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

February 3, 1993

MEMORANDUM FOR: Theodore R. Quay, Director
Project Directorate V
Division of Reactor Projects III/IV/V

FROM: James W. Clifford, Senior Project Manager
Project Directorate V
Division of Reactor Projects III/IV/V

SUBJECT: MEETING SUMMARY FROM BWROG MEETING ON WATER LEVEL INSTRUMENTATION ERRORS

We held a meeting with the BWR Owners' Group (BWROG) on October 29, 1992, to discuss current Owners' Group activities to assess and address potential reactor pressure vessel level instrumentation inaccuracies. The list of attendees is provided in Enclosure 1. The slides used by the BWR Owners' Group in its presentation are provided in Enclosure 2, and provide the details for the summary of issues provided below.

The BWROG discussed the history of their activities regarding BWR level instrumentation concerns. The Chairman of the BWROG Regulatory Response Group (RRG) stated that the BWROG was considering establishing a standing committee specifically to address BWR level instrumentation concerns.

The BWROG next discussed their conclusion that two different phenomena had been observed. One phenomenon was the "notching" observed at Pilgrim during normal plant shutdown and cooldown. Ultrasonic measurements taken at Pilgrim revealed a slow migration of gas through the level instrument piping, resulting in a transient level indication error when the gas translated through a vertical run of pipe. Level was observed to return to normal when gas was detected in horizontal runs of pipe. The BWROG determined that leakage from instrument rack connections causes gas-laden water to migrate down the reference legs, with subsequent controlled depressurization causing the gases to evolve. The BWROG concluded that "notching" is not a significant safety concern.

The BWROG then discussed concerns related to rapid depressurization and its effect on RPV level instrumentation, including followup to open issues from the July 29, 1992, meeting between the NRC staff and BWROG. The BWROG based

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its conclusion that there is no immediate safety concern on (1) conservative analyses performed by the BWROG that demonstrated that no signficant level errors will occur above 450 psig, and (2) operator sensitization that will assure identification of indeterminate water level when implementing the BWROG emergency procedure guidelines.

The BWROG provided details of additional guidance presented in an October 16, 1992, letter to BWR plant operations superintendents for additional sensitization of operators. The guidance provided the basis for determining if RPV level instrumentation was reliable, and methods for determining an approximate level in the case that rapid depressurization may cause gas evolution in the reference legs.

The BWROG then outlined its proposed long-term action plan, including a test program and more detailed analytic work. The BWROG explained that while the initial portions of the program are behind the schedule proposed at the July 29, 1992 meeting, the overall schedule to identify safety issues and proposed modifications remained unchanged. The BWROG made it clear that any data collection, plant specific calculations, and implementation of any operator guidance or training were plant specific issues, and would have to be addressed on a plant-specific basis. The BWROG also stated that they had not yet determined acceptance criteria for their test and analysis programs. The BWROG then discussed potential modifications that were possible if the test and analysis programs identified any need for modifications.

The NRC staff provided the opportunity for public comments. One member of the public provided his personal views on the issue, and how it has been handled to date. These comments are being considered in the staff review.

The NRC staff questioned the BWROG on their basis for no significant safety concern, on operator guidance, and implementation of the operator guidance at all BWRs. The BWROG stated that no changes to procedures were recommended, but the information that was sent to BWR plant superintendents on October 16, 1992, would enhance operator guidance with respect to potential RPV level indication errors. As discussed previously, the BWROG stated that operator guidance implementation would have to be addressed on a plant specific basis. One utility representative stated that the guidance was being incorporated into plant training programs, and would be provided to operators during the normal training cycle. Another utility representative stated that the guidance had been put into the night orders for reading by all shift personnel. The NRC staff stressed the need to assure that operators were

sufficiently "sensitized" to be able to apply the information developed by the BWROG. The BWROG again stated that the level of understanding by operators would have to be addressed by each BWR utility.

The meeting was closed to the public for a presentation of proprietary information frum Barsebeck in Sweden.

James W. Clifford, Senior Project Manager
Project Directorate V
Division of Reactor Projects III/IV/V

Enclosures:
As stated

cc w/enclosures:
T. Martin RI
S. Ebneter RII
B. Davis RIII
J. Milhoan RIV
J. Martin RV
D. Ward ACRS
S. Newberry
T. Collins
E. Jordan AEOD
H. Denton OIP
C. [illegible]si NRR
B. [illegible]mes NRR
J. Richardson NRR
F. Congel NRR

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Original signed by

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K. Perkins, RV	C. Carpenter	

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R. Hall

Mr. George J. Beck, Chairman
Regulatory Response Group
Boiling Water Reactor Owners' Group
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Mr. Ernest Hadley
414 Main Street
P.O. Box 3121
Wareham, MA 02571

ENCLOSURE 1

October 29, 1992

NRC/BWROG MEETING

Water Level Instrumentation Errors

List of Attendees

NAME	TITLE	ORGANIZATION
Jim Clifford	Senior PM	NRC/NRR/PDV
Robert Jones	Chief	NRC/NRR/SRXB
Gary Holahan	Deputy Director	NRC/NRR/DSSA
Amy Cubbage	Reactor Systems Engr.	NRC/NRR/DSSA
Scott Newberry	Chief	NRC/NRR/HICB
Fred Moody	Consulting Engineering	GE Nuclear Energy
David Weber	Engineer	PECO
Steven Hudson	Elec. Systems Engineering Div. Mgr.	Boston Edison
Pat Marriott	Mgr. Safety & Licensing	GENE/BWROG
J. H. Munchausen	Mgr. I & C Maintence	EPRI/PSE
Bob McKillip	Associate	EPRI
Ben Hayes	Director	OI
Edward Fiegler	Mech. Engineering Project Mgr.	ABB/CE
Ron Frahm	Section Chief	RSB/NRR
Ronald Eaton	Sr. Project Mgr.	NRR/PD1-3
Brenda Whitare	Reactor Engineer	NRR/SRXB
William Ruland	Section Chief Electrical Section	Region 1/DRS
Lawrence Vick	Reactur Engineer	NRR/DRCH/OLB
Wayne Hodges	Director, Reactor Safety	NRC/Region 1
Chuck Johnson	Consultant to Boston Edison	SLEVY Inc
Serge Deshmukh	I & C Engineer	GPU Nuclear
Jose Ibarra	Sr. I & C	AEOD/NRC
Richard Znerchez	Associate Editor	Nuclear
Alan Bilanin	Senior Associate	CDI/EPRI
Gerald Seay	Engineer	PECO/BWROG
George Beck	Chairman	BWROG/(PECo)
Richard Zuercher	Associate Editor	Nucleonics week
I. Ahmed	Sr. Electrical Engineer	NRR/NRC
W. Swenson	Section Chief	NRR/HHFB
Jim Wade	Sr. Engineer	Southern Nuclear
Bruce Veazie	Sr. Results Eng.	Penna Pwr & Light
Peter Miner	Sr. Scientist	Northeast Utilities
Girija Shukla	Sr. Lic. Engineer	Detroit Edison
Paul Blanch	I & C Eng. SOPV	SELF
David Desaulniers	Engineering Psychologist	NRR/HHFB
Lamont Youngbord	Principal Engineer	GENE
Lambros Lois	Sr. Nuclear Engineer	NRR/DSSA/SRXB
George Thomas	Nuclear Engineer	NRR/DSSA/SRXB
Harold Fossett	Inspector	NRC/OIG
Andrew Kugler	Reactor Engineer	NRC/OGCB

NAME	TITLE	ORGANIZATION
Vince SanAngelo	Licensing Engineer	Bechtel Power
Tom Collins	Technical Assistant	OCM/FR
Richard Zuercher	Associate Editor	Nucleonics week
Taggart Rogers	Exec. Consultant	OEI (BWROG)
A. Q. Howard	Researcher	Tokyo Electric Pwr.
Jocelyn Mitchell	Sr. Regional Coordinator	NRC/OEDO
Bob Dennig	Section Chief, BWR Events	NRC/NRR/DORS
Bill Berg	Senior Staff Engineer	PSE & G/BWROG/EPC

Regulatory Response Group
&
Steering Committee
Technical Meeting
With NRC
On
BWR Water Level Instrumentation

October 29, 1992

Rockville, Maryland

INTRODUCTION

- Attendees
- Agenda
- History
- Program overview
- Purpose of requesting this meeting

AGENDA

Introduction Purpose of this Meeting	G. J. Beck RRG Chairman
Issues	
o "Notching"	S. D. Hudson (BECO)
o Rapid Depressurization	G. R. Sealy (PECO) Steering Committee Chairman
o Operator Guidance	W. F. Berg (PSE&G) EPC Vice-Chairman S. T. Rogers (OEI)

AGENDA CONT'D

BWROG Action Plan	G. R. Sealy (PECO) Steering Committee Chairman
Analytical Model and Tests	
o Test Program Status	A. Bilanin (EPRI/CDI)
o Analytical Model Status	D. S. Weber (PECO) Model & Test Committee Chairman
Acceptance Criteria	W. F. Berg (PSE&G) EPC Vice-Chairman
Potential Modifications	J. A. Wade (SNC) Modifications & Procedures Committee Chairman

AGENDA CONT'D

Other Topics

o	Barsebeck/Swedish Data (Proprietary)	F. J. Moody (GENE)
Schedule/Conclusions		G. J. Beck (PECO) RRG Chairman

HISTORY

NRC Requests RRG Activation - July 22

RRG Presentation to NRC - July 29

RRG Action Items to NRC - August 5

RRG Plan and Schedule to NRC - August 12

NRC GL 92-04 Issued - August 19

RRG Generic Report to NRC - August 28

HISTORY (CONT'D)

NRC Letter - Sept 9
- Accelerate Program
- Questions on Generic Report

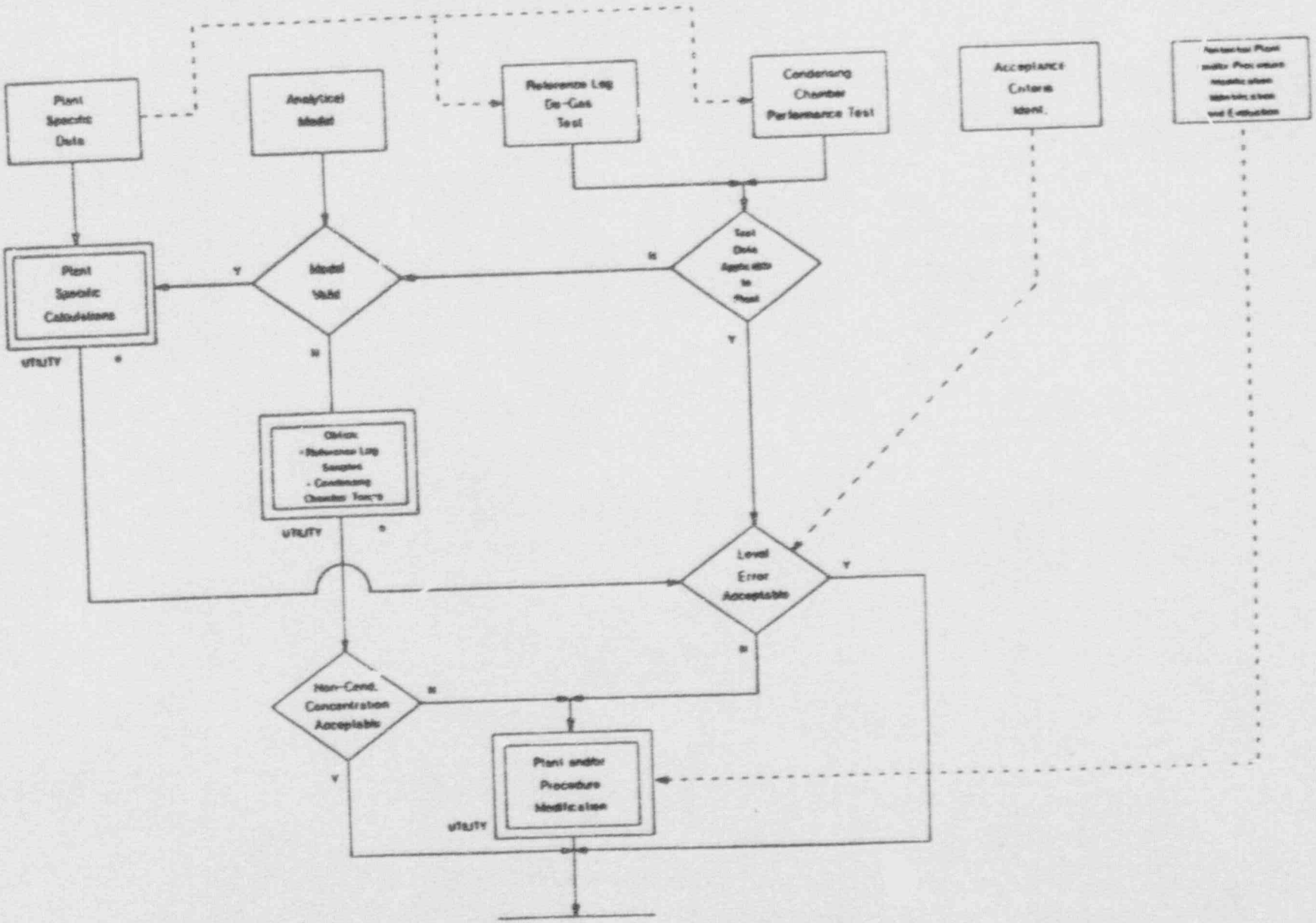
RRG/Committee Formation - Sept 15-17
- Reaffirm the Program Plan
- Steering Committee
- Model & Test Committee
- Modifications & Procedures Committee

BWROG/Utility Letter - Sept 24

GL 92-04 Utility Responses - Sept 27

Figure 1

BWROG Reactor Water Level Instrumentation Long Term Action Plan



WATER LEVEL ISSUE: Transition Organizational Structure

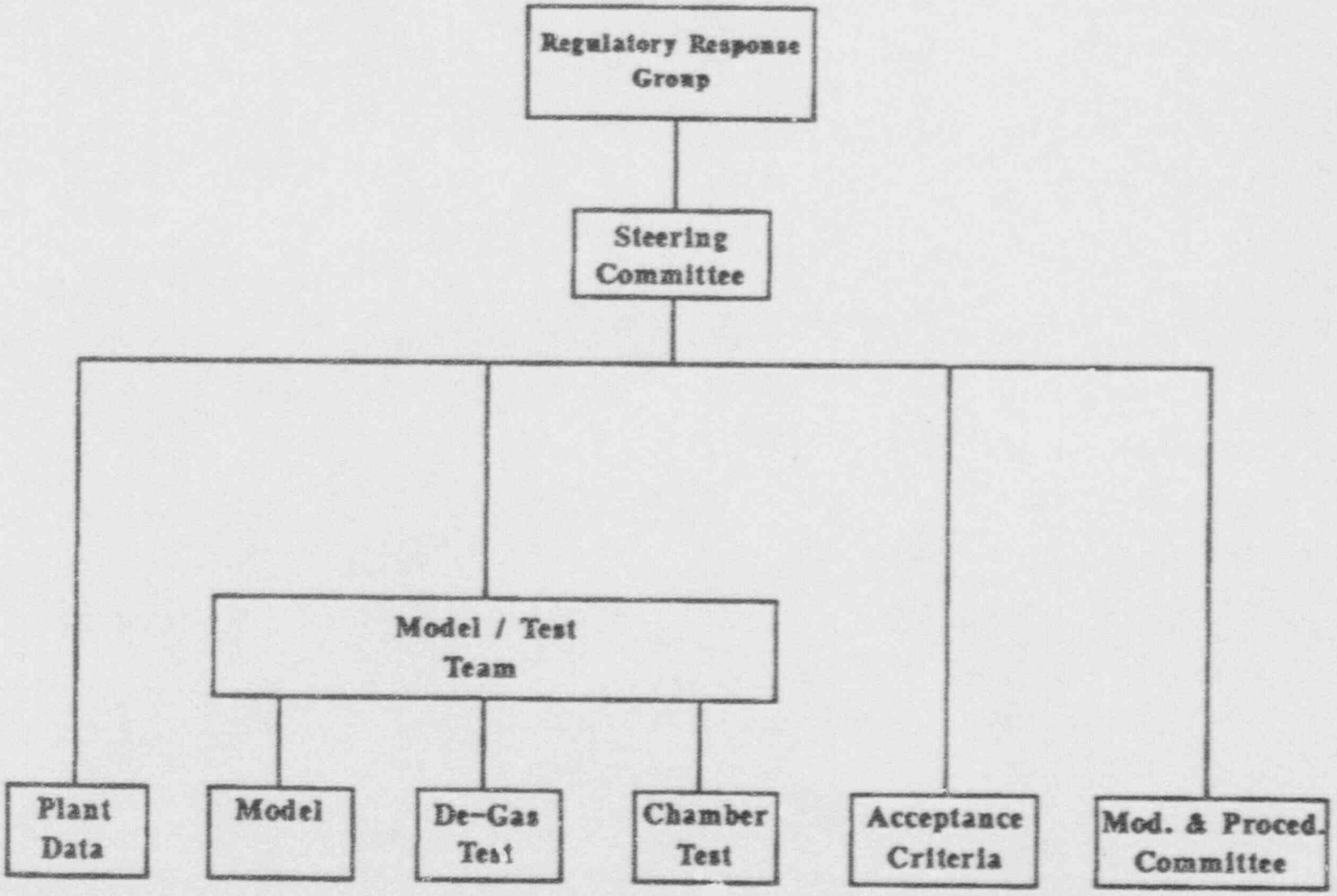


Figure 2

NOTCHING

Introduction

Steve Hudson, Boston Edison Company

Pilgrim Nuclear Power Station - BWR 3

Cold Reference Legs & Rosemount Transmitters

Level Error due to "Notching" is different than the level Error due to Rapid Depressurization

NOTCHING CONT'D

Notching

Seen during Normal Depressurization Following Reactor Shutdown

Indicated Level is Momentarily Greater than the Actual Level

Level Returns to Actual Level

Observable on both Level Recorders and Plant Computer

NOTCHING CONT'D

Experience

Instruments on "A" & "B" Racks Respond Differently

Begins at ~ 450 psig on "B" side

Typically, Square Wave shape approximately 4"-6" High
and 20-30 Seconds Duration

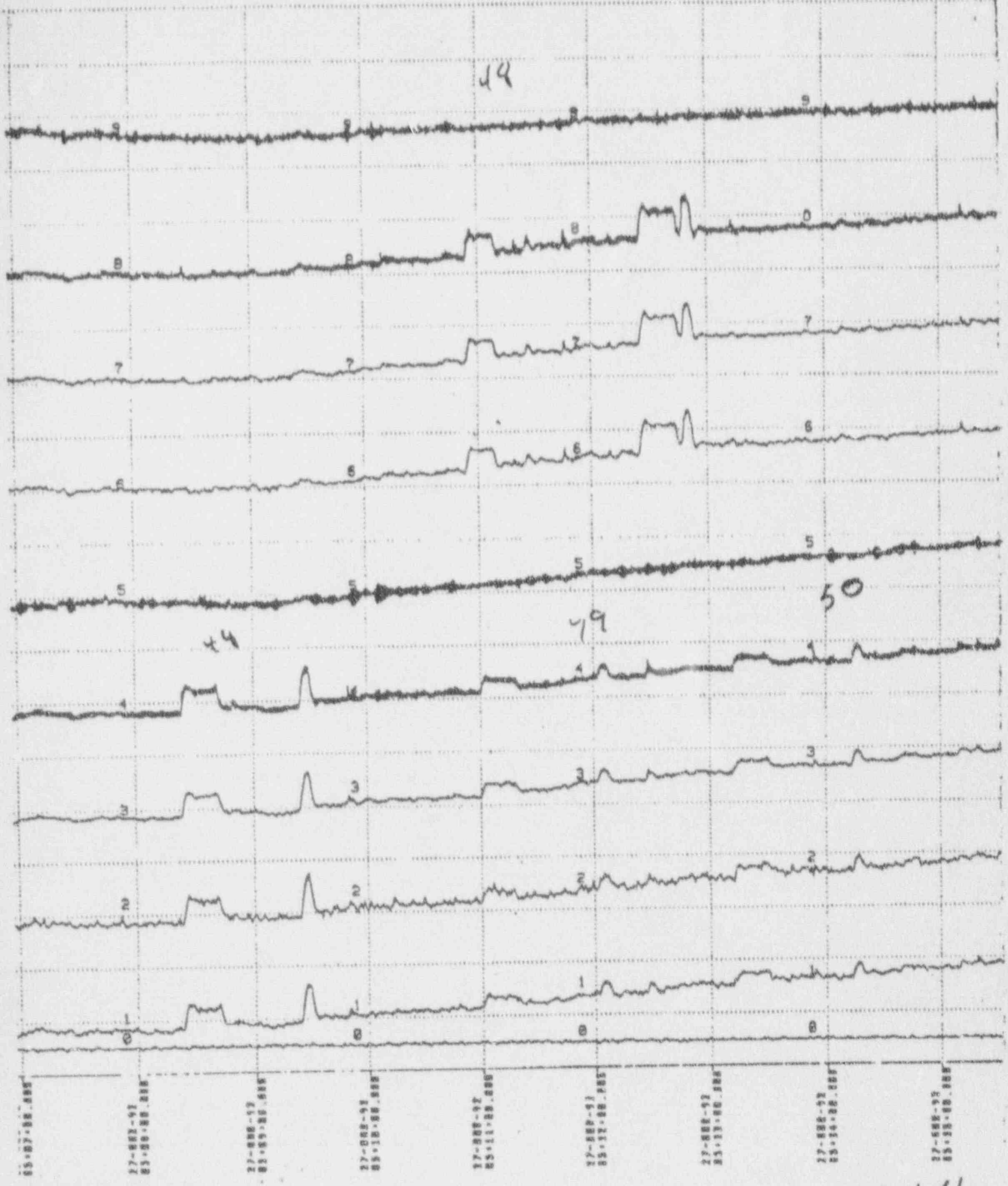
Amplitude Increases as Pressure Decreases

At Low Pressure (< 60 psig), Shape becomes more Irregular

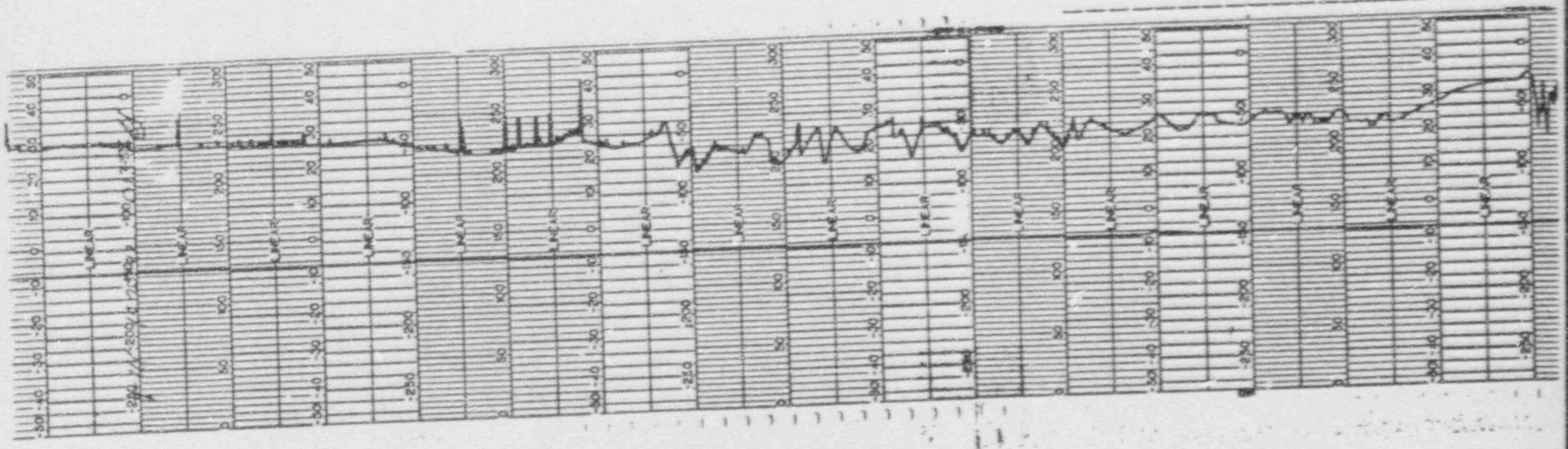
Maximum Recorded Notch Size > 29" (Limited by Instrument Range)

MSIV Isolations have occurred during Cooldown in '90, '91, & '92

2



"A" SIDE



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SDH5

NOTCHING CONT'D

Cause

Non-Condensable Gases Collect in the Condensing Chambers

Gas-Laden Water Migrates Down the Reference Leg due to Seepage at the Instrument Racks

During Depressurization, Gas comes out of Solution and eventually Forms a Bubble

- Supported by Ultrasonic Monitoring

With a Bubble in a Vertical Section of Piping, the Weight of the Water is Reduced. Therefore, the Indicated Level is Greater than the Actual Level

When the Bubble reaches a Horizontal Section of Piping, the Indicated Level Returns to the Actual Level

NOTCHING CONT'D

Factors

1. Non-condensable Gases build up in the Condensing Chambers

2. Horizontal section in the Reference Leg Piping

3. Small seepage at the Instrument Racks causes the gas-laden water to migrate down the Reference Leg

NOTCHING CONT'D

Future Actions

Fix Identified Seepage on "B" Rack during Mid Cycle Outage (MCO) 9

Measure As-Left External Seepage after Start-up

Measure instrument Bypass Valve Seepage on "A" & "B" Racks during MCO 9

Support BWROG Action Plan to increase Understanding of Rapid Depressurization Phenomenon

RAPID DEPRESSURIZATION

Generic Concern

- Non-condensable gases may dissolve in cold reference leg
- Reactor water level indication error may occur on rapid depressurization

RAPID DEPRESSURIZATION CONT'D

BWROG/NRC Discussion on July 29, 1992

- o BWROG Analysis Assumptions
  - Instantaneous Depressurization
  - Open Ended/Straight, Vertical Pipe
  - Conservative Parameters

RAPID DEPRESSURIZATION CONT'D

Open Issues/Actions Taken

- o Determination of "Actual" Possible Level Indication Error
  - Analyzed Depressurization Rates
  - Realistic Pipe Geometries
  - BWROG Reactor Water Level Program
- o Definition of "Indeterminate" Water Level
  - Operator Sensitization
  - Issued Clarification for Level Determination

OPERATOR GUIDANCE

Two guidance/information packages to utilities

- August 14 October 16

o Ensure adequate core cooling
  - Core submergence
  - Steam cooling

o Maintain EPG philosophy
  - Best available guidance
  - Any mechanistic event
    - o Bad and good level instruments
    - o ATWS
    - o Loss of injection - Containment flood

OPERATOR GUIDANCE CONT'D

- o Normal cooldown
  - Bottom of notch

- o Rapid depressurization
  - Stable pressure
  - Trend on instrument with tap above TAF

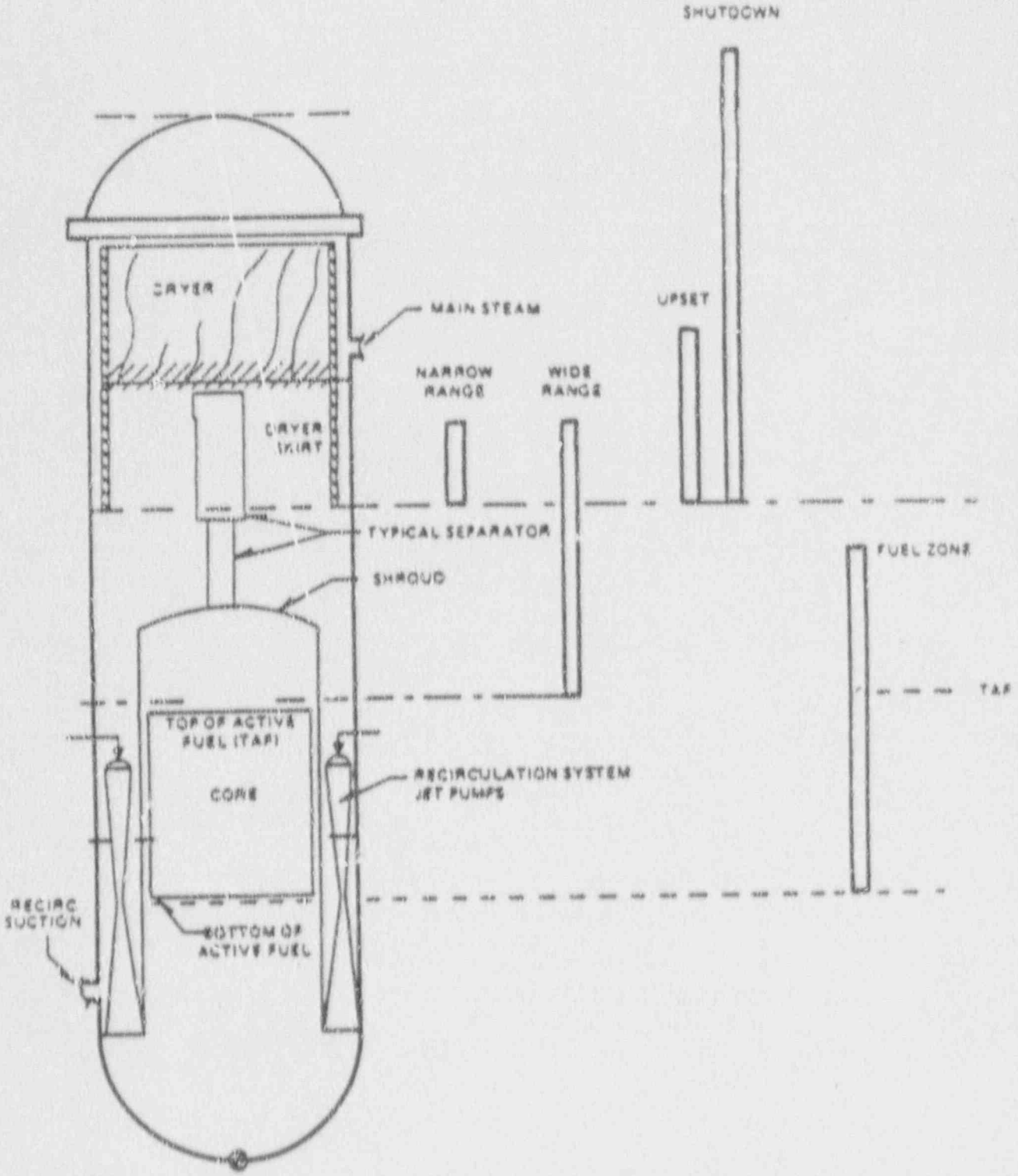


FIGURE 4-3. TYPICAL REACTOR VESSEL LEVEL RANGE COVERAGE (BWR/5 PLANTS)

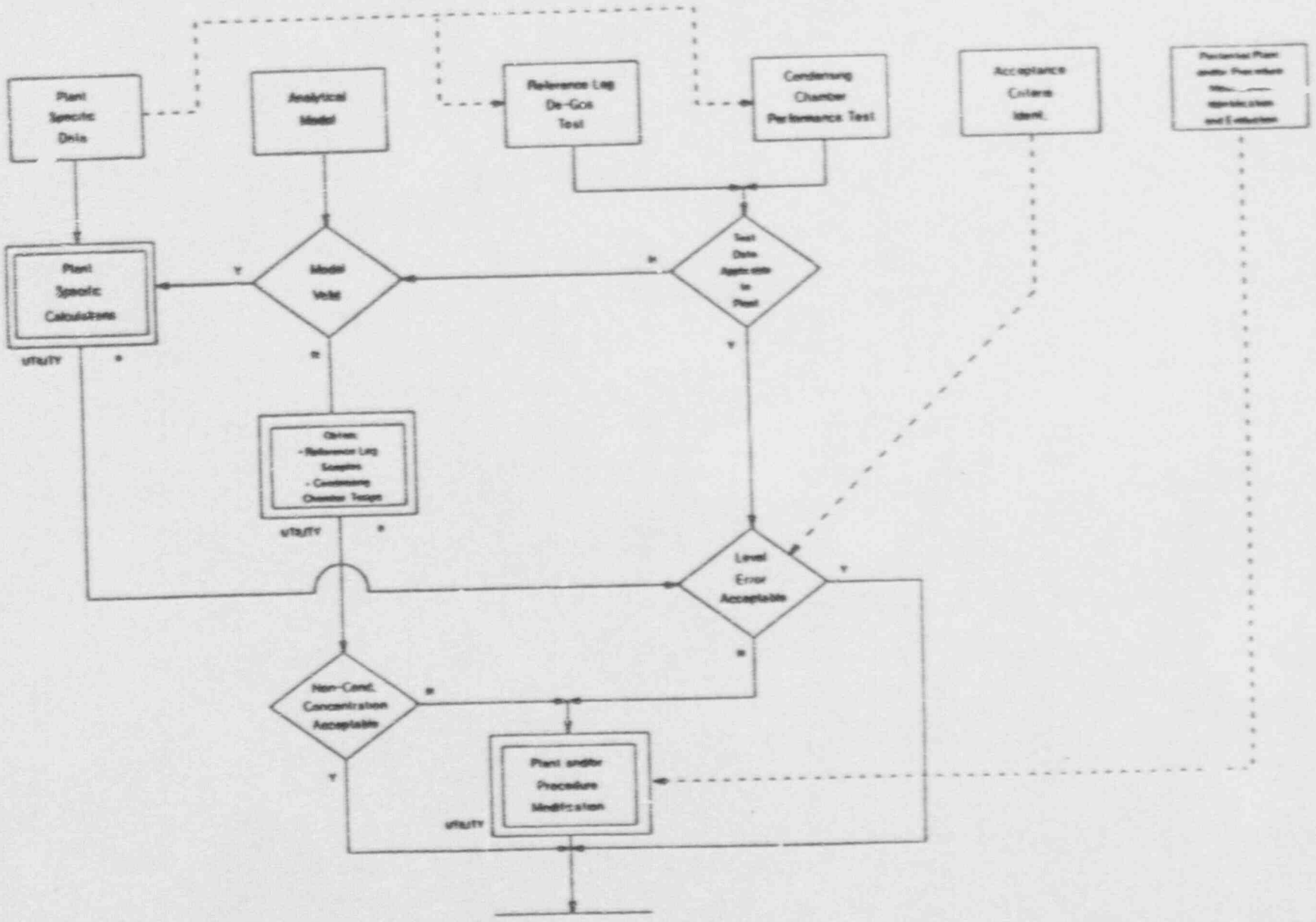
BWROG ACTION PLAN

BWROG Reactor Water Level Instrumentation Program

- A comprehensive plan which embodies prototypical testing, analytical modeling, plant unique testing, analysis, and hardware and/or procedure modifications
- Developed by a team of utility and industry experts
- A resource intensive program that will produce the most expeditious and technically appropriate resolution of this issue

Figure 1

BWROG Reactor Water Level Instrumentation Long Term Action Plan



Test Program Status

Status (Outline)

Objectives of Full Scale Tests

- De-Gas
- Condensing Chamber

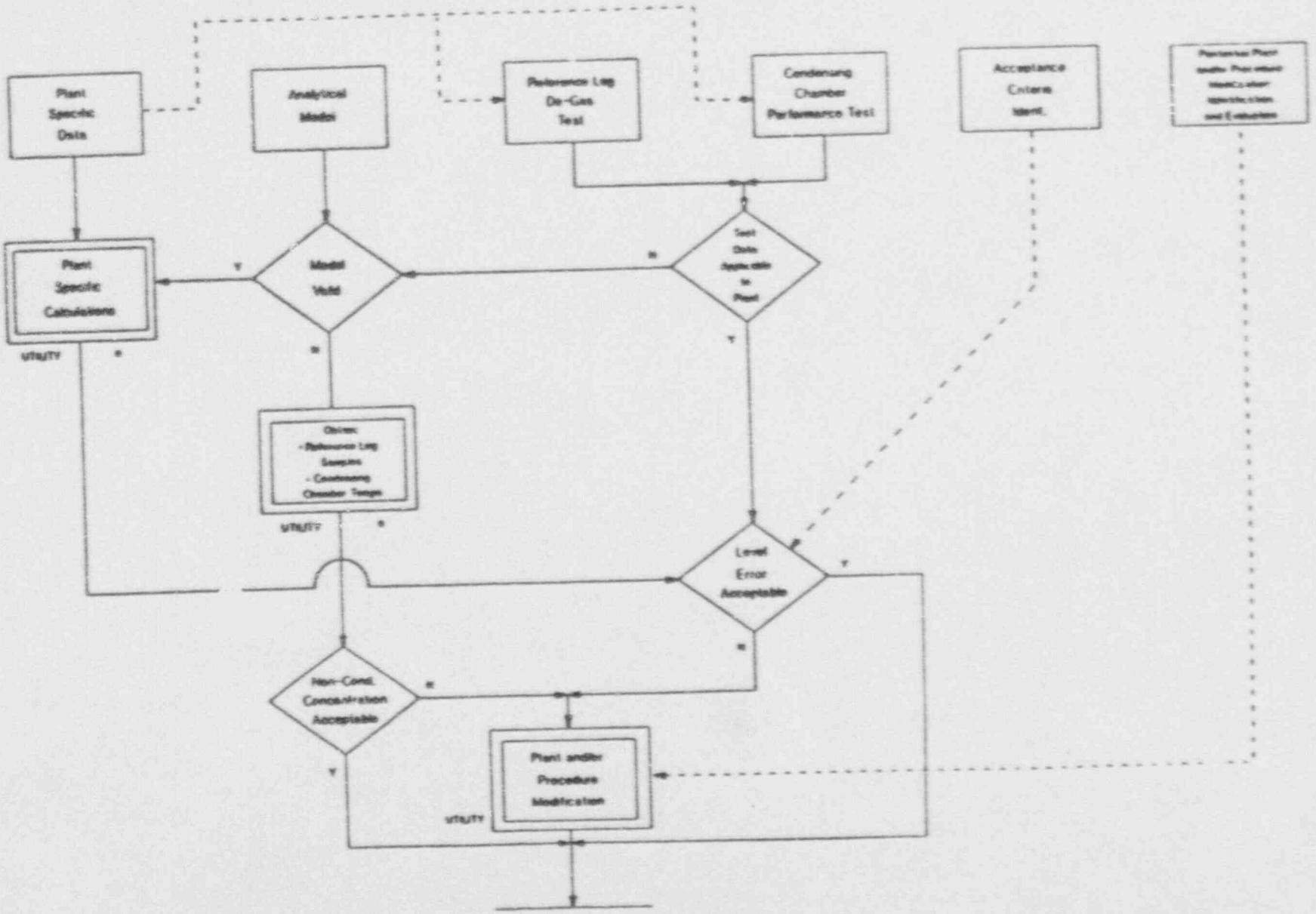
Description of Tests

- De-Gas
- Condensing Chamber

Status of Ongoing Activities

Figure 1

BWROG Reactor Water Level Instrumentation Long Term Action Plan



Generic Test Program

- Confirm that most water level systems are operating satisfactorily
- Will allow utilities to use test data directly
- Tests are split to meet aggressive program target completion date
- Leaves in-plant sampling as a utility option
- Provide design data for modification and evaluation

Condensate Pot - Steady State Operation

Leak Rate (%)	P_{H2} (psia)	M_C (lbm/hr)	time to fill pot (hr)	time to fill 150' leg (hr)
100	37.5	.96	64	62
75	49	.96	85	84
50	75	.96	133	125
25	150	.85	282	279
10	375	.62	859	967
3.75	996	0	∞	∞

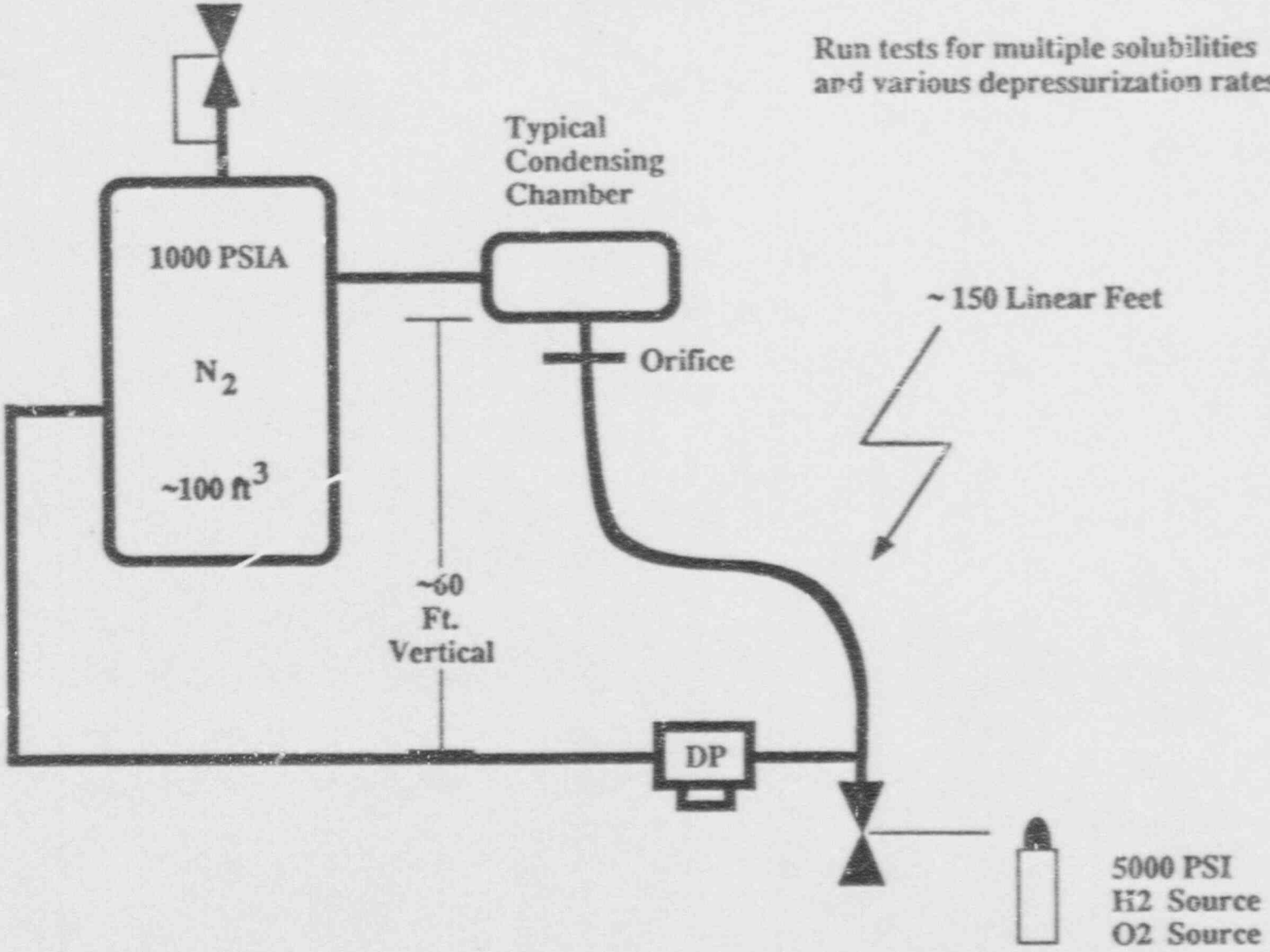
De-Gas Tests

Object - Show that prototypical depressurization of typical reference legs have acceptabie inventory loss

- Provide data in conjunction with pot tests to confirm as built water level instrumentation performance

- Provide data to calibrate / validate drift flux reference leg hydrodynamic model

Figure 2.1
Reference Leg De-Gas Test



Plant Specific Data

- Needed for Test Geometry
- Analytic Model

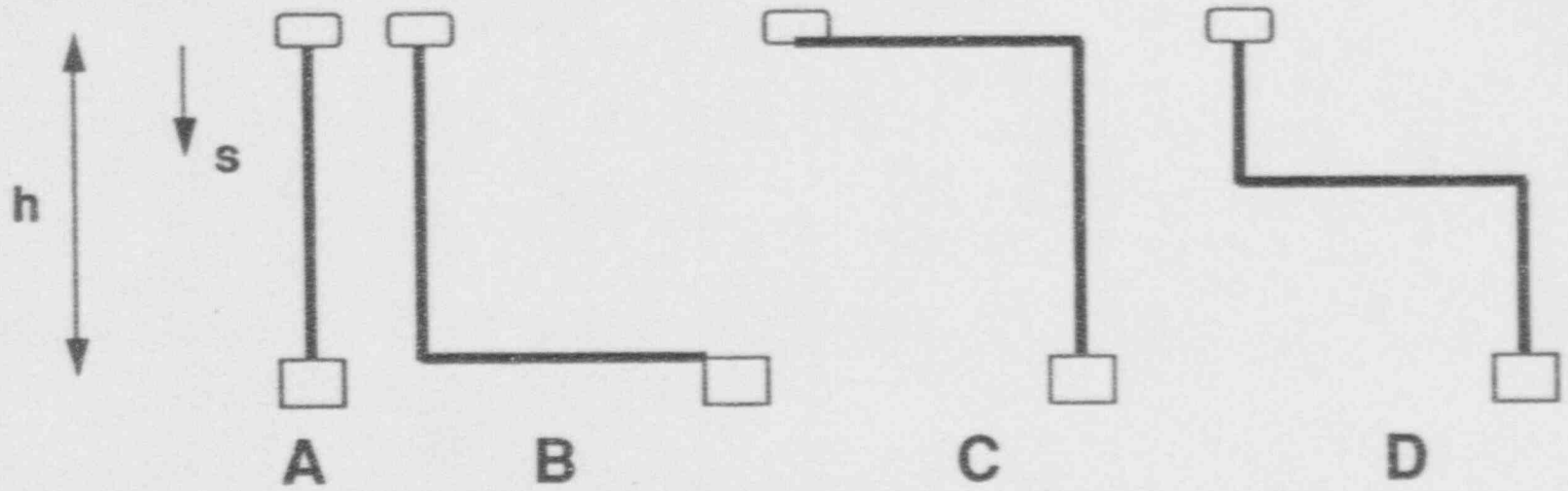
Data obtained by EPRI July 14 in support of PECO project

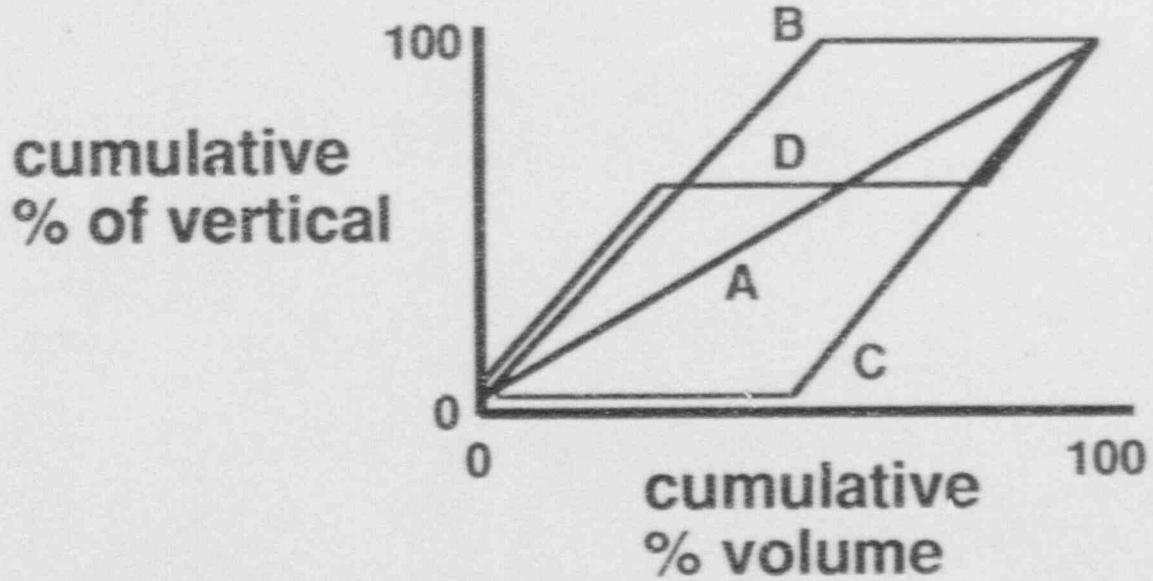
Data provided consists primarily of

Analysis -

- Generic Characterization
- Sensitivity Analysis
- Loss / ΔP

Generic Cold Leg Characterization





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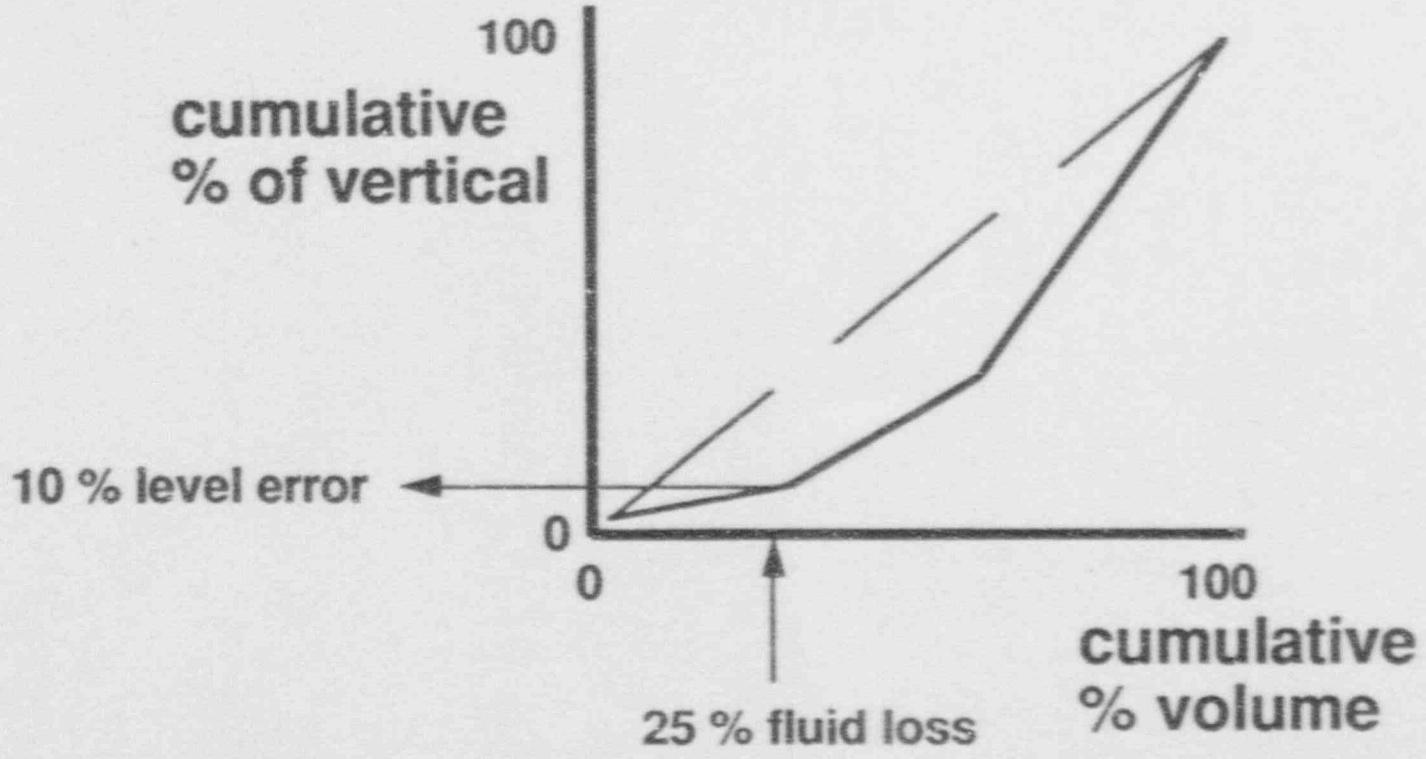
Simplified Sensitivity Analysis

> % Loss cf cold leg fluid = % loss of cold leg volume

> % Error in reference pressure is intersection of rise-run plot with % loss of total volume

> Geometries below 45 degree line are less sensitive to errors



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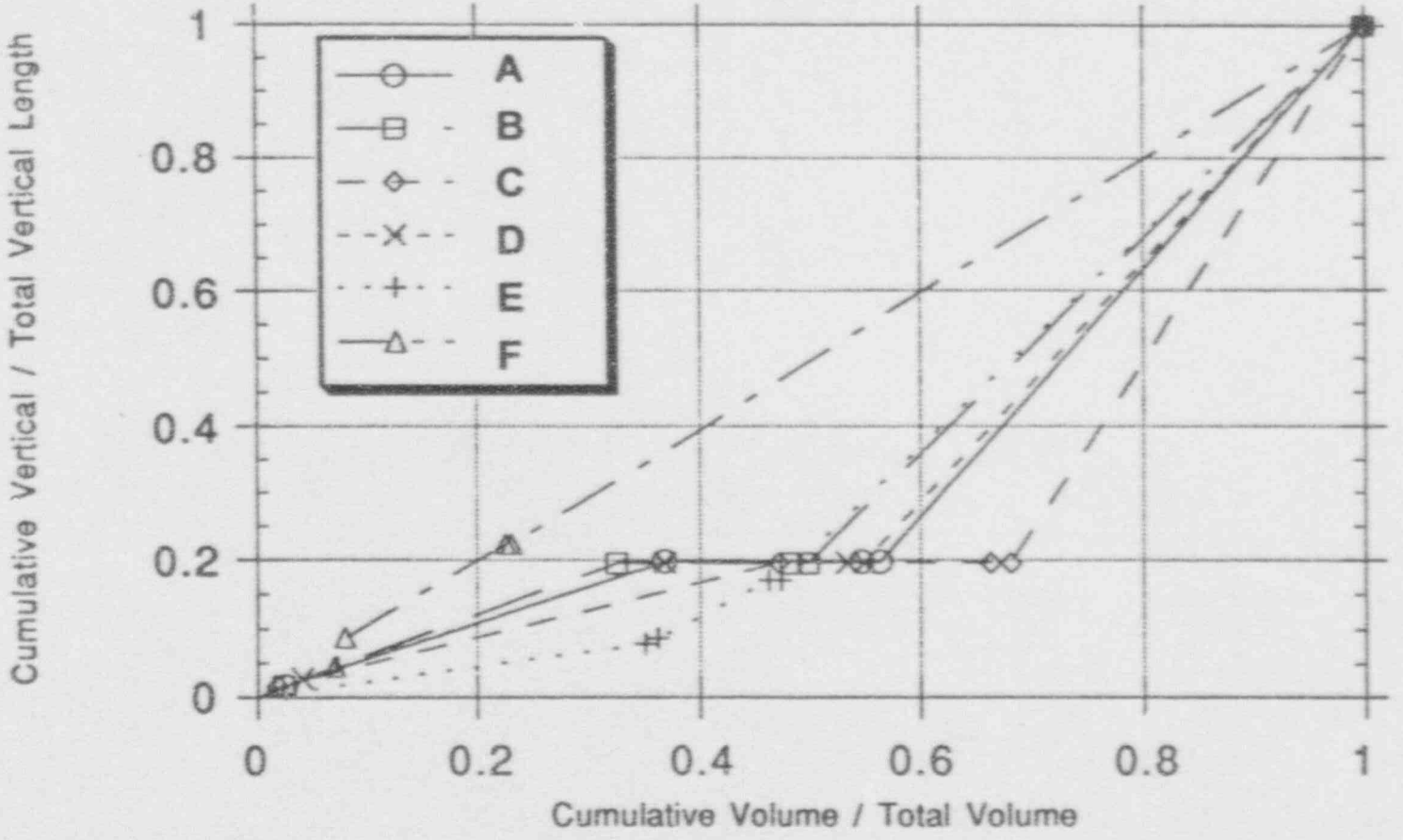
Plant Cold Leg Piping Geometry



Condensing Chamber Tests

Object - Determine performance of condensing chambers currently in use on BWRs

- Primary data is to measure dissolved gas species and concentration present in the cold reference leg
- Empirically determine nominal design geometries for condensing chamber and steam inlet piping
- Data to be used in conjunction with de-gas tests to evaluate plant unique level error
- Data to be used to validate steam inlet condensing chamber analytic model

Condensing Chamber Performance Test

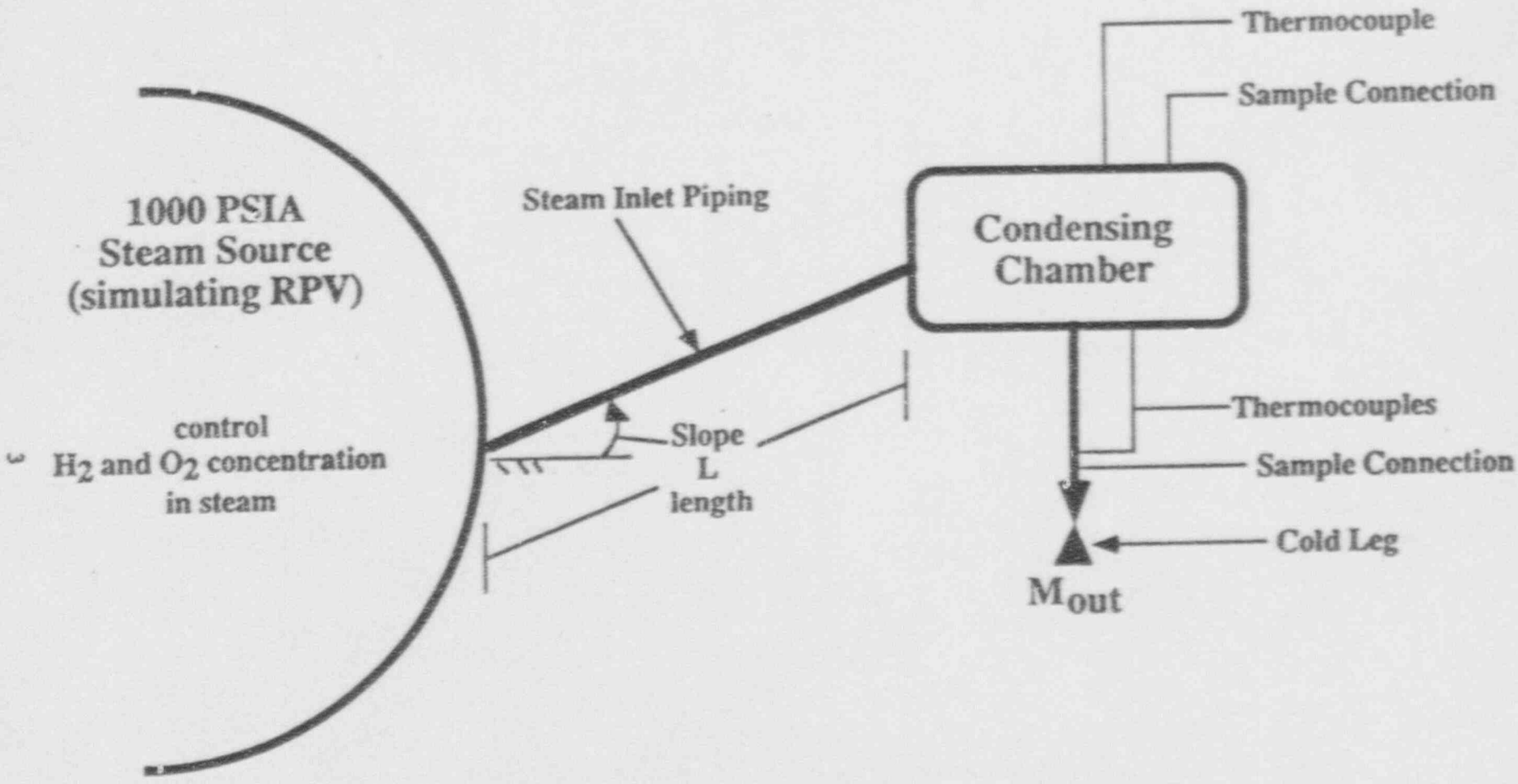
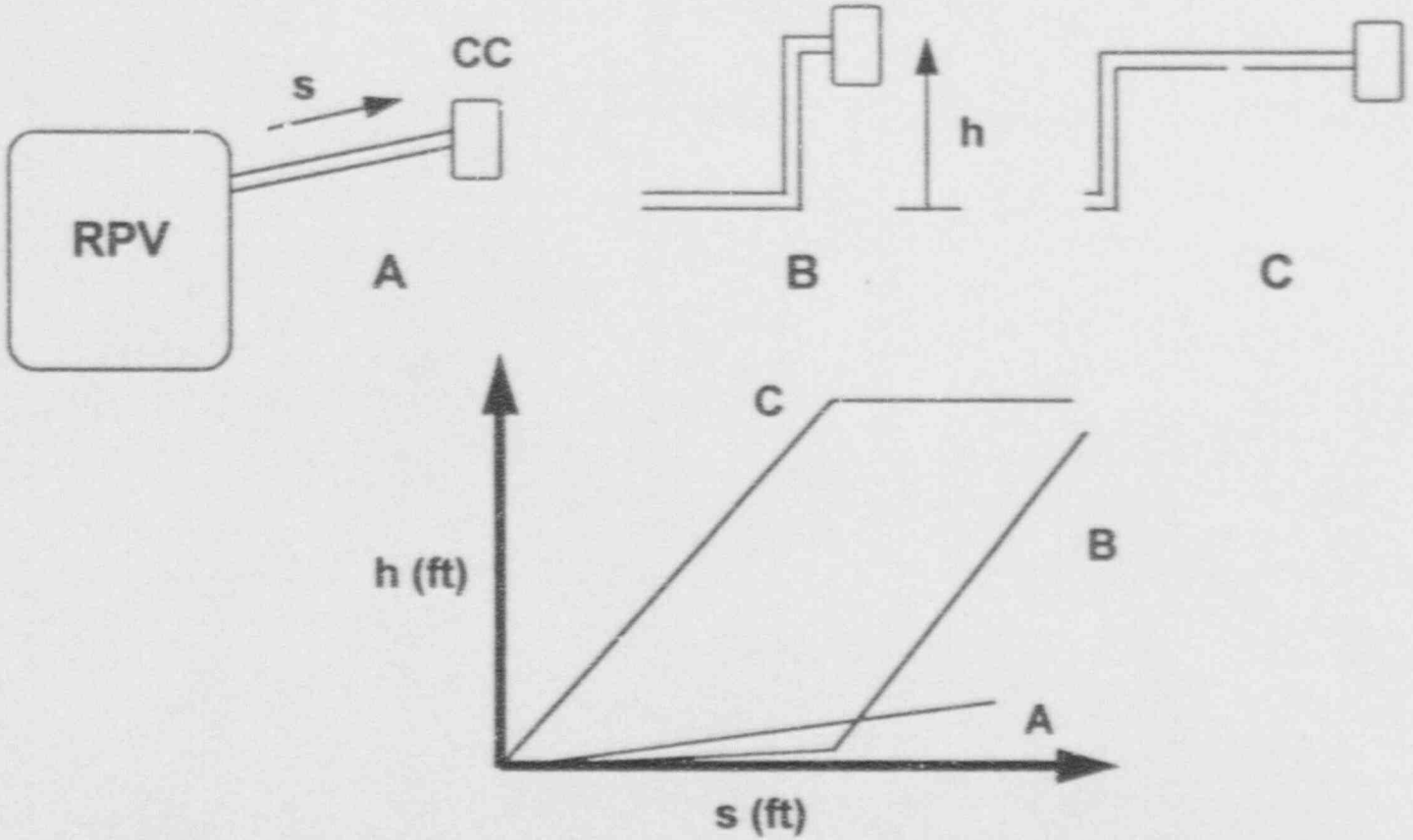


Figure 2.1. Test steam inlet geometries as well as CC geometry to obtain data for the concentration of non-condensible gases entering the cold leg.

Generic Steam Inlet Leg Characterization



Status of Ongoing Activities

"Scope of Work for Testing of BWR Condensing Chamber Performance Characteristics"

"Scope of Work Testing Protypical BWR Water Level Instrumentation Reference Leg Geometries During Rapid Depressurization Events"

Final utility approval by 11/6/92

Identification of Generic	% Complete
Steam Leg Inlet Geometries	50%
Cold Leg Geometries	70%

Test	Organization	Location
De-Gas	EPRI	Charlotte, NC
Cond. Chamber	TBD	TBD

MODEL AND TEST COMMITTEE

MISSION STATEMENT

- To oversee and direct the analytic model development and test programs which consist of:

  a) The condensing chamber test program

  b) The cold reference leg de-gas test program

  c) The detail analytic model development and validate against test data

STATUS

- Functional requirements documents have been drafted and reviewed
- Detail analytic model development continues
- Qualitative results of detail analytic model confirm results presented at July 29th meeting with NRC were conservative
- Analytic model requires validation using data from test programs prior to plant unique predictions

ANALYTICAL MODEL

- Two computer mathematical models in development
  - a) Model of inlet steam piping and condensing chamber
  - b) Cold reference leg model
- Inlet steam piping/condensing chamber model
  - a) De-gassing effect
  - b) Insulation
  - c) Inlet piping geometry
  - d) Chamber/inlet piping heat transfer characteristics
  - e) Solubility, diffusion, seepage

ANALYTICAL MODEL (CONT'D)

- Cold reference leg model

  a) Two-phase thermal hydraulics (drift flux)

  b) Solubility

  c) Gas coming out of solution (source term)

  d) Piping geometry

  e) Hydrostatic head

  f) Vessel depressurization time transient as boundary condition

ACCEPTANCE CRITERIA

- Define Acceptable Level Error for each BWR Type
- Based on Licensing Inputs for Level Instrumentation and EPGs
- Delayed to Provide Additional Operator Guidance

REACTOR WATER LEVEL MEASUREMENT

POTENTIAL MODIFICATIONS

OCTOBER 29, 1992

PREVENT THE BUILDUP OF NONCONDENSABLES

MITIGATE THE AFFECT OF NONCONDENSABLES BUILDUP

PROCEDURE CHANGES

RWL1.DRW

REACTOR WATER LEVEL MEASUREMENT

POTENTIAL MODIFICATIONS

OCTOBER 29, 1992

PREVENT THE BUILDUP OF NONCONDENSABLES

CONTINUOUS BACKFILL

METERED FLOW FROM THE CRD SYSTEM
(SIMILAR TO THE MILLSTONE MODIFICATION)

METERED FLOW FROM THE FUEL ZONE VARIABLE LEG
(USES JETPUMP FLOW)

LEAKAGE REDUCTION

REMOVE EQUALIZING VALVES

PLUG DRAIN LINES DOWN STREAM OF DRAIN VALVES

CONDENSING CHAMBER MODIFICATIONS

BAILEY STYLE CONDENSING CHAMBER

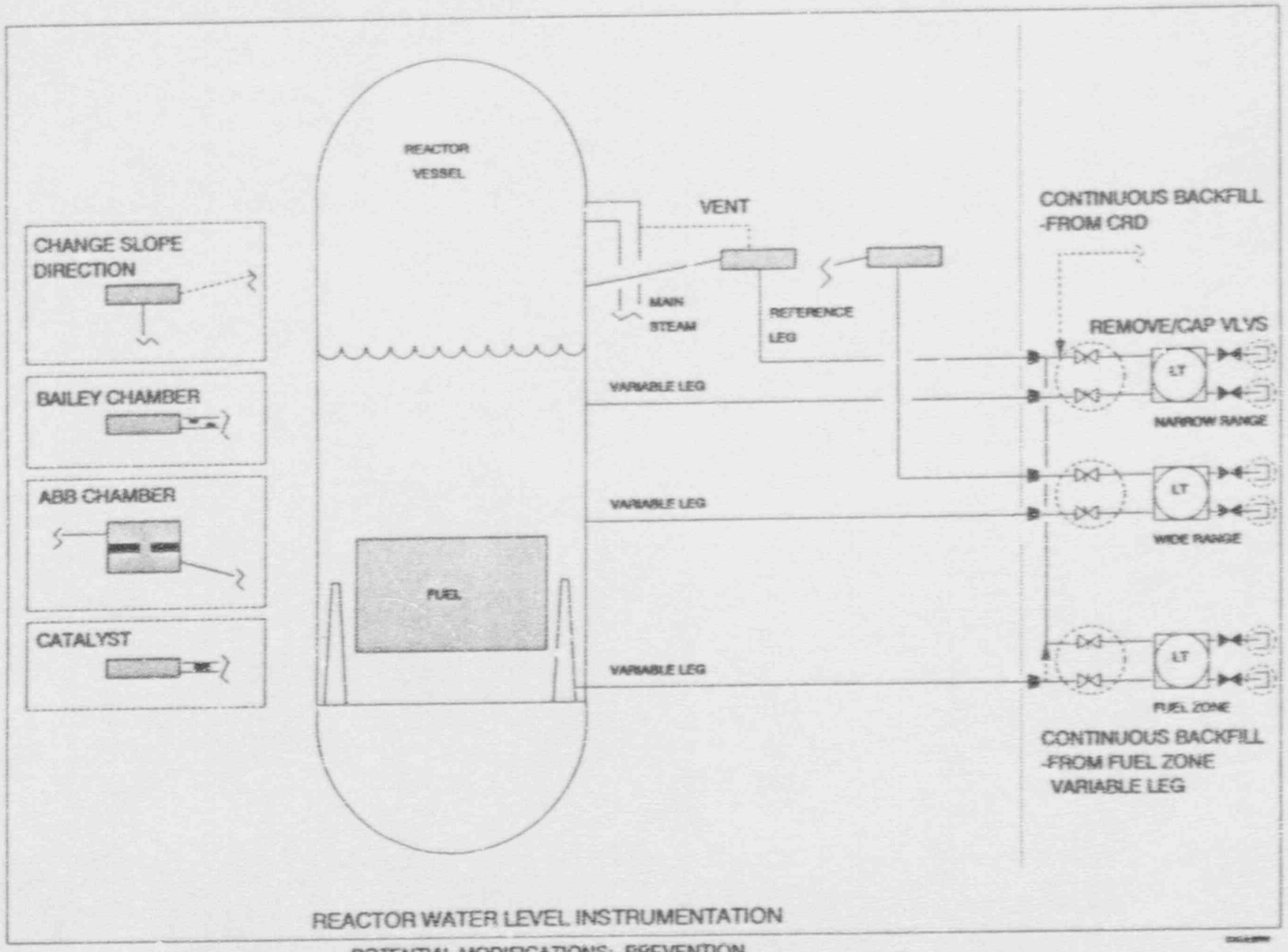
ABB CONDENSING CHAMBER

INSTALL CONDENSING CHAMBER VENT

CHANGE SLOPE DIRECTION OF CONDENSING CHAMBER STEAM LEG

CATALYST

RWL2.WPW



REACTOR WATER LEVEL INSTRUMENTATION

POTENTIAL MODIFICATIONS: PREVENTION

REACTOR WATER LEVEL MEASUREMENT

POTENTIAL MODIFICATIONS

OCTOBER 29, 1992

MITIGATE THE AFFECT OF NONCONDENSABLES BUILDUP

POST-ACCIDENT BACKFILL

REMOTE MANUAL FLOW FROM CORE SPRAY SYSTEM
(SIMILAR TO COOPER MODIFICATION)

NATURAL BACKFILL

INSTALL LARGER CONDENSING CHAMBER

INSTALL "ACCUMULATOR" VOLUME UNDER THE CONDENSING CHAMBER

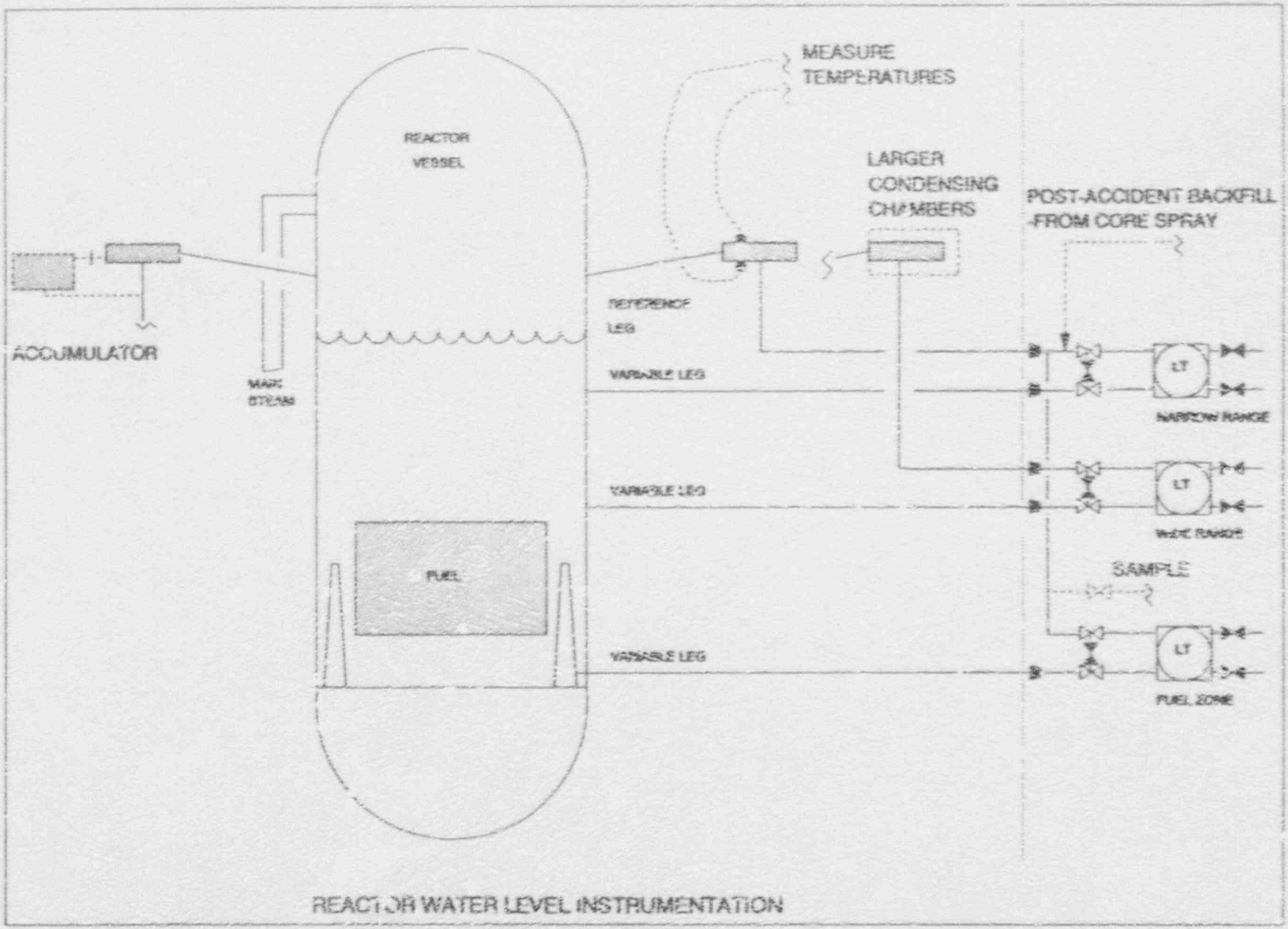
DETECTION OF NONCONDENSABLES

(REQUIRES BACKFILL PROCEDURES AND/OR MODIFICATIONS)

MEASURE TEMPERATURES OF THE CONDENSING CHAMBERS

PERIODICALLY SAMPLE REFERENCE LEG WATER

RWL2.DRW



REACTOR WATER LEVEL INSTRUMENTATION

POTENTIAL MODIFICATIONS: MITIGATION

REACTOR WATER LEVEL MEASUREMENT

POTENTIAL MODIFICATIONS

OCTOBER 29, 1992

PROCEDURE CHANGES

MODIFICATIONS SYSTEMS PROCEDURES

BACKFILL BASED ON RESULTS OF DETECTION METHODS

CONTINUOUS BACKFILL SYSTEMS
(MONITOR FLOW, SURVEILLANCE FOR LEAK DETECTION)

POST-ACCIDENT SYSTEM
(WHEN TO INITIATE BACKFILL)

NATURAL BACKFILL SYSTEMS
(COMPENSATE FOR INTRODUCED LEVEL ERROR)

EOP CHANGES (BWROG EMERGENCY PROCEDURES COMMITTEE)