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CONTAINMENT PRESSURE TRANSIENTS FOLLOWING END-OF-BLOWDOWN

Introduction and Summary

As part of the current ECCS review, a study was initiated by Reactor Systems Branch personnel to determine a representative PWR containment pressure transient following the end of primary system blowdown for a postulated cold leg failure (Task No. 13). A knowledge of the containment pressure following blowdown is necessary for the evaluation of steam binding and heat transfer coefficients derived from the FLECHT test data. Preliminary calculations performed for a typical large PWR with a dry containment indicate that the potential energy addition rate to the containment following the end of blowdown could exceed the energy removal capabilities of the containment engineered safety systems for several hundred seconds when operating on emergency power. The energy is derived from the large expulsion of ECCS fluid during core refilling. The fluid which exits the core is then superheated in the steam generators before discharge from the primary system to the containment atmosphere.

Discussion

The FLECHT test program has demonstrated that much of the ECCS fluid is expelled from the core during the core refilling process. The fluid is evaporated by the hot core surfaces and a significant quantity of water is entrained and carried out with the steam. The test data indicate that approximately eight-tenths of the fluid is expelled and only two-tenths remains behind the quench front (Figure F-1, Westinghouse Testimony for ECCS Hearing, Docket No. RM 50-1). This fluid exits the core mostely as steam and to a lesser degree as droplets of water. The fluid is vented from the system through the cold leg break and is superheated during passage through the steam generators. After the core is refilled, evaporation of the ECCS fluid occurs from the decay heat in the reactor fuel.

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Figure 1 shows the typical energy addition rates to the containment for a large PWR. The input consists of the following three major energy sources:

(1) Primary System blowdown - this input was obtained from a RELAP-3 computer run for a postulated double-ended cold leg break.

(2) Refill energy - the mass and energy addition rates to the containment were obtained as follows:

Mass addition rate = (RV) (MR) (A) ( )

Where RV = refill velocity (2 inches/sec.)

MR = mass ratio: 0 from 0 to 2 ft.*
0.8 from 2 to 10 ft.
0.7 from 10 to 12 ft.

A = core area

= fluid density

This fluid is superheated in the steam generators and has an enthalpy of approximately 1300 Btu/#.

(3) Core decay energy - the core decay energy is assumed to boil-off water in the core; this fluid is also superheated by the steam generators.

The energy removal capability of the containment sprays and fan coolers is approximately 4.5×10^8 Btu/hr when operating on emergency power and 8.1×10^8 Btu/hr when operating on off-site power. In both cases, additional heat removal capability is provided by the containment structures. As illustrated in Figure 1, the energy input rate during core refill significantly exceeds the heat removal capability of the containment assuming only emergency power is available. Containment pressure transients were calculated using the CONTEMPT Code assuming blowdown and decay heat energy sources as indicated above and refill velocities of 2 and 3 inches/second. Typical results are presented in Figure 2 which shows increases in containment pressure above the initial blowdown peak of 7 and 11 psi for the 2 and 3 inches/second refill velocities, respectively.

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* Some evaporation from heat vessel surfaces is assumed during this period.

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A CONTEMPT calculation for the 2 inch/second case indicated a negligible increase in pressure if off-site power is available.

Conclusion

A significant energy addition to the containment occurs during the core refill process following a postulated primary system failure. The energy addition occurs for several hundred seconds and should be considered in containment design analyses.

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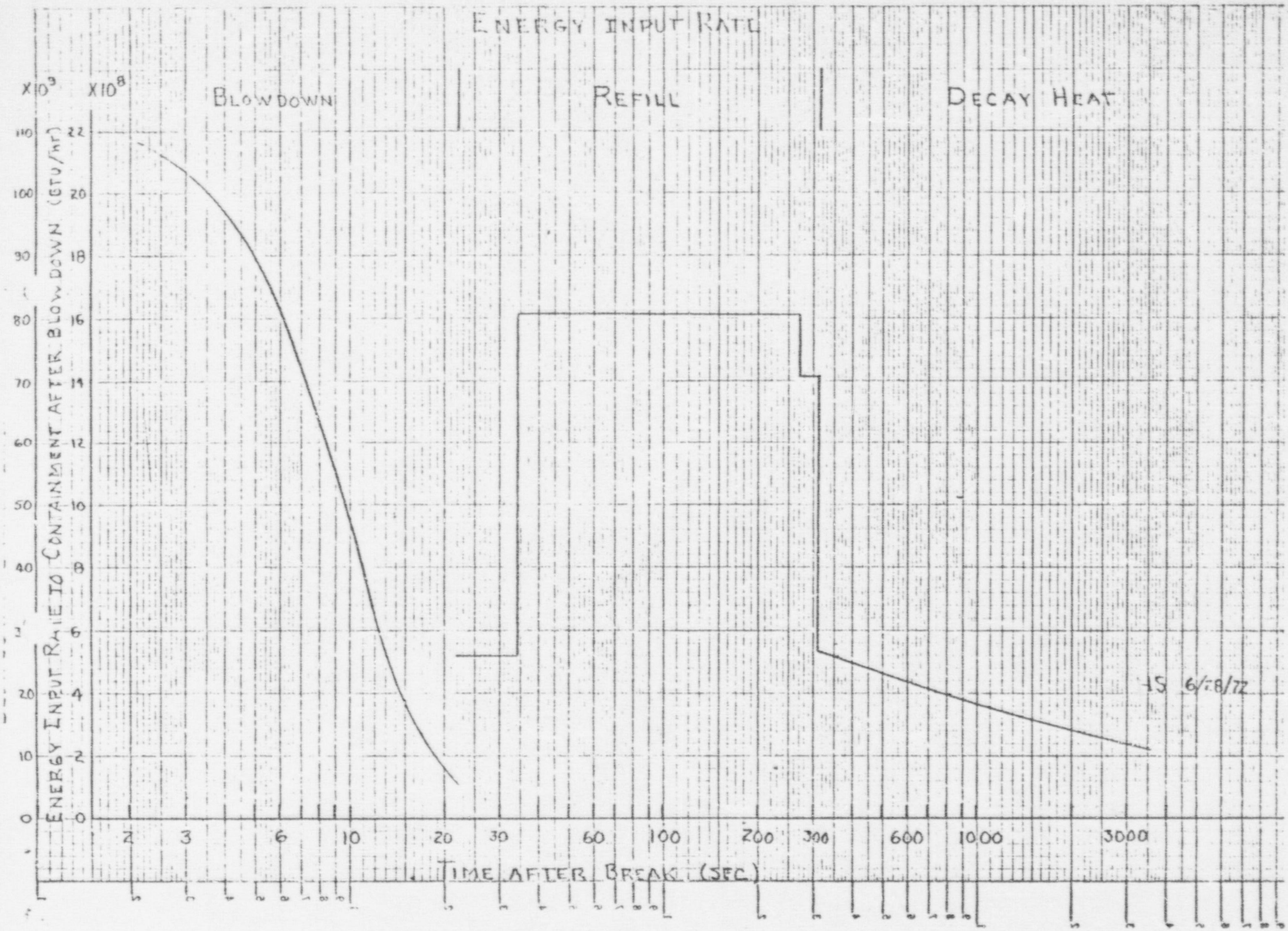
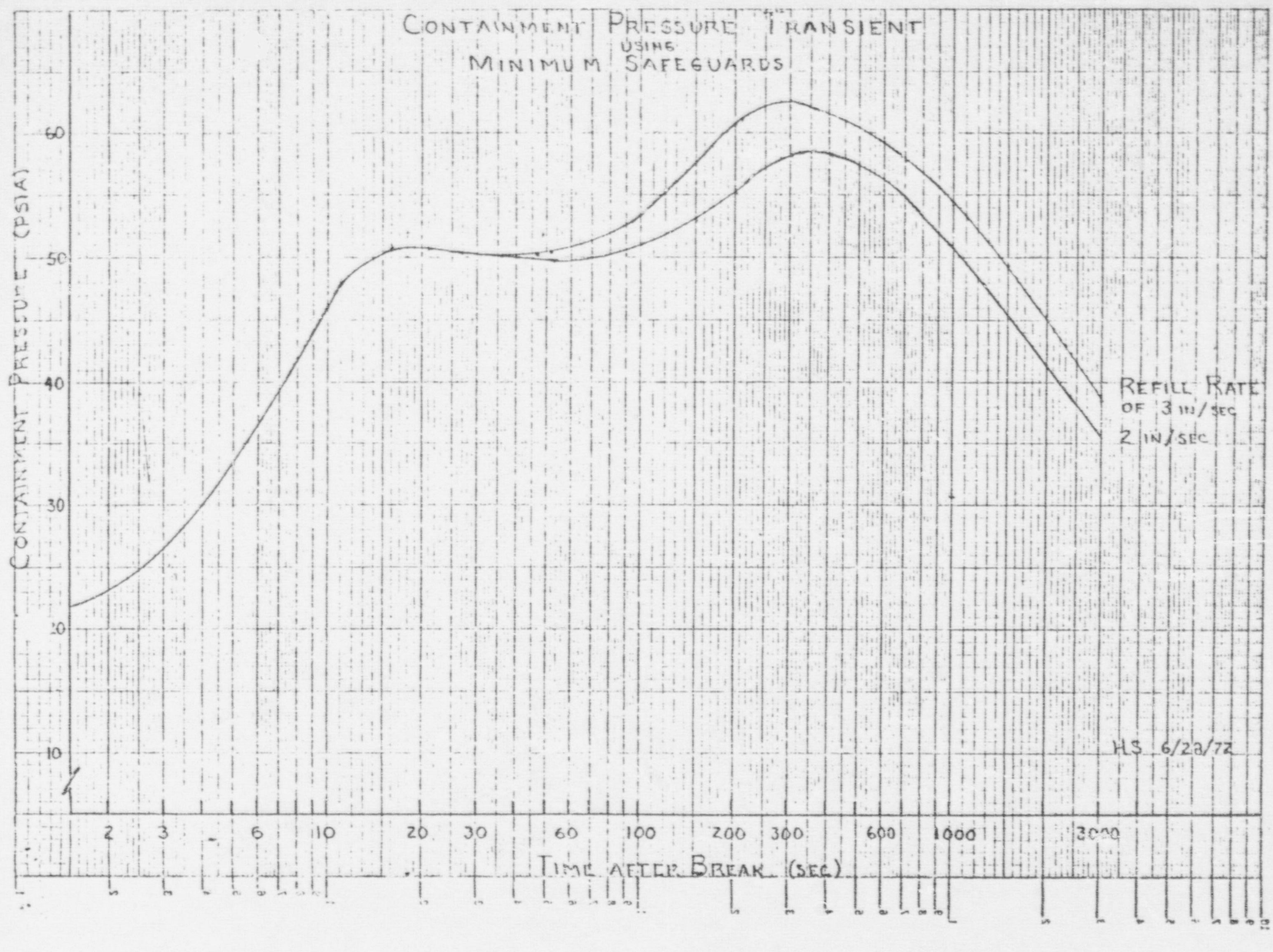


ENERGY INPUT RATE
BLOWDOWN
REFILL
DECAY HEAT
X10^3
X10^8
ENERGY INPUT RATE TO CONTAINMENT AFTER BLOWDOWN (BTU/hr)
110
100
90
80
70
60
50
40
20
10
0
22
20
18
16
14
12
10
8
6
4
2
0
2
3
6
10
20
30
60
100
200
300
600
1000
3000
TIME AFTER BREAK (SEC)
JS 6/8/72



CONTAINMENT PRESSURE TRANSIENT
USING
MINIMUM SAFEGUARDS
CONTAINMENT PRESSURE (PSIA)
60
50
40
30
20
10
2
3
6
10
20
30
60
100
200
300
600
1000
2000
TIME AFTER BREAK (SEC)
REFILL RATE
OF 3 IN/SEC
2 IN/SEC
HS 6/28/72