

A large industrial pressure vessel is being assembled in a factory. The vessel is composed of several large, cylindrical sections that are being joined together. The interior of the vessel is visible, showing a smooth, dark surface. The factory floor is concrete, and there are various pieces of equipment and workers visible in the background. The lighting is bright, highlighting the metallic surfaces of the vessel.

Part 1: Developments in Australian Pressure Vessel Standard AS 1548

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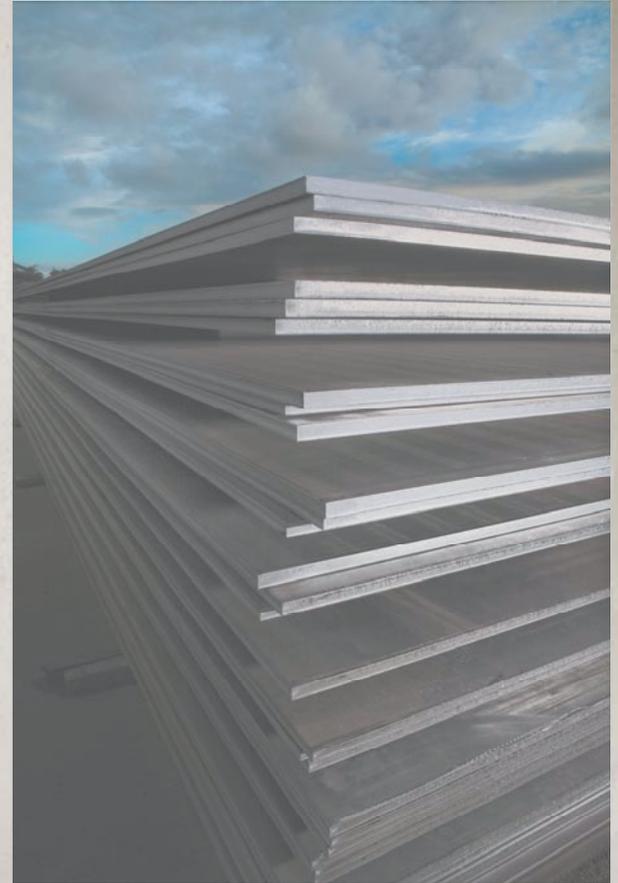
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Xlerplate[®]



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1. Grade designation changes

Grade Designation Changes

Grade Nomenclature

AS 1548-PT490TL20

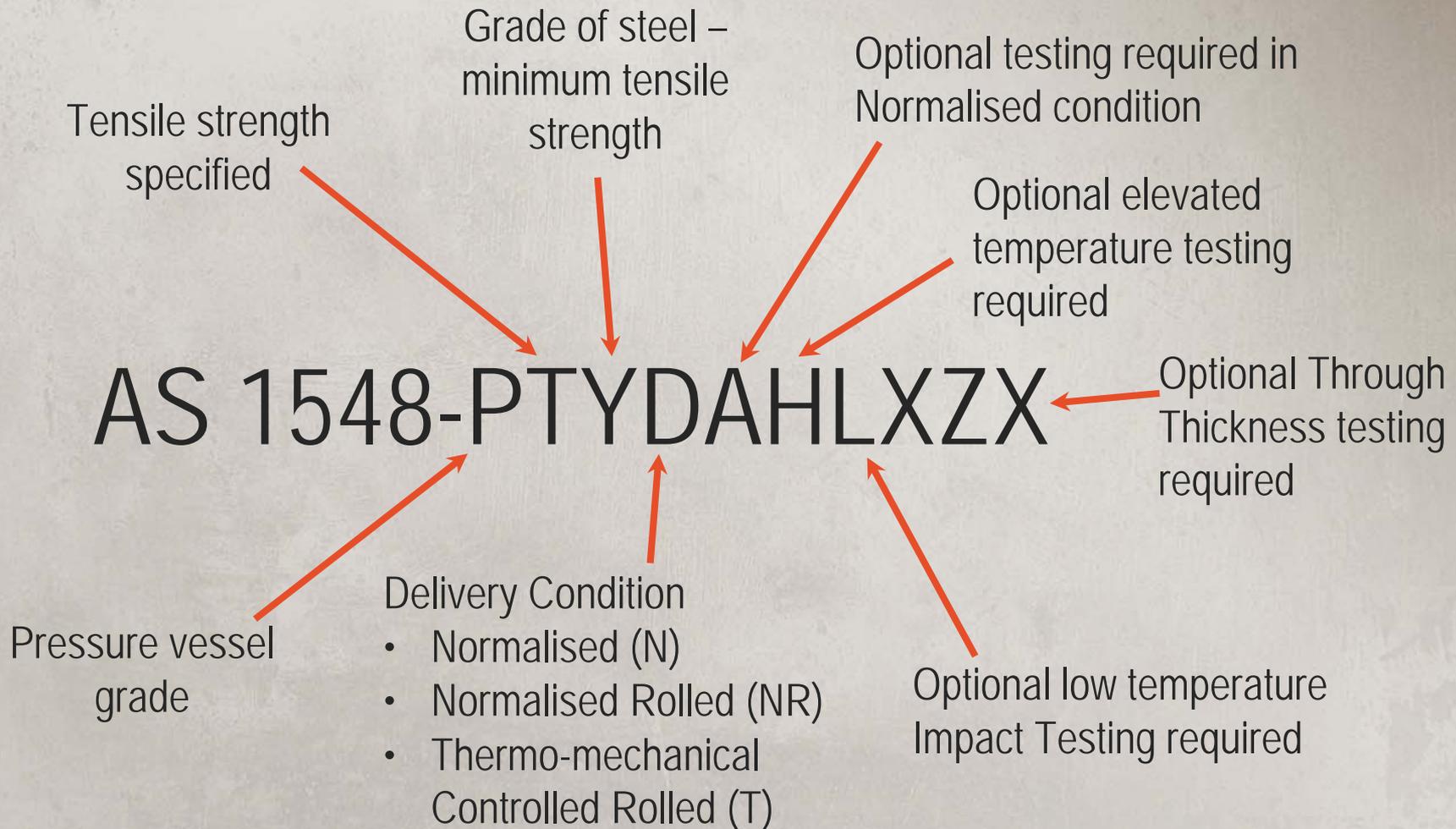
Grade of steel –
490 MPa minimum
tensile strength

Delivery Condition
- Thermo-mechanical
Controlled Rolled (T)

Low Temperature
Impact Testing required
at -20°C

Grade Designation Changes

Nomenclature – Generic Grade



Grade Designation Changes

Grade nomenclature example

AS 1548-PT460NRH

Grade of Steel –
460 MPa minimum
tensile strength

Delivery Condition
- Normalised Rolled

Elevated Temperature
Testing required

Grade Designation Changes

Grade nomenclature example

AS 1548-PT490N Z25

Grade of Steel –
490 MPa minimum
tensile strength

Delivery Condition
- Normalised

Through Thickness
Testing required (25%
minimum Raz)

Grade Designation Changes

1995 Designation	2008 Designation
AS 1548-7-460R	AS 1548-PT460NR
AS 1548-7-460NH	AS 1548-PT460NH
AS 1548-7-460AL20	AS 1548-PT460NRAL20
AS 1548-7-460T	AS 1548-PT460T
AS 1548-7-490TL20	AS 1548-PT490TL20
AS 1548-7-490R	AS 1548-PT490NR
AS 1548-7-490N	AS 1548-PT490N
AS 1548-5-490N	AS 1548-PT490N
AS 1548-5-490A	AS 1548-PT490NRA
AS 1548-5-490NH	AS 1548-PT490NH

2. Explanation of delivery conditions

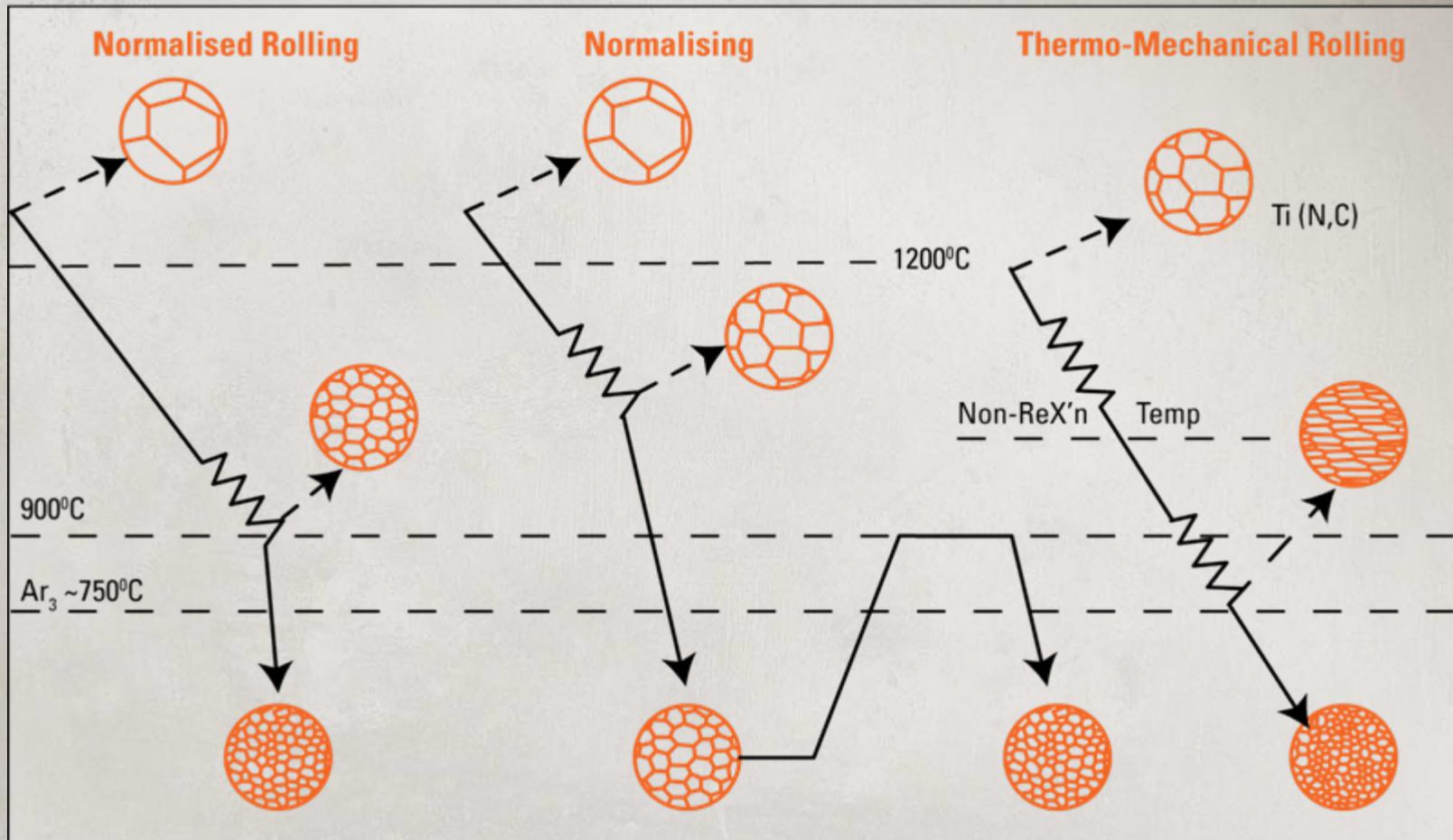
Explanation of Delivery Conditions

1. The 2008 version of AS 1548 recognises the following Delivery Conditions:
 - Normalised Rolled (NR)
 - Normalised (N)
 - Thermo-Mechanical Controlled Rolled (T)



Explanation of Delivery Conditions

PLATE PRODUCTION PROCESS



Explanation of Delivery Conditions

Normalised Rolled

1. A **rolling process** in which the final deformation (rolling pass) is carried out in a certain temperature range that produces a material condition **equivalent** to that obtained after normalising.
2. Normalised rolling is **NOT** normalising.
3. Normalised rolling replaces the R and A interchangeability clause of the AS 1548-1995 Standard.
4. Normalised rolled grades produce a fine grained structure that is suitable for hot forming or PWHT at normalising temperatures.

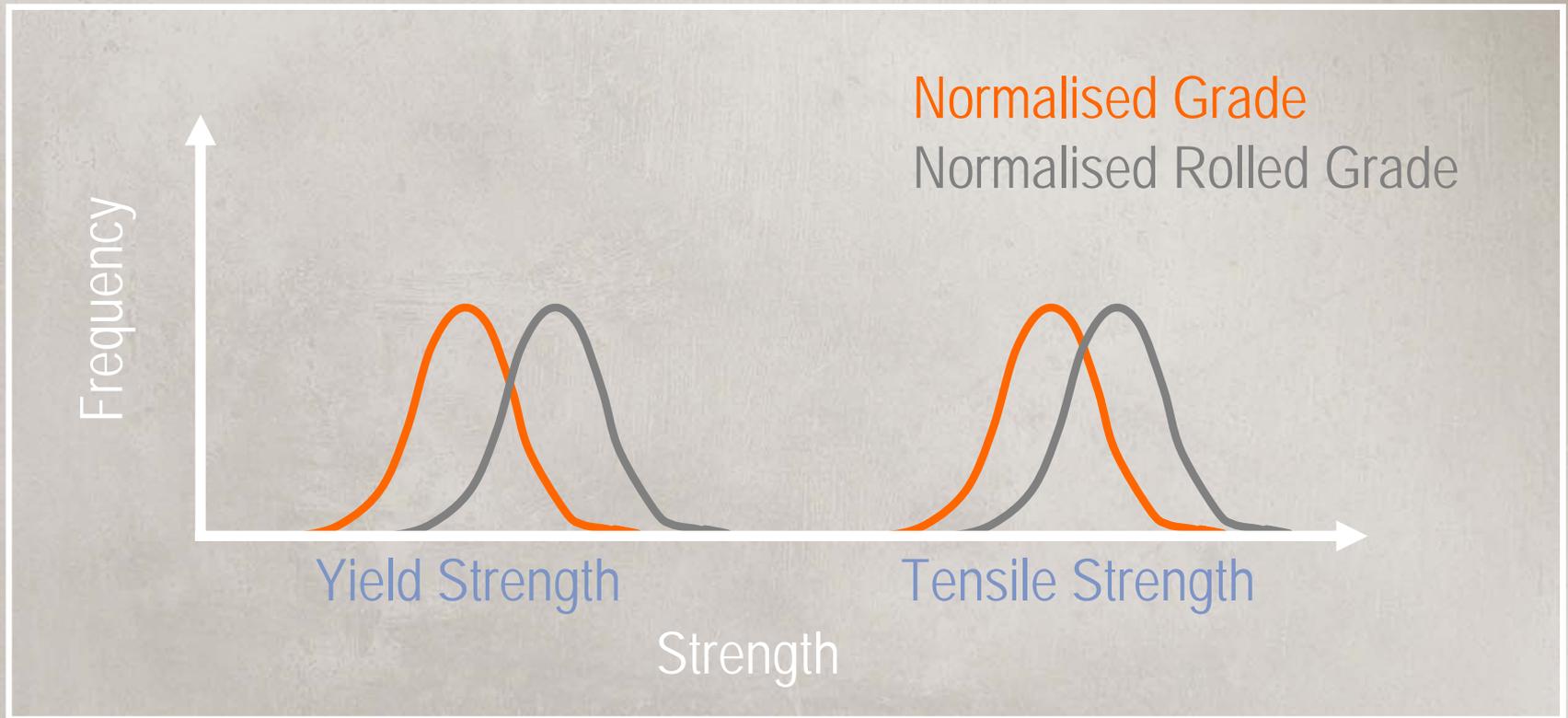
Explanation of Delivery Conditions

Normalised

1. Heat treatment process done **after rolling** in which the plate is heated in the temperature range of 870 – 930°C
2. Normalising:
 - used to refine the grain structure of the steel
 - increases strength and toughness (good low temperature Charpy properties)
 - generally relies on higher CEQ (than TMCP) to achieve strength
 - may be used for PWHT
3. Normalised grades (N) may be replaced by Normalised Rolled (NR) grades with agreement between the purchaser and the manufacturer.

Explanation of Delivery Conditions

A comparison of properties for Normalised and Normalised rolled grades



Explanation of Delivery Conditions

Thermo-Mechanical Controlled Rolled (T)

1. A **rolling process** in which a significant amount of deformation takes place at temperatures below the normalising range.
 - Leads to a fine grain structure
2. TMCR grades are used to achieve improved strength and toughness with relatively low CEQ's chemistries.
 - Developed to improve the weldability of high strength steels
3. Not suitable for hot forming at temperatures $>620^{\circ}\text{C}$
 - Hot forming at temperatures $>620^{\circ}\text{C}$ may lead to grain coarsening and a decrease in strength and toughness

Explanation of Delivery Conditions

Normalised Rolled with Normalised test pieces (NRA)

1. Grades with an NRA supply condition in the 2008 version of the Standard replace grades with an A designation from the 1995 version of AS 1548.
2. Grades with an NRA supply condition are supplied in the **as rolled** condition, but with tests carried out on normalised and stress relieved test pieces.
3. The fabricator **MUST** normalise or hot form grades with NRA designations to ensure the steel meets the properties on the test certificates.
4. Failure to carry out normalising or hot forming on NRA grades may mean the plate fails to meet the requirements of the Standard.

3. Reasons for the changes to AS 1548

Reasons for changes to AS 1548

1. Improved performance of the steel in fabrication and end use

- Lower Carbon and Carbon Equivalent maximums improve weldability
- All grades to have some level of Charpy testing, which improves the guaranteed toughness of steels manufactured to AS 1548 and hence the confidence of the end user in the material used for any application:
 - For the 460 grades the minimum requirement is for an impact test at 0°C to meet a minimum of 27 Joules (batch basis)
 - For the 490 and 540 grades the requirement is for an impact test at -20°C to meet a minimum of 27 Joules

2. Toughness levels in line with the expectations of AS 1210

- Reducing disconnect between fabrication and material standards and simplifies material selection decisions during design



Reasons for changes to AS 1548

Increased minimum Charpy Energy levels improves the guaranteed level of toughness of the steel

Grade	Impact Designation	1995 Standard Minimum absorbed Energy (J)	2008 Standard Minimum absorbed Energy (J)
460	L20	47	47
	L40	31	45
	L50	27	42
490	L20	47	55
	L40	31	45
	L50	27	42

Reasons for Changes to AS 1548

3. Improved guidance regarding the effect of excessive stress relieving
- Reduces the risk of incorrect stress relieving practices that may reduce the strength and toughness of a vessel.
 - Formula in Section 16.2 of AS 1548 allows the fabricator to determine if the required amount of stress relieving may have some deleterious effect on properties:

$$P = (273 + T_3) (20 + \log(t)) \times 10^{-3}$$

where T_3 = the stress relieving temperature in degrees Celsius
 t = the holding time in hours

- P = the time-temperature parameter used to describe the effect of time and temperature used during stress relieving.
- If the formula determines that the amount of stress relieving **may** have some effect on properties (ie. $P > 17.88$) then the fabricator should either discuss with the steel supplier or conduct tests on a coupon subjected to the same stress relieving cycle.
- BlueScope Steel can conduct multiple stress relieving cycles on test samples as part of the testing and certification of PV grades.

Reasons for changes to AS 1548

4. Improved alignment between Australian and ISO/EN Standards

- Removal of the 5 and 7 designations and introduction of PT designation simplifies the AS 1548 Standard and assists design engineers in material selection.
- Improved alignment of the Standards allows greater acceptance of Australian grades in major projects.
- Introduction of Normalised Rolling (NR) supply condition:
 - Aligns the interchangeability of R and A designations of the former Standard with the ISO/EN
- Charpy test requirement values changed to align with ISO/EN.
- Elevated temperature tensile test values changed to align with ISO/EN.
- Definition of fine grained steel provides clarity for design engineers where fine grained steels are a requirement of the specification.

Explanation of Delivery Conditions

Comparison of attributes for various delivery conditions

Delivery condition	CEQ	Charpy impact toughness	Hot forming	Cost effective
Normalised rolled (NR)	✓	✓	✓ ✓ ✓	✓ ✓ ✓
Thermo mechanical controlled rolled (TMCR)	✓ ✓ ✓	✓ ✓	✗	✓ ✓ ✓
Normalised (N)	✓	✓ ✓ ✓	✓ ✓ ✓	✓

4. Changes to 490 grades

Changes to 490 Grades

1. No 5 or 7 options under the new Standard, which simplifies material selection for the design engineer and improves availability of the 490 grades.
2. Strength levels in the new Standard are equivalent to the former 5-490N grade. ie. the higher of the previous 7-490 and 5-490 grades (design advantage).
3. The new Standard allows NR and T delivery condition options, which were not allowed with the 5-490 grade in the 1995 version of AS 1548.
 - Offers lower cost alternatives to Normalised grades
 - The previous Standard only allowed Normalised for the 5-490 type
4. The new Standard allows for the use of Niobium in all 490 strength grades up to 0.05%
 - Allows for improved toughness and rationalisation of grades



5. Introduction of new high strength grade

Introduction of new high strength grade

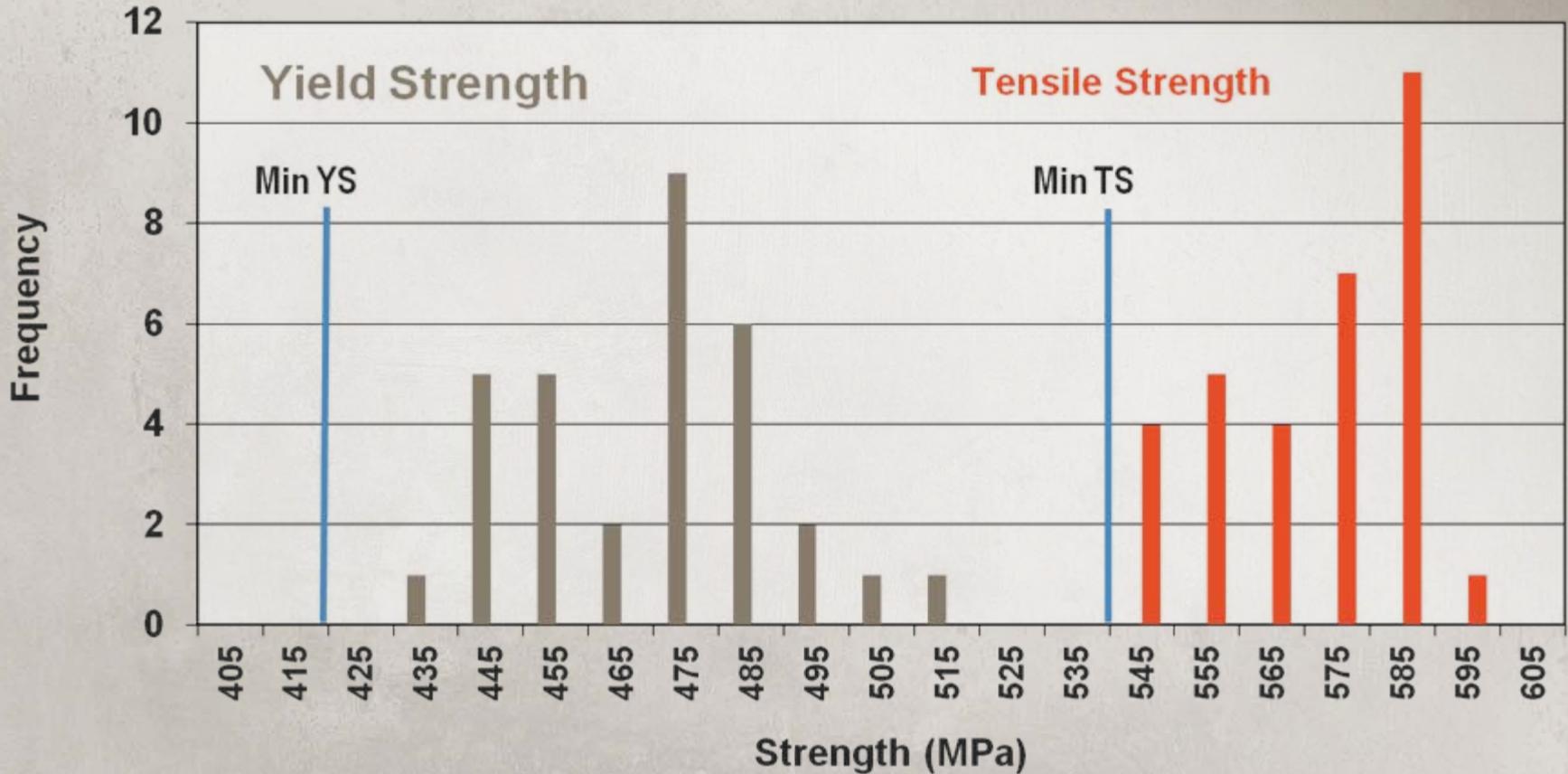
1. The 2008 version of the Standard introduces a PT540T grade allowing design engineers to utilise lower plate thicknesses for some applications.
2. Only available in Thermo-mechanical Controlled Rolled condition.
3. Available in thicknesses from 10 – 40mm
4. Similar weldability to 490 grades:
 - No significant penalty in terms of welding in moving to higher strength grade
5. No creep rupture information provided in the Standard as the data is not yet available.



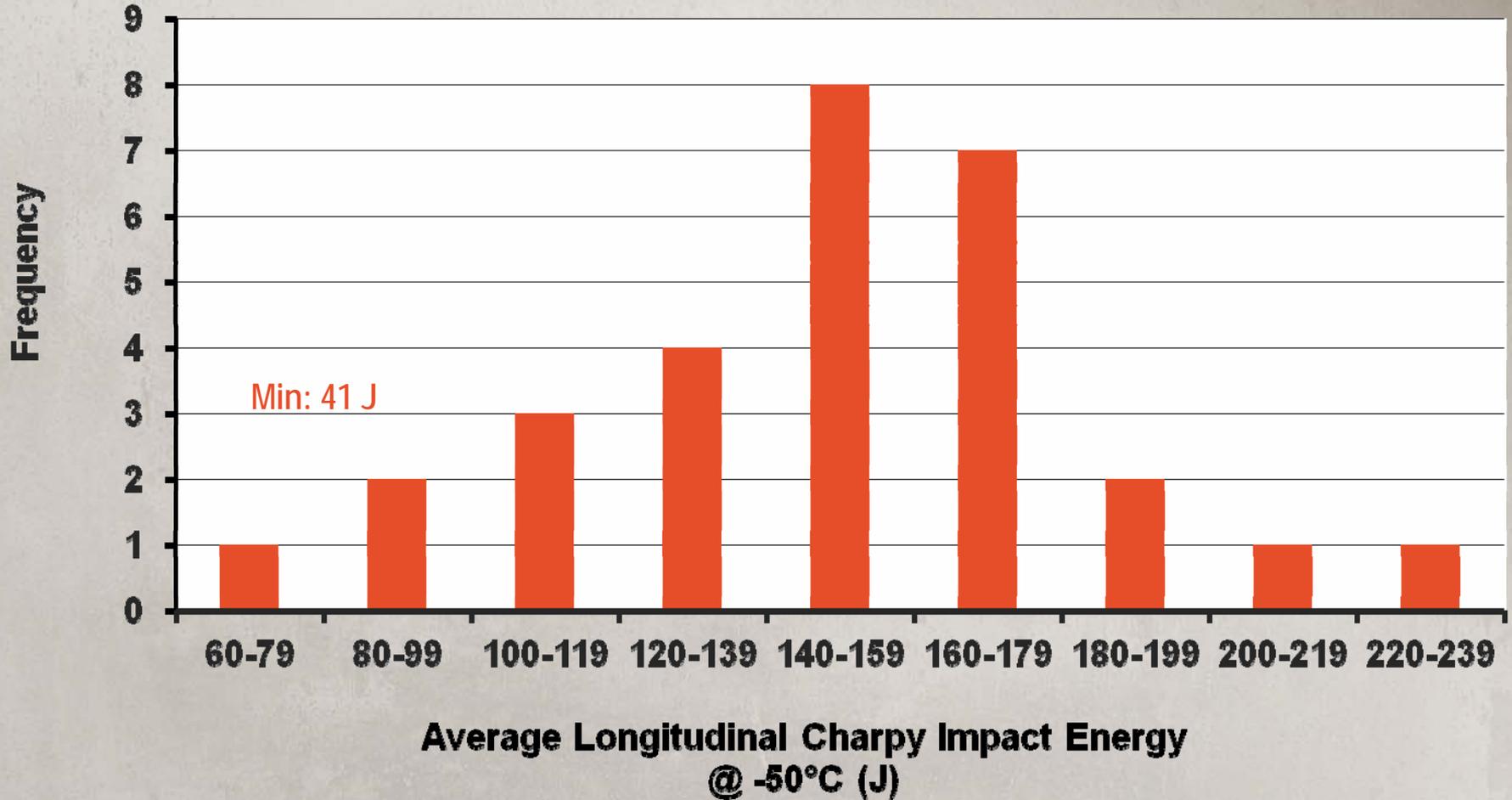
Comparison of the specified properties of AS 1548 5/490N and the new PT540T

Grade	YS (MPa)	TS (MPa)	%El.	Long. Cv
5/490N	340	490-610	20	-
PT540T	420	540-670	18	55J @ -20°C

Tensile properties of the new PT540T grade



Longitudinal impact properties for new PT540T grade



Indicative Comparative Pricing

Grade	Comparative Price
PT460NR	Base
PT460T	0
PT460N	+30%
PT490NR	+15%
PT490T	+15%
PT490N	+50%
PT490NL50Z35	+70%
PT540T	+25%

6. Summary of key changes

Summary of Key Changes

1. Alignment of AS 1548 with ISO/EN Standards
2. Lower Carbon and Carbon Equivalent maximums improve weldability
3. All grades to have some level of Charpy Impact testing
4. Increased minimum Charpy Energy values
5. Improved guidance regarding the effect of excessive stress relieving
6. Change to grade designations
7. Introduction of Normalised Rolled grades
8. Removal of 5 and 7 Class designations
9. Introduction of new high strength grade AS 1548-PT540T

7. What do the changes to AS 1548 mean to me?

What do changes to AS 1548 mean to me?

1. XLERPLATE® steel alloy designs remain unchanged. Current grades meet the enhanced requirements of AS 1548 2008, ensuring a seamless changeover to a more demanding Standard.
2. Changes to AS 1548 2008 offer advantages to design engineers, fabricators and end users which include:
 - Simplified material selection, hence speeding up the design process
 - Offer additional grades and delivery condition options, which provides the potential to reduce costs
 - Improve the guaranteed toughness of steel grades, ensuring the performance of the material in service meets requirements
 - Provide guidance on stress relieving to assist during fabrication

Questions?