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Application of the New ASME Design Margin to the Assessment of FAC-Induced Wall Thinning in Piping Systems

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PRODUCT DESCRIPTION

Recently, ASME B31.1, Power Piping (2005 addenda) and the ASME Boiler and Pressure Vessel Code, Section II, Material Specifications, Part D (1999 addenda) have increased the design allowable stresses for metallic piping. For example, the new allowable stress for SA 106 grade B carbon steel at temperatures up to 500°F (260°C) is 17,100 psi (117.9 MPa), which is 14% higher than the previous allowable stress of 15,000 psi (103.4 MPa). This report investigates the use of these higher allowable stresses to evaluate the fitness-for-service of existing piping systems that are subject to wall thinning caused by flow-accelerated corrosion.

Results and Findings

This report includes the following sections:

- Section 1 summarizes the background for the new, higher allowable stresses.
- Section 2 compares the use of the new, higher allowable stresses to the original, lower allowable stresses. The following three cases are presented:
  - Original design equations with the original, lower allowable stresses (labeled OO)
  - New design equations with the new, higher allowable stresses (labeled NN)
  - Original design equations with the new, higher allowable stresses (labeled ON)

  The comparison illustrates that (1) in all cases, the ON case provides more allowance for wall thinning than does OO, and (2) the NN case might or might not provide more allowance for wall thinning than does OO, depending on the type of fitting and whether hoop stresses, rather than longitudinal stresses, govern design.
- Section 3 provides an overview of the various options for the evaluation of wall thinning for safety-related and non-safety-related piping.
- Section 4 presents a three-level, step-by-step procedure for the evaluation of wall thinning.
- Appendix A presents the National Board of Inspectors Code interpretation 98-14 pertaining to the use of new higher allowable stresses for existing vessels.
- Appendix B provides a comparison of allowable nominal moment stress. The comparison applies to ASME SA 106 grade B carbon steel pipe, butt welds, and corresponding fittings. The charts presented in Appendix B indicate the potential for wall thinning allowance—the lower the curve, the more allowance for wall thinning.
- Appendix C presents the request for interpretation that was sent to ASME for application of original design equations with the new, higher allowable stresses (the ON case described in Section 2).

Challenges and Objectives

The challenges associated with this study reside in two areas. First, there is no method accepted by the Nuclear Regulatory Commission for the evaluation of wall thinning in safety-class piping systems, short of compliance with the original design equations and allowables. Second, the increase in allowable stress is relatively recent, so we were required to coordinate with the ASME Code Committee for the application of the ON case. A request for interpretation was sent to ASME in early 2009 for application of the ON option. A similar interpretation was approved by the National Board of Boiler and Pressure Vessel Inspectors for re-rating pressure vessels.

Application, Value, and Use

The report applies to class 2 and 3 piping systems that were installed in nuclear power plants in accordance with ASME B31.1, Power Piping, ASME B31.7, Nuclear Power Piping, and ASME Boiler and Pressure Vessel Code, Section III, Rules for Construction of Nuclear Power Plant Components, Division 1, Nuclear Components, Subparts NB, NC, and ND, provided the rate of wall thinning can be predicted or bounded.

EPRI Perspective

This report provides flow-accelerated corrosion engineers and designer–stress analysts with a tool to evaluate wall thinning without resorting to re-analyses, and in some cases, to prevent unnecessary repairs.

Approach

This report investigates the possibility of applying the new, higher allowable stresses to evaluate the fitness-for-service of existing piping systems that are subject to wall thinning from flow-accelerated corrosion. The report provides a step-by-step method to perform the assessment and make run-or-repair decisions.

Keywords

Flow-accelerated corrosion
Piping systems
Fitness-for-service

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INTRODUCTION

1.1 ASME Codes for Piping Design

Piping systems in nuclear power plants are designed and constructed in accordance with the requirements of the ASME Code. Depending on the licensing date of each plant, three ASME codes have been applied over the years:

- ASME B31.1 Power Piping, for safety-related piping systems up to 1969, and for non-safety related piping systems to the present day.
- ASME B31.7, Nuclear Power Piping, for safety-related piping systems from 1969 to 1971.
- ASME Boiler and Pressure Vessel Code Section III Division 1, Nuclear Components, Subsections NB, NC and ND, for safety-related piping systems, from1971 to the present day.

1.2 Design Margins

1.2.1 Allowable Stress

Below the creep regime (below around 700^{o}F), the allowable stress for pressure and sustained loads in piping components (for all three piping design codes, ASME B31.1, ASME B31.7, and ASME III) is a fraction of the minimum specified ultimate and yield strengths of the material. The fraction ratios for ultimate and yield strengths constitute the design margins which we call DM_u and DM_y respectively. With this nomenclature, the allowable stress can be written as

$$S = \min\left\{\frac{S_u(T)}{DM_u};\frac{S_y(T)}{DM_y}\right\}$$

S = ASME Code allowable stress
$S_u(T)$ = minimum specified ultimate strength at temperature T
$S_y(T)$ = minimum specified yield strength at temperature T
DM_u = design margin against ultimate strength
DM_y = design margin against yield strength

1.2.1 Design Margins DM_u and DM_y

The design margin against ultimate strength DM_u in the ASME Boiler and Pressure Vessel Code has evolved over the years. The changes in DM_u are summarized in Table 1-1.

The design margin against yield strength DM_y has also changed from 5/8 (0.625) to the slightly larger 2/3 (0.667) for ferritic steels (carbon steel). DM_y is 2/3 for austenitic stainless steel with an allowance to be as large as 0.9 where some distortion is not detrimental to the component.

1.3 Recent Change to Design Margin

1.3.1 WRC 435

The initial impetus for an increase in allowable stress started in the 1990's with the need to better align ASME VIII Division 1 with the developing European pressure vessel Code, which permits lower design margins than the ASME codes (Table 1-4). The technical basis for the increase in Code allowable stresses (the decrease in design margin DM_u) is documented in ASME Code Committee correspondence, and is compiled in WRC Bulletin 435, Evaluation of Design Margins for Section VIII, Div.1 and 2 of the ASME Boiler and Pressure Vessel Code, by E. Upitis and K. Mokhtarian, September 1998.

As explained in WRC Bulletin 435, the reduction in design margins results from three considerations:

- "The majority of failures [of vessels] seem to be related to poor notch toughness, service degradation, or operation related problems. The incidence of catastrophic failures due to design faults or fabrication faults is low. Very few failures can be attributed to inadequate design rules in ASME Code."
- The improvement in materials (including toughness), fabrication, construction, non-destructive examination and testing.
- The precedent set by European codes which have lower design margins against ultimate strength DM_u, summarized in Table 1-4, while "the basic design formula [of European codes] for shells are essentially the same … the formulas for design of components and for areas of discontinuity vary a great deal. In general, the ASME Section VIII Codes (especially Division 1) are more conservative than those of the European Codes studied".

The same report makes a series of recommendations and considerations when using the new, lower design margin in the design of pressure vessels. Recommendations and considerations listed in WRC 435 that are applicable to piping systems are:

- Prevent design details that would provide "a very low number of allowable cycles" if the design margin is reduced
- Develop rules for heads [pipe caps], cone-cylinder junction [pipe reducers]
- Address distortion of bolted flanges
- Verify effect on toughness exemptions
- Adjust the hydrotest pressure to prevent plastic deformation
- Caution against some joint types, for example fillet lap joints
- Review exemption for NDE of nozzle welds
- Consider more attention to the qualification of Designers
- Address documentation and possibly PE stamping design calculations
- Consider third-party review of designs (as required by the European vessel codes)
- Address stresses allowed for conditions such as wind or seismic design
- Review design rules for large openings
- Consider the effect on peaking and local imperfections at welds
- Review bearing an shear stress limits

With this work as technical basis, the ASME III Subgroup Design and the ASME B31.1 Committee concluded that the reduced design margin was appropriate for piping systems, and approved the larger allowable stresses through their inclusion in ASME II Part D for Class 2 and 3, and ASME B31.1 Appendix A.

1.3.2 Code Cases

Based on the consensus around WRC 435, two Code Cases were published to allow the higher allowable stresses:

Code Case 2278 "Alternative Method for Calculating Maximum Allowable Stresses Based on Factor of 3.5 on Tensile Strength, Section II, Part D, and Section VIII Division 1"
Code Case 2284 "Alternative Maximum Allowable Stresses for Section I Construction based on Factor of 3.5 on Tensile Strength, Section I".

ASME B31.1 Code Case 173, approved May 2001, permitted the use of the higher allowable stresses.

1.3.3 Code Change

In the 1999 addendum to ASME Boiler and Pressure Vessel Code, Section II, and in the 2005 addendum to ASME B31.1, the design margin against ultimate strength DM_u was reduced from 4.0 to 3.5. This change resulted in a corresponding increase in Code allowable stresses as illustrated in Tables 1-2 and 1-3. In the case of ASTM A 106 (SA 106) Grade B the increase is 14% from ambient temperature up to 500^{o}F.

The increase in allowable stress was found to be independent of other design, materials, fabrication or examination provisions. The only concurrent change was a reduction to the hydrostatic test pressure.

1.3.4 National Board of Inspection Code (NBIC NB-23)

NBIC Interpretation 98-14, reproduced in Appendix A, permits the use of the higher allowable stress for re-rating a pressure-retaining item.

1.4 The NRC 10CFR50.55a Acceptance

The NRC has approved the following ASME III Code Editions and Addenda, as excerpted from 10CFR50.55(a):

"(1) As used in this section, references to Section III of the ASME Boiler and Pressure Vessel Code refer to Section III, and include the 1963 Edition through 1973 Winter Addenda, and the 1974 Edition (Division 1) through the 2004 Edition (Division 1), subject to the following limitations and modifications …

(iii) Seismic design of piping. *Applicants and licensees may use Articles NB–3200, NB–3600, NC–3600, and ND–3600 for seismic design of piping, up to and including the 1993 Addenda, subject to the limitation specified in paragraph (b)(1)(ii) of this section. Applicants and licensees*

may not use these Articles for seismic design of piping in the 1994 Addenda through the latest edition and addenda incorporated by reference in paragraph (b)(1) of this section."

Except for seismic design, ASME III is approved through the 2004 Edition. Therefore, the increased allowable stress (introduced in the 1999 Addenda to ASME II) is approved, except for seismic design.

1.5 ASME Inquiry

An inquiry was submitted to ASME, for the February 2009 meeting in Montreal, to assess the applicability of the pre-1981 equations (based on 0.75i) with the post-1999 Addenda allowables. The Inquiry is provided in Appendix C.

Table 1-1
Evolution of Design Margin Against Ultimate Strength DM_u

Year	DM_u VIII	DM_u B31.1	DM_u B31.7	DM_u III Cl.2,3
1925	5	-	-	-
1943	4	4	-	-
1969	4	4	4	-
1971	4	4	-	4
1999 Addendum	3.5	4	-	3.5
2001	3.5	3.5 Code Case	-	3.5
2005 Addendum	3.5	3.5	-	3.5

Table 1-2
Evolution of Allowable Stress for A 106 (SA 106) Grade B Carbon Steel Pipe

DM_u	Allowable Stress (ksi)			
	-20°F to 100°F	200°F	400°F	600°F
DM_u = 4 (operating plants)	15.0	15.0	15.0	15.0
DM_u = 3.5 (recent change)	17.1	17.1	17.1	17.1
Increase	14%	14%	14%	14%

Table 1-3
Evolution of Allowable A312 (SA 312) Type 304L Stainless Steel Pipe

DM_u	Allowable Stress (ksi)			
	-20°F to 100°F	200°F	400°F	600°F
$DM_u = 4$ (operating plants)	15.7	15.7 (13.4)	14.7 (11.0)	14.0 (9.7)
$DM_u = 3.5$ (recent change)	16.7	16.7 (14.3)	15.8 (11.7)	14.0 (10.4)
Increase	6.4%	6.4%	7.5%	0%

Note: in parenthesis is the allowable stress if no minor distortion is permitted (for example near flange joints).

Table 1-4
Design Margins DM_u in European Codes

Code	DM_u
BS 5500 (UK)	2.35
Stoomwezen (Holland)	2.27
AD-Merkblatt (Germany)	Not specified
Draft CEN/TC54 (European)	2.4

2
DESIGN MARGINS

2.1 Pressure Design

2.1.1 Pressure Design Equation

The pressure design equations in ASME B31.1, ASME B31.7 and ASME III is (refer to Section 2.4 for nomenclature)

$$t_{min} = \frac{P_D \times D}{2 \times (S \times E + P \times y)}$$

$$t_m = t_{min} + c$$

2.1.2 Pressure Design Margin

For Class 2 and Class 3 piping systems P×y can typically be neglected relative to S×E. For example, an upper bound for P×y in lines susceptible to accelerated corrosion, based on a pressure of approximately 1000 psi at 500°F, P×y = 400 psi, compared to S×E = 15000 psi. Therefore the minimum wall thickness is nearly inversely proportional to S

$$t_{min} \approx \frac{P \times D_o}{2 \times S \times E} = \frac{x_P}{S}$$

The design margin for pressure loading is therefore the same as the margin in S, which is DM_u. A 14% increase in S would permit a corresponding 14% decrease in pressure-based t_{min}. The values of DM_u (design margin against ultimate strength), including over-pressure allowances, are listed in Table 2-1.

2.2 Sustained and Occasional Loads Design Margins

2.2.1 Design Equations

The sustained and occasional stress equations in ASME B31.1 and ASME III Class 2 and 3 (NB/NC-3600) have remained unchanged until the Winter 1981 addenda of ASME III. These equations are labeled here Original equations (pre-W.81). The corresponding allowable stress was the pre-1999 addenda allowable, and is labeled here the Original allowable (pre-A.99). Hence this first equation and allowable is labeled OO. For occasional loads OO is

$$\frac{P \times D}{4 \times t} + 0.75 \times i \times \frac{M}{Z} \leq 2.4 \times S_h \text{(pre} - \text{A.99)} \qquad \text{(OO)}$$

The sustained and occasional stress equations in ASME III Class 2 and 3 changed in the Winter 1981 addenda. These equations are labeled here New equations (post-W.81). The allowable stress changed between in 1999, and are labeled here the New allowable (pre-A.99). Hence this second equation and allowable is labeled NN. For occasional loads NN is

$$B_1 \times \frac{P \times D}{2 \times t} + B_2 \times \frac{M}{Z} \leq \min\{3 \times S_h (\text{post} - A.99); 2 \times S_y\} \qquad \text{(NN)}$$

A third equation-allowable combination is created by using the Original equation with the New allowable, hence labeled ON. For occasional loads ON is

$$\frac{P \times D}{4 \times t} + 0.75 \times i \times \frac{M}{Z} \leq 2.4 \times S_h (\text{post} - A.99) \qquad \text{(ON)}$$

Note: New stress indices B_2' and new equations for reversing dynamic loads (seismic) were introduced in 2004. These are are not addressed here since they are not approved by the NRC through 10CFR50.55a.

2.2.2 Comparison of Margins

Appendix B compares the three equations: OO, NN and ON. The comparison applies to ASME SA 106 Grade B carbon steel pipe, butt welds and corresponding fittings.

Two cases are studies: internal pressure P = 1000 psi and internal pressure P = 300 psi. In all cases we impose an unintensified moment stress M/Z = 10,000 psi.

The plots in Appendix B compare the minimum required wall thickness for OO, NN and ON, at the two pressures (1000 psi case and 300 psi case) and the concurrent unintensified moment stress of 10,000 psi. In Apppendix B, the lower the curve corresponds to more allowance for wall thinning.

2.3 Thermal Flexibility Design Margins

The thermal flexibility (expansion-contraction) design equation has remained unchanged, in the form:

$$i \times \frac{M_E}{Z} \leq S_a$$

Therefore, the increase in allowable stresses introduced in ASME II 1999 and ASME B31.1 2005, results in an equal allowance for wall thinning.

2.4 Nomenclature

B_1 = primary stress index, pressure
B_2 = primary stress index, moment
c = corrosion and erosion allowance
C_2 = secondary stress index
D = nominal outside diameter
E = seam weld joint efficiency factor
f = ASME cycle penalty factor
h = flexibility characteristic of pipe fitting
i = stress intensification factor
ID = pipe inside diamater
$M = M_A + M_B$
M_A = moment due to sustained loads
M_B = moment due to occasional loads
M_C = thermal expansion-contraction moment range
M_E = moment due to thermal expansion and contraction
OD = pipe outside diamater
P = design pressure
P_D = design pressure
S = code allowable stress at temperature
S_A = allowable stress for expansion and contraction-induced stresses
S_c = allowable stress in the cold condition
S_E = thermal expansion stress range
S_h = allowable stress in the hot condition
S_y = yield strength at temperature
t_m = minimum wall required by Code, including corrosion and erosion allowance
t_{min} = minimum wall required by Code
x_P = proportionality constant for pressure loading
y = material and temperature-dependent coefficient
Z = section modulus of pipe

Table 2-1
Evolution of Over-Pressure Allowance

Code	Over-Pressure Allowance	DM_u Pre-1999	DM_u Post-1999
B31.1, B31.7 and III Cl.2,3 to W.81	0% in continuous service	4	3.5
	15% during 10% of the operating period	4/1.15 = 3.5	3.5/1.15 = 3.0
	20% during 1% of the operating period	4/1.2 = 3.3	3.5/1.2 = 2.9
III Cl.2,3 since W.81	0% for level A	4	3.5
	0% for level B	4	3.5
	50% level C	4/1.5 = 2.7	3.5/1.5 = 2.3
	100% level D	4/2 = 2	3.5/2 = 1.8

Table 2-2
Evolution of Design Equation Indices

Code	α **Axial Pressure Stress Index**	β **Sust. – Occ. Moment Stress Index**	**k** **Allowable Stress Multiplier**
B31.1 1955 ⇨ 1967	0.5	0.75i Sust. - Occ. Not specified	1.0 for Sustained - Occasional not specified
B31.1.0 1967 ⇨ 1969		0.75 i	1.2
B31.7 Cl.2,3 1969 ⇨ 1971			
III Cl.2,3 1971 ⇨ W.1972			
III Cl.2,3 W.1972 ⇨ W. 1981			1.0 design and normal 1.2 upset (or occasional) 1.8 emergency 2.4 faulted
III Cl.2,3 W.1981 ⇨ 1999 Add.	B_1	B_2	1.5 design 1.0 level A 1.8 (but not to exceed $1.5S_y$) levels A and B 2.25 (but not to exceed $1.8S_y$) level C 3.0 (but not to exceed $2.0S_y$) level D
III Cl.2,3 1999 Add. ⇨ to-date	B_1	B_2	1.5 design 1.8 (but not to exceed $1.5S_y$) levels A and B 2.25 (but not to exceed $1.8S_y$) level C 3.0 (but not to exceed $2.0S_y$) level D
III Cl.2,3 2004 ⇨ to-date Alternative for Reverse Dynamic Loads (seismic)	B_1	B_2’	1.8 (but not to exceed $1.5S_y$) level B 2.1 level C with $C_2M_{SAM}/Z < 4.2S$ and $F_{SAM}/A < 0.7S$ 3.0 level D with $C_2M_{SAM}/Z < 4.2S$ and $F_{SAM}/A < 0.7S$

Sust. = sustained loads (pressure, weight); Occ. = occasional loads (seismic); W = winter addendum

3
FITNESS-FOR-SERVICE FOR WALL THINNING

There are several codes and standards that address the assessment of wall thinning (general or local). These are:

- For safety-related piping systems: ASME XI Code Cases N-597-2 and N-513-1.
- For safety-related piping systems: Non-mandatory Appendix H to ASME XI. While Appendix H addresses planar flaws (crack-like) rather than wall thinning, it provides insights into fitness-for-service margins.
- For non-nuclear plants, and for non-safety systems in nuclear power plants, the fitness-for-service codes are ASME B31G (pipelines) and API 579 / ASME FFS-1.

This Chapter provides a technical overview of these codes and standards. Chapter 4 will address the recommended approach for fitness-for-service assessment.

3.1 ASME XI Non-Mandatory Appendix H

Appendix H provides the evaluation procedures for flaws in piping based on the Failure Assessment Diagram (FAD). The safety factors (SF) (fitness-for-service FFS margins) for circumferential and axial flaws are reproduced in Tables 3-1 and 3-2.

3.2 ASME XI Code Case N-597-2 Wall Thinning Class 1, 2 and 3 Piping

The Code Case provides a procedure for the evaluation of wall thinning. It permits the wall thickness of a straight pipe to be 90% of the minimum wall thickness t_{min} required for design pressure. The resulting design margin DM_u for B31.1 as well as ASME III Class 2 and 3 is

$$DM_u = 0.9 \times 4 = 3.6$$

A DM_u = 3.5 would be just short of the 90% x 4 = 3.6 margin. However, in R.G. 1.147 condition (2) the NRC does not permit the use of 90% without their review (see hereunder).

If the wall thickness is below 90% of t_{min} then CC N-597-2 permits more detailed evaluations to be conducted. Depending on the extent and profile of wall thinning, the FFS margin varies from 0.1 DM_u = 0.4 to 0.9 DM_u = 3.6. However, these additional evaluations are subject to NRC review and approval in accordance with R.G. 1.147.

NRC R.G. 1.147 conditions of applicability for CC N-597-2

"(1) Code Case must be supplemented by the provisions of EPRI Nuclear Safety Analysis Center Report 202L-R2,"Recommendations for an Effective Flow Accelerated Corrosion Program" (Ref. 6), April 1999, for developing the inspection requirements, the method of predicting the

rate of wall thickness loss, and the value of the predicted remaining wall thickness. As used in NSAC-202L-R2, the term "should" is to be applied as "shall" (i.e, a requirement).

(2) Components affected by flow-accelerated corrosion to which this Code Case are applied must be repaired or replaced in accordance with the construction code of record and Owner's requirements or a later NRC approved edition of Section III, "Rules for Construction of Nuclear Power Plant Components," of the ASME Code (Ref. 7) prior to the value of t_p reaching the allowable minimum wall thickness, t_{min}, as specified in -3622.1(a)(1) of this Code Case. Alternatively, use of the Code Case is subject to NRC review and approval per 10 CFR 50.55a(a)(3). [Note that this NRC Condition of applicability requires that the original ASME III required minimum thickness be met, which implies that a reduction to 90% of the wall thickness is not permitted.]

(3) For Class 1 piping not meeting the criteria of -3221, the use of evaluation methods and criteria is subject to NRC review and approval per 10 CFR 50.55a(a)(3).

(4) For those components that do not require immediate repair or replacement, the rate of wall thickness loss is to be used to determine a suitable inspection frequency so that repair or replacement occurs prior to reaching allowable minimum wall thickness, t_{min}.

(5) For corrosion phenomenon other than flow accelerated corrosion, use of the Code Case is subject to NRC review and approval. Inspection plans and wall thinning rates may be difficult to justify for certain degradation mechanisms such as MIC and pitting."

3.3 ASME XI Code Case N-513-1 Flaws in Moderate Energy Piping

This Code Case applies to ASME B31.1, B31.7 and ASME III systems classified as Class 2 and 3. It applies to moderate energy piping ($T < 200^{o}$F and $P < 275$ psi).

Separate rules apply for planar and non-planar flaws. Planar flaws are narrow flaws, where the width of wall thinning below t_{min} is narrower than $\sqrt{(R_o t_{min})}$. The FFS margins for planar flaws are listed in Table 3-3.

The FFS margins for non-planar flaws (typical of FAC wall thinning) are a function of the extent and profile of wall thinning. A FFS margin corresponding to $DM_u = 3$ i.e. $t_{aloc} = ¾\ t_{min}$ is only permitted if the axial extent of wall thinning below t_{min} $L_{m(a)}$ is very limited in the range of ~ 0.8 to 3 times $\sqrt{(R_o t_{min})}$. In addition, for thinning over a wide region (transverse extent of wall thinning $L_{m(t)}$ wider than $\sqrt{(R_o t_{min})}$)

$$\frac{t_{aloc}}{t_{min}} \geq \frac{0.5 + \frac{t_{nom}}{t_{min}} \frac{\sigma_b}{S}}{1.8}$$

$$t_{aloc} \geq 0.28 \times t_{min} + \frac{\sigma_b}{1.8 \times S} \times t_{nom}$$

The NRC R.G. 1.147 conditions of applicability for CC N-513-1 are:

(1) Specific safety factors in paragraph 4.0 must be satisfied (see Table 3-3 above).
(2) Code Case N-513 may not be applied to:

(a) Components other than pipe and tube.
(b) Leakage through a gasket.
(c) Threaded connections employing nonstructural seal welds for leakage prevention (through seal weld leakage is nota structural flaw; thread integrity must be maintained).
(d) Degraded socket welds

3.4 ASME B31G Assessment of Wall Thinning in Pipelines

ASME B31G applies to the assessment of metal loss in oil and gas transmission pipelines. It was developed in the early 70's and remains applicable to this day. The fundamental relationship, developed based on original work by professor Folias, is

$$\sigma_{failure} = \sigma_{flow} \times \left(\frac{1 - \frac{A}{A_o}}{1 - \frac{1}{M} \times \frac{A}{A_o}} \right)$$

A = corroded (removed) area of pipe wall
A_o = original area of pipe wall before corrosion
M = Folias factor
$\sigma_{failure}$ = failure stress of thinned area
σ_{flow} = flow stress

$$M = \sqrt{1 + 0.8 \times \frac{d^2}{D \times t}}$$

Three assumptions are then introduced to simplify the equations:

$$\sigma_{flow} = 1.1 \times \sigma_{yield}$$

$$A = \frac{2}{3} \times d \times t$$

$$\sigma_{failure} = \frac{P \times D}{2 \times t} = \sigma_{yield}$$

D = pipe diamater
d = depth of wall thinning
P = internal pressure

With these assumptions the FFS assessment can then be expressed in very simple form, well suited to the analysis of large amounts of pig inspection measurements. The B31G approach is not applicable to nuclear piping systems since it does not account for loads other than pressure, and it is based on assuring integrity up to yield of the pipeline but not beyond, which is a lower margin that ASME XI would permit.

3.5 API 579 / ASME FFS 1 for Wall Thinning

API 579 provides separate assessment methods for each of the three types of wall thinning:

- General metal loss
- Local metal loss
- Pitting

API 579 is an exceptionally clear and well documented fitness-for-service assessment standard used in the chemical and petrochemical industries. The API 579 criteria for general wall thinning can be summarized as follows. For the prevention of pinhole leakage the minimum measured wall thickness t_{mm} is limited to

$$t_{mm} - FCA \geq 0.1 \text{ in}$$

For the prevention of burst, the minimum measured wall thickness t_{mm} and the minimum wall averaged over a defined area t_{am} are limited to

$$t_{mm} - FCA \geq \frac{t_{min}}{2}$$

$$t_{am} - FCA \geq RSF_a \times t_{min}$$

FCA = future corrosion allowance (further wall loss between this inspection and next)
RSF_a = remaining strength factor allowed
t_{am} = averaged minimum wall thickness
t_{min} = minimum wall required by the Design Code
t_{mm} = minimum measured wall thickness

Note that t_{mm} – FCA is the same parameter as t_p in ASME XI Code Case N-597-2. The API 579 method, because of its rigor and completeness is recommended for the assessment of wall thinning in non-safety related piping systems.

Table 3-1
ASME XI Ap. H Safety Factors SF for Circumferential Flaws

Service Level	Membrane Stress SF_m	Bending Stress SF_b
A	2.7	2.3
B	2.4	2.0
C	1.8	1.6
D	1.3	1.4

Table 3-2
ASME XI Ap. H Safety Factors SF for Axial Flaws

Service Level	Membrane Stress SF_m
A	2.7
B	2.4
C	1.8
D	1.3

Table 3-3
CC N-513-1 FFS Margins for Planar Flaws

Flaw Orientation	Service Level	Load Safety Margin SF
Circumferential	A and B	2.77
Circumferential	C and D	1.39
Axial	A and B	3.0
Axial	C and D	1.5

4

ASSESSMENT PROCEDURE

This Chapter presents the assessment procedures which are proposed for the fitness-for-service assessment of wall thinning in piping components subject to FAC wall thinning.

4.1 Summary of Assessment Procedures

4.1.1 Assessment Procedures

The fitness-for-service assessment procedures for wall thinning are summarized in Table 4-1 and Figure 4-1.

4.1.2 Use of the Reduced Design Margin of 3.5

The reduced design margin DM_u = 3.5, in accordance with ASME III 1999 addenda and later editions, and ASME B31.1 edition, (allowable stress 17,100 psi for ASTM A 106 (SA 106) Grade B to 500^{o}F) can be used for all piping systems and pipe fittings, provided:

- The conditions of applicability in Section 4.3.3 are satisfied
- The procedure of Section 4.3.3 for calculating the increased stress indices and stress intensification factors, the reduced section modulus, and the increased stress is followed
- The additional checks outlined in Section 4.3.3 are verified

4.2 Non-Safety Related Piping Systems

For non-safety related piping systems, the step-by-step methods of API 579 / ASME FFS-1 can be used to assess wall thinning. The API 579 / ASME FFS-1 approach is a three-level approach from the simplest, most conservative Level 1 to finite element analysis for Level 3.

As an alternative, the methods for safety related systems may be applied.

4.3 Safety Related Piping Systems

4.3.1 Level 1 Conservative Bounding Assessment

The Level 1 fitness-for-service assessment is based on full compliance of the corroded region to the original design equations and original allowable. This corresponds to the case OO in Section 3 and Appendix B. The Level 1 steps are depicted in Figure 4-1, and explained here.

Step 1 Wall Thickness Profile

- Determine the location and extent of wall thinning.
- Measure the wall thickness throughout the corroded-eroded region.
- Record the minimum measured wall t_{mm} at any point in the corroded zone.
- Establish a future corrosion allowance FCA, which is the further loss expected between this inspection and the next inspection or repair.

Step 2 Original Design Analysis

- Retrieve the stress analysis for the line under review.
- Compile the maximum stress in the region of wall thinning.

Step 3 Revised Equations

- Verify that t_{mm} minus FCA exceeds the minimum wall thickness required by the applicable ASME code t_{min} for new design:

$$t_{mm} - FCA \geq t_{min} = \frac{P \times D}{2 \times (S \times E + P \times y)}$$

- Calculate the increased stress intensification factor $i_{corroded}$ and the stress indices $B_{1\text{-}corroded}$, $B_{2\text{-}corroded}$, $C_{2\text{-}corroded}$ (as applicable) assuming uniform wall loss equal to t_{mm} – FCA takes place around the full circumference.
- Calculate the corroded (reduced) section modulus $Z_{corroded}$. This can be done either by conservatively assuming uniform wall loss equal to t_{mm} – FCA takes place around the full circumference, or calculating the section modulus of the actual corroded section.
- Calculate the increased code stresses (sustained and occasional, design, levels A, B, C and D) based on the corroded values $i_{corroded}$ $B_{1\text{-corroded}}$ $B_{2\text{-corroded}}$ $C_{2\text{-corroded}}$ and $Z_{corroded}$.
- Compare the increased corroded code stresses to the original allowable design stress.

Note Regarding Stress Indices

Figures 4.2 and 4.3 present some of the flexibility characteristics, stress indices and stress intensification factors in the ASME B31.1 and ASME III codes. For the assessment of a corroded condition at a pipe fitting, the stress index and stress intensification factors will have to be increased as follows:

- Reduce the wall thickness to account for corrosion (replace $t_{nominal}$ by t_{mm} – FCA)
- Calculate the increased flexibility factor $h_{corroded}$ for a wall thickness t_{mm} – FCA
- Calculate the increased stress intensification factor $i_{corroded}$ based on the reduced $h_{corroded}$
- Calculate the reduced stress index $B_{1corroded}$ and the increased stress indices $B_{2corroded}$ $C_{2corroded}$ based on the reduced flexibility characteristic $h_{corroded}$

Note Regarding the Section Modulus

The section modulus of a pipe is

$$Z = 0.0982 \times \frac{OD^4 - ID^4}{OD}$$

Which is approximately

$$Z \approx \pi \times OD^2 \times t$$

where R is the pipe radius and t its wall thickness. For a corroded pipe the approximate section modulus is reduced to $Z = \pi \times OD^2 \times t_{corroded}$.

Step 4 Compare to Allowable Stress

- If the allowable design stresses are not met, consider a Level 2 assessment, Section 4.3.3.

Step 5 Additional Checks

- If wall thinning is at equipment or component nozzles, compare the increased corroded code stresses to the nozzle limit stresses.
- If wall thinning is at a welded attachment, evaluate the local stresses assuming uniform wall loss equal to t_{mm} – FCA takes place around the full circumference.
- If D/(t_{mm}-FCA) exceeds 100, evaluate the local stresses in the contact area between pipe and supports to prevent buckling.
- Loads on pipe supports and braces need not be re-evaluated for the pipe corroded condition.
- Pipe movements need not be re-evaluated for the pipe corroded condition.

4.3.2 Level 2 Assessment for Moderate Energy Lines

For moderate energy lines (T < 200°F and P < 275 psi) the method of ASME XI Code Case N-513-1 may be applied, subject to the limitations of Regulatory Guide 1.147.

4.3.3 Level 2 Assessment for All Lines

The Level 2 fitness-for-service assessment is based on one of two methods:

- Level 2 ON - The evaluation of the corroded region to the original design equations and new increased allowable. This corresponds to the case ON in Section 3 and Appendix B.
- Level 2 NN - The evaluation of the corroded region to the original design equations and new increased allowable. This corresponds to the case NN in Section 3 and Appendix B.

The Level 2 approach (either ON or NN) can be used for B31.1, B31.7 and III NC/ND-3600 pre-2007. A line-by-line comparison of the plant code of record and the 2007 Edition of ASME III NC/ND-3600 is technically unnecessary. However, the following conditions apply:

Materials:

- The original material must conform to the same material specification in ASME II 2007, in chemistry, fabrication and heat treatment process, and mechanical properties (yield strength, ultimate strength and elongation at rupture).
- The material must be operating above the minimum permitted temperature in accordance with both the code of record and ASME III NC/ND-3600, 2007.

Design:

- The stress intensification factors and stress indices are to be based on the corroded cross section.

- The minimum measured wall thickness minus the projected wall thinning till the next inspection or till repair shall not be less than 0.10 in. This condition is based on API 579 / ASME FFS-1 Fitness-for-Service, and is intended to prevent a pinhole leak.

Fabrication:

- If wall thinning is at a weld, the weld shall be examined by 100% radiography or ultrasonic, in accordance with ASME III NC/ND-4000.

Regulatory Considerations:

- Obtain regulatory review and approval for application of the Level 2 assessment method.
- The Design Specification may have to be revised to reference the new allowable stresses, in accordance with NCA-1140.

4.3.4 Level 3 Assessment for All Lines

The level 3 assessment consists in finite element analysis (FEA) of the corroded region. The applied loads for the operating and design conditions should be obtained from the piping system stress analysis, plus internal pressure.

The stress evaluation criteria of the FEA results should be in accordance with ASME III or ASME VIII Division 2.

Table 4-1
Fitness-for-Service Assessment Procedures

FFS Assessment Method	Non-Safety Related	Safety Related	
		Moderate Energy	High Energy
API 579 / ASME FFS-1 Fitness-for-Service (section 4.2)	Yes	No	No
Original code equations with reduced wall thickness (Level 1, Section 4.3.1)	Yes	Yes	Yes
ASME XI Code Case N-513 (Level 2, Section 4.3.2)	Yes	Yes	No
ASME III 2007 (DM_u = 3.5) with reduced wall (Level 2, Section 4.3.3, conditions of applicability)	Yes	Yes	Yes

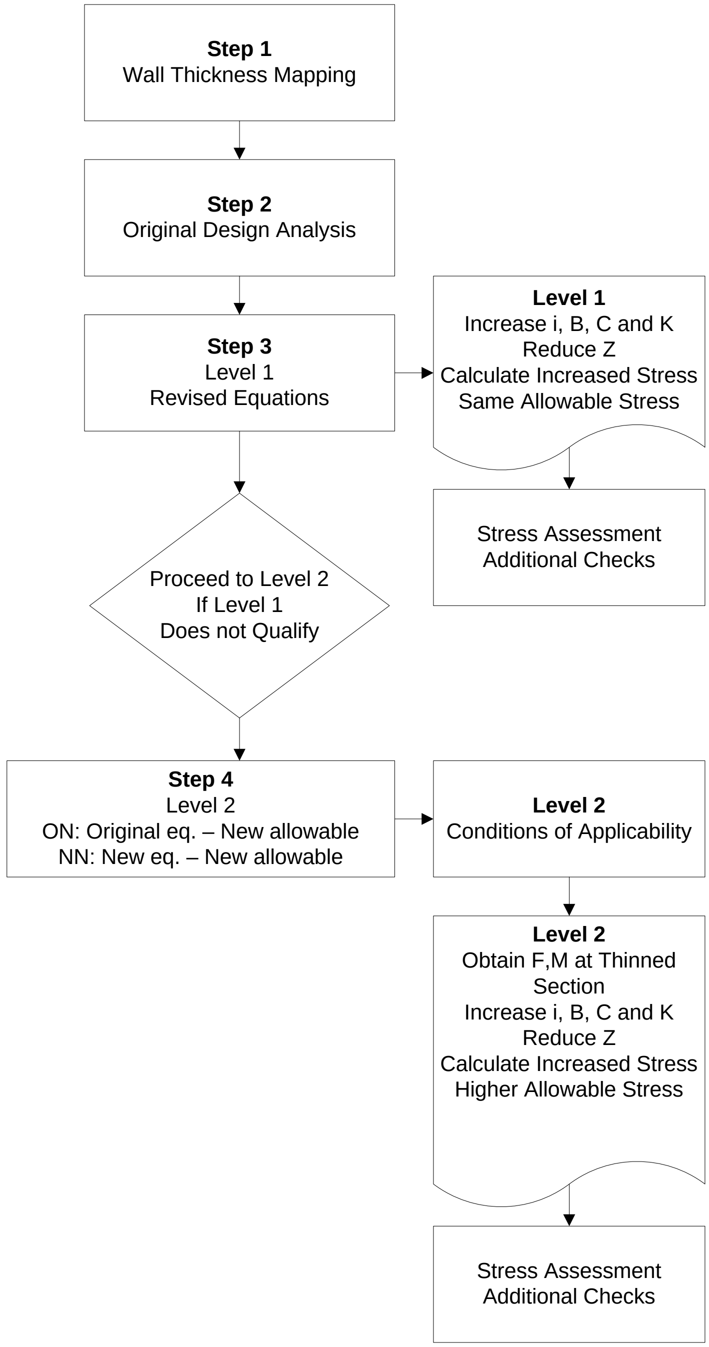


Figure 4-1
FFS Assessment Process for High Energy Lines

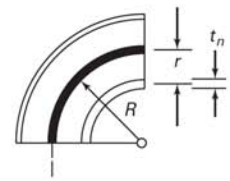
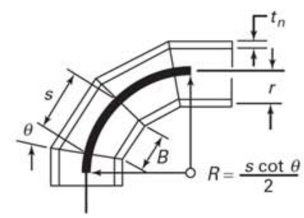
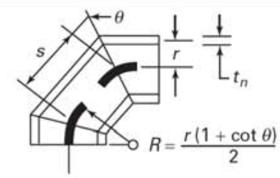
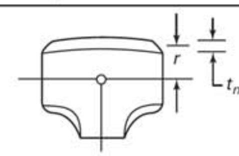
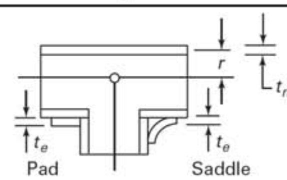
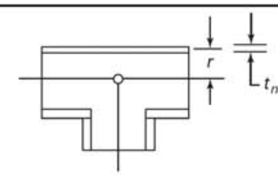
Description	Flexibility Characteristic h	Flexibility Factor k	Stress Intensification Factor i	Sketch
Welding elbow or pipe bend [Notes (1), (2), (3), (9), (13)]	$\frac{t_n R}{r^2}$	$\frac{1.65}{h}$	$\frac{0.9}{h^{2/3}}$	
Closely spaced miter bend [Notes (1), (2), (3), (13)] $s < r(1 + \tan\theta)$ $B \geq 6\ t_n$ $\theta \leq 22\frac{1}{2}$ deg.	$\frac{s t_n \cot\theta}{2r^2}$	$\frac{1.52}{h^{5/6}}$	$\frac{0.9}{h^{2/3}}$	
Widely spaced miter bend [Notes (1), (2), (4), (13)] $s \geq r(1 + \tan\theta)$ $\theta \leq 22\frac{1}{2}$ deg.	$\frac{t_n(1 + \cot\theta)}{2r}$	$\frac{1.52}{h^{5/6}}$	$\frac{0.9}{h^{2/3}}$	
Welding tee per ASME B16.9 [Notes (1), (2), (10)]	$\frac{4.4 t_n}{r}$	1	$\frac{0.9}{h^{2/3}}$	
Reinforced fabricated tee [Notes (1), (2), (5), (10)]	$\frac{\left(t_n + \frac{t_e}{2}\right)^{5/2}}{r(t_n)^{3/2}}$	1	$\frac{0.9}{h^{2/3}}$	
Unreinforced fabricated tee [Notes (1), (2), (10)]	$\frac{t_n}{r}$	1	$\frac{0.9}{h^{2/3}}$	

Figure 4-2
Example of Flexibility and Stress Intensification Factors ASME B31.1

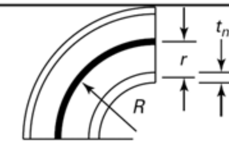
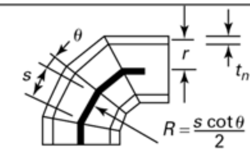
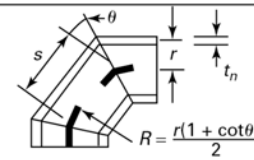
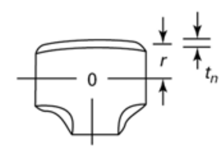
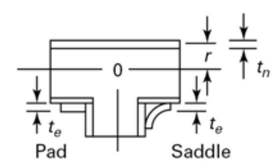
Description	Primary Stress Index B_1	Primary Stress Index B_2	Flexibility Characteristic h	Flexibility Factor k	Stress Intensification Factor i	Sketch
Welding elbow or pipe bend [Notes (4) and (5)]	$0.4\ h - 0.1 \leq 0.5$ and > 0	$\frac{1.30}{h^{2/3}}$	$\frac{t_n R}{r^2}$	$\frac{1.65}{h}$	$\frac{0.9}{h^{2/3}}$	
Closely spaced miter bend [Note (4)] $s < r\,(1 + \tan\,\theta)$	[Note (6)]	[Note (6)]	$\frac{s t_n \cot\,\theta}{2 r^2}$	$\frac{1.52}{h^{5/6}}$	$\frac{0.9}{h^{2/3}}$	
Widely spaced miter bend [Notes (4) and (7)] $s \geq r\,(1 + \tan\,\theta)$	[Note (6)]	[Note (6)]	$\frac{t_n\,(1 + \cot\,\theta)}{2r}$	$\frac{1.52}{h^{5/6}}$	$\frac{0.9}{h^{2/3}}$	
Welding tee per ANSI B16.9 [Note (8)]	0.5	Branch end: $B_{2b} = 0.4 \left(\frac{r}{t_n}\right)^{2/3}$ Run end: $B_{2r} = 0.5 \left(\frac{r}{t_n}\right)^{2/3}$	$\frac{4.4\ t_n}{r}$	1	$\frac{0.9}{h^{2/3}}$ For branch leg of a reduced outlet, use $\frac{0.9}{h^{2/3}}\left(\frac{T'_b}{T_r}\right)$	
Reinforced fabricated tee [Notes (8)–(10)]	0.5	[Note (6)]	$\frac{\left(t_n + \frac{t_e}{2}\right)^{5/2}}{r\,(t_n)^{3/2}}$	1	$\frac{0.9}{h^{2/3}} \geq 2.1$ For branch leg of a reduced outlet, use $\frac{0.9}{h^{2/3}}\left(\frac{T'_b}{T_r}\right) \geq 2.1$	

Figure 4-3
Example of Flexibility, Stress Indices, and Stress Intensification Factors ASME III NC/ND-3600

A

APPENDIX A – 1998 NBIC INTERPRETATION 98-14

Following are National Board of Inspectors Code (NBIC) interpretation 98-14 pertaining to the use of new higher allowable stresses for existing vessels.

"Question 4:

May a pressure-retaining item be re-rated using a later edition/addenda of the original code of construction which permits higher allowable stress values for the material than was used in the original construction?

Reply 4: Yes, in compliance with the following minimum criteria:

a. The "R" Certificate Holder verifies (by calculations and other means) that the re-rated item can be satisfactorily operated at the new service conditions (e.g., stiffness, buckling, external mechanical loadings, etc.),

b. The pressure-retaining item is not used for lethal service,

c. The pressure-retaining item is not in high-cycle operation or fatigue service (i.e., loadings other than primary membrane stress are controlling design considerations.),

d. The pressure-retaining item was constructed to the 1968 Edition or later edition/addenda of the original code of construction,

e. The pressure-retaining item is shown to comply with all relevant requirements of the edition/addenda of the code of construction which permits the higher allowable stress values (e.g., reinforcement, toughness, examination, pressure testing, etc.),

f. The pressure-retaining item has a satisfactory operating history and current inspection of the pressure-retaining item verifies that the item exhibits no unrepaired damage (e.g., cracks, corrosion, erosion, etc.),

g. The re-rating is acceptable to the Inspector and, where required, the jurisdiction,

h. All other requirements of Part RC are met, and

i. Use of this Interpretation is documented in the Remarks Section of Form R2.

Question 5:

May a new minimum required wall thickness be calculated for a pressureretaining item by using a later edition/addenda of the original code of construction which permits higher allowable stress values for the material than was used in the original construction?

Reply 5: Yes, in compliance with the following minimum criteria:

a. The "R" Certificate Holder verifies (by calculations and other means) that the affected portions of the pressure-retaining item can be satisfactorily operated (e.g., stiffness, buckling, external mechanical loadings, etc.),

b. The pressure-retaining item is not used for lethal service,

c. The pressure-retaining item is not in high-cycle operation or fatigue service (i.e., loadings other than primary membrane stress are controlling design considerations.),

d. The pressure-retaining item was constructed to the 1968 Edition or later edition/addenda of the original code of construction,

e. The pressure-retaining item is shown to comply with all relevant requirements of the edition/addenda of the code of construction which permits the higher allowable stress values (e.g., reinforcement, toughness, examination, pressure testing, etc.),

f. The pressure-retaining item has a satisfactory operating history and current inspection of the pressure-retaining item verifies that the item exhibits no unrepaired damage (e.g., cracks, etc.). Areas of corrosion or erosion may be left in place provided the remaining wall thickness is greater than the new minimum thickness,

g. The design change is acceptable to the Inspector and, where required, the jurisdiction,

h. All other requirements of Part RC are met, and

i. Use of this Interpretation is documented in the Remarks Section of Form R2."

B

APPENDIX B – COMPARISON OF ALLOWABLE NOMINAL MOMENT STRESS M/Z

Notes for Tables and corresponding Figures in Appendix B:
Two cases of internal pressure: 300 psi and 1000 psi
Bending stress taken as 10,000 psi
OO = original stress with original allowable (300 or 1000 psi)×D/4t + 0.75i × (10,000 psi x t_{nom})/t ≤ 2.4 × 15,000 psi
NN = new stress with new allowable B_1 × (300 or 1000 psi)×D/2t + B_2 × (10,000 psi x t_{nom})/t ≤ 3 × 17,100 psi
ON = original stress with new allowable (300 or 1000 psi)×D/4t + 0.75i × (10,000 psi x t_{nom})/t ≤ 2.4 × 17,100 psi

Curves are provided for guidance. A lower curve permits more wall loss than a curve above it. For precise, location specific analysis refer to Chapter 4 of this report.

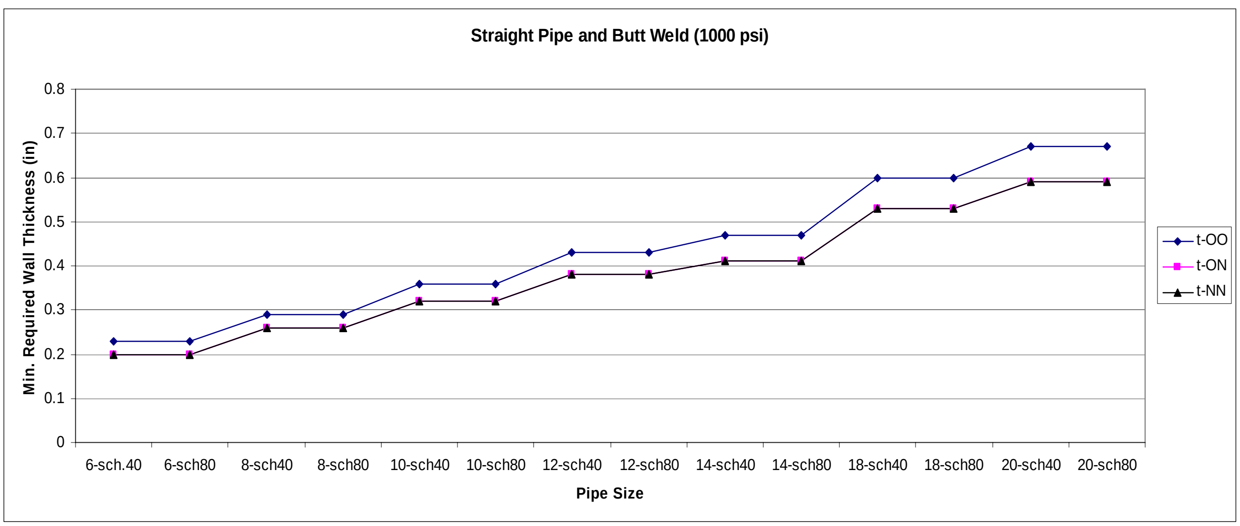


Figure B-1
Straight Pipe or Straight Butt Weld, 1000 psi

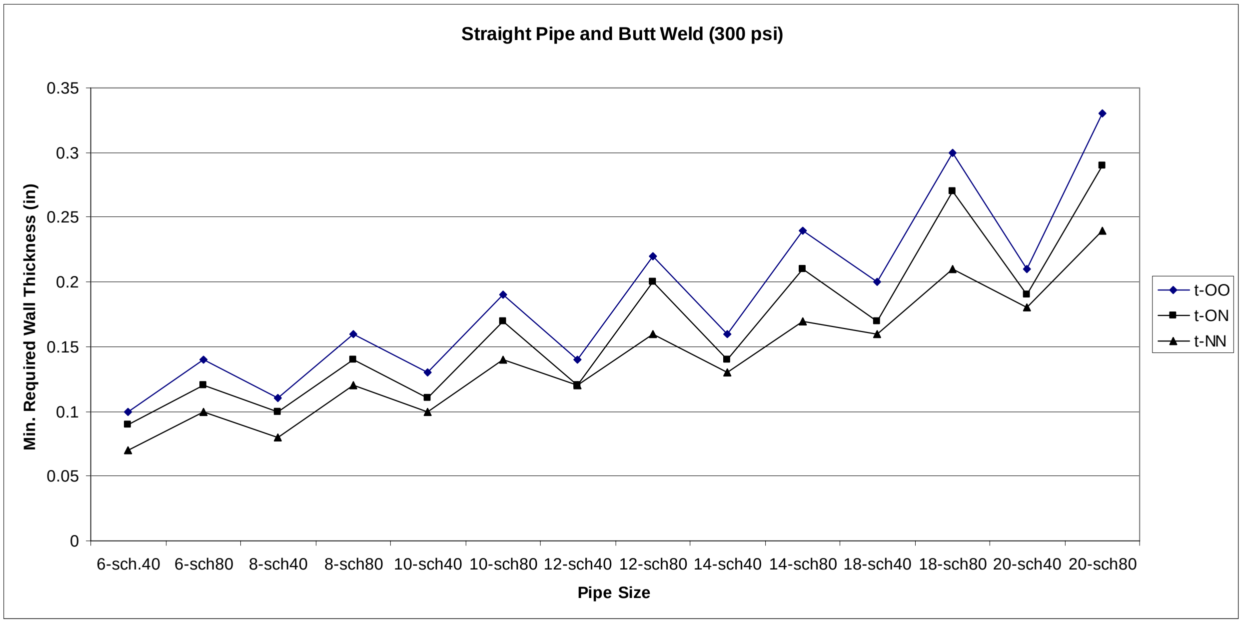


Figure B-2
Straight Pipe or Straight Butt Weld, 300 psi

see Notes above

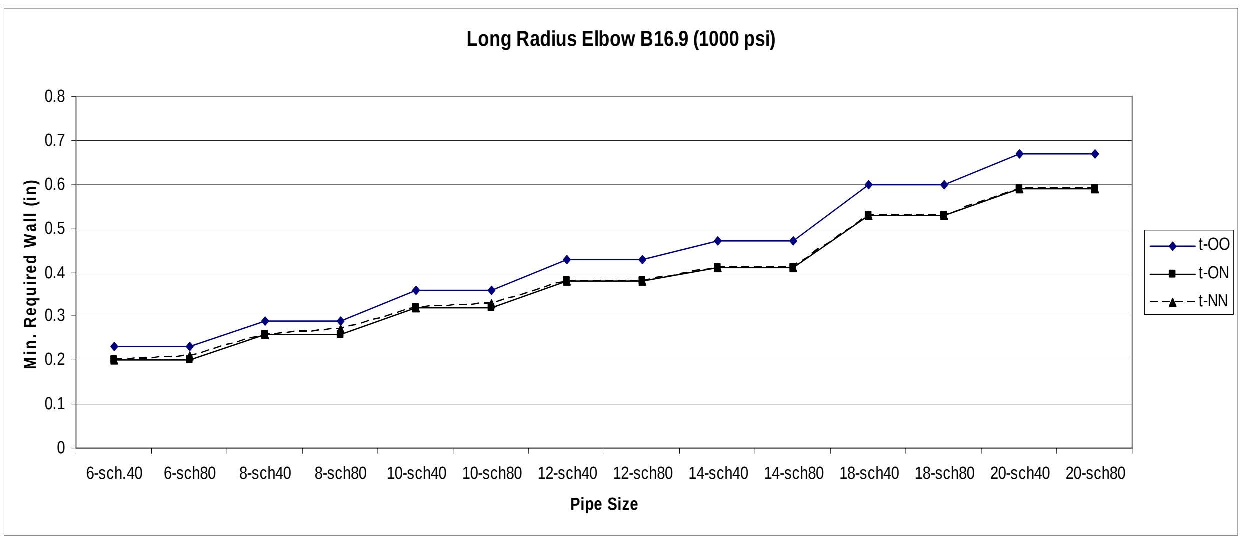


Figure B-3
Long Radius Elbow, 1000 psi

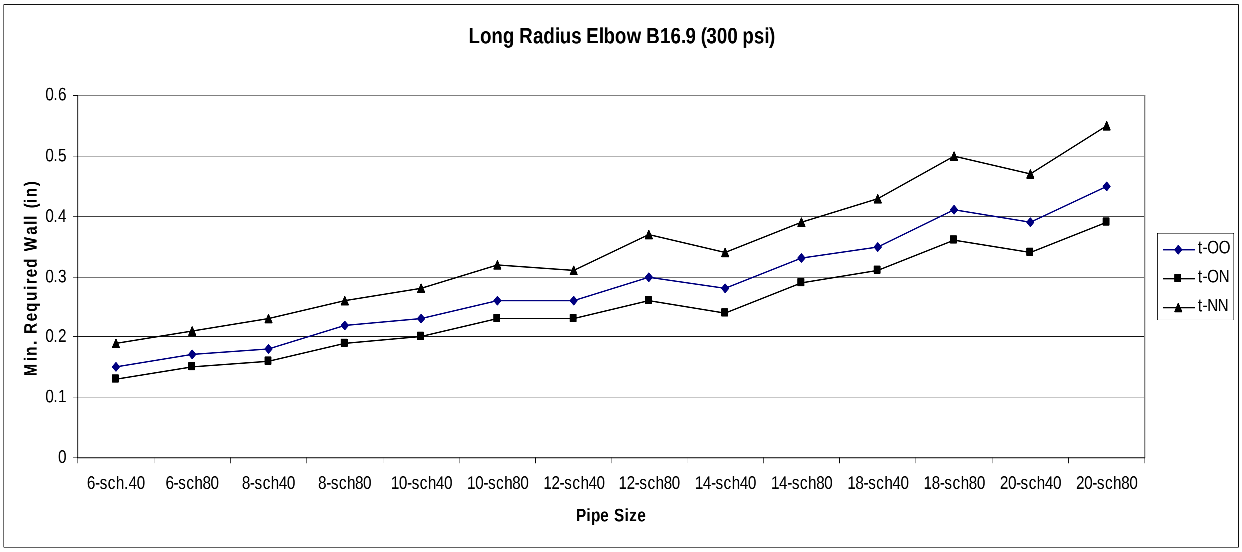


Figure B-4
Long Radius Elbow, 300 psi

See Notes Above

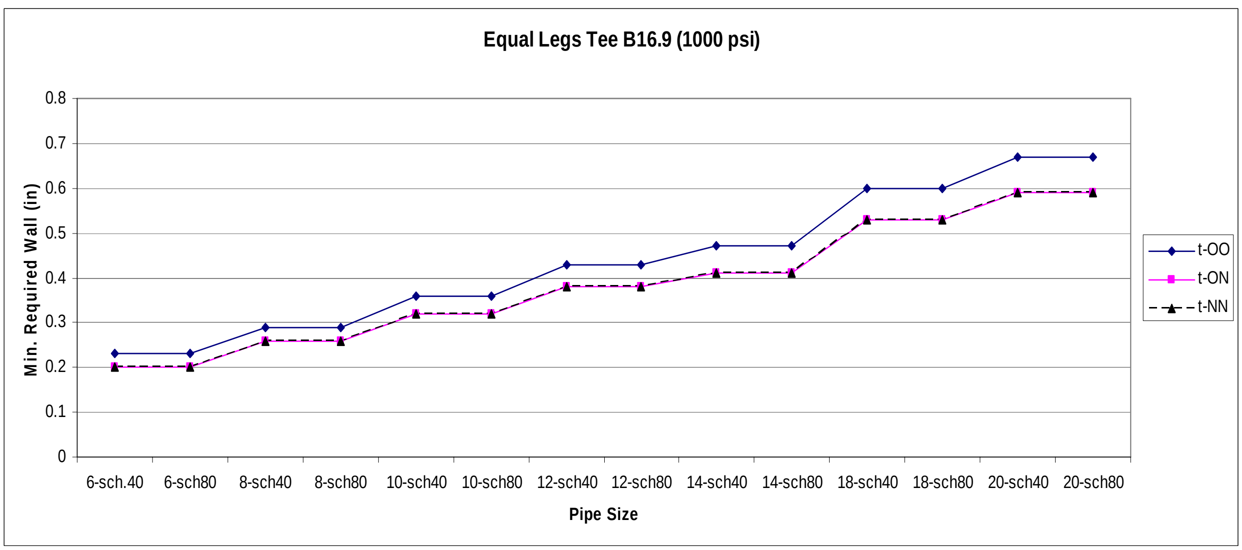


Figure B-5
Equal Leg Tee, 1000 psi

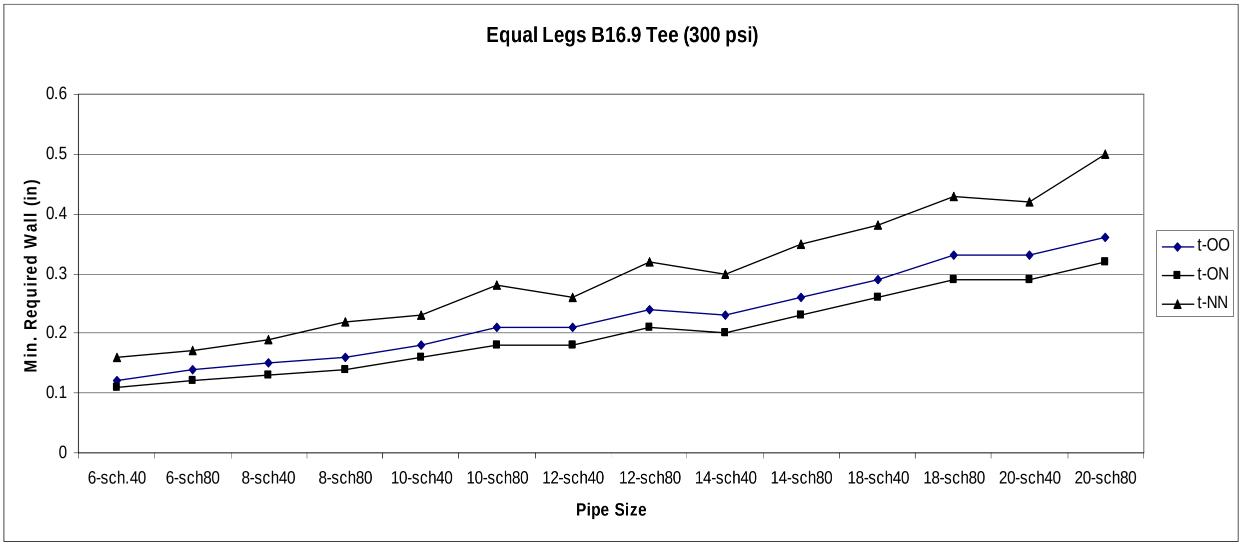


Figure B-6
Equal Leg Tee, 300 psi

See Notes Above

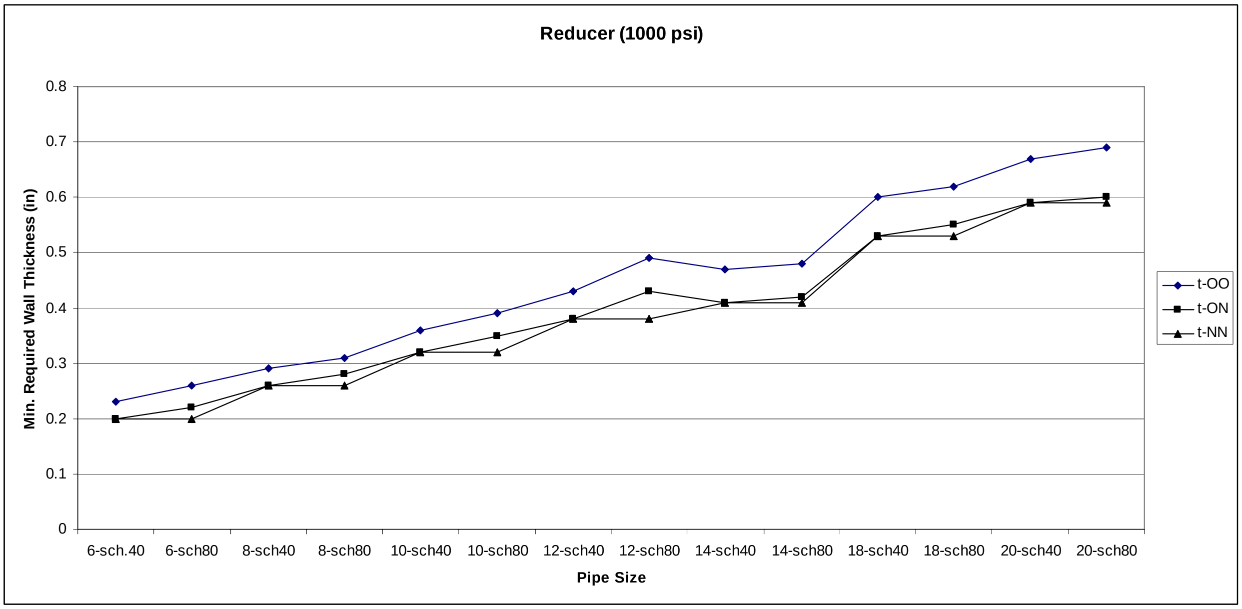


Figure B-7
Reducer, 1000 psi

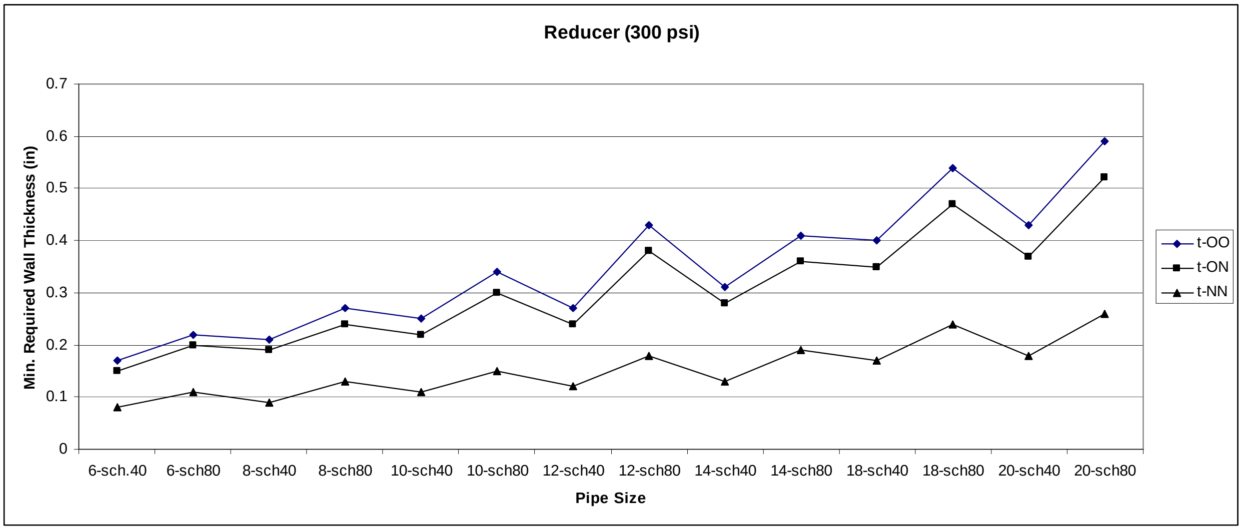


Figure B-8
Reducer, 300 psi

See Notes Above

Appendix B Calculation Checks

Straight Pipe and Butt Weld in Straight Pipe

Check calculation – OO straight pipe and butt weld in straight pipe

$$\frac{P \times D}{4 \times t} + 0.75 \times i \times \frac{M}{Z} \leq 2.4 \times S$$

$$\frac{1000 \times 10.75}{4 \times t} + 1 \times (10000 \times 0.365) \times \frac{1}{t} \leq 2.4 \times 15{,}000 \ \rightarrow t = 0.176 \text{ in OK}$$

Check calculation – NN straight pipe and butt weld in straight pipe

$$B_1 \times \frac{P \times D}{2 \times t} + B_2 \times \frac{M}{Z} \leq 3 \times S$$

$$0.5 \times \frac{1000 \times 10.75}{2 \times t} + 1 \times (10000 \times 0.365) \times \frac{1}{t} \leq 3 \times 17{,}100 \ \rightarrow t = 0.12 \text{ in OK}$$

Reducer

Check calculation – OO 45 degree reducer

$$i = 0.5 + 0.01 \times \alpha \times \sqrt{\frac{D}{t}} = 0.5 + 0.01 \times 45 \times \sqrt{\frac{10.75}{0.593}} = 2.42 \rightarrow 0.75 \times 2.42 = 1.8 \text{ in OK}$$

$$\frac{P \times D}{4 \times t} + 0.75 \times i \times \frac{M}{Z} \leq 2.4 \times S$$

$$\frac{1000 \times 10.75}{4 \times t} + 0.75 \times 2.42 \times (10000 \times 0.593) \times \frac{1}{t} \leq 2.4 \times 15{,}000 \rightarrow t = 0.37 \text{ in OK}$$

Check calculation – NN 45 degree reducer

$B_1 = B_2 = 1$

$$B_1 \times \frac{P \times D}{2 \times t} + B_2 \times \frac{M}{Z} \leq 3 \times S$$

$$1 \times \frac{1000 \times 10.75}{2 \times t} + 1 \times (10000 \times 0.593) \leq 3 \times 17{,}100 \rightarrow t = 0.22 \text{ in OK}$$

$$t = \frac{P \times D}{2 \times S} = \frac{1000 \times 10.75}{2 \times 17100} = 0.31 \text{ in OK}$$

B16.9 1.5D Elbow

Check calculation – OO Elbow 10 in Sch. 80 pipe

$$h = \frac{t_n \times R}{r^2} = \frac{0.593 \times 15}{5.125^2} = 0.339$$

$$i = \frac{0.9}{h^{2/3}} = \frac{0.9}{0.339^{2/3}} = 1.86 \rightarrow 0.75\, i = 1.4 \text{ OK}$$

$$\frac{P \times D}{4 \times t} + 0.75 \times i \times \frac{M}{Z} \leq 2.4 \times S$$

$$\frac{1000 \times 10.75}{4 \times t} + 1.4 \times (10000 \times 0.593) \times \frac{1}{t} \leq 2.4 \times 15{,}000 \rightarrow t = 0.31 \text{ in OK}$$

Check calculation – NN Elbow 10 in Sch. 80 pipe

$$h = \frac{t_n \times R}{r^2} = \frac{0.593 \times 15}{5.125^2} = 0.339$$

B_1 = 0.4 h – 0.1 = 0.4 × 0.339 – 0.1 = 0.0356 = 0.1

$$B_2 = \frac{1.3}{h^{2/3}} = \frac{1.3}{0.339^{2/3}} = 2.68 \text{ OK}$$

$$B_1 \times \frac{P \times D}{2 \times t} + B_2 \times \frac{M}{Z} \leq 3 \times S$$

$$0.1 \times \frac{1000 \times 10.75}{2 \times t} + 2.68 \times (10000 \times 0.593) \times \frac{1}{t} \leq 3 \times 17{,}100 \rightarrow t = 0.32 \text{ in OK}$$

B16.9 Tee Size-on-Size

Check calculation – OO Tee 10 in Sch. 80 x 10 in Sch. 80

$$h = \frac{4.4 \times R}{r} = \frac{4.4 \times 15}{5.125} = 0.43$$

$$i = \frac{0.9}{h^{2/3}} = \frac{0.9}{0.43^{2/3}} = 1.59 \rightarrow 0.75 \text{ i} = 1.2 \text{ OK}$$

$$\frac{P \times D}{4 \times t} + 0.75 \times i \times \frac{M}{Z} \leq 2.4 \times S$$

$$\frac{1000 \times 10.75}{4 \times t} + 1.2 \times (10000 \times 0.593) \times \frac{1}{t} \leq 2.4 \times 15{,}000 \rightarrow t = 0.27 \text{ in}$$

Check calculation – NN Tee 10 in Sch. 80 x 10 in Sch. 80

B_1 = 0.5 OK

$$B_2 = 0.5 \times \left(\frac{5.125}{0.593}\right)^{0.67} = 2.12 \text{ OK}$$

$$B_1 \times \frac{P \times D}{2 \times t} + B_2 \times \frac{M}{Z} \leq 3 \times S$$

$$0.5 \times \frac{1000 \times 10.75}{2 \times t} + 2.12 \times (10000 \times 0.593) \times \frac{1}{t} \leq 3 \times 17{,}100 \rightarrow t = 0.30 \text{ in OK}$$

C

APPENDIX C – ASME 2009 INQUIRY

BECHT ENGINEERING

January 16, 2009

Mr. Peter Deubler, Chairman Section III, Subgroup Design
Dr. Christopher Hoffman, Chairman Section III, Subgroup Materials, Fabrication and Examination, and Chairman Section II Subgroup on Strength Ferrous Alloys

cc.
Mr. An Nguyen, Secretary, Section III Subgroup Design
Mr. Paul Hirschberg, Chairman, Section III, Working Group Piping

Request for Interpretation

Dear Mr. Deubler and Dr. Hoffman,

Background: The design margin against ultimate strength was reduced from 4 to 3.5, and the allowable stresses increased accordingly, for Section VIII, Division 1 and Section III, Class 2 and Class 3 materials in Part D of Section II by a change implemented in the 1999 Addenda of the Code. The change to Section II Part D was approved by Section III without additional design limitations or requirements.

NCA-1140(c) permits the use of Editions and Addenda later than those established in the Design Specification, and it also permits the use of specific provisions within later Edition or Addenda provided all related requirements are met.

Question: Can the increase in allowable stress introduced in the 1999 Addenda be used with the design provisions of earlier Editions and Addenda?

Reply: Yes

Sincerely,

George Antaki, PE
Becht Nuclear Services

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