



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

October 23, 1992

Docket Nos. 50-275
and 50-323

LICENSEE: Pacific Gas and Electric Company (PG&E)
FACILITY: Diablo Canyon Nuclear Power Plant, Units 1 and 2
SUBJECT: SUMMARY OF SEPTEMBER 23, 1992 PUBLIC MEETING TO DISCUSS
DETENTIONING THE REACTOR VESSEL HEAD BOLTS TO SERVE AS A VENT PATH
DURING MID-LOOP OPERATION AT DIABLO CANYON (TAC NO. M69740)

On September 23, 1992, the NRC staff met with the Pacific Gas and Electric Company (PG&E or the licensee) staff and a Westinghouse Electric Corporation representative in Rockville, Maryland to discuss the subject stated above. Attendees at the meeting are given in Enclosure 1. Slides presented by PG&E at the meeting are given in Enclosure 2. The PG&E presentation summarized their analysis and conclusions of using the reactor vessel (RV) head as a vent path during mid-loop operation.

The licensee plans to shot-peen the steam generator tubes during the latter part of the current Diablo Canyon Unit 1 refueling outage. To do this, it is necessary to drain the reactor coolant system (RCS) down to mid-loop to facilitate the use of temporary nozzle dams in both the hot and cold legs to seal off the steam generator. The mid-loop operation will occur 30 to 40 days into the outage, at which time the decay heat power level will be less than 5 Mwt.

At the meeting, PG&E stated that during mid-loop operation, they plan to operate with the reactor vessel head bolts loosened, thereby allowing the reactor vessel head to serve as a vent path in the event of loss of residual heat removal (RHR). PG&E stated that using the pressurizer as a vent path, through either the safety valves or manways, is unsatisfactory due to the possibility of undesirable phenomena associated with flooding the pressurizer surge line. PG&E also indicated that conducting the mid-loop operation with the reactor vessel head totally removed is also undesirable; it would add 5 or 6 days to the length of the outage.

The licensee addressed several topics regarding the use of the reactor vessel head during mid-loop operation. These topics included: scopes of PG&E's efforts related to shutdown and head vent issues, PG&E's approach, thermal-hydraulic and mechanical analyses conclusions, and flow vent geometry. In addition, PG&E discussed several issues of concern, including reactor vessel head sticking, reactor head cocking, and reactor head drag. The licensee also addressed their steady state responses and final conclusions.

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PG&E's approach consisted of performing a thermal-hydraulic analysis of the head system to function as a vent upon a loss of RHR and of performing a mechanical analysis of the head and the associated components to address the issues of sticking, cocking, excessive drag, and cyclic impacting. The licensee also discussed the effects of the head vent to avoid pressurizer surge line flooding, and whether the head vent would fulfill Generic Letter 88-17 requirements for venting when using steam generator nozzle dams.

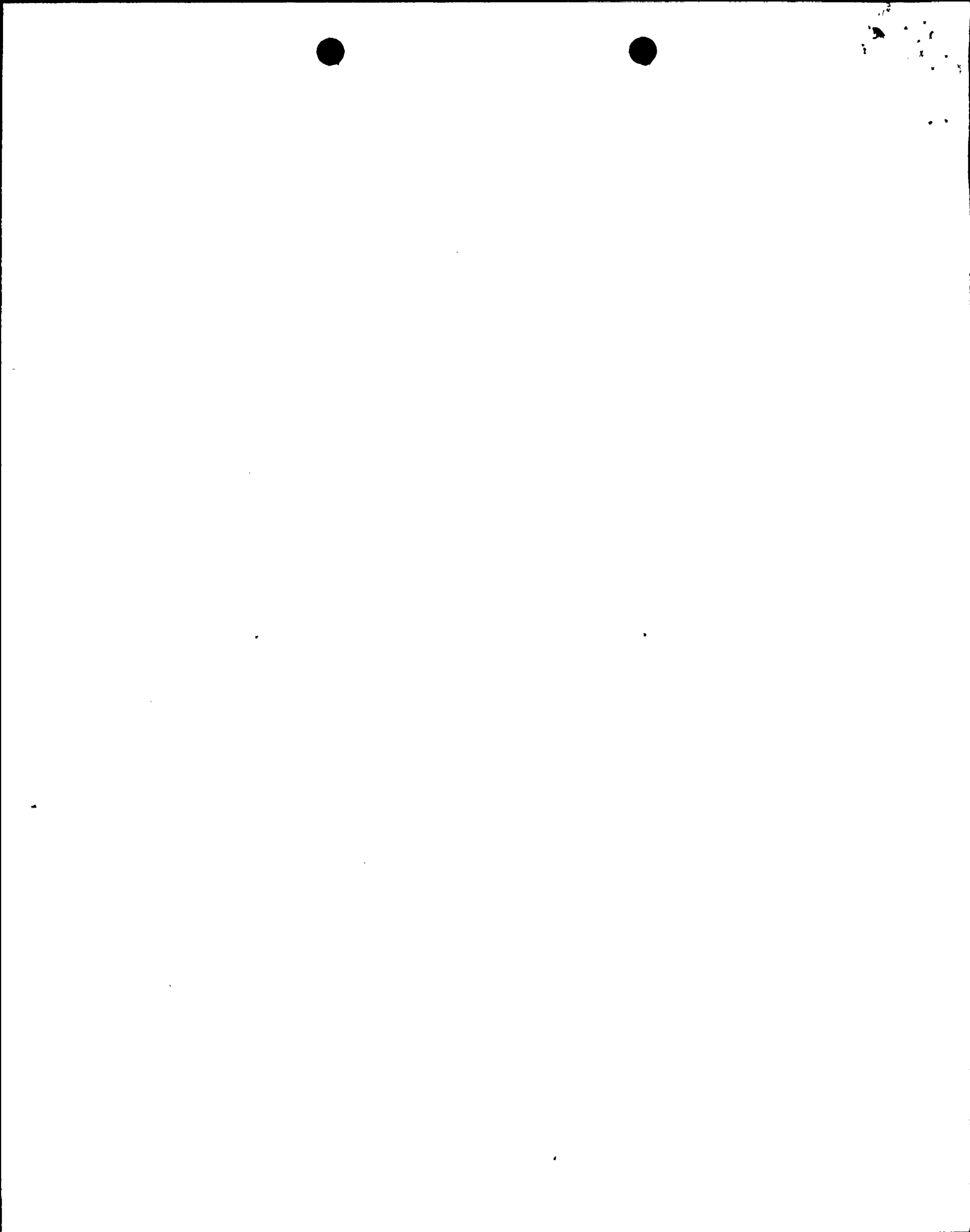
PG&E stated that their analysis demonstrated that the reactor pressure vessel (RPV) head could be used as a vent path without encountering mechanical damage to either the head or the RPV flange structure from cyclic impacting. In addition, PG&E stated that the possibility for inadequate RPV head lift due to sticking, cocking, or excessive drag as addressed in NUREG 1449 was shown to be highly unlikely if proper measures to limit lift are taken.

The licensee stated that the use of the reactor vessel head as a vent path during mid-loop operation late in the outage is acceptable because:

1. The mid-loop operation will be undertaken when decay heat is at a relatively low level.
2. The "fill and spill" method will be used to cool the core in the event of a loss of RHR. Water will be supplied from the refueling water storage tank (RWST), and will lift the reactor vessel head and spill over the vessel flange at 500-1200 gpm, which is sufficient to keep the core from boiling.
3. Flow from the RWST will be throttled using a flow control valve to prevent the reactor vessel head from lifting off the vessel flange by more than 0.7 inches (equivalent to about 12 psi pressure in the vessel). Keeping the head lift below this value will prevent it from lifting off the upper internals of the core. This is desirable because as long as the head rests on the upper internals, the internals' alignment pins will prevent it from cocking.

The staff noted that the acceptability of using the reactor vessel head as a vent path during mid-loop operation depends on a number of plant-specific factors, and that all relevant factors should be thoroughly evaluated in determining acceptability.

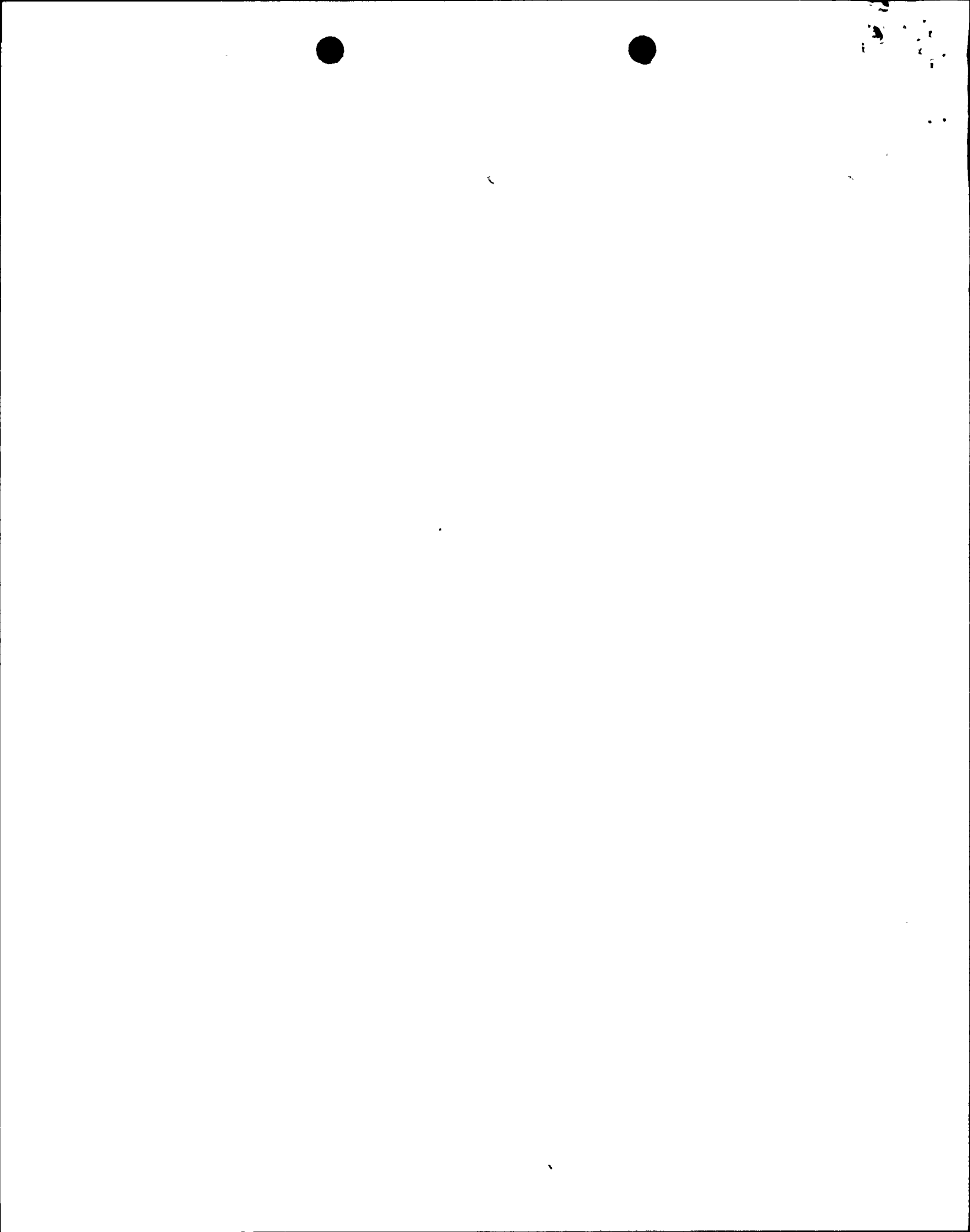
At the conclusion of the meeting, the NRC staff indicated that the PG&E presentation was very informative. In addition, the PG&E analysis was quite thorough and addressed a number of issues that had not previously been considered.



POST-MEETING STAFF ACTIONS:

In the September 23 meeting, the licensee presented analyses and plans for venting the RCS during mid-loop operation late in the present outage. The NRC staff has determined that it has no objection to use of the RV head as a potential vent path when conducted as described by PG&E for the potential conditions that reasonably could exist at Diablo Canyon. Specifically, this usage involves the following considerations:

- (1) This evolution will be conducted late in the outage when decay heat is relatively small.
- (2) Controlled flow from the refueling water storage tank (RWST) will be available even in the event of a loss of all AC electric power. The flow rate is to be controlled at less than a value that could induce head cocking, but great enough to maintain subcooled conditions in the RCS unless safety considerations necessitate the allowance of boiling in the RCS.
- (5) Incore thermocouples or their equivalent will be available to monitor upper RV temperature, should conditions occur where head lift may be used for venting the RCS. An initial period of less than approximately 1 day will exist before the thermocouple connections are made following head placement, but no operations will be permitted during this time that involve reduction in RCS level or that could reasonably jeopardize residual heat removal system operation.
- (6) No significant cold leg openings will be permitted as long as the head lift capability is depended upon for venting.
- (7) Suitable procedures and controls, including training in use of those procedures and controls, will be provided prior to entering a condition where head lift is used as a potential vent.



October 23, 1992

If an event should occur in which the RV head actually operates as a vent, then a complete evaluation, including staff approval, will be required prior to a return to power operation. Also, this finding is limited to the Diablo Canyon Power Plant because of the plant-specific nature of the analyses and operating conditions.

Original signed by
Harry Rood, Senior Project Manager
Project Directorate V
Division of Reactor Projects III/IV/V
Office of Nuclear Reactor Regulation

Enclosures:

- 1. List of Attendees
- 2. PG&E Viewgraphs

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Harry Rood, Senior Project Manager
Project Directorate V
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See next page



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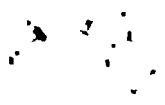
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List of Attendees

Meeting Between NRC & PG&E

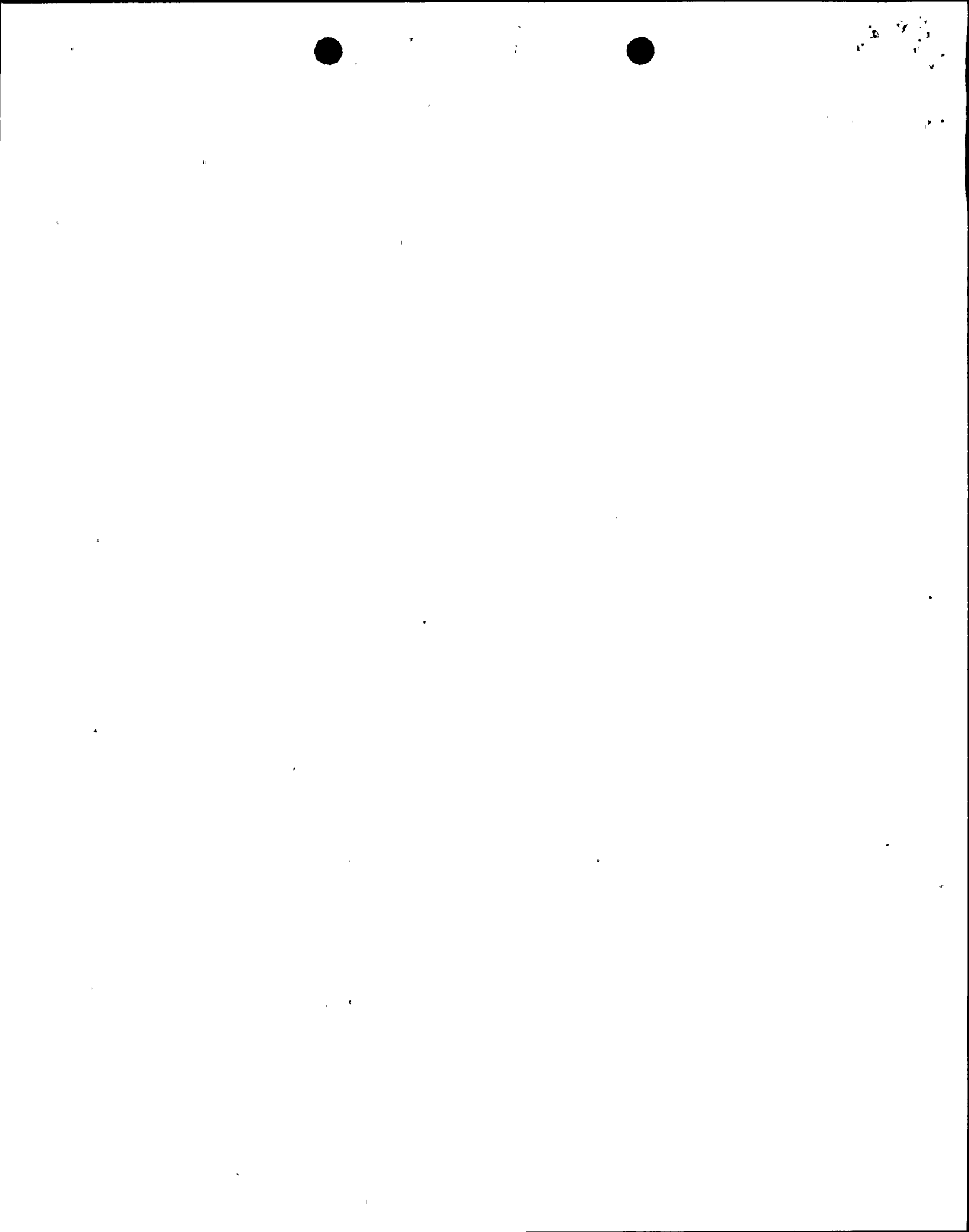
SEPTEMBER 23, 1992

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NRC/NRR/EMEB
NRC/NRR/SRXB
NRC/NRR/EMEB
NRC/NRR/EMEB
NRC/NRR/PD5
PG&E



NRC PRESENTATION

**SHUTDOWN ISSUE:
REACTOR HEAD VENT PATH**

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Thomas G. De Uriarte
John M. Gisclon**

**NUCLEAR TECHNICAL SERVICES
PACIFIC GAS AND ELECTRIC COMPANY**

Toby Burnett

**NUCLEAR AND ADVANCED TECHNOLOGY DIVISION
WESTINGHOUSE ELECTRIC CORPORATION**

September 23, 1992

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SCOPE OF PG&E EFFORTS ON SHUTDOWN ISSUES

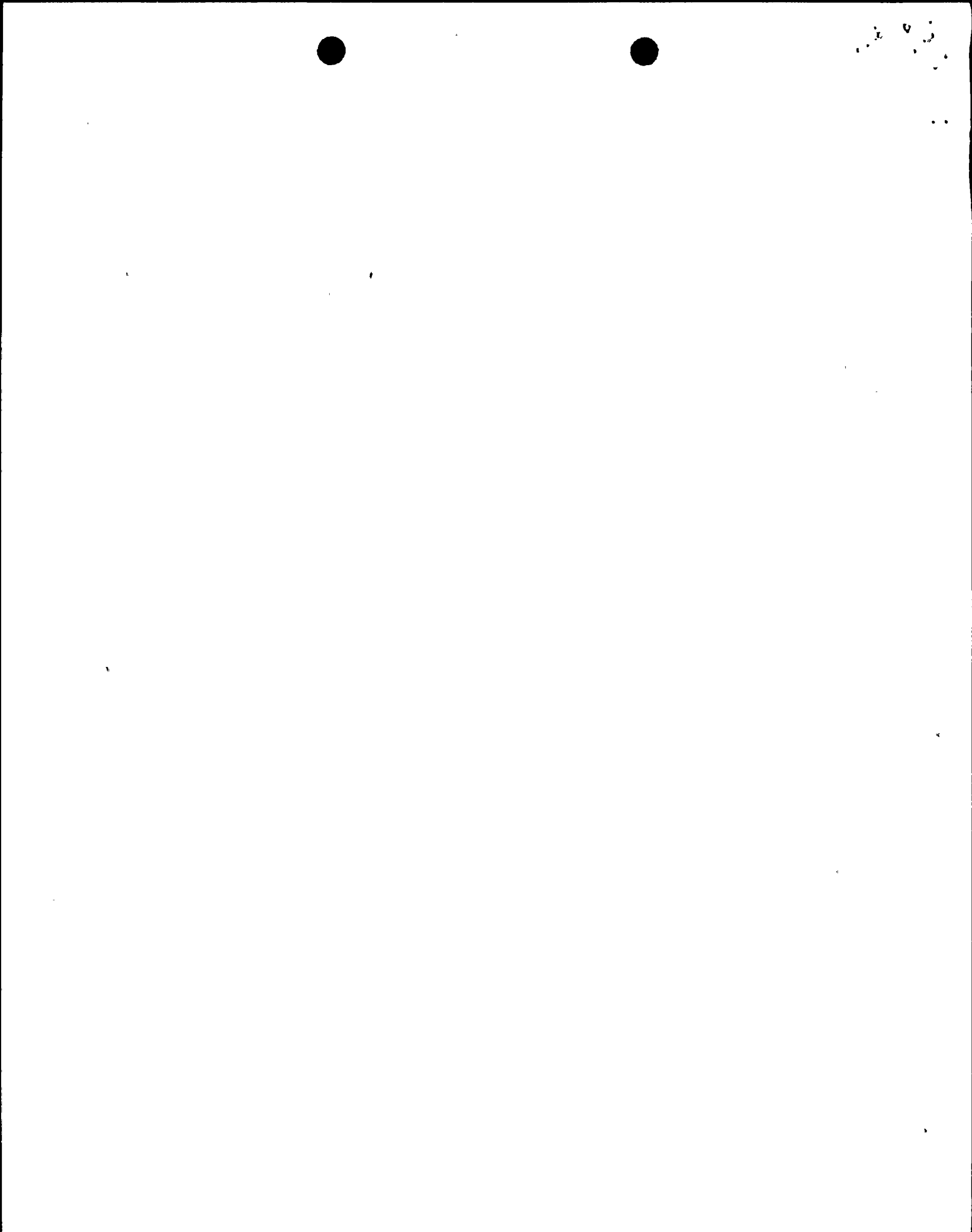
- **PARTICIPATED IN NUMARC SHUTDOWN ISSUES WORKING GROUP**
- **INDUSTRY LEADER IMPLEMENTING NUMARC 91-06 RECOMMENDATIONS**
- **LEAD PLANT AND COSPONSOR FOR EPRI ORAM PROGRAM**
- **DEVELOPED FORMAL PROCEDURES FOR MITIGATING LOSS OF SAFETY FUNCTIONS AT DIABLO CANYON**
- **CONTRACTED WESTINGHOUSE TO PERFORM HEAD VENT ANALYSIS**



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HEAD VENT ISSUE

- CAN IT PROVIDE A FLOWPATH FOR ALTERNATE DECAY HEAT REMOVAL?
- WILL IT LIMIT PRESSURE IN RCS WITHOUT FAILING NOZZLE DAMS AND SEAL TABLE LOW PRESSURE SEALS?
- ARE NRC OBJECTIONS IN NUREG-1449 VALID?
 - INADEQUATE LIFT/STICKING
 - NON-UNIFORM LIFT (COCKING)
 - IMPACT LOAD DAMAGE TO HEAD
- HOW DOES PRESSURIZER SURGE LINE FLOODING AFFECT IT?
- DOES IT COMPLEMENT G. L. 88-17 REQUIREMENTS FOR VENT WHEN USING HOT LEG DAMS?



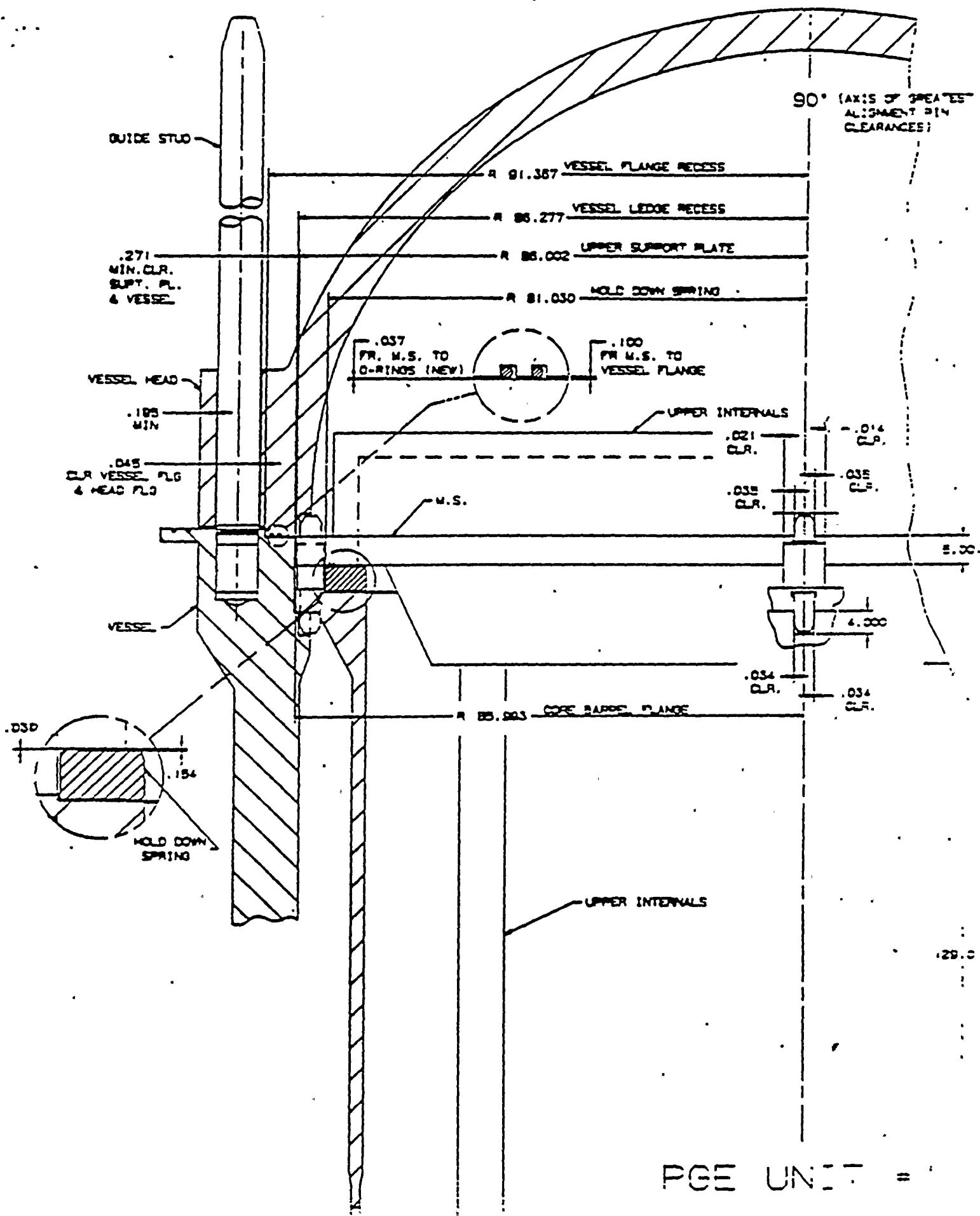
APPROACH

- **PERFORM A THERMAL HYDRAULIC ANALYSIS
OF THE HEAD SYSTEM TO FUNCTION AS A VENT
UPON A LOSS OF RHR**

- **PERFORM A MECHANICAL ANALYSIS OF THE
HEAD AND ASSOCIATED COMPONENTS TO
ADDRESS THE ISSUES OF STICKING, COCKING,
EXCESSIVE DRAG AND CYCLIC IMPACTING**



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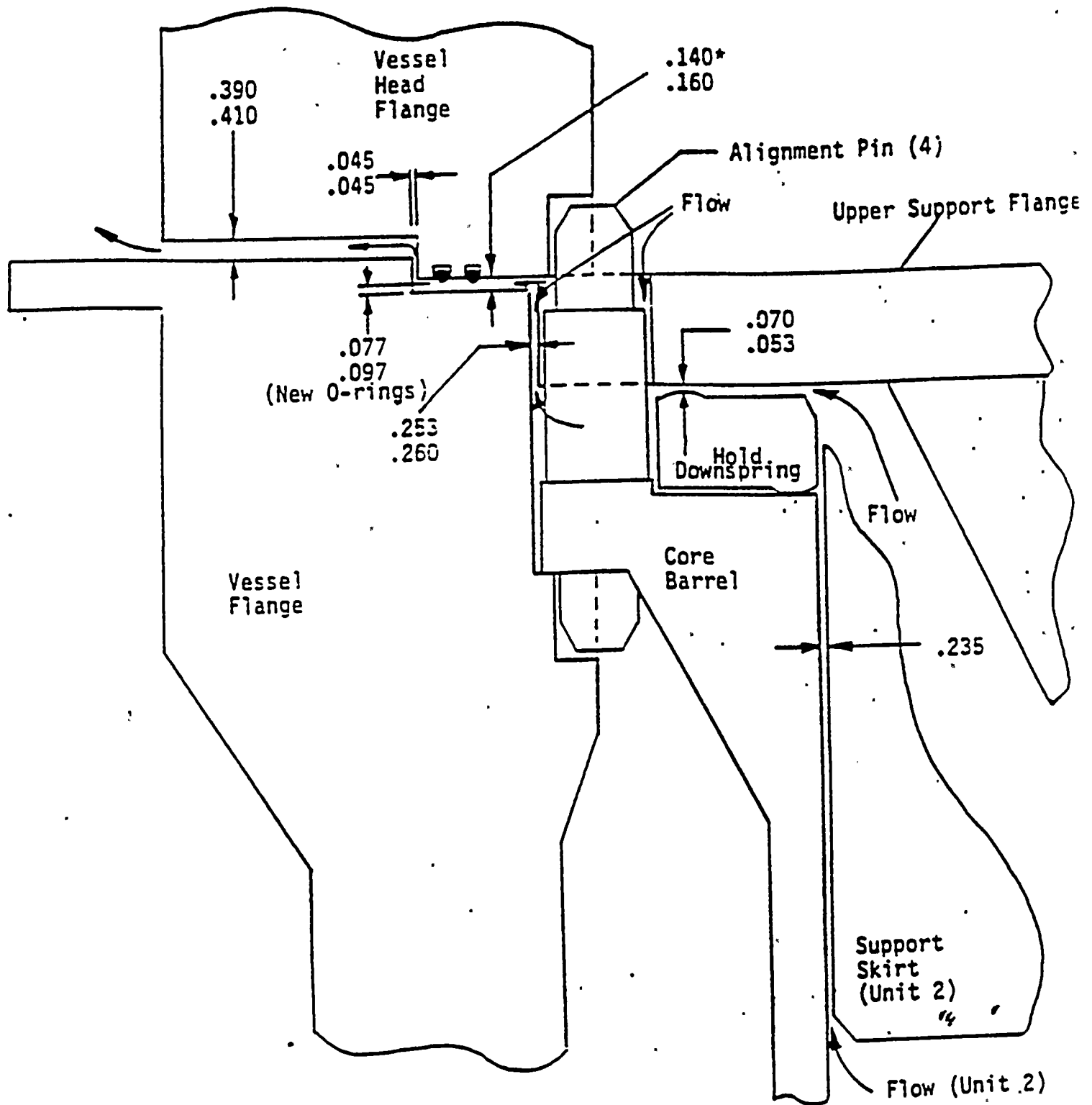


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* Upper Value - Unit 1
 Lower Value - Unit 2



VESSEL FLANGE AND ALIGNMENT PIN
 VENT GEOMETRY



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THERMAL-HYDRAULIC ANALYSIS CONCLUSIONS

- WITH THE REACTOR HEAD IN PLACE AND NUTS LOOSENED, VENT PATHS AT THE VESSEL FLANGE ARE ADEQUATE -- BY A WIDE MARGIN -- TO PERMIT GRAVITY FLOW FROM THE RWST AND TO PROTECT LOW PRESSURE SEALS IN THE EVENT OF LOSS OF RHR AFTER REFUELING.
 - IF COLD WATER IS BEING INJECTED WITH HOT WATER AT 200°F BEING SPILLED AT THE FLANGE, RCS PRESSURE AT THE FLANGE WOULD BE WITHIN THE RANGE OF 0.1 TO 3 PSIG, AND THE HEAD WOULD LIFT AN ADDITIONAL 0 TO 0.028 INCHES (DEPENDING ON THE UNIT, DECAY HEAT, AND UNCERTAINTIES IN FRICTION, SPRING FORCE, AND LOSS COEFFICIENTS).
 - IF NO COLD WATER IS BEING ADDED AND WATER LEVEL (OR FROTH HEIGHT) IS BELOW THE FLANGE, RCS PRESSURE AT THE FLANGE WOULD BE WITHIN THE RANGE OF 2 TO 7 PSIG, AND THE HEAD WOULD LIFT AN ADDITIONAL 0.004 TO 0.082 INCHES



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**THERMAL-HYDRAULIC ANALYSIS
CONCLUSION (Cont'd)**

- BY INJECTING COLD WATER AND SPILLING HOT WATER FROM THE FLANGE, 40 MW CAN BE REMOVED WITHOUT EXCEEDING 10 PSIG AT THE FLANGE. IF NO COLD WATER IS INJECTED AND WATER LEVEL (FROTH HEIGHT) IS BELOW THE FLANGE AND ABOVE THE TOP OF THE CORE, 7 MW OF DECAY HEAT WOULD CAUSE LESS THAN 10 PSIG AT THE VESSEL FLANGE. BOTH VALUES ARE WELL ABOVE 5 MW (THE MAXIMUM DECAY HEAT AFTER REFUELING).

- MAXIMUM TRANSIENT PRESSURE, WITH BOILING CAUSING FROTH HEIGHT ABOVE THE FLANGE, CANNOT EXCEED 12 PSIG FOR 5 MW DECAY HEAT.

- EXCESSIVE LIQUID INJECTION WILL BE CONTROLLED TO PREVENT RCS PRESSURES IN EXCESS OF 12 PSIG WITH THE VESSEL FLANGE VENT AVAILABLE.



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**THERMAL-HYDRAULIC ANALYSIS
CONCLUSION (Cont'd)....**

- **BECAUSE THE FLANGE VENT AREA IS SMALL UNTIL PRESSURE INCREASES, VENTING AT THE FLANGE IS NOT A FEASIBLE MEANS OF KEEPING RCS PRESSURE BELOW 2 PSIG FOLLOWING LOSS OF RHR WITH COOLANT BOILING. THEREFORE, IF COLD LEG OPENINGS EXIST, ANOTHER HOT LEG VENT PATH IS REQUIRED; I.E., A STEAM GENERATOR MANWAY OR DISASSEMBLED HOT LEG CHECK VALVES.**

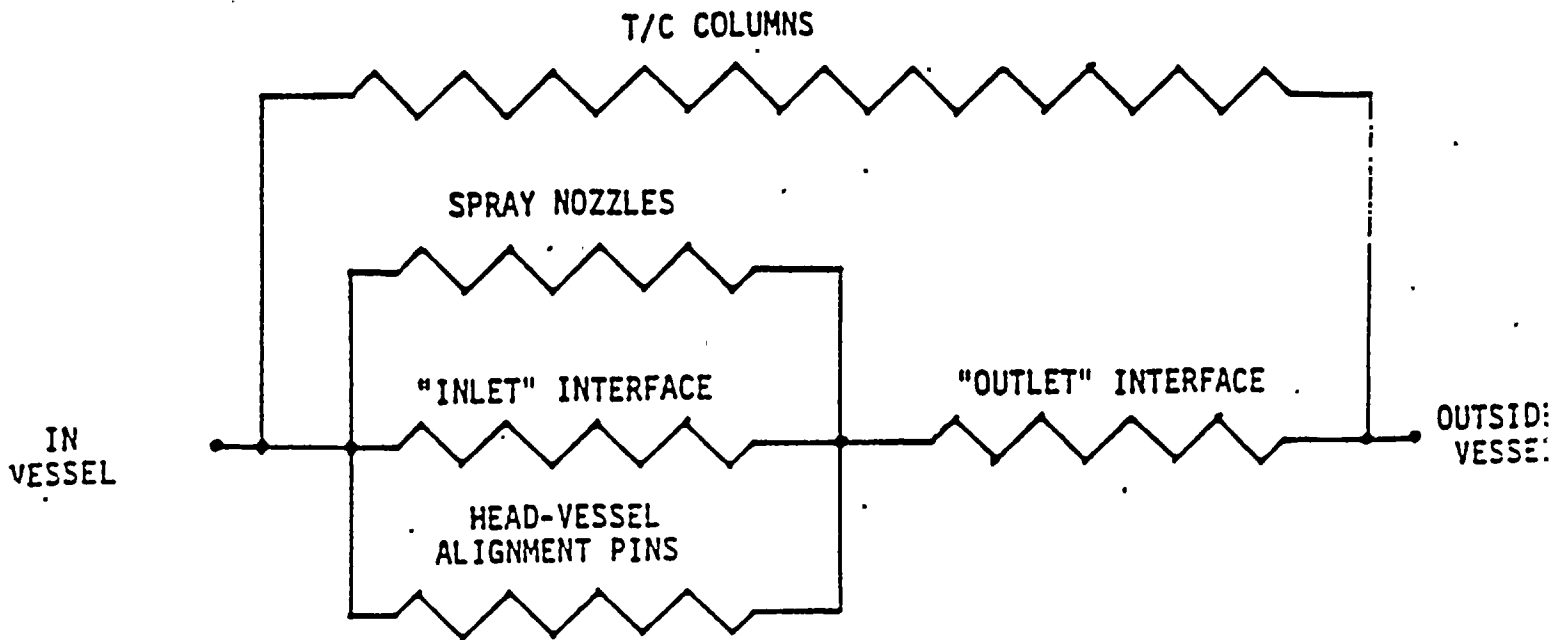


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MECHANICAL ANALYSIS



- FLOW VENT GEOMETRY
- VESSEL HEAD STICKING, COCKING AND DRAG



HEAD VENT FLOW NETWORK



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FLOW VENT GEOMETRY

- **THE VESSEL FLANGE/HEAD VENT GEOMETRY IS BASICALLY DIVIDED INTO TWO PARTS:**
 - **A MAJOR FLOW PATH THROUGH THE VESSEL FLANGE REGION, AND IN PARALLEL**
 - **A RELATIVELY SMALL FLOW PATH THROUGH THE FIVE THERMOCOUPLE COLUMNS (THE HEAD VENT LINE IS NORMALLY CLOSED AFTER DETENSIONING).**

PART OF THE VESSEL FLANGE FLOW PATH IS ALSO DIVIDED INTO THREE PARALLEL BRANCHES, THROUGH THE GAP AROUND THE INTERNALS HOLD DOWN SPRING, AROUND THE FOUR HEAD AND VESSEL ALIGNMENT PINS, AND THROUGH THE SIXTEEN UPPER PLENUM COOLING SPRAY NOZZLES.

THESE THREE PATHS IN TURN EXIT THROUGH A COMMON PATH PAST THE O-RINGS AT THE FLANGE MATING SURFACE, AND OUT PAST THE 1.5 INCH VERTICAL FLANGE COUNTERBORE RECESS.



FLOW VENT GEOMETRY (Cont'd)...

THE TOTAL THERMOCOUPLE MINIMUM AREA IS ONLY 2.0 IN.² AT THE TOP CONDUIT SEAL. THE TOTAL SPRAY NOZZLE AREA IS ALSO A MINOR FLOW PATH AT 3.3 IN.².

IN COMPARISON, THE FOUR ALIGNMENT PINS PROVIDE 18.5 IN.² FOR UNIT 1.

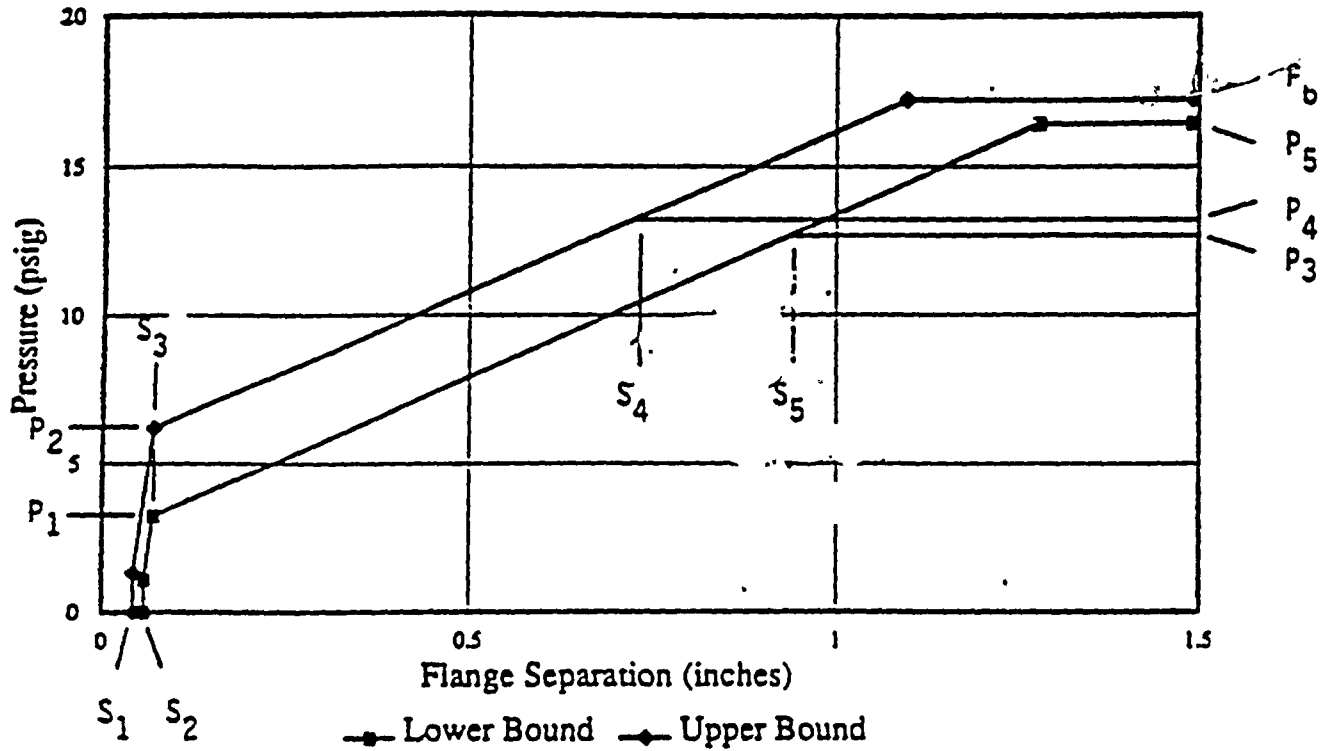
FROM THESE VARIOUS FLOW PATHS, A HYDRAULIC NETWORK ANALYSIS WAS PERFORMED TO GENERATE THE OVERALL FLOW CONDUCTANCE AS A FUNCTION OF FLANGE SEPARATION.



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Pressure vs. Flange Separation

For Unit 1 BCC 6

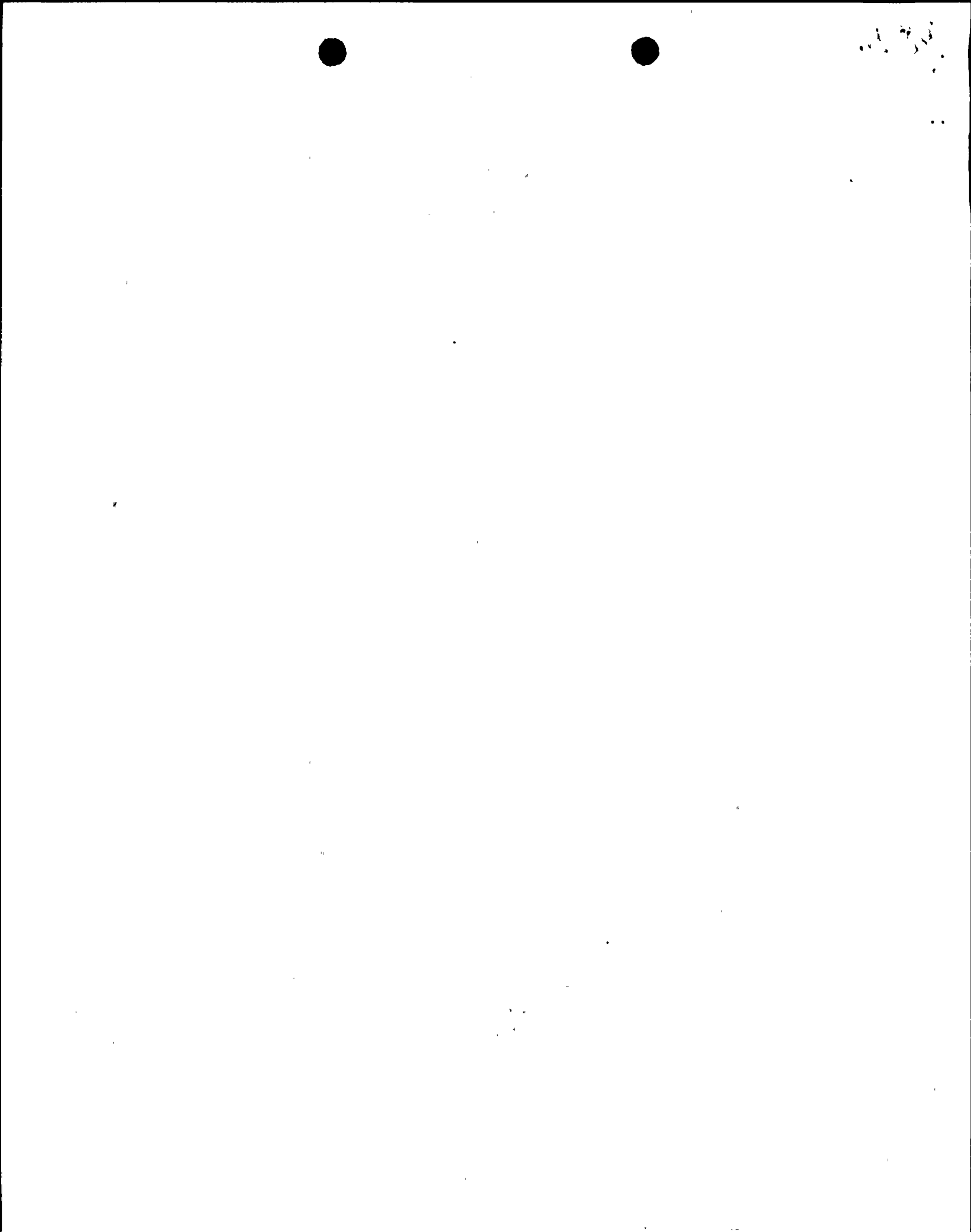




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VESSEL HEAD STICKING

- **ONLY VERTICAL CONTACTS ARE THE ALIGNMENT PINS**
- **NO MECHANISMS EXISTS FOR THE COEFFICIENT OF FRICTION TO BE GREATER THAN ONE OR FOR GENERATION OF A HIGH LATERAL FRICTIONAL FORCE**
- **THERE HAS BEEN NO PREVIOUS WESTINGHOUSE EXPERIENCE OF STICKING/BINDING AFTER STUD DETENSIONING**



REACTOR HEAD COCKING

- CAN NOT OCCUR AS LONG AS HEAD REMAINS ON THE UPPER SUPPORT FLANGE AND UPPER INTERNALS REMAIN ENGAGED ON THE ALIGNMENT PINS
- ENGAGEMENT OF UPPER SUPPORT FLANGE ON THE VESSEL/INTERNALS ALIGNMENT PINS IS MAINTAINED FOR 3.75 INCHES OF HEAD AND INTERNALS LIFT
- VENTING REQUIREMENT IS MUCH LESS
- SEPARATION OF THE HEAD FROM UPPER INTERNALS CAN OCCUR BETWEEN 0.7 INCH TO 1.0 INCH OF LIFT
- NEED TO LIMIT LIFT TO BELOW 0.7 INCH TO PREVENT SEPARATION AND FULFILL VENTING FUNCTION
- COCKING CAN NOT OCCUR IN THE EXPECTED RANGE OF MOTION POST-REFUELING AS THE VENT LEFT IS MUCH LESS THAN 0.7 INCH.



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REACTOR HEAD DRAG

- DRAG CAN OCCUR FROM TWO MAIN SOURCES:
 - FUEL ALIGNMENT PINS
 - UPPER INTERNALS/VESSEL HEAD ALIGNMENT PINS
- NO DRAG OR CONTACT CAN OCCUR AT:
 - GUIDE STUDS
 - UPPER SUPPORT FLANGE
 - UPPER CORE PLATE FLANGE
- DRAG FORCES:
 - SPRINGS = 20,000 LBF
 - FUEL ALIGNMENT PINS = 8,000 LBF
 - UPPER INTERNALS ALIGNMENT PINS = 2,000 LBF
- WEIGHT OF HEAD = 431,000 LBF
- DRAG FORCES HAVE ONLY A SMALL EFFECT ON HEAD LIFT

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STEADY STATE RESPONSE

- **POST-REFUELING:**

- **LIQUID INJECTION**

- **AT 5 MW, 272 GPM OF 70° F WATER WILL LIMIT EXIT TEMPERATURE AT THE FLANGE OF 200°F.**
- **RESULTANT SEPARATION WOULD BE 0.07 INCHES (UPWARD TRAVEL OF 0.014 INCHES);**
- **RESULTANT PRESSURE WOULD BE 3 PSIG.**

- **NO INJECTION - STEAMING**

- **RESULTANT SEPARATION OF 0.14 INCHES.**
- **RCS PRESSURE WOULD BE 2-7 PSIG.**
- **7 LBS/SEC. (EQUIVALENT OF 7 MW) OF STEAM CAN BE RELIEVED AT 10 PSIG.**

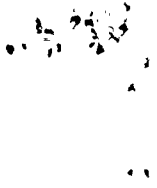


STEADY STATE RESPONSE (Cont'd)...

- **POST-REFUELING**

- **STABILITY**

- **ABOUT 1 PSI DELTA P REQUIRED TO CAUSE MOTION IN NEW DIRECTION**
- **IF RCS PRESSURE INCREASES, THE HEAD WILL RISE TO A NEW EQUILIBRIUM POINT AND STOP WITHOUT OSCILLATION.**
- **VESSEL HEAD LIFT LESS THAN 0.12 INCH FROM CORE DECAY HEAT.**
- **PRESSURE INCREASES CAUSED BY CORE DECAY HEAT ARE MUCH SMALLER THAN THE NATURAL PERIOD OF THE HEAD-SPRING SYSTEM.**
- **ANY PERTURBATIONS WILL BE RAPIDLY DAMPED OUT.**



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CONCLUSIONS

- **THE POSSIBILITY FOR THE VESSEL HEAD TO STICK BY ALL PRACTICAL CONSIDERATIONS DOESN'T EXIST. THERE HAS BEEN NO PREVIOUS WESTINGHOUSE EXPERIENCE OF HEAD STICKING.**
- **ANY CONCEIVABLE DRAG FORCE THAT CAN BE PRODUCED TO HINDER HEAD LIFT IS SMALL IN COMPARISON TO THE HEAD/LIFTING RIG WEIGHT, AND DOES NOT POSE ANY CONCERN FOR HEAD VENTING CAPABILITY:**
- **COCKING OF THE VESSEL HEAD CANNOT OCCUR AS LONG AS THE FLANGE SEPARATION IS LIMITED TO BELOW 0.70 INCHES. TO ASSURE THAT SEPARATION ABOVE 0.70 INCHES CANNOT OCCUR, PG&E CONTROLS THE FLUID PATH FROM THE RWST.**

