DESIGN CRITERIA BFN-50-C-7100

ATTACHMENT F

BROWNS FERRY NUCLEAR PLANT

DETAILED

DESIGN CRITERIA

FOR

STRUCTURAL AND MISCELLANEOUS STEEL/COMPONENTS

FOR CLASS I AND II STRUCTURES

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1.0 PURPOSE AND SCOPE

1.1 Purpose

The purpose of these criteria is as follows:

1. To establish the requirements for the design and evaluation of all structural and miscellaneous steel.
2. To provide a basis for detailed design and design control.
3. To establish requirements for the designer and checker to assure design uniformity and a safe complete design of steel components/features considering all applicable loading conditions.

1.2. Scope

These criteria provide the requirements for steel components/features located in all Class I and II structures.

The design of ASME (subject to the requirements of the ASME Boiler and Pressure Vessel Code) supports and associated miscellaneous steel are specifically excluded from the requirements given herein.

2.0 DESIGN SPECIFICATIONS

For either structural design or evaluation, the AISC Specification (Ref 7.1-1) shall be used.

3.0 LOADS

3.1 Loading Definitions

D or D_L - Dead load, including structural steel, or permanent equipment, hydrostatic loads and attached systems, e.g., piping, HVAC, cable trays, etc. An allowance may be made for future permanent loads.

DYNB, DYNC, and DYND - Dynamic Reaction of attached systems, e. g. piping, HVAC, cable trays, etc. due to upset (service level B), emergency (service level C), and faulted (service level D) dynamic events, respectively.

Note: Not all attached systems are analyzed for the faulted condition; therefore, some reaction points on the steel will only have upset and emergency loading.

DYBD - The larger of DYNB or DYND

DYCD - The larger of DYNC or DYND

E - Loads due the effects of OBE on structural steel and permanent floor mounted equipment. For the Lower Drywell Platforms, this excludes support loads from attached piping, HVAC ducts and cable trays (these loads are defined under DYNB, DYNC, and DYND).

E' - Loads due to the effects of DBE on structural steel and permanent floor mounted equipment. For the Lower Drywell Platforms, this excludes support loads from attached piping, HVAC ducts and cable trays (these loads are defined under DYNB, DYNC, and DYND).

L_o - Outage and maintenance loads, including any moveable equipment loads and other loads which vary with intensity and occurrence during an outage, i. e., these loads shall not be present while the plant is operating. An L_o of 100 psf applied to the loadable open area shall be evaluated as a baseline outage and maintenance live load for the initial analysis using these criteria. As concentrated live loads due to outage or maintenance procedures are identified these loads shall be evaluated against the base line case. If the results of the concentrated loads exceed the baseline case, the concentrated loads must be evaluated per these criteria.

L_L - Live loads (loads which vary in intensity and occurrence) including movable equipment and lateral soil pressures.

L_{LC} - Construction live loads (greater than normal operating live loads of a temporary or unusual nature).

P_a - Pressure equivalent static load effects from a Design Basis Accident (DBA) including an appropriate dynamic load factor.

RFE - Restraint of free end displacement loads due to thermal reactions from attached piping systems, based on the most critical thermal condition.* RFE loads can be subdivided as follows:

RFE_{U1} - RFE reactions which contribute to uplift.

RFE_s - All other RFE reactions, i. e. reactions which do not contribute to uplift.

*If reduced conservatism is needed, RFE loads may be defined for upset, emergency, and faulted conditions corresponding to the associated dynamic loading conditions (DYNB, DYNC & DYND).

R_o - Pipe reactions during normal conditions or upset conditions based upon the most critical transient or steady state conditions.

R_a - Pipe reactions under thermal conditions generated by the postulated pipe break and including R_o (faulted).

T_a - Thermal loads due to temperature differences under postulated pipe break accident conditions and including To .

T_o - Thermal loads due to temperature differences under normal operating or shutdown conditions, based upon the most critical transient or steady state condition.

T_w - Tornado generated loads due to the tornado wind pressure, the tornado created differential pressure, and tornado generated missiles.

W_L - Wind load acting on various parts of the building surface.

Y_j - Jet impingement equivalent static load generated by a postulated pipe break including an appropriate dynamic factor.

Y_m - Missile impact equivalent static load generated by postulated pipe break, including an appropriated dynamic factor.

Y_r - Equivalent static loads generated by the reaction of a broken high-energy pipe during a postulated break including an appropriate amplification factor.

The application of pipe rupture loads only at those locations where mitigation exists is consistent with the baseline approach to pipe rupture design inside the drywell. Only those locations where GE and/or TVA negotiated pipe rupture mitigation as part of the original design need by considered. See Design Criteria BFN-5-C- 7105,Section4.2 for further information.

3.2 Loads

3.2.1 Dead Loads

Concrete, Reinforced	150 pcf (For dead load calculation) 145 pcf (for stability analysis)
Steel Framing	Shall be calculated using 490 pcf
1 1/2" Steel Grating	12 psf; other size grating as listed in the manufacturer's catalog

Monorails, Hoist and Cranes	Obtain loads from the Mechanical discipline
Masonry Block Wall	Attachment B of Reference 7.3-1
Anchor Bolts, sleeves, plates and other embedded material	Shall be obtained from vendor/ supplier.
Ductwork	Section 1.5 of these criteria (Reference 7.3-1), BFN-50-C- 7103 (Reference 7.3-2) and BFN-50-C-7104 (Reference 7.3-3)
Stairwell Fire Protection Partitions	10 psf
Cable Trays	BFN-50-C-7103 (Reference 7.3-2) and BFN-50-C-7104 (Reference 7.3-3)
Conduit	BFN-50-C-7104 (Reference 7.3-3)
Piping	Mechanical Design Guide (Reference 7.2-1)
Pipe Insulation	Mechanical Design Guide (Reference 7.2-2)
Equipment	Shall be obtained from the Mechanical, Electrical, and/or other appropriate design discipline and from equipment manufacturers drawings as applicable, including the location of the center of gravity.

Note: The dead load for the lower drywell platforms El. 563'-2'' and El. 584'-11''attached systems, e. g. piping, HVAC, cable trays etc, shall be a minimum of 40 psf.

3.2.2 Live Loads

All live loads shall be in accordance with the Live Load Drawings when available. Otherwise, live loads listed herein shall be used.

For all load cases with seismic, live loads (L_L) shall be reduced to 10 psf (accelerated, horizontally and vertically) and combined with other seismic loads. For the drywell platforms at El. 563'-2", El. 584'-11", El. 604'-0", El. 616'-0" and El. 628'-0" this 10 psf live load can be excluded for seismic load cases due to the inaccessibility of the drywell during operation and the requirement to remove any live load during drywell closeout prior to plant operation.

Access Stairs	
Main stairs	100 psf
Miscellaneous	75 psf
Grating, general floor areas	Minimum of 150 psf plus equipment unless otherwise noted
Grating, access platforms	100 psf plus equipment (D_L + L_L) 10 psf + equipment (D_L + L_L + E or E')
Cable tray access walkways	BFN-50-C-7103 (Reference 7.3- 2) BFN-50-C-7104 (Reference 7.3- 3)
Hatch covers, shield plugs	Applicable floor live load
Access doors	Obtain loads from the Mechanical discipline
Missile shields	BFN-50-C-7105 (Reference 7.3- 4)
Ladders (portable and fixed)	200 pounds of single concentrated load as a minimum
Decking steel construction load	Weight of wet concrete plus 20 psf

Pressure loadings 0.25 psi
El. 582.0' Blowout panels

Note: The uniform live load shall not be applied in the areas occupied by specific defined equipment loads.

3.2.3 Seismic Loads

Steel components shall be designed to withstand Operating Basis Earthquake (OBE) loads resulting from maximum ground accelerations (0.10g) in the controlling horizontal direction and maximum vertical ground accelerations (0.067g) in combination with other loads specified herein, where g = gravitational constant = 386 in/sec^2. In addition, these components shall be designed to withstand Design Basis Earthquake (DBE) loads resulting from maximum ground accelerations (0.20g) in the controlling horizontal direction and maximum vertical ground acceleration (0.13g) in combination with other loads specified herein. Seismic accelerations and analyses shall be in accordance with BFN-50-C-7102 (Reference 7.3-5).

Stainless steel liner plates shall not be designed for seismic loadings.

3.2.4 Abnormal Accident Loads

Load terms Y_j , Y_m , Y_r , T_a , P_a , R_a are considered Abnormal Accident Loads (References 7.3-4, 7.3-1, and 7.3-2)

3.2.5 Thermal Loads

Environmental drawings will supply appropriate temperatures and pressures for calculating thermal loads T_o and T_a (Reference 7.3-1).

4.0 LOADING COMBINATIONS AND ALLOWABLE STRESSES

4.1 Definitions

F_y - Specified minimum yield stress of structural steel (psi).

f'c - Specified design compressive strength of concrete (psi).

S - The allowable stress based on the elastic design methods per AISC (Reference 7.1-1)

4.2 Allowable Stresses

4.2.1 Definition of Maximum Allowable Stress

The maximum allowable stress, S, is based on the AISC Code (Reference 7.1-1). The one-third increase in allowable stresses per the AISC Code due to earthquake or wind is not permitted.

4.2.2 Upper Limit to Allowable Stresses

The upper stress limit in the bending and tensile stresses shall be $0.90F_y$. Compressive stresses shall be limited to 0.90 times the critical buckling stress (Reference 7.2-4). Shear stresses shall be limited to $0.52F_y$.

4.3 Loading Combinations and Allowable Stresses

4.3.1 The Lower Drywell Platforms

The loading combinations and corresponding allowable stresses to be used for the Lower Drywell Platforms at El. 563'-2" and El. 584'-11" are given in Table 4.3.1.

4.3.2 Other Steel Features

The loading combinations and corresponding allowable stresses to be used for all other steel features are given in Table 4.3.2.

4.4 Maximum Allowable Bearing Stress in Concrete Supports

Bearing stress in concrete supports imposed by direct loads of structural steel members shall not exceed 0.3 f'c for normal and extreme loads except where the supporting surface is wider on all sides than the loaded area, in which case, the permissible bearing stress on the loaded area may be multiplied by $(A_2 / A_1)^{0.5}$ but not more than 2, where:

A_2 shall be the area of the lower base of a right pyramid or cone contained wholly within the support and having for its upper base the loaded area (A_1) and having side slopes of 1 vertical to 2 horizontal.

4.5 Punching Shear in Tube-to-Tube Connections

Tube-to-tube welded connections shall be designed for punching shear in accordance with Section 10.5 of AWS (Reference 7.1-2) or later editions.

TABLE 4.3.1

LOWER DRYWELL PLATFORMS

LOADING COMBINATIONS AND ALLOWABLE STRESSES

Combination No.	Combination	Allowable Stress	(4,5) Notes
A.	$D + L_o$	1.0S	
B.	D + E + DYNB	1.0S	
C.	$D + L_o + E + DYNB$	1.0S	
D.	$D + E + DYNB + T_o + RFE_s$	1.5S	1
E.	$D + L_o + E' + DYNC$	1.5S	
F.	$D + E' + DYNC + T_o + RFE$	1.5S	1
G.	$D + E' + DYCD + Y_r$	1.5S	2
H.	$D + DYND + T_a + RFE_s$	1.5S	1
I.	$D + E + DYBD + T_a + RFE_s + Y_r$	1.5S	1,2
J.	$D + E' + DYCD + T_a + RFE_s + Y_r$	1.5S	1,2

UPLIFT EVALUATION

	Static Loading	Dynamic Loading	
A.	$.9D + T_o + RFE_{U1}$	-	3
B.	.9D	DYNB + E	3
C.	$.9D + T_o + RFE_{U1}$	DYNB + E	3
D.	.9D	DYNC + E'	3
E.	$.9D + T_o + RFE_{U1}$	DYNC + E'	3
F.	$.9D + T_a + RFE_{U1}$	$DYND + E + Y_r$	3
G.	$.9D + T_a + RFE_{U1}$	$DYND + E' + Y_r$	3

TABLE 4.3.2

OTHER STEEL FEATURES
LOADING COMBINATIONS AND ALLOWABLE STRESSES

Combination No.	Combination	Allowable Stress	4, 5 Notes
1.	Normal Operating $D_L + L_L + R_o$	1.0S	6
2.	Normal Operating + OBE (Seismic) $D_L + L_L + E + R_o$	1.0S	
3.	Normal Operating + Wind $D_L + L_L + W_L + R_o$	1.0S	6
4.	OBE (Seismic) + Thermal $D_L + L_L + T_o + R_o + E$	1.5S	1
5.	Normal Operating + Thermal + Wind $D_L + L_L + T_o + R_o + W_L$	1.5S	1,6
6.	DBE (Seismic) $D_L + L_L + T_o + R_o + E'$	1.5S	1
7.	Normal Operating + Thermal + Tornado $D_L + L_L + T_o + R_o + T_w$	1.5S	1
8.	Abnormal Accident $D_L + L_L + T_a + R_a + P_a$	1.5S	1
9.	Abnormal Accident + OBE (Seismic) $D_L + L_L + T_a + R_a + P_a + 1.0$ $(Y_j + Y_m + Y_r) + E$	1.5S	1
10.	Abnormal Accident + DBE (Seismic) $D_L + L_L + T_a + R_a + P_a + 1.0$ $(Y_j + Y_m + Y_r) + E'$	1.5S	1
11.	Construction $D_L + L_L$ or $D_L + L_{LC}$	1.0S	6

NOTES FOR TABLES 4.3.1 AND 4.3.2

1. In the preceding factored load combinations, thermal loads (T_o and T_a) can be neglected when it can be shown that they are secondary and self limiting in nature and where the material is ductile.

   The secondary and self limiting nature of thermal loadings may be demonstrated using Civil Design Guide DG-C1.6.12, "Evaluation of Steel Structures with Thermal Restraints", with the following limitations:

   a. Ductility ratios shall be limited to less than or equal to three (3). Ductility ratios exceeding this value shall require further evaluation on a case-by-case basis.

   b. Self drilling concrete anchors may be considered acceptable for thermal loadings if the thermal shear displacement from thermal loads only (not combined with other loads) are less than or equal to 0.1 times the nominal anchor diameter.

   c. Concrete anchors other than self drilling anchors may be considered acceptable for thermal loading if the thermal shear displacements from thermal loads only (not combined with other loads) are less than or equal to 0.2 times the nominal anchor diameter.

   d. Weld stresses shall be limited to two thirds of nominal tensile strength of the weld metal.

2. Only one pipe whip reaction should be considered at any given time; however, all postulated breaks for which pipe rupture mitigation structures exist and are attached to the drywell steel must be considered.

3. In each combination, it must be shown that the magnitude of the beam seat reaction due to static loading is greater than the reaction due to dynamic loading, unless and adequate tie down exists or the magnitude of uplift is within acceptable limits of 0.05 inches.

4. The requirements of TVA Civil Design Standard DS-C1.7.1, as applicable, (Reference 7.2-3) shall be applied for evaluation and design of concrete anchorages for supports.

5. For limitations on allowable stresses, see Section 4.2.2.

6. Class II Structures shall be designed for load combinations 1,3,5 and 11 only. Class II Structures contained in Class I Structures shall also be designed for load combination 6.

5.0 SPECIAL DESIGN REQUIREMENTS FOR STAINLESS STEEL LINER PLATES AND ITS ANCHORAGE

5.1 Pressure Loadings for Sumps

Stainless steel liner plate pressure loads can be either external or internal. Internal positive pressure due to increased atmospheric pressure and hydrostatic pressure are resisted by the concrete with the liner plate assumed to be fully supported and acting only as a leakproof membrane. External positive pressure and internal negative pressure loads are to be resisted by the liner plate considering liner plate anchorages as supports. The external pressure loads are derived from hydrostatic loads. The hydrostatic loads can be generated by the separation of the liner plate from the concrete allowing water intrusion between the liner plate and the concrete. For an open top (no liner plate at the top) sump, the hydrostatic pressure is assumed to be produced by a height of water no greater than the height of the sump. For enclosed or sealed sumps the hydrostatic pressure is assumed to be produced by a height of water no greater than the height of the sump.

5.2 Pressure Loading for Spent Fuel Pools, Transfer Canals, and Fuel Cask Areas

The stainless steel liner plate shall not be used as formwork for wet concrete. The liner plate shall be designed for an internal pressure load. The internal pressure load is due to increased atmospheric pressure and hydrostatic pressure. This pressure is resisted by the concrete with the liner plate assumed to be fully supported and acting only as a leakproof membrane. The liner plate shall be backed by a system of drainage channels. The channels shall be capable of draining all water which might accumulate between the liner plate and the concrete.

5.3 Liner Plate Anchorage

The stainless steel liner plate, in order to maintain its function as a leakproof membrane, shall be restrained against excessive movement away from its concrete support. It should be noted that the stainless steel liner plate will buckle (inelastically deform) even under moderate temperature changes. The anchoragesystem shall be designed so as to prevent inordinate movement even though the liner plate has buckled (Ref. 7.2-3).

5.4 Inspection of Leak Tight Liner Welds

All leak tight field welding shall be one hundred percent (100%) inspected by the vacuum box liquid penetrant inspection method in accordance with Reference 7.1-3, with a note to this effect incorporated in the drawings.

6.0 ADDITIONAL DESIGN REQUIREMENTS

- All future design calculations and revisions to existing calculations shall be prepared in accordance with Reference 7.1-4.

- All field welding shall be performed in accordance with Reference 7.1-3 unless noted otherwise.

- Each drawing involving material to be furnished shall have a note incorporated on the drawing indicating the appropriate quality level to which the material will be purchased.

- For structural shapes called out on drawings or in calculations which are not contained in the 8th Edition of the AISC Specification, consult the 6th or 7th Editions of the AISC Specifications for section properties.

7.0 REFERENCES

7.1 Design Input

1) American Institute of Steel Construction (AISC) Specification for the Design, Fabrication & Erection for Structural Steel for Buildings, 8th edition, Nov. 1, 1978.

2) American Welding Society Structural Welding Code, AWS D1.1-81.

3) TVA General Construction Specification G-29.

4) TVA Engineering Procedure NEP-3.1, "Calculations."

7.2 Background

1) Mechanical Design Guide, DG-M5.1.3, "Steel Piping Materials Accessories and Systems Design Consideration."

2) Mechanical Design Guide, DG-M18.9.1, "Insulation for Piping and Equipment in Nuclear Power Plants."

3) TVA Civil Design Standards DS-C1.7.1, "General Anchorage to Concrete."

4) Design of Structural Steel Members (Building, Miscellaneous, and Supplement Steel), Civil Design Guide, DG-C1.6.7.

7.3 Design Criteria

1) BFN-50C-7100, "General Design Criteria - Design of Civil Structures."

2) BFN-50C-7103, "General Design Criteria - Structural Analysis and Qualification of Mechanical and Electrical Systems."

3) BFN-50-C-7104, "Design of Structural Supports"

4) BFN-50-C-7105, "General Design Criteria - Pipe Rupture, Internal Missiles, Internal Flooding, Seismic Equipment Qualification and Vibration Qualification of Piping."

5) BFN-50-C-7102, "Seismic Design."

6) BFN-50-C-7107, "Design of Class I Seismic Pipe and tubing supports."

ENCLOSURE 3
BROWNS FERRY NUCLEAR PLANT
SUMMARY OF COMMITMENTS

1) The Units 1 and 3 lower drywell steel platforms and miscellaneous steel will be evaluated and modified, if required, to meet the design criteria prior to the restart of Units 1 and 3, respectively.

2) The Unit 2 lower drywell steel platforms and miscellaneous steel will be evaluated and modified, if required, to meet the design criteria prior to Unit 2 restart from the next refueling outage.