ENCLOSURE 4

DESIGN CRITERIA WB-DC-20-21
MISCELLANEOUS STEEL COMPONENTS FOR CATEGORY I STRUCTURES

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TVA Tennessee Valley Authority

TENNESSEE VALLEY AUTHORITY

Division of Nuclear Engineering

NE NUCLEAR ENGINEERING

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DESIGN CRITERIA

NO. WB-DC-20-21

WATTS BAR NUCLEAR PLANT

TITLE: MISCELLANEOUS STEEL COMPONENTS FOR CATEGORY I STRUCTURES

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No.	Description of Revision	Date Approved
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	2. Paragraph 2.0--Revised general description.	
	3. Paragraph 2.1.1--Referenced DC for cable tray supports	
	4. Paragraph 2.1.10--Added anchor bolts as embedded parts	
	5. Paragraph 3.0--Revised seismic report title, added reference to Civil Design Standard DS-C6.1 and AWS D1.1, deleted reference G-29C.	
	6. Paragraph 4.2--Added reference to Civil Design Standard DS-C6.1. Revised pipe handrail material specification.	
	7. Paragraph 4.8--Deleted reference to TVA-QAP-II-2.4.	
	8. Revised Tables 1, 2, 3 and 4.	
	9. Paragraph 2.3.3--Added reference to CEB-76-5.	
	10. Paragraph 2.3.6--Added reference to WB-DC-40-31.8.	
2	1. Revised Section 2.0 to add a delineation of the term "Class I Structure."	12-7-82
	2. Revised Section 4.7 to require field welding to be performed in accordance with G-29C.	
	3. Miscellaneous revisions to Sections 2.1.6, 3.0, and Table 3.	
	4. Removed pipe supports from Section 2.1.1.	
3	Replaced cover sheet with an updated one and added a reference to the additions criteria (WB-DC-20-1.1.)	4-13-83
4	Cover sheet of Design Criteria was revised to reference Design Criteria WB-DC-20-1.1 which incorporates requirements of DIM-WB-20-21-1. (CEB 83 0825 017).	9-04-84
5	This revision incorporates applicable commitments and requirements through May 16, 1986. The revised portions of the document are identified by vertical lines.	7-22-88

Title: DESIGN CRITERIA FOR MISC. STEEL COMPONENTS FOR CATEGORY I STRUCTURES		REVISION LOG WB-DC-20-21
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5 (Cont)	Added Abbreviations page This page replaced by DCN S-16078-A Revised Sections 1.0, 2.0, 3.0, 5.0, and 7.0 Added Sections 4.0 and 6.0 Deleted Table 3.1-2 Revised Tables 5.1-1, and 5.1-2 to add references Added Appendix A.	
6	Incorporate requirements in accordance with DIM-WB-DC-20-21-2 (B26 881031 034), DIM-WB-DC-20-21-3 (B26 881013 025), and DIM-WB-DC-20-21-4 (B26 890322 021).	12-07-89

DCN # S-14373-A DCN RIMS NO. B26 '90 1204 828 DEC 04 1990

The DCN supersedes DIM WB-DC-20-21-5 and incorporates criteria for the evaluation of miscellaneous steel for thermal loads. The DCN also revises the format of Appendix A to be consistent with the main design criteria.
Pages iii, v, vi, 2, 4, 7, 11, A1, A2, A3, A4, and A6 are revised. Revision is indicated by a vertical bar.
Pages A4.1, A6.1 through A6.6, and A7 are added.

DCN # S-16078-A DCN RIMS NO. B26910513804

The DCN revises criteria in Section A8.0 for the evaluation of miscellaneous steel for thermal loads.
Pages iii, vi, A6, A6.1 through A6.4 are replaced. Revision is indicated by vertical bar.
Pages A6.5, A6.6, and A7 are deleted.

COORDINATION LOG

Document No: WB-DC-20-21

Title: MISCELLANEOUS STEEL COMPONENTS FOR CATEGORY I STRUCTURES

Revision: 6

R-Denotes review

A-Denotes approval/ agreement

ENGINEERING AND TECHNICAL SERVICES (E&TS)													
CEB		EEB		MEB		NEB		ECB		Contracts Section			
R	A	R	A	R	A	R	A	R	A	R	A	R	A

PROJECT ENGINEERING (PR ENG)															
BFEP		BLEP		SQEP		WBEP		WP		PSB		WBEP			
R	A	R	A	R	A	R	A	R	A	R	A	R	A	R	A
						FS	FS								
						[illegible]	[illegible]								

ENGINEERING ASSURANCE (EA)						DNQA		OPERATIONS ENGINEERING SERVICES (OES)							
SYS & EVAL		SVS		ADM				PMS		EI&C		MSB		RAM	
R	A	R	A	R	A	R	A	R	A	R	A	R	A	R	A

STAFFS						OTHER ORGANIZATIONS									
BACS		ERIS		PSS		BFN	NSD	BLN	NSD	SQN	NSD	WBN	NSD	DNC	
R	A	R	A	R	A	R	A	R	A	R	A	R	A	R	A

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ABBREVIATIONS

AISC - American Institute of Steel Construction

ASCE - American Society of Civil Engineers

ASME - American Society of Mechanical Engineers

ASTM - American Society for Testing Materials

AWS - American Welding Society

DBA - Design Basis Accident

ksi - Kips per square inch

NRC - Nuclear Regulatory Commission

OBE - Operating Basis Earthquake (1/2 SSE)

PMP - Probable Maximum Precipitation

pcf - Pounds per cubic foot

psf - Pounds per square foot

psi - Pounds per square inch

SSE - Safe Shutdown Earthquake

TVA - Tennessee Valley Authority

WBNP - Watts Bar Nuclear Plant

NEP - Nuclear Engineering Procedure

ZPA - Zero Period Acceleration (Acceleration @ 33Hz)

1.0 PURPOSE

The purpose of this design criteria is to establish a guide for the designer and checker to assure design uniformity so that a safe and complete design of miscellaneous steel features, considering all loading conditions, is achieved in conformance with Appendix A, 10CFR50, Criteria 2 and 4 (Reference 7.5.1).

The requirements provided in this design criteria shall be used for evaluations of the design of the existing miscellaneous steel. See Appendix A for additional requirements for new design of miscellaneous steel and modifications to existing miscellaneous steel. Appendix A to the criteria provides the design basis for the modification of existing or addition of new miscellaneous steel members.

2.0 GENERAL DESCRIPTION

Miscellaneous steel for all Category I structures is that segment of steel not covered by structural steel design criteria for the various Category I structures. The Category I structures include the reactor, auxiliary, control and diesel generator buildings and the essential raw cooling water facilities.

Miscellaneous steel components of the Category I structures for which this document applies are identified as:

2.1 Equipment supports not specifically covered by other design criteria, for example, pumps, fans, motors and control centers etc.

The following components are covered by other criteria:

WB-DC-20-21.1 (Ref. 7.2.4)	Cable Tray Supports
WB-DC-40-31.9 (Ref. 7.2.7)	Pipe Supports
WB-DC-40-31.6 (Ref. 7.2.12)	Tanks and Tank Supports
WB-DC-40-31.8 (Ref. 7.2.6)	Duct Supports
WB-DC-40-31.10 (Ref. 7.2.13)	Conduit Supports
WB-DC-40-31.11 (Ref. 7.2.14)	Lighting Supports

2.2 Monorail, hoist, and monorail supports.

2.3 Crane rails, stops, accessories, and anchorages.

2.4 Access stairs and platforms.

2.5 Hatch covers, shield plugs, access doors, and anchorages.

2.6 Liner plates (sump, spent fuel pool, fuel cask loading pit, etc.) and anchorages.

2.7 Supplementary framing.

2.8 Handrail.

2.9 Grating and decking.

2.10 Miscellaneous embedded parts (frames, curbs, sleeves, support plates, anchor bolts, etc.)

2.11 All other miscellaneous steel as required to ensure the proper functioning of the facilities.

2.12 Category I(L) equipment supports and anchorage. Refer to WB-DC-40-64, "Design Basis Events Design Criteria" for equipment requiring a minimum level of seismic qualification (Reference 7.2.~~3.4~~ 34). S-14373-A

3.0 DESIGN CONSIDERATIONS

The reactor, control, auxiliary, and diesel generator buildings and the essential raw cooling water facilities are Category I structures. All miscellaneous steel within or attached to these structures, which upon failure, would result in possible damage to safety equipment, piping, ducts, and related components which are designed to remain functional in the event of a safe shutdown earthquake, shall be designed for seismic loading. The miscellaneous steel design shall consider the effects from other attachments. The design loads and loading combinations are defined as follows:

3.1 Design Conditions

Definition of Load Terms

The following terms are used in the load combination equations:

Normal loads, which are those loads to be encountered during normal plant operation and shutdown, include:

D - Dead loads or their related internal moments and forces, including any permanent equipment loads, all hydrostatic loads, earth loads applied to horizontal surfaces and fireproofing.

L - Live loads or their related internal moments and forces, including any movable equipment loads and other loads which vary with intensity and occurrence, such as snow, rain, construction live load, etc.

Severe environment loads include:

E - Loads generated by the one-half safe shutdown earthquake (1/2 SSE also termed OBE-Operating Basis Earthquake).

W - Loads generated by the design wind specified for the plant.

Extreme environmental loads include:

E' - Loads generated by the safe shutdown earthquake (SSE also termed DBE-Design Basis Earthquake).

W_t - Loads generated by the design tornado specified for the plant. Tornado loads include loads due to the tornado wind pressure (Ww), the tornado-generated pressure differential (Wp), and tornado-generated missiles (Wm).

3.1.1 Dead Loads (D)

The following loads shall be used for the design:

3.1.1.1	Concrete floor	145 pcf
3.1.1.2	1 1/2-inch grating	12 psf
3.1.1.3	Pipe	Representative loads to be furnished by the appropriate engineering branch. Check against final loads when available. See report CEB-76-5. (Reference 7.2.11)
3.1.1.4	Equipment	To be furnished by appropriate design section.
3.1.1.5	Monorail, hoists and cranes	Self weight
3.1.1.6	HVAC	Load estimated, per WB-DC-40-31.8. (Reference 7.2.6)

3.1.1.7	Other Attachments	To be furnished by appropriate design section.
3.1.1.8	Anchor bolts, sleeves, and other embedded material	To be furnished by appropriate design section.
3.1.1.9	Steel roof decking (Auxiliary Building)	4 psf
3.1.1.10	Fireproofing	Shall be included as a dead load where applicable.
3.1.1.11	Conduit/Cable Tray	Representative loads to be furnished by the appropriate engineering branch.

3.1.2 Live Loads (L)

The following loads shall be used for the design:

3.1.2.1	Access stairs	
	Main stairs	100 psf
	Miscellaneous stairs	75 psf
3.1.2.2	Grating, general floor areas	As designated for the floor framing with a minimum of 150 psf or equipment.
3.1.2.3	Grating, access platforms	100 psf when seismic loads (E and E') are not present, 10 psf when seismic loads are present or, equipment.
3.1.2.4	Hatch covers, shield plugs	Applicable floor live load.
3.1.2.5	Access doors	To be furnished by appropriate design section

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3.1.2.6	Handrail	200 pounds concentrated load at top rail for maximum condition (Reference 7.2.21).
3.1.2.7	Monorails, hoists and cranes	Maximum hoist load, plus dynamic load factor.

3.1.3 Seismic loads (E and E')

Miscellaneous structural steel shall be designed for seismic loading using the response spectra as defined in the applicable Design Criteria (References 7.2.26 through 7.2.33) and WB-DC-20-24 (Reference 7.2.15). The appropriate damping values to use for SSE and 1/2 SSE and the methodology for directional combinations are contained in WB-DC-20-24 (Reference 7.2.15).

3.1.4 Environmental Conditions For The Roofs

3.1.4.1 Normal Wind (W)

The normal design wind speed is 95-mph at 30 feet above grade. This is based on Figure 1(b) of ASCE Paper 3269 (Reference 7.3.3), using the fastest wind speed for a 100-year period of recurrence. A gust factor of 1.1 is included for all wind loads and combinations of loads where wind is involved.

3.1.4.2 Tornado Wind (Ww) (Reference 7.2.16)

All Category I structures shall be designed for a "funnel" of wind having a 300-mph rotational velocity plus a 60-mph translational velocity. This includes individual members which are exposed during a tornado. A dynamic pressure load of 1.3q shall be applied to the roof (Reference 7.3.3). Where the dynamic wind pressuure, q is defined as $q = 0.00256V^2$, with q in psf and V is wind velocity in mph.

3.1.4.3 Tornado Depressurization (Wp)

All Category I structures shall be designed for an external despressurization of 3 psi occurring in 3 seconds. The resulting possible 3-psi pressure differential between the inside and outside of the structures may be reduced by venting. Where venting is used, the interior structural members shall be investigated and designed for the 3 psi pressure where applicable.

3.1.4.4 Missiles (Wm)

Missiles which the miscellaneous steel roof must withstand are listed in WB-DC-40-65, "Missiles" (Reference 7.2.17).

3.1.4.5 Snow

The maximum probable snow load is 20 pounds per square foot (psf).

3.1.4.6 Rainfall

The normal rainfall (4 in/hr) a conventional roof drain and downspout system will discharge roof runoff into the yard drainage system. However, during the local Probable Maximum Precipitation (PMP), as discussed in WB-DC-40-1, "Roof Drainage Systems" (Reference 7.2.24), one or more of the following methods shall be used to prevent buildup of standing water on the roofs of safety-related buildings.

a. The parapets may be deleted on one or more sides of the building.

b. The parapet height may be limited to preclude buildup of water in excess of the structural capacity of the roof for the design live loads on the roof.

c. Scuppers may be installed through the parapets to discharge the standing water over the edge of the building.

3.1.5 Miscellaneous steel in the steel containment vessel shall be designed for additional dynamic loads produced by DBA pressure transients. Response acceleration spectra are employed to compute dynamic response in the same manner as for seismic effects.

3.2 Load Combinations

For service load conditions, the elastic working stress design methods of part 1 of AISC Specification (Reference 7.3.1) shall be used and the following load combinations shall be considered.

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3.2.1 Load Combinations for Miscellaneous Steel Other Than Category I(L) Equipment Supports

Move → For service load ....

Allowable Stress		Load Combinations
(1)	AISC Allowable*	D + L
(2)	AISC Allowable*	D + L + E
(3)	AISC Allowable*	D + L + W

The 33 percent increase in allowable stresses for steel due to seismic or wind loadings that is allowed by AISC (Reference 7.3.1) is not permitted.

For factored load conditions, the following load combinations shall be considered:

Allowable Stress		Load Combinations
(4)	1.6 x AISC Allowable*	D + L + E'
(5)	1.6 x AISC Allowable*	D + L + W_t

*See Table 5.1-1 for limiting values

Thermal loadings shall be identified and demonstrated to be self limiting and secondary in nature. The effects of pipe rupture including pressure, impact, jet impingment, missiles and flood shall be designed in accordance with WB-DC-40-31.51, "Evaulating the Effects of Flooding Due to Moderate Energy Pipe Failures Inside and Outside Containment" (Reference 7.2.22), WB-DC-40-31.53, "Pipe Whip Restraints, Jet Deflectors and Sleeves" (Reference 7.2.8) and WB-DC-40-31.50, "Evaluating the Effects of a Pipe Failure Inside and Outside Containment" (Reference 7.2.25).

3.2.2 Load Combinations for Miscellaneous Steel Used as Category I(L) Equipment Supports

For service load conditions, the elastic working stress design methods of Part 1 of AISC specifications (Reference 7.3.1) shall be used and the load

combinations (1), (3), (4) and (5) as discussed in Section 3.2.1 shall be considered.

4.0 MATERIALS

In general, the materials shall conform to the following specifications unless other types of steel are required by design:

Structural shapes, plates and bars	ASTM A36
Structural tubing	ASTM A501 or A500, Grade B
Structural pipe	ASTM A53, Grade B
Aluminum plates and shapes	Alloy 6061-T6
Stainless steel plates	ASTM A167, Type 304
Plates and bars for trashracks	ASTM A36, with 0.2% minimum copper or ASTM A441
High-strength bolts	7/8 inch diameter, ASTM A325, except where other sizes or higher strength may be required for heavy loads or special connections.
Anchor bolts	ASTM A307 or A36.
Weld rods	AWS A5.1, E70 or E60 Series, as applicable, or others as required for material compatability (Reference 7.3.2).
Stainless steel weld rods	AWS A5.4, E308 Series
Pipe handrail	ASTM A120 or A36
Bolt anchors	Manufacturer's standard quality.
Headed concrete anchors	ASTM A108, Grade 1015 through 1020.
Threaded studs	ASTM A108

Steel grating (painted or galvanized)	Manufacturer's standard quality
Aluminum grating (not to be used in reactor building)	Manufacturer's standard quality
Metal Deck	Manufacturer's standard quality
Stainless steel grating (to be used in Reactor Building only)	ASTM A167, type 304 or 316 ASTM A240, type 304 or 316

5.0 DESIGN SPECIFICATIONS AND PROCEDURES

5.1 Allowable Stresses

5.1.1 Miscellaneous Steel Other Than Category I(L) Equipment Supports

Structural steel and welds are designed for Cases (1), (2), and (3) loading conditions so that the stress in the members and connections do not exceed the allowable stress criteria as set forth in AISC specifications (Reference 7.3.1).

For Cases (4) and (5) loading conditions, the actual stresses shall not exceed the allowable stresses as set forth in Table 5.1-1.

5.1.2 Miscellaneous Steel Used as Category I(L) Equipment Supports

Structural steel and welds are designed for Cases (1) and (3) loading conditions so that the stress in the members and connections do not exceed the allowable stress criteria as set forth in AISC specifications (Reference 7.3.1).

For Cases (4) and (5) loading conditions, the actual stresses shall not exceed the allowable stresses as set forth in Table 5.1-1.

5.1.3 Anchorage for Missile Shield and Hatches in the Divider Barrier of Reactor Building

Special considerations have been taken of the allowable unit stresses in the anchorages for the missile shield and hatches in the divider barrier of the reactor building. These allowable unit stresses shall be limited since it is not feasible to pressure test the divider barrier. The allowable unit stresses shall be AISC working stress under conditions of loading involving dead load, operating loads, design basis accident, and one-half safe shutdown earthquake. When the loading conditions result from a combination of dead load, operating loads, design basis accident, and safe shutdown earthquake, the loads shall be increased by 5 percent and the allowable unit stresses shall be limited to 80 percent of those normally permitted. The anchorages for the missile shields and hatches are designed for the end reactions per WB-DC-20-2 (Reference 7.2.29) and WB-DC-40-60 (Reference 7.2.9) respectively, increased by 5 percent as noted above.

5.2 Concrete Bearing

Allowable bearing pressure of concrete shall be 1125 psi for interior columns, 900 psi for columns near joints, and 750 psi for wall columns and beam base plates.

5.3 Connection Type

All connections and assemblies of miscellaneous steel shall be welded except where bolted connections are required or are more practical as determined by the supervisor.

5.4 Connection Design

All beams where bolted connections are required shall be provided with the AISC Table I (Reference 7.3.1) framed beam connection with the maximum rows of bolts unless a heavier connection is required. An acceptable connection design is provided in DG-C1.6.4 (Reference 7.2.10).

5.5 Welding Design

Unless otherwise noted by other specific design criteria, all welds shall be designed per AISC Specifications (Reference 7.3.1).

All field welding shall be performed in accordance with TVA General Construction Specification G-29 (Reference 7.2.2), unless otherwise specified.

All welds to the steel containment vessel shall conform to the requirements of ASME Section III (Reference 7.3.5).

Existing welds which do not meet the minimum size requirements in Table 1.17.5 of the AISC Specification (Reference 7.3.1) but which meet allowable stress requirements may be qualified in accordance with the provisions contained in paragraph 1.17.2 of the AISC Specification..

5.6 Anchor Bolts, Concrete Anchors, and Threaded Studs

Civil Design Standard DS-C1.7.1 (Reference 7.2.3) shall be used for the design of concrete bolt anchors and headed concrete anchors.

5.7 Torsion Design

Torsional Stresses induced by eccentric loads shall be considered for the design of the miscellaneous steel. This design shall be in accordance with AISC (Reference 7.3.1) and Civil Design Guide DC-C1.6.7, "Design of Structural Steel Members, (buildings, miscellaneous steel and supplementary steel)" (Reference 7.2.1).

5.8 Local Effects

Miscellaneous steel shall be evaluated for local effects at connections and attachment locations. Stiffeners shall be provided where required.

5.9 Component Seismic Loads

All components of seismic loads from pipe, HVAC and electrical support group shall be considered in the miscellaneous steel design.

5.10 Punching Shear in Tube-to-Tube Connections

Miscellaneous steel tube-to-tube welded connections shall be designed for punching shear in accordance with AWS D1.1-81, Section 10.5, or later revisions of the section (Reference 7.3.4).

5.11 Deflection

Deflection criteria for miscellaneous steel (including the effects of ponding) shall be in accordance with AISC Specification (Reference 7.3.1).

5.12 Metal Decking

Metal decking shall be designed in accordance with the recommended procedure of each manufacturer using the manufacturer's section material properties for the decking.

5.13 Thermal Considerations

Evaluation for thermal effects shall be in accordance with Section AB.0.

6.0 QUALITY ASSURANCE REQUIREMENTS

Structures/Systems which perform a safety-related function or have seismic requirements must have quality assurance applied in the design, procurement, and testing of the structure/system and structure/system components.

The following documents further clarify TVA's QA requirements.

a. TVA Topical Report TVA - TR75-1A, Quality Assurance (Reference 7.2.18).

b. Nuclear Quality Assurance Manual, (NQAM) (Reference 7.2.19).

c. DNE Nuclear Engineering Procedures (NEP) Manual (Reference 7.2.20).

7.0 REFERENCES

7.1 TVA Drawings (none)

7.2 TVA Documents

7.2.1 DG-C1.6.7, "Design of Structural Steel Members (buildings, miscellaneous steel and supplementary steel)"

7.2.2 TVA Construction Specification G-29, "Process Specifications for Welding, Heat Treatment, Nondestructive Examination, and Allied Field Fabrications Operations."

7.2.3 DS-C1.7.1, "General Anchorage to Concrete"

7.2.4 Design Criteria WB-DC-20-21.1, "Category I Cable Tray Supports"

7.2.5 Design Criteria WB-DC-20-22, "Miscellaneous Concrete Category I Yard Structures"

7.2.6 Design Criteria WB-DC-40-31.8, "Seismically Qualifying Round and Rectangular Ducts"

7.2.7 Design Criteria WB-DC-40-31.9, "Location and Design of Piping Supports and Supplemental Steel in Category I Structures"

7.2.8 Design Criteria WB-DC-40-31.53, "Pipe Whip Restraints, Jet Deflectors and Sleeves"

7.2.9 Design Criteria WB-DC-40-60, "Special Hatches and Manways"

7.2.10 DG-C1.6.4, "Design of Structural Connections"

7.2.11 TVA Report CEB-76-5

7.2.12 Design Criteria WB-DC-40-31.6, "Seismically Qualifying Tanks and Reservoirs, and Their Supports"

7.2.13 Design Criteria WB-DC-40-31.10, "Support of Conduits in Category I Structures"

7.2.14 Design Criteria WB-DC-40-31.11, "Support of Lighting Fixtures in Category I Structures"

7.2.15 Design Criteria WB-DC-20-24, "Dynamic Earthquake Analysis of Category I Structures and Earth Embankments"

7.2.16 DG-C1.3.4, "Loads and General Provisions Extreme Wind and Tornado Forces on Structures"

7.2.17 Design Criteria WB-DC-40-65, "Missiles"

7.2.18 TVA Topical Report TVA-TR75-1A "Quality Assurance"

7.2.19 Nuclear Quality Assurance Manual (NQAM)

7.2.20 DNE Nuclear Engineering Procedures (NEP) Manual

7.2.21 TVA Occupational Health and Safety Manual

7.2.22 Design Criteria WB-DC-40-31.51, "Evaluating the Effects of Flooding Due to Moderate Energy Pipe Failure Inside and Outside Containment"

7.2.23 Deleted

7.2.24 Design Criteria WB-DC-40-1, "Roof Drainage Systems"

7.2.25 Design Criteria WB-DC-40-31.50, "Evaluating the Effects of a Pipe Failure Inside and Outside Containment"

7.2.26 Design Criteria WB-DC-20-9, "Control Building Structural Steel"

7.2.27 Design Criteria WB-DC-20-10, "Auxiliary Building Structural Steel"

7.2.28 Design Criteria WB-DC-20-1.1, "Additional Diesel Generator Building and New Category I Structures"

7.2.29 Design Criteria WB-DC-20-2, "Reactor Building Concrete Structure"

7.2.30 Design Criteria WB-DC-20-3, "Reactor Building Containment Vessels - Structural Steel"

7.2.31 Design Criteria WB-DC-20-8, "Auxiliary-Control Building Concrete Structures"

7.2.32 Design Criteria WB-DC-20-17, "Diesel Generator Building Concrete Structure"

7.2.33 Design Criteria WB-DC-20-19, "Intake Pumping Station Concrete Structure, Intake Channel and Retaining Walls"

7.2.34 Design Criteria WB-DC-40-64, "Design Basis Events Design Criteria"

7.3 Codes and Standards

7.3.1 AISC Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings 1969 edition, as amended through June 12, 1974.

7.3.2 AWS, D1.1-72, "Structural Welding Code" as modified by TVA General Construction Specification G-29

7.3.3 ASCE Paper 3269, "Wind Forces on Structures."

7.3.4 AWS, D1.1-81, "Structural Welding Code"

7.3.5 ASME Boiler and Pressure Vessel Code Section II, III, and VIII, 1971, Winter Addenda, and applicable sections required for a Class MC nuclear vessel

7.4 TVA Calculations

7.4.1 Calculation for Allowable Stress for Safe Shutdown Earthquake for Compression Members - Table 5.1-2 (Later)

7.5 Others

7.5.1 NRC General Design Criteria (GDC) Appendix A to 10CFR50, July 1971.

TABLE 5.1-1

Loading Combinations	Tension	Shear	Compression	Bending
(1), (2), (3)	$0.60\ F_Y$	$0.40\ F_Y$	See Note 1	See Note 3
(1a) (2a), (3a) (4) thru (10)	$0.90\ F_Y$	$\frac{0.90\ F_Y}{\sqrt{3}}$	See Note 2	$0.90\ F_Y$

Note 1 - Varies with slenderness ratio, see AISC "Manual of Steel Construction," 7th Edition, Table 1-36, Page 5-84 (Reference 7.3.1).

Note 2 - Varies with slenderness ratio (see Table 5.1-2):

Note 3 - varies, see Section 1.5.1.4 of Reference 7.3.1 on bending.

Main and secondary members where $KL/R \leq C_c$:

$$F_a = 0.9\ F_Y \left[1 - \frac{(KL/r)^2}{2C_c^2} \right] \qquad \text{(A)}$$

Main members where $C_c < KL/r < 200$: $F_a = \frac{0.9\pi^2 E}{(KL/r)^2}$ (B)

Secondary members where $120 < L/r \leq 200$

$$F_{as} = F_a \frac{[\text{by Formula (A) or (B)}]}{1.6 - L/200r}$$

Where:

$C_c = \sqrt{\frac{2\pi^2 E}{F_Y}}$

E = Modulus of elasticity of steel

F_a = Axial compressive stress permitted in the absence of bending moment (kips per square inch)

F_{as} = Axial compressive stress, permitted in the absence of bending moment, for bracing and other secondary members (kips per square inch)

TABLE 5.1-1 (CONT'D)

F_Y = Specified minimum yield stress of materials (kips per square inch)

K = Effective length factor

L = Actual unbraced length (inches)

r = Governing radius of gyration (inches)

Material Properties

Steel Properties

E = 29,000,000 psi

F_Y = 36,000 psi

TABLE 5.1-2

ALLOWABLE STRESS FOR SAFE SHUTDOWN EARTHQUAKE FOR COMPRESSION MEMBERS

Allowable stress obtained from AISC Specifications Section 1.5 using formula 1.5-1 or 1.5-2 and 1.5-3 with a safety factor of 90 percent of yield (Reference 7.4.1).

For Compression Members of 36-ksi Specified Yield Point Steel

Main and Secondary Members Kl/r not over 120						Main Members Kl/r 121 to 200				Secondary Members l/r 121 to 200			
Kl/r	F_a (ksi)	Kl/r	F_a (ksi)	Kl/r	F_a (ksi)	Kl/r	F_a (ksi)	Kl/r	F_a (ksi)	l/r	F_{as} (ksi)	l/r	F_{as} (ksi)
1	32.40	41	30.69	81	25.72	121	17.43	161	9.94	121	17.57	161	12.50
2	32.40	42	30.60	82	25.55	122	17.24	162	9.82	122	17.41	162	12.42
3	32.39	43	30.52	83	25.38	123	16.99	163	9.70	123	17.25	163	12.35
4	32.38	44	30.43	84	25.21	124	16.74	164	9.58	124	17.08	164	12.28
5	32.37	45	30.34	85	25.04	125	16.48	165	9.46	125	16.90	165	12.21
6	32.36	46	30.24	86	24.87	126	16.23	166	9.35	126	16.73	166	12.14
7	32.35	47	30.15	87	24.69	127	15.97	167	9.24	127	16.55	167	12.07
8	32.34	48	30.05	88	24.51	128	15.72	168	9.13	128	16.38	168	12.01
9	32.32	49	29.95	89	24.33	129	15.48	169	9.02	129	16.21	169	11.95
10	32.30	50	29.85	90	24.15	130	15.24	170	8.91	130	16.05	170	11.88
11	32.28	51	29.75	91	23.96	131	15.01	171	8.81	131	15.88	171	11.82
12	32.25	52	29.65	92	23.78	132	14.78	172	8.71	132	15.73	172	11.77
13	32.23	53	29.54	93	23.59	133	14.56	173	8.61	133	15.57	173	11.71
14	32.20	54	29.43	94	23.40	134	14.35	174	8.51	134	15.43	174	11.66
15	32.17	55	29.32	95	23.21	135	14.13	175	8.41	135	15.28	175	11.60
16	32.14	56	29.21	96	23.01	136	13.93	176	8.32	136	15.14	176	11.55
17	32.11	57	29.09	97	22.81	137	13.72	177	8.22	137	15.00	177	11.50
18	32.07	58	28.97	98	22.62	138	13.53	178	8.13	138	14.86	178	11.45
19	32.03	59	28.85	99	22.41	139	13.33	179	8.06	139	14.73	179	11.40
20	31.99	60	28.73	100	22.21	140	13.14	180	7.95	140	14.60	180	11.36
21	31.95	61	28.61	101	22.01	141	12.96	181	7.86	141	14.48	181	11.31
22	31.91	62	28.48	102	21.80	142	12.78	182	7.78	142	14.35	182	11.27
23	31.86	63	28.36	103	21.59	143	12.60	183	7.69	143	14.23	183	11.23
24	31.81	64	28.23	104	21.38	144	12.42	184	7.61	144	14.12	184	11.19
25	31.76	65	28.10	105	21.17	145	12.25	185	7.53	145	14.00	185	11.15

TABLE 5.1-2 (Continued)

Allowable stress obtained from AISC Specifications Section 1.5 using formula 1.5-1 or 1.5-2 with a safety factor of 90 percent of yield (Reference 7.4.1).

For Compression Members of 36-ksi Specified Yield Point Steel

Main and Secondary Members Kl/r not over 120						Main Members Kl/r 121 to 200				Secondary Members l/r 121 to 200			
$\frac{Kl}{r}$	F_a (ksi)	$\frac{Kl}{r}$	F_a (ksi)	$\frac{Kl}{r}$	F_a (ksi)	$\frac{Kl}{r}$	F_a (ksi)	$\frac{Kl}{r}$	F_a (ksi)	$\frac{l}{r}$	F_{as} (ksi)	$\frac{l}{r}$	F_{as} (ksi)
26	31.71	66	27.96	106	20.95	146	12.08	186	7.45	146	13.89	186	11.11
27	31.66	67	27.83	107	20.74	147	11.92	187	7.37	147	13.78	187	11.05
28	31.60	68	27.69	108	20.52	148	11.76	188	7.29	148	13.67	188	11.04
29	31.54	69	27.55	109	20.30	149	11.60	189	7.21	149	13.57	189	11.01
30	31.48	70	27.41	110	20.07	150	11.45	190	7.14	150	13.47	190	10.98
31	31.42	71	27.26	111	19.85	151	11.30	191	7.06	151	13.37	191	10.95
32	31.36	72	27.12	112	19.62	152	11.15	192	6.99	152	13.27	192	10.92
33	31.29	73	26.97	113	19.39	153	11.00	193	6.92	153	13.18	193	10.89
34	31.22	74	26.82	114	19.16	154	10.86	104	6.84	154	13.09	194	10.86
35	31.15	75	26.67	115	18.93	155	10.72	195	6.77	155	13.00	195	10.84
36	31.08	76	26.52	116	18.69	156	10.58	196	6.71	156	12.91	196	10.82
37	31.01	77	26.36	117	18.45	157	10.45	197	6.64	157	12.82	197	10.79
38	30.93	78	26.20	118	18.21	158	10.32	198	6.57	158	12.74	198	10.77
39	30.85	79	26.04	119	17.97	159	10.19	199	6.50	159	12.66	199	10.75
40	30.77	80	25.88	120	17.73	160	10.06	200	6.44	160	12.58	200	10.73

APPENDIX A

MODIFICATIONS AND NEW DESIGN
OF MISCELLANEOUS STEEL COMPONENTS OF
CATEGORY I STRUCTURES

A1.0 PURPOSE

This appendix defines the additional design criteria for the modification of existing miscellaneous structural steel features and the design of new features that are added to the miscellaneous steel.

A2.0 SCOPE

This appendix provides the additional requirements for new design of miscellaneous steel and modifications to existing miscellaneous steel. Also, this appendix provides the design basis for the modification of existing or addition of new miscellaneous steel members.

A3.0 APPLICABLE CODES, STANDARDS, AND SPECIFICATIONS

The applicable codes, standards and specifications are identified in Section 7.3. The designer may optionally use the latest issued version provided that an evaluation is completed and documented to demonstrate that the design safety is not compromised.

A4.0 DESIGN CONSIDERATIONS ~~LOADS: DEFINITIONS AND NOMENCLATURE~~

A4.1 Design Conditions

~~A4.1~~ Definition of Additional Load Terms

~~The terms used in these load combination equations are defined in the main body of this design criteria with the addition of the following terms:~~ The following terms are used in the additional load combination equations in Section A4.3.

Normal loads, which are those loads to be encountered during normal plant operation and shutdown, include:

T_o — Thermal effects and loads during normal operating or shutdown conditions, based on the most critical transient or steady-state condition.

R_o — Pipe reactions during normal operating or shutdown conditions, based on the most critical transient or steady-state condition.

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Abnormal loads, which are those loads generated by a postulated high-energy pipe break accident, include:

T_a -- Thermal loads under thermal conditions generated by the postulated break and including T_o.

R_a -- Pipe reactions under thermal conditions generated by the postulated break including R_o.

P_a - Pressure equivalent static load within or across a compartment generated by the postulated break and including an appropriate dynamic load factor to account for the dynamic nature of the load.

Y_r - Equivalent static load on the structure generated by the reaction on the broken high-energy pipe during the postulated break and including an appropriate dynamic load factor to account for the dynamic nature of the load.

Y_j - Jet impingement equivalent static load on a structure generated by the postulated break and including an appropriate dynamic load factor to account for the dynamic nature of the load.

Y_m - Missile impact equivalent static load on a structure generated by or during the postulated break, as from pipe whipping, and including an appropriate dynamic load factor to account for the dynamic nature of the load.

In determining an appropriate equivalent static load for Y_r, Y_j, and Y_m, elastoplastic behavior may be assumed with appropriate ductility ratios, provided excessive deflections will not result in loss of function of any safety-related system.

Other loads include:

F -- Hydrostatic load from the design basis flood

F_a -- Flood load generated by a postulated pipe break

Any loads resulting from a postulated explosion shall be determined on a case-by-case basis.

Tornado wind loads, etc., can be determined by the methods of Reference A~~8~~9.1.1.

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A4.2 Additional Design Considerations

The roofs shall also be designed for the following:

Normal Condition

Temperature: -10 to 120°F
Radiation: Negligible

Extreme Condition

Temperature: -40 to 120°F
Radiation: Negligible

A4.3 ~~A5.0~~ ADDITIONAL LOAD COMBINATIONS #

A4.3.1 ~~A5.1~~ General

The load combinations included in this section shall be considered in addition to those included in Section 3.2 of the design criteria.

A4.3.2 ~~A5.1.1~~ Additional Load Combinations for Miscellaneous Steel Other Than Category I(L) Equipment Supports #

For service load conditions, If thermal stresses due to T_o and R_o are present, the following combinations shall also be considered: #

Allowable Stress		Load Combinations
(1a)	1.5 x AISC Allowable*	$D + L + T_o + R_o$
(2a)	1.5 x AISC Allowable*	$D + L + T_o + R_o + E$
(3a)	1.5 x AISC Allowable*	$D + L + T_o + R_o + W$

Both cases of L having its full value and of being completely absent shall also be checked. #

For factored load conditions, the following load combinations shall be considered:

Allowable Stress		Load Combinations
4a ~~(4)~~	1.6 x AISC Allowable*	$D + L + T_o + R_o + E'$
5a ~~(5)~~	1.6 x AISC Allowable*	$D + L + T_o + R_o + W_t$

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(6)	1.6 x AISC Allowable*	$D + L + T_a + R_a + P_a$
(7)	1.6 x AISC Allowable*	$D + L + T_a + R_a + P_a + 1.0\ (Y_j + Y_r + Y_m) + E$
(8)	1.7 x AISC Allowable*	$D + L + T_a + R_a + P_a + 1.0\ (Y_j + Y_r + Y_m) + E'$
(9)	1.6 x AISC Allowable*	$D + F_a$
(10)	1.6 x AISC Allowable*	$D + F$

*See Table 5.1-1 for limiting values.

~~In the above load combinations, thermal loads can be neglected when it can be shown that they are secondary and self-limiting in nature and where the material is ductile. The judgments and justifications for neglecting thermal loads must be documented in the calculations.~~

~~In the combinations (6), (7), and (8), the maximum values of P_a, T_a, R_a, Y_j, Y_r, and Y_m, including an appropriate dynamic load factor, shall be used unless a time-history analysis is performed to justify otherwise. Combinations (5), (7), and (8) should be first satisfied without the tornado missile load in (5) and without Y_r, Y_j, and Y_m in (7) and (8). When considering these concentrated loads, stresses may exceed maximum allowable stresses given in Table 5.1-1. See References 7.2.22, 7.2.8 and 7.2.25.~~

~~Where D or L reduce the effect of the loads given above, the corresponding coefficients shall be taken as 0.90 D and zero for L. The vertical pressure of liquids shall be considered as dead load with due regard to variation in liquid depth.~~

A4.3.3 Additional
~~A5.1.2~~ Load Combinations for Miscellaneous Steel Used as Category I(L) Equipment Supports

If thermal stresses due to T_o and R_o are present, the load combinations discussed in Section ~~A5.1.1~~ A4.3.2 are applicable except load combination (2a).

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A5.0 DESIGN SPECIFICATIONS AND PROCEDURES SEE PAGE A4.1

A6.0 EARTHQUAKES

A6.1 Application of Seismic Loads

To develop loads generated by the earthquake, the designer shall perform one of the following analysis methods:

~~(6)~~	~~1.6 x AISC Allowable*~~	~~$D + L + T_a + R_a + P_a$~~
(7)	1.6 x AISC Allowable*	$D + L + T_a + R_a + P_a + 1.0\ (Y_j + Y_r + Y_m) + E$
(8)	1.7 x AISC Allowable*	$D + L + T_a + R_a + P_a + 1.0\ (Y_j + Y_r + Y_m) + E'$
(9)	1.6 x AISC Allowable*	$D + F_a$
(10)	1.6 x AISC Allowable*	$D + F$

*See Table 5.1-1 for limiting values.

A5.0 Design Specifications and Procedures

A5.1 In the ~~above~~ load combinations of Section 4.3.2 thermal loads can be assumed equal to zero ~~neglected~~ when it can be shown that they are secondary and self-limiting in nature and where the material is ductile. The judgments and justifications for neglecting thermal loads must be documented in the calculations.

A5.2 In the combinations (6), (7), and (8), the maximum values of P_a, T_a, R_a, Y_j, Y_r, and Y_m, including an appropriate dynamic load factor, shall be used unless a time-history analysis is performed to justify otherwise. Combinations ~~(5)~~ 5a, (7), and (8) should be first satisfied without the tornado missile load in 5a ~~(5)~~ and without Y_r, Y_j, and Y_m in (7) and (8). When considering these concentrated loads, stresses may exceed maximum allowable stresses given in Table 5.1-1. See References 7.2.22, 7.2.8 and 7.2.25.

A5.3 Where D or L reduce the effect of the loads given above, the corresponding coefficients shall be taken as 0.90 D and zero for L. The vertical pressure of liquids shall be considered as dead load with due regard to variation in liquid depth.

~~A5.1.2 Load Combinations for Miscellaneous Steel Used as Category I(L)~~ Equipment Supports

If thermal stresses due to T_o and R_o are present, the load combinations discussed in Section A5.1.1 are applicable except load combination (2a).

A6.0 EARTHQUAKES

A6.1 Application of Seismic Loads

To develop loads generated by the earthquake, the designer shall ~~perform one of the following analysis methods:~~

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A6.1.1 Modal Analysis

A modal analysis considering the mass and stiffness of the structure can be performed. This analysis combines each of vibration < 33Hz to obtain the dynamic response of the structure.

A6.1.2 Static Equivalent Analysis

A6.1.2.1 1.5 Times Peak Acceleration

In lieu of a rigorous dynamic analysis of a structure, the designer may assume the seismic loads are equal to the mass of the mathematical model multiplied by 1.5 times the peak of the appropriate acceleration response spectrum. The 1.5 factor accounts for simultaneous multimode responses.

A6.1.2.2 1.0 Times Peak Acceleration or Rigid Body Acceleration

If, for a range of design parameters, the designer has demonstrated that a particular structure responds principally in one mode, the 1.5 factor above is not required and the design can be based on the peak of the acceleration response spectrum. If a structure has a fundamental mode of vibration greater than 33 Hz, it is considered dynamically rigid and can be statically designed for 1.0 times the ZPA acceleration based on the location of the structure.

A6.1.2.3 1.5 Times Actual Acceleration (Frequency Analysis)

A frequency analysis can be utilized to obtain a less conservative acceleration value. To develop earthquake loads the designer shall determine the relevant stiffness of the structural element (structural steel) under consideration. The frequency analysis will generate the fundamental frequency of the element. The designer shall identify the appropriate acceleration response spectrum based on the location of the element, the direction of acceleration, and the proper damping value.

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The designer shall then use the appropriate acceleration response spectrum curve to determine the earthquake acceleration (g) to be applied based on the fundamental frequency obtained. The designer shall include consideration of the effects of the participation of higher modes by multiplying the calculated earthquake acceleration (g) by 1.5. The consideration of higher modes may be neglected if all subsequent modes are greater than 33 Hz.

A7.0 FIRE PROTECTION

A7.1 Category I Structures with 3-Hour Fire Rating

A7.1.1 Fireproofing for Structured Steel

Exposed structural steel members shall be fireproofed in accordance with General Construction Specification No. G-74, "Fireproofing of Structural Steel for All Projects" (Reference A~~8~~9.1.2). The location of required fireproofing shall be shown on appropriate design drawings.

A8.0 QUALIFICATION OF STRUCTURES FOR THERMAL LOADING

SEE PG A6.~~1~~2 through A6.~~3~~4

A~~8~~9.0 REFERENCES

A~~8~~9.1 TVA Documents

A~~8~~9.1.1 Civil Design Guide, DG C1.3.4, "Loads and General Provisions Extreme Wind and Tornado Wind Forces on Structures."

A~~8~~9.1.2 General Construction Specification No. G-74, "Fireproofing of Structural Steel for All Projects."

A9.1.3 Civil Design Guide, DG C1.6.12, "Evaluation of Steel Structures with Thermal Restraint." Revision 1 (B41 910506 004)

A9.1.4 Calculation for Thermal Effects on Concrete Anchors, B04 890505 200.

(CONTINUED PAGE A6.1)

A9.2 Other Documents

A9.2.1 "Guide to Design Criteria for Bolted and Riveted Joints," by J.W. Fisher and J.H.A. Struik, Wiley 1974.

A9.2.2 "Specification for Structural Joints Using ASTM A325 or A490 Bolts," AISC, August 14, 1980.

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A9.0 REFERENCES (Continued)

A9.1 TVA Documents (Continued)

A9.1.5 Calculation WCG-1-610, "Thermal Analysis of Steel Structures Subjected To Temperature Differential Less Than 55 Degrees Fahrenheit", B18 910111 266

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A8.0 Qualification of Structures for Thermal Loading

This design criteria invokes certain portions of Civil Design Guide (DG) C1.6.12, "Evaluation of Steel Structures with Thermal Restraint" (Reference A9.1.3). Other portions of the design guide may be used provided reference is made to the section of the design guide. Reduced values of modulus of elasticity as specified in section 4.2 of the design guide shall be used at elevated temperatures.

A8.1 Qualification Methods

One of the following methods shall be used for evaluation or design of a structure under thermal loading.

A8.1.1 - Classify as Not Significantly Restrained

For those structures subjected to thermal loads which do not have restraint in accordance with guidelines provided in DG C1.6.12, Tc and Ta can be assumed equal to zero in load combinations (1) through (8). Structures of A36 steel which are not restrained are considered ductile and exhibit self-limiting behavior.

A8.1.2 - Evaluate for Operating Temperature

If the operating temperature of the compartment containing the structure to be evaluated will not exceed 120 degrees Fahrenheit in accordance with the environmental drawings, Tc can be assumed equal to zero in load combinations (1) through (5a) (Reference A9.1.5). Otherwise, detailed evaluation shall be performed. Ambient temperature shall be taken as 70 degrees Fahrenheit, and the temperature differential between ambient and operating shall be evaluated. The thermal coefficient described in section 4.3 of DG C1.6.12 may be used.

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A8.1.3 - Evaluate for Accident Temperature

For detailed evaluation of loads caused by accident temperature, ambient temperature shall be taken as 70 degrees Fahrenheit, and the temperature differential between ambient and accident shall be evaluated. Separate load cases for the operating temperature and the accident temperature may be evaluated provided the conditions in section 4.3 of DG C1.6.12 are met.

A8.1.4 - Detailed Evaluation

Either linear or non-linear analysis methods may be used for detailed evaluations. The methods identified in section 5.0 of DG C1.6.12 are acceptable for performing detailed evaluations. Acceptance criteria is specified in section A8.2. For non-linear analysis the ANSYS computer program may be used. Final analysis must include the effects of all applicable loads.

A8.1.5 - Heat Flow Analysis

The temperature of the member used for determining temperature rise is normally assumed to be the peak compartment temperature from the environmental drawings. This temperature may be reduced by coordinating with the mechanical engineering organization to perform a heat flow analysis to determine the actual member temperature considering boundary conditions and the response of the member over time.

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A8.1.6 - Comparison to Previously Qualified Structures

If the structure being evaluated is geometrically similar to a previously evaluated structure, acceptance may be based on satisfying the interaction equation in section 7.0 of DG C1.6.12.

A8.2 Acceptance Criteria

A8.2.1 Acceptance of linear evaluations shall be based on the provisions of section C2.0 of DG C1.6.12.

A8.2.2 Acceptance of non-linear evaluations shall be based on the provisions of section D3.0 of DG C1.6.12.

A8.2.3 Acceptance of connection evaluations, performed by either linear or non-linear evaluation, shall be based on the provisions of sections C3.0 through C9.0 of DG C1.6.12.