NMC
Committed to Nuclear Excellence

Nuclear Management Company, LLC

December 12, 2005

L-HU-05-24
10 CFR 50.55a

US Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Duane Arnold Energy Center
Docket 50-331
License No. DPR-49

Palisades Nuclear Plant
Docket 50-255
License No. DPR-20

Point Beach Nuclear Plant Units 1 and 2
Dockets 50-266 and 50-301
License Nos. DPR-24 and DPR-27

Monticello Nuclear Generating Plant
Docket 50-263
License No. DPR-22

Prairie Island Nuclear Generating Plant Units 1 And 2
Dockets 50-282 and 50-306
License Nos. DPR-40 And DPR-60

Request For Authorization To Utilize Code Case N-513-2

Pursuant to 10 CFR 50.55a(a)(3)(i), Nuclear Management Company, LLC (NMC) requests Nuclear Regulatory Commission (NRC) approval of the enclosed relief request for the In-service Inspection Program for the licensees identified above. Approval is requested to use the alternative requirements of Code Case N-513-2, "Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping," in lieu of certain American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, IWA-4000 requirements. The use of the proposed alternative will provide an acceptable level of quality and safety, as described in Enclosure 1. A copy of Code Case N-513-2 is provided as Enclosure 2.

NMC requests approval by June 30, 2006. NMC will use Code Case N-513-2 under the approved relief only until such time as the code case is published in a future version of the applicable Regulatory Guide as stated in 10 CFR 50.55a(b).

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Summary of Commitments

This letter contains no new commitments and no revisions to existing commitments.

Edward J. Weinkam
Director, Nuclear Licensing & Regulatory Services
Nuclear Management Company, LLC

Enclosures (2)

CC: Administrator, Region III USNRC

Project Managers, Duane Arnold Energy Center, Monticello Nuclear Generating Plant, Palisades Nuclear Plant, Point Beach Nuclear Plant, Prairie Island Nuclear Generating Plant. USNRC

Senior Resident Inspectors Duane Arnold Energy Center, Monticello Nuclear Generating Plant, Palisades Nuclear Plant, Point Beach Nuclear Plant, Prairie Island Nuclear Generating Plant. USNRC

ENCLOSURE 1
REQUEST FOR AUTHORIZATION TO UTILIZE CODE CASE N-513-2

1. ASME Code Component(s) Affected

ASME Section XI, Moderate Energy Class 2 and Class 3 Piping

2. Applicable ASME Section XI Code Edition and Addenda

The applicable code editions are as follows:

NMC Site	Inservice Inspection	Repair/Replacement
Monticello	1995 Edition with the 1996 Addenda	2001 Edition
Prairie Island	1998 Edition with the 2000 Addenda	1998 Edition with the 2000 Addenda
Point Beach	1998 Edition with the 2000 Addenda	1998 Edition with the 2000 Addenda
Palisades	1989 Edition	1989 Edition
Duane Arnold	1989 Edition	1992 Edition with the 1992 Addenda

Flaws that exceed the acceptance criteria of the above code editions/addenda are required to be accepted by either a repair/replacement activity or an analytical evaluation.

3. Applicable Code Requirements

The applicable code requirements are as follows:

ASME Section XI 1989 Edition

CLASS 3

IWD-3000 states, "This article is in course of preparation. The rules of IWB-3000 may be used."

IWB-3132 provides four ways in which an inservice volumetric or surface examination may be accepted.

1. IWB-3132.1, "Acceptance by Volumetric or Surface Examination"
2. IWB-3132.2, "Acceptance by Repair"

3. IWB-3132.3, "Acceptance by Replacement"
4. IWB-3132.4, "Acceptance by Analytical Evaluation"

IWB-3132.2 states, "Components whose volumetric or surface examination reveals flaws that exceed the acceptance standards listed in Table IWB-3410-1 shall be unacceptable for continued service until the additional examination requirements of IWB-2430 are satisfied, and the flaw shall be either removed by mechanical methods or the component repaired to the extent necessary to meet the acceptance standards of IWB-3000."

IWB-3132.3 states, "As an alternative to the repair requirement of IWB-3132.2, the component or the portion of the component containing the flaw shall be replaced."

IWB-3142 provides five ways in which an inservice visual examination may be accepted.

1. IWB-3142.1, "Acceptance by Visual Examination"
2. IWB-3142.2, "Acceptance by Supplemental Examination"
3. IWB-3142.3, "Acceptance by Corrective Measures or Repairs"
4. IWB-3142.4, "Acceptance by Analytical Evaluation"
5. IWB-3142.5, "Acceptance by Replacement"

IWB-3142.3 states, "Components containing relevant conditions shall be acceptable for continued service if the relevant conditions are corrected or the components are repaired to the extent necessary to meet the acceptance standards specified in Table IWB-3410-1."

IWB-3142.5 states, "As an alternative to either the supplemental examinations of IWB-3142.2, the corrective measures or repairs of IWB-3142.3, or the evaluation of IWB-3142.4, the component or that part of the component containing the relevant condition shall be replaced."

<u>CLASS 2</u>

IWC-3122 provides four ways in which an inservice volumetric and surface examination may be accepted.

1. IWC-3122.1, "Acceptance by Examination"
2. IWC-3122.2, "Acceptance by Repair"
3. IWC-3122.3, "Acceptance by Replacement"
4. IWC-3122.4, "Acceptance by Evaluation"

IWC-3122.2 states, "Components whose examination reveals flaws that exceed the acceptance standards listed in Table IWC-3410-1 shall be unacceptable for continued service until the additional examination requirements of IWC-2430 are satisfied, and the flaw shall be either removed by mechanical methods or the component repaired to the extent necessary to meet the acceptance standards of IWC-3000."

IWC-3122.3 states, "As an alternative to the repair requirements of IWC-3122.2, a component or the portion of the component containing the flaw shall be replaced."

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1. IWC-3132.1, "Acceptance by Supplemental Examination"
2. IWC-3132.2, "Acceptance by Corrective Measures or Repairs"
3. IWC-3132.3, "Acceptance by Evaluation"
4. IWC-3132.4, "Acceptance by Replacement"

IWC-3132.2 states, "Components containing relevant conditions shall be acceptable for continued service if the relevant conditions are corrected or the components are repaired to the extent necessary to meet the acceptance standards specified in Table IWC-3410-1."

IWC-3132.4 states, "As an alternative to the supplemental examinations of IWC-3132.1, the corrective measures or repairs of IWC-3132.2, or the evaluation of IWC-3132.3, a component or part of a component containing the relevant condition shall be replaced."

ASME Section XI 1995 Edition with the 1996 Addenda

CLASS 3

IWD-3000 states, "This Article is in course of preparation. The rules of IWB-3000 may be used."

IWB-3132 provides three ways in which an inservice volumetric or surface examination may be accepted.

1. IWB-3132.1, "Acceptance by Volumetric or Surface Examination",
2. IWB-3132.2, "Acceptance by Repair/Replacement Activity", or
3. IWB-3132.3, "Acceptance by Analytical Evaluation".

IWB-3132.2 states, "A component whose volumetric or surface examination detects flaws that exceed the acceptance standards of Table IWB-3410-1 is unacceptable for continued service until the additional examination requirements of IWB-2430 are satisfied and the component is corrected by a repair/replacement activity to the extent necessary to meet the acceptance standards of IWB-3000."

IWB-3142 provides four ways in which an inservice visual examination may be accepted.

1. IWB-3142.1, "Acceptance by Visual Examination"
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IWB-3142.3 states, "A component containing relevant conditions is acceptable for continued service if the relevant conditions are corrected by a repair/replacement activity or by corrective measure to the extent necessary to meet the acceptance standards of Table IWB-3410-1."

<u>CLASS 2</u>

IWC-3122 provides three ways in which an Inservice Volumetric and Surface Examinations may be accepted.

1. IWC-3122.1, "Acceptance by Examination"
2. IWC-3122.2, "Acceptance by Repair/Replacement Activity"
3. IWC-3122.3, "Acceptance by Analytical Evaluation"

IWC-3122.2 states, "A component whose examination detects flaws that exceed the acceptance standards of Table IWC-3410-1 is unacceptable for continued service until the additional examination requirements of IWC-2430 are satisfied and the component is corrected by a repair/replacement activity to the extent necessary to meet the acceptance standards of IWC-3000."

IWC-3132 provides four ways in which an inservice visual examinations may be accepted.

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IWC-3132.2 states, "A component containing relevant conditions is acceptable for continued service if the relevant conditions are corrected by a repair/replacement activity or by corrective measures to the extent necessary to meet the acceptance standards of Table IWC-3410-1."

ASME Section XI 1998 Edition with the 2000 Addenda

CLASS 3

IWD-3000 states, "This Article is in course of preparation. The rules of IWB-3000 may be used."

IWB-3132 provides three ways in which an Inservice Volumetric or Surface Examination may be accepted.

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IWB-3132.2 states, "A component whose volumetric or surface examination detects flaws that exceed the acceptance standards of Table IWB-3410-1 is unacceptable for continued service until the additional examination requirements of IWB-2430 are satisfied and the component is corrected by a repair/replacement activity to the extent necessary to meet the acceptance standards of IWB-3000."

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IWC-3122 provides three ways in which an Inservice Volumetric and Surface Examinations may be accepted.

1. IWC-3122.1, "Acceptance by Examination"
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3. IWC-3122.3, "Acceptance by Analytical Evaluation"

IWC-3122.2 states, "A component whose examination detects flaws that exceed the acceptance standards of Table IWC-3410-1 is unacceptable for continued service until the additional examination requirements of IWC-2430 are satisfied and the component is corrected by a repair/replacement activity to the extent necessary to meet the acceptance standards of IWC-3000."

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IWC-3132.2 states, "A component containing relevant conditions is acceptable for continued service if the relevant conditions are corrected by a repair/replacement activity or by corrective measures to the extent necessary to meet the acceptance standards of Table IWC-3410-1."

4. Reason for Request

Relief is requested from replacement or internal weld repair of wall thinning conditions resulting from various wall thinning degradation mechanisms such as erosion, corrosion, cavitation, and pitting in moderate energy Class 2 and 3 piping systems in accordance with the design specification and the original construction code. The use of Code Case N-513-2 will provide an acceptable method to evaluate flaws on a temporary basis until the next scheduled outage.

5. Proposed Alternative and Basis for Use

The Nuclear Regulatory Commission in Regulatory Guide 1.147, "Inservice Inspection Code Case Acceptability," Revision 14, has accepted Code Case N-513-1 with the following limitations:

1- Specific safety factors in paragraph 4.0 must be satisfied.
2- Code Case N-513 may not be applied to:
    i. Components other than pipe and tube.
    ii. Leakage through a gasket
    iii. Threaded connections employing nonstructural seal welds for leakage prevention (through seal weld leakage is not a structural flaw; thread integrity must be maintained).
    iv. Degraded socket welds

Code Case N-513-1 permits flaws in Class 2 and 3 moderate energy piping on a temporary basis until the next outage if it can be demonstrated that adequate pipe integrity and leakage containment are maintained. The Code Case is currently applicable to part-through and through wall planar flaws and part-through nonplanar flaws. Service experience has shown that some piping can suffer degradation from nonplanar flaws, such as pitting and microbiological attack, where local inconsequential leakage can occur.

The Code Case can be used for nonplanar through-wall flaws but in a restrictive situation where nonplanar geometry is dominant in one plane. Some plants have used the intent of N-513 for nonplanar leaking flaws; however, relief requests from code requirements are still required because of the stated limited scope of N-513 in section 3.0 of the Code Case. The Code Case was revised (N-513-2) to extend the application to cover all types of nonplanar flaws. The analysis procedures were expanded to address the general case of through-wall degradation. Code Case N-513-2 has broader applications and therefore has a real direct benefit for operating plants.

Code Case N-513-2 includes the incorporation of the improved flaw evaluation procedures for piping that are provided in the new Appendix C of Section XI in the 2002 Addenda.

Code Case N-513-2 addresses the limitations posed in Regulatory Guide 1.147 as follows:

1. Paragraph 4.0 was revised to incorporate references to Appendix C for acceptance and eliminated the provision that lower safety factors may be used.
2. 1.0(a) was revised to limit the application of the code case as specified in the limitation applied in Regulatory Guide 1.147.

NMC considers the proposed alternative of using Code Case N-513-2 to provide an acceptable level of quality and safety in accordance with 10 CFR 50.55a(3)(i).

6. Duration of Proposed Alternative

NMC requests approval of Code Case N-513-2 to be used for each plant's 10-year ISI interval (see table 1 below) or until the NRC publishes Code Case N-513-2 in a future revision of Regulatory Guide 1.147. Upon incorporation into the Regulatory Guide, NMC will review and follow the conditions specified. All other ASME Code, Section XI requirements for which relief was not specifically requested and authorized by the NRC staff will remain applicable including third party review by the Authorized Nuclear Inservice Inspector.

Plant	Applicable ASME Section XI	ISI Interval	Interval Dates
Monticello Nuclear Generating Plant 50-263	1995 Edition with the 1996 Addenda	Fourth	05/01/03 – 05/31/12
Prairie Island Nuclear Generating Plant 50-282 (Unit 1) & 50-306 (Unit 2)	1998 Edition with the 2000 Addenda	Fourth	12/21/04 – 12/20/14
Point Beach Nuclear Plant Units 1 & 2 (50-266 & 50-301)	1998 Edition with the 2000 Addenda	Fourth	07/01/02 – 06/30/12
Palisades Nuclear Plant 50-255	1989 Edition	Third	05/12/95 – 12/12/06
Duane Arnold Energy Center 50-331	1989 Edition	Third	11/01/96 – 10/31/06

7. **Precedent**

Tennessee Valley Authority (TVA) submitted a relief request pursuant to 10 CFR 50.55a(a)(3)(i), for Browns Ferry Nuclear Plant, Units 1, 2 and 3; Sequoyah Nuclear Plant, Units 1 and 2; and Watts Bar Nuclear Plant, Unit 1, dated November 23, 2003 (ADAMS Accession #ML033320222). TVA requested relief from using the specific formula in Code Case N-513, for the maximum allowable flaw width when planar flaw evaluation rules may be applied. As an alternative, TVA proposed the use of the formula for maximum allowable flaw width from Code Case N-513-1, with applicable errata while retaining the use of all the other provisions and requirements in Code Case N-513. The NRC approved this relief request by letter October 6, 2004 (ADAMS Accession #ML042150438). The TVA relief request is similar to the NMC relief request in that the request involves Code Case N-513. However, NMC is requesting relief to use Code Case N-513-2, which incorporates the limitations specified in Regulatory Guide 1.147 on Code Case N-513-1. In addition, Code Case N-513-2 added a procedure for evaluating non-planar through-wall flaws in moderate energy piping. This revision also includes the improved flaw evaluation procedures for piping added to Section XI, Appendix C, in the 2002 Addenda.

ENCLOSURE 2

ASME CODE CASE N-513-2, "EVALUATION CRITERIA FOR TEMPORARY ACCEPTANCE OF FLAWS IN MODERATE ENERGY CLASS 2 OR 3 PIPING"

11 Pages Follow

Approval Date: February 20, 2004

See Numeric Index for expiration and any reaffirmation dates.

Case N-513-2
Evaluation Criteria for Temporary Acceptance of Flaws in Moderate Energy Class 2 or 3 Piping Section XI, Division 1

Inquiry: What requirements may be used for temporary acceptance of flaws, including through-wall flaws, in moderate energy Class 2 or 3 piping, without performing a repair/replacement activity?

Reply: It is the opinion of the Committee that the following requirements may be used to accept flaws, including through-wall flaws, in moderate energy Class 2 or 3 piping, without performing a repair/replacement activity for a limited time, not exceeding the time to the next scheduled outage.

1.0 SCOPE

(a) These requirements apply to the ASME Section III, ANSI B31.1, and ANSI B31.7 piping, classified by the Owner as Class 2 or 3. The provisions of this Case do not apply to the following:

(1) pumps, valves, expansion joints and heat exchangers;

(2) socket welds;

(3) leakage through a flange joint;

(4) threaded connections employing nonstructural seal welds for leakage protection.

(b) The provisions of the Case apply to Class 2 or 3 piping whose maximum operating temperature does not exceed 200°F (93°C) and whose maximum operating pressure does not exceed 275 psig (1.9 MPa).

(c) The following flaw evaluation criteria are permitted for pipe and tube. The flaw evaluation criteria are permitted for adjoining fittings and flanges to a distance of $(R_o t)^{1/2}$ from the weld centerline.

(d) The provisions of this Case demonstrate the integrity of the item and not the consequences of leakage. It is the responsibility of the Owner to demonstrate system operability considering effects of leakage.

2.0 PROCEDURE

(a) The flaw geometry shall be characterized by volumetric inspection methods or by physical measurement. The full pipe circumference at the flaw location shall be inspected to characterize the length and depth of all flaws in the pipe section.

(b) Flaw shall be classified as planar or nonplanar.

(c) When multiple flaws, including irregular (compound) shape flaws, are detected, the interaction and combined area loss of flaws in a given pipe section shall be accounted for in the flaw evaluation.

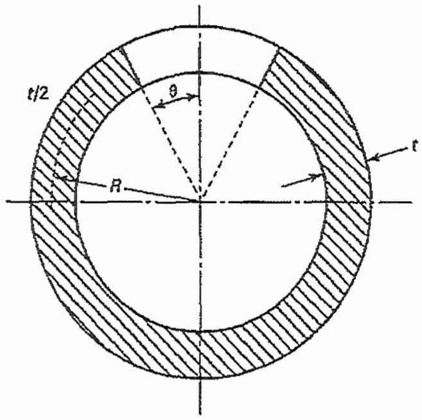
(d) A flaw evaluation shall be performed to determine the conditions for flaw acceptance. Section 3.0 provides accepted methods for conducting the required analysis.

(e) Frequent periodic inspections of no more than 30 day intervals shall be used to determine if flaws are growing and to establish the time at which the detected flaw will reach the allowable size. Alternatively, a flaw growth evaluation may be performed to predict the time at which the detected flaw will grow to the allowable size. The flaw growth analysis shall consider the relevant growth mechanisms such as general corrosion or wastage, fatigue, or stress corrosion cracking. When a flaw growth analysis is used to establish the allowable time for temporary operation, periodic examinations of no more than 90 day intervals shall be conducted to verify the flaw growth analysis predictions.

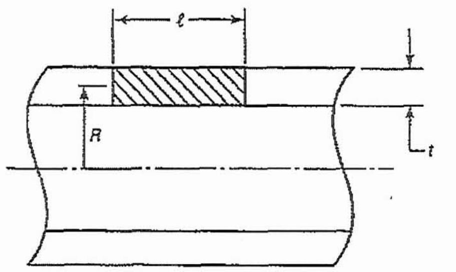
(f) For through-wall leaking flaws, leakage shall be observed by daily walkdowns to confirm the analysis conditions used in the evaluation remain valid.

(g) If examinations reveal flaw growth rate to be unacceptable, a repair or replacement shall be performed.

(h) Repair or replacement shall be performed no later than when the predicted flaw size from either periodic inspection or by flaw growth analysis exceeds the acceptance criteria of 4.0, or the next scheduled outage, whichever occurs first. Repair or replacement shall be in accordance with IWA-4000 or IWA-7000, respectively, in Editions and Addenda prior to the 1991 Addenda; and, in the 1991 Addenda and later, in accordance with IWA-4000.



(a) Circumferential Flaw



(b) Axial Flaw

FIG. 1 THROUGH-WALL FLAW GEOMETRY

(i) Evaluations and examination shall be documented in accordance with IWA-6300. The Owner shall document the use of this Case on the applicable data report form.

3.0 FLAW EVALUATION

(a) For planar flaws, the flaw shall be bounded by a rectangular or circumferential planar area in accordance with the methods described in Appendix C. IWA-3300 shall be used to determine when multiple proximate flaws are to be evaluated as a single flaw. The geometry of a through-wall planar flaw is shown in Fig. 1.

(b) For planar flaws in austenitic piping, the evaluation procedure in Appendix C shall be used. Flaw depths up to 100% of wall thickness may be evaluated. When through-wall circumferential flaws are evaluated, the formulas for evaluation given in C-5320 of Appendix C may be used, with the flaw penetration (a/t) equal to unity.

When through-wall axial flaws are evaluated, the allowable flaw length is:

$$\ell_{all} = 1.58\sqrt{Rt}\left[\left(\frac{\sigma_f}{(SF_m)\sigma_h}\right)^2 - 1\right]^{1/2} \quad (1)$$

$$\sigma_h = pD_o/2t \quad (2)$$

$$\sigma_f = (S_y + S_u)/2 \quad (3)$$

where

p = pressure for the loading condition
D_o = pipe outside diameter
σ_f = flow stress
S_y = Code specified yield strength
S_u = Code specified ultimate tensile strength and
SF_m = structural factor on primary membrane stress as specified in C-2622

Material properties at the temperature of interest shall be used.

(c) For planar flaws in ferritic piping, the evaluation procedure of Appendix C shall be used. Flaw depths up to 100% of wall thickness may be evaluated. When through-wall circumferential flaws are evaluated in accordance with C-5300 or C-6300, the flaw penetration (a/t) shall be set to unity. When through-wall axial flaws are evaluated in accordance with C-5400, the allowable length is defined by Eqs. (1) through (3), with the appropriate structural factors from Appendix C, C-2622. When through-wall flaws are evaluated in accordance with C-7300 or C-7400, the formulas for evaluation given in C-4300 may be used, but with values for F_m, F_b, and F applicable to through-wall flaws. Relations for F_m, F_b, and F that take into account flaw shape and pipe geometry (R/t ratio) shall be used. The appendix to this Case provides equations for F_m, F_b, and F for a selected range of R/t. Geometry of a through-wall crack is shown in Fig. 1.

(d) For nonplanar flaws, the pipe is acceptable when the remaining pipe thickness (t_p) is greater than or equal to the minimum wall thickness t_{min}:

$$t_{min} = \frac{pD_o}{2(S + 0.4p)} \quad (4)$$

where

p = maximum operating pressure at flaw location

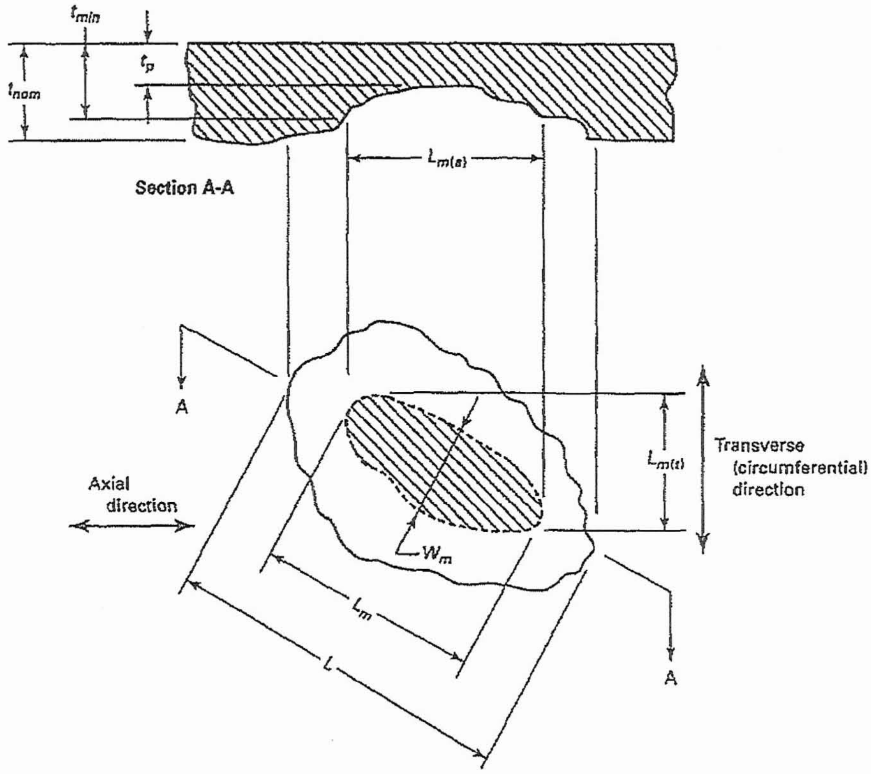


FIG. 2 ILLUSTRATION OF NONPLANAR FLAW DUE TO WALL THINNING

S = allowable stress at operating temperature and the longitudinal stress limits for the Construction Code are satisfied for a uniform wall thickness equal to t_p

Alternatively, an evaluation may be performed as given below. The evaluation procedure is a function of the depth and the extent of the affected area as illustrated in Fig. 2

(1) When the width of wall thinning W_m that exceeds t_{min}, is less than or equal to $0.5\,(R_o t)^{1/2}$, where R_o is the outside radius and W_m is defined in Fig. 2, the flaw can be classified as a planar flaw and evaluated in accordance with 3.0(a) through 3.0(c), above. When the above requirement is not satisfied, (2) shall be met.

(2) When the transverse extent of wall thinning that exceeds t_{min}, $L_{m(t)}$, is not greater than $(R_o t_{min})^{1/2}$, t_{aloc} is determined from Curve 1 of Fig. 3, where $L_{m(t)}$ is defined in Fig. 2. When the above requirement is not satisfied, (3) shall be met.

(3) When the maximum extent of wall thinning that exceeds t_{min}, L_m, is less than or equal to $2.65\,(R_o t_{min})^{1/2}$ and t_{nom} is greater than $1.13 t_{min}$, t_{aloc} is determined by satisfying both of the following equations:

$$\frac{t_{aloc}}{t_{min}} \geq \frac{1.5\sqrt{R_o t_{min}}}{L}\left[1 - \frac{t_{nom}}{t_{min}}\right] + 1.0 \tag{5}$$

$$\frac{t_{aloc}}{t_{min}} \geq \frac{0.353 L_m}{\sqrt{R_o t_{min}}} \tag{6}$$

When the above requirements are not satisfied, (4) shall be met.

(4) When the requirements of (1), (2), and (3) above are not satisfied, t_{aloc} is determined from Curve 2 of Fig. 3. In addition, t_{aloc} shall satisfy the following equation:

$$\frac{t_{aloc}}{t_{min}} \geq \frac{\left[0.5 + \left(\frac{t_{nom}}{t_{min}}\right)\left(\frac{\sigma_b}{S}\right)\right]}{1.8} \tag{7}$$

where σ_b is the nominal pipe longitudinal bending stress resulting from all primary pipe loadings.

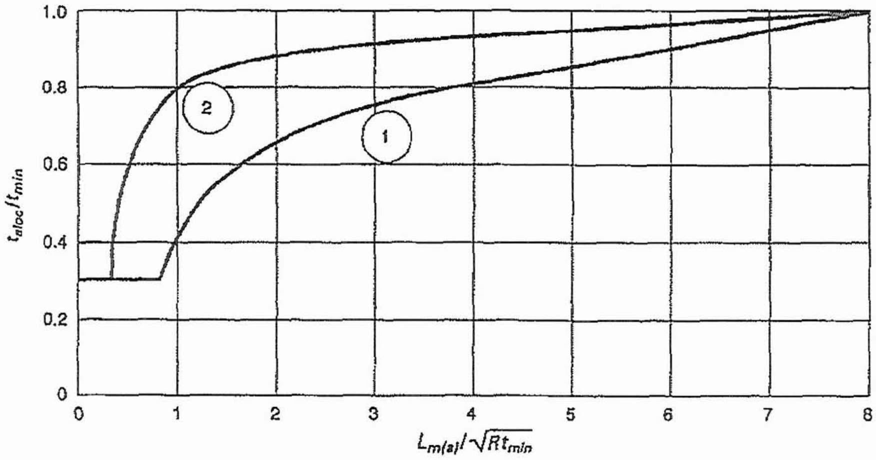


FIG. 3 ALLOWABLE WALL THICKNESS AND LENGTH OF LOCALLY THINNED AREA

(e) When there is through-wall penetration along a portion of the thinned wall, as illustrated in Fig. 4, the flaw may be evaluated by the branch reinforcement method. The thinned area including the through-wall penetration shall be represented by a circular opening at the flaw location. Only the portion of the flaw lying within t_{adj} need be considered as illustrated in Fig. 5. When evaluating multiple flaws in accordance with IWA-3330, only the portions of the flaws contained within t_{adj} need be considered.

The minimum wall thickness, t_{min}, shall be determined by Eq. (4). For evaluation purposes, the adjusted wall thickness, t_{adj}, is the postulated thickness as shown in Fig. 5. The pipe wall thickness is defined as the thickness of the pipe in the non-degraded region as shown in Fig. 5(a). The diameter of the opening is equal to d_{adj} as defined by t_{adj} as shown in Fig 5(a). The postulated value for t_{adj} shall be greated than t_{min} and shall not exceed the pipe wall thickness. The t_{adj} value may be varied between t_{min} and the pipe wall thickness to determine whether there is a combination of t_{adj} and d_{adj} that satisfies the branch reinforcement requirements.

The required area reinforcement for the postulated circular opening, d_{adj} and t_{adj}, as illustrated in Fig. 5(b), shall be calculated in accordance with NC-3643.3 or ND-3643.3, as appropriate. If a flaw growth analysis is performed, the growth in flaw dimensions shall consider the degradation mechanism(s) as relevant to the application. The flaw is acceptable when there is sufficient thickness in the degraded area to provide the required area reinforcement. Compliance with the primary stress limits of the Construction Code shall be verified. The flow area of the flaw, or the total of the flow areas of multiple flaws that are combined into a single flaw for the purpose of evaluation, shall not exceed the lesser of the flow area of the pipe or 20 in.^{2} (130 cm^2).

(f) Alternatively, when there is through-wall penetration along a portion of the thinned wall as illustrated in Fig. 4 the flaw may be evaluated as two independent planar through-wall flaw-one oriented in the axial direction and the other oriented in the circumferential direction. The minimum wall thickness t_{min}, shall be determined by Eq. (4). The through-wall lenghts for each flaw are the lenghts L_{axial} and L_{circ}, where the local wall thickness is equal to t_{min} as projected along the axial and circumferential planes as shown in Fig. 4. The two planar flaws so constructed shall be evaluated to 3.0(a) and 3.0(b) or 3.0(c), as appropriate. If a flaw growth analysis is performed, the growth in flaw dimensions shall consider both corrosion and crack-growth mechanisms as relevant to the application. The flow area of the flaw, or the total of the flow areas of multiple flaws that are combined into a single flaw for the purpose of evaluation, shall not exceed the lesser of the flow area of the pipe or 20 in.^{2} (130 cm^2).

(g) In performing a flaw growth analysis, the procedures in C-3000 may be used as guidance. Relevant growth rate mechanisms shall be considered. When stress corrosion cracking (SCC) is active, the following growth rate equation shall be used:

$$da/dt = S_T C K_{max}^n \quad (8)$$

where da/dt is flaw growth rate in inches/hour, K_{max} is the maximum stress intensity factor under long-term

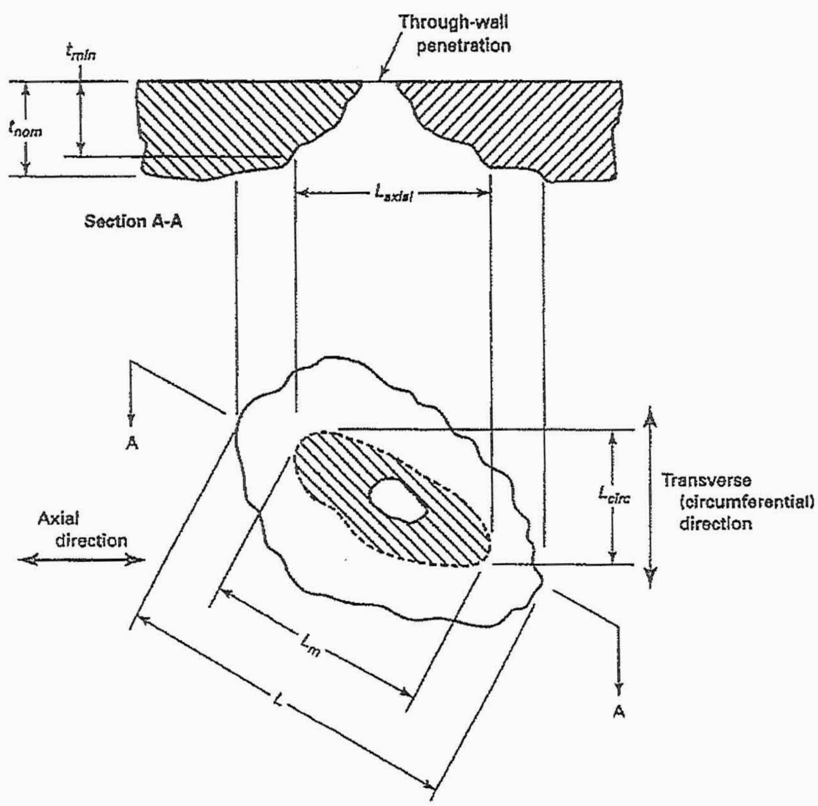
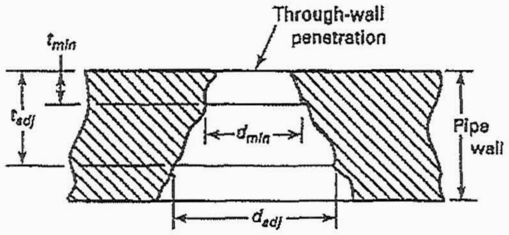
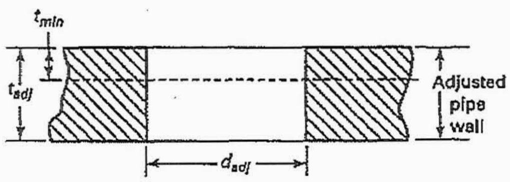


FIG. 4 ILLUSTRATION OF THROUGH-WALL NONPLANAR FLAW DUE TO WALL THINNING



(a) Adjusted Wall Thickness



(b) Equivalent Hole Representation

FIG. 5 ILLUSTRATION OF ADJUSTED WALL THICKNESS AND EQUIVALENT HOLE DIAMETER steady state conditions in ksi in. 0.5 S_T is a temperature correction factor, and C and n are material constants.

For intergranular SCC in austenitic steels, where $T \leq$ 200°F (93°C).

$C = 1.79 \times 10^{-8}$
$S_T = 1$
$n = 2.161$

For transgranular SCC in austenitic steels, where $T \leq$ 200°F (93°C).

$C = 1.79 \times 10^{-7}$
$S_T = 3.71 \times 10^{-8}\,[10^{(0.01842\,T - 12.25)}]$
$n = 2.161$

The temperature T is the metal temperature in degrees Fahrenheit. The flaw growth rate curves for the above SCC growth mechanisms are shown in Figs. 6 and 7. Other growth rate parameters in Eq. 8 may be used, provided they are supported by appropriate data.

(h) For nonferrous materials, nonplanar and planar flaws may be evaluated following the general approach of 3.0(a) through 3.0(g) above. For planar flaws in ductile materials, the approach given in 3.0(b) and 3.0(g) may be used; otherwise, the approach given in 3.0(c) and 3.0(g) should be applied. Structural factors provided in 4.0 shall be used. It is the responsibility of the evaluator to establish conservative estimates of strength and fracture toughness for the piping material.

4.0 ACCEPTANCE CRITERIA

Piping containing a circumferential planar flaw is acceptable for temporary service when flaw evaluation provides a margin using the structural factors in Appendix C, C-2621. For axial planar flaws, the structural factors for temporary acceptance are as specified in Appendix C, C-2622. Piping containing a nonplanar part through-wall flaw is acceptable for temporary service if $t_p \geq t_{aloc}$, where t_{aloc} is determined from 3.0(d). Piping containing a nonplanar through-wall flaw is acceptable for temporary service when the flaw conditions of 3.0(e) or 3.0(f) are satisfied.

5.0 AUGMENTED EXAMINATION

An augmented volumetric examination or physical measurement to assess degradation of the affected system shall be performed as follows:

(a) From the engineering evaluation, the most susceptible locations shall be identified. A sample size of at least five of the most susceptible and accessible locations, or, if fewer than five, all susceptible and accessible locations shall be examined within 30 days of detecting the flaw.

(b) When a flaw is detected, an additional sample of the same size as defined in 5(a) shall be examined.

(c) This process shall be repeated within 15 days for each successive sample, until no significant flaw is detected or until 100% of susceptible and accessible locations have been examined.

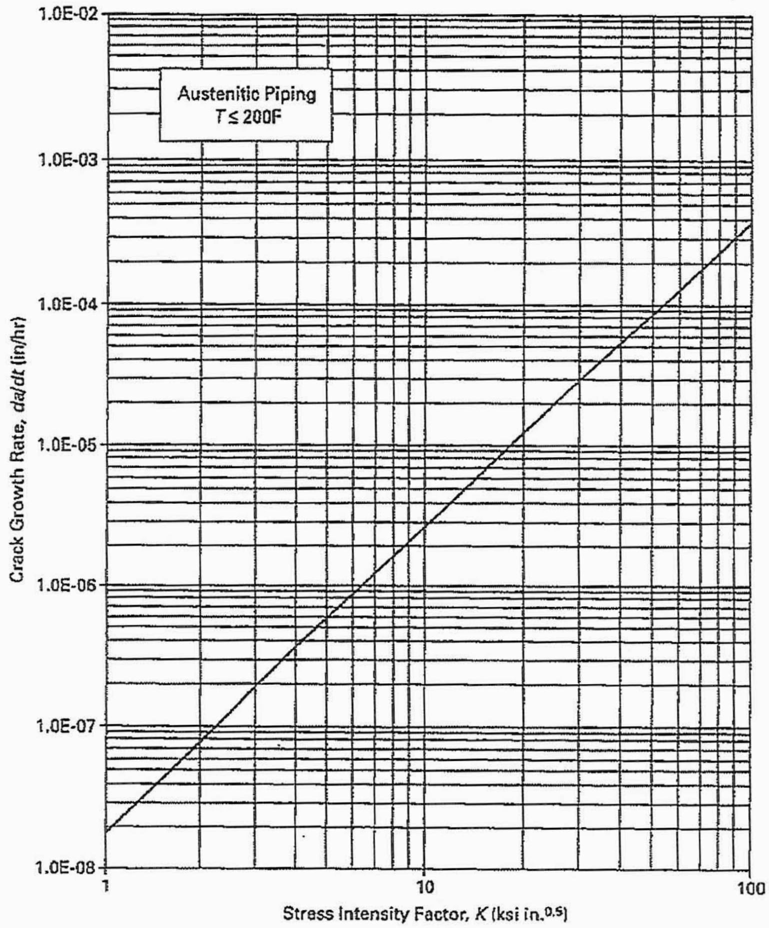
6.0 NOMENCLATURE

C = coefficient in the crack growth relationship
D_o = outside pipe diameter
F = nondimensional stress intensity factor for through-wall axial flaw under hoop stress
F_b = nondimensional stress intensity factor for through-wall circumferential flaw under pipe bending stress
F_m = nondimensional stress intensity factor for through-wall circumferential flaw under membrane stress
L = maximum extent of a local thinned area with $t < t_{nom}$
L_{axial} = length of through-wall crack for the hole penetration in the axial direction of the pipe
L_{circ} = length of through-wall crack for the hole diameter penetration in the circumferential direction of the pipe
L_m = maximum extent of a local thinned area with $t < t_{min}$
$L_{m(a)}$ = axial extent of wall thinning below t_{min}
$L_{m(t)}$ = circumferential extent of wall thinning below t_{min}
R = pipe radius
R_o = outside pipe radius
S = allowable stress at operating temperature
SF_m = structural factor on primary membrane stress
S_T = coefficient for temperature dependence in the crack growth relationship
S_u = Code-specified ultimate tensile strength
S_y = Code-specified yield strength
W_m = maximum extent of a local thinned area perpendicular to L_m with $t < t_{min}$
c = half crack length
da/dt = flaw growth rate for stress corrosion cracking
d_{adj} = diameter equivalent circular hole at t_{adj}
d_{min} = diameter of equivalent circular hole at t_{min}
ℓ = total crack length $= 2c$

ℓ_{all} = allowable axial through-wall flaw length
n = exponent in the crack growth relationship
p = maximum operating pressure at flaw location
t = wall thickness
t_{adj} = adjusted wall thickness which is varied for evaluation purposes in the evaluation of a through-wall nonplanar flaw
t_{aloc} = allowable local thickness for a nonplanar flaw
t_{min} = minimum wall thickness required for pressure loading
t_{nom} = nominal wall thickness
t_p = minimum remaining wall thickness
λ = nondimensional half crack length for through-wall axial flaw
σ_f = material flow stress
σ_h = pipe hoop stress due to pressure
σ_b = nominal longitudinal bending stress for primary loading without stress intensification factor
θ = half crack angle for through-wall circumferential flaw

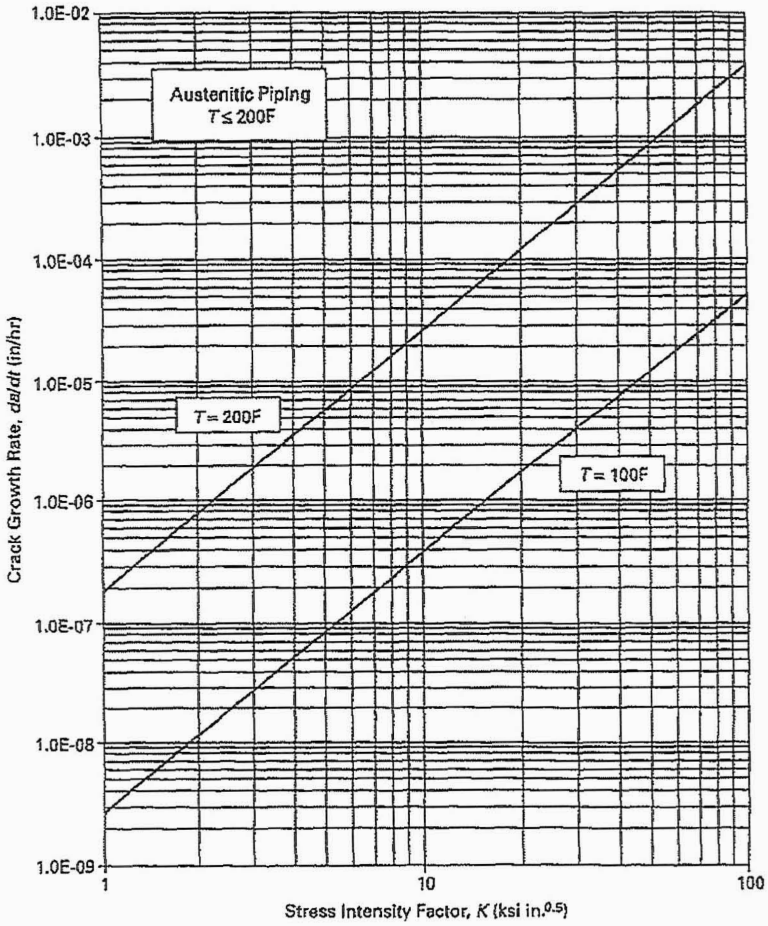
7.0 APPLICABILITY

This Case is applicable from the 1983 Edition with the Winter 1985 Addenda through the 2001 Edition with the 2003 Addenda. References in this Case to Appendix C shall mean Appenidx C of the 2002 Addenda. For editions and addenda prior to 2002 Addenda, Class 1 pipe flaw evaluation procedures may be used for other piping classes. As a matter of definition, the term "structural factor" is equivalent to the term "safety factor" that is used in earlier editions and addenda.



GENERAL NOTE: (SI conversion: 1.0 in/hr = 7.06 x 10^{-3} mm/sec; 1.0 Ksi $in.^{0.5}$ = 1.099 MPa $m^{0.5}$; °C = (°F - 32)/1.8).

FIG. 6 FLAW GROWTH RATE FOR IGSCC IN AUSTENITIC PIPING



GENERAL NOTE: (SI conversion: 1.0 in/hr = 7.06 x 10^{-3} mm/sec; 1.0 Ksi in.$^{0.5}$ = 1.099 MPa m$^{0.5}$; °C = (°F - 32)/1.8).

FIG. 7 FLAW GROWTH RATE FOR TGSCC IN AUSTENITIC PIPING

APPENDIX I
RELATIONS FOR F_m, F_b, AND F FOR THROUGH-WALL FLAWS

I-1.0 DEFINITIONS

For through-wall flaws, the crack depth (a) will be replaced with half crack length (c) in the stress intensity factor equations in C-7300 and C-7400 of Section XI, Appendix C. Also, Q will be set equal to unity in C-7400.

I-2.0 CIRCUMFERENTIAL FLAWS

For a range of R/t between 5 and 20, the following equations for F_m and F_b may be used:

$$F_m = 1 + A_m (\Theta/\pi)^{1.5} + B_m (\Theta/\pi)^{2.5} + C_m (\Theta/\pi)^{3.5}$$

$$F_b = 1 + A_b (\Theta/\pi)^{1.5} + B_b (\Theta/\pi)^{2.5} + C_b (\Theta/\pi)^{3.5}$$

where

Θ = Half crack angle = c/R
R = Mean pipe radius
t = Pipe wall thickness

and

$$A_m = -2.02917 + 1.67763 (R/t) - 0.07987 (R/t)^2 + 0.00176 (R/t)^3$$
$$B_m = 7.09987 - 4.42394 (R/t) + 0.21036 (R/t)^2 - 0.00463 (R/t)^3$$
$$C_m = 7.79661 + 5.16676 (R/t) - 0.24577 (R/t)^2 + 0.00541 (R/t)^3$$
$$A_b = -3.26543 + 1.52784 (R =/t) - 0.072698 (R/t)^2 + 0.0016011 (R/t)^3$$
$$B_b = 11.36322 - 3.91412 (R/t) + 0.18619 (R/t)^2 - 0.004099 (R/t)^3$$
$$C_b = -3.18609 + 3.84763 (R/t) - 0.18304 (R/t)^2 + 0.00403 (R/t)^3$$

Equations for F_m and F_b are accurate for R/t between 5 and 20 and become increasingly conservative for R/t greater than 20. Alternative solutions for F_m and F_b may be used when R/t is greater than 20.

I-3.0 AXIAL FLAWS

For internal pressure loading, the following equation for F may be used:

$$F = 1 + 0.072449\lambda + 0.64856\lambda^2 - 0.2327\lambda^3 + 0.038154\lambda^4 - 0.0023487\lambda^5$$

where

c = half crack length
$\lambda = c/(Rt)^{1/2}$

The equation for F is accurate for λ between 0 and 5. Alternative solutions for F may be used when λ is greater than 5.