ENCLOSURE 2

Technical Evaluation Report

Assessment of Florida Power And Light Relief Request

Oak Ridge National Laboratory

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ASSESSMENT OF FLORIDA POWER AND LIGHT RELIEF REQUEST

Summary

We do not agree that pumps can be meaningfully tested without measuring flow rate. Flow rates must be known to ensure acceptable pump performance and to detect degradation. Without measuring flow in the low flow regime (especially in the region of miniflow for the pumps in question), it is not possible to determine what the flow rate is. It can even be zero!

The argument presented by Florida Power & Light Company (FP&L) relative to the way in which pumps degrade is not technically supportable. The pumps under consideration tend to degrade by exhibiting significant performance degradation at relatively high flow rates, rather than uniformly, as indicated in FP&L's Fig. 1 of Ref. 1. Hence, the argument that pump degradation would result in a change in Delta P under miniflow conditions is also technically unsupportable, since substantial degradation in pump performance can occur at high flow rates with no observable change in the low-flow end of the curve. (For an example of such degradation, see LER 87-003 for the Shearon Harris plant.)

Inability to detect degradation of the minimum flow path without measuring flow is recognized by FP&L. This inability in itself points out the importance of having flow instrumentation in that path; most miniflow recirc paths for pumps, including those in the low pressure safety injection (LPSI), high pressure safety injection (HPSI) and auxiliary feedwater (AFW) systems at St. Lucie Unit 2, incorporate an orifice and a check valve in series. It is important that these paths be unimpeded to prevent pump damage. For this reason, flow through miniflow lines should be periodically monitored to demonstrate that proper pump protection is provided.

Because of these concerns, both flow rate measurement and the inservice (ISI) testing program at St. Lucie Unit 2 were addressed. The examinations conducted were based on system P&IDs, FSAR information, and relief request correspondence, as well as personal experience and judgment.

It was concluded that, in addition to the need for flow measuring devices, there are a number of valves not now included in the ISI program that should be added. It must be emphasized that both pumps and flow paths should be subjected to regular examinations. In addition, the adequacies of the miniflow rates being used need re-examination in light of current knowledge.

It is recommended that both miniflow and full flow testing of pumps be carried out. Miniflow testing is to be conducted quarterly for HPSI and monthly for AFW pumps. The HPSI and AFW pumps are to be full flow tested during refueling and cold shutdown outages, respectively. Full flow testing at quarterly intervals is recommended for LPSI and containment spray (CS) pumps. Boric acid (BA) makeup pumps are to be tested quarterly using existing level instrumentation. Diesel oil transfer (DOT) pump tests are to be performed quarterly using a selected path in which flow can be measured. Details associated with these recommendations are given in the following section.

Pump and System Test Requirements

HPSI

It is agreed that quarterly full flow testing is not feasible, and could not be accomplished without major piping modifications. While Mode 5 (cold shutdown) testing at full flow can be done (taking some precautions) without violating Tech Specs, it is not a recommended practice. It is agreed that full flow testing should be conducted in Mode 6 (refueling).

Note that the HPSI miniflow line check valves are not included in the St. Lucie ISI program. The miniflow lines provide a critical function in St. Lucie's HPSI system, since it is a relatively low head system, and the Reactor Coolant System may remain above HPSI pump shutoff head for substantial periods following certain design basis accidents. For this reason, check valves V3102 and V3103 should be included in the ISI program (for forward flow delivery demonstration).

Since the pumps would be operating on the flat (high-head) portion of their curves when operating in recirculation conditions, pump delta p monitoring would not provide indication of flow. The only way to verify adequate flow and proper operation of the check valves is to measure recirculation flow. The current revision of the Safety Injection Flow Diagram (2998-G-078, Rev. 2) indicates surface mounted flow elements (presumably ultrasonic flowmeters), with low flow alarms, installed in the suction piping of both HPSI pumps (FE-03-3 and FE-03-4) as well as in the pump recirculation lines (FE-03-3-1 and FE-03-4-1). These instruments could be used to perform this periodic recirculation flow monitoring function.

Recommended actions:

a. Quarterly testing of each HPSI pump, using the installed suction and/or minimum flow line surface mounted flow elements.

b. Mode 6 full flow testing of each HPSI pump (which is not only needed to demonstrate pump capability, but forward flow stroking of various check valves as well).

c. Addition of check valves V3102 and V3103 to the ISI program.

LPSI

It does not appear impractical to test LPSI on a quarterly basis. The LPSI pumps can be (and should be) tested at full flow through line 6-CS-500. Note that this is a nonnuclear safety class line (Quality Group D). This line currently does not have flow instrumentation. If flow instrumentation were added to this line, both the LPSI and containment spray pumps could be individually tested with the single flow element. The path would allow testing in normal operation. Note that a similar full-flow recirculation line is used at other plants for quarterly full flow testing of similar pumps.

As in the case of HPSI, the minimum flow lines are critical to pump protection. The current revision of the Safety Injection Flow Diagram (2998-G-078, Rev. 2) indicates flow elements, with low flow alarms, in the minimum flow lines for the LPSI pumps (FE-03-1-1 and FE-03-2-1). These instruments could be used to perform this periodic recirculation flow monitoring function.

It should be noted that the minimum flow provided for the LPSI pumps is 100 gpm per pump. For the same model pump (and used in the same service) at another plant, Ingersoll-Rand specified 500 gpm minimum flow for long duration, but allowed as little as 335 gpm for very limited periods.

Also note that the miniflow line check valves V3104 and V3105 are not included in St. Lucie's ISI program. The discussion included in the HPSI section relative to the importance of miniflow check valves in providing pump protection following certain design basis accident events applies here as well.

Recommended actions:

a. Installation of a flow element in line 6-CS-500 for full flow testing.

b. Testing each LPSI pump quarterly at full flow.

c. Simultaneous with each full flow test under b, monitor flow through the miniflow flow path (to demonstrate pump protection and check valve stroking).

d. Further review of the design adequacy of the minimum flow line. (Although not specifically ISI related).

e. Addition of check valves V3105 and V3104 to the ISI program.

AFW

In general, the FP&L line of reasoning relative to pump testing is supportable. However, as in the cases of HPSI and LPSI, the miniflow lines must provide adequate recirculation flow for pump protection. The AFW discharge isolation valves (MV-09-09, -10, -11, and -12) open in response to an Auxiliary Feedwater Actuation Signal, but will still act as level control valves and cycle open/closed on low/high SG level. While closed, the miniflow lines must provide adequate flow for pump protection.

The miniflow line check valves are not currently included in the St. Lucie ISI program, and flow instrumentation for these lines does not exist. In order to provide periodic verification of adequate flow and proper operation of the miniflow check valves, a flow instrument should be installed in the common miniflow line.

An alternative, from the standpoint of the check valves, would be periodic disassembly and inspection. Note that while this would be roughly equivalent from the standpoint of the check valves, it would not detect other potential problems, such as a mispositioned manual valve or degraded flow restricting orifice.

Another observation which is pertinent to the turbine driven AFW pump relates to the turbine steam supply check valves.

According to the St. Lucie ISI program, these valves (V-8130 and V-8163) are tested quarterly. Since the turbine is run in recirc only on a quarterly basis, it is doubtful that these valves are fully opened quarterly. The required forward flow would be verified by periodically running the pump at full flow (to which St. Lucie has committed), so that is not a significant concern. It would appear that a relief request to identify the fact that the valves are only partially stroked open on a quarterly basis, but fully opened in conjunction with full flow testing of the pump, would be prudent.

A concern relative to the steam supply check valves which is significant is the fact that they cannot be reverse flow closure tested. For St. Lucie, prevention of reverse flow is necessary for mitigation of such accidents as steamline and feedline break. Without reverse flow closure, the closing of main steam and main feed isolation valves, as well as AFW discharge isolation valves to the faulted SG would still not isolate the break flow, since steam from the intact SG would continue to be dumped out of the break. This would increase the positive reactivity insertion of cooldown associated with a steam line break as well as increase the heat-up and pressurization of containment. It would also be a likely source of confusion for operators in that both SGs would appear to be faulted. Finally, turbine driven pump performance would be substantially degraded.

Recommended actions:

a. Installation of a flow element in the common miniflow line.

b. Performance of monthly tests in recirc (NRC requires monthly, versus quarterly, tests for AFW pumps).

c. Full flow testing at each cold shutdown (Mode 5). Note that the turbine driven pump would have to be tested in Mode 3 or 4 (hot standby or hot shutdown).

d. Addition of check valves V9303, V9304, and V9305 to the ISI program.

e. Include verification of reverse flow closure (can probably best be performed by periodic disassembly and inspection) for AFW turbine steam supply valves V-8130 and V-8163 in the ISI program testing.

Boric Acid (BA) Makeup

It would appear, contrary to FP&L contentions, that there are practical flow paths available for pump testing. There also appear to be a number of inconsistencies in the pump/valve testing, as well as omission from the ISI program of some valves which are vital to pump delivery. Discussions of the apparent inconsistencies and omissions pertinent to pump performance are given below.

Pump Testing

St. Lucie states that BA Tank volume is insufficient for using level instrumentation to monitor flow. This does not appear to be the case.

BA tank volume is 9975 gallons (each), per Table 9.3-6 of the FSAR.

Per Tech Spec 3.1.2.8, approximately 6100-6500 gallons are required in one tank to meet required operability. Thus, over 3000 gallons of excess capacity are available for addition/depletion during testing.

The system design is such that the BA pumps can pump from one tank to the other. By starting, for example, with the 2A tank at 8000 gallons and 2B at 6500 gallons, 1500 gallons could be transferred from the 2A tank to the 2B tank by the 2A pump. At least two alternative flow paths are available. Either existing tank level instrumentation or test instrumentation could be used to determine volume change/unit time. Even at pump design flow (142 gpm), over 10 minutes transfer time would be available under the above scenario.

Recirculation Valves V2650 and V2651

These valves are shown as normally open valves which close on a Safety Injection Actuation Signal (SIAS). These valves (and their lines) are large enough to allow fairly rapid mixing of the BA tanks during batching or to prevent stratification. These valves are not included in the ISI program, yet their closure is necessary in order to assure sufficient flow delivery from the BA pumps to the suction of the charging pumps.

Check Valves V2443 and V2444; FCV 2210Y

The check valves are listed as being tested quarterly. However, the logical boric acid flowpath which would be used for partial forward flow demonstration would be through FCV 2210Y. This will blend the acid with make up water and preclude injection of concentrated boric acid into the charging flow path. (Check valve V2175, which is included in the list of valves tested quarterly is also in this flowpath.) Yet there is a relief request for FCV 2210Y to only test at Cold Shutdown. While quarterly partial flow testing of the check valves could be performed, for instance, by blending and delivering flow to the RWT, this would involve opening FCV 2210Y. Thus, it is not clear how check valves V2443 and V2444 are tested since St. Lucie doesn't want to open FCV 2210Y. (In contrast, the rationale for not testing FCV 2210Y would appear to preclude forward flow testing V2443 and V2444, if the logic were extended.)

As for FCV 2210Y, which closes on a SIAS, full stroke testing could be readily performed without concern of overboration by closing valve

V2645. While this would temporarily disable the VCT auto makeup function (which is not a Tech Spec required function and is infrequently in use), it would allow testing to be conducted on FCV 2210Y in accordance with code while having a minimal or no impact on operation.

It is interesting to consider that FP&L notes that failure of FCV 2210Y in the open position could result in injection of concentrated boric acid into the RCS which "could place the plant in an unsafe mode of operation." Since a safety injection does exactly the same thing, only at a higher rate, and through a different path, one might conclude from this logic that a safety injection (and reactor shutdown) is "unsafe." Also, since this particular valve must close on a SIAS, failure to close is precisely the kind of problem that needs to be detected.

Check Valve V2526

This valve must open to allow flow from the BA pumps (as well as the gravity flow path) to reach the charging pump suction.

This valve is not included in the ISI program.

It should be noted that the complexity of the BA system piping along with the above noted inconsistencies and omissions (as well as numerous others which are not noted since they do not have a direct bearing on the pumps) make it extremely difficult to discern exactly what ISI testing is being conducted in the BA system. This could only be determined by a review of testing procedures.

Recommended actions:

a. Testing of each BA pump quarterly, using existing or test level instrumentation on the BA tanks to determine flow by transferring boric acid from one tank to the other.

b. A more thorough review of ISI testing in this system. (This would require test procedure review and direct discussions with St. Lucie personnel.)

Containment Spray

As noted in the LPSI section, these pumps, as well as the LPSI pumps could be individually tested at full flow by the addition of the single flow element recommended to be installed in line 6-CS-500 (see LPSI section).

Recommended actions:

Quarterly, full flow testing through the full flow path discussed under LPSI.

Diesel Fuel Oil Transfer (DOT)

Testing of the DOT pump, and the determination of flow, does not appear impractical. Various flow paths are available, including transfer to

day tanks, or transfer from one storage tank to the other, whereby existing level instrumentation could be used to determine flow rate (if, as FP&L has argued, the level instrumentation is not accurate enough to meet code requirements, either a relief request on instrument accuracy or use of test instruments would be appropriate). There are a number of other possible means of measuring pump flow rate which would not require system modification, including:

a. Use of ultrasonic flowmeter

b. Use of the "Truck Fill (Without Pump) Connection" to pump oil from a truck or other source to the storage tank using the DOT pump. Flow measurement could be made by observing the volume transferred in a specified time period.

c. Use of the "Truck Fill (With Pump) Connection" to pump oil from the storage tank to a temporary receiver. Flow measurement could be made by observing the volume transferred in a specified time period.

There are some features in the St. Lucie design that make the monitoring of DOT pump flow essential:

a) The "fixed resistance" path for the DOT pumps is not, in reality, a fixed resistance path, since it incorporates an active component [Relief Valve 2I-SR17221 (1A) for the A pump 2I-SR17222 (1B) for the B pump].

b) There is no permanently installed pump suction pressure instrumentation. It is assumed that St. Lucie determines suction pressure for pump performance testing by use of storage tank level instrumentation. In general, this would be acceptable (although it would contradict FP&L's contention that storage tank instrumentation does not satisfy code accuracy requirements, and therefore cannot be used, as a partial justification for not measuring flow). However, for the DOT pumps, suction strainers are shown to be installed in the suction piping. DOT pump strainers have clogged at operating plants, rendering the pumps inoperable (see Ginna LER 87-001. Note that one of the corrective actions implemented by Ginna was to include flow and pressure measurements in their monthly tests of the diesels). Thus, using tank level or even temporary instrumentation in the suction line to monitor pressure upstream of the suction strainer (there are no isolable connections downstream of the strainer) does not necessarily give a true indication of <u>pump</u> suction pressure. Further, a partially clogged suction strainer could allow the pump to operate in recirculation conditions with no apparent degradation, but prevent the pump from delivering required flow to the day tanks (and/or damage the pump due to lack of required suction pressure).

It should be noted that there are no DOT system valves in the ISI program. There are two Class 3 check valves and two Class 3 solenoid valves per pump.

In addition, it was noted that the oil storage tank capacity, per FSAR Table 9.5-1 is 40,000 gallons. This is also the Tech Spec required volume. Unless there is an error in the FSAR, it would appear that there is no margin between tank capacity and required inventory, thereby resulting in an LCO each time a DOT pump is used to transfer fuel.

Recommended actions:

a. Performance of a quarterly test of each DOT pump through a selected path in which flow is measured (multiple potential paths available).

b. Inclusion of check valves and solenoid valves between the DOT pumps and the day tanks in the ISI program.

c. Require monitoring of suction pressure downstream of the suction strainer.

Recommendations for inservice testing of the six types of pumps are summarized in Table 1.

<u>General Comments</u>

1. If existing instrumentation is not accurate enough to meet code requirements, a relief request on the existing instrumentation accuracy (or use of test gauges), would be the appropriate avenue (as opposed to a relief request on testing altogether).

2. Where the addition of flow elements is recommended, it is not intended that an entire safety grade loop be added. Examples of satisfactory devices would be:

   a. An in-line flow orifice with flange taps, tap isolation valves, and pipe caps. This, in conjunction with a delta p test gauge, could be used as a flow meter. (Would require hookup of test gauge and manual correlation of delta p to flow).

   b. Use of a surface mounted ultrasonic flowmeter. If required code accuracy cannot be met, a relief request on instrumentation accuracy should be acceptable. Note that if ultrasonic flowmeters are installed in locations that are suitable for other flowmeters (adequate straight pipe section without turbulence inducing fittings), they can be reasonably accurate, and if left in a fixed position, very repeatable. Since ISI programs are, in general, primarily concerned with detecting degradation, repeatability is the parameter of most concern.

3. If the length of time a pump must be run would result in too much fluid transfer through the preferred or instrumented flow path, a relief request which allows, for example, running five minutes in recirc and then switching to the desired valve lineup for monitoring flow and pressure conditions would be reasonable. Flow stability could be achieved and measurements documented in 30 seconds (or less) if necessary. A total relief from testing just

because of a time-volume problem appears neither necessary nor justifiable.

4. There are numerous valves (check valves) which cannot be properly tested unless pumps are properly tested. The review of valves to be tested in the St. Lucie ISI program was focused on only those valves which have a direct impact upon pump performance.

   Based upon observations made as a part of this review, a full, detailed review of St. Lucie's pump and valve program appears warranted.

5. It was noted that the prints provided by FP&L indicated the presence of suction strainers for all pumps reviewed. If this is in fact true,[1] and the strainers were not removed after preoperational testing, monitoring of pressure drop across the strainers or monitoring suction pressure downstream of the strainers before and during the pump run is critical, particularly for systems which are likely to have solids in the stream.

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[1]It is probable that some strainers are still in use, such as for the diesel fuel oil pump strainer, but that some others, such as the LPSI pump strainers, were removed following preoperational test.

Table 1. Current and Recommended Pump Inservice Testing

PUMP	CURRENT TESTING (as deduced from references)		RECOMMENDED TESTING	
	QUARTERLY	MODE 5 or 6	QUARTERLY	MODE 5 or 6
HPSI	Miniflow recirculation flowpath used. Flow not monitored. Pump suction pressure and developed head monitored.	Injection flowpath used. Pump flow, suction pressure and developed head monitored. (Full flow, Mode 6)	Monitor flow, suction pressure and developed head in miniflow recirculation flowpath. Use installed flow instrumentation.	Same as Current.
LPSI	Miniflow recirculation flowpath used. Flow not monitored. Pump suction pressure and developed head monitored.	Shutdown cooling flowpath used. Pump flow, suction pressure and developed head monitored. (Full flow, Mode 5)	Monitor flow through miniflow recirculation flowpath[1] and full flow recirculation flowpath (through line 6-CS-500), along with suction pressure and developed head. Use installed flow instrumentation for normal recirculation flowpath. Add new flow instrument to line 6-CS-500 for full flow monitoring.	Same as Current
AFW	Miniflow recirculation flowpath used. Flow not monitored. Pump suction pressure and developed head monitored	Safety related flowpath to SGs used. Pump flow, suction pressure and developed head monitored. (Full flow, Mode 5)	Monitor flow, suction pressure and developed head in recirculation flowpath. Will require new instrumentation. (Monthly in this case.)	Same as current.

PUMP	CURRENT TESTING (as deduced from references)		RECOMMENDED TESTING	
	QUARTERLY	MODE 5 or 6	QUARTERLY	MODE 5 or 6
BORIC ACID	Miniflow recirculation flowpath used. Flow not monitored. Pump suction pressure[2] and developed head monitored.	Flow monitored using "existing flow-rate meters" (could be flow to BA blender or charging pump discharge flow).[2] Suction pressure[2] and developed head monitored.	Monitor flow by transferring boric acid from one tank to the other and observing level change. Also monitor pump suction pressure and developed head.	Same as current. provided that the current testing delivers flow through the emergency boration flowpath and monitors flow by use of charging pump discharge flow meter.
CONTAINMENT SPRAY	Minimum flow recirculation flowpath used. Flow not monitored. Pump suction pressure and developed head monitored.	No specific additional testing.	Monitor flow through full flow recirculation flowpath (through line 6-CS-500), along with suction pressure and developed head. Add new flow instrument to line 6-CS-500 for full flow monitoring.	No specific additional testing.
DIESEL FUEL OIL	Minimum flow recirculation flowpath (which includes a relief valve) used. Flow not monitored. Pump suction pressure[3] and developed head monitored.	No specific additional testing.	Monitor full flow through one of several alternative flowpaths (see discussion). Monitor suction pressure and developed head.	No specific additional testing.

FOOTNOTES

1. Only one flow test is intended, with both the full recirculation flowpath (6-CS-500) and the recirculation flowpath monitored.

2. The boric acid pumps are not provided with a suction pressure gauge. It is assumed that suction pressure is monitored by conversion of boric acid tank level indication.

3. While the St. Lucie plan indicates that pump suction pressure is monitored, it does not appear that it can be monitored by any means other than by use of storage tank level. While this would generally be acceptable, the fact that suction strainers are indicated between the source tank and the pump suction make use of tank level an invalid indication of pump suction pressure. The presence of strainers also makes periodic full flow monitoring more critical.

References:

1. Letter, C. O. Woody to USNRC, July 31, 1987, "Relief from Parts of ASME Section XI"

2. Letter, C. O. Woody to Mr. Ashok C. Thadani (NRC), October 13, 1986, "Relief from Parts of ASME Section XI"

3. Letter, C. O. Woody to USNRC, January 28, 1988, "Request for Additional Information, ASME Code Relief Requests for Various Safety-Related Pumps"

4. Letter, W. F. Conway to USNRC, May 12, 1988, "2nd Request for Additional Information, ASME Code Relief Requests for Various Safety-Related Pumps"