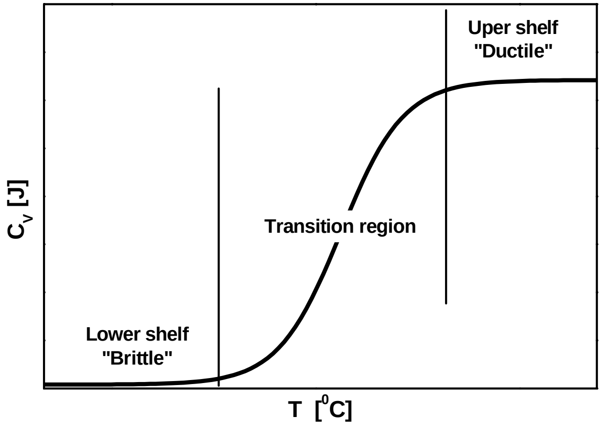


Sub-sized CVN specimen conversion methodology

ASTM A01-13 meeting Tampa 2015

Kim Wallin

ASTM A370 Table 9

TABLE 9 Charpy V-Notch Test Acceptance Criteria for Various Sub-Size Specimens

Full Size, 10 by 10 mm		¾ Size, 10 by 7.5 mm		⅔ Size, 10 by 6.7 mm		½ Size, 10 by 5 mm		⅓ Size, 10 by 3.3 mm		¼ Size, 10 by 2.5 mm	
ft·lbf	[J]	ft·lbf	[J]	ft·lbf	[J]	ft·lbf	[J]	ft·lbf	[J]	ft·lbf	[J]
40[A]	[54]	30	[41]	27	[37]	20	[27]	13	[18]	10	[14]
35	[48]	26	[35]	23	[31]	18	[24]	12	[16]	9	[12]
30	[41]	22	[30]	20	[27]	15	[20]	10	[14]	8	[11]
25	[34]	19	[26]	17	[23]	12	[16]	8	[11]	6	[8]
20	[27]	15	[20]	13	[18]	10	[14]	7	[10]	5	[7]
16	[22]	12	[16]	11	[15]	8	[11]	5	[7]	4	[5]
15	[20]	11	[15]	10	[14]	8	[11]	5	[7]	4	[5]
13	[18]	10	[14]	9	[12]	6	[8]	4	[5]	3	[4]
12	[16]	9	[12]	8	[11]	6	[8]	4	[5]	3	[4]
10	[14]	8	[11]	7	[10]	5	[7]	3	[4]	2	[3]
7	[10]	5	[7]	5	[7]	4	[5]	2	[3]	2	[3]

[A] Table is limited to 40 ft·lbf because the relationship between specimen size and test results has been reported to be non-linear for higher values.

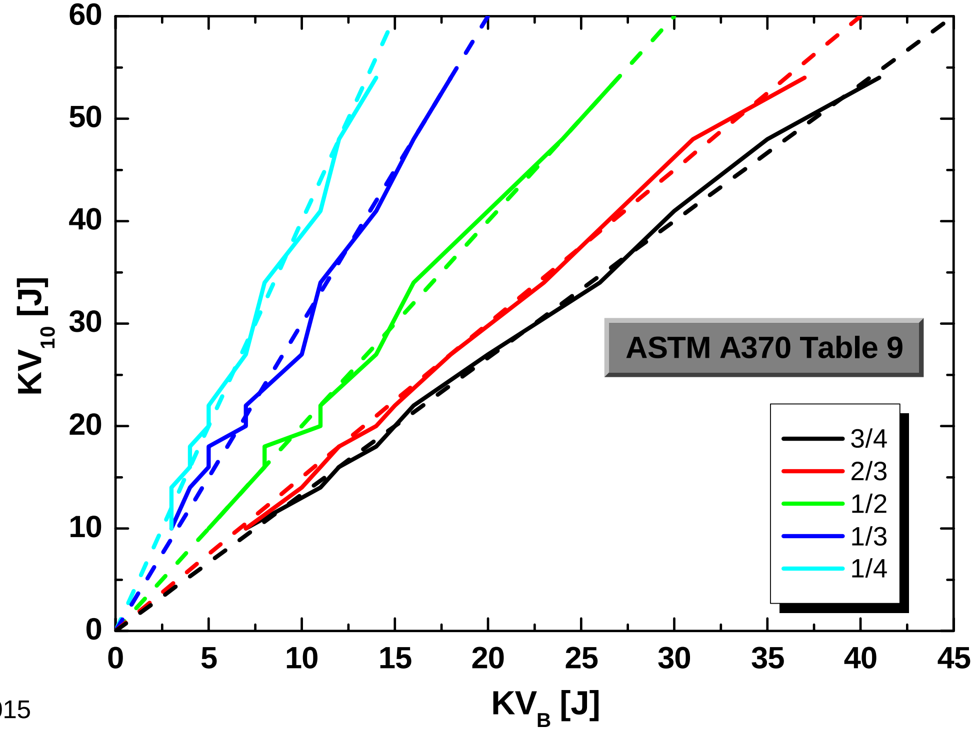
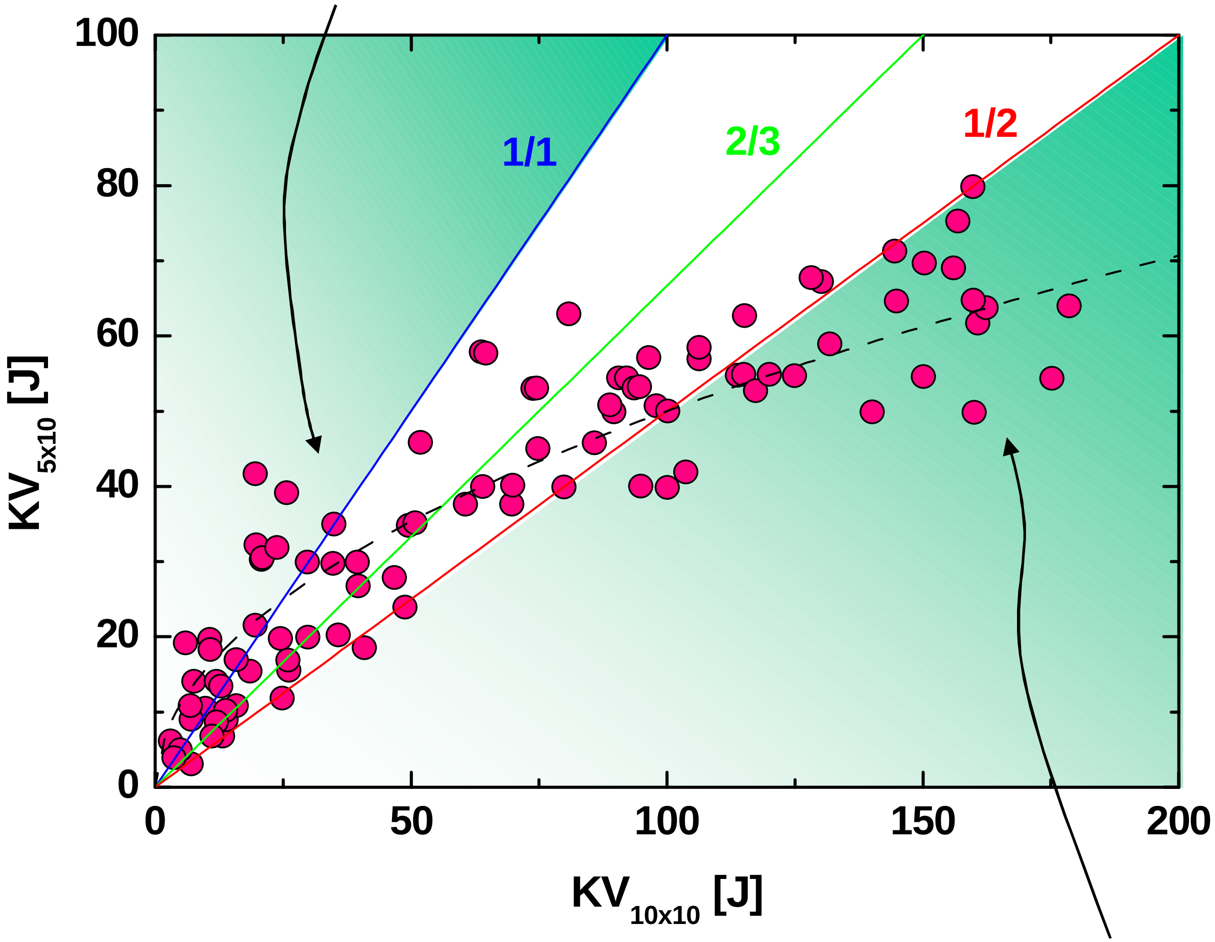


Table 9 is based on a simple thickness-ratio correction.

Subsized specimens

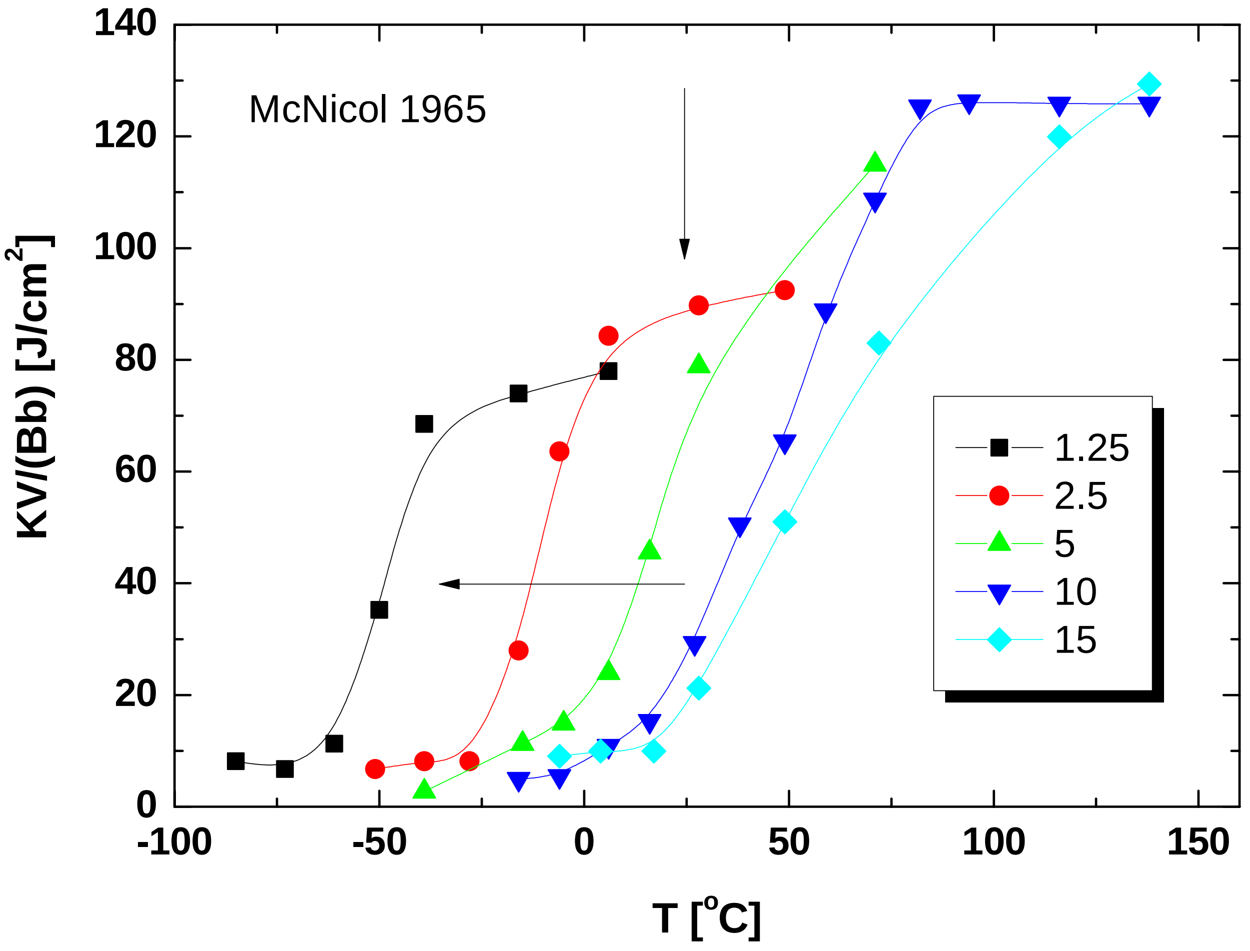
Sub-size specimens yield higher absolute energies



Sub-size specimens yield lower proportional energies

A simple ratio-correction is not sufficient for the adjustment of sub-size Charpy-V specimen energies.

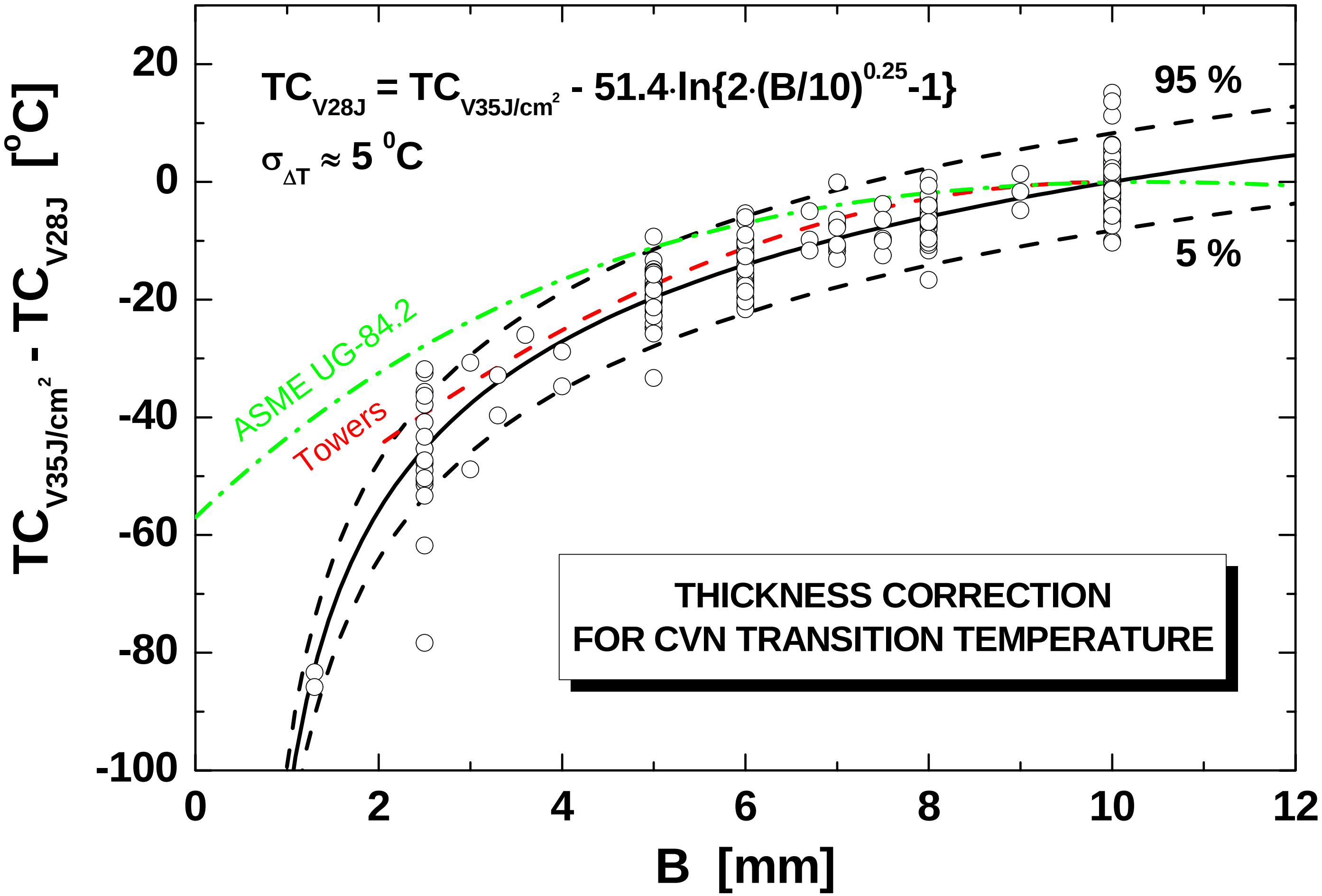
Effect of thickness on transition curve



McNicol, R. (1965, September). Correlation of Charpy Test Results for Standard and Nonstandard Size Specimens. Welding Research Supplement, pp. 385-393.

Subsized specimens

Sub-size specimens yield lower transition temperature



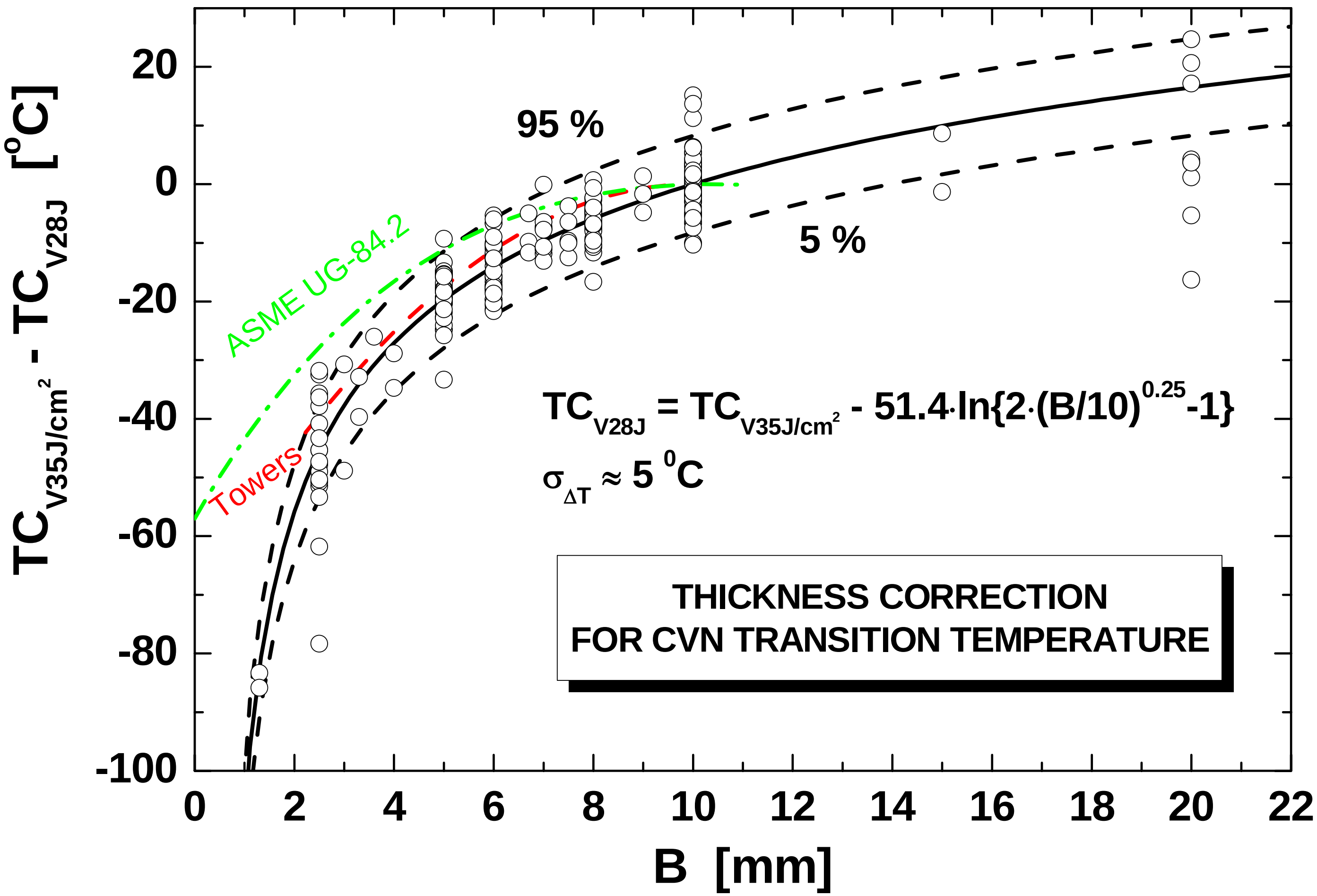
Similar to a statistical size effect related to cleavage initiation. See e.g. ASTM E1921.

Included in BS7910-13

Wallin K. Methodology for selecting Charpy toughness criteria for thin high strength steels - Part 1: Determining the fracture toughness: D733. Jernkontorets Forskning, 1994.

Subsized specimens

Sub-size specimens yield lower transition temperature



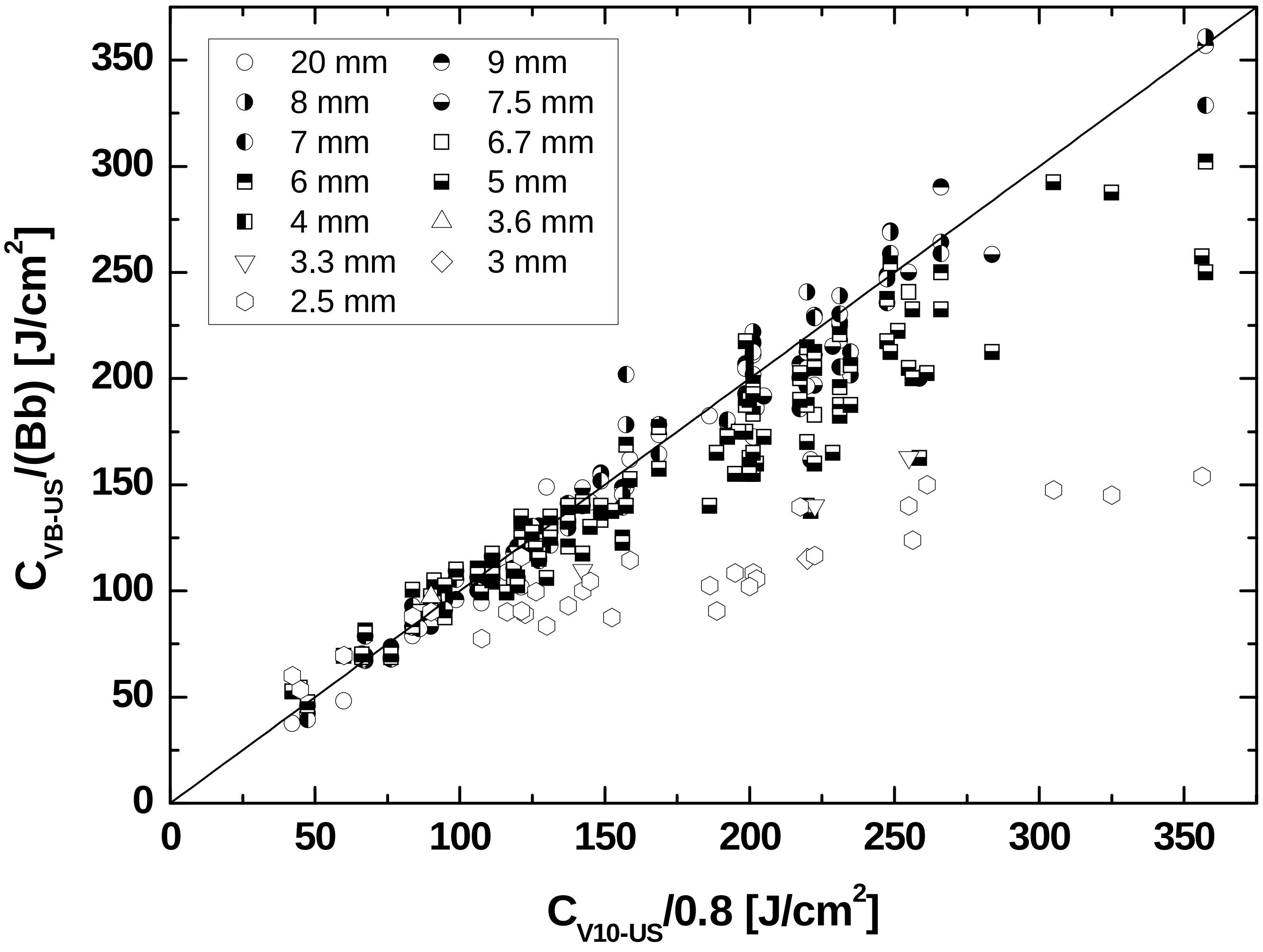
Similar to a statistical size effect related to cleavage initiation. See e.g. ASTM E1921.

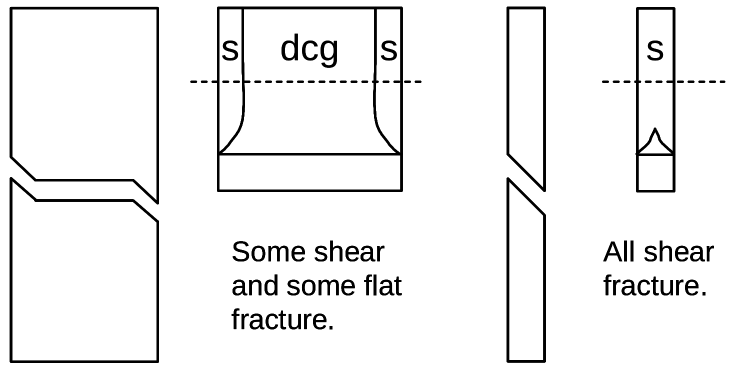
Included in BS7910-13

Wallin K. Methodology for selecting Charpy toughness criteria for thin high strength steels - Part 1: Determining the fracture toughness: D733. Jernkontorets Forskning, 1994.

Subsized specimens

Sub-size specimens yield lower proportional upper shelf energies



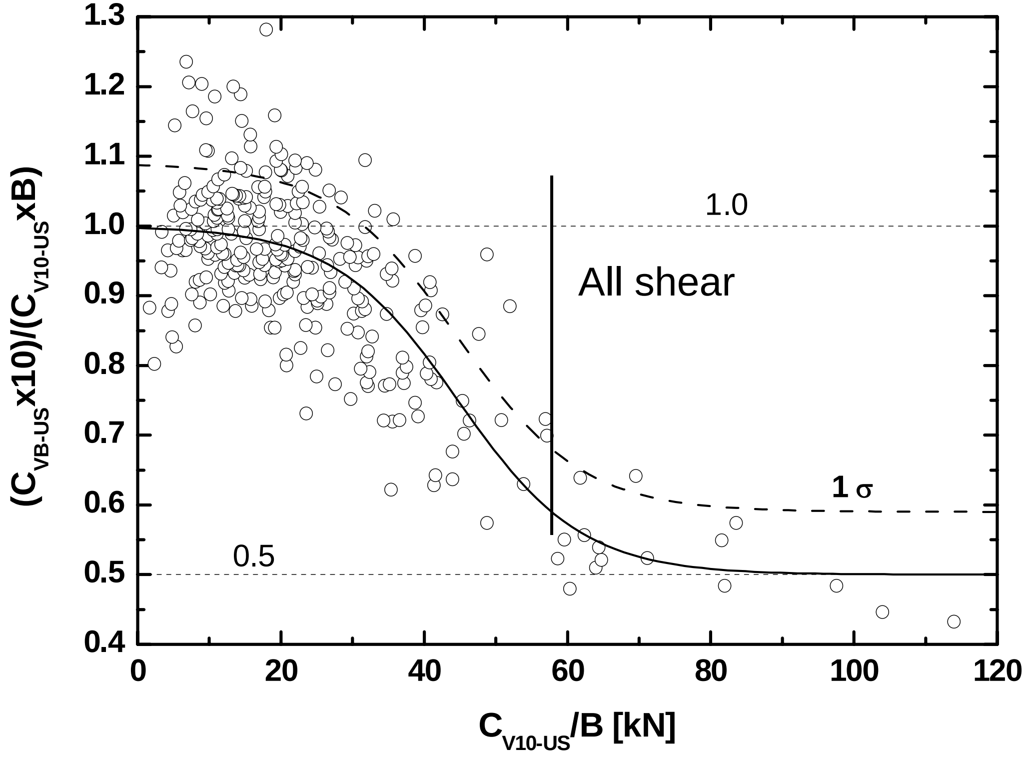


Due to a competition between shear and flat fracture.

Wallin K Upper shelf energy normalisation for sub-sized Charpy-V specimens. Int J of Pressure Vessels and Piping, 78, 2001, pp 463-470.

Subsized specimens

Sub-size specimens yield lower proportional upper shelf energies

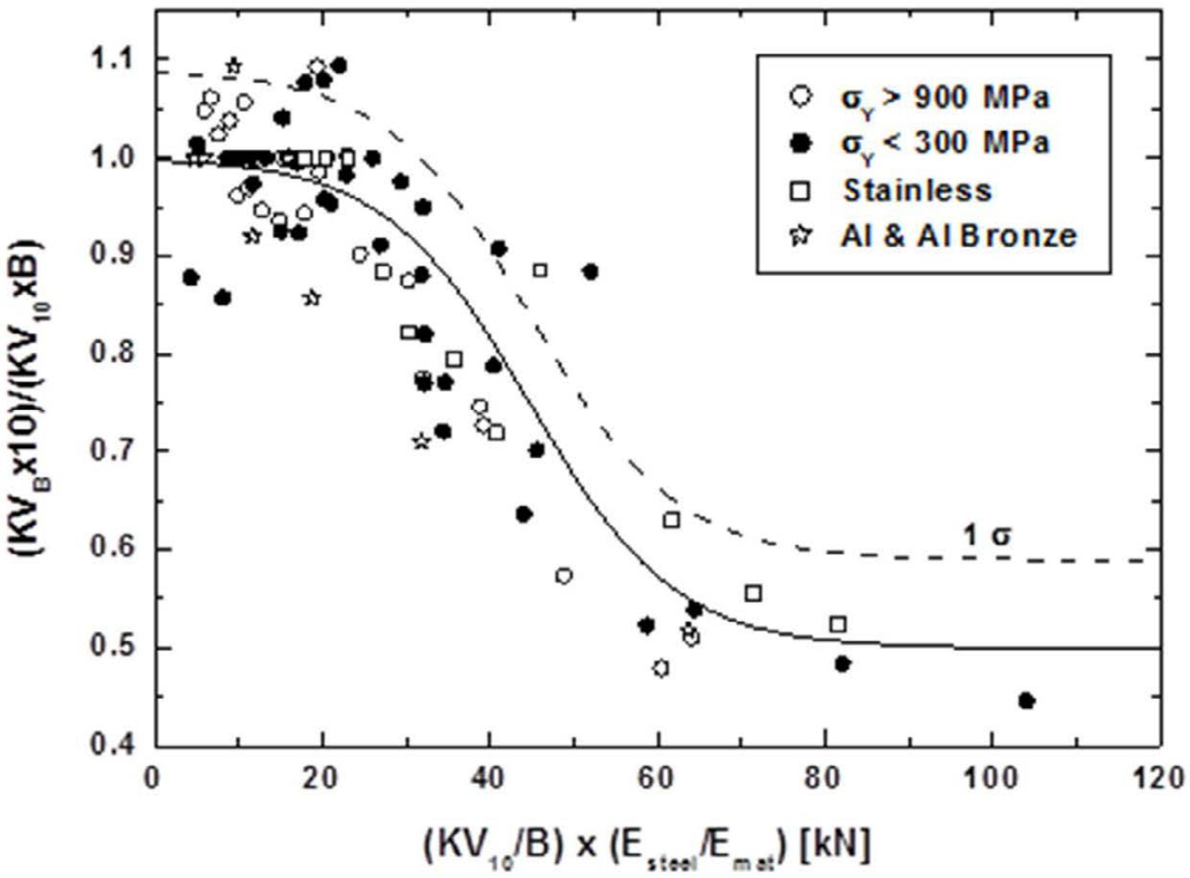


$$\frac{C_{VB-US}\cdot 10}{C_{V10-US}\cdot B} = 1 - \frac{0.5\cdot \exp\left\{\dfrac{2\cdot\left(C_{V10-US}/B-44.7\right)}{17.3}\right\}}{1+\exp\left\{\dfrac{2\cdot\left(C_{V10-US}/B-44.7\right)}{17.3}\right\}} \ldots [\mathrm{J, mm}]$$

Wallin K Upper shelf energy normalisation for sub-sized Charpy-V specimens. Int J of Pressure Vessels and Piping, 78, 2001, pp 463-470.

Subsized specimens

Sub-size specimens yield lower proportional upper shelf energies

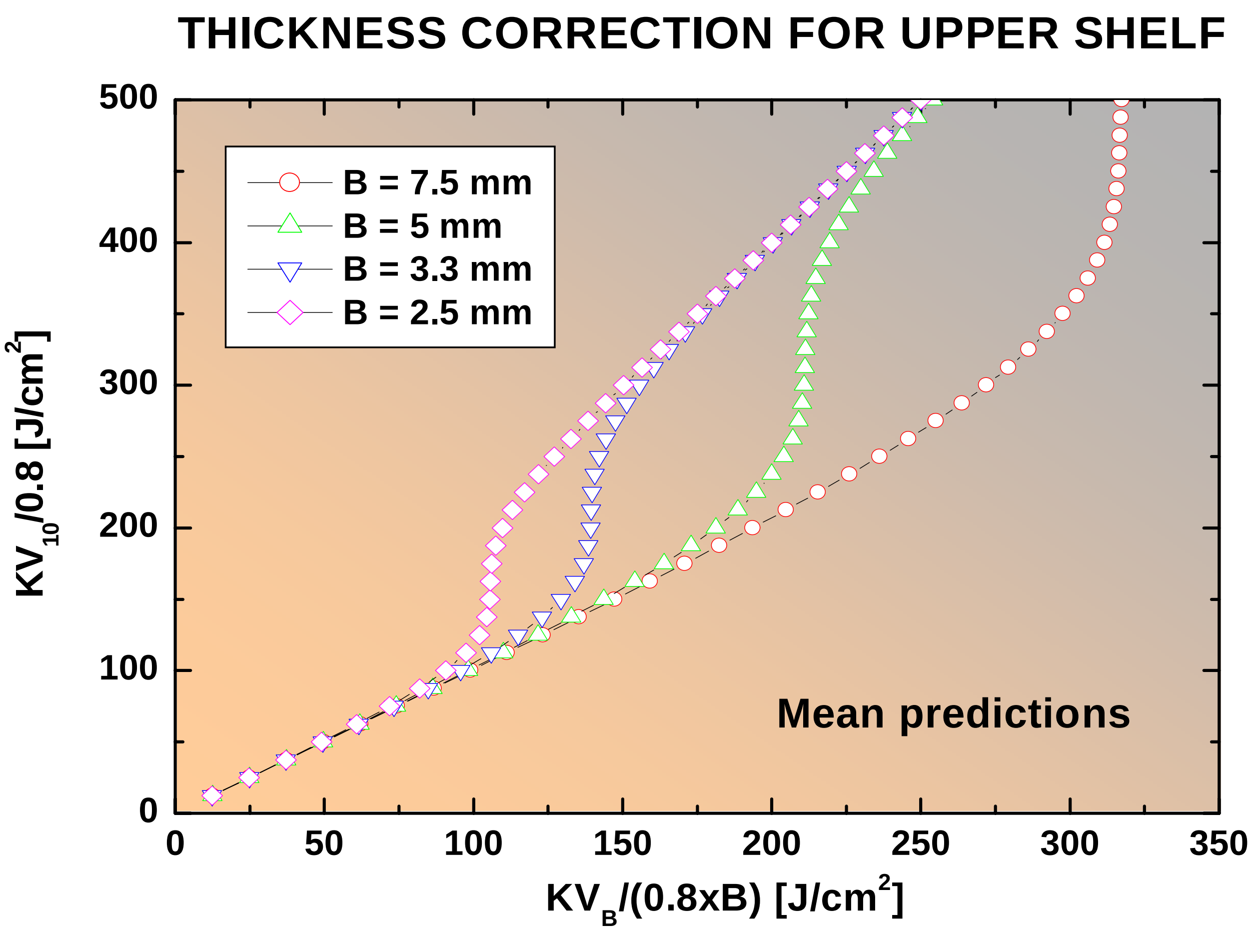


Normalisation is insensitive to strength but sensitive to modulus of elasticity .⇒ Austenitic stainless slightly different than structural steel.

Wallin K Upper shelf energy normalisation for sub-sized Charpy-V specimens. Int J of Pressure Vessels and Piping, 78, 2001, pp 463-470.

Subsized specimens

Sub-size specimens yield lower proportional upper shelf energies



Wallin K Upper shelf energy normalisation for sub-sized Charpy-V specimens. Int J of Pressure Vessels and Piping, 78, 2001, pp 463-470.

Temperature adjustment

$$\Delta T = -51.4°C \cdot \ln\left\{2 \cdot \left(\frac{B}{10\,mm}\right)^{0.25} - 1\right\}$$

Energy conversion

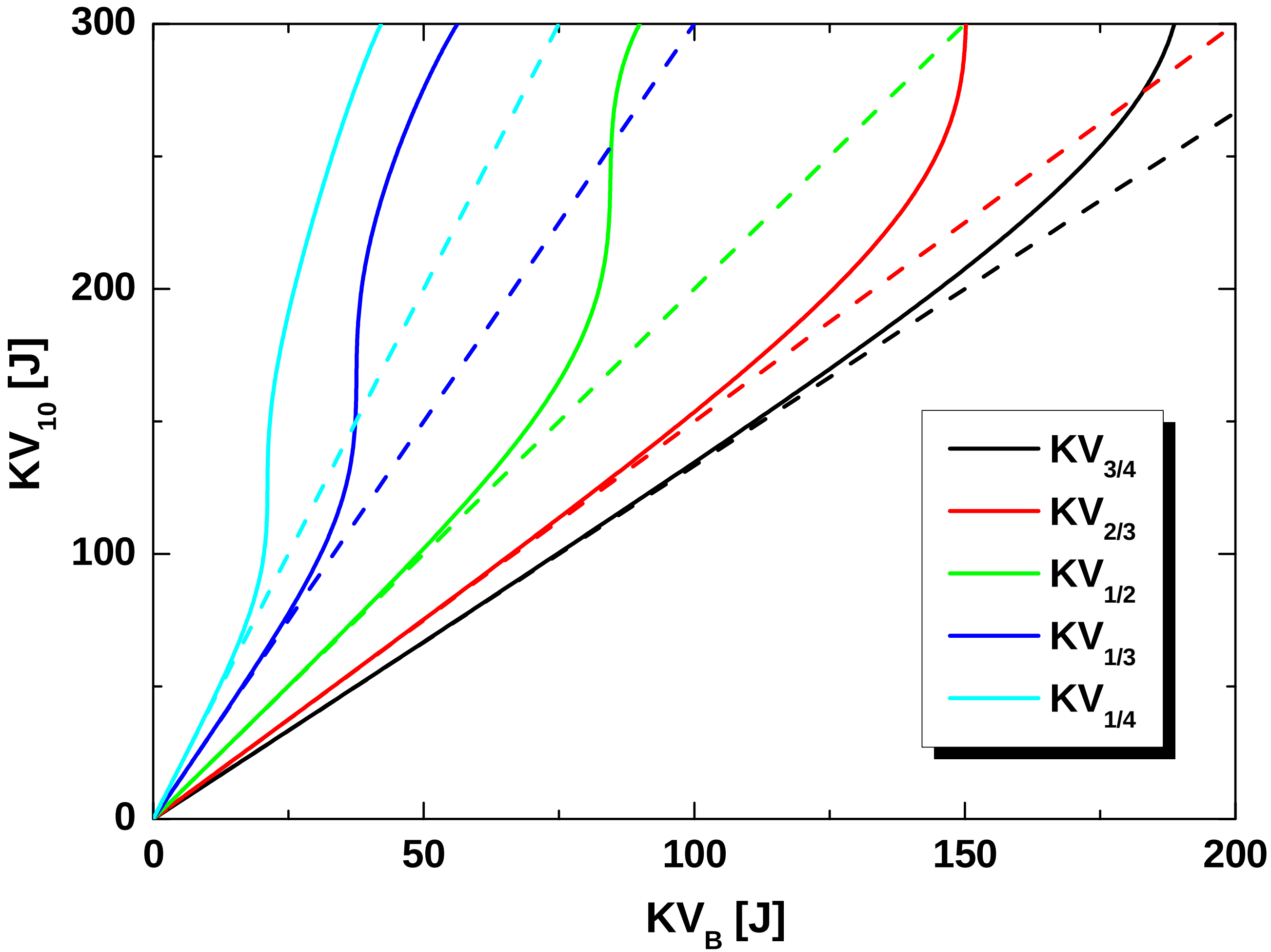
$$\frac{C_{VB} \cdot 10}{C_{V10} \cdot B} \approx 1 - \frac{0.5 \cdot \exp\left\{\frac{2 \cdot (C_{V10} / B - 44.7)}{17.3}\right\}}{1 + \exp\left\{\frac{2 \cdot (C_{V10} / B - 44.7)}{17.3}\right\}} \ldots [J, mm]$$

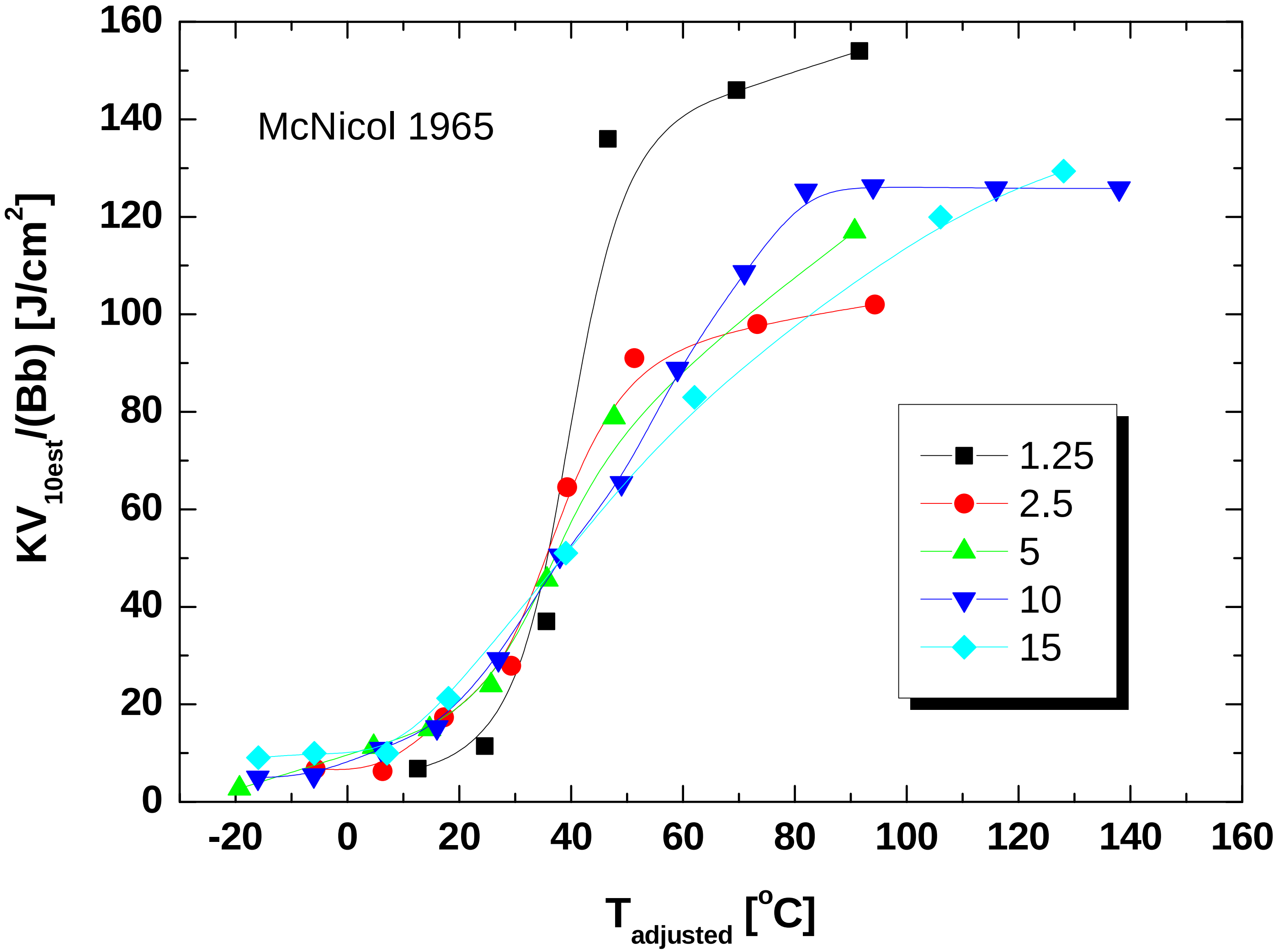
$$\frac{C_{VB-US}\cdot 10}{C_{V10-US}\cdot B}=1-\frac{0.5\cdot\exp\left\{\frac{2\cdot\left(C_{V10-US}/B-44.7\right)}{17.3}\right\}}{1+\exp\left\{\frac{2\cdot\left(C_{V10-US}/B-44.7\right)}{17.3}\right\}}\ldots[\mathrm{J,\ mm}]$$

- The conversion accounts for the lower energy required to fracture shear lips.
- $C_{V10\text{-}US}$ corresponds basically to a value without shear lips.
- For high CVN energies the measured full size specimen energy becomes therefore less than indicated by the equation.
- Begins to effect when C_{V10} > 100 J.

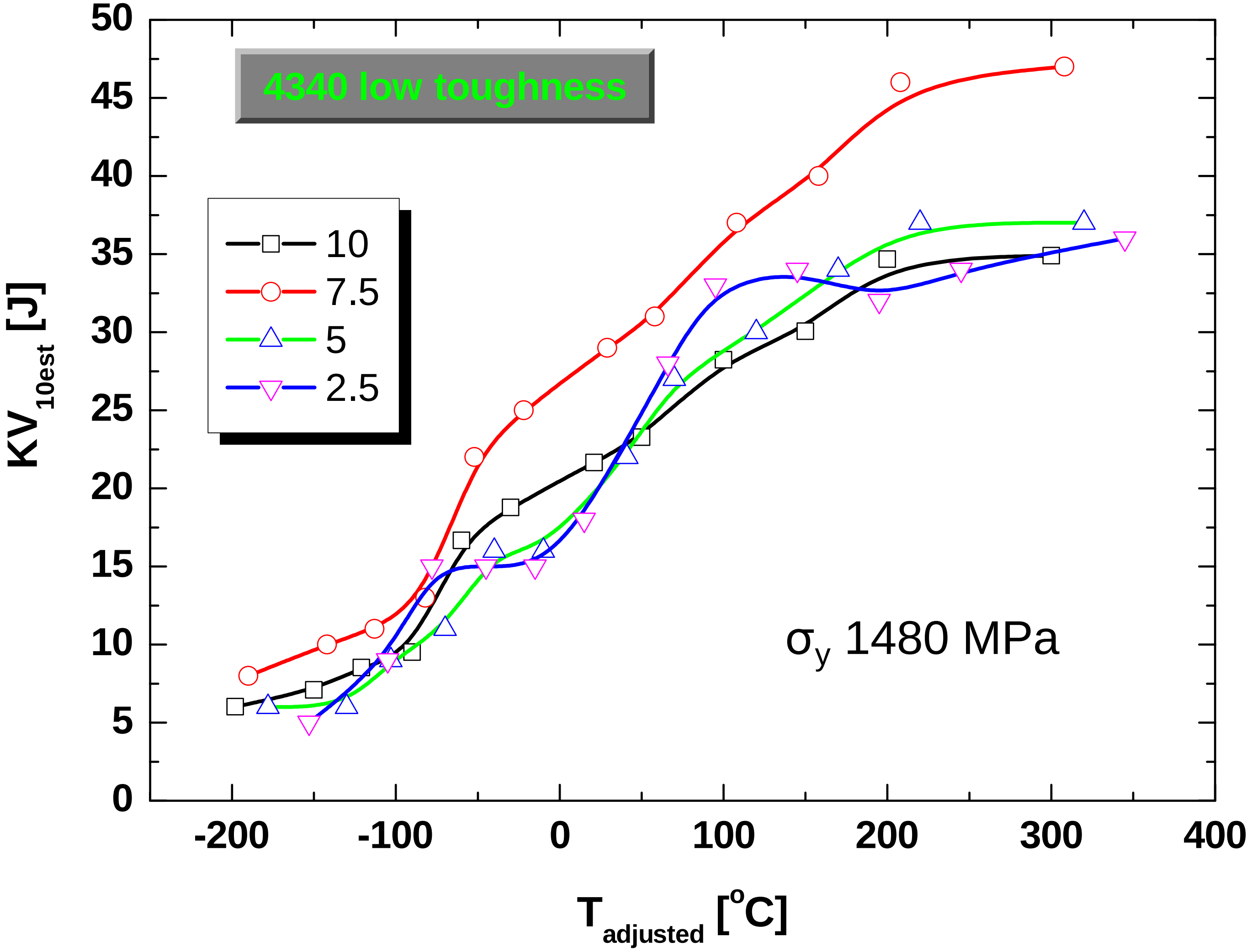
Energy conversion

Estimated measured energy.

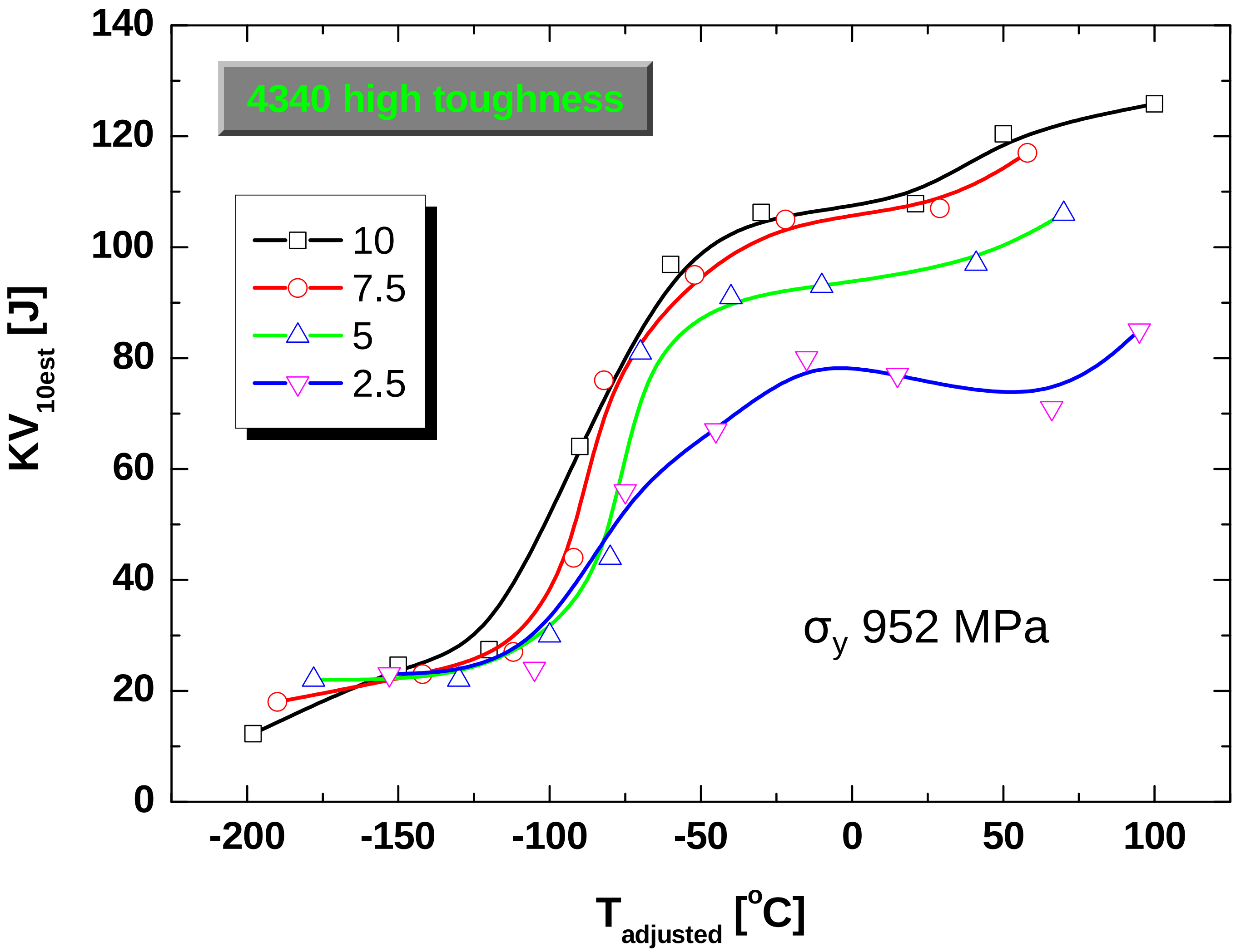




McNicol, R. (1965, September). Correlation of Charpy Test Results for Standard and Nonstandard Size Specimens. Welding Research Supplement, pp. 385-393.



Enrico Lucon, C. N. (2015). Impact Characterization of 4340 and T200 Steels by Means of Standard, Sub-Size and Miniaturized Charpy Specimens. NIST Technical Note 1858.



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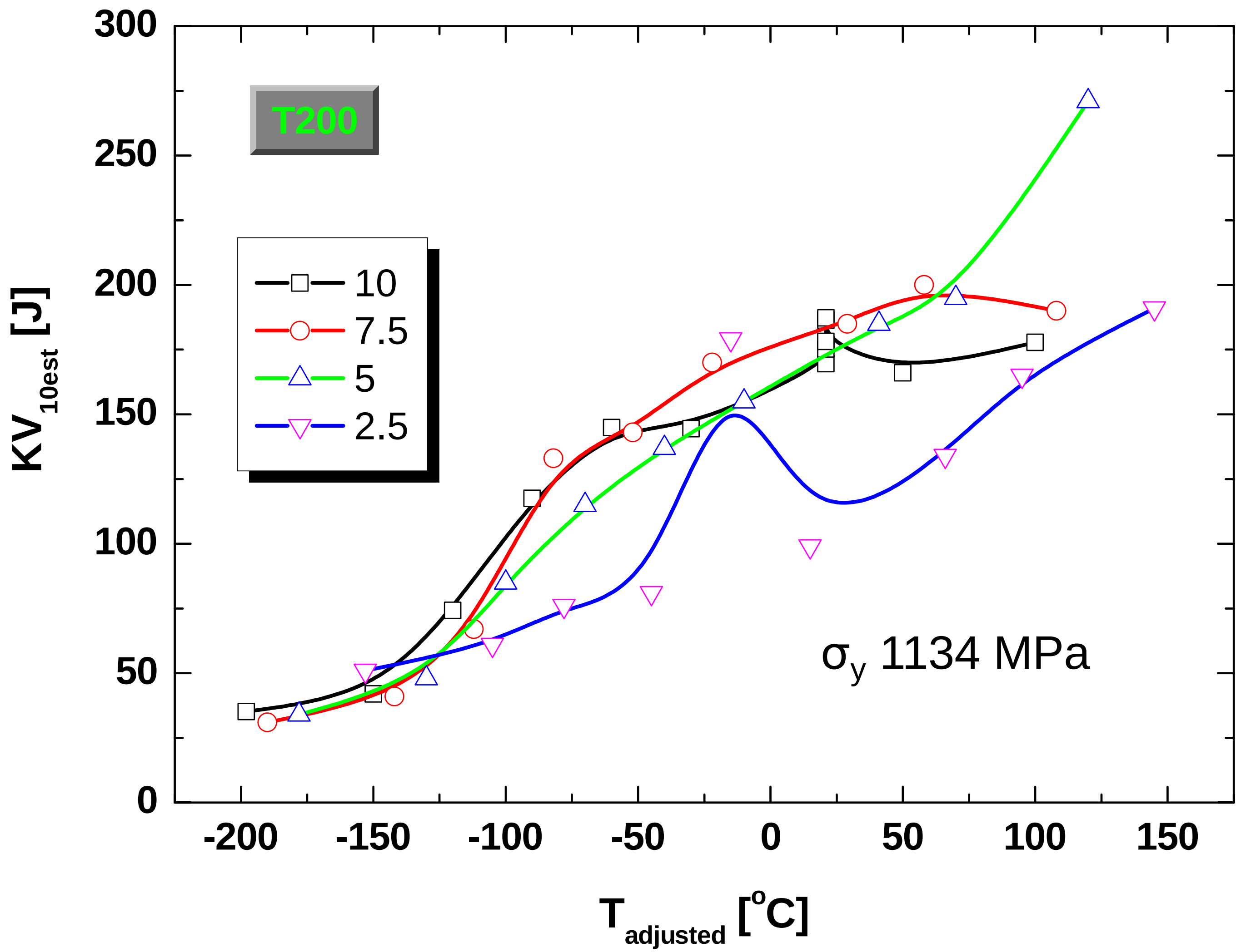

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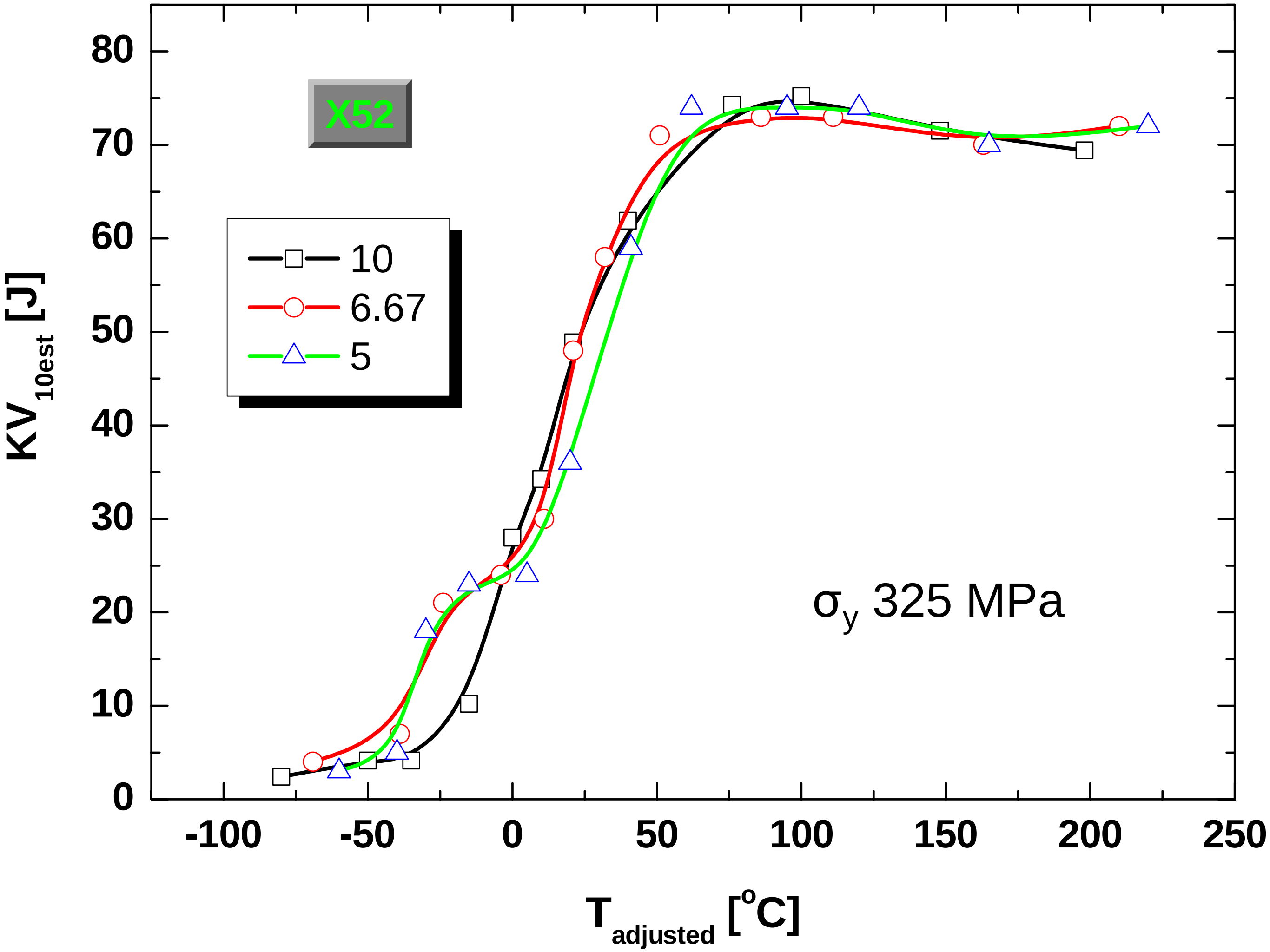
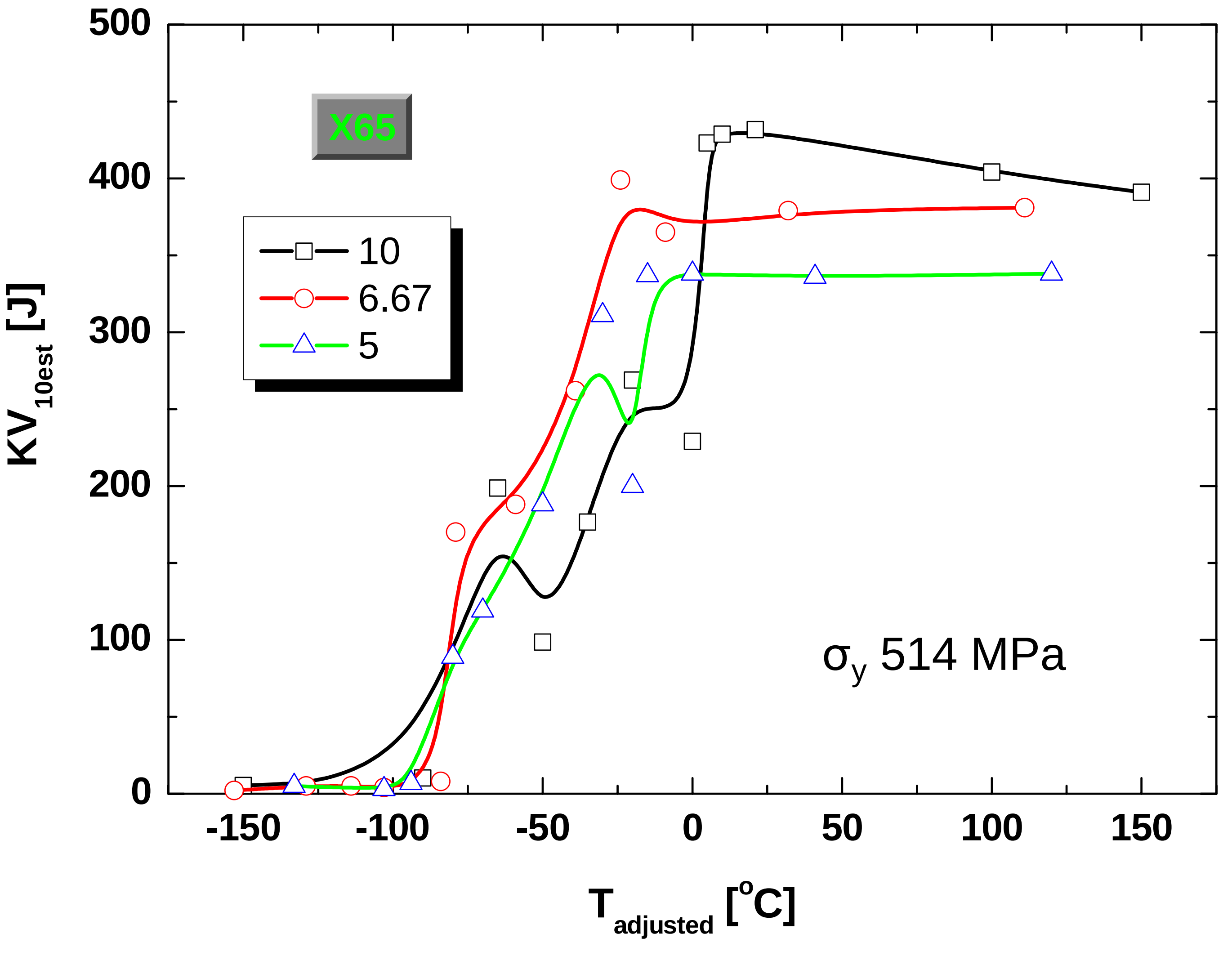


E. Lucon, C. N. McCowan, and R. L. Santoyo, (2015). Impact Characterization of Line Pipe Steels by Means of Standard, Sub-Size and Miniaturized Charpy Specimens. NIST Technical Note 1865.



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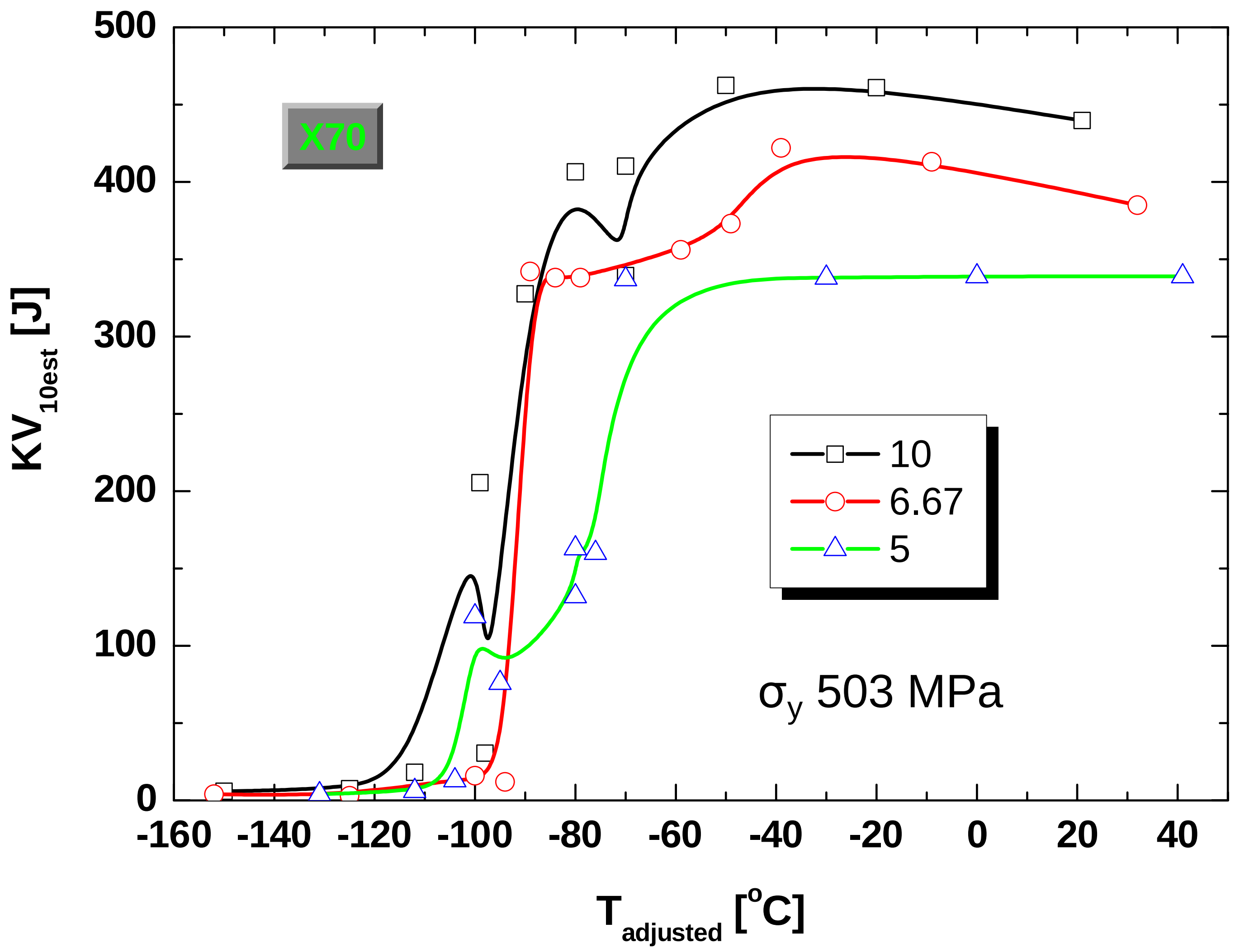

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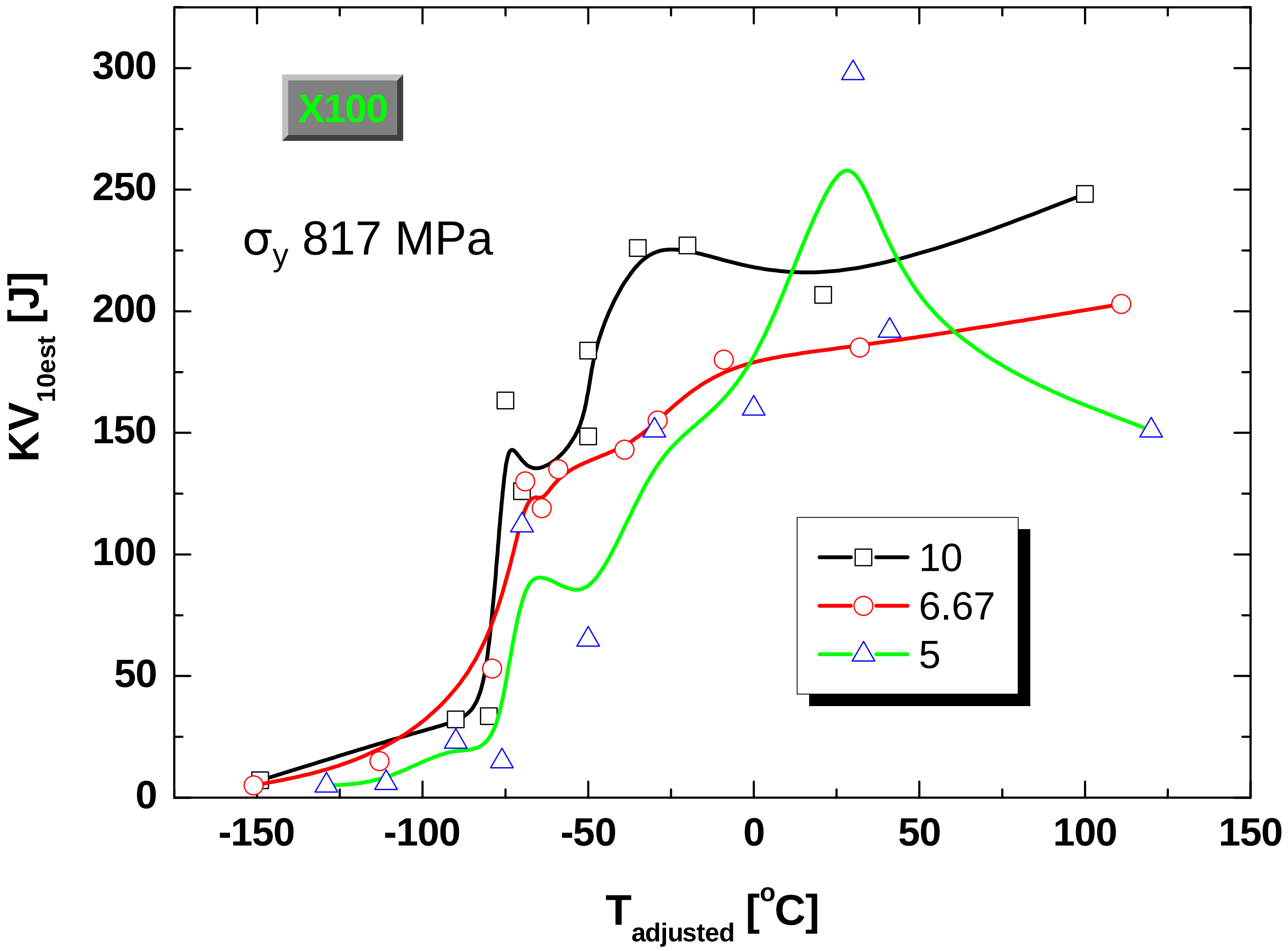
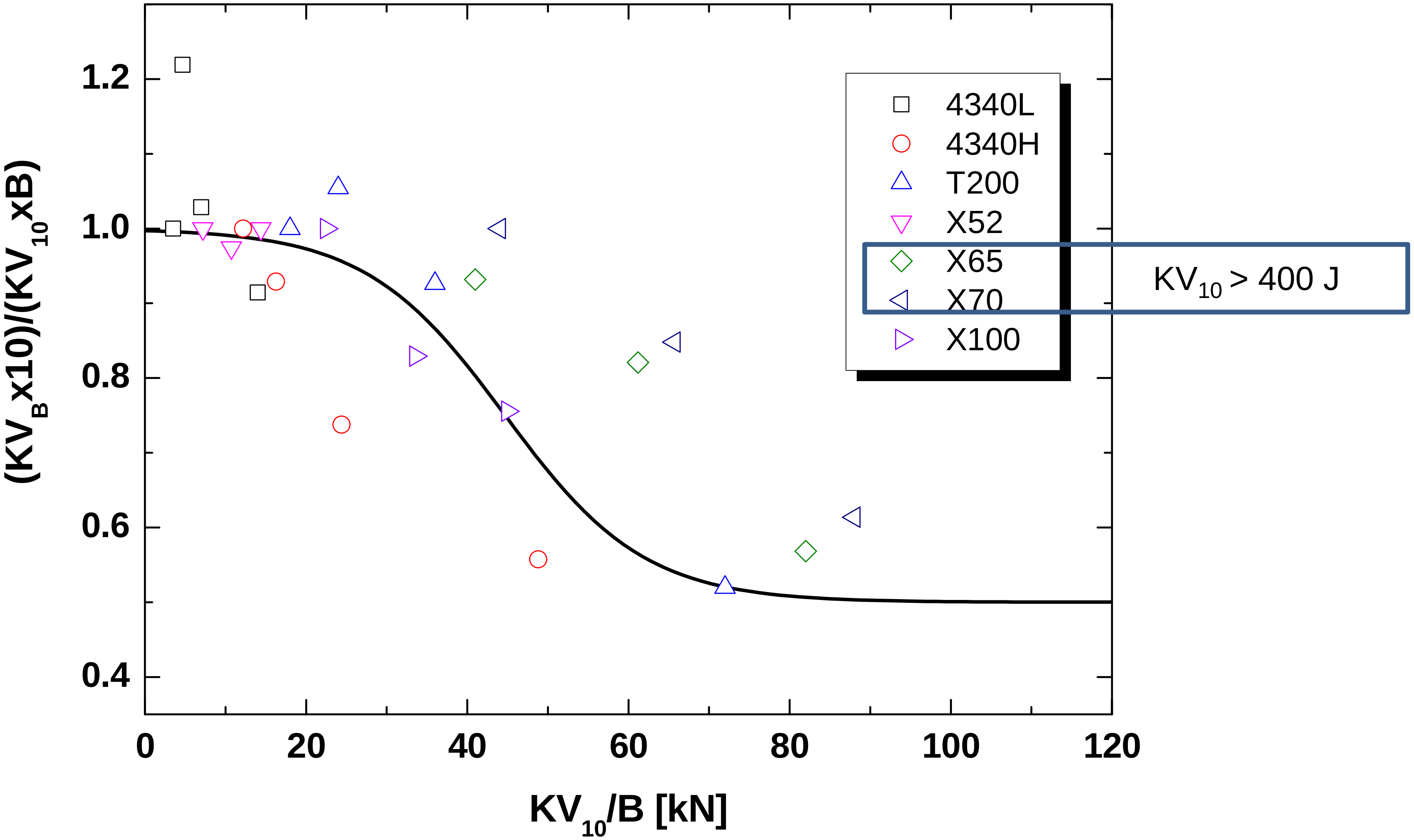
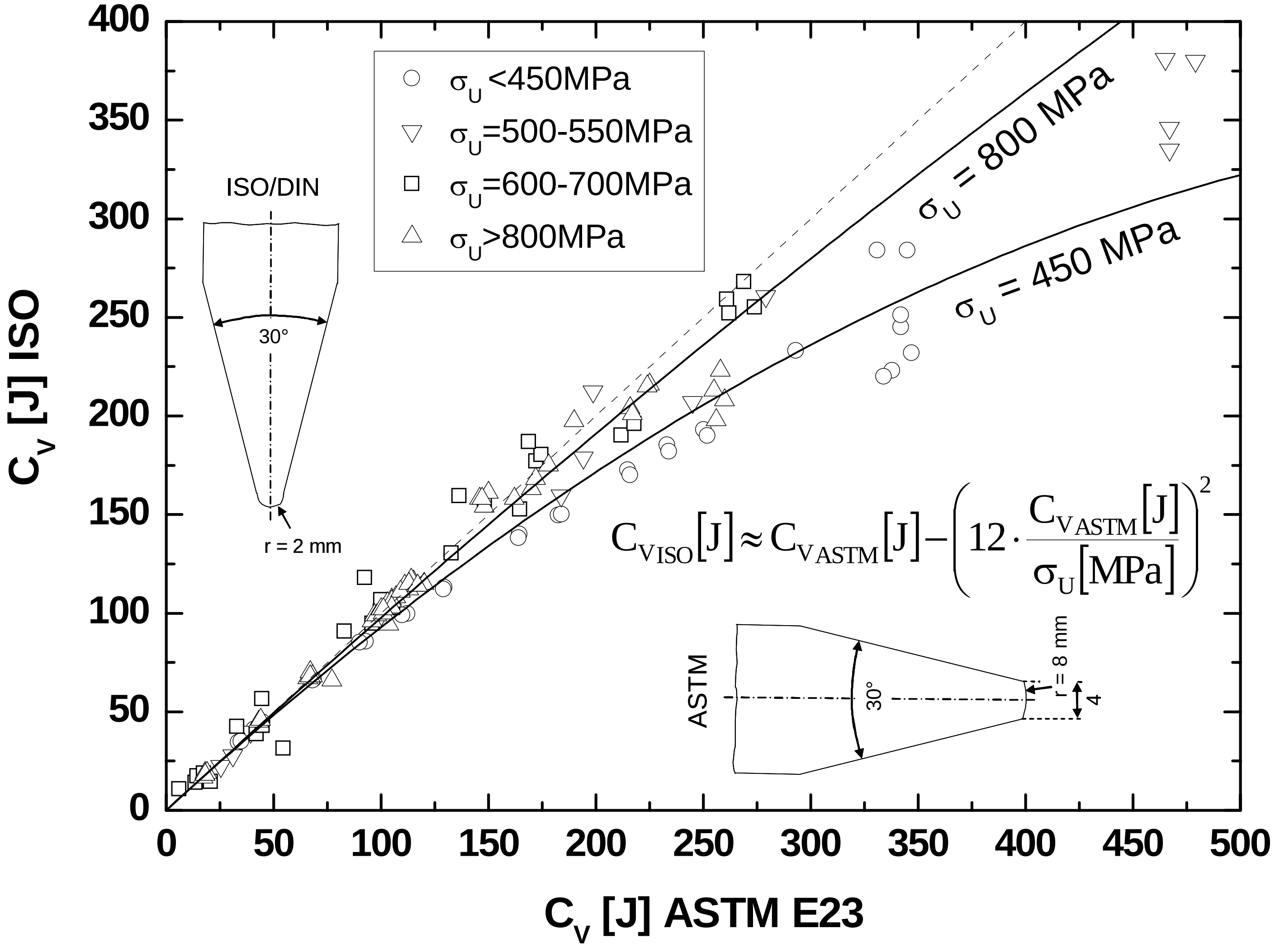


E. Lucon, C. N. McCowan, and R. L. Santoyo, (2015). Impact Characterization of Line Pipe Steels by Means of Standard, Sub-Size and Miniaturized Charpy Specimens. NIST Technical Note 1865.

Upper shelf behaviour





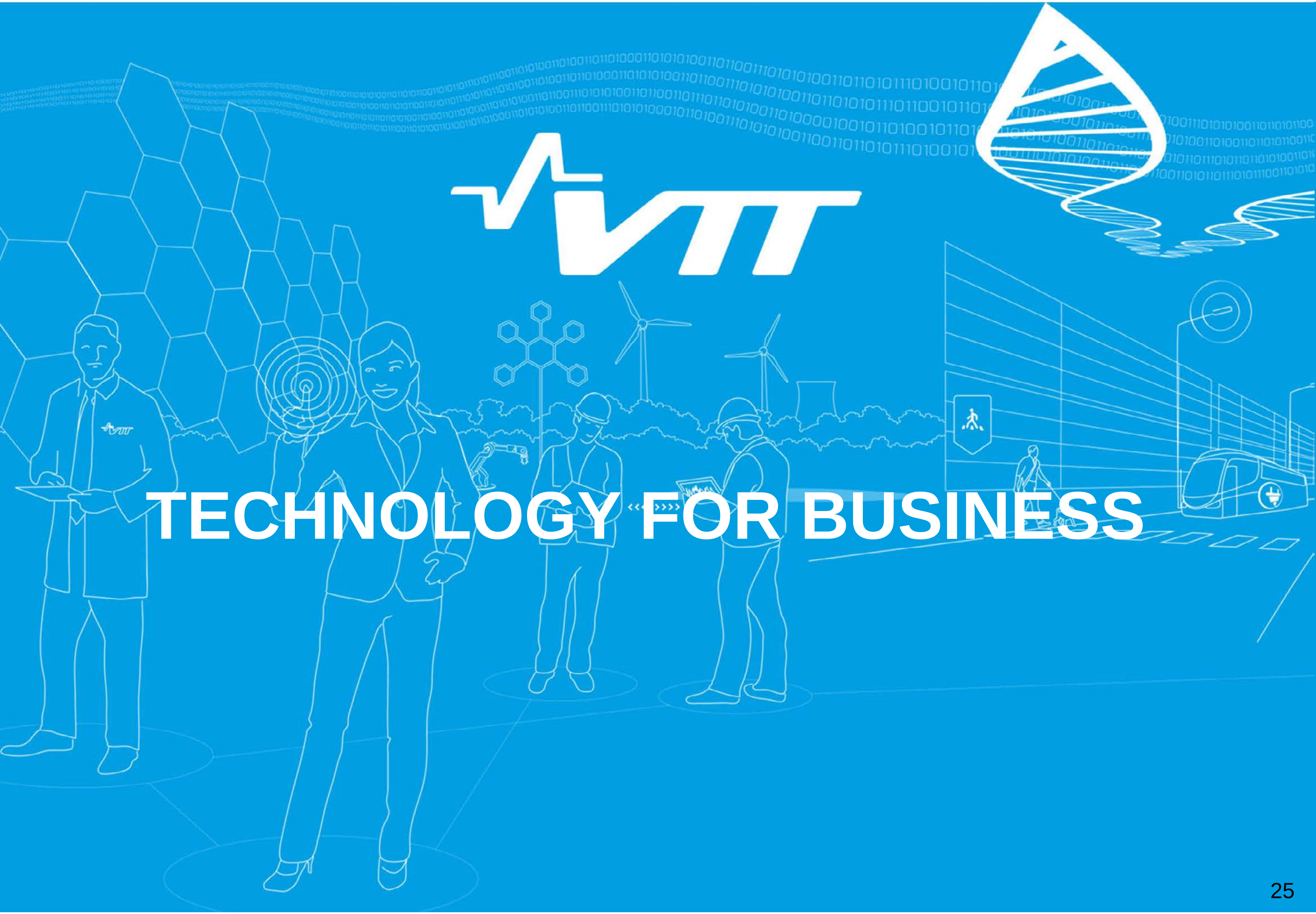
The ASTM hammer show for high toughness higher energies than the ISO hammer

energy conversion

Full size [J]	3/4 [J]	2/3 [J]	1/2 [J]	1/3 [J]	1/4 [J]
10	7	7	5	3	2
14	10	9	7	5	3
16	12	11	8	5	4
18	13	12	9	6	4
20	15	13	10	7	5
22	16	15	11	7	5
27	20	18	13	9	7
34	25	23	17	11	8
41	31	27	20	14	10
48	36	32	24	16	12
54	40	36	27	18	13
60	45	40	30	20	14
68	51	45	34	22	16
76	57	51	38	25	18
86	65	57	43	27	19
100	75	66	49	31	20

temperature adjustment

Thickness	Adjustment [°C]
Full size	0
3/4	8
2/3	11
1/2	20
1/3	34
1/4	45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