ArevaEPRDCPEm Resource

From: WILLIFORD Dennis (AREVA) [Dennis.Williford@areva.com]
Sent: Wednesday, May 25, 2011 3:03 PM
To: Tesfaye, Getachew
Cc: BENNETT Kathy (AREVA); DELANO Karen (AREVA); ROMINE Judy (AREVA); RYAN Tom (AREVA)
Subject: Response to U.S. EPR Design Certification Application RAI No. 442, FSAR Ch. 7, Supplement 12
Attachments: RAI 442 Supplement 12 Response US EPR DC.pdf

Getachew,

On November 19, 2010, AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the questions in RAI 442. Supplement 1 response was sent on January 7, 2011 to provide a revised schedule for four of the questions. Supplement 2 response was sent on February 9, 2011 to provide a revised schedule. Supplement 3 response was sent on February 18, 2011 to provide technically correct and complete responses to four questions. Supplement 4 response was sent on February 25, 2011 to provide technically correct and complete response to one question. Supplement 5 response was sent on March 2, 2011 to provide technically correct and complete responses to three of the 12 remaining questions. Supplement 6 response was sent on March 15, 2011 to provide technically correct and complete responses to two of the 9 remaining questions. Supplement 7 response was sent on April 5, 2011 to provide a revised schedule. Supplement 8 response was sent on April 25, 2011 to provide a revised schedule. Supplement 9 response was sent on May 20, 2011 to provide a technically correct and complete response to one of the 7 remaining questions. Supplement 10 response was sent on May 25, 2011 to provide a technically correct and complete response to one of the 6 remaining questions. Supplement 11 response was sent on May 25, 2011 to provide a technically correct and complete response to one of the 5 remaining questions.

The attached file, "RAI 442 Supplement 12 Response US EPR DC.pdf" provides a technically correct and complete response to Question 07.03-32, as committed. Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 442, Question 07.03-32.

The following table indicates the respective pages in the attachment that contain AREVA NP's response to the subject question.

Question #	Start Page	End Page
RAI 442 07.03-32	2	3

AREVA NP's schedule for providing a technically correct and complete response to the remaining 3 questions in RAI 442 has been changed and is provided below.

Question #	Response Date
RAI 442 — 7.1-26	June 22, 2011
RAI 442 — 7.1-30	June 3, 2011
RAI 442 — 7.1-31	June 22, 2011

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.

7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Wednesday, May 25, 2011 12:11 PM
To: 'Tesfaye, Getachew'
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 442, FSAR Ch. 7, Supplement 11

Getachew,

On November 19, 2010, AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the questions in RAI 442. Supplement 1 response was sent on January 7, 2011 to provide a revised schedule for four of the questions. Supplement 2 response was sent on February 9, 2011 to provide a revised schedule. Supplement 3 response was sent on February 18, 2011 to provide technically correct and complete responses to four questions. Supplement 4 response was sent on February 25, 2011 to provide technically correct and complete response to one question. Supplement 5 response was sent on March 2, 2011 to provide technically correct and complete responses to three of the 12 remaining questions. Supplement 6 response was sent on March 15, 2011 to provide technically correct and complete responses to two of the 9 remaining questions. Supplement 7 response was sent on April 5, 2011 to provide a revised schedule. Supplement 8 response was sent on April 25, 2011 to provide a revised schedule. Supplement 9 response was sent on May 20, 2011 to provide a technically correct and complete response to one of the 7 remaining questions. Supplement 10 response was sent on May 25, 2011 to provide a technically correct and complete response to one of the 6 remaining questions.

The attached file, “RAI 442 Supplement 11 Response US EPR DC.pdf” provides a technically correct and complete response to Question 07.01-28, as committed. Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format to support the response to RAI 442, Question 07.01-28.

The following table indicates the respective pages in the attachment that contain AREVA NP's response to the subject question.

Question #	Start Page	End Page
RAI 442 07.01-28	2	3

AREVA NP's schedule for providing a technically correct and complete response to the remaining 4 questions in RAI 442 is unchanged and is provided below.

Question #	Response Date
RAI 442 — 7.1-26	May 27, 2011
RAI 442 — 7.1-30	May 27, 2011
RAI 442 — 7.1-31	May 27, 2011
RAI 442 — 7.3-32	May 27, 2011

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager

AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Wednesday, May 25, 2011 7:42 AM
To: Tesfaye, Getachew
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 442, FSAR Ch. 7, Supplement 10

Getachew,

On November 19, 2010, AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the questions in RAI 442. Supplement 1 response was sent on January 7, 2011 to provide a revised schedule for four of the questions. Supplement 2 response was sent on February 9, 2011 to provide a revised schedule. Supplement 3 response was sent on February 18, 2011 to provide technically correct and complete responses to four questions. Supplement 4 response was sent on February 25, 2011 to provide technically correct and complete response to one question. Supplement 5 response was sent on March 2, 2011 to provide technically correct and complete responses to three of the 12 remaining questions. Supplement 6 response was sent on March 15, 2011 to provide technically correct and complete responses to two of the 9 remaining questions. Supplement 7 response was sent on April 5, 2011 to provide a revised schedule. Supplement 8 response was sent on April 25, 2011 to provide a revised schedule. Supplement 9 response was sent on May 20, 2011 to provide a technically correct and complete response to one of the 7 remaining questions.

The attached file, "RAI 442 Supplement 10 Response US EPR DC.pdf" provides a technically correct and complete response to Question 07.01-27, as committed. Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 442, Question 07.01-27.

The following table indicates the respective pages in the attachment that contain AREVA NP's response to the subject question.

Question #	Start Page	End Page
RAI 442 07.01-27	2	2

AREVA NP's schedule for providing a technically correct and complete response to the remaining 5 questions in RAI 442 remains unchanged and is provided below.

Question #	Response Date
RAI 442 — 7.1-26	May 27, 2011
RAI 442 — 7.1-28	May 27, 2011
RAI 442 — 7.1-30	May 27, 2011
RAI 442 — 7.1-31	May 27, 2011
RAI 442 — 7.3-32	May 27, 2011

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WILLIFORD Dennis (RS/NB)
Sent: Friday, May 20, 2011 5:32 PM
To: Tesfaye, Getachew
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 442, FSAR Ch. 7, Supplement 9

Getachew,

On November 19, 2010, AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the questions in RAI 442. Supplement 1 response was sent on January 7, 2011 to provide a revised schedule for four of the questions. Supplement 2 response was sent on February 9, 2011 to provide a revised schedule. Supplement 3 response was sent on February 18, 2011 to provide technically correct and complete responses to four questions. Supplement 4 response was sent on February 25, 2011 to provide technically correct and complete response to one question. Supplement 5 response was sent on March 2, 2011 to provide technically correct and complete responses to three of the 12 remaining questions. Supplement 6 response was sent on March 15, 2011 to provide technically correct and complete responses to two of the 9 remaining questions. Supplement 7 response was sent on April 5, 2011 to provide a revised schedule. Supplement 8 response was sent on April 25, 2011 to provide a revised schedule.

The attached file, "RAI 442 Supplement 9 Response US EPR DC.pdf" provides a technically correct and complete response to Question 07.09-64, as committed. Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report in redline-strikeout format which support the response to RAI 442, Question 07.09-64.

The following table indicates the respective pages in the enclosure that contain AREVA NP's response to the subject question.

Question #	Start Page	End Page
RAI 442 07.09-64	2	3

AREVA NP's schedule for providing a technically correct and complete response to the remaining 6 questions in RAI 442 remains unchanged and is provided below.

Question #	Response Date
RAI 442 — 7.1-26	May 27, 2011
RAI 442 — 7.1-27	May 27, 2011
RAI 442 — 7.1-28	May 27, 2011
RAI 442 — 7.1-30	May 27, 2011
RAI 442 — 7.1-31	May 27, 2011

RAI 442 — 7.3-32	May 27, 2011

Sincerely,

Dennis Williford, P.E.
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
7207 IBM Drive, Mail Code CLT 2B
Charlotte, NC 28262
Phone: 704-805-2223
Email: Dennis.Williford@areva.com

From: WELLS Russell (RS/NB)
Sent: Monday, April 25, 2011 4:43 PM
To: Tesfaye, Getachew
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 442, FSAR Ch. 7, Supplement 8

Getachew,

On November 19, 2010, AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the questions in RAI 442. Supplement 1 response was sent on January 7, 2011 to provide a revised schedule for four of the questions. Supplement 2 response was sent on February 9, 2011 to provide a revised schedule. Supplement 3 response was sent on February 18, 2011 to provide technically correct and complete responses to four questions. Supplement 4 response was sent on February 25, 2011 to provide technically correct and complete response to one question. Supplement 5 response was sent on March 2, 2011 to provide technically correct and complete responses to three of the 12 remaining questions. Supplement 6 response was sent on March 15, 2011 to provide technically correct and complete responses to two of the 9 remaining questions. Supplement 7 response was sent on April 5, 2011 to provide a revised schedule.

To provide additional time to interact with the NRC, a revised schedule is provided in this e-mail.

AREVA NP's schedule for providing a technically correct and complete response to the remaining questions in RAI 442 is provided below.

Question #	Response Date
RAI 442 — 7.1-26	May 27, 2011
RAI 442 — 7.1-27	May 27, 2011
RAI 442 — 7.1-28	May 27, 2011
RAI 442 — 7.1-30	May 27, 2011
RAI 442 — 7.1-31	May 27, 2011
RAI 442 — 7.3-32	May 27, 2011
RAI 442 — 7.9-64	May 27, 2011

Sincerely,

Russ Wells
U.S. EPR Design Certification Licensing Manager
AREVA NP, Inc.
3315 Old Forest Road, P.O. Box 10935
Mail Stop OF-57
Lynchburg, VA 24506-0935
Phone: 434-832-3884 (work)
434-942-6375 (cell)
Fax: 434-382-3884
Russell.Wells@Areva.com

From: WELLS Russell (RS/NB)
Sent: Tuesday, April 05, 2011 10:56 AM
To: 'Getachew.Tesfaye@nrc.gov'
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 442, FSAR Ch. 7, Supplement 7

Getachew,

On November 19, 2010, AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the questions in RAI 442. Supplement 1 response was sent on January 7, 2011 to provide a revised schedule for four of the questions. Supplement 2 response was sent on February 9, 2011 to provide a revised schedule. Supplement 3 response was sent on February 18, 2011 to provide technically correct and complete responses to four questions. Supplement 4 response was sent on February 25, 2011 to provide technically correct and complete response to one question. Supplement 5 response was sent on March 2, 2011 to provide technically correct and complete responses to three of the 12 remaining questions. Supplement 6 response was sent on March 15, 2011 to provide technically correct and complete responses to two of the 9 remaining questions.

To provide additional time to interact with the NRC, a revised schedule is provided in this e-mail.

AREVA NP's schedule for providing a technically correct and complete response to the remaining questions in RAI 442 is provided below.

Question #	Response Date
RAI 442 — 7.1-26	**April 28, 2011**
RAI 442 — 7.1-27	**April 28, 2011**
RAI 442 — 7.1-28	**April 28, 2011**
RAI 442 — 7.1-30	April 28, 2011
RAI 442 — 7.1-31	**April 28, 2011**
RAI 442 — 7.3-32	**April 28, 2011**
RAI 442 — 7.9-64	April 28, 2011

Sincerely,

Russ Wells
U.S. EPR Design Certification Licensing Manager
AREVA NP, Inc.
3315 Old Forest Road, P.O. Box 10935
Mail Stop OF-57

Lynchburg, VA 24506-0935
Phone: 434-832-3884 (work)
434-942-6375 (cell)
Fax: 434-382-3884
Russell.Wells@Areva.com

From: WELLS Russell (RS/NB)
Sent: Tuesday, March 15, 2011 12:51 PM
To: 'Tesfaye, Getachew'
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 442, FSAR Ch. 7, Supplement 6

Getachew,

On November 19, 2010, AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the questions in RAI 442. Supplement 1 response was sent on January 7, 2011 to provide a revised schedule for four of the questions. Supplement 2 response was sent on February 9, 2011 to provide a revised schedule. Supplement 3 response was sent on February 18, 2011 to provide technically correct and complete responses to four questions. Supplement 4 response was sent on February 25, 2011 to provide technically correct and complete response to one question. Supplement 5 response was sent on March 2, 2011 to provide technically correct and complete responses to three of the 12 remaining questions. Based on discussions with NRC, the attached file, "RAI 442 Supplement 6 Response US EPR DC.pdf" provides technically correct and complete responses to two of the 9 questions, as committed.

The following table indicates the respective pages in the response document, "RAI 442 Supplement 6 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 442 07.01-32	2	3
RAI 442 07.09-67	4	5

AREVA NP's schedule for providing a technically correct and complete response to the remaining questions in RAI 442 remains unchanged and is provided below.

Question #	Response Date
RAI 442 — 7.1-26	April 21, 2011
RAI 442 — 7.1-27	April 14, 2011
RAI 442 — 7.1-28	April 7, 2011
RAI 442 — 7.1-30	April 28, 2011
RAI 442 — 7.1-31	April 7, 2011
RAI 442 — 7.3-32	April 14, 2011
RAI 442 — 7.9-64	April 28, 2011

Sincerely,

Russ Wells
U.S. EPR Design Certification Licensing Manager
AREVA NP, Inc.
3315 Old Forest Road, P.O. Box 10935

Mail Stop OF-57
Lynchburg, VA 24506-0935
Phone: 434-832-3884 (work)
434-942-6375 (cell)
Fax: 434-382-3884
Russell.Wells@Areva.com

From: WELLS Russell (RS/NB)
Sent: Wednesday, March 02, 2011 4:52 PM
To: Tesfaye, Getachew
Cc: BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 442, FSAR Ch. 7, Supplement 5

Getachew,

On November 19, 2010, AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the questions in RAI 442. Supplement 1 response was sent on January 7, 2011 to provide a revised schedule for four of the questions. Supplement 2 response was sent on February 9, 2011 to provide a revised schedule. Supplement 3 response was sent on February 18, 2011 to provide technically correct and complete responses to four questions. Supplement 4 response was sent on February 25, 2011 to provide technically correct and complete response to one question. Based on discussions with NRC, the attached file, “RAI 442 Supplement 5 Response US EPR DC.pdf” provides technically correct and complete responses to three of the 12 questions, as committed.

The following table indicates the respective pages in the response document, “RAI 442 Supplement 5 Response US EPR DC.pdf,” that contain AREVA NP’s response to the subject question.

Question #	Start Page	End Page
RAI 442 07.03-33	2	2
RAI 442 07.03-34	3	4
RAI 442 07.09-61	5	8

AREVA NP's schedule for providing a technically correct and complete response to all questions in RAI 442 remains unchanged and is provided below.

Question #	Response Date
RAI 442 — 7.1-26	April 21, 2011
RAI 442 — 7.1-27	April 14, 2011
RAI 442 — 7.1-28	April 7, 2011
RAI 442 — 7.1-30	April 28, 2011
RAI 442 — 7.1-31	April 7, 2011
RAI 442 — 7.1-32	April 7, 2011
RAI 442 — 7.3-32	April 14, 2011
RAI 442 — 7.9-64	April 28, 2011
RAI 442 — 7.9-67	April 7, 2011

Sincerely,

Russ Wells
U.S. EPR Design Certification Licensing Manager
AREVA NP, Inc.
3315 Old Forest Road, P.O. Box 10935
Mail Stop OF-57
Lynchburg, VA 24506-0935
Phone: 434-832-3884 (work)
434-942-6375 (cell)
Fax: 434-382-3884
Russell.Wells@Areva.com

From: WELLS Russell (RS/NB)
Sent: Friday, February 25, 2011 8:07 AM
To: Tesfaye, Getachew
Cc: BRYAN Martin (External RS/NB); BENNETT Kathy (RS/NB); DELANO Karen (RS/NB); ROMINE Judy (RS/NB); RYAN Tom (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 442, FSAR Ch. 7, Supplement 4

Getachew,

On November 19, 2010, AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the questions in RAI 442. Supplement 1 response was sent on January 7, 2011 to provide a revised schedule for four of the questions. Supplement 2 response was sent on February 9, 2011 to provide a revised schedule. Supplement 3 response was sent on February 18, 2011 to provide technically correct and complete responses to four questions. Based on discussions with NRC, the attached file, "RAI 442 Supplement 4 Response US EPR DC.pdf" provides technically correct and complete responses to one of the 13 questions, as committed.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report and Technical Report ANP-10309P, in redline-strikeout format which support the response to RAI 442 Question 07.09-63.

The following table indicates the respective pages in the response document, "RAI 442 Supplement 4 Response US EPR DC.pdf," that contain AREVA NP's response to the subject question.

Question #	Start Page	End Page
RAI 442 07.09-63	2	2

Based upon the information presented to the NRC during the February 15, 2011, Public Meeting, the schedule for the remaining questions has been changed.

AREVA NP's schedule for providing a technically correct and complete response to all questions in RAI 442 is provided below.

Question #	Response Date
RAI 442 — 7.1-26	April 21, 2011
RAI 442 — 7.1-27	April 14, 2011
RAI 442 — 7.1-28	April 7, 2011
RAI 442 — 7.1-30	April 28, 2011
RAI 442 — 7.1-31	April 7, 2011

RAI 442 — 7.1-32	April 7, 2011
RAI 442 — 7.3-32	April 14, 2011
RAI 442 — 7.3-33	April 7, 2011
RAI 442 — 7.3-34	April 7, 2011
RAI 442 — 7.9-61	April 7, 2011
RAI 442 — 7.9-64	April 28, 2011
RAI 442 — 7.9-67	April 7, 2011

Sincerely,

Russ Wells
U.S. EPR Design Certification Licensing Manager
AREVA NP, Inc.
3315 Old Forest Road, P.O. Box 10935
Mail Stop OF-57
Lynchburg, VA 24506-0935
Phone: 434-832-3884 (work)
434-942-6375 (cell)
Fax: 434-382-3884
Russell.Wells@Areva.com

From: BRYAN Martin (External RS/NB)
Sent: Friday, February 18, 2011 12:21 PM
To: Tesfaye, Getachew
Cc: DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BENNETT Kathy (RS/NB); RYAN Tom (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 442, FSAR Ch. 7, Supplement 3

Getachew,

On November 19, 2010, AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the questions in RAI 442. Supplement 1 response was sent on January 7, 2011 to provide a revised schedule for four of the questions. Supplement 2 response was sent on February 9, 2011 to provide a revised schedule. Based on discussions with NRC, the attached file, "RAI 442 Supplement 3 Response US EPR DC.pdf" provides technically correct and complete responses to four of the 17 questions, as committed.

Appended to this file are affected pages of the U.S. EPR Final Safety Analysis Report and Technical Report ANP-10281P, in redline-strikeout format which support the response to RAI 442 Question 07.01-29.

The following table indicates the respective pages in the response document, "RAI 442 Supplement 3 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 442 07.01-29	2	2
RAI 413 07.09-62	3	4
RAI 413 07.09-65	5	5
RAI 413 07.09-66	6	6

The schedule for technically correct and complete responses to the remaining 13 questions is unchanged and provided below:

AREVA NP's schedule for providing a technically correct and complete response to all questions in RAI 442 is provided below.

Question #	Response Date
RAI 442 — 7.1-26	March 15, 2011
RAI 442 — 7.1-27	March 15, 2011
RAI 442 — 7.1-28	March 15, 2011
RAI 442 — 7.1-30	March 15, 2011
RAI 442 — 7.1-31	March 15, 2011
RAI 442 — 7.1-32	March 15, 2011
RAI 442 — 7.3-32	March 15, 2011
RAI 442 — 7.3-33	March 15, 2011
RAI 442 — 7.3-34	March 15, 2011
RAI 442 — 7.9-61	March 15, 2011
RAI 442 — 7.9-63	March 15, 2011
RAI 442 — 7.9-64	March 15, 2011
RAI 442 — 7.9-67	March 15, 2011

Sincerely,

Martin (Marty) C. Bryan
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
Tel: (434) 832-3016
702 561-3528 cell
Martin.Bryan.ext@areva.com

From: BRYAN Martin (External RS/NB)
Sent: Wednesday, February 09, 2011 5:07 PM
To: Tesfaye, Getachew
Cc: DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BENNETT Kathy (RS/NB); RYAN Tom (RS/NB)
Subject: Response to U.S. EPR Design Certification Application RAI No. 442, FSAR Ch. 7, Supplement 2

Getachew,

On November 19, 2010, AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the questions in RAI 442. Supplement 1 response was sent on January 7, 2011 to provide a revised schedule for four of the questions. To allow additional time to interact with the staff and to process the responses a revised schedule is provided below. It should be noted that the dates below may need to be adjusted following the February 15, 2011 public meeting between AREVA and the NRC on digital instrumentation and controls.

AREVA NP's schedule for providing a technically correct and complete response to all questions in RAI 442 is provided below.

Question #	Response Date
RAI 442 — 7.1-26	March 15, 2011
RAI 442 — 7.1-27	March 15, 2011
RAI 442 — 7.1-28	March 15, 2011
RAI 442 — 7.1-29	March 15, 2011
RAI 442 — 7.1-30	March 15, 2011
RAI 442 — 7.1-31	March 15, 2011
RAI 442 — 7.1-32	March 15, 2011
RAI 442 — 7.3-32	March 15, 2011
RAI 442 — 7.3-33	March 15, 2011
RAI 442 — 7.3-34	March 15, 2011
RAI 442 — 7.9-61	March 15, 2011
RAI 442 — 7.9-62	March 15, 2011
RAI 442 — 7.9-63	March 15, 2011
RAI 442 — 7.9-64	March 15, 2011
RAI 442 — 7.9-65	March 15, 2011
RAI 442 — 7.9-66	March 15, 2011
RAI 442 — 7.9-67	March 15, 2011

Sincerely,

Martin (Marty) C. Bryan
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
Tel: (434) 832-3016
702 561-3528 cell
Martin.Bryan.ext@areva.com

From: BRYAN Martin (External RS/NB)
Sent: Friday, January 07, 2011 11:15 AM
To: Tesfaye, Getachew
Cc: DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BENNETT Kathy (RS/NB); RYAN Tom (RS/NB); PANNELL George (CORP/QP)
Subject: Response to U.S. EPR Design Certification Application RAI No. 442, FSAR Ch. 7, Supplement 1

Getachew,

On November 19, 2010, AREVA NP Inc. (AREVA NP) provided a schedule for a technically correct and complete response to the questions in RAI 442. To allow additional time to interact with the staff a revised schedule is provided below for questions 7.1.29, 7.1.32, 7.9-65 and 7.9-67. The schedule for the other questions remains unchanged.

AREVA NP's schedule for providing a technically correct and complete response to all questions in RAI 442 is provided below.

Question #	Response Date
RAI 442 — 7.1-26	March 15, 2011
RAI 442 — 7.1-27	March 15, 2011
RAI 442 — 7.1-28	March 15, 2011

RAI 442 — 7.1-29	**February 9, 2011**
RAI 442 — 7.1-30	February 9, 2011
RAI 442 — 7.1-31	March 15, 2011
RAI 442 — 7.1-32	**February 9, 2011**
RAI 442 — 7.3-32	February 9, 2011
RAI 442 — 7.3-33	February 9, 2011
RAI 442 — 7.3-34	March 15, 2011
RAI 442 — 7.9-61	February 9, 2011
RAI 442 — 7.9-62	February 9, 2011
RAI 442 — 7.9-63	February 9, 2011
RAI 442 — 7.9-64	March 15, 2011
RAI 442 — 7.9-65	**March 15, 2011**
RAI 442 — 7.9-66	February 9, 2011
RAI 442 — 7.9-67	**February 9, 2011**

Sincerely,

Martin (Marty) C. Bryan
U.S. EPR Design Certification Licensing Manager
AREVA NP Inc.
Tel: (434) 832-3016
702 561-3528 cell
Martin.Bryan.ext@areva.com

From: BRYAN Martin (External RS/NB)
Sent: Friday, November 19, 2010 5:12 PM
To: 'Tesfaye, Getachew'
Cc: DELANO Karen (RS/NB); ROMINE Judy (RS/NB); BENNETT Kathy (RS/NB); PANNELL George (CORP/QP)
Subject: Response to U.S. EPR Design Certification Application RAI No. 442, FSAR Ch. 7

Getachew,

Attached please find AREVA NP Inc.'s response to the subject request for additional information (RAI). The attached file, "RAI 442 Response US EPR DC.pdf" provides a schedule since a technically correct and complete response to the 17 question (s) is not provided.

The following table indicates the respective pages in the response document, "RAI 442 Response US EPR DC.pdf," that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 442 — 7.1-26	2	2
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RAI 442 — 7.9-61	13	13
RAI 442 — 7.9-62	14	14
RAI 442 — 7.9-63	15	15
RAI 442 — 7.9-64	16	16
RAI 442 — 7.9-65	17	17
RAI 442 — 7.9-66	18	18
RAI 442 — 7.9-67	19	19

A complete answer is not provided for the 17 questions. The schedule for a technically correct and complete response to these questions is provided below.

Question #	Response Date
RAI 442 — 7.1-26	March 15, 2011
RAI 442 — 7.1-27	March 15, 2011
RAI 442 — 7.1-28	March 15, 2011
RAI 442 — 7.1-29	January 7, 2011
RAI 442 — 7.1-30	February 9, 2011
RAI 442 — 7.1-31	March 15, 2011
RAI 442 — 7.1-32	January 7, 2011
RAI 442 — 7.3-32	February 9, 2011
RAI 442 — 7.3-33	February 9, 2011
RAI 442 — 7.3-34	March 15, 2011
RAI 442 — 7.9-61	February 9, 2011
RAI 442 — 7.9-62	February 9, 2011
RAI 442 — 7.9-63	February 9, 2011
RAI 442 — 7.9-64	March 15, 2011
RAI 442 — 7.9-65	January 7, 2011
RAI 442 — 7.9-66	February 9, 2011
RAI 442 — 7.9-67	January 7, 2011

Sincerely,

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From: Tesfaye, Getachew [mailto:Getachew.Tesfaye@nrc.gov]
Sent: Wednesday, October 20, 2010 8:09 AM
To: ZZ-DL-A-USEPR-DL
Cc: Zhao, Jack; Morton, Wendell; Mott, Kenneth; Spaulding, Deirdre; Truong, Tung; Zhang, Deanna; Jackson, Terry; Canova, Michael; Colaccino, Joseph; ArevaEPRDCPEm Resource
Subject: U.S. EPR Design Certification Application RAI No. 442(4295,5076,5068,5067), FSAR Ch. 7

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on September 10, 2010, and discussed with your staff on October 13, 2010. Drat RAI Questions 07.01-26 and 07.03-33 were modified as a result of that discussion. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30 day period so that the staff can assess how this information will impact the published schedule.

Thanks,
Getachew Tesfaye
Sr. Project Manager
NRO/DNRL/NARP
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Hearing Identifier: AREVA_EPR_DC_RAIs
Email Number: 3019

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Request for Additional Information No.442 (4295, 5076, 5068, 5067), Supplement 12

10/20/2010

U.S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 07.01 - Instrumentation and Controls - Introduction
SRP Section: 07.03 - Engineered Safety Features Systems
SRP Section: 07.09 - Data Communication Systems

QUESTIONS for Instrumentation, Controls and Electrical Engineering 1 (AP1000/EPR Projects) (ICE1)

Question 07.03-32:

Follow-up to RAI 285, Question 07.03-27

After reviewing the applicant's response to RAI 285, Question 07.03-27, the staff requests the applicant to explicitly identify in Chapter 7 which Protection System (PS) manual functions are credited in the safety analysis.

U.S. EPR DC-FSAR, Section 15.0.0.3.7 identifies operator actions that are credited for isolating an affected SG during a steam generator tube rupture (SGTR) event. U.S. EPR DC-FSAR Chapter 7 does not address the crediting of manual actions for a SGTR event. Nor did Chapter 7 address component level control in Section 7.3. The staff generated an RAI requesting the applicant to clarify the issue. Although the applicant provided a response with good information that addressed some of the staff's concerns, there are issues that still require resolution before this question can be closed. This RAI question is intended to address compliance of the PS design with IEEE 603-1998, Clauses 4.e, 5.8.1 and 6.2.b. The staff used Standard Review Plan Section 7.1-C and 7.3 as guidance.

1. For Section 7.3....for each ESF function section, explicitly state in that section there are safety-related, component level manual controls available on both PICS and SICS in the Main Control Room. This is consistent with how manual system-level control is discussed in Section 7.3
2. For Section 7.3....state explicitly, in each applicable ESF system section, that its safety-related manual actuation is credited in the safety analysis. This is consistent with how manual system-level control is discussed in Section 7.3.
3. For Chapter 7....for other manual actions credited in the safety analysis, state explicitly in the applicable section. For example Section 15.0.0.3.7 states that there is a manual action to perform a reactor trip if the chemical and volume control system (CVCS) is running during an SGTR. This should be called out in Section 7.2.

Response to Question 07.03-32:

U.S. EPR FSAR Tier 2, Section 7.2, 7.3 and 15.0.0.3.7 will be revised to include the requested information. The revision to U.S. EPR FSAR Tier 2, Section 7.3 and 15.0.0.3.7 is included with this response. The revision to U.S. EPR FSAR Tier 2, Section 7.2 is included with the Response to RAI 442, Question 7.1-27.

U.S. EPR FSAR Tier 2, Section 7.3 does not address manual actions credited when the plant is in a stable, controlled state because these are not considered engineered safety feature (ESF) functions. Reactor trip and ESF functions are used to get the plant to a stable, controlled state as addressed in U.S. EPR FSAR Tier 2, Section 15.0.0.3.7.

Proposed changes to the instrumentation and controls (I&C) architecture were communicated to the NRC staff in the public meeting on February 15, 2011. U.S. EPR FSAR Tier 2, Section 7.3 will be revised to incorporate the revised I&C architecture. This section is provided in its entirety with this response to facilitate NRC review.

The issue pertaining to U.S. EPR FSAR Tier 2, Section 15.0.0.3.7 operator actions will be clarified in the response, and included with the enclosed markup for RAI 442, Question 7.1-30.

FSAR Impact:

U.S. EPR FSAR Tier 2, Section 7.3 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR Final Safety Analysis Report Markups

7.3 Engineered Safety Features Systems

7.3.1 Description

The U.S. EPR provides safety-related instrumentation and controls to sense accident conditions and automatically initiate the engineered safety features (ESF) systems. ESF systems are automatically actuated when selected variables exceed setpoints that are indicative of conditions that require protective action. Additionally, the ability to manually initiate ESF systems is provided in the main control room (MCR). Manual system-level actuation of ESF systems initiates all actions performed by the corresponding automatic actuation, including starting auxiliary or supporting systems and performing required sequencing functions. Component-level control ESF system actuators is also provided in the MCR.

7.3.1.1 System Description

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Automatic actuation of ESF systems and auxiliary supporting systems is performed by the protection system (PS) when selected plant parameters reach the appropriate setpoints. These automatic actuation orders are sent to the priority and actuator control system (PACS) for prioritization and interface to the actuators. ~~The typical~~An example of an ESF actuation sequence ~~performed~~actuated by four divisions of the ~~protection system~~PS is illustrated in Figure 7.3-1 (Sheet 1), and is described as follows:

- An acquisition and processing unit (APU) in each division acquires one-fourth of the redundant sensor measurements through the signal conditioning and distribution system (SCDS) that are inputs to a given ESF actuation function.
- The APU in each division performs any required processing using the measurements acquired by that division (e.g., filtering, range conversion, calculations). The resulting variable is compared to a relevant actuation setpoint in each division. If a setpoint is breached, the APU in that division generates a partial trigger signal for the appropriate ESF function.
- The partial trigger signals from each division are sent to redundant actuation logic units (ALU) in the PS division responsible for the associated actuation. Two out of four voting is performed in each ALU on the partial trigger signals from all four divisions. If the voting logic is satisfied, an actuation order is generated.
- The actuation signals of the redundant ALU in each subsystem are combined in a hardwired "functional OR" configuration so that either redundant ~~unit~~ALU can actuate the function.

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ESF functions actuated by less than four dvisiions are illustrated in Figure 7.3-1 (Sheets 3 through 5).

Actuation orders are sent from the PS to the PACS priority module associated with each actuator required for the function. ~~Exceptions to this are the emergency diesel~~

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generator (EDG) start function andThe exception to this is the turbine trip function. These actuation orders are received by the associated control system (EDG or turbine controls) and doThe actuation order is transmitted via hardwired connections to the turbine-generator instrumentation and control system (TG I&C) and does not involve the PACS. The connections between the PS and TG I&C are shown in Figure 7.1-27. The connections between the PS and TG I&C are shown in Figure 7.1-27. The PS and the PACS are discussed in Section 7.1. The TG I&C system is described in Section 10.2.

The safety automation system (SAS) performs closed loop automatic controls of certain ESF systems following their actuation by the PS. These controls are described in Section 7.3.1.2 with their associated actuation functions. The SAS is described in Section 7.1.

The capability for manual system-level ESF actuations is available to the operator through the safety information and control system (SICS) in the MCR. These manual actuations are acquired by the ALUs in the protection system and combined with the automatic actuation logic. The manual actuations are described with the corresponding automatic function in Section 7.3.1.2.

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The capability for component-level control of ESF system actuators is available to the operator on both the PICS and the SICS in the MCR. Commands from the PICS are processed by the PAS and sent to the PACS for prioritization. Commands from the SICS are processed by the SAS and sent directly to the PACS for prioritization. SICS is the safety-related actuation path and PICS is the non-safety-related actuation path. For any ESF actuator commands from the SICS have priority over those from the PICS.The typical manual ESF actuation sequence is shown in Figure 7.3-1 (Sheet 2). The manual actuations are described with the corresponding automatic function in Sections 7.3.1.2.

For an extra borating system (EBS) malfunction event, the component-level controls on SICS are credited to terminate EBS. For the failure of small lines carrying primary coolant outside the Reactor Containment Building (Section 15.0.0.3.5), component-level controls from SICS are credited to isolate the failed line. Operator actions credited in mitigating accidents are addressed in Section 15.0.0.3.7.

The capability for manual reset of sense and command ESF actuation outputs is provided on both the process information and control system (PICS) and the SICS. Not all ESF actuations require a manual reset. There are cases where a sense and command output is cleared after the PS determines that the initiating condition has cleared. The reset functionality related to each ESF actuation is described in Section 7.3.1.2. Further description of the operation of the PICS and SICS is presented in Section 7.1.

7.3.1.2 Engineered Safety Features Actuation Functional Descriptions

7.3.1.2.1 Safety Injection System Actuation

To mitigate a loss of coolant accident (LOCA), a safety injection signal is required to actuate the appropriate ESF and support systems and to isolate non-qualified reactor coolant system (RCS) piping.

In case of a decrease in RCS water inventory due to a LOCA, the RCS is supplied by medium head safety injection (MHSI) in the high pressure phase of the event and low head safety injection (LHSI) in the low pressure phase.

The operation of the MHSI and LHSI systems is described in Section 6.3.

The U.S. EPR design provides for automatic generation of the safety injection signal during all modes of plant operation by utilizing three different initiation parameters depending on the current plant state:

07.03-32

- Pressurizer pressure <Min3p.
- Hot leg ΔP_{sat} <Min1p.
- ~~RCS~~ Hot leg loop level <Min1p.

Safety injection system (SIS) actuation based on pressurizer pressure results from ~~narrow range (NR)~~ pressurizer pressure (narrow range (NR)) measurements below a fixed setpoint (Min3p) in any two of the four PS divisions. This initiation parameter is used above the P12 permissive ~~P12~~ pressure threshold and is bypassed below the P12 permissive setpoint~~threshold~~.

SIS actuation based on hot leg ΔP_{sat} results from the difference between measured pressure and saturation pressure being below a fixed setpoint (Min1p) in any two of the four PS divisions. The measured pressure is obtained from one ~~wide range (WR)~~ pressure (wide range (WR)) measurement in each hot leg. The saturation pressure is calculated from one ~~WR~~ temperature (WR) measurement in each hot leg. This initiation parameter is used when RCS pressure is below the P12 pressure threshold and above the P15 pressure and temperature thresholds. It is bypassed above the P12 threshold and below the P15 thresholds.

07.03-32

SIS actuation based on ~~RCS~~ hot leg loop level results from RCS water level measurements below the fixed setpoint (Min1p) in any two of the four PS divisions. One loop level measurement is taken in each of the hot legs. This initiation parameter is used below the P15 pressure and temperature thresholds with all four reactor coolant pumps (RCP) shut down. It is bypassed above the P15 thresholds. ~~or when any RCP is running.~~ A manual bypass of SIS actuation on low ~~RCS~~ hot leg loop level is provided for protection of personnel working in the RCS components during outages.

The logic for generation of the P12 and P15 permissive signals is described in Section 7.2.1.3Section 7.2.1.3.7 and Section 7.2.1.3.10.

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The capability for manual system-level initiation of the SIS is provided to the operator on the SICS in the MCR. This manual system-level initiation starts the four trains of safety injection as well as the associated protective actions, such as partial cooldown and reactor trip. For an SG tube rupture (SGTR) event, the operator is credited to perform a manual system-level initiation of SIS from the SICS. Four manual system-level initiation controls are provided, any two of which will start the four SIS trains.

The capability for component-level control of the SIS actuators is available to the operator on both the PICS and the SICS in the MCR. Operator actions credited in mitigating accidents are addressed in Section 15.0.0.3.7.

Reset of the SIS actuation sense and command output is available from both the PICS and SICS in the MCR and RSS. A reset of the SIS actuation output does not result in stopping the actions of the SIS actuators; it allows the operator to take further actions to stop specific trains of safety injection or manipulate individual components as may be necessary to follow plant operating procedures.

The logic for the SIS actuation function is shown in Figure 7.3-2—SIS Actuation.

7.3.1.2.2 Emergency Feedwater System Actuation

To mitigate the effects of a loss of main feedwater (MFW) event, the emergency feedwater system (EFWS) is actuated as a safety-related classified means to remove residual heat via the steam generators (SG). A number of failure mechanisms can result in loss of MFW (e.g., feedwater line break, loss of offsite power, feedwater pump failure). Regardless of the initiating event, a low SG level condition is characteristic of a loss of MFW and is used to actuate the EFWS.

An anticipatory EFWS actuation is also included to cope with the possibility of a LOOP, concurrent with a LOCA, to enhance natural circulation cooldown.

The operation of the EFWS is described in Section 10.4.9.

The U.S. EPR design uses the following initiating conditions to actuate the EFWS:

- SG level < Min2p.
- Loss of offsite power (LOOP) and SIS actuation signals generated.

07.03-32

EFWS actuation based on low SG level is performed on a per SG basis. The actuation order is generated when two of four SG WR level (WR) measurements (SG pressure sensors are used to improve the accuracy of the level measurement) are below the

Min2p setpoint in any one SG. Only the EFWS train corresponding to the SG with the low level condition is actuated.

EFWS actuation based on LOOP and SIS actuation is performed concurrently on all SGs. Generation of the SIS actuation signal is described in Section 7.3.1.2.1. Generation of the LOOP signal is described in Section 7.3.1.2.12.

In both cases, EFWS actuation is bypassed when hot leg temperature is below the P13 permissive setpoint. The bypass is automatically removed above the P13 permissive setpoint. Generation of the P13 permissive signal is discussed in ~~Section 7.2.1.3~~Section 7.2.1.3.8.

When EFWS actuation occurs due to a low SG level, the sense and command actuation output is reset automatically when the SG level returns above the Min2p setpoint. This is done so that the safety-related SG level control loop, performed by the SAS, can control the actuators needed to maintain the correct water level in the SG. Additionally, the capability for manual reset of the EFWS actuation signal is available, on a per train basis, from ~~both~~ the ~~PICS and~~ SICS in the MCR and the RSS. The manual reset does not result in stopping the EFWS actuation; it allows the operator to take further manual actions to stop the actuation.

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When EFW actuation occurs due to LOOP and SIS actuation, the PS sends a pulse signal of limited duration to start the actuation. The duration of the pulse is long enough for the intended actions of the execute features to go to completion. No reset is needed in this case, as the SG water level is already above the Min2p setpoint when the EFW actuation occurs and the safety-related SG level control loop can immediately take control of the actuators.

07.03-32

The EFWS SG level control and EFWS pump flow protection functions provide the EFWS control valves with a position correction signal to move the valves in the close or open direction as needed. The actual SG level and EFWS pump discharge flow are compared to their respective setpoints. A proportional and integral (PI) step controller sends a close or open signal, depending on the valve position, to maintain the SG level and EFWS pump discharge flow parameters at their respective setpoints.

The safety-related closed loop control for SG water level following EFWS actuation is performed by the SAS. When EFWS actuation occurs, the PS signals the SAS to initiate the closed loop control. Separately, ~~D~~during SG water level control by the SAS, a second closed loop control is also performed by SAS that regulates pump flow to protect the EFW pump from an overflow condition.

The capability for manual system-level initiation of the EFWS on a per-train basis is provided on the SICS in the MCR. Three manual system-level initiation controls are provided per EFW train. One-out-of-two logic is used on two of these controls to start the EFW pump, open the associated EFW valves, and isolate the SG blowdown line. The third control is used only to close SG blowdown isolation valves that are redundant to those closed by the first two controls.

07.03-32

The capability for component-level control of the EFWS actuators is available to the operator on both the PICS and the SICS in the MCR. Following an FWLB, manual component-level control from the SICS is credited with redirecting the EFWS train feeding the affected SG to an intact SG. Operator actions credited in mitigating accidents are addressed in Section 15.0.0.3.7.

The functional logic for automatic actuation of the EFWS is shown in Figure 7.3-3—EFWS Actuation, Figure 7.3-6—EFWS Actuators (Div. 1&2), and Figure 7.3-7—EFWS Actuators (Div. 3&4).

The functional logic for SG water level control following EFWS actuation, and EFW pump overflow protection, is shown in Figure 7.3-4—EFWS SG Level Control and Pump Flow Protection.

7.3.1.2.3 Emergency Feedwater System Isolation

To mitigate the effects of a steam generator tube rupture (SGTR), the EFWS is isolated at a high level setpoint to avoid SG overfill and potential radioactive water discharge via the main steam relief train.

The operation of the EFWS ~~system~~ is described in Section 10.4.9.

The U.S. EPR design uses the following initiating condition to isolate the EFWS:

- SG level (WR) > Max1p.
- SG isolation signal (Section 7.3.1.2.14).

07.03-32

EFWS isolation based on SG level is performed on a per SG basis. The actuation order is generated when two of four ~~WR~~ SG level (WR) measurements (SG pressure sensors are used to improve the accuracy of the level measurement) are above the Max1p setpoint in any one SG. Only the EFWS train corresponding to the SG with the high level condition is isolated.

EFWS isolation is bypassed when hot leg temperature is below the P13 permissive setpoint. The bypass is automatically removed above the P13 permissive setpoint. Generation of the P13 signal is discussed in ~~Section 7.2.1.3~~Section 7.2.1.3.8.

The capability for manual system-level EFWS isolation on a per train basis is provided to the operator on the SICS in the MCR. Two manual system-level isolation controls are provided per EFWS train. Any one of these two controls actuates the isolation function.

07.03-32 07.03-27

The capability for component-level control of the EFWS actuators is available to the operator on both the PICS and the SICS in the MCR. Following a main steam line break (MSLB), manual initiation from the SICS is credited with terminating EFWS in the affected SG. Operator actions credited in mitigating accidents are addressed in Section 15.0.0.3.7.

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The sense and command output to isolate the EFWS can be reset manually from ~~both~~ the ~~PICS and~~ SICS in the MCR and RSS. Reset of the sense and command output does not result in opening of the EFWS isolation valve; it allows the operator to take further manual actions to open the valves. The manual reset is only allowed after the SG level returns below the Max1p setpoint.

The functional logic for isolation of the EFWS is shown in Figure 7.3-5—EFWS Isolation, Figure 7.3-6—EFWS Actuators (Div. 1&2), and Figure 7.3-7—EFWS Actuators (Div. 3&4).

7.3.1.2.4 Partial Cooldown Actuation

When a safety injection signal is generated, it is necessary to perform a secondary side partial cooldown to lower RCS pressure to a point where the MHSI is effective. This is necessary due to the MHSI shutoff head discharge pressure being lower than the nominal RCS pressure.

The safety-related partial cooldown function consists of lowering the Max1p main steam relief isolation valve (MSRIV) opening setpoint (Section 7.3.1.2.5) according to a predefined cooldown gradient. If SG pressure exceeds the decreasing Max1p setpoint, the MSRIV is opened and the main steam relief control valve (MSRCV) is used to maintain SG pressure at the decreasing Max1p setpoint. Control of the MSRCV is described in Section 7.3.1.2.5.

07.03-32

The partial cooldown is preferably performed by controlling the turbine bypass valves, in a non-safety-related capacity, to a decreasing pressure setpoint that is maintained slightly lower than Max1p. During accident conditions where containment pressure is greater than Max1p and a safety injection signal is generated, the main steam isolation valves (MSIV) (including bypass piping) are closed. This prevents the use of the turbine bypass valves for partial cooldown. The operator has the capability to reset the main steam isolation signal, and further manual actions are necessary to open the MSIVs. The safety-related partial cooldown via the main steam relief train (MSRT) is provided to cope with turbine bypass control failure, as the success of the safety injection function can depend on successful partial cooldown. Both the safety-related and non-safety-related partial cooldown are initiated by the PS. The PS detects the condition requiring partial cooldown and sends an initiation signal via an isolated hardwired connection to the process automation system (PAS). Control loops for partial cooldown via turbine bypass are performed by the PAS. The partial cooldown via turbine bypass is described in Section 7.7. The PS also sends the partial cooldown initiation signal to the safety-related SAS. Control loops for partial cooldown via MSRT are performed by the SAS.

Operation of the main steam system and main steam relief train is described in Section 10.3.

The U.S. EPR design uses the following initiating condition to actuate a partial cooldown:

- SIS actuation signal generated.

Generation of the SIS actuation signal is described in Section 7.3.1.2.1. Partial cooldown is initiated any time a SIS actuation signal occurs, except during conditions when RHR can be connected. In such conditions, the primary pressure is already low enough for MHSI to be successful and partial cooldown is not needed. For this reason, the partial cooldown actuation due to SIS actuation is bypassed below the P14 permissive pressure and temperature conditions. Generation of the P14 permissive signal is discussed in ~~Section 7.2.1.3~~Section 7.2.1.3.9.

07.03-32

The capability for manual system-level actuation of partial cooldown is provided on the SICS in the MCR. This manual initiation starts the partial cooldown via all four main steam trains if P14 is inhibited and the reactor is tripped. Four manual initiation controls are provided, any two of which will start the partial cooldown.

When the Max1p setpoint has reached a pre-defined value, a partial cooldown finished signal is generated and the sense and command output to actuate partial cooldown is reset automatically. The partial cooldown finished signal can then be reset manually from ~~both~~ the ~~PICS and~~ SICS in the MCR.

The functional logic for partial cooldown actuation is shown in Figure 7.3-8—Partial Cooldown Actuation.

7.3.1.2.5 Main Steam Relief Isolation Valve Opening

In case of loss of the secondary side heat sink, heat has to be removed via steam relief to the atmosphere. The four MSRTs provide this functionality. The MSRTs are also used for SG over-pressure protection to minimize the actuation of the main steam safety valves and the associated risk of the safety valves failing to re-seat. Additionally, the MSRTs participate in the partial cooldown function (Section 7.3.1.2.4).

Operation of the main steam system (MSS) and MSRTs is described in Section 10.3.

The U.S. EPR design uses the following initiating condition to actuate MSRIV opening:

- SG pressure > Max1p.

The actuation order for MSRIV opening is generated when two out of four SG pressure measurements on any one SG exceed the variable Max1p setpoint. This is a loop-specific actuation; only the MSRIV associated with the affected SG is opened. Four different conditions determine the value of Max1p that is used:

- During normal operation, Max1p is maintained at one of two fixed values to provide SG overpressure protection. The higher of the two is used when RCS pressure and temperature are above the P14 permissive thresholds; the lower is used below the P14 permissive thresholds. Generation of the P14 permissive signal is discussed in ~~Section 7.2.1.3~~Section 7.2.1.3.9.
- When a SG isolation signal is generated (Section 7.3.1.2.14), Max1p is set to a high fixed value to prevent radioactive release to the atmosphere.
- During partial cooldown, Max1p decreases according to a predefined schedule.
- When partial cooldown is finished, Max1p is maintained at a fixed value for all SGs for which a SG isolation signal is not present.

Whenever the Max1p setpoint is exceeded and the MSRIV opens, the MSRCV is modulated by a closed-loop control to maintain SG pressure at the Max1p setpoint. This control is performed by the SAS and uses the difference between measured SG pressure and the Max1p value to determine the control valve position. When the MSRIV is not open, the MSRCV is continuously controlled by the SAS based on reactor power. This is a pre-positioning function that allows the MSRCV to be in a reasonable position when the MSRIV receives a protection order to open.

07.03-32

The MSRCV control function provides the MRSCV with a position correction signal to move the valve in the close or open direction, as needed. The actual MSRCV position is compared to the program position based on plant condition. The PI step controller sends a close or open signal, as needed, depending on the actual valve position.

The capability for manual system-level opening of the MSRIV on a per-train basis is provided on the SICS in the MCR. Two manual system-level initiation controls are provided per MSRIV. Any one of these two controls opens the desired MSRIV.

The capability for component-level control of the MSRIV actuators is available to the operator on both the PICS and the SICS in the MCR.

The sense and command output to open the MSRIV can be reset manually from ~~both~~ the ~~PICS and~~ SICS in the MCR and the RSS. Reset of the sense and command output does not result in closure of the MSRIV; it allows the operator to take further manual action to close the valve.

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The functional logic for formation of the MSRIV opening setpoint is shown in Figure 7.3-9—MSRT Setpoint Formation.

The functional logic for automatic opening of the MSRIV is shown in Figure 7.3-10—MSRIVT Opening (Div. 1&2) and Figure 7.3-11—MSRIVT Opening (Div. 3&4).

The functional logic for control of the MSRCV is shown in Figure 7.3-12—MSRCV Control.

7.3.1.2.6 Main Steam Relief Train Isolation

As described in Section 7.3.1.2.5, the MSRIV opens due to high SG pressure conditions and the MSRCV is pre-positioned appropriately based on reactor power. At 100 percent power, the MSRCV is positioned fully open. A single failure is postulated on a given MSRCV in which it is not properly pre-positioned and remains full open during a decrease in reactor power, such as following reactor trip (RT). A MSRIV opening after such a single failure could result in overcooling of the RCS. Therefore, the MSRIV and MSRCV both receive a closing order in the event of a low SG pressure condition.

Operation of the MSS and MSRT is described in Section 10.3.

The U.S. EPR design uses the following initiating condition to actuate MSRT isolation:

- SG pressure < Min3p.

The actuation order for MSRT isolation is generated when two-out-of-four SG pressure measurements on any one SG are below the Min3p setpoint. This is a looptrain-specific actuation; only the MSRT associated with the affected SG is isolated. The MSRT isolation function is bypassed when RCS pressure is below the P12 permissive setpoint. The bypass is automatically removed when RCS pressure is above the P12 permissive setpoint. Generation of the P12 permissive signal is discussed in Section 7.2.1.3Section 7.2.1.3.7.

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The capability for manual system-level isolation of the MSRT on a per train basis is provided on the SICS in the MCR. Two manual system-level isolation controls are provided per MSRT. Any one of these two controls isolates the desired MSRT.

The capability for component-level control of the MSRT actuators is available to the operator on both the PICS and the SICS in the MCR.

The sense and command output to isolate the MSRT can be reset manually from both the PICS and SICS in the MCR and RSS. Reset of the sense and command output does

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not result in opening of the MSRT; it allows the operator to take further manual action to open the valves.

The functional logic for isolation of the MSRT is shown in Figure 7.3-13—MSRT Isolation.

7.3.1.2.7 Main Steam Isolation

In case of steam or feedwater system piping failure, a depressurization of the affected SG is anticipated. In order to limit the overcooling transient and to limit energy release into the containment, a main steam isolation signal is generated for a SG pressure drop greater than an allowed rate for large pipe failure, and also for SG pressure less than a fixed low setpoint for small steam line failure. The actions that result from a main steam isolation signal are MSIV closure, MSIV bypass line closure, and SG blowdown line closure.

Operation of the MSS is described in Section 10.3.

The U.S. EPR design uses the following initiating conditions to actuate main steam isolation:

- SG pressure drop.
- SG pressure < Min1p.
- SG isolation signal (Section 7.3.1.2.14).
- Containment equipment compartment pressure > Max1p.
- Containment service compartment pressure (NR) > Max2p.

An actuation order is generated for main steam isolation when two-out-of-four SG pressure measurements on any one SG decrease faster than the specified allowable rate. When this condition occurs in any one SG, all four main steam trains are isolated. A SG pressure drop is detected by using a variable low setpoint equal to the actual SG pressure minus a fixed value, with a limitation placed on the rate of decrease of the setpoint. The maximum value of the setpoint is also limited in order to avoid MSIV closure during a SG pressure decrease following RT and turbine trip, which could result in a SG over-pressure condition.

There are no permissive conditions associated with main steam isolation due to SG pressure drop; this initiation parameter is used in all plant operating conditions.

An actuation order is also generated for main steam isolation when two-out-of-four SG pressure measurements on any one SG are below the fixed Min1p setpoint. When this condition occurs in any one SG, all four main steam trains are isolated. Main steam isolation due to low SG pressure is bypassed when RCS pressure is below the P12 permissive setpoint. The bypass is automatically removed above the P12 permissive setpoint. Generation of the P12 permissive signal is discussed in Section 7.2.1.3Section 7.2.1.3.7.

An actuation order is generated for main steam isolation when two-out-of-four PS divisions detect high containment pressure. Either two-out-of-four equipment compartment pressure measurements exceeding the Max1p setpoint, or two-out-of-four service compartment pressure (NR) measurements exceeding the Max2p setpoint results in main steam isolation. There are no operating bypasses associated with main steam isolation on high containment pressure.

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The capability for manual system-level actuation of main steam isolation is provided on the SICS in the MCR. This manual system-level initiation closes all four MSIVsisolates the main steam trains. Four manual system-level initiation controls are provided, any two of which will actuate the main steam isolation.

The capability for component-level control of the main steam and blowdown valves is available to the operator on both the PICS and the SICS in the MCR. For small main steam line breaks (MSLB) and FWLB, manual initiation from the SICS is credited with closing the main steam and blowdown valves when operating below the P12 permissive setpoint. Operator actions credited in mitigating accidents are addressed in Section 15.0.0.3.7.

The sense and command output for main steam isolation can be reset manually from both the PICS and SICS in the MCR. Reset of the sense and command output does not result in opening of the associated valves; it allows the operator to take further manual actions to open the valves.

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The functional logic for automatic main steam isolation is shown in Figure 7.3-14—MSIVMain Steam Isolation (Div. 1&2) and Figure 7.3-15—MSIVMain Steam Isolation (Div. 3&4).

7.3.1.2.8 Main Feedwater Isolation

To protect against a loss of SG level control arising from a SGTR, pipe fault, or level control malfunction, and to prevent overcooling of the RCS following a RT, isolation of the main feedwater (MFW) system is performed. The MFW isolation is actuated in two steps, full load isolation or startup and shutdown system (SSS) isolation, depending upon the severity of the SG level deviation. The SSS isolation includes the closure of the main MFW isolation valve, which prevents flow via the full load path as well as SSS.

Operation of the MFW system is described in Section 10.4.

The U.S. EPR design uses the following initiating conditions to actuate MFW isolation:

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- ~~Confirmation~~Initiation of RT (full load isolation).
- SG level (NR) > Max1p (full load isolation).
- SG level (NR) > Max0p for a period of time following RT (SSS isolation).
- SG pressure drop > Max2p (SSS isolation).
- SG pressure < Min2p (SSS isolation).
- SG isolation signal (Section 7.3.1.2.14).
- Containment equipment compartment pressure > Max1p (SSS isolation).
- Containment service compartment pressure (NR) > Max2p (SSS isolation).

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Following RT, a MFW full load isolation of all four SG is required in order to avoid RCS overcooling, which could result in a return to critical conditions with a potential power excursion. ~~The confirmation of RT signal is generated when two out of four RT breakers are in the open position.~~ This MFW isolation secures the full load flow path and allows for SG level control from the low load valves, in the absence of close commands for the low load valves.

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Redundant to the MFW full load isolation due to RT on SG level > Max1p, a separate, SG-specific MFW full load isolation order is also generated at the Max1p setpoint to avoid SG overfill and moisture carryover. This actuation order is generated when two out of four ~~NR~~ SG level (NR) measurements on any one SG exceed the Max1p setpoint. Only the full load lines feeding the SG with the high water level are isolated due to this signal. The other full load lines are isolated on ~~confirmation~~initiation of RT due to the same high level measurement. The high SG level initiation is bypassed when hot leg temperature is below the P13 permissive setpoint. The bypass is automatically removed when hot leg temperature is above the P13 permissive setpoint. Generation of the P13 permissive signal is discussed in ~~Section 7.2.1.3~~Section 7.2.1.3.8.

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Following RT on high SG level, the SG level is expected to decrease initially due to the prompt reduction in steam flow and then be maintained at a normal level by the SG level control system. A persistent high SG level may be indicative of a SGTR or a failure of the SG level control system. If the SG level remains greater than the Max0p setpoint for a fixed amount of time following RT and MFW full load isolation, MFW SSS isolation is performed. This actuation order is generated when two-out-of-four ~~NR~~ SG level (NR) measurements remain above the Max0p setpoint, following expiration of a time delay initiated by RT ~~confirmation~~signal. The SSS isolation is performed only on a SG in which the level remains above the Max0p setpoint. This initiation signal is bypassed when hot leg temperature is below the P13 permissive setpoint. The bypass is automatically removed when hot leg temperature is above the P13 permissive setpoint. Generation of the P13 permissive signal is discussed in ~~Section 7.2.1.3~~Section 7.2.1.3.8.

Following a main steam or feedwater system piping failure, a complete feedwater isolation of the MFW train feeding the affected SG is desirable. In this case, MFW full load isolation occurs on all four steam generators because of the reactor trip on either SG pressure drop or on SG pressure < Min1p. A MFW SSS isolation of the affected SG will occur on a more severe SG pressure drop (to mitigate fast depressurizations) or on SG pressure < Min2p (to mitigate slower depressurizations). The logic to initiate MFW isolation on SG pressure drop is the same as that described for main steam isolation on SG pressure drop described in Section 7.3.1.2.7, except that the variable low setpoint for SSS isolation is maintained below the RT and ~~MSIV~~main steam isolation setpoint. 07.03-27 The actuation order for SSS isolation due to SG pressure < Min2p is generated when two out of four SG pressure measurements on any one SG are below the Min2p setpoint. There is no operating bypass associated with SSS isolation on SG pressure drop. SSS isolation on SG pressure < Min2p is bypassed when RCS pressure is below the P12 permissive setpoint. The bypass is automatically removed when RCS pressure is above the P12 permissive setpoint. Generation of the P12 permissive signal is discussed in ~~Section 7.2.1.3~~Section 7.2.1.3.7.

An actuation order is generated for SSS isolation when two-out-of-four PS divisions detect high containment pressure. Either two-out-of-four equipment compartment pressure measurements exceeding the Max1p setpoint, or two-out-of-four service compartment pressure (NR) measurements exceeding the Max2p setpoint results in SSS isolation. There are no operating bypasses associated with SSS isolation on high containment pressure.

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The capability for manual system-level isolation of MFW on a per-train basis is provided on the SICS in the MCR. This manual system-level initiation isolates both full load and SSS lines on the desired SG. Two manual system-level isolation controls are provided per MFW train. Either of the two controls isolates the MFW train.

The capability for component-level control of the MFW actuators is available to the operator on both the PICS and the SICS in the MCR.

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The sense and command outputs for MFW isolation can be reset manually from ~~both~~ the ~~PICS and~~ SICS in the MCR. Reset of the sense and command output does not result in opening of the associated valves; it allows the operator to take further manual actions to open the valves. 07.03-27

The functional logic for MFW isolation is shown in Figure 7.3-16—MFWS Isolation - Full Load, Figure 7.3-17—MFWS Isolation - SSS, Figure 7.3-18—MFW Actuators (Div. 1&2), and Figure 7.3-19—MFW Actuators (Div. 3&4).

7.3.1.2.9 Containment Isolation

During a LOCA, radioactive coolant is released into the containment. Therefore, the containment has to be isolated to prevent activity release to the environment. The U.S. EPR provides containment isolation in two stages to isolate nonessential components based on the size of the break. Containment pressure measurements and high-range activity monitors are used to initiate containment isolation and to determine which stage is actuated. Additionally, containment isolation is actuated anytime a safety injection actuation signal is generated.

The containment isolation actuators and their functionality are described in Section 6.2.4.

The U.S. EPR design uses the following initiating conditions to isolate the containment:

- Containment equipment compartment pressure > Max1p (stage 1).
- Containment service compartment pressure (NR) > Max2p (stage 1).
- Containment activity > Max1p (stage 1).
- SIS actuation signal (stage 1).
- Containment service compartment pressure (WR) > ~~Max2p~~Max3p (stage 1 and 2).

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Stage one isolation is provided for a small break loss of coolant accident (SBLOCA) to isolate containment penetrations that have no active function for LOCA mitigation and to start ventilation of containment annulus. A stage one containment isolation order is generated when two-out-of-four PS divisions detect high containment pressure. Either two-out-of-four equipment compartment pressure measurements exceeding the Max1p setpoint, ~~or~~ two-out-of-four ~~NR~~ service compartment pressure (NR) measurements exceeding the ~~Max1p~~Max2p setpoint, or two-out-of-four containment service compartment pressure (WR) measurements exceeding the Max3p setpoint results in stage one isolation. If two-out-of-four high range containment activity sensors indicate radioactivity in containment, a stage one isolation order is also generated. A safety injection actuation signal also results in a stage one containment isolation actuation.

Stage two containment isolation order is generated when two-out-of-four ~~WR~~ service compartment pressure (WR) measurements exceed ~~Max2p~~Max3p setpoint. A LOCA of sufficient size to raise containment pressure to ~~Max2p~~Max3p setpoint does not require RCPs for mitigation. In fact, on a stage two containment isolation signal, RCPs are tripped to limit energy input to containment, and containment penetrations for processes that support RCP operation are isolated.

There are no operating bypasses associated with containment isolation. This function is available during all plant conditions.

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Capability for manual system-level initiation of containment isolation on a per-stage basis is provided on the SICS in the MCR. Four manual system-level isolation controls are provided for each stage. Any two of the four controls actuate the appropriate stage of containment isolation.

The capability for component-level control of the containment isolation actuators is available to the operator on both the PICS and the SICS in the MCR.

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Sense and command outputs for containment isolation can be reset manually from ~~both PICS and~~ SICS in the MCR. Reset of sense and command outputs does not result in change of state of containment isolation actuators; it allows the operator to take further manual actions to change state of individual actuators. 07.03-27

Functional logic for actuation of containment isolation is shown in Figure 7.3-20—Containment Isolation.

7.3.1.2.10 Chemical and Volume Control System (CVCS) Charging Isolation

A malfunction of the chemical and volume control system (CVCS) could result in overfilling the pressurizer and opening of the pressurizer safety relief valves (PSRV). Isolation of the CVCS ~~system~~ is therefore required when the pressurizer water level increases inadvertently.

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~~This isolation is performed in two stages with staggered setpoints. The following initiating conditions are used to perform the two stages of CVCS charging isolation:~~The isolation is performed by redundant isolation valves. The following initiating condition is used to perform the CVCS charging isolation:

- ~~Pressurizer Level > Max1p.~~
- Pressurizer Level (NR) > Max2p.

~~If two-out-of-four level measurements exceed the Max1p setpoint, orders are generated to isolate the auxiliary pressurizer spray lines.~~ If two-out-of-four level measurements exceed the Max2p setpoint, orders are generated to isolate the CVCS charging flow ~~as well~~and the auxiliary spray.

These CVCS charging isolation functions are bypassed when cold leg temperature is below the P17 permissive setpoint. The bypass is automatically removed above the P17 permissive setpoint. Generation of the P17 permissive signal is discussed in ~~Section 7.2.1.3~~Section 7.2.1.3.12.

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The capability for manual system-level initiation of CVCS charging isolation is provided on a per-division basis on the SICS in the MCR. One manual system-level isolation control is provided for PS Division 1, and one control is provided for PS Division 4.

The capability for component-level control of the CVCS actuators for CVCS charging isolation is available to the operator on both the PICS and the SICS in the MCR.

A manual reset of the sense and command outputs is not required for the CVCS charging isolation function. The outputs are automatically reset when the level measurements return below the appropriate setpoint. A pulse order is used to provide assurance that the actions of the execute features go to completion. The automatic reset of the sense and command outputs does not result in change of state of the isolation actuators; it allows the operator to take further manual actions to change the state of individual actuators.

The functional logic for CVCS charging isolation is shown in Figure 7.3-21—CVCS Charging Isolation.

7.3.1.2.11 CVCS Isolation for Anti-Dilution

To mitigate the risk of dilution of the RCS boron concentration, a CVCS isolation is required to secure potential dilution flow paths. This function provides protection during all plant conditions by using different combinations of input signals depending on the current plant state. The function is divided as follows:

- Power operation (above the P8 permissive P8).
- Shutdown conditions with RCPs in operation (below the P8 permissive P8 and above the P7 permissive P7).
- Shutdown conditions without RCPs in operation (below the P7 permissive P7).

An online calculation of the boron concentration in the RCS is performed during power operation based on the boron concentration measurement in the CVCS charging line and the measured CVCS charging flow. The calculated boron concentration is compared to a fixed setpoint corresponding to the critical boron concentration of the core at hot zero power with the highest worth rod not inserted. The boron concentration calculation is performed according to the following:

$$BC_P^N = \frac{R}{1+R} BC_{Inj}^N + \frac{R}{1+R} BC_P^{N-1}$$

Where:

$$R = \frac{QF_{Inj} \times \Delta t}{M_P^N}$$

And:

B_P^N = RCS boron concentration at time t_N

BC_P^{N-1} = RCS boron concentration at time t_{N-1}

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BC_{Inj}^N = Boron concentration measured by the boron concentration measurement system (BCMS) in the CVCS charging line

QF_{Inj} = Measured flow in the CVCS charging line

M_p^N = Mass of reactor coolant (fixed value during power operation)

Δt = Time from N-1 to N

N = Integer

In shutdown conditions with RCPs in operation, the same calculation is used based on the same input measurements with the addition of the cold leg temperature (WR) measurements. The cold leg temperature is used to determine the mass of reactor coolant, and also determines which value is used for the actuation setpoint. The determination of reactor coolant mass is made according to a lookup table with linear interpolation between eight pairs (cold leg temperature, RCS mass). The setpoint determination is also made based on a lookup table with linear interpolation between eight pairs (cold leg temperature, setpoint value). The selected setpoint represents the critical boron concentration of the current shutdown condition as dictated by cold leg temperature.

In shutdown conditions without RCPs in operation, the measured boron concentration is simply compared to a fixed setpoint. This setpoint represents the boron concentration required under outage conditions, minus built-in margin to prevent spurious actuations.

Regardless of the current operating conditions, if any two of the four PS divisions determine that dilution is occurring, redundant valves downstream of the volume control tank are closed. This isolates the main CVCS source of dilution. Additionally, the ~~RHR~~CVCS letdown isolation valve is closed.

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The capability for manual system-level initiation of CVCS isolation for anti-dilution on a per-division basis is provided on the SICS in the MCR. One manual system-level isolation control is provided for PS Division 1, and one control is provided for PS Division 4.

The capability for component-level control of the CVCS actuators for CVCS isolation for anti-dilution is available to the operator on both the PICS and the SICS in the MCR.

The sense and command outputs for CVCS isolation for anti-dilution can be reset manually from both the PICS and SICS in the MCR. Reset of the sense and command outputs does not result in change of state of the isolation valves; it allows the operator to take further manual actions to change the state of individual actuators. 07.03-27

The functional logic for CVCS isolation for anti-dilution is shown in Figure 7.3-22—CVCS Isolation for Anti-Dilution.

7.3.1.2.12 Emergency Diesel Generator (EDG) Actuation

During normal plant operation, the electrical power for the safety-related loads is provided by dedicated offsite emergency auxiliary transformers (EAT) for distribution to the emergency power supply system (EPSS). To mitigate the effects of a loss of offsite power (LOOP) event, each division of the EPSS is provided an EDG as a standby source to supply electrical power to the necessary loads.

The EPSS consists of different voltage levels: medium voltage (MV) for large safety-related loads and low voltage for other loads. The four main MV distribution buses that provide power to the four divisions of the EPSS have a normal connection to one of the two dedicated EATs but can be alternately supplied from the other dedicated EATs or the EDG for that division.

The three phases of voltage on each main MV bus are monitored by the PS to detect either a degraded voltage condition or a loss of voltage condition. ~~If the voltage measurements for two of the three phases on a bus fall below a fixed setpoint for a fixed amount of time, a degraded voltage condition exists.~~ If the voltage measurements for two of the three phases on a bus fall below a fixed setpoint (Min DEGV) for a fixed amount of time and an SIS signal is received, a degraded voltage condition exists. After this fixed amount of time, if the voltage measurements for two of the three phases on a bus stay below the same fixed setpoint (Min DEGV) for an additional fixed amount of time without an SIS, a degraded voltage condition exists. If the voltage measurements for two of the three phases on a bus fall below a lower fixed setpoint (Min LOV) for a fixed amount of time, a loss of voltage condition exists. In ~~either case~~these cases, a LOOP signal is generated within the PS which starts the corresponding EDG and begins the loading sequence. All four EDGs are also started automatically when a safety injection signal is generated, but they are not connected to the EPSS unless a LOOP signal is also generated.

The automatic EDG start and load sequence consists of the following:

- Each main MV bus is monitored for proper voltage and if ~~the voltage is below a setpoint for greater than a predetermined period of time~~a degraded voltage condition or loss of voltage condition exists, a LOOP signal is generated.
- The EDG is started.
- The EPSS is isolated from the division's preferred sources of power.
- The large loads are removed from the EPSS.
- The EDG is connected to the EPSS.
- The loads are sequenced onto the EPSS.

In general, smaller loads that were energized before the loss of power automatically re-start when power from the EDG becomes available. This functionality is provided by the priority modules associated with each actuator. Large electrical loads are sequenced onto the EPSS according to diesel load steps (DLS) to maintain EDG output voltage and frequency reductions within acceptable limits. The PS performs the DLS functionality by maintaining an "off" signal to the actuators, and then removing the signal to a sub-set of actuators at each load step which allows them to be re-started. Essential service water (ESW) pumps and component cooling water (CCW) pumps are automatically started as part of the load sequence regardless of whether or not they were previously running.

When a LOOP signal is generated, different DLS sequences are used depending on whether or not a safety injection signal is also present. The different sequences are detailed in Table 8.3-4 through Table 8.3-7.

In absence of a safety injection signal, the CCW and ESW pumps are started as part of the first two load steps. The "off" signal is removed from the safety injection components at their predefined steps, but the safety injection pumps are not started. If a safety injection signal is generated after the LOOP-only loading sequence has begun, the sequence is stopped, the LOCA mitigation loads are started, then the LOOP-only sequence is re-entered and completed.

If a safety injection signal is present when the LOOP signal is generated, the LOCA mitigation loads are started in the first several steps of the load sequence. The other loads are then sequenced onto the EPSS according to pre-defined load steps.

The EDG actuation function is implemented in the PS architecture differently than the remainder of the ESF actuation functions. The three phases of voltage measurement for any one electrical division are acquired by the corresponding PS division. The processing and actuation of the related EDG are also carried out completely within the same PS division. For the actuation of any one EDG, redundancy within the PS is obtained by utilizing the functionally independent sub-systems within each division. Both sub-systems within a division acquire the voltage measurements and either sub-system can actuate the same EDG. For this function, the two ALU within a sub-system are combined in an "functional AND" logic. The result of the "functional AND" logic in each sub-system are combined in an "functional OR" logic so that either sub-system within a division can start the corresponding EDG.

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The capability for manual system-level start-up of EDGs on a per-EDG basis is provided on the SICS in the MCR. Two manual system-level controls are provided per EDG. Either of the two controls starts the desired EDG.

The capability for component-level control of the EDG is available to the operator on both the PICS and the SICS in the MCR.

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The sense and command outputs for EDG actuation can be manually reset from the SICS in the MCR. Reset of the sense and command outputs does not result in change of state of the actuators; it allows the operator to take further manual actions to change the state of individual actuators.

The functional logic used to generate an EDG actuation order is shown in Figure 7.3-23—EDG Actuation.

7.3.1.2.13 Pressurizer Safety Relief Valve Opening (Brittle Fracture Protection)

The integrity of the reactor pressure vessel (RPV) must be protected under all plant conditions. During normal power operation, overpressure protection is provided by three spring-loaded PSRVs. At low coolant temperatures, the cylindrical part of the vessel could fail by brittle fracture before the design pressure of the RCS is reached. In cold operating conditions, low-temperature overpressure protection (LTOP) is provided by opening two of the three PSRVs via redundant electrical solenoids values.

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Operation of the PSRVs is described in Section 5.4.13.

The U.S. EPR design uses the following initiating conditions to actuate PSRV opening:

- Hot leg pressure (NR) > Max1p.
- Hot leg pressure (NR) > Max2p.

PSRV opening orders are generated when two-out-of-four NR hot leg pressure (NR) measurements are above either setpoint. The setpoints are staggered with Max1p <

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Max2p. One PSRV is opened at each setpoint. Each division of PS actuates one solenoid valve.

To avoid spurious PSRV opening during power operation, this function is automatically bypassed when cold leg temperature is above the P17 permissive setpoint. Operator action is required to remove the bypass when temperature is below the P17 permissive setpoint. Generation of the P17 permissive signal is discussed in ~~Section 7.2.1.3~~Section 7.2.1.3.12.

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The capability for manual system-level PSRV opening on a per-PSRV basis is provided to the operator on the SICS in the MCR. Two manual system-level initiation controls are provided per PSRV, both of which must be activated to open a PSRV.

The capability for component-level control of the PSRV redundant solenoid valves is available to the operator on both the PICS and the SICS in the MCR.

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No manual reset of the PSRV opening sense and command output is required. The output is automatically reset when the hot leg pressure measurements return within an acceptable range. Reset of the sense and command output results in valve closure.

The functional logic for automatic PSRV opening is shown in Figure 7.3-24—PSRV Opening (Brittle Fracture Protection).

7.3.1.2.14 Steam Generator Isolation

In case of an SGTR, partial cooldown is initiated to depressurize the RCS to the point where MHSI becomes effective. The SG containing the tube rupture is isolated after the partial cooldown is initiated if a high SG level or high main steam activity level is detected. This is done to prevent the release of contaminated fluid from the affected SG, and to prevent other water sources from adding to the uncontrolled SG level increase. SG isolation consists of the following main actions:

- MSRT opening setpoint increase.
- MSIV, MSIV bypass, and SG blowdown closure.
- MFW and SSS isolation.
- EFWS isolation (confirmatory action; EFWS should already be isolated as described in Section 7.3.1.2.3).

Operation of the main steam system is described in Section 10.3. Operation of the SG blowdown system is described in Section 10.4.8. Operation of the MFW and SSS systems is described in Section 10.4. Operation of the EFW system is described in Section 10.4.9.

The U.S. EPR design uses the following initiating conditions to actuate SG isolation:

- Partial cooldown actuated and SG level (NR) > Max2p.
- Partial cooldown actuated and main steam activity > Max1p.

SG isolation orders are generated when two-out-of-four SG level (NR) measurements on any one SG exceed the Max2p setpoint and partial cooldown has been actuated. The same isolation orders are generated when two-out-of-four main steam activity measurements on any one SG exceed the Max1p setpoint and partial cooldown has been actuated. In both cases, only the affected SG is isolated and the partial cooldown function is performed via the remaining SGs.

The SG ~~I~~isolation function is bypassed when hot leg temperature is below the P13 permissive setpoint. Generation of the P13 permissive signal is discussed in ~~Section 7.2.1.3~~Section 7.2.1.3.8. However, when the partial cooldown actuation function is bypassed (Section 7.3.1.2.4), the SG isolation function is bypassed by association to the partial cooldown actuation signal.

The capability for manual system-level initiation of SG isolation on a per SG basis is provided on the SICS in the MCR. Four manual system-level initiation controls are provided per SG, any two of which will isolate the desired SG.

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The capability for component-level control of the actuators used in SG isolation is available to the operator on both the PICS and the SICS in the MCR. For an SGTR event, the operator is credited to perform a manual system-level initiation of SG isolation from the SICS in the MCR. Operator actions credited in mitigating accidents are addressed in Section 15.0.0.3.7.

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Reset of the SG isolation sense and command output is available from ~~both~~ the ~~PICS and~~ SICS in the MCR and the RSS. A reset of the sense and command output does not result in a change of state of the isolation actuators; it allows the operator to take further actions to manipulate individual components as may be necessary to follow plant operating procedures.

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The functional logic for automatic SG isolation is shown in Figure 7.3-25—SG Isolation (Div. 1&2) and in Figure 7.3-26—SG Isolation (Div. 3&4).

7.3.1.2.15 Reactor Coolant Pump Trip

In case of a SBLOCA, RCPs are tripped when conditions indicate that two-phase flow is present. This is done because the RCPs may subsequently be lost due to cavitation or operation in a degraded environment. Forced convection of the two-phase flow increases the mass lost via the break. If the RCPs are permitted to operate for an extended period of time in this condition and then are shut down, an inadequate core cooling condition may occur due to insufficient liquid inventory as the two phases separate. For this reason, an automatic RCP pump trip is provided early after two-phase flow is indicated, while the void fraction is still relatively low, to enhance long term accident mitigation and minimize the potential for RCS mass depletion.

Additionally, the RCPs are tripped on a containment isolation (stage two2) signal.

The operation of the RCPs is described in Section 5.4.1.

The U.S. EPR design uses the following initiating conditions to actuate RCP trip:

- ΔP across RCP < Min1p and SIS actuation signal generated.
- Stage two cContainment isolation (stage 2) signal generated.

The RCP trip based on differential pressure across the RCP results from one of two ΔP measurements below the Min1p setpoint on any two-of-the-four RCPs. A safety injection signal must also be present in addition to the low ΔP condition for this actuation to occur. This reduces the possibility of a spurious RCP trip.

The parameters that result in RCP trip due to a stage two containment isolation (stage 2) are described in Section 7.3.1.2.9.

When the conditions for RCP trip are satisfied, orders are issued to open the circuit breakers that supply power to each RCP. When the orders are issued, a time delay begins. When the time delay expires, an order is issued to trip the corresponding bus supply circuit breaker upstream of the RCP circuit breaker to remove power from the RCP.

There are no operating bypasses associated with the RCP trip function.

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The capability for manual system-level RCP trip on a per-pump basis is provided to the operator on the SICS in the MCR. Two system-level initiation controls are provided for each pump. Either of the controls will trip the desired RCP.

The capability for component-level control for the RCP trip function is available to the operator on both the PICS and the SICS in the MCR. Following an FWLB, manual trip of two RCPs from the SICS is credited. Operator actions credited in mitigating accidents are addressed in Section 15.0.0.3.7. 07.03-27

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When RCP trip has occurred due to low ΔP measurements, concurrent with a safety injection signal, the sense and command output can be reset manually regardless of whether or not the safety injection signal has been reset. The manual reset is available on both PICS and SICS in the MCR. When RCP trip based on stage two containment isolation (stage 2) occurs, the RCP trip output is reset when the stage two containment isolation (stage 2) output is reset. 07.03-27

The functional logic for automatic actuation of RCP trip is shown in Figure 7.3-27—RCP Trip.

7.3.1.2.16 Main Control Room Air Conditioning System Isolation and Filtering

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This function is provided to maintain the habitability of the MCR during ~~design basis accidents~~ anticipated operational occurrences (AOO) and postulated accidents (PA) when the MCR and associated rooms become vulnerable to a radioactive environment.

The U.S. EPR design uses the following initiating conditions to isolate and filter the MCR air conditioning system:

- MCR air intake activity > Max1p.

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- Containment isolation (stage 1) signal.

High radioactivity is detected by two sensors located in each of two MCR air intake ducts (four sensors total). If any one out of the four sensors detects activity, orders are generated by the PS to isolate both intakes and to re-route the air flow path through iodine filtering units.

The parameters that result in the isolation and filtering of the MCR air conditioning system due to a containment isolation (stage 1) are described in Sections 7.3.1.2.9.

There are no operating bypasses associated with this function.

The capability for manual system-level initiation of this function is provided on the SICS in the MCR. Two manual system-level initiation controls are provided, any one of which reconfigures both air intake paths.

The capability for component-level control of the actuators for this function is available to the operator on both the PICS and the SICS in the MCR.

Reset of the MCR air intake reconfiguration sense and command outputs is available from ~~both~~ the ~~PICS and~~ SICS in the MCR. A reset of the sense and command output does not result in a change of state of the actuators; it allows the operator to take further actions to manipulate individual components as may be necessary to follow plant operating procedures. 07.03-27

The functional logic for MCR air conditioning system isolation and filtering is shown in Figure 7.3-28—MCR Air Conditioning System Isolation and Filtering.

7.3.1.2.17 Turbine Trip on Reactor Trip ~~Confirmation~~Initiation

A turbine trip (TT) is required following any RT in order to avoid a mismatch between primary and secondary power, which would result in excessive RCS cooldown with a potential inadvertent return to critical conditions and a power excursion.

A short delay is implemented between the RT activation and the TT demand to limit the overpressure effect.

The U.S. EPR design uses the following initiating condition to actuate the TT:

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- ~~Confirmation of~~ RT Initiation.

~~The logic used to confirm RT breaker opening is described in Section 7.3.1.2.8.~~ The various conditions that lead to RT are described in Section 7.2.

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Each divisional TT signal from the PS is sent to the TG I&C via a hardwired, isolated connection. A two-out-of-four logic is performed in each division of the TG I&C on the four PS divisional signals. These connections between the PS and TG I&C are shown in Figure 7.1-27.

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The capability for manual system-level initiation of TT is provided on the SICS in the MCR. Four manual system-level initiation controls are provided; the activation of any two of the four results in turbine trip.

The capability for component-level control for the TT function is available to the operator on both the PICS and the SICS in the MCR.

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Manual reset of the sense and command output for TT ~~is not required; it can be reset only by resetting the RT breakers~~is available from the SICS in the MCR. A reset of the sense and command output does not result in a change of the state of the actuators; it allows the operator to take further actions to manipulate individual components as may be necessary to follow plant operating procedures.

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The functional logic for turbine trip is shown in Figure 7.3-29—Turbine Trip on Reactor Trip Initiation.

7.3.1.2.18 Hydrogen Mixing Dampers Opening

This function provides convection and atmospheric mixing in the event of an AOO or PA to enable atmospheric circulation within the whole Reactor Containment Building.

The U.S. EPR design uses the following initiating conditions to open the hydrogen mixing dampers (HMD):

- Containment service compartment pressure (NR) > Max1p.
- Containment equipment compartment/containment service compartment ΔP > Max1p.

If two-out-of-four service compartment pressure (NR) measurements exceed the Max1p setpoint, then orders are generated by the PS to open the HMDs. Additionally, the HMDs are opened if the differential pressure between the service compartment and equipment compartment exceeds the Max1p setpoint. This differential pressure is detected by eight differential pressure measurements (two in each division of the PS). If two-out-of-eight equipment compartment/service compartment ΔP measurements exceed the Max1p setpoint, then orders are generated by the PS to open the HMDs.

There are no operating bypasses associated with this function.

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The capability for manual system-level initiation of this function is provided on the SICS in the MCR. Four manual system-level initiation controls are provided, any two of which will open the HMDs.

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The capability for component-level control for the HMD opening function is available to the operator on both the PICS and the SICS in the MCR.

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Reset of the hydrogen mixing dampers opening sense and command outputs is available from the SICS in the MCR. A reset of the sense and command output does not result in a change of state of the actuators; it allows the operator to take further actions to manipulate individual components as may be necessary to follow plant operating procedures. 07.03-27

The functional logic for hydrogen mixing dampers opening is shown in Figure 7.3-30—Hydrogen Mixing Dampers Opening.

7.3.2 Analysis

7.3.2.1 Design Basis Information

Clause 4 of IEEE Std 603-1998 (Reference 5) specifies the information used to establish the design basis for safety-related systems. This section discusses design basis information for the ESF actuation functions. These functions are performed automatically by the PS and the PACS, and manually through the SICS in conjunction with the PS and PACS. The design basis information related to the equipment of these safety-related systems, environmental conditions in which they must function, and methods used to determine their reliability are discussed in Section 7.1.

The design basis information below pertains to the requirements placed on the ESF actuation functions and the variables monitored to initiate ESF systems.

7.3.2.1.1 Design Basis: Applicable Events (Clause 4.a and 4.b of IEEE Std 603-1998)

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The ~~design basis events~~AOOs and PAs requiring protective action are analyzed in Chapter 15. The initiating events analyzed are listed in Table 15.0-1. The initial conditions analyzed for each event are presented in Table 15.0-6. Correlation between each event and specific ESF actuation functions is found in Table 15.0-10.

7.3.2.1.2 Design Basis: Permissive Conditions for Operating Bypasses (Clause 4.c of IEEE Std 603-1998)

The operating bypasses applicable to each ESF actuation function are identified in Section 7.3.1.2.1 through ~~Section 7.3.1.2.17~~Section 7.3.1.2.18. Each operating bypass (permissive signal) is described in Section 7.2.1.3. The functional logic used to generate each operating bypass is also specified in Section 7.2.1.3.

7.3.2.1.3 Design Basis: ESF Actuation Input Variables (Clause 4.d of IEEE Std 603-1998)

Each ESF actuation function is listed in Table 15.0-8 with the relevant nominal trip setpoint, normal and degraded uncertainties, and time delays for the function. For each of these functions, Table 7.3-1—ESF Actuation Variables lists the input variables that are used either directly or as inputs to a calculation to actuate an ESF system. The range to be monitored for each of these variables is also listed in Table 7.3-1.

7.3.2.1.4 Design Basis: Manual ESF System Actuation (Clause 4.e of IEEE Std 603-1998)

The capability for manual system-level actuation and manual component level control of ESF actuators is available to the operator as described in Section 7.3.1.1. Manual actions credited to mitigate ~~design basis events~~AOOs and PAs are identified in Section 15.0, Section 7.2, and in each credited function in Section 7.3.1.2. The variables to be displayed to the operator to use in manual ESF actuation are determined as part of the methodology used for selecting Type A PAM variables as described in Section 7.5.

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7.3.2.1.5 Design Basis: Spatially Dependent Variables (Clause 4.f of IEEE Std 603-1998)

The U.S. EPR design uses no spatially dependent variables as inputs to ESF actuation functions.

7.3.2.1.6 Design Basis: Critical Points in Time or Plant Conditions (Clause 4.j of IEEE Std 603-1998)

The PS initiates operation of ESF systems when selected variables exceed the associated setpoints. The plant conditions that define the proper completion of the safety function performed by an ESF system are defined on an event-by-event basis in the Chapter 15 analyses. The actions of the execute features for an ESF actuation function are complete when, for example, a valve has reached its full open or full closed position, or required flow has been established by a pump.

The ESF actuation logic generally allows ESF actuation outputs generated by the PS to be reset after completion of the actions of the execute features. The reset of the ESF actuation signal does not result in change of state (return to normal) of the ESF actuator. Plant specific operating procedures govern the point in time when the ESF actuators can be returned to normal following their actuation.

7.3.2.2 Failure Modes and Effects Analysis

A system-level failure modes and effect analysis (FMEA) is performed on the PS to identify potential single point failures and their consequences. The architecture of the PS as defined in the U.S. EPR Digital Protection System Technical Report (ANP-10309P) (Reference 1) is used as the basis for the analysis. The FMEA considers each major part of the system, how it may fail, and the effect of the failure on the system.

Because the PS is an integrated RT and engineered safety features actuation system (ESFAS), a single failure in the system has the potential to affect both types of functions. Therefore, a single FMEA is performed on the PS and the effects on both RT and ESFAS functions are considered. The result of the FMEA with regard to ESF actuation functions is in ANP-10309P.~~summarized in this section. A summary of the effects of single failures on the RT functions is provided in Section 7.2.~~

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~~To define the major parts of the system for which failures are assumed, a single division of the PS is divided into functional units as described in Reference 1. The PS consists of four identical divisions, so the definition of functional units is the same for each division. The following are defined as functional units that participate in the generation of automatic ESF actuation functions and are included in the analysis:~~

- ~~Acquisition and processing units (APU).~~
- ~~Actuation logic units (ALU).~~

~~In addition to the equipment defined as functional units of the system, the following equipment contribute to automatic ESF actuation functions and are analyzed as part of the system-level FMEA:~~

- ~~Sensors that provide input measurements to ESF actuation functions.~~
- ~~Hardwired output logic used in ESF actuation function.~~
- ~~PACS priority modules.~~

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In order to bound the possible failures, both detected and undetected failures of sensors and digital equipment are analyzed and the worst case effect of each failure is identified. Detected failures are defined as those automatically detected by the inherent and engineered monitoring mechanisms of the system. Two types of undetected failures are analyzed. A failure denoted "undetected – spurious" is defined as a failure not automatically detected which results in a spurious partial trigger or actuation. A failure denoted "undetected – blocking" is defined as a failure not automatically detected which results in failure to issue a partial trigger or actuation when needed.

Failures in the hardwired output logic are generally not detected automatically by the PS. Therefore, only undetected single failures of these devices are considered. A failure of the output logic can result in a spurious actuation ("undetected – spurious"), or failure to actuate when needed ("undetected – blocking").

Network failures within the PS allow the receiver of data to be affected in one of three ways. First, the network failure can result in an invalid message being received. By definition, invalid messages are always detected failures, and are analyzed as single failures. Second, a network failure can result in a message received as valid that contains spurious information. This type of failure is bounded by the "undetected – spurious" failure of the sending equipment, and is therefore not considered. Third, a network failure can result in a message received as valid that fails to request an action when one is needed. This type of failure is bounded by the "undetected – blocking" failure of the sending equipment, and is therefore not considered. Further information regarding the communication methods used and communication failure detection capabilities is found in Reference 1 and in the Reactor Protection System Topical Report (Reference 2).

The architecture of the PS allows APUs and ALUs to be analyzed for single failure without regard to which specific APU or ALU in the division is the failure point. For these single failures, all functions of the system are considered affected, as every function is processed by at least one APU and two ALU in a division. Considering the effect on every function of the system bounds all cases of specific APU and ALU single failures.

When referring to the nature of a single failure, the terms "detected" and "undetected" used in the context of the PS FMEA do not correspond to the definition of a detectable failure in Reference 5. All of the failures denoted "undetected" in the FMEA are detectable through periodic testing. The terms "detected" and "undetected", as used in the FMEA, refer to the ability of the PS to automatically detect a failure through self-surveillance.

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~~Failures of instrument air systems are not considered in support of the PS FMEA. The ESF actuation and control functions in the U.S. EPR design do not rely on common instrument air systems.~~

~~The results of the FMEA with regard to the effects of single failures on ESF actuation functionality are summarized in Table 7.3-2—FMEA Summary for ESF Actuations.~~

~~The unique nature of the EDG actuation function described in Section 7.3.1.2.12 requires unique treatment in the FMEA. In this case, redundancy is obtained completely within a single division of the PS, so the results of the system level FMEA do not hold true for this function. The FMEA results for the EDG actuation function are summarized in Table 7.3-3—FMEA Summary for EDG Actuation.~~

~~The number and allocation of sensors as inputs to the RCP trip function described in Section 7.3.1.2.15 require unique treatment in the FMEA as well. The FMEA Results for the RCP trip function are summarized in Table 7.3-4—FMEA Summary for RCP Trip.~~

7.3.2.3 Compliance with and Conformance to Applicable Criteria

7.3.2.3.1 Compliance ~~of~~with ESF Actuation Functions to the Single Failure Criterion (Clause 5.1 of IEEE Std 603-1998)

The PS maintains the ability to perform all ESF actuation functions in the presence of any credible single failure of an input sensor, functional unit of the PS, or PACS priority module. This is an extension of the redundancy designed into the ESF systems themselves. In general, different divisions of the PS are assigned to actuate those parts of an ESF system considered redundant to one another. Additional redundancy is designed into the PS in the form of redundant ALUs within each division, each capable of actuating one redundant portion of an ESF system.

In most cases, single failures upstream of the ALU voting logic (sensor or APU failure) are accommodated by the voting logic. The voting logic is modified to disregard the input affected by the failure and the ability to actuate based on the remaining inputs is retained. In the case of the EDG actuation function, sensor failures are accommodated

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by a ~~second min. signal selection~~two-out-of-three voting logic. Failure of an APU is accommodated in the EDG actuation function by a redundant APU in the other subsystem of the same division performing the same function.

Single failures at the level of the voting logic are accommodated by both redundancy within each division and redundancy between more than one division. In all cases, either of two redundant ALUs within a division can actuate one redundant portion of an ESF function and, except for EDG actuation and EFWS isolation, at least one other division can actuate a second redundant portion of the same ESF function. In the cases of the EDG actuation and the EFWS isolation functions, either of two redundant ALU within a division can perform the voting logic and actuation portions of the functions.

Single failures of PACS priority modules are bounded by the single failure tolerance of the ESF systems themselves. An individual PACS priority module is assigned to each individual actuator so that the failure of a single PACS priority module is no different than the failure of the actuator itself.

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A system level FMEA is performed to verify ~~conformance~~compliance with the single failure criterion. The FMEA is ~~described in Section 7.3.2.2, and the results are summarized in Table 7.3-2, Table 7.3-3, and Table 7.3-4~~in ANP-10309P.

7.3.2.3.2 Compliance ~~to~~with Requirements and Conformance to Guidances for Quality of Components and Modules (Clause 5.3 of IEEE Std 603-1998 and Clause 5.3 of IEEE Std 7-4.3.2-2003)

Protection system components and modules that are required to perform ESF actuation functions are classified as safety-related, are designed to Class 1E standards, and are applied in accordance with a stringent quality assurance program. Software used to perform ESF actuation functions is developed and applied in accordance with a safety-related software program. Further discussion of ~~conformance~~compliance ~~to~~with requirements for quality is found in Section 7.1.

7.3.2.3.3 Compliance ~~to~~with Requirements for Independence of ESF Actuation Functions (Clauses 5.6 and 6.3 of IEEE Std 603-1998 and GDC 24)

Redundant portions of the PS are independent from one another so that a failure in any one portion of the system does not prevent the redundant portions from performing an ESF actuation function. Both electrical and communication independence are maintained as described in Section 7.1 and in ANP-10309P~~Reference 1~~.

Equipment required to perform ESF actuation functions is independent from the effects of the events which the ESF function mitigates. The functional units of the PS are located in areas that are not subject to degraded environmental conditions as the result of an event. Equipment located in areas subject to a degraded environment following an event (e.g., sensors) is qualified to operate as required in the expected post-event environment. Environmental qualification of instrumentation and control equipment is discussed in Section 3.11 and Section 7.1.

The PS does not rely on input from any non-safety-related control system to perform an ESF actuation function. The plant accident analysis does not credit actions taken by non-safety-related control systems to improve the response of ESF actuation functions. If a control system action can make the effects of an event more severe, then the action is assumed to occur. In this way, the ESF actuation function is demonstrated to mitigate the event independently of any non-safety-related control system. Certain sensor measurements are shared as inputs to both an ESF actuation function and a plant control function. In these cases, the measurement is acquired by the signal conditioning of the PSSCDS. The signal is multiplied and passed to the control system through an electrically isolated connection, to maintain the independence of the ESF actuation function. Single failures of shared sensors do not impair the functioning of the control system or the ESF actuation function.

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ConformanceCompliance towith requirements concerning independence of safety-related instrumentation and control (I&C) systems is addressed further in Section 7.1.

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7.3.2.3.4 Compliance towith Requirements for Completion of Protective Action (Clauses 5.2 and 7.3 of IEEE Std 603-1998)

Once an ESF actuation function is initiated by the PS, the intended actions of the execute features proceed to completion. The return-to-normal state of ESF actuators requires deliberate operator intervention. In most cases, operator action is required to reset the actuation signal, and separate operator action is required to change the state of the actuated device. When operator action is not required to reset the actuation signal, measures are taken to prevent change in state of the actuated device until the intended actions of the execute features are completed. In many cases, the removal of the PS actuation order from the associated PACS priority module does not result in a change of state of the actuator (e.g., motor operated valves). In cases where removal of the PS actuation order from the associated PACS priority module would result in the actuator changing state (e.g., certain solenoid operators), seal-in features are incorporated in the execute features. These seal-in features allow the reset of the actuation signal while requiring additional operator action to affect the state of the actuated device.

7.3.2.3.5 Compliance towith Requirements Concerning Diversity and Defense in Depth (Clause 5.16 of IEEE Std 603-1998)

A non-safety-related diverse actuation system (DAS) is provided to perform selected automatic ESF actuation functions in the unlikely event of an common cause softwareSWCCF failure that renders the entire PS inoperable. The hardware and software technology utilized in the DAS are diverse from that used in the PS so that the DAS cannot be subject to the same common cause failure as the PS. The functionality of the DAS is described in Section 7.1 and Section 7.8.

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Additionally, manipulation of every ESF system component at the individual component level is available through a processing path completely diverse from the software-based portions of the PS.

The overall EPR I&C approach to diversity and defense in depth is described in the ~~Instrumentation and Control~~U.S. EPR Diversity and Defense-in-Depth Assessment Technical Report (ANP-10304) (Reference 3).

7.3.2.3.6 Compliance ~~to~~with System Testing and Inoperable Surveillance Requirements (Clause 5.7 of IEEE Std 603-1998)

The design of the PS allows for testing of automatic ESF actuation functions while retaining the capability to perform the functions in response to an event requiring protective action. The majority of the PS and PACS components required for ESF actuation can be tested with the reactor at power. Surveillance of the PS consists of overlapping tests to verify performance of the ESF actuation function from sensor to PACS priority module. Surveillance of the ESF system components consists of actuating the component through the PACS priority module in a manner that overlaps the PS surveillance of the PACS priority module.

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The functional units ~~computerized portions~~ of the PS are continuously monitored through self-testing during power operation. During outages, extended ~~computer~~ self-testing is performed to verify functionality that cannot be tested with the reactor at power.

Sensors and acquisition circuits are periodically tested. The input channel to be tested is placed in a lockout condition, and the downstream voting logic is automatically modified to disregard the input being tested. The ESF actuation functions are still performed using the redundant input channels.

The connections between the PS output circuits and the PACS priority modules can be tested during power operation. One division of the PS is tested at a time and the outputs of the PACS priority modules are disabled so that the actuators are not affected by the test. If an ESF actuation order is generated during the time that a PACS priority module is in test mode, the outputs of the PACS priority module are enabled and the ESF actuation is carried out.

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7.3.2.3.7 ~~Compliance to Requirements~~Conformance to Guidance Regarding the Use of Digital Systems (IEEE~~-~~ Std 7-4.3.2-2003)

The automatic ESF actuation functions are implemented using the TELEPERM XS digital platform (Reference 2) which is approved for use in safety-related systems of nuclear power generating stations in the United States. The ESF actuation functions are implemented in an architecture designed to satisfy requirements applicable to all safety-related I&C systems, digital or otherwise.

Implementation of safety-related I&C systems is governed by the requirements of IEEE Std 603-1998 (Reference 5). Compliance with this requirement is described in Section 7.1. Guidance on the use of digital computers in safety-related systems is provided by IEEE Std 7-4.3.2-2003 (Reference 6). Conformance to ~~these standards~~ this guidance is described in Section 7.1.

7.3.2.3.8 ~~Conformance to~~Compliance with Requirements for ESF Actuation Setpoint Determination (Clause 6.8 of IEEE Std 603-1998)

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Each setpoint used to actuate an ESF system is selected based on the safety limits assumed in the plant accident analysis. The ESF actuation setpoints provide margin to the safety limit and take into account measurement uncertainties. The methodology to determine setpoints for ESF actuation functions is documented in the U.S. EPR Instrument Setpoint Topical Report (ANP-10275P-A) (Reference 4). The single-sided measurement uncertainty reduction factor shall not be used in determining U.S. EPR setpoints.

7.3.3 References

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1. ANP-10309P, Revision ~~0~~2, "U.S. EPR Digital Protection System Technical Report," AREVA NP Inc., ~~November 2009~~May 2011.

2. EMF-2110(NP)(A), Revision 1, "TELEPERM XS: A Digital Reactor Protection System," Siemens Power Corporation, July 2000.

3. ANP-10304, Revision ~~1~~3, "U.S. EPR Diversity and Defense-In-Depth Assessment Technical Report," AREVA NP Inc., ~~December 2009~~May 2011.

4. ANP-10275P-A, Revision 0, "U.S. EPR Instrument Setpoint Methodology Topical Report," AREVA NP Inc., ~~March 26, 2007~~January 2008.

5. IEEE Std 603-1998, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, 1998.

6. IEEE Std 7~~.~~-4.3.2-2003, "IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, 2003.

Table 7.3-1—ESF Actuation Variables
(Sheet 1 of 2)

Protective Function	Variables To Be Monitored	Range of Variables
Safety Injection System Actuation	Pressurizer Pressure (NR)	1615-2515 psia
	Hot Leg Pressure (WR)	15-3015 psia
	Hot Leg Temperature (WR)	32-662°F
07.03-32	RCSHot Leg Loop Level	0-30.71 in.
Reactor Coolant Pump Trip	RCP differential pressure	0-120% nominal
Emergency Feedwater System Actuation	SG Level (WR)	0-100% MR
Emergency Feedwater System Isolation	SG Level (WR)	0-100% MR
SG Isolation	Main Steam Line Activity	$1x10^{-1}$ – $1x10^{4}$ counts/ sec.
	SG Level (NR)	0-100% MR
Main Steam Relief Isolation Valve OpeningTrain Actuation	SG Pressure	15-1615 psia
Main Steam Relief Train Isolation	SG Pressure	15-1615 psia
Main Steam Isolation	SG Pressure	15-1615 psia
	Cont. Equipment Compartment Pressure	-3 to +7 psig
	Cont. Service Compartment Pressure (NR)	-3 to +7 psig
Main Feedwater Isolation	SG Level (NR)	0-100% MR
	SG Pressure	15-1615 psia
07.03-32	RT Breaker Position	Open/Closed
	Cont. Equipment Compartment Pressure	-3 to +7 psig
	Cont. Service Compartment Pressure (NR)	-3 to +7 psig
Containment Isolation	Cont. Service Compartment Pressure (NR)	-3 to +7 psig
	Cont. Service Compartment Pressure (WR)	-5 to +220 psig
	Cont. Equipment Compartment Pressure	-3 to +7 psig
	Containment High Range Activity	$1x10^{-1}$ – $1x10^{7}$ Rad/hr
Emergency Diesel Generator Actuation	6.9 kV Bus Voltage	0-8.625 kV
PSRV Opening	Hot Leg Pressure (NR)	0-870 psia
CVCS Charging Isolation	Pressurizer Level (NR)	0-100% MR

Table 7.3-1—ESF Actuation Variables
(Sheet 2 of 2)

Protective Function	Variables To Be Monitored	Range of Variables
CVCS Isolation for Anti-Dilution	Boron Concentration	0-5000 ppm
	~~Boron Temperature~~	~~32-212°F~~
	CVCS Charging Flow	0-320,000 lb/hr
	Cold Leg Temperature (WR)	32-662°F
MCR ~~A/C~~Air Conditioning System Isolation and Filtering	MCR Air Intake Duct Activity	$1x10^{-5} - 1x10^{1}$ Rad/hr
~~Turbine Trip~~	~~RT Breaker Position~~	~~Open/Closed~~
Hydrogen Mixing Dampers Opening 07.03-32	Cont. Service Compartment Pressure (NR)	-3 to +7 psig
	Cont. Equipment Compartment and Cont. Service Compartment Differential Pressure	-7.25 to +7.25 psi

Notes on Table 7.3–1: MR = Measuring Range

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Table 7.3-2—Deleted~~FMEA Summary for ESF Actuations~~

~~(Sheet 1 of 2)~~

~~Single Failure~~	~~Nature of Failure~~	~~System Response (Effect on ESF Actuation Portion)~~	~~Effect on Plant~~
~~Sensors~~	~~Detected~~	~~Failed sensor marked invalid; Downstream voting logic modified to 2/3~~	~~None~~
	~~Undetected—Spurious~~	~~Downstream voting logic becomes 1/3~~	~~None~~
	~~Undetected—Blocking~~	~~Downstream voting logic becomes 2/3~~	~~None~~
~~APU~~	~~Detected~~	~~All signals sent from APU marked invalid; Downstream voting logic modified to 2/3~~	~~None~~
	~~Undetected—Spurious~~	~~Downstream voting logic becomes 1/3~~	~~None~~
	~~Undetected—Blocking~~	~~Downstream voting logic becomes 2/3~~	~~None~~
~~Network APU—ALU~~	~~Detected~~	~~All signals sent from APU marked invalid; Downstream voting logic modified to 2/3~~	~~None~~
~~ALU~~	~~Detected~~	~~ALU fails into state requesting no actuation; Redundant ALU performs the function~~	~~None~~
	~~Undetected—Spurious~~	~~ALU fails into state requesting actuation; A spurious divisional actuation signal is generated~~	~~Spurious actuation of the actuators of one division (Note 1)~~
	~~Undetected—Blocking~~	~~The affected ALU cannot issue actuation orders; Redundant ALU performs the function~~	~~None~~
~~Hardwired Output Logic~~	~~Undetected—Spurious~~	~~Spurious divisional actuation signal is generated~~	~~Spurious actuation of the actuators of one division (Note 1)~~
	~~Undetected—Blocking~~	~~The division cannot generate actuation signal; Redundant divisions remain operational (Note 2)~~	~~None~~

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Table 7.3-2—Deleted~~FMEA Summary for ESF Actuations~~

~~(Sheet 1 of 2)~~

~~Single Failure~~	~~Nature of Failure~~	~~System Response (Effect on ESF Actuation Portion)~~	~~Effect on Plant~~
~~Priority Module~~	~~Undetected—Spurious~~	~~Spurious actuation signal given to attached actuator~~	~~Spurious actuation of a single actuator (Note 1)~~
	~~Undetected—Blocking~~	~~Failure to actuate attached actuator; Redundant divisions remain operational (Note 2)~~	~~None~~

~~Notes:~~

1. ~~Plant actuators which, if spuriously actuated, can challenge plant safety require actuation signals from more than one division to actuate (e.g., more than one pilot operator actuated from different divisions are required to change the state of the main valve).~~
2. ~~For EFWS isolation function, redundancy is within the same division with two sets of hardwired logic and two separate priority modules.~~

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Table 7.3-3—DeletedFMEA Summary for EDG Actuation (Sheet 1 of 2)

Single Failure	Nature of Failure	System Response (Effect on ESF Actuation Portion)	Effect on Plant
6.9 kV sensor	Detected	Failed sensor marked invalid; 2/3 voting logic modified to 1/2	None
	Undetected - Spurious	2/3 voting logic becomes 1/2	None
	Undetected - Blocking	2/3 voting logic satisfied by remaining two sensors	None
APU	Detected	All signals sent from APU marked invalid; Affected sub-system cannot perform the function; Function is performed by other sub-system in same division.	None
	Undetected - Spurious	Spurious actuation signal given to ALUs in affected sub-system	Spurious start of 1 EDG
	Undetected - Blocking	Affected sub-system cannot perform function; Function is performed by other sub-system in same division	None
Network APU - ALU	Detected	All signals sent from APU marked invalid; Affected sub-system cannot perform the function; Function is performed by other sub-system in same division.	None
ALU	Detected	ALU fails into state requesting no actuation; Affected sub-system cannot perform the function; Function is performed by other sub-system in same division. (Note 1)	None
	Undetected - Spurious	ALU fails into state requesting actuation; Actuation is blocked by "AND" logic with other ALU in same sub-system; Function is performed by other ALU in same sub-system. (Note 1)	None
	Undetected - Blocking	The affected sub-system cannot perform the function; Function is performed by other sub-system in same division. (Note 1)	None
Hardwired Output Logic	Undetected - Spurious	Spurious divisional actuation signal is generated	Spurious start of 1 EDG
	Undetected - Blocking	The division cannot generate actuation signal; 1 EDG cannot be started; plant level safety functions are performed by 3 redundant electrical divisions	Failure to start 1 EDG

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Table 7.3-3—DeletedFMEA Summary for EDG Actuation (Sheet 2 of 2)

Single Failure	Nature of Failure	System Response (Effect on ESF Actuation Portion)	Effect on Plant
Priority Module	Undetected - Spurious	Not Applicable; The EDG start signal does not use a PAC module, it is sent to the EDG controls	None
	Undetected - Blocking	Not Applicable; The EDG start signal does not use a PAC module, it is sent to the EDG controls	None

Notes:

1. The outputs to start EDG from the two ALU in each sub-system are combined in "AND" logic. The result of the "AND" logic of each sub-system is combined with the same from the other sub-system within the division. In this configuration, redundancy is obtained between sub-systems rather than between the two ALU within a sub-system.

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Table 7.3-4—Deleted~~FMEA Summary for RCP Trip (Sheet 1 of 2)~~

~~Single Failure~~	~~Nature of Failure~~	~~System Response (Effect on ESF Actuation Portion)~~	~~Effect on Plant~~
~~dP Sensor~~	~~Detected~~	~~Failed sensor marked invalid; 1/2 voting logic modified to 1/1~~	~~None~~
	~~Undetected - Spurious~~	~~2/4 voting logic becomes 1/3~~	~~None~~
	~~Undetected - Blocking~~	~~Redundant dP sensor performs the function~~	~~None~~
~~RCP Stopped Sensor~~	~~Detected~~	~~Sensor is invalidated; 2/3 voting logic modified to 1/2~~	~~None~~
	~~Undetected - Spurious~~	~~2/3 voting logic becomes 1/2~~	~~None~~
	~~Undetected - Blocking~~	~~2/3 voting logic becomes 2/2~~	~~None~~
~~APU~~	~~Detected~~	~~All signals sent from APU marked invalid; 2/4 voting logic modified to 2/3~~	~~None~~
	~~Undetected - Spurious~~	~~2/4 voting logic becomes 1/3~~	~~None~~
	~~Undetected - Blocking~~	~~2/4 voting logic becomes 2/3~~	~~None~~
~~Network APU - ALU~~	~~Detected~~	~~All signals sent from APU marked invalid; 2/4 voting logic modified to 2/3~~	~~None~~
~~ALU~~	~~Detected~~	~~ALU fails into state requesting no actuation; Redundant ALU in the division performs the function~~	~~None~~
	~~Undetected - Spurious~~	~~ALU fails into state requesting actuation; A spurious divisional actuation signal is generated (Note 1)~~	~~Spurious trip of 1 RCP~~
	~~Undetected - Blocking~~	~~The affected ALU cannot issue actuation orders; Redundant ALU performs the function~~	~~None~~
~~Hardwired Output Logic~~	~~Undetected - Spurious~~	~~Spurious divisional actuation signal is generated~~	~~Spurious trip of 1 RCP~~
	~~Undetected - Blocking~~	~~The division cannot generate actuation signal; After time delay, another division opens redundant breaker~~	~~None~~

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Table 7.3-4—DeletedFMEA Summary for RCP Trip (Sheet 2 of 2)

Single Failure	Nature of Failure	System Response (Effect on ESF Actuation Portion)	Effect on Plant
Priority Module	Undetected - Spurious	Spurious actuation signal given to attached actuator	Spurious trip of 1 RCP
	Undetected - Blocking	Failure to actuate attached actuator; After time delay, another division opens redundant breaker	None

Note:

1. The failure of a processing unit such that all outputs are "1" is not a postulated single failure mode. The failure in question would result from an output card failing with all outputs "1". Therefore the two RCP trip outputs from the same ALU (to two different pumps) must be through different output cards. This precludes the single failure from resulting in multiple spurious pump trips.

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Figure 7.3-1—~~Typical~~ ESF Actuation (Sheet 1 of 5)

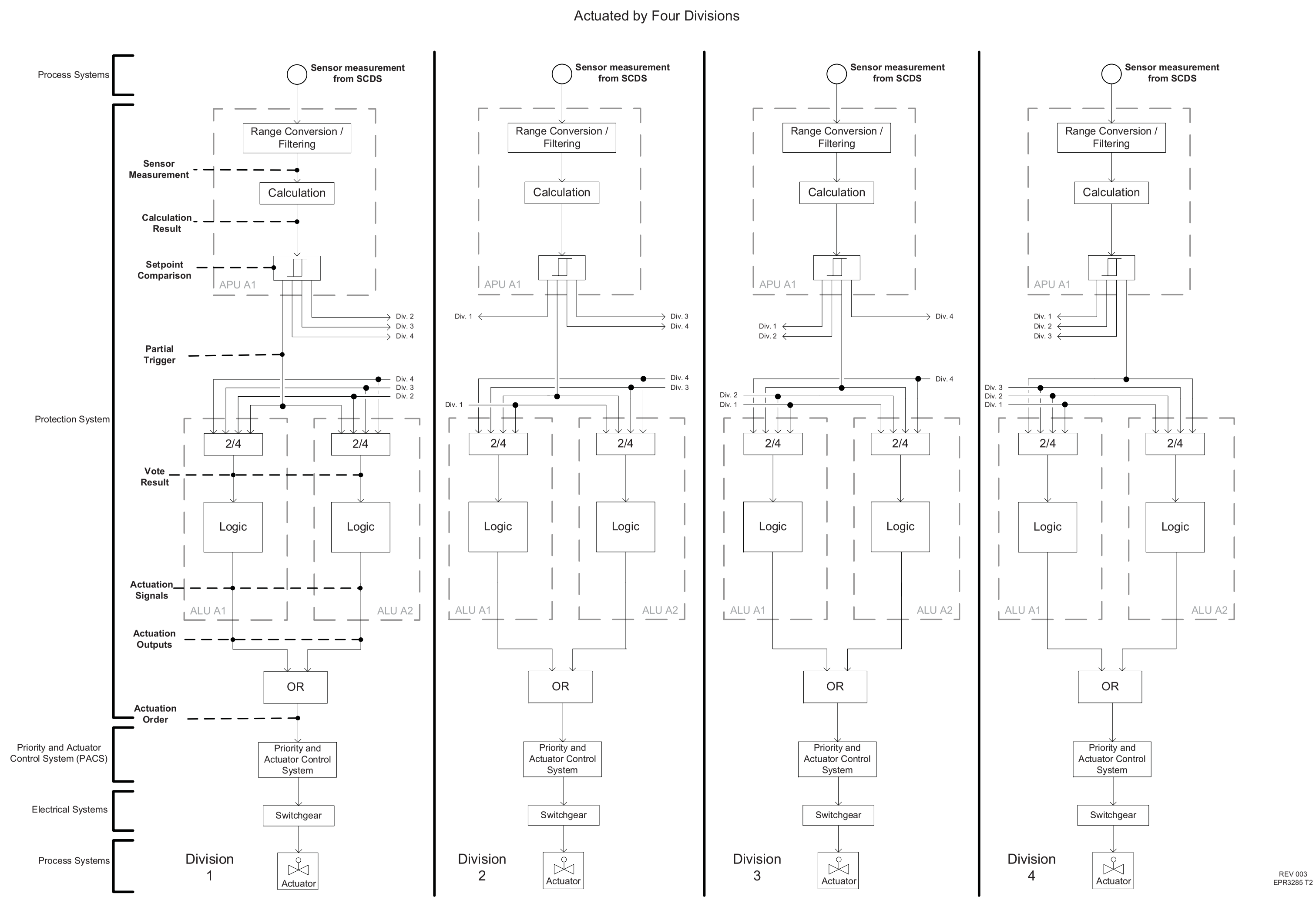

Figure 7.3-1—ESF Actuation (Sheet 2 of 5)

Manual Actuation

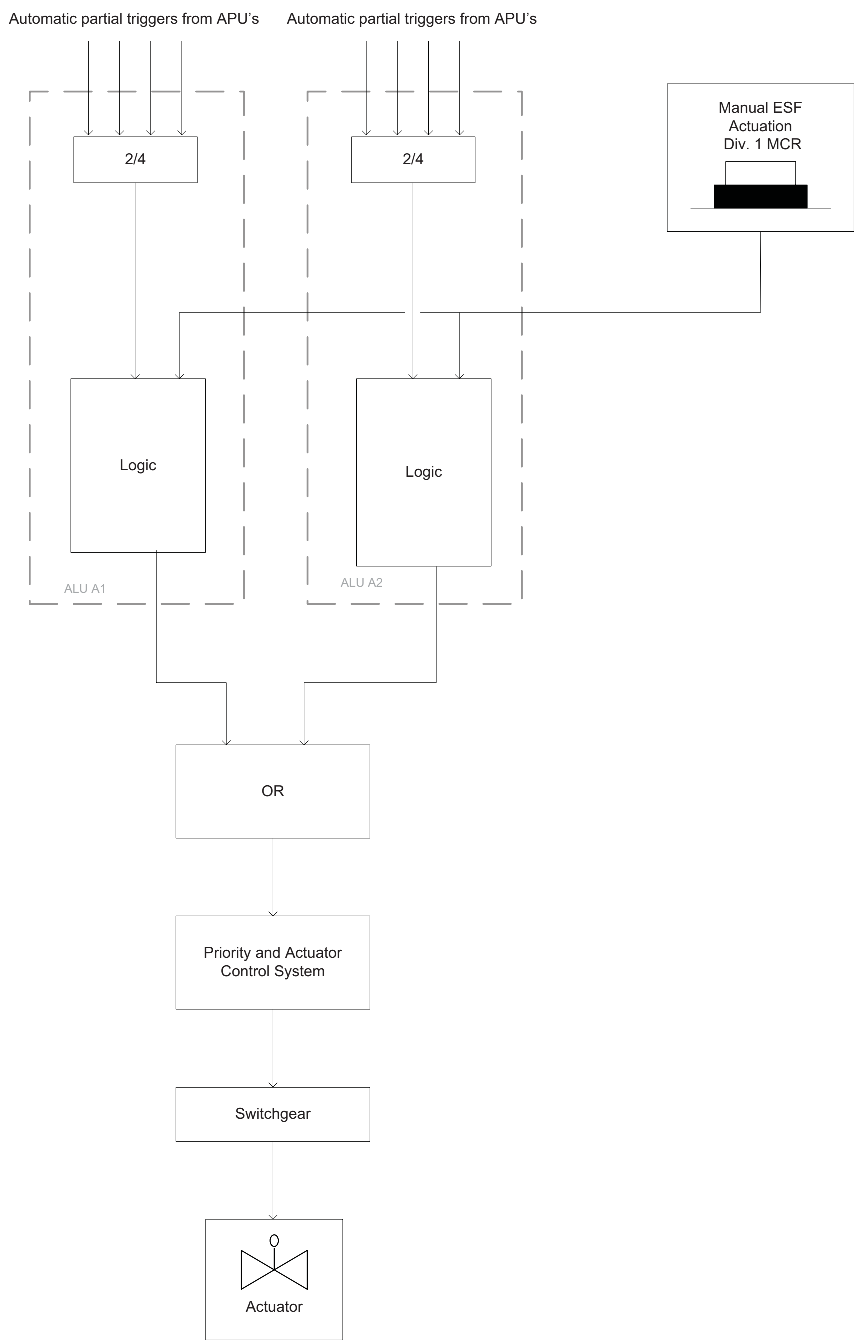

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Figure 7.3-1—ESF Actuation (Sheet 3 of 5)

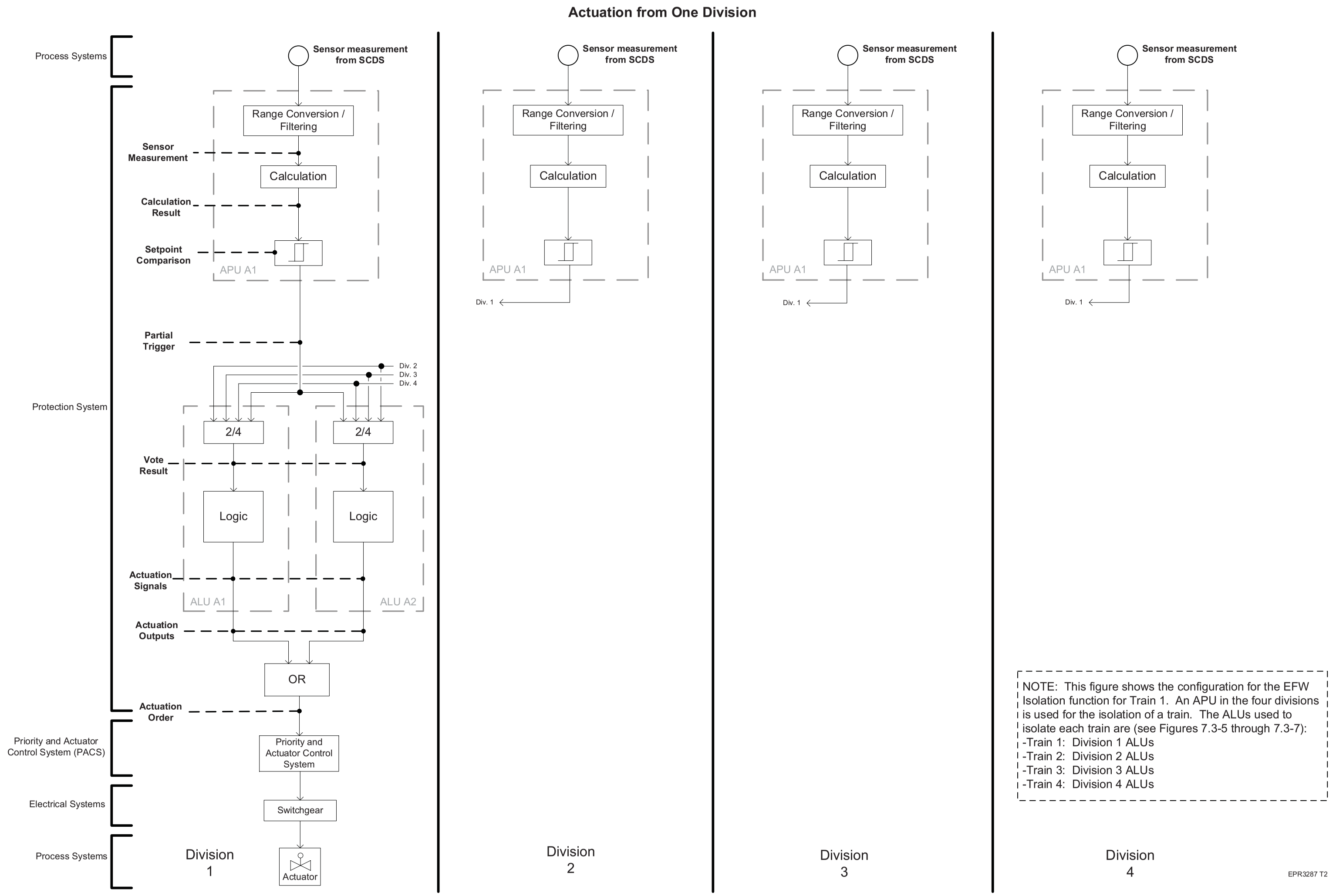

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Figure 7.3-1—ESF Actuation (Sheet 4 of 5)

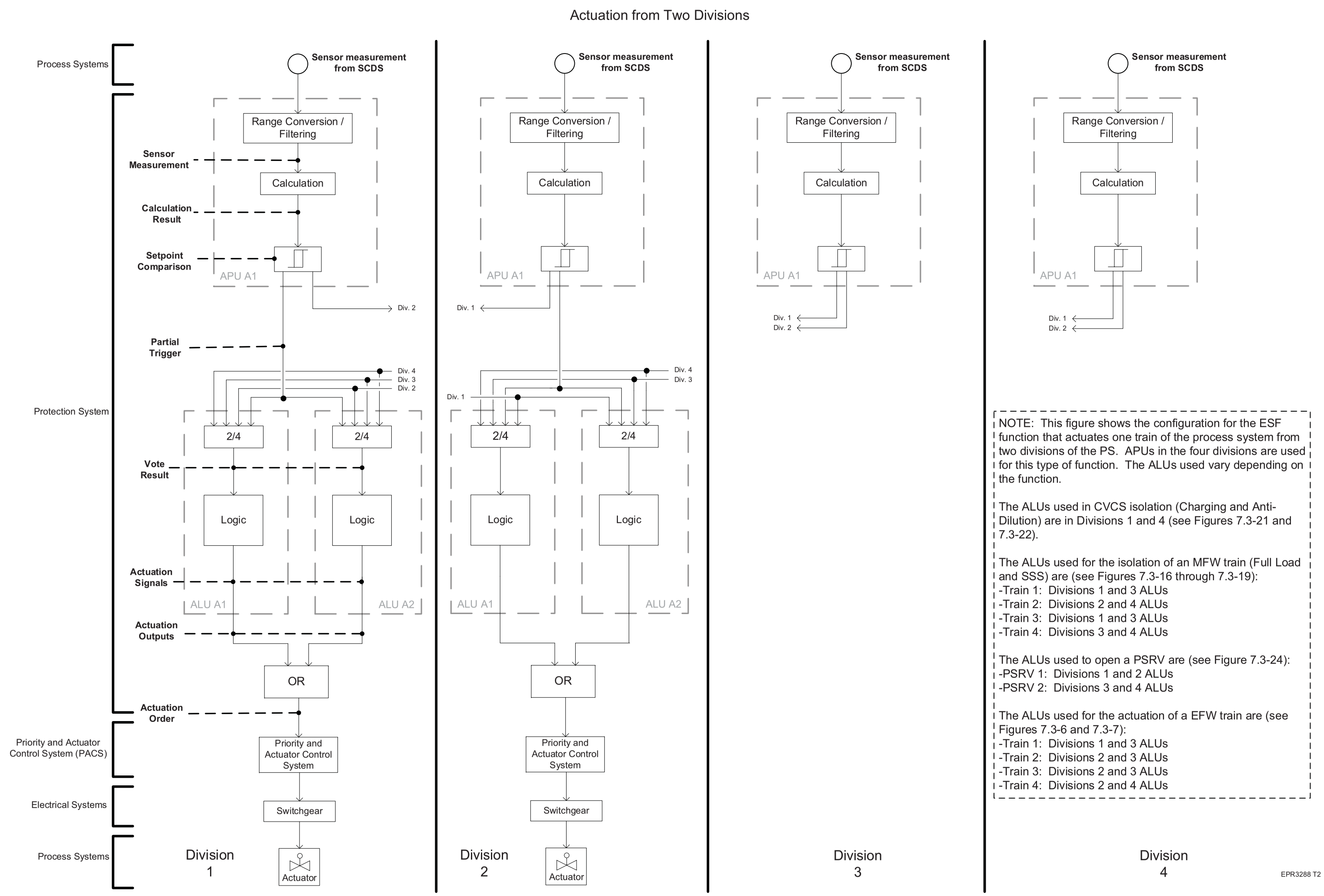
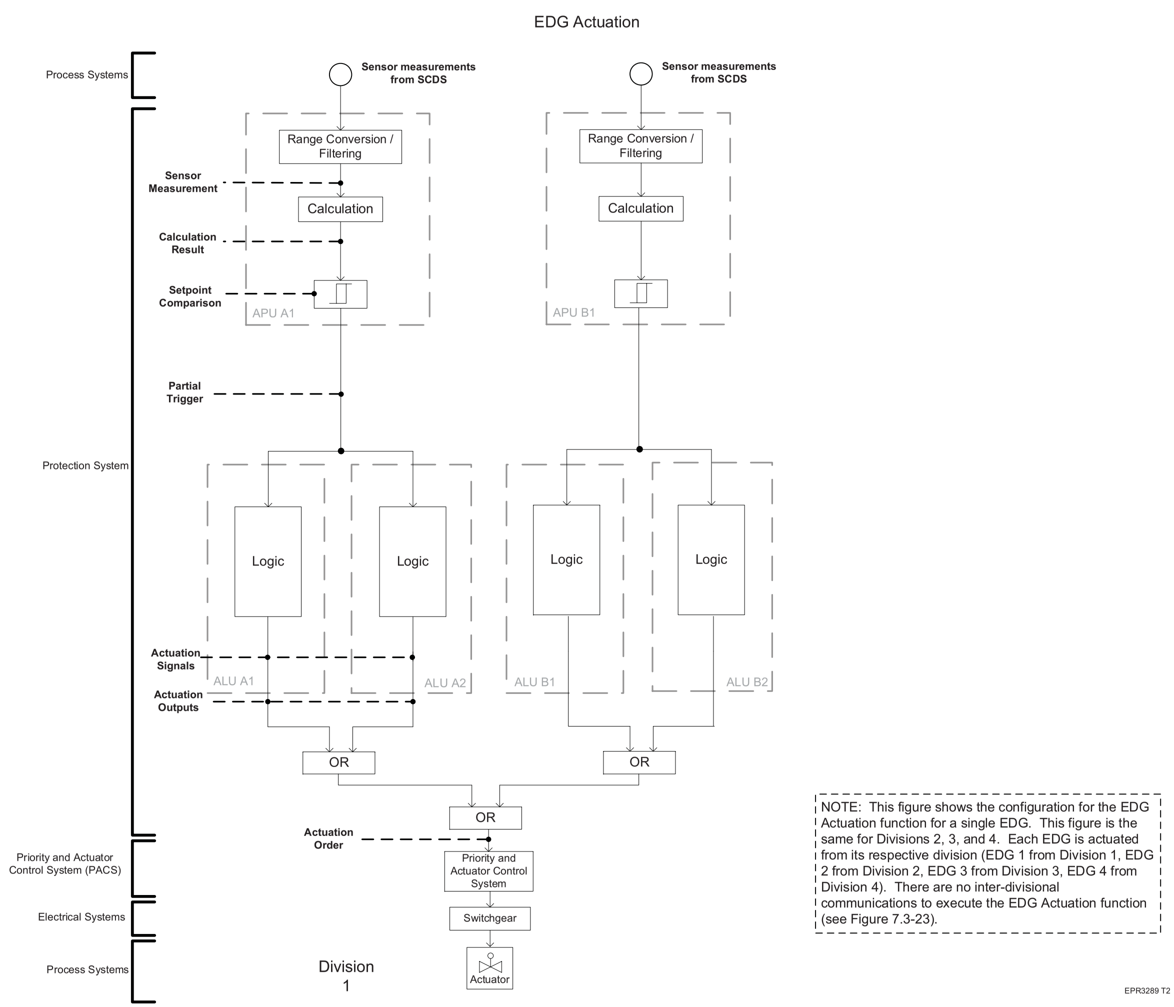


Figure 7.3-1—ESF Actuation (Sheet 5 of 5)



NOTE: This figure shows the configuration for the EDG Actuation function for a single EDG. This figure is the same for Divisions 2, 3, and 4. Each EDG is actuated from its respective division (EDG 1 from Division 1, EDG 2 from Division 2, EDG 3 from Division 3, EDG 4 from Division 4). There are no inter-divisional communications to execute the EDG Actuation function (see Figure 7.3-23).

Figure 7.3-2—SIS Actuation

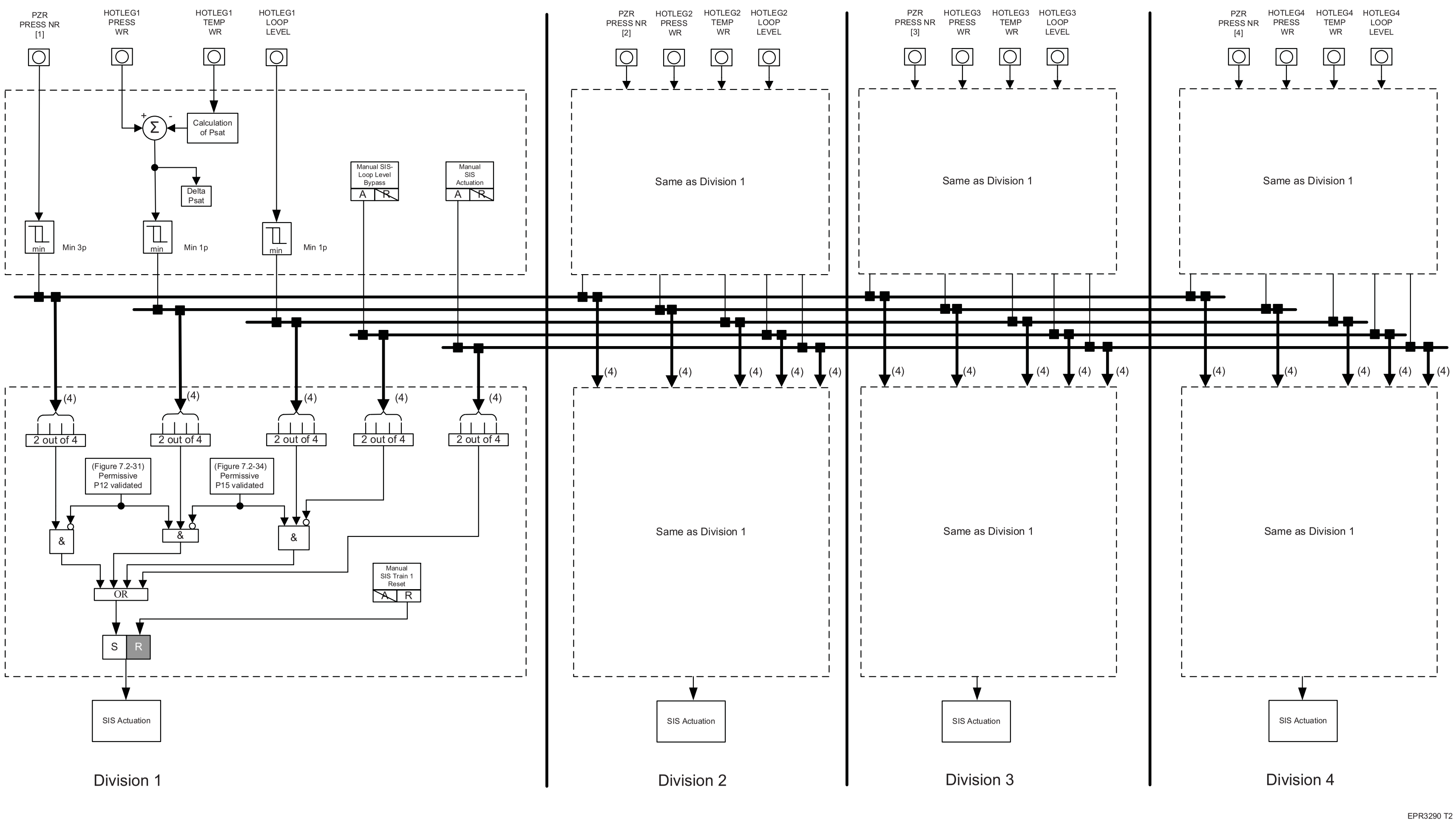


Figure 7.3-3—EFWS Actuation

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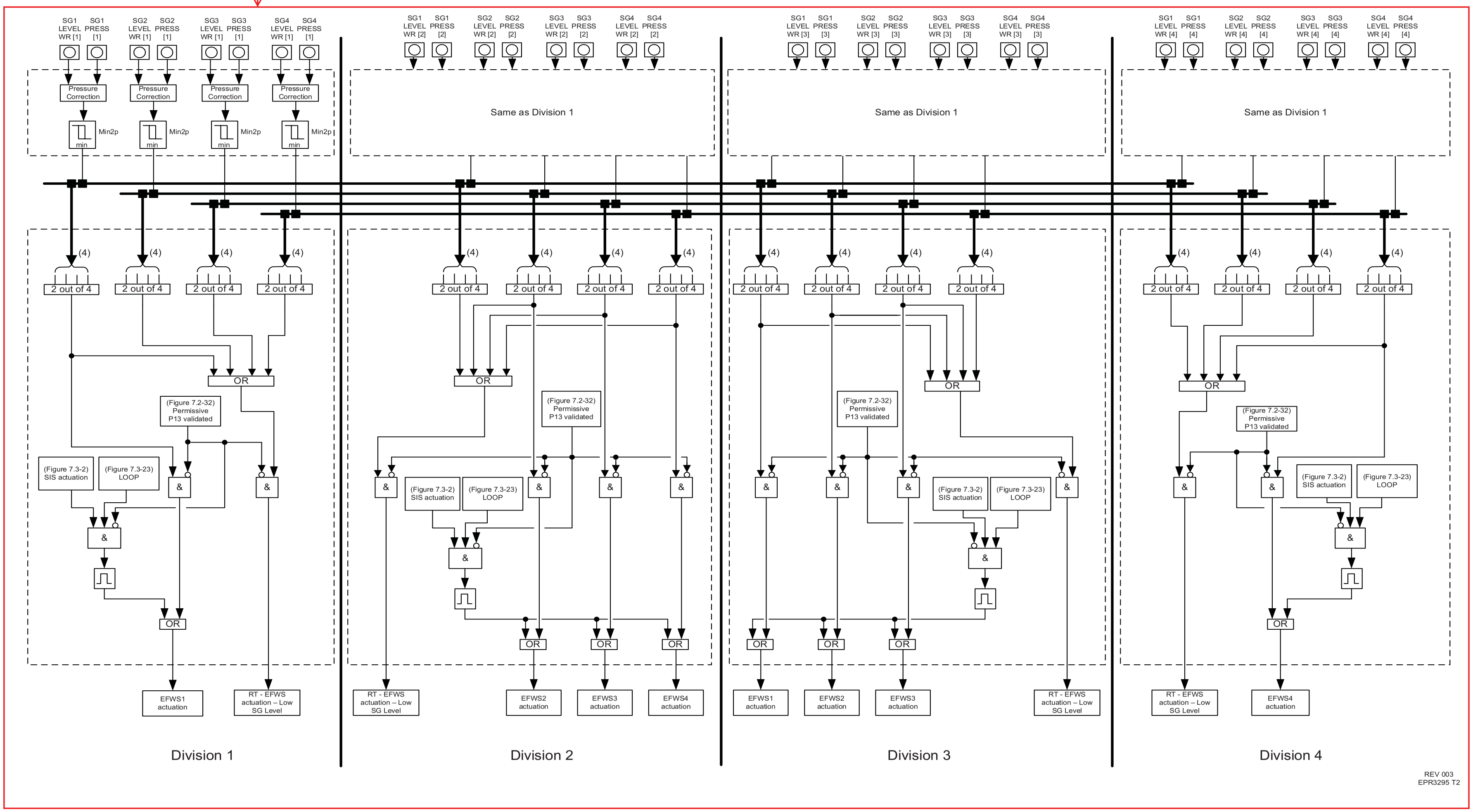

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Figure 7.3-4—EFWS SG Level Control and Pump Flow Protection

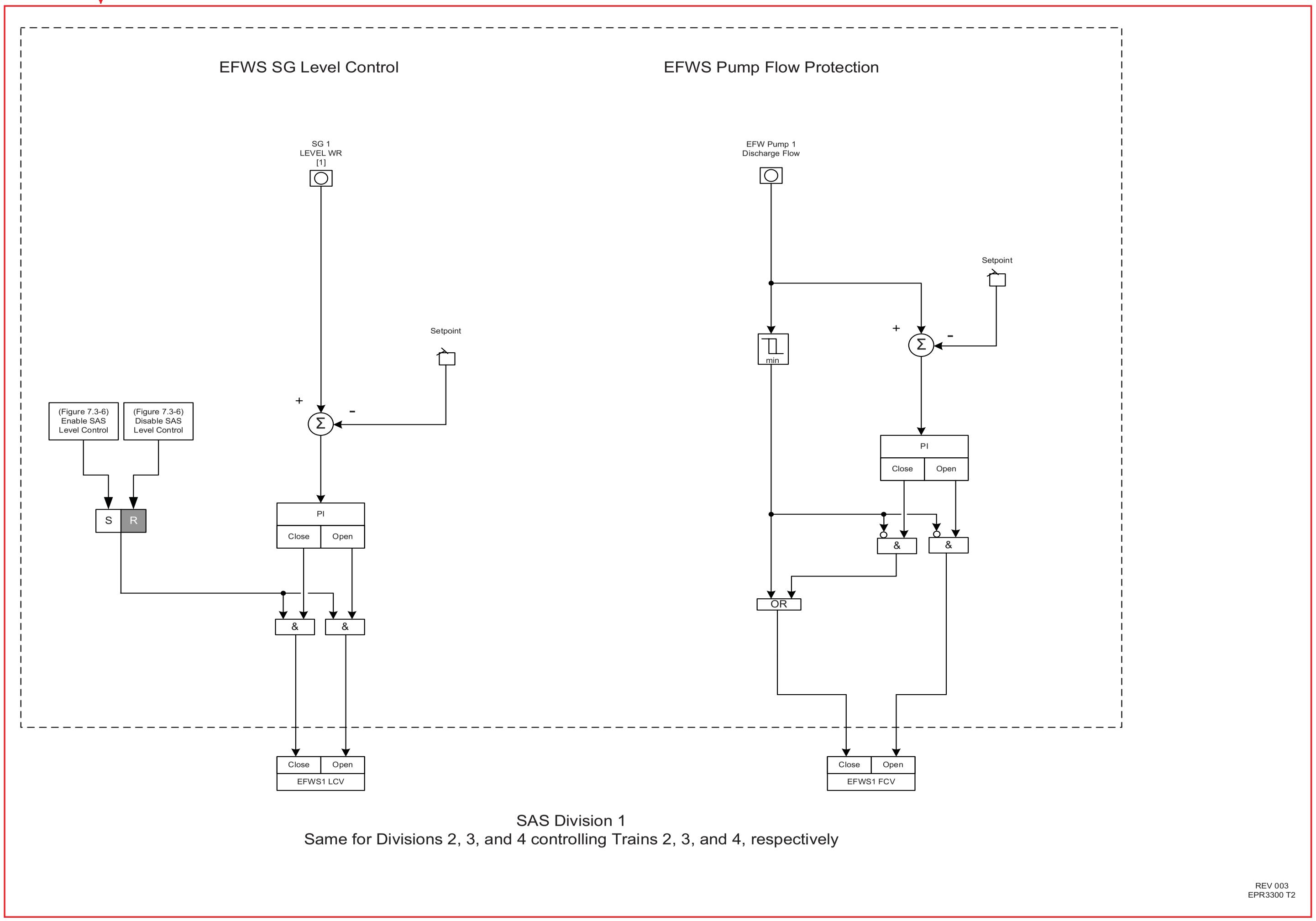

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Figure 7.3-5—EFWS Isolation

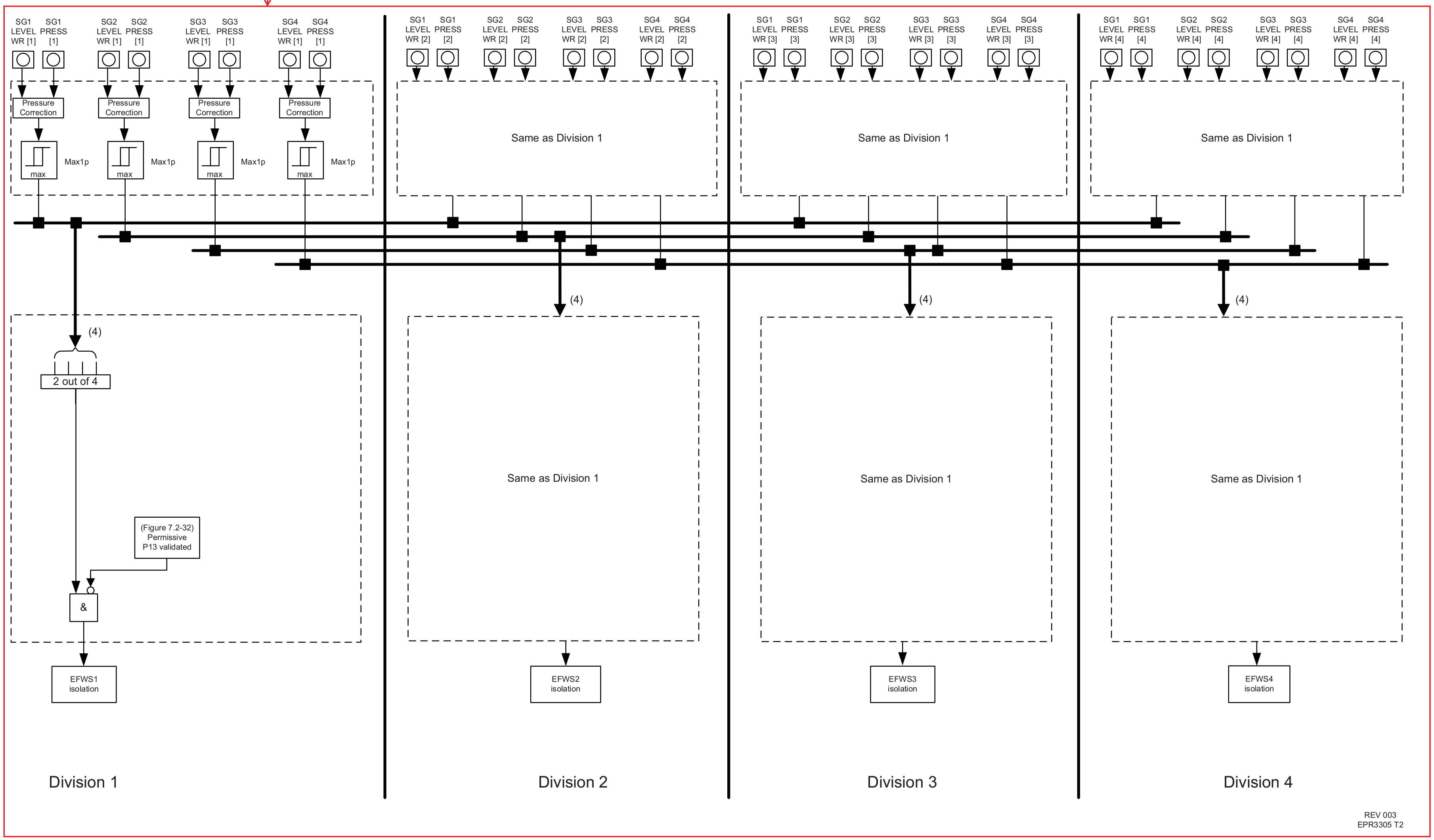

Figure 7.3-6—EFWS Actuators (Div. 1&2)

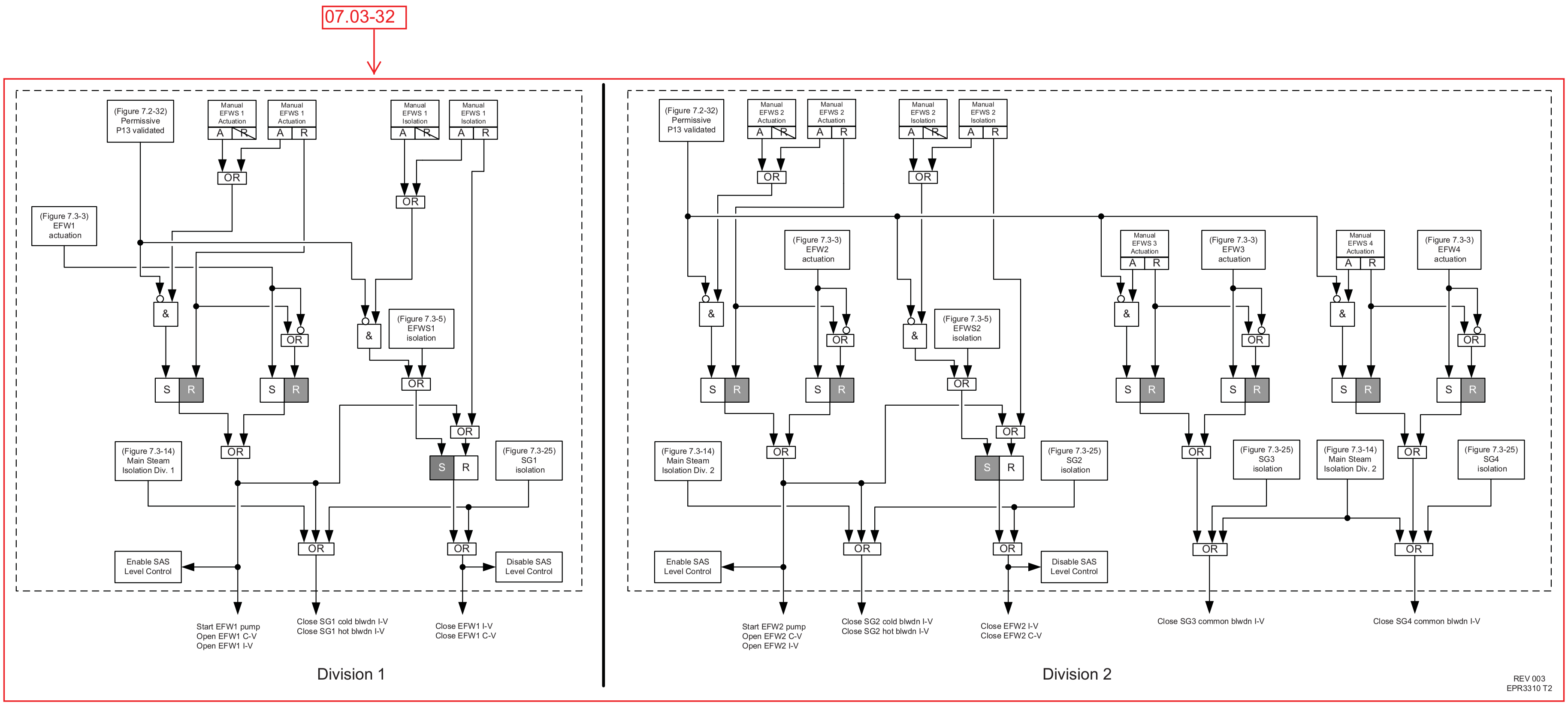

Figure 7.3-7—EFWS Actuators (Div. 3&4)

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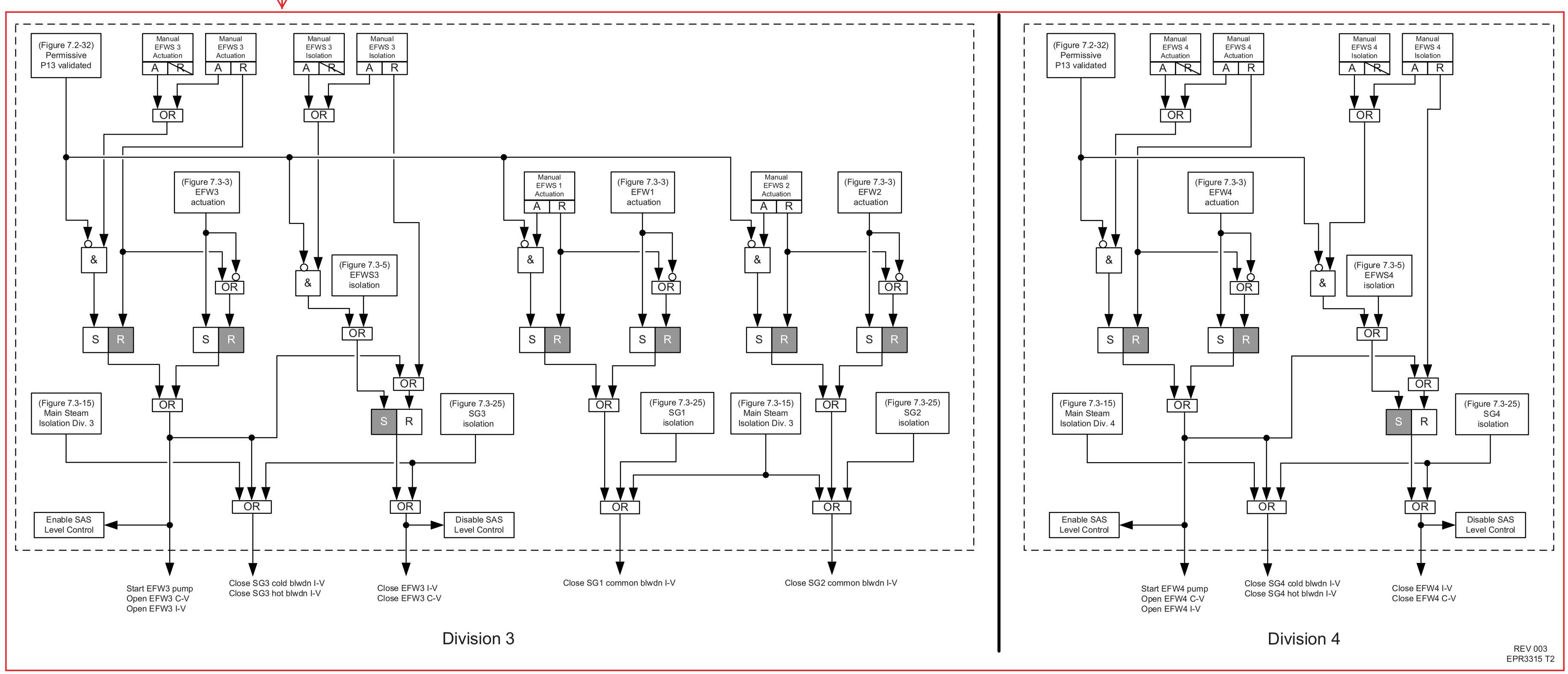

Figure 7.3-8—Partial Cooldown Actuation

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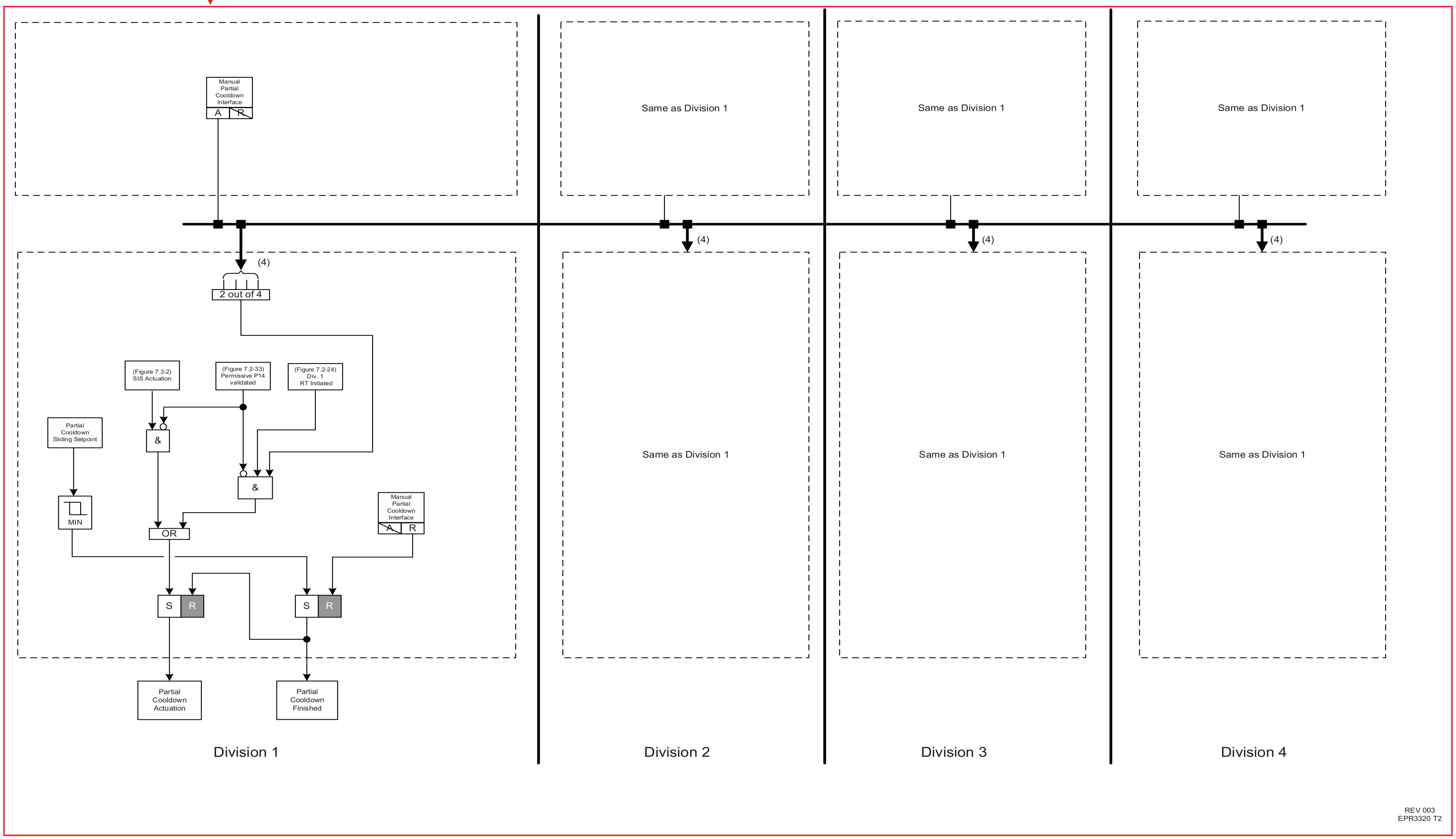

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Figure 7.3-9—MSRT Setpoint Formation

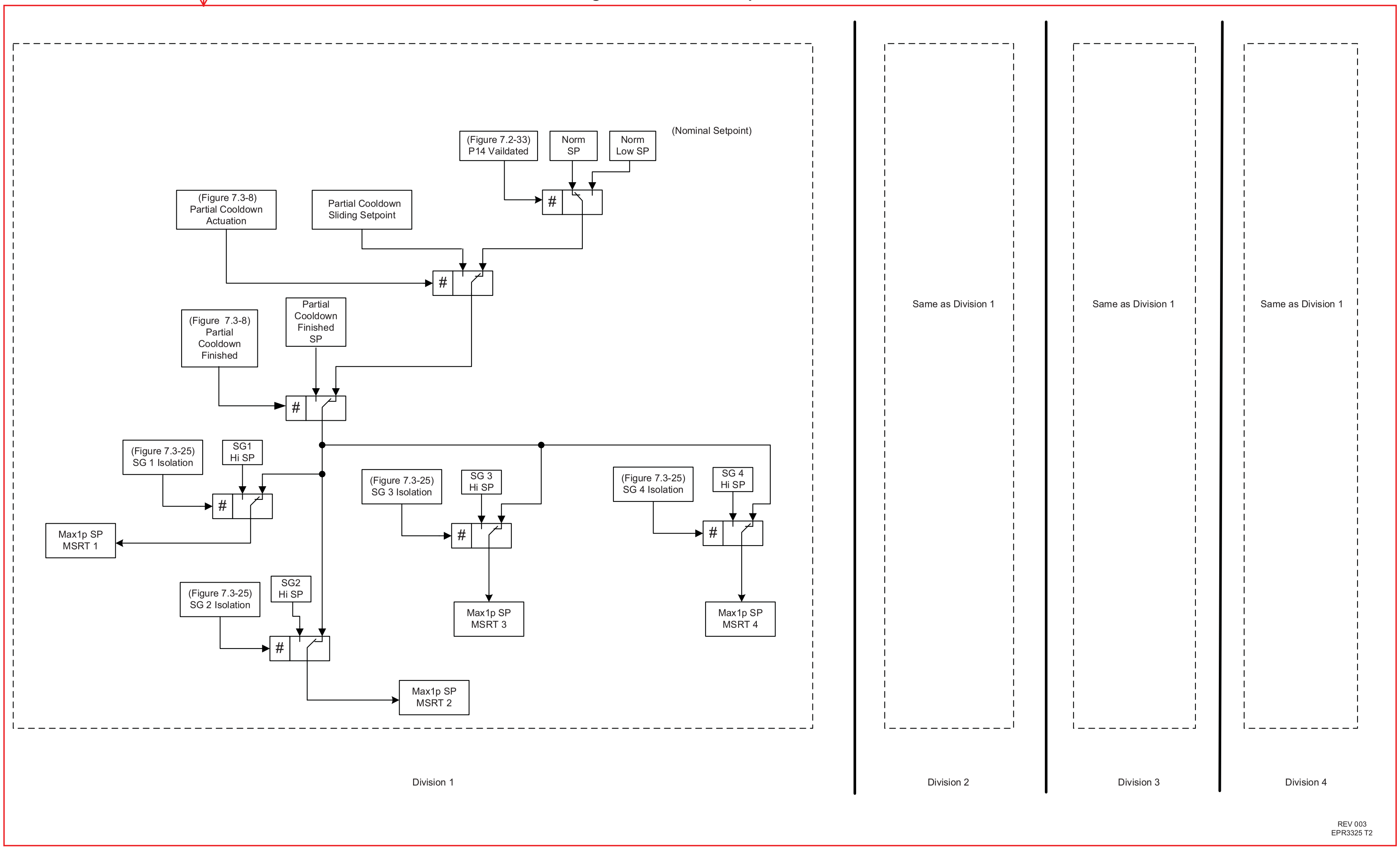

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Figure 7.3-10—MSRIVT Opening (Div. 1&2)

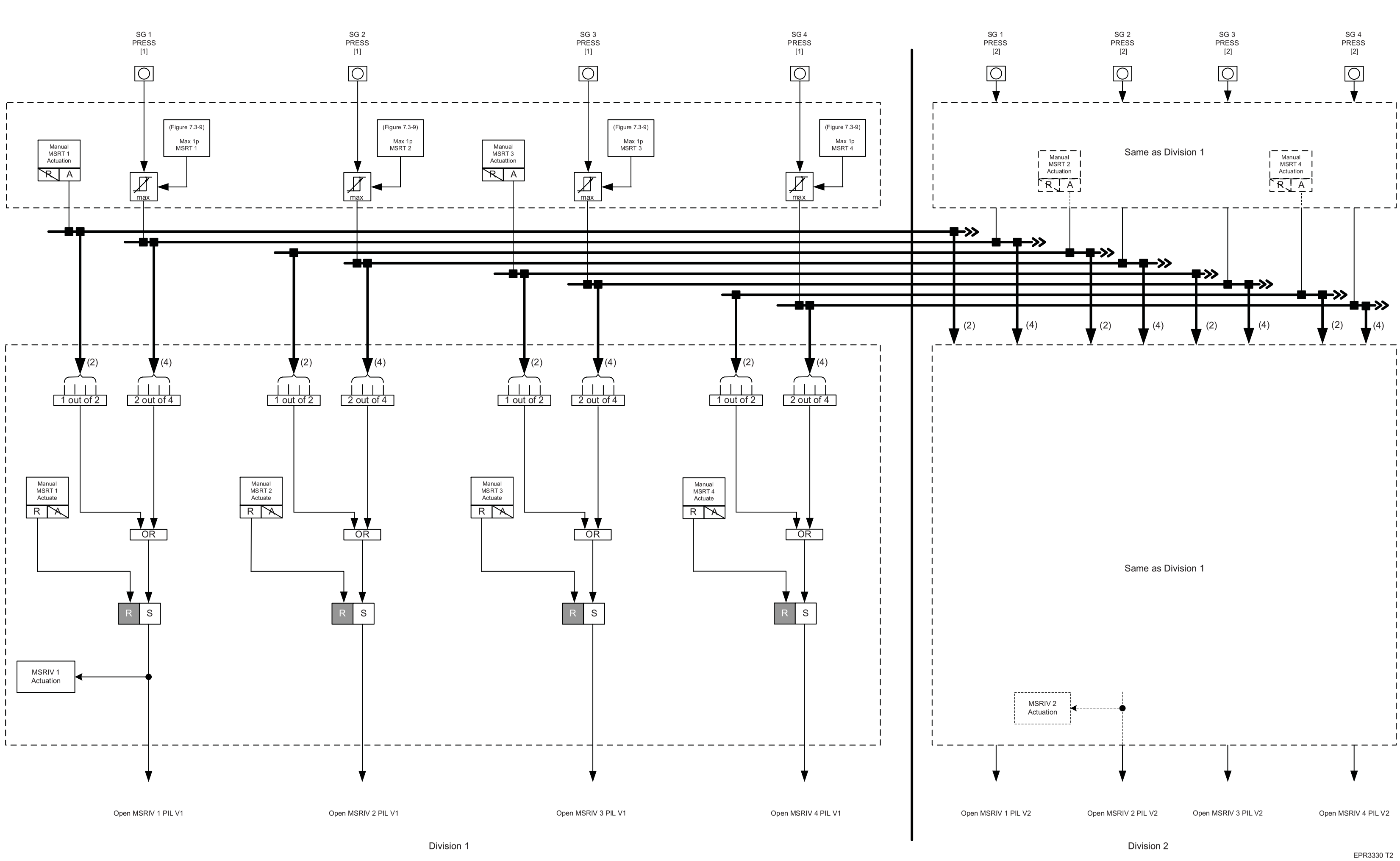

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Figure 7.3-11—MSRIV~~T~~ Opening (Div. 3&4)

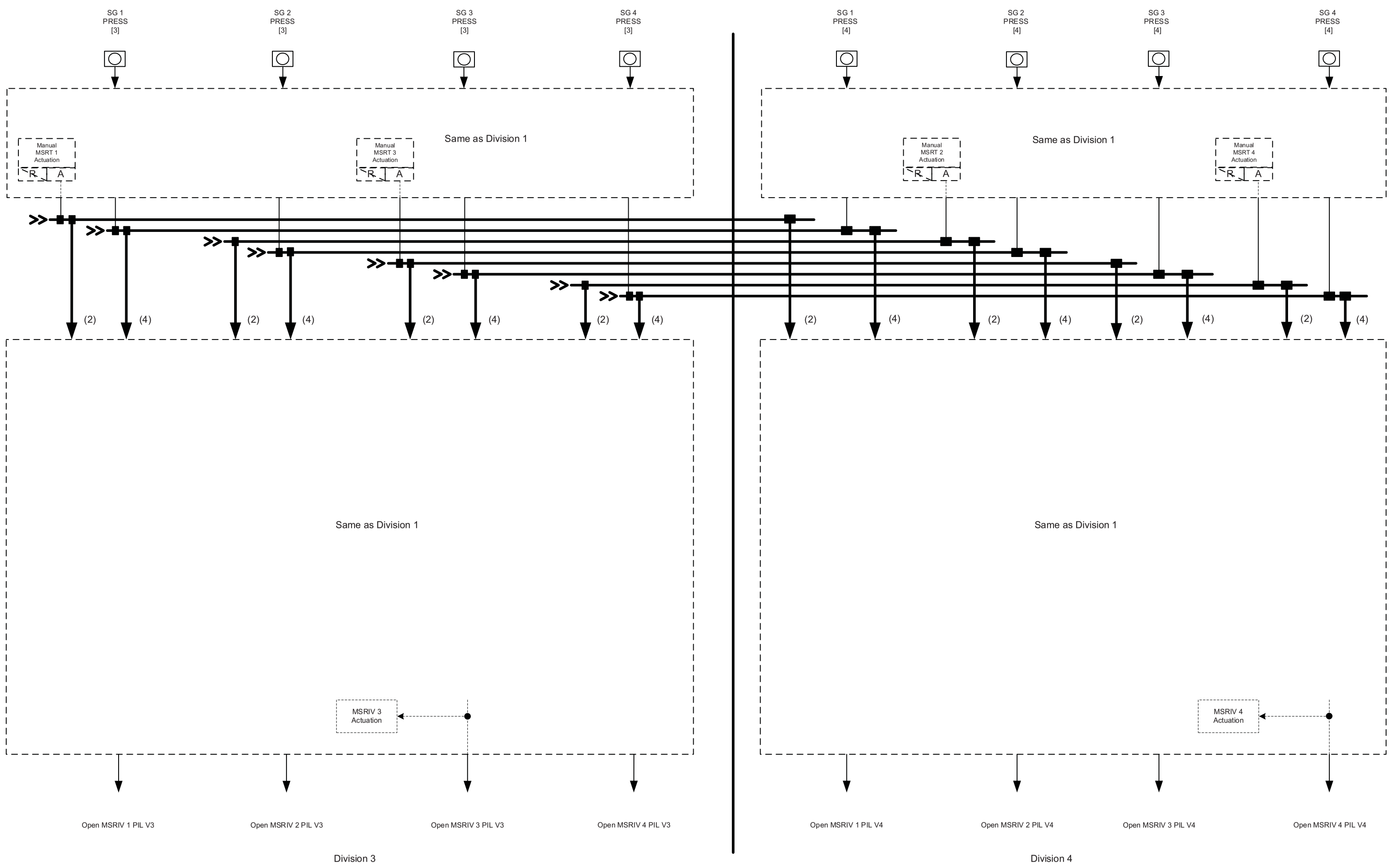

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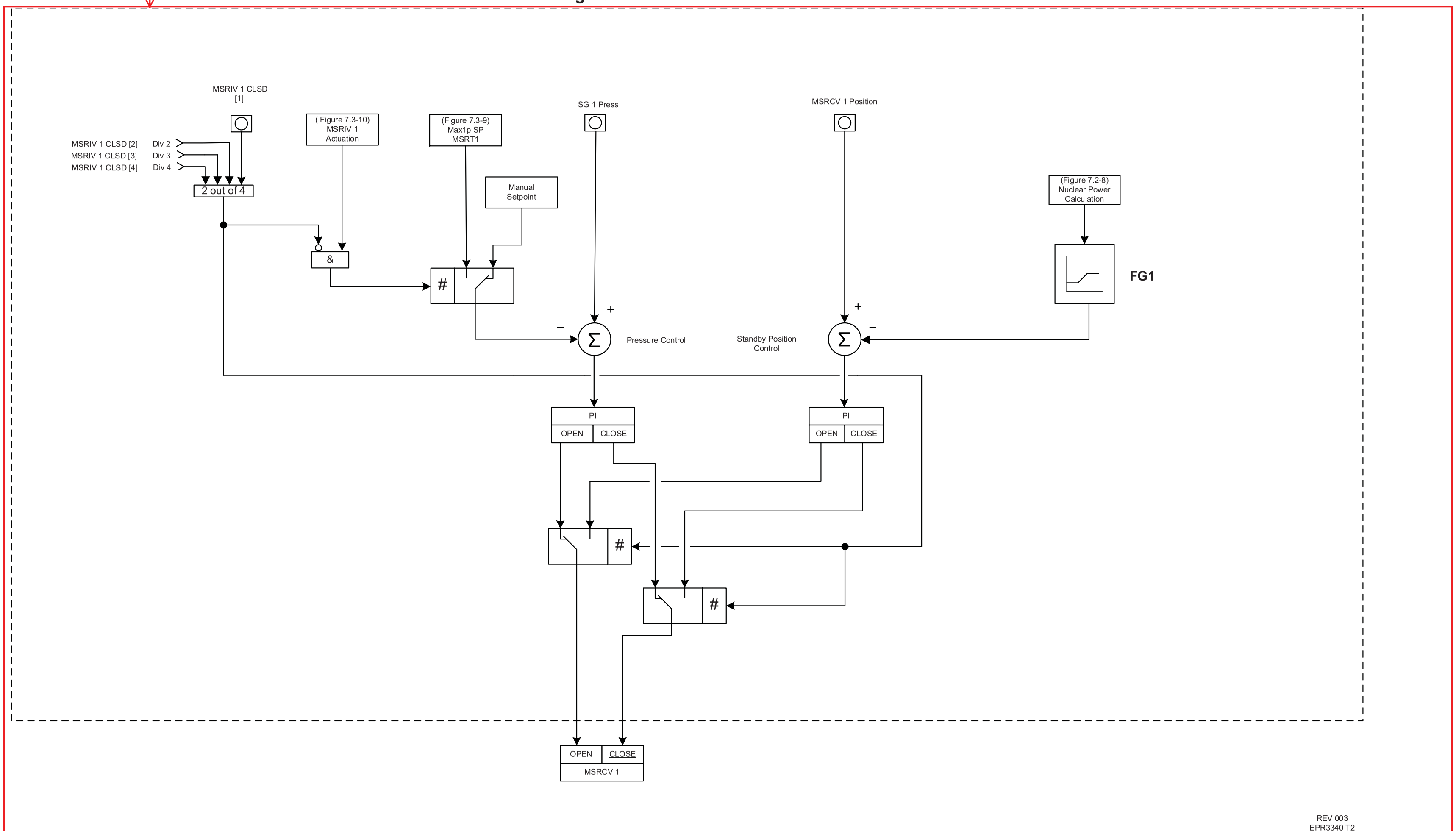
Figure 7.3-12—MSRCV Control



SAS Division 1
Same for Divisions 2, 3, and 4 controlling Trains 2, 3, and 4, respectively

Figure 7.3-13—MSRT Isolation

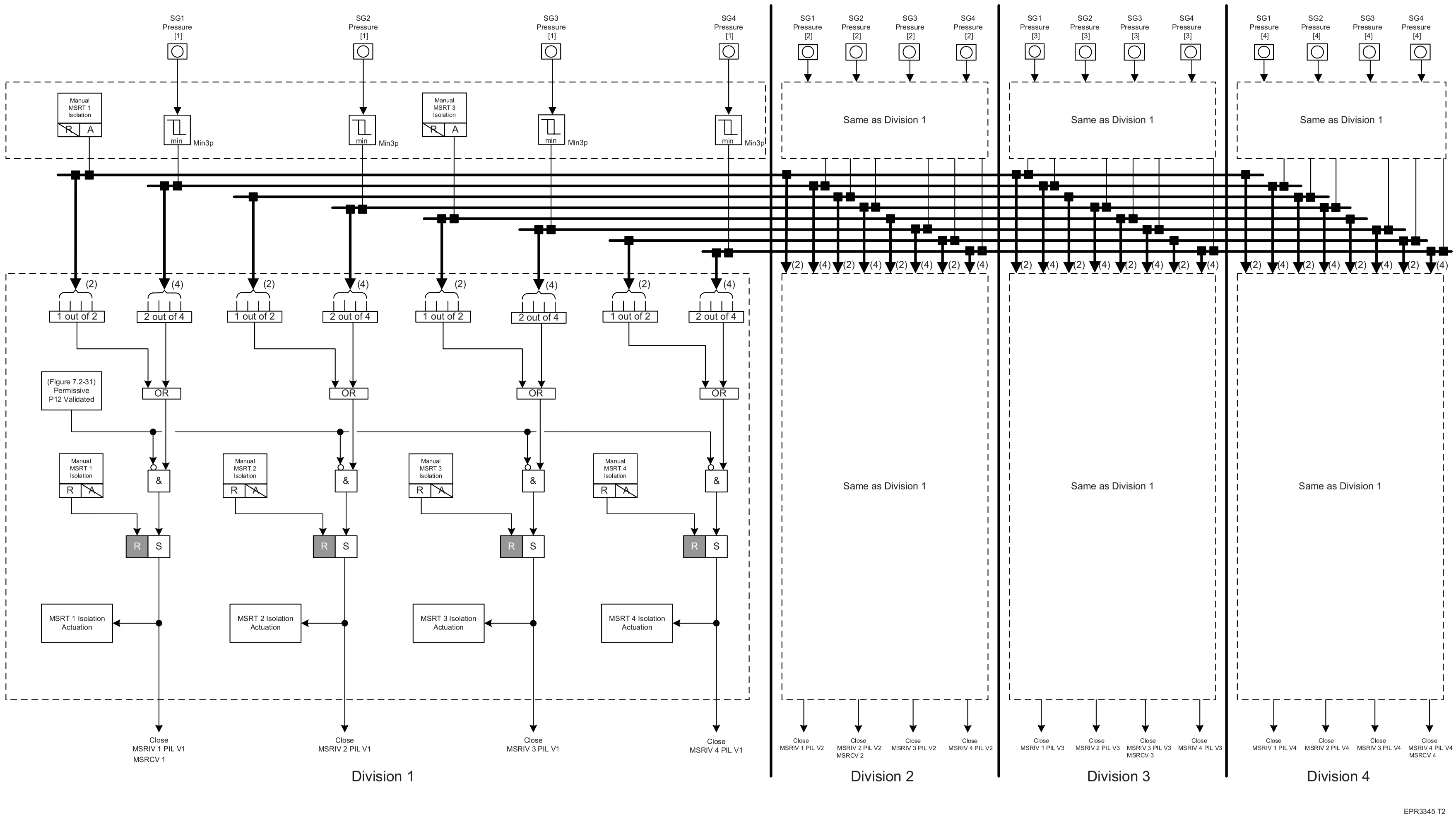


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Figure 7.3-14—~~MSIV~~Main Steam Isolation (Div. 1&2)

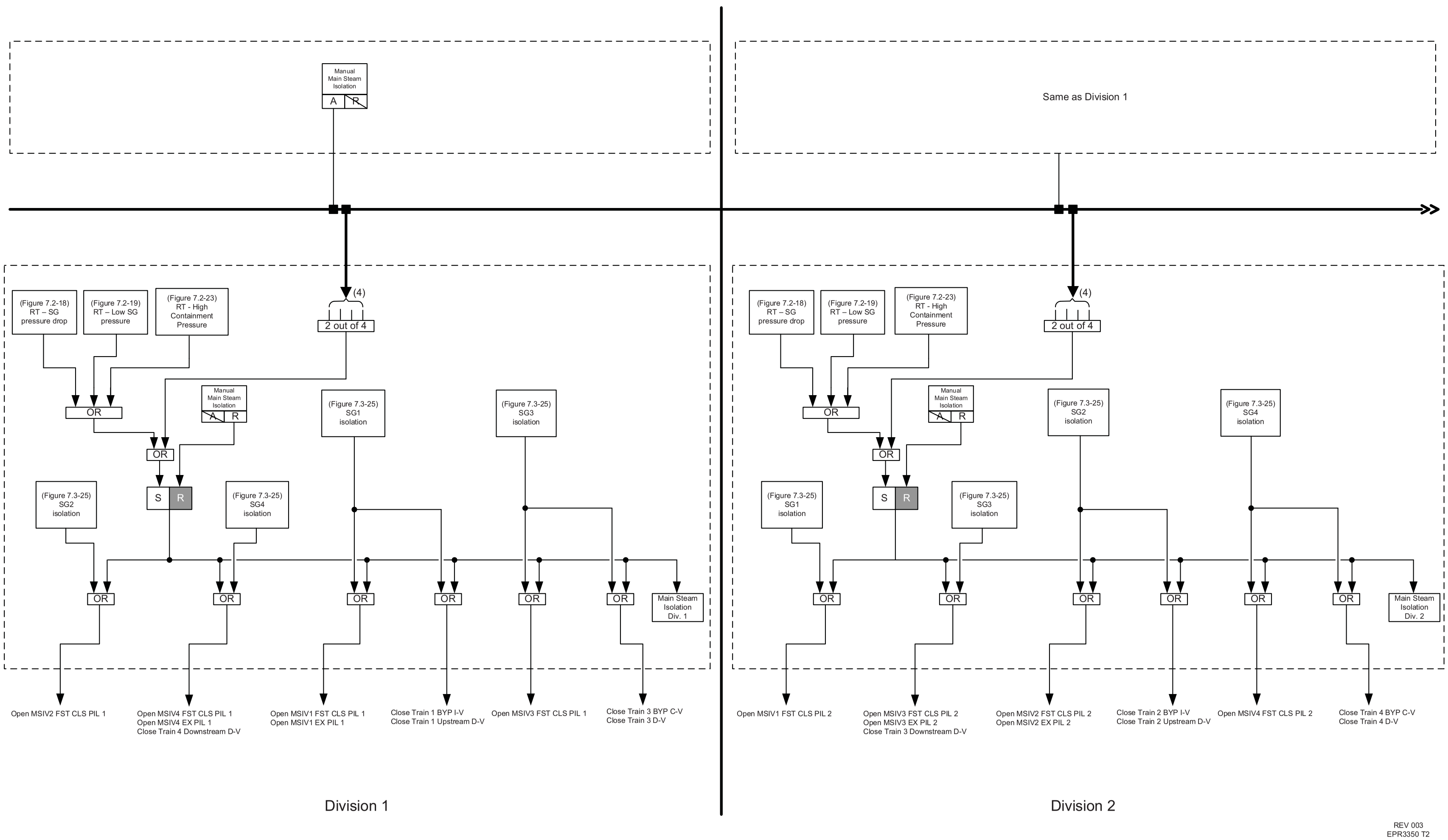

Figure 7.3-15—~~MSIV~~Main Steam Isolation (Div. 3&4)

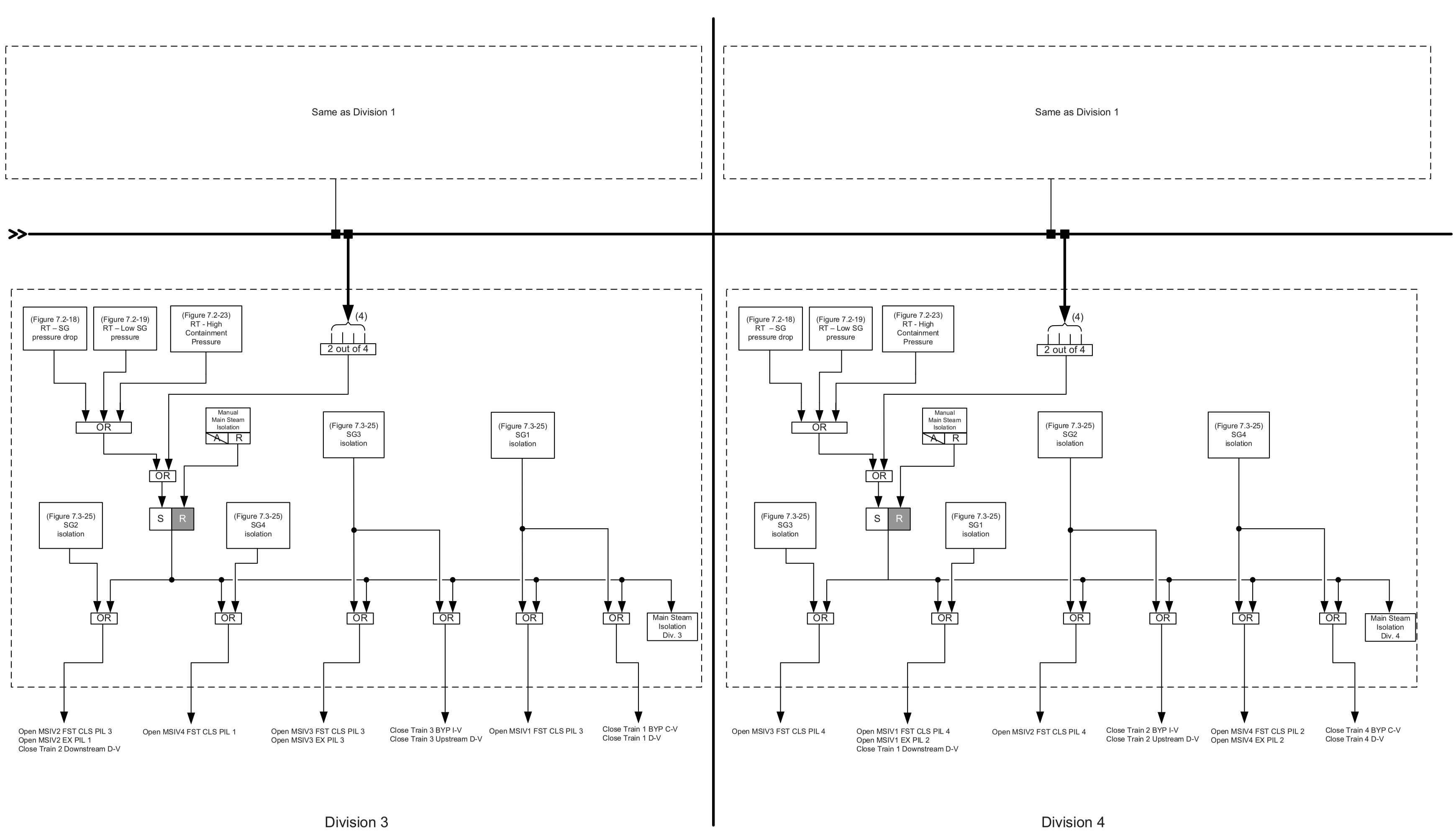

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Figure 7.3-16—MFWS Isolation - Full Load

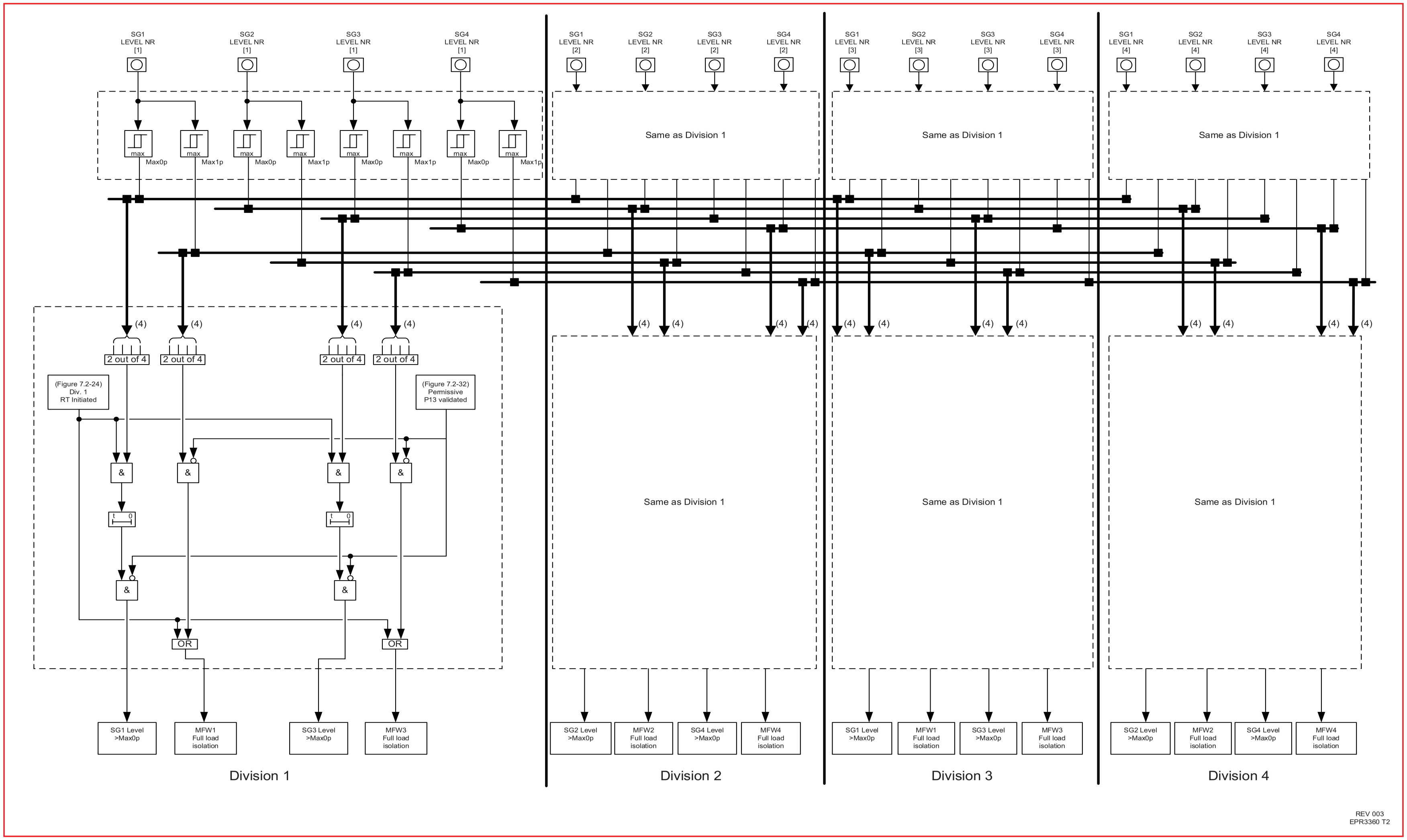
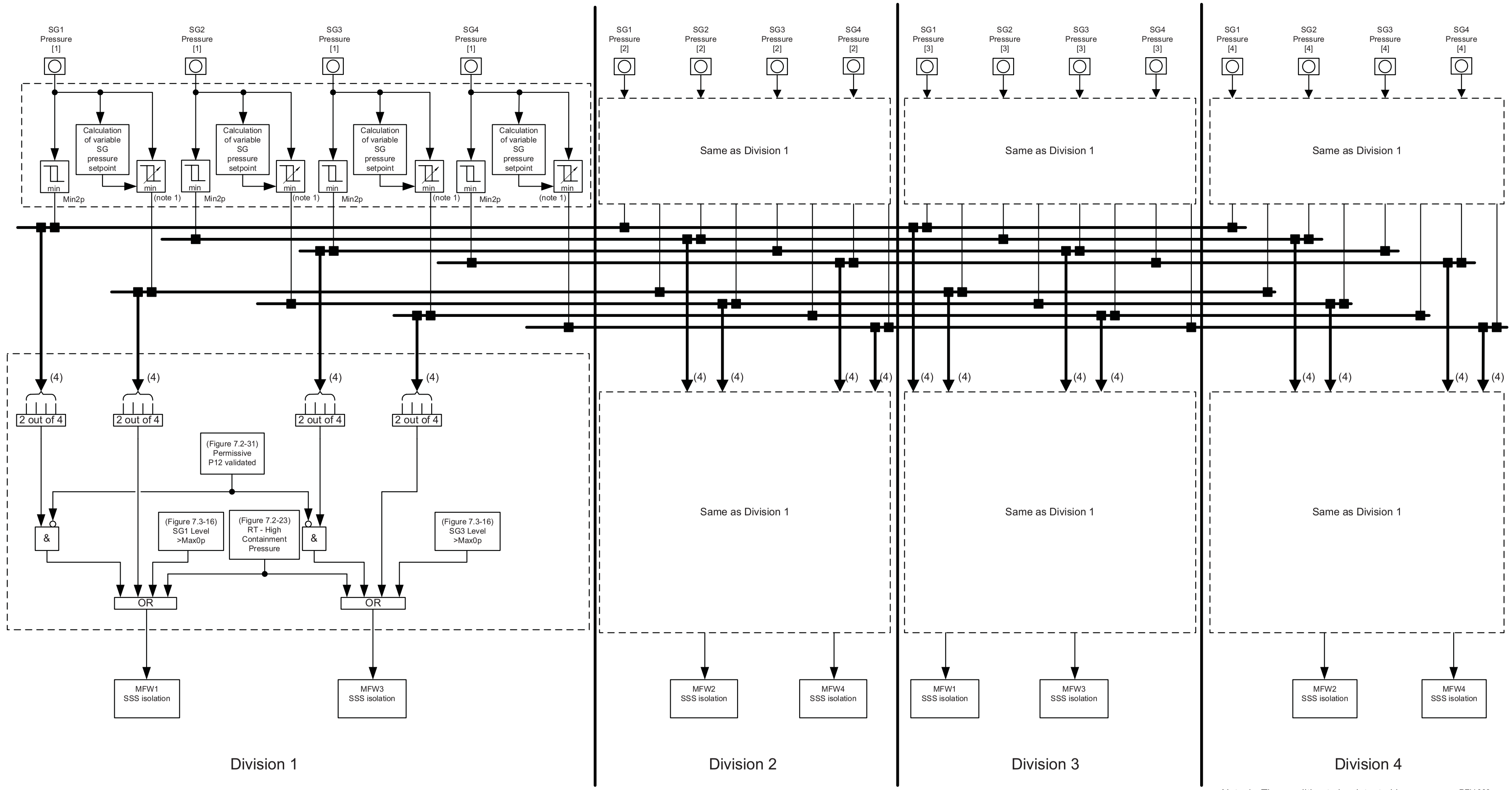


Figure 7.3-17—MFWS Isolation - SSS



Note 1: The condition to be detected is a SG pressure drop > Max 2p. This is implemented with a variable "Min" setpoint that decreases in a rate-limited manner.

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Figure 7.3-18—MFW Actuators (Div. 1&2)

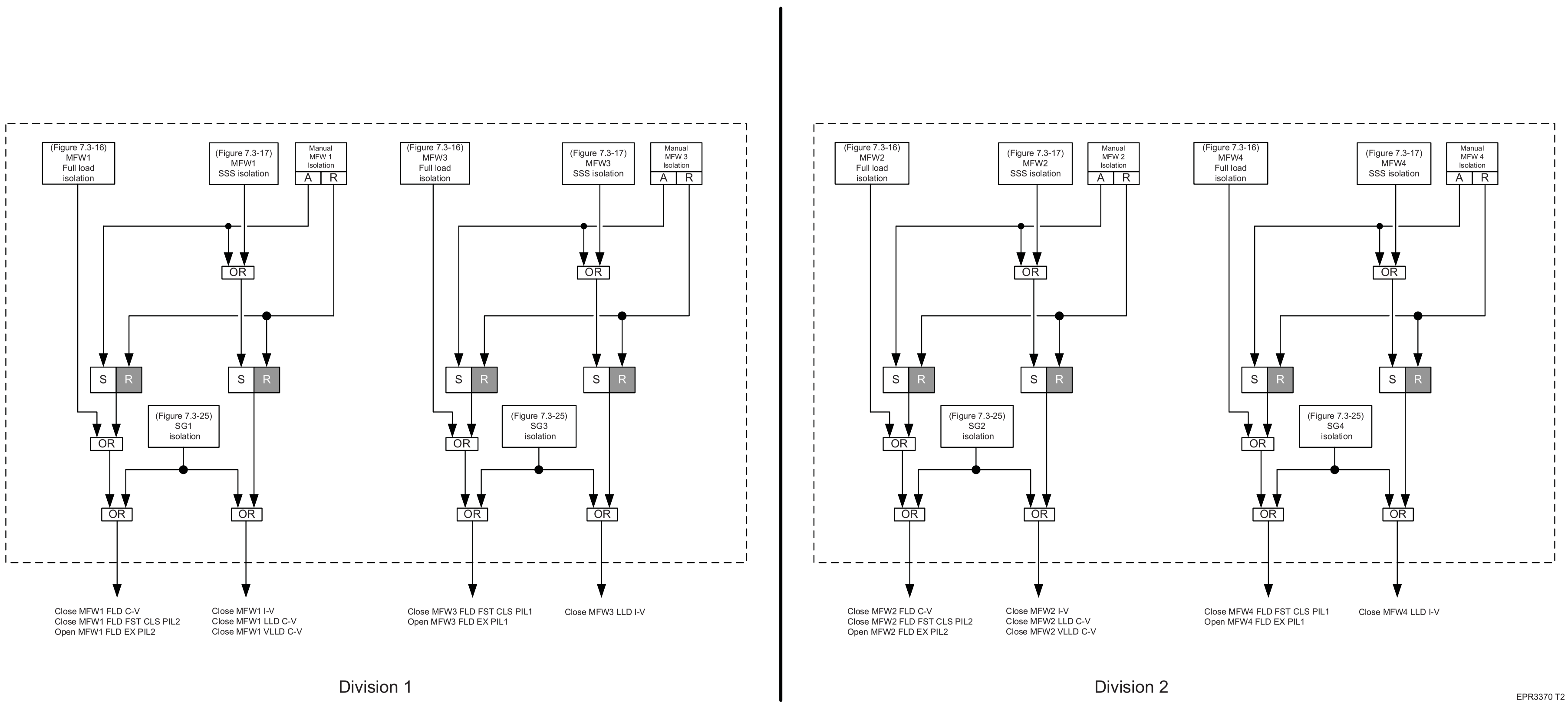

Figure 7.3-19—MFW Actuators (Div. 3&4)

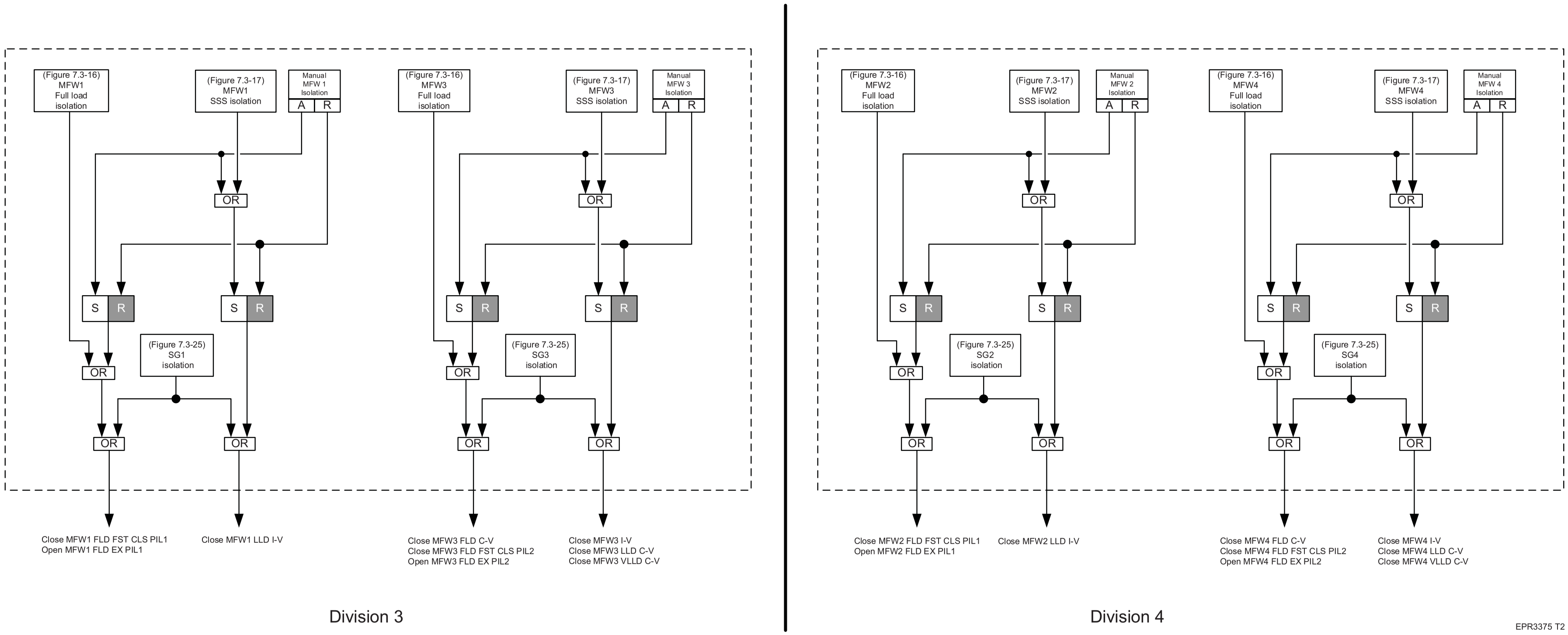

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Figure 7.3-20—Containment Isolation

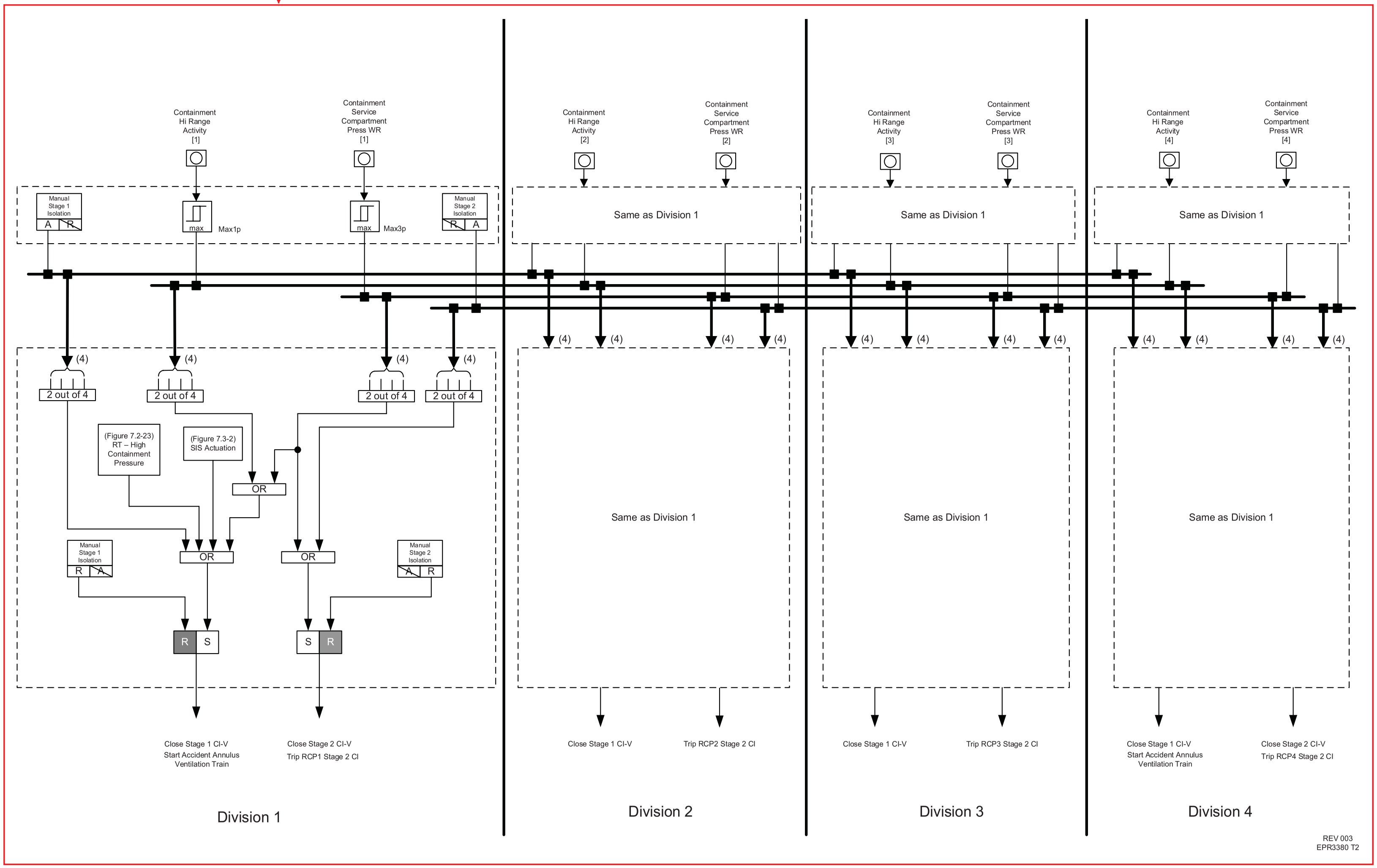

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Figure 7.3-21—CVCS Charging Isolation

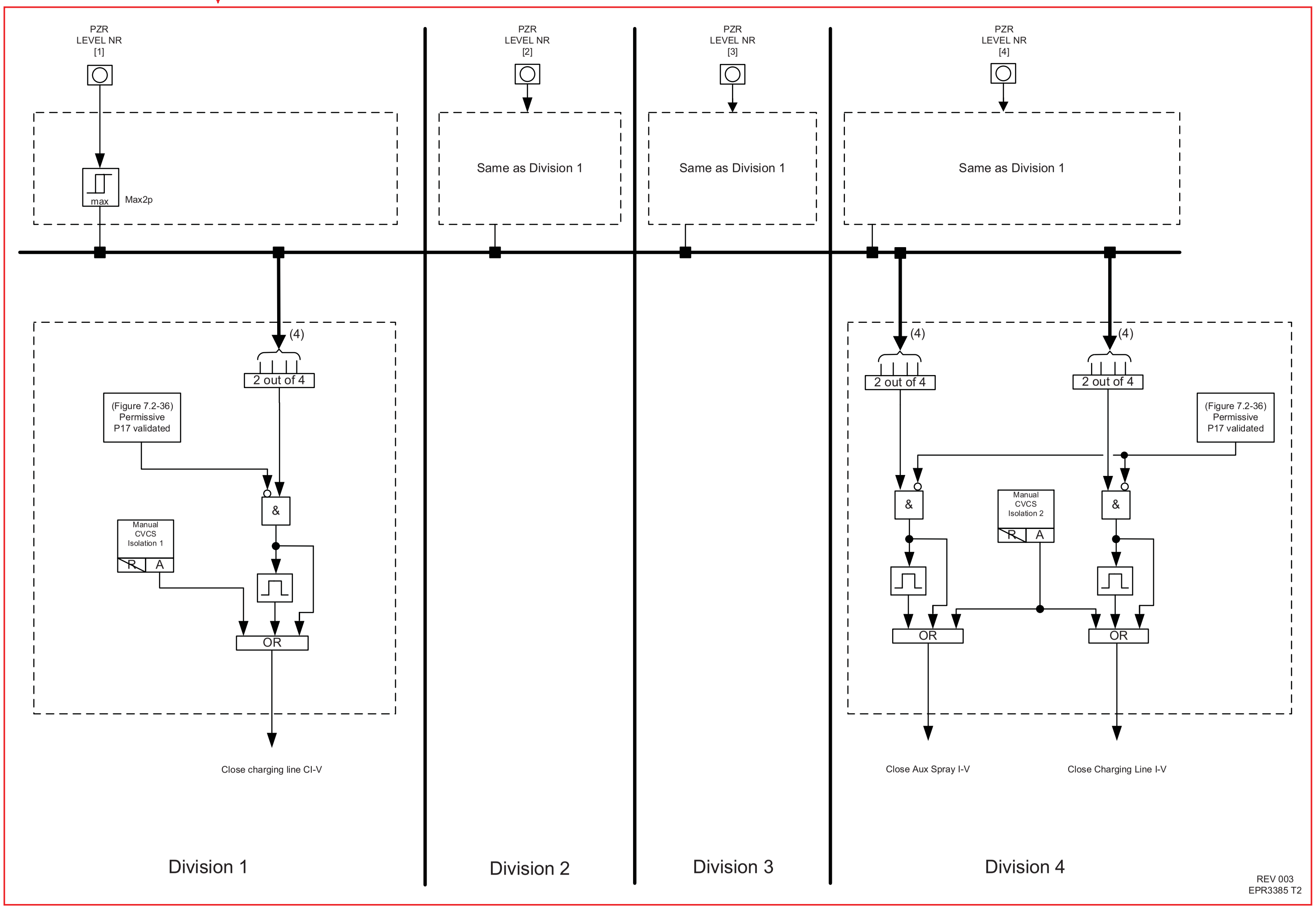

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Figure 7.3-22—CVCS Isolation for Anti-Dilution

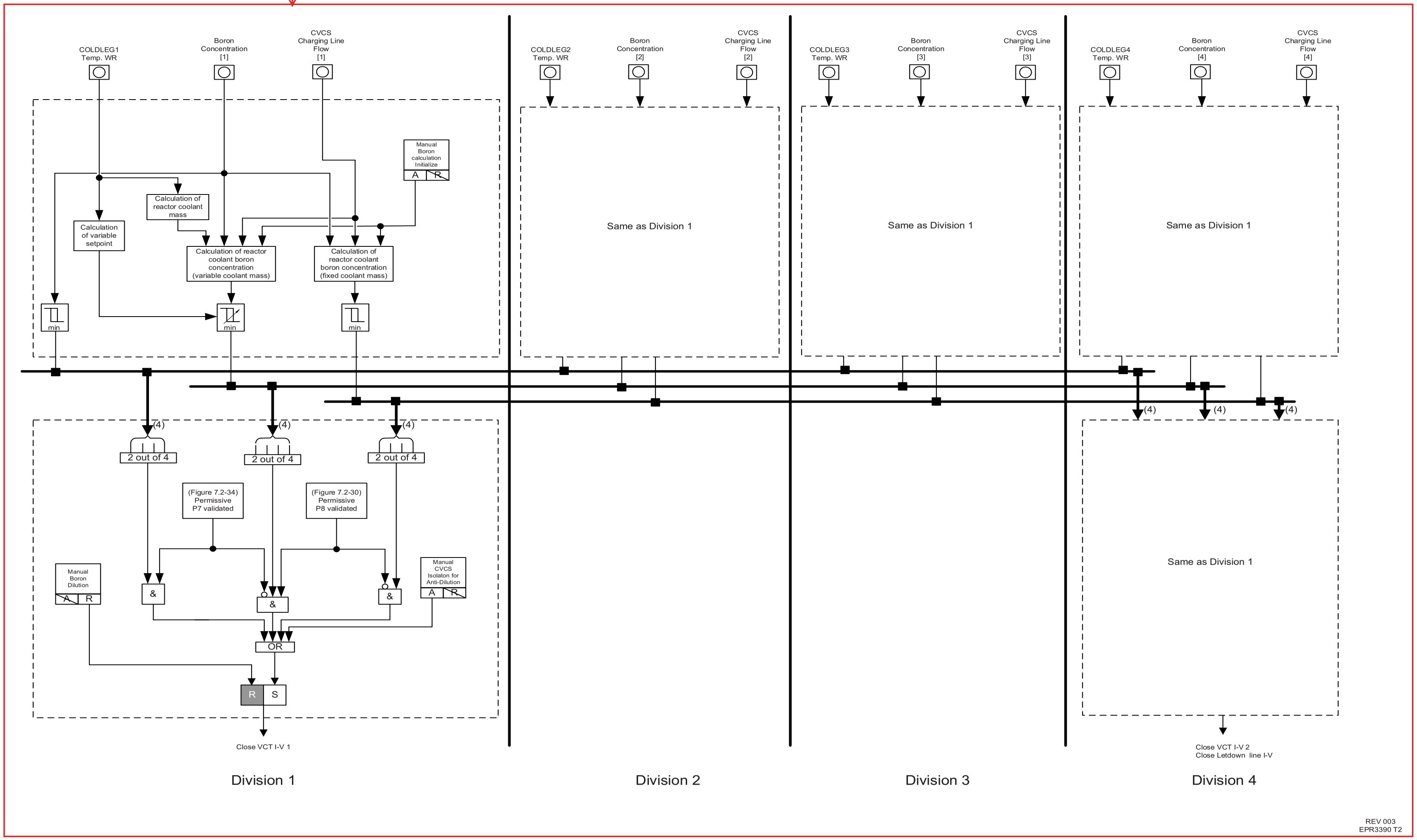

Figure 7.3-23—EDG Actuation

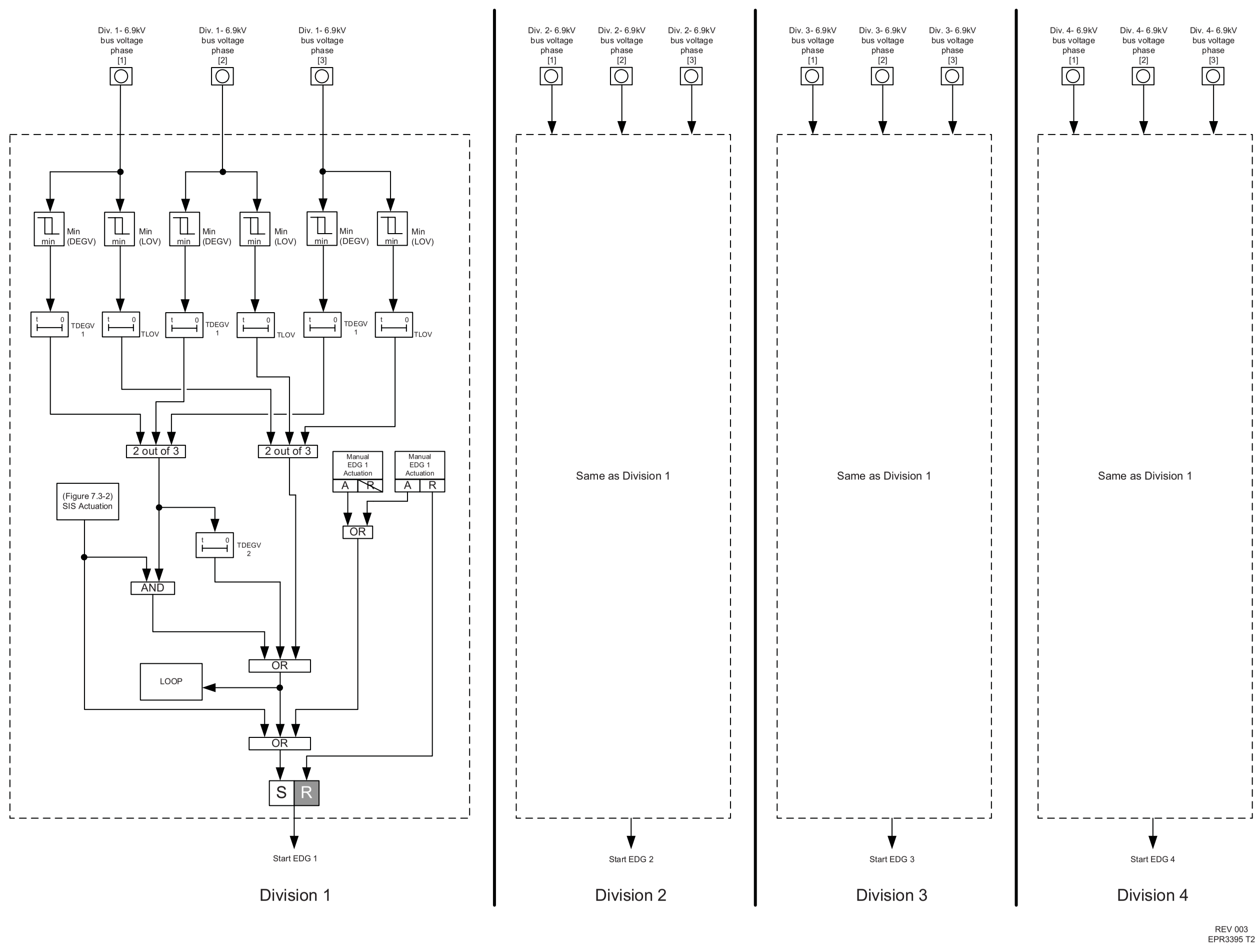

Figure 7.3-24—PSRV Opening (Brittle Fracture Protection)

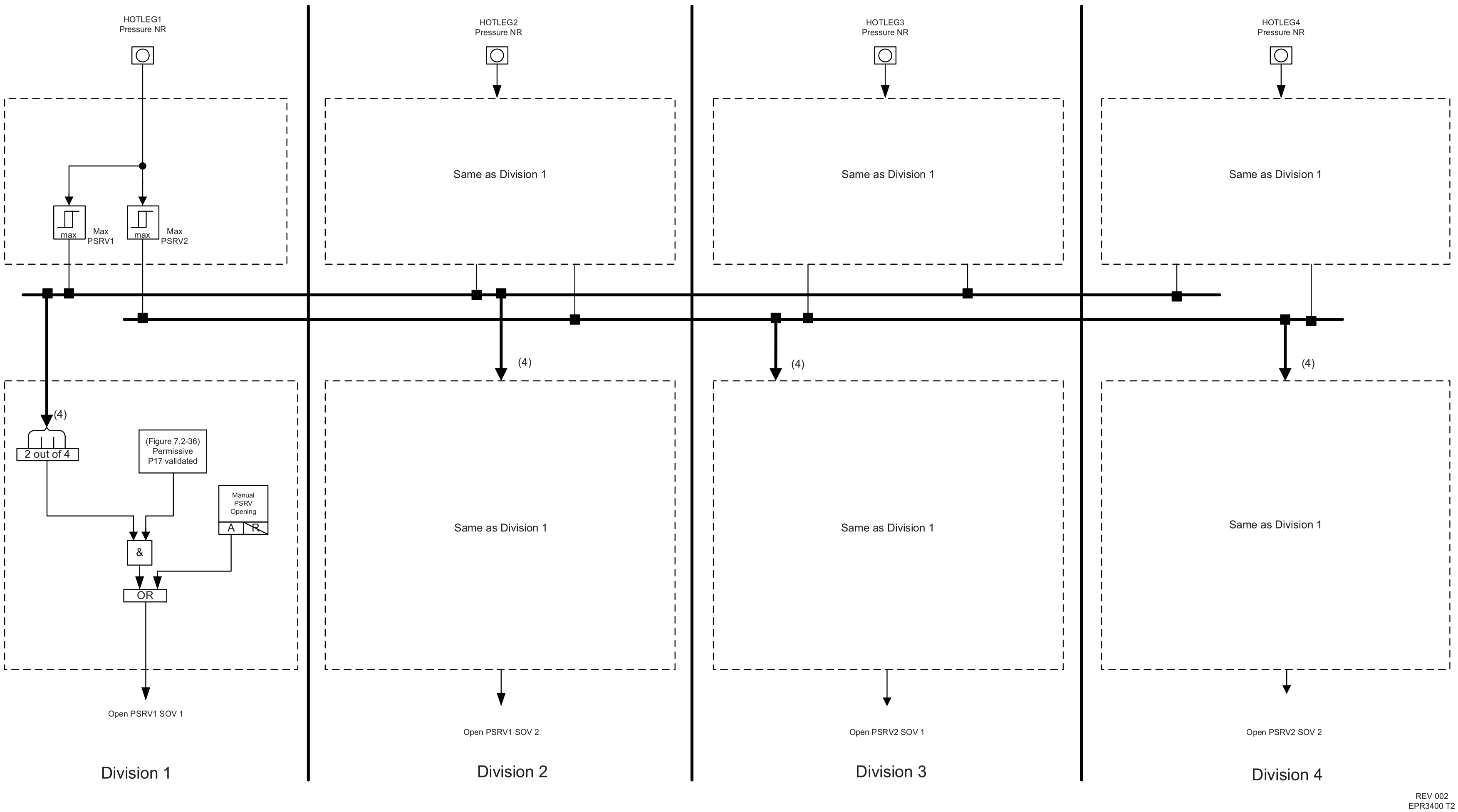

Figure 7.3-25—SG Isolation (Div. 1&2)

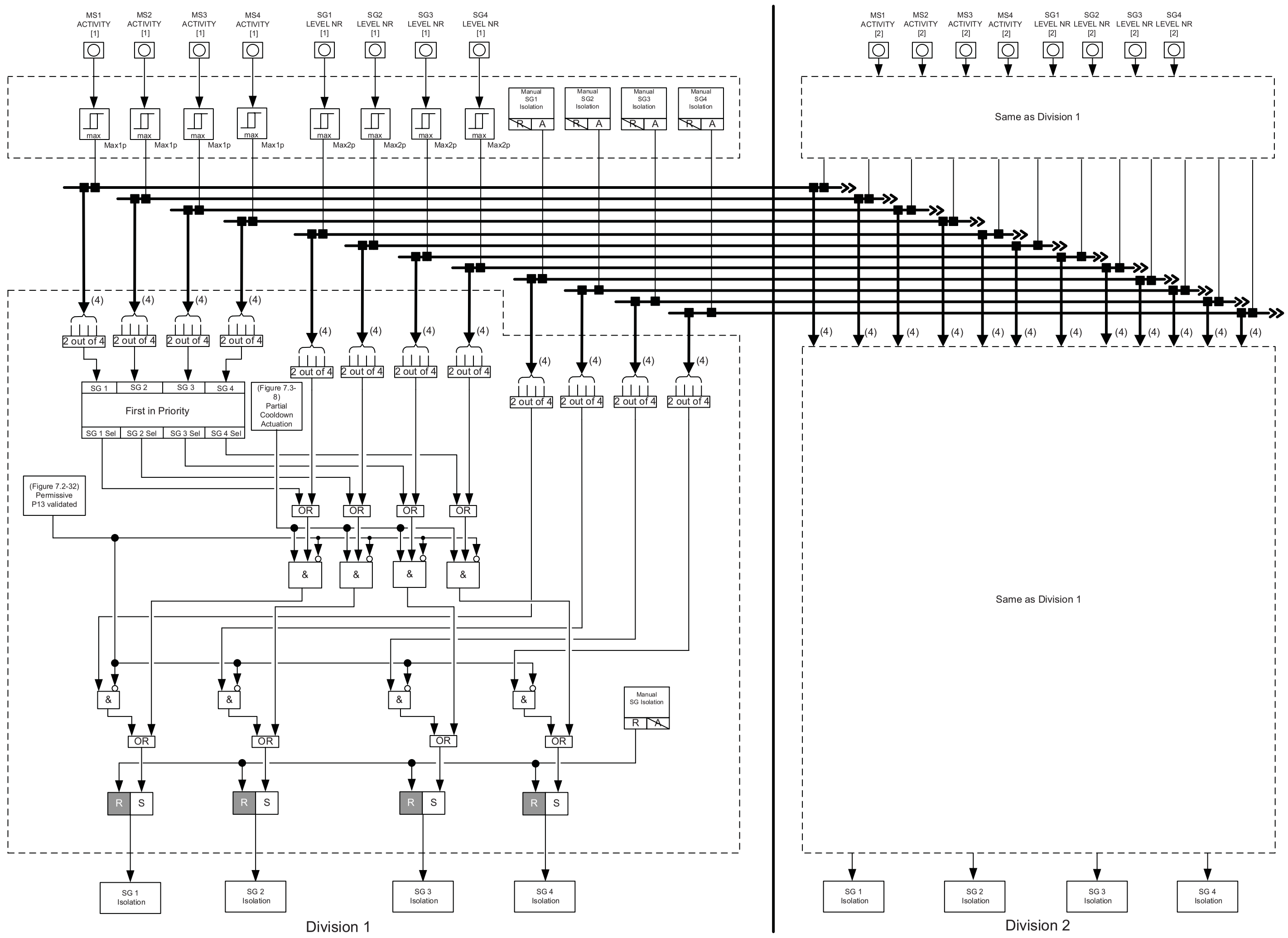

Figure 7.3-26—SG Isolation (Div. 3&4)

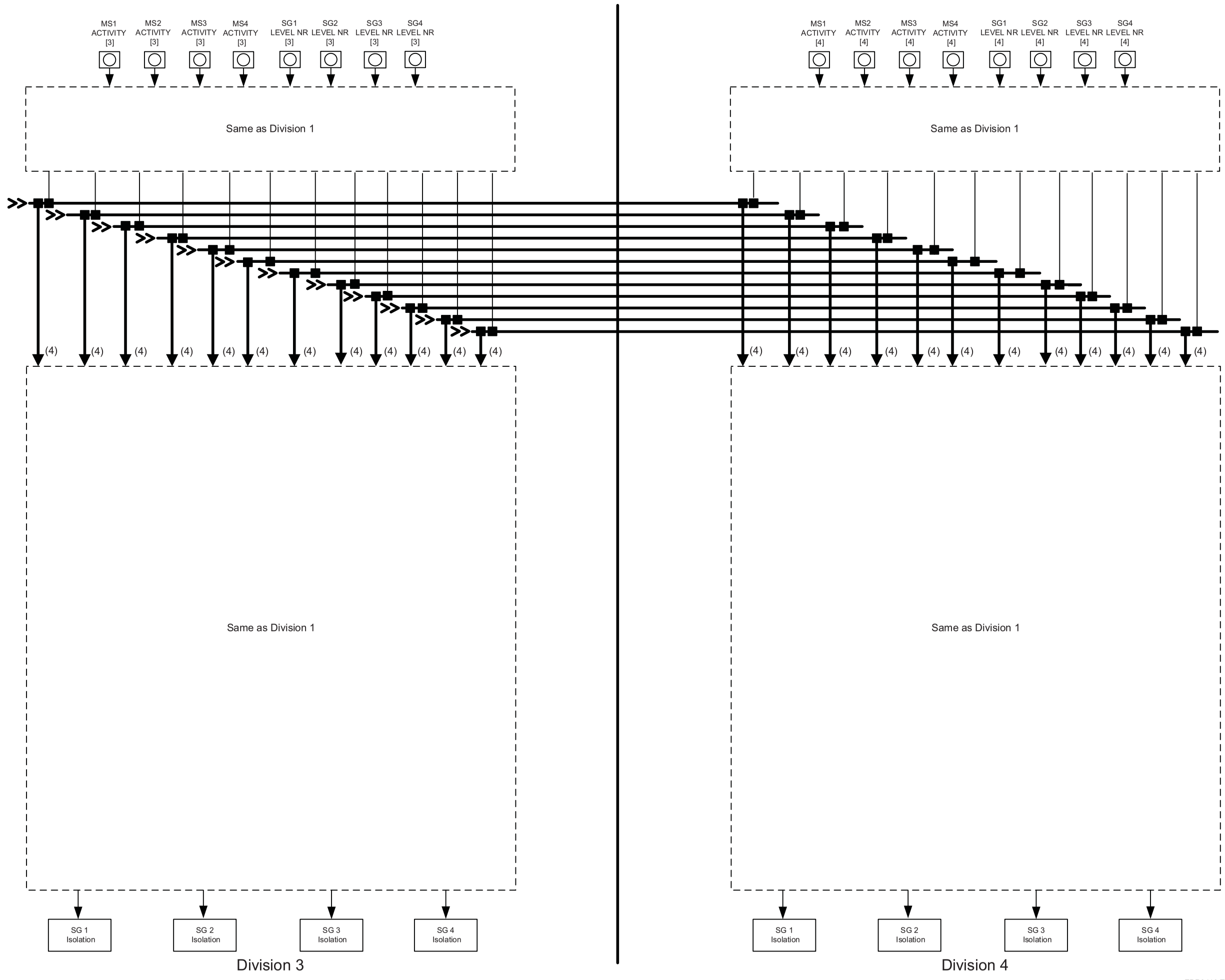

Figure 7.3-27—RCP Trip

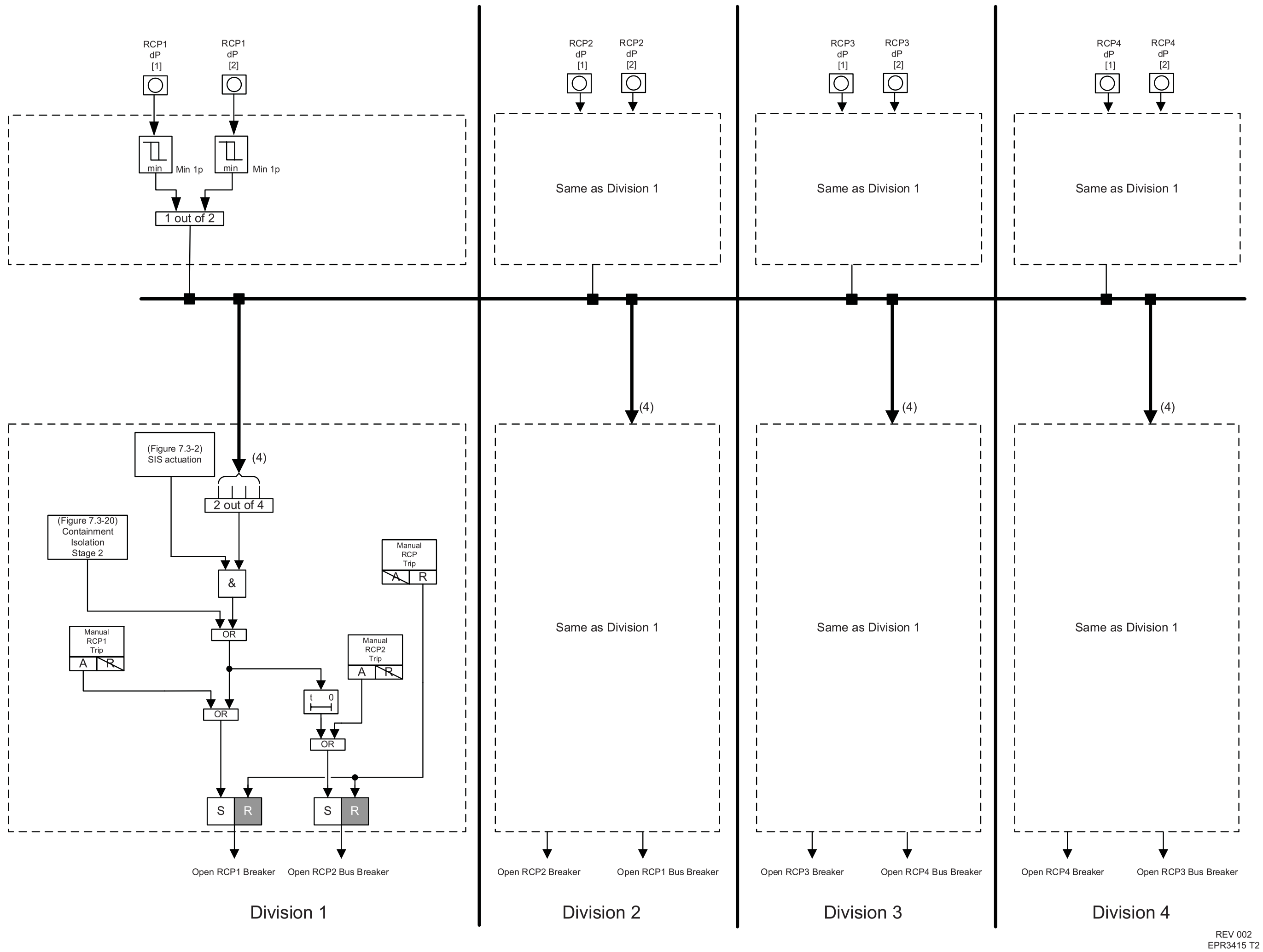

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Figure 7.3-28—MCR Air Conditioning System Isolation and Filtering

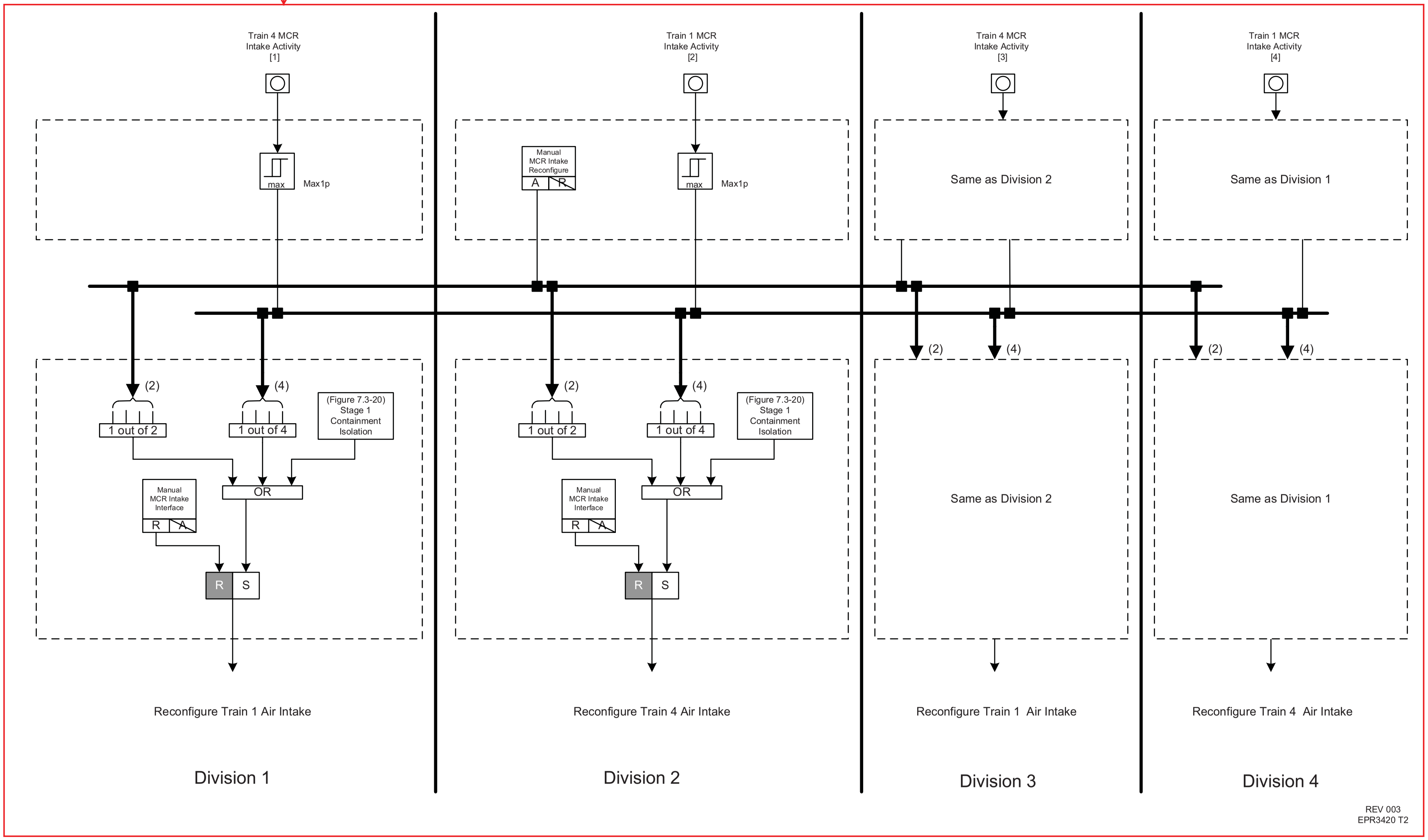

Figure 7.3-29—Turbine Trip on Reactor Trip Initiation

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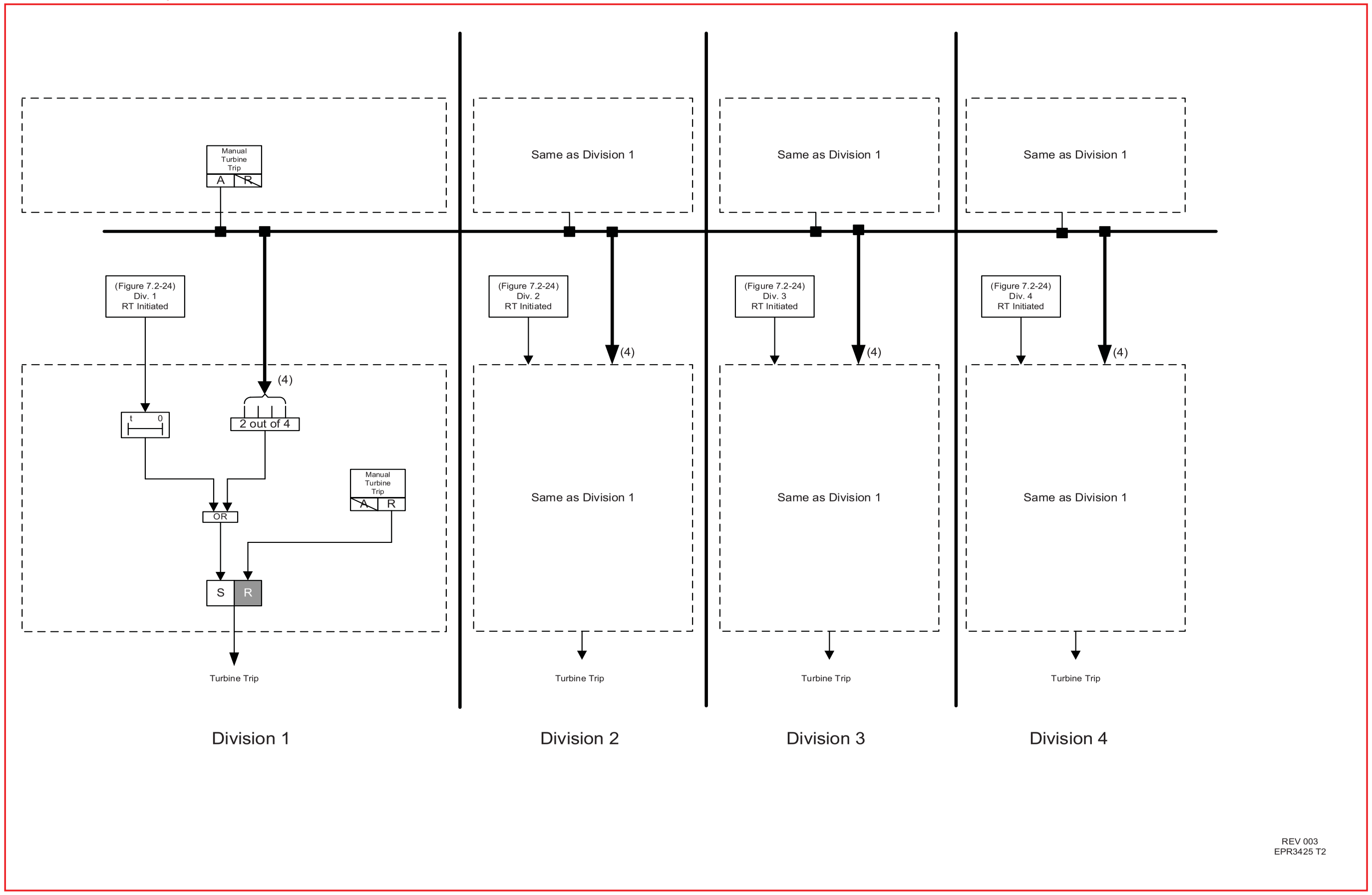
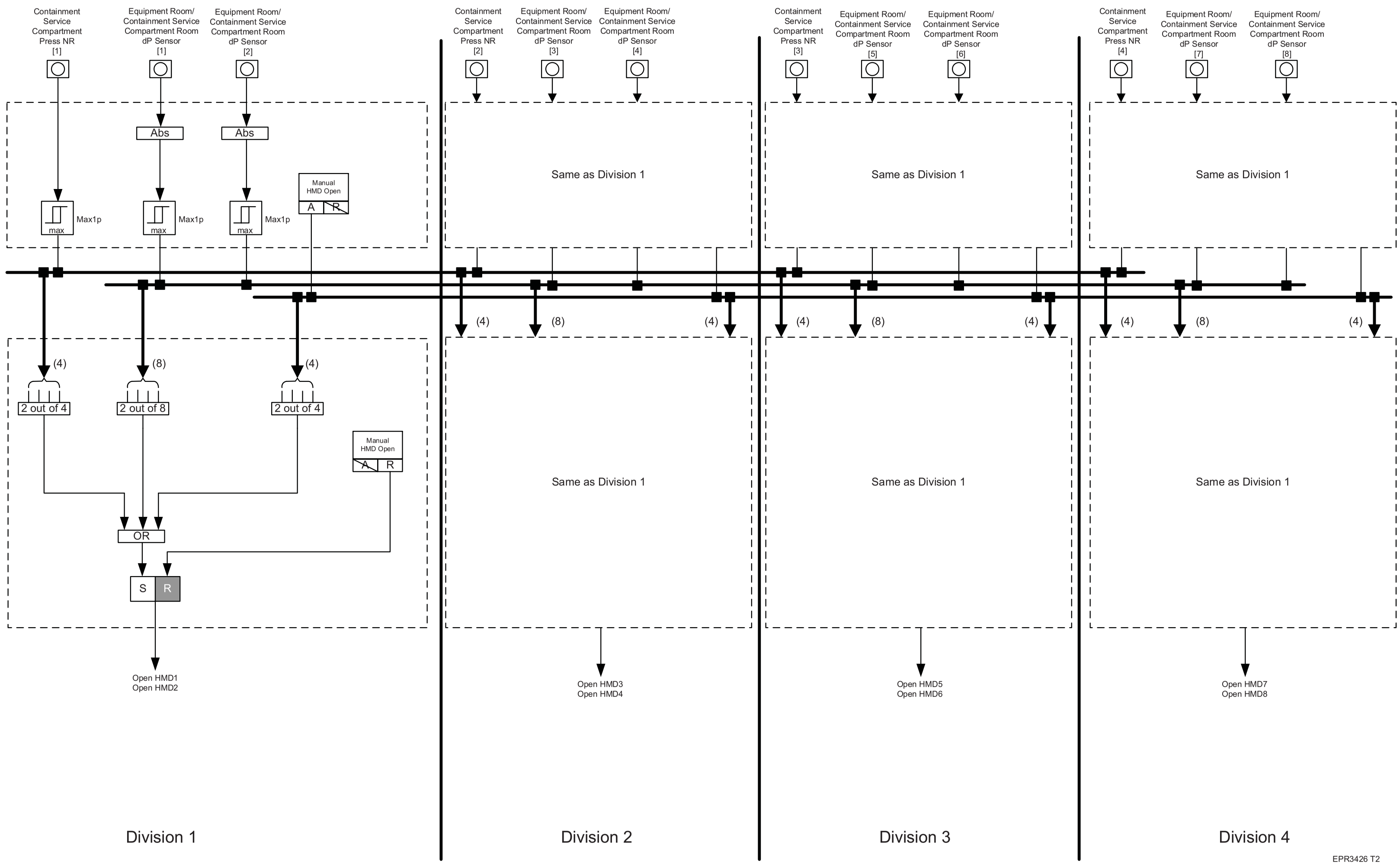


Figure 7.3-30—Hydrogen Mixing Dampers Opening.



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