

Client:	Duke Power Carolinas, LLC	Calculation No.	07Q3691-CAL-007	
Title:	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator "2A" Unit 2			
Project:	Catawba Unit #1 and Unit #2 – Buried HDPE Pipe Design and Analysis			
Method:	Computer and Manual Calculations			
Acceptance Criteria:	N/A			
Remarks:				
Verification Method ☒ Design Review Method ☐ Alternate Calculation ☐ Qualification Test ☐ Other ☐ No Verification Necessary				
Results:				
Computer Programs Used	Program Name	Version/Revision	Computer Type	QA Verified
	ADLPIPE	4F10.1	PC	YES
	Microsoft Word	2003	PC	N/A
	Mathcad	2000	PC	N/A
REVISIONS				
Revision No.	0			
Description	Original Issue			
Total Pages (Cumulative)	86			
By/Date	<i>S. Hailer</i> 11-10-08			
Checked/Date	<i>Bruce P. Dubouché</i> 11-11-08			
Approved/Date	<i>[Signature]</i> 11-11-08			
 Stevenson & Associates		CALCULATION COVER SHEET		CONTRACT NO. 07Q3691

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By:	<i>L. Hailer</i>	Date	11/10/08
		Chk'd by	<i>Bruce P. Dubosechif</i>
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DOCUMENT INDEX

DIN No.	Document Number/Title	Revision, Edition, Date	Reference	Input	Output
1	“Nondestructive Evaluation: Seismic Design Criteria for Polyethylene Pipe Replacement Code Case,” EPRI, Palo Alto, CA, 2006, Report Number 1013549	September 2006	☐	☒	☐
2	“Guidelines for the Seismic Design of Oil and Gas Pipeline Systems,” ASCE	1984	☐	☒	☐
3	“Catawba Updated Final Safety Analysis Report”	Rev. 12, April 2006	☐	☒	☐
4	“Polyethylene (PE) Pressure Pipe and Fittings, 4in. (100 mm) through 63 in. (1,575 mm) for Water Distribution and Transmission,” ANSI/AWWA C906-99, American Water Works Association, 6666 West Quincy Ave., Denver, CO 80235	March 1, 2000	☐	☒	☐
5	Catawba Nuclear Station Units 1&2, Yard Layout, Buried Systems, Drawing No. CN-1038-06.		☐	☒	☐
6	Catawba Nuclear Station Units 1&2, Yard Layout, Buried Systems, Drawing No. CN-1038-11.		☐	☒	☐
7	Catawba Nuclear Station Units 1&2, Yard Layout, Buried Systems, Drawing No. CN-1038-12.		☐	☒	☐
8	HDPE Product Catalog, ISCO Industries	Version 2.1, 2005	☐	☒	☐
9	Ladish General Catalog No. 55	1971	☐	☒	☐
10	Navco Piping Catalog	Edition No. 10, June 1, 1974	☐	☒	☐
11	ASME Boiler and Pressure Vessel Code, Section III, Division I, Subsection ND-3600	1998 Edition with 2000 Addenda	☐	☒	☐
12	ASME BPVC Code Case N-755, High Density Polyethylene (HPDE) Buried Pipe, Section III, Division I, Class 3	March 22, 2007	☐	☒	☐
13	CNS ISFSI Haul Path Evaluation Calculation, CNM 1140.04-0005 001	Rev. 0, December 21, 2006	☐	☒	☐
14	Request for relief Number 06-CN-003 “Use of Polyethylene Material in Nuclear Safety-Related Piping Applications” (TAC Numbers MD 3729 and MD 3730)	March 13, 2008	☒	☐	☐
15	S&A Calculation 07Q3691-CAL-001 “Calculation of Soil Spring Stiffness for Buried HDPE Pipe”	Rev. 0, 2008	☐	☒	☐
16	Catawba Nuclear Station Units 1 and 2 Calculation CNC-1206.02-84-001, “Nuclear Service Water Pipe Seismic Analysis (Buried Portion)”	Rev. 16, 9-7-06	☐	☒	☐

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DIN No.	Document Number/Title	Revision, Edition, Date	Reference	Input	Output
17	Bonney Forge Stress Intensification Factors: Weldolet, Sockolet, Thredolet, Sweepolet, Latrolet, Insert Weldolet, Bulletin SI-1	1988	☒	☐	☐
18	S&A Calculation 07Q3691-CAL-002 “Calculation of Equivalent Thermal Strain for Seismic Analysis of Buried HDPE Pipe”	Rev. 0, 2008	☐	☒	☐
19	Catawba Nuclear Station Specification CNS-1206.02-01-008	Rev. 1, January 3, 1998	☐	☒	☐
20	018B00Y020GLOT_Digitized Spectra (4-14)	-	☐	☒	☐
21	Young, W. C., “Roark’s Formulas for Stress and Strain”.	McGraw-Hill, Sixth Edition, 1989	☒	☐	☐
22	Fatigue and Capacity Testing of High-Density Polyethylene Pipe and Pipe Components Fabricated from PE4710 (1015062)	Final Report, December 2007	☒	☐	☐
23	3691-LSC-002, “HDPE Pipe Interface Loads Applied to Steel Pipe”	March 17, 2008	☒	☐	☐
24	S&A Calculation 07Q3691-CAL-011, “Definition of Break Selection Criteria and Functional Capability Criteria for the Piping Design Specification”	August 30, 2008	☒	☐	☐
25	S&A Calculation 07Q3691-CAL-013, “Technical Basis for Design Acceptance Criteria”	September, 30, 2008	☐	☒	☐
26	CNS-1574-00_RN-00-0002, “ ASME Design Specification for the Nuclear Service Water System (RN) Diesel Generator Cooling Supply and Return Piping; Modification, Repair, and Replacement”	Preliminary Draft	☐	☒	☐
27	S&A Document 3691-DI-001, “ Design Instructions for Analysis of Polyethylene Pipe”	Rev. 0, 7/2008	☒	☐	☐
28	Welding Research Council Bulletin 300, “Technical Position on Industry Practice”	December, 1984	☒	☐	☐
29	ASME Boiler and Pressure Vessel Code, Section III, Division I, Subsection ND-3600	1989 Edition	☐	☒	☐
			☐	☐	☐
			☐	☐	☐

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1.0 PURPOSE OR OBJECTIVE

Catawba Nuclear Station has decided to replace the buried nuclear service water piping lines connecting the 42-in Nuclear Service Water System (NSWS) supply and return headers to Unit 1 and Unit 2 Diesel Generator (DG) buildings. The existing 10-in carbon steel piping will be replaced by 12-in high-density polyethylene (HDPE) piping. The purpose of this calculation is to demonstrate the Design Basis ASME BPVC Code and Regulatory compliance for the buried HDPE piping system connecting the 42-in supply header 'A' to the DG building of Unit 2.

2.0 SCOPE AND LIMITATIONS

Results of this calculation are limited to the 12-in buried HDPE piping system supplying cooling water from the 42-in NSWS supply header 'A' to the Diesel Generator Building of Unit 2. The piping model goes from the anchor at the wall (column lines 76 & EE) to the 42"ø Supply A header pipe of the NSWS. There is a manhole (MH-4) at Diesel Generator Building Unit 2, and there is also a manhole (MH-7) at the connection to the 42" ø Supply A header pipe of the NSWS. The manholes provide access to the steel to HDPE flanged connections for the purpose of inspection and maintenance of the steel to HDPE connections. The HDPE pipe passes through the wall penetration of the manhole, but is not attached to the structure. The manhole does not transfer any load to the HDPE pipe. The gap between the manhole penetration and the HDPE pipe is sealed to prevent water from entering the manhole through this penetration. The piping qualification includes the following:

- (a) The Steel Pipe from the Unit 2 Diesel Generator Building anchor steel to the High Density Polyethylene (HDPE) pipe Flange.
- (b) HDPE Piping from Steel – HDPE Flange near the Unit 2 Diesel Generator Building Anchor to the Steel – HDPE Flange near the 42" NSWS Supply Header 'A'
- (c) The Steel Pipe from the Steel – HDPE Flange anchor to the 42" NSWS Supply Header 'A', including qualification of the 12" NSWS Supply Header 'A' branch connection to the NSWS Supply Header pipe.

3.0 DEFINITIONS

Nomenclature per Ref. [14], Request for Relief Number 06-CN-003, "Use of Polyethylene Material in Nuclear Safety-Related Piping Applications" (TAC Numbers MD 3729 and MD 3730). This nomenclature may differ somewhat from the nomenclature used in the ASME BPVC Code Case N-755 Ref. [12]. Nomenclature is provided at point of use.

A = Cross sectional area of pipe [in²]

α = Coefficient of thermal expansion [in/in/°F]

B_1 and B_2 = Primary stress indices

B' = Burial factor

BS = Building settlement loads

c = Allowance for erosion or mechanical damage, [in]

D = Outside diameter of pipe [in]

DR = Dimensional ratio of pipe; for OD-controlled pipe, $DR = D/t$

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DW = Deadweight of pipe and contents [lb]

E' = Modulus of soil reaction [psi]

E_{pipe} = Elastic modulus of pipe [psi]

f_0 = Ovality correction factor

F = Impact factor for surface loads.

FS = Factor of safety ($FS = 2.0$ Level A, 1.8 for Level B, and 1.5 for Levels C and D)

γ_{soil} = Specific weight of the soil [lb/ft³]

γ_{water} = Specific weight of the water [lb/ft³]

H = Height of fill (or cover) above top of pipe [ft]

H_{gw} = height of groundwater above pipe [ft]

k = Longitudinal stress factor

K_b = Bedding factor, usually 0.1.

K_o = Coefficient of soil pressure at rest, 0.5 to 1.0, may conservatively be taken as 1.0

K_{po} = Spring due to pipe ovaling [lb/in]

L = Deflection lag factor (recommended values: 1.0 for short term and 1.5 for long term loads)

OBE_w = Operating Basis Earthquake due to effects of seismic wave passage

OBE_s = Operating Basis Earthquake due to effects of soil movement

OBE_D = Operating Basis Earthquake due to effects of anchor movements

P_D = Long-term design pressure for the pipe [psi]

P_A, P_B, P_C and P_D = Maximum Pressures for Service Levels A through D [psi]

P_{bs}, P_{cs} , and P_{ds} = Surge Pressures for Service Levels B through D [psi]

P_E = Vertical soil pressure loads due to weight of soil cover [psi]

P_{gw} = Ground water pressure loads [psi]

P_L = Vertical surcharge (transportation) loads [psi]

PS = Loads due to pump startup and shutdown

R_b = Buoyancy reduction factor

S_h = Design allowable stress for HDPE piping at temperature [psi]

SSE_w = Safe Shutdown Earthquake due to effects of seismic wave passage

SSE_s = Safe Shutdown Earthquake due to effects of soil movement

SSE_D = Safe Shutdown Earthquake due to effects of anchor movements

$T_{A,max}, T_{B,max}, T_{C,max}$ and $T_{D,max}$ = Maximum temperature for Service Levels A through D [°F]

$T_{A,min}, T_{B,min}, T_{C,min}$ and $T_{D,min}$ = Minimum temperature for Service Levels A through D [°F]

t = Actual (not nominal) pipe wall thickness [in]

VOT = Valve Operating Transients

ν = Poisson's ratio for piping

ν_r = Poisson ratio for the bedrock

W_p = Weight of empty pipe [lb/ft]

W_w = Ground water floatation loads [lb]

Z = Section modulus of pipe cross section [in³]

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4.0 ASSUMPTIONS

4.1 Assumptions Not Requiring Verification

- [1] Due to the small Seismic Building Displacement of the Unit 2 Diesel Generator Building (0.003”), the seismic response of the buried steel pipe from the Diesel Generator building anchor to the HDPE piping is predominantly due the effect of seismic wave passage. The effect of the Diesel Generator Building Amplified Floor Response does not need to be considered in the analysis of the buried pipe Ref. [25].
- [2] Per discussion with Catawba Systems Engineering, it is concluded that the buried HDPE piping at Catawba is not subjected to any pressure surge loads. Ref. [25]
- [3] Seismic Anchor Movements of 0.003” are much less than 1/16” and, therefore, will have negligible effect on the piping and are not considered in the analysis

4.2 Assumptions To Be Verified

- [1] Stress Intensification Factors (SIF's) for mitered elbows less than 90° are enveloped by SIF's of 90° elbows.

5.0 ANALYSIS METHODOLOGY AND APPROACH

5.1 Background

The buried water supply system to and from the Diesel Generator (DG) buildings to the 42-in Nuclear Service Water System (NSWS) currently uses 10-in carbon steel pipes. Catawba Nuclear Station (CNS) has decided to replace the 10-in steel pipes with 12-in high-density polyethylene (HDPE) pipes. There are a total of eight cooling water piping lines—four supply lines and four return lines.

- Two cooling water supply lines to the DG building of Unit 1. One line originates from the 42-in supply header ‘A’ and the other originates from the 42-in supply header ‘B’.
- Two cooling water supply lines to the DG building of Unit 2. One line originates from the 42-in supply header ‘A’ and the other originates from the 42-in supply header ‘B’.
- Two cooling water return lines originating from the DG building of Unit 1. One line returns water to the 42-in return header ‘A’ and the other returns water to the 42-in return header ‘B’.
- Two cooling water return lines originating from the DG building of Unit 2. One line returns water to the 42-in return header ‘A’ and the other returns water to the 42-in return header ‘B’.

The HDPE pipes are connected to the steel pipes by means of a flanged joint. At the DG building wall entrance, a transition is made from 10-in to 12-in using a 10x12 steel reducer with flanges to provide the necessary flanged connection to the HDPE pipe and a means of providing future access for examination

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of all joints from the inside surface per Ref. [14]. At the 42-in header side, a short 12-in flanged steel pipe is welded to the header. An additional steel flanged joint attached to the 12-in pipe provides the necessary connection to the HDPE pipe and serves as future access. The HDPE piping system is considered anchored at both ends.

The buried HDPE piping system considered in this calculation is the cooling water supply line from the 42-in supply header 'A' to the Diesel Generator Building of Unit 2. The effects of pressure, deadweight, seismic and temperature loads on the buried HDPE piping are analyzed.

5.2 Methodology and Approach

The piping is qualified to the requirements of the Piping Design Specification Ref. [26]. The Design Specification is based on ASME BPVC Code Case N-755 Ref. [12] and the commitments in Relief Request Number 06-CN-003 Ref. [14]. In addition, further guidance on design and analysis methods is provided in EPRI Report 1013549 Ref. [1] and S & A Design Instruction 3691-DI-001 Ref. [27]. However, the controlling design document is the Piping Design Specification Ref. [26].

The Code of Record for the Design and Analysis of the HDPE Pipe is the 1998 Edition of the ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection ND up to and including the 2000 Addenda. However, ND-3600 of the ASME Boiler and Pressure Vessel Code 1989 Edition shall be used to comply with the limitations imposed by 10 CFR 50.55 a (b) (1) (iii) except as amended by the governing document Relief Request Number 06-CN-003 Ref. [14]. The piping is classified as ASME Class 3 Duke Class C.

The piping system is analyzed using a combination of hand calculations and the ADLPIPE computer program. ADLPIPE analyzes complex piping systems subjected to static and dynamic loads. The basic load cases (deadweight, thermal, seismic OBE, seismic SSE, etc.) and their combinations (such as thermal plus seismic) are included in the ADLPIPE analysis.

Stresses in steel pipes are automatically computed by ADLPIPE according to an ASME Code year of interest. However, ADLPIPE does not calculate the stresses for all piping load cases and combinations in the HDPE pipe because HDPE material, properties, and qualification criteria are not yet included in the ADLPIPE computer code. Therefore, manual calculations are performed for the HDPE piping according to the relief request Ref. [14] which is consistent with the ASME BPVC Code Case N-755 [Ref. 12]. The required manual calculations are presented in sections 5.2.1 and 5.2.2.

5.2.1 HDPE Calculations Dependent Only on Design Conditions and Pipe Size

These calculations do not require ADLPIPE analysis results as input. The HDPE pipe size and the design conditions are the only inputs needed to perform the manual calculations in this section.

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Minimum Required Wall Thickness

Per Section 3131.1 of Ref. [12], the minimum required wall thickness (t_{min}) of straight pipe sections is determined from:

$$t_{min} = \frac{P_D D}{2S + P_D} + c \quad (5.1)$$

where:

P_D = internal design gage pressure at the specified design temperature, psi

D = outside diameter of pipe, in

S = allowable stress, psi

c = allowance for mechanical and erosion damage, in.

The actual wall thickness of the HDPE pipe shall not be less than t_{min} .

Ring Deflection

Per Section 3210 of Ref. [12], the deflection of the pipe diameter (Ω) due to soil and surcharge loads should be less than the maximum allowable value (Ω_{max}):

$$\Omega = \frac{1}{144} \cdot \frac{K \cdot L \cdot P_E + K \cdot P_L}{\frac{2E_{pipe}}{3} \left(\frac{1}{DR - 1} \right)^3 + 0.061F_s E_s} \leq \Omega_{max} \quad (5.2)$$

where:

$P_E = \rho_{saturated} H_w + \rho_{dry} (H - H_w)$

K_b = bedding factor

L = deflection lag factor, 1.25 to 1.50, or 1.0 if using the soil prism pressure

P_E = vertical soil pressure due to earth loads, [lb/ft²]

P_L = vertical soil pressure due to surcharge loads, [lb/ft²]

E_{pipe} = apparent modulus of elasticity of pipe at 50 years, [psi]

DR = dimensional ratio of pipe (D/t)

D = outside pipe diameter [in]

F_s = soil support factor

E' = modulus of soil reaction, [psi]

$\rho_{saturated}$ = density of saturated soil, [lb/ft³]

ρ_{dry} = density of dry soil, [lb/ft³]

H = height of ground cover, [ft]

H_w = height of water table above pipe, [ft]

t = minimum pipe wall thickness [in]

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Compression of Sidewalls

The circumferential compressive stress (σ_{SW}) in the sidewalls of pipe and miters due to soil and surcharge loads per Section 3220 of Ref. [12] should be less than 1000 psi. This 1000 psi is based on PE-3408 material and assumes a temperature of 70° F. Per Ref. [25] the allowable value at a temperature of 140° F for PE-4710 material is 530 psi. The value used in this analysis is 500 psi which is conservative. This 140° F temperature was selected because it is the maximum discharge line temperature. This lower bound value was conservatively applied to all eight piping analyzes.

$$\sigma_{SW} = \frac{(P_E + P_L) \cdot DR}{2 \times 144} \leq 500 \text{ psi} \quad (5.3)$$

where:

P_E = vertical soil pressure due to earth loads, lb/ft²
 P_L = vertical soil pressure due to surcharge loads, lb/ft²
 DR = dimensional ratio of pipe (D/t)
 D = outside pipe diameter, [in]
 t = minimum pipe wall thickness [in]

Buckling Due to External Pressure

External pressure from ground water, earth loads, and surcharge loads on the buried HDPE pipe shall not cause the pipe to buckle per Section 3221.1 of Ref. [12]; that is,

$$\frac{P_E + P_L + P_{gw}}{144} \leq 2.8 \cdot \left[R \cdot B \cdot E_s \frac{E_{pipe}}{12 \cdot (DR - 1)^3} \right]^{1/2} \quad (5.4)$$

where:

$R = 1 - 0.33 \frac{H_{gw}}{H}$
 $B = \frac{1}{1 + 4e^{-0.065H}}$
 P_E = vertical soil pressure due to earth loads, [lb/ft²]
 P_L = vertical soil pressure due to surcharge loads, [lb/ft²]
 P_{gw} = pressure due to ground water, [lb/ft²]
 R = buoyancy reduction factor
 B = burial factor
 E_{pipe} = modulus of elasticity of pipe, [psi]
 E_s = modulus of soil reaction, [psi]
 DR = dimensional ratio of pipe (D/t)
 H = depth of cover, [ft]
 H_{gw} = height of ground water above pipe, [ft]
 D = outside pipe diameter, [in]
 t = minimum pipe wall thickness, [in]

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Effects of Negative Internal Pressure

Per Section 3221.2 of Ref. [12], when the pipe is subjected to a negative internal pressure, it should withstand the differential pressure (ΔP) without credit for the surrounding soil, that is:

$$\Delta P \leq \frac{f_o}{2} \frac{2E_{pipe}}{(1-\nu^2)} \left(\frac{1}{DR-1} \right)^3 \quad (5.5)$$

where:

f_o = ovality correction factor

E_{pipe} = modulus of elasticity of pipe, [psi]

ν = Poisson's ratio (0.35 for short duration loads to 0.45 for long duration loads)

DR = dimensional ratio of pipe (D/t)

D = outside pipe diameter, [in]

t = minimum pipe wall thickness, [in]

Floating

To prevent floating by groundwater, the buried pipe must have sufficient cover or be anchored to the ground. Per Section 3222 of Ref. [12], the following criterion must be satisfied:

$$W_w < W_p + \frac{P_E \cdot D}{12} \quad (5.6)$$

where:

W_w = weight of water displaced by pipe, [lb/ft]

W_p = weight of empty pipe, [lb/ft]

P_E = vertical soil pressure due to earth loads, [lb/ft²]

D = outside pipe diameter, [in.]

5.2.2 HDPE Calculations Requiring the Input of Geometry Specific Loads

The manual calculations in this section require the ADLPIPE analysis results as input. HDPE pipe stresses are computed using the forces and moments obtained from ADLPIPE analysis. The stress calculations are performed both for straight pipes and mitered elbows.

Longitudinal Stress

Per Section 3223.1 of Ref. [12], the longitudinal stresses due to axial forces and bending moments resulting from applied mechanical loads shall not exceed $k \cdot S$:

$$B_1 \frac{P_a D}{2t} + 2B_1 \frac{F_a}{A} + B_2 \frac{M}{Z} \leq k \cdot S \quad (5.7)$$

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where:

B_1 and B_2 = primary stress indices defined in Table 3223-1 of Ref. [12]
 P_a = design or service level A, B, C or D pressure, [psi]
 D = outside diameter of pipe at the section where the evaluation is conducted, [in.]
 t = nominal pipe wall thickness at the section where the evaluation is conducted, [in.]
 F_a = axial force due to the specified design, level A, B, C or D applied mechanical loads, [lb]
 M = resultant bending moment due to the specified design, level A, B, C or D applied mechanical loads, [in.-lb]
 P_E = vertical soil pressure due to earth loads, [lb/ft²]
 A = cross section area of pipe at the section where the force is calculated, [in²]
 Z = section modulus of pipe cross section at the section where the moment is calculated, [in³]
 k = longitudinal stress factor per Table 3223-2 of Ref. [12]
 S = allowable stress per Table 3223-3 of Ref. [12], [psi]

Thermal Expansion and Contraction

(a) Fully Constrained Thermal Contraction

The tensile stress, per Section 3311.1 of Ref. [12], resulting from the assumption of fully constrained thermal contraction of the buried pipe when $T_{\text{water}} < T_{\text{ground}}$, increased by the tensile stress due to axial contraction from Poisson effect, shall not exceed the allowable stress (S):

$$\left| E_{\text{pipe}} \cdot \alpha \cdot \Delta T - \nu \frac{P \cdot D}{2t} \right| \leq S \quad (5.8)$$

where: E_{pipe} = modulus of elasticity of pipe, [psi]
 α = coefficient of thermal expansion, [in/in/°F]
 $\Delta T = T_{\text{water}} - T_{\text{ground}} < 0$
 ν = Poisson's ratio (0.35 for short duration loads to 0.45 for long duration loads)
 P = internal design gage pressure including pressure spikes due to transients from anticipated water hammer events, [psi]
 D = outside pipe diameter, [in.]
 t = nominal pipe wall thickness, [in.]
 S = allowable stress, [psi], from Table 3021-1 Ref. [14]

(b) Fully Constrained Thermal Expansion

The tensile stress resulting from the assumption of fully constrained thermal expansion of the buried pipe when $T_{\text{water}} > T_{\text{ground}}$, per Section 3311.2 of Ref. [12], shall not exceed the allowable stress (S):

$$E_{\text{pipe}} \cdot \alpha \cdot \Delta T \leq S \quad (5.9)$$

where:

E_{pipe} = modulus of elasticity of pipe, [psi]
 α = coefficient of thermal expansion, [in/in/°F]
 $\Delta T = T_{\text{water}} - T_{\text{ground}} > 0$
 S = allowable stress, [psi], from Table 3021-1 Ref. [14]

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(c) Alternative Evaluation for Thermal Expansion or Contraction

When the soil stiffness is accounted for to calculate the pipe expansion and contraction stresses, per Section 3311.3 of Ref. [12], the stresses must satisfy the following condition:

$$\frac{i \cdot M_C}{Z} + \frac{F_{aC}}{A} \leq 1100 \text{ psi} \quad (5.10)$$

where:

i = stress intensification factor

F_{aC} = axial force range due to thermal expansion or contraction and/or the restraint of free end displacement, [lb]

M_C = resultant moment range due to thermal expansion or contraction and/or the restraint of free end displacement, [in.-lb]

A = cross section area of pipe at the section where the force is calculated, [in²]

Z = section modulus of pipe cross section at the section where the moment is calculated, [in³]

Non-repeated Anchor Movements

Per Section 3312 of Ref. [12], the effects of any single non-repeated anchor movement shall meet the requirements of the following equation:

$$\frac{i \cdot M_D}{Z} + \frac{F_{aD}}{A} \leq 2 \cdot S \quad (5.11)$$

where:

i = stress intensification factor

F_{aD} = axial force due to the non-repeated anchor motion, [lb]

M_D = resultant moment due to the non-repeated anchor motion, [in.-lb]

A = cross section area of pipe at the section where the force is calculated, [in²]

Z = section modulus of pipe cross section at the section where the moment is calculated, [in³]

S = allowable stress, [psi], from Table 3021-1 Ref. [14]

Seismic Induced Stresses

Per Section 3410 of Ref. [12], the stresses in the buried pipe due to soil strains caused by seismic wave passage, seismic soil movement, and building seismic anchor motion effects, where applicable, must satisfy the following equation:

$$\frac{i \cdot M_E}{Z} + \frac{F_{aE}}{A} \leq 1100 \text{ psi} \quad (5.12)$$

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where:

i = stress intensification factor

F_{aE} = axial force range due to the combined effects of seismic wave passage, seismic soil movement, and building seismic anchor motion effects, [lb]

M_E = resultant moment range due to the combined effects of seismic wave passage, seismic soil movement, and building seismic anchor motion effects, [in.-lb]

A = cross section area of pipe at the section where the force is calculated, [in²]

Z = section modulus of pipe cross section at the section where the moment is calculated, [in³]

Seismic wave passage, seismic soil movement, and building seismic anchor motions are combined by square root sum of the squares. This equation is applicable to both OBE and SSE. Ref. [25] Section 7.0 provides the basis of this applicability.

5.2.3 Steel Pipe Criteria

The steel pipe from the Diesel Generator building anchor to the HDPE pipe flange connection and from the HDPE pipe flange connection to the 42"Ø supply header are qualified in the ADLPIPE analysis. The stresses for the steel pipe are shown in Section 7.4.

6.0 ANALYSIS INPUTS

6.1 Design Loads

Design temperature and pressure values supplied by Duke Power Carolinas and used as input in this calculation are listed in Table 6.1.

Design Temperature	100 °F
Ambient Temperature	55 °F
Minimum Temperature	32 °F
Maximum Temperature	100 °F
Design Pressure	100 psig
Operating Pressure	75 psig

6.2 Pipe Properties

Geometric and other relevant properties for the pipes used in this calculation are shown in Table 6.2. Outside diameter (OD), thickness and weight values for steel pipes were taken from standard piping catalogs, Ref. [10]. For IPS HDPE pipe, values were obtained from ANSI/AWWA Standard C906-99, Ref. [4], thickness values were obtained from Ref. [12], and weight values were taken from manufacturers' literature Ref. [8]. For the same nominal pipe size, the ODs of the HDPE and the steel pipes are equal; therefore, the IPS sizing system is used.

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	Cr-Mo Steel Pipe		Carbon Steel Pipe	HDPE Pipe/Elbow
Nominal size	10-in	12-in	12-in	12-in
Material	A6XLN ⁽¹⁾	A6XLN ⁽¹⁾	A-106, Gr. B	PE 4710 ⁽²⁾
Schedule	Standard	Standard	Standard	DR 11/DR 9
Outside Diameter [in]	10.75	12.75	12.75	12.75
Wall Thickness [in]	0.365	0.375	0.375	1.159/1.417
Contents	Water	Water	Water	Water
Wt. of Contents [lb/ft]	34.1	49.0	49.0	37.0/33.5
Wt. of Pipe [lbs/ft]	40.5	49.6	49.6	18.4/22
⁽¹⁾ This is a manufacturer's designation for a Cr-Mo alloy used for piping as SB-675 and SB-690, for forgings as SB-462, and for castings as SB-366. ⁽²⁾ The cell classification of PE4710 material is 445574C				

6.3 Material Properties

Properties of A-106 carbon steel and A6XLN (Cr-Mo) are given in Tables 6.3a and 6.3b. The values in Table 6.3a were obtained from the 1989 edition of the ASME B&PVC, Section III [Ref. 29]. The values in Table 6.3b were obtained from the 1998 edition of the ASME B&PVC, Section III, Part D [Ref. 11].

Temperature, T [°F]	32	55	65	100
Coeff. of Thermal Exp., α [in/in/°F]	6.5×10^{-6}	6.5×10^{-6}	6.5×10^{-6}	6.5×10^{-6}
Modulus of Elasticity, E [ksi]	27,900	27,900	27,900	27,900
Allowable Stress, S_h [psi]	15000	15000	15000	15000
S_c [psi]	15000	15000	15000	15000
Yield Stress, S_y [psi]	35,000	35,000	35,000	35,000

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Temperature, T [°F]	32	55	65	100
Coeff. of Thermal Exp., α [in/in/°F]	8.2×10^{-6}	8.2×10^{-6}	8.2×10^{-6}	8.2×10^{-6}
Modulus of Elasticity, E [ksi]	28,000	28,000	28,000	28,000
Allowable Stress ⁽¹⁾ , S_c [psi]	24,300	24,300	24,300	24,300
S_h [psi]	24,300	24,300	24,300	24,300
Yield Stress ⁽²⁾ , S_y [psi]	45,000	45,000	45,000	45,000
Notes: ⁽¹⁾ A6XLN is a manufacturer's designation for the following Cr-Mo alloys: SB-675, SB-690, and SB-462. The values shown here correspond to the minimum values listed in the 1998 ASME Code. ⁽²⁾ The yield strength shown here corresponds to that of SB-675, SB-690, and SB-462.				

The mechanical properties of HDPE vary significantly with load duration. Therefore, different values must be used for different load cases. Tables 6.3c thru 6.3f provide the mechanical properties of HDPE for various load durations.

Mechanical properties obtained for 50-year load duration are given in Table 6.3c. These properties are used for deadweight and thermal analysis.

Temperature, T [°F]	32	55	65	100
Coeff. of Thermal Exp., α [in/in/°F]	90×10^{-6}	90×10^{-6}	90×10^{-6}	90×10^{-6}
Modulus of Elasticity ⁽¹⁾ , E [ksi]	28	28	28	23
Allowable Stress, S [psi]	800	800	800	620
Poisson's Ratio, ν [-]	0.45	0.45	0.45	0.45
(1) Per Table 3210-3 of Ref. [12]				

Mechanical properties obtained for short-term load duration are shown in Table 6.3d. These are used for OBE, SSE, and equivalent thermal strain analysis.

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Temperature, T [°F]	32	55	65	100
Coeff. of Thermal Exp., α [in/in/°F]	90×10^{-6}	90×10^{-6}	90×10^{-6}	90×10^{-6}
Modulus of Elasticity ⁽¹⁾ , E [ksi]	110	110	110	100
Allowable Stress ⁽²⁾ , S [psi]	1200	1200	1200	940
Poisson's Ratio, ν [-]	0.35	0.35	0.35	0.35
(1) Per Table 3210-3 of Ref. [12]				
(2) Per Table 3223-3 of Ref. [12]				

Temperature, T [°F]	32	55	65	100
Coeff. of Thermal Exp., α [in/in/°F]	90×10^{-6}	90×10^{-6}	90×10^{-6}	90×10^{-6}
Modulus of Elasticity ⁽¹⁾ , E [ksi]	44	44	44	36
Allowable Stress ⁽²⁾ , S [psi]	840	840	840	620
Poisson's Ratio, ν [-]	0.45	0.45	0.45	0.45
(1) Per Table 3210-3 of Ref. [12]				
(2) The allowables for 10-year duration listed in Table 3131-1 of Ref. [12] are used. This is conservative.				

Temperature, T [°F]	32	55	65	100
Coeff. of Thermal Exp., α [in/in/°F]	90×10^{-6}	90×10^{-6}	90×10^{-6}	90×10^{-6}
Modulus of Elasticity ⁽¹⁾ , E [ksi]	32	32	32	26
Allowable Stress ⁽²⁾ , S [psi]	840	840	840	620
Poisson's Ratio, ν [-]	0.45	0.45	0.45	0.45
(1) Per Table 3210-3 of Ref. [12]				
(2) Per Table 3131-1 of Ref. [12]				

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6.4 HDPE to Steel Boundary

The HDPE pipe is connected to the steel pipe by means of a flanged connection. The following piping components are used for the joints at the entrance to the DG building wall and at the 42-in header:

- A 10-in by 12-in steel reducer
- 10-in, 150-lb ANSI B16.5 raised face welding neck steel flanges
- 12-in, 150-lb ANSI B16.5 raised face welding neck steel flanges
- A 12-in, short-radius, 90° steel elbow
- Two HDPE flange adapters
- Two special steel backup rings that possess the same bolt pattern as 12-in, 150-lb steel flanges and are used in conjunction with the HDPE adapters

Relevant properties for the above piping components were obtained from manufacturers' catalogs – Ref. [9] for the steel components and Ref. [8] for the HDPE components and steel backup rings. The properties are listed in Table 6.6.

Piping Component	Nominal Size [in]	Thickness [in]	Length [in]	O. D. [in]	Weight [lb]
150-lb, Welding Neck Steel Flange	10	0.365	4	12 ⁽¹⁾	54
	12	0.375	4.5	14.375 ⁽¹⁾	88
Steel Reducer	10x12	NA ⁽²⁾	8	NA ⁽²⁾	34
90° Steel Elbow	12	0.375	12 ⁽³⁾	12.75	80
HDPE Flange Adapter	12	1.55	12	12.75	24
Steel Backup Ring	12	1.25	1.25	19	24
⁽¹⁾ These values represent the diameter of the flange hub at base.					
⁽²⁾ OD and thickness for a reducer are variable and are not required as input.					
⁽³⁾ This is the center to face length; it is also equal to the radius of the elbow.					

6.5 HDPE Elbows

The piping system includes 45° HDPE mitered elbows. The mitered elbows are size DR 9 (one DR ratio lower than the HDPE pipe that is DR 11) to comply with the requirements of the ASME BPVC Code Case N-755 Paragraph -3132(d) Ref. [12]. These elbows are modeled according to the manufacturer's catalog specifications Ref. [8]. The 45° mitered elbow has 3 segments as shown in Fig. 6.5. This piping analysis has only 45° mitered elbows in the model

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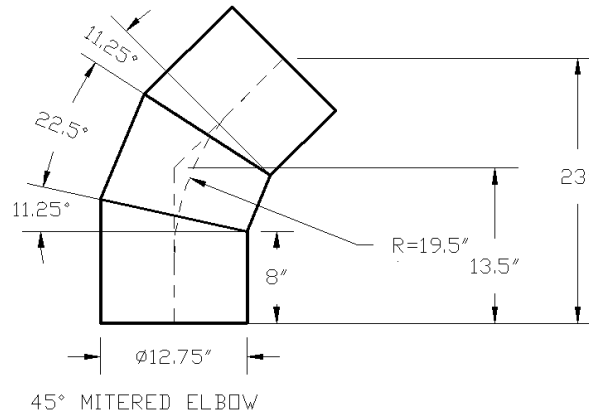


Fig. 6.5: Geometry of 45° HDPE mitered elbow

6.6 Stress Indices and SIFs

ADLPIPE automatically calculates stress indices and stress intensification factors (SIF) for the steel piping components based on the 1989 Code Ref. [29]. The 10-in and 12-in carbon steel piping has butt welded fittings. The analysis is based on the 1989 Class 3 ASME Code.

6.6.1 HPDE Pipe

The buried HDPE piping is a DR 11 butt welded, straight pipe. The following stress index and SIF values, as listed in Tables 3223-1 and 3311.2-1 of Ref. [12], are used:

Stress Indices: $B_1 = 0.5$

$B_2 = 1.0$

Stress Intensification Factor: $i = 1.0$

6.6.2 HPDE Mitered Elbows

The 45° mitered elbows are DR 9. SIF and stress index values for these components, as obtained from Tables 3223-1 and 3311.2-1 of Ref. [12], are as follows:

Stress Indices: $B_1 = 0.69$

$B_2 = 1.64$

Stress Intensification Factor: $i = 2.0$

These SIF's are for 5 segment 90° mitered elbows. Pre Ref. [25], Section 6.1, it is assumed these Stress Indices and SIF's envelope the 3 segment 45° mitered elbows.

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6.6.3 Flexibility Factors for Mitered Elbows

The flexibility factor calculated by ADLPIPE for the 12"Ø mitered elbows is $1.79 \approx 1.82$ which is the calculated flexibility factor per Table NB-3673.2 (b)(1), Section 5.6.2.3 of Ref. [22]. The preliminary mean flexibility factor from testing Ref. [22] of the 12"Ø elbows is 2.15 for in-plane and 2.44 for out-of-plane Ref. [22]. The lower flexibility factor calculated by ADLPIPE will result in higher moments on the piping system due to less flexibility. The calculated Stress Intensification Factor (SIF) calculated from Table NB-3673.2(b)(1) for 12" Ø elbows is 1.04 in-plane and 0.87 out-of-plane. This piping analysis uses a 2.0 SIF for in-plane and out-of-plane for the mitered elbows which is from the ASME BPVC Code Case N-755 Ref. [12].

6.6.4 Weldolet

A Weldolet is used for attaching the 12-in pipe to the 42-in header. The stress intensification factor for the Weldolet is determined from the following equation given in Ref. [17]:

$$i = \frac{0.9}{(3.3t/r)^{2/3}}$$

where: i = stress intensification factor

t = nominal wall thickness of run pipe [in]

r = mean radius of run pipe [in]

For the 42-in diameter pipe, T = 0.500 in. [Ref. 10], and the mean radius, $r = (42 - 0.500)/2 = 20.75$ in. The stress intensification factor is therefore:

$$i = \frac{0.9}{(3.3 * 0.5 / 20.75)^{2/3}} = 4.87$$

6.7 Soil Springs

The buried piping is subject to loads from earthquake, temperature and surrounding soil. To determine the pipe stresses resulting from these loads, the soil spring stiffness is required as input. Soil spring stiffness values obtained from Ref. [15] and shown below will be used as input in the ADLPIPE analysis of the piping system. Soil springs are generally applied at 2 ft intervals around elbows (over 6ft sections on each side of elbows) and at 10 ft intervals elsewhere.

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H = 5.0 ft	Lateral	130	3120	15600
	Vertical	540	12960	64800
	Axial	425	10200	51000

Note that soil spring stiffness values for pipe sections of length other than shown in Table 6.7 can be determined by proportion.

6.8 Seismic Analysis Input

6.8.1 Seismic Anchor Motion

Per Calculation CNC-1206.02-84-0001 [Ref. 16] provided by CNS, the seismic displacement of the DG building is less than 0.003 inches for OBE or SSE analysis. The 42"ø Supply Line is attached at the Auxiliary Building and has the following seismic displacements Lateral = 0.014328" < 1/16 in, Axial = 0.01374" < 1/16 in, and Vertical = 0.0" for OBE or SSE analysis. These displacements are considered insignificant for this analysis and a seismic anchor motion analysis is therefore not conducted.

6.8.2 Seismic Wave Passage

Since the piping system is completely buried and isolated from aboveground piping, the methodology of Non-Mandatory Appendix D of the ASME BPVC Code Case N-755 will be used to qualify the piping for seismic wave passage. In Ref. [18], the strains due to seismic wave passage were computed and then converted to an equivalent thermal strain resulting in a temperature change (ΔT) of 10 °F. This change in temperature will be used as input in the ADLPIPE computer model of the piping system to determine the seismic loads.

6.8.3 Decoupling of 12" Steel Pipe

If the ratio of the moment of inertia of the run pipe to branch pipe (decoupled pipe) is equal to or greater than 25, the branch piping may be considered to have no significant effect on the response of the run pipe. Ref. [28]. $I_{12" \text{ branch pipe}} = 300 \text{ in}^4$; $I_{42" \text{ run pipe}} = 14037 \text{ in}^4$; Ratio of run to branch is 46. The analysis of the decoupled piping shall consider the thermal, seismic, and other movements of the run pipe at the intersection point. There are no thermal or seismic anchor movements (See section 6.8.1) on the run pipe. The steel buried pipe will not have seismic response from the seismic wave passage. Therefore, there are no anchor movements at the 12" pipe (branch) to the 42" pipe (run) connection.

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6.9 Piping Layout

The layout of the piping system is shown in the following drawings provided by Duke Power Carolinas: CN-1038-06 [Ref. 5], CN-1038-11 [Ref. 6] and CN-1038-12 [Ref. 7]. Dimensions and orientations of piping shown on these drawings were used in generating the ADLPIPE computer model for the piping system. A sketch of the piping layout is shown in Fig. 6.9.

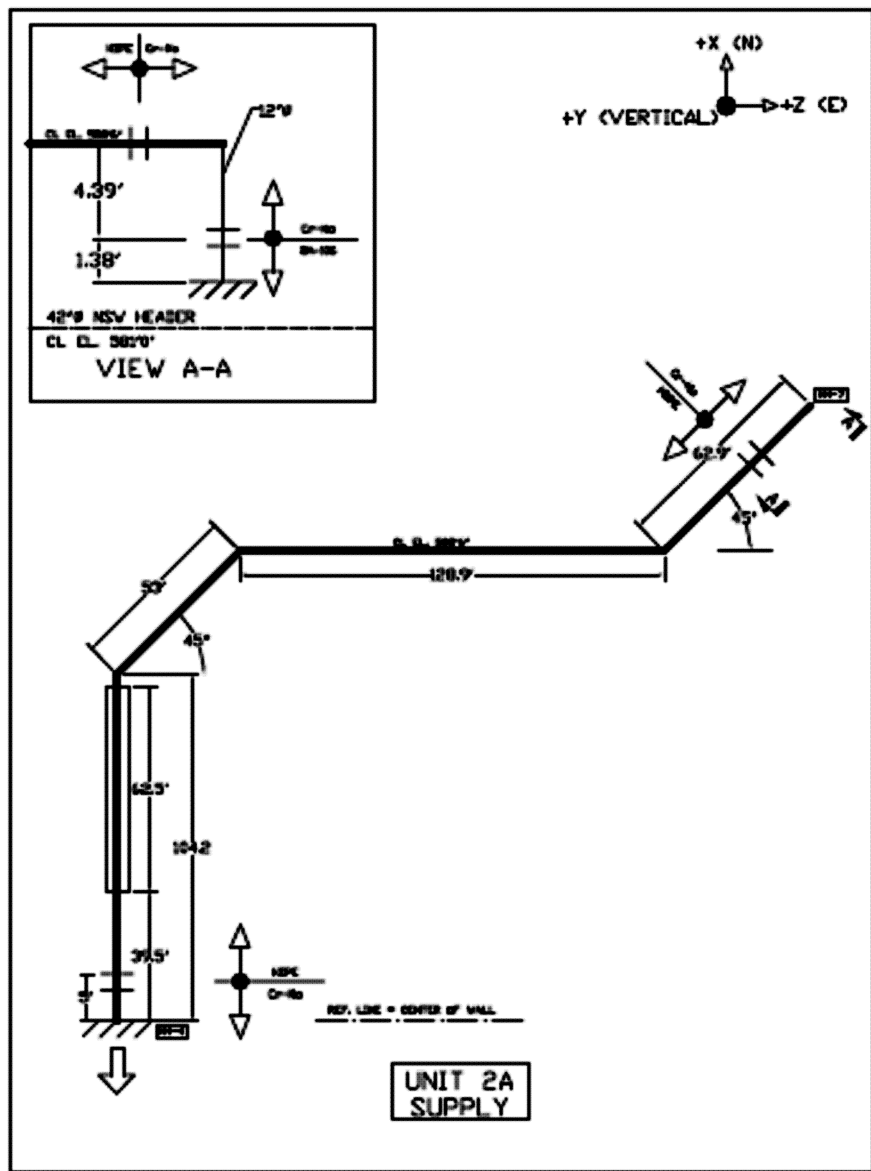


Figure 6.9

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6.10 Pipe Criteria – Steel and HDPE

The pipe load combinations considered and shown in Table 6.10(a) – Steel

Table 6.10(a) Buried Steel Piping Load Combinations		
Service Level	Stress Condition	Load Combination
Design	Primary	P
	Primary	P + DW
A	Primary	P_a
	Primary - - Longitudinal Stress	$P_a + DW$
	Secondary	Range of ($T_{a \min}$, $T_{a \max}$)
	Non Repeated Anchor Motion	BS
B	Primary	P_b
	Primary	P_{bs}
	Primary - - Longitudinal Stress	$P_b + DW + VOT$ $P_b + DW + PS$
	Secondary – Thermal and Seismic	(a) Range of ($T_{b \min}$, $T_{b \max}$) (b) $ T_{b \max} + \left[OBE_W^2 + (OBE_S + OBE_D)^2 \right]^{1/2}$ (c) $ T_{b \min} + \left[OBE_W^2 + (OBE_S + OBE_D)^2 \right]^{1/2}$
C	Primary	P_c
D	Primary	P_d
	Secondary - Seismic	$[SSE_W^2 + (SSE_S + SSE_D)^2]^{1/2}$

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The pipe load combinations considered and shown in Table 6.10(b) – HDPE

Table 6.10 - Buried HDPE Piping Load Combinations		
Service Level	Stress Condition	Load Combination
Design		P_D
		$P_D + D$
A	Primary - Side Wall Compression	$P_E + P_L$
	Primary - Buckling due to External Pressure	$P_E + P_L + P_{gw}$
	Primary - Flotation	W_W
	Primary	P_a
	Primary - - Longitudinal Stress	$P_a + D$
	Secondary	Range of $(T_{a \min}, T_{a \max})$
	Non Repeated Anchor Motion	BS
B	Primary - Side Wall Compression	$P_E + P_L$
	Primary - Buckling due to External Pressure	$P_E + P_L + P_{gw}$
	Primary – Flotation	W_W
	Primary - Pressure	P_b
	Primary – Surge Pressure	P_{bs}
	Primary - - Longitudinal Stress	$P_b + D + VOT$ $P_b + D + PS$
	Secondary – Thermal	Range of $(T_{b \min}, T_{b \max})$
	Secondary – Seismic	$[OBE_W^2 + (OBE_S + OBE_D)^2]^{1/2}$
C	Primary - Side Wall Compression	$P_E + P_L$
	Primary - Buckling due to External Pressure	$P_E + P_L + P_{gw}$
	Primary – Flotation	W_W
	Primary - Pressure	P_c
	Primary – Surge Pressure	P_{cs}
	Secondary – Thermal	Range of $(T_{c \min}, T_{c \max})$
D	Primary - Side Wall Compression	$P_E + P_L$
	Primary - Buckling due to External Pressure	$P_E + P_L + P_{gw}$
	Primary – Flotation	W_W
	Primary - Pressure	P_d
	Primary – Surge Pressure	P_{ds}
	Secondary – Thermal	Range of $(T_{d \min}, T_{d \max})$
	Secondary – Seismic	$[SSE_W^2 + (SSE_S + SSE_D)^2]^{1/2}$

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6.11 Acceptance Criteria -- Steel and HDPE

The criteria used to evaluate the adequacy of the buried steel piping system are summarized in Table 6.11(a)

Table 6.11(a) - Buried Steel Piping Capacity Criteria		
Service Level	Stress Condition	Capacity Criteria
Design	Primary	Requirements of ND-3640
	Primary	ND-3652, Equation (8) with a Stress Limit of $1.5 S_h$
A	Primary	Less than $1.0 P$
	Primary - - Longitudinal Stress	ND-3653.1, Equation (9) with a stress limit of Lesser of $1.8 S_h$ or $1.5 S_y$
	Secondary	ND-3653.2(a), Equation (10) with a stress limit of S_A
	Non Repeated Anchor Motion	ND-3653.2(b), Equation (10a) with a stress limit of $3.0 S_c$
B	Primary	Less than $1.1 P$
	Primary - - Longitudinal Stress	ND-3653.1, Equation (9) with a stress limit of Lesser of $1.8 S_h$ or $1.5 S_y$
	Secondary – Thermal and Seismic	ND-3653.2(a), Equation (10) with a stress limit of S_A
C	Primary	Less than $1.8 P$
D	Primary	Less than $2.0 P$
	Secondary - Seismic	ND-3653.2(a), Equation (10) with a stress limit of S_A

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The criteria used to evaluate the adequacy of the buried HDPE piping system are summarized in Table 6.11(b).

Table 6-11(b) - Buried HDPE Capacity Criteria		
Service Level	Stress Condition	Capacity Criteria
Design		Requirements of N755-3131.1
		Requirements of N755-3223.1 with k=1.0
A	Primary – Side Wall Compression	500 psi (N755-3220) ⁽¹⁾
	Primary – Buckling due to External Pressure	Requirements of N755-3221.1
	Primary – Flotation	$W_P + [P_E * (D/12)]$
	Primary	Less than $1.0 * P_D$
	Primary – Longitudinal Stress	Requirements of N755-3223.1 with k=1.0
	Secondary – Thermal	1100 psi (N755-3311.3)
	Non Repeated Anchor Motion	$2 * S$ (N755-3312)
B	Primary – Side Wall Compression	500 psi (N755-3220) ⁽¹⁾
	Primary – Buckling due to External Pressure	Requirements of N755-3221.1
	Primary – Flotation	$W_P + [P_E * (D/12)]$
	Primary – Pressure	Less than $1.1 * P_D$
	Primary – Surge Pressure	$1.5 * P_D$
	Primary – Longitudinal Stress	Requirements of N755-3223.2 or $0.4 * \text{Material tensile strength at yield}$
	Secondary – Thermal	1100 psi (N755-3311.3)
	Secondary – Seismic	1100 psi (N755-3410)
C	Primary – Side Wall Compression	500 psi (N755-3220)
	Primary – Buckling due to External Pressure	Requirements of N755-3221.1
	Primary – Flotation	$W_P + [P_E * (D/12)]$
	Primary – Pressure	Less than $1.33 * P_D$
	Primary – Surge Pressure	$2.0 * P_D$
	Secondary - Thermal	1100 psi (N755-3311.3)
D	Primary – Side Wall Compression	500 psi (N755-3220) ⁽¹⁾
	Primary – Buckling due to External Pressure	Requirements of N755-3221.1
	Primary – Flotation	$W_P + [P_E * (D/12)]$
	Primary – Pressure	Less than $1.33 * P_D$
	Primary – Surge Pressure	$2.0 * P_D$
	Secondary – Thermal	1100 psi (N755-3311.3)
	Secondary -- Seismic	1100 psi (N755-3410)

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7.0 ANALYSIS

The analysis of the piping system is done per the Piping Design Specification Ref. [26] using analysis methods consistent with the relief request Ref. [14], and the ASME BPVC Code Case N-755 Ref. [12] as outlined in Section 5.2 of this calculation. The calculations presented in Section 5.2.1 are dependent only on design conditions and pipe size. For the calculations described in Section 5.2.2, the loads acting on the piping system (due to pressure, deadweight, thermal, seismic, etc.) for the various service levels are required. These loads are determined using the ADLPIPE computer program

7.1 Computer Model

The run starts at the DG building wall of Unit 2 (Node Pt. = 100) and ends at the centerline of the 42-in Supply Header ‘A’ (Node Pt. = 990). The piping system is considered anchored at each end.

A steel flange is welded to the 10-in pipe coming out of the DG building wall. A 10x12 steel reducer, with flanges on both ends, is attached to the 10-in pipe coming out of the DG building wall. A flanged joint is created (Node Pt. 130) between the steel reducer and the HDPE pipe by fusing an HDPE flange adapter, with a steel backup ring mounted on it, to the end of the HDPE pipe. The steel backup ring and the flange on the reducer have the same bolt pattern.

A 12-in pipe with a flange on one end is welded to the 42-in header. An additional 12-in steel pipe with flanges welded to its ends extends to Node Pt. 880. A flanged joint between the steel pipe and the HDPE pipe is created (Node Pt. 880) by fusing an HDPE flange adapter, with a steel backup ring mounted on it, to the end of the HDPE pipe. The steel backup ring and the flange on the 12-in pipe piece have the same bolt pattern.

Various mitered elbows are used as the HDPE pipe is routed from Node Pt. 130 at EL. 588'-6" to Node Pt. 880 at EL. 588'-6". Details of the piping dimensions and routing are found in Refs. [5], [6], and [7].

The isometric sketch of the piping system is attached in Appendix A. The ADLPIPE computer model was created for this piping system using the inputs listed in Section 6 of this calculation. Soil springs were generally applied at 2 ft intervals around elbows and at 10 ft intervals in the remaining section of the piping. A complete listing of the ADLPIPE model (input file) and analysis results (output file) are attached in Appendix B.

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7.2 Results of ADLPIPE Analysis

7.2.1 Load Cases Analyzed

Steel and HDPE pipe load cases as well as load combinations analyzed using the ADLPIPE piping analysis program are shown in Tables 7.2.1a and 7.2.1b. Thermal cases are required for Level A, B, C, and D because of the time dependence of the Elastic Modulus for HDPE pipe. The following durations were assumed for each service level:

Service Level A: 50 Years Ref. [14] $E_c = 28,000$ psi $E_h = 23,000$ psi

Service Level B: 10 Years Ref. [14] $E_c = 32,000$ psi $E_h = 26,000$ psi

Service Level C: 1000 Hrs Ref. [14] $E_c = 44,000$ psi $E_h = 36,000$ psi

Service Level D: 1000 Hrs Ref. [14] $E_c = 44,000$ psi $E_h = 36,000$ psi

Load Type	Load Case
Deadweight + Pressure	10
Level A Thermal at Minimum Temperature, $T_{min} = 32^\circ \text{ F } (\Delta T = -23^\circ \text{ F})$	21
Level A Thermal at Maximum Temperature, $T_{max} = 100^\circ \text{ F } (\Delta T = 45^\circ \text{ F})$	22
Level B Thermal at Minimum Temperature, $T_{min} = 32^\circ \text{ F } (\Delta T = -23^\circ \text{ F})$	23
Level B Thermal at Maximum Temperature, $T_{max} = 100^\circ \text{ F } (\Delta T = 45^\circ \text{ F})$	24
Level C/D Thermal at Minimum Temperature, $T_{min} = 32^\circ \text{ F } (\Delta T = -23^\circ \text{ F})$	25
Level C/D Thermal at Maximum Temperature, $T_{max} = 100^\circ \text{ F } (\Delta T = 45^\circ \text{ F})$	26
Thermal at $T = 65^\circ \text{ F } (\Delta T = 10^\circ \text{ F})^{(1)}$	30

⁽¹⁾ This is a pseudo-seismic case. ΔT is the equivalent temperature rise for computing the seismic loads on the piping system.

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Load Type	Load Case
Level A : Absolute Range of Load Cases 21 and 22	27
Level B : Absolute Range of Load Cases 23 and 24	28
Level C/D : Absolute Range of Load Cases 25 and 26	29
Level D : Absolute Range of Load Case 30 (SSE)	31
Level B : Load Case 31 / 1.875 (OBE) ⁽¹⁾	32
Level B: Absolute Thermal Max (L.C. 24) + OBE Seismic (L.C. 32)	40
Level B: Absolute Thermal Min (L.C. 23) + OBE Seismic (L.C. 32)	41
Level B: Max of Load Case 28, 40 and 41	45

⁽¹⁾ Per page 94 of Ref. [16], OBE = SSE/1.875.

7.2.2 Summary of HDPE Loads at Critical Locations

The loads acting at the critical locations on the HDPE pipe (i.e., where the maximum stresses occur) for Service Levels A, B, C and D are extracted from the results of the ADLPIPE analysis. These loads are summarized in Tables 7.2.2a to 7.2.2d and will be used for computing pipe stresses as described in Section 5 of this calculation.

Service Level A

Load Case	Straight Pipe				Mitered Elbow			
	F [lb]	Node No.	M [ft-lb]	Node No.	F [lb]	Node No.	M [ft-lb]	Node No.
10	0	815	505	815	0	485	28	485

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Load Case	Straight Pipe				Mitered Elbow			
	F [lb]	Node No.	M [ft-lb]	Node No.	F [lb] ⁽¹⁾	Node No.	M [ft-lb]	Node No.
27 (Level A)	5244	880	536	880	2473	650	1164	650
28 (Level B)	5842	880	635	880	2783	650	1343	650
29 (Level C/D)	7668	880	977	880	3754	650	1934	650
⁽¹⁾ Values shown here were obtained from the SRSS of forces acting on the mitered elbow. Using these values for axial force is therefore conservative.								

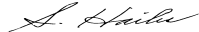
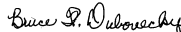
Service Level B

Load Case	Straight Pipe				Mitered Elbow			
	F [lb]	Node No.	M [ft-lb]	Node No.	F [lb] ⁽¹⁾	Node No.	M [ft-lb]	Node No.
32 (OBE)	2803	880	597	880	1526	780	1000	780
⁽¹⁾ Values shown here were obtained from the SRSS of forces acting on the mitered elbow. Using these values for axial force is therefore conservative.								

Service Level D

Load Case	Straight Pipe				Mitered Elbow			
	F [lb]	Node No.	M [ft-lb]	Node No.	F [lb] ⁽¹⁾	Node No.	M [ft-lb]	Node No.
31 (SSE)	5255	880	1119	880	2861	780	1875	780
⁽¹⁾ Values shown here were obtained from the SRSS of forces acting on the mitered elbow. Using these values for axial force is therefore conservative.								

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7.3 Calculations per ASME BPVC Code Case N-755

The HDPE piping system was analyzed per the Design Specification Ref. [26] which is consistent with Relief Request 06-CN-003 Ref. [14], and the ASME BPVC Code Case N-755 Ref. [12], as described in Sections 5.2.1 and 5.2.2, of this calculation. The manual calculations were performed using MathCad. The design conditions and the maximum loads obtained from ADLPIPE analysis (as listed in Tables 7.2.2a to 7.2.2d) were used to qualify the HDPE piping based on the applicable criteria for the design load cases. The manual calculations are provided below.

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Manual Calculations Per ASME BPVC Code Case N-755:

Define Variables:

$$S := 620 \cdot \frac{\text{lb}}{\text{in}^2}$$

Allowable stress at 100° F

$$E_{\text{pipe50y}} := 23000 \cdot \frac{\text{lb}}{\text{in}^2}$$

Elastic modulus at 100° F for 50 yr load duration

$$E_{\text{pipe10h}} := 100000 \cdot \frac{\text{lb}}{\text{in}^2}$$

Elastic modulus at 100° F for short term load duration

$$E' := 2000 \cdot \frac{\text{lb}}{\text{in}^2}$$

Modulus for fine grain sand compacted to > 95%

$$W_p := 18.4 \frac{\text{lb}}{\text{ft}}$$

Weight of empty pipe per foot

$$\gamma_w := 62.4 \frac{\text{lb}}{\text{ft}^3}$$

Specific weight of water

$$P := 100 \frac{\text{lb}}{\text{in}^2}$$

Design pressure, psig

$$\gamma_{\text{soil}} := 105 \cdot \frac{\text{lb}}{\text{ft}^3}$$

Specific weight of dry soil

$$L := 1.5$$

Deflection lag factor

$$K_{\text{bed}} := 0.1$$

Bedding factor

$$D := 12.75 \cdot \text{in}$$

Outside diameter of pipe

$$t = 1.159 \cdot \text{in}$$

Minimum wall thickness for DR-11 pipe, Ref. [12]

$$t = 1.417 \cdot \text{in}$$

Minimum wall thickness for DR-9 pipe, Ref. [12]

$$DR = \frac{D}{t}$$

Dimensional ratio (DR = 11 for straight pipe and DR = 9 for mitered elbows)

$$c := 0.0\text{in}$$

Allowance for mechanical and erosion damage

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Section 3131.1 - Minimum Required Wall Thickness

Calculate the pressure design thickness, t_{min} :

$$t_{min} := \frac{P \cdot D}{(2 \cdot S + P)} \quad t_{min} = 0.95 \text{ in}$$

Determine the minimum required wall thickness, t_{design} :

$$t_{design} := t_{min} + c \quad t_{design} = 0.95 \text{ in}$$

Pipe wall thickness (DR 11), $t = 1.159 \text{ in} > 0.95 \text{ in}$**O.K.**

Pipe wall thickness (DR 9), $t = 1.417 \text{ in} > 0.95 \text{ in}$**O.K.**

Note that DR-11 governs. Therefore, for subsequent calculations, only DR-11 needs to be considered; that is::

$$DR := 11$$

Section 3210 - Ring Deflection

Determine the vertical soil pressure (P_L) due to surcharge loads.

Per Drawing No. CN-1038-06 [Ref. 5], the Transporter Haul Path crosses over the HDPE pipe lines of Unit 2. The Haul Path is at EL. 594'-0" and the pipe centerline is at EL. 588'-6". Hence, the soil depth from surface to top of pipe = 5 ft.

$$H := 5 \text{ ft}$$

As shown on page 21 of 79 of Ref. [13], the maximum vertical soil pressure(P_v) due to the combined weight of the transporter and cask at 5 feet below surface, not including impact, is:

$$P_v := 15.58 \frac{\text{lb}}{\text{in}^2}$$

This soil pressure value was obtained based on a cask weight of 310 kip and transporter weight of 170 kip. Per Sheet 25 of EC/VN No. CD500920D (DOC. ID. 32-5053646-01 Rev. 1) dated 2-20-07, the cask weight is 314.6 kip, which is 1.5% greater than the original value used in computing soil pressure. Therefore, in this calculation, the vertical soil pressure value will be increased by 1.5%; that is:

$$P_v := 1.015 \cdot P_v$$

$$P_v = 15.814 \frac{\text{lb}}{\text{in}^2}$$

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Per Ref. [13], the impact load factor (F) due to the cask dropping from a maximum height of 8.0 inches is:

$$F := 3.033$$

The maximum vertical soil pressure due to surcharge loads, including impact, is computed by applying the impact load factor to the combined weight of the transporter and cask. This is conservative since the impact load factor actually applies to the cask weight only. Therefore:

$$P_L := F \cdot P_v \qquad P_L = 47.96 \frac{\text{lb}}{\text{in}^2}$$

Calculate the vertical soil pressure due to earth loads. Note that there is no water above pipe; hence, dry soil is the only source of pressure.

$$P_E := \gamma_{\text{soil}} \cdot H \qquad P_E = 3.65 \frac{\text{lb}}{\text{in}^2}$$

Compute the ring deflection Ω by letting Soil Support Factor, $F_s = 0$. Note that as shown in Table 3210-2 of Ref. [12], the value of F_s depends on properties of the trench and native soil, and on pipe diameter and trench width. Using zero for F_s (see equation below) will yield a conservative value for Ω .

$$F_s := 0$$

Compute the ring deflection Ω .

$$\Omega_1 := \frac{K_{\text{bed}} \cdot L \cdot P_E}{\frac{2 \cdot E_{\text{pipe50y}}}{3} \cdot \left(\frac{1}{\text{DR} - 1} \right) + 0.061 \cdot F_s \cdot E'} \qquad \Omega_1 = 3.57 \times 10^{-4}$$

$$\Omega_2 := \frac{K_{\text{bed}} \cdot P_L}{\frac{2 \cdot E_{\text{pipe10h}}}{3} \cdot \left(\frac{1}{\text{DR} - 1} \right) + 0.061 \cdot F_s \cdot E'} \qquad \Omega_2 = 7.19 \times 10^{-4}$$

Note that the equation given in Ref. [12] for computing Ω includes a conversion factor of 144. Since MathCad automatically converts units, this conversion factor is not included in the above equation.

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$$\Omega := \Omega_1 + \Omega_2$$

$$\Omega = 1.08 \times 10^{-3}$$

The maximum allowable ring deflection (Ω_{max}) is given in Ref. [12] as percent of the original diameter.
Per Table 3210-1 of Ref. [12], for DR = 11:

$$\Omega_{max} = 5\% = 0.05 > \Omega = 1.08 \times 10^{-3} \text{O.K.}$$

Section 3220 - Compression of Sidewalls

Calculate the circumferential compressive stress (σ_{sw}) in the sidewalls of pipe and miters.

$$\sigma_{sw} := \frac{(P_E + P_L) \cdot DR}{2}$$

$$\sigma_{sw} = 283.8 \frac{\text{lb}}{\text{in}^2}$$

Note that the equation given in Ref. [12] for computing σ_{sw} includes a conversion factor of 144.
Since MathCad automatically converts units, the conversion factor is omitted here.

Compare σ_{sw} to the allowable stress value of 500 psi:

$$\sigma_{sw} = 283.8 \frac{\text{lb}}{\text{in}^2} < 500 \text{ psiO.K.}$$

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Section 3221.1 - Buckling Due to External Pressure

Check that external pressure from ground water (P_{gw}), earth loads (P_E) and surcharge loads (P_L) does not cause the pipe to buckle.

$$P_{hydro} = (P_{gw} + P_E + P_L) \leq 2.8 \cdot \left[R_b \cdot B \cdot E' \cdot \frac{E_{pipe50y}}{12 \cdot (DR - 1)^3} \right]^{0.5}$$

Note that the equation provided in Ref. [12] for computing the external buckling pressure includes a conversion factor of 144. The conversion factor is not needed here since MathCad automatically converts units.

There is no water above the pipe. Hence:

$$H_{gw} := 0 \text{ ft} \qquad P_{gw} := 0 \frac{\text{lb}}{\text{in}^2}$$

$$R_b := 1 - 0.33 \frac{H_{gw}}{H} \qquad R_b = 1$$

Compute the burial factor, B. Note that for computing burial factor, height of soil above pipe (H) needs to be redefined as a quantity H_B with no units.

$$H_B := 5$$

$$B := \frac{1}{1 + 4 \cdot \exp(-0.065 \cdot H_B)} \qquad B = 0.257$$

$$P_{gw} + P_E + P_L = 51.6 \frac{\text{lb}}{\text{in}^2}$$

$$2.8 \cdot \left[R_b \cdot B \cdot E' \cdot \frac{E_{pipe50y}}{12 \cdot (DR - 1)^3} \right]^{0.5} = 87.9 \frac{\text{lb}}{\text{in}^2}$$

($P_{gw} + P_E + P_L$) is less than 87.9 lb/in².....**O.K.**

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Section 3221.2 - Effects of Negative Internal Pressure

$$\Delta P \leq \frac{f_o}{2} \cdot \frac{2 \cdot E_{\text{pipe}} 10h}{(1 - \nu^2)} \cdot \left(\frac{1}{DR - 1} \right)^3$$

$$f_o := 0.64$$

Ovality correction factor per Table 3221.2-1 for 5% ovality

$$\nu := 0.35$$

Use short-term values for elastic modulus and Poisson ratio

$$\frac{f_o}{2} \cdot \frac{2 \cdot E_{\text{pipe}} 10h}{(1 - \nu^2)} \cdot \left(\frac{1}{DR - 1} \right)^3 = 72.9 \frac{\text{lb}}{\text{in}^2}$$

Therefore, ΔP may not exceed 72.9 psi.

Section 3222 - Flotation

For floatation, the minimum height of soil above top of pipe ($H = 5\text{ft}$) should be used to calculate the vertical earth load P_E . The P_E value calculated in the preceding sections is still valid since $H = 5\text{ft}$ was used to calculate that value.

$$W_w < W_p + P_E \cdot D$$

The equation given in Ref.[12] includes a conversion factor of 12. Mathcad automatically converts units; therefore, the conversion factor is not needed here.

$$W_w := \frac{\pi \cdot D^2}{4} \cdot \gamma_w$$

W_w is the unit weight of the water displaced by the pipe

$$W_w = 55.3 \frac{\text{lb}}{\text{ft}}$$

$$W_p + P_E \cdot D = 576.2 \frac{\text{lb}}{\text{ft}}$$

W_w is less than $W_p + P_E \cdot D$ **O.K.**

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Calculation of Stresses Per Code Case N-755 [Ref. 12]

Define Variables:

$$P_a := 100 \cdot \frac{\text{lb}}{\text{in}^2}$$

Design or Service Level A, B, C, or D pressure

$$D := 12.75 \cdot \text{in}$$

Outside diameter of pipe and mitered elbow

Properties of Straight Pipe

Straight pipe is DR-11

$$D_i := 10.432 \cdot \text{in}$$

Inside Diameter of straight pipe, per Ref. [12]

$$t := 1.159 \cdot \text{in}$$

Wall thickness of straight pipe, per Ref. [12]

$$A := \frac{\pi}{4} \cdot (D^2 - D_i^2)$$

$$A = 42.2 \text{ in}^2$$

Cross sectional area of straight pipe

$$Z := \left(\frac{\pi}{32} \right) \cdot \frac{D^4 - D_i^4}{D}$$

$$Z = 112.3 \text{ in}^3$$

Section modulus of straight pipe

$$i := 1.0$$

Stress Intensification Factor of straight pipe
(per Table 3311.2-1)

$$B_1 := 0.5$$

$$B_2 := 1.0$$

Stress Indices of straight pipe
(per Table 3223-1)

Properties of Mitered Elbow

Elbow is DR-9

$$D_{ie} := 9.916 \cdot \text{in}$$

Inside Diameter of elbow, per Ref. [12]

$$t_e := 1.417 \cdot \text{in}$$

Wall thickness of elbow, per Ref. [12]

$$A_e := \frac{\pi}{4} \cdot (D^2 - D_{ie}^2)$$

$$A_e = 50.5 \text{ in}^2$$

Cross sectional area of elbow

$$Z_e := \left(\frac{\pi}{32} \right) \cdot \frac{D^4 - D_{ie}^4}{D}$$

$$Z_e = 129.0 \text{ in}^3$$

Section modulus of elbow

$$i_e := 2.0$$

Stress Intensification Factor of elbow
(per Table 3311.2-1)

$$B_{1e} := 0.69$$

$$B_{2e} := 1.64$$

Stress Indices of elbow
(per Table 3223-1)

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The Design/Operating Temperature is 100 degrees F. The design pressure for the inlet line is 100 psig. The Level A, B, C, and D operating pressure for the inlet line is 75 psig. The maximum deadweight and pressure loads (Load Case 10) are obtained from the ADLPIPE analysis and listed in Section 7.3 of this calculation. Qualification of the HDPE pipe is based on Design Level factors and Allowable stress using the Design temperature and pressure. Design pressure envelopes Service Levels A, B, C, and D pressures.

3223.1 - Longitudinal Stress Design

$$S := 620 \cdot \frac{\text{lb}}{\text{in}^2}$$

Allowable stress at 100 degrees F
(per Table 3131-1)

$$k := 1.0$$

Longitudinal Stress Factor for Design
(per Table 3223-2)

$$k \cdot S = 620 \frac{\text{lb}}{\text{in}^2}$$

Straight Piping Section:

Straight pipe is DR-11

$$B_1 \cdot \frac{P_a \cdot D}{2 \cdot t} + 2 \cdot B_1 \cdot \frac{F_a}{A} + B_2 \cdot \frac{M}{Z} \leq k \cdot S$$

$$F_a := 0 \cdot \text{lb}$$

Axial force due to deadweight on the
straight pipe

$$M := 505 \cdot \text{lb} \cdot \text{ft}$$

Resultant bending moment due to
deadweight on the straight pipe

$$B_1 \cdot \frac{P_a \cdot D}{2 \cdot t} + 2 \cdot B_1 \cdot \frac{F_a}{A} + B_2 \cdot \frac{M}{Z} = 329.0 \frac{\text{lb}}{\text{in}^2} \quad \text{which is less than } 620 \frac{\text{lb}}{\text{in}^2} \dots\dots\dots \mathbf{OK}$$

Mitered Elbow:

Elbow is DR-9

$$B_{1e} \cdot \frac{P_a \cdot D}{2 \cdot t_e} + 2 \cdot B_{1e} \cdot \frac{F_{ae}}{A_e} + B_{2e} \cdot \frac{M_e}{Z_e} \leq k \cdot S$$

$$F_{ae} := 0 \cdot \text{lb}$$

Axial force due to deadweight on the
mitered elbow

$$M_e := 28 \cdot \text{lb} \cdot \text{ft}$$

Resultant bending moment due to
deadweight on the mitered elbow

$$B_{1e} \cdot \frac{P_a \cdot D}{2 \cdot t_e} + 2 \cdot B_{1e} \cdot \frac{F_{ae}}{A_e} + B_{2e} \cdot \frac{M_e}{Z_e} = 314.7 \frac{\text{lb}}{\text{in}^2} \quad \text{which is less than } 620 \frac{\text{lb}}{\text{in}^2} \dots\dots\dots \mathbf{OK}$$

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3311 - Design for Thermal Expansion and Contraction

Soil springs were applied to account for the soil stiffness. Therefore, the alternative method of 3311.3 is used: The maximum thermal range force and moment are used to check the stresses in the HDPE pipe. The thermal range of Service Level C/D envelopes Service Level A and B.

Straight Piping Section:

Straight pipe is DR-11

$$i \cdot \frac{M_c}{Z} + \frac{F_{ac}}{A} \leq 1100 \cdot \frac{\text{lb}}{\text{in}^2}$$

$$F_{ac} := 7668 \cdot \text{lb}$$

Axial force range due to thermal expansion and/or contraction on the straight pipe (Level C/D)

$$M_c := 977 \cdot \text{ft} \cdot \text{lb}$$

Resultant moment range due to thermal expansion and/or contraction on the straight pipe (Level C/D)

$$i \cdot \frac{M_c}{Z} + \frac{F_{ac}}{A} = 286.1 \frac{\text{lb}}{\text{in}^2} \quad \text{which is less than } 1100 \frac{\text{lb}}{\text{in}^2} \dots\dots\dots \mathbf{OK}$$

Mitered Elbow:

Elbow is DR-9

$$i_e \cdot \frac{M_{ce}}{Z_e} + \frac{F_{ace}}{A_e} \leq 1100 \cdot \frac{\text{lb}}{\text{in}^2}$$

$$F_{ace} := 3754 \cdot \text{lb}$$

Axial force range due to thermal expansion and/or contraction on the mitered elbow (Level C/D)

$$M_{ce} := 1934 \cdot \text{ft} \cdot \text{lb}$$

Resultant moment range due to thermal expansion and/or contraction on the mitered elbow (Level C/D)

$$i_e \cdot \frac{M_{ce}}{Z_e} + \frac{F_{ace}}{A_e} = 434.1 \frac{\text{lb}}{\text{in}^2} \quad \text{which is less than } 1100 \frac{\text{lb}}{\text{in}^2} \dots\dots\dots \mathbf{OK}$$

3312 - Nonrepeated Anchor Movements

There are no nonrepeated (thermal) anchor movements .

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3410 - Seismic Induced Stresses

This is applicable for both SSE and OBE loads. These stresses are based on evaluation of the SSE (Level D) conditions which also qualifies the piping for OBE (Level B) conditions as OBE loads are lower and OBE and SSE limits are the same

Straight Piping Section:

Straight pipe is DR-11

$$i \cdot \frac{M_E}{Z} + \frac{F_{aE}}{A} \leq 1100 \cdot \frac{\text{lb}}{\text{in}^2}$$

$$F_{aE} := 5255 \cdot \text{lb}$$

Axial force range due to seismic loads on the straight pipe

$$M_E := 1119 \cdot \text{ft} \cdot \text{lb}$$

Resultant moment range due to seismic loads on the straight pipe

$$i \cdot \frac{M_E}{Z} + \frac{F_{aE}}{A} = 244.1 \frac{\text{lb}}{\text{in}^2} \quad \text{which is less than} \quad 1100 \frac{\text{lb}}{\text{in}^2} \dots\dots\dots \mathbf{OK}$$

Mitered Elbow:

Mitered elbow is DR-9

$$i_e \cdot \frac{M_{Ee}}{Z_e} + \frac{F_{aEe}}{A_e} \leq 1100 \cdot \frac{\text{lb}}{\text{in}^2}$$

$$F_{aEe} := 2861 \cdot \text{lb}$$

Axial force range due to seismic loads on the mitered elbow

$$M_{Ee} := 1875 \cdot \text{ft} \cdot \text{lb}$$

Resultant moment range due to seismic loads on the mitered elbow

$$i_e \cdot \frac{M_{Ee}}{Z_e} + \frac{F_{aEe}}{A_e} = 405.4 \frac{\text{lb}}{\text{in}^2} \quad \text{which is less than} \quad 1100 \frac{\text{lb}}{\text{in}^2} \dots\dots\dots \mathbf{OK}$$

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7.4 Stress Summary for Unit 2 Steel Pipe

Acceptance Criteria	Calculated Stress [psi]	Allowable Stress [psi]	<u>Calculated</u> <u>Allowable</u>	Node Point
Equation 8 (Design)	2104	22500	0.09	985
Equation 9 (Level A)	1579	27000	0.06	985
Equation 9 (Level B)	1579	27000	0.06	985
Equation 10 (Level A)	8025	22500	0.36	985
Equation 10 (Level B)	9170	22500	0.41	985
Equation 10 (Level C/D)	7809	22500	0.35	985

7.5 Flange Summary for Unit 2 HDPE Pipe

The EPRI flange capacity tests Ref. [22] demonstrated that if the pipe stresses at the fusion joint joining the HDPE flange adapter to the piping were less than the maximum code capacities, the flanges were adequate. For this system, all pipe stresses at the fusion joint, joining the HDPE flange adapter to the piping are less than the maximum permitted code capacities.

7.5 Evaluation of Buoyancy over Condenser Cooling Water Lines

This piping system goes over the 10-ft diameter Condenser Cooling Water (CCW) lines in the region with plant coordinates 49+50X to 50+00X and 54+00Y to 55+00Y. The HDPE cooling water pipe line is at EL. 588'-6" and the CCW lines are at EL. 579'-2". In the event a CCW line breaks and completely floods the region, the buoyancy force acting on the HDPE cooling water line needs to be checked if it would result in pipe floatation.

The HDPE pipe in this location rests on a composite bed made up of a 16-in HDPE pipe and an 18-in steel pipe as shown in Fig. 7.5 below. The 18-in pipe is attached to concrete piers at its ends.

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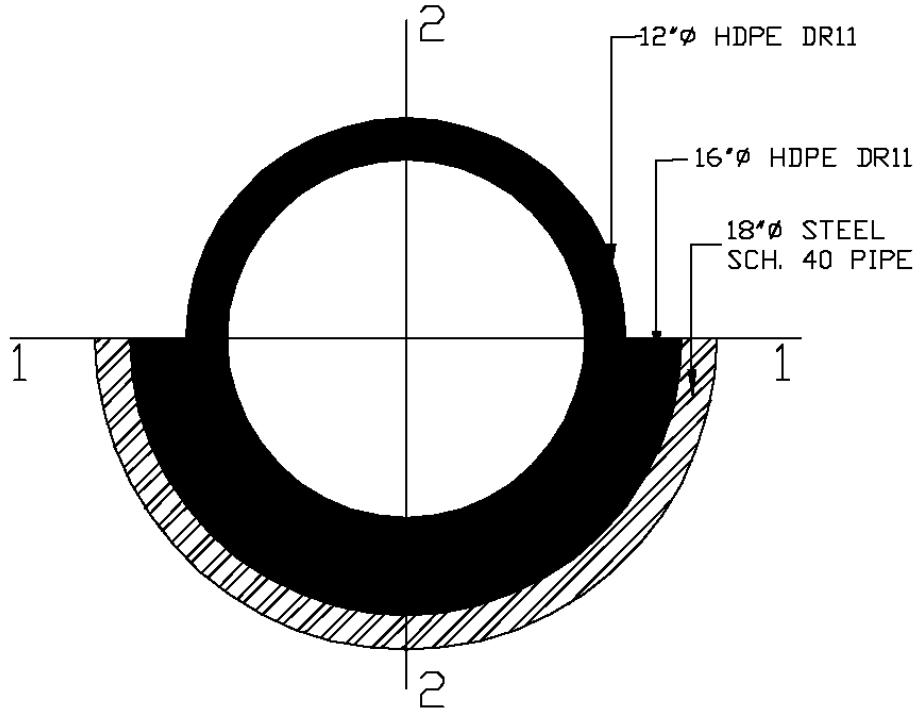


Fig. 7.5: Support provided for HPDE pipe system in the region where it lies over the CCW lines

The buoyancy force (F_b) per unit length acting on the pipe is:

$$F_b = \gamma_{\text{water}} A_b$$

where:

γ_{water} = specific weight of water [lb/ft³]; $\gamma_{\text{water}} = 62.4 \text{ lb/ft}^3$

A_b = cross-sectional area of related to the displaced volume [ft²]

The area A_b can be conservatively estimated from:

$$A_b = \frac{\pi}{4} \left(\frac{D_{18}^2 + D_{12}^2}{2} \right)$$

where:

D_{18} and D_{12} are the ODs for 18-in steel pipe and 12-in HDPE pipe, respectively.

Noting that $D_{18} = 18/12 = 1.5 \text{ ft}$ and $D_{12} = 12.75/12 = 1.0625 \text{ ft}$, and substituting yields:

$$F_b = 62.4 * \frac{\pi}{4} \left(\frac{1.5^2 + 1.0625^2}{2} \right) = 82.8 \text{ lb/ft}$$

The forces resisting buoyancy force are:

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- weight of 18-in steel pipe = 104.7 lb/ft; use only ½ of this weight → 52.3 lb/ft
- weight of 16-in HDPE pipe = 29.0 lb/ft; use only ½ of this weight → 14.5 lb/ft
- weight of 12-in HDPE pipe = 18.4 lb/ft
- weight of soil above pipe = $\gamma_{\text{soil}} * H * D_{12} = 105 \text{ lb/ft}^3 * 5 \text{ ft} * 1.0625 \text{ ft} = 557.8 \text{ lb/ft}$

Note that in computing the soil weight above pipe, for conservatism, D_{12} was used instead of D_{18} and the height of soil above pipe (H) was taken as 5 ft.

Force resisting buoyancy = $52.3 + 14.5 + 18.4 + 557.8 = 643.0 \text{ lb/ft} > F_b = 82.8 \text{ lb/ft}$

The 18-in pipe is attached to concrete piers on both ends. The concrete piers are $3' \times 2' \times 14' - 10'' = 89 \text{ ft}^3$. Concrete weighs about 144 lb/ft^3 . Hence, the weight of the concrete piers is $89 \text{ ft}^3 \times 144 \text{ lb/ft}^3 = 12.8 \text{ kips}$. This is an additional force that is resisting the buoyancy force.

It is concluded that in the event the CCW lines break and flood the region, the HDPE piping will be OK against floatation.

7.7 Evaluation of Steel Bridge Pipe over Condenser Cooling Water Lines

This evaluation is for the steel pipe bridge over the 10'-0" $\varnothing$ Condenser Cooling Water lines should they rupture and erode the soil supporting the 12" $\varnothing$ Nuclear Service Water (NSW) lines to the Diesel Generator Building. This is a faulted condition on the piping system.

Three concrete piers split the 58 span into two 29 foot spans simply supported. The bridge is composed of ½ of a 18" $\varnothing$ sch. 40 carbon steel pipe ($104.7 \text{ lb/ft} / 2 = 52.4 \text{ lb/ft}$) as shown in Figure 7.5. The bridge is essentially as pipe support that supports the half section of a 16" $\varnothing$ DR11 HDPE pipe ($29 \text{ lb/ft} / 2 = 14.5 \text{ lb/ft}$) that acts as protection for the pressure retaining 12" $\varnothing$ DR 11 HDPE pipe with water (54.4 lb/ft)

The weight per foot supported by the bridge is:

$$\begin{aligned}
 \frac{1}{2} \text{ of a } 18" \varnothing \text{ sch } 40 \text{ steel pipe} &= 104.7 \text{ lb/ft} / 2 = 52.35 \text{ lb/ft} \\
 \frac{1}{2} \text{ of a } 16" \varnothing \text{ DR11 HDPE pipe} &= 29 \text{ lb/ft} / 2 = 14.5 \text{ lb/ft} \\
 12" \varnothing \text{ DR11 HDPE pipe w/water} &= 54.4 \text{ lb/ft}
 \end{aligned}$$

$$\text{Total wt.} = 121.25 \text{ lb/ft}$$

Check the half section of 18" steel pipe acting as a bridge for deadweight bending stress over a 29 foot span. Conservatively assume simply supported connections for the bridge.

$$M_{\text{bending}} = \frac{wl^2}{8}$$

$$w = 121.25 \text{ lb/ft} / 12 = 10.104 \text{ lb/in}$$

$$l = 29 \text{ ft} \times 12 \text{ in/ft} = 348 \text{ in}$$

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$$M_{\text{bending}} = \frac{10.104 * 348^2}{8}$$

$$M_{\text{bending}} = 152,954 \text{ lb/in}$$

$$\sigma_{\text{bending}} = \frac{M}{Z}$$

Calculate the Section Properties of the Half 18” Section:

18 in. Sch. 40 pipe $t_m = 0.562$ in

From, [Ref. 21], “Roark’s Formulas for Stress and Strain”, 6th Edition Page 69, Section 22

Dia. = 18 inches
 $t_m = 0.562$ inches

$R = 9$ inches
 $R_i = 8.438$ inches

See Section in Figure 7-5.

$$A = \frac{\pi}{2} * (R^2 - R_i^2)$$

$$A = \frac{\pi}{2} * (9^2 - 8.438^2)$$

$$A = 15.394 \text{ in}^2$$

$$I_{2-2} = \frac{\pi}{8} (R^4 - R_i^4)$$

$$I_{2-2} = \frac{\pi}{8} (6561 - 5069.418) \quad \text{where the 2-2 axis is the vertical axis about the centroid of the section.}$$

$$I_{2-2} = \frac{\pi}{8} (1491.582)$$

$$I_{2-2} = 585.743 \text{ in}^4$$

$$Z_{2-2} = 585.743 \text{ in}^4 / 9'' = 65.08 \text{ in}^3$$

Calculate the centroid for computing the section modulus in the 1-1 direction

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$$y_{lb} = \frac{4}{3\pi} \left[\frac{R^3 - Ri^3}{R^2 - Ri^2} \right]$$

$$y_{lb} = \frac{4}{3\pi} * \left[\frac{9^3 - 8.438^3}{9^2 - 8.438^2} \right]$$

$$y_{lb} = \frac{4}{3\pi} * \left[\frac{128.216}{9.80} \right]$$

$$y_{lb} = 5.553 \text{ in}$$

Calculate I_{1-1} about the centroid about the horizontal axis:

$$I_{1-1} = \frac{\pi}{8} (R^4 - Ri^4) - \frac{8}{9\pi} \left[\frac{(R^3 - Ri^3)^2}{R^2 - Ri^2} \right]$$

$$I_{1-1} = \frac{\pi}{8} (9^4 - 8.438^4) - \frac{8}{9\pi} \left[\frac{(9^3 - 8.438^3)^2}{9^2 - 8.438^2} \right]$$

$$I_{1-1} = \frac{\pi}{8} (1,491.582) - \frac{8}{9\pi} \left[\frac{16,439.270}{9.80} \right]$$

$$I_{1-1} = \frac{\pi}{8} (1,491.582) - \frac{8}{9\pi} [1,677.450]$$

$$I_{1-1} = 585.743 - 474.621$$

$$I_{1-1} = 111.122 \text{ in}^4$$

$$z_{1-1} = \frac{I_{x1-x1}}{y_{16}} = \frac{111.122}{5.553} = 20.01 \text{ in}^3$$

Deadweight Stress in the Pipe Bridge:

$$\sigma_{\text{bending}} = \frac{152,954}{20.01}$$

$$\sigma_{\text{bending}} = 7,644 \text{ psi} < 0.60 * F_y = 0.60 * 36 \text{ ksi} = 21.6 \text{ ksi OK}$$

Where: $0.60 * F_y$ is the normal AISC Allowable Stress for a Steel Pipe Support

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Earthquake Stress in the Pipe Bridge

The peak seismic acceleration near the DG building is 0.324g vertical and 0.486g horizontal Ref. [19] & Ref. [20].

$$\delta_{\text{seis-horizontal}} = 0.486g * 152,954 \text{ lb-in} / 65.083 \text{ in}^3 = 1,142 \text{ psi}$$

$$\delta_{\text{seis-vertical}} = 0.324g * 152,954 \text{ lb-in} / 20.01 \text{ in}^3 = 2,477 \text{ psi}$$

$$\delta_{\text{seis-total}} = [(1,142)^2 + (2,477)^2]^{1/2} = 2,728 \text{ psi}$$

$$\sigma_{\text{faulted}} = \text{Deadweight} + \text{Seismic}_{\text{faulted}} < 0.90 * F_y$$

$$\sigma_{\text{faulted}} = 7,644 + 2,728 = 10,372 \text{ psi} < 0.90 * 36 \text{ ksi} = 32.4 \text{ ksi OK}$$

Where: $0.90 * F_y$ is an appropriate Faulted Allowable Stress for a Steel Pipe Support

Therefore the 18" $\varnothing$ steel pipe will support the 12" $\varnothing$ HDPE pipe in the event of a rupture of the CCW pipe and a subsequent SSE event.

7.8 Evaluation of 12" $\varnothing$ HDPE Pipe over Condenser Cooling Water Lines

As discussed in Section 7.7, the 12" $\varnothing$ HDPE piping is supported by the steel pipe bridge in the unlikely event that the Condenser Cooling Water lines wash out the soil surrounding the HDPE piping crossing this piping. Section 7.7 resulted in the conclusion that the bridge analyzed as a support is acceptable. This portion of the calculation analyzes the pressure retaining 12" $\varnothing$ HDPE for this faulted event. The 12" $\varnothing$ HDPE will deflect with the pipe bridge. Therefore, the deflection of the bridge will be calculated. Using this displacement, an equivalent load will be calculated for the 12" $\varnothing$ HDPE. This load will be combined appropriately with other loads (pressure) and the resulting stresses will be compared to the allowable stress.

Deflection of Pipe Support Bridge for Dead Weight

For a simply supported beam deflection is as follows:

$$\Delta_{\text{max}} = 5 \omega l^4 / 384 EI = 5 * 10.104 \text{ lb/in} * 348^4 \text{ in}^2 / (384 * 29 \times 10^6 \text{ lb/in}^2 * 111.112 \text{ in}^4) = 0.888 \text{ in.}$$

Deflection of Pipe Support Bridge for Earthquake Load

For a simply supported beam deflection is as follows:

$$\Delta_{\text{max-vertical-earthquake}} = 0.324g * 0.888 \text{ in.} = 0.288 \text{ in.}$$

$$\Delta_{\text{max-horizontal-earthquake}} = 0.486g * 5 * 10.104 \text{ lb/in} * 348^4 \text{ in}^2 / (384 * 29 \times 10^6 \text{ lb/in}^2 * 585.743 \text{ in}^4) = 0.0552 \text{ in.}$$

$$\Delta_{\text{max-total-earthquake}} = (0.288^2 \text{ in}^2 + 0.0552^2 \text{ in}^2)^{0.50} = 0.293 \text{ in}$$

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Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2		
By:	<i>L. Hailer</i>	Date	11/10/08
		Chk'd by	<i>Bruce P. Dubosech</i>
		Date	11/11/08

Calculation of Bending Stress in the HDPE Piping Due to Deflection

In the case of the 12" HDPE pressure retaining piping, the stress is at it's highest when the system is stiffest since the stress in this case is displacement dependent. Therefore, the piping will be conservatively assumed to have a fixed connection on either side of the span.

HDPE Properties:

$$I = 1/64 \pi (D_o^4 - D_i^4) = 1/64 \pi (12.75^4 - 10.45^4) = 711.8 \text{ in}^4$$

$$Z = I * 2 / D = 711.8 \text{ in}^4 * 2 / 12.75 \text{ in.} = 111.7 \text{ in}^3$$

For a Fixed – Fixed Beam Dead Weight @ Ambient Temperature:

$$\Delta = \omega l^4 / 384 E I \rightarrow \omega = 384 E I \Delta / l^4 = 384 * 110,000 \text{ lb/in}^2 * 711.8 \text{ in}^4 * 0.888" / 348^4 \text{ in}^4 = 1.82045 \text{ lb/in}$$

(Equivalent Load on Pipe)

Where: 28,000 psi is E for the HDPE Pipe @ Ambient Temperature and short term duration (Table 6.3d, conservative for calculating stress), and 0.888" is the deflection at the center of the bridge due to Dead Weight

$$M_{Max} = \omega l^2 / 24 = 1.82045 \text{ lb/in} * (348^2) / 24 = 9,186 \text{ in-lb}$$

$$\delta_{bending-Deadweight} = 9,186 \text{ in-lb} / 111.7 \text{ in}^3 = 82.24 \text{ psi}$$

$$\delta_{bending-Earthquake} = 82.24 \text{ psi} * 0.293" / 0.888" = 27.13 \text{ psi}$$

The earthquake does not act concurrently with the wash out from the CCW pipes. These stresses are small enough that they do not control design when combined appropriately with pressure stress. They are acceptable by inspection.

CALCULATION CONTINUATION SHEET

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By:	<i>L. Hailer</i>	Date	11/10/08
		Chk'd by	<i>Bruce P. Dubosech</i>
		Date	11/11/08

8.0 RESULTS

The HDPE piping system was found to be adequate. Table 8.a summarizes these results.

Table 8.a Result Summary for 12” HDPE Pipe				
Acceptance Criteria	Calculated Value	Allowable Value	<u>Calculated Allowable</u>	Node Pt.
Minimum Required Wall Thickness	0.95”	1.159”	0.82	N/A
Ring Deflection	0.00108”	0.05”	0.02	N/A
Compression of Side Walls	284 psi	500 psi	0.57	N/A
Buckling Due to External Pressure	51.6 psi	87.9 psi	0.59	N/A
Effects of Negative Internal Pressure	> - 72.9 psi	0 psi	***0.0	N/A
Flotation	55.3 lb/ft	576 lb/ft	0.10	N/A
Deadweight + Pressure Stress – Straight Pipe	329.0 psi	620 psi	0.53	815
Deadweight + Pressure Stress – Mitered Elbow	314.7 psi	620 psi	0.51	485
Thermal Stress – Straight Pipe	286.1psi	1100 psi	0.26	880
Thermal Stress – Mitered Elbow	434.1psi	1100 psi	0.39	650
Seismic SSE Stress – Straight Pipe	244.1psi	1100 psi	0.22	880
Seismic SSE Stress – Mitered Elbow	405.4psi	1100 psi	0.37	780

*** The HDPE pipe is not under a vacuum per the Design Specification Ref. [26]

CALCULATION CONTINUATION SHEET

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By:	<i>L. Hailer</i>	Date	11/10/08
		Chk'd by	<i>Bruce P. Dubosech</i>
		Date	11/11/08

The steel piping system was found to be adequate. Table 8.b summarizes these results

Table 8.b Result Summary for 10” and 12” Steel Pipe				
Acceptance Criteria	Calculated Stress [psi]	Allowable Stress [psi]	Calculated Allowable	Node Point
Deadweight and Pressure (Design)	2104	22500	0.09	985
Deadweight and Pressure (Level A)	1579	27000	0.06	985
Thermal (Level A)	8025	22500	0.36	985
Deadweight and Pressure (Level B)	1579	27000	0.06	985
Thermal and Seismic (Level B)	9170	22500	0.41	985
Seismic (Level C/D)	7809	22500	0.35	985

8.1 Functionality Capability and Break Postulation

This piping analysis meets functional capability as defined in Ref. [24]. The maximum Level D Pressure and Temperature do not exceed design Pressure and Temperature. All piping stress limits given in ASME BPVC Code Case N-755 are met for all applied Level D loads and the capacities used in this review are based on the Design Temperature.

This piping is classified as moderate energy as defined in Ref. [24]. Moderate energy piping is piping that has a temperature of less than 200 ° F and a pressure of 275 psig or less. Per Ref [26], for this piping, the maximum temperature is 100° F and the operating pressure is 75 psig. Leak cracks are to be postulated at points based on the following equation:

$$\frac{PD}{4t} + 0.75i \left[\frac{M_A}{Z} + \frac{F_{aA}}{A} \right] + i \left[\frac{M_C}{Z} + \frac{F_{aC}}{A} \right] + i \left[\frac{M_E}{Z} + \frac{F_{aE}}{A} \right] \leq 0.4(1.1S + 1100 + 1100)psi = 0.4(1.1S + 2200)psi$$

where:

- P = Operating pressure
- D = Outside pipe diameter
- t = Nominal pipe wall thickness

CALCULATION CONTINUATION SHEET

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i = Stress intensification factor
 A = Cross sectional area of pipe
 Z = Section modulus of pipe
 F_{aA} = Axial force due to deadweight loads
 F_{aC} = Axial force range due to thermal loads
 F_{aE} = Axial force range due to seismic loads
 M_A = Moment due to deadweight loads
 M_C = Moment range due to thermal loads
 M_E = Moment range due to seismic loads

The deadweight, thermal, and seismic loads at the critical locations will be taken from Tables 7.2.2a to 7.2.2d for straight pipe and mitered elbows and checked to the postulated break equation. The maximum stresses for deadweight, seismic and thermal cases may occur at different locations. The equation uses the maximum stresses even when they are found in separate locations. This is conservative.

$$S = 620 \text{ psi} \rightarrow 0.4(1.1S + 2200) = 0.4 (1.1*620 + 2200) = 1153 \text{ psi}$$

For straight pipe:

$$\begin{array}{llll}
 D = 12.75 \text{ in} & t = 1.159 \text{ in} & A = 42.2 \text{ in}^2 & Z = 112.3 \text{ in}^3 \\
 P = 75 \text{ psi} & i = 1.0 & 0.75i = 1.0 & (\text{Note: } 0.75i \text{ cannot be less than } 1.0) \\
 M_A = 505 \text{ ft-lb} = 6060 \text{ in-lb} & M_C = 977 \text{ ft-lb} = 11724 \text{ in-lb} & M_E = 1119 \text{ ft-lb} = 13428 \text{ in-lb} & \\
 F_{aA} = 0 & F_{aC} = 7668 \text{ lb} & F_{aE} = 5255 \text{ lb} &
 \end{array}$$

Substituting these values into the equation yields:

$$\frac{75 * 12.75}{4 * 1.159} + 1.0 \left[\frac{6060}{112.3} + \frac{0}{42.2} \right] + 1.0 \left[\frac{11724}{112.3} + \frac{7668}{42.2} \right] + 1.0 \left[\frac{13428}{112.3} + \frac{5255}{42.2} \right] = 790 \text{ psi} < 1153 \text{ psi}$$

Therefore, there are no postulated moderate energy leak cracks on the straight HDPE piping.

For mitered elbows:

$$\begin{array}{llll}
 D = 12.75 \text{ in} & t = 1.417 \text{ in} & A = 50.5 \text{ in}^2 & Z = 129.0 \text{ in}^3 \\
 P = 75 \text{ psi} & i = 2.0 & 0.75i = 1.5 & \\
 M_A = 28 \text{ ft-lb} = 336 \text{ in-lb} & M_C = 1934 \text{ ft-lb} = 23208 \text{ in-lb} & M_E = 1875 \text{ ft-lb} = 22500 \text{ in-lb} & \\
 F_{aA} = 0 & F_{aC} = 3754 \text{ lb} & F_{aE} = 2861 \text{ lb} &
 \end{array}$$

Substituting these values into the equation yields:

$$\frac{75 * 12.75}{4 * 1.417} + 1.5 \left[\frac{336}{129} + \frac{0}{50.5} \right] + 2.0 \left[\frac{23208}{129} + \frac{3754}{50.5} \right] + 2.0 \left[\frac{22500}{129} + \frac{2861}{50.5} \right] = 1143 \text{ psi} < 1153 \text{ psi}$$

Therefore, there are no postulated moderate energy leak cracks on the mitered HDPE piping.

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8.2 Final Loads at the Anchor at the Diesel Generator Building due to Soil Effects

The maximum loads acting from the HDPE pipe for Service Levels A, B, C and D acting on the anchor at the face of the Diesel Generator Building are extracted from the results of the ADLPIPE analysis. These loads are summarized in Tables 8.2a and 8.2b and compared to the maximum loads that the HDPE pipe can contribute to anchor load at the face of the Diesel Generator Building.

Table 8.2a: HDPE Loads from ADLPIPE for Anchor at Diesel Generator Building

Load Case	Node Point	Fx (lbs)	Fy (lbs)	Fz (lbs)	Mx (ft-lb)	My (ft-lb)	Mz (ft-lb)
10 (DW)	100	0	513	0	0	0	1212
27 (Th)	100	6722	0	0	0	0	0
28 (Th)	100	7608	0	0	0	0	0
29 (Th)	100	10431	0	0	0	0	0
31 (SSE)	100	8558	0	0	0	0	0
32(OBE)	100	4564	0	0	0	0	0

Table 8.2b: HDPE Loads combined for maximum forces and moments to be compared to allowable interface loads applied to the steel pipe per Ref. [23]

Load Case	Node Point	Axial Force (lbs)		Shear Force (lbs)		Resultant Moment (in-lbs)	
		Combined from ADLPIPE	Maximum	Combined from ADLPIPE	Maximum	Combined from ADLPIPE	Maximum
10 (DW)	130	0	4200	95	4200	420	100000
27 (Th)	130	6722 (1)	4200	0	4200	0	100000
28 (Th)	130	7608 (1)	4600	0	4600	0	100000
29 (Th)	130	10431 (1)	5500	0	5500	0	100000
31 (SSE)	130	8558 (1)	4600	0	4600	0	100000
32 (OBE)	130	4564	4600	0	4600	0	100000

(1) The thermal axial forces exceed the maximum for the HDPE pipe. These forces are acceptable due to the very small shear force and moment at the same node point. Therefore, the loads shown above will be used as input for the anchor design at the Diesel Generator Building.

8.3 Final Loads at the Centerline of the 42" ø Supply Line due to Soil Effects

Table 8.3a: HDPE Loads from ADLPIPE at the Centerline of the 42" ø Supply Line

Load Case	Node Point	Fx (lbs)	Fy (lbs)	Fz (lbs)	Mx (ft-lb)	My (ft-lb)	Mz (ft-lb)
10 (DW)	990	19	2409	19	111	0	111
27 (Th)	990	3708	301	3708	27210	0	27210
28 (Th)	990	4131	351	4131	30276	0	30276
29 (Th)	990	5422	517	5422	39574	0	39574
31 (SSE)	990	3716	499	3716	26665	0	26664
32 (OBE)	990	1982	266	1982	14220	0	14220

CALCULATION CONTINUATION SHEET

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8.4 Branch Line Qualification

The branch line meets the 1989 ASME BPVC Code allowable stresses. Table 8.4a below shows the results of the ADLPIPE analysis for the branch line (Nodes 880 to 985).

Table 8.4a Result Summary for 12” Steel Branch Line				
Acceptance Criteria	Calculated Stress [psi]	Allowable Stress [psi]	<u>Calculated</u> <u>Allowable</u>	Node Point
Deadweight and Pressure (Design)	2104	22500	0.09	985
Deadweight and Pressure (Level A)	1579	27000	0.06	985
Thermal (Level A)	8025	22500	0.36	985
Deadweight and Pressure (Level B)	1579	27000	0.06	985
Thermal and Seismic (Level B)	9170	22500	0.41	985
Seismic (Level C/D)	7809	22500	0.35	985

9.0 CONCLUSIONS

The existing 10-in carbon steel buried nuclear service water piping lines connecting the 42-in Nuclear Service Water System (NSWS) supply headers to Unit 2 Diesel Generator (DG) building piping at the Catawba Nuclear Station will be replaced by 12-in high-density polyethylene (HDPE) piping system. This calculation determined that the buried HDPE piping system connecting the 42-in supply header ‘A’ to the DG building of Unit 2 meets all applicable acceptance criteria as defined in the piping design specification Ref. [26] which is consistent with the relief request Ref. [14], and the ASME BPVC Code Case N-755 [Ref. 12] as summarized in Table 8.1.

CALCULATION CONTINUATION SHEET

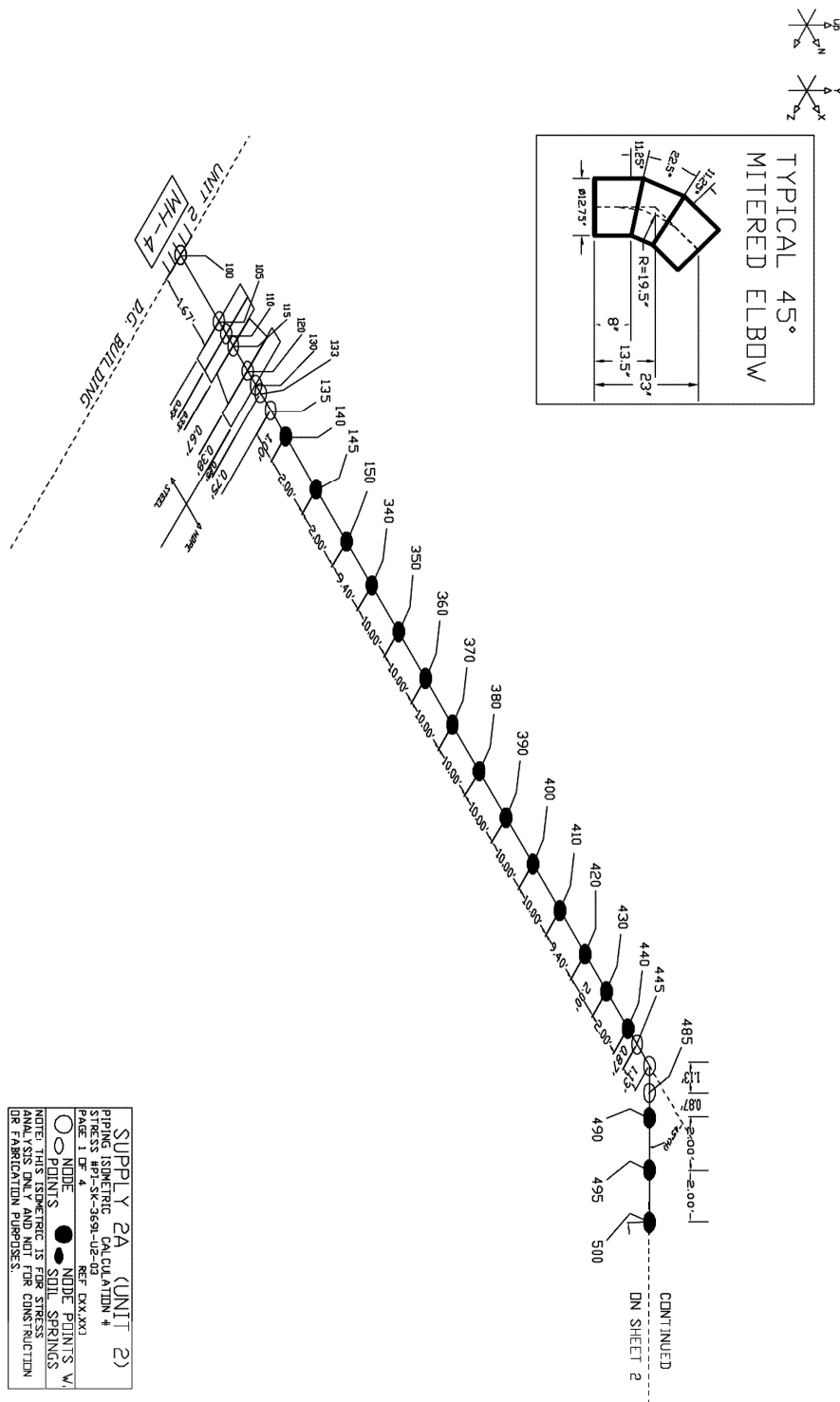
Client	Duke Power Carolinas, LLC				Calculation No.	07Q3691-CAL-007	
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis						
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2						
By:		Date	11/10/08	Chk'd by		Date	11/11/08

Appendix A

ADLPIPE Model Isometrics

CALCULATION CONTINUATION SHEET

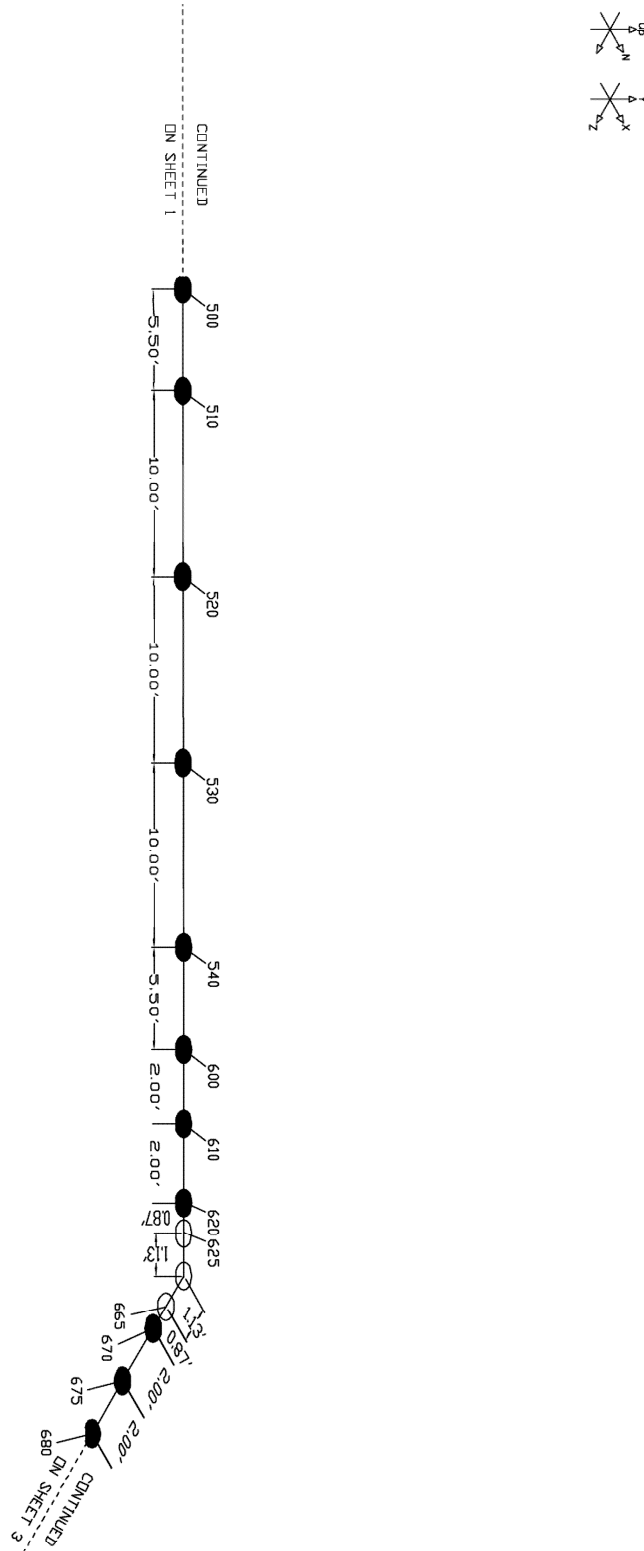
Client	Duke Power Carolinas, LLC			Calculation No.	07Q3691-CAL-007		
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis						
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CALCULATION CONTINUATION SHEET

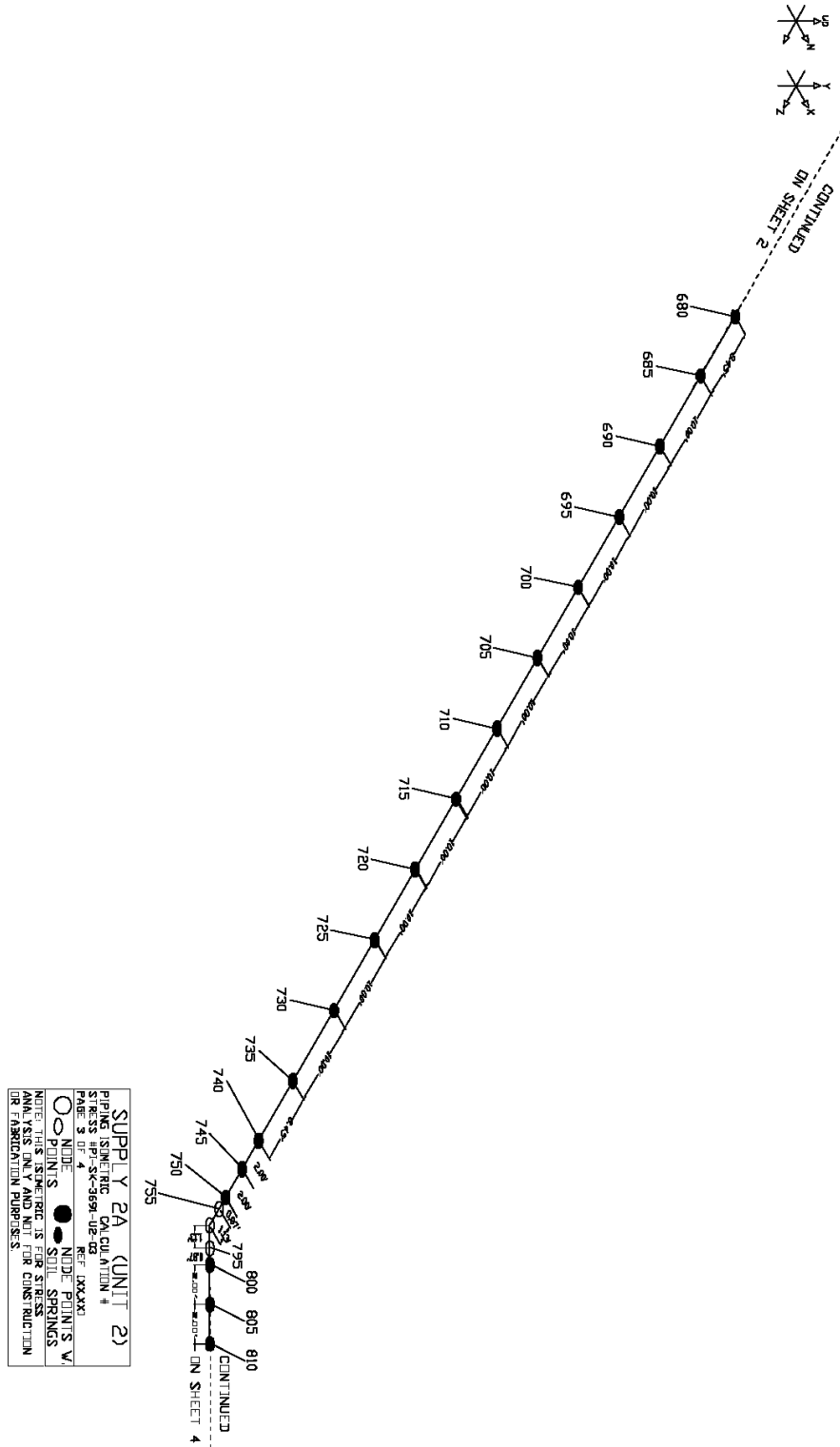
Client	Duke Power Carolinas, LLC	Calculation No.	07Q3691-CAL-007
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By:	<i>L. Hailer</i>	Date	11/10/08
Chk'd by	<i>Bruce P. Dubosech</i>	Date	11/11/08

SUPPLY 2A (UNIT 2)
 PIPE ISOMETRIC CALCULATION #1
 STRESS HP1-SV-3691-02-03
 PAGE 2 OF 4
 REF: 199901
 ○ NODE
 ○ POINTS
 ● SOIL SPRINGS
 NOTE: THIS ISOMETRIC IS FOR STRESS ANALYSIS ONLY AND NOT FOR CONSTRUCTION OR FABRICATION PURPOSES.



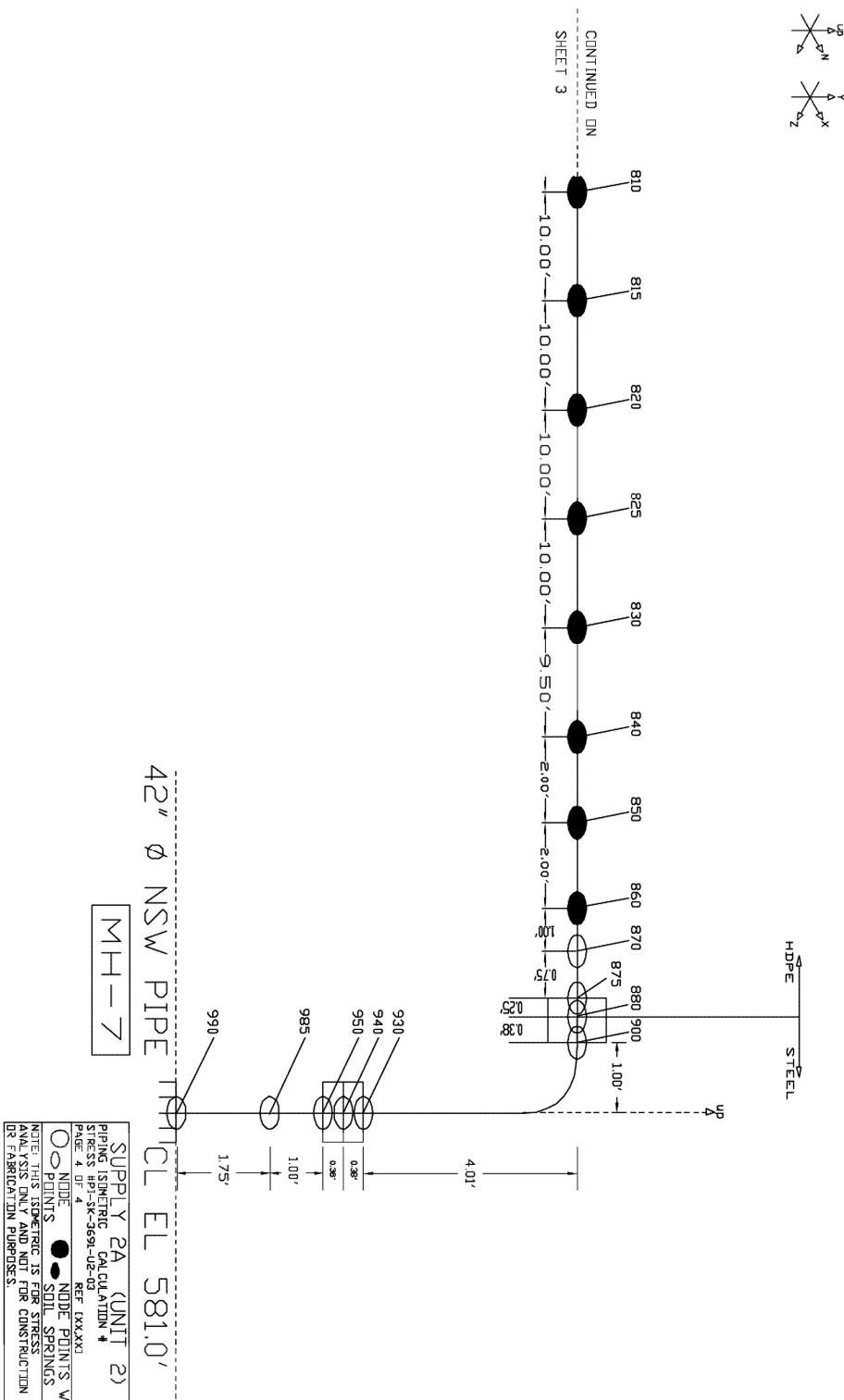
CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC	Calculation No.	07Q3691-CAL-007
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis		
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2		
By:	<i>L. Hailer</i>	Date	11/10/08
Chk'd by	<i>Bruce P. Dubosech</i>	Date	11/11/08

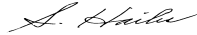
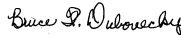


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Appendix B

ADLPIPE Input and Output files

CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC	Calculation No.	07Q3691-CAL-007
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Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2		
By:	<i>L. Hailer</i>	Date	11/10/08
		Chk'd by	<i>Bruce P. Dubosechif</i>
		Date	11/11/08

INPUT FILE:

```

GE,***** CATAWBA NUCLEAR STATION *****
GE,COOLING WATER SUPPLY LINE FROM 42-IN HEADER 'A' TO D/G BLDG OF UNIT 2
UN,0,0,0,
NOTE,MODEL=supply2a adi
NO,*****
NO,THERE ARE TWO SUPPLY LINES RUNNING TO THE D/G BUILDING OF UNIT 2
NO,THIS IS THE LINE THAT ORIGINATES FROM THE 42-IN SUPPLY HEADER 'A'
NO,*****
NO,GLOBAL COORDINATE SYSTEM: +X = NORTH, +Z = EAST, Y = VERTICAL
NO,*****
NO,PIPING: 10" AND 12", SCH. 40, Cr-Mo AND CARBON STEEL PIPES,
NO, 12", DR-11, IPS HDPE PIPE,
NO,CONTENTS:
NO, WATER FILLED, NO INSULATION,
NO,DESIGN CONDITIONS:
NO, T(AMBIENT) = 55 F, T(DESIGN) = 100 F, P(DESIGN) = 100 PSIG
NO,CODE: ASME, YEAR 1989,
NO,*****
NO,PIPING SYSTEM IS CONSIDERED ANCHORED AT BOTH ENDS
AN,,100,
RE,,100,1,1,1,1,1,1,
AN,,990,
RE,,990,1,1,1,1,1,1,
NO,*****
NO,THE FOLLOWING SOIL SPRING STIFFNESS VALUES IN [LB/IN] ARE USED.
NO,
NO, LENGTH OF PIPE BETWEEN SPRINGS
NO, SOIL HEIGHT DIRECTION -----
NO, ABOVE PIPE OF SPRING 2FT SECTION 10FT SECTION
NO, -----
NO, H = 5 FT LATERAL 3120 15600
NO, VERTICAL 12960 64800
NO, AXIAL 10200 51000
NO,
NO,STIFFNESS VALUES FOR OTHER LENGTHS ARE OBTAINED BY PROPORTION
NO,*****
NO,
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CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC				Calculation No.	07Q3691-CAL-007	
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis						
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2						
By:		Date	11/10/08	Chk'd by		Date	11/11/08

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 RE,,2600,1,1,1,1,1,1,
 RE,,3600,1,1,1,1,1,1,
 RE,,1610,1,1,1,1,1,1,
 RE,,2610,1,1,1,1,1,1,
 RE,,3610,1,1,1,1,1,1,
 RE,,1620,1,1,1,1,1,1,
 RE,,2620,1,1,1,1,1,1,
 RE,,3620,1,1,1,1,1,1,
 RE,,1670,1,1,1,1,1,1,
 RE,,2670,1,1,1,1,1,1,
 RE,,3670,1,1,1,1,1,1,
 RE,,1675,1,1,1,1,1,1,
 RE,,2675,1,1,1,1,1,1,
 RE,,3675,1,1,1,1,1,1,
 RE,,1680,1,1,1,1,1,1,
 RE,,2680,1,1,1,1,1,1,
 RE,,3680,1,1,1,1,1,1,
 RE,,1685,1,1,1,1,1,1,
 RE,,2685,1,1,1,1,1,1,
 RE,,3685,1,1,1,1,1,1,

CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC				Calculation No.	07Q3691-CAL-007	
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis						
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2						
By:		Date	11/10/08	Chk'd by		Date	11/11/08

RE,,1690,1,1,1,1,1,1,
 RE,,2690,1,1,1,1,1,1,
 RE,,3690,1,1,1,1,1,1,
 RE,,1695,1,1,1,1,1,1,
 RE,,2695,1,1,1,1,1,1,
 RE,,3695,1,1,1,1,1,1,
 RE,,1700,1,1,1,1,1,1,
 RE,,2700,1,1,1,1,1,1,
 RE,,3700,1,1,1,1,1,1,
 RE,,1705,1,1,1,1,1,1,
 RE,,2705,1,1,1,1,1,1,
 RE,,3705,1,1,1,1,1,1,
 RE,,1710,1,1,1,1,1,1,
 RE,,2710,1,1,1,1,1,1,
 RE,,3710,1,1,1,1,1,1,
 RE,,1715,1,1,1,1,1,1,
 RE,,2715,1,1,1,1,1,1,
 RE,,3715,1,1,1,1,1,1,
 RE,,1720,1,1,1,1,1,1,
 RE,,2720,1,1,1,1,1,1,
 RE,,3720,1,1,1,1,1,1,
 RE,,1725,1,1,1,1,1,1,
 RE,,2725,1,1,1,1,1,1,
 RE,,3725,1,1,1,1,1,1,
 RE,,1730,1,1,1,1,1,1,
 RE,,2730,1,1,1,1,1,1,
 RE,,3730,1,1,1,1,1,1,
 RE,,1735,1,1,1,1,1,1,
 RE,,2735,1,1,1,1,1,1,
 RE,,3735,1,1,1,1,1,1,
 RE,,1740,1,1,1,1,1,1,
 RE,,2740,1,1,1,1,1,1,
 RE,,3740,1,1,1,1,1,1,
 RE,,1745,1,1,1,1,1,1,
 RE,,2745,1,1,1,1,1,1,
 RE,,3745,1,1,1,1,1,1,
 RE,,1750,1,1,1,1,1,1,
 RE,,2750,1,1,1,1,1,1,
 RE,,3750,1,1,1,1,1,1,
 RE,,1800,1,1,1,1,1,1,
 RE,,2800,1,1,1,1,1,1,
 RE,,3800,1,1,1,1,1,1,
 RE,,1805,1,1,1,1,1,1,
 RE,,2805,1,1,1,1,1,1,
 RE,,3805,1,1,1,1,1,1,
 RE,,1810,1,1,1,1,1,1,
 RE,,2810,1,1,1,1,1,1,
 RE,,3810,1,1,1,1,1,1,
 RE,,1815,1,1,1,1,1,1,
 RE,,2815,1,1,1,1,1,1,
 RE,,3815,1,1,1,1,1,1,
 RE,,1820,1,1,1,1,1,1,
 RE,,2820,1,1,1,1,1,1,
 RE,,3820,1,1,1,1,1,1,
 RE,,1825,1,1,1,1,1,1,
 RE,,2825,1,1,1,1,1,1,
 RE,,3825,1,1,1,1,1,1,
 RE,,1830,1,1,1,1,1,1,
 RE,,2830,1,1,1,1,1,1,
 RE,,3830,1,1,1,1,1,1,
 RE,,1840,1,1,1,1,1,1,
 RE,,2840,1,1,1,1,1,1,

CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC	Calculation No.	07Q3691-CAL-007
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis		
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2		
By:	<i>L. Hailer</i>	Date	11/10/08
		Chk'd by	<i>Bruce P. Dubosechif</i>
		Date	11/11/08

RE,,3840,1,1,1,1,1,1,
 RE,,1850,1,1,1,1,1,1,
 RE,,2850,1,1,1,1,1,1,
 RE,,3850,1,1,1,1,1,1,
 RE,,1860,1,1,1,1,1,1,
 RE,,2860,1,1,1,1,1,1,
 RE,,3860,1,1,1,1,1,1,
 SE,,0,
 NO,*****
 NO,THE PIPING SYSTEM STARTS AT THE SURFACE OF THE D/G BUILDING WALL
 NO,WITH A 10-IN Cr-Mo STEEL PIPE THAT IS CONSIDERED ANCHORED AT THE
 NO,SURFACE OF THE WALL (NODE PT. 100).
 NO,
 NO,PIPE CENTERLINE IS AT ELEVATION 588'-6"
 NO,
 NO,A 10X12 STEEL REDUCER, WITH FLANGES WELDED ON ITS ENDS, CONNECTS,
 NO,THE 10-IN PIPE TO A 12-IN HDPE PIPE.
 NO,*****
 NO,10-IN, SCH. 40 Cr-Mo STEEL PIPE PROPERTIES:,
 NO, OUTSIDE DIAMETER = 10.75 IN
 NO, WALL THICKNESS = 0.365 IN
 NO, WT(PIPE)= 40.5LB/FT = 3.38 LB/IN
 NO, WT(WATER) = 34.1 LB/FT= 2.84 LB/IN
 NO, WT(PIPE+WATER) = 3.38 + 2.84 = 6.22 LB/IN
 NO,
 NO,PROPERTIES OF PIPE MATERIAL (SB-690/SB-675) AT 70 F:
 NO, E = 28E+06 PSI
 NO, ALPHA = 8.1E-06 IN/IN/F
 NO,*****
 NO,
 PI,100,105,10.75,0.365,28.0,8.1,.01,6.22,
 NO,
 NO,*****
 NO,LENGTH OF 10-IN DIAMETER PIPE COMING OUT OF WALL = 20IN = 1.67FT
 NO,*****
 NO,
 RU,100,105,1.67,,
 NO,
 NO,*****
 NO,ATTACH A 150-LB WELDING NECK (WN) FLANGE TO END OF 10-IN PIPE
 NO,AND TO THE 10" SIDE OF REDUCER
 NO,FOR 10-IN WN FLANGE (PER LADISH CATALOG):
 NO, TOTAL LENGTH = 4.0 IN = 0.33 FT
 NO, FLANGE THICKNESS = 1.188 IN
 NO, O. D. OF FLANGE = 16 IN
 NO, DIAMETER AT HUB BASE= 12.0 IN
 NO, WALL THICKNESS (MIN) = 0.365 IN
 NO, WEIGHT OF FLANGE= 54 LB --> UNIT WT = 13.50 LB/IN
 NO, WT(FLANGE+WATER)= 13.50 + 2.84 = 16.3 LB/IN
 NO,USE DIAMETER AT HUB BASE AS O.D. FOR MODELING
 NO,*****
 NO,
 NO,NOTE,IV=WNFL,END=FLG
 1V,105,110,0.33,,12.0,0.365,16.3,
 NO,NOTE,IV=WNFL,BEG=FLG
 1V,110,115,0.33,,12.0,0.365,16.3,
 NO,
 NO,*****
 NO,INSTALL A 10X12 STEEL REDUCER.
 NO,PER LADISH CATALOG:
 NO, REDUCER LENGTH = 8 IN = 0.67 FT
 NO, REDUCER WEIGHT = 34 LB --> UNIT WT = 4.25 LB/IN

CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC	Calculation No.	07Q3691-CAL-007
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis		
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2		
By:	<i>L. Hailer</i>	Date	11/10/08
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NO,WEIGHT OF WATER:

NO, FOR 10" PIPE = 34.1 LB/FT = 2.84 LB/IN
 NO, FOR 12" PIPE = 49.0 LB/FT = 4.08 LB/IN
 NO, FOR 10X12 REDUCER = (2.84+4.08)/2 = 3.46 LB/IN
 NO,WT (REDUCER+WATER) = 4.25 + 3.46 = 7.7 LB/IN
 NO,FOR 12" PIPE: OD = 12.75 IN AND WALL THICKNESS = 0.375 IN

NO,*****

NO,
 RD,115,120,0.67,,,12.75,0.375,7.7,

NO,*****

NO,ATTACH A WELDING NECK (WN) FLANGE TO THE 12-IN SIDE OF REDUCER

NO,FOR 12-IN,150-LB WN FLANGE (PER LADISH CATALOG):,

NO, TOTAL LENGTH = 4.5 IN = 0.38 FT
 NO, FLANGE THICKNESS = 1.25 IN
 NO, O. D. OF FLANGE = 19 IN
 NO, DIAMETER AT HUB BASE= 14.375 IN
 NO, WALL THICKNESS (MIN) = 0.375 IN
 NO, WEIGHT OF FLANGE= 88 LB --> UNIT WT = 19.56 LB/IN
 NO, WT(FLANGE+WATER)= 19.56 + 4.08 = 23.6 LB/IN
 NO,USE DIAMETER AT HUB BASE AS O.D. FOR MODELING

NO,*****

NO,
 NOTE,IV=WNFL,END=FLG
 1V,120,130,0.38,,,14.375,0.375,23.6,

SE,,0,

NO,*****

NO, CHANGE TO 12" HDPE PIPE

NO,*****

NO,12-IN, DR 11 HDPE PIPE PROPERTIES:,

NO, OUTSIDE DIAMETER, OD = 12.75 IN
 NO, MIN.WALL THICKNESS, t = 1.159 IN
 NO, INSIDE DIAMETER, ID = OD - 2t = 10.432 IN
 NO, WT(PIPE) = 18.41 LB/FT = 1.53 LB/IN
 NO, WT(WATER) = 37.04 LB/FT = 3.09 LB/IN
 NO, WT(WATER+PIPE) = 1.53 + 3.09 = 4.62 LB/IN

NO,
 NO,HDPE PROEPRITIES AT 70F AND 50-YEAR DURATION:

NO, E = 28 KSI
 NO, ALPHA = 90.0E-6 IN/IN/F

NO,*****

NO,
 PI,130,133,12.75,1.159,28.0E-3,90.0,0.01,4.62,

NO,*****

NO,INSTALL A FLANGE ADAPTER WITH A STEEL BACKUP RING MOUNTED ON IT

NO,
 NO,FOR 12-IN, DR 11, IPS HDPE FLANGE ADAPTER (PER ISCO CATALOG):,

NO, TOTAL LENGTH = 12.0 IN = 1.0 FT
 NO, FLANGE THICKNESS = 1.55 IN
 NO, WEIGHT OF ADAPTER = 24 LB
 NO,FOR 12-IN STEEL BACKUP RING (PER ISCO CATALOG):
 NO, THICKNESS = 1.25 IN, WEIGHT = 24 LB

NO,
 NO,MODEL ADAPTER AND RING ASSEMBLY AS A PIPE AND FLANGE COMBINATION

NO,FOR FLANGE, USE:,
 NO, LENGTH = 1.55+1.25 = 2.8" --> LENGTH = 3 IN
 NO, WALL THICKNESS = 1.159 IN
 NO, O.D. OF FLANGE = 15.5 IN
 NO, WEIGHT = WT(RING+ADAPTER) - WT(9" LONG PIPE)
 NO, = 24.0 + 24.0 - 18.4*(9/12) = 34.2 LB

CALCULATION CONTINUATION SHEET

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Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis		
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By:	<i>L. Hailer</i>	Date	11/10/08
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		Date	11/11/08

NO, WT(FLANGE+WATER)= (34.2/3)+3.09 = 14.5 LB/IN

NO,

NO,FOR PIPE, USE:,

NO, LENGTH = 12.0 - 3.0 = 9 IN

NO, WT(PIPE+WATER) = 4.62 LB/IN

NO, *****

NO,

NOTE,IV=WNFL,BEG=FLG

1V,130,133,0.25,,,15.5,1.159,14.5,

RU,133,135,0.75,,,

NO,

NO, *****

NO,PIPE ORIENTATION: PARALLEL TO X-AXIS

NO

NO,SINCE PIPE AXIS IS AT ELEVATION 588'-6", HEIGHT OF SOIL (H) FROM,

NO,TOP OF PIPE = 5 FT. THEREFORE, USE THE FOLLOWING SOIL SPRING

NO,STIFFNESS VALUES OBTAINED FOR H = 5 FT.

NO

NO, SPRING STIFFNESS [LB/IN]

NO, DIRECTION -----

NO, OF SPRING 2FT SECTION 10FT SECTION

NO, -----

NO, LATERAL 3120 15600

NO, VERTICAL 12960 64800

NO, AXIAL 10200 51000

NO

NO,APPLY SOIL SPRINGS AT 2 FT INTERVALS AROUND MITERED ELBOWS AND

NO,WITHIN THE 'INFLUENCE LENGTH'(TOTAL = 12 FT).

NO,

NO,LOCATION OF 1ST SPRING SET FROM END OF FLANGE ADAPTER= 1.0 FT

NO, *****

NO,

RU,135,140,1.0,

SE,,0,

RU,140,1140,1.0,,,

2SP,140,1140,10200,,,

SE,,0,

RU,140,2140,,1.0,,

2SP,140,2140,12960,,,

SE,,0,

RU,140,3140,,,1.0,

2SP,140,3140,3120,,,

SE,,0,

RU,140,145,2.0,

SE,,0,

RU,145,1145,1.0,,,

2SP,145,1145,10200,,,

SE,,0,

RU,145,2145,,1.0,,

2SP,145,2145,12960,,,

SE,,0,

RU,145,3145,,,1.0,

2SP,145,3145,3120,,,

SE,,0,

RU,145,150,2.0,

SE,,0,

RU,150,1150,1.0,,,

2SP,150,1150,10200,,,

SE,,0,

RU,150,2150,,1.0,,

2SP,150,2150,12960,,,

SE,,0,

CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC				Calculation No.	07Q3691-CAL-007	
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis						
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2						
By:		Date	11/10/08	Chk'd by		Date	11/11/08

RU,150,3150,,,1.0,
 2SP,150,3150,3120,,,
 SE,,0,
 NO, *****
 NO,CHANGE SOIL SPRING SPACING FROM 2 FT TO 10 FT
 NO,
 NO,REMAINING LENGTH UP TO 45 DEGREE ELBOW = 100.8FT-6FT=94.8 FT
 NO,DEDUCT 6FT TO APPLY SPRINGS EVERY 2FT AROUND 45-DEGREE ELBOW
 NO,
 NO,THEREFORE, LENGTH AVAILABLE TO APPLY SPRINGS AT 10FT INTERVALS
 NO, = 94.8FT - 6FT = 88.8 FT
 NO,DIVIDE THIS LENGTH AS FOLLOWS: 88.8FT = 7*10FT + 2*9.4FT
 NO, *****
 NO,
 NO, *****
 NO,NEXT PIPNG SECTION IS 9.4 FT LONG. SOIL SPRING STIFFNESS VALUES
 NO,ARE ADJUSTED (PROPORTIONAL TO SECTION LENGTH)
 NO, *****
 RU,150,340,9.4,,,
 SE,,0,
 RU,340,1340,1.0,,,
 2SP,340,1340,47940,,,
 SE,,0,
 RU,340,2340,,1.0,,
 2SP,340,2340,60912,,,
 SE,,0,
 RU,340,3340,,,1.0,
 2SP,340,3340,14664,,,
 SE,,0,
 NO, *****
 NO,SOIL SPRING SPACING IS 10 FT OVER THE NEXT 70 FT SECTION
 NO, *****
 RU,340,350,10,,,
 SE,,0,
 RU,350,1350,1.0,,,
 2SP,350,1350,51000,,,
 SE,,0,
 RU,350,2350,,1.0,,
 2SP,350,2350,64800,,,
 SE,,0,
 RU,350,3350,,,1.0,
 2SP,350,3350,15600,,,
 SE,,0,
 RU,350,360,10,,,
 SE,,0,
 RU,360,1360,1.0,,,
 2SP,360,1360,51000,,,
 SE,,0,
 RU,360,2360,,1.0,,
 2SP,360,2360,64800,,,
 SE,,0,
 RU,360,3360,,,1.0,
 2SP,360,3360,15600,,,
 SE,,0,
 RU,360,370,10,,,
 SE,,0,
 RU,370,1370,1.0,,,
 2SP,370,1370,51000,,,
 SE,,0,
 RU,370,2370,,1.0,,
 2SP,370,2370,64800,,,
 SE,,0,

CALCULATION CONTINUATION SHEET

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Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis						
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By:		Date	11/10/08	Chk'd by		Date	11/11/08

RU,370,3370,,,1.0,
 2SP,370,3370,15600,,,
 SE,,0,
 RU,370,380,10,,,
 SE,,0,
 RU,380,1380,1.0,,,
 2SP,380,1380,51000,,,
 SE,,0,
 RU,380,2380,,1.0,,
 2SP,380,2380,64800,,,
 SE,,0,
 RU,380,3380,,,1.0,
 2SP,380,3380,15600,,,
 SE,,0,
 RU,380,390,10,,,
 SE,,0,
 RU,390,1390,1.0,,,
 2SP,390,1390,51000,,,
 SE,,0,
 RU,390,2390,,1.0,,
 2SP,390,2390,64800,,,
 SE,,0,
 RU,390,3390,,,1.0,
 2SP,390,3390,15600,,,
 SE,,0,
 RU,390,400,10,,,
 SE,,0,
 RU,400,1400,1.0,,,
 2SP,400,1400,51000,,,
 SE,,0,
 RU,400,2400,,1.0,,
 2SP,400,2400,64800,,,
 SE,,0,
 RU,400,3400,,,1.0,
 2SP,400,3400,15600,,,
 SE,,0,
 RU,400,410,10,,,
 SE,,0,
 RU,410,1410,1.0,,,
 2SP,410,1410,51000,,,
 SE,,0,
 RU,410,2410,,1.0,,
 2SP,410,2410,64800,,,
 SE,,0,
 RU,410,3410,,,1.0,
 2SP,410,3410,15600,,,
 SE,,0,
 NO,

 NO,NEXT PIPNG SECTION IS 9.4 FT LONG. SOIL SPRING STIFFNESS VALUES
 NO,ARE ADJUSTED (PROPORTIONAL TO SECTION LENGTH)
 NO, *****
 NO,
 NO,
 RU,410,420,9.4,,,
 SE,,0,
 RU,420,1420,1.0,,,
 2SP,420,1420,47940,,,
 SE,,0,
 RU,420,2420,,1.0,,
 2SP,420,2420,60912,,,
 SE,,0,
 RU,420,3420,,,1.0,
 2SP,420,3420,14664,,,

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By:	<i>L. Hailer</i>	Date	11/10/08
Chk'd by	<i>Bruce P. Dubouché</i>	Date	11/11/08

SE,,0,
 NO, *****
 NO, CHANGE SPACING OF SOIL SPRINGS TO 2 FT (AROUND 45-DEGREE ELBOW)
 NO, *****
 NO,
 RU,420,430,2,,,
 SE,,0,
 RU,430,1430,1.0,,,
 2SP,430,1430,10200,,,
 SE,,0,
 RU,430,2430,,1.0,,
 2SP,430,2430,12960,,,
 SE,,0,
 RU,430,3430,,,1.0,
 2SP,430,3430,3120,,,
 SE,,0,
 RU,430,440,2,,,
 SE,,0,
 RU,440,1440,1.0,,,
 2SP,440,1440,10200,,,
 SE,,0,
 RU,440,2440,,1.0,,
 2SP,440,2440,12960,,,
 SE,,0,
 RU,440,3440,,,1.0,
 2SP,440,3440,3120,,,
 SE,,0,
 NO, *****
 NO, NEXT RUN GOES UP TO BEGINNING OF 45-DEGREE MITERED ELBOW
 NO, LENGTH OF 45-DEG. MITERED ELBOW (SEE BELOW): FC = 1.13 FT
 NO, THEREFORE, LENGTH OF RUN = 2.0'-1.13' = 0.87 FT
 NO, *****
 NO,
 RU,440,445,0.87,
 NO,
 NO, *****
 NO, ***** 45 DEGREE IPS HDPE ELBOW *****
 NO, *****
 NO, THIS IS A 3-SEGMENT MITERED ELBOW.
 NO, FOR 12-IN, DR-9, MITERED ELBOW (PER ISCO CATALOG);
 NO, OUTSIDE DIAMETER, OD = 12.75 IN
 NO, MIN. WALL THICKNESS, t = 1.417 IN
 NO, INSIDE DIAMETER, ID = OD - 2t = 9.916 IN
 NO, RADIUS, R = 19.5 IN
 NO, LENGTH, FC = 13.5 IN = 1.13 FT
 NO, WT(PIPE) = 21.97 LB/FT = 1.83 LB/IN
 NO, WEIGHT OF WATER FOR ID = 9.916 IN:
 NO, WT(WATER) = 33.46 LB/FT = 2.79 LB/IN
 NO, WT(PIPE+WATER) = 1.83 + 2.79 = 4.62 LB/IN
 NO,
 NO, SIF AND STRESS INDICES FOR MITERED ELBOW:
 NO, SIF = 2.0 B1 = 0.69 B2 = 1.64
 NO,
 NO, ELBOW STARTS AT NODE PT. 445 AND ENDS AT NODE PT. 485
 NO, *****
 NO,
 RU,445,450,1.13,,,
 CM,450,460,12.75,1.417,,19.5,11.25,4.62,
 IB,450,460,2.0,.69,1.64,
 CM,460,470,12.75,1.417,,19.5,22.5,4.62,
 IB,460,470,2.0,.69,1.64,
 CM,470,480,12.75,1.417,,19.5,,4.62,

CALCULATION CONTINUATION SHEET

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Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis						
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By:		Date	11/10/08	Chk'd by		Date	11/11/08

IB,470,480,2.0,,.69,1.64,
 RU,480,485,0.8,,0.8,
 NO,
 NO, *****
 NO,PIPE AXIS OF NEXT SECTION MAKES 45 DEGREES (CCW) WITH THE Z-AXIS
 NO,LENGTH OF PIPE = 53 FT
 NO, *****
 NO,APPLY SOIL SPRINGS EVERY 2FT AROUND ELBOWS (6FT ON EACH END)
 NO,AND EVERY 10FT IN THE REMAINING SECTION (LENGTH= 53'-12')= 41FT
 NO,
 NO,LOCATION OF 1ST SPRING SET FROM END OF ELBOW= 2.0-1.13= 0.87FT
 NO, *****
 NO,
 RU,485,490,0.615,,0.615,
 SE,,0,
 RU,490,1490,0.707,,0.707,,1,,
 2SP,490,1490,10200,
 SE,,0,
 RU,490,2490,,1,,
 2SP,490,2490,12960,
 SE,,0,
 RU,490,3490,0.707,,0.707,,1,,
 2SP,490,3490,3120,
 SE,,0,
 RU,490,495,1.414,,1.414,
 SE,,0,
 RU,495,1495,0.707,,0.707,,1,,
 2SP,495,1495,10200,,
 SE,,0,
 RU,495,2495,,1.0,,
 2SP,495,2495,12960,,
 SE,,0,
 RU,495,3495,0.707,,0.707,,1,,
 2SP,495,3495,3120,,
 SE,,0,
 RU,495,500,1.414,,1.414,
 SE,,0,
 RU,500,1500,0.707,,0.707,,1,,
 2SP,500,1500,10200,,
 SE,,0,
 RU,500,2500,,1.0,,
 2SP,500,2500,12960,,
 SE,,0,
 RU,500,3500,0.707,,0.707,,1,,
 2SP,500,3500,3120,,
 SE,,0,
 NO, *****
 NO,CHANGE SPACING OF SOIL SPRINGS FROM 2 FT TO 10 FT
 NO,AVAILABLE LENGTH TO APPLY SPRINGS EVERY 10FT = 53FT-12FT = 41FT
 NO,DIVIDE THIS LENGTH AS: 41FT = 5.5FT + 3*10FT + 5.5FT
 NO, *****
 NO,NEXT PIPING SECTION IS 5.5 FT LONG. SOIL SPRING STIFFNESS VALUES
 NO,ARE ADJUSTED (PROPORTIONAL TO SECTION LENGTH)
 NO, *****
 NO,
 RU,500,510,3.89,,3.89,
 SE,,0,
 RU,510,1510,0.707,,0.707,,1,,
 2SP,510,1510,28050,,
 SE,,0,
 RU,510,2510,,1.0,,
 2SP,510,2510,35640,,

CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC				Calculation No.	07Q3691-CAL-007	
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis						
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2						
By:		Date	11/10/08	Chk'd by		Date	11/11/08

SE,,0,
 RU,510,3510,0.707,,,-0.707,,1,,
 2SP,510,3510,8580,,,
 SE,,0,
 NO,*****
 NO,SOIL SPRING SPACING FOR NEXT SECTIONS = 10 FT
 NO,*****
 RU,510,520,7.07,,7.07,
 SE,,0,
 RU,520,1520,0.707,,0.707,,1,,
 2SP,520,1520,51000,,,
 SE,,0,
 RU,520,2520,,1.0,,
 2SP,520,2520,64800,,,
 SE,,0,
 RU,520,3520,0.707,,,-0.707,,1,,
 2SP,520,3520,15600,,,
 SE,,0,
 RU,520,530,7.07,,7.07,
 SE,,0,
 RU,530,1530,0.707,,0.707,,1,,
 2SP,530,1530,51000,,,
 SE,,0,
 RU,530,2530,,1.0,,
 2SP,530,2530,64800,,,
 SE,,0,
 RU,530,3530,0.707,,,-0.707,,1,,
 2SP,530,3530,15600,,,
 SE,,0,
 RU,530,540,7.07,,7.07,
 SE,,0,
 RU,540,1540,0.707,,0.707,,1,,
 2SP,540,1540,51000,,,
 SE,,0,
 RU,540,2540,,1.0,,
 2SP,540,2540,64800,,,
 SE,,0,
 RU,540,3540,0.707,,,-0.707,,1,,
 2SP,540,3540,15600,,,
 SE,,0,
 NO,*****
 NO,NEXT PIPING SECTION IS 5.5 FT LONG. SOIL SPRING STIFFNESS VALUES
 NO,ARE ADJUSTED (PROPORTIONAL TO SECTION LENGTH)
 NO,*****
 RU,540,600,3.89,,3.89,
 SE,,0,
 RU,600,1600,0.707,,0.707,,1,,
 2SP,600,1600,28050,,,
 SE,,0,
 RU,600,2600,,1.0,,
 2SP,600,2600,35640,,,
 SE,,0,
 RU,600,3600,0.707,,,-0.707,,1,,
 2SP,600,3600,8580,,,
 SE,,0,
 NO,*****
 NO,CHANGE SPACING OF SOIL SPRINGS TO 2 FT (AROUND 45-DEGREE ELBOW)
 NO,*****
 NO,
 RU,600,610,1.414,,1.414,
 SE,,0,
 RU,610,1610,0.707,,0.707,,1,,

CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC	Calculation No.	07Q3691-CAL-007
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis		
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2		
By:	<i>L. Hailer</i>	Date	11/10/08
Chk'd by	<i>Bruce P. Dubosechif</i>	Date	11/11/08

2SP,610,1610,10200,,,
 SE,,0,
 RU,610,2610,,1.0,,
 2SP,610,2610,12960,,,
 SE,,0,
 RU,610,3610,0.707,, -0.707,, 1,,
 2SP,610,3610,3120,,,
 SE,,0,
 RU,610,620,1.414,, 1.414,
 SE,,0,
 RU,620,1620,0.707,, 0.707,, 1,,
 2SP,620,1620,10200,,,
 SE,,0,
 RU,620,2620,, 1.0,,
 2SP,620,2620,12960,,,
 SE,,0,
 RU,620,3620,0.707,, -0.707,, 1,,
 2SP,620,3620,3120,,,
 SE,,0,
 NO, *****
 NO,NEXT RUN GOES UP TO BEGINNING OF 45-DEGREE MITERED ELBOW
 NO,LENGTH OF 45-DEG. MITERED ELBOW (SEE ELBOW DIMENSIONS):FC= 1.13FT
 NO,THEREFORE, LENGTH OF NEXT RUN = 2.0'-1.13' = 0.87 FT
 NO, *****
 NO,
 RU,620,625,0.615,, 0.615,
 NO,
 NO, *****
 NO, ***** 45 DEGREE IPS HDPE ELBOW *****
 NO, *****
 NO,THIS IS A 3-SEGMENT MITERED ELBOW. THE PROPERTIES ARE AS LISTED
 NO,EARLIER.
 NO,
 NO,ELBOW STARTS AT NODE PT. 625 AND ENDS AT NODE PT. 665
 NO, *****
 NO,
 RU,625,630,0.8,, 0.8,
 CM,630,640,12.75,1.417,, 19.5,11.25,4.62,
 IB,630,640,2.0,, 0.69,1.64,
 CM,640,650,12.75,1.417,, 19.5,22.5,4.62,
 IB,640,650,2.0,, 0.69,1.64,
 CM,650,660,12.75,1.417,, 19.5,, 4.62,
 IB,650,660,2.0,0.69,1.64,
 RU,660,665,,, 1.13,
 NO,
 NO, *****
 NO,PIPING IS NOW ORIENTED PARALLEL TO THE Z-AXIS. X IS LATERAL
 NO,
 NO,LENGTH OF PIPING PARALLEL TO Z-AXIS = 128.9 FT
 NO,APPLY SOIL SPRINGS EVERY 2FT AROUND ELBOWS (6FT AT EACH END) AND
 NO,EVERY 10 FT IN THE REMAINING SECTION (LENGTH= 128.9-2*6=116.9 FT)
 NO,
 NO,LOCATION OF 1ST SPRING SET FROM END OF ELBOW= 2.0-1.13= 0.87FT
 NO, *****
 NO,
 RU,665,670,,, 0.87,
 NO,
 SE,,0,
 RU,670,1670,1.0,,,
 2SP,670,1670,3120,
 SE,,0,
 RU,670,2670,, 1.0,,

CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC				Calculation No.	07Q3691-CAL-007	
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis						
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2						
By:		Date	11/10/08	Chk'd by		Date	11/11/08

2SP,670,2670,12960,
 SE,,0,
 RU,670,3670,,,1.0,
 2SP,670,3670,10200,
 SE,,0,
 RU,670,675,,,2.0,
 SE,,0,
 RU,675,1675,1.0,,,
 2SP,675,1675,3120,
 SE,,0,
 RU,675,2675,,1.0,,
 2SP,675,2675,12960,
 SE,,0,
 RU,675,3675,,,1.0,
 2SP,675,3675,10200,
 SE,,0,
 RU,675,680,,,2.0,
 SE,,0,
 RU,680,1680,1.0,,,
 2SP,680,1680,3120,
 SE,,0,
 RU,680,2680,,1.0,,
 2SP,680,2680,12960,
 SE,,0,
 RU,680,3680,,,1.0,
 2SP,680,3680,10200,
 SE,,0,
 NO *****

NO,CHANGE SPACING OF SOIL SPRINGS TO 10 FT
 NO,AVAILABLE LENGTH = 116.9 FT
 NO,DIVIDE THIS LENGTH AS: $116.9\text{FT} = 10*10\text{FT} + 2*8.45\text{FT}$
 NO *****

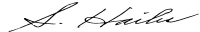
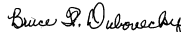
NO,
 NO,*****
 NO,NEXT SECTION IS 8.45 FT LONG. SOIL SPRING STIFFNESS VALUES ARE
 NO,ADJUSTED (PROPORTIONAL TO SECTION LENGTH)
 NO *****

RU,680,685,,,8.45,
 SE,,0,
 RU,685,1685,1.0,,,
 2SP,685,1685,13182,
 SE,,0,
 RU,685,2685,,1.0,,
 2SP,685,2685,54756,
 SE,,0,
 RU,685,3685,,,1.0,
 2SP,685,3685,43095,
 SE,,0,
 NO *****

NO,SOIL SPRING SPACING IS 10FT OVER THE NEXT 100 FT
 NO *****

RU,685,690,,,10.0,
 SE,,0,
 RU,690,1690,1.0,,,
 2SP,690,1690,15600,
 SE,,0,
 RU,690,2690,,1.0,,
 2SP,690,2690,64800,
 SE,,0,
 RU,690,3690,,,1.0,
 2SP,690,3690,51000,
 SE,,0,
 NO *****

CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC				Calculation No.	07Q3691-CAL-007	
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis						
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2						
By:		Date	11/10/08	Chk'd by		Date	11/11/08

RU,690,695,,,10.0,
 SE,,0,
 RU,695,1695,1.0,,,
 2SP,695,1695,15600,
 SE,,0,
 RU,695,2695,,1.0,,
 2SP,695,2695,64800,
 SE,,0,
 RU,695,3695,,,1.0,
 2SP,695,3695,51000,
 SE,,0,
 RU,695,700,,,10.0,
 SE,,0,
 RU,700,1700,1.0,,,
 2SP,700,1700,15600,
 SE,,0,
 RU,700,2700,,1.0,,
 2SP,700,2700,64800,
 SE,,0,
 RU,700,3700,,,1.0,
 2SP,700,3700,51000,
 SE,,0,
 RU,700,705,,,10.0,
 SE,,0,
 RU,705,1705,1.0,,,
 2SP,705,1705,15600,
 SE,,0,
 RU,705,2705,,1.0,,
 2SP,705,2705,64800,
 SE,,0,
 RU,705,3705,,,1.0,
 2SP,705,3705,51000,
 SE,,0,
 RU,705,710,,,10.0,
 SE,,0,
 RU,710,1710,1.0,,,
 2SP,710,1710,15600,
 SE,,0,
 RU,710,2710,,1.0,,
 2SP,710,2710,64800,
 SE,,0,
 RU,710,3710,,,1.0,
 2SP,710,3710,51000,
 SE,,0,
 RU,710,715,,,10.0,
 SE,,0,
 RU,715,1715,1.0,,,
 2SP,715,1715,15600,
 SE,,0,
 RU,715,2715,,1.0,,
 2SP,715,2715,64800,
 SE,,0,
 RU,715,3715,,,1.0,
 2SP,715,3715,51000,
 SE,,0,
 RU,715,720,,,10.0,
 SE,,0,
 RU,720,1720,1.0,,,
 2SP,720,1720,15600,
 SE,,0,
 RU,720,2720,,1.0,,
 2SP,720,2720,64800,

CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC				Calculation No.	07Q3691-CAL-007	
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis						
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2						
By:		Date	11/10/08	Chk'd by		Date	11/11/08

SE,,0,
 RU,720,3720,,,1.0,
 2SP,720,3720,51000,
 SE,,0,
 RU,720,725,,,10.0,
 SE,,0,
 RU,725,1725,1.0,,,
 2SP,725,1725,15600,
 SE,,0,
 RU,725,2725,,1.0,,
 2SP,725,2725,64800,
 SE,,0,
 RU,725,3725,,,1.0,
 2SP,725,3725,51000,
 SE,,0,
 RU,725,730,,,10.0,
 SE,,0,
 RU,730,1730,1.0,,,
 2SP,730,1730,15600,
 SE,,0,
 RU,730,2730,,1.0,,
 2SP,730,2730,64800,
 SE,,0,
 RU,730,3730,,,1.0,
 2SP,730,3730,51000,
 SE,,0,
 RU,730,735,,,10.0,
 SE,,0,
 RU,735,1735,1.0,,,
 2SP,735,1735,15600,
 SE,,0,
 RU,735,2735,,1.0,,
 2SP,735,2735,64800,
 SE,,0,
 RU,735,3735,,,1.0,
 2SP,735,3735,51000,
 SE,,0,
 NO, *****

NO,NEXT SECTION IS 8.45 FT LONG. SOIL SPRING STIFFNESS VALUES ARE
 NO,ADJUSTED (PROPORTIONAL TO SECTION LENGTH)

NO, *****
 NO,

RU,735,740,,,8.45,
 SE,,0,
 RU,740,1740,1.0,,,
 2SP,740,1740,13182,
 SE,,0,
 RU,740,2740,,1.0,,
 2SP,740,2740,54756,
 SE,,0,
 RU,740,3740,,,1.0,
 2SP,740,3740,43095,
 SE,,0,
 NO, *****

NO,APPLY SOIL SPRINGS AT 2 FT INTERVALS

NO, *****
 NO,
 RU,740,745,,,2.0,
 SE,,0,
 RU,745,1745,1.0,,,
 2SP,745,1745,3120,
 SE,,0,

CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC	Calculation No.	07Q3691-CAL-007
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis		
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2		
By:	<i>L. Hailer</i>	Date	11/10/08
Chk'd by	<i>Bruce P. Dubosechif</i>	Date	11/11/08

RU,745,2745,,1.0,,
 2SP,745,2745,12960,
 SE,,0,
 RU,745,3745,,,1.0,
 2SP,745,3745,10200,
 SE,,0,
 RU,745,750,,,2.0,
 SE,,0,
 RU,750,1750,1.0,,,
 2SP,750,1750,3120,
 SE,,0,
 RU,750,2750,,,1.0,,
 2SP,750,2750,12960,
 SE,,0,
 RU,750,3750,,,1.0,
 2SP,750,3750,10200,
 SE,,0,
 NO, *****
 NO,NEXT RUN GOES UP TO BEGINNING OF 45-DEGREE MITERED ELBOW
 NO,LENGTH OF 45-DEG. MITERED ELBOW (SEE ELBOW DIMENSIONS):FC= 1.13FT
 NO,THEREFORE, LENGTH OF NEXT RUN = 2.0'-1.13' = 0.87 FT
 NO, *****
 NO,
 RU,750,755,,,0.87,
 NO,
 NO, *****
 NO, ***** 45 DEGREE IPS HDPE ELBOW *****
 NO, *****
 NO,THIS IS A 3-SEGMENT MITERED ELBOW. THE PROPERTIES ARE AS LISTED
 NO,EARLIER.
 NO,
 NO,ELBOW STARTS AT NODE PT. 755 AND ENDS AT NODE PT. 795
 NO, *****
 NO,
 RU,755,760,,,1.13,
 CM,760,770,12.75,1.417,,19.5,11.25,4.62,
 IB,760,770,2.0,.69,1.64,
 CM,770,780,12.75,1.417,,19.5,22.5,4.62,
 IB,770,780,2.0,.69,1.64,
 CM,780,790,12.75,1.417,,19.5,,4.62,
 IB,780,790,2.0,.69,1.64,
 RU,790,795,0.8,,0.8,
 NO,
 NO, *****
 NO,PIPE AXIS OF NOW MAKES 45 DEGREES (CCW) WITH Z-AXIS
 NO,
 NO,TOTAL LENGTH OF PIPING SECTION= 62.9 FT
 NO,LENGTH OF STEEL COMPONENTS= ELBOW(12")+FLANGE(4.5")= 16.5"=1.4'
 NO,LENGTH OF HDPE PIPING = 62.9' - 1.4' = 61.5 FT
 NO,
 NO, *****
 NO,APPLY SOIL SPRINGS AROUND HPDE ELBOW AT 2FT INTERVALS
 NO,
 NO,LOCATION OF 1ST SPRING SET FROM END OF ELBOW= 2.0-1.13= 0.87FT
 NO, *****
 NO,
 RU,795,800,0.615,,0.615,
 SE,,0,
 RU,800,1800,0.707,,0.707,,1,,
 2SP,800,1800,10200,
 SE,,0,
 RU,800,2800,,1,,

CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC				Calculation No.	07Q3691-CAL-007	
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis						
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2						
By:		Date	11/10/08	Chk'd by		Date	11/11/08

2SP,800,2800,12960,
 SE,,0,
 RU,800,3800,0.707,,,-0.707,,1,,
 2SP,800,3800,3120,
 SE,,0,
 RU,800,805,1.414,,1.414,
 SE,,0,
 RU,805,1805,0.707,,0.707,,1,,
 2SP,805,1805,10200,
 SE,,0,
 RU,805,2805,,1,,
 2SP,805,2805,12960,
 SE,,0,
 RU,805,3805,0.707,,,-0.707,,1,,
 2SP,805,3805,3120,
 SE,,0,
 RU,805,810,1.414,,1.414,
 SE,,0,
 RU,810,1810,0.707,,0.707,,1,,
 2SP,810,1810,10200,
 SE,,0,
 RU,810,2810,,1,,
 2SP,810,2810,12960,
 SE,,0,
 RU,810,3810,0.707,,,-0.707,,1,,
 2SP,810,3810,3120,
 SE,,0,
 NO *****
 NO,CHANGE SOIL SPRING SPACING TO 10FT
 NO,LENGTH AVAILABLE TO APPLY SPRINGS EVERY 10FT= 61.5' - 12'= 49.5'
 NO,
 NO,DIVIDE THIS LENGTH AS FOLLOWS: 49.5FT = 4*10FT + 1*9.5FT
 NO,*****
 RU,810,815,7.07,,7.07,
 SE,,0,
 RU,815,1815,0.707,,0.707,,1,,
 2SP,815,1815,51000,,
 SE,,0,
 RU,815,2815,,1.0,,
 2SP,815,2815,64800,,
 SE,,0,
 RU,815,3815,0.707,,,-0.707,,1,,
 2SP,815,3815,15600,,
 SE,,0,
 RU,815,820,7.07,,7.07,
 SE,,0,
 RU,820,1820,0.707,,0.707,,1,,
 2SP,820,1820,51000,,
 SE,,0,
 RU,820,2820,,1.0,,
 2SP,820,2820,64800,,
 SE,,0,
 RU,820,3820,0.707,,,-0.707,,1,,
 2SP,820,3820,15600,,
 SE,,0,
 RU,820,825,7.07,,7.07,
 SE,,0,
 RU,825,1825,0.707,,0.707,,1,,
 2SP,825,1825,51000,,
 SE,,0,
 RU,825,2825,,1.0,,
 2SP,825,2825,64800,,

CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC	Calculation No.	07Q3691-CAL-007
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis		
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2		
By:	<i>L. Hailer</i>	Date	11/10/08
Chk'd by	<i>Bruce P. Dubouché</i>	Date	11/11/08

SE,,0,
 RU,825,3825,0.707,,,-0.707,,1,,
 2SP,825,3825,15600,,,
 SE,,0,
 RU,825,830,7.07,,7.07,
 SE,,0,
 RU,830,1830,0.707,,0.707,,1,,
 2SP,830,1830,51000,,,
 SE,,0,
 RU,830,2830,,1.0,,
 2SP,830,2830,64800,,,
 SE,,0,
 RU,830,3830,0.707,,,-0.707,,1,,
 2SP,830,3830,15600,,,
 SE,,0,
 NO,*****
 NO,LENGTH OF NEXT SECTION = 9.5 FT. SOIL SPRING STIFFNESS VALUES
 NO,ARE ADJUSTED (PROPORTIONAL TO SECTION LENGTH)
 NO,*****
 NO,
 NO,
 RU,830,840,6.72,,6.72,
 SE,,0,
 RU,840,1840,0.707,,0.707,,1,,
 2SP,840,1840,48450,,,
 SE,,0,
 RU,840,2840,,1.0,,
 2SP,840,2840,61560,,,
 SE,,0,
 RU,840,3840,0.707,,,-0.707,,1,,
 2SP,840,3840,14820,,,
 SE,,0,
 NO,*****
 NO,CHANGE SOIL SPRING SPACING TO 2 FT (INSIDE 'INFLUENCE LENGTH')
 NO,*****
 NO,
 RU,840,850,1.414,,1.414,
 SE,,0,
 RU,850,1850,0.707,,0.707,,1,,
 2SP,850,1850,10200,,,
 SE,,0,
 RU,850,2850,,1.0,,
 2SP,850,2850,12960,,,
 SE,,0,
 RU,850,3850,0.707,,,-0.707,,1,,
 2SP,850,3850,3120,,,
 SE,,0,
 RU,850,860,1.414,,1.414,
 SE,,0,
 RU,860,1860,0.707,,0.707,,1,,
 2SP,860,1860,10200,,,
 SE,,0,
 RU,860,2860,,1.0,,
 2SP,860,2860,12960,,,
 SE,,0,
 RU,860,3860,0.707,,,-0.707,,1,,
 2SP,860,3860,3120,,,
 SE,,0,
 NO,*****
 NO,NEXT 2FT SECTION CONTAINS THE FLANGED END OF HDPE PIPE
 NO,
 NO,LENGTH OF PIPE UP TO THE BEGINNING OF FLANGE ADAPTER:
 NO, 2.0FT - 1.0 FT = 1.0 FT

CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC	Calculation No.	07Q3691-CAL-007
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis		
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2		
By:	<i>L. Hailer</i>	Date	11/10/08
Chk'd by	<i>Bruce P. Dubosechif</i>	Date	11/11/08

NO,*****
 NO,
 RU,860,870,0.707,,0.707,
 NO,
 NO,*****
 NO,INSTALL A FLANGE ADAPTER WITH A STEEL BACKUP RING MOUNTED ON IT
 NO,
 NO,PROPERTIES OF ADAPTER AND RING ARE AS LISTED EARLIER (NEAR THE
 NO,BEGINNING OF THIS MODEL)
 NO,*****
 NO,
 RU,870,875,0.530,,0.530,
 NOTE,IV=WNFL,END=FLG
 1V,875,880,0.177,,0.177,15.5,1.159,14.5,
 SE,,0,
 NO,*****
 NO, CHANGE TO STEEL PIPE
 NO,*****
 NO,12-IN, SCH. 40 Cr-Mo STEEL PIPE PROPERTIES:,
 NO, OUTSIDE DIAMETER = 12.75 IN
 NO, WALL THICKNESS = 0.375 IN
 NO, WT(PIPE)= 49.6 LB/FT = 4.13 LB/IN
 NO, WT(WATER) = 49.0 LB/FT= 4.08 LB/IN
 NO, WT(PIPE+WATER) = (49.6+49.0)/12 = 8.22 LB/IN
 NO,*****
 NO,
 PI,880,900,12.75,0.375,28.0,8.1,0.01,8.22,
 NO,
 NO,*****
 NO,INSTALL A 90-DEGREE ELBOW WITH A FLANGE WELDED TO ONE END
 NO,*****
 NO,FOR 12-IN SHORT RADIUS 90-DEG. ELBOW (BASED ON LADISH CATALOG):
 NO, LENGTH = 12 IN T = 0.375 IN
 NO, RADIUS = 12 IN WT(ELBOW)= 80 LB
 NO, WT(ELBOW+WATER)= 129.0 LB/FT = 10.75 LB/IN
 NO,*****
 NO,PROPERTIES OF 12-IN, 150-LB WELDING NECK FLANGE ARE AS LISTED,
 NO,EARLIER
 NO,*****
 NO,90-DEG. ELBOW WILL BE CONNECTED TO A VERTICAL 12-IN PIPE
 NO,*****
 NO,
 NOTE,IV=WNFL,BEG=FLG
 1V,880,900,0.269,,0.269,14.375,0.375,23.6,
 RU,900,910,0.71,,0.71,
 EL,910,920,,12.0,,10.75,
 RU,920,925,,-1.01,,
 NO,
 NO,*****
 NO,PIPE IS ORIENTED PARALLEL TO THE Y-AXIS
 NO,
 NO,WELD ONE END OF A 3 FT LONG, 12-IN PIPE TO END OF 90-DEG. ELBOW.
 NO,WELD A FLANGE TO OTHER END OF THE 3FT LONG PIPE.
 NO,*****
 NO,
 RU,925,930,,-3.0,,
 NOTE,IV=WNFL,END=FLG
 1V,930,940,,-0.38,,14.375,0.375,23.6,
 SE,,0,
 NO,
 NO,*****
 NO,CHANGE MATERIAL TO CARBON STEEL (SA-106)

CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC	Calculation No.	07Q3691-CAL-007
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis		
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2		
By:	<i>L. Hailer</i>	Date	11/10/08
		Chk'd by	<i>Bruce P. Dubosech</i>
		Date	11/11/08

NO, *****
 NO,
 PI,940,950,12.75,0.375,27.9,6.01,0.01,8.22,
 NO,
 NO, *****
 NO,WELD A FLANGE TO A 12-IN CARBON STEEL PIPE AND ATTACH THE PIPE TO
 NO,42-IN HEADER LENGTH OF PIPE = 12 IN = 1.0 FT
 NO, *****
 NO,
 NOTE,IV=WNFL,BEG=FLG
 1V,940,950,-0.38,,14.375,0.375,23.6,
 RU,950,985,-1.0,,
 NO,
 NO, *****
 NO,A WELDOLET IS USED BETWEEN THE 12-IN PIPE AND 42-IN HEADER
 NO,APPLY SIF=4.87 FOR WELDOLET AT JUNCTION POINT (CENTER OF 42" PIPE)
 NO, *****
 NO,42-IN DIAMETER PIPE PROPERTIES:
 NO, OD = 42 IN WALL THICKNESS = 0.500 IN
 NO, WT(PIPE) = 221.6LB/FT WT(WATER) = 571.7LB/FT
 NO, WT(PIPE+WATER)= 66.1LB/IN
 NO, *****
 NO,
 SE,,0,
 RU,985,990,-1.75,
 CH,985,990,42,0.500,,,66.1,
 JB,985,990,4.87,
 NO,
 EN,,0
 NO, ***** END OF RUN *****
 NO,
 EXECUTE
 NO, ***** DEADWEIGHT ANALYSIS *****
 NO,LOADING CASE NO. 10
 NO,CODE= ASME, YEAR = 1989, CLASS = 3
 NO,FOR 1989 ASME CODE, CLASS 3 ANALYSIS = CLASS 2 ANALYSIS
 NO,DESIGN PRESSURE = 100 PSI, PEAK PRESSURE = 75 PSI
 NO,SA-106 GRADE B CARBON STEEL PROPERTIES:
 NO, Sc = 15000 PSI Sh = 15000 PSI
 NO, Sy = 35000 PSI POISSON RATIO = 0.3
 NO, Ec = 27.9E+06 PSI
 NO,HDPE 50-YEAR DURATION PROPERTIES:
 NO, Sc = 800 PSI Sh = 800 PSI
 NO, Sy = 2500 PSI POISSON RATIO = 0.45
 NO, Ec = 0.028E+06 PSI
 NO,SB-690/SB-675 Cr-Mo STEEL PROPERTIES:
 NO, Sc = 23100 PSI Sh = 22200 PSI
 NO, Sy = 45000 PSI POISSON RATIO = 0.3
 NO, Ec = 28E+06 PSI
 NO,
 CL,,,3.0,1989,1,
 CO,3,1,10,100,75,23100,22200,
 MA,,,45000,,0.3,,,28.0,
 CL,130,133,3.0,100,75,800,800,
 MA,130,133,2500,,0.45,,,0.028,
 CL,880,900,3.0,100,75,23100,22200,
 MA,880,900,45000,,0.3,,,28.0,
 CL,940,950,3.0,100,75,15000,15000,
 MA,940,950,35000,,0.3,,,27.9,
 DEADWEIGHT,,,,-1,,
 XP,-27,20,
 EN,,,

CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC	Calculation No.	07Q3691-CAL-007
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis		
Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2		
By:	<i>L. Hailer</i>	Date	11/10/08
		Chk'd by	<i>Bruce P. Dubosech</i>
		Date	11/11/08

NO,
EXECUTE
NO,***** THERMAL ANALYSIS AT MIN TEMP = 32 F, LEVEL A *****
NO,LOADING CASE NO. 21
NO,Delta T = 32 F - 55 F = -23 F
NO,PROPERTIES OF HDPE, Cr-Mo AND CARBON STEEL ARE SAME AS DW CASE,
NO,
CL,,,3.0,1989,1,
CO,3,0,21,100,75,23100,22000,
MA,,,45000,,0.3,,,28.0,
CL,130,133,3.0,100,75,800,800,
MA,130,133,2500,,0.45,,,0.028,
CL,880,900,3.0,100,75,23100,22200,
MA,880,900,45000,,0.3,,,28.0,
CL,940,950,3.0,100,75,15000,15000,
MA,940,950,35000,,0.3,,,27.9,
CH,100,105,10.75,0.365,28.0,8.1,-23.,6.22,
CH,130,133,12.75,1.159,0.028,90.,-23.,4.62,
CH,880,900,12.75,0.375,28.0,8.1,-23.,8.22,
CH,950,985,12.75,0.375,27.9,6.07,-23,8.22,
TH,,0,
EN,,,
EXECUTE
NO,***** THERMAL ANALYSIS AT MAX TEMP = 100 F, LEVEL A *****
NO,LOADING CASE NO. 22
NO,Delta T = 100 F - 55 F = 45 F
NO,CARBON STEEL AND Cr-Mo STEEL PROPERTIES ARE SAME AS FOR DW CASE
NO,
NO,HDPE 50-YEAR DURATION PROPERTIES:
NO, Sc = 800 PSI Sh = 620 PSI
NO, Sy = 2500 PSI POISSON RATIO = 0.45
NO, Ec = 0.023E+06 PSI
CL,,,3.0,1989,1,
CO,3,0,22,100,75,23100,22000,
MA,,,45000,,0.3,,,28.0,
CL,130,133,3.0,100,75,800,620,
MA,130,133,2500,,0.45,,,0.023,
CL,880,900,3.0,100,75,23100,22000,
MA,880,900,45000,,0.3,,,28.0,
CL,940,950,3.0,100,75,15000,15000,
MA,940,950,35000,,0.3,,,27.9,
CH,100,105,10.75,0.365,28.0,8.1,45.,6.22,
CH,130,133,12.75,1.159,0.023,90.,45.,4.62,
CH,880,900,12.75,0.375,28.0,8.1,45.,8.22,
CH,950,985,12.75,0.375,27.9,6.07,45,8.22,
TH,,0,
EN,,,
EXECUTE
NO,***** THERMAL ANALYSIS AT MIN TEMP = 32 F, LEVEL B *****
NO,LOADING CASE NO. 23
NO,DELTA T=32 F - 55 F = -23F
NO,CARBON STEEL AND Cr-Mo STEEL PROPERTIES ARE SAME AS DW CASE
NO,HDPE 10 YEAR DURATION PROPERTIES
NO, Sc=840 PSI Sh=840 PSI
NO, Sy=2500 PSI POISSON RATIO=0.45
NO, Ec=0.032E+6 PSI
CL,,,3.0,1989,1,
CO,3,0,23,100,75,23100,22000,
MA,,,45000,,0.3,,,28.0,
CL,130,133,3.0,100,75,840,840,
MA,130,133,2500,,0.45,,,0.032,
CL,880,900,3.0,100,75,23100,22000,

CALCULATION CONTINUATION SHEET

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By:	<i>L. Hailer</i>	Date	11/10/08
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		Date	11/11/08

MA,880,900,45000,,0.3,,28.0,
 CL,940,950,3.0,100,75,15000,15000,
 MA,940,950,35000,,0.3,,27.9,
 CH,100,105,10.75,0.365,28.0,8.1,-23,6.22,
 CH,130,133,12.75,1.159,0.032,90,-23,4.62,
 CH,880,900,12.75,0.375,28.0,8.1,-23,8.22,
 CH,950,985,12.75,0.375,27.9,6.07,-23,8.22,
 TH,,0,
 EN,,,

EXECUTE

NO,***** THERMAL ANALYSIS AT MAX TEMP = 100 F, LEVEL B *****

NO,LOADING CASE NO. 24

NO,DELTA T = 100 F - 55 F = 45 F

NO,CARBON STEEL AND Cr.-Mo STEEL PROPERTIES ARE SAME FOR DW CASE

NO,HDPE 10 YEAR DURATION PROPERTIES

NO, Sc=840 PSI Sh=620 PSI

NO, Sy=2500 PSI POISSON=0.45

NO, Ec=0.026E+6 PSI

CL,,3.0,1989,1,

CO,3,0,24,100,75,23100,22200,

MA,,45000,,0.3,,28.0,

CL,130,133,3.0,100,75,840,620,

MA,130,133,2500,,0.45,,0.026,

CL,880,900,3.0,100,75,23100,22200,

MA,880,900,45000,,0.3,,28.0,

CL,940,950,3.0,100,75,15000,15000,

MA,940,950,35000,,0.3,,27.9,

CH,100,105,10.75,0.365,28.0,8.1,45,6.22,

CH,130,133,12.75,1.159,0.026,90,45,4.62,

CH,880,900,12.75,0.375,28.0,8.1,45,8.22,

CH,950,985,12.75,0.375,27.9,6.07,45,8.22,

TH,,0,

EN,,,

EXECUTE

NO,***** THERMAL ANALYSIS AT MIN TEMP = 32 F, LEVEL C/D *****

NO,LOADING CASE 25

NO,DELTA T = 32 F - 55 F = -23 F

NO,

NO,CARBON STEEL AND Cr.-Mo. STEEL PROPERTIES ARE SAME AS DW CASE

NO,HDPE 1000 HOUR DURATION PROPERTIES

NO, Sc=840 PSI Sh=840 PSI

NO, Sy=2500 PSI POISSON=0.45

NO, Ec=0.044E+6 PSI

CL,,3.0,1989,1,

CO,3,0,25,100,75,23100,22200,

MA,,45000,,0.3,,28.0,

CL,130,133,3.0,100,75,840,840,

MA,130,133,2500,,0.45,,0.044,

CL,880,900,3.0,100,75,23100,22200,

MA,880,900,45000,,0.3,,28.0,

CL,940,950,3.0,100,75,15000,15000,

MA,940,950,35000,,0.3,,27.9,

CH,100,105,10.75,0.365,28.0,8.1,-23,6.22,

CH,130,133,12.75,1.159,0.044,90,-23,4.62,

CH,880,900,12.75,0.375,28.0,8.1,-23,8.22,

CH,950,985,12.75,0.375,27.9,6.07,-23,8.22,

TH,,0,

EN,,,

EXECUTE

NO,***** THERMAL ANALYSIS AT MAX TEMP = 100 F, LEVEL C/D *****

NO,LOADING CASE 26

NO,DELTA T = 100 F - 55 F = 45 F

CALCULATION CONTINUATION SHEET

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Title	Analysis of Buried HDPE Piping System— Nuclear Service Water (NSW) Supply Line Diesel Generator “2A” Unit 2		
By:	<i>L. Hailer</i>	Date	11/10/08
		Chk'd by	<i>Bruce P. Dubosechif</i>
		Date	11/11/08

NO,CARBON STEEL AND Cr.-Mo. STEEL PROPERTIES ARE SAME DW CASE

NO,HDPE 1000 YEAR DURATION PROPERTIES

NO, Sc=840 PSI Sh=620 PSI

NO, Sy=2500 PSI POISSON=0.45

NO, Ec=0.036E+6 PSI

CL,,,3.0,1989,1,

CO,3,0,26,100,75,23100,22000,

MA,,,45000,,0.3,,,28.0,

CL,130,133,3.0,100,75,840,620,

MA,130,133,2500,,0.45,,,0.036,

CL,880,900,3.0,100,75,23100,22000,

MA,880,900,45000,,0.3,,,28.0,

CL,940,950,3.0,100,75,15000,15000,

MA,940,950,35000,,0.3,,,27.9,

CH,100,105,10.75,0.365,28.0,8.1,45,6.22,

CH,130,133,12.75,1.159,0.036,90,45,4.62,

CH,880,900,12.75,0.375,28.0,8.1,45,8.22,

CH,950,985,12.75,0.375,27.9,6.07,45,8.22,

TH,,0,

EN,,,

EXECUTE

NO,***** THERMAL ANALYSIS AT 65 F, PSEUDO-SEISMIC *****

NO,LOADING CASE NO. 30

NO,

NO,Delta T = 10 F

NO,CARBON STEEL AND Cr.-Mo. STEEL PROPERTIES ARE SAME AS DW CASE

NO,

NO,*** FOR HDPE, USE SHORT-TERM (< 10 HRS) PROPERTIES:,

NO, Sc = 1200 PSI Sh = 1200 PSI

NO, Sy = 2500 PSI POISSON RATIO = 0.35

NO, Ec = 0.110E+06 PSI

CL,,,3.0,1989,1,

CO,3,0,30,100,75,23100,22200,

MA,,,45000,,0.3,,,28.0,

CL,130,133,3.0,100,75,1200,1200,

MA,130,133,2500,,0.35,,,0.110,

CL,880,900,3.0,100,75,23100,22200,

MA,880,900,45000,,0.3,,,28.0,

CL,940,950,3.0,100,75,15000,15000,

MA,940,950,35000,,0.3,,,27.9,

CH,100,105,10.75,0.365,28.0,8.1,10.,6.22,

CH,130,133,12.75,1.159,0.110,90.,10.,4.62,

CH,880,900,12.75,0.375,28.0,8.1,10.,8.22,

CH,950,985,12.75,0.375,27.9,6.07,10,8.22,

TH,,0,

EN,,0,

NO,

EXECUTE

NO,***** COMBINE LOAD CASES 21 AND 22, LEVEL A *****

NO,METHOD OF LOAD COMBINATION = ABSOLUTE VALUE OF RANGE

NO,LOADING CASE NO. 27

CL,,,3.0,1989,3,

NE,7,,21,22,,,,27,

OU,4,,27,

EN,,,

EXECUTE

NO,***** COMBINE LOAD CASES 23 AND 24, LEVEL B *****

NO,METHOD OF LOAD COMBINATION = ABSOLUTE VALUE OF RANGE

NO,LOADING CASE NO. 28

CL,,,3.0,1989,3,

NE,7,,23,24,,,,28,

OU,4,,28,

CALCULATION CONTINUATION SHEET

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By:	<i>L. Hailer</i>	Date	11/10/08
Chk'd by	<i>Bruce P. Dubouché</i>	Date	11/11/08

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EN,,0,
EXECUTE
NO,***** COMBINE LOAD CASES 25 AND 26, LEVEL C/D *****
NO,METHOD OF LOAD COMBINATION = ABSOLUTE VALUE OF RANGE
NO,LOADING CASE NO. 29
CL,,,3.0,1989,3,
NE,7,,25,26,,,,,29,
OU,4,,29,
EN,,0,
EXECUTE
NO,***** COMPUTE ABSOLUTE RANGE FOR LOAD CASE 30 (SEISMIC) *****
NO,THESE LOADS REPRESENT SSE SEISMIC LOAD RANGES
NO,METHOD OF COMPUTING = ABSOLUTE LOAD CASE 30 + ABSOLUTE LOAD CASE 30
NO,LOADING CASE NO. 31
CL,,,3.0,1989,3,
NE,3,,30,30,,,,,31,
OU,4,,31,
EN,,0,
EXECUTE
NO,***** DIVIDE ABSOLUTE RANGE OF LOAD CASE 30 BY 1.875 *****
NO,THESE LOADS REPRESENT OBE SEISMIC LOAD RANGES
NO,METHOD OF COMPUTING = FACTORING --> 0.5333*LOAD CASE 31
NO,LOADING CASE NO. 32
CL,,,3.0,1989,3,
NE,8,,31,0.5333,,,,,32,
OU,4,,32,
EN,,0,
EXECUTE
NO,***** COMBINE THERMAL AND OBE LOADS: LEVEL B *****
NO,METHOD OF COMBINATION = ADD ABSOLUTE VALUES OF EACH LOAD
NO,LOAD CASE NO. 40 -- USE THERMAL LOADS OBTAINED AT MINIMUM TEMP. (LOAD CASE 21)
NO,LOAD CASE NO. 41 -- USE THERMAL LOADS OBTAINED AT MAXIMUM TEMP. (LOAD CASE 22)
CL,,,3.0,1989,3,
NE,3,,21,32,,,,,40
NE,3,,22,32,,,,,41
OU,1,,40,
OU,1,,41,
EN,,0,
EXECUTE
NO,***** SEARCH FOR HIGHEST LOADS FROM LOAD CASES 27, 40, AND 41: LEVEL B *****
NO,LOAD CASE NO. 45
CL,,,3.0,1989,3,
NE,9,,27,40,41,,,,,45
OU,1,,45,
EN,,0,
EXECUTE
NO,***** GENERATE STRESS REPORT: LEVEL A *****
CL,,,3.0,1989,1,
EQUATION,8,,10
EQUATION,9,,10
EQUATION,10,,,27
EN,,0,
EXECUTE
NO,***** GENERATE STRESS REPORT: LEVEL B *****
CL,,,3.0,1989,2,
EQUATION,8,,10
EQUATION,9,,10
EQUATION,10,,,45
EN,,0,
EXECUTE
NO,***** GENERATE STRESS REPORT: LEVEL C/D *****
CL,,,3.0,1989,4,

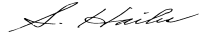
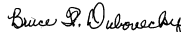
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CALCULATION CONTINUATION SHEET

Client	Duke Power Carolinas, LLC			Calculation No.	07Q3691-CAL-007		
Project	Catawba Unit # 1 and #2 – Buried HDPE Piping Design and Analysis						
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By:		Date	11/10/08	Chk'd by		Date	11/11/08

EQUATION,10,,,31
EN,,0,

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OUTPUT FILE:

Output file on CD-Rom