EBERSOLE QUESTION AND B&W (DUNN) RESPONSE. EBERSOLE LIST PRESENTED AT OCTOBER '77 PEBBLE SPRINGS ACRS SUBCOMMITTEE

ITEM (2)

QUESTION:

Does applicant know that time-dependent levels will occur in pressurizer, steam generator and reactor vessel after a relatively small primary coolant break which causes coolant to approach or even partly uncover fuel pins? What does operator do in respect to interpreting level in pressurizer?

During primary system refill from high pressure injection pumps there is some period when neither condensation nor natural convection is present to effect heat transport to secondary side. How is transition to natural convection without assistance from primary coolant pumps obtained.

Why didn't Dunn include Kelly's concerns?

RESPONSE:

There are two overriding concerns with any Loss of Coolant Accident;

1) Initial removal of fuel stored heat;

2) Continuous removal of decay heat.

For small breaks, fuel stored heat is removed during the first few seconds of blowdown. The B&W ECCS system, utilizing internals vent valves, precludes the interruption of decay heat removal for all accidents within the range of small breaks. Consideration of phase separation, internals vent valves, break location, steam generator condensation and ECCS injection have been made in arriving at this conclusion. Mixture levels are calculated in the RCS throughout the transient.

As I understand your concerns, they relate to the possible interruption of steam condensation within the steam generator due to refilling of the primary system. Such an event can only occur at greatly extended times during final recovery when steam condensation is no longer required. However, even if the event occurred earlier, the action of the vent valves would be to equalize water levels between the hot and cold regions of the primary system, thereby assuring continuous fluid coverage of the core with no adverse consequences.

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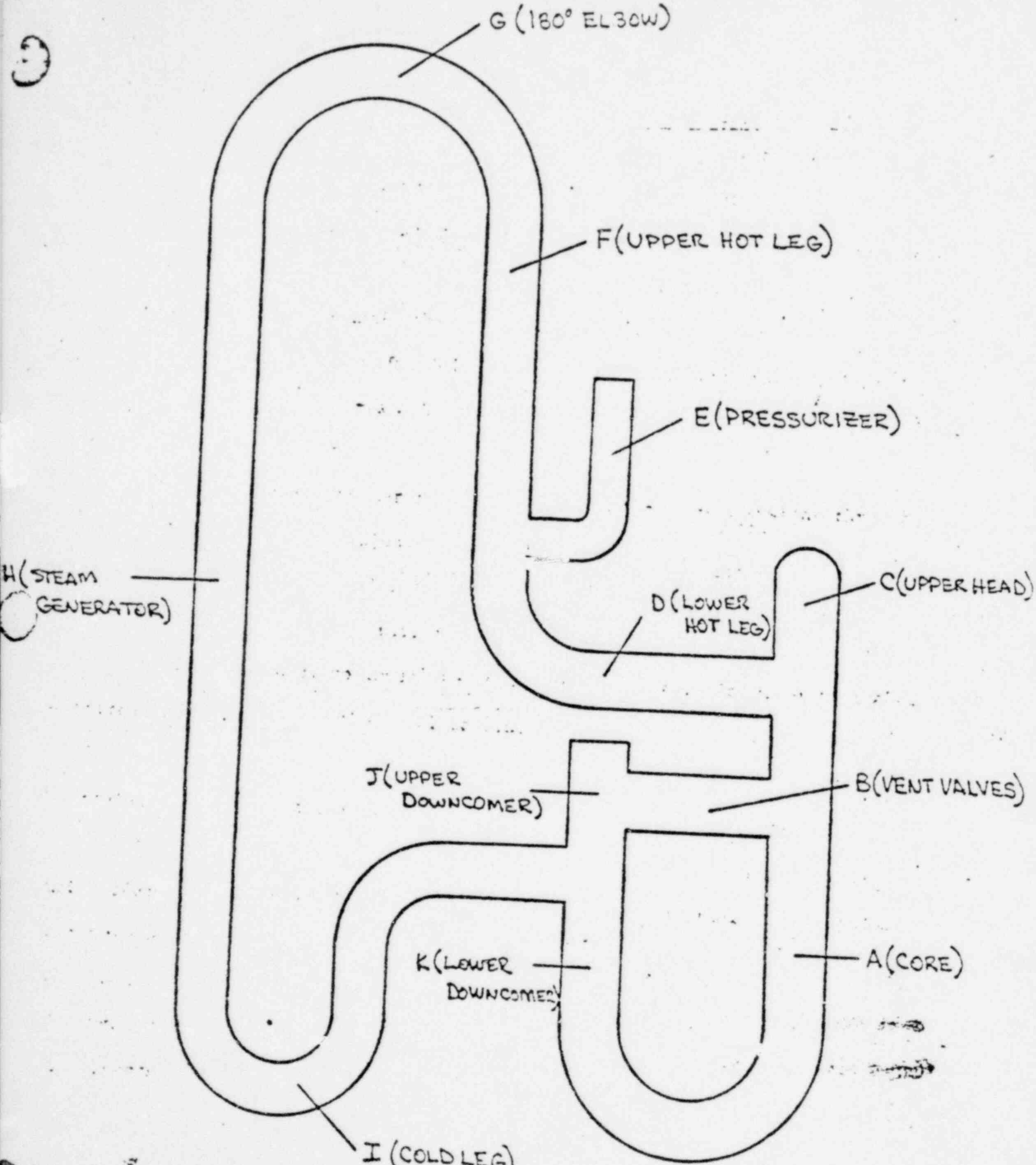
A more detail examination of the fluid conditions surrounding a small LOCA may be helpful. Small LOCA can rightly be viewed as such a slow transient during which, at any particular time, the system is not meaningfully different from steady state. The RCS (reactor coolant system) is then properly described as a sealed manometer. For the B&W system, this manometer is double looped because of the vent valves. Such a manometer is illustrated on the next page with important volumes identified by letters.

Many experiments have been run which show that so long as a fluid (quality less than, say, 70%) covers the core, no adverse core temperature escursion can occur at decay heat power levels (see BAW-10064 etc.). Thus, the problem in small LOCA is to achieve steady mass and ~~energy~~ balances which assure core covery. This means we must achieve mass injection equal to mass loss and energy loss equal to decay heat. B&W carries out computer analysis over a spectrum of break sizes to assure that no core ~~uncovery occurs~~ prior to achieving excess mass injection. Concerns over very small breaks deal with the energy balance once excess injection has been achieved.

For certain small breaks, ($A \lesssim .01A^2$) the steam generator would act as an energy removing device. Initially, a solid flow ~~forced convec~~tion process would control, later a two-phase natural circulation process involving both convection and condensation heat transfer, and finally a pure condensation mode would evolve. In this later mode, ~~fluid levels~~ have fallen to approximately level B, on the diagram, steam is produced in the core through boiling, it travels through D, E and G and is condensed in the lower regions of H. Concerns over the impact of non-condensibles have been examined for this phase. The following points apply.


G (180° ELBOW)
F (UPPER HOT LEG)
E (PRESSURIZER)
H (STEAM GENERATOR)
C (UPPER HEAD)
D (LOWER HOT LEG)
J (UPPER DOWNCOMER)
B (VENT VALVES)
K (LOWER DOWNCOMER)
A (CORE)
I (COLD LEG)

1. Insufficient non-condensibles are available in the initial RCS fluid to block the flow of steam at G. (This is a 3-foot diameter pipe).
2. Heat transfer coefficients with non-condensibles present are sufficient to condense steam in the lower regions of H. (Even if they were momentarily inadequate, this would merely cause a pressure increase and resultant temperature increase until the ΔT compensated for the lower h).
3. The open manometer paths D,F,G,H, and B assure that hydrostatic balances exist between regions H and A and between regions K and A. If these balances do not exist, fluid movement will occur to produce them.

As mentioned, B&W uses computer analysis to follow the LOCA transient through these phases until excess injection is achieved and the system starts to refill.

During the refill a rising water level in region H may eliminate condensing heat transfer. Note that a rise of level in H also means a rising level in K and A. Thus, no immediate core concern exists. Steam pockets will be formed at I and C. If the level continues to rise, a two phase mixture will be forced into D and F. This will occur through the necessity of maintaining a hydrostatic balance with H. However, if condensation has been shut off, the energy balance is no longer maintained. As energy is not being adequately removed from the system, it must repressurize. Two results are now possible.

1. The break flow increases until it removes enough energy or the break removes enough mass to reestablish condensation, or,
2. repressurization continues until energy removal is through the pressurizer relief valve path E.

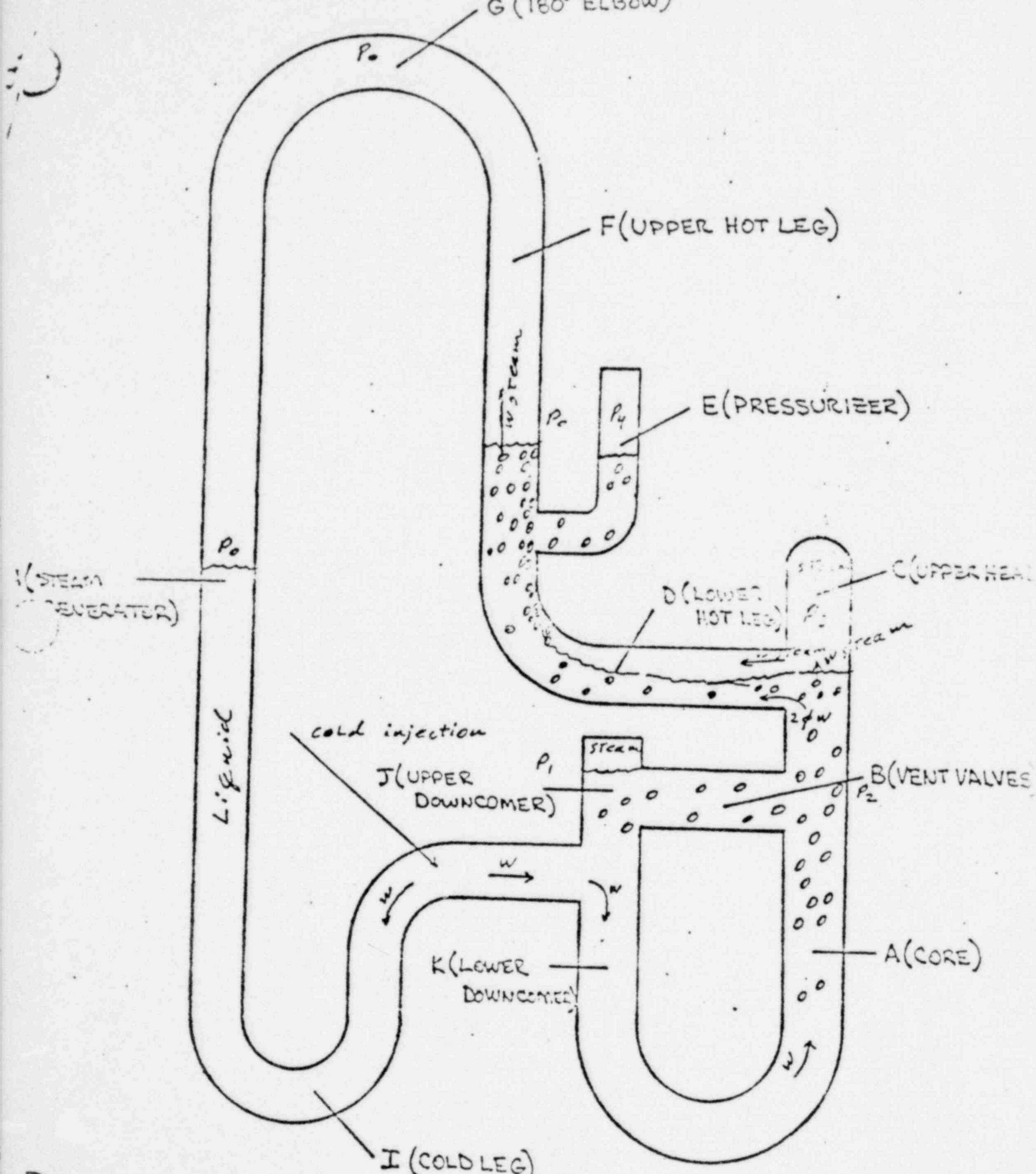
Most likely, result 1 will repeat for several cycles prior to result 2 occurring. In any case, core uncovery cannot occur. Again, if core fluid level is low, then the fluid level in H must be low and condensation is a credible phenomena.

The flow pattern in D, the horizontal section of the hot leg, is of interest during repressurization. This is illustrated in the following diagram along with the pressures within the system. The following hierarchy of pressures exist;

$$P_o < P_3 < P_1 < P_2$$

mainly because of static balances and the two-phase nature of the fluid in the core and hot legs.

Thus, for the entire spectrum of small LOCAs, the B&W system not only assures compliance with the requirements of 10CFR50.46, but eliminates any core temperature excursion whatsoever in excess of 700F.


G (180° ELBOW)
F (UPPER HOT LEG)
E (PRESSURIZER)
C (UPPER HEA
D (LOWER HOT LEG)
B (VENT VALVES
J (UPPER DOWNCOMER)
cold injection
A (CORE)
K (LOWER DOWNCOMER)
I (COLD LEG)
Liquid
steam
STEAM