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January 17, 1973

Mr. David D. Comey
Businessmen for the Public Interest
Suite 1001
109 North Dearborn Street
Chicago, Illinois 60602

50-305

Re: Kewaunee Nuclear Power Plant

Dear Dave:

Pursuant to your request, I am enclosing an Operating Experiences Report on Valve Malfunctions in Nuclear Power Plants.

In addition, I am enclosing RO Inquiry Report No. 050-305/73-01Q(CDR) as part of the continuing discovery process in regard to the above referenced plant.

Sincerely,

R. Rex Renfrow, III
Counsel for AEC Regulatory Staff

Enclosures (2)
Operating Experiences Report
RO Inquiry Report

| | | | | | | |
|---|---|---|---|---|---|---|
| OFFICE ▶ | OGC | | | | | Hearing |
| SURNAME ▶ | RRENFROW:ml | | | | | |
| DATE ▶ | 1/17/73 | | | | | |

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U. S. ATOMIC ENERGY COMMISSION
DIRECTORATE OF REGULATORY OPERATIONS

REGION III

RO Inquiry Report No. 050-305/73-01Q (CDR)

Subject: Wisconsin Public Service Corporation
P. O. Box 1200
Green Bay, Wisconsin 54305
License No. CPPR-50
Kewaunee Nuclear Power Plant
Two Main Steam Isolation Check Valve Disks Were Found to Have Crack Indications

Prepared by: R. A. Rohrbacher [signature] 1-10-73 (Date)

Reviewed by: D. W. Hayes [signature] 1-10-73
Senior Project Inspector (Acting) (Date)

A. Date and Manner AEC was Informed:

RO:III received a telephone call from a representative of the licensee on January 2, 1973.

B. Description of Particular Event or Circumstance:

Two 30" main steam isolation check valve disks were found to have significant crack indications during nondestructive testing performed at the site.

The material (ASTM 538, Grade B) was ultrasonically tested at the mill prior to machining, and the disk overlay was liquid penetrant tested prior to shipment to the site. These two tests did not reveal unacceptable defects. However, the final liquid penetrant test of the entire disk area was not performed prior to shipment, and it was this test, which was performed at the site, that indicated the defects.

C. Action by Licensee:

The licensee stated that these two disks have been removed from the valves and will be shipped to the vendor (Schutte and Koerting Company) for further examination and resolution. The licensee stated that he will keep RO:III informed of activities relative to this matter and will submit a written report pursuant with 10 CFR Part 50.55(e).

OPERATING EXPERIENCES

REACTOR SAFETY

UNITED STATES ATOMIC ENERGY COMMISSION

# VALVE MALFUNCTIONS IN NUCLEAR POWER PLANTS

## 1.0 Introduction

This report describes the results of three independent surveys of data describing malfunctions of valves used in reactor facilities, during three different but somewhat overlapping time intervals, and a fourth survey of experience concerning the structural integrity of valves.

None of the valve problems covered by the reviews have involved a threat to the health and safety of the off-site public. In a few cases valve malfunctions have led to non-radiological injuries to plant personnel.

The surveys did not include consideration of the total population of valves in nuclear plants from which the malfunction data were derived. Although the number of malfunctions reported appears to be large, the total number of all the valves in all the plants is a much larger number (i.e., thousands) for which actual service conditions and experience are very difficult to determine accurately. Many of the malfunctions occurred during preoperational or surveillance tests that were designed specifically to detect off-normal conditions in a controlled manner prior to actual plant operation. Thus, the sample probably overestimates the frequency of true malfunctions under operating conditions. Also, it should be noted that a uniform definition of the term "malfunction" was not applied in each survey.

## 2.0 Summary

The integrity and operability of valves in nuclear power plants have been a continuing operational concern. Maintenance of valves has constituted one of the largest elements of the maintenance work load in most plants.

Independent surveys were made of reports of valve malfunctions reported to the AEC over three separate but overlapping periods: 1967-1971;

January 1971-July 1972; and May through September, 1972. The data from these three surveys were generally consistent in a quantitative sense. Each of the surveys confirmed the previous qualitative observations that: (1) malfunctions have occurred in plants designed and constructed by all of the light water reactor vendors and all of the major architect-engineers involved in the U. S. market; (2) valves supplied by at least ten of the major valve manufacturers are involved; (3) the causes of the malfunctions reported cover a broad spectrum, including design, fabrication, installation, operation and maintenance deficiencies; (4) valves of a wide variety of sizes and types are involved; (5) malfunctions included both lack of leak tightness and improper operation; and (6) malfunctions of valve operators, power sources or signal initiators occurred about twice as often as did malfunctions of valves proper. The detailed data from all three cannot be combined uniformly, however, because of the overlapping time intervals and because the categories of data collected differed slightly.

The apparent rates of malfunction of valves, based on the number of power reactors in operation during the time periods covered by each of the surveys were as follows. The 1967-1971 survey yielded an "average" rate of 2.5 malfunctions per plant per year. The comparable "average" rate for the 1971-1972 survey is approximately 2.8 malfunctions per plant per year. The shorter, but most recent, survey of 1972 discloses an "average" rate of 8.1 malfunctions per plant per year. The larger number of plants entering the preoperational test phase during the later surveys, and the increased scope of events required to be reported to the AEC in the more recent data tend to reduce the significance of the differences in these "average" rates. Nevertheless, it appears highly possible that the incidence of malfunctions of valves actually is increasing.

A fourth survey considered the adequacy of the structural integrity of valves. This survey was not based on operability data, but was conducted to determine the extent to which valves were being installed with wall thicknesses less than specified in the valve design. Cast valves in a wide spectrum of sizes, and forged-body valves in the 10-14 inch size range, were found to have wall thicknesses less than design specifications in about 15% of the sample surveyed.

## 3.0 Discussion

### 3.1 Survey No. 1 - 1967-71

This survey was conducted during late 1971 and early 1972, covering documented malfunctions of valves during the period 1967 to mid 1971.

The data derived from the study were categorized by: type of component involved, type of drive or operator, systems involved, general cause, and reactor status at the time of detection. The results are tabulated in the first column on the right side of Table I.

3.2 Survey No. 2 - January 1971 - July 1972

The results of Survey No. 1 indicated the desirability of supplementing and updating the information. Survey No. 2 was based on a computer search of publicly available records kept by the Nuclear Safety Information Center (NSIC) at the Oak Ridge National Laboratory. The NSIC search revealed 121 valve malfunctions or failure events reported by AEC licensees in accordance with requirements of the Technical Specifications of their licenses. Some of the events were common mode failures; that is, a single failure mechanism affected two or more valves simultaneously. For that reason, approximately 250 valves were involved in the 121 events. The reports covered events occurring at 12 boiling water reactors and ten pressurized water reactors.

Most of the events occurred during the operational phase of plant life; i.e., after issuance of the operating license. Many of these events, in turn, occurred during the early "shakedown" phase of plant operation. A review of the specific events reported revealed that many of the malfunctions could have been identified and corrected with much less consequence by more comprehensive and thorough preoperational testing programs.

The data derived from Survey No. 2 were categorized by: type of component involved, functional description of valves involved, systems involved, and general cause of malfunction. The results are tabulated in the second column on the right side of Table I.

Of the 26 valves involved in the 22 events caused by worn or damaged drive components, 17 apparently also had malfunctioning limit or torque switches as evidenced by cracked or broken yokes (5), galled threads on valve stems (6), broken or faulty worm gears or bearings (4) and bent stems (2).

Fourteen of the 20 events were attributed to mechanical problems or to loose-parts-involved vibration, either by parts working loose from their designed positions or by linkages breaking, thus raising questions about the extent to which expected environmental and service conditions were considered in the selection of these valves.

When these data were tabulated by the plant system involved, it was found that over 40% of the events involved systems normally associated with steam service, raising the question of whether the severity of the service conditions for valves in these systems had been considered adequately in the design. The severe service demands on steam line isolation valves - fast closing times and rigid leak tightness - undoubtedly contribute to this functional type of valve displaying more failures than others did.

About ten percent of the events involved valves associated with the turbine. At least two of these malfunctions were the principal cause of blowdown transients at large boiling water reactor facilities.

3.3 Survey No. 3 - May - September 1972

The most recent study of operational malfunctions (including scheduled tests performed during the operating phase of plant life) was based on slightly different sources of information than the earlier study. The reviewer conducted an independent computer-assisted manual search of reports of abnormal events made by licensees to the AEC and the inspection reports made by AEC inspectors. The study covered the five-month period from May through September 1972.

During the period covered by this study, 81 events involving valve malfunctions were reported. Of these, only about 10% involved manually operated valves. Because the time period covered by the survey was so recent, a significant fraction (26%) of the reports were preliminary in nature, and did not include identification of the cause of malfunction. Investigations of these events are continuing.

The data derived from Survey No. 3 were categorized by: type of components involved, systems involved, and general causes involved. The results are tabulated in the third column on the right side of Table I.

Survey No. 3 is of significance primarily because it confirms the data of the earlier more comprehensive and detailed surveys, and because it indicates that rather than decreasing in frequency, instances of operating problems with valves appear to be more frequent in recent experience.

3.4 Survey No. 4 - Adequacy of Structural Integrity of Valves

In early 1970, several 28-inch cast valves in recirculation systems at a BWR were identified as apparently having stamped pressure and temperature ratings that did not conform to the design conditions specified for the system. In the course of investigating the apparent nonconformance, it was revealed that in certain areas of the valve bodies, the wall thickness was less than design specifications.

Followup action at other contemporary facilities disclosed similar problems with comparable valves. Inspection of valve manufacturers' facilities disclosed that these manufacturers and their casting suppliers did not routinely inspect valve castings to verify that specified wall thicknesses were actually achieved. As a result of this investigation, other facilities were requested to verify that valves being installed did have wall thicknesses conforming to specifications. This verification program included examination of 633 valves at 33 plants. Of these, 97 (15%) valves had wall thicknesses below specifications. The survey also showed that several forged-body valves in the 10-14 inch size range had "thin walls." (Initially the problem had been identified in cast valves only.)

The thin-walled valve problem involved only the identification of potential future problems. No actual malfunctions or failures of valves were involved.

The survey on thin-walled valves identified deficient valves at 20 different reactor facilities (8 PWR's, 12 BWR's), owned by 15 different utilities. Gate, globe and check valves, in size ranges from 1-1/2 to 28 inches (23-8"; 19-10"; 17-28"; 11-12"; one each 1-1/2, 2-1/2, 6, 20, and 22") were found to have the problem in varying degrees (maximum weld buildup required was about 1/4", in most cases for which weld buildup was used, no more than 1/8" was required). Affected systems included: main steam, feedwater, recirculation, safety injection, reactor core isolation cooling, residual heat removal, chemical and volume control and low pressure coolant injection systems.

## 4.0 Corrective Actions

The specific corrective actions associated with individual problems have not been described in this report because of the large number and variety of events and conditions involved. In general, however, the immediate corrective actions can be summarized as follows.

Corrective actions for operational malfunctions involved: repair or replacement of affected components, design modifications to components for which service conditions were found to be different from those for which the valves were originally designed, increased frequency of surveillance tests, preparation and implementation of more stringent procedures for operation, testing and maintenance of valves, and supplemental training for operators, technicians, mechanics and electricians responsible for operating and servicing valves.

Correction of the specific cases of thin-walled valves involved: weld buildup of affected areas (varying in size from 2 to 117 square inches), rejection and replacement of specific valves, recalculation of stress conditions based on strain gage measurements during special hydrotests, reevaluation of service conditions, and derating of the acceptable operating conditions for affected systems.

Several steps have been, or are being taken on a generic basis, to improve the operability and integrity of valves. On November 20, 1972, a meeting of representatives from the AEC, utilities with nuclear power plants, reactor vendors, architect-engineers, valve manufacturers, standards writing bodies, and consultants was held in Bethesda, Maryland. The purpose of the meeting was to present the experience reported herein and to outline a proposed course of action to improve both operability and integrity of valves. Dissemination of this report for the purpose of informing all concerned of the extent of the overall problem is one of the steps being taken.

Office of Operations Evaluation
U. S. Atomic Energy Commission

TABLE I

VALVE MALFUNCTIONS

| | Survey No. 1 1967-1971 | Survey No. 2 1971-1972 | Survey No. 3 May-Sept. 1972 |
|---|---|---|---|
| Total number of malfunctions included in survey | 171 | 121 | 81 |
| Average malfunction rate of valves (Malfunctions per plant per year) | 2.5 | 2.8 | 8.1 |
| By type of component involved (number of events): | | | |
| Valves and integral devices | 74(43%) | 47(39%) | 25(31%) |
| Valve operators and external devices | 97(57%) | 74(61%) | 35(43%) |
| Not yet identified | | | 21(26%) |
| By functional valve types most often involved: | | | |
| Steam line isolation valves | | 19 | |
| Other steam service valves (turbine bypass, stop or control valves) | | 12 | |
| Regulator valves (pressure, level or volume) | | 6 | |
| Safety or relief valves | | 16 | |
| By type of drive or operator: | | | |
| Electric motor | 54(32%) | | |
| Other (Solenoid, Air, Hydraulic, etc.) | 117(68%) | | |
| By systems most often involved: | | | |
| Reactor coolant and power conversion | 75(44%) | | 49(60%) |
| Steam Services | | | |
| Isolation valves | | 19(16%) | |
| Turbine systems | | 8(7%) | |
| HPCI or RCIC systems | | 7(6%) | |

TABLE I (Continued)

| | Survey No. 1 1967-1971 | Survey No. 2 1971-1972 | Survey No. 3 May-Sept. 1972 |
|---|---|---|---|
| Emergency Core Cooling | 37(22%) | | 11(14%) |
| Other engineered safety features | 43(25%) | 17(13%) | 8(10%) |
| Emergency or isolation condenser | | 10(8%) | |
| Liquid (Boron) control systems | | 4(3%) | |
| Diesel-Generator air lines | | 3(2%) | |
| Auxiliary, general service, etc. | 16(9%) | | |
| By general causes (not necessarily sole causes): | | | |
| External (Operator error, poor procedures, remote devices) | 81 | | |
| Improper design or application | 42 | | 26 |
| Improper maintenance, testing or calibration | 44 | 17(14%) | 31 |
| Fabrication/QC deficiencies or improper install. | 19 | | |
| Improper operation | | | 3 |
| Worn or damaged drive components | | 22(18%) | |
| Mechanical-loose parts | | 20(16%) | |
| Excessive leakage | | 17(14%) | |
| Foreign material in valves or actuators | | 14(12%) | |
| Other electrical circuit operator problems | | 14(12%) | |
| Packing deficiencies | | 11(9%) | |
| Lubrication deficiencies | | 6(5%) | |
| Not yet identified or Random | 48 | | 21 |
| By reactor status at time of detection: (Numbers in parentheses indicate malfunctions detected by scheduled tests concurrent with indicated status) | | | |
| Normal power operation | 54(36) | | |
| Starting up (partial power) | 6(5) | | |
| Shutting down | 3(3) | | |
| Reactor trip | 3(0) | | |
| Shutdown, including partial thermal power for testing under pressure and temperature conditions | 105(105) | | |

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ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20546

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