Cryogenic properties of aluminum-beryllium and beryllium materials

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Objective

Determine ultimate tensile strength, yield strength and elongation:

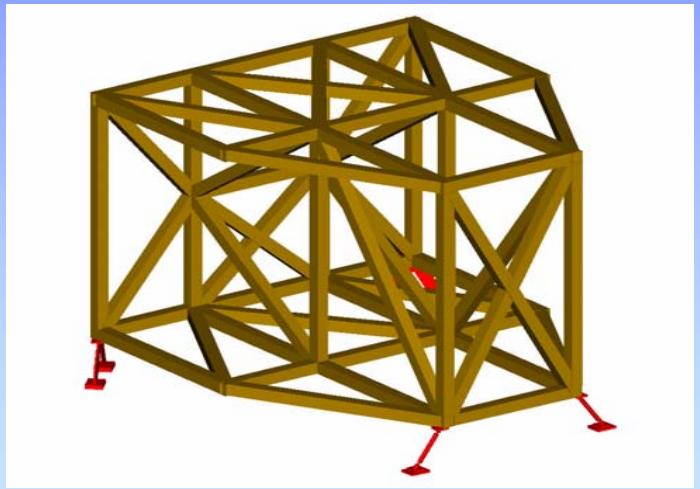
Extruded aluminum-beryllium alloy, AlBeMet162, at -195.5°C (77K) and -252.8°C (20K)

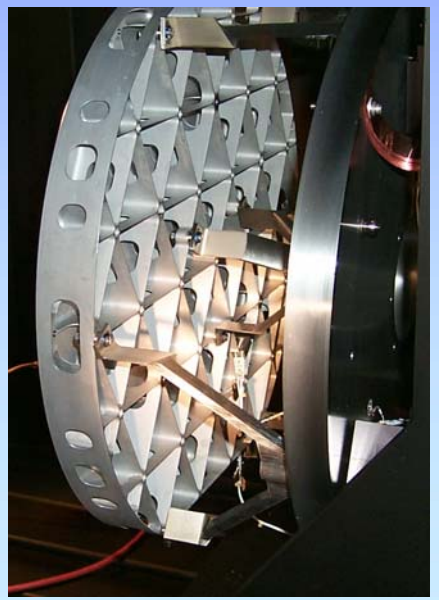
HIP consolidated optical grade beryllium alloy, O-30H, at -252.8°C (20K)

Background

Testing conducted for James Webb Space Telescope

- Integrated Science Instrument Module Structure





- Sub-scale Beryllium Mirror Demonstrator

Specifications

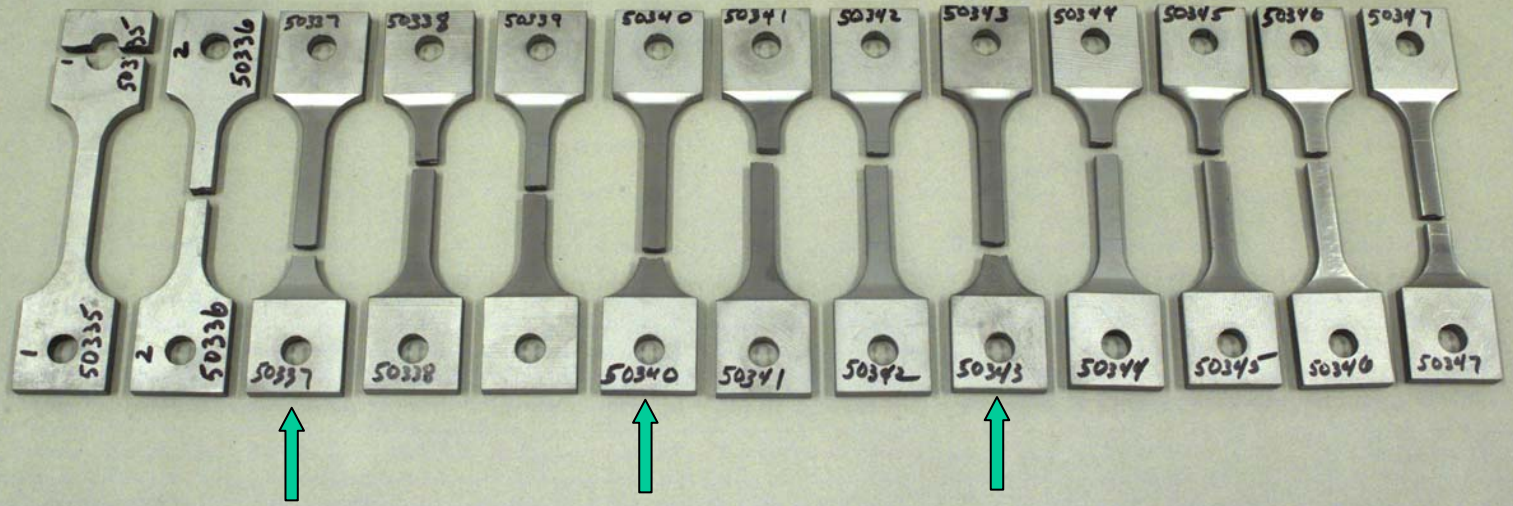
AlBeMet162 material purchased to SAE-AMS7912, "Aluminum-Beryllium Alloy, Extrusions."

O-30H material purchased to Brush Wellman Inc. specification "O-30H Optical Grade Beryllium."

Specimen Configuration

2 Be and
All AlBeMet

11 Be Samples modified because of Hole Failure:
Larger Holes and Thinner T-Section, did not Round Edges



Failed outside of Extensometer Region

HIP'ed Beryllium

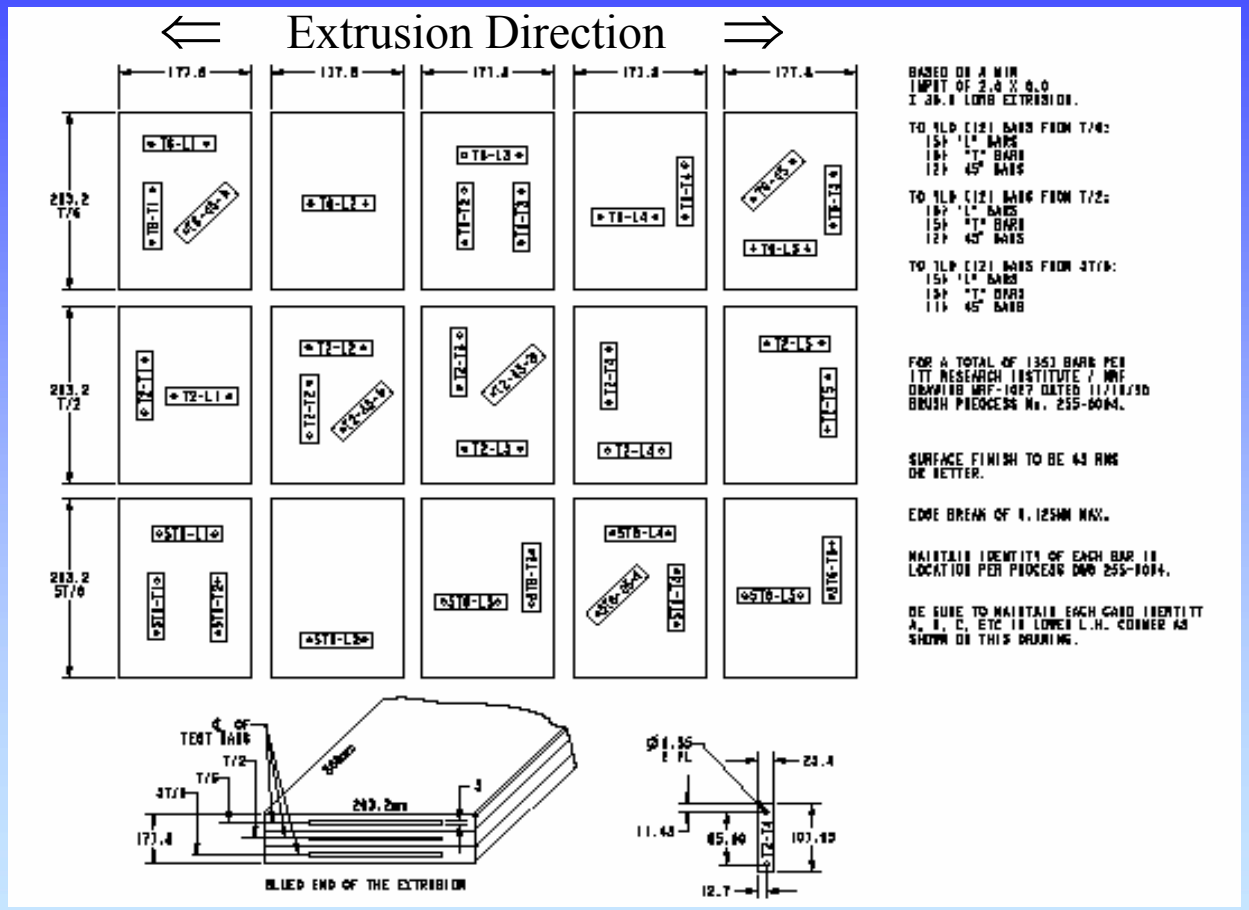
O-30H Beryllium Material

Specimen extraction locations for AlBeMet162

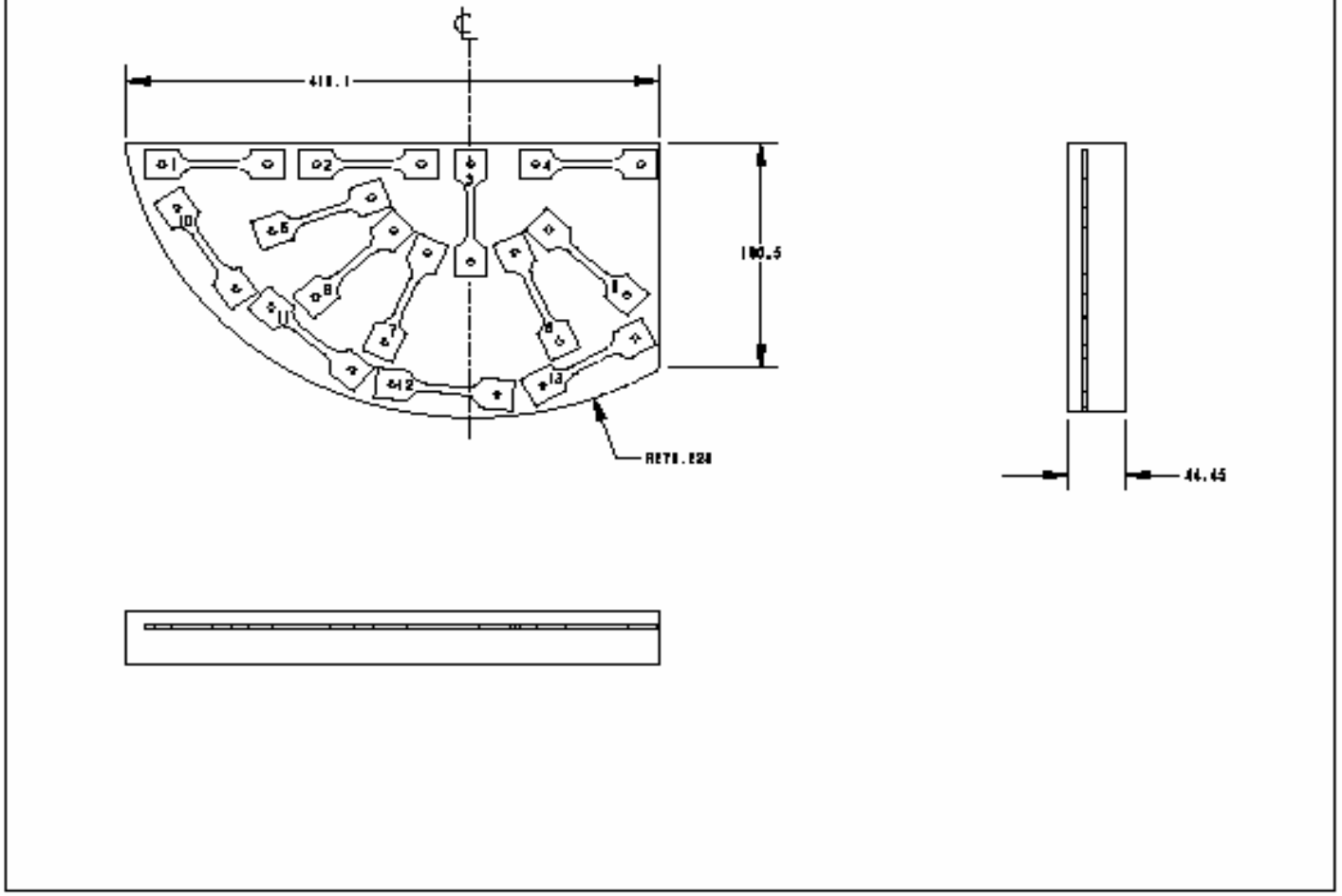
Top

Middle

Bottom



Room Temp AMS Spec shows different AlBeMet properties in different directions – samples to test at cryo.



Specimen extraction locations for O-30H beryllium

Cryogenic Test Procedure

All testing with MSFC Liquid Hydrogen Test Cell

Tensile testing per ASTM E8

Elastic Modulus per ASTM E111

(excluding statistical reduction techniques)

Just ran up & down elastic portion of stress/strain curve.

AlBeMet162 Results

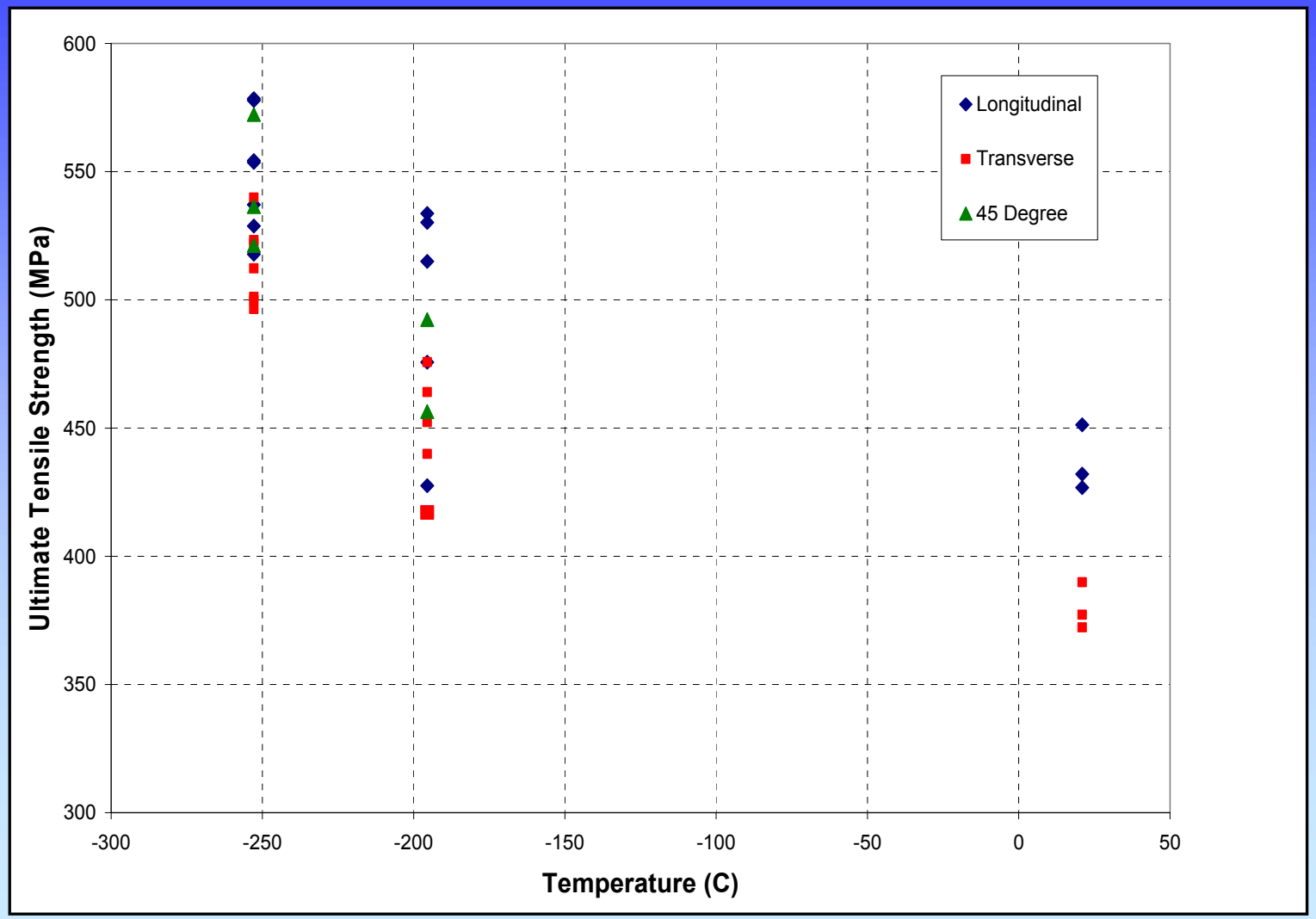
Mechanical mean property data
UTS (ultimate tensile strength) versus temperature
YS (yield strength) versus temperature
Elongation versus temperature
Design properties for UTS & YS versus temperature

AlBeMet162 Mean Properties

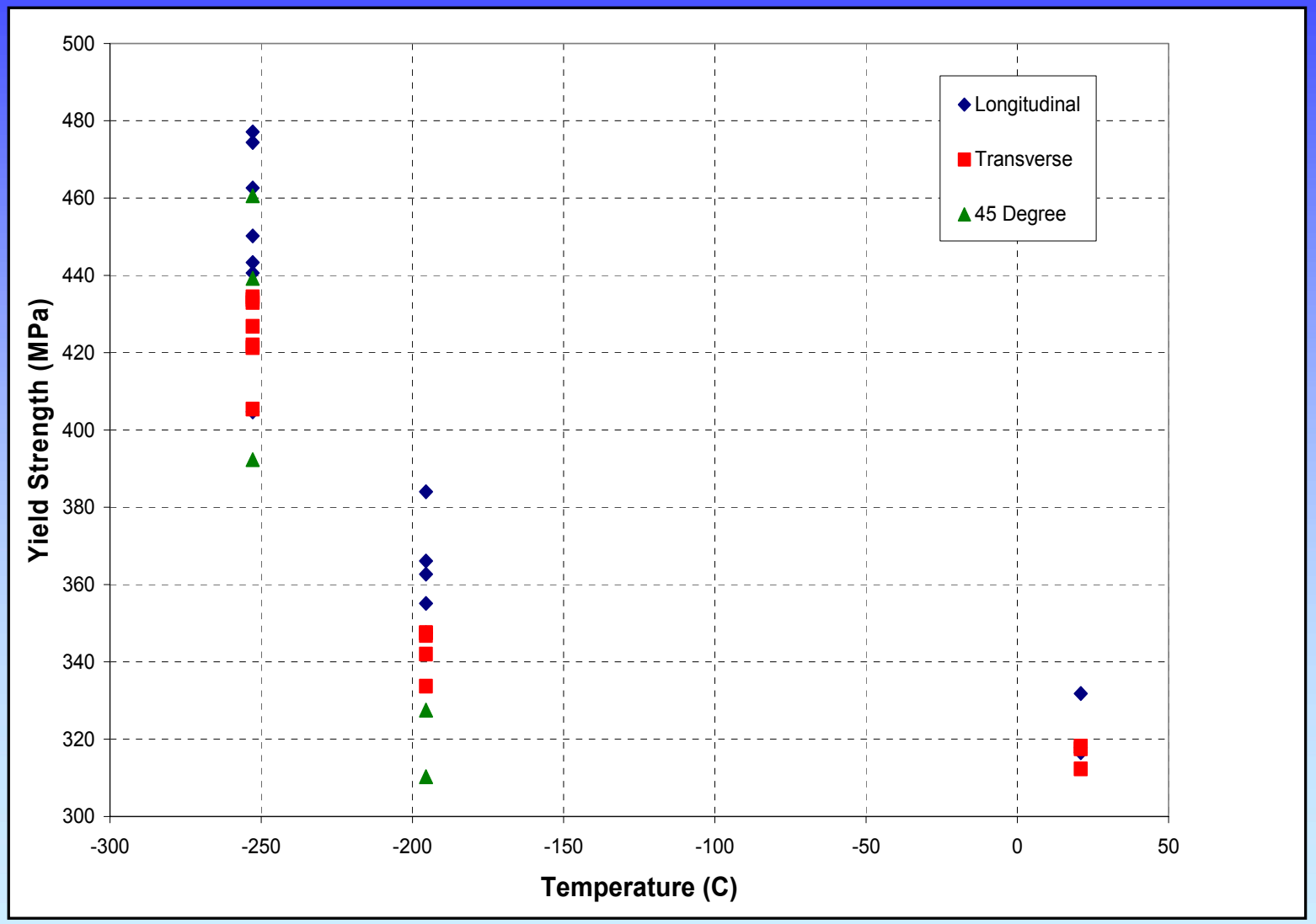
Temperature (°C)	Orientation	No. Specimens	UTS (MPa)	YS (MPa)	1" Elongation (%)
-252.8	L	7	549.7	450.4	1.2
-252.8	T	7	513.6	425.2	1.1
-195.5	L	5	496.4	363.1	3.0
-195.5	T	5	449.8	343.5	1.7
21.0	L	3	436.7	322 .0	7.4
21.0	T	3	379.8	316.0	2.6

L > T

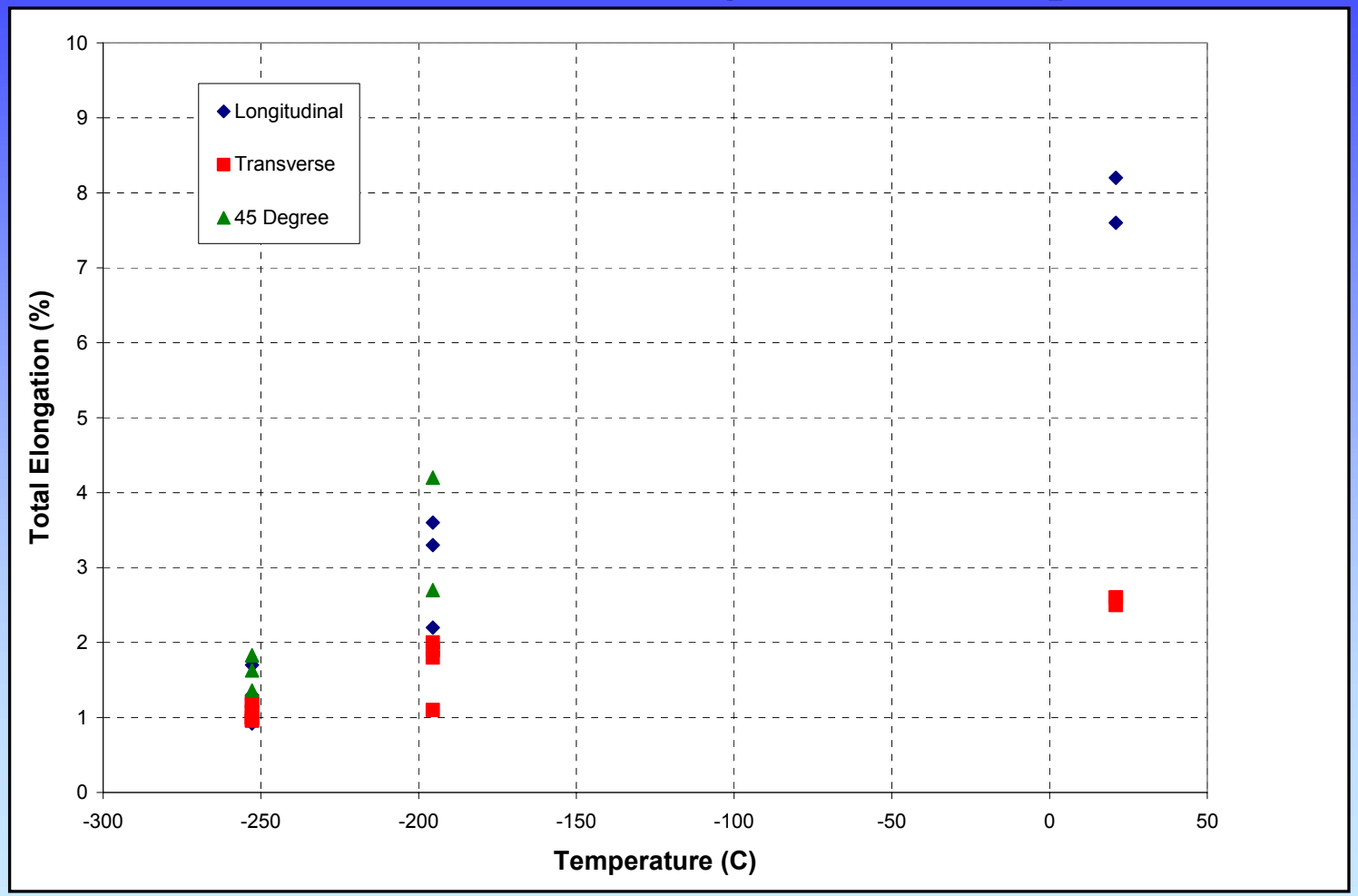
AlBeMet162 Ultimate Tensile Strength vs Temperature



AlBeMet162 Yield Strength vs Temperature



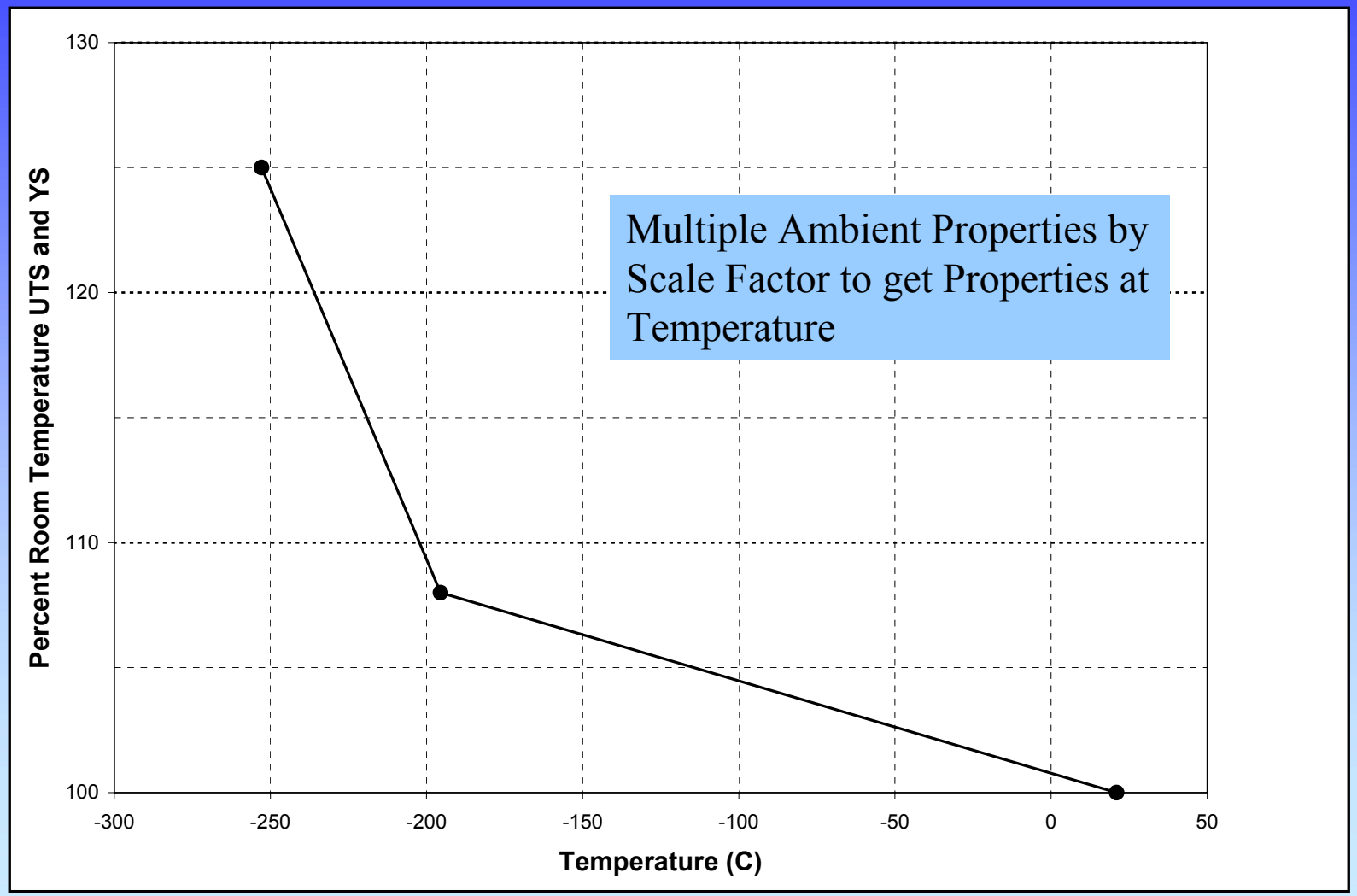
AlBeMet162 Total Elongation vs Temperature



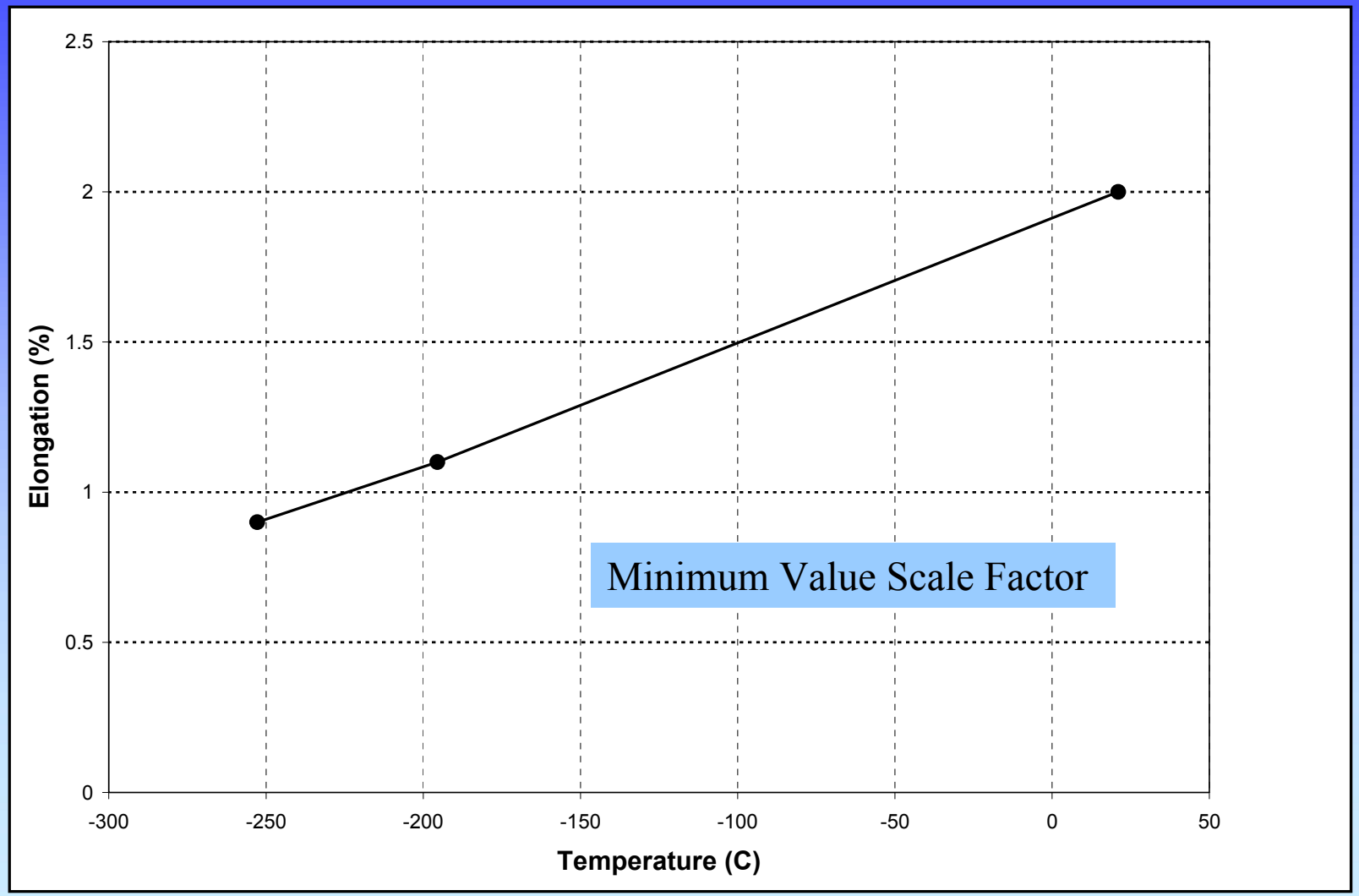
Spread at Ambient is consistent with AMS Spec

Convergence of Data is because of Low Ductility

AlBeMet162 Design Properties for UTS and YS vs Temperature



AlBeMet162 Design Properties for Elongation vs Temperature



O-30H Results

Mechanical mean property data

UTS versus temperature

Elongation versus temperature

Elastic Modulus versus temperature

O-30H Beryllium Mean Properties

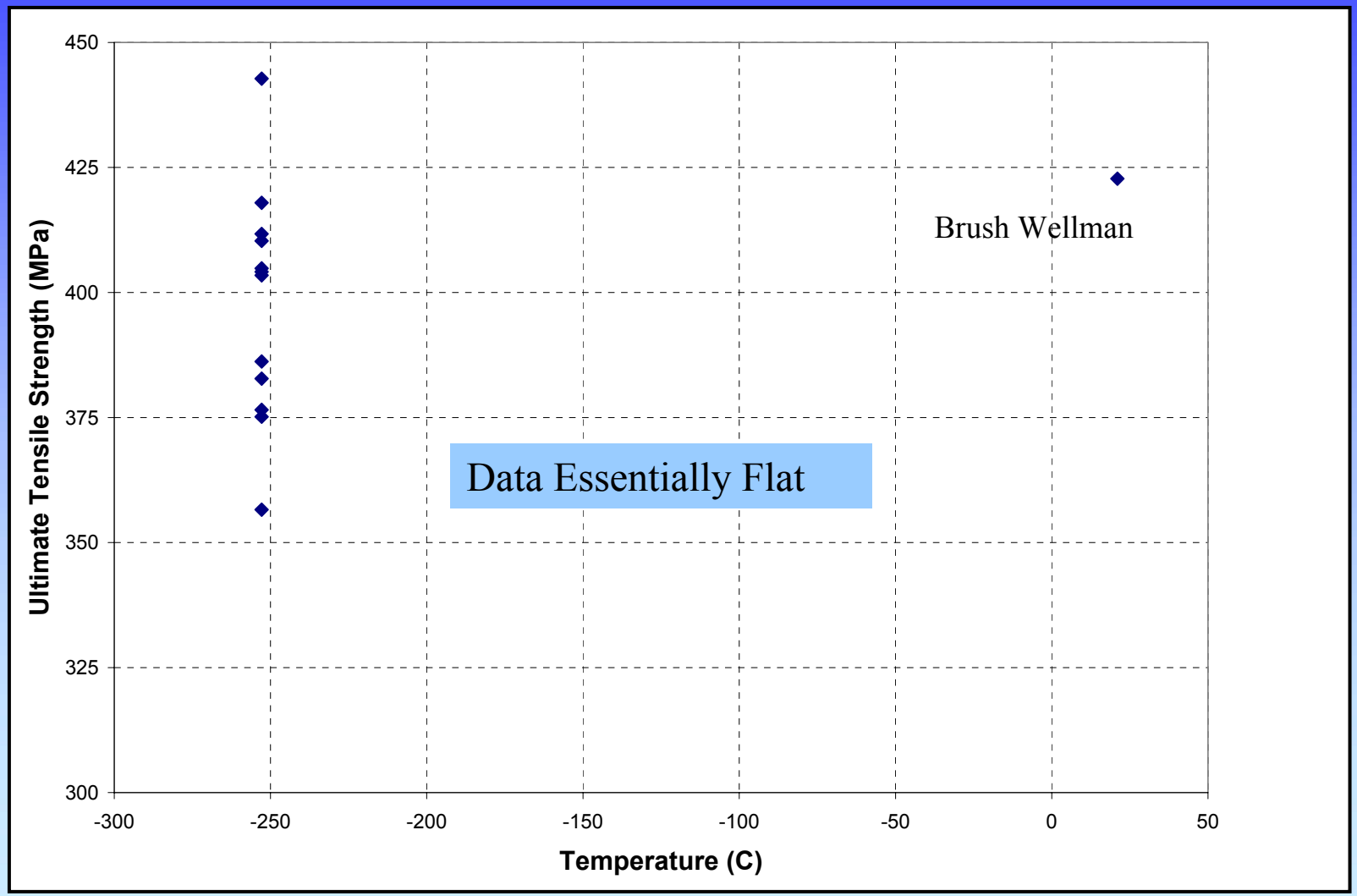
Temp. (°C)	Number of Specimens	Ultimate Tensile Strength (MPa)	1" Elongation (%)
-252.8	12	397.7	0.3
21.0	1	422.8	2.5

2 Ambient Data Sets Provide by Brush-Wellman

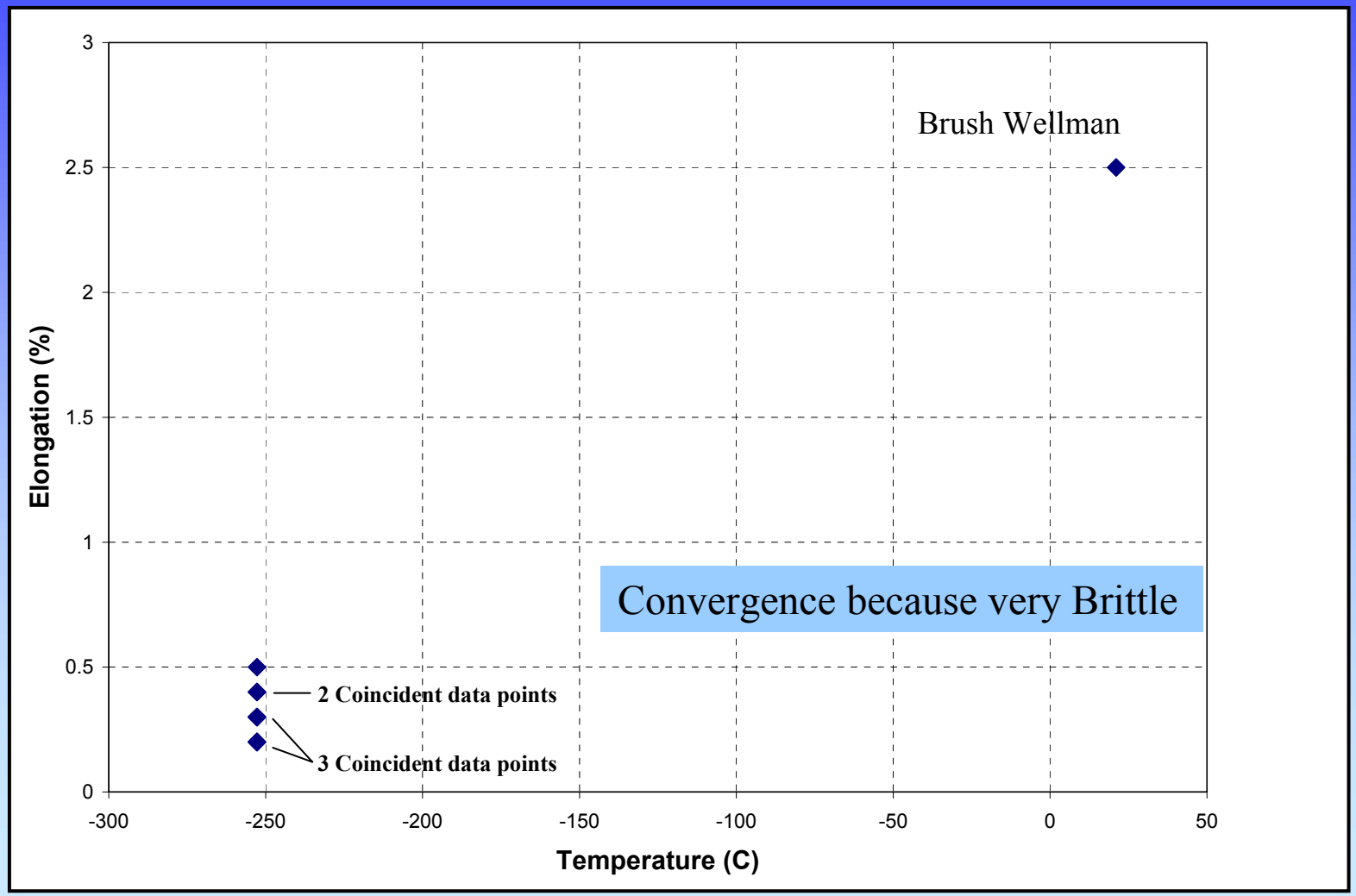
No Ambient Data taken at MSFC

No Yield Strength Data – Too Brittle – No Ductility

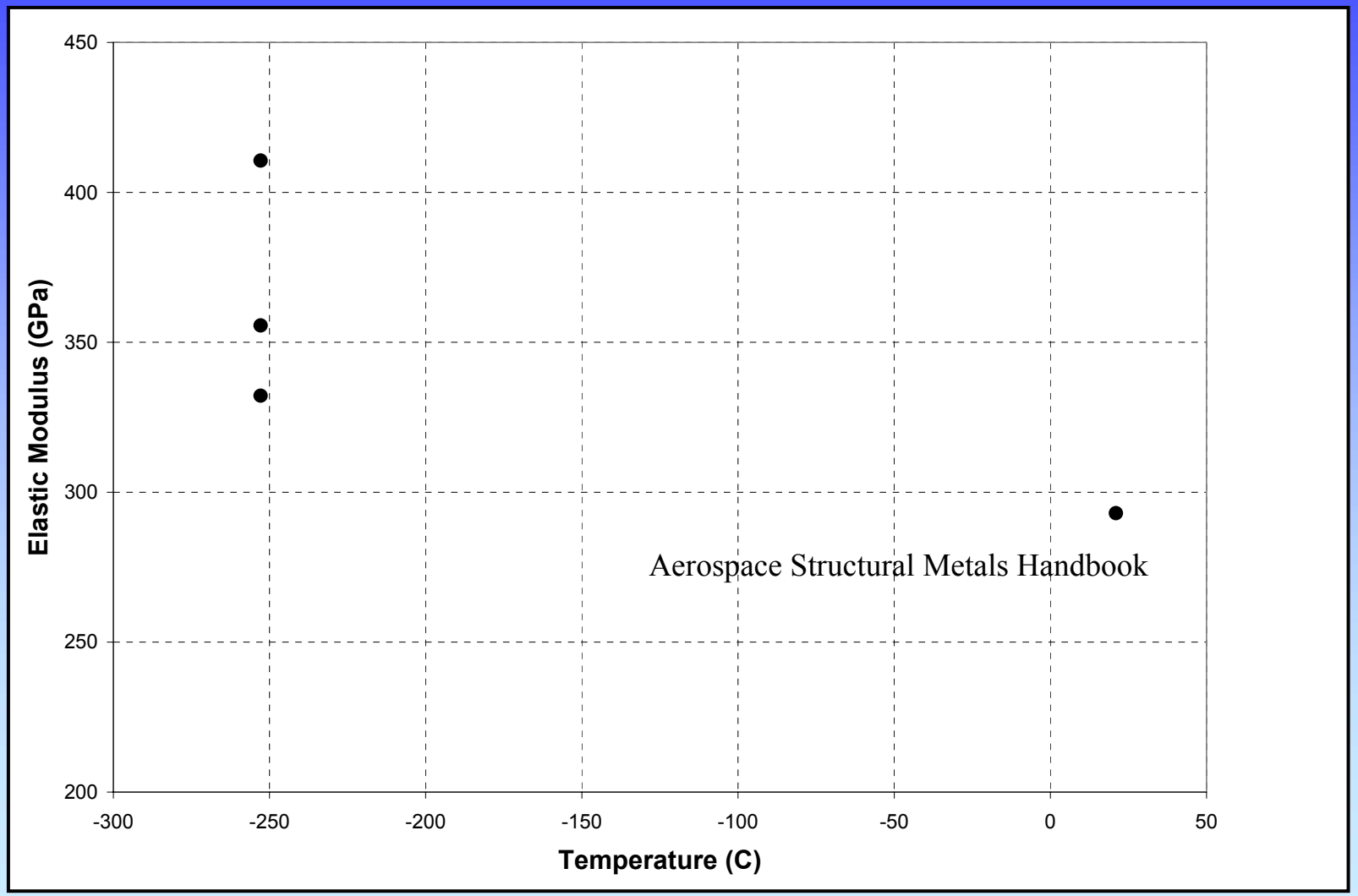
O-30H Beryllium Ultimate Tensile Strength vs Temperature



O-30H Beryllium Total Elongation vs Temperature



O-30H Beryllium Elastic Modulus vs Temperature



Conclusions

Both Materials do not have good Ductility

AlBeMet162:

- UTS & YS increased with decreasing temperature
- Elongation decreased with decreasing temperature
- UTS & YS are higher in the L direction than the L-T direction at cryogenic temperatures

O-30H:

- UTS remained unchanged at –252.8°C (20K) from room temperature value.
- Expected to be due to the notch sensitivity and low elongation of the material at cryogenic temperatures
- Elongation decreased with decreasing temperature
- Elastic modulus increased with decreasing temperature