UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

NRC INSPECTION MANUAL

SRXB

TEMPORARY INSTRUCTION 2515/101

LOSS OF DECAY HEAT REMOVAL (GENERIC LETTER NO. 88-17)
10 CFR 50.54(f)

2515/101-01 PURPOSE

To assure licensee (all PWRs) actions to prevent and, if necessary, respond to loss of decay heat removal during operations with the reactor coolant system partially drained.

2515/101-02 OBJECTIVE

To verify licensee preparation for lowered inventory operation in accordance with "Loss of Decay Heat Removal" (Generic Letter No. 88-17), 10 CFR 50.54(f) October 17, 1988.

2515/101-03 DEFINITIONS

Containment Closure: Containment closure is defined as a containment condition where at least one integral barrier to the release of radioactive material is provided.

Mid-Loop Condition: A mid-loop condition exists whenever the RCS water level is below the top of the flow area of the hot legs at the junction with the reactor vessel.

Reduced Inventory Condition: A reduced inventory condition exists whenever the reactor vessel water level is lower than three feet below the reactor vessel flange.

2515/101-04 BACKGROUND

Loss of decay heat removal (DHR) during non-power operation and the consequences of such a loss have been of increasing concern to the NRC . Many events of loss of DHR have occurred while the reactor coolant system has been drained down for mid-loop activities such as steam generator inspection or repair of a reactor coolant pump. The possibility exists that two fission product barriers could be breached while these activities are in progress, since the reactor coolant system and the containment will both be open.

GL 87-12, "Loss of Residual Heat Removal (RHR) while the Reactor Coolant System (RCS) is Partially Filled" was issued to all licensees of operating PWRs and holders of construction permits on July 9, 1987. Responses indicated that licensees did not understand the identified problems, and the problem has continued, as evidenced by the event at Waterford on May 12, 1988 and Sequoyah on May 23, 1988.

The seriousness and continuation of this problem has resulted in the issuance of GL 88-17. In addition, the Director of NRR has written to the CEO of each licensee operating a PWR, in which he said "We consider this issue to be of high priority and request that you assure that your organization addresses it accordingly." He also wrote to each licensed operator at all PWR plants on "Operator Diligence While in Shutdown Conditions," and enclosed a copy of GL 88-17. A copy is enclosed as Appendix A.

GL 88-17 requires the recipients to respond with two plans of actions:

a. A short-term program entitled "expeditious actions," and

b. A longer-term program entitled "programmed enhancements."

This TI addresses the short-term licensee program entitled "expeditious actions." Another TI will be prepared at a later date which will address the longer-term program entitled "programmed enhancements."

2515/101-05 INSPECTION REQUIREMENTS

05.01 General. In those instances where the licensee has completed its response to the expeditious actions, the inspector should review the submitted response for implementation. Where the licensee has not yet submitted its response for the expeditious actions, the inspector should inspect for the present status of the response and determine whether the licensee proposes to meet the remaining requirements.

05.02 Training. By interviews with plant personnel, verify that the licensee has discussed with appropriate plant personnel the Diablo Canyon event of April 10, 1987, related events, lessons learned, and has taken steps to provide training to these personnel prior to entering a reduced inventory condition. Verify that the training included detailed reviews of all procedural and administrative changes implemented as a result of the licensee's response to GL 88-17.

05.03 Containment Closure. Verify that the licensee has prepared procedures and administrative controls to reasonably assure that containment closure will be achieved prior to the time at which core uncovery could occur as a result of a loss of DHR event. These procedure and administrative controls shall be in place prior to:

a. entering a reduced inventory condition for NSSSs supplied by Combustion Engineering or Westinghouse, or

b. entering an RCS condition where water level is lower than four inches below the top of the flow area of the hot legs at the junction of the hot legs to the reactor vessel for NSSSs supplied by Babcock and Wilcox.

05.04 Temperature Indication. Verify that for a mid-loop condition, with the reactor vessel head placed on the vessel, the licensee has taken adequate administrative and procedural steps to provide at least two independent, continuous coolant temperature indicators that are representative of the core exit conditions. Temperature monitoring should be performed by either:

a. an operator in the control room, or

b. a location outside the containment building with provision for providing immediate temperature values to an operator in the control room if significant changes occur.

05.05 RCS Water Level Indication. Verify that the licensee has made adequate procedural provisions to provide at least two independent, continuous RCS water level indications whenever the RCS is in a reduced inventory condition. Water level monitoring should be capable of being performed by either:

a. an operator in the control room, or

b. a location other than the control room with provisions for providing immediate water level values to an operator in the control room if significant changes occur.

05.06 RCS Perturbations. Verify that the licensee has implemented procedures and administrative controls that generally avoid operations that deliberately or knowingly lead to perturbations to the RCS and/or to systems that are necessary to maintain the RCS in a stable and controlled condition.

If operations that could perturb the RCS or systems supporting the RCS must be conducted while in a reduced inventory condition, then the procedures and administrative controls will require additional measures to assure that the RCS will remain in a stable and controlled condition.

05.07 RCS Inventory. Verify that the licensee has procedures and administrative controls to provide at least two available (ready for use quickly enough to meet the intended functional need) or operable means of adding inventory to the RCS that are in addition to pumps that are a part of the normal DHR systems. The path of water addition must be specified to assure the flow does not bypass the reactor vessel before exiting any opening in the RCS.

05.08 Hot Leg Flow Paths. Verify that the licensee for Westinghouse and Combustion Engineering NSSS designs has implemented procedures and administrative controls that reasonably assure that all hot legs are not blocked simultaneously by nozzle dams unless a vent path is provided that is large enough to prevent pressurization of the upper plenum of the RV.

05.09 Loop Stop Valves. Verify that licensees that utilize loop stop valves have implemented procedures and administrative controls that reasonably assure that all hot legs are not blocked simultaneously by closed stop valves unless a vent path is provided that is large enough to prevent pressurization of the reactor vessel upper plenum or unless the RCS configuration prevents reactor vessel water loss if reactor vessel pressurization should occur. Note: Closing cold legs by nozzle dams does not meet this condition.

2515/101-06 GUIDANCE

06.01 General Guidance. No further licensee responses to GL 87-12 are required; however, some licensees committed to operation and hardware changes in their GL 87-12 response. Licensees may modify or cancel such commitments in the response to GL 88-17.

Prior to conducting inspections required by this TI, the inspector should read and become completely familiar with GL 88-17, including both enclosures. The inspector should also become familiar with the information contained in Appendix B to this TI.

06.02 Specific Guidance.

a. Inspection Requirement 05.02. Training conducted by the licensee should ensure that licensee personnel are aware of the risks associated with operation in a condition with the RCS partially drained, and are aware of their activities with respect to:

   1. Industry experience so that they understand these events can happen at their plant.

   2. Pertinent aspects of each recommended action identified in GL 88-17.

   3. Operations affecting or potentially affecting the NSSS, containment, and the systems necessary for the support of the NSSS and containment.

b. Inspection Requirement 05.03. The concern for this area is to ensure that containment closure can be achieved before uncovering the core. The inspector may want to review containment closure procedures that should be located in the control room in addition to administrative procedures written to support containment-associated operations. The inspector should determine whether there is reasonable assurance that containment closure can be achieved, using available manpower, prior to the core uncovery times calculated by the licensee or specified in GL 88-17.

c. Inspection Requirement 05.04. At least two independent reactor vessel coolant temperature indicators should provide core exit temperature data when the RCS is partially drained with the reactor vessel head on the reactor vessel. If the temperature is monitored in the control room, it should be capable of giving an alarm or be periodically checked and recorded by operating personnel. If the temperature is monitored outside of the control room, it should be observed and recorded at intervals of 15 minutes or less, and there should be a provision for immediate notification of the operator of values outside the predetermined range.

d. Inspection Requirement 05.05. The concern in this area is to provide at least two independent RCS water level indications when in a reduced inventory condition. If the water level is monitored in the control room, it should be alarmed or level readings periodically checked and

recorded by operating personnel. If the level readout is outside the control room, it should be observed and recorded by operating personnel at intervals of 15 minutes or less, and there should be a provision for immediate notification of the operator for values outside the predetermined range. Since inaccurate level indications have been a major contributor to loss of DHR, the inspector should consider the issues discussed in Appendix B.

e. Inspection Requirement 05.06. The concern in this area is that the licensee has prepared procedures and established controls to avoid perturbations while in a reduced inventory condition. Procedures and administrative controls are particularly important during the first four weeks following shutdown when decay heat removal rates are high.

f. Inspection Requirement 05.07. The concern in this area is that the licensee has two additional means of adding water to the RCS if DHR is lost. Areas to consider would be:

1. One high pressure safety injection pump (or an equally effective and reliable means of injecting water) has been specified.

2. At least one other means of water addition specified.

3. Flow path established to add water to the reactor vessel.

4. Required time to initiate the addition of water is consistent with prevention of uncovering the core.

5. Flow rate sufficient to prevent uncovering the core.

6. Path provided for steam or water to leave RCS during water injection.

7. Procedures and administrative controls sufficient to reasonably ensure the above measures are achieved.

g. Inspection Requirement 05.08. The area of concern is to prevent inappropriate use of nozzle dams to reasonably assure that all hot legs are not blocked simultaneously by nozzle dams unless a vent path is provided that is large enough to prevent pressurization of the reactor vessel upper plenum. The vent path established (by either analysis or test) should be large enough to ensure that pressurization will be less than one psi if cold leg openings exist or less than nozzle dam design capability, with a 25 percent safety factor.

h. Inspection Requirement 05.09. The area of concern is to prevent the inappropriate use of loop stop valves to reasonably assure that all hot legs are not blocked simultaneously by closed stop valves unless a vent path is provided that is large enough to prevent pressurization of the reactor vessel upper plenum, or unless the RCS configuration prevents reactor vessel water loss if reactor vessel pressurization should occur.

2515/101-07 REPORTING REQUIREMENTS

The inspection findings should be documented in a routine inspection report, with a copy sent to:

M. Wayne Hodges, Chief
Reactor Systems Branch, NRR
OWFN, 8E-23

Findings of significant deficiencies in the licensee's implementation of GL 88-17 should be communicated by telephone conference call between the inspector, the inspector's supervisor (as appropriate), the NRR project manager for the plant, and Wayne Hodges, 301-492-0895.

2515/101-08 COMPLETION SCHEDULE

This inspection should be completed before the plant is operated in a reduced RCS inventory condition. The inspection should be done immediately if the plant is in an outage that involves a reduced inventory condition.

The inspection may be scheduled for completion just before a lowered inventory condition. If this option is used, the inspector(s) should be prepared to complete the inspection immediately if an unplanned outage occurs.

The NRR staff will prepare letter reports that assess the licensee responses to GL 88-17. The letter report could include questions to the licensee which may be applicable to this inspection. Thus, where letter reports are available, the inspector may wish to schedule the inspection (or portions thereof) for these plants first. Inspection should be completed before NRR review letter report input only for plants entering a low inventory condition.

2515/101-09 EXPIRATION

This TI expires two years after the date of issuance.

2515/101-10 CONTACT

Questions should be addressed to Wayne Hodges, Chief, Reactor Systems Branch, NRR, 301-492-0895.

2515/101-11 STATISTICAL DATA REPORTING

Record actual inspection time to module 255101 for this effort.

2515/101-12 ORIGINATING ORGANIZATION INFORMATION

12.01 Organization Responsibility.

NRR/SRXB originated this TI and retains responsibility for the technical review of responses to GL 88-17.

12.02 Estimated Resources.

The following direct inspection effort is estimated.

Item	Hours of Effort
Containment closure	6
RCS inventory addition	6
Training	8
RCS level	4
RCS perturbations	2
RCS temperature	2
Nozzle dams/loop stop valves	2
Total	30

END

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

November 3, 1988

TO: ALL HOLDERS OF REACTOR OPERATOR AND SENIOR REACTOR OPERATOR LICENSES FOR PRESSURIZED WATER REACTORS

SUBJECT: OPERATOR DILIGENCE WHILE IN SHUTDOWN CONDITIONS

The NRC is issuing this generic letter to ensure that licensed operators at the controls of nuclear power plants are made aware that serious accidents can occur while in shutdown conditions. Enclosed is a copy of Generic Letter 88-17 that the NRC has just transmitted to all pressurized water reactor licensees. The NRC's concern is based on technical evaluations and studies of operational events which have occurred when plants are in cold shutdown and have lost decay heat removal capability. We have found that loss of decay heat removal during cold shutdown conditions can lead to serious consequences sooner than previously recognized.

I am sending this information so that you are aware of our concerns. We are confident that your management will react quickly and appropriately to Generic Letter 88-17, but it will take some time to fully address the issues raised. Your awareness of these insights into non-power operation are particularly important during this interim period.

Thomas E Murley

Thomas E. Murley, Director
Office of Nuclear Reactor Regulation

Enclosure:
Generic Letter 88-17

cc w/encl: NRC Regional Offices
NRC Resident Inspectors

cc w/o encl: Addresses of Generic Letter 88-17

APPENDIX B

SUPPLEMENTAL INFORMATION

A. INTRODUCTION

Appendix A contains information on events and level instrumentation.

B. EVENTS

The events listed, can provide valuable experience and insight to the inspector. Additional information is listed below.

1. Arkansas Nuclear One, Unit 1, October 26, 1988.

Electricians caused a decay heat removal (DHR) system valve to close which stopped DHR flow. Operators were slow to respond because of many previous loss-of-flow alarms, which relegated the alarm to a "nuisance" status. Reactor coolant system (RCS) heatup was small since the reactor had been refueled.

Discussion of this event by Arkansas and staff personnel identified the following areas that may also apply to other facilities:

a. Level indication - RCS level instruments did not agree.

b. Level behavior within the RCS - A flow analysis did not exist that would have determined if level variation was significant within the B&W-designed RCS.

c. Accuracy of vortexing correlations - Apparently air ingestion was occurring at a level at which this should not have occurred.

d. Operating procedures - Operators (correctly) reduced DHR flow rate to eliminate air ingestion. They did not have the flexibility to change the low-flow alarm setpoint.

e. Training - Operators attempted to compensate for the operating difficulties. Lowered inventory operation can be challenging, and operators should not be placed in positions that complicate operation.

f. Management followup - It is not clear whether management was addressing the operating problems.

g. Maintenance and test activities - Such activities were continued during lowered inventory operation. However, refueling had been completed and decay heat generation rate was low which was a compensating consideration.

h. Failure behavior - The licensee initiated investigation of

(1) Whether the valve should fail open rather than closed upon loss of electrical power to the controllers, and

(2) Whether one electrical power source was adequate for both controllers.

2. Surry Unit 2, September 19, 1988.

DHR loss occurred when purging the RCS under conditions that led to erroneous level indications. This event is an example of a failure to understand:

a. RCS geometry

b. The effect of geometry on RCS behavior

c. The effect of geometry and operations on level indications

Particularly noteworthy is the rapid operator response, which perhaps was made possible by an alarm on DHR system suction pressure. The operators immediately confirmed the alarm by observing fluctuating pump motor current, promptly reduced DHR flow rate, and increased RCS inventory. These actions eliminated the problem without loss of DHR. Operator response to the symptoms was excellent. However, the operators had been observing abnormal level behavior. Procedures and training should have guided them to stop operations until they understood the abnormalities and reacted accordingly.

3. Byron Unit 1, September 19, 1988.

DHR loss occurred when draining the refueling water pool via the DHR system with the reactor vessel upper internals in place. Apparently, springs holding the upper internals had lost resilience, allowing the upper internals to seat and closing the pool to the RCS flow area. Personnel did not realize this circumstance and drained the RCS while attempting to empty the pool.

This is an example of accidental entry into lowered inventory (and mid-loop) operation, which occurred despite warnings from personnel at the pool that they were having trouble observing water level.

Observing water level in receiving tanks might have identified the problem. Good level instruments with alarms would have done so.

4. Oconee, September 11, 1988.

Loss of DHR occurred because of loss of all safety-related AC electrical power. Testing caused the failure. Of note is the single failure causing loss of all DHR and pumped RCS makeup/cooling capability.

The licensee responded by improving procedures and training.

5. San Onofre Unit 2. July 7, 1988.

DHR loss occurred in part because of level instrument dependency. Maintenance personnel blocked the only reference connection to the pressurizer. This is an example of:

a. Inadequate training - Personnel should be aware that they do not arbitrarily block penetrations.

b. Inadequate procedures - Checking water level behavior in receiving tanks as a function of RCS level would have identified a problem.

c. Lack of independence - Complete instrument independence would have shown contradictory level readings.

Note that alarms on RCS level would not have helped because of the dependency on a common pressurizer connection.

6. Sequoyah, May 23, 1988.

DHR loss was due to opening the wrong valve and draining water from the RCS. Operators restored DHR 3 1/2 hours later. The plant had been shut down for some time, and vessel thermocouples showed a temperature increase of a few degrees.

The loss occurred because of mistakes and inadequate procedures. The 3 1/2-hour restoration time is of no concern if:

a. Procedures guided operator response

b. More rapid response would have been achieved if needed

c. Technical specifications were met.

(Technical specifications that allow stopping DHR for extended times are sometimes acceptable: see GL 88-17 guidance.)

7. Waterford Unit 3, May 12, 1988.

DHR loss occurred because of:

a. Poor installation of temporary instrument tubing

b. Failure to monitor the tubing

c. Failure to identify why level instruments disagreed

d. Failure to identify the problem following the initial loss of DHR

e. Training deficiencies

f. Inadequate procedures, etc.

This event is also an example of problems that can occur during instrument improvement operations.

8. Salem Unit 1, October 9, 1987.

Procedures allowed too much water in the RCS. As a result, steam generator tubes did not fully drain and the opening of a steam generator dumped RCS water onto personnel.

Overreaction to avoiding DHR loss led to this problem. Both procedures writers and operators wanted to be sure that there was enough water in the RCS for DHR operation. Procedures were written with tolerances that allowed the hot leg to be full, and operators controlled level at the upper limit of the tolerances. As a result, there was no path for air to enter the steam generator tubes.

Problem avoidance steps include:

a. Independent checking and verification of procedure changes

b. Comparing receiving tank level with expected level during draining

c. Improved draining procedures

d. Better understanding of plant configuration

e. Better understanding of phenomena and expected behavior

Regarding item 1(h)3, we have recommended nitrogen injection directly under the steam generators or into the steam generator plena to allow controlled tube draining with a high RCS level. We recently learned that this procedure is covered by U.S. Patent Number 4,649,019, issued to John C. Jawor. Apparently, he is asking an initial fee and an annual fee for use of this process. We have no information regarding the correctness of this information.

Steam generator tubes can also be safely drained by allowing nitrogen to flow along the top of the hot leg from either the pressurizer or the reactor vessel.

9. Diablo Canyon Unit 2, April 10, 1987.

This event triggered issuance of Generic Letter (GL) 87-12 and GL 88-17. The licensee and NRC inspectors, working together, found the following conditions at Diablo Canyon:

a. Design inadequacies

b. Inadequate installation documentation

c. Inadequate installation

d. No independent review of hardware following installation

e. Few or no periodic walkdowns of hardware

f. Limited maintenance planning

g. Level instrument behavior not understood

h. NSSS behavior during normal operation not understood

i. NSSS behavior during off-normal situations not understood

j. Analysis and test basis nonexistent

Failure to recognize problems extended into planning, operator training, maintenance, and followup of operator difficulties. Management involvement in these and other difficulties ranged from weak to nonexistent. (See NUREG 1269, Appendices C and D.)

We later found many of the problems to be generic to most licensed PWR operations.

10. Waterford Unit 3, July 14, 1986.

Waterford is of interest because of:

a. Potentially serious consequences

b. Unrecognized behavior

c. Extensive and extended boiling in the RCS

d. Inability to restore DHR

e. The inappropriate amount of time with no DHR, and many more items that have been identified above.

The DHR suction line at Waterford has a section higher than the connection to the RCS. Once saturation developed in the RCS, it was no longer possible to prevent flashing in that elevated section. This is a potential problem at many plants in which elevated suction line sections extend to near the hot leg elevation. Unlike Waterford, many of these plants do not have vacuum pumps to aid in removing vapor or gas from such sections. We seen little recognition of this potential problem.

C. RCS LEVEL INDICATION

1. Level indication accuracy.

The closer the actual level to the elevation at which DHR will be lost, the more stringent is the accuracy requirement. Actual accuracy requirements will vary between plants.

Small level variations may occur within the RCS during DHR operation. These variations should be considered in determining level uncertainty at the DHR drop line connection to the RCS hot leg. Effects of interest include friction throughout the RCS, density variation, air entrainment, and dynamics associated with turns and "tees" in the flow path. Note that these effects may be functions of flow rate, temperature, temperature difference, and RCS level.

The lower limit of the uncertainty band shall be used in determining whether the RCS is in a lowered inventory or mid-loop condition.

2. Level instrument calibration.

Level readings should be compared whenever their ranges overlap. Expected differences, such as those caused by flow, should be factored into the comparison.

3. Temporary level installations.

For this temporary instruction, a temporary installation is any installation that:

a. Is incapable of withstanding RCS conditions that follow an extended loss of DHR, exclusive of severe core damage conditions

b. Includes temporary tubing runs, exclusive of spool pieces

Use of ordinary plastic tubing is inconsistent with a permanent installation.

Licensees may use temporary installations to provide information to the operators during the short term. The monitoring conditions discussed in GL 88-17 should be followed.

Licensees may also use temporary installations in the longer term to supplement information displayed to operators in the control room. Valves that isolate such installations from the RCS shall be provided for all connections below the RCS water level. These valves should be closed:

a. Whenever the installation is unattended for more than 1 hour, or

b. Upon containment evacuation if the valves can be closed without risk to operating personnel.

4. Level instrument installation.

All tubing runs should avoid elevation changes that could provide either liquid or vapor/gas traps. When this avoidance is impractical, provision should be made for collection of the liquid or vapor/gas and for its periodic removal. Temporary installations should be walked down immediately before use and should be walked down daily during use.

Many feet of small diameter tubing are often used in combinations of horizontal or near horizontal and vertical runs. Merely providing a slope may not ensure that water slugs or air bubbles move to maximum or minimum elevations. For example, consider a horizontal, air filled tube that contains a water slug that undergoes an RCS level change that causes air movement in the tube. There will be little effect on the level reading as long as the slug remains in the horizontal section. But if an RCS level change causes the slug to move into a vertical section, the slug may simply hang in the tube. A level instrument connected via this tube will be erroneous by the vertical height of the slug.

END