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STN-50-530 Palo Verde Nuclear Station, Unit 3, Arizona Publi 05000530
AUTH.NAME AUTHOR AFFILIATION
LEVINE,J.M. Arizona Public Service Co. (formerly Arizona Nuclear Power
RECIP.NAME RECIPIENT AFFILIATION
Document Control Branch (Document Control Desk)

SUBJECT: Forwards Rev 9 to UFSAR for PVNGS Units 1,2 & 3.QA program changes made in accordance w/10CFR50.54(a)(3),which do not reduce commitments previously accepted by NRC,included in Rev 9.

per 4/6/98 lw

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AA4

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Palo Verde Nuclear
Generating Station

James M. Levine
Senior Vice President
Nuclear

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Phoenix, AZ 85072-2034

102-04055 – JML/AKK/RJR
December 17, 1997

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Dear Sirs:

**Subject:** **Palo Verde Nuclear Generating Station (PVNGS)**
**Units 1, 2, and 3**
**Docket Nos. STN 50-528/529/530**
**Updated Final Safety Analysis Report, Revision 9**

Pursuant to 10 CFR 50.71(e) and in accordance with 10 CFR 50.4(b)(6), Arizona Public Service Company (APS) is submitting the original and 10 copies of the replacement pages, insertion instructions, and a list of effective pages for Revision 9 to the PVNGS Updated Final Safety Analysis Report (UFSAR). One copy is also being provided to the NRC Region IV Office, the Walnut Creek Field Office, and the NRC Resident Inspector's Office at PVNGS.

Quality assurance program changes made in accordance with 10 CFR 50.54(a)(3), which do not reduce commitments previously accepted by the NRC, are included in Revision 9.

Should you have any questions, please contact Scott A. Bauer at (602) 393-5978.

Sincerely,

JML/AKK/RJR/mah

Enclosure

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| | J. W. Clifford | (w/o Enclosure) |
| | J. H. Moorman | (w/o Enclosure) |
| | A. V. Godwin | (w/o Enclosure) |

STATE OF ARIZONA )
) ss.
COUNTY OF MARICOPA )

I, W. E. Ide, represent that I am Vice President Nuclear Engineering, Arizona Public Service Company (APS), that the foregoing document has been signed by me on behalf of APS with full authority to do so, and that to the best of my knowledge and belief, the statements made therein are true and correct.

W. E. Ide

Sworn To Before Me This 17 Day Of December, 1997.

Nora E. Meador
Notary Public

My Commission Expires

April 6, 1999

OFFICIAL SEAL
NORA E. MEADOR
Notary Public - State of Arizona
MARICOPA COUNTY
My Comm. Expires April 6, 1999

# Enclosure List

Enclosed in this package are the following items:

1. Cover letter
2. Enclosure List
3. Text Insertion Package "A"
4. Text Insertion Package "B"
5. Text Insertion Package "C"
6. Drawing Insertion Package "A"
7. Drawing Insertion Package "B"
8. Insertion Instructions for Items 3, 4, 5, 6, and 7
9. List of Effective Pages, Revision 9

If for some reason your package is missing any of these items please contact Rich Rogalski at **(602) 393-5806** or E-Mail **z99706@apsc.com** prior to trying to update your set of the PVNGS UFSAR.

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Palo Verde Nuclear
Generating Station

James M. Levine
Senior Vice President
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Quality assurance program changes made in accordance with 10 CFR 50.54(a)(3), which do not reduce commitments previously accepted by the NRC, are included in Revision 9.

Should you have any questions, please contact Scott A. Bauer at (602) 393-5978.

Sincerely,

Will E Ide Jr

JML/AKK/RJR/mah

Enclosure

# PACKAGE A

# Text Pages
# Insert "B"

# Text Insertion Package "C"

# PVNGS UPDATED UFSAR
# REVISION 9 – PACKAGE A
# INSERTION INSTRUCTIONS

Note

**These insertion instructions are for Text Insertion Package A.**

**These pages must be inserted first prior to inserting Text Insertion Package B, Text Insertion Package C, and Figure Insertion Packages A and B.**

The following instructions indicate replacement pages and additional pages for incorporating Revision 9 into the Updated Final Safety Analysis Report for the Palo Verde Nuclear Generation Station. Replace the existing pages with the new pages. Please note, some of these pages will be new pages, as indicated by the word "Insert." Retain these instructions in the front of Volume I as a record of changes.

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**insert** 1.8-22.a/1.8-22.b
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**insert** 1.8-62.a/1.8-62.b
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**insert** 5.4-1.b/5.4-1.c
**insert** 5.4-1.d/5.4-2
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**insert** Figure 8B.2a-1

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**insert** Figure 8B.2b.-1
**insert** 8B.3a-1 through 8B.3a-12
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**insert** 9A-86.a/9A-86.b
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**insert** 9B.2-596.a/9B.2-596.b
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**insert** 9B.2-600.a/9B.2-600.b
9B.2-601/9B.2-602
**insert** 9B.2-602.a/9B.2-602.b
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**insert** 9B.2-646.a/9B.2-646.b
9B.2-655/9B.2-656
**insert** 9B.2-656.a/9B.2-656.b
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9B.2-693/9B.2-694
9B.2-697/9B.2-698
replace 9B.2-745 with 9B.2-745/9B.2-746
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**insert** 9.1-35.b/9.1-36
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**insert** 9.5-23.b/9.5-24
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**insert** 9.5-53.b through 9.5-54
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**insert** 9.5-80.a/9.5-80.b
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10.4-39 through 10.4-42
**insert** 10.4-42.a/10.4-42.b
10.4-45 through 10.4-48
replace 10.4-49/10.4-50 with 10.4-49/10.4-49.a
**insert** 10.4-49.b/10.4-50
replace 10.4-51/10.4-52 with 10.5-51/10.4.51.a
**insert** 10.4-51.b/10.4-52
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11.2-23/11.2-24
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**insert** 11.4-2.a/11.4-2.b
11.4-13/11.4-14
11.4-17/11.4-18
replace 11.4-23/11.4-24 with 11.4-23/11.4-23.a
**insert** 11.4-23.b/11.4-24

11.5-1 through 11.5-4
11.5-45/11.5-46
11.5-49/11.5-50

Chapter 12

12.2-15/12.2-16

12.3-1/12.3-2
12.3-11 through 12.3-14
12.3-21/12.3-22
**insert** 12.3-22.a/12.3-22.b
12.3-25/12.3-26

12.5-1 through 12.5-4
12.5-9/12.5-9.a
12.5-11 through 12.5-22

Chapter 13

13.1-5 through 13.1-38

Figures 13.1-1 through 13.1-7

13.2-1 through 13.2-4

13.4-1/13.4-2
**insert** 13.4-2.a/13.4.2.b

13.5-3 through 13.5-8

13A-19/13A-20

Chapter 14

14.2-33/14.2-34

14A-5/14A-6

14B-iii/14B-iv

14B-41/14B-42

Chapter 15

15-i/15-ii
15-vii/15-viii
15-ix/15-x
**insert** 15-x.a/15-x.b
replace 15-xxiii/15-xxiv with 15-xxiii/15-xxiii.a
**insert** 15-xxiii.b/15-xxiv

15.0-21 through 15.0-24

15.1-17/15.1-18
15.1-19.b/15.1-20
replace 15.1-51/15.1-52 with 15.1-5115.1-51.a
**insert** 15.1-51.b through 15.1-52

Figures 15.1.6-1 through 15.1.6-26

15.2-3 through 15.2-8
15.2-11 through 15.2-16
replace 15.2-17/15.2-18 with 15.2-17/15.2-17.a
**insert** 15.2-17.b/15.2-18
15.2-19/15.2-20
15.2-23 through 15.2-28
15.2-31/15.2-32

15.3-5/15.3-6
15.3-9/15.3-10
15.3-13/15.3-13.a
15.3-19 through 15.3-22
15.3-27 through 15.3-30

15.4-13/15.4-14
15.4-31/15.4-32
15.4-35 through 15.4-38
**insert** 15.4-38.a/15.4-38.b

15.4-39 through 15.4-42
15.4-45/15.4-46

15.5-5/15.5-6
15.5-13/15.5-14

15.6-9/15.6-10
15.6-15 through 15.6-18.b
15.6-25 through 15.6-28
15.6-33 through 15.6-36
15.6-45 through 15.6-48
15.6-55 through 15.6-58
15.6-69/15.6-70
replace 15.6-71/15.6-72 with 15.6-71/15.6-71.a
**insert** 15.6-71.b/15.6-72
15.6-73/15.6-74

15.7-9/15.7-10
15.7-13/15.7-14

15A-43/15A-44

15B-5/16B-6
15B-9 through 15B-14
15B-17/15B-18

15E-13 through 15E-20
15E-23 through 15E-30

Chapter 17

17-v/17-vi

17.2-1 through 17.2-6
**insert** 17.2-6.a/17-2-6.b
17.2-7 through 17.2-14
17.2-17/17.2-18
17.2-21 through 17.2-24
17.2-27/17.2-28
17.2-47 through 17.2-50
17.2-53/17.2-54
17.2-67 through 17.2-70
17.2-79 through 17.2-80
**insert** 17.2-80.a/17.2-80.b
17.2-81/17.2-81.a
17.2-83/17.2-84
17.2-87/17.2-88
replace 17.2-91/17.2-92 with 17.2-91/17.2-91.a
**insert** 17.2-91.b/17.2-92

17.2-93/17.2-94

17.2C-5/17.2C-6

17.2E-1/Blank

17.2F-5/17.2F-6
17.2F-11 through 17.EF-14
17.2F-17/17.2F-18
17.2F-21/17.2F-22
17.2F-25/17.2F-26
17.2F-33 through 17.2F-36

Chapter 18

18.I.A-1/18.I.A-2
18.I.A-5 through 18.I.A-12

18.I.B-1/18.I.B-2

18.I.C-3/18.I.C-4

18.II.B-3/18.II.B-4
18.II.B-21 through 18.II.B-24

18.II.E-11/18.II.E-12

18.III.A-3/18.III.A-4
18.III.A-17/18.III.A-18

18.III.D-1 through 18.III.D-6

PVNGS UPDATED UFSAR
REVISION 9 – PACKAGE B
INSERTION INSTRUCTIONS

Note

**These insertion instructions are for Package B.**

**These pages must be inserted after inserting Text Insertion Package A and prior to Text Insertion Package C, and Figure Insertion Packages A and B.**

The following instructions indicate replacement pages, pages to be removed and additional pages for incorporating Revision 9 into the Updated Final Safety Analysis Report for the Palo Verde Nuclear Generation Station. Replace the existing pages with the new pages. Please note, some of these pages will be new pages, as indicated by the word "Insert." Retain these instructions in the front of Volume I as a record of changes.

Chapter 1

1.2-13/1.2-14

1.3-1/1.3-2

1.8-7/1.8-8
1.8-11/1.8-12
1.8-87/1.8-88
**insert** 1.8-88.a/1.8-88.b
1.8-101/1.8-102

Chapter 3

3.9-51/3.9-52
**insert** 3.9-52.a/3.9-52.b

Chapter 4

4-i/4-ii

4.2-17/4.2-18
4.2-97/4.2-98
4.2-98.a/4.2-98.b

4.3-5 through 4.3-8
4.3-11 through 4.3-14
4.3-23/4.3-24
**insert** 4.3-24.a/4.3-24.b

4.4-39 through 4.4-42

Chapter 6

6-viii.a/6-viii.b
6-ix/6-x

6.2-111 through 6.2-118
**insert** 6.2-118.a through 6.2-118.d
6.2-119 through 6.2-122
**insert** 6.2.1-122a/blank

Figures 6.2.1-21 through 6.2.1-24
**insert** Figure 6.2.1-25

6.3-29/6.3-29.a
6.3-33.b through 6.3-66
6.3-69/6.3-70
6.3-75 through 6.3-84
6.3-91/6.3-92
**insert** 6.3-93/6.3-94

**Remove** all Figures from the following sections:
6.3.3.2
6.3.3.3
6.3.3.4

Replace with the following Figures:

6.3.3.2-1A through 6.3.3.2-1H
6.3.3.2-2A through 6.3.3.2-2H
6.3.3.2-3A through 6.3.3.2-3H
6.3.3.2-4A through 6.3.3.2-4H
6.3.3.2-5A through 6.3.3.3-5H
6.3.3.2-6A through 6.3.3.2-6U
6.3.3.2-7A through 6.3.3.2-7H

6.3.3.3-1A through 6.3.3.3-1H
6.3.3.3-2A through 6.3.3.3-2H
6.3.3.3-3A through 6.3.3.3-3H
6.3.3.3-4A through 6.3.3.3-4H
6.3.3.3-5A through 6.3.3.3-5H
6.3.3.3-6

6.3.3.4-1 through 6.3.3.4-6

Chapter 8

**insert** 15.2-33 through 15.2-60

**insert** Figure 15.2.3-2A
**insert** Figure 15.2.3-3A
**insert** Figure 15.2.3-4A
**insert** Figure 15.2.3-5A
**insert** Figure 15.2.3-7A
**insert** Figure 15.2.3-10A

Figures 15.2.8-1 through 15.2.8-8
**insert** Figures 15.2.8-9 through 15.2.8-48

15.3-3/15.3-4
replace 15.3-5/15.3-6 with 15.3-5/15.3-5.a
**insert** 15.3-5.b/15.3-6
15.3-11 through 15.3-46
replace 15.3-47 with 15.3-47/15.3-48

Figure 15.3.1-4
Figure 15.3.1-5
Figure 15.3.1-6
Figure 15.3.1-9

**remove** Figures 15.3.3-1 (sheet 1 through 4) through 15.3.3-10

**insert** Figures 15.3.4-1 through 15.3.4-8

15.4-11/15.4-12
15.4-19/15.4-20
15.4.23 through 15.4-26
15.4-29 through 15.4-34
15.4-39 through 15.4-42
15.4-47 through 15.4-63/blank

15.5-5/15.5-6
15.5-9/15.5-10
15.5-13/15.5-14

15.6-9 through 15.6-12
15.6-25/15.6-26
15.6-29/15.6-30
15.6-39/15.6-39.a
15.6-41 through 15.6-50
15.6-59 through 15.6-68
15.6-73/15.6-74

15.7-7 through 15.7-10
15.7-13/15.7-14

15C-7/15C-8

8.2-3/8.2-4

Chapter 9

9-iii/9-iv

replace 9.1-7/9.1-8 with 9.1-7/9.1-7.a
**insert** 9.1-7.b/9.1-8
9.1-13 through 9.1-26
9.1-29/9.1-30
9.1-37/9.1-38

9.2-31/9.2-32

**remove** pages 9.3-85 through 9.3-112
**insert** pages 9.3-85 through 9.3-127/blank

Chapter 11

11.4-13/11.4-14

11.5-7/11.5-8

Chapter 15

15-ix/15-x

15.0-9 through 15.0-14
15.0-17 through 15.0-20

15.1-9 through 15.1-20
15.1-25 through 15.1-40
15.1-43 through 15.1-48
15.1-51/15.1-52
**insert** 15.1-53 through 15.1-64

Figure 15.1.4-1.15
Figure 15.1.4-2.15

15.2-3/15.2-4
**insert** 15.2-4.a/15.2-4.b
replace 15.2-5/15.2-6 with 15.2-5/15.2-5.a
**insert** 15.2-5.b/15.2-6
**insert** 15.2-6.a/15.2-6.b
15.2-11 through 15.2-18
15.2-21 through 15.2-32

15C-11/15C-12

15E-23 through 15E-26

Chapter 17

17.2C-3/17.2C-4

# PVNGS UPDATED UFSAR
# REVISION 9 – PACKAGE C
# INSERTION INSTRUCTIONS

Note

**These insertion instructions are for Package C.**

**These pages must be inserted after inserting Text Insertion Package B and prior to Figure Insertion Packages A and B.**

The following instructions indicate replacement and new pages for incorporation into Revision 9 of the Updated Final Safety Analysis Report for the Palo Verde Nuclear Generation Station. Replace the existing pages with the new pages. Retain these instructions in the front of Volume I as a record of changes.

Chapter 2

2.2-5 through 2.2-8
2.2-21/2.2-22

Figure 2.4-41

Chapter 3

Figure 3.6-23
Figure 3.6-33

3.9-21/3.9-22
3.9-107/3.9-108

Chapter 4

Figure 4.1-1

Chapter 5

5.4-89/5.4-90

Chapter 6

Figure 6.2.4-1, Sheet 9 of 10
Figure 6.2.4-1, Sheet 10 of 10

Chapter 7

7.1-9/7.1-10

7.1-27/7.1-28

Figure 7.2-0F
**Insert** Figure 7.2-9

Chapter 8

Figure 8.1-1

8.2-3/8.2-4

Chapter 9A

9A-53/9A-54

Chapter 9B

9B.2-451/9B.2-452

Chapter 9

9.1-33/9.1-34
9.1-35.b/9.1-36
9.1-39.f/9.1-40

9.2-101/9.2-102

9.5-79/9.5-80
9.5-99/9.5-100

Figure 9.5-6, Sheet 1 of 2
Figure 9.5-6, Sheet 2 of 2

Chapter 10

10.4-63/10.3-64

Chapter 11

11-i/11-ii

Chapter 12

12.3-21/12.3-22

Chapter 15

15.0-21/15.0-22

15.5-13/15.5-14

15.6-9/15.6-10
15.6-25/15.6-26
15.6-73/15.6-74

Figure 15.6.3-1, Sheet 1 of 4

15.7-13/15.7-14

Figure 15B-1

Folded Figure(s)

Figure 7.2-2

Insert Figure 7.2-8

## PVNGS UPDATED FSAR REVISION 9
## FIGURE PACKAGE A&B INSERTION INSTRUCTIONS

**These pages must be inserted after inserting Text Insertion Package C.**

Please note that the Volume Number is no longer given as some UFSAR sets have had binders replaced and or contents split and moved to into additional binders. Also note that depending upon how the set of UFSAR volumes were originally configured and maintained, the specific order of sheets within a set of figures may vary. Example 1: all Unit 1 figures sheets may be in order (U1, Sheet 1 of 2, Unit 1 Sheet 2 of 2, Unit 2 Sheet 1 of 2, etc.). Example 2: figures may be grouped by sheet number (Unit 1 sheet 1 of 2, Unit 2 Sheet 1 of 2, Unit 3 Sheet 1 of 2, Unit 1 Sheet 2 of 2 etc.)

- ☐ Replace Figure 1.2-3 Sheet 1 of 2, Revision 1 with Revision 9
- ☐ Replace Figure 1.2-8, Original with Revision 9
- ☐ Replace Figure 1.2-9, Original with Revision 9
- ☐ Replace Figure 1.2-12, Original with Revision 9
- ☐ Replace Figure 1.7-2 Sheet 1 of 4, Revision 7 with Revision 9
- ☐ Replace Figure 3.8-36, Revision 8 with Revision 9
- ☐ Replace Figure 5.1-1 Unit 2 Sheet 1 of 3, Revision 8 with Revision 9
- ☐ Replace Figure 5.1-1 Unit 3 Sheet 2 of 3, Revision 8 with Revision 9 then add Unit 3 to the Title Block
- ☐ Replace Figure 5.2-3 Unit 1, Revision 4 with Revision 9
- ☐ Remove Figure 5.2-3 Units 2 & 3, Original
- ☐ Insert Figure 5.2-3 Unit 2, Revision 9
- ☐ Insert Figure 5.2-3 Unit 3, Revision 9
- ☐ Replace Figure 6.3-1 Unit 1 Sheet 2 of 3, Revision 8 with Revision 9
- ☐ Replace Figure 6.3-1 Unit 2 Sheet 2 of 3, Revision 8 with Revision 9
- ☐ Replace Figure 6.3-1 Unit 3 Sheet 2 of 3, Revision 8 with Revision 9
- ☐ Replace Figure 8.3-2 Unit 1, Revision 7 with Revision 9
- ☐ Replace Figure 8.3-2 Unit 3, Revision 7 with Revision 9
- ☐ Replace Figure 8.3-4 Unit 1 Sheet 2 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.1-8 Unit 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.1-8 Unit 3 Sheet 1 of 1, Revision 8 with Revision9
- ☐ Replace Figure 9.2-1 Unit 1 Sheet 1 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.2-1 Unit 2 Sheet 1 of 2, Revision 8 with Revision 9 then add Unit 2 to the Title Block
- ☐ Replace Figure 9.2-1 Unit 3 Sheet 1 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.2-1 Unit 3 Sheet 1A of 2, Revision 7 with Revision 9
- ☐ Replace Figure 9.2-3 Unit 1, Revision 8 with Revision 9
- ☐ Replace Figure 9.2-3 Unit 2, Revision 7 with Revision 9

- ☐ Replace Figure 9.2-3 Unit 3, Revision 7 with Revision 9
- ☐ Replace Figure 9.2-4 Unit 3 Sheet 3 of 3, Revision 7 with Revision 9 then add Unit 3 to the Title Block
- ☐ Replace Figure 9.2-6 Sheet 1 of 4, Revision 8 with Sheet 1 of 3 Revision 9 then change sheet number to 1 of 4
- ☐ Replace Figure 9.2-6 Sheet 2 of 4, Revision 8 with Sheet 2 of 3 Revision 9 then change sheet number to 2 of 4
- ☐ Replace Figure 9.2-6 Sheet 3 of 3, Revision 8 with Sheet 3 of 3 Revision 9 then change sheet number to 3 of 4
- ☐ Replace Figure 9.2-7 Unit 1, Revision 8 with Revision 9
- ☐ Replace Figure 9.2-7 Unit 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.2-7 Unit 3, Revision 8 with Revision 9
- ☐ Replace Figure 9.2-8 Unit 1 Sheet 1 of 3, Revision 8 with Revision 9
- ☐ Replace Figure 9.2-8 Unit 2 Sheet 1 of 3, Revision 8 with Revision 9
- ☐ Replace Figure 9.2-8 Unit 3 Sheet 1 of 3, Revision 8 with Revision 9
- ☐ Replace Figure 9.2-10 Unit 1, Revision 8 with Revision 9
- ☐ Replace Figure 9.2-10 Unit 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.2-10 Unit 3, Revision 8 with Revision 9
- ☐ Replace Figure 9.3-1 Unit 1 Sheet 2 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.3-1A Unit 1 Sheet 1 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.3-1 Unit 2 Sheet 2 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.3-1A Unit 2 Sheet 1 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.3-1 Unit 3 Sheet 2 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.3-1A Unit 3 Sheet 2 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.3-2 Unit 1 Sheet 1 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.3-2 Unit 1 Sheet 2 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.3-2A Unit 2 Sheet 1 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.3-2A Unit 2 Sheet 2 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.3-2A Unit 3 Sheet 1 of 2, Revision 7 with Revision 9
- ☐ Replace Figure 9.3-2A Unit 3 Sheet 2 of 2, Revision 7 with Revision 9
- ☐ Replace Figure 9.3-2C Unit 1 Sheet 1 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.3-2C Unit 1 Sheet 2 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.3-2 Unit 3 Sheet 1 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.3-2 Unit 3 sheet 2 of 2, Revision 8 with Revision 9
- ☐ Replace Figure 9.3-3 Unit 2 sheet 1 of 3, Revision 8 with Revision 9
- ☐ Replace Figure 9.3-3 Unit 3 Sheet 1 of 3, Revision 7 with Revision 9
- ☐ Replace Figure 9.3-3 Unit 1 Sheet 1A of 3, Revision 8 with Revision 9

☐ Replace Figure 9.3-3 Unit 2 Sheet 1A of 3, Revision 8 with Revision 9

☐ Replace Figure 9.3-3 Unit 2 Sheet 1B of 3, Revision 8 with Revision 9

☐ Replace Figure 9.3-3 Unit 1 Sheet 2A of 3, Revision 7 with Sheet 2A of 5 Revision 9 then change sheet number to 2A of 3

☐ Replace Figure 9.3-3 Unit 3 Sheet 1A of 3, Revision 7 with Revision 9

☐ Replace Figure 9.3-3 Unit 3 Sheet 1B of 3, Revision 7 with Revision 9

☐ Replace Figure 9.3-3 Unit 1 Sheet 3 of 3, Revision 6 with Revision 9

☐ Replace Figure 9.3-3 Unit 2 Sheet 3 of 3, Revision 6 with Revision 9

☐ Replace Figure 9.3-3 Unit 3 Sheet 3 of 3, Revision 7 with Revision 9

☐ Replace Figure 9.3-5 Unit 1, Revision 8 with Revision 9

☐ Replace Figure 9.3-5 Unit 2, Revision 8 with Revision 9

☐ Replace Figure 9.3-5 Unit 3, Revision 8 with Revision 9

☐ Replace Figure 9.3-7 Unit 1, Revision 8 with Revision 9

☐ Replace Figure 9.3-7 Unit 2, Revision 8 with Revision 9

☐ Replace Figure 9.3-7 Unit 3, Revision 8 with Revision 9

☐ Replace Figure 9.3-8 Unit 1, Revision 8 with Revision 9

☐ Replace Figure 9.3-8 Unit 2, Revision 8 with Revision 9

☐ Replace Figure 9.3-8 Unit 3, Revision 8 with Revision 9

☐ Replace Figure 9.3-10 Unit 1 Sheet 2 of 3, Revision 8 with Revision 9

☐ Replace Figure 9.3-10 Unit 2 Sheet 1 of 3, Revision 8 with Revision 9

☐ Replace Figure 9.3-10 Unit 3 Sheet 1 of 3, Revision 2 with Revision 9

☐ Replace Figure 9.3-11 Unit 1 Sheet 3 of 4, Revision 8 with Revision 9

☐ Replace Figure 9.3-11 Sheet 4 of 4, Revision 8 with Revision 9

☐ Replace Figure 9.3-12, Revision 6 with Revision 9

☐ Replace Figure 9.3-13 Unit 1 Sheet 2 of 5, Revision 8 with Revision 9

☐ Replace Figure 9.3-13 Unit 2 Sheet 2 of 5, Revision 8 with Revision 9

☐ Replace Figure 9.3-13 Unit 3 Sheet 2 of 5, Revision 8 with Revision 9

☐ Replace Figure 9.3-13 Unit 3 Sheet 2A of 5, Revision 8 with Revision 9

☐ Replace Figure 9.3-14 Unit 1 Sheet 1 of 3, Revision 8 with Revision 9

☐ Replace Figure 9.3-14 Unit 2 Sheet 1 of 3, Revision 7 with Revision 9

☐ Replace Figure 9.3-14 Unit 1 Sheet 2 of 3, Revision 7 with Revision 9

☐ Replace Figure 9.3-14 Unit 2 Sheet 2 of 3, Revision 7 with Revision 9

☐ Replace Figure 9.3-14 Unit 3 Sheet 1 of 3, Revision 8 with Revision 9

☐ Replace Figure 9.4-1 Unit 1 Sheet 1 of 2, Revision 8 with Revision 9

☐ Replace Figure 9.4-1 Unit 1 Sheet 2 of 2, Revision 8 with Revision 9

☐ Replace Figure 9.4-1 Unit 2 Sheet 1 of 3, Revision 8 with Revision 9

☐ Replace Figure 9.4-1 Unit 2 Sheet 2 of 3, Revision 8 with Revision 9

☐ Replace Figure 9.4-1 Unit 3 Sheet 1 of 2, Revision 8 with Revision 9

☐ Replace Figure 9.4-1 Unit 3 Sheet 2 of 2, Revision 8 with Revision 9

☐ Replace Figure 9.4-13 Unit 1, Revision 7 with Revision 9

☐ Replace Figure 9.4-13 Unit 2, Revision 8 with Revision 9

☐ Replace Figure 9.4-16 Unit 2, Revision 5 with Revision 9

☐ Replace Figure 9.5-1 Unit 1 Sheet 1 of 6, Revision 8 with Revision 9

☐ Replace Figure 9.5-1 Unit 2 Sheet 1 of 6, Revision 8 with Revision 9

☐ Replace Figure 9.5-1 Unit 3 Sheet 1 of 6, Revision 8 with Revision 9

☐ Replace Figure 9.5-1 Unit 3 Sheet 3 of 6, Revision 8 with Revision 9

☐ Replace Figure 9.5-1 Unit 1 Sheet 4 of 6, Revision 8 with Revision 9

☐ Replace Figure 9.5-1 Unit 2 Sheet 4 of 6, Revision 8 with Revision 9

☐ Replace Figure 9.5-1 Unit 3 Sheet 4 of 6, Revision 8 with Revision 9

☐ Replace Figure 9.5-1 Sheet 5 of 6, Revision 8 with Revision 9

☐ Replace Figure 9.5-7 Unit 2, Revision 8 with Revision 9

☐ Replace Figure 9B-8, Revision 8 with Revision 9

☐ Replace Figure 9B-9, Revision 8 with Revision 9

☐ Replace Figure 9B-10, Revision 8 with Revision 9

☐ Replace Figure 9B-11, Revision 8 with Revision 9

☐ Replace Figure 9B-12, Revision 8 with Revision 9

☐ Replace Figure 9B-33, Revision 8 with Revision 9

☐ Replace Figure 10.2-1 Unit 1 Sheet 1 of 3, Revision 8 with Revision 9

☐ Replace Figure 10.2-1 Unit 1 Sheet 2 of 3, Revision 7 with Revision 9

☐ Replace Figure 10.2-1 Unit 2 Sheet 2 of 3, Revision 7 with Revision 9

☐ Replace Figure 10.2-1 Unit 3 Sheet 2 of 3, Revision 3 with Revision 9

☐ Replace Figure 10.2-2 Unit 1 Sheet 1 of 5, Revision 7 with Revision 9

☐ Replace Figure 10.2-2 Unit 2 Sheet 1 of 5, Revision 8 with Revision 9

☐ Replace Figure 10.2-2 Unit 3 Sheet 1 of 5, Revision 7 with Revision 9

☐ Replace Figure 10.2-2 Unit 2 Sheet 3 of 5, Revision 8 with Revision 9

☐ Replace Figure 10.2-2 Unit 3 Sheet 3 of 5, Revision 7 with Revision 9

☐ Replace Figure 10.2-2 Unit 1 Sheet 5 of 5, Revision 8 with Revision 9

☐ Replace Figure 10.2-2 Unit 3 Sheet 5 of 5, Revision 8 with Revision 9

☐ Replace Figure 10.3-1 Unit 1 Sheet 2 of 3, Revision 8 with Revision 9

☐ Replace Figure 10.3-1 Unit 2 Sheet 2 of 3, Revision 8 with Revision 9

☐ Replace Figure 10.3-2 Unit 1, Revision 8 with Revision 9

☐ Replace Figure 10.3-3 Unit 1, Revision 8 with Revision 9

☐ Replace Figure 10.3-3 Unit 2, Revision 8 with Revision 9

☐ Replace Figure 10.4-1 Unit 2, Revision 8 with Revision 9

☐ Replace Figure 10.4-1 Unit 3, Revision 7 with Revision 9
☐ Replace Figure 10.4-2 Unit 1, Revision 7 with Revision 9
☐ Replace Figure 10.4-2 Unit 2, Revision 7 with Revision 9
☐ Replace Figure 10.4-2 Unit 3, Revision 7 with Revision 9
☐ Replace Figure 10.4-4 Unit 1, Revision 8 with Revision 9
☐ Replace Figure 10.4-4 Unit 2, Revision 8 with Revision 9
☐ Replace Figure 10.4-4 Unit 3, Revision 8 with Revision 9
☐ Replace Figure 10.4-7 Unit 1 Sheet 1 of 2, Revision 8 with Revision 9
☐ Replace Figure 10.4-7 Unit 2 Sheet 1 of 2, Revision 8 with Revision 10
☐ Replace Figure 10.4-7 Unit 3 Sheet 1 of 2, Revision 8 with Revision 9
☐ Replace Figure 10.4-7 Unit 3 Sheet 2 of 2, Revision 8 with Revision 9
☐ Replace Figure 10.4-9 Unit 1 Sheet 1 of 5, Revision 7 with Revision 9
☐ Replace Figure 10.4-9 Unit 2 Sheet 1 of 5, Revision 7 with Revision 9
☐ Replace Figure 10.4-9 Unit 3 Sheet 1 of 5, Revision 7 with Revision 9
☐ Replace Figure 10.4-9 Unit 3 Sheet 2 of 5, Revision 7 with Revision 9
☐ Replace Figure 10.4-9 Unit 3 Sheet 3 of 5, Revision 7 with Revision 9
☐ Replace Figure 10.4-10 Unit 1, Revision 8 with Revision 9
☐ Replace Figure 10.4-10 Unit 2, Revision8 with Revision 9
☐ Replace Figure 10.4-10 Unit 3, Revision 8 with Revision 9
☐ Replace Figure 10.4-11 Unit 1, Revision 8 with Revision9
☐ Replace Figure 10.4-11 Unit 3, Revision 8 with Revision 9
☐ Replace Figure 11.2-2 Unit 1 Sheet 1 of 3, Revision 8 with Revision 9
☐ Replace Figure 11.2-2 Unit 2 sheet 1 of 3, Revision 8 with Revision 9
☐ Replace Figure 11.2-2 Unit 3 Sheet 1 of 3, Revision 8 with Revision 9
☐ Replace Figure 11.2-2 Unit 1 Sheet 2 of 3, Revision 6 with Revision 9
☐ Replace Figure 11.2-2 Unit 2 Sheet 2 of 3, Revision 8 with Revision 9
☐ Replace Figure 11.2-2 Unit 3 Sheet 2 of 3, Revision 7 with Revision 9
☐ Replace Figure 11.2-2 Unit 3 Sheet 2A of 3, Revision 7 with Revision 9
☐ Replace Figure 11.4-2 Unit 1 Sheet 1 of 3, Revision 7 with Revision 9
☐ Replace Figure 11.4-2 Unit 2 Sheet 1 of 3, Revision 7 with Revision 9
☐ Replace Figure 11.4-2 Unit 3 Sheet 1 of 3, Revision 7 with Revision 9
☐ Replace Figure 18.III.A-2, Revision 6 with Revision 9
☐ Replace Figure 18.III.A-3, Revision 5 with Revision 9

SUPERSEDED pg per Rev 9 to UFSAR dtd 12/17/97
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# LIST OF EFFECTIVE PAGES

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| iv | 3 |
| v | 0 |
| vi | 3 |
| vii | 0 |
| viii | 0 |
| ix | 0 |
| x | 0 |
| xi | 0 |
| xii | 0 |
| xiii | 8 |
| xiv | 6 |
| xiv.a | 1 |
| xiv.b | 1 |
| xv | 0 |
| xvi | 3 |
| xvii | 7 |
| xviii | 5 |
| xviii.a | 1 |
| xviii.b | 1 |
| xix | 5 |
| xx | 5 |
| xxi | 0 |
| xxii | 6 |
| xxiii | 6 |
| xxiv | 6 |
| xxv | 6 |
| xxvi | 6 |
| xxvii | 6 |
| xxviii | 6 |
| xxix | 6 |
| xxx | 6 |
| xxxi | 6 |
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| 1-iv | 6 |
| 1-v | 0 |
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| 1.1-2 | 4 |
| 1.1-3 | 4 |
| 1.1-4 | 4 |
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| 1.2-14.b | 1 |
| 1.2-15 | 5 |
| 1.2-16 | 8 |
| 1.2-17 | 5 |
| 1.2-18 | 8 |
| 1.2-19 | 0 |
| 1.2-20 | 8 |
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| Fig. 1.2-2 | 0 |
| Fig. 1.2-3 | |
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| (Sh 2 of 2) | 6 |
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| Fig. 1.2-5 | 5 |
| Fig. 1.2-6 | 0 |
| Fig. 1.2-7 | 6 |
| Fig. 1.2-8 | 0 |
| Fig. 1.2-9 | 0 |
| Fig. 1.2-10 | 0 |
| Fig. 1.2-11 | 6 |
| Fig. 1.2-12 | 0 |
| Fig. 1.2-13 | 0 |
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| 1.7-75 | 6 | 1.8-41 | 3 | 1.8-93.a | 3 |
| 1.7-76 | 6 | 1.8-42 | 3 | 1.8-93.b | 3 |
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| 1.7-80 | 6 | 1.8-46 | 3 | 1.8-96.a | 7 |
| 1.7-81 | 6 | 1.8-47 | 0 | 1.8-96.b | 7 |
| 1.7-82 | 6 | 1.8-48 | 0 | 1.8-96.c | 6 |
| 1.7-83 | 6 | 1.8-49 | 0 | 1.8-96.d | 6 |
| 1.7-84 | 6 | 1.8-50 | 0 | 1.8-97 | 4 |
| Fig. 1.7-1 (Unit 1) | 0 | 1.8-51 | 0 | 1.8-98 | 4 |
| Fig. 1.7-1 (Unit 2) | 0 | 1.8-52 | 0 | 1.8-99 | 8 |
| Fig. 1.7-1 (Unit 3) | 0 | 1.8-53 | 0 | 1.8-100 | 1 |
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| (Sh 2 of 4) | 8 | 1.8-56 | 0 | 1.8-101 | 8 |
| (Sh 3 of 4) | 7 | 1.8-57 | 0 | 1.8-102 | 0 |
| (Sh 4 of 4) | 7 | 1.8-58 | 3 | 1.8-103 | 8 |
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| 1.8-2 | 0 | 1.8-63 | 7 | 1.9 Tab | -- |
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| 1.8-11 | 0 | 1.8-68 | 8 | 1.9-8 | 0 |
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| 1.8-14 | 0 | 1.8-69.b | 1 | 1.9-11 | 0 |
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| 2-xiv | 0 |
| 2-xv | 0 |
| 2-xvi | 1 |
| 2-xvii | 4 |
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| 2-xx | 0 |
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| Fig. 3.5-5 | 0 |
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| Fig. 3.5-7 | 0 |
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| 3.6-10 | 0 |
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| 3.6-12 | 6 |
| 3.6-13 | 6 |
| 3.6-14 | 6 |
| 3.6-15 | 6 |
| 3.6-16 | 6 |
| 3.6-17 | 6 |
| 3.6-17.a | 6 |
| 3.6-17.b | 6 |
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| 3.6-30 | 0 | 3.7-3 | 0 | Fig. 3.7-2 | 0 |
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| 3.6-38 | 7 | 3.7-11 | 0 | Fig. 3.7-9A | 0 |
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| 3.6-45 | 0 | 3.7-18 | 0 | Fig. 3.7-16 | 0 |
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| 3.6-48 | 0 | 3.7-21 | 0 | Fig. 3.7-19 | 0 |
| 3.6-49 | 0 | 3.7-22 | 0 | Fig. 3.7-20 | 0 |
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| (Sh 2 of 2) | 0 | 3.7-31 | 0 | (Sh 8 of 14) | 0 |
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| Fig. 3.6-3 | 0 | 3.7-32.a | 4 | (Sh 10 of 14) | 0 |
| Fig. 3.6-4 | 0 | 3.7-32.b | 4 | (Sh 11 of 14) | 0 |
| Fig. 3.6-5 | 0 | 3.7-33 | 0 | (Sh 12 of 14) | 0 |
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| Fig. 3.6-7 | 0 | 3.7-35 | 0 | (Sh 14 of 14) | 0 |
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| Fig. 3.6-12 | 7 | 3.7-40 | 0 | (Sh 4 of 12) | 0 |
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| Fig. 3.6-15 | 7 | 3.7-42.a | 8 | (Sh 7 of 12) | 0 |
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| Fig. 3.6-20 | 0 | 3.7-46 | 7 | (Sh 12 of 12) | 0 |
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| Fig. 3.6-26 | 4 | 3.7-52 | 3 | (Sh 5 of 22) | 0 |
| Fig. 3.6-27 | 7 | 3.7-53 | 3 | (Sh 6 of 22) | 0 |
| Fig. 3.6-28 | 4 | 3.7-54 | 3 | (Sh 7 of 22) | 0 |

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| (Sh 14 of 22) | 0 | 3.8-36 | 0 | 3.8-101 | 0 |
| (Sh 15 of 22) | 0 | 3.8-37 | 0 | 3.8-102 | 0 |
| (Sh 16 of 22) | 0 | 3.8-38 | 0 | 3.8-103 | 0 |
| (Sh 17 of 22) | 0 | 3.8-39 | 0 | 3.8-104 | 0 |
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| Fig. 3.8-17 | 0 | 3.9-31 | 0 | 3.9-96 | 8 |
| Fig. 3.8-18 | 4 | 3.9-32 | 0 | 3.9-97 | 8 |
| Fig. 3.8-19 | 0 | 3.9-33 | 0 | 3.9-98 | 8 |
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| Fig. 3.8-22 | 0 | 3.9-36 | 0 | 3.9-101 | 0 |
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| Fig. 3.8-34 |  | 3.9-49 | 0 | 3.9-112.b | 3 |
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| 3.9-7 | 0 | 3.9-72 | 0 | 3.10-6 | 3 |
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| | | 3B-xv | 0 | Fig. 3B.3-14 | 0 |
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| 3A-8 | 7 | 3B.2-4 | 0 | (Sh 2 of 2) | 0 |
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| 3A-12 | 7 | 3B.2-8 | 0 | Fig. 3B.4-3 | |
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| 3A-18 | 0 | Fig. 3B.2-4 | 0 | (Sh 2 of 2) | 0 |
| 3A-19 | 0 | Fig. 3B.2-5 | 0 | Fig. 3B.4-6 | |
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| 3A1-2 | 0 | Fig. 3B.2-10 | 0 | Fig. 3B.4-9 | |
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| Fig. 3A-2 | 0 | Fig. 3B.2-12 | 0 | (Sh 2 of 2) | 0 |
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| (Sh 1 of 2) | 7 | Fig. 3B.2-15 | 0 | (Sh 2 of 2) | 0 |
| (Sh 2 of 2) | 7 | Fig. 3B.2-16 | 0 | Fig. 3B.4-11 | |
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| Fig. 3A-5 | 7 | Fig. 3B.2-18 | 0 | (Sh 2 of 2) | 0 |
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| | | 3B.3-4 | 0 | (Sh 2 of 2) | 0 |
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| 18.II.K-6 | 0 |
| 18.II.K-7 | 0 |
| 18.II.K-8 | 0 |
| 18.II.K-9 | 0 |
| **18.III.A Tab** | – |
| 18.III.A-1 | 6 |
| 18.III.A-2 | 6 |
| 18.III.A-3 | 0 |
| 18.III.A-4 | 8 |
| 18.III.A-5 | 0 |
| 18.III.A-6 | 0 |
| 18.III.A-7 | 0 |
| 18.III.A-8 | 0 |
| 18.III.A-9 | 0 |
| 18.III.A-10 | 0 |
| 18.III.A-11 | 0 |
| 18.III.A-12 | 0 |
| 18.III.A-13 | 0 |
| 18.III.A-14 | 0 |
| 18.III.A-15 | 0 |
| 18.III.A-16 | 0 |
| 18.III.A-17 | 5 |
| 18.III.A-18 | 8 |
| 18.III.A-19 | 0 |
| Fig. 18.III.A-1 | 6 |
| Fig. 18.III.A-2 | 6 |
| Fig. 18.III.A-3 | 5 |
| Fig. 18.III.A-4 | 7 |
| **18.III.D Tab** | – |
| 18.III.D-1 | 0 |
| 18.III.D-2 | 0 |
| 18.III.D-3 | 5 |
| 18.III.D-4 | 0 |
| 18.III.D-5 | 0 |
| 18.III.D-6 | 0 |
| 18.III.D-7 | 0 |
| 18.III.D-8 | 0 |
| 18.III.D-9 | 0 |
| 18.III.D-10 | 0 |
| 18.III.D-11 | 0 |
| 18.III.D-12 | 0 |
| 18.III.D-13 | 5 |
| 18.III.D-14 | 7 |
| 18.III.D-15 | 7 |
| 18.III.D-16 | 5 |
| 18.III.D-17 | 0 |
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| **Appendix 18A Title Page** | 0 |
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energy generated by PVNGS and compatible with the transmission systems of the participants.

PVNGS, as established by the ANPP Participation Agreement, is neither a corporate entity, partnership, nor joint venture; but rather it is a jointly owned facility, consisting of all equipment, structures, nuclear fuel, and other property and rights that are or may be used or useful in the operation and maintenance of the facility, but excluding the high voltage switchyard and all transmission facilities connected thereto. Each joint owner has the sole and exclusive right to a percentage equal to its ownership interest of the generating capability of each of the PVNGS units. Accordingly, no sales of power and energy will be made by PVNGS or by APS as agent for other participants in PVNGS. Instead, all sales of power and energy from any PVNGS generating unit will be made by the various joint owners, individually, to their respective customers and to third parties separately from and independent of the ANPP Participation Agreement.

### 1.1.1 TYPE OF LICENSE REQUESTED

The application is for a Class 103 license for each of the PVNGS Units 1, 2, and 3.

### 1.1.2 PROPOSED STATION LOCATION

PVNGS is located on a site situated in Section 34 and portions of Sections 26, 27, 28, 33, and 35 in Township One North, Range Six West of the Gila and Salt River Base and Meridian, and Section 3 and portions of Sections 2, 4, 9, and 10 in Township One South, Range Six West of the Gila and Salt River Base and Meridian, Maricopa County, Arizona.

This location is approximately 34 miles west of the nearest boundary of the city of Phoenix, Arizona. The closest population center of more than 25,000 residents is Sun City, which is approximately 34 miles east-northeast of the PVNGS site.

### 1.1.3 CONTAINMENT TYPE

The containment for each unit is a single containment system consisting of a steel-lined, prestressed concrete, cylindrical structure, with a hemispherical dome. The containment structures are designed by Bechtel Power Corporation (Bechtel).

### 1.1.4 THERMAL POWER LEVELS AND ELECTRICAL OUTPUT

The rated core thermal power level at which each NSSS will be operated is 3800 MWt plus 17 MWt net of heat from nonreactor sources, primarily pump heat, for a total of 3817 MWt for each unit.

The turbine-generator electrical output for 3817 MWt is 1304 MWe at 3.5 inches Hg abs backpressure. The nominal net output of each unit is 1270 MWe.

### 1.1.5 SCHEDULED COMPLETION AND COMMERCIAL OPERATION DATES

The scheduled completion or fuel loading dates and the scheduled commercial operation dates for PVNGS Units 1, 2, and 3 are as follows:

| PVNGS Unit | Operating License Date | Commercial Operation Date[a] |
|---|---|---|
| 1 | Licensed December 31, 1984 | January 28, 1986 |
| 2 | Licensed December 9, 1985 | September 19, 1986 |
| 3 | Licensed March 25, 1987 | January 8, 1988 |

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a. ANPP terminology is firm power operation date in lieu of commercial operation date.

## 1.2.7 POWER CONVERSION SYSTEM

### 1.2.7.1 Turbine-Generator

The turbine-generator is an 1800 r/min, tandem compound, six-flow, 43-inch last-stage bucket reheat unit with an electrohydraulic control system.

The rated NSSS power level is 3800 MWt, plus 17 MWt net heat from nonreactor sources, for a total of 3817 MWt per unit. The corresponding turbine-generator gross output is 1304 MWe at 3.5 inches Hg abs backpressure. The nominal net output of PVNGS is 1270 MWe per unit.

The generator is a direct-driven, three-phase, 60 Hz, 24,000V, 1800 r/min, conductor cooled synchronous generator rated at approximately 1559 MVA at 0.90 power factor and 75 psig hydrogen pressure.

### 1.2.7.2 Main Steam Supply System

The main steam supply system provides steam from the steam generators for the turbine-generator, the feedwater pump turbines, the turbine gland sealing system, condensate and feedwater heating, and main turbine reheat steam as required.

### 1.2.7.3 Main Condenser

Steam from the low-pressure turbine is exhausted directly downward into the condenser shells through exhaust openings in the bottom of the turbine casings and is condensed. The condenser is a multisection, multipressure condenser, each section serving one double-flow, low-pressure turbine section. The condenser also serves as a heat sink for the turbine bypass system.

### 1.2.7.3.1 Condenser Air Removal System (CARS)

The condenser air removal system removes air and noncondensable gases from the main condenser and exhausts them to the atmosphere via the plant vent. The CARS consists of four 7| two-stage mechanical vacuum pumps. Three vacuum pumps are used during startup and normal operation. One additional vacuum pump serves as backup to the three pumps in operation.

### 1.2.7.4 Circulating Water System

The circulating water system provides the main condenser with a continuous supply of cooling water to remove the heat rejected from the turbine thermal cycle. The circulating water system consists of three circular mechanical draft cooling towers and four vertical, motor-driven pumps. The circulating water pumps circulate the cooling water from the cooling tower basins through the main condenser and then back to the cooling towers. Makeup water to compensate for drift, blowdown, and evaporative losses is supplied from the makeup water reservoir.

### 1.2.7.5 Condensate and Feedwater System

Three condensate pumps take the deaerated condensate from the hotwells of the main condenser and deliver it through the low-pressure feedwater heaters to two feedwater pumps. Drains from moisture separators and reheaters, and the high-pressure feedwater heaters, are pumped into the suction stream of the feedwater pumps by two heater drain pumps, and the drains from low-pressure heaters are cascaded back to the main condenser. The feedwater pumps discharge the total feedwater flow through the high-pressure feedwater heaters to the steam generators.

1.2.10.3.3.3 Ultimate Heat Sink. One ultimate heat sink is provided for each generating unit. The ultimate heat sink consists of two Seismic Category I essential spray ponds. The ultimate heat sink is utilized for normal and emergency shutdown in conjunction with the ESPS and the ECWS. The ultimate heat sink has a storage capacity that enables the associated ESPS trains to operate continuously for 26 days without any makeup water supply. However, normal makeup to replace evaporative loss from the ultimate heat sink is provided from the domestic water system. An alternate source of water is the makeup water reservoir. Refer to subsection 9.2.5 for a detailed description of the ultimate heat sink. |8

1.2.10.3.3.4 Plant Cooling Water System. During normal operation, the plant cooling water system (PCWS) is utilized to remove heat from the NCWS and the turbine cooling water system (TCWS).

The PCWS rejects heat to the circulating water system. Redundant heat exchangers and pumps are provided. The PCWS is described in detail in subsection 9.2.10.

1.2.10.3.3.5 Turbine Cooling Water System. The TCWS is a nonsafety-related cooling system that provides treated demineralized cooling water to components in the turbine plant and acts as an intermediate system between turbine plant components and the PCWS. A detailed description of the TCWS is provided in subsection 9.2.8.

1.2.10.3.3.6 Spent Fuel Pool Cooling and Cleanup System. The spent fuel pool cooling system provides forced cooling of the pool water as required under normal and emergency (loss of offsite power) operating conditions. During normal operation, the fuel pool heat exchangers are supplied with cooling water by the NCWS. In the event of loss of offsite power, cooling water is available from the ECWS. The fuel pool and the fuel pool cooling system are Seismic Category I systems. The shutdown cooling system described in CESSAR Section 1.2.10.1 can also be used to provide fuel pool cooling.

The purification loop is used to maintain the purity and clarity of water in the fuel transfer canal, the spent fuel pool, and refueling pool. The loop has a filter and demineralizer for purifying the water.

These systems are described in detail in subsection 9.1.3.

1.2.10.3.3.7 Evaporation Ponds. Evaporation ponds will be added incrementally as the units are brought on line. They are earth embankments, lined with an artificial liner to limit seepage. The ponds will store and evaporate cooling tower
3 | blowdown water and wastewater. Pond No. 1 is lined with hyplon on the side slopes and rubberized asphalt on the bottom. Pond No. 2 is lined with an 80 mil HOPE liner on both the side slopes and bottom.

#### 1.2.10.3.4 Plant Fire Protection System

The fire protection water system provides water to any plant area where fire protection may be required. Units 1, 2, and 3 share a common fire protection water system. Water is taken from its two fire protection/well water storage tanks. The system consists of one electric-driven pump, two diesel engine driven pumps, one jockey pump, and the associated piping, valves, hydrants, and hose stations.

Chemical, carbon dioxide, and Halon 1301 firefighting systems also are provided in addition to the water fire protection system.

Necessary instrumentation and controls are provided for proper operation of the fire protection system. The fire protection system is described in subsection 9.5.1.

1.2.10.3.3.3 Ultimate Heat Sink. One ultimate heat sink is provided for each generating unit. The ultimate heat sink consists of two Seismic Category I essential spray ponds. The ultimate heat sink is utilized for normal and emergency shutdown in conjunction with the ESPS and the ECWS. The ultimate heat sink has a storage capacity that enables the associated ESPS trains to operate continuously for 26 days without any makeup water supply. However, normal makeup to replace evaporative loss from the ultimate heat sink is provided from the domestic water system or makeup water reservoir (Units 2 and 3 only). Refer to subsection 9.2.5 for a detailed description of the ultimate heat sink. 9

1.2.10.3.3.4 Plant Cooling Water System. During normal operation, the plant cooling water system (PCWS) is utilized to remove heat from the NCWS and the turbine cooling water system (TCWS).

The PCWS rejects heat to the circulating water system. Redundant heat exchangers and pumps are provided. The PCWS is described in detail in subsection 9.2.10.

1.2.10.3.3.5 Turbine Cooling Water System. The TCWS is a nonsafety-related cooling system that provides treated demineralized cooling water to components in the turbine plant and acts as an intermediate system between turbine plant components and the PCWS. A detailed description of the TCWS is provided in subsection 9.2.8.

1.2.10.3.3.6 Spent Fuel Pool Cooling and Cleanup System. The spent fuel pool cooling system provides forced cooling of the pool water as required under normal and emergency (loss of offsite power) operating conditions. During normal operation, the fuel pool heat exchangers are supplied with cooling water by the NCWS. In the event of loss of offsite power, cooling water is available from the ECWS. The fuel pool and the fuel pool cooling system are Seismic Category I systems. The shutdown cooling system described in CESSAR Section 1.2.10.1 can also be used to provide fuel pool cooling.

The purification loop is used to maintain the purity and clarity of water in the fuel transfer canal, the spent fuel pool, and refueling pool. The loop has a filter and demineralizer for purifying the water.

These systems are described in detail in subsection 9.1.3.

1.2.10.3.3.7 Evaporation Ponds. Evaporation ponds were added incrementally as the units were brought on line. They are earth embankments, lined with an artificial liner to limit seepage. The ponds store and evaporate cooling tower blowdown 9 water and wastewater. Pond No. 1 has a primary liner system of 80 mil HDPE and a secondary system of hypalon on the side slopes and rubberized asphalt on the bottom. Pond No. 2 is lined with an 80 mil HDPE liner on both the side slopes and bottom.

### 1.2.10.3.4 Plant Fire Protection System

The fire protection water system provides water to any plant area where fire protection may be required. Units 1, 2, and 3 share a common fire protection water system. Water is taken 9 from its two fire water/well water reserve tanks. The system consists of one electric-driven pump, two diesel engine driven pumps, one jockey pump, and the associated piping, valves, hydrants, and hose stations.

Chemical, carbon dioxide, and Halon 1301 firefighting systems also are provided in addition to the water fire protection system.

Necessary instrumentation and controls are provided for proper operation of the fire protection system. The fire protection system is described in subsection 9.5.1.

### 1.2.10.3.6 Lighting System

The three lighting systems provided are described as follows:

A. Normal Lighting

The normal lighting system provides illumination for the entire plant. The lighting load is distributed between two non-Class 1E lighting transformers.

B. Essential Lighting

The essential lighting system is connected to ESF buses. In general, the essential lighting system is designed to provide sufficient illumination to allow safe personnel access/egress throughout the plant in the event of a loss of normal lighting. It is also 5 designed to provide sufficient illumination for the local manual operation of safe shutdown equipment in the event of fire. It provides 100% lighting in the control room area and remote shutdown room.

C. Emergency Lighting

The emergency lighting system is provided in areas used during shutdown or emergency. These areas include the control room, the local control stations required to shut down and maintain the plant in a hot shutdown condition from outside the control room, and the emergency exit routes. All emergency lighting is served by either self-contained battery units or 5 battery backed UPS systems.

The lighting systems are described in detail in subsection 9.5.3.

### 1.2.10.3.7 Demineralized Water System

The demineralized water system furnishes demineralized water to each unit. Water from the reverse osmosis subsystem of the domestic water system is used to supply the demineralized water makeup system. The demineralizers consist of three mixed bed demineralize units. Any two demineralize beds operate in series to form a makeup train. A condensate tank, a demineralized water tank, and a reactor makeup tank are used at each unit to maintain the required demineralized water storage. The system is described in subsection 9.2.3.

#### 1.2.10.3.8 Domestic Water System

The domestic water system provides necessary potable water to each unit for the consumptive use of plant personnel and water for other general plant uses. Well water is filtered, processed, and chlorinated prior to distribution throughout the plant. The domestic water system is described in subsection 9.2.4.

#### 1.2.10.3.9 Alternate AC Power System

8 The station blackout gas turbine generation system is available to provide ac power to station loads that have been identified as important to the mitigation of a station blackout in any one unit of PVNGS. Two redundant 100 percent capacity turbine generators are available for providing power to one of the safety related 4.16kV busses in each unit. The system is described in section 8.3.1.1.10

### 1.2.11 RADIOACTIVE WASTE MANAGEMENT SYSTEMS

The radioactive waste management system is designed to safely control potentially radioactive liquid, gaseous, and solid wastes. The system includes three principal subsystems:

- Liquid radwaste system (LRS)
- Gaseous radwaste system (GRS)
- Solid radwaste system (SRS)

The LRS is designed so that during normal operation there is no offsite release of radioactive liquids of plant origin from the plant site. The design of all radwaste systems ensures that all radioactive releases are as low as is reasonably achievable (ALARA).

#### 1.2.11.1 Liquid Radwaste System

The LRS recovers radioactive or chemical liquid wastes for solidification. The system can accommodate liquid wastes generated at maximum anticipated rates, including demineralizer resin chemical regenerants from the condensate demineralizers, and can segregate waste on the basis of total dissolved solids (TDS) for optimal economic treatment.

## 1.3 COMPARISON TABLES

### 1.3.1 COMPARISONS WITH SIMILAR FACILITY DESIGNS

Tables 1.3-1 and 1.3-2 present a summary of the characteristics of the Palo Verde Nuclear Generating Station for Unit 1 Cycle 1 (the reference cycle for the three PVNGS 7
units). Table 1.3-1 presents similar reactor core and coolant system data for Pilgrim Station Unit 2 and San Onofre Units 2 and 3. Table 1.3-2 presents similar containment system, engineered safety features, and electrical components data for Farley Units 1 and 2, Calvert Cliffs 1 and 2, and San Onofre Units 2 and 3.

The Pilgrim Station Unit 2 and San Onofre Units 2 and 3 designs were selected for comparison in table 1.3-1 because of the basic similarity of the reactor core and coolant systems. In addition, San Onofre was selected for comparison because this reactor is nearing completion of its operating license application review with the NRC.

### 1.3.2 COMPARISON OF FINAL AND PRELIMINARY INFORMATION

Table 1.3-3 contains a discussion of significant changes that have been made in plant design since submittal of the PVNGS 1, 2, and 3 PSAR and amendments 1 through 20.

## Table 1.3-1

## REACTOR CORE AND COOLANT SYSTEM PARAMETERS (Sheet 1 of 9)

| Item | Palo Verde | Reference Section | Pilgrim Station Unit 2 | San Onofre Units 2 and 3 |
|---|---|---|---|---|
| <u>Hydraulic and Thermal Design Parameters</u> | | | | |
| Rated core heat output, MWt | 3800 | 4.4 | 3,456 | 3,390 |
| Rated core heat output, Btu/h | 12,970 x $10^6$ | 4.4 | 11,800 x $10^6$ | 11,570 x $10^6$ |
| Heat generated in fuel, % | 97.5 | 4.4 | 96.5 | 97.5 |
| System pressure, nominal, psia | 2250 | 4.4 | 2,250 | 2,250 |
| System pressure, minimum steady state, psia | 2200 | 4.4 | 2,200 | 2,200 |
| Hot channel factors, | | | | |
| Heat flux, Fq | 2.35 | 1.3 | 2.35 | 2.35 |
| Enthalpy rise, $F_H$ (outlet enthalpy = 699) | 1.56 | 4.4 | 1.55 | 1.55 |
| DNB ratio at nominal conditions | 1.79 (CE-1) | 4.4 | 2.26 (W-3) | 2.07 (CE-1) |
| Coolant flow | | | | |
| Total flowrate, lb/h | 164.0 x $10^6$ | 5.2 | 148 x $10^6$ | 148 x $10^6$ |
| Effective flowrate for heat transfer, lb/h | 157.4 x $10^6$ | 4.4 | 142.8 x $10^6$ | 142.8 x $10^6$ |
| Effective flow area for heat transfer, $ft^2$ | 60.9 | 4.4 | 54.8 | 54.7 |
| Average velocity along fuel rods, ft/s | 16.4 | 4.4 | 16.5 | 16.3 |
| Average mass velocity, lb/h-$ft^2$ | 2.58 x $10^6$ | 4.4 | 2.60 x $10^6$ | 2.61 x $10^6$ |
| Coolant temperatures, °F | | | | |
| Nominal inlet | 568 | 4.4 | 557.5 | 553. |
| Design inlet | 564.5 | 4.4 | 560.5 | 556 |
| Average rise in vessel | 56 | 4.4 | 58.3 | 58 |
| Average rise in core | 59 | 4.4 | 60.3 | 60 |
| Average in core | 594 | 4.4 | 588 | 583 |

## Table 1.3-2

## COMPARISON OF PLANT CHARACTERISTICS (Sheet 5 of 5)

| Item | Palo Verde (FSAR) | San Onofre Units 2 and 3 (FSAR) | Farley Units 1 and 2 (FSAR) | Calvert Cliffs Units 1 and 2 (FSAR) | Significant Similarities | Significant Differences | References by Sections |
|---|---|---|---|---|---|---|---|
| Radioactive Waste Management System (cont) | | | | | | | |
| Radwaste solidification system (cont) | | | | | | | |
| On site storage: | | | | | | | |
| High level solidification | 42-80 ft$^3$ drums or 294-55 gal drums | 20-50 ft$^3$ drums | 175-55 gal drums | - | | | |
| Low level solidification baling station | 50-55 gal drums | 25-55 gal drums | 400-55 gal drums | - | | | |
| Shipping containers used | 55-gal drums and 80 ft$^3$ drums | 55 gal drums and 50 ft$^3$ drums | 55 gal drums | - | | | |

Table 1.3-3

SIGNIFICANT DESIGN CHANGES

| Items | System Described in FSAR Section | Reason for Change |
|---|---|---|
| Containment spray | 6.1 | The containment spray solution was changed from sodium hydroxide (NaOH) to hydrazine to provide for improved iodine removal, better pH control, and elimination of alkali attack on containment equipment. |
| Condensate storage tank | 3.8 | Changed from steel tank with concrete missile barrier to concrete, Seismic Category I structure with stainless steel liner. |
| Refueling water tank | 3.8 | Changed from steel tank with concrete missile barrier to concrete, Seismic Category I structure with stainless steel liner. |
| Atmospheric dump valves | 9.3.6 | Changed to safety grade controls. |
| Hydrogen purge filters | 6.2.5 | The hydrogen purge system is a backup nonsafety-related system to the safety-related redundant hydrogen recombiners. The filters provided in this system are not required in order to meet the dose criteria of 10CFR100. For this reason, the hydrogen purge filters will not be tested in accordance with Regulatory Guide 1.52. |

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There is no specific design capacity limit on the number of personnel permitted in the control room under normal operation. 0

D. Safety Evaluation Four

Food, water, medical supplies (including a potassium iodide drug supply), and sanitary facilities are provided for a minimum occupancy of six persons for 7 days. Storage locations provided ensure that the above supplies will not be contaminated as a result of postulated accidents.

The supply of food and water is sufficient for a prolonged occupancy since outside supplies can be provided within the 7-day interval.

Refer to subsection 18.III.D.3.4 for TMI-related information pertaining to "Control Room Habitability Requirements".

E. Safety Evaluation Five

The control room air purification system and shielding designs are based on the most limiting design basis assumptions contained in NRC Regulatory Guide 1.4.

Automatic transfer of the control room normal ventilation system to the essential system is accomplished upon receipt of a high radiation signal from the outside air intake duct detectors, receipt of LOP signal, receipt of a safety injection actuation signal, or receipt of a fuel building high radiation signal from the ESF actuation system. Transfer to the essential system also may be manually initiated from the control room. Refer to section 7.3 for a discussion of the actuation logic.

materials is compatible with the normal and accident environments postulated in the control room and the fuel building.

Accident environments (i.e., extreme temperature or radiation) that could potentially produce radiolytic or pyrolytic decomposition of filter materials are not applicable to the control room or fuel building. Thus, filter system decomposition products will not be present.

## 6.5.2 CONTAINMENT SPRAY SYSTEMS

Except as specifically modified in this section, the design bases, system design, design evaluation, tests and inspections, instrumentation requirements, and materials of the containment spray system and the iodine removal system are presented in Appendices 6A and 6B of CESSAR.

### 6.5.2.1 Design Bases

Credit for the iodine removal capability is discussed in paragraph 6.5.2.3. This credit, due to system performance, is used to meet the requirements of 10CFR100 for the design basis accidents presented in chapter 15.

### 6.5.2.2 System Design (for Fission Product Removal)

The spray header arrangement is shown in figures 6.5-1 through 6.5-3.

Regions within the containment can be shielded from direct spray by flooring, missile shielding, and equipment. The PVNGS containment design limits these unsprayed regions to approximately 6% of the containment volume. Most of the containment volume receives direct spray coverage from the primary spray headers (located above the operating floor), although some of the containment volume receives direct spray coverage from auxiliary headers (located below the 120-foot and 140-foot levels under concrete slabs on the eastern end of the refueling pool). These volumes that are sprayed by the auxiliary headers receive the same spray flowrate per unit volume of gas space (gallons per minute per cubic foot) as the volumes which are sprayed by the primary spray headers. Detailed plans and sections of the containment which illustrate the unsprayed regions are given in figures 6.5-4 through 6.5-9. Table 6.5-2 lists the unsprayed regions by volume above elevation 100 feet. Except for the steam generator compartment, areas below elevation 100 feet are not sprayed. The gross containment volume above elevation 100 feet is $2.72 \times 10^6$ cubic feet. Therefore, the sprayed containment volume above elevation 100 feet is $2.45 \times 10^6$ cubic feet. The sprayed volume below elevation 100 feet of the steam generator compartment is $2.05 \times 10^4$ cubic feet. Thus, the total containment sprayed volume is $2.47 \times 10^6$ cubic feet. As the containment net free volume is $2.62 \times 10^6$ cubic feet, only 6% of the net free volume is unsprayed.

3 Manually-operated valves are provided for filling, draining, and testing of the iodine removal system as described in CESSAR Appendix 6B, Section 3.2.4.2, except that valves IR-128 and 148 have been replaced by valves IR-985 and 984.

### 6.5.2.3 Design Evaluation

Refer to CESSAR Appendix 6B. Additionally, the elemental iodine removal constant (spray $\lambda$) for the sprayed region is 22.9 $h^{-1}$.

A reduction of the iodine concentration occurs in the unsprayed regions as well as the sprayed regions due to several mechanisms. These include iodine plateout on the wet surfaces within the unsprayed regions(1)(2), diffusion, and a general bulk mass transfer between regions due to such factors as break location, natural convection, and steam condensation by containment spray.

Only the bulk mass transfer between the sprayed and unsprayed regions due to steam condensation is used in the evaluation of the reduction of iodine concentration within the unsprayed region. For a containment with the majority of the mass and energy releases occurring below the operating level and the

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appendix 6A, Question 6A.11). It also uses 80 Spraco 17651308 (3 gallons per minute) nozzles in each train of the auxiliary spray headers.

### 6.5.2.4 Tests and Inspection

Preoperational testing is performed on the system in accordance with the test description in section 14.2. Periodic testing is performed in accordance with the requirements of Section 3/4.6.2 of the Technical Specifications.

### 6.5.2.5 Instrumentation Requirements

The iodine removal system is provided with instrumentation and controls to allow the operator to monitor the status of the system. All instrumentation, with the exception of pressure instrumentation, receives emergency onsite power from separate, redundant, and train-aligned power supplies.

Level indication is provided locally and in the control room
to monitor spray chemical storage tank (SCST) availability. A 8
low-low level signal will stop the spray chemical addition
pumps (SCAPs) and will close the SCST isolation valves. Level
switches are also provided to close the IRS isolation valves
at the low-low SCST level setpoint.

Flow indication in the control room is provided to monitor system operation and to facilitate periodic inservice testing.

Redundant pressure indication is provided on the SCST to 8
assure that the integrity of the nitrogen overpressure is
maintained. Pressure indication is provided downstream of the
SCAPs to facilitate periodic inservice testing.

8

Refer also to CESSAR Appendix 6B.

### 6.5.2.6 Materials

The materials used in the IRS are compatible with reactor coolant and a nuclear environment by the following means:

A. The specifications restrict metals contacted by reactor coolant to austenitic stainless steel, type 304, or an acceptable alternative material.

B. A list of materials used in the component assembly gas has been reviewed and approved prior to release for manufacture.

C. None of the materials used are subject to decomposition by the radiation or thermal environment. The specifications require that the materials withstand the equipment design temperature and the total integrated radiation dose.

Refer to section 6.2 for a description of the material of the containment spray system and their compatibility with the containment sump solution. Refer also to CESSAR Appendix 6B.

### 6.5.2.7 CESSAR Interface Requirements

A. CONTAINMENT SPRAY SYSTEM

The following interface criteria are repeated from Section 7.0 of CESSAR Appendix 6A.

(A)7.0 INTERFACE REQUIREMENTS

(A)7.1 POWER

(A)7.1.1 The containment spray system pumps, valves, and instrumentation shall be capable of being powered from the plant turbine generator (onsite power source), room to assist in assessing post-LOCA conditions. The type of instrument, parameter measured, instrument range and accuracy are listed in Sections 6.1 and 6.2.

## (A)7.9 OPERATIONAL AND CONTROLS

Refer to Section 7.1.

## (A)7.10 INSPECTION AND TESTING

4

Inspection and testing requirements for the CSS are contained in Section 8.0 and in CESSAR Section 16. Prior to initial plant startup, CSS flow tests which comply with Section 9.0 shall be performed. An adequate supply of water and the necessary test connections at the containment sump and containment spray header piping penetrations shall be provided.

## (A)7.11 CHEMISTRY AND SAMPLING

(A)7.11.1 The CSS shall be designed for the following fluid conditions:

| | |
|---|---|
| Basic Fluid | Water |
| with: $H_3BO_3$ | 3.5 w/o |
| $N_2H_4$ | 50 to 100 ppm |

phosphate controlled pH of 10 max.

### (A)7.11.2 SAMPLING

(A)7.11.2.1 The sampling system shall provide a means of obtaining remote liquid samples from the CSS for chemical and radiochemical laboratory analysis.

(A)7.11.2.2 The sample lines in contact with the reactor coolant shall be austenitic stainless steel or equivalent, such that the material is compatible with the fluid chemistry.

(A)7.11.2.3 The fluid velocity in the sample lines should be selected to obtain representative samples. The purge flowrate should be high enough to remove crud from lines.

(A)7.11.2.4 Sample taps should be located on vertical runs of pipe whenever possible. Where this cannot be done, it is permissible to take samples from the top of horizontal pipe runs.

## (A)7.12 MATERIALS

(A)7.12.1 CSS piping and fittings shall be Seismic Category I.

(A)7.12.2 Design and fabrication of the CSS piping and fittings shall conform to ASME Boiler and Pressure Vessel Code (B&PV) Section III, Class 2 as identified on CESSAR Section 6.3.1.

(A)7.12.3 Pipes and all parts in contact with the system fluid shall be of austenitic stainless steel. The stainless steel shall be type 316, type 304, or CE approved alternate. Selection of the type of stainless steel shall be on the basis of compatibility with design pressure and temperature considerations reactions, fluid reaction forces) resulting from failure of equipment or piping inside or outside the containment.

(A)7.13.12 Where required, bellows shall be provided between piping and the containment wall to prevent excessive forces on the piping.

(A)7.13.13 Each CS pump bypass flow line shall be capable of passing 150 gpm with its CS pump operating at design operating conditions.

(A)7.13.14 The design of the CSS piping and spray headers shall consider the effects of water hamper. Fill and drain connections together with associated valves and instrumentation shall be provided if filling of the riser piping inside the containment is required to preclude the effects of water hammer.

The maximum spray header elevation above the RWT outlet nozzles shall not exceed 185 feet.

(A)7.13.15 The resistance of the RWT return lines shall be established so as to permit periodic testing of each spray pump at conditions as near to design (see Table 1) as practicable. For preoperational testing, provisions should be made to provide full flow. For this test, the RWT return line or an alternate may be used.

(A)7.13.16 All CSS ASME, Section III components shall be arranged to provide adequate clearances to permit inservice inspection. The design of the arrangement should conform to the guidelines of Section XI of the ASME Code. Manually-operated valves which contain reactor coolant or other potentially radioactive liquids during normal plant operations, shall be provided with hand wheel extensions and shielding, to allow periodic actuation as per ASME Section XI, Subsection IWV. CSS components which contain reactor coolant or other potentially radioactive liquids during normal plant operations, and which require access for periodic pressure tests and nondestructive examination (ASME Section XI, Subsection IWC), shall be flushed with RWT water prior to testing. The containment spray pumps shall be capable of providing the driving head for flushing. The discharge shall be collected and processed by the shutdown purification portion of the chemical and volume control system.

Access to system components not designed to ASME, Section III should be provided for periodic visual inspection for leakage, structural distress and corrosion.

(A)7.13.17 Protection shall be provided from internally generated flooding that could prevent performance of safety-related functions.

## (A)7.14 RADIOLOGICAL WASTE COLLECTION

Containment spray system leakage to the safeguards room will normally drain to the room sump. Provisions shall be

Cooling water flow shall be established to the shutdown cooling heat exchanger prior to or simultaneously with the start of recirculation.

The cooling water temperature to the inlet of the heat exchangers shall be within the limits of 65-120F during a LOCA.

## (A)7.16.4 FIRE PROTECTION

A fire protection system shall be provided to protect the containment spray system consistent with the requirements of GDC 3, and shall include, as a minimum, the following features:

a. Facilities for fire detection and alarming.

b. Facilities or methods to minimize the probability of fire and its associated effects.

c. Facilities for fire extinguishment.

d. Methods of fire prevention such as use of fire resistant and noncombustible materials whenever practical, and minimizing exposure of combustible materials to fire hazards.

e. Assurance that fire protection systems do not adversely affect the functional and structural integrity of safety-related structures, systems, and components.

f. Care should be exercised to ensure fire protection systems are designed to assure that their rupture or inadvertent operation does not significantly impair the capability of safety-related structures, systems, and components.

(A)7.17 ENVIRONMENTAL

See Section 7.7 for environmental interfaces.

(A)7.18 MECHANICAL INTERACTION

(A)7.18.1 CSS components shall be properly supported such that pipe stresses and support reactions are within allowable limits, as defined in CESSAR Section 3.9.2. C-E provides the applicant with the loads at the support/structure interface locations for components that C-E supplies, under normal, upset, emergency, faulted, and test conditions.

(A)7.18.2 CSS piping and fittings shall be Seismic Category I.

## B. IODINE REMOVAL SYSTEM

The following interface criteria are repeated from Section 7.0 of CESSAR Appendix 6B.

(B)7.0 INTERFACE REQUIREMENTS

(B)7.1 POWER

(B)7.1.1 The iodine removal system pumps, valves, and instrumentation shall be capable of being powered from the plant turbine generator (onsite power source), plant startup power source (offsite power), and the emergency generators (emergency power).

(B)7.1.2 Power connections shall be through two independent power trains so that in the event of a LOCA, in conjunction with loss of the preferred emergency power source and a single failure in the emergency electrical supply system, the flow from one IRS train will be available to its associated CSS train.

(B)7.1.3 The emergency generators and the automatic sequencers necessary for loading shall be designed such that power is available to IRS components within 30 seconds following a CSAS.

(B)7.1.4 Each electrical bus of the above shall be connected to one spray chemical addition pump and associated valves and instrumentation.

(B)7.1.5 Instrument power supplies shall be provided as stated in CESSAR Section 8.3.1.

## (B)7.2 PROTECTION FROM NATURAL PHENOMENA

Design provisions shall be incorporated such that IRS components are capable of functioning in the event of the maximum probable flood or other natural phenomenon defined in GDC 2.

## (B)7.3 PROTECTION FROM PIPE FAILURE

(B)7.3.1 The maximum expected leakage from a moderate energy pipe rupture postulated during normal plant conditions in the iodine removal system shall be as defined by the methods of CESSAR Section 3.6.1.

Isolation valves used to contain leakage shall be protected from the adverse effects of a high or moderate energy pipe rupture which might preclude their operation when required.

(B)7.3.2 No limited leakage passive failure or the effects thereof (such as flooding, spray impingement, steam, temperature, pressure, radiation, or loss of NPSH, in the IRS during the recirculation mode shall preclude the availability of minimum acceptable capability (minimum acceptable capability is defined as that which is provided by the operation of one subsystem).

(B)7.3.3 The iodine removal system shall be protected from the effects of pipe rupture.

(B)7.3.4 The iodine removal system shall be protected from the effects of pipe whip.

## (B)7.4 MISSILES

The iodine removal system shall be protected from missiles in accordance with the missiles barrier design interface requirements of CESSAR Section 3.5.3.1.

## (B)7.5 SEPARATION

(B)7.5.1 Adequate physical separation shall be maintained between the redundant piping paths of the IRS such that the IRS will meet its functional requirements even with the failure of a single active component.

(B)7.5.2 The cabling which is associated with redundant channels of Class 1E circuits for the IRS shall be physically separated to preserve redundancy and prevent a single event from causing multiple channel malfunctions or interactions between channels. Associated circuit cabling from redundant channels shall either be separated, provided with isolation devices, or analyzed and/or tested to demonstrate that no credible single failure could adversely affect redundant channels of Class 1E circuits.

(B)7.5.3 In the routing of IRS Class 1E circuits and location of equipment served by these Class 1E circuits, consideration shall be given to their exposure to potential hazards such as postulated ruptures of piping, flammable material, flooding, and nonflame retardant wiring. Adequate separation or protective measures shall be provided.

(B)7.5.4 Failures of nonsafety grade systems shall not compromise redundancy of the IRS.

## (B)7.6 INDEPENDENCE

(B)7.6.1 Each IRS train shall be provided with an independent environmental control system.

(B)7.6.2 Power connections for IRS components shall be from a minimum of two independent electrical buses. See 7.1.2 above.

(B)7.6.3 Two independent vital instrument power sources shall be provided for the IRS instrumentation. See 7.1.5 above.

(B)7.6.4 Mechanical. See 7.3, 7.4, and 7.5 above.

## (B)7.7 THERMAL LIMITATIONS

Each IRS train shall be provided with an independent environmental control system such that the safety-related equipment in each train operates within the environmental design limits specified in CESSAR Section 3.11.

## (B)7.8 MONITORING

Provisions shall be made for the detection, containment, and isolation of the maximum expected leakage from a moderate energy pipe rupture, in one train as discussed in 7.3.1 above.

Process instrumentation shall be available to the operator in the control room to assist in assessing post-LOCA conditions. The type of instrument, parameter measured, instrument range and accuracy are listed in Sections 6.1 and 6.2.

## (B)7.9 OPERATIONAL AND CONTROLS

Refer to Section 7.1.

## (B)7.10 INSPECTION AND TESTING

Inspection and testing requirements for the IRS are contained in Section 8.0 and in CESSAR Section 16. Prior to initial plant startup, IRS flow tests which comply with Section 8.0 shall be performed.

## (B)7.11 CHEMISTRY AND SAMPLING

### (B)7.11.1 FLUID COMPONENTS

| | | |
|---|---|---|
| Basic Fluid | | Water |
| with: | $H_3BO_3$ | 3.5 w/o |
| | $N_2H_4$ | 35 w/o |

(B)7.11.2 Provisions shall be made to mitigate the consequences of hydrazine spillage. A means of containing, flushing and diluting spills should be provided.

(B)7.11.3 Any applicant-supplied equipment (pumps, valves, etc.) handling concentrated hydrazine solutions shall be leak-tight. Mechanical collection is satisfactory.

(B)7.11.4 Provisions shall be made to mitigate the consequences of the accumulation of hydrazine vapors in all areas where hydrazine is handled or stored.

(B)7.11.4.1 Electrical equipment shall be qualified for use in areas where hydrazine vapors may be present.

(B)7.11.4.2 Provisions shall be made to allow personnel access to areas containing hydrazine vapors for maintenance or post-accident system refill.

(B)7.11.5 Sampling shall be performed via the drain connections at the SCST discharge piping and the SCAP discharge piping. Flanged connections shall be furnished to facilitate hydrazine handling requirements.

(B)7.11.6 Sample lines on contact with the system fluid shall be austenitic stainless steel or equivalent, such that the material is compatible with the fluid chemistry.

(B)7.11.7 The fluid velocity in the sample lines should be selected to obtain representative sample. The purge flowrate should be high enough to remove crud from lines.

## (B)7.12 MATERIALS

(B)7.12.1 Design and fabrication of the IRS piping and fittings shall conform to ASME Boiler and Pressure Vessel Code (B&PV) Section III, Class 2 as identified on Figure 3.5.

(B)7.12.2 Pipes and all parts in contact with the system fluid shall be austenitic stainless steel. The stainless steel shall be type 347, type 304, or C-E-approved alternate. Selection of the type of stainless steel shall be on the basis of compatibility with design pressure and temperature considerations and with the chemistry of the fluid. Valve packings, gaskets, and valve diaphragm materials shall also be compatible with the chemistry of the fluid and the radiation dose at that location.

(B)7.12.3 Care shall be taken to prevent sensitization and to control the delta ferrite content of: (1) the welds which join any system fabricated of austenitic stainless steel to the IRS, and (2) the field welds on the IRS. The guidance of Regulatory Guides 1.44, "Control of the Use of Sensitized Stainless Steel", and 1.31, "Control of Ferrite Content in Stainless Steel Weld Metal" is relevant at these weld locations.

(B)7.12.4 Controls shall be exercised to assure that contaminants do not significantly contribute to stress corrosion of stainless steel. Regulatory Guides 1.36, "Nonmetallic Thermal Insulation for Austenitic Stainless Steel", and 1.37, "Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water Cooled Nuclear Power Plants" are relevant for IRS components, and for all IRS field welds, including welds at the IRS boundaries.

(B)7.12.5 Materials used for the containment and its internal structures shall withstand exposure to all post-accident conditions without causing deleterious or undesirable reactions, or significantly altering the existing recirculating water chemistry.

## (B)7.13 PHYSICAL ARRANGEMENT

(B)7.13.1 The arrangement of the spray headers shall provide for maximum coverage of the containment free volume. Depending on the resulting fraction of the volume which is effectively sprayed and the required performance, provisions for mixing sprayed and unsprayed volumes may be required.

(B)7.13.2 A minimum free fall height of 90 feet shall be provided between the spray nozzle headers located in the upper part of the containment and the operating deck to provide adequate spray drop residence time.

(B)7.13.3 The spray nozzle headers shall be located as high as practicable in the upper regions of the containment to minimize unsprayed volume above the headers.

(B)7.13.4 The region defined as the sprayed volume shall have a 90% spray area coverage at the operating deck level. Coverage shall be evaluated at containment design pressure.

(B)7.13.5 The spray nozzles shall be selected on the basis of droplet size. They shall be a nonclogging design, having a nominal throat diameter of 3/8 inch, with a pressure differential of 40 psid across the nozzle at design flow conditions and containment design pressure. Two hundred thirty nozzles should be provided for each CSS train to achieve the required containment coverage and drop size distribution.

| | |
|---|---|
| (B)7.13.6 | The maximum height of the containment sump above the CSS/IRS junction shall not exceed 60 feet. |
| (B)7.13.7 | The head losses in the piping from the SCST to the CCS/IRS junction shall not exceed 15 feet at a flow of 0.65 gpm. |
| (B)7.13.8 | The full height of the SCST above the CSS/IRS junction shall not exceed 100 feet. |
| (B)7.13.9 | The spray chemical addition pumps (SCAP) shall have a minimum net positive suction head available of 25 feet of water assuming a SCST pressure of -5 psig. |
| (B)7.13.10 | Head losses in the IRS test line piping shall not exceed 15 feet at a flow of 0.65 gpm. |
| (B)7.13.11 | The backpressure (superimposed plus buildup) at the SCST relief valve (IR-250) discharge shall not exceed 3.0 psig at a gas flowrate of 90 SCFM. |
| (B)7.13.12 | The thermal relief valves (IR-157 and 158) shall be located at a level no more than 20 feet below the full SCST level. |
| (B)7.13.13 | Valves IR-680, IR-681, IR-120, and IR-130 shall be located as close to the CSP suction as practicable. |
| (B)7.13.14 | The IRS test line shall join the process piping as close as practicable to valves IR-680 and IR-681 in order to test the maximum fraction of system piping. |

(B)7.13.15 Valves IR-682 and IR-683 shall be located as close to the SCST discharge as practicable.

(B)7.13.16 Valves IR-100, IR-118 and IR-250 shall be located as close to the SCST as practicable.

(B)7.13.17 All piping, including the required fittings, expanders, reducers, and supports, is supplied by the applicant. Layout of the piping runs depends on the arrangement of the system components. Valve locations shall be chosen to allow easy access for operation and maintenance. Piping, vent, and drain valves shall be chosen to allow easy access for operation and maintenance. Piping, vent, and drain valves shall be provided as required. Root valves should be accessible.

(B)7.13.18 Flow measuring orifices are provided in the SCST discharge lines. Straight piping runs upstream and downstream of the orifices shall be provided of sufficient length to meet the recommendations of ASME fluid meters. Parts 1 and 2.

(B)7.13.19 Manually-operated valves shall be provided with locking provisions as shown on the P&ID, Figure 3.5.

(B)7.13.20 Physical identification of safety-related IRS equipment and cabling shall be provided to allow recognition of safety status by plant personnel.

(B)7.13.21 In the routing of IRS Class 1E circuits and location of equipment served by these Class 1E circuits, consideration shall be given to their exposure to potential hazards. See 7.5 above.

(B)7.13.22 All IRS ASME Boiler and Pressure Vessel Code Section III components shall be arranged to provide adequate clearances to permit inservice inspection. The design of the arrangement should conform to the guidelines of Section XI of the ASME Code.

(B)7.13.23 Access to the IRS shall be provided such that at time periods greater than 4 hours post-LOCA, capability of refilling the SCST with the concentration hydrazine solution is possible.

(B)7.13.24 Protection shall be provided from internally generated flooding that could prevent performance of safety-related functions.

## (B)7.14 WASTE COLLECTION

(B)7.14.1 The IRS components are designed for zero external leakage. In the unlikely event that leakage should occur, provisions shall be provided to accept the maximum leakage rates listed below for purposes of room sump design.

a. SCAP seals: 100 cc/hr/pump

b. Valves

backseat leakage: 10 cc/hr/inch seat diameter/valve

| | |
|---|---|
| across the valve seat: | 10 cc/hr/inch of nominal valve size/valve |

All leakages shall be treated as potentially toxic waste with a low dissolved solids and organic content.

(B)7.14.2 The SCST should be drained using the nitrogen overpressure as the motive force in order to minimize the possibility of drawing air into the SCST.

(B)7.14.3 The drain area should be provided with the safety precautions discussed in Section 7.11 to control hydrazine spillage.

## (B)7.15 OVERPRESSURE PROTECTION

Relief valves are provided for overpressure protection of IRS components and isolated piping sections. Relief valve discharges shall be collected in conformance with Sections 7.11, 7.13, and 7.14.

## (B)7.16 RELATED SERVICES

### (B)7.16.1 PLANT VENTILATION SYSTEM

(B)7.16.1.1 Venting of hydrazine storage areas shall be through vent headers to assure that personnel are protected from hydrazine vapors. Applicable ventilation supply systems shall be designed such that they cannot serve to distribute hydrazine vapors to other plant areas in the event of accidental spills.

(B)7.16.1.2 The SCST relief valve (IR-250) and vent valve (IR-152) shall be directed to vent headers to assure that personnel are protected from hydrazine vapors or solution and to assure immediate dilution of hydrazine vapors or solution.

### (B)7.16.2 CONTAINMENT SUMP

Long term post-LOCA containment sump solution pH control shall be provided. The solution pH shall be regulated between 7.0 and 8.5 within 4 hours post-LOCA and maintained between those values throughout the long term post-LOCA period. Storage of baskets containing di- or tri-sodium phosphate within the containment is the recommended method of pH control.

### (B)7.16.3 COMPRESSED NITROGEN SYSTEM

(B)7.16.3.1 The compressed nitrogen system shall have the capability to supply a blanket of nitrogen at 5 psig to the spray chemical storage tank (SCST).

(B)7.16.3.2 The compressed nitrogen system shall be designed such that the maximum flow to the SCST shall not exceed the SCST relief valve gas flow capacity of 90 SCFM given a failure of the upstream pressure regulator.

### (B)7.16.4 HYDRAZINE FILL SYSTEM

(B)7.16.4.1 The maximum fill rate shall not exceed the SCST relief valve liquid flow capacity.

(B)7.16.4.2 Provisions shall be made to preclude the introduction of air into the SCST or shipping containers during fill operations.

(B)7.16.4.3 If a pump is used to transfer hydrazine to the SCST, all of the metal components of the pump should be type 304 or 347 stainless steel. Seals should be the mechanical type and should be constructed according to the pump supplier's recommendations for hydrazine service.

### (B)7.16.5 FIRE PROTECTION

A fire protection system shall be provided to protect the iodine removal system and shall include, as a minimum, the following features:

a. Facilities for fire detection and alarming.

b. Facilities or methods to minimize the probability of fire and its associated effects.

c. Facilities for fire extinguishment.

d. Methods of fire prevention such as use of fire resistant and non-combustible materials whenever practical, and minimizing exposure of combustible materials to fire hazards.

e. Assurance that fire protection systems do not adversely affect the functional and structural integrity of safety-related structures, systems, and components.

f. Care should be exercised to ensure fire protection systems are designed to assure that their rupture or inadvertent operation does not significantly impair the capability of safety-related structures, systems, and components.

## (B)7.17 ENVIRONMENTAL

See Section 7.7 and CESSAR Section 3.11 for environmental interfaces.

## (B)7.18 MECHANICAL INTERACTION

(B)7.18.1 IRS components shall be properly supported such that pipe stresses and support reactions are within allowable limits, as defined in CESSAR Section 3.9.2. C-E provides the applicant the loads at the supports/ structures interface locations for components that C-E supplies, under normal, upset, emergency, faulted, and test conditions, as described in CESSAR Section 3.8.5. |1

(B)7.18.2 IRS piping and fittings shall be Seismic Category I.

### 6.5.2.8 CESSAR Interface Evaluations

The numbering of this interface section corresponds to that used for the presentation of interface requirements in CESSAR Appendices 6A and 6B. An R prefaces the numbering to denote that these are the responses to paragraph 6.5.2.7. Refer to appendix 6A, Question 6A.42, for additional discussion. 0

#### A. INTERFACE EVALUATION FOR CONTAINMENT SPRAY SYSTEM

(RA)7.1 POWER

(RA)7.1.1 The containment spray pumps, valves, and associated instrumentation can be powered from three power sources: onsite power, offsite power, or diesel generators. For more details, see chapter 8.

(RA)7.1.2 Two independent power trains are provided, one for each train of containment spray pump, valves, and associated instrumentation.

(RA)7.1.3 See (RA)7.1.2.

(RA)7.1.4 The full containment spray flow can be attained within 90 seconds after a CSAS. Refer to section 1.9.

(RA)7.1.5 Instrument power supplies are provided as stated in CESSAR Section 8.3.1.

(RA)7.2 PROTECTION FROM NATURAL PHENOMENA

Design provisions for maintaining functional capability of the safety-related systems during a flood, earthquake, tornado, or high winds as defined in GDC 2 are discussed in subsection 3.1.2.

In addition, prior to initial plant startup, the CSS system will be tested in accordance with section 14.2.

## (RA)7.11 CHEMISTRY AND SAMPLING

(RA)7.11.1 The CSS is designed for the following fluid conditions:

| | |
|---|---|
| Basic fluid:<br>with $H_3BO_3$: | Water<br>3.5 w/o |
| $N_2H_4$ | 50-100 ppm |

Trisodium phosphate controlled pH of 7 to 8.5 maximum.

### (RA)7.11.2 SAMPLING

(RA)7.11.2.1 The nuclear sampling system (NSS) is designed to provide a means of obtaining remote liquid samples from the CSS for chemical and radiochemical laboratory analysis.

(RA)7.11.2.2 The sample lines in contact with the reactor coolant are fabricated of austenitic stainless steel.

(RA)7.11.2.3 The fluid velocity in the sample lines is designed to obtain representative samples. The purge flowrate is high enough to remove crud from lines.

(RA)7.11.2.4 Sample taps are located on vertical runs of pipe whenever possible. Where this cannot be done, the samples are taken from the top of horizontal pipe runs.

(RA)7.12 MATERIALS

(RA)7.12.1 Containment spray system piping and fittings are Seismic Category I.

(RA)7.12.2 Design and fabrication of the CSS piping and fittings conform to ASME Boiler and Pressure Vessel (B&PV) Code, Section III, Class 2, as identified in CESSAR Section 6.3.1.

(RA)7.12.3 Materials in contact with the system fluid are fabricated of austenitic stainless steel of type 316, type 304, or C-E-approved alternate. Selection of the type of stainless steel is based on compatibility with design pressure and temperature considerations and with the chemistry of the fluid.

Valve packings, gaskets, and valve diaphragm materials are also compatible with the chemistry of the fluid and the radiation dose at that location.

(RA)7.12.4 Care is taken to prevent sensitization and to control the delta ferrite content of (1) the welds which join any system fabricated of austenitic stainless steel to the CSS, and (2) the field welds on the CSS. The guidance of Regulatory Guides 1.44, Control of the Use of Sensitized Stainless Steel, and 1.31, Control of Ferrite Content in Stainless Steel Weld Metal, is relevant at these weld locations (refer to section 1.8).

as near to design as practicable (the pumps will be flow-tested at approximately half-full flow).

(RA)7.13.16 All CSS ASME Section III components are arranged to provide adequate clearances to permit inservice inspection. The design of the arrangement conforms to the guidelines of Section XI of the ASME Code. Manually-operated valves that contain reactor coolant or other potentially radioactive liquids during normal plant operations, are provided with hand wheel extensions and shielding to allow periodic actuation as per ASME Section XI, Subsection IWV. Containment spray system components that contain reactor coolant or other potentially radioactive liquids during normal plant operations, and which require access for periodic pressure tests and nondestructive examination (ASME Section XI, Subsection IWC), can be flushed with RWT water prior to testing. The containment spray pumps are capable of providing the driving head for flushing. The discharge is collected and processed by the shutdown purification portion of the chemical and volume control system.

Access to system components not designed to ASME Section III is provided for periodic visual inspection for leakage, structural distress, and corrosion.

(RA)7.13.17 Protection is provided from internally generated flooding that could prevent performance of safety-related functions. Also refer to section 3.6 and subsection 9.3.3.

## (RA)7.14 RADIOLOGICAL WASTE COLLECTION

Containment spray system leakage to the engineered safety features room will normally drain to the room sump. Provisions are provided to accept the maximum leakage rates listed below:

| | | |
|---|---|---|
| a. | CSS pump seals: | 100 cc/h/pump |
| b. | Valves | |
| | backseat leakage: | 10 cc/h/in. seat diameter/ valve |
| | across the valve seat: | 10 cc/h/in. of nominal valve size/valve |

Leakages will be treated as radioactive waste with a low dissolved solids and organic content.

## (RA)7.15 OVERPRESSURE PROTECTION

Relief valves are provided for overpressure protection.

## (RA)7.16 RELATED SERVICES

### (RA)7.16.1 Refueling Water Tank

The RWT has 100% of the capacity required to operate the CSS pumps at a flow of 4400 gallons per minute per pump for the required minimum injection period of (approximate elevation 80.5 feet) to approximately 18 inches above the maximum flood level (approximate elevation 92.5 feet). This range is above the minimum level for NPSH requirements (elevation 77.1 feet). A total range of 12 feet is provided in the control room. This safety grade instrumentation is redundant, physically separated, environmentally qualified to post-LOCA environment, seismically qualified to function during and following an SSE and powered from redundant Class 1E sources.

### (RA)7.16.3 Shutdown Cooling Heat Exchanger

Cooling water will be provided to each shutdown cooling heat exchanger to transfer heat from the sump fluid during the recirculation mode.

The miminum required flow of cooling water supplied to each shut-down cooling heat exchanger is a flowrate of 12,600 gallons per minute. | 8

Cooling water flow will be established to the shutdown cooling heat exchanger prior to or simultaneously with the start of recirculation.

The cooling water temperature to the inlet of the heat exchangers will be within the limits of 49-132F. | 8

(RA)7.16.4 Fire Protection

The fire protection system provided to protect the CSS is discussed in subsection 9.5.1.

(RA)7.17 ENVIRONMENTAL

For environmental interfaces, see (RA)7.7.

(RA)7.18 MECHANICAL INTERACTION

(RA)7.18.1 Containment spray system components are properly supported such that pipe stresses and support reactions are within allowable limits, as defined in CESSAR Section 3.9.2.

(RA)7.18.2 Containment spray system piping and fittings are Seismic Category I.

## B. INTERFACE EVALUATION FOR IODINE REMOVAL SYSTEM

(RB)7.1 POWER

(RB)7.1.1 Both ac power via a 4.16 kV, Class 1E bus and dc power via a 125V, Class 1E bus can be supplied to the iodine removal system pumps, valves, and instrumentation from offsite power (see section 8.1), onsite power (see section 8.3), or onsite emergency (diesel generator) power (see section 8.3).

(RB)7.1.2 Two redundant, independent Class 1E ac and dc power trains are provided so that in the event of a LOCA, in conjunction with loss of the preferred emergency power source and a single failure in the emergency electrical power supply system, the flow from one IRS train will be available to its associated CSS train. These power trains are described in section 8.1.

(RB)7.1.3 Power is available to IRS components within 30 seconds following a CSAS as described in section 7.4, subsection 8.3.1 and CESSAR Section 7.3.

(RB)7.1.4 Each electrical bus described above is connected to one spray chemical addition pump and associated valves and instrumentation.

(RB)7.1.5 Instrument power supplies are provided as described in subsection 8.3.2.

## (RB)7.2 PROTECTION FROM NATURAL PHENOMENA

The IRS is capable of operating in the event of extreme natural phenomena as discussed in sections 3.1, 3.3, 3.4, and 3.7.

## (RB)7.3 PROTECTION FROM PIPE FAILURE

(RB)7.3.1 The maximum expected leakage from a moderate energy pipe rupture is defined by the methods of subsection 3.6.1. Isolation valves used to contain leakage are protected from the effects of pipe rupture as described in section 3.6.

(RB)7.3.2 No limited leakage passive failure or its effects will preclude the operation of both subsystems, as discussed in section 3.6.

(RB)7.3.3 The IRS is protected from the effects of pipe rupture, as discussed in section 3.6.

(RB)7.3.4 The IRS is protected from the effects of pipe whip, as discussed in section 3.6.

### (RB)7.4 MISSILES

The IRS is protected from missiles in accordance with paragraph 3.5.4.2. This meets the requirements of CESSAR Section 3.5.3.1.

### (RB)7.5 SEPARATION

(RB)7.5.1 Separation between redundant piping for the IRS is maintained as described in section 3.6.

(RB)7.5.2 Separation between redundant Class 1E circuits is provided as described in section 8.3

(RB)7.5.3 Protection and separation of IRS Class 1E circuits, and the equipment served by them, is provided as described in sections 3.6 and 8.3, and subsection 9.5.1.

(RB)7.5.4 The IRS can function using only safety grade equipment.

### (RB)7.6 INDEPENDENCE

(RB)7.6.1 Environmental control for the IRS is provided by natural air circulation. No active component environmental control is required to meet the requirements of CESSAR Section 3.11. Refer to section 1.9.

(RB)7.6.2 Refer to evaluation (RB)7.1.2 of paragraph 6.5.2.8.

(RB)7.6.3 Refer to evaluation (RB)7.1.5 of paragraph 6.5.2.8.

(RB)7.6.4 Refer to evaluations (RB)7.3, (RB)7.4, and (RB)7.5 of paragraph 6.5.2.8.

### (RB)7.7 THERMAL LIMITATIONS

Refer to evaluation (RB)7.6.1 of paragraph 6.5.2.8.

### (RB)7.8 MONITORING

Detection, containment, and isolation provisions for pipe rupture leakage are discussed in section 3.6.

Process instrumentation is provided as described in paragraph 6.5.2.5.

### (RB)7.9 OPERATION AND CONTROLS

Refer to evaluation (RB)7.1 of paragraph 6.5.2.8.

### (RB)7.10 INSPECTION AND TESTING

IRS inspection and testing procedures are described in paragraph 6.5.2.4 and section 14.2.

## (RB)7.11 CHEMISTRY AND SAMPLING

(RB)7.11.1 The fluid chemistries are within the design limits as discussed in CESSAR Appendix 6B.

(RB)7.11.2 The floor of the spray chemical storage tank room is sloped towards a floor drain. A hose station is located within 50 feet.

(RB)7.11.3 All concentrated hydrazine handling system equipment is supplied by C-E. All piping is stainless steel.

(RB)7.11.4 The spray chemical storage tank room is ventilated as described in section 9.4.

(RB)7.11.4.1 Venting of hydrazine storage areas is provided through vent headers to assure that electrical equipment is protected from hydrazine vapors. Applicable ventilation supply systems are designed such that they cannot serve to distribute hydrazine vapors to other plant areas in the event of accidental spills.

(RB)7.11.4.2 Ventilation is provided to allow personnel access to hydrazine storage areas.

(RB)7.11.5 Sampling will be performed using the drain connections on the SCST and SCAP discharge piping. Flanged connections are provided.

(RB)7.11.6 Sample lines are made of austenitic stainless steel.

(RB)7.11.7 Sample line fluid velocities will allow the taking of representative samples. The flowrate during purge will remove any crud from the lines.

## (RB)7.12 MATERIALS

(RB)7.12.1 Iodine removal system piping and fittings are designed and fabricated in conformance with ASME B&PV Code, Section III, Class 2, as shown in CESSAR Figure 3.5 (Appendix 6B).

(RB)7.12.2 Piping in contact with hydrazine is constructed of type 304 stainless steel.

(RB)7.12.3 Welding is performed in accordance with procedures that incorporate the guidance of Regulatory Guides 1.31 and 1.44 as given in section 1.8.

(RB)7.12.4 Welding procedures have been developed in accordance with applicable Regulatory Guides 1.31 and 1.44 as discussed in section 1.8.

(RB)7.12.5 Refer to sections 6.1 and 3.11.

## (RB)7.13 PHYSICAL ARRANGEMENT

(RB)7.13.1 The spray coverage of the containment volume is described in paragraph 6.5.2.2.

(RB)7.13.2 The minimum spray free fall height is approximately 92 feet.

(RB)7.13.3 The spray nozzle headers are located on the underside of the containment dome.

(RB)7.13.4 At least 90% of the area at the operating deck is sprayed.

(RB)7.13.5 The spray nozzles are described in paragraph 6.5.2.3.

(RB)7.13.6 The maximum height of the containment sump above the CSS/IRS junction does not exceed 60 feet.

(RB)7.13.7 The head losses in piping from the SCST to the CSS/IRS junction do not exceed 15 feet at a flow of 0.65 gallons per minute.

(RB)7.13.8 The SCST is less than 100 feet above the CSS/IRS junction.

(RB)7.13.9 The spray chemical addition pumps have a minimum net positive suction head of 25 feet of water available, assuming a SCST pressure of -5 psig.

(RB)7.13.10 Head losses in the IRS test line piping do not exceed 15 feet at a flow of 0.65 gallons per minute.

(RB)7.13.11 The backpressure (superimposed plus buildup) at SCST relief valve SIE-PSV250 discharge does not exceed 3.0 psig at a gas flowrate of 90 standard cubic feet per minute.

(RB)7.13.12 Thermal relief valves SIA-PSV159 and SIB-PSV160 are located at a level no more than 20 feet below the full SCST level.

(RB)7.13.13 Valves SIB-UV680, SIA-UV681, SIB-V120, and SIA-V130 are located as close to the CSP suction as practical.

(RB)7.13.14 The IRS test line joins the process piping as close as practical to valves SIB-UV680 and SIA-UV681 in order to test the maximum fraction of system piping.

(RB)7.13.15 Valves SIB-UV602 and SIA-UV603 are located as close to the SCST discharge as practical.

(RB)7.13.16 Valves SIE-PSV100, SIE-PSV-118, and SIE-PSV250 are located as close to the SCST as practical.

(RB)7.13.17 All piping, including the required fittings, expanders, reducers, and supports, is supplied by the applicant. Layout of the piping runs depends on the arrangement of the system components. Valve locations have been chosen to allow easy access for operation and maintenance. Piping, vent, and drain valves are provided as required. Root valves are accessible.

(RB)7.13.18 Flow measuring orifices are provided in the SCST discharge lines. Straight piping runs upstream and downstream of the orifices have sufficient length to meet the recommendations of ASME Fluid Meters, Parts 1 and 2.

(RB)7.13.19 Manually-operated valves are provided with locking provisions.

(RB)7.13.20 Physical identification of safety-related IRS equipment and cabling is provided to allow recognition of safety status by plant personnel.

(RB)7.13.21 In the routing of IRS Class 1E circuits and location of equipment served by these Class 1E circuits, consideration has been given to their exposure to potential hazards. See (RB)7.5 above.

(RB)7.13.22 All IRS ASME Boiler and Pressure Vessel Code, Section III, components are arranged to provide adequate clearances to permit inservice inspection. The design of the arrangement conforms to the guidelines of Section XI of the ASME Code.

(RB)7.13.23 Access to the IRS is provided such that at time periods greater than 4 hours post-LOCA, capability of refilling the SCST with concentrated hydrazine solution is possible.

(RB)7.13.24 Protection is provided from internally generated flooding that could prevent performance of safety-related functions. Refer also to section 3.6 and subsection 9.3.3.

## (RB)7.14 WASTE COLLECTION

(RB)7.14.1 The IRS components are designed for zero external leakage. In the unlikely event that leakage should occur, provisions exist to accept the maximum leakage rates listed below for purposes of room sump design.

| | | |
|---|---|---|
| a. | SCAP seals: | 100 $cm^3$/h/pump |
| b. | Valves | |
| | backseat leakage: | 10 $cm^3$/h/in. seat diameter/valve |
| | across the valve seat: | 10 $cm^3$/h/in. of nominal valve size/valve |

Iodine removal system leakages are treated as potentially toxic waste with a low dissolved solids and organic content.

(RB)7.14.2 The SCST can be drained using the nitrogen overpressure as the motive force.

(RB)7.14.3 The drain area is provided with the safety precautions discussed in CESSAR Section 7.11 to control hydrazine spillage.

## (RB)7.15 OVERPRESSURE PROTECTION

Relief valves are provided for overpressure protection of IRS components and isolated piping sections. Relief valve discharges are collected in conformance with CESSAR Sections 7.11, 7.13, and 7.14.

## (RB)7.16 RELATED SERVICES

### (RB)7.16.1 PLANT VENTILATION SYSTEM

(RB)7.16.1.1 Venting of hydrazine storage areas is provided through vent headers to assure that personnel are protected from hydrazine vapors. Applicable ventilation supply systems are designed such that they cannot serve to distribute hydrazine vapors to other plant areas in the event of accidental spills.

(RB)7.16.1.2 Spray chemical storage tank relief valve SIE-PSV250 and vent valve are directed to vent headers to assure that personnel are protected from hydrazine vapors or solution and to assure dilution of hydrazine vapors or solution.

### (RB)7.16.2 CONTAINMENT SUMP

Long-term, post-LOCA containment sump solution pH control is provided with baskets containing trisodium phosphate within the containment.

### (RB)7.16.3 COMPRESSED NITROGEN SYSTEM

(RB)7.16.3.1 The compressed nitrogen system has the capability to supply a blanket of nitrogen at 5 psig to the SCST.

(RB)7.16.3.2 The compressed nitrogen system is designed such that the maximum flow to the SCST will not exceed the SCST relief valve has flow capacity of 90 standard cubic feet per minute given a failure of the upstream pressure regulator.

### (RB)7.16.4 HYDRAZINE FILL SYSTEM

(RB)7.16.4.1 The maximum fill rate does not exceed the SCST relief valve liquid flow capacity.

(RB)7.16.4.2 Provisions have been made to preclude the introduction of air into the SCST or shipping containers during fill operations.

(RB)7.16.4.3 Metal components of the pump used to transfer hydrazine to the SCST are type 304 or 347 stainless steel. Seals are suitable for hydrazine service.

### (RB)7.16.5 FIRE PROTECTION

A fire protection system is provided to protect the iodine removal system and includes, as a minimum, the following features:

a. Facilities for fire detection and alarming

b. Facilities or methods to minimize the probability of fire and its associated effects

c. Facilities for fire extinguishment

d. Methods of fire prevention such as use of fire-resistant and non-combustible materials whenever practical, and minimizing exposure of combustible materials to fire hazards

e. Assurance that fire protection systems do not adversely affect the functional and structural integrity of safety-related structures, systems, and components

f. Care has been exercised to ensure that fire protection systems have been designed such that their rupture or inadvertent operation does not significantly impair the capability of safety-related structures, system, and components.

Refer to subsection 9.5.1 for further discussion of the fire protection system.

(RB)7.17 ENVIRONMENTAL

See evaluation (RB)7.6.1 of this section.

(RB)7.18 MECHANICAL INTERACTION

(RB)7.18.1 Iodine removal system components are properly supported such that pipe stresses and support reactions are within allowable limits, as defined in CESSAR Section 3.9.2.

(RB)7.18.2 Iodine removal system piping and fittings are Seismic Category I.

## 6.5.3 FISSION PRODUCT CONTROL SYSTEMS

### 6.5.3.1 Primary Containment

The primary containment structure consists of a reinforced concrete cylinder and hemispherical dome, lined with welded 1/4 inch steel plates, forming a continuous, leaktight pressure boundary. Details of the containment structural design are discussed in section 3.8. Layout drawings of the containment structure and the hydrogen purge system are given in the general arrangement drawings of section 1.2 (hydrogen purge equipment is located in the auxiliary building at elevation 100 feet).

The containment walls, liner plate, mechanical penetrations, isolation valves, hatches, and locks function to limit release of radioactive materials, subsequent to postulated accidents, such that the resulting offsite doses are less than the guideline values of 10CFR100. Containment parameters affecting fission product release accident analyses are given in table 6.5-3.

## Table 6.5-3
## PRIMARY CONTAINMENT OPERATION FOLLOWING A DESIGN BASIS ACCIDENT

| | | |
|---|---|---|
| General | | |
| Type of structure | Steel-lined, reinforced cylinder and base with hemispherical dome | |
| Internal fission product removal systems | Redundant containment water spray systems with hydrazine | |
| Free volume of containment | $2.6 \times 10^6$ ft$^3$ | |
| Hydrogen purge system operation assumptions | See paragraph 6.2.5.3 | |
| **Time Dependent Parameters** | **Anticipated** | **Conservative** |
| Containment leakage rate | | |
| 0 to 24 hours | <0.1 vol%/d | 0.1 vol%/d |
| 1 to 30 days | <0.05 vol%/d | 0.05 vol %/d |
| Iodine spray removal coefficient (spray λ, elemental) | >22.9 h$^{-1}$ | 22.9 h$^{-1}$ |

Long-term containment pressure responses to the design basis accidents are discussed in subsection 6.2.1. Relative to this time period, the CSS is operated to reduce iodine concentrations and containment atmospheric temperature and pressure from the time commencing with system initiation, at approximately 90 seconds, until containment pressure has returned to normal. For the purpose of post-LOCA dose calculations discussed in chapter 15, spray iodine removal, credit is taken only during the 0 to 2 hour time frame.

The containment preaccess purge system may be operated for personnel access to the containment when the reactor is at power. Even though the purge frequency is a small percentage of the total annual operating period, operation of the preaccess purge system at the time of occurrence of a design basis accident is assumed in the analyses of radiological releases. The preaccess purge will terminate and the containment will isolate within 5 seconds after a CPIAS is generated as discussed in subsection 6.2.4.

Redundant, safety-related hydrogen recombiners are provided for the containment atmosphere as the primary means of controlling post-accident hydrogen concentrations. A hydrogen purge system is provided for backup hydrogen control.

### 6.5.3.2 Secondary Containments

This paragraph is not applicable to PVNGS.

## 6.5.4 ICE CONDENSER AS A FISSION PRODUCT CLEANUP SYSTEM

This subsection is not applicable to PVNGS.

[Area] 2. Prepare emergency procedures or review existing ones that will be used by control room operators, including procedures required to achieve a cold shutdown condition, upon loss of power to each Class 1E and non-Class 1E bus supplying power to safety- and nonsafety-related instrument and control systems. The emergency procedures should include:

a. The diagnostics/alarms/indicators/ symptom resulting from the review and evaluation conducted per [Area] 1 above.

b. The use of alternate indication and/or control circuits which may be powered from other non-Class 1E or Class 1E instrumentation and control buses. 0

c. Methods for restoring power to the bus.

Describe any proposed design modifications or administrative controls to be implemented resulting from these procedures, and your proposed schedule for implementing the changes.

[Area] 3. Re-review IE Circular No. 79-02, Failure of 120 Volt Vital AC Power Supplies, dated January 11, 1979, to include both Class 1E and non-Class 1E safety-related power supply inverters. Based on a review of operating experience and your re-review of IE Circular No. 79-02, describe any proposed design modifications or administrative controls to be implemented as a result of the re-review.

## Evaluation

Our review has determined that the PVNGS design consists of two ungrounded non-Class 1E, 120 V-ac instrument distribution panels E-NNN-D11 and E-NNN-D12 and four ungrounded vital (Class 1E) 120 V-ac instrument distribution panels E-PNA-D25, E-PNB-D26, E-PND-D27, and E-PND-D28.

Each ungrounded non-Class 1E volt ac instrument distribution panel is normally supplies from a 480 V-ac, non-Class 1E motor control center through a voltage regulator-transformer to a transfer switch. A backup source is provided from a 480 V-ac, Class 1E motor control center through a Class 1E voltage regulator-transformer as an isolation device to the transfer switch. The transfer switch automatically transfers, upon loss of power on the normal source, to the backup source. Manual transfer is required to return to the normal source. The distribution panel is fed from the transfer switch through a 0 panel feeder breaker. Distribution to the instrument cabinets is through branch circuit breakers.

Each ungrounded vital (Class 1E), 120 V-ac instrument distribution panel is normally supplied from a 125 V-dc, Class 1E control center through an inverter to a manual transfer switch. A backup source is provided from a 480 V-ac, non-Class 1E motor control center through a voltage regulator-transformer to the manual transfer switch. The distribution panel is fed from the transfer switch through a panel feeder breaker.

Our specific response to [Area] 1.a is that an alarm for each non-Class 1E instrument distribution panel is provided to the operator in the control room. Annunciation will occur on the following:

- Normal source undervoltage
- Backup source undervoltage

### 7.1.3.13 System Component Arrangement

Safety-related components shall be located so as to conform to the separation, independence, and other criteria specified in this section. The safety-related components shall be located to provide access for maintenance, testing and operation as required.

Analog and digital signals provided to the safety-related components shall not share the same multiconductor cable, unless specifically called for or approved by Combustion Engineering.

### 7.1.3.14 Radiological Waste

Radiological waste discharge lines or components shall not be routed or located next to protection system electronic components in a manner that will result in exceeding the radiation limits specified in Section 3.11.

### 7.1.3.15 Overpressure Protection

The components of the safety-related equipment shall be located so as not to exceed the pressure limits specified in Section 3.11.

### 7.1.3.16 Related Services

A fire protection system shall be provided to protect the safety-related equipment, including sensors, consistent with GDC 3. This shall include facilities for detection, alarming, and extinguishing of fires. Facilities and methods for minimizing the probability and effects of fires, including fire barriers, fire resistant and non-combustible materials, and other such items, shall be employed whenever possible. Adequate drainage shall be provided if water is used to extinguish fires.

Inadvertent operation or rupture of fire protection systems shall not result in the reduction of the functional capability of safety-related systems or components below that required to perform their safety function.

Physical identification shall be provided to enable plant personnel to recognize that PPS, ESFAS Auxiliary Relay Cabinets, RTSS, and their cabling are safety-related. The cabinets shall be identified by nameplates. A color coding scheme shall be used to identify the physically separated channel cabling from sensor to the PPS (refer to section 7.1.3.5); the same color code shall be used for interbay or intercabinet identification.

Cabling or wiring within a bay at the cabinet which is in the channel of its circuit classification shall not be color coded.

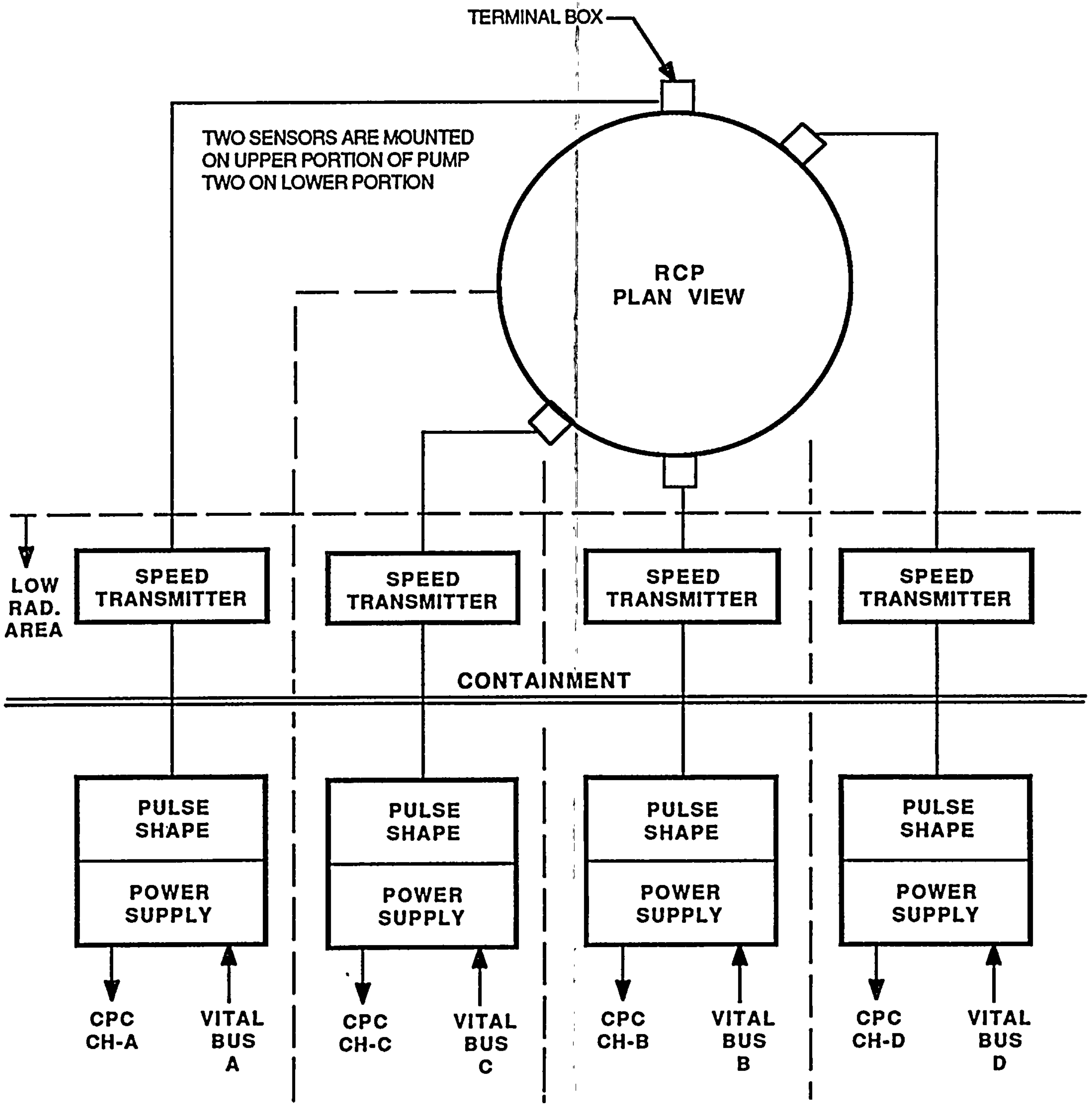
The cabinet nameplates and cabling shall be color coded as follows:

| Protective | ESF Trains | Associated |
|---|---|---|
| Channel A: Red | A: Red | Channel J: Red Stripe |
| Channel B: Green | B: Green | Channel K: Green Stripe |
| Channel C: Yellow | | Channel L: Yellow Stripe |
| Channel D: Blue | | Channel M: Blue Stripe |

All non-panel mounted protection system instrumentation and control components are identified with a name tag which provides the channel number and the suffix A, B, C, or D to specifically identify the protection channel with which the component is identified.

### 7.1.3.17 Environmental

Environmental support systems shall be provided to ensure that the environmental conditions of the safety-related systems do not exceed the requirements for 1E equipment as defined in Section 3.11.



NOTE: SPEED SENSORS S2 AND S5, WHICH ARE NOT SHOWN, ARE USED FOR MONITORING FUNCTIONS ONLY.

**Palo Verde Nuclear Generating Station**
**Updated FSAR**

REACTOR COOLANT PUMP SPEED SENSORS
TYPICAL FOR EACH REACTOR COOLANT PUMP

Figure 7.2-0F

## FIGURES

FIGURES (Cont)

[Area] 2. Prepare emergency procedures or review existing ones that will be used by control room operators, including procedures required to achieve a cold shutdown condition, upon loss of power to each Class 1E and non-Class 1E bus supplying power to safety- and nonsafety-related instrument and control systems. The emergency procedures should include:

a. The diagnostics/alarms/indicators/symptom resulting from the review and evaluation conducted per [Area] 1 above.

b. The use of alternate indication and/or control circuits which may be powered from other non-Class 1E or Class 1E instrumentation and control buses. 0

c. Methods for restoring power to the bus.

Describe any proposed design modifications or administrative controls to be implemented resulting from these procedures, and your proposed schedule for implementing the changes.

[Area] 3. Re-review IE Circular No. 79-02, Failure of 120 Volt Vital AC Power Supplies, dated January 11, 1979, to include both Class 1E and non-Class 1E safety-related power supply inverters. Based on a review of operating experience and your re-review of IE Circular No. 79-02, describe any proposed design modifications or administrative controls to be implemented as a result of the re-review.

Evaluation

Our review has determined that the PVNGS design consists of two ungrounded non-Class 1E, 120 V-ac instrument distribution panels E-NNN-D11 and E-NNN-D12 and four ungrounded vital (Class 1E) 120 V-ac instrument distribution panels E-PNA-D25, E-PNB-D26, E-PND-D27, and E-PND-D28.

9| Each ungrounded non-Class 1E volt ac instrument distribution panel is normally supplied from a 480 V-ac, non-Class 1E motor control center through a voltage regulator-transformer to a transfer switch. A backup source is provided from a 480 V-ac, Class 1E motor control center through a Class 1E voltage regulator-transformer as an isolation device to the transfer switch. The transfer switch automatically transfers, upon loss of power on the normal source, to the backup source. Manual transfer is required to return to the normal source. The distribution panel is fed from the transfer switch through a panel feeder breaker. Distribution to the instrument cabinets is through branch circuit breakers.

Each ungrounded vital (Class 1E), 120 V-ac instrument distribution panel is normally supplied from a 125 V-dc, Class 1E control center through an inverter to a manual transfer switch. A backup source is provided from a 480 V-ac, non-Class 1E motor control center through a voltage regulator-transformer to the manual transfer switch. The distribution panel is fed from the transfer switch through a panel feeder breaker.

Our specific response to [Area] 1.a is that an alarm for each non-Class 1E instrument distribution panel is provided to the operator in the control room. Annunciation will occur on the following:

- Normal source undervoltage
- Backup source undervoltage

- Ground detection
- Overload tripping of the panel feeder breaker
- Overload tripping of any branch circuit breaker

An alarm is provided for each Class 1E instrument distribution panel and an alarm for each Class 1E inverter and transfer switch. Annunciation will occur on the following:

- Inverter output or input breaker tripped
- Inverter output voltage low or high
- Inverter overcurrent (overload)
- Input dc voltage low
- Loss of synchronization (of the inverter only)
- Transfer switch not on normal source
- Inverter fan failure
- Distribution panel undervoltage 0
- Ground detection
- Overload tripping of the panel feeder breaker

For [Area] 1.b, the instrument and control system loads connected to each instrument distribution panel are provided as noted on table 7.1-1.

Those specific instrument parameters and controls detailed in CESSAR 7.4.1.1.10.7 as being required to achieve cold shutdown are listed in table 7.1-2. Instrument loop displays and controls available to the control room operator and the instrument distribution panel supply are identified.

Motor-operated valves, pumps, pressurizer heaters, and solenoids required to achieve cold shutdown are powered from buses other than the instrument distribution panels.

## Table 7.1-1

## 120 V-AC UNGROUNDED INSTRUMENT DISTRIBUTION PANEL INSTRUMENT AND CONTROL SYSTEM LOADS

| E-PNA-D25 | E-PNB-D26 | E-PNC-D27 | E-PND-D28 | E-NNN-D11 | E-NNN-D12 |
|---|---|---|---|---|---|
| • ESFAS Aux. Relay Cab. J-SAA-C01<br>• Process Protective Instr. Cab. A-1 J-SBA-C02A<br>• Supplementary Protect. Sys. J-SBA-C04<br>• Radiation Monitors J-SQA-RU-29, 31 & 33<br>• Remote Shutdown Panel<br>• BOP Analog Instr. Cab. J-ZJA-C02A & B<br>• Aux. Prot. Cab. J-SAA-C03<br>• Plant Prot. Sys. (PPS) J-SBA-C01<br>• Process Prot. Instr. Cab. A-2 J-SBA-C02B<br>• BOP ESFAS & Load Sequencer J-SAA-C02A<br>• MOV Position Indicators<br>• Containment Hydrogen Analyzer J-HPA-E01 | • ESFAS Aux. Relay Cab. J-SAA-C01<br>• Process Protective Instr. Cab. B-2 J-SBB-C02B<br>• Supplementary Protect. Sys. J-SBB-C04<br>• Radiation Monitors J-SQB-RU-1, 30, 32 & 34<br>• Remote Shutdown Panel<br>• BOP Analog Instr. Cab. J-ZJB-C02A<br>• Aux. Prot. Cab. J-SAB-C03<br>• Plant Prot. Sys. (PPS) J-SBB-C01<br>• Process Protective Instr. Cab. B-1 J-SBB-C02A<br>• BOP ESFAS & Load Sequencer J-SAB-C02B<br>• MOV Position Indicators<br>• Containment Hydrogen Analyzer J-HPB-E02 | • ESFAS Aux. Relay Cab. J-SAB-C01<br>• Supplementary Protect. Sys. J-SBC-C04<br>• CEDMCS Aux. Cab. C5 J-SFC-C01<br>• Aux. Prot. Cab. J-SAC-C03<br>• Plant Prot. Sys. (PPS) J-SBC-C01<br>• Process Protective Instr. Cab. C J-SBC-C02A<br>• MOV Position Indicators | • ESFAS Aux. Relay Cab. J-SAB-C01<br>• Supplementary Protect. Sys. J-SBD-C04<br>• CEDMCS Aux. Cab. C6 J-SFD-C01<br>• Aux. Prot. Cab. J-SAD-C03<br>• Plant Prot. Sys. (PPS) J-SBD-C01<br>• Process Protective Instr. Cab. D J-SBD-C02A<br>• MOV Position Indicators | • RCS-2 & CVCS-2 Process Instr. J-ZJN-C01B&D<br>• SIS/RCP-1 Process Instr. J-ZJN-C01F<br>• NSSS Rad. Mon. Cab. J-SQN-C02 (Process & Gas Stripper Eff. Rad. Mon., Reactor Power Cutback, Boronometer, S/U & Control Ch. 1)<br>• BOP Analog Instr. Cab. J-ZJN-C02B&D<br>• BOP Analog Instr. Cab. J-ZJN-C02F<br>• Radwaste Instr. Cab. J-ZRN-C01 & C02<br>• CEDMCS (incl. core mimic)<br>• NSSS Control Sys. J-SFN-C03 (FWCS-1 & 2 & SBCS)<br>• MICDS No. 1<br>• Reactor Trip Swgr. Current Monitor C<br>• Loose Parts & Vibration Mon.<br>• Gen. Pyrolysate Collector | • RCS-1 & CVCS-1 Process Instr. J-ZJN-C01A & C<br>• NSSS Rad. Mon. Cab. J-SQN-C02 (MICD Amp., CEA Display, S/U & Control Ch. 2<br>• CVCS-3 & SIS/RCP-2 Process Instr. J-ZJN-C01E & G<br>• BOP Analog Instr. Cab. J-ZJN-C02A & C & -C07<br>• BOP Analog Instr. Cab. J-ZJN-C02E & G<br>• Fuel Pool Instr. J-PCN-E02<br>• CEDMCS<br>• NSSS Control Sys. J-SFN-C03 (RRS, SBCS permissives, & AMI setpoint display)<br>• MICDS NO. 2<br>• Reactor Trip Swgr. Current Monitor D |

### 7.1.3.13 System Component Arrangement

Safety-related components shall be located so as to conform to the separation, independence, and other criteria specified in this section. The safety-related components shall be located to provide access for maintenance, testing and operation as required.

Analog and digital signals provided to the safety-related components shall not share the same multiconductor cable, unless specifically called for or approved by Combustion Engineering.

### 7.1.3.14 Radiological Waste

Radiological waste discharge lines or components shall not be routed or located next to protection system electronic components in a manner that will result in exceeding the radiation limits specified in Section 3.11.

### 7.1.3.15 Overpressure Protection

The components of the safety-related equipment shall be located so as not to exceed the pressure limits specified in Section 3.11.

### 7.1.3.16 Related Services

A fire protection system shall be provided to protect the safety-related equipment, including sensors, consistent with GDC 3. This shall include facilities for detection, alarming, and extinguishing of fires. Facilities and methods for minimizing the probability and effects of fires, including fire barriers, fire resistant and non-combustible materials, and other such items, shall be employed whenever possible. Adequate drainage shall be provided if water is used to extinguish fires.

Inadvertent operation or rupture of fire protection systems shall not result in the reduction of the functional capability of safety-related systems or components below that required to perform their safety function.

Physical identification shall be provided to enable plant personnel to recognize that PPS, ESFAS Auxiliary Relay Cabinets, RTSS, and their cabling are safety-related. The cabinets shall be identified by nameplates. A color coding scheme shall be used to identify the physically separated channel cabling from sensor to the PPS (refer to section 7.1.3.5); the same color code shall be used for interbay or intercabinet identification.

Cabling or wiring within a bay at the cabinet which is in the channel of its circuit classification shall not be color coded.

The cabinet nameplates and cabling shall be color coded as follows:

9

| Protective | ESF Trains | Associated |
|---|---|---|
| Channel A: Red | A: Red | White Stripe with Red Stripe or White Stripe over Red Jacket |
| Channel B: Green | B: Green | White Stripe with Green Stripe or White Stripe over Green Jacket |
| Channel C: Yellow | | White Stripe with Yellow Stripe or White Stripe over Yellow Jacket |
| Channel D: Blue | | White Stripe with Blue Stripe or White Stripe over Blue Jacket |

All non-panel mounted protection system instrumentation and control components are identified with a name tag which provides the channel number and the suffix A, B, C, or D to specifically identify the protection channel with which the component is identified.

### 7.1.3.17 Environmental

Environmental support systems shall be provided to ensure that the environmental conditions of the safety-related systems do not exceed the requirements for 1E equipment as defined in Section 3.11.

## Table 7.2-1
## REACTOR PROTECTION SYSTEM DESIGN INPUTS
(Sheet 1 of 2)

| Type | Typical Value (full power) | Typical Trip Setpoint | Typical Margin To Trip |
|---|---|---|---|
| High logarithmic power level | NA | 0.010% power | NA |
| Variable overpower | 100% power<br>0%/min<br>NA | 110% power<br>10.6%/min<br>9.7% band (a) | 10% power<br>10.6%/min<br>NA |
| Low DNBR | 1.79 (b) | ≥1.30 (i) | ≤0.55 |
| (Low pressure floor, psia) | (2,250) | (1,860) | (390) |
| High local power density, kW/ft | ≤13.5 (peak) (c) | 21 | ≥7.5 |
| High pressurizer pressure, psia | 2,250 | 2,383 | 133 |
| Low pressurizer pressure, psia | 2,250 | 1,837 (d) (e) | 413 |
| Low steam generator water level, % (f) | 82 | 44.2 | 37.8 |
| Low steam generator pressure, psia | 970 | 919 (d) | 51 |
| High containment pressure, psig | 0 | 3.0 | 3.0 |
| High steam generator water level, % (g) | 55 | 91.0 | 36 |
| Low reactor coolant flow, floor | 22.5 psid (h) | 11.9 psid | 10.6 psi |
| rate | 0.0 psi/sec | 0.115 psi/sec | 0.115 psi/sec |
| band | NA | 10.0 psid (h) | 10.0 psid |

## Table 7.2-1

## REACTOR PROTECTION SYSTEM DESIGN INPUTS

(Sheet 2 of 2)

a. % band is percent above measured excore power level.

b. Calculated value of DNBR assures trip conservatively considering all sensor and processing time delays and inaccuracies. Calculated DNBR will be less than or equal to actual core DNBR.

c. Peak value is unit and cycle specific.

d. Setpoint can be manually decreased to an increment below existing pressure as pressure is reduced and is automatically increased as pressure is increased maintaining this increment. This increment is no greater than 200 psia for low steam generator pressure. This increment is no greater than 400 psia for low pressurizer pressure.

e. Trip setpoint has a minimum value of 100 psia.

f. % of the distance between the wide range level instrument nozzles above the lower nozzle.

g. % of the distance between the narrow range level instrument nozzles above the lower nozzle.

h. Hot, no load, steam generator primary differential pressure.

i. Starting with Unit 3 Cycle 5, this value is ≥1.30. For Units 1 and 2 Cycle 5 this value is ≥1.24, and will be increased to ≥1.30 for Cycle 6. | 7 incremental and minimum values are given in table 7.2-1. This ensures the capability of a trip when required during plant cooldown.

The trip may be manually bypassed by the operator. This bypass point is provided in table 7.2-2. The bypass is automatically removed as pressure is increased above a fixed value and the low pressure setpoint automatically increases, maintaining the fixed increment between the plant pressure and the setpoint. These values are shown in table 7.2-1.

Pre-trip alarms are initiated above the trip setpoint to provide audible and visible indication of approach to a trip condition.

7.2.1.1.1.7 Low Steam Generator Water Level. The low steam generator water level trip is provided to trip the reactor when measured steam generator water level falls to a low preset value. Separate trips are provided from each steam generator. The typical trip setpoint is provided in table 7.2-1.

Pre-trip alarms are initiated above the trip setpoint to provide audible and visible indication of approach to a trip condition.

7.2.1.1.1.8 Low Steam Generator Pressure. The low steam generator pressure trip is provided to trip the reactor when the measured steam generator pressure falls to a low preset value. Separate trips are provided from each steam generator. The typical trip setpoint during normal operation is provided in table 7.2-1. At steam generator pressures below normal, the operator has the ability to manually decrease the setpoint to a fixed increment below existing system pressure. This is used during plant cooldown. During startup, this setpoint is automatically increased and remains at the fixed increment below generator pressure. This fixed increment is provided in table 7.2-1. | 3

Pre-trip alarms are initiated to provide audible and visible indication of approach to a trip condition.

7.2.1.1.1.9 High Containment Pressure. The high containment pressure trip is provided to trip the reactor when measured containment pressure reaches a high preset value. The typical trip setpoint is provided in table 7.2-1. The trip is provided as additional design conservatism (i.e., additional means of providing a reactor trip). The high containment pressure trip setpoint is selected in conjunction with the high-high containment pressure setpoint to prevent exceeding the containment design pressure during a design basis LOCA or main steam line break accident.

Pre-trip alarms are initiated to provide audible and visible indication of approach to a trip condition.

1 7.2.1.1.1.10 High Steam Generator Water Level. A high steam generator water level trip is provided to trip the reactor when measured steam generator water level rises to a high preset value. Separate trips are provided from each steam generator. The typical trip setpoint is provided in table 7.2-1.

Pre-trip alarms are initiated to provide audible and visible indication of approach to a trip condition.

7.2.1.1.1.11 Manual Trip. A manual reactor trip is provided to permit the operator to trip the reactor. Actuation of two adjacent pushbutton switches in the main control room will cause interruption of the ac power to the CEDMs. Two independent sets of trip pushbuttons are provided, either one of which will cause a reactor trip. There are also manual reactor trip switches at the reactor trip switchgear.

The remote manual initiation portion of the reactor protection system is designed as an input to the reactor trip switchgear system (RTSS). This design is consistent with the

## Table 7.2-4

## REACTOR PROTECTION SYSTEM MONITORED PLANT VARIABLE RANGES

| Monitored Variable | Minimum | Typical (full power) | Maximum | |
|---|---|---|---|---|
| Neutron flux power, % | $2 \times 10^{-7}$ of full power | 100 power | 200 of full power | |
| Cold leg temperature, °F | 465 | 555 | 615 | 7 |
| Hot leg temperature, °F | 375 | 611 | 675 | 7 |
| Pressurizer pressure (narrow range), psia | 1,500 | 2,250 | 2,500 | |
| Pressurizer pressure (wide range), psia | 0 | 2,250 | 3,000 | |
| CEA positions | full in | NA | full out | |
| Reactor coolant pump speed, rpm | 100 | 1,188 | 1,200 | |
| Steam generator water level, %(a) | 0 | 82 | 100 | |
| Steam generator water level, %(b) | 0 | 55 | 100 | |
| Steam generator pressure, psia | 0 | 970 | 1,524 | 7 |
| Containment pressure, psig | -4 | 0 | 20 | |
| Steam generator primary pressure differential, psid | 0 | 22.5 | 70 | |

a. % of the distance between the wide range level instrument nozzles (above the lower nozzle).

b. % of the distance between the narrow range level instrument nozzles (above the lower nozzle).

the nuclear instruments, and (2) the reactor coolant pump
speed sensors which provide a pulsed voltage signal. Signal
isolation is provided for computer inputs. Each redundant
1 channel is powered from a separate vital ac bus.

7.2.1.1.2.2 CEA Position Measurements. The position of each
CEA is an input to the RPS. These positions are measured by
means of redundant and independent reed switch position
transmitters (RSPTs) on each CEA. The RSPTs transmit analog
2 signals to two redundant and independent control element
assembly calculators (CEACs).

Each RSPT consists of a series of magnetically actuated reed
1 switches spaced at intervals along the CEA housing and wired
with precision resistors in a voltage divider network (see
2 figure 7.2-0B). A magnet attached to the CEA extension shaft
1 actuates the adjacent reed switches, causing voltages
2 proportional to position to be transmitted for each RSPT. The
RSPT assemblies and wiring are physically and electrically
1 separated from each other (see figure 7.2-0C).

The CEAs are arranged into subgroups that are controlled as
control groups of CEAs. The subgroups are symmetric about the
core center. The subgroups of a control group are required to
move together and to follow a set insertion sequence.

2 Each CEAC monitors the position of all CEAs within each
subgroup. Should a CEA deviate by more than a specific
deadband limit, the CEACs will detect the event, sound an
annunciator alarm, and transmit appropriate "penalty" factors
to the CPCs.

The CEACs display the position of each regulating, shutdown,
1 and part-length CEA to the operator in a bar chart format on a
cathode ray tube (CRT). Optical isolation is utilized at each
2 CEAC output to the CRT display generator. The operator has
the capability to select either CEAC for display.

The CPCs utilize 22 selected "target" CEA position reed switch signals as a measure of CEA subgroup and group position. When the CPCs determine that the subgroups of a control group are not moving together, or that the control groups are not moving in the required sequence, they generate penalty factors. The CPCs utilize single CEA deviation penalty factors from the CEACs to modify calculational results in a conservative manner. These factors may result in a reduction in margins-to-trip for low DNBR and high LPD. This assures conservative operation of the RPS during CEA deviations which require a RPS trip. The detailed signal paths of CEA position information within the RPS are shown in figure 7.2-0D.

7.2.1.1.2.3 Excore Neutron Flux Measurements. The excore nuclear instrumentation includes neutron detectors located around the reactor core, and signal conditioning equipment located within the containment and the auxiliary building. Neutron flux is monitored from source levels through full power operation, and signal outputs are provided for reactor protection and information display. There are four channels of safety instrumentation (see figure 7.2-0E).

The four safety channels provide neutron flux information from startup neutron flux levels to 200% of rated power covering a single range of approximately $2 \times 10^{-7}$ to 200% power (9 decades). Each safety channel consists of three fission chambers, a preamplifier and a signal conditioning drawer containing power supplies, a logarithmic amplifier (including combination counting and mean square variation techniques), linear amplifiers, test circuitry, and a rate-of-change of power circuit. These channels provide signals for the rate-of-change power display, RPS for logarithmic power level high and variable over power trips, and CPCs for use in calculations for low DNBR and high LPD trips.

The detector assembly provided for each safety channel consists of three identical fission chambers stacked vertically along the length of the reactor core. The use of multiple subchannel detectors in this arrangement permits the determination of axial power shape during power operation.

The fission chambers are mounted in holder assemblies which in turn are located in four dry instrument wells (thimbles) at the primary shield. The wells are spaced around the reactor vessel to provide optimum neutron flux information.

Preamplifiers for the fission chambers are mounted outside the primary shield, with two inside containment, and two outside containment in the auxiliary building. Physical and electrical separation of the preamplifiers and cabling between redundant channels are provided.

7.2.1.1.2.4 Reactor Coolant Flow Measurements. The speed of 1 each reactor coolant pump motor is measured to provide a basis for calculation of reactor coolant flow through each pump. The measurement of reactor coolant pump speed is accurate to within 0.43% of the actual pump speed. Two metal discs, each with 44 uniformly spaced slots about its periphery, are scanned by proximity devices. The metal discs are attached to the pump motor shaft, one to the upper portion and one to the lower portion (see Figure 7.2-6 of CESSAR). Each scanning device produces a voltage pulse signal. The pulse train that is input to the CPCs to calculate flow rate is based upon every $n^{th}$ pulse from the scanning device. The frequency of this pulse train is proportional to pump speed. Adequate separation between proximity devices is provided.

The mass flow rate is obtained using the pump speed inputs from the four reactor coolant pumps, the cold leg temperatures, and the hot leg temperatures. The volumetric flow rate through each reactor coolant pump is dependent upon the rotational

#### 7.2.1.1.6 Interlocks

Refer to CESSAR Section 7.2.1.1.6.

#### 7.2.1.1.7 Redundancy

Refer to CESSAR Section 7.2.1.1.7.

#### 7.2.1.1.8 Diversity

Refer to CESSAR Section 7.2.1.1.8.

#### 7.2.1.1.9 Testing

Refer to CESSAR Section 7.2.1.1.9.

The required response time testing discussed in CESSAR Section 7.2.1.1.9.8 is addressed in the Technical Specifications. The methods, equipment, and test frequency are also provided in the Technical Specifications. The reactor protective instrumentation response time limits are identified in table 7.2-4AA. 7

#### 7.2.1.1.10 Vital Instrument Power Supply

Refer to CESSAR Section 7.2.1.1.10.

### 7.2.1.2 Design Bases

Refer to CESSAR Section 7.2.1.2.

Instrument location layout drawings are presented in figures 7.2-1, 7.2-2, 7.2-3, and 7.2-4.

### 7.2.1.3 Final System Drawings

Refer to CESSAR Section 7.2.1.3.

In addition, for a list of applicable drawings and diagrams, see section 1.7.

## Table 7.2-4AA

## REACTOR PROTECTIVE INSTRUMENTATION RESPONSE TIMES

(Sheet 1 of 2)

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| FUNCTIONAL UNIT | RESPONSE TIME |
|---|---|
| I. TRIP GENERATION | |
| A. Process | |
| 1. Pressurizer Pressure - High | ≤ 0.50 seconds |
| 2. Pressurizer Pressure - Low | ≤ 1.15 seconds |
| 3. Steam Generator Level - Low | ≤ 1.15 seconds |
| 4. Steam Generator Level - High | ≤ 1.15 seconds |
| 5. Steam Generator Pressure - Low | ≤ 1.15 seconds |
| 6. Containment Pressure - High | ≤ 1.15 seconds |
| 7. Reactor Coolant Flow - Low | ≤ 0.58 second |
| 8. Local Power Density - High | |
| a. Neutron Flux Power from Excore Neutron Detectors | ≤ 0.75 second(a) |
| b. CEA Positions | ≤ 1.35 second(b) |
| c. CEA Positions: CEAC Penalty Factor | ≤ 0.75 second(b) |
| 9. DNBR - Low | |
| a. Neutron Flux Power from Excore Neutron Detectors | ≤ 0.75 second(a) |
| b. CEA Positions | ≤ 1.35 second(b) |
| c. Cold Leg Temperature | ≤ 0.75 second(d) |
| d. Hot Leg Temperature | ≤ 0.75 second(d) |
| e. Primary Coolant Pump Shaft Speed | ≤ 0.30 second(c) |
| f. Reactor Coolant Pressure from Pressurizer | ≤ 0.75 second(e) |
| g. CEA Positions: CEAC Penalty Factor | ≤ 0.75 second(b) |
| B. Excore Neutron Flux | |
| 1. Variable Overpower Trip | ≤ 0.55 second(a) |
| 2. Logarithmic Power Level - High | |
| a. Startup and Operating | ≤ 0.55 second(a) |
| b. Shutdown | ≤ 0.55 second(a) |

## Table 7.2-4AA
## REACTOR PROTECTIVE INSTRUMENTATION RESPONSE TIMES
## (Sheet 2 of 2)

| FUNCTIONAL UNIT | RESPONSE TIME |
|---|---|
| C. Core Protection Calculator System | |
| 1. CEA Calculators | Not Applicable |
| 2. CEA Protection Calculators | Not Applicable |
| D. Supplementary Protection System | |
| Pressurizer Pressure - High | ≤ 1.15 second |
| II. RPS LOGIC | |
| A. Matrix Logic | Not Applicable |
| B. Initiation Logic | Not Applicable |
| III. RPS ACTUATION DEVICES | |
| A. Reactor Trip Breakers | Not Applicable |
| B. Manual Trip | Not Applicable |

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a. Neutron detectors are exempt from response time testing. The response time of the neutron flux signal portion of the channel shall be measured from the detector output or from the input of first electronic component in channel.

b. Response time shall be measured from the output of the sensor.

c. The pulse transmitters measuring pump speed are exempt from response time testing. The response time shall be measured from the pulse shaper input.

d. Response time shall be measured from the output of the resistance temperature detector (sensor). RTD response time shall be measured at least once per 18 months. The measured response time of the slowest RTD shall be less than or equal to 8 seconds.

e. Response time shall be measured from the output of the pressure transmitter. The transmitter response time shall be less than or equal to 0.7 second.

## 7.2.2 ANALYSIS

### 7.2.2.1 Introduction

The RPS is designed to provide the following protective functions:

- Initiate automatic protective action to assure that acceptable RCS and fuel design limits are not exceeded during specified incidents of moderate frequency and infrequent incidents.
- Initiate automatic protective action during limiting faults to aid the ESF systems in limiting the consequences of the limiting faults.

A description of the reactor trips provided in the RPS is given in paragraph 7.2.1.1.1. Paragraph 7.2.2.2 provides the bases for all the RPS trips and table 7.2-1 gives the applicable typical trip setpoints.

1 Most of the trips in the RPS are single parameter trips (i.e., a trip signal is generated by comparing a single measured variable with a fixed setpoint). The RPS trips that do not fall into this category are as follows:

A. Low pressurizer pressure trip

This trip employs a setpoint that is determined as a function of the measured pressurizer pressure or that is varied by the operator.

B. Low steam generator pressure trip

This trip employs a setpoint that is determined as a function of the measured steam generator pressure or that is varied by the operator.

C. High local power density trip

This trip is calculated as a function of several measured variables.

- Reactor coolant pump shaft seizure;
- Depressurization due to inadvertent actuation of primary or secondary safety valves at 100% power; 1
- A reactor coolant pump sheared shaft; and
- Steam generator tube rupture.

### 7.2.2.2 Trip Bases

The RPS consists of fifteen trips in each RPS channel that will initiate the required automatic protective action utilizing a coincidence of two like trip signals.

A brief description of the inputs and purpose of each trip is presented in paragraphs 7.2.2.2.1 through 7.2.2.2.11.

#### 7.2.2.2.1 Variable Overpower Trip

7.2.2.2.1.1 Input. The input is neutron flux power from the excore neutron flux monitoring system.

7.2.2.2.1.2 Purpose. This trip provides a reactor trip to assist the ESF systems in the event of an ejected CEA limiting fault. 1

#### 7.2.2.2.2 High Logarithmic Power Level Trip

7.2.2.2.2.1 Input. The input is neutron flux power from the excore neutron flux monitoring system.

7.2.2.2.2.2 Purpose. This trip assures the integrity of the fuel cladding and RCS boundary in the event of unplanned criticality from a shutdown condition, resulting from either dilution of the soluble boron concentration or uncontrolled withdrawal of CEAs. In the event that CEAs are in the withdrawn position, automatic trip action will be initiated.

If all CEAs are inserted, an alarm is provided to alert the operator to take appropriate action in the event of an unplanned criticality.

7.2.2.2.3 High Local Power Density Trip

1 7.2.2.2.3.1 <u>Inputs</u>. The inputs are

- Neutron flux power and axial power distribution based on the excore neutron flux monitoring system;
- Radial peaking factors based on CEA position
2 measurement system (RSPTs);
- ΔT power based on coolant temperatures, pressure, and RCP speed measurements;
- Penalty factors from CEACs for CEA deviation within a subgroup; and
- Penalty factors generated within the CPC for subgroup deviation and groups out-of-sequence.

7.2.2.2.3.2 <u>Purpose</u>. This trip prevents the linear heat rate (kW/ft) in the limiting fuel pin in the core from exceeding fuel design limits in the event of defined incidents of
1 moderate frequency or infrequent incidents.

7.2.2.2.4 Low DNBR Trip

7.2.2.2.4.1 <u>Inputs</u>. The inputs are

- Neutron flux power and axial power distribution based on the excore neutron flux monitoring system;
- RCS pressure from pressurizer pressure measurement;
- ΔT power based on coolant temperatures, pressure, and RCP speed measurements;
- Radial peaking factors based on CEA position
2 measurement (RSPTs);

## Table 7.2-4A

## PLANT PROTECTION SYSTEM FAILURE MODES AND EFFECTS ANALYSIS

(Sheet 121 of 129)

| Name | Failure Mode | Cause | Symptoms and Local Effects Including Dependent Failures | Method of Detection | Inherent Compensating Provision | Effect Upon PPS | Remarks and Other Effects |
|---|---|---|---|---|---|---|---|
| 66) Matrix Hold Push-button (e.g., "AB" Matrix) | a) Open - Matrix relay circuit contacts. | Mech. failure, contact deterioration. | Unable to energize matrix relay test coils which inhibits matrix response when selected pair of contacts in "AB" logic matrix is actuated. Matrix will pass test signal as bonafide actuation signal (e.g., CSAS). | Matrix relay hold and drop-out indicator lights inoperative. Annunciation. | None required | Test signal initiator actuation signal for selected system channel trip switch contacts are make-before-break, which would allow detection of prior contact. | Test procedure requires matrix and channel switch at off position. The failure of these contact pairs can be detected before channel is tested. |
| | b) Closed-Matrix relay circuit contacts. | Mech. damage, welded contacts. | Matrix relay test coils remain energized, preventing reactor trip initiated by same matrix. | Matrix relay hold and drop-out indicator lights remain on. | Removal of test power. | Affected logic matrix cannot initiate trip when required during test. | Reactor trip logic becomes 2-out-of-2 during test period only. (4th input signal bypassed at bistable). |
| | c) Open - Bistable relay circuit contacts | Mech. failure, contact deterioration. | Unable to energize any system channel trip select switch or RPS channel trip select switch, bistable test relay coils. | Unable to release bistable relay. No trip indicator lights. | None required | None. Unable to conduct matrix logic test for "AB" matrix. | No affect on operation of PPS. Operator cannot test bistables, pair associated with matrix logic (e.g. "AB"). |
| | d) Closed-Bistable relay circuit contacts | Mech. damage, welded contacts. | Bistable relay test coils connected to system channel trip select switch remains energized during test. | Bistable relay trip indicator light is on. | Removal of test power supply or positioning CRT switches to off. | Actuation signal is initiated when test switch is turned on. | First position of system channel trip select switch is RPS trip, and when Operator starts test sequence the reactor may trip. |

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# Table 7.2-4A

## PLANT PROTECTION SYSTEM FAILURE MODES AND EFFECTS ANALYSIS

(Sheet 122 of 129)

| Name | Failure Mode | Cause | Symptoms and Local Effects Including Dependent Failures | Method of Detection | Inherent Compensating Provision | Effect Upon PPS | Remarks and Other Effects |
|---|---|---|---|---|---|---|---|
| 67) System Channel Trip Select Switch | Intermittent contact (Open) | Mech. damage, contact deterioration. | Unable to energize bistable relay test coils associated with system channel trip select switch. | No bistable test light indication. | None required | Unable to test logic matrices for affected system channel trip. | |
| 68) RPS Channel Trip Select Switch | Intermittent contact (Open) | Mech. damage, contact deterioration. | Unable to energize bistable relay test coils associated with test switch position. | No bistable test light at test switch position location. | None required | Unable to test logic matrices for affected bistable pair. | No affect on operation of PPS. |
| 69) Bistable relay test coil (e.g., A1-1) | a) Open | Overvoltage, mech. damage. | Unable to energize affected bistable test coil to initiate relay trip for the particular parameter under test. | Bistable test light stays off. | None required | Unable to test that portion of logic matrices completely for the parameter under test. | No effect on operation of PPS. |
| | b) Short | Mech. damage. | Test power supply will be reduced to approx. zero. | Power supply indicator light inoperative. | None required | Unable to test logic matrices completely. | |
| | | Deterioration of Insulation | Bistable relay test coil cannot be energized. | Bistable test light stays off. | None required | | |
| 70) Matrix Relay Trip Select Switch | Intermittent contact (Open) (e.g., position 1). | Mech. damage, contact deterioration. | Matrix relay test coils for the affected position (e.g., "1") remain de-energized during test period. | Matrix relay hold indicator light inoperative. Annunciation. | None required | Reactor trip could occur during bistable relay trip test. | |

# Table 7.2-4A

# PLANT PROTECTION SYSTEM FAILURE MODES AND EFFECTS ANALYSIS

## (Sheet 125 of 129)

| Name | Failure Mode | Cause | Symptoms and Local Effects Including Dependent Failures | Method of Detection | Inherent Compensating Provision | Effect Upon PPS | Remarks and Other Effects |
|---|---|---|---|---|---|---|---|
| 75) Channel A Test Switch (Cont.) | f) Contacts to Ch. B test switch fail closed. | Contact weld, mech. damage. | Power still provided to Ch. B test switch when ch. A is in test. Possible to test two ch's. at same time. | None. | Procedures preclude testing two ch's. at same time. | None. | |
| | g) Contacts to test annunc. fail open. | Contact deterioration, mech. damage, open lead. | Spurious "Test in Progress" alarms. | Annunciation. | None. | None. | |
| | h) Contacts to test annunc. fail closed. | Contact weld, mech. binding. | "Test in Progress" alarm not sound when Ch. A switch engaged. | Operator, when starting test. | Ch. A "Test in Progress" lamp comes on. | None. | |
| 76) Ch. A Test Lamp | Fails off. | Burnt out, mech. damage. | Loss of visual indication when Ch. A is in Test. | Operator, when starting test. | Test annunc. not affected. | None. | |
| 77) Ch. A Test Relay | a) Fails open. | Overstress, open winding, mech. damage. | Relay contacts in matrix hold button power lines will not close. Unable to test Ch. A. | Operator, when starting test. | None. | None. | |
| | b) N.O. contacts in power circuit fail open. | Open lead, contact corrosion. | Same as 77 a) | Same as 77 a) | Same as 77 a) | Same 77 a) | |

# Table 7.2-4A

## PLANT PROTECTION SYSTEM FAILURE MODES AND EFFECTS ANALYSIS

## (Sheet 126 of 129)

| Name | Failure Mode | Cause | Symptoms and Local Effects Including Dependent Failures | Method of Detection | Inherent Compensating Provision | Effect Upon PPS | Remarks and Other Effects |
|---|---|---|---|---|---|---|---|
| 77) Ch. A Test Relay | c) One N.O. contact in power circuit fails closed. | Contact weld, mech. binding. | None. | None. | None. | None. | |
| 78) PPS Calibration and Test Panel Trip Test Pushbutton (PB -) (e.g., Channel "A") | a) Open | Mech. damage, contact deterioration. | Unable to energize bistable relay trip test circuit and supply test signal to bistable selected for test. | No bistable trip indication. | None. | None. | No effect on operation of PPS. May not be able to test bistables in affected channel (e.g., Channel "A"). |
| | b) Closed | Mech. damage, welded contacts. | Bistable relay trip test circuit energized when test signal power supply is turned on. | Bistable in test indicator. | Depressing matrix hold pushbutton and/or reducing signal level below trip level. | Half logic matrix trip could occur during testing. | Operator will be aware of problem as soon as test power supply is turned on and before test sequence starts. |
| 79) Trip Test Circuit Relay (K-1, e.g., Channel "A") | a) Open coil. | Overvoltage, mech. damage. | Unable to energize trip test circuit. The contacts which connect the bistable selected for test to the test signal will not be energized. | No trip signal indication. | None. | Selected bistable relays cannot be tested in affected channel (e.g., "A") | No effect on operation of PPS. |

2

signals originating in the RPS which feed the plant monitoring system (PMS) are isolated to maintain their channel independence.

7.2.2.3.2.7 Sections 4.7 through 4.22. Refer to the respective CESSAR sections.

### 7.2.2.3.3 Testing Criteria

Conformance to IEEE 338-1971 and Regulatory Guide 1.22 are discussed in paragraphs 7.1.2.7 and 7.1.2.15. Test intervals and their bases are included in the Technical Specifications. A complete channel can be tested without causing a reactor trip and without affecting system operability. Overlap in the RPS channel tests is provided to assure that the entire channel is functional. The testing scheme is discussed in detail in paragraph 7.2.1.1.9. For the organization for testing and documentation, refer to chapter 13. 1

Since operation of the RPS will be infrequent, the system is periodically and routinely tested to verify its operability. A complete channel can be individually tested without initiating a reactor trip, without violating the single failure criterion, and without inhibiting the operation of the system. The system can be checked from the sensor signal through the circuit breakers of the RTSS. The RPS can be tested during reactor operation. The sensors can be checked by comparison with similar channels or channels that involve related information. Minimum frequencies for checks, calibration, and testing of the RPS instrumentation are given in the Technical Specifications. Overlap in the checking and testing is provided to assure that the entire channel is functional. The use of individual trip and ground detection lights, in conjunction with those provided at the supply bus, assures that possible grounds or shorts to another source of voltage will be detected.

1

### 7.2.2.4 Failure Modes and Effects Analysis (FMEA)

2

A FMEA for the RPS and ESFAS is provided in table 7.2-4A. The FMEA is for protection systems' sensors, and coincidence and actuating logics. Refer to CESSAR Section 7.2.2.4 for logic interface for protection systems.

1

#### 7.2.2.4.1 Potential Impacts of Control Systems Failures

Table 7.2-5 identifies the control systems that were considered in the evaluation of potential impacts on plant safety due to common power source or common sensor failures. As discussed below, the consequential malfunctioning of these systems due to a common power/sensor failure has less impact on plant safety than the bounding chapter 15 analyses.

Table 7.2-5

CONTROL SYSTEMS CONSIDERED TO HAVE POTENTIAL IMPACTS UPON PLANT SAFETY DUE TO COMMON POWER SOURCE OR COMMON SENSOR FAILURES

| Control System | Acronym |
|---|---|
| Reactor regulating system | RRS |
| Control element drive mechanism control system | CEDMCS |
| Reactor power cutback system | RPCS |
| Boron control system | BCS |
| Steam bypass control system | SBCS |
| Turbine-generator control system | TGCS |
| Moisture separator reheat control system | MSRCS |
| Feedwater control system | FWCS |
| Main feedwater turbine pump control system | MFTPCS |
| Condenser level control system | CLCS |
| Pressurizer level control system | PLCS |
| Pressurizer pressure control system | PPCS |

7.2.2.4.1.1 Power Source Failures. The power source failures which would affect more than one control system, and a brief description of the impact on each control system, are provided below. Except for the loss of offsite electrical power, which is specifically addressed by the chapter 15 analyses, no other power failures have been identified which would introduce additional control system malfunctions to those described. This is due to the degree of separation inherent in the electrical power distribution network and the availability of backup power sources within the network.

7.2.2.4.1.1.1 Impact Due to Loss of 120 V-ac Distribution Panel E-NNN-D11.

| | |
|---|---|
| FWCS | - The main feedwater pump speed will decrease to its minimum controlled speed, reducing feedwater flow. In addition, the feedwater control valves will fail as-is (in the position they were in when power was lost). |
| SBCS | - The control system cannot generate quick open and modulate open signals to open the turbine bypass valves. In addition, control room indication of the automatic permissive signal will be lost. |
| RPCS | - The control system will be unable to generate CEA drop demand and turbine runback signals. |
| PLCS<br>PPCS | - The letdown control valve closes and the normally running and standby charging pumps will not operate. They can be started manually from BO3. With either HS-100 and/or HS-100-3 in "Y" position, the 1E and non-1E backup heaters and the proportional heaters will trip off. |

| | |
|---|---|
| CEDMCS - | Loss of one of two redundant power sources to the interlock relays. Therefore, CEDMCS will not be impacted. |

7.2.2.4.1.1.2 Impact Due to Loss of 120 V-ac Distribution Panel E-NNN-D12.

| | |
|---|---|
| SBCS - | Inability to generate an automatic motion inhibit (AMI) signal. |
| RRS - | Inability to generate CEA motion demand signals. Loss of CEA motion demand indication in the control room. |
| PPCS -<br>PLCS | The control for pressurizer spray control valve inlet will not close. With either HS-100 and/or HS-100-3 in "X" position, all 1E and non-1E backup heaters and proportional heaters will trip off. With both HS-100 and HS-100-3 in "Y" position, the proportional heaters will turn fully on with no controls, while the 1E and non-1E backup heaters will be fully on with control. Pressure indication in the control room goes to 0 psia. 1 |
| CLCS - | Inability to generate condensate storage tank control valve opening signal. The valve will remain in its normally closed state. |
| CEDMCS - | Loss of one of two redundant power sources to the interlock relays. Therefore, CEDMCS will not be impacted. |

7.2.2.4.1.1.3 Impact Due to Loss of 125 V-dc Load Center E-NKN-M45.

| | |
|---|---|
| SBCS - | Inability to actuate turbine bypass valve quick open or permissive solenoids. Loss of quick open indication in the control room. |

control valves ensures primary system mass is controllable within the time frame before operator 1 action. The loss of backup heaters is within the analysis, and they become available in any event upon 2 switching control to the unaffected loop.

The calculation of the pressurizer level swell used the following assumptions:

- The maximum initial pressurizer liquid level is 60%
- Each charging pump operates at 44 gallons per minute
- The letdown is completely isolated due to the panel failure
- The charging flow is heated to RCS temperatures

Using this data, it can be calculated that the operator has at least 20 minutes to take action before the 1 safety valve nozzles are submerged. This is the same operator action response time used to set the initial pressurizer level technical specifications. This calculation is conservative in that the RCS temperatures, and hence pressurizer level, are assumed to attain post-trip values approximately equal to their initial values predicted for the loss of condenser vacuum event. The panel failure event will not result in the reactor coolant pump coastdown assumed in the loss of condenser vacuum event and, therefore, will experience better heat transfer and a lower post-trip pressurizer liquid level. The reduced post-trip pressurizer level will result in additional margin for operator action.

The mass addition prior to reactor trip (approximately one minute) does not significantly increase the maximum pressurizer level (less than 30 cubic feet) and will

2 not affect maximum RCS pressure. Figure 15E-6 illustrates this insensitivity of maximum RCS pressure to pre-trip RCS mass addition (analogous to an increase in the initial pressurizer water volume).

B. Panel E-NNN-D12 Failure

The loss of this panel will result in the loss of automatic pressurizer pressure control. However, if HS-100 and HS-100-3 are in the "Y" position, the 1E and non-1E backup heaters will be available. With either handswitch in the "X" position, backup heaters will trip off. Also, when HS-100 and HS-100-3 are in the "Y" position, proportional heaters will turn full on with no control, and with either handswitch in the "X" position, the proportional heaters will trip off. The condenser hotwell level may decrease due to the inability to automatically control it. In addition, the RRS and SBCS will behave as if they were in their manual mode of operation. 1

The loss of heaters with closure of spray valves is not a concern. Auxiliary spray remains available to control increases in RCS pressure and all heaters will be available if control is switched to the unaffected control loop. With HS-100 or HS-100-3 in the "Y" position, proportional heaters will turn full on with no automatic control, but are still able to be deenergized from the control room. A total loss of feedwater flow (LOFW) due to the condenser hotwell level decrease may occur. However, the LOFW event 2 presented in subsection 15.2.7 assumed that the PPCS, SBCS, and RRS are in the manual mode of operation, unable to automatically respond to challenges. 1 Therefore, the LOFW event bounds the panel failure event.

C. Load Center E-NKN-M45 Failure

Failure of this load center effectively results in the SBCS, CLCS, and MFTPCS being placed in the manual mode of operation. In addition, pressurizer pressure control will be hindered, due to lack of control of all the non-Class 1E heaters. If RCS pressure drifts below 1
the backup heater actuation setpoint the class 1E-powered backup heaters cannot be energized due to the presence of a trip signal. The loss of backup heaters is within the bounds of chapter 15 analyses and is listed in the analyzed failures of table 15.0-0. 2
This panel failure is not of concern with respect to peak RCS pressure, fuel performance, or radiological releases.

### 7.2.2.4.1.2.2 Evaluation of Common Sensor Failures.

A. RCS Cold Leg Temperature Sensor (CEDMCS, RRS, PLCS)

The PLCS receives an average reactor coolant temperature ($T_{avg}$) signal from the RRS based on either loop or both loop cold leg and hot leg temperatures ($T_{cold}$ and $T_{hot}$) measurements. The measured $T_{avg}$ determines the programmed pressurizer 1
level. If a $T_{cold}$ channel fails such that $T_{avg}$ (indicated) does not agree with $T_{avg}$ (actual) then the PLCS will adjust charging and letdown to change the pressurizer level to the new programmed level within the normal operating band.

The RRS and CEDMCS have several features which protect against inadvertent CEA motion following failure of $T_{cold}$ channel. These include input channel deviation alarm, automatic motion inhibit, and automatic withdrawal prohibit. In addition, the consequences of inadvertent CEA insertion (withdrawal) resulting from indicated $T_{cold}$ failing higher (lower) than actual $T_{cold}$ in combination with pressurizer level variations within the control band are bound by the CEA withdrawal event described in subsection 15.4.2.

B. Pressurizer Level Sensor (PPCS, PLCS)

In response to a high indicated pressurizer level ($L_{pzr}$) the PLCS will decrease charging flow and increase letdown flow resulting in a slow decrease in RCS inventory and pressurizer level. If the indicated $L_{pzr}$ is high enough, a high level alarm will be generated, the normally running charging pump will be secured, and an insufficient charging alarm will be generated. In addition, if the pressurizer level error $L_{pzr}$ (indicated) - $L_{pzr}$ (programmed) is large enough, the PLCS will signal the PPCS to energize pressurizer heaters. The high indicated $L_{pzr}$ will disable one of two channels of heater cutout. 1 Normally, however, one channel is sufficient to activate the heater interlock and generate a low $L_{pzr}$ alarm. Also, under the conditions of maximum letdown flow and minimum charging flow, it would require in excess of 30 minutes for pressurizer level to drop from the full power programmed level to the level corresponding to the top of the heaters. This time interval would allow the operator to arrest the level transient prior to heater uncovery.

The thermal-hydraulic effects of the slow decrease in RCS inventory are bounded by the double-ended break of a letdown line as described in subsection 15.6.2.

If the indicated $L_{pzr}$ fails low, the PLCS would increase charging and decrease letdown. This would result in a slow increase in RCS inventory. If the indicated $L_{pzr}$ fails low enough, a low level alarm

### 7.3.1.1.5 Redundancy

For two-out-of-four logic redundancy features, refer to CESSAR Section 7.3.1.1.5.

Redundant features of the one-out-of-two ESFAS include:

A. Two independent channels, from process sensor/transmitter through and including bistable output relays, are provided.

B. Two trip paths are present for each actuation signal.

C. Each actuation signal actuates two output trains so that redundant system components may be actuated from separate trains.

D. Power for the system is provided from two separate buses. Power for control and operation of redundant actuated components comes from separate buses. Load group 1 components and systems are energized only by the load group 1 bus and load group 2 components and systems are energized only by the load group 2 bus.

The result of the redundant features is a system that meets the single failure criterion and can be tested during plant operation.

### 7.3.1.1.6 Diversity

For two-out-of-four logic diversity features, refer to CESSAR Section 7.3.1.1.6. The one-out-of-two ESFAS is designed to eliminate credible dual channel failures originating from a common cause. The failure modes of redundant channels and the conditions of operation that are common to them are analyzed to ensure reasonable assurance that:

A. The monitored variables provide adequate information during the accidents.

B. The equipment can perform as required.

C. The interactions of protective actions, control actions, and the environmental changes that cause, or are caused by, the design basis events do not prevent the mitigation of the consequences of the event.

D. The system cannot be made inoperable by the inadvertent actions of operating and maintenance personnel.

In addition, the design is not encumbered with additional components or channels without reasonable assurance that such additions are beneficial.

### 7.3.1.1.7 Sequencing

There is no sequencing for any ESF equipment other than that necessary for ESF bus loading. The automatic load sequencer is discussed in paragraph 8.3.1.1.3.

### 7.3.1.1.8 Testing

For two-out-of-four testing capabilities, see CESSAR Section 7.3.1.1.8. In addition, provisions are made to permit periodic testing of the one-out-of-two ESFAS. These tests cover the trip actions from sensor input through the protection system and the actuation devices. The system test does not interfere with the protective function of the system. The testing system meets the criteria of IEEE Standard 338-1971 and Regulatory Guide 1.22. For the testing of the radiation measurement channels, see section 11.5 and the ODCM. 6

Since actuation of the ESF systems controlled by the one-out-of-two ESFAS does not disturb normal plant operating conditions, the one-out-of-two ESFAS is tested by complete actuation as described below. Frequency of accomplishing the tests is listed in Section 3/4.3.2 of the Technical Specifications.

7.3.1.1.8.1 Sensor Checks. During reactor operation, the measurement channels providing an input to the ESFAS are checked by comparing the outputs of similar channels, and by cross-checking with related measurements.

During extended shutdown periods or refueling, these measurement channels are checked and calibrated against known standards.

7.3.1.1.8.2 Trip Bistable Test. Testing of the system is accomplished by manually varying the input signal to the trip setpoint level on one bistable at a time and observing the trip action.

When the bistable of a protective channel is in a tripped condition, the following conditions should exist:

- The bistable output relay is deenergized.
- The group relay in each actuation channel is deenergized.
- The ESF components are in the ESFAS actuation position.
- Actuation is annunciated on the control room annunciator panel.

Proper operation may be verified by the following:

- Checking the position of each ESF component
- Checking the actuation annunciation
- Checking the ESF component status indication

The test is repeated for the other bistable.

7.3.1.1.8.3 Response Time Tests. Refer to CESSAR Section 7.3.1.1.8.8. Response time testing required at refueling intervals are given in Section 3/4.3.2 of the Technical Specifications. These tests include the sensors for each

ESFAS channel and are based on the criteria defined in paragraph 7.3.2.3.3. The ESF response times limits are identified in table 7.3-14. 7

### 7.3.1.1.9 Vital Instrument Power Supply

The vital instrument power supply for the ESFAS is described in chapter 8.

### 7.3.1.1.10 Actuated Systems

Refer to CESSAR Section 7.3.1.1.10. Paragraphs 7.3.1.1.10.1 through 7.3.1.1.10.7 supplement the information presented in CESSAR. Paragraphs 7.3.1.1.10.8 through 7.3.1.1.10.11 describe the additional ESF systems. 7 Table 7.3-1B presents the design basis events that require specific ESF system action. Table 7.3-3 presents the monitored variable required for ESF system actuation.

7.3.1.1.10.1 <u>Containment Isolation System</u>. Refer to CESSAR Section 7.3.1.1.10.1, and:

A. See table 6.2.4-1 for a list of devices actuated on a containment isolation actuation signal (CIAS). In addition to the devices listed in table 6.2.4-1, the two electrical penetration room essential cooling units are started on a CIAS.

B. CESSAR Figure 7.3-1b, ESFAS signal logic (CIAS).

C. Figure 6.2.4-1, containment penetration valve arrangements.

D. Figure 7.2-2, instrumentation location layout drawing for CIAS input services.

The procedure for removing the containment isolation system from service for containment leaktesting is referenced in section 13.5.

## Table 7.3-1B

## ENGINEERED SAFETY FEATURES RESPONSE TIMES

(Sheet 1 of 3)

| INITIATING SIGNAL AND FUNCTION | RESPONSE TIME IN SECONDS |
|---|---|
| 1. Manual | |
| a. SIAS | |
| Safety Injection (ECCS) | Not Applicable |
| Containment Isolation | Not Applicable |
| Containment Purge Valve Isolation | Not Applicable |
| b. CSAS | |
| Containment Spray | Not Applicable |
| c. CIAS | |
| Containment Isolation | Not Applicable |
| d. MSIS | |
| Main Steam Isolation | Not Applicable |
| c. RAS | |
| Containment Sump Recirculation | Not Applicable |
| f. AFAS | |
| Auxiliary Feedwater Pumps | Not Applicable |
| 2. Pressurizer Pressure - Low | |
| a. Safety Injection (HPSI) | ≤ 30(a)/30(b) |
| b. Safety Injection (LPSI) | ≤ 30(a)/30(b) |
| c. Containment Isolation | |
| 1. CIAS actuated mini-purge valves | ≤ 10.6(a)/10.6(b) |
| 2. Other CIAS actuated valves | ≤ 31(a)/31(b) |
| 3. Containment Pressure - High | |
| a. Safety Injection (HPSI) | ≤ 30(a)/30(b) |
| b. Safety Injection (LPSI) | ≤ 30(a)/30(b) |
| c. Containment Isolation | |
| 1. CIAS actuated mini-purge valves | ≤ 10.6(a)/10.6(b) |
| 2. Other CIAS actuated valves | ≤ 31(a)/31(b) |

### Table 7.3-1B
### ENGINEERED SAFETY FEATURES RESPONSE TIMES
### (Sheet 2 of 3)

| INITIATING SIGNAL AND FUNCTION | RESPONSE TIME IN SECONDS |
|---|---|
| d. Main Steam Isolation | |
| 1. MSIS actuated MSIV's | ≤ 5.6(a)/5.6(b) |
| 2. MSIS actuated MFIV's(c) | ≤ 10.6(a)/10.6(b) |
| e. Containment Spray Pump | ≤ 33(a)/23(b) |
| 4. Containment Pressure - High-High | |
| a. Containment Spray | ≤ 33(a)/23(b) |
| 5. Steam Generator Pressure - Low | |
| a. Main Steam Isolation | |
| 1. MSIS actuated MSIV's | ≤ 5.6(a)/5.6(b) |
| 2. MSIS actuated MFIV's(c) | ≤ 10.6(a)/10.6(b) |
| 6. Refueling Water Tank - Low | |
| a. Containment Sump Recirculation | ≤ 45(a)/45(b) |
| 7. Steam Generator Level - Low | |
| a. Auxiliary Feedwater (Motor Drive) | ≤ 46(a)/23(b) |
| b. Auxiliary Feedwater (Turbine Drive) | ≤ 30(a)/30(b) |
| 8. Steam Generator Level - High | |
| a. Main Steam Isolation | |
| 1. MSIS actuated MSIV's | ≤ 5.6(a)/5.6(b) |
| 2. MSIS actuated MFIV's(c) | ≤ 10.6(a)/10.6(b) |
| 9. Steam Generator ΔP-High-Coincident with Steam Generator Level Low | |
| a. Auxiliary Feedwater Isolation from the Ruptured Steam Generator | ≤ 16(a)/16(b) |
| 10. Control Room Essential Filtration Actuation | ≤ 180(a)/180(b)(d) |

## Table 7.3-1B
## ENGINEERED SAFETY FEATURES RESPONSE TIMES
(Sheet 3 of 3)

| INITIATING SIGNAL AND FUNCTION | RESPONSE TIME IN SECONDS |
|---|---|
| 11. 4.16 kV Emergency Bus Undervoltage (Degraded Voltage) | |
| Loss of Power 90% system voltage | ≤ 35.0 |
| 12. 4.16 kV Emergency Bus Undervoltage (loss of Voltage) | |
| Loss of Power | ≤ 2.4 |

7

TABLE NOTATIONS

a. Diesel generator starting and sequence loading delays included. Response time limit includes movement of valves and attainment of pump or blower discharge pressure.

b. Diesel generator starting delays not included. Offsite power available. Response time limit includes movement of valves and attainment of pump or blower discharge pressure.

c. MFIV valves tested at simulated operating conditions; valves tested at static flow conditions to ≤ 8.6[a]/8.6[b] seconds.

d. Radiation detectors are exempt from response time testing. The response time of the radiation signal portion of the channel shall be measured from the detector output or from the input of first electronic component in channel to closure of dampers M-HJA-M01, M-HJA-M52, M-HJB-M01 and M-HJB-M55.

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## Table 7.3-2

## DESIGN BASIS EVENTS REQUIRING ESF SYSTEM ACTION (Sheet 1 of 2)

7

| Design Basis Events \ Systems | Containment Isolation System | Containment Spray System | Iodine Removal System | Main Steam Isolation System | Safety Injection System | Auxiliary Feedwater System[f] | Fuel Building Essential Ventilation System | Containment Purge Isolation System | Control Room Essential Ventilation System | Containment Combustible Gas Control System |
|---|---|---|---|---|---|---|---|---|---|---|
| Loss of reactor coolant -- large break | * | * | * | | * | | *[e] | *[c] | * | *[b] |
| Loss of reactor coolant -- small break[a] | * | * | * | | * | * | *[e] | *[c] | * | *[b] |
| Steam generator tube rupture | | | | *[b] | * | * | | | | |
| Steam line break (inside containment) | * | * | | * | * | * | | | | |
| Steam line break (outside containment)[d] | | | | * | * | * | | | | |

a. Includes CEA ejection and pressurizer safety valve opening

b. Manual actuation

c. Actuated by initiation of CPIAS or CIAS

d. Includes opening of secondary safety valve

e. On SIAS the fuel building essential ventialation system starts and is aligned to exhaust from the auxiliary building

f. Design basis event not defined for an ATWS event 7

### Table 7.3-2

### DESIGN BASIS EVENTS REQUIRING ESF SYSTEM ACTION (Sheet 2 of 2)

| Systems<br>Design Basis Events | Containment Isolation System | Containment Spray System | Iodine Removal System | Main Steam Isolation System | Safety Injection System | Auxiliary Feedwater System | Fuel Building Essential Ventilation System | Containment Purge Isolation System | Control Room Essential Ventilation System | Containment Combustible Gas Control System |
|---|---|---|---|---|---|---|---|---|---|---|
| Fuel handling accident -- containment building | | | | | | | | * | * | |
| Fuel handling accident -- spent fuel pool | | | | | | | * | | * | |
| Feedwater line break (inside containment) | * | * | | * | * | | | | | |
| Fire / smoke - plant vicinity | | | | | | | | | * (b) | |

## Table 7.3-3

## MONITORED VARIABLES FOR ESF SYSTEM PROTECTIVE ACTION (Sheet 1 of 2)

| Systems<br>Variable | Containment Isolation System | Containment Spray System | Iodine Removal System | Main Steam Isolation System | Safety Injection System | Auxiliary Feedwater System | Fuel Building Essential Ventilation System | Containment Purge Isolation System | Control Room Essential Ventilation System | Containment Combustible Gas Control System(a) |
|---|---|---|---|---|---|---|---|---|---|---|
| Pressurizer pressure | * | | | | * | | *(e) | *(b) | *(c) | |
| Containment pressure | * | * | * | * | * | | *(e) | *(b) | *(c) | |
| Steam generator pressure | | | | * | | * | | | | |
| Refueling water tank level | | * | * | | * | | | | | |
| Steam generator level | | | | * | | *(f) | | | | |

a. Manual actuation post-LOCA

b. Actuated by initiation of CRVIAS or CIAS

c. Actuated by initiation of CREFAS or SIAS

d. Manual actuation - detectors are nonsafety-related

e. Actuated by initiation of SIAS, system aligned to exhaust from the auxiliary building

f. Steam generator level is also used to initiate an ATWS DAFAS actuation if diverse scram signal is present and normal ESFAS has not initiated AFAS or MSIS 7

## Table 7.3-2

## MONITORED VARIABLES FOR ESF SYSTEM PROTECTIVE ACTION (Sheet 2 of 2)

| Variable / Systems | Containment Isolation System | Containment Spray System | Iodine Removal System | Main Steam Isolation System | Safety Injection System | Auxiliary Feedwater System | Fuel Building Essential Ventilation System | Containment Purge Isolation System | Control Room Essential Ventilation System | Containment Combustible Gas Control System[a] |
|---|---|---|---|---|---|---|---|---|---|---|
| Containment airborn activity | | | | | | | | * | * | |
| Fuel handling airborn activity | | | | | | | * | | * | |
| Control room ventilation intake activity | | | | | | | | | * | |
| Control room ventilation intake smoke | | | | | | | | | *(d) | |
| Containment hydrogen | | | | | | | | | | * |

7.3.1.1.10.2 Containment Spray System. Refer to CESSAR Appendix 6A for a description of the containment spray system, and:

A. Table 6.2.4-1 for a list of devices actuated on a containment spray actuation signal (CSAS) and recirculation actuation signal (RAS).

B. Table 7.3-4 for additional CSAS actuated devices.

C. Table 7.3-5 for additional RAS actuated devices.

D. CESSAR Figure 7.3-1b, ESFAS signal logic (CSAS and RAS).

E. Figure 6.3-1, P&I diagram (safety injection system)

F. Figures 7.2-2 and 7.2-4, instrumentation location layout drawing for CSAS and RAS input devices.

Table 7.3-4

CONTAINMENT SPRAY ACTUATION SIGNAL
ACTUATED DEVICES LIST

| Figure No. | Description | Function |
|---|---|---|
| 6.3-1 | Containment spray pumps and pump room cooling unit (2) | Start |

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### Table 7.3-5
### RECIRCULATION ACTUATION SIGNAL ACTUATED DEVICES LIST

| Figure No. | Description | Function |
|---|---|---|
| 6.3-1 | Low pressure safety injection pumps (2) | Stop |
| 6.3-1 | LPSI pump miniflow valves | Close |
| 6.3-1 | HPSI pump miniflow valves | Close |
| 6.3-1 | Containment spray miniflow valves (2) | Close |
| 6.3-1 | Combined SI miniflow return to RWT valves (2) | Close |

The procedure for removing the containment spray system from service for containment leaktesting is referenced in section 13.5.

7.3.1.1.10.3 Iodine Removal System. Refer to CESSAR Appendix 6B for a description of the iodine removal system, and paragraph 7.3.1.1.10.2 for references applicable to the iodine removal system.

7.3.1.1.10.4 Main Steam Isolation System. Refer to CESSAR Section 7.3.1.1.10.4, and:

A. Table 6.2.4-1 for a list of devices actuated on a main steam isolation signal (MSIS)

B. CESSAR Figure 7.3-1c, ESFAS signal logic (MSIS)

C. Figure 10.3-1, P&I diagram (main steam system)

D. Figures 7.2-2 and 7.2-3, instrumentation location layout drawing for MSIS input devices

7.3.1.1.10.5 Safety Injection System. Refer to CESSAR Section 7.3.1.1.10.5, and:

A. Table 6.2.4-1 for a list of devices actuated on a safety injection actuation signal (SIAS)

B. Table 7.3-6 for additional SIAS actuated devices

C. CESSAR Figure 7.3-1a, ESFAS signal logic (SIAS)

D. Figure 6.3-1, P&I diagram (safety injection system)

E. Figures 7.2-1 and 7.2-2, instrumentation location layout drawing for SIAS input devices. |0

In addition, the procedure for removing the safety injection system from service for containment leaktesting is referenced in section 13.5.

7.3.1.1.10.6 Recirculation Actuation. Refer to CESSAR Section 7.3.1.1.10.6 and Section 7.3.1.1.10.2 for references applicable to the recirculation actuation signal.

In addition, the procedure for removing an RAS from the LPSI pumps to allow them to be used for the shutdown cooling system is referenced in section 13.5.

7.3.1.1.10.7 Auxiliary Feedwater System. Refer to CESSAR Section 7.3.1.1.10.7. The Seismic Category I portion of the auxiliary feedwater system (corresponding to the emergency feedwater system discussed in CESSAR) is provided to automatically initiate residual heat removal capability during emergency conditions such as a steam line rupture, loss of normal feedwater, or loss of offsite and normal onsite power. The non-Seismic Category I portion of the auxiliary feedwater system is provided for normal nonemergency operation during startup, cooldown, and hot standby. The non-Seismic Category I portion of the auxiliary feedwater system is not an engineered safety feature system and, therefore, is not addressed in this

## Table 7.3-6
## SAFETY INJECTION ACTUATION SIGNAL ACTUATED DEVICES LIST (Sheet 1 of 2)

| Figure No. | Description | Function |
|---|---|---|
| 6.3-1 | SI tanks No. 1 through 4 fill and sample isolation valves (4) | Close |
| 6.3-1 | SI tanks No. 1 through 4 check valve leakage line isolation valves (4) | Close |
| 6.3-1 | HPSI pumps and pump room essential cooling units (2) | Start |
| 6.3-1 | LPSI pumps and pump room essential cooling units (2) | Start |
| 6.3-1 | CS pumps and pump room essential cooling units (2) | Start |
| 6.3-1 | SI tanks No. 1 through 4 isolation valves (4) | Open |
| 9.3-13 | Letdown line isolation valve (1) | Close |
| 6.3-1 | Hot leg injection check valve leak isolation valve (2) | Close |
| 9.2-4 | Essential cooling water system and pump room essential cooling units | Refer to paragraph 7.4.1.1.5 |
| 9.2-1 | Essential spray pond system | Refer to paragraph 7.4.1.1.4 |
| 9.5-9 | Diesel generator system | Refer to paragraph 7.4.1.1.1 |
| 9.4-1 | Control room essential filtration system | Refer to table 7.3-9 and paragraph 7.3.1.1.10.10 |
| 9.2-8 | Condensate transfer system | Refer to subsection 9.2.6 |

### Table 7.3-6

### SAFETY INJECTION ACTUATION SIGNAL ACTUATED DEVICES LIST (Sheet 2 of 2)

| Figure No. | Description | Function |
|---|---|---|
| 9.2-11 | Essential chilled water system | Start |
| 9.2-10 | Normal chilled water system | Stop |
| 9.4-9 | Fuel building essential ventilation system | Refer to paragraph 9.4.5.2 |
| 9.4-7 | Containment normal reactor cavity cooling units (4) | Stop |
| 9.4-7 | Containment normal cooling units (4) | Stop |
| 9.4-7 | Containment CEDM cooling units (2) | Stop |

section. Subsequent references in this section to the auxiliary feedwater system apply to the Seismic Category I portions only. The Seismic Category I portion of the auxiliary feedwater system is described in subsection 10.4.9.

The safety-related display instrumentation for the auxiliary feedwater system, which provides the operator with sufficient information to monitor and perform the required safety features, is described in section 7.5.

Further information on the actuation system is provided by the following:

A. Table 6.2.4-2 for a list of valves actuated on an AFAS

B. Table 7.3-7 for additional AFAS actuated devices.

C. Figure 7.3-1d in CESSAR and FSAR figure 7.4-4, ESFAS signal logic (CESSAR signal EFAS corresponds to AFAS for PVNGS)

D. Figure 10.4-11, P&I diagram

0 E. Figure 7.2-2, instrumentation location layout drawing for AFAS input devices

7.3.1.1.10.8 Fuel Building Essential Ventilation Systems. Radioactive contamination may occur in the spent fuel area in the unlikely event that a spent fuel element is severely damaged during handling. If a fuel handling accident occurs, sensors in the fuel building detect the fission products released from the fuel and initiate appropriate action, as discussed in section 9.4, to reduce the release of fission products into the environment.

The fuel building essential ventilation system, as described in section 9.4, is composed of components in redundant load groups, load group 1 and load group 2. The instrumentation and controls of the components and equipment in load group 1 in load group 2. Independence is adequate to retain the redundancy required to maintain equipment functional capability following those design basis events shown in table 7.3-2 that are mitigated by the containment purge isolation system.

The containment purge isolation system is automatically actuated by the CPIAS from the ESFAS. CPIAS is initiated by one-out-of-two high airborne activity signals from two redundant radiation monitors located in close proximity to the power access purge exhaust duct and the refueling purge exhaust duct. The monitors are identified as the "PAPA-A" and "PAPA-B" monitors.

The system is designed so that loss of electric power to one-out-of-two electronic remote indication and control units or to the actuating logic actuates the containment purge isolation system. | 6

The CPIAS is combined with the CIAS in the control circuits of the isolation valving common to both the containment purge isolation system and the containment isolation system so that either signal (logical OR) can actuate these valves. Figure 7.3-4 presents a typical control logic for these valves.

The safety-related display instrumentation for the containment purge isolation system that provides the operator with sufficient information to monitor and perform the required safety functions is described in section 7.5.

Further information on the actuation system is provided by the following:

A. Table 6.2.4-1 for a list of devices actuated on a CPIAS

B. Figure 7.3-1, ESFAS signal logic (CPIAS)

C. Figure 9.4-7, P&I diagram (containment purge system)

D. Section 12.3, instrument location layout drawing for CPIAS input devices

7.3.1.1.10.10 Control Room Essential Ventilation Systems. The control room essential ventilation systems are the control room ventilation isolation system and the control room essential filtration system.

Upon detection of a high airborne activity signal in the normal air intake, the control room essential filtration system is actuated. Both control room essential ventilation systems, as discussed in section 6.4, are composed of components in redundant load groups, load group 1 and load group 2. Instrumentation and controls of the components and equipment in load group 1 are physically and electrically separate and independent of instrumentation and controls of the components and equipment in load group 2. Independence is adequate to retain the redundancy required to maintain control room habitability following those design basis events shown in table 7.3-2.

The control room essential filtration system is automatically actuated by a CREFAS. The CREFAS is initiated by one-out-of-two air intake high airborne activity signals, a FBEVAS, or a CPIAS as shown in figure 7.3-2. The CPIAS is discussed in paragraph 7.3.1.1.10.9. The FBEVAS is discussed in paragraph 7.3.1.1.10.8. The system is designed so that loss of electrical power to one-out-of-two electronic remote indication and control units or to the actuating logic actuates the control room essential filtration system. 6

The CREFAS is combined with the SIAS in the device control circuits so that any one of the signals (logical OR) actuates the devices listed in table 7.3-9. The development of the SIAS is discussed in CESSAR Section 7.3.2.2.1. Figure 7.3-5 presents a typical control logic to show the combination of these signals.

In addition to the automatic initiating signals, two independent smoke detectors are provided in the outside air intake plenum.

Further information on the system is provided by the following:

A. Table 7.3-11, Containment Combustible Gas Control System Actuated Devices List

B. Figure 6.2.5-1, P&I diagram (containment combustible gas control system)

### 7.3.1.2 Design Basis Information

Refer to CESSAR Section 7.3.1.2. In addition, the actuation setpoints not given in table 7.3-11A are provided in table 7.3-12. The design bases for the additional one-out-of-two ESFAS are as follows. |1

The one-out-of-two ESFAS is designed to provide initiating signals for components that require automatic actuation following a DBA.

The systems are designed on the following bases to ensure adequate performance of their protective functions:

A. The system is designed in compliance with the applicable criteria of Appendix A of 10CFR50, 1971.

B. System testing conforms to the requirements of IEEE Standard 338-1971 and Regulatory Guide 1.22.

C. IEEE 279-1971 establishes specific protection system design bases. The following paragraphs describe how the design bases listed in Section 3 of IEEE 279-1971 are implemented.

   1. The additional generating station condition that requires protective action is:

      a. Fuel handling accident

      b. Fire/smoke-plant vicinity

## Table 7.3-11

## CONTAINMENT COMBUSTIBLE GAS CONTROL SYSTEM ACTUATED DEVICES LIST

| Figure No. | Description | Relation to Containment | Function |
|---|---|---|---|
| 6.2.5-1 | Containment combustible gas control hydrogen purge exhaust unit heater (1) | Outside | Start[(a)] |
| 6.2.5-1 | Containment combustible gas control hydrogen purge exhaust unit inlet (2) | Outside | Open[(a)] |
| 6.2.5-1 | Containment combustible gas control system inlet isolation valves (2) | Inside | Open[(b)] |
| 6.2.5-1 | Containment combustible gas control recombiner and $H_2$ purge unit inlet isolation valves (2) | Outside | Open[(b)] |
| 6.2.5-1 | Containment combustible gas control recombiner outlet isolation valves (2) | Outside | Open[(b)] |
| 6.2.5-1 | Containment combustible gas control analyzer valves (4) | Outside | Open[(a)] |
| 6.2.5-1 | Containment hydrogen recombiners (2) | Outside | Start[(a)] |

a. Manually actuated

b. CIAS overridden

## Table 7.3-11A

## ENGINEERED SAFETY FEATURES ACTUATION SYSTEM SETPOINTS AND MARGINS TO ACTUATION

| Actuation Signal | Typical Full Power | Normal Operation Range | Typical Actuation Setpoint | Margin to Actuation |
|---|---|---|---|---|
| SIAS & CIAS | | | | |
| Low pressurizer pressure | 2,250 psia | 2,100-2,350 psia | 1,837 psia[a] | 263 psi |
| High containment pressure | 0 psig | 0 psig | 3 psig | 3 psi |
| CSAS | | | | |
| High-high containment pressure | 0 psig | 0 psig | 8.5 psig | 8.5 psi |
| RAS | | | | |
| Low refueling water tank level | -- | 70-95% | 7.4% | 62.6% |
| MSIS | | | | |
| Low steam generator pressure | 970 psia | 970-1,070 psia | 919 psia[a] | 51 psi |
| High containment pressure | 0 psig | 0 psig | 3 psig | 3 psi |
| High steam generator level | 55% | 30-74% | 91% | 17% |
| AFAS | | | | |
| Low steam generator level and | 82% | 72-90% | 25.8% | 46.2 |
| Steam generator differential pressure[b] | 0 psid | 0 psid | 185 psid | 185 psi |
| DAFAS | | | | |
| Low steam generator level[c] | 82% | 72-90% | 20.3% | 51.7 |

a. Setpoint can be manually decreased as pressure is reduced and is automatically increased as pressure increases.

b. This is a calculated, not sensed, variable.

c. Low steam generator levels, diverse scram signals present without normal ESFAS initiation of AFAS or MSIS (ATWS requirements).

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#### 7.3.5.1.16 Conformance to Regulatory Guide 1.75

The DAFAS design is in compliance with the "Physical Independence of Electrical System", Regulatory Guide 1.75.

#### 7.3.5.1.17 Conformance to Regulatory Guide 1.22

The DAFAS is in compliance with Regulatory Guide 1.22, "Periodic Testing of Protection System Actuation Function", in conjunction with the current AFAS actuation devices.

#### 7.3.5.1.18 Conformance to Regulatory Guide 1.53

The DAFAS is in compliance with Regulatory Guide 1.53, "Application of the Single-Failure Criterion to Nuclear Power Plant Protection System."

#### 7.3.5.1.19 Conformance to IEEE-338, 1971 7

The DAFAS system testing conforms to the IEEE-338 Standard, "Trial-Use Criteria for the Periodic Testing of Nuclear Power Generating Station Protection Systems."

#### 7.3.5.1.20 Conformance to IEEE-384

The DAFAS fiber optic and internal module connection wiring conforms to IEEE-384, 1981, "Criteria for Independence of Class 1E Equipment and Circuits", where DAFAS A is "Associated A" and DAFAS B is "Associated B." The interfaces with the DAFAS in the PPC, EIS and ARC are also in compliance with this standard.

#### 7.3.5.1.21 Conformance to IEEE-379

The DAFAS is in compliance with the applicable criteria of IEEE-379, 1977, "Application of the Single Failure Criterion to Nuclear Power Generating Station Class 1E System."

### 7.3.5.2 Functional Description of the DAFAS

The DAFAS actuation mitigates the consequence of an ATWS event. This consequence is high RCS pressure due to reduced heat removal through the S/Gs. The DAFAS actuation is provided following an ATWS, which is characterized as an Anticipated Operational Occurrence (AOO) requiring auxiliary feedwater, coincident with a failure of the PPS to initiate a reactor trip. Failure of the PPS is indicated by a reactor trip initiated on high-high pressurizer pressure by the supplementary protection system (SPS), also known as (AKA) the supplementary protection logic assemblies (SPLA), AKA the diverse scram system (DSS). The DAFAS initiation signals cause actuation of the auxiliary feedwater systems (train A and B) only if there is a demand for auxiliary feed as indicated by low S/G level, and there is an SPS initiated reactor trip, and there is no MSIS and an AFAS-1 or -2 has not been generated by 7 the PPS. Indication of an MSIS or an AFAS in the PPS concurrent with the absence of an enable from the DSS indicates that conditions indicative of an ATWS have not occurred and the DAFAS actuation is not necessary. Therefore, under these conditions the DAFAS actuation will be blocked through DAFAS logic in the auxiliary Relay Cabinets.

#### 7.3.5.2.1 DAFAS Input

The DAFAS uses four existing wide range safety channels (A,B,C and D) level sensor inputs from each of the two steam generators at the process protective cabinets (PPC) JSBA-C02A, JSBB-C02A, JSBC-C02A and JSBD-C02A. Each of the DAFAS channels (A and B) receive these eight steam generator level inputs. These level signals are input to a fiber optic transmitter (FOT) which converts the analog voltage signal to an optical signal. The optical signals are then split by fiber optic splitters (FOS) for transmission to both of the DAFAS cabinets over FO cables. These fiber optics communications links

## 7.4 SYSTEMS REQUIRED FOR SAFE SHUTDOWN

A listing of systems fulfilling the functional requirements for safe shutdown in the event of a fire (per 10CFR50, Appendix R) is provided in appendix 9B.

Refer to CESSAR Section 7.4 for the systems required for safe shutdown in CESSAR scope.

The instrumentation and control functions which are required to be aligned for maintaining safe shutdown of the reactor are discussed in this section. These functions will permit the necessary operations that will:

A. Prevent the reactor from achieving criticality in violation of the Technical Specifications.

B. Provide an adequate heat sink such that design and safety limits are not exceeded.

### 7.4.1 DESCRIPTION

The following systems are required for safe shutdown of the reactor:

- Auxiliary feedwater system (AFS) (paragraph 7.4.1.1.6)
- Atmospheric steam dump system (ASDS) (paragraph 7.4.1.1.7)
- Shutdown cooling system (SCS) (CESSAR Section 7.4.1.1.8)
- Chemical and volume control system (CVCS), boron addition portion (CESSAR Section 7.4.1.1.9)
- Condensate storage system (CSS) (subsection 9.2.6)

The following auxiliary support systems are also required to function.

- Essential spray pond system (ESPS) (subsection 9.2.1 and paragraph 7.4.1.1.4)

- Essential cooling water system (ECWS) (subsection 9.2.2 and paragraph 7.4.1.1.5)
- Onsite power system (OPS) (paragraph 8.3.1.1.2), including diesel generator systems (DGSs) (subsections 9.5.4 through 9.5.8 and paragraph 7.4.1.1.1)
- Heating, ventilating, and air conditioning (HVAC) systems (sections 6.4 and 9.4)

### 7.4.1.1 System Description

#### 7.4.1.1.1 Emergency Generators

Two independent, 100% capacity diesel generators provide a dependable onsite power source capable of starting and supplying the essential loads necessary to shut down the plant safely and to maintain it in a safe shutdown condition under loss of offsite power (LOP) conditions. Load sequencers are provided to sequentially load the diesel generators and are a part of the engineered safety features (ESF) system actuation.

The diesel generators are started automatically by undervoltage on the associated 4.16 kV ESF bus, resulting from an LOP by an auxiliary feedwater actuation signal (AFAS), or by a safety injection actuation signal (SIAS).

The actuation system instrumentation and controls for the diesel generators are described below. Refer to paragraph 8.3.1.1.3 for a description of the ESF power system, including automatic load shedding and load sequencing. Paragraph 8.3.1.1.4 describes the standby power supply (diesel generator) and the diesel generator starting system is described in subsection 9.5.6. Additional information on diesel generator supporting auxiliaries may be found in subsections 9.5.4, 9.5.5, 9.5.7, and 9.5.8.

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A. Sensors

The undervoltage monitors consist of four ~~independent~~ sensor ~~channels~~ circuits for each 4.16 kV ESF bus. Each independent sensor channel consists of ~~potential~~ transformers, voltage ~~level~~ monitors, trip signal isolation, ~~bus~~ voltage indication, setpoint adjustment, ~~and~~ trip signal annunciation output.

The components and operation of the undervoltage monitors are described in section 8.3.1.1.3.13, subsection B.

The sensors for AFAS and SIAS signals are described in section 7.3.

B. Initiating Circuits and Logic

The undervoltage starting signal (LOP) for the diesel generators is produced by coincidence of two-out-of-four trip of the undervoltage sensors described in ~~listing A above~~ Section 8.3.1.1.3.13, subsection B.

There is no time delay in initiating start of the diesel generator for loss of offsite power except for 0
an inverse time response lag and delayed time lag provided in the undervoltage monitors. Manual starting control also is provided at the diesel generator and in the control room to facilitate testing and as a backup to the automatic start.

C. Interlocks and Bypasses

The various interlocks and actuation bypasses built into the diesel generator system are presented in paragraphs 8.3.1.1.4.4 and 8.3.1.1.4.5, respectively.

D. Redundancy

Redundant sensing with two-out-of-four coincidence logic and control is provided for diesel generator automatic actuation. Independent actuation is provided so that each diesel generator is started by its own actuation system.

A. Sensors

The undervoltage monitors consist of four sensor circuits for each 4.16 kV ESF bus. The components and operation of the undervoltage monitors are described in section 8.3.1.1.3.13, subsection B.

The sensors for AFAS and SIAS signals are described in section 7.3.

B. Initiating Circuits and Logic

The undervoltage starting signal (LOP) for the diesel generators is produced by coincidence of two-out-of-four trip of the undervoltage sensors described in section 8.3.1.1.3.13, subsection B.

There is no time delay in initiating start of the diesel generator for loss of offsite power except for an inverse time response lag and delayed time lag provided in the undervoltage monitors. Manual starting control also is provided at the diesel generator and in the control room to facilitate testing. 8

C. Interlocks and Bypasses

The various interlocks and actuation bypasses built into the diesel generator system are presented in paragraphs 8.3.1.1.4.4 and 8.3.1.1.4.5, respectively.

D. Redundancy

Redundant sensing with two-out-of-four coincidence logic and control is provided for diesel generator automatic actuation. Independent actuation is provided so that each diesel generator is started by its own actuation system.

E. Actuated Devices and Automatic Load Sequencing System

The actuated devices for automatic diesel generator starting are the diesel air starting solenoid valves.

In the event that diesel generators are required to power ESF or safe shutdown loads, sequential loading must be employed to avoid diesel generator overloading. Loads to be supplied and the loading sequences are described in subsection 8.3.1.

Diesel generator load sequencing is actuated when the diesel generator output breakers close. The signal to close the diesel generator output breaker is blocked by circuit breaker interlocks that are provided to prevent automatic closing of a diesel generator breaker to an energized or faulted bus. A faulted bus is detected by inverse time overcurrent relays in the main feeder circuits of each 4.16 kV ESF bus. A sequencer is provided for each load group. The sequencer loads safe shutdown and ESF equipment onto the ESF bus so that essential loads are started within the time limits specified in CESSAR Table 8.3.1-4.

Undervoltage trip outputs are delayed in accordance with the inverse time characteristics of the induction disc type relay used to confirm that a power failure has occurred. In addition, sustained undervoltage outputs are delayed 33 seconds to prevent spurious diesel generator actuation. 0

Undervoltage on the ESF bus trips all bus load automatically. After the diesel generator attains rated speed and voltage, its own circuit breaker is ready to close automatically without delay, but automatic or manual closure is blocked whenever an ESF bus fault exists. A diesel generator breaker closed signal starts the loading sequence.

valves are located outside the containment upstream of the main steam isolation valves.

The valves are used to remove decay heat from the steam generator in the event that the main condenser is unavailable for service for any reason, including a loss of ac power. The decay heat is dissipated by venting steam to the atmosphere. In this way, the reactor coolant system (RCS) can either be maintained at hot standby conditions or cooled down. The system instrumentation and controls for the atmospheric dump valves are described below and are shown on figure 10.3-1.

A. Initiating Circuits and Logic

There are no automatic initiating circuits for operation of the atmospheric dump valves.

The atmospheric dump valves are positioned manually by a controller (manual loading station) from either the main control room or the remote shutdown panel as part of the capability for emergency shutdown from outside the control room (see CESSAR Section 7.4.1.1.10). Each valve has two separate permissive control circuits. Valve position indication is provided at each remote control station. A handwheel is also provided with the atmospheric dump valve for hand operation.

B. Bypasses, Interlocks, and Sequencing

No bypasses, interlocks, or sequencing are provided for the atmospheric dump valves.

C. Redundancy

Atmospheric dump valves are provided to maintain the reactor at hot standby or to initiate a plant cooldown. Two redundant atmospheric dump valves are provided for each steam generator, one per main steam line. However, in the event of failure of these valves, reactor decay heat will be removed through the main steam line safety valves, which will be opened when pressure in the steam generator reaches the pressure relief setpoint. Steam release will continue until the pressure is reduced to the safety valve reset pressure. The safety valves will continue to cycle in this manner as steam generator pressure rises and is relieved. The RCS will remain at hot standby conditions during this pressure relief cycling. Cooldown of the reactor coolant can be accomplished through remote manual operation of the atmospheric dump valves. Each valve has a handwheel that can be operated locally.

D. Design Bases

1. Refer to section 10.3 for design bases for the atmospheric dump valves.
2. The two separate permissive control circuits are designed to IEEE Standards 279-1971 and 308-1974. This ensures that no single failure of the control circuits will cause a spurious opening of a valve or prevent the operation of at least one atmospheric dump valve on each steam generator.
3. The operation of the atmospheric dump valves is considered in determining the release of iodine due to steam escaping from the dumps during cooldown.

### 7.4.1.1.8 Shutdown Cooling System

Refer to CESSAR Section 7.4.1.1.8.

A. The system consists of two portions; one reporting the status of safety train A equipment, the other reporting the status of safety train B equipment. The system accepts channelized (channel A, B, C, or D) Class 1E associated inputs. The system is nonsafety-related, but since inputs are Class 1E associated, the system is powered from Class 1E 125 V-dc power supplies.

B. Status contacts continuously monitor the availability of control power and the position of circuit breakers of all automatically actuated ESF devices. A loss of control power or deliberate racking out of a breaker automatically initiates a system level indication with audible alarm, except for the containment purge refueling mode isolation valves. The circuit breakers for these valves are locked open during normal operation. An alarm is not initiated when the valve circuit breakers are locked open and the valve is in the safe position (closed). An alarm will be initiated if the valve is not in a safe position and a loss of power develops, or the valve is not in a safe position and its circuit breaker is open. 1

C. The capability for initiating a manual bypass indication and alarm is provided via a system level manual bypass switch used to indicate the bypass condition to the operator for those manual valves and other components which are not automatically monitored. The initiation and removal of manual bypass indication will be under administrative control.

D. All systems affected by the bypassing/inoperability of a given component that are shared by multiple systems automatically generate a bypass/inoperable audible and visual alarm in each system affected.

E. Indication and annunciation test capability is provided by simulating a trouble contact condition when the test button is depressed. The test feature generates the audible alarm and causes all windows to flash in unison. The test feature is independent for each channel.

## 7.7 CONTROL SYSTEMS NOT REQUIRED FOR SAFETY

Refer to paragraph 7.2.2.4.1 and CESSAR section 7.7 for additional discussion of control systems not required for safety.

### 7.7.1 DESCRIPTION

Refer to CESSAR Section 7.7.1.

### 7.7.1.1 Control Systems

#### 7.7.1.1.1 Reactivity Control Systems

Refer to CESSAR Section 7.7.1.1.1.

#### 7.7.1.1.2 Reactor Coolant System Pressure Control System

Refer to CESSAR Section 7.7.1.1.2.

#### 7.7.1.1.3 Pressurizer Level Control System

Refer to CESSAR Section 7.7.1.1.3. 1

#### 7.7.1.1.4 Feedwater Control System

Refer to CESSAR Section 7.7.1.1.4 for operation from 15 to 100% power.

For operation between 0 and 15% power, the feedwater control system (FWCS) is designed to automatically control the steam generator downcomer water level. Steam generator level will be controlled during the following conditions (assuming that all other control systems are operating in automatic):

- Steady-state operations;
- 1% per minute turbine load ramps between 0 and 15% NSSS power;

- Loss of one of two operating feedwater pumps; and
- Load rejection of any magnitude.

The discussion of the FWCS will refer to only one steam generator. Each FWCS controls the level in its corresponding steam generator. Refer to figure 7.7-1 for the FWCS block diagram.

Below 15% NSSS power, the FWCS performs dynamic compensation on the level signal to generate an output signal indicative of the required feedwater flow. The output signal is used to generate the downcomer valve position demand signal. When in this control mode the economizer valve will be closed and the pump speed setpoint will be at its minimum value.

#### 7.7.1.1.5 Steam Bypass Control System

1

Refer to CESSAR Section 7.7.1.1.5.

The CESSAR system is modified for PVNGS to dump steam to atmosphere through two of the turbine bypass valves. These valves are the last to open and first to close during steam bypass operation. Refer to figure 7.7-2 for the SBCS block diagram.

#### 7.7.1.1.6 Reactor Power Cutback System

Refer to CESSAR Section 7.7.1.1.6.

#### 7.7.1.1.7 Boron Control System

Refer to CESSAR Section 7.7.1.1.7.

#### 7.7.1.1.8 Loose Parts Monitoring System

Refer to CESSAR Section 4.2.5.H.2.

## TABLES

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# FIGURES

H. A separate nonsafety-related dc system is provided for nonsafety-related controls and pump motors.

I. Raceways are not shared by safety and nonsafety cables. However, the nonsafety cables that are supplied from or are derived from Class 1E sources (associated) are treated as safety-related cables up to and including the isolation device with regard to redundant system separation and identification criteria in conformance with Regulatory Guide 1.75 as qualified in section 1.8.

J. Special identification criteria apply for Class 1E equipment cabling and raceways (see paragraph 8.3.1.3).

K. Separation criteria, which establish requirements for preserving the independence of redundant Class 1E electric systems, comply with Regulatory Guide 1.75 as qualified in section 1.8.

L. Safety-related equipment is designed with the capacity to be tested periodically.

M. 10CFR50, Appendix A, is followed in the design of the electric power system.

N. A non-safety related Alternate AC (AAC) power source consisting of two redundant gas turbine generators is available to provide power to cope with a four hour station blackout event in any one nuclear unit. 8

### 8.1.4.3 Design Criteria, Regulatory Guides, and IEEE Standards

A discussion of General Design Criteria 17 and 18 and IEEE standards is provided in paragraphs 8.3.1.2 and 8.3.2.2. Consistency of design with the recommendations of NRC Regulatory Guides 1.6, 1.9, 1.22, 1.29, 1.30, 1.32, 1.40, 1.41, 1.47, 1.53, 1.62, 1.63, 1.73, 1.75, 1.81, 1.89, 1.93, and IEEE 387-1972 are discussed in paragraphs 8.3.1.2 and 8.3.2.2. In addition, Regulatory Guides 1.100, 1.108, 1.118 and 1.155 are discussed in section 1.8. 8

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CHAPTER 11

## RADIOACTIVE WASTE MANAGEMENT

## CONTENTS

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## CONTENTS (cont)

# 11. RADIOACTIVE WASTE MANAGEMENT

## 11.1 SOURCE TERMS

Refer to CESSAR Section 11.1.

### 11.1.1 FISSION PRODUCTS

Refer to CESSAR Section 11.1.1.

### 11.1.2 DEPOSITED CRUD ACTIVITIES

Refer to CESSAR Section 11.1.2.

### 11.1.3 TRITIUM

#### 11.1.3.1 Tritium Production

Refer to CESSAR Section 11.1.3.1.

#### 11.1.3.2 Tritium Activities

##### 11.1.3.2.1 Tritium Liquid Concentrations

The tritium concentrations in the plant are dependent on the production rate in the reactor coolant system; the losses due to radioactive decay, plant discharges, leakage and evaporation; and the transfer of plant water. The concentrations are based upon discharging a sufficient amount of boric acid concentrator distillate (as vapor) as necessary to maintain plant tritium airborne concentrations below 10CFR20 limits. A tritium balance is performed on the entire plant by simultaneously solving the following differential equations for the equilibrium case. Each equation represents the tritium activity in a major water source for tritium transfer. The model used for determining the equations is shown in figure 11.1-1.

RCS

$$\frac{dN}{dt} = P + \lambda_6 R + \lambda_3 M - (\lambda_1 + \lambda_D + \lambda_L + \lambda_2 + \lambda_{10})N \qquad (1)$$

RMWT

$$\frac{dM}{dt} = [(1 - X)\lambda_9 + \lambda_{10}]N - (\lambda_D + \lambda_3 + \lambda_5)M \qquad (2)$$

SFP

$$\frac{dS}{dt} = (\lambda_4 + \lambda_7)\ R - (\lambda_S + \lambda_D + \lambda_8)S \qquad (3)$$

RWT

$$\frac{dR}{dt} = \lambda_5 M + (\lambda_2 + \lambda_{RT})N + \lambda_8 S - (\lambda_7 + \lambda_D + \lambda_4 + \lambda_6 + \lambda_R)R \qquad (4)$$

where:

RCS = reactor coolant system

RMWT = reactor makeup water tank

SFP = spent fuel pool

RWT = refueling water tank (includes refueling pool)

BAC = boric acid concentrator

N = tritium activity in the reactor coolant system (Ci)

M = tritium activity in the reactor makeup water tank (Ci)

S = tritium activity in the spent fuel pool (Ci)

R = tritium activity in the refueling water tank (or refueling pool) (Ci)

P = tritium production rate in reactor coolant (Ci/yr)

t = time (yr)

$\lambda_L$ = leakage constant =

$$\frac{\text{Primary-to-secondary leakage (gal/yr)}}{\text{RCS water volume (gal)}},\ (\text{yr}^{-1})$$

$$\lambda_D = \text{tritium decay constant} = \frac{\ln 2}{\text{half-life}},\ (\text{yr}^{-1})$$

Normal RMWT ($\lambda_{11}$) makeup is from a demineralized water source that uses nontritiated water, and is, therefore, not considered in the analysis.

Makeup to the RCS ($\lambda_3$) is from the RMWT. This is equal to the letdown flow to the BAC ($\lambda_1$) plus the leakage from the RCS ($\lambda_L + \lambda_{10}$).

The fractions of water exchanged between pools during refueling ($\lambda_7$ and $\lambda_8$) are assumed to include only the volume of one fuel transfer tube per fuel assembly transferred, as the fuel pool cooling and cleanup system acts independently on each pool.

Utilizing the above equations and the assumptions given in table 11.1-1, under the design basis of limiting the tritium airborne concentration to 1/2 of the 10CFR20 limit in the most restrictive building, the equilibrium tritium concentrations and inventories are determined. This also determines the approximate vapor discharge of boric acid concentrator distillate necessary to maintain concentration below this level, for equilibrium conditions. For the average tritium production rate of 1224 curies per year, this corresponds to 14% of the annual average distillate flow or 160,000 liquid gallons per year as vapor. For the maximum tritium production rate of 2347 curies per year, this corresponds to 51% of the annual average distillate flow or 600,000 liquid gallons per year as vapor. Equilibrium tritium liquid concentrations and inventories for the RCS, RMWT, RWT, SFP, refueling pool, and secondary system are given in table 11.1-2.

### 11.1.3.2.2 Tritium Airborne Concentrations

Tritium airborne concentrations for various buildings are reported in subsection 12.2.2.

## Table 11.1-1
## ASSUMPTIONS USED IN DETERMINING TRITIUM ACTIVITIES
## (Sheet 1 of 3)

| No. | Assumption |
|---|---|
| 1. | Equilibrium tritium production rate in reactor Coolant is as per CESSAR Table 11.1.3-3.<br>Average = 1224 curies per year<br>Maximum = 2347 curies per year |
| 2. | Tritium activities are based on the maximum building airborne tritium concentration being 1/2 of 10CFR20 limits. |
| 3. | Reactor coolant leakage is as per NUREG-0017. |
| 4. | The tritium balance is as per figure 11.1-1. |
| 5. | Boric acid is concentrated to 4400 ppm boron from an average RCS concentration of 600 ppm boron. |
| 6. | Core cycle and primary coolant parameters are per CESSAR Table 11.1.1-1. |
| 7. | One-third of the core, or 81 assemblies, is changed at each refueling. The fuel transfer operation takes 6 days and 1 fuel transfer tube volume is exchanged between pools for each fuel assembly transferred. |
| 8. | Primary-to-secondary leakage is 100 pounds per day. |
| 9. | Leakage from the secondary system in the turbine building is:<br>1700 pounds per day, steam<br>7200 gallons per day, condensate |
| 10. | 68,500 gallons of primary coolant are available for mixing with the refueling pool water after draining prior to refueling. |

Table 11.1-3

TRITIUM RELEASES (Ci/yr/unit)

| Source | Expected Tritium Production Releases | Maximum Tritium Production Releases |
|---|---|---|
| Boric acid concentrator distillate vapor exhaust | 333 | 1480 |
| HVAC systems exhaust | 715 | 718 |
| Total | 1048 | 2198 |

activity is assumed to become instantly airborne. Noble gases dissolved in the liquid leakage are assumed to become airborne, as they are for other buildings' liquid leakage. A partition factor (PF) of 0.0075 for iodines dissolved in plant liquid leakage is assumed for calculating airborne iodine activities. A PF of 0.1 is assumed for calculating airborne tritium activities from plant liquid leakage. A PF of 0.0001 is conservatively assumed for calculating airborne activities of other isotopes from plant liquid leakage.

A daily leakage rate of 1% of the noble gas inventory and 0.001% of the iodine inventory in the primary coolant is assumed released to containment atmosphere.

Airborne releases inside the plant are handled by the appropriate ventilation system. The containment, auxiliary, radwaste, turbine, and fuel building HVAC systems are discussed in section 9.4. Airborne activity in the plant is monitored by area monitors and airborne monitors before release from the plant. Airborne releases are discussed in subsection 11.3.3.

Means of controlling leakage from the reactor coolant pressure boundary are discussed in subsection 5.2.5.

## 11.1.7 FUEL POOL FISSION PRODUCT AND CORROSION PRODUCT ACTIVITIES

CESSAR Section 11.1.7 discusses spent fuel pool fission product and corrosion product activities. Some of the assumptions used in developing these activities do not apply to PVNGS. This section, therefore, replaces CESSAR Section 11.1.7.

The fuel pool cooling and cleanup system (FPCCS) described in subsection 9.1.3 is comprised of two purification loops and one cooling loop with redundant heat exchangers. One purification loop and the cooling loop act on the spent fuel pool, and the other purification loop acts on the refueling pool. Since the loops return the flow to the respective pool from which flow was taken, the only exchange of water between the two pools is through the fuel transfer tube as a result of fuel transfer.

The primary source of activity in the pools is the reactor coolant water available for mixing with the refueling pool water upon reactor vessel head removal. Upon shutdown for refueling, the RCS is cooled down for a period of approximately 2 days until the reactor coolant temperature is less than 125F. During this time, the primary coolant is let down through the purification filter, purification ion exchanger, gas stripper, and volume control tank. The gas space of the volume control tank is vented to help reduce fission gas activity and hydrogen concentration to less than 10 cc/kg of water at STP before head removal. This letdown process, therefore, accomplishes the removal of combustible gases to safe levels and the removal of noble gases and dissolved fission and corrosion product activities. At the end of this cooldown and letdown period, the coolant above the reactor vessel flange is drained to the reactor drain tank. The head is unbolted and the refueling pool is filled with 470,000 gallons of water from the refueling water tank. The remaining coolant volume of 68,500 gallons is then mixed with the water in the refueling pool and, to a lesser extent, by the fuel transfer operation, with the 390,000 gallons in the spent fuel pool. After refueling, the spent fuel pool is isolated and the water in the refueling pool is returned to the refueling water tank. This series of events determines the total activity in the pools. The refueling pool activity is at a maximum at the start of refueling as it is conservatively assumed that reactor coolant water mixes with refueling pool water instantly and completely upon head removal. The activity in the spent fuel pool reaches a maximum level 5 days into the refueling operation. The maximum spent fuel pool activity level is defined as the activity that would result in the highest dose to operating personnel. The expected and maximum refueling pool and spent fuel pool peak concentrations under the assumptions listed in table 11.1-4 are given in table 11.1-5. Equilibrium tritium concentrations given are based on the assumptions and methods presented in subsection 11.1.3.

The spent fuel pool activity contribution from stored defective fuel elements is assumed to be negligible. Due to the cooldown and letdown prior to refueling, the majority of the fission products available for release will evolve from the elements. However, upon detection of significant failed fuel during the sipping operation, the defective element may be isolated in a separate container, ensuring that additional activity released by the element will not add to the refueling pool and spent fuel pool activity.

### 11.1.8 SECONDARY SYSTEM SOURCES

The secondary system will become contaminated if steam generator tube leaks exist coincident with failed fuel. This primary-to-secondary leakage is expected to be less than 100 pounds per day. Secondary system steam and condensate leakage are listed in sections 11.3 and 11.2, respectively. Equilibrium secondary system activities in the steam

## Table 11.1-4

## ASSUMPTIONS USED IN DETERMINING REFUELING ACTIVITIES

<table>
<tr><th>No.</th><th>Assumption</th></tr>
<tr><td>1.</td><td>Primary coolant activity at shutdown is based on the model presented in CESSAR Section 11.1.7.<br>Note: Specific radionuclides listed in CESSAR Table 11.1.1-2 differ from those listed in CESSAR Table 11.1.1-3 due to different models used to determine maximum versus expected case source terms.</td></tr>
<tr><td>2.</td><td>The fuel transfer operation occurs over a 12-day period.</td></tr>
<tr><td>3.</td><td>The spent fuel pool volume is 390,000 gallons.</td></tr>
<tr><td>4.</td><td>68,500 gallons of primary coolant are mixed with 470,000 gallons of refueling pool water at RWT activity upon head removal.</td></tr>
<tr><td>5.</td><td>Decontamination factors (DF) of purification equipment are:
<table>
<tr><th></th><th>Xe,Kr,H,N</th><th>I,Br</th><th>Cs,Rb</th><th>Others</th></tr>
<tr><td>Fuel pool filter</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Fuel pool ion exchangers</td><td>1</td><td>100</td><td>2</td><td>100</td></tr>
</table>
</td></tr>
<tr><td>6.</td><td>Fuel pool purification train flowrate is 150 gallons per minute for both the refueling pool and the spent fuel pool.</td></tr>
<tr><td>7.</td><td>Activity losses due to evolution from the pool are negligible.</td></tr>
<tr><td>8.</td><td>One fuel transfer tube volume of water (296 cubic feet) is exchanged in each direction between pools for each fuel assembly transferred during refueling.</td></tr>
<tr><td>9.</td><td>Eighty-one fuel assemblies are changed during each refueling.</td></tr>
<tr><td>10.</td><td>Expected case values are based on primary coolant activities given in CESSAR Table 11.1.1-3 and maximum case values are based on primary coolant activities given in CESSAR Table 11.1.1-2.</td></tr>
</table>

calculation for PWRs using the format given in Chapter 4 of NUREG-0017, April 1976, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors" are summarized on a per unit basis as follows:

A. General

1. Maximum core thermal power is 4100 MWt (CESSAR-F Table 11.1.1-1).
2. Expected tritium released is 1224 Ci/yr (CESSAR-F Table 11.1.3-3).

B. Primary System

1. Normal primary coolant mass is 571,300 pounds (CESSAR-F Table 11.1.1-1).
2. Average letdown rate is 72 gallons per minute (CESSAR-F Table 11.1.1-1).
3. Average purification flow is 14.4 gallons per minute (CESSAR-F Table 11.1.1-1).
4. Average shim bleed flow is 0.48 gallon per minute (CESSAR-F Table 11.1.1-1).

C. Secondary System

1. Two vertical U-tube steam generators with iodine and nonvolatile carryover factor of 1/400
2. Total secondary steam flow is 17,452,271 pounds per hour.
3. Mass of liquid per steam generator is 167,000 pounds.
4. Average primary-to-secondary leakage rate is 100 pounds per day.

5. Average steam generator blowdown rate is 34,905 pounds per hour. Flashed steam from the blowdown flash tank is returned back to the system via the number 4 feedwater heaters. Two blowdown demineralizers provide a total DF of 1 for noble gases, tritium, and nitrogen, 10 for Cs and Rb, and 100 for all others.

6. The condensate demineralizers are expected to be normally in service. DF of 1 is assumed to maximize the gaseous source term.

7. A detailed description of the condensate demineralizers is given in subsection 10.4.6.

D. Liquid Waste Processing Systems

As stated above, liquid source term data is not applicable to PVNGS. Refer to section 11.2 for a discussion of processing capability and system description.

E. Gaseous Waste Processing System

4 Gaseous source term data is provided in subsections 11.3.1 and 11.3.2, tables 11.3-4 and 11.3-7, and figures 11.3-1 and 11.3-2.

F. Ventilation and Exhaust Systems

Refer to subsection 11.3.3 for ventilation and exhaust data. In addition:

1. Data regarding provisions for reducing radioactivity releases through the ventilation or exhaust systems, DFs assumed, and their bases are provided in table 11.3-7.

2. Release rates are provided in table 11.3-6.

3. Data on release points are provided in PVNGS Environmental Report - Operating License Stage, Section 3.1.3.1.

4. The plant vent is a 72-inch x 84-inch rectangular duct discharging vertically. The vacuum pump
exhaust is a 12-inch pipe discharging 0
horizontally. The fuel building exhaust is a 60-inch circular duct discharging vertically.

5. Containment building internal circulation filtration data are provided in subsection 9.4.6 and table 11.3-7.

## 11.2 LIQUID WASTE MANAGEMENT SYSTEMS

The liquid waste management systems consist of the secondary chemistry control system (SCCS), fuel pool cooling and cleanup system (FPCCS), and liquid radwaste system (LRS).

The SCCS and FPCCS are discussed in subsections 10.4.6 and 9.1.3, respectively. Laundry is handled by private contractors. The site possesses no radioactive laundry system. The liquid waste management systems are not shared between units. 2

### 11.2.1 DESIGN BASES

### 11.2.1.1 Design Objectives

The function of the liquid waste management systems is to collect and process radioactive or potentially radioactive liquid wastes generated during plant operation.

The principal design objectives of the liquid waste management systems are:

A. To collect liquid wastes generated during plant operation which contain potentially radioactive material.

B. To provide sufficient processing capacity, redundancy, and flexibility to meet the concentration limits of 10CFR20 during periods of equipment downtime and during operation at design basis fuel leakage.

C. To control releases of radioactive materials within the numerical design objectives of 10CFR50, Appendix I, in maintaining releases "as-low-as-is-reasonably-achievable (ALARA)."

D. To purify the radioactive liquid wastes to enable reclaimed water to be reused in the plant.

The liquid waste systems, as designed, contain items of reasonably demonstrated technology that, when added to the system and in order of diminishing cost-benefit return, can, for a favorable cost-benefit ratio, effect reductions in dose to the population reasonably expected to be within 50 miles of the site. Section 5.2 of the Environmental Report-Operating License Stage provides a summary of the results of the cost-benefit analysis performed to demonstrate that the design of the liquid waste system meets the ALARA guidelines set forth in Appendix I to 10CFR50.

A discussion of the ability of the liquid waste systems to provide sufficient capacity, redundancy, and flexibility to control wastes in order to prevent radioactive liquid releases and minimize solidified waste is given in subsection 11.2.2.

#### 11.2.1.2 System Design

The components of the LRS are listed in table 11.2-1. Included are equipment sizes and/or capacities, process flowrates, storage capabilities, materials of construction, and design temperatures and pressures. Applicable codes and standards of process equipment are listed in table 11.2-2. The ability of the SCCS, FPCCS, and LRS to process surge waste volumes in excess of the design assumptions is discussed in subsection 11.2.2.

The layout of LRS components is indicated in figures 1.2-4 through 1.2-13. The seismic and quality group classifications for the LRS components and piping are provided in table 3.2-1. Compliance with General Design Criteria 60 and 64 of Appendix A to 10CFR50 are not applicable to the PVNGS liquid waste systems as there are no provisions or pathways for the release of radioactive liquids to the environment.

NOTE

8| Liquids with activity levels less than the release limits cited in the Offsite Dose Calculation Manual (ODCM) are discharged to the onsite evaporation ponds.

## Table 11.2-1
## LIQUID RADWASTE SYSTEM EQUIPMENT DESCRIPTIONS
## (Sheet 5 of 6)

Pumps (continued)

LRS steam condensate pump (P-11)
- Quantity/unit = 1
- Type = Centrifugal
- Capacity = 40 gal/min
- Design head/temp = 150 feet/270F
- Material = 316 SS
- Motor rpm/bhp = 3505/5

Concentrate monitor tank pumps (P-04 A,B)
- Quantity/unit = 2
- Type = Centrifugal
- Capacity = 130 gal/min
- Design pressure/temp = 275 psig/100F
- Material = W20
- Motor rpm/bhp = 1760/30

Filters

LRS ion exchanger prefilters (F-01 A,B)
- Quantity/unit = 2
- Size = 5 μm 98%, 25 μm 100%
- Capacity = 150 gal/min
- Design pressure/temp = 200 psig/250F
- Operating pressure/temp = 90 psig/80F
- Material (shell) = 304 SS

Ion exchangers

LRS adsorption bed (D-01)
- Quantity/unit = 1
- Capacity = 50 cubic feet of organic adsorber (825 gal)
- Flowrate = 130 gal/min
- Design pressure/temp = 200 psig/250F

## Table 11.2-1
## LIQUID RADWASTE SYSTEM EQUIPMENT DESCRIPTIONS
## (Sheet 6 of 6)

Ion exchangers (continued)

Material (shell) = 304L SS
Operating pressure/temp = 90 psig/125F

LRS mixed bed ion exchangers (D-02 A,B)

Quantity/unit = 2
Capacity = 50 cubic feet of mixed bed resin (825 gal)
Flowrate = 130 gal/min
Design pressure/temp = 200 psig/250F
Material (shell) = 304L SS
Operating pressure/temp = 90 psig/125F

Evaporator

LRS evaporator package

Quantity/unit = 1
Capacity = 30 gal/min
Type = forced circulation
Design pressure/temp(a) = 20 psig/250F
Operating pressure/temp(a) = 1 psig/219F
Material = Incoloy 825 (concentrate side)
= 304 SS (distillate side)

a. Data stated are for vapor body.

## Table 11.2-2

## LIQUID RADWASTE SYSTEM EQUIPMENT CODES

| Equipment | Codes | | | |
|---|---|---|---|---|
| | Design and Fabrication | Materials | Welder Qualifications and Procedures | Inspection and Testing |
| Tanks, atmospheric or 0-15 psig (steel) | API 620 and 650 | ASME Code Section II | ASME Code Section IX | API 620 and 650 |
| Pressure Vessels | ASME Code Section VIII, Div 1 | ASME Code Section II | ASME Code Section IX | ASME Code Section VIII, Div 1 |
| Pumps | Manufacturer's[(a)] standards | Manufacturer's standards | ASME Code Section IX | Hydraulic Institute |
| Piping and valves | ANSI B31.1 | ASTM, ASME Section II | ASME Code Section IX | ANSI B31.1 |
| Ion exchangers | ASME Code Section VIII, Div 1 | ASME Code Section II | ASME Code Section IX | ASME Code Section VIII, Div 1 |
| Filters and strainers | ASME Code Section VIII, Div 1 | ASME Code Section II | ASME Code Section IX | ASME Code Section VIII, Div 1 |
| Evaporators | ASME Code Section VIII, Div 1 | ASME Code Section III | ASME Code Section IX | ASME Code Section VIII, Div 1 |

a. Manufacturer's standard for the intended service. Hydrotesting is 1.5 times the design pressure.

used where justified in the liquid waste systems to reduce crud trap formation. Redundant or backup pumps and process lines allow for flushing and maintenance of mechanical components without restricting system operation. Pumps are provided with mechanical seals to minimize leakage. Less frequent equipment maintenance is provided for by utilizing corrosion-resistant materials.

Provisions have also been incorporated to control the release of radioactive materials due to overflows or leakage from potentially radioactive liquid tanks. Overflow of atmospheric tanks is minimized by the installation of level instrumentation and high level alarms that are annunciated in respective control rooms to alert operators of potential overflow situations. In addition, overflow lines of indoor tanks are routed to their respective building sump whose contents are sent to the LRS for processing. Overflow protection of outdoor LRS tanks is provided by interconnecting the overflow lines of the redundant tanks and routing the common flow to a sump, as in the case of the LRS recycle monitor tanks. There are no potentially radioactive pressurized tanks in the LRS. Table 11.2-3 provides a list of the potentially radioactive LRS atmospheric tanks and the design provisions incorporated to prevent releases by the control of tank overflow. Control of liquid releases due to tank leakage is provided for by plant design. Indoor tanks are surrounded by curbs or are in compartments provided with thresholds to contain any leakage. Radioactive leakage is directed to the same sump as the tank overflow indicated in table 11.2-3. Outdoor LRS tanks, that is, the holdup tanks and recycle monitor tanks, are surrounded by a dike capable of preventing runoff in the event of a tank overflow. As discussed in subsection 2.4.13, release of the contents of the refueling water tank to the groundwater results in concentrations at the site boundary well below the maximum permissible concentrations in water listed in 10CFR20, Appendix B, Table II. The specific activities and total isotopic

## Table 11.2-7
## FPCCS EXPECTED PROCESS POINT ACTIVITIES ($\mu$Ci/g)
## (Sheet 3 of 3)

| Radionuclide | Spent Fuel Pool | Refueling Pool | Fuel Pool IX No. 1 Outlet[(a)] | Fuel Pool IX No. 2 Outlet[(a)] |
|---|---|---|---|---|
| BA-140 | See table 11.1-5 | See table 11.1-5 | 2.1E-8 | 2.1E-10 |
| LA-140 | | | 6.9E-9 | 1.2E-11 |
| CE-141 | | | 8.4E-9 | 1.0E-10 |
| CE-143 | | | 1.5E-9 | 1.7E-12 |
| CE-144 | | | 8.8E-9 | 1.2E-10 |
| PR-143 | | | 4.8E-9 | 5.0E-11 |
| PR-144 | | | 0.0 | 0.0 |
| NP-239 | | | 6.9E-8 | 2.1E-10 |
| CR-51 | | | 1.6E-7 | 1.9E-9 |
| MN-54 | | | 3.3E-8 | 1.9E-9 |
| FE-55 | | | 1.7E-7 | 2.3E-9 |
| FE-59 | | | 8.8E-8 | 1.1E-9 |
| CO-58 | | | 1.5E-6 | 1.9E-8 |
| CO-60 | | | 2.2E-7 | 3.0E-9 |

### 11.2.2.3 Liquid Radwaste System

Each unit of PVNGS is equipped with an identical and independent LRS. The principal functions of the LRS are:

A. To collect for processing radioactive and potentially radioactive liquid wastes from the plant.

B. To process liquid wastes to the high degree of purity necessary for recycle in the plant, since liquid releases are precluded by plant design.

C. To minimize the quantity of liquid waste transferred to the solid radwaste system for solidification and ultimate disposal.

The flow diagram of the LRS, indicating process parameters for the various modes of operation, is shown in figure 11.2-1. The piping and instrumentation diagram (P&ID) of the LRS is shown in figure 11.2-2.

Input waste streams to the LRS, as shown in figure 11.2-1, are identified in table 11.2-8. This table includes annual average daily input flowrates and specific activities of the input streams as a fraction of primary coolant activity.

Input waste streams are segregated to facilitate treatment. Wastes containing a high degree of total dissolved solids (TDS), including wastes from the chemical waste neutralizer tanks, chemical drain tanks, and the auxiliary, containment, radwaste, and fuel building sumps, are collected for processing in the high TDS holdup tank. Wastes containing a low degree of TDS, including radioactive wastes from the turbine building, auxiliary steam condensate receiver tank, LRS adsorption bed, and recycle monitor tanks, are collected for processing in the low TDS holdup tank. Samples from the high and low TDS tanks are available by placing the tanks in a recirculation lineup and drawing a sample of the pump discharge. Turbine building drains are normally nonradioactive, activity being present only when there are primary-to-secondary leaks. To avoid processing more waste through the LRS than necessary, nonradioactive turbine building drains are processed by the chemical waste system. Besides the low TDS tank, an additional holdup tank is provided to accommodate overflow from either the low TDS or the high TDS holdup tank and is normally isolated from the supply headers. If necessary, this tank can be used to collect either low TDS or high TDS liquid waste. An internal mixing header uniformly mixes the contents of each holdup tank prior to and during processing. Acidic or caustic agents may be added for pH control, and antifoaming agents may be added if surfactants exist in the tank contents. Decontamination facility wastes from Unit 1 only and radio-chemistry laboratory wastes are collected in the chemical drain tanks prior to processing.

High TDS wastes are pumped directly from the holdup tank to the LRS evaporator for processing. The evaporator concentrates the waste up to 50 wt% total dissolved solids excluding neutralized boric acid which is concentrated up to 25 wt%. The evaporator concentrate is pumped to the concentrate monitor tanks and ultimately to the solid radwaste system. The concentrate monitor tanks are kept in a continuous recirculation mode while they contain radioactive concentrate. Samples are taken from an analysis point off the pump discharge. The distillate from the evaporator is passed through the LRS adsorption bed and mixed bed ion exchangers arranged in series and then is sent to the recycle monitor tanks. The monitor tanks' liquid content is then stored for eventual use as makeup for the primary coolant system, the secondary system, or the spent fuel pool. The monitor tanks' contents may also be sent back to the low TDS holdup tank should further processing be desired.

Low TDS wastes are pumped from the holdup tank through the LRS ion exchanger prefilter for removal of larger particles, through the adsorption bed for removal of organics, and through the two mixed bed ion exchangers arranged in series for removal of trace radioisotopes, to the recycle monitor tanks.

Wastes collected in the chemical drain tanks are normally pumped to the high TDS holdup tank for processing, but, if desired, may be sent directly to the solidification system for disposal.

Boric acid from the chemical volume and control system (CVCS), although normally processed through the boric acid concentrator and sent to the refueling water tank, can also be processed through the LRS evaporator should the boric acid concentrator become inoperable. When processing boric acid, the LRS evaporator receives CVCS flow from the CVCS holdup tank pumps. Concentrated boric acid is sent to the concentrate monitor tanks and then to the solidification system. Distillate is sent to the adsorption bed and mixed bed ion exchangers for further processing and is eventually used as plant makeup water.

The LRS may also receive concentrated boric acid from the CVCS boric acid concentrator, should it be desired to dispose of the boric acid. In this case, concentrator bottoms are sent to the LRS concentrate monitor tanks and ultimately to the solidification system discussed in section 11.4.

Spent resin from the beds is sluiced with water from the reactor water makeup tank and is pumped to either the low activity or high activity spent resin tanks, or to a portable waste processing system. New resin for the LRS adsorption bed and mixed bed demineralizers is added manually from a drum containing new resin.

Liquid radwaste system expected process point specific activities, based on the assumptions given in table 11.2-9, are listed in table 11.2-10. Maximum LRS component inventories are listed in table 12.2-5.

### 11.2.2.4.1 LRS Operation

The LRS is normally utilized to process floor and equipment drains. During periods of primary-to-secondary leakage, however, the LRS may also receive and process wastes generated in the turbine building, such as floor drains and demineralizer regenerants. Design inputs to the LRS are tabulated in table 11.2-8. Typically, the LRS is divided into three process trains; those liquids containing a low degree of total dissolved solids, those containing a high degree of total dissolved solids, and those containing chemicals. The LRS is designed so that the three trains may operate simultaneously.

11.2.2.4.1.1 Low Total Dissolved Solids Wastes. The low TDS holdup tank normally collects wastes from the turbine building sump as shown on figure 11.2-2. This sump contains radioactivity when steam generator tube leaks exist coincident with failed fuel. The primary sources of this sump are equipment and floor drains and condensate polishing and blowdown demineralizer regenerants. Other infrequent low TDS inputs include flows from the auxiliary steam condensate receiver tank, and the recycle water monitor tanks. Flow from the LRS adsorption bed may also be recirculated to the low TDS holdup tank if necessary for further removal of organics. When the low TDS holdup tank has been filled (as indicated by a high level alarm in the radwaste control room) or reaches some predetermined level, the contents are then recirculated and sampled for radiological and chemical analysis. Based on the analysis, acid, caustic, or an antifoaming agent is added, if necessary. The holdup tank contents are then recirculated for uniformity of flow composition while a portion of the flow is processed through an ion exchanger prefilter, the LRS adsorption bed, and two mixed bed demineralizers arranged in series, and is finally sent to the recycle monitor tanks. The prefilter removes large particles, the adsorption bed removes organic contaminants, and the mixed bed demineralizers remove |2 ionic species. Demineralized water collected in the recycle monitor tanks is then stored until needed for plant makeup or recycled to the low TDS holdup tank for further processing. Flow from the low TDS holdup tank is normally terminated manually upon a low level alarm, but is terminated automatically upon a low-low level signal. Flow is terminated or diverted to an alternate path by operator action based on a high-pressure drop across the prefilter, adsorption bed, or ion exchangers, an exhausted resin bed, or when the unit radwaste supervisor determines it necessary.

11.2.2.4.1.2 High Total Dissolved Solids Wastes. The high TDS holdup tank normally collects radioactive wastes from the auxiliary building, fuel building, containment radwaste and radwaste building sumps, the chemical waste neutralizer tank, and the chemical drain tanks. When the high TDS holdup tank has been filled (as indicated by a high level alarm in the radwaste control room) or reaches some predetermined level, the contents are then recirculated and sampled for radiological and chemical analysis. Based on the analysis, acid, caustic, or an antifoaming agent is added, if necessary. The holdup tank contents are then recirculated for uniformity of flow composition while a portion of the flow is pumped directly to the LRS evaporator for processing. The evaporator is designed to operate on a batch or semicontinuous basis and the process flow is concentrated up to 50 wt% total dissolved solids excluding neutralized boric acid which is concentrated to 25 wt%. When the desired concentration is achieved, as indicated by evaporator density instrumentation, the evaporator concentrate is pumped to the concentrate monitor tanks and ultimately to the solid radwaste system for solidification and shipment offsite. Evaporator distillate is further processed by the adsorption bed and mixed bed demineralizers before reaching the recycle monitor tanks. Flow from the high TDS holdup tank is normally terminated manually upon a low level

NOTE

Liquids with radioactivity levels less than the release limites cited in the Offsite Dose Calculation Manual (ODCM) are discharged to the evaporation ponds. Therefore, evaporation pond leakage represents a potential (though insignificant) liquid release pathway. Liquid releases due to evaporation or through ground pathway will not exceed the concentration or dose limits for effluents in 10CFR20 and 10CFR50. | 8

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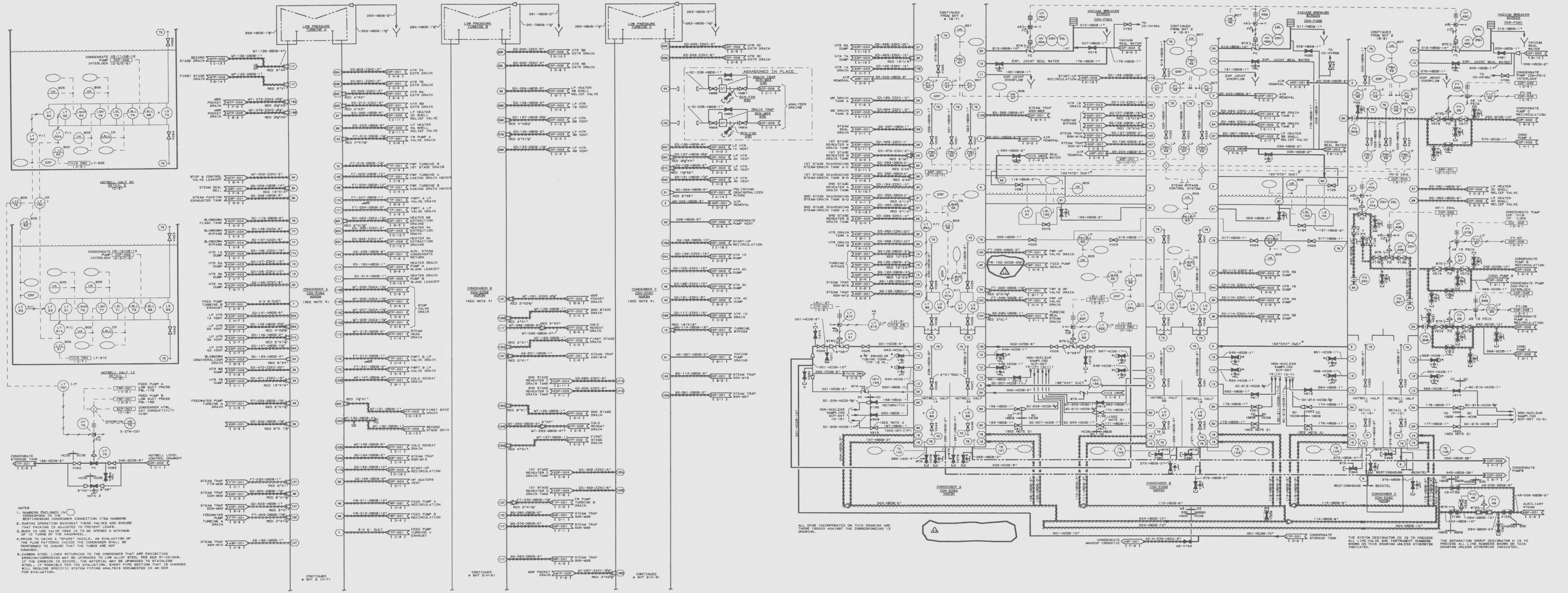

NOTES

1. NUMBERS ENCLOSED IN ⬡ CORRESPOND TO THE WESTINGHOUSE CONDENSER CONNECTION ITEM NUMBERS
2. DURING OPERATION BACKSEAT THESE VALVES AND ENSURE THAT PACKING IS ADJUSTED TO PREVENT LEAKS.
3. WHEN IN USE VALVE V862 IS TO BE OPENED A MINIMUM OF 10 TURNS OF THE HANDWHEEL.
4. PRIOR TO USING A "SPARE" NOZZLE, AN EVALUATION OF THE FLOW PATTERNS INSIDE THE CONDENSER SHALL BE PERFORMED TO INSURE THAT THE TUBES ARE NOT DAMAGED.
5. CARBON STEEL LINES RETURNING TO THE CONDENSER THAT ARE EXHIBITING EROSION/CORROSION MAY BE UPGRADED TO LOW ALLOY STEEL PER EER 91-CD-008. IF THE EROSION IS SEVERE, THE MATERIAL MAY BE UPGRADED TO STAINLESS STEEL, IF POSSIBLE PER THE EVALUATION. EVERY PIPE SECTION THAT IS CHANGED WILL REQUIRE SPECIFIC SYSTEM PIPING ANALYSIS DOCUMENTED IN AN EER FOR EVALUATION.

ALL DCNS INCORPORATED ON THIS DRAWING ARE THOSE ISSUED AGAINST THE CORRESPONDING 13 DRAWING.

THE SYSTEM DESIGNATOR CD IS TO PRECEDE ALL LINE, VALVE AND INSTRUMENT NUMBERS SHOWN ON THIS DRAWING UNLESS OTHERWISE INDICATED.

THE SEPARATION GROUP DESIGNATOR N IS TO PRECEDE ALL LINE NUMBERS SHOWN ON THIS DRAWING UNLESS OTHERWISE INDICATED.

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**Palo Verde Nuclear Generating Station**
**Updated FSAR**

P&I DIAGRAM
CONDENSATE SYSTEM
(Sheet 1 of 5)
Figure 10.4-9
(Unit 1)

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