U.S. NUCLEAR REGULATORY COMMISSION
APPROVED OMB NO. 3150-0104
EXPIRES: 8/31/88

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Fort St. Vrain, Unit No. 1	0 5 0 0 0 2 6 7	1 OF 0 7

TITLE (4): LOOP I SHUTDOWN AND MANUAL SCRAM

EVENT DATE (5) MONTH	DAY	YEAR	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	REPORT DATE (7) MONTH	DAY	YEAR	OTHER FACILITIES INVOLVED (8) FACILITY NAMES	DOCKET NUMBER(S)
0 2	1 0	8 8	8 8	0 0 2	0 0	0 3	1 1	8 8	N/A	0 5 0 0 0
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OPERATING MODE (9): N
POWER LEVEL (10): 0 7 7

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following) (11)

[ ] 20.402(b)	[ ] 20.405(c)	[X] 50.73(a)(2)(iv)	[ ] 73.71(b)
[ ] 20.405(a)(1)(i)	[ ] 50.36(c)(1)	[ ] 50.73(a)(2)(v)	[ ] 73.71(c)
[ ] 20.405(a)(1)(ii)	[ ] 50.36(c)(2)	[ ] 50.73(a)(2)(vii)	[ ] OTHER (Specify in Abstract below and in Text, NRC Form 366A)
[ ] 20.405(a)(1)(iii)	[ ] 50.73(a)(2)(i)	[ ] 50.73(a)(2)(viii)(A)	
[ ] 20.405(a)(1)(iv)	[ ] 50.73(a)(2)(ii)	[ ] 50.73(a)(2)(viii)(B)	
[ ] 20.405(a)(1)(v)	[ ] 50.73(a)(2)(iii)	[ ] 50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER AREA CODE	
Mark A. Joseph, Technical Services Supervisor	3 0 3	6 2 0 - 1 2 0 3

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS
X	S J	R L Y	S 3 4 5	N					

SUPPLEMENTAL REPORT EXPECTED (14)

[ ] YES (If yes, complete EXPECTED SUBMISSION DATE) [X] NO

EXPECTED SUBMISSION DATE (15): MONTH | DAY | YEAR

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

At 1545 hours on 2/10/88, with the reactor operating at 77% power, "A" circulator tripped on programmed speed low because of a misconnected speed sensing cable from "B" circulator to the speed control system of "A" circulator. The turbine and reactor ran back to 50% on the circulator trip, as designed. The main discharge valve on "B" feed pump failed to close on the circulator trip, causing the two turbine-driven feed pumps to back themselves off line. "A" and "C" feed pumps were supplying the emergency feedwater header and backup bearing water system, which supplies normal makeup to the bearing water surge tanks. The reduction in emergency feedwater header pressure caused a loss of bearing water surge tank makeup and a decreasing level. When the feed pump output control system was placed in manual to recover emergency feedwater header pressure, makeup to the bearing water surge tanks was restored too rapidly, resulting in buffer helium trips of "B" and "D" circulators and an automatic shutdown of Loop 1. With only one circulator running, the decision was made to manually scram the reactor.

Measures have been instituted to provide positive control of the installation of the circulator speed cables. The defective relay that prevented the closure of "B" feed pump discharge valve has been replaced. The reactor was restarted on 2/12/88.

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EVENT DESCRIPTION

At the onset of the transient, "B" circulator speed control was in manual to perform the daily balancing of the speed modifiers on the control and protective systems for that circulator. A spare speed cable sensing "B" circulator speed was misconnected to one of the two speed control channels on "A" circulator. The control system uses the highest of the two measured speed inputs from each circulator as its measured speed. The misconnection is believed to have occurred during removal of a defective cable on February 2, 1988. The condition did not immediately result in an upset because "A" circulator has normally operated slightly faster than "B" in the recent past, thereby controlling off the proper signal. It was only when "B" circulator was placed in manual for the speed modifier balance that "A" circulator speed became slightly lower. The "B" signal then became controlling, and the speed of "A" circulator began decreasing. It quickly reached the programmed circulator speed low trip, and a trip of the steam turbine valves occurred. The circulator auxiliaries, buffer helium and bearing water, do not isolate on this trip.

With two exceptions, the plant responded to this trip as designed. The turbine and reactor both ran back to 50%. "B" circulator did not increase in speed as designed to make up for the loss of "A", as designed, because it was in manual control at the time of the trip. The speed of this circulator was increased by the operator to rated and the control system was then placed in remote-automatic. In addition, the main discharge valve of "B" feed pump did not close, as designed, to allow flow control via the bypass valve. This failure has been traced to a defective relay.

"B" feed pump is motor-driven and operates at a fixed speed while "A" and "C" feed pumps are turbine driven and are capable of variable speed operation. Below about 50% power, "B" feed pump is either shut down or operated through a throttling valve bypassing the main discharge valve. Above 50% power, the main discharge valve is opened and this pump supplies full flow while the two turbine-driven pumps control the total feedwater supply. In addition to the feedwater supply to the steam generators, the three feed pumps also supply the emergency feedwater header which, among other things, supplies the backup bearing water system for the helium circulators. The backup bearing water system, in turn, is the normal source of makeup for the bearing water surge tanks in the helium circulator auxiliary system. Because of its control system characteristics, "B" feed pump is not normally connected to the emergency feedwater header.

The failure of the main discharge valve to close resulted in "B" feed pump supplying all of the steam generators' requirements and the flow demand of "A" and "C" feed pumps reduced toward zero demand. As a result, the speed of those pumps began decreasing. Once the discharge pressure of the pumps fell below the normal bearing water system pressure, the normal bearing water makeup pump started, as designed. The operators at this point manually shutdown "C" feed pump, placed the feedwater demand controller in manual and raised the output. This caused the speed of the operating turbine driven feed pump to increase and the emergency feedwater header pressure to follow. The pressure transient on the emergency feedwater header caused a similar transient on the backup bearing water header and an inflow to the bearing water system via the individual backup bearing water isolation valves on all four circulators. Because the gas volume in the bearing water surge tanks is connected to the buffer helium system, this change in surge tank level resulted in a buffer seal upset on all four circulators. "B" and "D" circulators and their auxiliaries tripped on buffer seal malfunction, thereby preventing (per design) a similar trip of the other circulator in each loop. Because "A" circulator had previously received only a steam turbine trip, the fact that it was not running would not prevent a buffer seal malfunction trip on "B". With both circulators tripped in Loop 1, an automatic loop shutdown was received. With only one circulator running, the decision was made to manually scram the reactor.

CAUSE DESCRIPTION

The initial cause of the event was a misconnected circulator speed sensing cable which delivered a speed signal from "B" circulator to the speed control system for "A" circulator.

Each circulator has a total of twelve (12) internal speed sensing probes and dedicated cables extending to the control room. Of these, two (2) are required for use by the control system and three (3) are needed by the plant protective system, which has several circulator trip outputs requiring speed as an input. All of the others are spares and each function is provided with at least one dedicated spare cable/probe combination. The control system speed modifiers for the circulators in each loop, which convert a modulated 50 kHz carrier signal from the probes to a square wave pulse signal, are adjacent to each other while the modules for the different loops are mounted in physically separate bays. Considerable difficulty has been experienced in recent months with circulator speed signal reliability, and troubleshooting and testing of spare cables has occurred. It is physically possible to cross-connect the speed signals between the two circulators in each loop, and this is apparently what happened.

The two speed inputs to the speed control system for each circulator are high-selected, and the higher reading of the two becomes the measured input for both speed controllers on each circulator. In this case, "A" circulator consistently ran at a higher speed than "B" since the cable was misconnected, with the result that the misconnected cable had no effect. The misconnection only became apparent when "A" circulator speed became lower than that of "B"; this situation occurred when "B" circulator speed control was placed in manual for the daily testing and balancing of its speed and wobble measurement circuits. Because the two speed control signals are high selected, the effect of any such single misconnection will always be to drive the affected circulator speed low, meaning that overspeed conditions will not occur. If the Interlock Sequence Switch is in the "power" position, as it was during this event, then a circulator trip will occur due to circulator speed going below the normal program band.

The speed cable misconnection was the cause of "A" circulator trip, and the failure of the main discharge valve on "B" feed pump to close as a result of the plant protective system circulator trip signal, was the immediate cause of the Loop 1 shutdown and subsequent manual reactor scram.

The feedwater system has one fixed-speed motor-driven feed pump and two variable-speed turbine-driven feed pumps of approximately equal capacity. "B" feedpump, the motor driven one, is capable of supplying full plant feedwater requirements up to approximately 50% power even though it is nominally rated at 33 1/3%, but it is sensitive to control actions and is therefore normally used only at higher power levels. The turbine-driven pumps, being variable-speed machines, have better control characteristics over the full operating range. The motor-driven pump has a main discharge valve, which is opened at high power levels when the maximum pump output is desired, and a smaller, separate control valve used to control pump discharge flow under other conditions. This pump is operated on the bypass control below about 50-60% reactor power.

There are two feedwater headers, designated normal and emergency, each of which can be supplied from any combination of the three feed pumps. The normal feedwater header supplies feedwater to the steam generators, while the emergency feedwater header supplies the steam generators, the helium circulator water turbine drives, and the circulator backup bearing water system, among others. Because control is more sensitive with "B" feed pump, normal plant practice is to supply the emergency feedwater header from the turbine-driven pumps.

When a single circulator trips, turbine load is run back to approximately 50%, followed by reactor power, in order to allow the remaining circulator in the affected loop to increase speed and maintain the required helium flow in that loop. A circulator trip signal also closes the main discharge valve on "B" feed pump in order to allow it to be controlled on the bypass throttle valve. When the valve failed to close after the circulator trip, the motor driven feed pump continued to deliver maximum output and the flow demanded of the two turbine-driven pumps went to zero.

With no flow demand on the turbine-driven feed pumps, their speed began to decrease steadily toward zero. Because they were supplying the emergency feedwater header, emergency feedwater header pressure began to fall. When this pressure fell below that of the bearing water surge tanks, makeup from this source was no longer possible and the bearing water makeup pump started, as designed. Operations personnel shutdown "C" feedpump and attempted to close the motor-driven feedpump discharge valve manually. They then placed the combined feedpump output controller, which controls both turbine-driven feedpump speed and motor-driven pump bypass throttle valve position, in manual and raised its output to increase the speed of the operating turbine-driven pump. These actions were successful in increasing the speed of the operating turbine-driven pump and restoring emergency feedwater header pressure.

The backup bearing water system, besides serving as the normal source of makeup water to the bearing water surge tanks during plant operation, is controlled in pressure to "ride" on the normal bearing water system, providing 5 to 10 gpm of bearing water flow through isolation valves separate from the normal system and ready to come into operation should the normal system fail. When emergency feedwater header pressure was raised, the initial bearing water flow into all four circulators resulted in a large net inflow into both bearing water surge tanks. This type of transient compresses the helium cover gas in the tank, reduces circulator buffer helium return flow on both circulators in the affected loop(s), gives a downscale indication on the buffer mid-buffer differential pressure instrumentation, and trips the circulator along with its buffer helium and bearing water systems in anticipation of a possible water ingress into the primary coolant system. Once the auxiliaries of the first circulator in each loop trip, the second is locked out to prevent a complete loss of the cooling capability of that loop. The initial trip of "A" circulator involved only the steam turbine motive power and not the auxiliaries, leaving "B" circulator vulnerable to a buffer upset. "B" and "D" circulators tripped as a result of this transient, leaving only "C" in operation and resulting in an automatic loop shutdown. The decision was made at this point to manually scram the reactor.

ANALYSIS

This event was an unplanned actuation of the reactor protective system and a manual reactor scram, and is being reported per 10CFR50.73(a)(2)(iv).

The misconnection of the circulator speed cable, by itself, could only result in the loss of a single circulator. The loss of the second circulator in Loop 1 caused an automatic shutdown of that loop, leaving Loop 2 operable and operating for continued core cooling. The manual reactor scram was ordered by the Superintendent of Operations as a prudent measure in the face of degrading plant conditions. After the manual scram, plant shutdown was completed without major problems and active core cooling was maintained throughout the incident.

Based on this analysis, it is concluded that this incident posed no threat to the health and safety of the public.

Similar events involving mislanded leads/cables were reported in LER's 87-015, 87-028, and 87-029

CORRECTIVE ACTION

The misconnected speed cable was removed from the control circuit for "A" circulator and a proper cable was connected in its place.

The circulator speed cables and the input connectors to the speed modules have all been labeled with color-coded markers to ensure proper connection. Administrative controls have been established to require documentation and independent verification whenever it becomes necessary to move speed cables.

The failed relay, which allowed the discharge valve of "B" feed pump to remain open after the first circulator tripped, has been replaced.

The plant was returned to power on 2/12/88.

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TEXT (If more space is required, use additional NRC Form 366A's) (17)

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March 11, 1988
Fort St. Vrain
Unit No. 1
P-88090

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

Docket No. 50-267

SUBJECT: Licensee Event Report 88-002, Final Report

REFERENCE: Facility Operating License No. DPR-34

Gentlemen:

Enclosed please find a copy of Licensee Event Report No. 50-267/88-002, Final, submitted per the requirements of 10 CFR 50.73(a)(2)(iv).

If you have any questions, please contact Mr. M. H. Holmes at (303) 480-6960.

Sincerely,

C. H. Fuller
Manager, Nuclear Production

Enclosure

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ATTN: Mr. T. F. Westerman, Chief
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