VERMONT YANKEE
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January 17, 2000
BVY 00-010

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington D.C. 20555

Subject: **Vermont Yankee Nuclear Power Station**
License No. DPR-28 (Docket No. 50-271)
Reportable Occurrence No. LER 99-06, Rev. 0

As defined by 10CFR50.73, we are reporting the attached Reportable Occurrence as LER 99-06, Rev. 0.

Sincerely,

VERMONT YANKEE NUCLEAR POWER CORPORATION

Michael A Balduzzi

Michael A. Balduzzi
Plant Manager

cc: USNRC Region I Administrator
USNRC Resident Inspector – VYNPS
USNRC Project Manager – VYNPS
VT Dept. of Public Service

IE22

NRC FORM 366 U.S. NUCLEAR REGULATORY COMMISSION
(6-1998)

LICENSEE EVENT REPORT (LER)

APPROVED BY OMB NO. 3150-0104 EXPIRES 06/30/2001

Estimated burden per response to comply with this mandatory information collection request: 50 hrs. Reported lessons learned are incorporated into the licensing process and fed back to industry. Forward comments regarding burden estimate to the Records Management Branch (T-6 F33), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, and to the Paperwork Reduction Project (3150-0104), Office of Management and Budget, Washington, DC 20503. If an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

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TITLE (4)

LIMITORQUE ACTUATOR MALFUNCTION RESULTS IN FAILURE OF AN RHR HEAT EXCHANGER BYPASS VALVE STEM.

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
12	16	99	99	06	00	01	17	00	N/A	

OPERATING MODE (9)	N	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR • : (Check one or more) (11)							
POWER LEVEL (10)	100		20.2201(b)		20.2203(a)(2)(v)		50.73(a)(2)(i)		50.73(a)(2)(viii)
			20.2203(a)(1)		20.2203(a)(3)(i)	X	50.73(a)(2)(ii)		50.73(a)(2)(x)
			20.2203(a)(2)(i)		20.2203(a)(3)(ii)		50.73(a)(2)(iii)		73.71
			20.2203(a)(2)(ii)		20.2203(a)(4)		50.73(a)(2)(iv)		OTHER
			20.2203(a)(2)(iii)		50.36(c)(1)		50.73(a)(2)(v)		Specify in Abstract below or in NRC Form 366A
			20.2203(a)(2)(iv)		50.36(c)(2)		50.73(a)(2)(vii)		

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER (Include Area Code)
Michael A. Balduzzi, Plant Manager	(802) 257-7711

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (12)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX		CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX
B & D	BO	FCV	A200	YES		N/A				
B	BO	75	L200	YES		N/A				

SUPPLEMENTAL REPORT EXPECTED (14)			EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
	YES (If yes, complete EXPECTED SUBMISSION DATE).	X NO				

ABSTRACT (Limit to 1400 spaces, i.e., approximately 15 single-spaced typewritten lines) (16)

On 12/16/99, Vermont Yankee (VY) determined that one of two Residual Heat Removal (RHR) subsystems had been operated for approximately 18 months with a degraded heat exchanger bypass valve. A review of historical data and valve manufacturer specifications revealed that the "B" RHR heat exchanger bypass valve stem had broken between 03/24/98 and 05/29/98, but had gone undetected. The valve stem has been replaced. The as-found condition of the stem was a through-stem break above the valve backseat. The root cause of this event was a failure of the actuator to cease open movement at its open limit setting (backseating). The most likely cause of the backseating was a loosened motor-actuator worm gear locknut identified in 1995. Securing the MOV worm gear locknut is properly controlled/verified in the current VY MOV maintenance procedure as was recommended in industry operating experience. The failed actuator worm gear lock nut had been installed in 1989, when VY maintenance procedures lacked their current controls

The VY RHR heat exchanger bypass valve is a 20 inch globe valve. With the valve stem separated, the valve consistently performed as expected, throttling upon demand to direct flow through the RHR heat exchanger for torus/shutdown cooling, and opening sufficiently to allow the necessary flow via the LPCI injection path. The disk guides apparently provided adequate alignment of the separated disk and stem segment to allow the valve to function as a stop-check valve. The valve was repeatedly operated and tested during the period it was degraded, showing itself consistently capable of opening or throttling closed upon demand. Therefore, this event did not significantly increase the risk to public health and safety.

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TEXT *(If more space is required, use additional copies of NRC Form 366A)* (17)

DESCRIPTION

On 12/16/99, while operating at 100% power, Vermont Yankee (VY) determined that one of two Residual Heat Removal (RHR, EIIS=BO) subsystems had been operated for approximately 18 months with a degraded heat exchanger bypass valve (EIIS=FCV). The determination was the result of an ongoing investigation initiated by an unexpected valve response during RHR heat exchanger (EIIS=CLR) capacity testing during the 1999 refueling outage. The degraded RHR heat exchanger bypass valve had been repaired during the previous refueling outage. The VY RHR heat exchanger bypass valves are 20 inch, normal seating, Walworth globe valves, model 5281 WE, with model SMB-4 Limitorque actuators.

On 10/30/99, while shut down for refueling, VY personnel were performing RHR heat exchanger capacity testing when the "A" and "B" RHR heat exchanger bypass valves (RHR-65A/B) failed to go fully closed upon demand. Investigation revealed that the steps allowed by the controlling procedures caused the differential pressure across the RHR-65 valves to reach a value corresponding to their motor operated valve (MOV) torque switch settings. The controlling procedures allowed the valves to be throttled in the shut direction after having throttled the heat exchanger inlet valves (RHR-23A/B). The behavior of the RHR-65A valve was fully explainable with the higher than normal differential pressure created during testing by throttling the 23A valve. However, because the operators encountered additional difficulty while trying to manually seat the RHR-65B valve during the heat exchanger testing, it was concluded that the condition of the RHR-65B valve merited further investigation. The RHR-65B valve was considered potentially degraded but operable, based partly upon the limited system requirements while the reactor was in cold shutdown.

On 10/31/99, a VY internal event report (VYER) was initiated to identify that the RHR-65B did not fully close during the RHR heat exchanger testing. The "B" Loop of RHR was declared inoperable.

On 11/02/99, a second VYER was initiated to assess the cause and corrective action for the unexpected RHR-65A&B valve operation during the heat exchanger capacity test and its potential impact upon RHR heat exchanger capability.

Through 11/03 and 11/04/99, VY's Fluid Systems Engineering Department (FSD) assessed the details of the RHR-65B performance and the valve's maintenance history. FSD identified that there were anomalies present in MOV test data for the RHR-65B valve. VY reviewed the facts available and determined that additional information was needed.

On 11/05/99 a work order was initiated to perform non-intrusive diagnostic testing of the RHR-65B valve under dynamic conditions. Again, the information obtained was inconclusive. The "B" RHR subsystem was subsequently placed in the torus cooling mode of operation. During that operation the RHR-65B valve closed upon demand from the control room as expected. No other abnormal system response was noted.

On 11/14/99, because VY Engineering believed that the most likely cause of the abnormal indications was a loose motor actuator stem nut lock nut, a measurement of the actuator stem nut clearance was taken. The measurement was within tolerance. While stroking the valve closed to recheck the gap, an unexpected mechanical noise emanated from the valve, which required further investigation.

On 11/16/99 a work order request was initiated to disassemble the RHR-65B valve. The valve was disassembled, which revealed a stem failure. The as-found condition of the stem was a through-stem break approximately 4 inches above the stem backseat. A Technical Representative from the valve vendor inspected the "as-found" condition of the valve. It was the Technical Representative's assessment that the valve had been functioning as a stop check valve since the stem separation. He also noted indications that the valve had previously been subjected to high seating forces onto its backseat (a groove was noted in the hardened seating surface).

The RHR-65B valve performance anomalies present motivated VY to seek further evidence to assess the operability of the redundant RHR valve (RHR-65A). A plan was developed to perform an Ultrasonic Test (UT) through the length of the RHR-65A valve stem to ensure it was intact.

On 11/20/99, the UT showed a defect in the RHR-65A valve stem. Although, the technique did not allow quantifying the size of the defect, the RHR-65A valve was assessed to be fully capable of supporting TS operability requirements with the plant in the cold shutdown condition. While the condition of the RHR-65A valve was being fully assessed, and the need for expanded Ultrasonic Testing of other valve stems was being evaluated, the RHR-65B valve repair was completed, restoring its operability. However, the operability of the "B" loop of Low Pressure Coolant Injection (LPCI) was not credited until 12/01/99. A third VYER was initiated to ensure proper assessment of the RHR-65A conditions.

By 11/24/99, a total of 11 valves had been tested using the UT method. Only the RHR-65A valve was found to have a defect. The RHR-65A valve was tested to confirm/assess its operability. The Ultrasonic Testing was expanded to 11 valves due to the indication found in the RHR-65A valve stem, to assess the extent of condition. The valves to be tested were selected based upon a combination of safety significance, severity of valve service (i.e. throttling applications), history of backseating, and stem material.

By 11/28/99, the RHR-65A valve stem was replaced, and tested satisfactory.

Analysis of the Event

With both RHR heat exchanger bypass valves repaired and operable, the VY investigation mandated by the VYER continued. As a part of that investigation a review of the RHR-65B valve maintenance history was performed. The following describes the steps taken to determine the cause(s), the information gathered during that investigation, and the conclusions drawn.

Key Historical Events:

In 03/95, the RHR-65B valve actuator was discovered in a degraded condition. The actuator worm shaft bearing lock nut was discovered to have backed off and its threads were stripped. Repairs were made, as necessary, and the equipment tested to verify operability. The actuator installed on the 65B valve at the time was a Limitorque SMB-4T. A root cause for the indicated high opening thrust was not determined.

On 05/29/98, maintenance records show that the RHR-65B valve failed to close during a static In Service Test (IST). Investigation at that time showed that the actuator motor breaker had tripped on thermal overload. Repairs were made, as necessary, and the equipment subsequently tested to verify operability. No root cause was determined for the failure.

On 11/16/99, the RHR-65B valve stem failure was discovered.

Historical Event Details:

The 03/95 event revealed that the actuator worm shaft bearing lock nut to have backed off and stripped its threads. This condition indicates that the valve actuator had delivered excessive thrust in the open direction. This would have produced indications consistent with those observed by the Vendor Technical Representative during his inspection of the 11/99 as-found condition. The valve stroke time and stroke length remained unchanged, indicating that the valve stem did not separate at that time.

Review of the 05/29/98 event, in which the RHR-65B valve failed to go fully closed during a static IST test, revealed the following. Initial local conditions seemed to indicate that the valve was fully closed. The limit switches that should have provided full shut indication to the control room operator, and deenergized the actuator during the closing sequence (intended setpoints at 2.0%) appeared to be set at 0% (fully closed). Investigating technicians attempted to open the valve manually to determine the actual settings of the valve control limit switches. It was not possible to move the valve with the local handwheel. The valve was opened electrically by "bumping it" using the motor actuator. The valve moved smoothly after being unseated. The RHR-65B valve was manually cycled several times to determine and verify the full valve stroke length and set the valve control limit switches at the appropriate positions. The stroke length was found to be approximately 0.5 inches longer than recorded in the maintenance records. The limit switches were reset using the newly determined valve stroke. It was concluded that an error had been made during an 11/97 design change, that replaced the RHR-65B valve actuator and set the limit switches.

Nature of the RHR-65B Stem Failure:

After the 11/99 replacement of RHR-65B valve stem, the failed valve stem was delivered to a metallurgical laboratory for analysis. The laboratory identified that the break was caused by a fatigue failure that started at a notch type defect in the valve stem. The notch was due to impingement between the type 410 stainless steel lantern ring and the type 410 stainless steel valve stem. The notch then propagated as a fatigue failure due to tensile stresses applied to the stem. Laboratory analysis confirmed that the valve stem hardness was in the acceptable range (consistent with guidance provided in industry operating experience) and did not significantly contribute to an accelerated failure.

Nature of the RHR-65A Stem Crack:

After the 11/99 replacement of RHR-65A valve stem, the flawed valve stem was delivered to a metallurgical laboratory for analysis. The flaw in the RHR-65A valve stem was also a fatigue type defect. However, it had initiated at the shoulder formed at the back seat. The size of the crack (approximately 33% of the stem cross section) was insufficient to have challenged valve operability. Laboratory analysis of the crack showed that it had been present for an extended period of time and had not propagated in recent years. During the period it was propagating, it did so in multiple stages. That is, it did not achieve the as-found size from a single event but through a series of applied loads. Like the RHR-65B valve stem, the RHR-65A valve stem hardness was in the acceptable range.

Observations:

The information gained from the analysis of the RHR-65A valve stem crack is essential to understanding what occurred with the RHR-65B valve stem failure. As stated above, the crack in the RHR-65A valve, gives evidence that during some period of the valve operating history, operating stresses were such that the crack was caused to propagate, and that those stresses occurred repeatedly. Additionally, the evidence also shows that those stresses ceased some time ago. By April of 1988, VY had implemented a design change that discontinued the practice of torquing the RHR-65A valve onto its backseat. Since there has been no other significant change in the stresses routinely applied to the RHR-65A valve stem, it was concluded that it was this change that arrested the propagation of the crack in the RHR-65A valve stem.

The practice of torquing the RHR-65B valve onto its backseat was halted soon after, with a 03/89 design change. Additionally, a review of the RHR system operating history reveals that the "A" RHR Subsystem is used for the Shutdown Cooling and Suppression Pool Cooling modes of RHR system operation more frequently than the "B" RHR subsystem. Absent an off-normal event, any crack present in the RHR-65B valve stem would have propagated more slowly than the rate shown in the RHR-65A valve stem.

The 03/95 event, in which the RHR-65B valve actuator worm shaft bearing lock nut was discovered to have backed off, resulted in delivering high thrust against the valve backseat. The failure disabled the open torque switch function, while simultaneously disrupting the gearing that provides valve position indication in the SMB-4T actuator. This resulted in the stopping of the actuator motor (in the open direction) to be dependent solely upon the position of the manual control switch. This allowed full motor torque to be applied to the stem while against its backseat, greatly accelerating the propagation of the existing flaw. Absent this off-normal event, it is evident that the condition of the RHR-65B valve stem would have been, at worst, consistent with the condition found in the RHR-65A valve. The RHR-65B valve would have been degraded, but operable, with its crack propagation having been arrested by the 03/89 design change. However, it is apparent that the 03/95 motor actuator malfunction caused sufficient damage to allow normal operating loads (despite the cessation of torquing the valve onto the backseat) to propagate the crack.

On 05/29/98, the failure of the RHR-65B valve to go closed during IST testing, provided the first evidence that the stem had separated. The "as-found" valve stroke during the 05/29/98 event was 6.375 inches.

On 12/16/99, during the VYER investigation, it was recognized that the 6.375 inch valve stroke exceeds the design stroke of the valve (5.875 inches). With that realization, an attempt was made to quantify what the actuator stroke would have been if the stem had separated on 05/29/98. The stroke length, should such a failure have occurred, would be limited by the length of the anti-rotation key slot in the open direction, and contact with the lower stem segment in the close direction. The length of travel under the failed condition was determined to be 6.4 inches. This is close enough to the 6.375 inch as-found stroke length to conclude that the valve stem had separated on or before 05/29/98. It also substantiates the assessment of the Vendor Technical Representative that the valve disk and stem assembly had been held in position by the disk guides. If the stem segments were not in alignment, the actuator stroke would have been approximately 7.0 inches. MOV test data obtained on 03/24/98 shows the RHR-65B stem to have been intact at that time. Therefore the evidence shows that the stem separation occurred between 03/24/98 and 05/29/98 but the stem segments remained in alignment.

As a result of the VYER investigation it was recognized that the susceptibility of the worm gear bearing locknut backing off had been identified in previous industry operating experience. NRC IE Information Notice 84-36, "Loosening of Locking Nut on Limitorque Operator," identified multiple occurrences of this problem at other nuclear facilities. Information Notice 84-36, also referenced an NRC IE Circular 79-04, "Loose Locking Nut on Limitorque Valve Operators," noting that, "The concerns and recommended actions noted in that document are also applicable here."

VY's review of INF 84-36 determined that a one-time inspection of MOV's to verify that the condition was not present in VY actuators was appropriate. However, the concerns and recommendations of the reference Circular were not addressed. IE Circular 79-04 stated, "The recommended action is to . . . verify that assembly and maintenance instructions contain directions for securing the locking nut either by staking, per the vendor's recommendation, or another acceptable manner."

In 1989, the spring pack was replaced in the RHR-65B valve actuator. A one time inspection in the 1984 time frame would have identified problems present at that time. However, the failure to incorporate the IE Circular's recommendations regarding the adequacy of VY maintenance instructions, may have allowed inadequate securing of the worm gear bearing locknut during the spring pack replacement.

CAUSE

1. The root cause of this event was a failure of the actuator to cease open movement at its open limit setting. The most likely cause was a loosened worm shaft bearing locknut. This may have occurred as a result of a spring pack replacement in 1989, or during the excessive backseating event in 1995 that damaged the assembly. The worm shaft bearing locknut backing off, allowed excessive thrust to be applied to the valve stem. This was a major precursor to the RHR-65B valve stem separation.

   The failure to fully utilize the information provided in INF 84-36 may have allowed an inadequate installation of the locknut.

2. A major contributing cause was the past practice of torquing the RHR-65B valve onto its backseat. This practice was discontinued in 1989.

ASSESSMENT OF SAFETY SIGNIFICANCE

The Residual Heat Removal System consists of two 100% capacity subsystems of two pumps, one heat exchanger, valves and piping that fulfill the following functions:

1. Removal of decay heat during and after plant shutdown.

2. Injection of water into the reactor vessel following a loss-of-coolant accident and depressurization rapidly enough to reflood the core and prevent fuel clad conditions from exceeding 10CFR50.46 criteria independent of other core cooling systems.

3. Removal of heat from the primary containment following a loss-of-coolant accident to limit the increase in primary containment pressure. This is accomplished by cooling and recirculating the water inside the primary containment. The redundancy of the equipment provided for containment is further extended by a separate part of the RHR System that sprays cooling water into the drywell.

Relative to LPCI injection & Containment Spray - A Technical Representative from the valve vendor visited VY and inspected the "as-found" condition of the valve during its initial inspection. It was the Technical Representative's assessment that the valve had been functioning as a stop check valve since the stem separation. The valve's operation in support of Low Pressure Coolant Injection was largely unaffected. The globe design, installed with system flow entering under the valve disk, combined with disk and body mounted alignment guides, allowed the valve to open upon demand sufficiently to allow the necessary flow via the LPCI path.

Additionally, each Core Spray subsystem had a system availability greater than 99% during the period that the RHR "B" subsystem was degraded. Either Core Spray subsystem is capable of mitigating the consequences of a Design Basis Loss of Coolant Accident, as described in the VY Final Safety Analysis Report, maintaining the consequences within the limits of 10CFR100.

Relative to Suppression Pool Cooling & Shutdown Cooling - The disk guides also appear to have consistently maintained the alignment between the upper stem segment and the lower stem and disk assembly, allowing the actuator to drive the valve closed against normal system differential pressures in support of containment and reactor cooling safety functions. The valve actuator would have positioned the valve disk, directing more flow through the heat exchanger, achieving flows that would have approached, if not attained, design values. During the operating period while the RHR-65B valve was degraded, the system was operated in the suppression pool cooling mode multiple times. On no occasion was the system response other than that anticipated. The RHR-65B valve position and other controlled parameters, such as suppression pool temperature responded as expected. Therefore system challenges due to elevated suppression pool temperatures, such as reduced RHR or Core

Spray pump suction head, would not have occurred. Further, for transient scenarios requiring suppression pool cooling, the VY Individual Plant Examination credits either the "A" RHR Subsystem or the hard-piped torus vent system.

Additionally, during the period when the RHR-65B valve was degraded, the "A" RHR subsystem has had an availability in excess of 98% (using VY maintenance rule program guidelines for determining unavailability).

Therefore, this event did not significantly increase the risk to public health and safety.

CORRECTIVE ACTIONS

1. VY internal event report was initiated to ensure that a formal cause determination is performed and that appropriate corrective actions are implemented.

2. A sampling of other valves were tested using UT to determine the extent of condition. Only the RHR-65A valve stem was found to be flawed.

3. The valve stems of the RHR-65A and RHR-65B valves were replaced.

4. The RHR-65B valve actuator was upgraded, from an SMB-4T to an SMB-4, in 1995 as part of an unrelated design change.

5. Current VY MOV maintenance procedures contain the directions recommended by the cited operating experience documents. No change was required as a result of this event.

6. A major upgrade of the VY Operating Experience review program was performed in 1996. The current program would not allow oversights such as the omission of the recommendations provided in IE Circular 79-04.

7. A review of Motor Actuator maintenance history will be performed to determine the need for additional inspection/testing.

8. VY Safety Class MOV wiring is no longer configured to torque the valves onto their backseats. This change was made as part of an unrelated design change.

ADDITIONAL INFORMATION

The opportunity to identify the failure of the RHR-65B valve during the 1998 refueling outage was missed, due in part, to the lack of definitive evidence to clearly identify a valve internals problem. The additional insights gained during the 1999 refueling outage via valve and RHR system testing provided information necessary to determine the ultimate cause. This lack of definitive evidence further complicated the corrective action determination process in 1998.

The RHR-65A & B valves stem seal designs have been modified. The change included the removal of lantern ring and installation of high performance packing. The improvement in packing design was made prior to, and independent to the discovery of this event.

VY has reported the following similar events to the NRC.

LER 98-05, 04/09/98 - Failure to Fully Understand the Scope of Water Hammer Issues as Described in a 1973 Operating Experience Document Results in HPCI/RCIC Exhaust Lines Being Susceptible to Water Hammer.

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TEXT *(If more space is required, use additional copies of NRC Form 366A)* (17)

LER 96-22, 09/13/96 - Combination of Poor Man-machine Interface, an Inadequate Procedure, a Mechanical Failure, and Inadequate Operating Experience Review Results in an Emergency Diesel Generator to Exceed Technical Specification Outage Time.