ASME B 31.1 & ASME B 31.3 CODE COMPARISON CHART *PipingStudy*	
ASME B31.1-POWER PIPING	**ASME B 31.3-PROCESS PIPING**
B31.3 uses higher allowable stress values than B31.1 (B31.1 uses an allowable of approx 117 MPa for A53-B whereas B31.3 uses about 137MPa).	for the same material ASME B31.3 uses relatively less allowable stresses
B31.1 has an SIF on reducers.	B31.3 doesn't use SIFs on reducers
B31.1 includes torsional stresses in sustain case loading.	B31.3 neglect torsion in sustain case laoding
B31.1 explicitly defines calculation methods for sustained and occasional loads	B31.3 calculation methods are undefined for sustained and occasional loads
B31.1 Code allowable stress is based upon a factor of safety of 4	B31.3 Code allowable stress is based upon a factor of safety of 3
the B31.1 Code has a narrow scope - Power Plants and District Heating Plants. It focuses on the steam - water loop.	B31.3 has the greatest width of scope of any B31 Pressure Piping Code. That is why B31.3 created several "fluid services", each with specific rules.
B31.1 on the other is about 40 years.	B31.3 plants generally have a plant life of of about 20 to 30 years.
B31.1 Power code is designed to have a higher reliability since safety of thousand people and industries will be affected.	B31.3 Process code,with a lower factor of safety relatively, a lower reliability can be tolerated
we dont compute SIF separately in B31.1,for example in B31.1 does not recognize extruded welding tee nor weldolet. If its considered then validity of using the SIF from B31.3.	In B31.3 the SIF are computed separately for each component
B31.1 uses a simplified one SIF approach (the maximum) for in and out plane .In the B31.1 Code, the SIF used is the LARGER of the two (inplane as compared to out-of-plane)and this larger SIF is applied to both of the bending moments occuring about mutually perpendiculat axes.	B31.3 uses two separate values.The B31.3 Code applies the inplane SIF to the Inplane moment and the out-of-plane SIF to the out-of-plane moment (all SIF's calculated per Appendices "D" of both Codes).
B31.1 simply warns deterious effect of the corrosion when joined in cyclic loadings.	B31.3 instruct the user to remove the Corrosion Allowance from the Z before making sustained and occasional stress calculations.

Figure 1: Chart Comparison of B31.1 & B31.3 Codes.

In Figure 1 above, one can see in the highlighted red box that B31.3 Code is "based upon a factor of safety of 3."

In addition, welding consumables are better, and welding processes are under better control than they were in 1950. Hhydrogen cracking and the need to use preheat and low-hydrogen electrodes is understood by the fabrication and construction industry. Postweld heat treatment is commonplace, whereas it was unusual in 1950.

In 1935, radiography was done using x-ray tubes and the thickness limit was 4 inches. More powerful energy sources, including radioactive isotopes, were developed after WWII, but their use was not commonplace until well after 1950. The quality and sensitivity of radiographic film has improved significantly since then, too. Ultrasonic examination has also advanced to where a competent technician can find and characterize very small flaws in very thick materials.

The Changes. . . .

Some allowable stresses <u>did not change</u> as a result of this change to the design margin:

- The design margins for cast and ductile iron.
- The design margins for materials in which yield strength governs (like 304 stainless)
- The design margins for elevated temperature (i.e. creep range) service.

What did change mostly was the allowable stress for low to mid-temperature service for carbon and low alloy steel. The typical increase in allowable stress is 14%. This advantage disappears as service temperature increases. For example, typical increases are:

Material	650°F	750°F	900°F
SA-516-70	7.4%	0%	Not permitted
SA-299	14%	5.3%	Not permitted
SA-213-T11	14%	3.6%	0%
SA-213-T22	14%	3.6%	0%

Conclusions

The change in design margin is the consequence of advancements in materials technology, including maturing of fracture mechanics as an engineering discipline and superior steelmaking technology, advancements in welding technology and advancements in non-destructive examination techniques. In addition, refinements in code rules and better understanding of how failures occur since 1951 make the reduction in design margin inconsequential to safety.

Further work is being done to reduce the margins for Division 2to less than 3.0.

ASME B31.3 has had a design margin of 3.0 for more than 20 years

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<u>Figure 2: Technical Report Explaining how ASME determined Safety Factor.</u>

Figure 2 is a clipping from a technical report written in order to explain the origin of why ASME uses certain safety factors. Again, the highlight red box outlines how B31.3 has used a design margin or safety factor of 3 for many of years.

(7) 80% of minimum stress for rupture at the end of 100 000 h

(b) *Gray Iron.* Basic allowable stress values at temperature for gray iron shall not exceed the lower of the following:

(1) one-tenth of the specified minimum tensile strength at room temperature

(2) one-tenth of the tensile strength at temperature [see para. 302.3.2(f)]

(c) *Malleable Iron.* Basic allowable stress values at temperature for malleable iron shall not exceed the lower of the following:

(1) one-fifth of the specified minimum tensile strength at room temperature

(2) one-fifth of the tensile strength at temperature [see para. 302.3.2(f)]

(d) *Other Materials.* Basic allowable stress values at temperature for materials other than bolting materials, gray iron, and malleable iron shall not exceed the lowest of the following:

(1) the lower of one-third of S_T and one-third of tensile strength at temperature

(2) except as provided in (3) below, the lower of two-thirds of S_Y and two-thirds of yield strength at temperature

(3) for austenitic stainless steels and nickel alloys having similar stress–strain behavior, the lower of two-thirds of S_Y and 90% of yield strength at temperature [see (e) below]

(4) 100% of the average stress for a creep rate of

shall be derived by multiplying the average expected tensile (yield) strength at temperature by the ratio of S_T (S_Y) divided by the average expected tensile (yield) strength at room temperature.

302.3.3 Casting Quality Factor, E_c

(a) *General.* The casting quality factors, E_c, defined herein shall be used for cast components not having pressure–temperature ratings established by standards in Table 326.1.

(b) *Basic Quality Factors.* Castings of gray and malleable iron, conforming to listed specifications, are assigned a basic casting quality factor, E_c, of 1.00 (due to their conservative allowable stress basis). For most other metals, static castings that conform to the material specification and have been visually examined as required by MSS SP-55, Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components — Visual Method, are assigned a basic casting quality factor, E_c, of 0.80. Centrifugal castings that meet specification requirements only for chemical analysis, tensile, hydrostatic, and flattening tests, and visual examination are assigned a basic casting quality factor of 0.80. Basic casting quality factors are tabulated for listed specifications in Table A-1A.

(c) *Increased Quality Factors.* Casting quality factors may be increased when supplementary examinations are performed on each casting. Table 302.3.3C states the increased casting quality factors, E_c, that may be used for various combinations of supplementary examination. Table 302.3.3D states the acceptance criteria for the examination methods specified in the Notes to

Figure 3: Details from B31.3 on how the Allowable Stress is Calculated.

Figure 3 outlines the basis of how B31.3 calculates the allowable stress of a material. For most Carbon Steels, the allowable will be the lower of (1/3)*Tensile Strength or (2/3)*Yield Strength.

(14) **Table A-1 Basic Allowable Stresses in Tension for Metals (Cont'd)**

Numbers in Parentheses Refer to Notes for Appendix A Tables; Specifications Are ASTM Unless Otherwise Indicated

Material	Spec. No.	Type/ Grade	UNS No.	Class/ Condition/ Temper	Size, in.	P-No. (5)	Notes	Min. Temp., °F (6)	Specified Min. Strength, ksi Tensile	Specified Min. Strength, ksi Yield	Min. Temp. to 100	200	300
...	A53	B	K03005	...	...	1	(57)(59)	B	60	35	20.0	20.0	20.0
...	A106	B	K03006	...	...	1	(57)	B	60	35	20.0	20.0	20.0
...	A333	6	K03006	...	...	1	(57)	−50	60	35	20.0	20.0	20.0
...	A334	6	K03006	...	...	1	(57)	−50	60	35	20.0	20.0	20.0
...	A369	FPB	K03006	...	...	1	(57)	−20	60	35	20.0	20.0	20.0
...	A381	Y35	...	...	...	1	...	A	60	35	20.0	20.0	20.0
...	API 5L	B	...	...	...	1	(57)(59)(77)	B	60	35	20.0	20.0	20.0

Figure 4: Example of Carbon Steel Pipe Allowable Stress.

From Figure 4, the Tensile Strength is 60 ksi and the Yield Strength is 35 ksi. To find the allowable, find the lower of the two products of the following equations: [(1/3)*60 ksi = 20 ksi], and [(2/3)*35 ksi =23.3 ksi[. The lower of the two products is 20 ksi. Therefore, B31.3 allowable is 20 ksi as seen above in Figure 4. From here, a safety factor can be computed. SF = (S_{max}/$S_{allowed}$) which computes to [SF = 60ksi/20ksi = 3]. From this series of calculations, one can see that the A106B piping uses a Safety Factor of 3 per B31.3.

(14) **Table A-1 Basic Allowable Stresses in Tension for Metals (Cont'd)**

Numbers in Parentheses Refer to Notes for Appendix A Tables; Specifications Are ASTM Unless Otherwise Indicated

Nominal Composition	Spec. No.	UNS No.	Class/Condition/ Temper	Size Range, in.	P-No. (5)	Notes	Min. Temp., °F (6)	Specified Min. Strength, ksi Tensile	Yield	Min. Temp. to 100	200	300	400	500	600	650
Nickel and Nickel Alloy (4a)																
Pipes and Tubes (2)																
Low C–Ni	B161	N02201	Annealed	> 5 O.D.	41	...	−325	50	10	6.7	6.4	6.3	6.3	6.3	6.3	6.2
Low C–Ni	B725	N02201	Annealed	> 5 O.D.	41	...	−325	50	10	6.7	6.4	6.3	6.3	6.3	6.3	6.2
Ni	B161	N02200	Annealed	> 5 O.D.	41	...	−325	55	12	8.0	8.0	8.0	8.0	8.0	8.0	...
Ni	B725	N02200	Annealed	> 5 O.D.	41	...	−325	55	12	8.0	8.0	8.0	8.0	8.0	8.0	...
Low C–Ni	B161	N02201	Annealed	≤ 5 O.D.	41	...	−325	50	12	8.0	7.7	7.5	7.5	7.5	7.5	7.5
Low C–Ni	B725	N02201	Annealed	≤ 5 O.D.	41	...	−325	50	12	8.0	7.7	7.5	7.5	7.5	7.5	7.5
Ni	B161	N02200	Annealed	≤ 5 O.D.	41	...	−325	55	15	10.0	10.0	10.0	10.0	10.0	10.0	...
Ni	B725	N02200	Annealed	≤ 5 O.D.	41	...	−325	55	15	10.0	10.0	10.0	10.0	10.0	10.0	...
Ni–Cu	B165	N04400	Annealed	> 5 O.D.	42	...	−325	70	25	16.7	14.6	13.6	13.2	13.1	13.1	13.1
Ni–Cu	B725	N04400	Annealed	> 5 O.D.	42	...	−325	70	25	16.7	14.6	13.6	13.2	13.1	13.1	13.1
Ni–Fe–Cr	B407	N08800	H.F. or H.F. ann.	...	45	...	−325	65	25	16.7	*16.7*	*16.7*	*16.7*	*16.7*	*16.7*	*16.7*
Ni–Cr–Fe	B167	N06600	H.F. or H.F. ann.	> 5 O.D.	43	...	−325	75	25	16.7	*16.7*	*16.7*	*16.7*	*16.7*	*16.7*	*16.7*
Ni–Fe–Cr	B407	N08810	C.D. sol. ann. or H.F. ann.	...	45	(62)	−325	65	25	16.7	16.7	16.7	16.7	16.7	16.5	16.1
Ni–Fe–Cr	B514	N08810	Annealed	...	45	(62)	−325	65	25	16.7	16.7	16.7	16.7	16.7	16.5	16.1
Ni–Fe–Cr	B407	N08811	C.D. sol. ann. or H.F. ann.	...	45	(62)	−325	65	25	16.7	16.7	16.7	16.7	16.7	16.5	16.1
Ni–Cu	B165	N04400	Annealed	≤ 5 O.D.	42	...	−325	70	28	18.7	16.4	15.2	14.7	14.7	14.7	14.7
Ni–Cu	B725	N04400	Annealed	≤ 5 O.D.	[illegible]	...	[illegible]	70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ni	B161	N02200	Annealed	≤ 5 O.D.	41	...	−325	55	15	10.0	10.0	10.0	10.0	10.0	10.0	...
Ni	B725	N02200	Annealed	≤ 5 O.D.	41	...	−325	55	15	10.0	10.0	10.0	10.0	10.0	10.0	...

Figure 5: 800HT Safety Factor Check.

Using the B31.3 calculation basis for austinetic stainless steel and nickel alloys, the allowable is found by comparing the lower of the following two equations: [(2/3)*Yield Strength)] and [0.9*Yield Strength]. The product for these two equations result with [(2/3)*25 ksi = 16.7 ksi] and [0.9*25 ksi = 22.5 ksi]. The smaller of the two is 16.7 ksi which matches the allowable seen for 800HT in Figure 5 above. Again, to find the Safety Factor, perform SF = ($S_{max}/S_{allowed}$), SF = (25 ksi / 16.7 ksi). The quotient of this equation is 1.5. This means that the Safety Factor applied to the Incoloy 800HT material is 1.5.