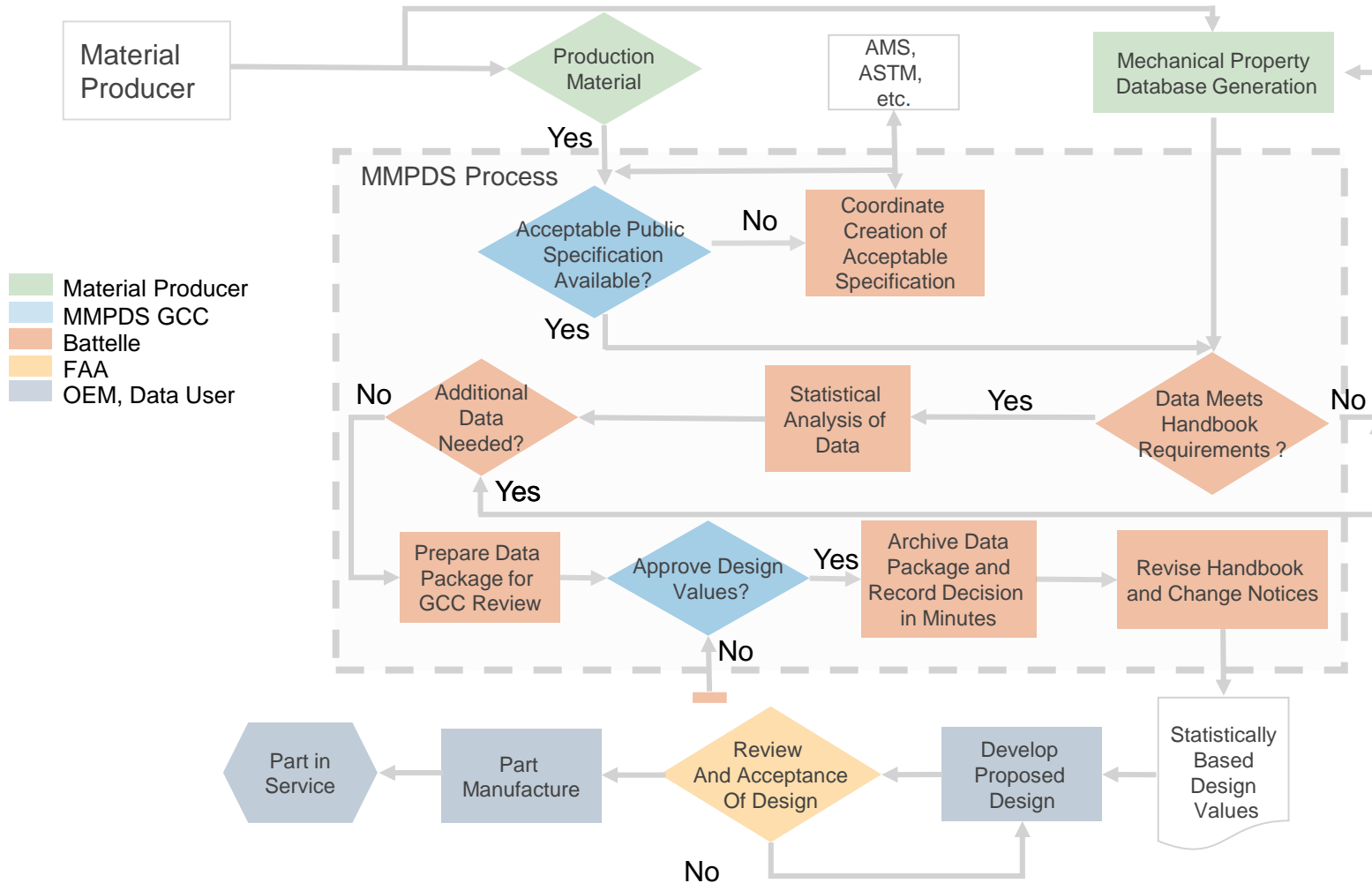
- S-Basis
- For tensile, compression, elongation, RA, fracture toughness
- 3 Heats, Chemistries
- 30 Tests

# Analysis Methods used by MMPDS

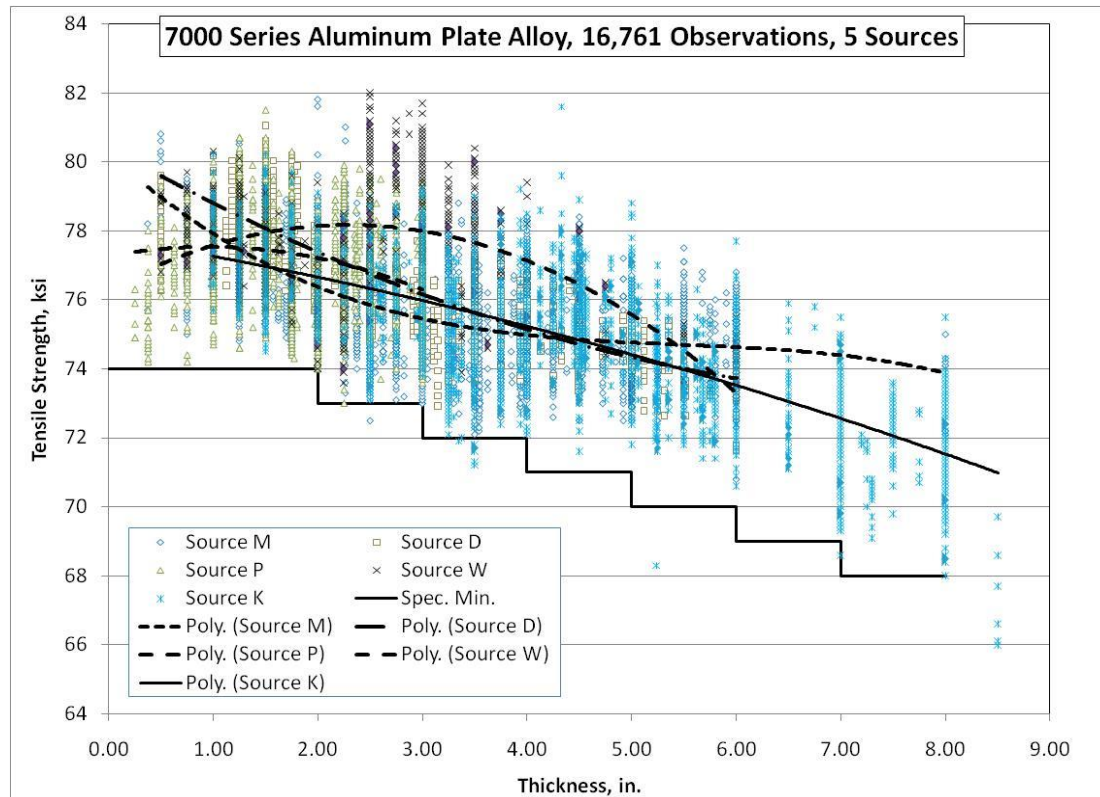
- Direct (minimum of 100 required for A- and B-basis)
  - 3 parameter Weibull
    - Upper tail censoring
    - Upper tail censoring with backoff
  - Pearson type III
    - backoff
  - Non-parametric (minimum of 299)
  - Normal (for small sample sizes <100)
- Indirect using reduced ratios
- Regression;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



# Design Value Development Process

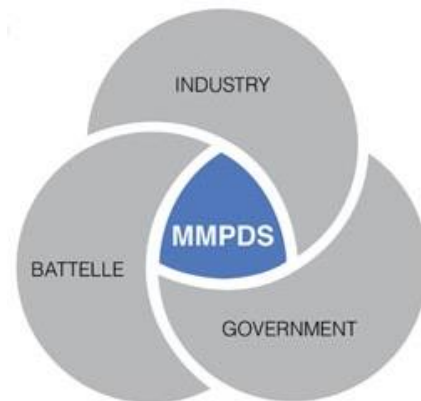


# Reality – producer-to-producer variability often significant



# 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?

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