Exelon Nuclear
200 Exelon Way
Kennett Square, PA 19348

www.exeloncorp.com

Exelon Nuclear

PROPRIETARY INFORMATION – WITHHOLD UNDER 10 CFR 2.390

10 CFR 50.55a

TMI-11-078
April 25, 2011

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Three Mile Island Nuclear Station, Unit 1
Renewed Facility Operating License No. DPR-50
NRC Docket No. 50-289

Subject: Response to Request for Additional Information - Submittal of Relief Request RR-10-02 Concerning the Weld Overlay of the Pressurizer Spray Nozzle to Safe-End and Safe-End to Elbow Dissimilar Metal Welds

References:

1) Letter from P. B. Cowan (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, "Submittal of Relief Request RR-10-02 Concerning the Weld Overlay of the Pressurizer Spray Nozzle to Safe-End and Safe-End to Elbow Dissimilar Metal Welds," dated September 30, 2010

2) Letter from P. Bamford (U.S. Nuclear Regulatory Commission) to M. J. Pacilio, "Three Mile Island Nuclear Station, Unit 1 - Request for Additional Information Regarding Relief Request RR-10-02, Weld Overlay of the Pressurizer Spray Nozzle to Safe-End and Safe-End to Elbow Dissimilar Metal Welds (TAC NO. ME4795)," dated February 28, 2011

3) Letter from D. P. Helker (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, "Response to Request for Additional Information - Submittal of Relief Request RR-10-02 Concerning the Weld Overlay of the Pressurizer Spray Nozzle to Safe-End and Safe-End to Elbow Dissimilar Metal Welds," dated March 9, 2011

4) Letter from D. P. Helker (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission, "Response to Request for Additional Information - Submittal of Relief Request RR-10-02 Concerning the Weld Overlay of the Pressurizer Spray Nozzle to Safe-End and Safe-End to Elbow Dissimilar Metal Welds," dated April 6, 2011

In the Reference 1 letter, Exelon Generation Company, LLC (Exelon) requested relief to perform a weld overlay of pressurizer spray nozzle to safe-end and safe-end to elbow dissimilar metal welds at Three Mile Island Nuclear Station (TMI), Unit 1. In the Reference 2 letter, the U.S. Nuclear Regulatory Commission requested additional information. References 3 and 4 provided a response to this request.

Attachment 1 transmitted herewith contains Proprietary Information.
When separated from attachments, this document is decontrolled.

Based on further discussions with the U.S. Nuclear Regulatory Commission, Attachment 1 contains copies of Calculation No. 1000320.310, Revision 0 with updated proprietary markings. Attachment 1 contains information proprietary to AREVA NP Inc. (AREVA) and Structural Integrity Associates (SI), Inc. AREVA and SI request that Calculation No. 1000320.310, Revision 0 be withheld from public disclosure in accordance with 10 CFR 2.390(b)(4). Attachment 2 contains a non-proprietary version of Calculation No. 1000320.310, Revision 0. Affidavits supporting AREVA and SI's request are contained in Attachment 3.

There are no regulatory commitments contained in this submittal.

If you have any questions concerning this letter, please contact Tom Loomis at (610) 765-5510.

Respectfully,

D. P. Helker

David P. Helker
Manager - Licensing & Regulatory Affairs
Exelon Generation Company, LLC

Attachments:
1) Calculation No. 1000320.310, "Pressurizer Spray Nozzle Weld Overlay Sizing Calculation," Revision 0 (Proprietary Version)
2) Calculation No. 1000320.310, "Pressurizer Spray Nozzle Weld Overlay Sizing Calculation," Revision 0 (Non-Proprietary Version)
3) Affidavits

cc: Regional Administrator, Region I, USNRC
USNRC Senior Resident Inspector, TMI
USNRC Project Manager, [TMI] USNRC

ATTACHMENT 2

Non-Proprietary Version

Calculation No. 1000320.310, "Pressurizer Spray Nozzle Weld Overlay Sizing Calculation," Revision 0

Structural Integrity Associates, Inc.®	File No.: 1000320.310
CALCULATION PACKAGE	**Project No.: 1000320** Quality Program: ☒ Nuclear ☐ Commercial

PROJECT NAME:
TMI Pressurizer Spray Nozzle WOL

CONTRACT NO.:
59091

CLIENT:	**PLANT:**
Welding Services Inc. (WSI)	Three Mile Island Nuclear Generating Station, Unit 1

CALCULATION TITLE:
Pressurizer Spray Nozzle Weld Overlay Sizing Calculation

Document Revision	Affected Pages	Revision Description	Project Manager Approval Signature & Date	Preparer(s) & Checker(s) Signatures & Date
0	1 - 18	Initial Issue	R. L. Bax RLB 03/11/11	Nader Sadeghi N. Sadeghi NS 03/10/11 A. Alleshwaram AA 03/10/11

Table of Contents

List of Tables

List of Figures

1.0 INTRODUCTION

A weld overlay repair is being designed for the 4" nominal diameter pressurizer spray nozzle-to-safe end dissimilar metal weld (DMW1) and the safe end-to-elbow dissimilar metal weld (DMW2) at Three Mile Island Nuclear Generating Station, Unit 1 (TMI-1). This calculation documents the required structural sizing calculations for a full structural weld overlay (FSWOL) repair of these welds, based on plant-specific geometry and loadings, and the design requirements of ASME Code, Section XI, Code Cases N-504-3 [4] and N-638-1 [5] (Note: A relief request will be prepared to allow the use of these two Code Cases).

2.0 DESCRIPTION OF CONFIGURATION AND REPAIR PROCESS

The pressurizer spray nozzle is SA-508 Class 1 carbon steel [redacted] the safe end is SB-166 [redacted] and the attached spray line elbow is SA-403 WP316 stainless steel [redacted] 16]. The DMWs, which join the pressurizer spray nozzle to the safe end and the safe end to the elbow, are assumed to be fabricated using Alloy 82/182 weld metal. This assumption is based on the Alloy 600 visual examination records for these welds [redacted]

The FSWOL repair will be performed using primary water stress corrosion cracking (PWSCC) resistant Alloy 52M material deposited around the circumference of the configuration. The overlay material will be deposited using the machine gas tungsten arc welding (GTAW) process. For the Alloy 52M weld overlay filler metal, the selected material is SB-166, Rod & Bar [3], corresponding to Alloy 690 (58Ni-29Cr-9Fe).

3.0 ASME CODE CRITERIA

The applicable ASME Code of repair and replacement for TMI-1 is the 2004 Edition of ASME Code, Section XI [1] per Reference 6. The basis for FSWOL sizing is the ASME Code, Section XI, Code Case N-504-3 [4] and the ASME Code, Section XI, Division 1, Class 1 [1] rules for allowable flaw sizes in austenitic and ferritic piping (IWB-3640). The ASME Code, Section XI, Code Case N-504-3 [4], and the temper bead welding approach documented in Code Case N-638-1 [5], are used herein and are applied to dissimilar metal welds using nickel alloy filler, Alloy 52M. To determine the overlay thickness, Code Case N-504-3 refers to the requirements of ASME Code, Section XI, IWB-3640. IWB-3640 of the 2004 edition of the Code refers to Appendix C, which contains the specific methodology for meeting the allowable flaw sizes. The overlays are to be applied using the GTAW process, which is a non-flux process. Therefore, for circumferential flaws, the source equations in Reference 1, Appendix C, Section C-5320 (limit load criteria) are the controlling allowable flaw size equations for combined loading (membrane plus bending) and membrane-only loading. These equations are valid for flaw depth-to-thickness ratios for flaw lengths ranging from 0 to 100% of the circumference as defined in Reference 1, Section C-5320 of Appendix C. For purposes of designing the overlay, a circumferential flaw is assumed to be 100% through the original wall thickness for the entire circumference of the item being overlaid.

The overlay is sized by using the source equations in Section C-5320 [1].

The allowable bending stress under combined membrane plus bending loads is given by the equation:

$$S_c = \frac{\sigma_b^c}{SF_b} - \sigma_m\left[1 - \frac{1}{SF_m}\right]$$ Reference 1, C-5321,

where,

$$\sigma_b^c = \frac{2\sigma_f}{\pi}\left(2 - \frac{a}{t}\right)\sin\beta, \text{ for } (\theta + \beta) > \pi,$$

$$\beta = \frac{\pi}{2 - \frac{a}{t}}\left(1 - \frac{a}{t} - \frac{\sigma_m}{\sigma_f}\right).$$

The allowable membrane stress is given by the equation:

$$S_t = \frac{\sigma_m^c}{SF_m}$$ Reference 1, C-5322,

where,

$$\sigma_m^c = \sigma_f\left[1 - \left(\frac{a}{t}\right)\left(\frac{\theta}{\pi}\right) - \frac{2\varphi}{\pi}\right],$$

$$\varphi = \arcsin\left[0.5\left(\frac{a}{t}\right)\sin\theta\right],$$

and

S_c	=	allowable bending stress for a circumferentially flawed pipe
σ^c_b	=	bending stress at incipient plastic collapse
SF_m	=	safety factor for membrane stress based on Service Level as shown in Table 1 [1, C-2621]
SF_b	=	safety factor for bending stress based on Service Level as shown in Table 1 [1, C-2621]
a	=	flaw depth
t	=	total wall thickness (includes overlay thickness, in this case)
S_t	=	allowable membrane stress for a circumferentially flawed pipe
σ^c_m	=	membrane stress at incipient plastic collapse
θ	=	half flaw angle [1, Figure C-4310-1], 180° or π for a 100% full circumferential flaw
β	=	angle to neutral axis of flawed pipe in radians

σ_m = unintensified primary membrane stress at the flaw location
σ_f = flow stress = $(S_y + S_u)/2$ [1, C-8200(a)]
S_y = specified value for material yield strength taken at the evaluation (operating) temperature from Reference 3
S_u = specified value for material ultimate strength taken at the evaluation (operating) temperature from Reference 3

Safety factors are provided in Appendix C of Section XI for evaluation of flaws in austenitic stainless steel piping. The safety factors used for the weld overlay sizing are shown in Table 1 and are taken from C-2621 [1].

Table 1: Safety Factors for Sizing – Circumferential Flaw

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

The overlay thickness must be established so that the flaw assumption herein meets the allowable flaw depth-to-thickness ratio requirement of the source equations [1, C-5320], for the thickness of the weld-overlaid item, considering combined primary membrane-plus-bending stresses and membrane-only stresses, per the source equations defined previously. Since the weld overlay is an austenitic material and applied with a non-flux welding process, which has high fracture toughness, the limit load failure mode is applicable [1, Figure C-4210-1 for non-flux welds] and hence, limit load evaluation techniques are used here.

The non-overlaid piping stresses for use in the equations are usually obtained from the applicable stress reports for the items to be overlaid. However, in this calculation, they are calculated based on forces and moments at the welds using equations from C-2500 of Section XI, Appendix C as described below.

Primary membrane stress (σ_m) is given by:

$\sigma_m = pD/(4t)$, where:

p = operating pressure for the Service Level being considered
D = outside diameter of the component including the overlay
t = thickness, consistent with the location at which the outside diameter is taken including the overlay (note that the inside diameter (ID) cladding is not counted toward wall thickness)

Primary bending stress (σ_b) is given by:

$\sigma_b = DM_b/(2I)$, where:

D	=	outside diameter of the component including the overlay
d	=	inside diameter, consistent with the point at which the outside diameter is taken (note that the ID cladding is not counted in the inside diameter)
M_b	=	resultant moment for the appropriate primary load combination for each Service Level (square root of the sum of the squares (SRSS) of three moment components in X, Y, and Z directions)
I	=	moment of inertia, $(\pi/64)\,(D^4 - d^4)$

The contribution of axial and shear forces to piping stress (other than force couples contributing to moments) is not included based on C-2500 of Section XI, Appendix C [1].

The following load combinations are used for the full structural weld overlay[redacted]

Service Level A (Normal):	Pressure (P) + Deadweight (DW)
Service Level B (Upset):	P + DW + Operational Basis Earthquake (OBE)
Service Level C (Emergency):	P + DW + Safe Shutdown Earthquake (SSE)
Service Level D (Faulted):	P + DW + SSE

Service Levels A, B, C, and D in the ASME Code [1] are alternatively referred as Normal, Upset, Emergency, and Faulted conditions, respectively, in this evaluation. Per ASME Code, Section XI C-5311 for the Combined Loading case, test conditions shall be included with the Service Level B Load Combination. However, the hydrostatic pressure test is not applicable to the weld overlay repair and is not included in the FSWOL design.

The weld overlay sizing is an iterative process, in which the allowable stresses are calculated and then compared to the stresses in the overlaid component. If the stresses in the component are larger than the allowable stresses in the component then the overlay thickness is increased, and the process is repeated until it converges to an overlay thickness which meets the allowable stresses.

The thickness of the weld overlay is determined through an iterative process. The thickness of the overlay (t_{ol}) is assumed resulting in a total thickness of ($t_p + t_{ol}$) where t_p is the original pipe thickness. The applied flaw size-to-thickness ratio based on a FSWOL (flawed through the original pipe wall thickness, t_p) is $t_p/(t_p + t_{ol})$. The allowable stresses are then determined from the source equations (see the beginning of Section 3.0). If this allowable stress value is greater than the calculated stress for the overlaid component, the overlay thickness (t_{ol}) is reduced. On the other hand, if the allowable stress value is less than the calculated stress for the overlaid component, the overlay thickness (t_{ol}) is increased. The process is repeated until the assumed overlay thickness results in a stress ratio of the calculated stress to the allowable stress that is equal or less than 1.0. As the maximum allowed value for a/t is 0.75 [1, C-5320], t_{ol} is initially set as $t_p/3$. If the overlay thickness of $t_p/3$ meets the allowable stresses for pure membrane and combined membrane plus bending stresses, then no more iterations are performed. If the allowable stresses are not met, then the overlay thickness is increased until the ratio of the computed stress to the allowable stress is less than or equal to 1.0.

In this process, the allowable stresses and adjusted stresses due to overlay thickness iterations are calculated for all applicable Service Levels (A, B, C, and D) and compared. The service level with the maximum ratio of the calculated stress to the allowable stress will control the overlay thickness.

The axial length and end slope of the FSWOL are sized to be sufficient to provide for load redistribution (considering both axial force due to pressure and bending loads) from the overlaid component to the weld overlay and back, such that applicable stress limits of the ASME Code, Section III, NB-3200 [2] are satisfied. Shear stress calculations are performed to assure that the weld overlay length meets these requirements.

4.0 LOADS AND DESIGN INPUTS

[redacted] In order to determine the loads at the nozzle-to-safe end weld, the forces and moments must be transformed such that the revised coordinate system is aligned with the nozzle axis. After the transformation performed in the spreadsheet TMI.xlsx, the loads are in a local coordinate system with local-y axial to the nozzle. See Table 2 for the transformed results.

Tables 2 and 3 do not include forces and moments due to thermal expansion of the piping attached to the nozzle. For designing FSWOLs, only primary loads are considered and the secondary loads, such as thermal expansion, need not be included in the design calculations. For the transformed result, all forces and moments are taken on an absolute basis. That is, in Table 2 (Post-Transformation), all forces and moments are taken as positive.

The loads shown in Table 2 are assumed to be applied at the safe end-to-elbow weld. These moments are adjusted for the nozzle-to-safe end weld to account for the eccentricity between the shear forces (transformed F_x and F_z) at the safe end-to-elbow weld and the nozzle-to-safe end weld centerlines. [redacted]

Table 2: Specified Forces and Moments at the Safe End-to-Elbow Weld Location

Pre-Transformation

	F_x (lbs)	F_y (lbs)	F_z (lbs)	M_x (in-lbs)	M_y (in-lbs)	M_z (in-lbs)
Dead Weight	-3	-19	-1	252	312	1416
OBE	422	96	793	10932	25332	3096
SSE	844	192	1586	21864	50664	6192

[redacted]

Post-Transformation

	F_x (lbs)	F_y (lbs)	F_z (lbs)	M_x (in-lbs)	M_y (in-lbs)	M_z (in-lbs)
Dead Weight	3	14	13	252	1222	781
OBE	422	629	493	10932	20102	15723
SSE	844	1257	986	21864	40203	31446

Notes: 1) Transformed forces and moments are listed on an absolute basis.
2) F_y is oriented in the axial direction of the nozzle.

Table 3: Forces and Moments at Weld Locations

	Forces and Moments, Nozzle-to-Safe End Weld (DMW1)(1)(2)							Forces and Moments, Safe End-to-Elbow Weld (DMW2)						
	Fx (lbs)	*Fy* (lbs)	*Fz* (lbs)	*Mx* (in-lbs)	*My* (in-lbs)	*Mz* (in-lbs)	*MRSS* (in-lbs)	*Fx* (lbs)	*Fy* (lbs)	*Fz* (lbs)	*Mx* (in-lbs)	*My* (in-lbs)	*Mz* (in-lbs)	*MRSS* (in-lbs)
DW	3	14	13	347	1222	803	----	3	14	13	252	1222	781	----
OBE	422	629	493	14628	20102	18888	----	422	629	493	10932	20102	15723	----
SSE	844	1257	986	29257	40203	37776	----	844	1257	986	21864	40203	31446	----
Service Level A (Normal)	3	14	13	347	1,222	803	**1,503**	3	14	13	252	1,222	781	**1,472**
Service Level B (Upset)	425	643	506	14,976	21,324	19,691	**32,661**	425	643	506	11,184	21,324	16,504	**29,192**
Service Level C (Emergency)	847	1,271	998	29,604	41,425	38,580	**63,881**	847	1,271	998	22,116	41,425	32,227	**56,954**
Service Level D (Faulted)	847	1,271	998	29,604	41,425	38,580	**63,881**	847	1,271	998	22,116	41,425	32,227	**56,954**

Notes:
1) The nozzle-to-safe end weld moments account for the eccentricity of 7.5" between the centerlines of DMW1 and DMW2.
2) Forces at the nozzle-to-safe end weld are assumed equivalent to the forces at the safe end-to-elbow weld.

5.0 WELD OVERLAY THICKNESS SIZING

The normal operating pressure [6], dimensions [redacted] and overlay thickness are shown in Table 4. At the nozzle side of the DMW1, Location 1B includes the thickness of the nozzle plus the thickness of the ID cladding, while Location 1A considers only the thickness of the nozzle (excluding the thickness of the ID cladding) (see Figure 1). An initial *a/t* value of 0.75 (the limiting value as stated in C-5322 of Appendix C of Section XI [1]) was the initial input to the iteration. The assumed 360° flaw results in a flaw length to circumference ratio of 1.0. Figure 1 shows the locations for FSWOL sizing.

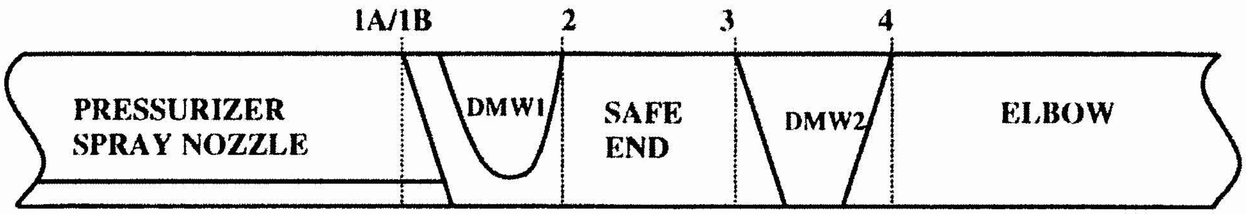

Figure 1: Locations Examined for FSWOL Sizing

Table 4: Dimensions for Overlay Sizing

	Location 1A	Location 1B	Location 2	Location 3	Location 4
	Nozzle Side of DMW1 w/o Clad	Nozzle Side of DMW1 w/ Clad	Safe End Side of DMW1	Safe End Side of DMW2	Elbow Side of DMW2
p, psig(5)	2155	2155	2155	2155	2155
[redacted]					
t_{base}, in	0.563	0.750	0.750	0.435	0.404
a/t	0.748	0.750	0.750	0.744	0.743
t_{ol}, in	**0.19**	**0.25**	**0.25**	**0.15**	**0.14**
$t_{base+ol}$, in	0.753	1.000	1.000	0.585	0.544
D_{ol}, in	5.505	5.625	5.625	4.863	4.780
$I_{base+ol}$, in^4	32.515	40.667	40.667	18.321	16.506

[redacted]

(5) Normal operating pressure of 2155 psig [6] is used.

The final calculated membrane stresses (σ_m) and bending stresses (σ_b) at each service level for the pipe + overlay configuration are shown in Table 5. This table also shows the ratio of the membrane stress (σ_m)

to the flow stress (σ_f) at the selected locations. The material properties are evaluated at the normal operating temperature of 650° F [6] using Section II, Part D of the ASME Code [3].

Table 5: Calculated Stresses

		Location 1A	Location 1B	Location 2	Location 3	Location 4
		Nozzle Side of DMW1 w/o Clad	Nozzle Side of DMW1 w/ Clad	Safe End Side of DMW1	Safe End Side of DMW2	Elbow Side of DMW2
Service Level	σ_m, psi	3941	3030	3030	4476	4734
	S_y, psi	27,500	27,500	27,500	27,500	27,500
	S_u, psi	80,000	80,000	80,000	80,000	80,000
	σ_f, psi	53,750	53,750	53,750	53,750	53,750
	σ_m/σ_f	0.0733	0.0564	0.0564	0.0833	0.0881
A	Normal σ_b, psi	127	104	104	195	213
B	Upset σ_b, psi	2765	2259	2259	3874	4227
C	Emergency σ_b, psi	5408	4418	4418	7558	8247
D	Faulted σ_b, psi	5408	4418	4418	7558	8247

Table 6 shows the allowable stresses as determined from the source equations discussed in Section 3.0. The membrane and bending stresses from Table 5 are compared to the allowable stresses as shown by the ratios in Table 6. The limiting cases for the membrane and bending stresses are shown in bold. In the limit load analyses, the flow stress of the Alloy 52M weld overlay material is used, consistent with the assumption of a full 360° flaw through the original pipe wall for the design of the full structural weld overlay.

Table 6: Allowable Stresses and Calculated Stress to Allowable Stress Ratios

Service Level		Location 1A Nozzle Side of DMW1 w/o Clad	Location 1B Nozzle Side of DMW1 w/ Clad	Location 2 Safe End Side of DMW1	Location 3 Safe End Side of DMW2	Location 4 Elbow Side of DMW2
	β in radians	0.4494	0.4866	0.4866	0.4327	0.4230
	σ^c_b, psi	18619	20002	20002	18025	17660
Level A	Normal S_c, psi	5613	6789	6789	5019	4698
Level B	Upset S_c, psi	7010	8233	8233	6401	6069
Level C	Emergency S_c, psi	9885	11155	11155	9276	8934
Level D	Faulted S_c, psi	12389	13588	13588	11842	11522
Level A	Normal σ_b/S_c	0.0227	0.0153	0.0153	0.0389	0.0454
Level B	Upset σ_b/S_c	0.3944	0.2743	0.2743	0.6051	0.6965
Level C	Emergency σ_b/S_c	**0.5471**	**0.3961**	**0.3961**	**0.8148**	**0.9231**
Level D	Faulted σ_b/S_c	0.4365	0.3251	0.3251	0.6382	0.7158
	σ^c_m, psi	13571	13438	13438	13776	13833
Level A	Normal S_t, psi	5026	4977	4977	5102	5123
Level B	Upset S_t, psi	5655	5599	5599	5740	5764
Level C	Emergency S_t, psi	7540	7465	7465	7653	7685
Level D	Faulted S_t, psi	10440	10337	10337	10597	10641
Level A	Normal σ_m/S_t	**0.7841**	**0.6089**	**0.6089**	**0.8773**	**0.9240**
Level B	Upset σ_m/S_t	0.6970	0.5413	0.5413	0.7798	0.8213
Level C	Emergency σ_m/S_t	0.5227	0.4059	0.4059	0.5849	0.6160
Level D	Faulted σ_m/S_t	0.3775	0.2932	0.2932	0.4224	0.4449

Notes:
σ^c_b = Bending stress at incipient plastic collapse [1, C-5320]
S_c = Allowable bending stress [1, C-5320]
S_t = Allowable membrane stress [1, C-5320]
σ^c_m = Membrane stress at incipient plastic collapse [1, C-5320]
(All terms defined in Section 3.0)

6.0 WELD OVERLAY LENGTH REQUIREMENTS

The weld overlay length must consider three requirements: (1) length required for structural reinforcement, (2) length required for preservice examination access of the overlaid weld, and (3) limitation on the area of the nozzle surface that can be overlaid.

6.1 Structural Reinforcement

Structural reinforcement requirements are expected to be satisfied if the weld overlay length is $0.75\sqrt{Rt}$ on either side of the susceptible weld being overlaid [4], where R is outside radius of the item and t is the nominal thickness of the item at the applicable side of the overlay. However, to assure ASME Code, Section III, NB-3200 [2] compliance, detailed shear stress calculations are instead performed to determine the minimum required structural length.

The section along the length of the overlay is evaluated for axial shear due to transfer of axial load and moment from the overlaid item to the overlay. Subparagraph NB-3227.2 [2] limits pure shear due to Design Loadings, Test Loading or any Service Level loadings except Service Level D to $0.6S_m$. For Service Level D (Faulted) conditions, the stress intensity limit is the lesser of $2.4S_m$ and $0.7S_u$ [2, NB-3225 and Appendix F], equivalent to the lesser of $1.2S_m$ and $0.35S_u$ for shear stress, since stress intensity is equal to twice the shear stress. These values are shown in Table 7 for the spray nozzle, attached elbow, and weld overlay materials.

Shear stress around the circumference at the overlay-base material interface due to axial force and moment loading equals:

$$\tau = p \times \pi \times R_o^2/A_s + M/S_s,$$

where,

R_o	=	outside radius of overlaid item at crack
L	=	length of overlay at outside surface of overlaid item on one side of crack
A_s	=	shear area, $2\pi R_o L$
S_s	=	$\pi R_o^2 L$
p	=	pressure
M	=	resultant moment from piping interface loads at crack

Thus $\qquad \tau = p\pi R_o^2/(2\pi R_o L) + M/(\pi R_o^2 L)$

Solving for L and equating τ with the allowable shear stress (S_{allow}) yields:

$$L = [pR_o/2 + M/(\pi R_o^2)]/S_{allow}, \text{ where,}$$

$S_{allow} = 0.6S_m$ (Service Levels A, B, and C)

S_{allow} = Lesser of $1.2S_m$ and $0.35S_u$ (Service Level D)

The evaluation for required length is documented in Table 7 for the pressurizer spray nozzle and elbow. The overlay weld metal is also evaluated as it may control if the base metal has a higher value of S_m *or* S_u. The greater value of the required overlay length will be taken. The material properties are evaluated at the normal operating temperature of 650°F [6] using Section II, Part D of the ASME Code [3].

Since the overlay ends on the pressurizer spray nozzle at one end and the elbow at the other end, and extends over the safe end, the surface shear transfer into the base metal occurs onto the nozzle and elbow only. In this configuration, the requirements for shear lengths at intermediate locations (safe end) are not relevant and would have no influence on the required overlay. Therefore, they are not included herein.

The required overlay length is calculated at Locations 1 and 4 along the nozzle and elbow configuration (both sides of the DMW1 and DMW2). The evaluation results are presented in Table 7. The design drawing implements a configuration that meets all the designed FSWOL thickness and length requirements. The lengths shown in Table 7 ensure adequate shear stress transfer along the length of the weld overlay. Service Level C is the most limiting of all cases. This length is sufficient to transfer the imposed loads and maintain stresses (shear) within the appropriate ASME Code allowable limits [2].

Table 7: Minimum Required Overlay Length

	Location 1A/1B	Location 1A/1B	Location 4	Location 4
	Nozzle Side of DMW1	Nozzle Side of DMW1	Elbow Side of DMW2	Elbow Side of DMW2
R_o, in	2.563	2.563	2.25	2.25
Material	Alloy 52M	SA-508 Class 1	Alloy 52M	SA-403 WP316
S_m, ksi	23.30	17.80	23.30	16.60
Service Level A $0.6S_m$, ksi	13.980	10.680	13.980	9.960
Service Level B $0.6S_m$, ksi	13.980	10.680	13.980	9.960
Service Level C $0.6S_m$, ksi	13.980	10.680	13.980	9.960
Service Level D $1.2S_m$, ksi	27.960	21.360	27.960	19.920
S_u, ksi	80.00	70.00	80.00	71.80
Service Level D $0.35S_u$, ksi	28.000	24.500	28.000	25.130
Service Level A L, in	0.2027	0.2654	0.1800	0.2527
Service Level B L, in	0.3108	0.4068	0.3047	0.4277
Service Level C L, in	**0.4190**	**0.5485**	**0.4296**	**0.6030**
Service Level D L, in	0.2095	0.2742	0.2148	0.3015

6.2 Preservice Examination

Weld overlay access for preservice examination requires that the overlay length and profile be such that the overlaid weld and any adjacent welds can be inspected using the required NDE techniques. This requirement could cause the overlay length to be longer than required for structural reinforcement. The specific overlay length required for preservice examination is determined based on the examination techniques and proximity of adjacent welds to be inspected.

6.3 Area Limitation on Nozzle

The total weld overlay surface area is limited to 500 in^2 (this value will be specified in the relief request) on the nozzle (carbon steel base material) when using ambient temperature temper bead welding to apply the overlay. Using an outside diameter of 5.125", the maximum length is limited to $500/(\pi D_o) = 31.0"$ on the carbon steel nozzle material. The required overlay length on the nozzle will be less than this limit (see Table 7).

6.4 Maximum Overlay Sizing

This calculation documents the minimum overlay thickness and length necessary for structural requirements. Additional thickness and length may be added to address inspectability and crack growth concerns. In addition, a maximum overlay thickness (typically an additional 0.25") and a maximum overlay length will be determined. The determination of the maximum length is based on implementation factors and is intended to be large enough so as to not unnecessarily constrain the overlay process. These dimensions will be indicated on a subsequent design drawing to create a "box" within which the overlay is analyzed. In the subsequent analyses, the finite element models use the geometry (minimum or maximum) that will produce conservative results.

7.0 DISCUSSIONS AND CONCLUSIONS

Table 8 and Figure 2 summarize the minimum required overlay dimensions. This calculation documents the development of a weld overlay design for the 4" nominal diameter pressurizer spray nozzle-to-safe end dissimilar metal weld and the safe end-to-elbow dissimilar metal weld at TMI-1. The design meets the requirements of the ASME Code, Section XI, Code Case N-504-3 [4] and ASME Code, Section XI, Appendix C [1] for a full structural weld overlay.

The weld overlay sizing presented in Table 8 is based upon the primary loadings documented in Section 4.0 and using the criteria from the ASME Code, Section XI, Appendix C. The overlay thicknesses and lengths listed in Table 8 meet ASME Code stress criteria.

Table 8: Minimum Required Overlay Dimensions

	Location	Thickness, in.	Length, in.
Nozzle Side of DMW1	1A/1B	0.19/0.25	0.55
Safe End Side of DMW1	2	0.25	NA
Safe End Side of DMW2	3	0.15	NA
Elbow Side of DMW2	4	0.14	0.61

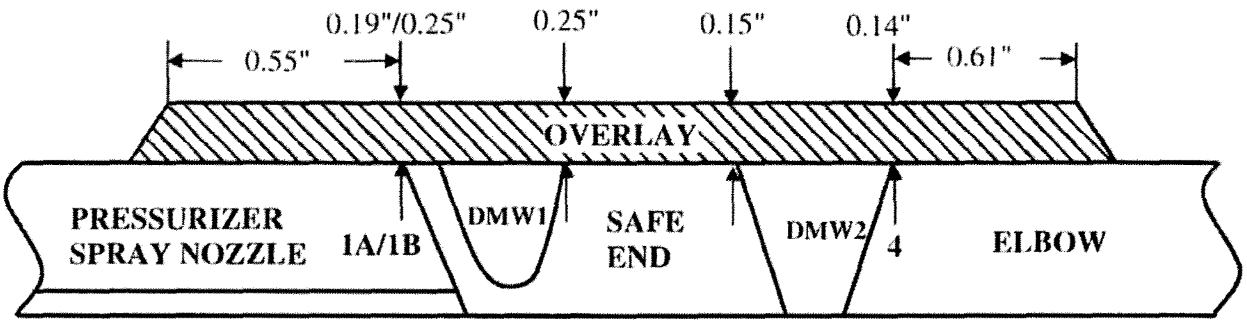

Figure 2: Full Structural Weld Overlay Geometry, Minimum Dimensions (Schematic Representation)

8.0 REFERENCES

1. ASME Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, 2004 Edition.
2. ASME Boiler and Pressure Vessel Code, Section III, Rules for Construction of Nuclear Facility Components, 2004 Edition.
3. ASME Boiler and Pressure Vessel Code, Section II, Part D, Material Properties, 2004 Edition.
4. ASME Boiler and Pressure Vessel Code, Code Case N-504-3, "Alternative Rules for Repair of Classes 1, 2, and 3 Austenitic Stainless Steel Piping, Section XI, Division 1."
5. ASME Boiler and Pressure Vessel Code, Code Case N-638-1, "Similar and Dissimilar Metal Welding Using Ambient Temperature Machine GTAW Temper Bead Technique, Section XI, Division 1."
6. Email from William McSorley (Exelon) to Norman Eng (SI), dated March 02, 2011, Subject: "Status of Pzr Spray SWOL Analysis," includes attached file "GDeBoo Review of 310, 314, 315 & 316.doc", SI File No. 1000320.212.

[redacted]

[redacted]

15. Crane Company, Technical Paper No. 410, "Flow of Fluids through Valves, Fittings, and Pipe," 1976.

16. GPU Nuclear Drawing No. ID-212-23-028, Sheet 2 of 6, Rev. 1, "LPSI/Decay Heat Removal, Piping Analysis," SI File No. 1000320.204.

ATTACHMENT 3

Affidavits

AFFIDAVIT

COMMONWEALTH OF VIRGINIA)
) ss.
CITY OF LYNCHBURG)

1. My name is Gayle F. Elliott. I am Manager, Product Licensing, for AREVA NP Inc. (AREVA NP) and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA NP to determine whether certain AREVA NP information is proprietary. I am familiar with the policies established by AREVA NP to ensure the proper application of these criteria.

3. I am familiar with the AREVA NP information contained in the Structural Integrity Associates, Inc. Calculation Package, No. 1000320.310, Revision 0, entitled "Pressurizer Spray Nozzle Weld Overlay Sizing Calculation," dated March of 2011 and referred to herein as "Document." Information contained in this Document has been classified by AREVA NP as proprietary in accordance with the policies established by AREVA NP for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA NP and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is

made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information."

6. The following criteria are customarily applied by AREVA NP to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA NP's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA NP.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA NP in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA NP, would be helpful to competitors to AREVA NP, and would likely cause substantial harm to the competitive position of AREVA NP.

The information in the Document is considered proprietary for the reasons set forth in paragraphs 6(b) and 6(c) above.

7. In accordance with AREVA NP's policies governing the protection and control of information, proprietary information contained in this Document have been made available, on a limited basis, to others outside AREVA NP only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA NP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

SUBSCRIBED before me this 15th

day of April, 2011.

Kathleen A. Bennett

Kathleen Ann Bennett
NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES: 8/31/11
Reg. # 110864

KATHLEEN ANN BENNETT
Notary Public
Commonwealth of Virginia
110864
My Commission Expires Aug 31, 2011

Structural Integrity Associates, Inc.®

5215 Hellyer Ave.
Suite 210
San Jose, CA 95138-1025
Phone: 408-978-8200
Fax: 408-978-8964
www.structint.com

April 15, 2011

AFFIDAVIT

I, Marcos Legaspi Herrera, state as follows:

(1) I am a Vice President of Structural Integrity Associates, Inc. (SI) and have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in SI Calculation 1000320.310, Rev. 0, "Pressurizer Spray Nozzle Weld Overlay Sizing Calculation." This calculation is to be treated as SI proprietary information, because it contains significant information that is deemed proprietary and confidential to AREVA NP. AREVA NP design input information was provided to SI in strictest confidence so that we could generate the aforementioned calculation on behalf of SI's client, Exelon Nuclear Company, LLC (Exelon).

Paragraph 3 of this Affidavit provides the basis for the proprietary determination.

(3) SI is making this application for withholding of proprietary information on the basis that such information was provided to SI under the protection of a Proprietary/Confidentiality and Nondisclosure Agreement between SI and AREVA NP. In a separate Affidavit requesting withholding of such proprietary information prepared by AREVA NP, AREVA NP relies upon the exemption of disclosure set forth in NRC Regulation 10 CFR 2.390(a)(4) pertaining to "trade secrets and commercial or financial information obtained from a person and privileged or confidential" (Exemption 4). As delineated in AREVA NP's Affidavit, the material for which exemption from disclosure is herein sought is considered proprietary for the following reasons (taken directly from Items 6(b) and 6(c) of AREVA NP's Affidavit):

a) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service; and

b) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA NP.

Public disclosure of the information sought to be withheld is likely to cause substantial harm to AREVA NP with which SI has established a Proprietary/Confidentiality and Nondisclosure Agreement.

I declare under penalty of perjury that the above information and request are true, correct, and complete to the best of my knowledge, information, and belief.

Executed at San Jose, California on this 15th day of April, 2011.

Márcos Legaspi Herrera, P.E.
Vice President
Nuclear Plant Services

State of California

County of Santa Clara

Subscribed and sworn to (or affirmed) before me

on this 15th day of April, 2011,
Date Month Year

by

(1) Marcos Legaspi Herrera
Name of Signer

proved to me on the basis of satisfactory evidence to be the person who appeared before me (.) (~~X~~)
(and

(2) ______
Name of Signer

proved to me on the basis of satisfactory evidence to be the person who appeared before me.)

C. METZGER
Commission # 1866327
Notary Public - California
Santa Clara County
My Comm. Expires Sep 27, 2013

Place Notary Seal and/or Stamp Above

Signature ______
Signature of Notary Public