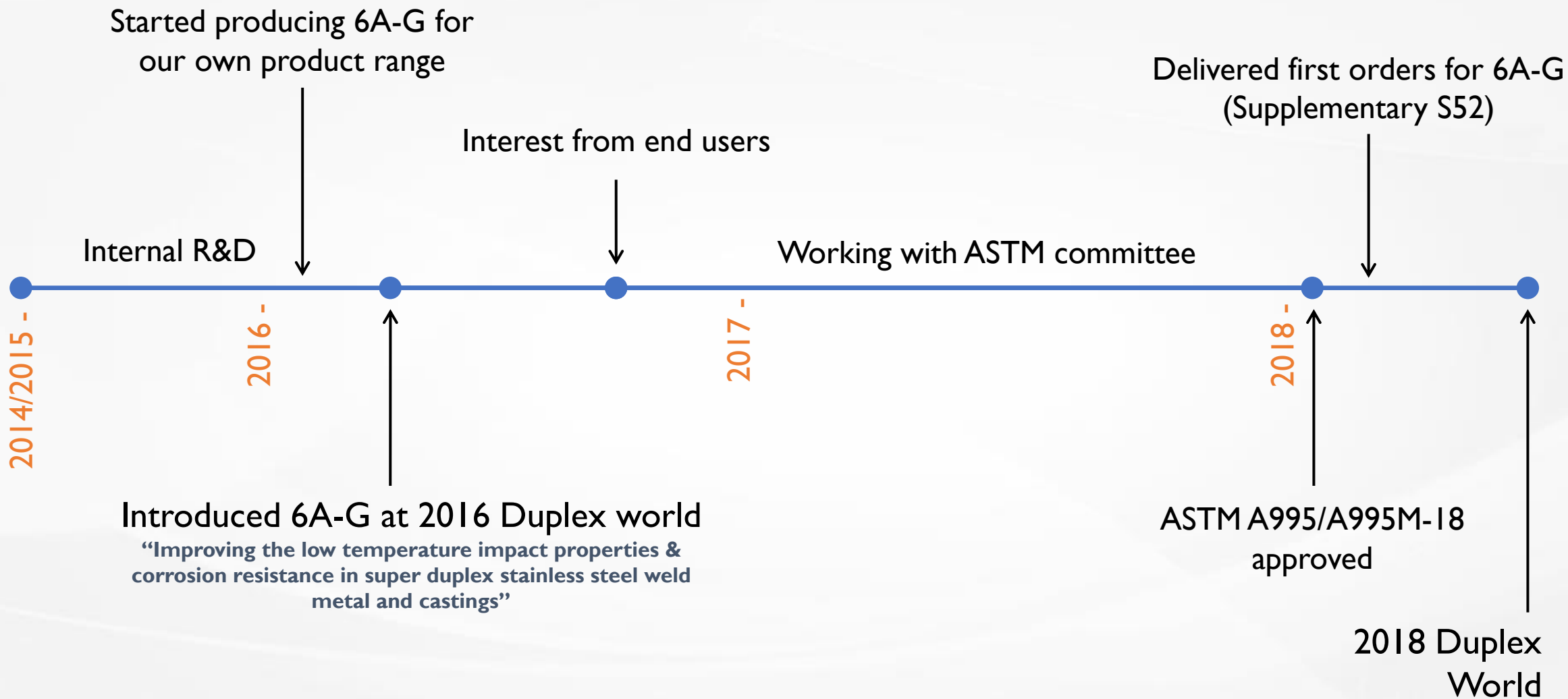




**Inclusion of the achievable properties from the new Super Duplex Grade 6A-G into the ASTM A995 standard as supplementary requirement S52.
“Additional Requirements for Grade 6A”.**

**Authors: Steve Roberts, Steve Birks
Presented by: Ryan Leese**

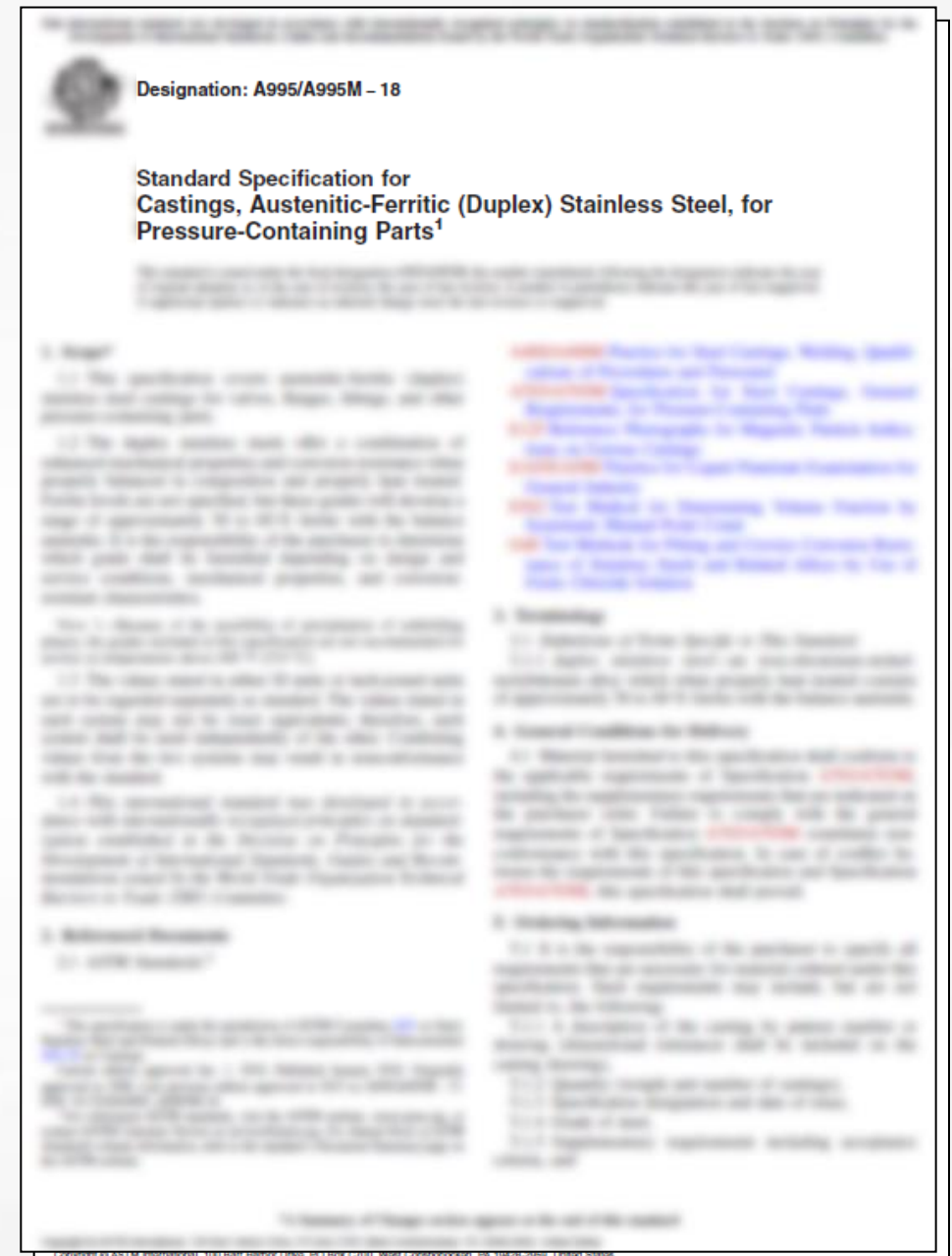


6A-G SUPER DUPLEX

SOPHISTICATED MATERIALS FOR DEMANDING APPLICATIONS

- Compliant with the chemical requirements of A995 grade 6A
- Technical performance is achieved by having a far more stringent chemistry control than required by conventional specifications.
- The precipitation of sigma phase is retarded in 6A-G compared to conventional grade 6A
- Impact properties increased. Suitable for Arctic conditions down to -101°C
- Pitting corrosion properties are enhanced
- Heavy wall thickness casting can be manufactured up to 300mm
- Matching weld consumables developed by WB alloys – GTAW, SMAW & TIG

- ASTM approached by end users interested in the potential of an enhanced grade of 6A
- Subcommittee A01 worked on a revision to the standard A995 to include supplementary testing. The purpose this was to allow purchasers to specify enhanced properties giving greater levels of confidence and safety margins.
- Goodwin provided mechanical test data to the subcommittee
- Supplementary in ASTM A995-18 approved January 2018



ASTM A995

Testing options

ASTM A995-13		ASTM A995-18	
Tensile Testing	9.1	Tensile Testing	9.1
Estimating ferrite content	S50	Estimating ferrite content	S50
		Casting thickness	S52.1
		Charpy impact test	S52.2
		Corrosion Testing	S52.3
		Weld qualification	S52.4

ASTM A995

Testing options

ASTM A995-13		ASTM A995-18	
Tensile Testing	9.1	Tensile Testing	9.1
Estimating ferrite content	S50	Estimating ferrite content	S50
		Casting thickness	S52.1
		Charpy impact test	S52.2
		Corrosion Testing	S52.3
		Weld qualification	S52.4

S52.1 Casting Thickness, T—The casting thickness, T , is the maximum thickness of the pressure-containing wall of the casting exclusive of padding added for directional solidification, flanges, appendages, and sections designated by the designer as noncritical. The order, inquiry, and drawing shall designate what the test dimension, T , is for the casting.

- Test blocks have to be equal thickness of the casting, T
- Larger castings have slower cooling rates
- It is important the test material represents the casting
- ASTM A1067 does not adequately specify test block size



ASTM A995

Testing options

ASTM A995-13		ASTM A995-18	
Tensile Testing	9.1	Tensile Testing	9.1
Estimating ferrite content	S50	Estimating ferrite content	S50
		Casting thickness	S52.1
		Charpy impact test	S52.2
		Corrosion Testing	S52.3
		Weld qualification	S52.4

S52.2 Charpy Impact Test—Charpy impact test properties shall be determined by testing a set of three Charpy V-notch impact specimens made from each heat of material.

S52.2.1 The thickness of the test blocks used to create Charpy impact test specimens shall be equal to the casting thickness, T . Charpy impact test specimens shall be removed from a location at one-half the thickness of the test block.

S52.2.2 When the thickness of the test block is less than or equal to 4 in. (100 mm), Charpy impact testing shall be performed at one of the test temperatures listed in Table S52.1.

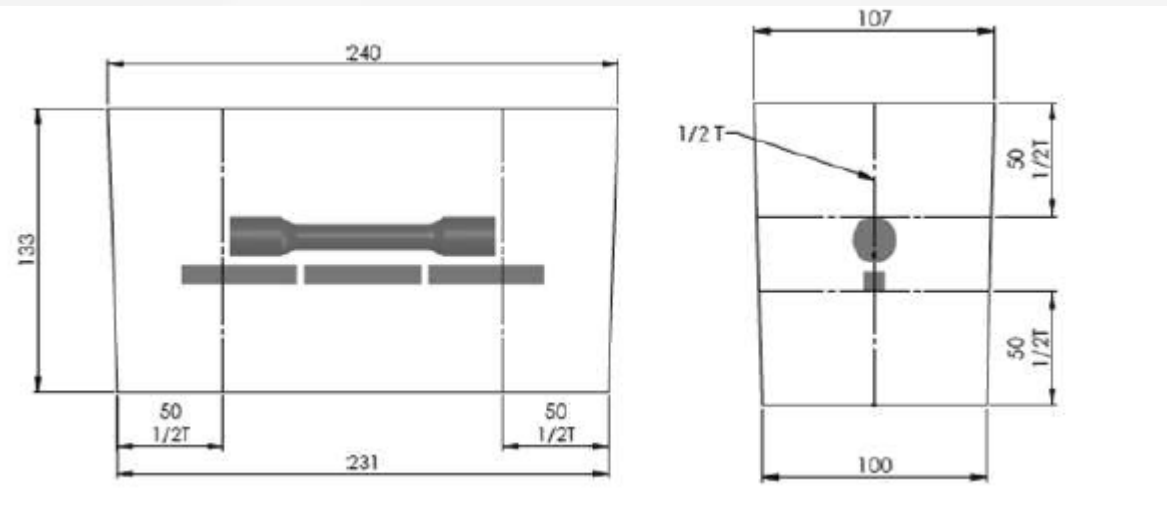
TABLE S52.1 Charpy Impact Testing of Base Material

NOTE 1—It is recommended that test temperature selection be determined based on the intended service temperature of the casting.

Test Temperature °F [°C]	Charpy V-Notch Impact Requirements	
	Energy Value, ft-lbf [J], min value for two specimens and min average of three speci- mens	Energy Value, ft-lbf [J], min for single specimen
-51 [-46]	103 [140]	77 [105]
-105 [-76]	66 [90]	48 [65]
-150 [-101]	44 [60]	33 [45]

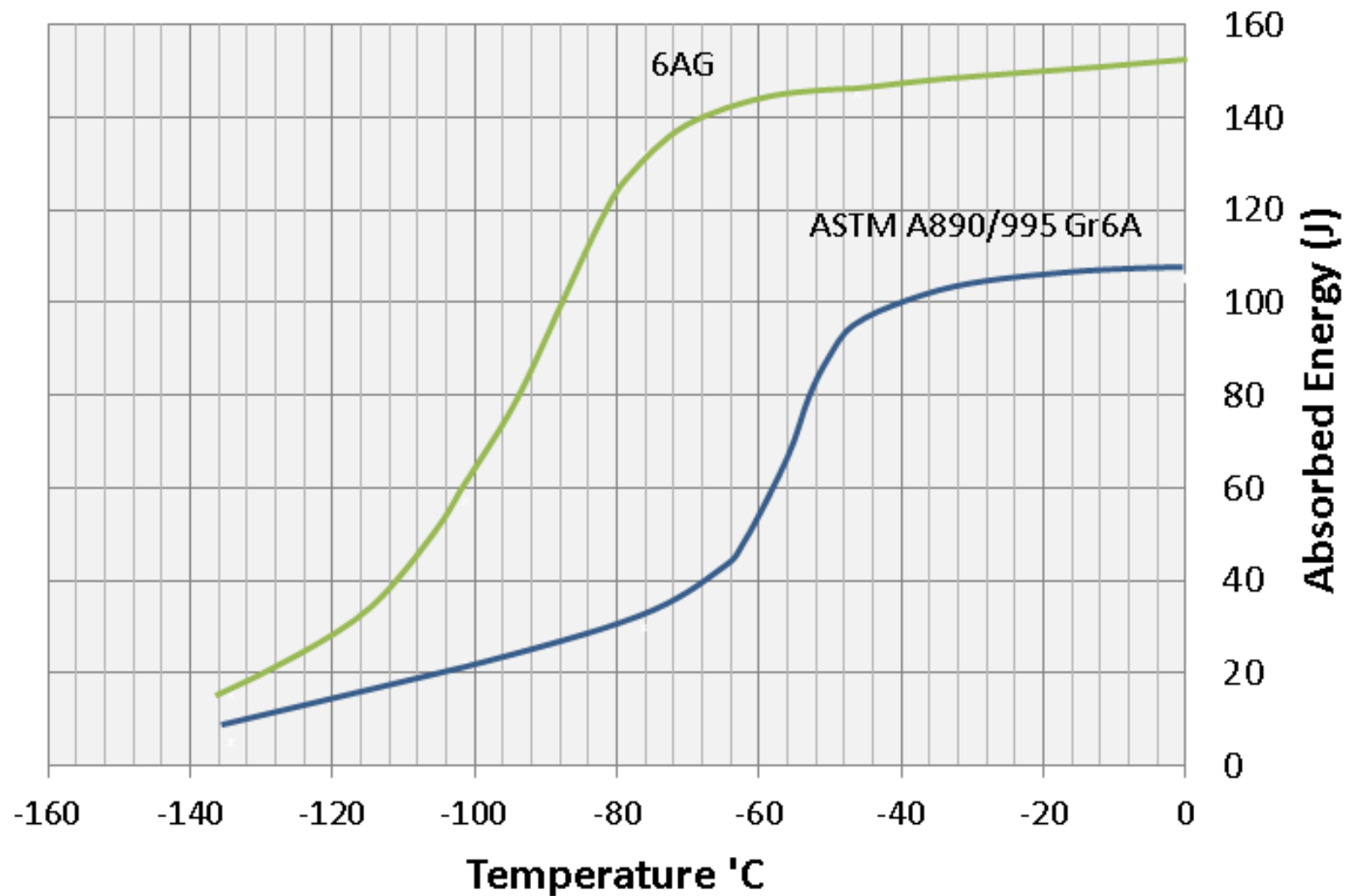
The test temperature shall be provided by the purchaser. If the test temperature is not specified, the test temperature used shall be -51°F (-46°C). The average value of the three specimens shall not be less than specified in Table S52.1, with no more than one value permitted below the average minimum specified and no value permitted below the minimum specified for a single specimen.

S52.2.3 When the thickness of the test block is greater than 4 in. (100 mm), test temperature and absorbed energy values shall be agreed upon between the purchaser and the manufacturer.



- $\frac{1}{2} T$ Testing of representative block
- A choice of -46°C , -76°C or -101°C
- Elevated minimum values
- Up to $T=100\text{mm}$. Anything over 100mm is to be agreed between purchaser and manufacturer
- Allows for greater level of confidence and safety factor

IMPACT PROPERTIES versus TEMPERATURE
6AG & conventional 6A Cast Super Duplex - (1/2T where T= 150mm)



ASTM A995

Testing options

ASTM A995-13		ASTM A995-18	
Tensile Testing	9.1	Tensile Testing	9.1
Estimating ferrite content	S50	Estimating ferrite content	S50
		Casting thickness	S52.1
		Charpy impact test	S52.2
		Corrosion Testing	S52.3
		Weld qualification	S52.4

S52.3 *Corrosion Testing*—A Test Methods G48 Method A ferric chloride pitting resistance test shall be performed for a duration of 24 h at 60 °C.

S52.3.1 The thickness of the test blocks used to create corrosion test specimens shall be equal to the casting thickness, *T*. Corrosion test specimens shall be removed from a location at one-quarter the thickness of the test block.

S52.3.2 When the thickness of the test block is less than or equal to 4 in. (100 mm), test specimens shall show no evidence of pitting when examined optically at 20× magnification, and have a weight loss of 4g/m^2.

S52.3.3 When the thickness of the test block is greater than 4 in. (100 mm), test block size and acceptance criteria shall be agreed upon between the purchaser and the manufacturer.

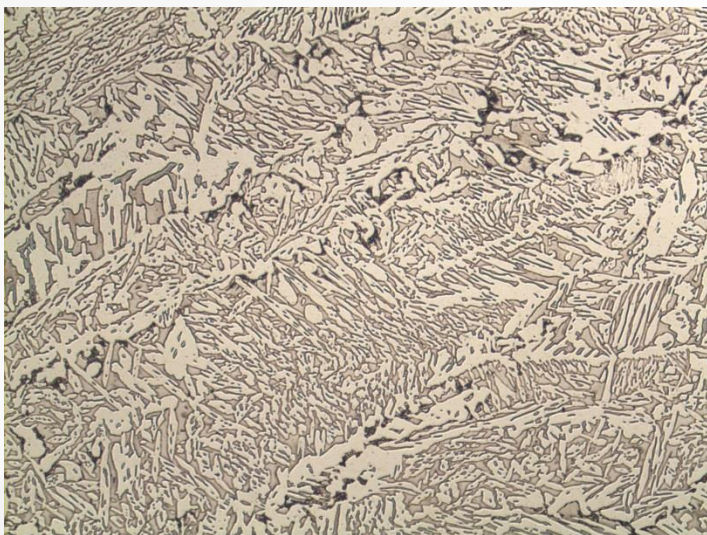
- 10°C above conventional specifications
- Testing at ¼ T of representative block
- Up to T=100mm. Anything over 100mm is to be agreed between purchaser and manufacturer
- Allows for greater level of confidence and safety factor

ASTM A995

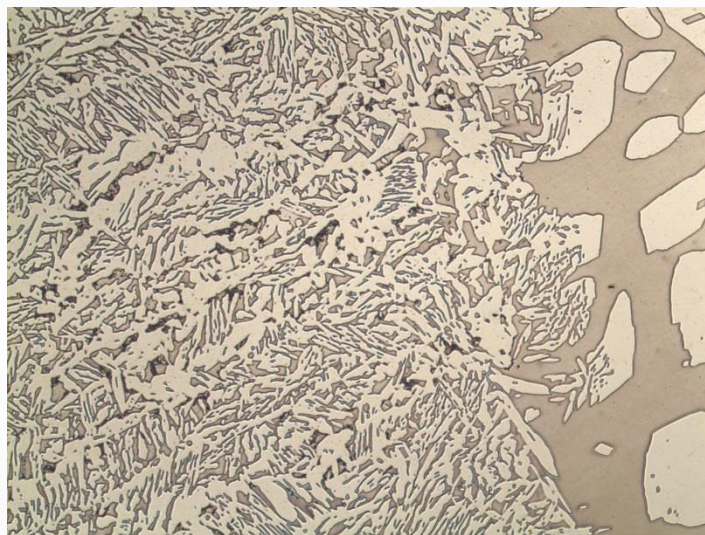
Testing options

ASTM A995-13		ASTM A995-18	
Tensile Testing	9.1	Tensile Testing	9.1
Estimating ferrite content	S50	Estimating ferrite content	S50
		Casting thickness	S52.1
		Charpy impact test	S52.2
		Corrosion Testing	S52.3
		Weld qualification	S52.4

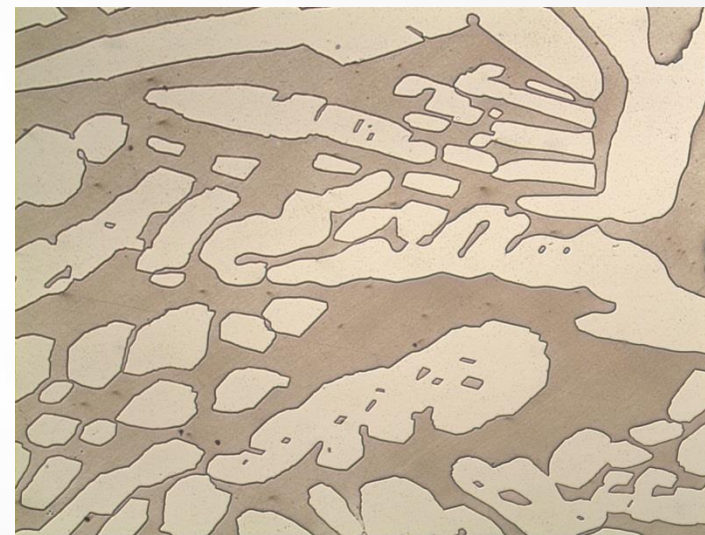
- In our opinion, ASME and ASTM welding codes for duplex steel are not stringent enough
- Super Duplex filler materials precipitate sigma faster than the parent material



Weld



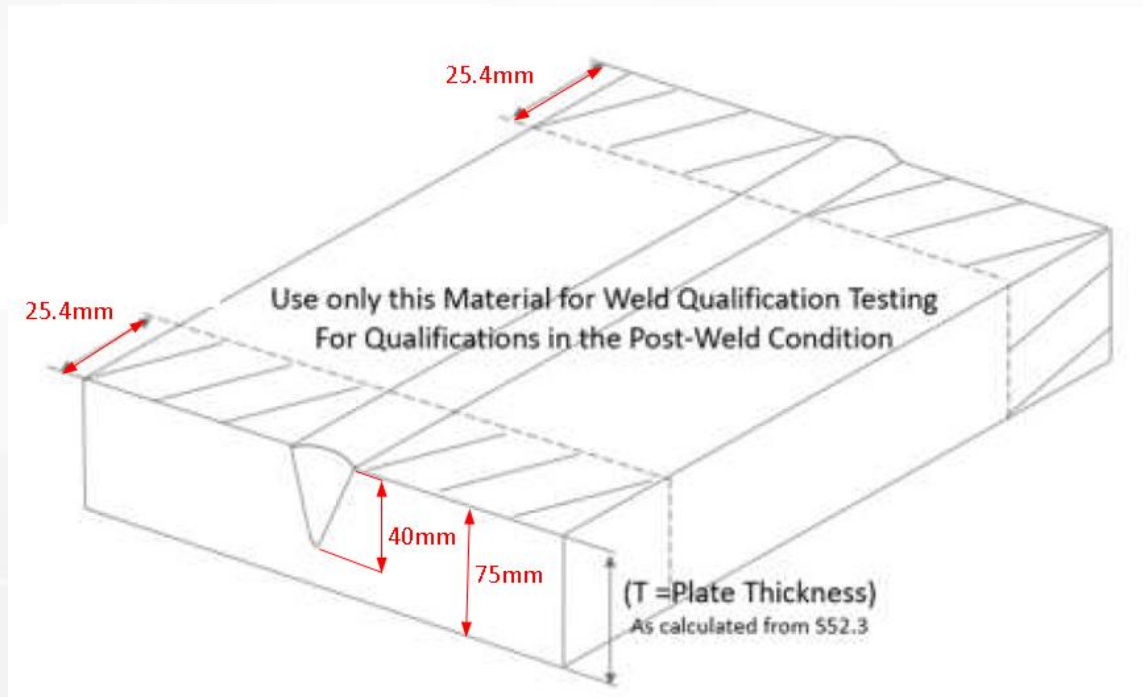
Fusion Line



Parent

100mm depth – mid thickness

- S52.4 ensures the casting supplier and purchaser agree weld coupon / test plate thickness for the PQR
- Coupon / plate no less than **1.5** times the maximum weld repair depth
- Weld deposit thickness shall be at least **80%** of the max repair depth



Example:

To qualify a 50mm deep weld repair

Weld test plate [**1.5** × 50mm] = 75mm

Weld deposit thickness [**0.8** × 50mm = 40mm]

- Testing at weld cap, mid-thickness, FL, FL+2 & FL+5
- A choice of -46°C, - 76°C or -101°C
- G48 Method A (50% parent, 50% weld)
 - PWHT'd @ 50°C
 - As Welded @ 60°C
- Weld coupon / plate to T=100mm. Anything over 100mm is to be agreed between purchaser and manufacturer

TABLE S52.2 Weld Qualification Impact Testing for Post-Weld Solution-Treated Coupons

NOTE 1—It is recommended that test temperature selection be determined based on the intended service temperature of the casting.

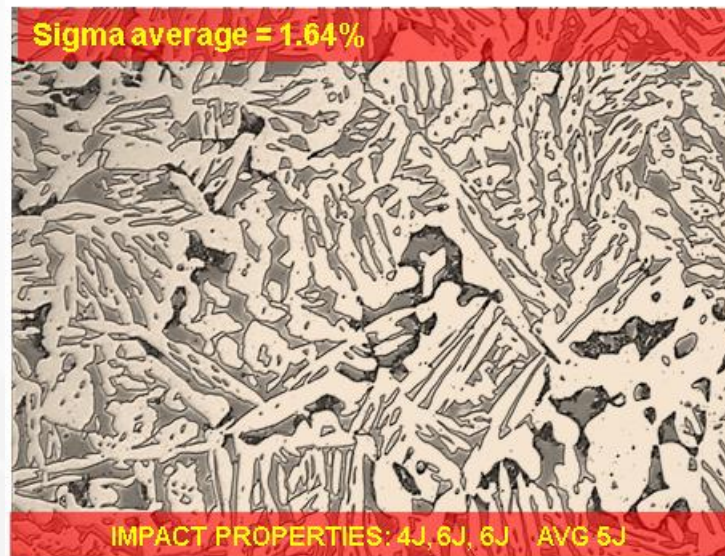
Test Temperature °F [°C]	Charpy V-Notch Impact Requirements	
	Energy Value, ft-lbf [J], min value for two specimens and min average of three specimens	Energy Value, ft-lbf [J], min for single specimen
-51 [-46]	74 [100]	55 [75]
-105 [-76]	44 [60]	33 [45]
-150 [-101]	33 [45]	26 [35]

TABLE S52.3 Weld Qualification Impact Testing for As-Welded Coupons

Test Temperature °F [°C]	Charpy V-Notch Impact Requirements	
	Energy Value, ft-lbf [J], min value for two specimens and min average of three specimens	Energy Value, ft-lbf [J], min for single specimen
-51 [-46]	89 [120]	66 [90]
-105 [-76]	44 [60]	33 [45]
-150 [-101]	33 [45]	26 [35]

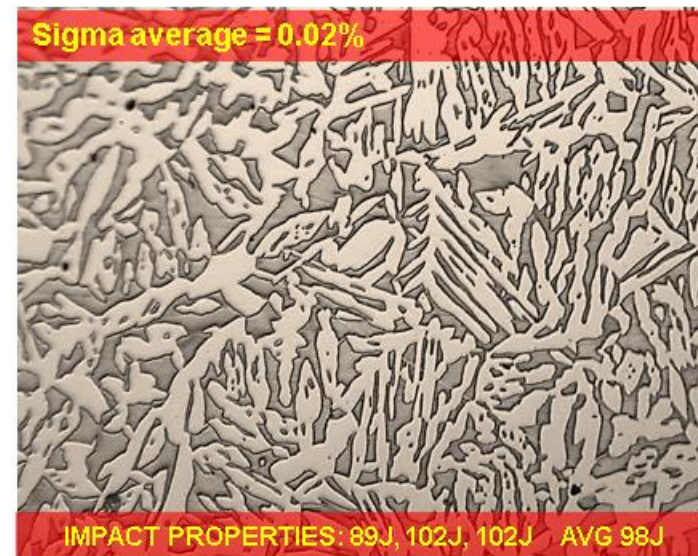
- Testing at weld cap, mid-thickness, FL, FL+2 & FL+5
- A choice of -46°C, - 76°C or -101°C
- G48 Method A (50% parent, 50% weld)
 - PWHT'd @ 50°C
 - As Welded @ 60°C
- Weld coupon / plate to T=100mm. Anything over 100mm is to be agreed between purchaser and manufacturer

Filler: Conventional



Magnification : x200
Etchant: electrolytic NaOH

Filler: WB Alloys 6A-G



Magnification : x200
Etchant: electrolytic NaOH

100mm depth – mid thickness



**Inclusion of the achievable properties from the new Super Duplex Grade 6A-G into the ASTM A995 standard as supplementary requirement S52.
“Additional Requirements for Grade 6A”.**

Summary

- **6A-G has enhanced properties over conventional 6A**
- **Industry / end user interest**
- **ASTM A995-18 supplementary S52**
- **Reinstall faith in cast super duplex**

Authors: Steve Roberts, Steve Birks
Presented by: Ryan Leese