Attachment

Technical Evaluation

Flow Measurement
of
Centrifugal Pumps
in
Fixed Resistance
Systems
at
St. Lucie Plant

July 31, 1987

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1.0 Executive Summary

An engineering evaluation was conducted by Combustion Engineering to provide a technical justification for relief from quarterly inservice flow measurement testing of certain ASME Class 2 and 3 pumps as required by the 1980 Edition, Winter 1980 Addenda of the ASME B&PV Code Section XI. The evaluation is applicable to St. Lucie Units 1 and 2 and addresses the pumps shown in *Table 1,* which are all centrifugal pumps in fixed resistance systems. The key elements considered in the evaluation are as follows:

- Analysis of pump failures
- Assessment of flow measurement practicality
- Comparison of alternative test intervals and methods
- Qualitative analysis of flow measurement vs. differential pressure measurement.

PUMP	St. Lucie 1	St. Lucie 2
High Presure Safety Injection (HPSI A & B) (C, Unit 1 only)	Bingham Williamette	Bingham Williamette
Low Pressure Safety Injection (LPSI A & B)	Ingersol Rand	Ingersol Rand
Containment Spray (CS A & B)	Byron Jackson	Ingersol Rand
Auxilliary Feedwater (AFW A, B & C)	Byron Jackson	Ingersol Rand
Boric Acid Makeup (BAM A & B)	Goulds	Goulds
Diesel Oil Transfer (DOT A & B)	Crane	Goulds

Pump Identification
Table 1

The results of the evaluation are summarized below:

1) A review of industry failure history on similar centrifugal pumps indicates that approximately 93% of the failures are attributable to mechanical degradation or failure while only 7% of the failures affected hydraulic performance. A review of the St. Lucie maintenance records indicated that only 4% of the maintenance was attributable to hydraulic performance degradation *(See Section 2).*

2) In each instance where review of historical data revealed cases of hydraulic degradation, the data indicates that the degradation was detected through periodic testing methods other than flow measurement. Measurement of differential pressure in a fixed resistance system, along with vibration measurement and operator observation, is adequate to detect all reported degradation or failure scenarios as well as any credible postulated degradation or failures *(See Section 2).*

3) It has been determined, through system reviews, that full or partial flow testing through the main system flow paths is impractical on a quarterly basis *(see Section 3).* Furthermore, such testing would not provide any information in addition to the measurement of pump differential pressure, which is currently measured at St. Lucie *(See Sections 3 and 4).*

4) The effectiveness of differential pressure measurement as an indication of degradation is virtually independent of the flow rate (i.e. the effectiveness is as great at mini-flow rates as at the design or run out flow rates). (See Section 4).

5) In a fixed resistance system, flow is related to differential pressure by the equation

$$\boxed{Q = K\sqrt{\Delta P}}$$

where:

Q = Flow
ΔP = Differential Pressure
K = point where the system head curve meets the pump head curve

If flow changes in this fixed system the differential pressure also changes and vice versa. Since this relationship can be calculated, there is no additional benefit gained from measuring the flow if the differential pressure is measured. In fact, if a fixed resistance mini-recirc system could change or did change slightly, (e.g., partially closed valve, eroded or partially clogged orifice, etc.) resulting in a new recirc flow, the change in differential pressure would probably not be detectable because operation (the point where the system head curve meets the pump head curve) would remain along the flat part of the pump head curve. If there was degradation of the pump, however, a change in ΔP would be observed because degradation of the pump is reflected by a change in the pump head curve, and thus a change in ΔP, as shown in *Figure 1.* Therefore, any detectable change in differential pressure can be assumed to be attributable to hydraulic degradation. The measurement of flow provides no additional benefits nor does it enhance the level of safety. (See Section 4).

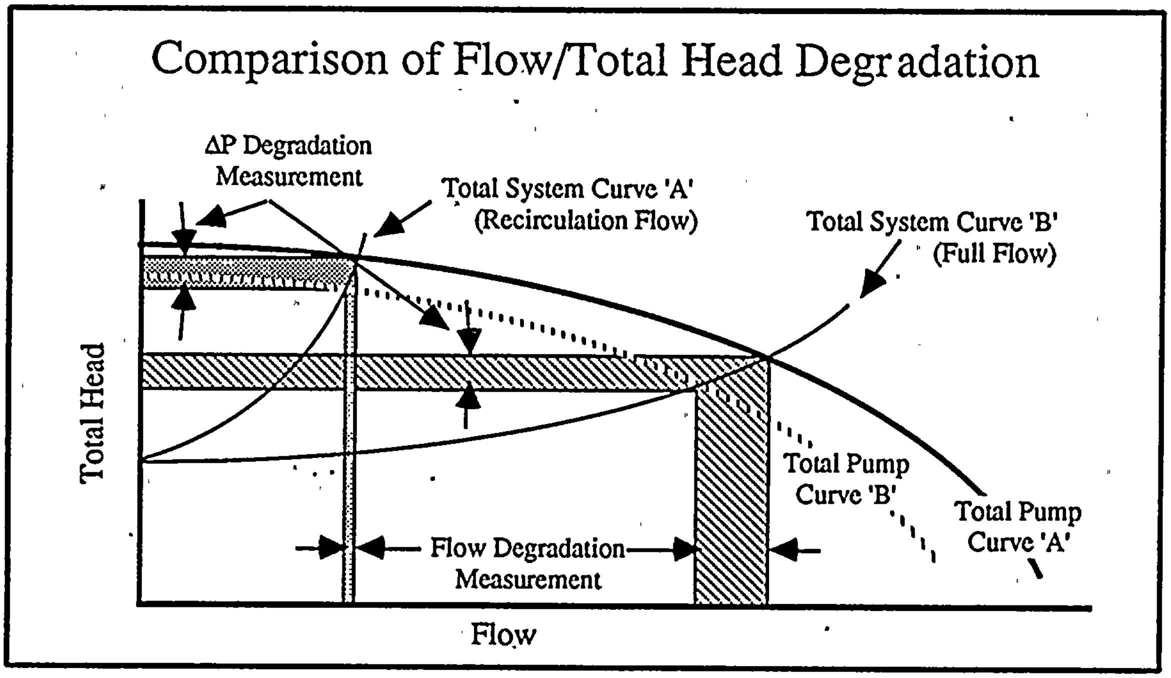

Figure 1

6) The measurement of differential pressure in a fixed resistance system provides for a more conservative indication of degradation than does the measurement of flow in that same fixed resistance system, i.e., the tolerances imposed on differential pressure per ASME Code bound the flow. This means that for a given degradation, if the differential pressure is within the limits imposed by the Code, then the flow for that same given fixed system will also be within the limits of the Code. On the other hand, if flow is within the limits imposed by the Code it does not necessarily mean that the differential pressure is within the limits of the Code. Therefore, differential pressure alone is required to establish pump operational readiness within Code limits *(See Section 4)*.

2.0 Pump Failure Analysis

The failure of a pump to perform its intended function is related to degradation during its defined service. The degradation can affect hydraulic or mechanical performance. Hydraulic degradation is characteristic of the loss in the ability to deliver sufficient head or flow and is usually caused by wear of the impeller or wearing rings due to continuous operation over extended periods. Mechanical degradation is characteristic of increased vibration and/or noise, mechanical seal or packing leakage, loosening of bolting, etc.

A technical evaluation of the HPSI, LPSI, CS, AFW, BAM and DOT pumps was conducted to establish the mechanisms that could cause degradation and/or failure of centrifugal pumps and to ascertain which test methods are capable of detecting the various mechanisms for degradation and failure. The analysis is based upon review of industry historical data (*Source:* NPRDS, LERs) and St. Lucie Plant operating and maintenance experience. *Table 2*, which summarizes the results of the evaluation, reveals that the test methods currently in use at St. Lucie are capable of detecting all credible modes of failure or degradation. A complete tabulation of historical data (excluding motor-related events) is included in Appendix 'A'.

Analysis of operating times (See *Appendix 'C'*) for St. Lucie pumps shows that operation can be considered *intermittent* based on the low service usage. Because of this low service usage, pump degradation is more likely to be mechanical in nature than hydraulic as shown in both *Appendix 'A'* and *Appendix 'B'*. This indicates that visual observation and vibration quarterly testing is adequate to detect most degradation. Because the most credible cause of hydraulic degradation is wearing ring and/or impeller wear, which are associated with high service usage and are often detectable by mechanical and hydraulic induced vibration, it is reasonable to conclude that an 18 or 24 month test interval would provide for an adequate means of detection for hydraulic degradation.

Pump Failure/Test Matrix

Component	Failure Mode	Detection Method		
		ΔP	Vibration	Observation
Seals Packing	Worn Packing			▨
	Tight Packing			▨
	Worn Seal			▨
	Defective Seal			▨
Internals	Worn Impeller	▨	▨	
	Casing Channel Rings Warped		▨	
	Impeller Clearance	▨		
Bearings/ Lubrication	Worn Bearings		▨	
	Worn Bearing Retainining Screw		▨	
	High/Low Lube Oil Level			▨
Other	Misalignment		▨	
	Loose Studs			▨
	Galled Gaskets			▨
	High Vibration		▨	
	Low/High ΔP	▨		
	Impeller Imbalance		▨	
	Inadequate Venting	▨		
	Loss Of Prime	▨		
	Leaking Foot Valves	▨		

Table 2

3.0 Assessment of Flow Measurement Practicality

Technical assessment of the practicality of flow measurement is addressed in terms of system operation with respect to pump run times, plant responses, safety implications, and thermal shock concerns. Also, a review of as-built system configurations was conducted to determine whether alternative system alignments could be employed to satisfy Section XI pump flow test requirements during normal plant operations. The results of these assessments are addressed in the following paragraphs on a pump-by-pump basis.

High Pressure Safety Injection (HPSI)

The review of the HPSI system indicates quarterly flow testing to be impractical, based upon the operational characteristics of the system. In order to flow test the HPSI pumps, sufficient pump discharge head must be developed to overcome system resistance and check valves which are back-biased by Reactor Coolant System pressure. HPSI pump shutoff head (approximately 1250 psig) is not sufficient to overcome RCS pressure during normal operation. Further, the HPSI pumps cannot be tested at Cold Shutdown (Mode 5) because it could subject the Reactor Pressure Vessel to conditions exceeding the pressure-temperature limits of Technical Specification 3.4.9.1.

The main system flow path may be used for pump flow testing only during the Refueling mode of operation, while filling the refueling cavity with the RPV head removed. Obviously, it is impractical to go to Cold Shutdown every 3-months in order to do so.

A review of the Safety Injection System P&ID shows that no alternative path exists for testing on a quarterly basis other than the mini-flow lines, which are not instrumented to measure flow. Although the mini recirc path design could be modified to include flow instrumentation, the resulting flow measurement would be high on the pump head curve. Measuring ΔP high on the pump head curve provides, as a minimum, as accurate an indication of pump performance as does measuring flow *(see Section 4)*. Thus, there is no technically justifiable basis for being required to measure both. Additionally, pump usage (≈10 hours/year) does not support hydraulic degradation as a credible failure mechanism.

Low Pressure Safety Injection (LPSI)

Review of the LPSI system shows quarterly flow testing to be impractical during normal operation based upon characteristics of the system. In order to flow test the LPSI pumps, sufficient pump discharge head must be developed to overcome system resistance and check valves which are back-biased by Reactor Coolant System Pressure. However, LPSI pump shutoff head (approximately 175-216 psig) is not sufficient to overcome RCS pressure during normal operation. Therefore, the LPSI pumps can only be full or partial flow tested during Mode 5 (Cold Shutdown) or Mode 6 (Refueling). In addition, the design flow rate of 3000 gpm dictates that a volume be available of sufficient capacity to accept the total volumetric discharge from the LPSI pump at design flow conditions over the duration of the test. This volumetric capacity requirement can be met, due to system characteristics, only by the refueling cavity volume.

Based upon the above considerations it is impractical to flow test the LPSI system on a quarterly basis during any mode of plant operation above Cold Shutdown (Mode 5). Although the LPSI system can be flow tested during Cold Shutdown, it is obviously impractical to go to Cold Shutdown every 3-months in order to do so.

Review of the Safety Injection System P&ID's reveals no alternative flow paths for testing on a quarterly basis other than the pump miniflow lines, which are not instrumented to measure flow. Although the mini recirc path design could be modified to include flow instrumentation, the resulting flow measurement would be high on the pump head curve. Measuring ΔP high on the pump head curve provides, as a minimum, as accurate an indication of pump performance as does measuring flow *(see Section 4)*. Thus, there is no technically justifiable basis for being required to measure both.

Auxiliary Feedwater (AFW)

The review of the AFW system shows quarterly flow testing to be impractical based upon two considerations. The first deals with thermal shock of the Auxiliary Feedwater nozzle at the Main Feedwater system interface. During Auxiliary Feedwater injection, a large (as much as 380°F) temperature differential occurs which can create a large thermal shock and additional fatigue cycling of the nozzle. Clearly, this is not desirable. The second consideration deals with flow testing of the AFW pump to the time duration requirements of the ASME Code. Given the required test time durations and the design. pump flow rate of approximately 275 gpm, the RCS would experience a cooldown and contraction induced by steam generator secondary side cooldown. This cooldown can cause reactivity variations and power fluctuations during Mode 1 operation, which are clearly undesirable.

Testing of the AFW pump may be accomplished using the main system flow paths and installed flow meters during normal plant cooldown or during Mode 5 Cold Shutdown operation. It is obviously impractical to go to Cold Shutdown every 3-months in order to accomplish pump flow testing.

Review of the Auxiliary Feedwater System P&ID's reveals no alternative flow paths for testing on a quarterly basis other than the pump miniflow lines, which are not instrumented to measure flow. Although the mini recirc path design could be modified to include flow instrumentation, the resulting flow measurement would be high on the pump head curve. Measuring ΔP high on the pump head curve provides, as a minimum, as accurate an indication of pump performance as does measuring flow *(see Section 4)*. Thus, there is no technically justifiable basis for being required to measure both.

Based upon the above considerations it is impractical to conduct AFW pump testing, other than miniflow ΔP testing, on a quarterly basis.

Boric Acid Makeup (BAM)

The review of the BAM system shows flow testing to be impractical. This impracticality determination is based upon the implications of injecting concentrated boric acid into the Reactor Coolant System during plant operation. Using the main system flow path for the pump test would cause excess boron addition to the RCS with a resultant decreases in core reactivity. When coupled with the test duration time requirements of the Code, a test using the main system flow path becomes prohibitive because of the large boron addition. Therefore, it is impractical to flow test the BAM pumps using the main system flow path on a quarterly basis, i.e., during plant operation.

A review of the Boric Acid Makeup System P&IDs indicates the availability of two possible flow paths for quarterly testing.

One flow path is the BAM pump recirculation line back to the BAM tank. The other flow path is the BAM flow path to the Refueling Water Tank (RWT).

Although there is a flow path back to the BAM tank using the recirculation line, the flow path is not instrumented to measure flow. This flow path also offers the possibility to determine the pump flow rate based upon a change in water level in the BAM Tank. However, the BAM tank capacity is insufficient, even when the tank level is lowered to the Technical Specification minimum, to accomodate the BAM pump design flow rate over the time duration requirement of the Code when bearing temperatures are measured.

An alternate flow path available for quarterly pump testing is the makeup flow path to the RWT. This is a restricted flow path and contains the BAM system flow instrumentation. However, the flow instrumentation is not capable of satisfying the 2% accuracy requirement of the Code. Additionally, a portion of the makeup flow path to the RWT is not heat traced, creating the possibility for boron precipitation difficulties. Also, the maximum indicated flow capacity of this path is 30 gpm, which is significantly less than system full flow (≈142 gpm). Any flow measurement taken in this flow path will thus be high on the pump curve. Measuring ΔP high on the pump curve provides, as a minimum, as accurate an indication of pump performance as does measuring flow *(see Section 4)*. Thus, there is no technically justifiable basis for being required to measure both.

Based upon all of the above considerations, quarterly flow testing in accordance with the Code requirements is impractical. The best indication of pump operational readiness is provided by employing the test method currently in use; measuring pump ΔP on a quarterly basis.

Containment Spray (CS)

The review of the CS system shows flow testing on a quarterly basis to be impractical based upon the system configuration and its function. The containment spray system uses its main flow path to discharge into the containment atmosphere to ensure that design values for containment temperature and containment pressure are not exceeded during a postulated loss of coolant or steamline break accident in containment. Full flow testing of the system using the normal (flow instrumented) flow path would require actual containment spray down. Clearly, this is impractical for test purposes.

Alternatively, a partial flow test path does exist for the containment spray pumps through taking a suction on the RWT, flowing RWT fluid to the containment spray pump discharge header, and to the Shutdown Cooling heat exchanger. From the Shutdown Cooling heat exchanger RWT fluid would flow through the containment spray system main piping into the Shutdown Cooling System discharge pipe and finally inject into the RCS through the low pressure safety injection headers, which are flow instrumented. This would be accomplished with containment spray header isolation valves closed to prevent containment spray down. However, there are tube side flow limitations on the Shutdown Cooling Heat Exchanger and the containment spray pump is designed for 3600 gpm flow while the Shutdown Cooling heat exchanger tubes are designed for 3000 gpm; thus, only partial flow testing is possible. Furthermore, this option for partial flow testing is available only during refueling cavity fill, Mode 6. Thus, this alternative is clearly impractical since it would involve plant shutdown and RPV head removal every 3-months.

Review of the containment spray system P&ID reveals no alternative flow paths for testing on a quarterly basis other than the pump miniflow lines, which are not instrumented to measure flow. Although the mini recirc path design could be modified to include flow instrumentation, the resulting flow measurement would be high on the pump head curve. Measuring ΔP high on the pump head curve provides, as a minimum, as accurate an indication of pump performance as does measuring flow *(see Section 4)*. Thus, there is no technically justifiable basis for being required to measure both. Additionally, pump usage (≈5 hours/year) does not support hydraulic degradation as a credible failure mechanism.

Diesel Fuel Oil Transfer (DOT)

Review of the DOT System shows full flow testing to the Day Tanks to be impractical because of limitations imposed by the Day Tank capacity. The Day Tanks are 343 gallon tanks with a Technical Specification minimum volume of 200 gallons. Considering the 25 GPM flow rate of the DOT pumps, the remaining available volume is insufficient for the test duration requirement of Code when bearing temperature measurements are required. Even if flow testing to the Day Tank were possible, the tank level indicators that would be used to calculate the flow rate would fail to satisfy the 2% accuracy requirements of Code.

Based upon the Day Tank capacity limitation, the uncertainty of the level indication and the potential for inadvertently lowering the Day Tank oil level below the Technical Specification minimum, it is impractical to flow test the DOT pump while discharging to the Day Tanks.

Although there is a flow path back to the Diesel Oil Storage Tank, that flow path is not instrumented to measure flow. Flow rates as determined by a change of level over time are subject to a ±3% uncertainty, failing to satisfy the Code requirement for 2% accuracy.

Based upon the above considerations, quarterly flow testing in accordance with Code requirements is impractical. Flow testing to the Diesel Oil Storage Tank could be offered as an alternative test, although relief from the 2% accuracy requirement of the Code would be required. Lacking the accuracy of the Code required flow test, however, it does not appear that this alternative would produce meaningful results. The best indication of pump operational readiness is provided employing the test method currently in use, i.e., measuring ΔP on a quarterly basis in the recirc. flow path. Additionally, pump usage (≈4 hours/year) does not support hydraulic degradation as a credible failure mechanism.

4. Measurement of Differential Pressure in a Fixed Resistance System

Analysis of fixed resistance systems indicates that the measurement of differential pressure always provides for as conservative an indicator of pump degradation as the measurement of flow and that the point of measurement on the curve is inconsequential. It also shows that there will be no impact on safety regardless of the point of measurement.

For a fixed set of conditions in any system there is only one total pump head for a given flow. This total head can be determined by either measuring pressure across the pump and the pump flow or by measuring the energy difference between any two points in the system, one each side of the pump, providing all losses between these two points are credited to the pump and are added to the energy-head difference.

Flow produced by a centrifugal pump varies with the system total head which, at equilibrium, must equal pump total head. The point of intersection of the pump and system curves represents the maximum flow possible with respect to the fixed system defined and provides the equilibrium conditions necessary to perform an energy balance using Bernoulli's General Equation for Fluid Flow. Any change in the system would require a new energy balance to be performed, as each condition is unique and the results obtained on one system curve cannot be used to

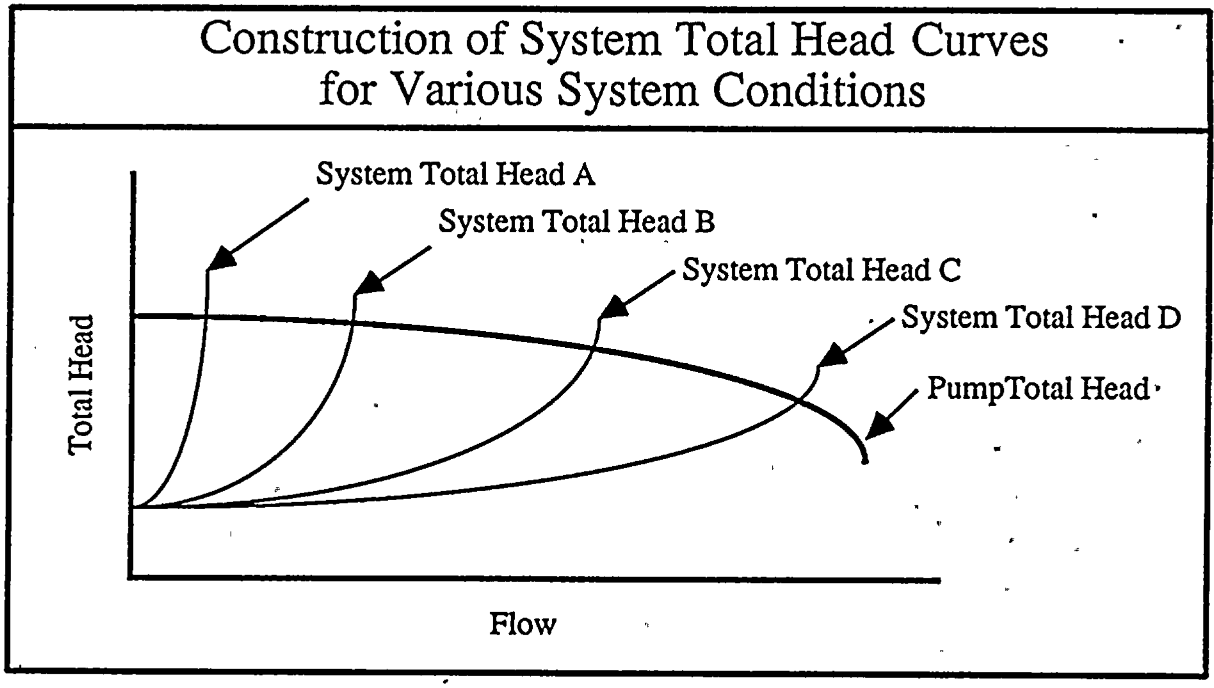
Construction of System Total Head Curves for Various System Conditions

Figure 2

extrapolate conditions on another system curve, as shown in *Figure 2.* The points of intersection with the pump total head curve and system total head curve change as the system changes.

The system total head is comprised of two parts, a fixed part due to the energy required to overcome system static head and a variable part which is related to the energy required to overcome losses due to flow in the system. *Figure 3* shows this relationship.

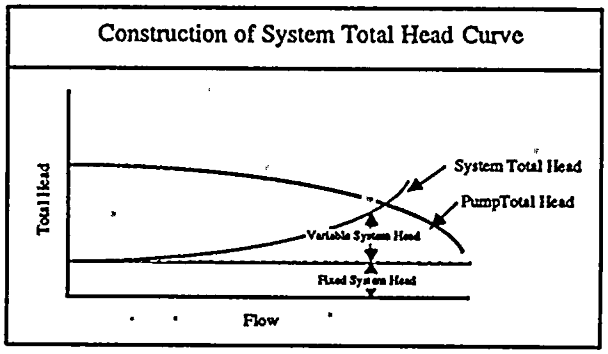
Construction of System Total Head Curve

Figure 3

Variable system head and flow are described by the following relationship:

$$\boxed{Q = K\sqrt{\Delta P}}$$

where:

Q = Flow
ΔP = Differential Pressure
K = Constant defined by the fixed system

Since the variable system total head is dependent on the pump, and all energy changes are attributable to the pump, any change in flow or differential pressure would be attributed to pump degradation. This degradation would be present on any system total head curve considered. Therefore, degradation is independent of which system total head curve is used and the impact on safety would not be compromised if measurements were taken at full flow or minimum flow conditions, the only requirement being that the same system total head curve be used for comparison.

To determine pump degradation, differential pressure and/or flow is required to be measured. For centrifugal pumps, the flow degradation differences are greater when the system total head curve is flat (full flow conditions) as compared to a steep system total head curve (recirculation flow conditions). However, differences in differential pressure due to pump degradation remain relatively constant irrespective of the shape of the system total head curve. *Figure 1* shows this relationship. Since the system total head characteristics in a fixed resistance system are known and are repeatable without having to set up conditions by throttling discharge valves, the measurement of flow is not necessary to determine pump degradation. The measurement of pump differential pressure is all that is required.

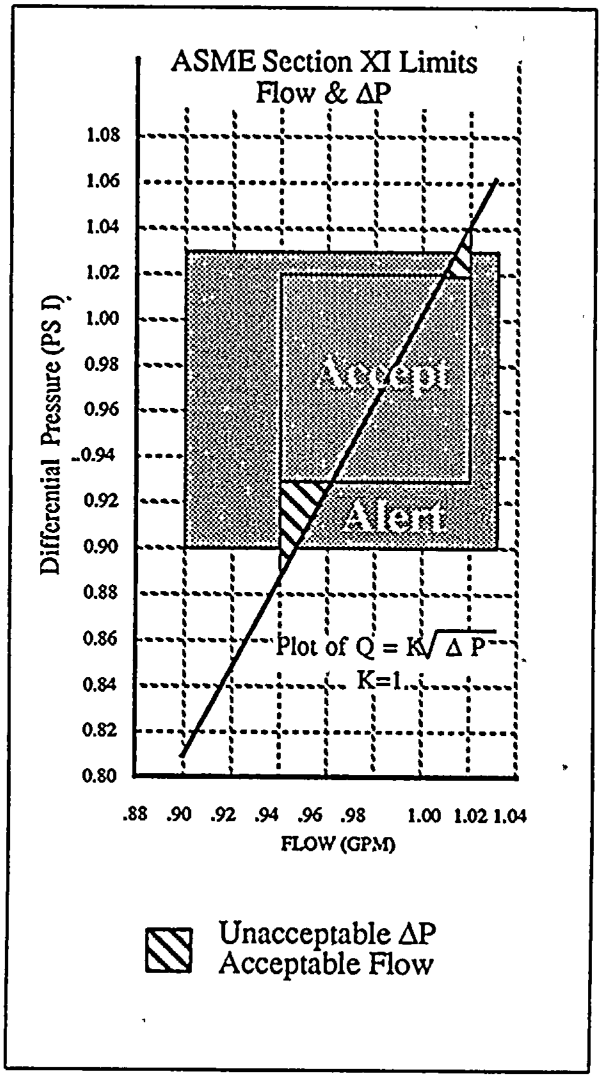

Figure 4

In addition, the measurement of differential pressure provides for more conservatism when determining degradation than the measurement of flow. As seen in *Figure 4*, the limitations imposed by the Code for the high and low value, differential pressure alert limits bound flow in the acceptable range. However, the high and low flow alert limits would allow for differential pressures to be unacceptable.

Based upon the above discussions and analyses, the following is concluded:

- For a fixed resistance system there is one total head for a given flow.
- Centrifugal pump flow varies with the total system head.
- Losses in differential pressure are attributed to pump degradation.
- Degradation measured on one system total head curve indicates that there will be degradation on other system total head curves.
- For a fixed resistance system, only

differential pressure measurement is required to determine pump degradation, flow can be calculated by:

$$\boxed{Q = K\sqrt{\Delta P}}$$

where K is defined by the fixed system.

- The measurement of differential pressure always provides for conservative indication of degradation.
- The point of measurement, i.e., system total head curve used, is arbitrary and will not impact safety no matter where measured.

CONCLUSIONS

1) Full or partial flow testing through main system lines for the purpose of flow measurement on a quarterly basis is impractical at St. Lucie.

2) Flow measurement testing in a fixed resistance recirc-line is not necessary to detect pump degradation or oncoming failure if pump differential pressure is measured. Therefore, the addition of flow measurement devices to the mini-recirc lines at St. Lucie would not result in an increase in the level of safety or quality.

3) FPL's present method of inservice testing without flow measurement is adequate to meet the intent of the ASME Code Section XI.

APPENDIX A
Mechanical/Hydraulic Pump Degradation

ITEM DESCRIPTION	AFW	CS	DOT	HPSI	LPSI	TOTAL EVENTS
Alignment						
Misalignment Pump/Driver (V)	2	3	2	2		9
Mechanical Seal/Packing						
Worn Packing (O)	5					5
Packing too Tight (O)		2				2
Worn Packing (O)	7	1		1	1	10
Worn Mechanical Seal (O)		3			10	13
Defective Mechanical Seal (O)					1	1
Pump Internals						
Worn Impeller (P)	1			1		2
Worn Impeller (V)		2				2
Casing/Channel Rings Warped (V)	1					1
Bearing/Lubrication						
Worn Bearings (V)			2	2	3	7
Worn Bearing Retaining Screw (V)				1		1
Low Lube Oil Level (O)	1		1			2
High Lube Oil Level (O)	1					1
Other						
Loose Studs (O)		1				1
Galled Gaskets (O)	2		1			3
High Vibrations-Cause Unk (V)		1	2			3
Low Diff Pressure-Cause Unk (P)					1	1
High Diff Pressure-Cause Unk (P)			1			1
Impeller Imbalance (V)			1			1
Total Events Related to Pump	20	13	10	7	16	66

<u>Detection Method (When Known)</u>
(V)=Vibration
(P)=Pressure
(O)=Operator Observation

Appendix B
St. Lucie 1 & 2
Operating/Maintenance History

ITEM DESCRIPTION	AFW	CS	DOT	HPSI	LPSI	BAM	LESS BAM	TOTAL EVENTS
Alignment								
Misalign, Pump/Driver (V)	1	1	1	3	2	1	8	9
Mechanical Seal/Packing								
Worn Packing (O)			6				6	6
Worn Mechanical Seal (O)		2		2		7	4	11
Pump Internals								
Worn Impeller (V)			1			1	1	2
Bearing/Lubrication								
Worn Bearings (V)	2						2	2
Other								
Loose Studs (O)		1		3	5	4	9	13
Repair Oiler Leak (O)	1					1	1	2
Adjust Oiler (O)	1						1	1
Water in Oil (O)	1						1	1
Impeller Clearance Adj. (P)			1			1	1	2
Total Maintenance Items	6	4	9	8	7	15	34	49

<u>Detection Method (When Known)</u>
(V)=Vibration
(P)=Pressure
(O)=Operator Observation

Appendix C
St. Lucie Plant
Estimated Pump Operating Hours

(Preoperational runtimes not included)

PUMP	TOTAL HOURS	TEST %	TOTAL OPER. HOURS	TOTAL TEST HOURS	AVG. OPER. HOURS BETWEEN TESTS
AFW 1A	1600	3.00%	1552	48	13
AFW 1B	1600	3.00%	1552	48	13
AFW 1C	40	67.50%	13	27	0
BAM 1A	5100	0.25%	5087	13	42
BAM 1B	5100	0.25%	5087	13	42
CS 1A	55	100.00%	0	55	0
CS 1B	55	100.00%	0	55	0
DOT 1A	40	100.00%	0	40	0
DOT 1B	40	100.00%	0	40	0
HPSI 1A	110	33.64%	73	37	1
HPSI 1B	110	33.64%	73	37	1
HPSI 1C	105	40.00%	63	42	1
LPSI 1A	10100	1.00%	9999	101	0
LPSI 1B	10100	1.00%	9999	101	0
AFW 2A	670	2.99%	650	20	11
AFW 2B	670	2.99%	650	20	11
AFW 2C	40	67.50%	13	27	0
BAM 2A	1700	0.24%	1696	4	26
BAM 2B	1700	0.24%	1696	4	0
CS 2A	20	100.00%	0	20	0
CS 2B	20	100.00%	0	20	0
DOT 2A	30	100.00%	0	30	0
DOT 2B	30	100.00%	0	30	0
HPSI 2A	45	33.33%	30	15	0
HPSI 2B	45	33 33%	30	15	0
LPSI 2A	4000	0.45%	3982	18	0
LPSI 2B	4000	0.45%	3982	18	0