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HANNEN,R.L. Iowa Electric Light & Power Co.
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SUBJECT: LER 88-004-00:on 880609,HPCI sys inoperability from
inadequate periodic insp of governor actuator.
W/8 ltr.

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TITLE: 50.73 Licensee Event Report (LER), Incident Rpt, etc.

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July 11, 1988
DAEC-88-0532

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Subject: Duane Arnold Energy Center
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Gentlemen:

In accordance with 10 CFR 50.73 please find attached a copy of the subject Licensee Event Report.

Very truly yours,

7/11/88

Rick L. Hannen
Plant Superintendent - Nuclear

RLH/JRP/go

cc: Mr. A. Bert Davis
Regional Administrator
Region III
U. S. Nuclear Regulatory Commission
799 Roosevelt Road
Glen Ellyn, IL 60137

NRC Resident Inspector - DAEC

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

LICENSEE EVENT REPORT (LER)

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TITLE (4) High Pressure Coolant Injection System Inoperability from Inadequate Periodic Inspection of Governor Actuator and Failed Oil System Pressure Microswitch

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAMES	DOCKET NUMBER(S)
0 6	0 9	8 8	8 8	— 0 0 4 —	0 0	0 7	1 1	8 8	None	0 5 0 0 0
										0 5 0 0 0

OPERATING MODE (9): N

POWER LEVEL (10): 1 0 0

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)	[ ] 50.73(a)(2)(iv)	[ ] 73.71(b)
[ ] 20.405(a)(1)(i)	[ ] 50.36(c)(1)	[X] 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)
James R. Probst, Technical Support Engineer	3 1 9 8 5 1 - 7 3 0 8

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
D	B J	T C	W 2 9 0	NO					
B	B J	P S	S 3 4 5	YES					

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)

On June 9, 1988, with the reactor in power operation, during a routine surveillance test the High Pressure Coolant Injection System (HPCI) reached rate pressure and flow within 30.08 seconds versus the limit of 30 seconds. The HPCI stop valve also failed to open within the requirement of 30 seconds, taking 30.78 seconds. HPCI was declared inoperable at 1435 hours. There were two root causes: 1) an out of calibration electro-mechanical hydraulic actuator (EGR) in the turbine governor system due to inadequate periodic testing and preventive maintenance, and 2) the failure of a microswitch within a pressure switch in the HPCI oil system which provides automatic control of the HPCI Auxiliary Oil Pump on system startup and shutdown. Immediate corrective actions were to replace the microswitch and recalibrate the EGR. The HPCI system was successfully fast started in 17 seconds the evening of June 10, and was left in a functionally operable condition at 1928 hours. The HPCI system was formally declared operable on June 11 at 1605 hours after fast-starting under cold conditions in 19.6 seconds, with the stop valve opening in 19.8 seconds. Long-term corrective actions are increased monitoring and investigation of EGR upgrading.

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

I. DESCRIPTION OF EVENTS:

On June 9, 1988, the reactor was operating at 100% thermal power. During a scheduled High Pressure Coolant Injection System (HPCI, EIIS System BJ) operability surveillance test, the HPCI turbine pump did not provide 3000 gpm at rated pressure within 30 seconds, as required. The HPCI System started in 30.08 seconds. The HPCI stop valve also did not meet its required time for opening of 30 seconds, requiring 30.78 seconds. HPCI was declared inoperable at 1435 hours and a seven day Limiting Condition for Operation (LCO) was entered in accordance with Technical Specification 3.5.D.2. Required testing was initiated to verify the operability of the redundant systems: the Automatic Depressurization System (ADS, EIIS System SB), the Low Pressure Coolant Injection System (LPCI, EIIS System BO), the Core Spray System (CS, EIIS System BM) (verified as operable earlier in the day), and the Reactor Core Isolation Cooling System (RCIC, EIIS System BN).

Troubleshooting of the HPCI system began shortly after it was declared inoperable on June 9 and continued through the evening of June 10. PS2288, a pressure switch which controls the HPCI control and lubrication oil system Auxiliary Oil Pump (Aux Oil Pump), had a microswitch within it replaced. (The attached Figure One details the HPCI oil system). The HPCI turbine governor EGR Electro-Mechanical Hydraulic Actuator (EGR), which controls oil flow to the turbine governor valve, was recalibrated.

The evening of June 10, 1988, following the replacement of the microswitch within PS2288 and recalibration of the EGR, the HPCI turbine-pump satisfactorily reached required operating flow and pressure within 22 seconds. After some further refinement of the EGR calibration, the night of June 10 the HPCI system was left in a functionally operable condition from 1928 hours such that it would automatically initiate upon an actuation signal, but was not declared operable. The turbine was allowed to cool overnight. At 1554 hours on June 11, 1988 the HPCI turbine successfully started under cold conditions, reaching rated flow and pressure in 19.6 seconds. The HPCI stop valve reached full open position in 19.8 seconds. The HPCI operability test was completed and the HPCI system formally declared operable and the seven day LCO exited on June 11, 1988 at 1605 hours.

II. CAUSE OF EVENT

The cause of the HPCI event was twofold: the drifting out of tolerance of the EGR offset voltage, considered the primary cause, and the failure of PS2288 to provide adequate control of the HPCI Aux Oil Pump. (See Section III., Analysis of Event.)

The root cause of the EGR offset voltage drift was a lack of sufficient scheduled periodic testing and preventive maintenance on the instrument. The EGR was last calibrated in May, 1987 during the 1987 refueling outage, and had not been examined since. Rust due to condensation noted on the EGR solenoid may have been a contributory factor.

The root cause of failure of PS2288 to perform properly was a faulty microswitch. The microswitch was examined and one contact on the high pressure trip side was noted to be slightly pitted. High current or voltage in the DC circuit which controls PS2288 is not suspected to have occurred. Slightly loose internals within the microswitch were also noted. This is considered to be a random beginning of life failure based on previous microswitch performance in PS2288. This switch was first installed and successfully calibrated on 4/11/88, as reported in LER 88-002. (See Section V. Par B., Previous Similar Events).

III. ANALYSIS OF EVENT

A. Safety Effect Analysis

At the time of its declared inoperability, the HPCI system would have provided its designed flow rate of 3000 gpm at operating pressure within 30.08 seconds of initiation, versus the required 30 seconds. This would have had an insignificant impact in limiting HPCI's response to an actual event. In addition, redundant systems were operable the day of the event. With the reactor in Run mode, the worst case effect of the failure or inability of the HPCI system to operate would be the loss of the ability to maintain reactor vessel inventory after small line breaks that do not rapidly depressurize the vessel. ADS, in conjunction with the LPCI or CS systems, provides full redundancy for HPCI. The RCIC system was also available to mitigate the loss of HPCI, but is not considered fully redundant to HPCI.

During much of the troubleshooting, HPCI was available to inject if required. Although the system was not declared operable until June 11 at 1605 hours after its cold start time was verified to be acceptable, the HPCI turbine was in an operable condition and available for automatic initiation at 1928 hours on June 10.

B. Description of Affected Systems

The HPCI turbine-pump output is controlled under normal conditions by the performance of, and interaction between, two HPCI subsystems: the HPCI turbine control and lubrication oil system and the HPCI governor control system. These work separately and interact with each other to provide the proper amount of oil to position the HPCI turbine governor and stop valves so that the HPCI turbine-pump will produce the desired output flow and pressure.

i. The HPCI Control and Lubrication Oil System

The first HPCI subsystem is the HPCI turbine oil system. (See Figure One). Control for this system is provided to ensure an adequate supply of oil will be available to control and lubricate the HPCI turbine. There are two pumps in the HPCI turbine oil system: the Main Oil Pump, which is driven by the turbine shaft, and the Aux Oil Pump, which is DC motor-driven. Each of these pumps can feed the main HPCI oil system header. When not operating the pumps are each separated from the system header by a check valve.

Upon receipt of a HPCI initiation signal, the HPCI Aux Oil Pump starts and provides sufficient oil pressure and flow for HPCI turbine bearing lubrication and operation of the governor and stop valves. The stop valve opens and the governor valve is used to control the turbine speed. As the HPCI turbine increases in speed, the shaft-driven Main Oil Pump develops increased oil pressure and flow. The discharge pressure of the Main Oil Pump is monitored by pressure switch PS2288. By design, when the Main Oil Pump output oil pressure reaches 95 psi, PS2288 trips to shut off the Aux Oil Pump. On HPCI shutdown, when the HPCI turbine is tripped, the system oil pressure decreases as the shaft-driven Main Oil Pump winds down. By design, when the output pressure of the Main Oil Pump (which is the only system oil pump operating at the time) drops to 37.5 psig, PS2288 resets. This restarts the Aux Oil Pump to provide for bearing oil pressure and flow during turbine coastdown.

ii. The HPCI Governor Control System

The second system involved in control of the HPCI output is the turbine governor control system. This system monitors the pump output flow and turbine speed, and adjusts turbine speed to meet a flow setpoint (slightly greater than 3000 gpm for an autostart). This adjustment is made via oil flow to the turbine governor valve. The oil flow is directed via the EGR Electro-Mechanical Hydraulic Actuator (EGR), which is located atop the turbine. The EGR controls oil flow by means of a solenoid-actuated plunger which moves up and down, covering and uncovering oil ports. The solenoid for this plunger is held in place by centering springs, with a given "offset" voltage (.75 to 1 volt by design) required to move the plunger off its "steady-state" position. The larger the offset voltage, the greater the difference between demand and actual flow must be in order to move the plunger.

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The interaction of the oil flow system and the turbine governor system ultimately determine the HPCI turbine speed and therefore the HPCI pump flow. Following the slightly slow start of the HPCI turbine on June 9, 1988, both of these systems were examined, and both were found to be experiencing problems which would effect the HPCI turbine start time.

C. HPCI Troubleshooting Summary

LER 88-002 reported sensing port flow blockage of an oil system pressure switch, PS2288, which controls the Aux Oil Pump. This resulted in HPCI being declared inoperable for 45 hours in April, 1988 when the Aux Oil pump did not start on turbine coastdown. Following this switch's replacement as a corrective action for the HPCI inoperability, it was noted that while the HPCI startup times still remained within the licensing basis, they had increased approximately 5 seconds. A change in startup times was not unexpected due to the characteristics of the newly installed PS2288 compared with the removed switch. The previously installed switch may have had a partially blocked sensing port for some time, which could have effected the switch trip and reset point, thereby effecting oil system performance and ultimately the HPCI system response. Investigation of this most recent HPCI system response was continuing at the time of the June 9, 1988 inoperability.

Troubleshooting of the failure of the HPCI turbine to provide 3000 gpm within 30 seconds was conducted on June 9th and June 10th, 1988. Problems with the turbine oil system were suspected. Operations personnel in the HPCI room at the time of the turbine startup had noted the HPCI Aux Oil Pump cycling on and off at improper times. Also, the turbine governor and stop valves did not appear to be opening as quickly as they had several months earlier. The most likely source of the oil system problem was judged to be HPCI oil system pressure switch PS2288, which had been replaced in April. As noted in the preceding paragraph, this switch was replaced in April, 1988 after failing to reset. (See LER 88-002). Turbine governor control problems were also considered a possibility.

As previously detailed, PS2288 senses the output pressure of the turbine-shaft driven Main Oil Pump, and cycles the Aux Oil Pump accordingly. PS2288 was jumpered out to allow the Aux Oil Pump to operate continuously and the HPCI turbine started with the Aux Oil Pump running during the entire startup sequence to provide maximum oil flow. This resulted in a HPCI startup time of approximately 22 seconds, eight seconds faster than with PS2288 controlling the Aux Oil pump.

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PS2288 was tested and its trip setpoint and reset values, which turn the Aux Oil Pump off and on, were found to be non-repeatable. The drift was such that the pump would cycle more frequently than intended. Further examination of the switch removed in June determined its microswitch was not performing as designed. The microswitch within the switch body was replaced and the switch successfully calibrated and then returned to service. With no other significant adjustments having been made, HPCI was then fast-started and reached required flow and pressure in approximately 30 seconds.

Investigation of the turbine governor control circuitry began in parallel with work on PS2288. It was determined the turbine governor EGR had an offset voltage of approximately 1.6 volts, versus the nominal .75 to 1 volt. The effect of this larger offset was to slow turbine governor response time to a demand signal, which would have increased the turbine startup time approximately 5 to 10 seconds. The EGR unit was recalibrated on June 10, 1988.

Troubleshooting runs demonstrated the effect of the EGR drift. Some minimal initial troubleshooting on the unit which would not have significantly changed the EGR performance characteristics was conducted. The turbine was then fast started with an operable PS2288, and the start time was approximately 30 seconds. This time was reduced to the final value of 19.6 seconds by subsequent calibration of the EGR unit. Examination of the EGR internals on June 27, 1988, found some rust evident on the solenoid. This may have been a factor in the EGR performance, but is judged not an operability concern.

Based on the troubleshooting results, the drift of the EGR offset voltage appears to be the primary cause of the slow HPCI start on June 9. The failure of the microswitch within PS2288 to properly operate the HPCI Aux Oil Pump was likely also a factor, as it would have limited oil availability during the early moments of startup. Troubleshooting test results were inconclusive on this matter. A reduction in startup time with the Aux Oil Pump continuously running for maximum oil availability was noted, indicating improper control of this pump could result in a slower time. However, with a calibrated PS2288 controlling the Aux Oil Pump, and the EGR offset voltage having not yet been calibrated, startup times did not decrease below thirty seconds. As previously described, turbine startup times are dependent upon the interaction between the HPCI oil system and governor control system. An out of calibration PS2288 was noted as the root cause in a slow start of HPCI in 1983.

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D. Summary of System Performance Characteristics

An examination of the HPCI pump flow startup curve revealed the primary difference between the 30.08 second fast start on June 9 and the post-troubleshooting successful 19.6 second fast start on June 11 was a greater length of time prior to the HPCI pump beginning to produce flow. Therefore, the slow startup was due primarily to problems at the beginning of the startup cycle, when both the stop valve and governor valve are opening, and not during the latter half of the cycle, when the stop valve is open and the governor valve is controlling flow. Visual observation of the valves during troubleshooting startups confirmed this. The corrective actions taken for the June 9 HPCI inoperability, the replacement of the microswitch within PS2288 and the recalibration of the EGR, increased startup oil flow and ensured proper and timely oil supply to the system during the early portions of the startup sequence. As previously noted, the 30.08 versus 30 second startup time would not have had a significant impact in limiting HPCI's response to an actual event.

IV. CORRECTIVE ACTIONS

The immediate corrective actions taken for the slightly slow startup of HPCI turbine pump were to commence the required testing of the systems which provide redundancy to HPCI, and to initiate troubleshooting of the HPCI system itself.

Troubleshooting of the HPCI system resulted in replacement of a defective microswitch within the HPCI Aux Oil Pump pressure switch, PS2288, and recalibration of the offset voltage of the HPCI turbine governor EGR unit. The microswitch failure is considered to be a random beginning of life failure, and based on previous microswitch performance in PS2288 no further corrective action is deemed necessary. The internals of the EGR unit were examined on June 27, 1988 for corrosion and some rust was seen on the solenoid. This rust is not an operability concern at present and will be dealt with by long-term corrective action.

Several long term corrective actions are being taken. The HPCI EGR offset voltage will be monitored quarterly, and recalibrated if required. (It was monitored during the next HPCI operability test on July 7, and found to be acceptable with minimal drift). Replacement of the HPCI EGR with one containing an oil-covered solenoid, which would inhibit rust formation, is being planned for the upcoming Fall 1988 Refueling Outage. The EGR for the RCIC Turbine will be replaced as well.

The failure of the HPCI system to meet its requirement of 3000 gpm at reactor pressure in 30 seconds is being reported per 10 CFR 50.73(a)(2)(v).

V. ADDITIONAL INFORMATION

A. Failed Component Identification

PS2288 - HPCI Oil Pump pressure switch
Manufacturer - Square D Company
Model 9012-ACW-22
Internal Microswitch - Part No. 65011-009-50
(Microswitch Failure)

EGR - Woodward Governor Company R 8250-133
(Setpoint Drift)

B. Previous Similar Events

The failure of HPCI to reach its desired discharge flow rate and pressure when starting (for various reasons) has been reported previously via LERs 77-77, 77-95, 77-96, 78-25, 83-018. 83-022, 83-056 and 86-010.

The slow start reported in LER 83-056 was due to an out of calibration PS2288. As previously noted, a clogged port in PS2288 resulted in LER 88-002, when the Aux Oil Pump failed to start on HPCI coastdown. The switch was replaced at that time.

LER 83-022 documents the failure of the HPCI turbine EGR due to moisture intrusion. It was replaced at that time. As previously mentioned, replacement of the EGR with a newer model less susceptible to moisture intrusion and internal corrosion is being investigated.

LERs 83-018 and LER 86-010 were submitted to document out of calibration conditions of the HPCI governor control system EGM control box, which feeds electrical signals to the EGR actuator noted in this report. Following discussions with the vendor, at the recommendation of the DAEC HPCI/RCIC Task Force, the EGM control box was moved from on top of the turbine to a separate panel during the 1987 refueling outage. The EGR cannot be moved from its position on top of the turbine.

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C. <u>Referenced Equipment</u>

The following equipment was referenced within this report:

DAEC ID	Function	EIIS System and Component Code
1S201/GOV	HPCI EGR Governor Actuator	BJ-TC
PS2288	HPCI Aux Oil Pump control	BJ-PS
1S201	HPCI Turbine, Terry Model CS	BJ-TRB
1P216	HPCI Turbine Pump	BJ-P
1P217	HPCI Turbine Pump	BJ-P
1P218	HPCI Aux Oil Pump	BJ-P
HV2200	HPCI Governor Valve	BJ-FCV
HV2201	HPCI Stop Valve	BJ-SHV

NRC Form 366A
(9-83)

LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

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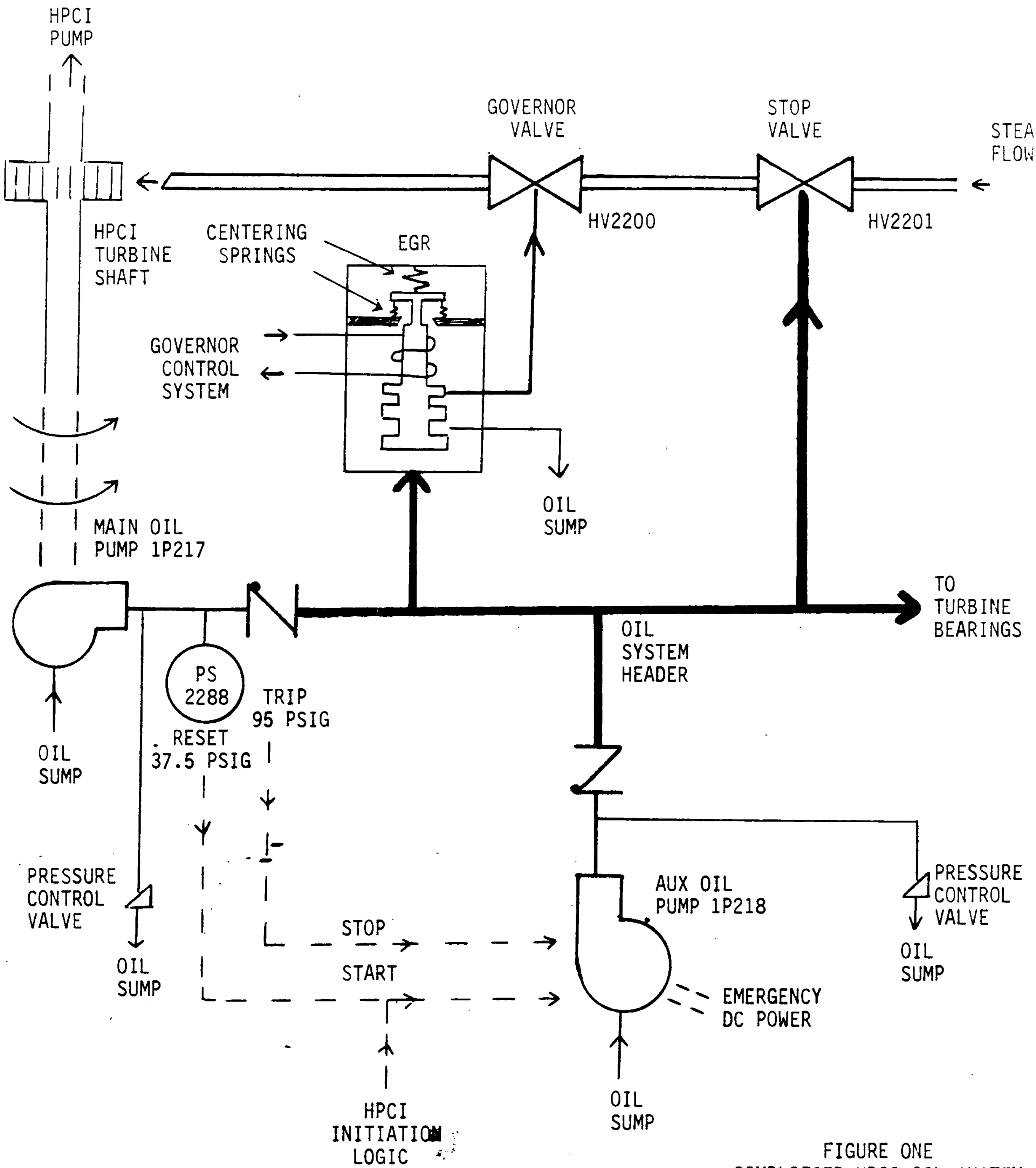

FIGURE ONE
SIMPLIFIED HPCI OIL SYSTEM