WESTINGHOUSE EVALUATION OF RVLIS PERFORMANCE AT THE SEMISCALE TEST FACILITY FOR TEST S-IB-1

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The purpose of this report is to present the Westinghouse evaluation of the Reactor Vessel Level Indication System (RVLIS) performance during test S-IB-1 at the Semiscale Test Facility in Idaho Falls, Idaho. The objectives of this test, concerning RVLIS, were to:

1) verify that short term conditions, such as over-ranging during the large pressure transient will not adversely affect the long term performance of the RVLIS and

2) verify that the RVLIS will provide a useful indication of the level in the vessel during the reflooding portion of the transient.

Test S-IB-1 was intended to simulate a 100 percent communicative, cold leg break loss of coolant accident. The experiment incorporated early primary coolant pump trip and normal emergency core cooling injection into the intact loop cold leg. The Semiscale mod-2A system configuration, with the upper internals modified to more accurately model a PWR, was used for this test.

The results indicate that the RVLIS performs as expected during the refilling portion of the transient; that is, the indication follows the trend in level and provides a conservative underprediction of the level in the vessel.

II. Applications of Level Measurements

The Westinghouse Reactor Vessel Level Indication System (RVLIS) was developed to provide:

- a supplemental indication of the approach to inadequate core cooling (ICC)

- a supplemental indication of the effectiveness of operator action to prevent ICC

- an aid to the use of the reactor head vent system.

The RVLIS, together with core exit thermocouples, can be used to indicate the approach to ICC. ICC is defined as a high temperature condition in the core such that operator action is required to cool the core before significant core damage occurs. When the reactor coolant pumps are not operating, the RVLIS narrow-range indication is used. This indication represents the collapsed liquid level in the vessel, which is a conservative indication of the mixture level. A prerequisite of ICC is a mixture level below the top of the core.

The RVLIS indication will be most useful during transients characterized by slowly decaying pressure where appropriate operator action can mitigate the consequences of the event. The RVLIS will not be used by the operator during a large LOCA event to determine the approach to inadequate core cooling. The transient progresses so quickly that the operator would not have time to take any action based on the RVLIS indication. In addition, no operator action is required during the event, since the safeguards systems would actuate automatically to bring the reactor coolant system to a safe condition. The operator is instructed to verify that the automatic functions performed as expected regardless of the RVLIS reading. If any necessary safeguards equipment is not operating, the operator is instructed to take steps to establish operation, regardless of the RVLIS indication. The primary objective of operator action in the Inadequate Core Cooling Procedure Guidelines is to depressurize the reactor coolant system to maximize the ECCS flow delivery and to allow the SI accumulators and low head safety injection to inject. For a large break LOCA, the RCS inherently reaches a pressure that maximizes ECCS flow delivery and allows full SI accumulator discharge and low head safety injection without operator action.

The RVLIS narrow range indication will be useful following a large break transient only as a confirmatory indication of the effectiveness of the automatic safeguards system The operator can use the RVLIS indication to determine if the vessel is refilling and to determine when the core has been recovered.

The RVLIS upper range indication, measuring the level from the hot leg elevation to the top of the vessel, will be used during long-term recovery operations to aid in the use of the reactor vessel head vent. The emergency procedure for operating the head vent requires that the system be returned to a subcooled condition, so any void measured by the upper range would indicate non-condensible gases. Although the indication provides information on voids, the indication is not used for emergency operations until subcooled conditions are reached in the reactor coolant system as indicated by the core exit thermocouples or hot leg RTD's. Since this measurement extends down only to the hot legs, the indication is not used in the ICC procedure. For a large break transient, a stable condition is reached when the level in the core is at the hot and cold leg elevations. The upper range will, therefore, never be used for this event.

III. Test S-IB-1

A. Test Description

After the break initiation, the Semiscale system pressure decreased from the steady state operating pressure of approximately 15.5 MPa to a pressure of less than 0.5 MPa. This blowdown occurred in approximately 50 seconds. During this time the system inventory was drastically depleted. The level of liquid in the vessel dropped below the bottom of the active fuel.

At the end of the blowdown, the system pressure stabilized. The system was slowly refilled until the test was terminated at approximately 8 minutes.

The standard RVLIS configuration was used for this test; the narrow and wide range DP's were measured from the top of the vessel to the bottom of the vessel and the upper range ΔP was measured from the top of the vessel to the hot leg. In PWR applications the RVLIS output will be displayed in terms of percent of span. In this report the RVLIS output is presented in units of centimeters above or below the cold leg pipe elevation.

The RVLIS measures the differential pressure across a given span. This differential pressure is compensated for coolant density to determine the equivalent collapsed liquid level. A more detailed description of the RVLIS is available in Reference 2.

The Semiscale Facility instrumentation measures level or fluid inventory with differential pressure instruments and gamma densitometers. The locations of the RVLIS pressure taps, the Semiscale pressure taps, and the densitometers are shown in Figure 1.

B. Comparison of RVLIS and Semiscale Measurements

A comparison of the RVLIS narrow range indication and the level determined from the Semiscale differential pressure measured from just below the cold leg elevation to the bottom of the vessel is shown in Figure 2. There are differences between these two measurements early in the transient due to the rapid pressure fluctuations in the vessel, in addition to the difference in the measurement spans. This behavior was expected during the blowdown and is not important in evaluating the RVLIS since the RVLIS will not be used during the early stages of a large break transient. After approximately 100 seconds the agreement between the two indications is good. This indicates that conditions in the upper portion of the vessel (flows and water level) do not significantly affect the RVLIS indication during the refill transient.

A comparison of the RVLIS narrow range indication and the gamma-densitometer recovery times is shown in Figure 3. This comparison shows that, except for fluctuations in the indicated two-phase level early in the transient, the RVLIS gives a good indication of the vessel mixture level. The RVLIS collapsed liquid level indication accurately follows the trend in the vessel two-phase mixture level and consistently under-predicts the actual level.

These comparisons indicate that the RVLIS will provide useful information during the refilling portion of a large break transient.

References

1. Stephens, A. G., "Experiment Operating Specification for Semiscale MOD-2A Experiments S-I-B-1 and S-I-B-2." EG&G, EGG-SEMI-5722.

2. Westinghouse Electric Corporation, "Westinghouse Reactor Vessel Level Indicating System for Monitoring Inadequate Core Cooling." December 1980.

3. Westinghouse Electric Corporation, "Westinghouse Evaluation of RVLIS Performance at the Semiscale Test Facility." December, 1981.

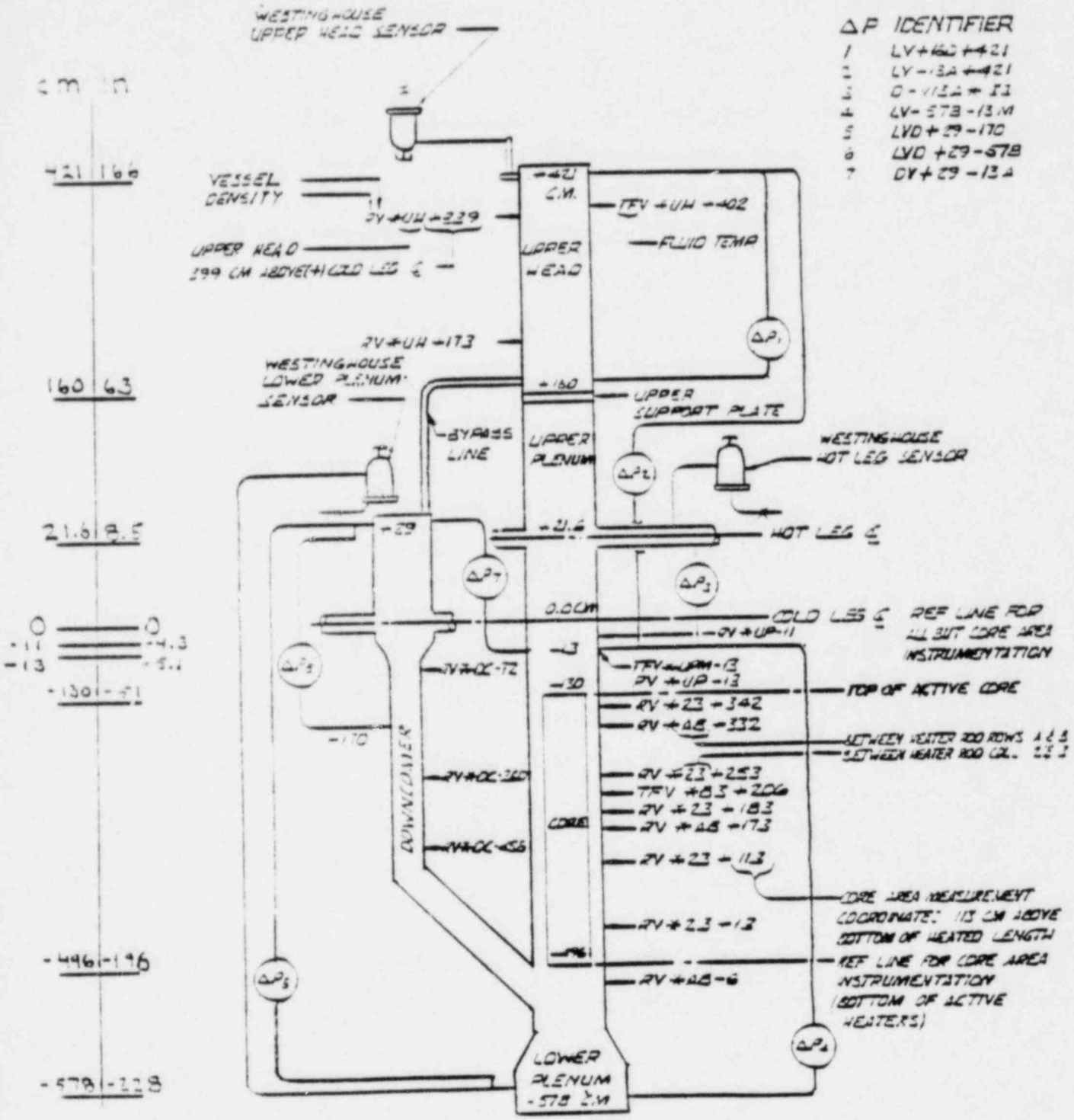

Figure 1. Locations of RVLIS and Semiscale differential pressure measurements and Semiscale densitometer measurements.

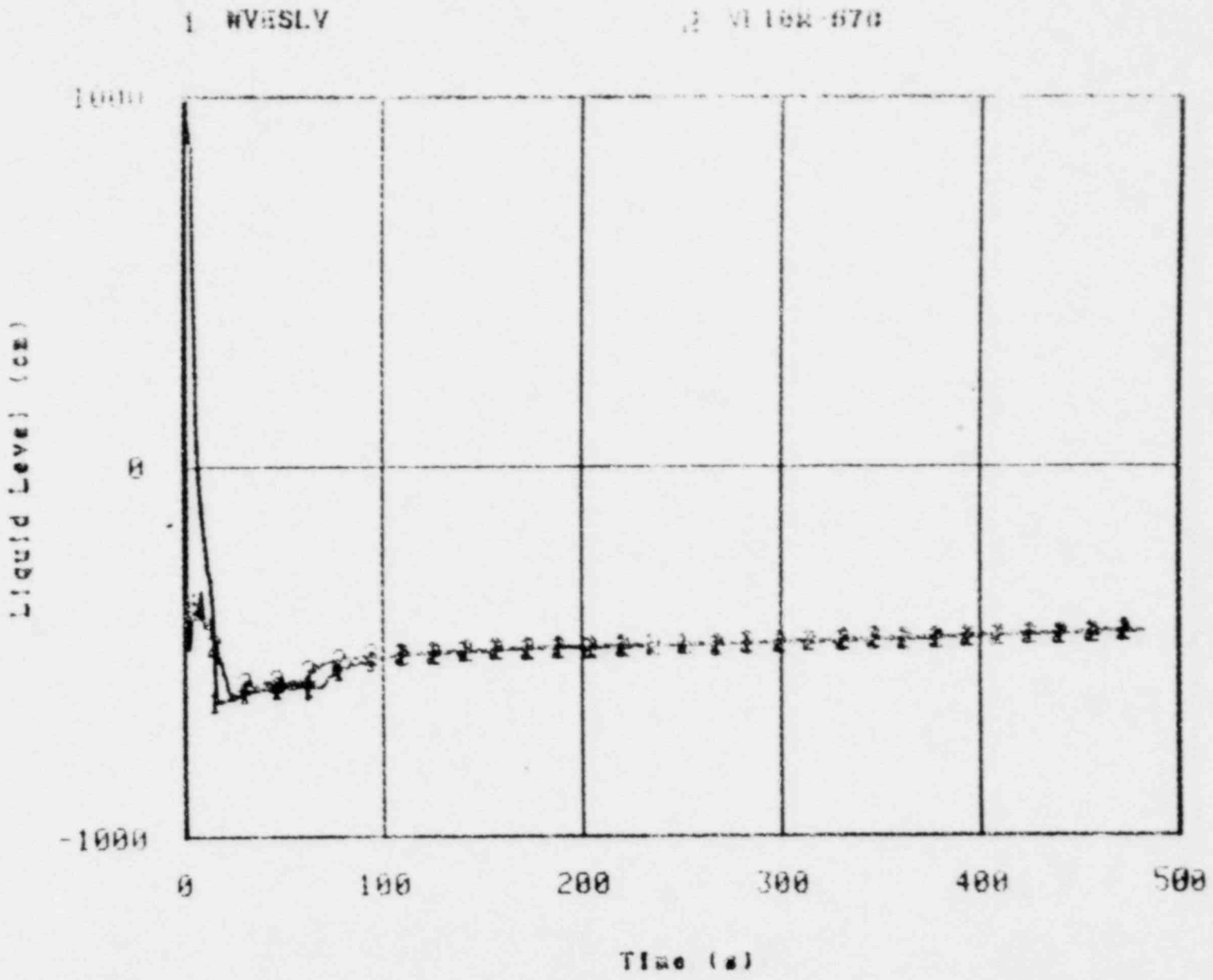

Figure 2. Comparison of RVLIS narrow range indication with Semiscale measurement VL13M-578 (ΔP_4)

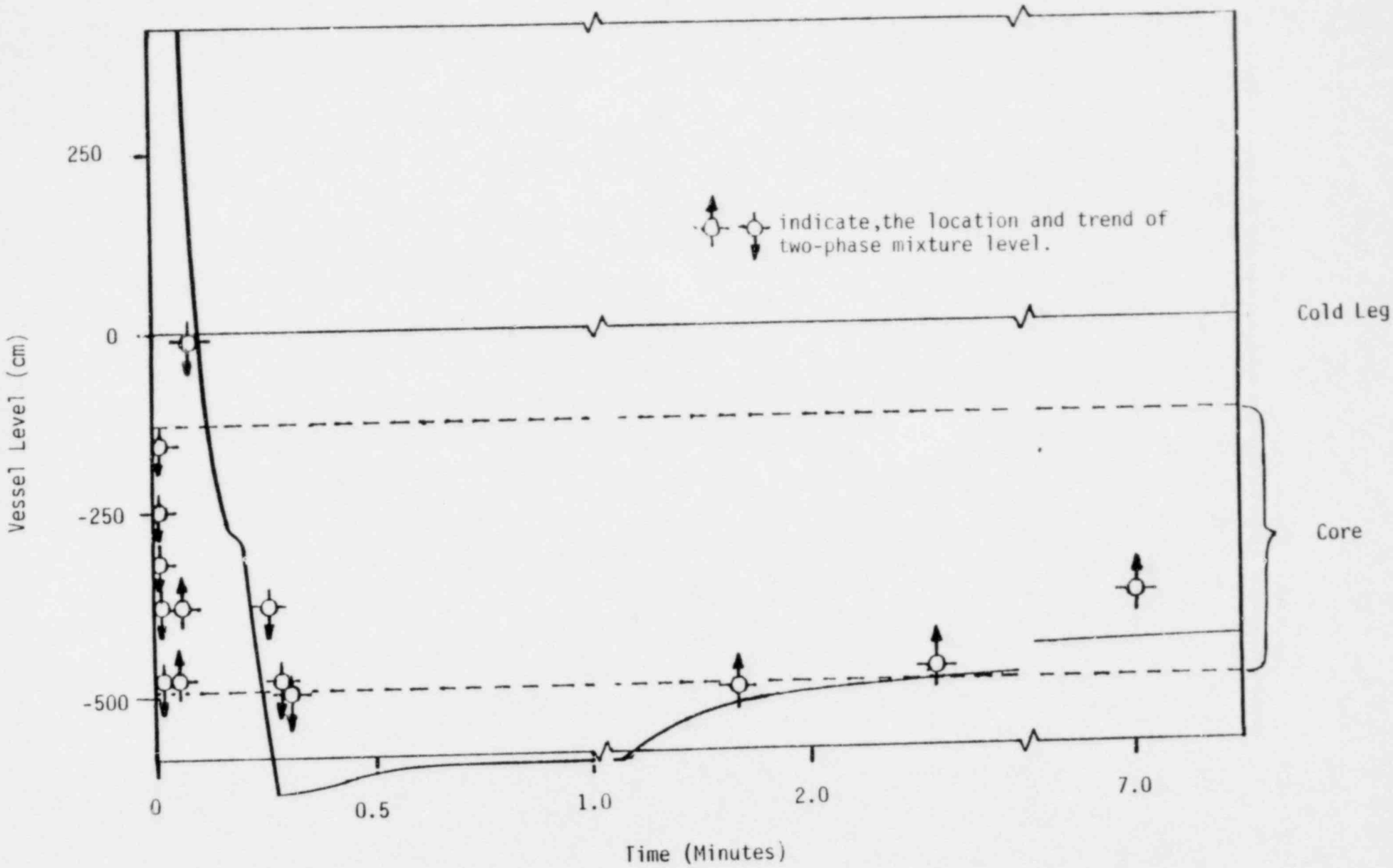

Figure 3. Comparison of RVLIS narrow range indication with two-phase mixture level determined from densitometer readings.