ENGINEERING EVALUATION OF FEEDWATER TRANSIENT AND SYSTEM PIPE BREAK AT TURKEY POINT UNIT 3 ON NOVEMBER 19, 1980

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DESCRIPTION AND SEQUENCE OF OCCURRENCES

The findings and evaluation contained in this report are based on information gathered through informal channels between Florida Power and Light Company and the Nuclear Regulatory Commission.

The following is a description of events taking place at Turkey Point Unit 3 on November 19, 1980. The sequence of occurrences (shown on Figure 1) is clarified in further detail below.

During power operation, a reactor trip was initiated at Turkey Point 3 due to a steam flow/feed flow (SF/FF) mismatch coincident with steam generator (S/G) low level signal on the "A" steam generator. The cause of the initial trip was believed to be due to a loose connection on the signal converter associated with the feedwater control valve to the "A" S/G. All systems responded as expected to the trip. The loose connection was repaired, the valve stroked and the Unit returned to power. However, during the power ascension stage, feedwater control problems were experienced on all three steam generators. In an attempt to stablize this condition, a second feedwater pump was placed into service to help stabilize the level oscillations in the steam generators and increase the feedwater pressure. Following the initiation of the second feedwater pump, secondary system vibration increased significantly. Based on these occurrences, load was being reduced in order to remove the unit from the line. During the load reduction, a two-inch alternate feed line connection to the "B" feedwater bypass line (shown on Figure 2) ruptured resulting in a reactor trip due to SF/FF mismatch coincident with low steam generator level on "C" S/G. The pipe rupture was manually

isolated within thirty minutes. Investigation revealed that the plug had separated from the stem on valve FCV-3-489 (indicated on Figure 2), S/G "B" feedwater flow control bypass valve. Repairs to the flow control valve and the ruptured two-inch alternate feed line were completed and the unit was returned to power.

During this second power ascension, feedwater control problems were again encountered due to inability to achieve flow through FCV-3-478, S/G "A" main feedwater flow control valve. The load increase to the unit was terminated at approximately 90 MWe. Control problems were also associated with FCV-3-479, S/G "A" feedwater flow control bypass valve such that the flow controller would only respond to permit flow between 30 and 100 percent. The unit was taken off line. Investigation revealed that the stem had separated from the plug on the S/G "A" main feedwater flow control valve and the flow control bypass valve was out of calibration. Repairs were made to the valves in question and the unit was returned to power and remained at power until the 26th of November when it was taken off line due to increased leakage in the "B" steam generator from 0.6 to 11.0 gallons per hour.

FINDINGS CONCERNING THE EVENT

The underlying cause of the series of occurrences was the plug/stem separation of valve FCV-3-478, steam generator "A" main feedwater flow control valve. According to the licensee, the apparent cause of the stem failure was improper load distribution between the stem and plug due to the taper on the valve stem caused by improper manufacturing tolerances. This stem failure was the most probable cause of the flow oscillation and the feed control valve failing closed on the first reactor trip. When the unit tripped, the stem on the feed control valve was driven back into the plug on the feedwater isolation signal (reactor trip signal and low Tavg. < 554°F). There is evidence to support this in that three rows of threads above the break on the stem were damaged.

However, this was not known at the time of the initial trip. It was assumed that the loose connection on the signal converter associated with the feedwater control valve was the cause of the trip. After effecting repairs to the converter the valve was stroked to verify operability. This by itself, would not have indicated that the plug had separated from the stem but rather that stem travel had been demonstrated. The feedwater control problems that resulted in the second reactor trip were probably precipitated when the broken plug dislodged from the stem. As the upward forces under the valve plug closely approximated the weight of the plug, oscillations were induced into the feedwater system. These oscillations were further enhanced when the second feedwater pump was placed into service in an attempt to stabilize the level fluctuations in the steam generators. The end result was a reactor trip due to SF/FF mismatch coincident with low steam generator level on "C" S/G. However, according to the licensee, the damage to the main feedwater control valve was not discovered because the trip was attributed to visible

damage to FCV-3-489, feedwater flow control bypass valve, and the break of the two-inch ancillary feedwater pipe rather than the main feedwater control valve.

Hot feedwater flowing from the break (located on the main turbine deck outside containment) resulted in the loss of several hundred gallons per minute for approximately 30 minutes. Licensee personnel using air eductors and water hoses cleared the area of steam vapor (caused by hot feedwater flashing to steam), located the break, and manually isolated the ruptured line. There was no blow-down from the steam generator through the break. This was prevented by closure of the feedwater flow control bypass valve and the upstream check-valve in the main feedwater line. Therefore, radioactivity release to the outside from the primary to secondary leakage was essentially non-existent. According to the resident inspector, radiological surveys conducted after the break showed no signs of contamination. The auxiliary feedwater system functioned normally and maintained S/G levels without difficulty. All safety systems functioned normally following the trip.

The resident inspector attended licensee management meetings which covered their recovery plans. Action items involved during this time included: (1) repair of "B" feedwater flow control bypass valve (FCV-3-489), (2) calibration of all feedwater flow control bypass valves, (3) PCM (Plant Change Memo) issued to remove and capweld the remaining two-inch alternate feed sources to the bypass feed lines, and (4) visual inspection of all feed and condensate systems inside and outside containment. After the actions were completed the unit was brought back up to power. However, during this second power ascension stage, feedwater control problems were again exhibited by inability to pass flow through the steam generator "A" main feedwater flow control

valve. Control problems were also associated with the S/G "A" feedwater control bypass valve, in that the controller would only respond to a flow between 30 and 100 percent. The unit was removed from the line and investigation revealed the broken stem/plug on the main feed flow control valve and the bypass valve was out of calibration. Repairs were made to the valves and the unit was returned to power.

Because of these problems associated with this type of feedwater flow control valve (Copes-Vulcan), the licensee has inspected all valve stem/plug interfaces on Units 3 and 4. The results of the investigation showed evidence of cracking at the interface point on two of three valves on Unit 4 in addition to the two valves repaired on Unit 3. This issue is not a new problem and has been identified in the past at this plant according to plant personnel . The original cage, plug and stem in the feedwater flow control valves were replaced with a modified cage, plug and stem in accordance with a Plant Change/Modification (PC/M) originating in 1974. Vendor replacement parts were not available and evidently the tolerances on the manufactured stem and plug were unacceptable. The valve stems on all three valves of both Units No. 3 and 4 have been replaced. Additionally, all connections to the alternate feedwater system from Fossil Unit No. 2 have been removed and caps welded in place.

EVALUATION

Although there was no evidence of a water hammer at Turkey Point Unit 3 during this event, there are generic concerns arising from such flow control instability and the unnecessary challenges to the feedwater system which

could compromise safety-related equipment and systems associated with it and the feedwater system itself. The flow control valves in main feedwater systems have the potential for producing significant water hammer loads as the result of relatively high fluid velocities and short closure and opening times. Twenty-two events are attributed to main feedwater flow control valve opening, closing, or instability.[1/] In several of these events the water hammer resulted from a sudden flow rate decrease following valve failure in which the plug separated from the valve stem. These valve failures could be attributed in part to piping vibrations during normal operation. Components damaged as the result of these water hammer events include piping supports and restraints, valve bodies and operators, and the piping. Resolution of feedwater control valve instability problems and measures to minimize operational transients would reduce the challenges to the safety systems.

COMMENT

AEOD believes that there may be a potential need for informing the licensees of operating reactors regarding the possibility of valve failures due to this mechanism of improper load distribution between the stem and plug. We believe that an IE Circular or Information Notice might be considered which cautions licensees to review their feedwater flow control valves and bypass valves to assure that those plants which utilize Copes-Vulcan valve components in their feed system are aware of this failure mode and can take steps to modify their system. However, unless additional events of this nature occur at another plant, we are not recommending any action at this time.

1/ Water Hammer in Nuclear Power Plants, NUREG-0582, July 1979.

SEQUENCE OF OCCURRENCES

Date	Time (Approx)	Occurrence
11/05/80	0500	S/G tube leak at 0.4 gph
11/19/80	1000	Reactor trip due to steam flow/feed flow mismatch and low S/G "A" level.
		Possible feedwater isolation.
		EFW actuated manually.[1/] Steam generator "A" feedwater valve failed closed. Initially believed to be due to loose wire on feedwater control valve (most probable cause was separation of plug from stem).
	1238	Feedwater control problems during power accession.
		Started second feedwater pump.
		Secondary system vibration increased.
		Started load reduction.
		Two-inch line rupture on auxiliary circulating feedwater line connected to bypass feedwater line.
	1410	Reactor trip on steam flow/feed flow mismatch and S/G "C" low level.
		Possible feedwater isolation.
	later	EFW actuated manually.[1/]
		Isolated break and repaired line.
		Discovered broken bypass valve on S/G "B" (stem/plug separated on FCV-3-489).

[1/] EFW turbine automatically start, but manual opening of EFW valves required

Date	Time (Approx)	Occurrence
11/20/80	1200	Return to power.
		Experienced feedwater control problems with S/G "A" feedwater valve (FCV-3-478) and bypass feedwater control valve (FCV-3-479).
		Unit removed from grid.
		Discovered S/G "A" feedwater valve broken (stem/plug separated).
		Discovered S/G "A" bypass feedwater valve out of calibration.
11/21/80	0500	Return to power.

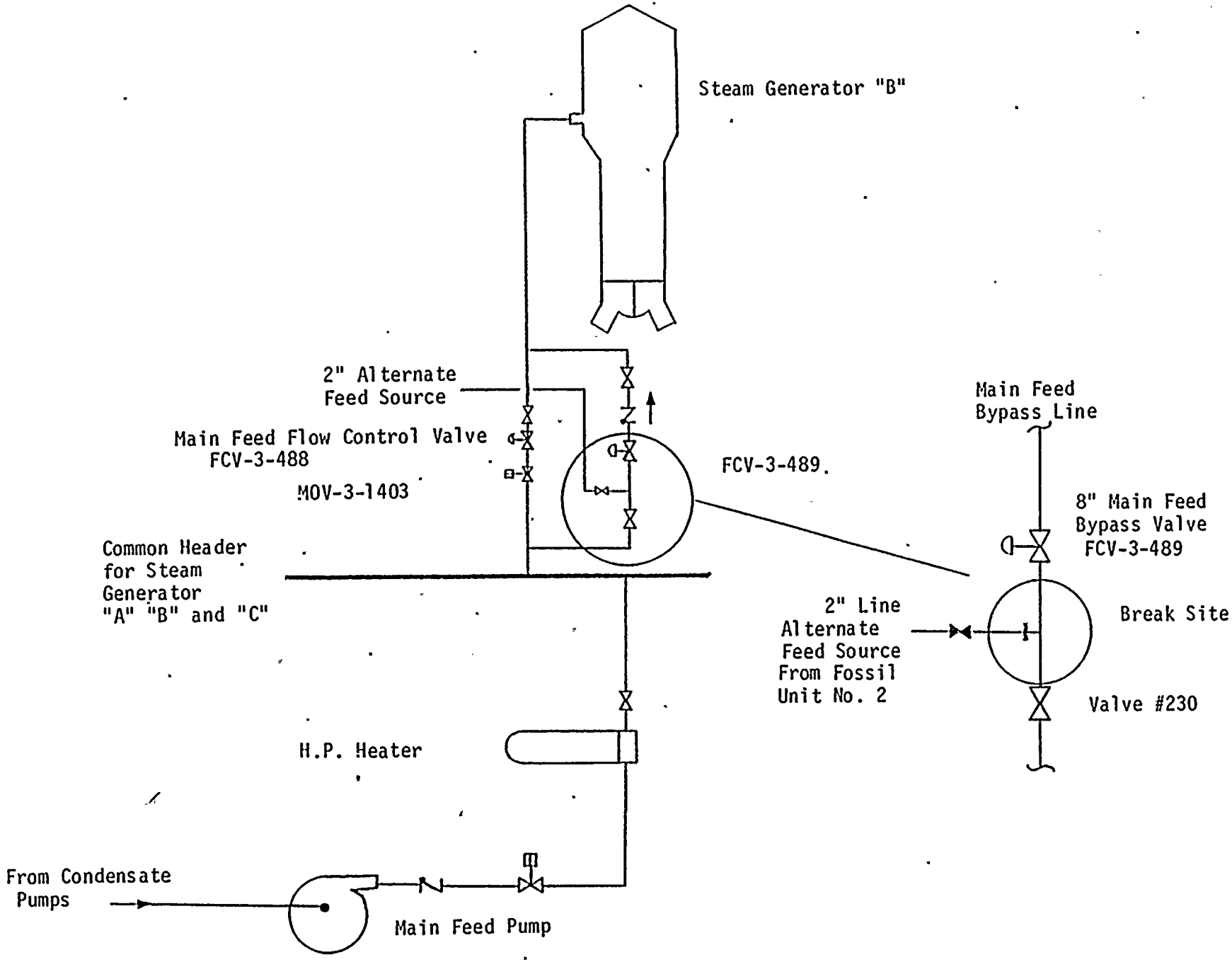

FIGURE 2 - TYPICAL FEEDWATER SYSTEM LAYOUT