UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

October 20, 1993

NRC INFORMATION NOTICE 93-84: DETERMINATION OF WESTINGHOUSE REACTOR COOLANT PUMP SEAL FAILURE

Addressees

All holders of operating licenses or construction permits for pressurized water reactors (PWRs).

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to a potential problem that could result from the use of Westinghouse-designed reactor coolant pump (RCP) shutdown procedures for pumps whose No. 1 seals have failed. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Background

Westinghouse supplied the Braidwood Station RCPs, incorporating a three-stage seal series arrangement to limit coolant flow up the pump shaft. The No. 1 seal, the main seal of the pump, is a controlled-leakage, film riding face seal. The No. 2 and No. 3 seals are rubbing face seals. During normal operation, an injection flow of nominally 30.3 liters [8 gallons] per minute enters the pump below the No. 1 seal (see Attachment 1). Here the flow splits. A portion (approximately 18.9 liters [5 gallons] per minute) flows down through the thermal barrier heat exchanger and enters the reactor coolant system. In this manner, the primary coolant is prevented from entering the radial bearing and seal section of the pump unit. The remainder (11.4 liters [3 gallons] per minute) (controlled leakage) passes through the pump radial bearing and enters the No. 1 seal. Above the No. 1 seal, most of the flow leaves the pump through the No. 1 seal leakoff line and returns to the chemical and volume control system. Minor flow passes through the No. 2 seal and its leakoff line to the reactor coolant drain tank. A back flush injection of 0.8 liters [0.21 gallons] per hour from a head tank flows into the No. 3 seal between its "double dam" seal area. At this point, half of the flow passes through one side of the seal and out the No. 2 seal leakoff line while the remaining flow passes through the other side and out the No. 3 seal leakoff line. This arrangement ensures essentially zero leakage of reactor coolant from the pump.

During normal operation, the No. 1 seal is subject to full reactor coolant system pressure. When the injection flow passes through the No. 1 seal, it produces a pressure drop of approximately 15.41 MPa [2235 psi]. The No. 2 seal has the capability to withstand full operating pressure, and its major function is to act as a backup in case the No. 1 seal fails. If the No. 1 seal fails, leakage through the No. 2 seal increases. The No. 2 seal high leak flow alarm actuates at 3.8 liters [1 gallon] per minute.

Description of Circumstances

In the middle of 1992, while developing shutdown procedures for the RCPs at the Braidwood Station, Commonwealth Edison Company (the licensee) found that its abnormal operating procedure contained inadequate instructions for responding to a failure of the RCP No. 1 seal. On a high RCP No. 1 seal leakoff condition, the abnormal operating procedure directed the operating personnel to check the condition of the No. 2 seal. If the No. 2 seal was acting as the primary pressure boundary on the basis of leakage of at least 3.8 liters [1 gallon] per minute from the No. 2 seal, the procedure required that the RCP be shut down. If the condition of the No. 2 seal was normal, the procedure required no further action and gave no further guidance. Discussions with Westinghouse indicated that the condition of the No. 2 seal might not be a sufficient indication of the operability of the No. 1 seal.

Discussion

The inadequacies in the operating procedure stem from the limitations of the instrumentation used to monitor the leakage. The relevant No. 1 seal instrumentation limits maximum readings to 22.7 liters [6 gallons] per minute. Although the No. 2 seal high leak flow alarm was set at 3.8 liters [1 gallon] per minute, very high No. 1 seal leak rates, more than 113.6 liters [30 gallons] per minute, are needed for the No. 2 seal to reach this flow rate. Thus, the No. 1 seal could have substantial leakage (e.g., 22.7-113.6 liters [6-30 gallons] per minute) even though the No. 2 seal high leak flow alarm was not actuated. In the mean time, the RCP seal system might be severely damaged if loss of injection were to occur or the No. 1 seal leak rates were more than 30.3 liters [8 gallons] per minute. Therefore, monitoring for high No. 2 seal leakage is not a reliable method of determining whether the No. 1 seal has failed.

After finding that the condition of the No. 2 seal might not indicate the operability of the No. 1 seal, Westinghouse provided guidance for the Braidwood Station that significantly enhances operator ability to determine if immediate shutdown of an RCP is required or if a more orderly shutdown can be conducted. Westinghouse completed a safety evaluation and issued Technical Bulletin, NSD-TB-93-01-R0, "Revised Procedures for RCP Shutdown with No. 1 Seal Leakage Outside Operating Limits," dated March 30, 1993, to other PWRs that might be affected. An excerpt from this document is attached to this information notice (see Attachment 2).

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

Brian K. Grimes, Director
Division of Operating Reactor Support
Office of Nuclear Reactor Regulation

Technical contacts: Steve DuPont, RIII
(815) 458-2852

Martin Farber, RIII
(708) 790-5774

Chu-Yu Liang, NRR
(301) 504-2878

Attachments:
1. Simplified Braidwood Seal Water Injection and Leakoff Flow Diagram
2. Excerpt from Westinghouse Technical Bulletin, NSD-TB-93-01-R0, "Revised Procedures for RCP Shutdown with No. 1 Seal Leakage Outside Operating Limits"
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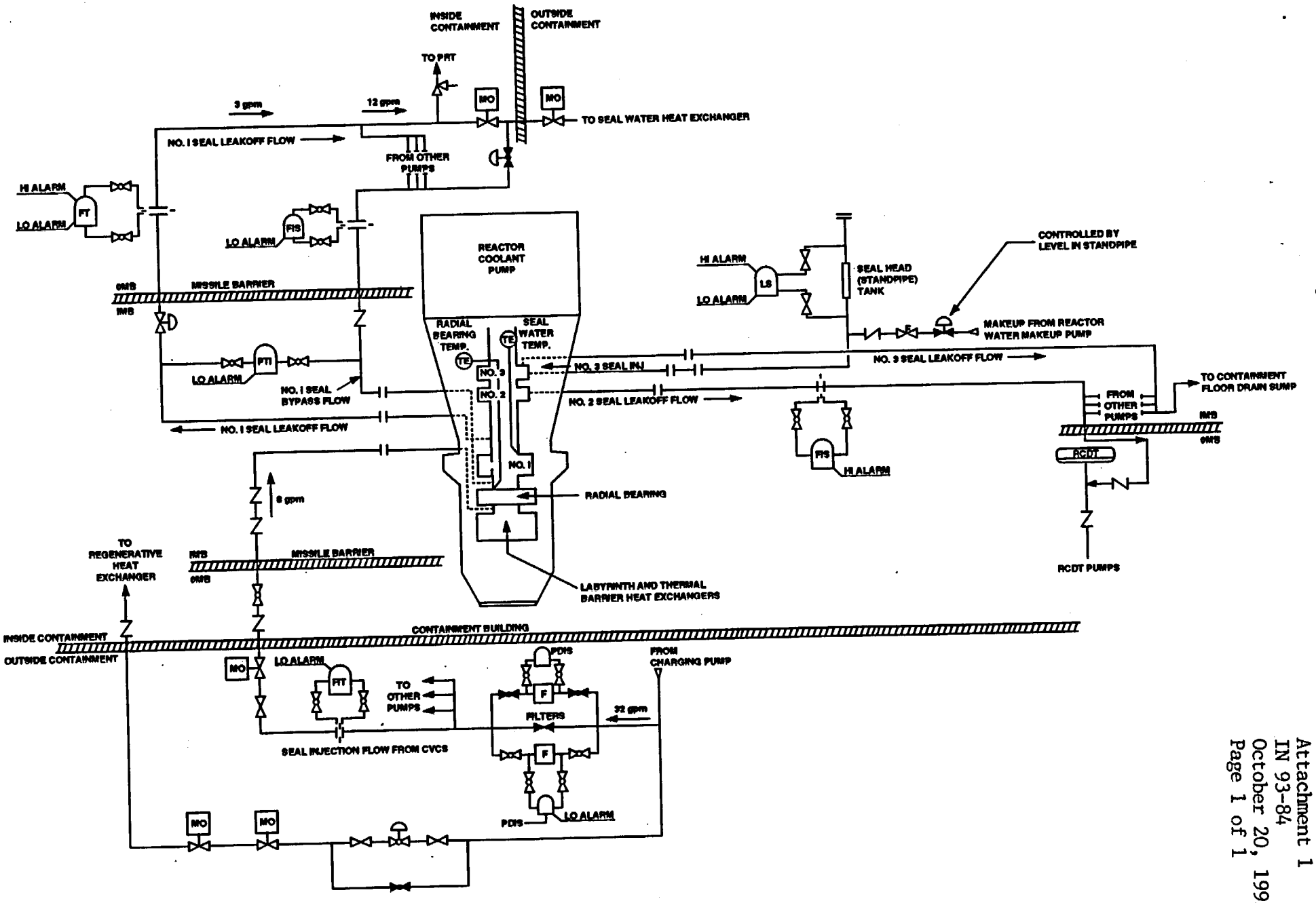

SIMPLIFIED BRAIDWOOD SEAL WATER INJECTION AND LEAKOFF FLOW DIAGRAM

Attachment 1
IN 93-84
October 20, 1993
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NSD Nuclear Services Division

Westinghouse Technical Bulletin

An advisory notice of a recent technical development pertaining to the installation or operation of Westinghouse-supplied Nuclear Plant equipment. Recipients should evaluate the information and recommendation, and initiate action where appropriate.

P.O. BOX 355, Pittsburgh, PA 15230

Subject: REVISED PROCEDURES FOR RCP SHUTDOWN WITH NO. 1 SEAL LEAKAGE OUTSIDE OPERATING LIMITS			Number: NSD-TB- 93-01-R0
System(s): REACTOR COOLANT SYSTEM			Date: 03/30/93
Plants: ALL WESTINGHOUSE REACTOR COOLANT PUMPS WITH CONTROLLED LEAKAGE SEALS (See Attachment B)			S.O.(s): 125
References: EMD PRODUCT UPDATE S-009	Is Safety Related Equipment Impacted	Yes ☒ No ☐	Page: 1 of 8

BACKGROUND

Years of Westinghouse RCP operating experience has demonstrated that complete failure of the No. 1 seal is a rare occurrence. A complete failure is defined as excessive No. 1 seal leakage in conjunction with pump bearing/seal inlet and/or No. 1 leakoff temperatures approaching or exceeding the maximum limits. Current operating procedures for failed No. 1 seals direct that the No. 1 seal leakoff be isolated within 5 minutes and RCP shutdown within 30 minutes. These procedures are specified in the RCP instruction books or addenda to the books.

After a review of current operating procedures and actual operating experiences with high and low leaking No. 1 seals, it was concluded that distinct procedures could specify steps for both emergency and orderly RCP shutdowns. The two items that follow have been incorporated into the revised procedures in this technical bulletin. As used within this bulletin, the term "emergency" refers to a condition that is related only to RCP operation and in no way pertains to emergency conditions for plant operation as defined in a plant Final Safety Analysis Report (FSAR).

1) A damaged No. 1 seal may produce debris or leak at a high enough rate to exceed the injection rate and introduce unfiltered, high temperature reactor coolant into the seals. In the presence of debris, the ability of the No. 2 seal to survive and function as a backup for the No. 1 seal is more favorable under static conditions. Thus, it is preferred to have pump shutdown precede No. 1 seal leakoff isolation.

Additional Information, if Required, may be Obtained from the Originator. Telephone 412- 963-5634 or (WIN) 298-5634

Originator

T. W. Dunn

T. W. Dunn, Manager, Field Service & RCP Engineering

R. F. Pfeifer

R. F. Pfeifer, Manager, CRDM & Seal Engineering

Approval

M. J. Harper

Energy Systems Sales Support

2) High No. 1 seal leakage (> 6.0 gpm) or low No. 1 seal leakage (< 0.8 gpm) can occur while no other RCP parameter limits are approached or violated. In these cases, pump shutdowns within several hours are within the capabilities of the RCPs and are more conducive to orderly plant shutdowns.

The following new procedures are provided to address each of four conditions that indicate No. 1 seal flow outside of the operating limits (0.8-6.0 gpm). The first three conditions address high No. 1 seal leakage and the fourth condition addresses low leakage. Each condition with its respective procedure is specified below and is summarized in Attachment A.

PROCEDURES

The following procedures supersede those in the RCP instruction books or addenda to the books relative to:

1) RCP emergency operation and shutdown procedures for high or low No. 1 seal leakage. Apply the Conditions 1 through 4 procedures that follow.

2) RCP emergency operation and shutdown procedure for No. 2 and No. 3 seals. Apply the procedure for shutdown specified under Condition 1 below. The No. 2 and No. 3 seal parameters that indicate emergency operation remain the same as specified in the RCP instruction books.

Definitions:

No. 1 seal leakoff indication:	Flowmeter readout of No. 1 seal leak rate
No. 2 seal leakoff indication:	Flowmeter readout or estimate of No. 2 seal leak rate
Total No. 1 Seal Flow:	Sum of No. 1 and No. 2 seal leakoff indications
Immediate Shutdown:	RCP shutdown and isolation of No. 1 seal leakoff within 5 minutes
Orderly Shutdown:	RCP shutdown within 8 hours of high/low No. 1 seal leakoff flow indication

NOTE: A manual plant trip must precede an "Emergency" or "Orderly" RCP shutdown. This will prevent an automatic plant trip on a "low flow" signal which represents an unnecessary challenge to installed safety systems.

If no alternative Westinghouse direction has been provided to address a specific RCP seal performance condition at a plant, the following are the recommended shutdown procedures for No. 1 seal leak rates outside the operating limits (0.8-6.0 gpm).

Condition 1: a) No. 1 seal leakoff indication > 6.0 gpm.

b) Increasing pump bearing/seal inlet temperature.

and/or

Increasing No. 1 seal leakoff temperature.

Procedure:

1) Shut down the RCP immediately.

2) Isolate the No. 1 seal leakoff after the RCP has come to a complete stop.

3) Monitor component cooling water (CCW) to ensure adequate flow and manually override automatic isolation as required. (Local boiling in the thermal barrier of the affected pump may cause isolation of the CCW system.)

4) Do not restart the pump until the cause of the seal malfunction has been determined and corrected.

Condition 2: a) No. 1 seal leakoff indication > 6.0 gpm.

and/or

Total No. 1 seal flow > 6.0 gpm and < 8.0 gpm.

b) Pump bearing/seal inlet temperature is not increasing.

c) No. 1 seal leakoff temperature (if equipped) is not increasing.

Procedure:

1) Prepare for an orderly pump shutdown to take effect within 8 hours of exceeding 6.0 gpm No. 1 seal flow. Ensure that seal injection flow rate is 9 gpm or greater to the affected RCP.

2) Continue to monitor the No. 1 seal for further degradation during the orderly shutdown. If the total No. 1 seal flow exceeds 8.0 gpm or temperatures begin to increase, proceed with immediate shutdown in accordance with the Condition 3 procedure. Otherwise, proceed with the orderly shutdown.

3) Secure the pump within 8 hours of exceeding a No. 1 seal leakoff indication or total No. 1 seal flow of 6.0 gpm.

4) Monitor component cooling water (CCW) to ensure adequate flow and manually override as required. (Local boiling in the thermal barrier of the affected pump may cause isolation of the CCW system.)

5) No. 1 seal leakoff may be isolated at the discretion of operations to mitigate inventory loss and to assure that seal injection flow exceeds total No. 1 seal flow on the affected pump.

6) Do not restart the pump until the cause of the seal malfunction has been determined and corrected.

Condition 3: a) Total No. 1 seal flow $\geq$ 8.0 gpm.

Procedure: 1) Shut down the RCP immediately.

2) Isolate the No. 1 seal leakoff after the RCP has come to a complete stop.

3) Monitor component cooling water (CCW) to ensure adequate flow and manually override automatic isolation as required. (Local boiling in the thermal barrier of the affected pump may cause isolation of the CCW system.)

4) Do not restart the pump until the cause of the seal malfunction has been determined and corrected.

Condition 4: a) No. 1 seal leakoff indication < 0.8 gpm.

b) Zero (or negligible) No. 2 seal leak rate such that total No. 1 seal flow < 0.8 gpm.

c) Pump bearing/seal inlet temperature and No. 1 seal leakoff temperature (if equipped) are stable (i.e., not continuously increasing) and within limits.

Procedure:

1) Prepare for an orderly pump shutdown to take effect within 8 hours of violating the minimum 0.8 No. 1 seal leak rate limit.

2) Continue to monitor the No. 1 seal for further degradation during the orderly shutdown. If the low No. 1 seal leakage reverses to high leakage (> 6.0 gpm) or temperatures start to increase, proceed with immediate shutdown in accordance with the Condition 1 procedure. Otherwise, proceed with the orderly shutdown.

3) Secure the pump within 8 hours of violating the minimum 0.8 No. 1 seal leak rate limit.

4) Do not restart the pump until the cause of the seal malfunction has been determined and corrected.

ATTACHMENT A

Condition	No. 1 Leakoff Indication	No. 2 Leakoff Indication	Total No. 1 Seal Flow	Pump Bearing/Seal Inlet and/or No. 1 Leakoff Temp.	RCP Shutdown
1	> 6.0 gpm		> 6.0 gpm	Increasing	Immediate (within 5 minutes)
2	> 6.0 gpm		> 6.0 and < 8.0 gpm	Stable	Orderly (within 8 hours)
3			> 8.0 gpm	Stable or increasing	Immediate (within 5 minutes)
4	< 0.8 gpm	zero (or negligible)	< 0.8 gpm	Stable	Orderly (within 8 hours)

Note:

Total No. 1 seal flow = No. 1 leakoff plus No. 2 leakoff indications

LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
93-83	Potential Loss of Spent Fuel Pool Cooling Following A Loss of Coolant Accident (LOCA)	10/07/93	All holders of OLs or CPs for boiling water reactors (BWRs).
93-82	Recent Fuel and Core Performance Problems in Operating Reactors	10/12/93	All holders of OLs or CPs for nuclear power reactors and all NRC-approved fuel suppliers.
93-81	Implementation of Engineering Expertise on Shift	10/12/93	All holders of OLs or CPs for nuclear power reactors.
93-80	Implementation of the Revised 10 CFR Part 20	10/08/93	All byproduct, source, and and special nuclear material licensees.
93-79	Core Shroud Cracking at Beltline Region Welds in Boiling-Water Reactors	09/30/93	All holders of operating licenses or construction permits for boiling-water reactors (BWRs).
93-78	Inoperable Safety Systems At A Non-Power Reactor	10/04/93	All holders of OLs or CPs for test and research reactors.
93-77	Human Errors that Result in Inadvertent Transfers of Special Nuclear Material at Fuel Cycle Facilities	10/04/93	All nuclear fuel cycle licensees.
93-76	Inadequate Control of Paint and Cleaners for Safety-Related Equipment	09/21/93	All holders of OLs or CPs for nuclear power reactors.
93-75	Spurious Tripping of Low-Voltage Power Circuit Breakers with GE RMS-9 Digital Trip Units	09/17/93	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

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Original signed by
Brian K. Grimes

Brian K. Grimes, Director
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*SEE PREVIOUS CONCURRENCE

OFF	*OGCB:DORS	*SRXB:DSSA	*SRI:DRP:RIII	*TECH ED
NAME	PCWen	CYLiang	SGDuPont	MMejac
DATE	07/26/93	07/26/93	07/26/93	07/27/93

*SC/DRP:RIII	*C/DRP:RIII	*SC/SRXB:DSSA	*C/SRXB:DSSA
MJFarber	BClayton	MACaruso	RCJones
07/29/93	07/29/93	08/05/93	08/09/93

*D/DSSA	*C/OGCB:DORS	D/DORS
ACThadani	GHMarcus	BKGrimes
09/23/93	09/28/93	10/15/93

DOCUMENT NAME: 93-84.IN

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*D/DSSA	C/OGCB:DORS	D/DORS
ACThadani	GHMarcus /RA/ for	BKGrimes /gll
09/23/93	09/28/93	09/ /93

DOCUMENT NAME: WRCPSEAL.WEN

ADDITIONAL INFO:

- The Braidwood PM (Ramin Assa) and RES (Prasad Kadambi) were provided with copies of the draft IN. Their comments have been incorporated.
- W Strategic Licensing Manager (Hank Sepp) was informed of the development of this IN. He provided the W Technical Manual.

- PER TELEPHONE CONVERSATION BETWEEN MR. SEPP AND P. WEN (10-1-93), MR. SEPP STATED THAT HE HAS NO OBJECTION TO THE NRC ATTACHING THE WESTINGHOUSE TECHNICAL BULLETIN TO THIS INFO NOTICE

Peter Wen 10/1/93

Peter Wen.

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PCW PCW

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for MJFarber	for BClayton	RCJones
07/29/93	07/29/93	08/9/93
	PER TELECON 7/29/93	

D/DSSA	C/OGCB:DORS	D/DORS
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