MEASUREMENT REQUIREMENTS FOR ASSESSMENT

OF SMALL BREAK LOCA CODES

F. ODAR

PHENOMENA OF INTEREST IN SMALL BREAKS

I. MASS BALANCE

- A. BREAK FLOW
- B. ECC FLOW
- C. VESSEL INVENTORY - MASS DISTRIBUTION
- D. STEAM GENERATOR - MASS DISTRIBUTION
- E. PHASE SEPARATION - HORIZONTAL AND VERTICAL COMPONENTS
- F. PRESSURIZER INVENTORY
- G. NONCONDENSIBLES

II. ENERGY BALANCE

- A. BREAK FLOW
- B. ECC FLOW
- C. STEAM GENERATOR HEAT TRANSFER
- D. CORE POWER
- E. CLAD TEMPERATURES
- F. LIQUID TEMPERATURES
- G. HEAT LOSS

III MOMENTUM BALANCE

A. FLOW RATES AND PRESSURE DROPS

1. NATURAL CIRCULATION

- STEAM GENERATOR H.T.

FEED AND BLEED

- PHASE SEPARATION - REFLUX BOILING

- NONCONDENSIBLE

B. PUMP DEGRADATION

- UPSTREAM INCLUDING LOOP SEAL

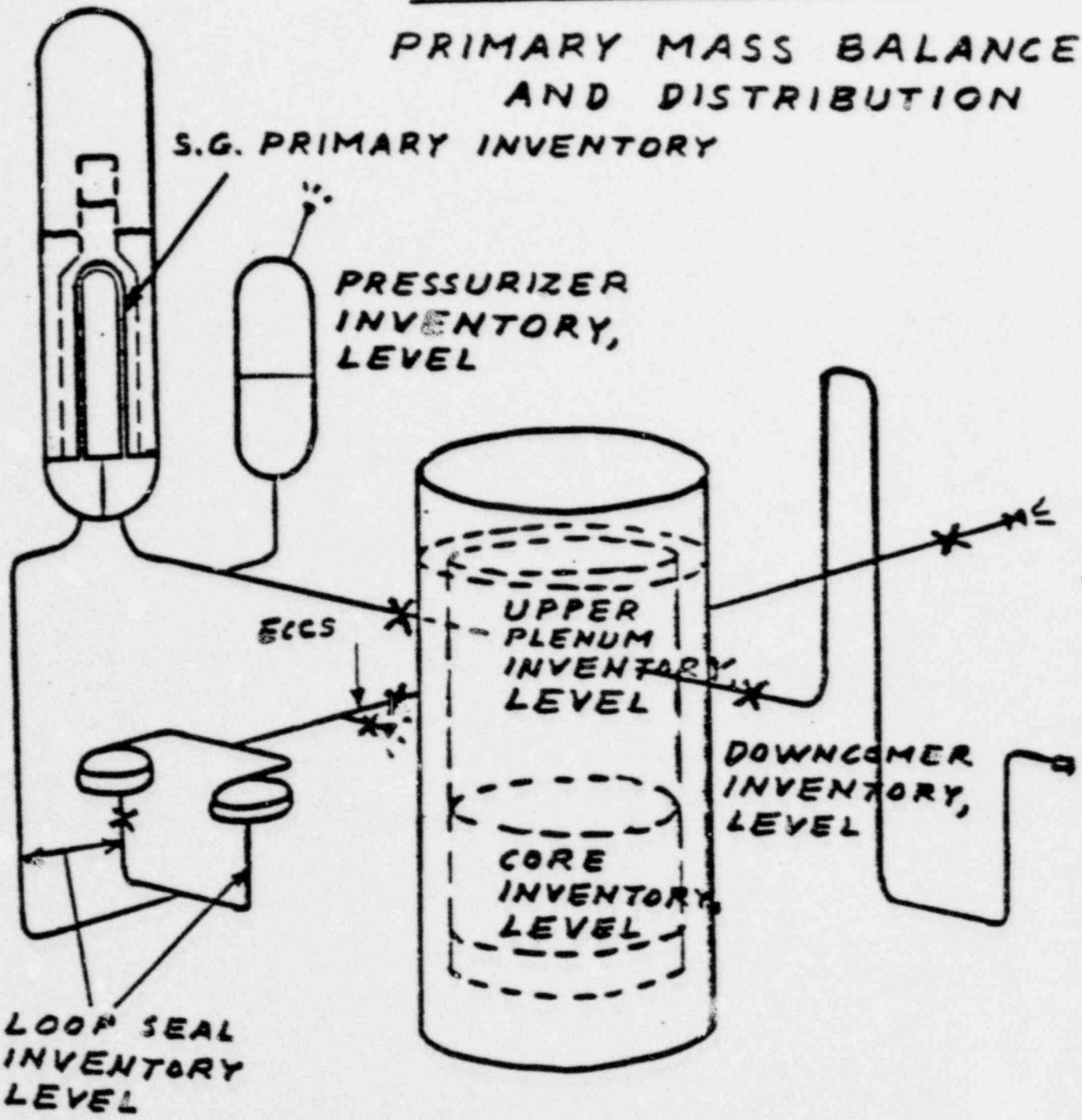
- DOWNSTREAM INCLUDING DOWNCOMER

C. PHASE SEPARATION AND VOID DISTRIBUTION IN ALL COMPONENTS - VESSEL, S.G., PIPING, EFFECTS OF ECC INJECTION

D. EFFECTS OF GEOMETRY AND SCALING

LOFT SMALL BREAK TESTS

PRIMARY MASS BALANCE AND DISTRIBUTION



MEASUREMENT REQUIREMENTS:

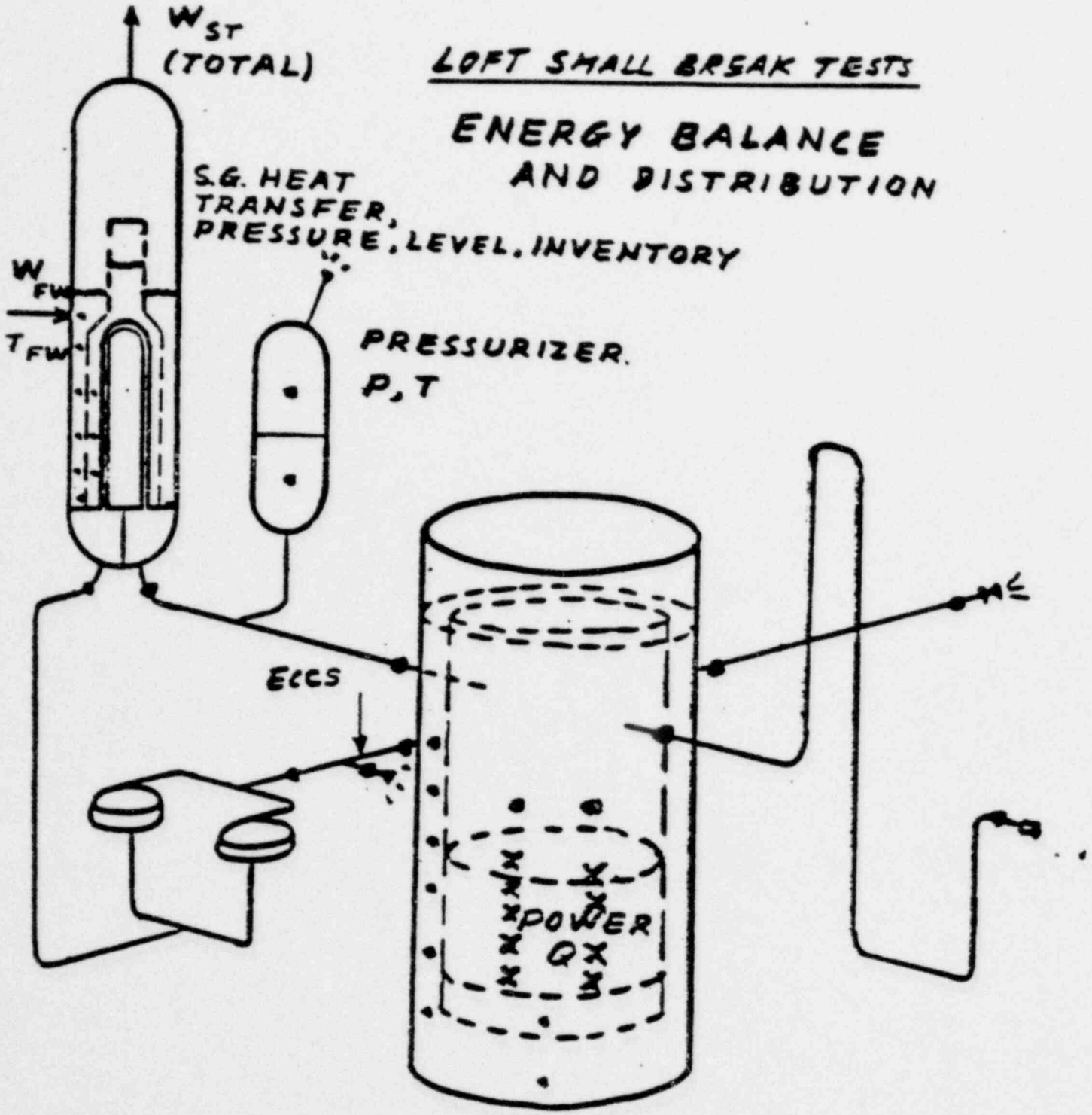
A. INVENTORIES INCLUDING PIPING

B. DISCHARGE FLOW AT BREAK AND R.V.

C. DENSITY MEASUREMENTS

X EXISTING

X NEW



LOFT SMALL BREAK TESTS

ENERGY BALANCE
AND DISTRIBUTION

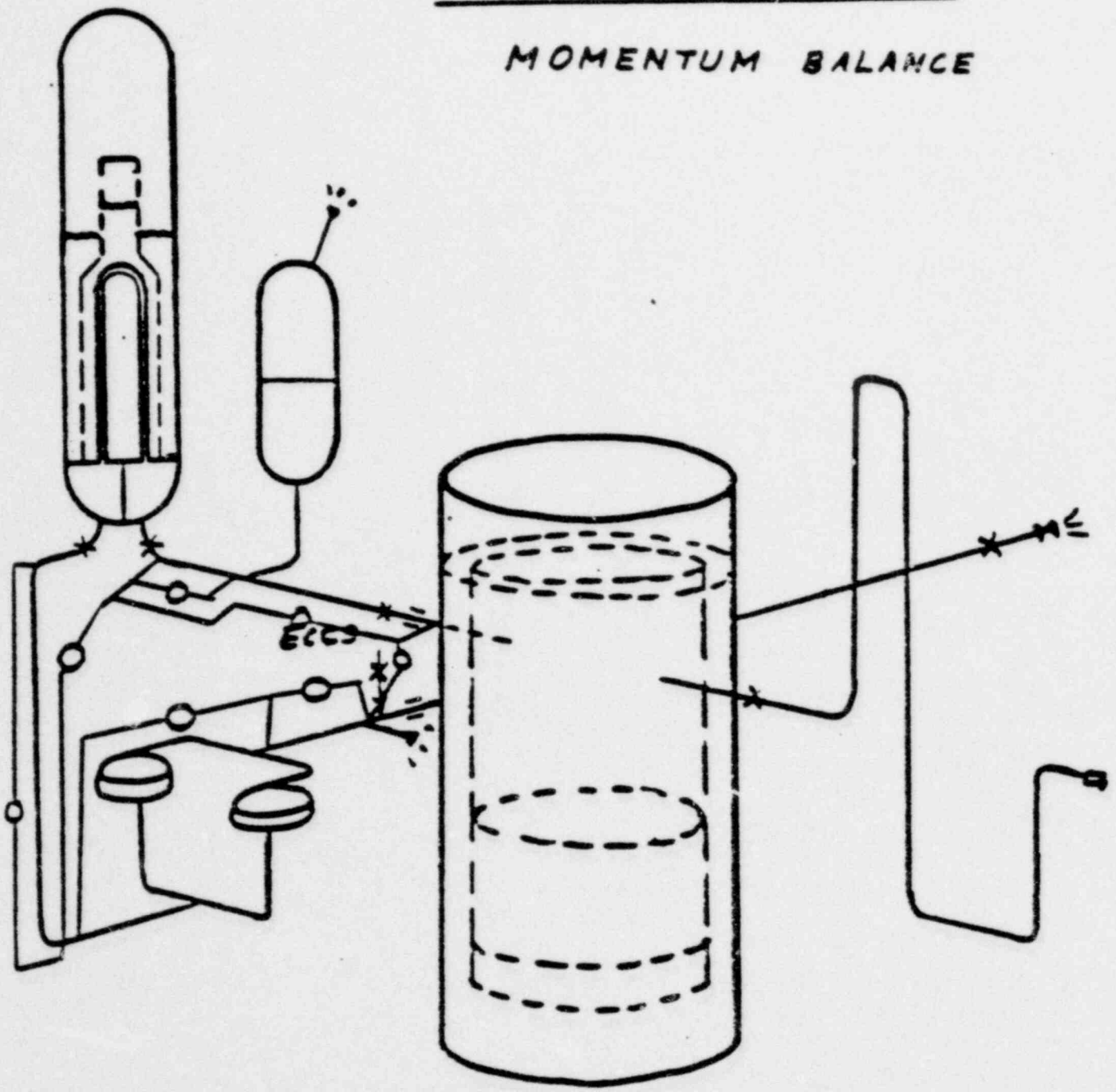
REQUIRED MEASUREMENTS

- x CLAD TEMPERATURES (EXISTING)
- • FLUID TEMPERATURES (EXISTING)
- • FLUID TEMPERATURES (NEW)

AND ENERGY LOSS THROUGH BREAKS AND R.V

LOFT SMALL BREAK TESTS

MOMENTUM BALANCE



= PHASIC (LIQUID) VELOCITIES, DIRECTIONS (NEW) OR FLOW RATE IF NO SEPARATION

x FLOW RATE (NEW)

x FLOW RATE (EXISTING)

DP EXISTING

SUMMARY OF IMPORTANT MEASUREMENTS

a. System mass balance as affected by:

1. Flow through the break,
2. ECC injection, and
3. Effects of geometry and scale on the stratified or homogeneous flow pattern at the break.

b. Heat balance as affected by:

1. Core void distribution,
2. Core heat transfer,
3. Heat leakage to environment through pipe and components walls,
4. Void distribution on the primary and secondary side of steam generator,
5. S.G. secondary side pressure,
6. S.G. secondary side steam exit flow rate and feedwater flow rate and temperature,
7. Flow rates (and directions of flow) of the liquid and the vapor phases, through the S.G. tubing,
8. S.G. heat transfer regimes,
9. Thermal energy delivered to the coolant by the pumps, and
10. Effects of geometry and scale in Items 1 through 9.

c. Coolant flow through the primary system as affected by:

1. Coolant properties (void fraction, velocity) at pump(s) inlet,
2. Pump head and torque degradation effect on the water level in downcomer.
3. Void distribution in all vertical sections of piping (loop seals) and of system components (vessel, S.G.),
4. Flow stratification in the horizontal pipes and recognition of flow direction and velocities of each phase,
5. Natural circulation of the single phase and of the two phase types including the reflux boiler type,
6. Effects of feed and bleed (through break flow) on natural circulation, and
7. Effects of geometry and scale on Items 1 through 7.

SUMMARY OF MINIMUM MEASUREMENTS

1. Break Flow:
   * Mass flow rate through the break and any other location through which the coolant is escaping the system.
   * Enthalpy flux for the fluid leaving the system (through the break or other locations).
   * Void fraction and indication of flow regime of fluid reaching the break.
2. Steam Generator Performance as it affects the system behavior:
   * Secondary side pressure
   * Secondary side feedwater and steam line flow rates and fluid temperature
   * Axial pressure differentials on the secondary side. Overall DP is a must; axial distribution would be welcome.

   "SS"- Fluid axial temperature distribution on the secondary side

   "SS"- Outer surface temperatures of tubes

   "SS"- Mass flow rate and average void fraction entering and leaving the primary side

   * Pressure differential, inlet-to-outlet of primary side.
   * Fluid temperatures of inlet and outlet of the primary side
   * Fluid density or average void fraction at inlet and outlet of the primary side in LOFT, together with indication of flow regime.

3 System pressure and pressure distribution in loop.

4. System mass distribution:

   * DP (axial) in all vertical components including vessel, pressurizer, loop seals (both the S.G. and pump sides) and accumulator

   * Average void fraction in spool pieces located in horizontal pipes together with indication of flow stratification

   "SS" - Axial void distribution in the reactor vessel

   * Mixture level indication in the upper plenum, upper head, and core (in LOF

5. Core heat transfer:

   * Heater rod or fuel (cladding) temperatures (axial and lateral distribution)

   * Fluid temperatures in core

6. Fluid temperatures throughout the system, especially where stratification or phase separation is expected.

7. Fluid velocities in hot legs, cold legs, and at core exit (in LOFT). Velocities and flow directions of the individual phases are of interest for stratified and countercurrent flows in horizontal pipes.

8. Pump performance:

   * Pressure differential across each pump

   * Mass flow rate, or volumetric flow rate, or phase velocities at pump inlet

   * Average void and flow pattern at pump inlet (and outlet if feasible)

   * Pump RPM and torque