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JAY E. SILBERG, P.C.

December 17, 1982

Docketing and Service Section
Office of the Secretary
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: The Cleveland Electric Illuminating Co. (Perry Nuclear Power Plant, Units 1 and 2); Docket Nos. 50-440 and 50-441

Gentlemen:

On December 13, 1982, Applicants filed their Answer to Ohio Citizens for Responsible Energy Eighth Set of Interrogatories to Applicants, accompanied by an Affidavit of Kenneth A. Matheny. On December 13, 1982, Applicants filed their Answers to Sunflower Alliance, Inc. *et al.*, Second Set of Interrogatories, Nos. 20, 28 and 31, accompanied by an Affidavit of Robert A. Stratman. On December 15, 1982, Applicants filed their Answer in Support of NRC Staff's Motion for Summary Disposition of Issue No. 4, accompanied by an Affidavit of W. A. Sutherland. Each of the affidavits submitted was a facsimile copy. Enclosed are the signed originals of the affidavits of Messr. Metheny, Stratman and Sutherland.

Very truly yours,

Jay E. Silberg

JAY E. SILBERG
Counsel for Applicants

cc: service list (w/enc.)
Enclosure
JES:lam

DS03

THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

CLEVELAND, OHIO

Kenneth A. Matheny, being duly sworn according to law, deposes that he is Senior Engineer, Nuclear Engineering, of The Cleveland Electric Illuminating Company and that the facts set forth in the foregoing Applicant's Answers to Ohio Citizens for Responsible Energy Eighth Set of Interrogatories 8-1 through 8-8 dated November 12, 1982, are true and correct to the best of his knowledge, information and belief.

Kenneth A. Matheny

Sworn to and subscribed

before me this 10th day

of December, 1982

Joanne Kilvinskas

[illegible] Notary Public

State of Ohio - Lake County

My comm. exp. Nov. 12, 1983

THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

CLEVELAND, OHIO

Robert A. Stratman, being duly sworn according to law, deposes that he is General Supervisor, Nuclear Services Section of the Cleveland Electric Illuminating Company and that the facts set forth in the foregoing Applicants' Answers to Sunflower Alliance, Inc. et al, Second Set of Interrogatories, Nos. 20, 28 and 31, dated December 13, 1982, are true and correct to the best of his knowledge, information and belief.

Robert A. Stratman

Sworn to and subscribed
before me this 13th day
of December, 1982

Joanne Rabinsras

Notary Public
State of Ohio - Lake County
My comm. exp. Nov. 12, 1983

December 15, 1982

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
THE CLEVELAND ELECTRIC ILLUMINATING COMPANY, et al.	)	Docket Nos. 50-440 50-441
	)	
(Perry Nuclear Power Plant, Units 1 and 2)	)	

AFFIDAVIT OF W. A. SUTHERLAND
IN SUPPORT OF NRC STAFF'S MOTION
SUMMARY DISPOSITION OF ISSUE NO. 4

W. A. Sutherland, being duly sworn, deposes and says as follows:

1. I, W. A. Sutherland, am manager of the LOCA Systems Technology organization of the General Electric Company. My business address is 175 Curtner Avenue, San Jose, California 95125. A summary of my professional qualifications and experience is attached hereto as Exhibit "A". I have personal knowledge of the matters set forth herein and believe them to be true and correct.

2. I have reviewed the NRC Staff's Motion for Summary Disposition of Issue No. 4, dated November 5, 1982, and supporting documents, including the Affidavit of S. B. Sun in Support of Summary Disposition of Issue #4. I agree with the statements contained therein and give this affidavit in support of the Staff's motion.

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I. SUMMARY

2. Issue 4 states:

> The safety of the Applicant's emergency core cooling system has not been demonstrated with appropriate experimental data because a full scale 30 degree sector steam test has not been performed.

3. The Special Prehearing Conference Order questioned whether the 30° sector steam test was required by 10 CFR Part 50, App. K, § I.D.6. Appendix K does not require a full scale 30° sector steam test. Section I.D.6 of Appendix K states: "Following the blowdown period, convective heat transfer shall be calculated using coefficients based on appropriate experimental data". The tests providing the basis for these convective heat transfer coefficients are documented in APED-5529, "Core Spray and Core Flooding Heat Transfer Effectiveness in a Full-Scale Boiling Water Reactor Bundle", June 1968. The 30° sector steam tests do not address convective heat transfer coefficients. They do, however, confirm the core spray design methodology.

4. Two of the emergency core cooling systems in the BWR, in addition to simply replenishing water, use spray nozzles to distribute the water across the top of the core. In 1974 it was found that the spray distribution from some spray nozzles may not be the same in a steam environment and in an air environment. To address this effect, General Electric developed a core spray design methodology that measures the effect of steam, and factors the effect into the optimization of the core spray sparger design.

This methodology was used in the design of PNPP spargers. Further, to demonstrate the adequacy of this methodology, General Electric proposed the full scale 30° sector steam test. The NRC concurred with this approach in TAP A-16 and subsequently, based on the results of the tests, approved the methodology in a letter from R. L. Tedesco to G. G. Sherwood, dated January 30, 1981.

II. BACKGROUND

5. A General Electric BWR, such as Perry, has multiple safety systems that provide water to cool the core in the event of a loss-of-coolant accident (LOCA). Two of these systems are core sprays: one a high pressure core spray (HPCS) system and the other a low pressure core spray (LPCS) system. The HPCS supplies coolant over the entire range of system pressure. Its purpose is to maintain reactor vessel liquid inventory for "small breaks", which do not result in depressurization of the reactor vessel, and to distribute liquid across the top of the core as well as to replenish liquid inventory when the system pressure has been reduced to a lower level. The LPCS, an independent system to the HPCS, distributes liquid across the top of the core as well as replenishing liquid inventory when the system pressure has been reduced to a lower level.

6. Prior to 1974, full-scale mock-ups of the BWR/2 through BWR/5 type core spray sparger assemblies (i.e., the spray nozzles,

headers, and piping) were tested in an air environment at the General Electric Vallecitos Nuclear Center. These tests showed that all spray sparger designs provided adequate core spray distribution.

7. In 1974, tests of single nozzles in a steam environment, performed by a European licensee of General Electric, showed that condensation affects the distribution from some spray nozzle types. General Electric performed additional single nozzle tests in steam, as well as multiple nozzle tests in air, to further study the condensation effects and the effects of steam on spray sparger designs. One of the early results from these investigations was the identification of spray nozzle characteristics, i.e., drop size, distribution leaving the nozzle, etc., that are affected by steam condensation. Candidate nozzle types were selected for the BWR/6 designs that had a minimum sensitivity to condensation. The results of these studies were submitted to the NRC in 1977.

8. A Safety Evaluation Report (SER) was issued by the NRC in 1978 which outlined and concurred with the General Electric approach for developing the core spray design methodology for designing BWR/6 core spray spargers. The core spray design methodology for obtaining and utilizing the information from air environment tests and steam environment tests was confirmed by the 30° sector steam tests and approved by the NRC in January 1981.

III. GENERAL ELECTRIC CORE SPRAY DESIGN METHODOLOGY

9. The General Electric core spray design methodology predicts spray distribution performance of multiple-nozzle core spray systems operating in a steam or air environment. Measurements of single nozzle spray distribution in steam and measurements of single and multiple nozzle spray distributions in air are utilized to account for the thermodynamic effects due to steam condensation and the hydrodynamic effects due to flow field interaction in the design of core spray sparger assemblies. The design methodology investigates steam condensation effects and spray interaction effects separately, and then predicts the combined effects on overall spray distribution. This approach is possible because the condensation primarily takes place close to the nozzles (less than about 6") where the spray flow fields are not intersecting, and the interaction takes place away from the nozzles (greater than 6") in the "hydrodynamic" region, where the spray flow fields are interacting. Condensation occurs at a high rate in the film region near the nozzle exit, before the breakup of the spray into drops, while little condensation occurs on the droplets in the hydrodynamic region, where the condensation rate is relatively slow. Therefore, the local steam velocity induced by condensation in the hydrodynamic region is very small and has negligible influence on spray drop trajectories.

10. The spray distribution from each nozzle type is measured in a steam environment with representative flow rates and aiming angles, and the characteristic nozzle parameters correlated (e.g., distribution at the nozzle face, cone angle, distribution at the top of the core, etc.). A similar nozzle is then developed for each nozzle type which provides a spray distribution in air environment similar to the reactor nozzle spray distribution in steam.

11. Full scale 360° mock-up tests, run in an air environment with the reactor nozzles, verify the hydrodynamic performance of the spray sparger assembly and demonstrate the spray distribution for a non-condensing environment. The full scale test is repeated with simulator nozzles to determine the hydrodynamic performance of the spray flow field when the nozzle parameters have been affected by a condensing environment. The hydrodynamic multiple nozzle interaction redistribution effect is determined by comparing the idealized spray distribution for the assembly with the measured distribution.

12. The individual nozzle characteristics data and the multiple nozzle interaction redistribution data are then utilized for final optimization of system performance in steam. To confirm the methodology, spray performance for a full-scale 30° sector system was predicted and compared with measurements made in a steam environment in the General Electric Steam Sector Test Facility (SSTF) at Lynn, Massachusetts in 1979.

IV. SSTF TESTS

13. The purpose of the Lynn Steam Sector Test Facility (SSTF) tests is confirmation of the General Electric core spray design methodology for LOCA conditions during which the spray distribution system is designed to distribute liquid across the top of the core. The conditions, a saturated steam environment in the upper plenum region, are accurately represented in all SSTF tests. These tests are described in detail in NEDO-24712, "Core Spray Design Methodology Confirmation Tests", August 1979.

14. To verify the separability of the hydrodynamic and thermodynamic effects, and confirm the methodology, it is necessary to test over a distance of only about two or three feet from the spargers. However, the SSTF was sized to provide a spray distribution as representative of a full 360° core spray distribution as possible. Before design of the facility, tests were run with various sector sizes which showed that spray distribution is sensitive to sector size only for the center two feet of the core, an area where little (if any) condensation effects occur. Since the core center region cannot be modelled by any sector size short of 360°, 30° was selected for the SSTF design.

15. The SSTF is a 30° segment representation of the BWR/6-213 size (624 bundle) reactor (Figure 1). The upper plenum is a full-scale mock-up of a 30° sector of the reference reactor,

with the geometric shape, shroud head curvature, and height accurately simulated. Steam separator standpipes extend upward from the shroud head. The upper and lower core spray spargers are full-scale mock-ups of the HPCS and LPCS spargers with regard to size, curvature, location and nozzles. (Since other ECCS systems neither use core sprays nor affect the performance of the HPCS and LPCS sprays, such other systems did not have to be included in the tests.) The core region is full-scale in cross-section, but approximately 5 feet shorter than the reactor due to overall facility height limitations. This shortened core mock-up does not effect the vapor flow paths or the spray distribution in the upper plenum. Fifty-eight simulated 8x8 fuel bundles are used in the 30° sector, including 42 complete bundles and 16 partial bundles. The partial bundles have cover plates and baffles to define the 30° boundary within a partial bundle.

16. The individual bundles utilize production hardware for channels, channel fasteners, spacers, upper tie plates, and lower tie plates. Upper fuel rod simulation includes production expansion springs, end plugs, locking tab washers, hexagon nuts and one fuel rod spacer. A steam injector is provided in each bundle to deliver steam simulating vapor generation. A weir tube device for measuring downward water flow is also provided in each bundle.

17. The bypass region outside the channels is simulated, including dummy control rods, the tcp fuel guide, and the core plate. There are twelve volume scaled guide tube regions, one for each of the centrally located fuel supports. The lower plenum volume is scaled to match the reference reactor lower plenum region outside the guide tubes. The elevation of the jet pump inlet and outlet, and the height of the steam separator stand pipes above the shroud head, in relation to the core height and the fuel support casting orifice location, are matched to the reference reactor.

18. The results from the 30° sector steam tests confirmed the core spray design methodology which has been used to design all BWR/6 systems.

V. SSTF TEST RESULTS COMPARED TO THE PRE-TEST PREDICTION

19. A pre-test report was submitted to the NRC in which the bundle flows along the centerline of the sector were predicted. In addition, acceptance criteria for methodology confirmation were supplied in the form of 95% confidence level uncertainty bands. Confirmation was defined as 95% of the measured channel flows falling within these two-sigma uncertainty bands of the predicted flows. Measured channel flows falling anywhere within these uncertainty bands would provide adequate core cooling. Indeed, test data show that for all conceivable steam flow rates, there would be adequate core cooling in BWR/6's even if all core spray water bypassed the fuel rods.

This means that core spray distribution is of no safety significance.

a. LPCS - The measured centerline data are plotted in Figure 2 along with the pre-test prediction and the two-sigma uncertainty bands. The data points all fall within the bands. This agreement between the predicted and measured spray distribution satisfies the criteria and confirms the methodology and assumptions.

b. HPCS - The first pre-test prediction for the HPCS did not include values at the 27, 33 and 39 inch radius because independent single nozzle test results for one of the nozzles could not be obtained prior to submitting the report to the NRC. To overcome this limitation on the range of the prediction, single nozzle tests of this nozzle were subsequently performed and the data used to extend the pre-test prediction. The resulting prediction, shown in Figure 3, agrees with the 30° SSTF data and further confirms the prediction methodology.

V. CRITICISMS OF 30° SECTOR STEAM TEST

20. Intervenors have raised a number of questions and criticisms of the 30° sector steam test during the discovery process. None of these raise any substantial issues regarding the validity of the tests or of GE's core spray design methodology.

a. Tests conducted in Japan supposedly call the GE program into question. In December 1981 the NRC stated that core spray distribution tests, designed to simulate a BWR/5 type, had been run in Japan. However, although spray sparger assemblies are similar in various BWR types, for the BWR/6 type (including PNPP), the spray nozzles in the core spray system were selected to have a minimum sensitivity to condensation and the sparger assembly design optimized for spray distribution in a steam environment. As a result, BWR/6 spray sparger assemblies have unique differences from those used in a BWR/5. Therefore, the Japanese test results are not applicable to PNPP.

b. GE's report on the 30° sector tests (NEDO-24712) is quoted to support the argument that the tests did not accurately model the center two feet of the core. Intervenors also cited a December 11, 1981 memorandum to the Shoreham ASLB from R. L. Tedesco for its language that "the Lynn test data are believed to be atypical of a BWR 360° configuration". The 30° sector tests are "atypical" due to the fact that the center two feet only received water from the sprays of the 30° sector being modeled. This "atypicality" is conservative in that in the actual 360° core, the nozzle spray patterns converge and overlap in the center two feet, thus increasing the flow in the central region. This increase does not occur in the sector test. The tests thus conservatively understated the amount of water reaching the center two feet of the core. Although the sector test did not duplicate the center two feet of the core, this region was modelled by GE's core spray methodology and validated in the 360° tests.

c. The intervenors question the applicability of the SSTF to Perry since the SSTF was modelled after a 218-inch core while Perry has a 238-inch core. The SSTF was intended to confirm GE's core spray methodology, and it did.

That methodology was applied to the 238 size installed at Perry. The SSTF was not intended to test each specific core size; nor was such a test necessary.

d. The intervenors ask whether the tests adequately addressed such core-wide phenomena as swirling and vortex. Vortex and swirling were investigated in full scale 360° mock-up tests with both reactor and simulator nozzles and found not to be present in BWR core spray sparger designs. Therefore, there was no need to specifically include an analysis for these effects in the 30° sector steam tests.

e. The intervenors questioned whether the effects of non-condensible gases had been accounted for. Although non-condensible gases may be present in the later (lower pressure) stages of certain accident conditions, they are not present in the early time period for which core spray distribution in a steam environment would be required. The affect of non-condensible gases is to stop condensation of steam by the spray near the nozzles, with the result that the spray distribution is the same as it is in an air environment. The full size flow tests with reactor nozzles provide the distribution results for this situation.

f. The intervenors indicated that the tests did not evaluate steam flows greater than 20,000 pounds per hour. Such conditions did not have to be evaluated in the 30° sector steam tests. A steam flow rate exceeding 240,000 lb/hr (i.e., 20,000 lb/hr in a 30° sector) provides adequate core cooling in and of itself, obviating the need for distribution of liquid across the top of the core by the core sprays.

g. The intervenors claimed that the maximum pressure of 73.5 psia used in the test was too low since higher pressures can occur during accidents. The BWR core spray system is not needed for pressures greater than 73.5 psia. At such pressures, two phase froth buildup will occur. Two-phase froth build-up provides liquid to all bundles and, therefore, adequate core cooling.

h. The intervenors questioned whether varying gas temperatures had been adequately accounted for in the 30° sector steam test.

The varying gas temperatures that might be encountered during accident conditions will not affect core spray distribution, because they do not affect the non-condensible gas effect of stopping condensation. Therefore, they need not have been included in the 30° sector steam tests. The same holds true for consideration of the thermal properties of hydrogen, another issue raised by intervenors.

i. The intervenors claimed that the 30° sector steam test had not modelled the bypass region steam flow. The lack of bypass region steam flow in the 30° sector steam tests allows spray drops to fall more easily into the bypass than into the bundles at the higher core steam updraft rates. As a result, the measured spray flow in the bundles is slightly lower than would be the case if bypass region steam flow were included. The lack of bypass region steam flow thus adds conservatism to the test results.

j. The intervenors have asked questions about the counter-current flow limiting (CCFL) phenomenon. The CCFL phenomenon controls the amount of liquid entering the core from the upper plenum when there is steam flowing up through the core. The experimental basis for the spray heat transfer coefficients in the bundle includes tests in which CCFL is present at the top of the bundle. During depressurization the core spray systems deliver more liquid to the upper plenum than flows into the top of the core. The excess liquid accumulates as a two-phase mixture that extends across the upper plenum making liquid available at the top of every bundle. Two-phase froth buildup refers to this liquid continuous flow regime, which is characterized by steam bubbles in a continuous pool of liquid. The design pressure range for the core spray distribution extends up to 73.5 psia, since at pressures above this, the two-phase froth build-up provides liquid to all bundles and, therefore, adequate core cooling.

k. The intervenors stated that GE had not justified the assumption that one-half of the Appendix K core spray heat transfer coefficients can be used when spray flow is below the minimum design flow. As shown in the NRC's 1978 Safety Evaluation Report, this assumption only applies to BWR/4 and BWR/5 reactors. For BWR/6 reactors such as Perry, this assumption is not made.

l. The intervenors claim that no information was provided on the investigation of interaction between entrained water droplets and the core spray. Any effect of entrained water droplets in the steam environment is present in the tests as a result of the interaction of liquid falling into the bundles and the core steam updraft. In the SSTF tests, the effect of core steam updraft on spray distribution was found to be negligible at steam flow rates up to approximately 20,000 lb/hr. As noted above, at steam flow rates above 20,000 lb/hr, core spray distribution is not needed to provide adequate core cooling.

m. The intervenors stated that information on the size of the steam condensing region around a nozzle is incomplete, specifically with respect to the Staff's report that 25% of the total steam condensation may occur in the "hydrodynamic" region. Although some condensation does occur in the hydrodynamic region, the rate at which condensation occurs in this region is so slow that it does not effect the distribution of core sprays.

VI. CONCLUSION

GE's core spray methodology has conservatively bounded the conditions in which the core sprays would be required to function. The 30° sector steam test demonstrates that the methodology is an appropriate basis for the design of the Perry core sprays.

W A Sutherland

W. A. SUTHERLAND

Subscribed and sworn to me this 14th day of December, 1982.

Ruthe M. Kinnamon

NOTARY PUBLIC

My commission expires:

April 26, 1985

OFFICIAL SEAL
RUTHE M KINNAMON
NOTARY PUBLIC - CALIFORNIA
SANTA CLARA COUNTY
My comm. expires APR 26, 1985

175 Curtner Avenue, San Jose, CA 95125

EDUCATION AND PROFESSIONAL QUALIFICATIONS
WILLIAM A. SUTHERLAND

Dr. Sutherland has been engaged in reactor technology in the areas of heat transfer and thermal hydraulics for the past 25 years, and has been with General Electric since 1959. In his present position, he is responsible for planning and specification of reactor safety experiments with the Full Integral System Test (FIST) Facility and for utilization of test results from this, and other programs in qualifying large computer models for safety analysis.

From 1975 until March, 1981, he was manager of the Thermal Development Unit. During this period, responsibilities included core spray design methodology development, testing of spray nozzles in steam and air environments to support the BWR/6 designs, and the methodology confirmation test program at the Sector Steam Test Facility (SSTF), carried out in 1979. He was also responsible for the Refill/Reflood Program testing in SSTF during 1980 and 1981.

Prior to 1975, Dr. Sutherland held managerial and project management positions in a number of reactor safety programs.

Dr. Sutherland received his B.S., M.S., and Ph.D. degrees in Mechanical Engineering from Stanford University. He has authored several technical papers on heat transfer, reactor core performance, and reactor safety. He is a member of the American Society of Mechanical Engineers, and is a registered professional engineer in California.

30° Steam Sector Test Facility

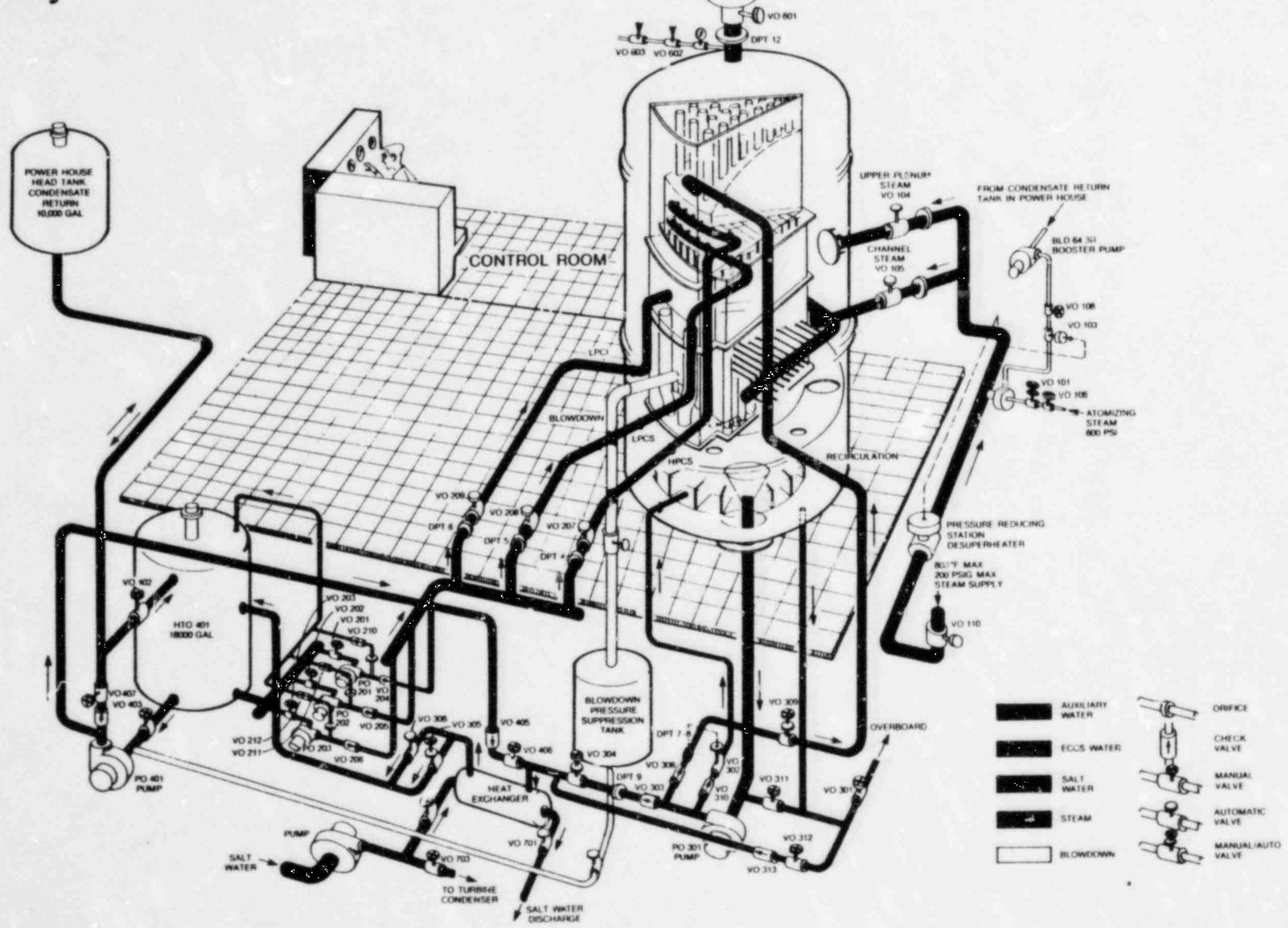

Figure 1

Figure 1

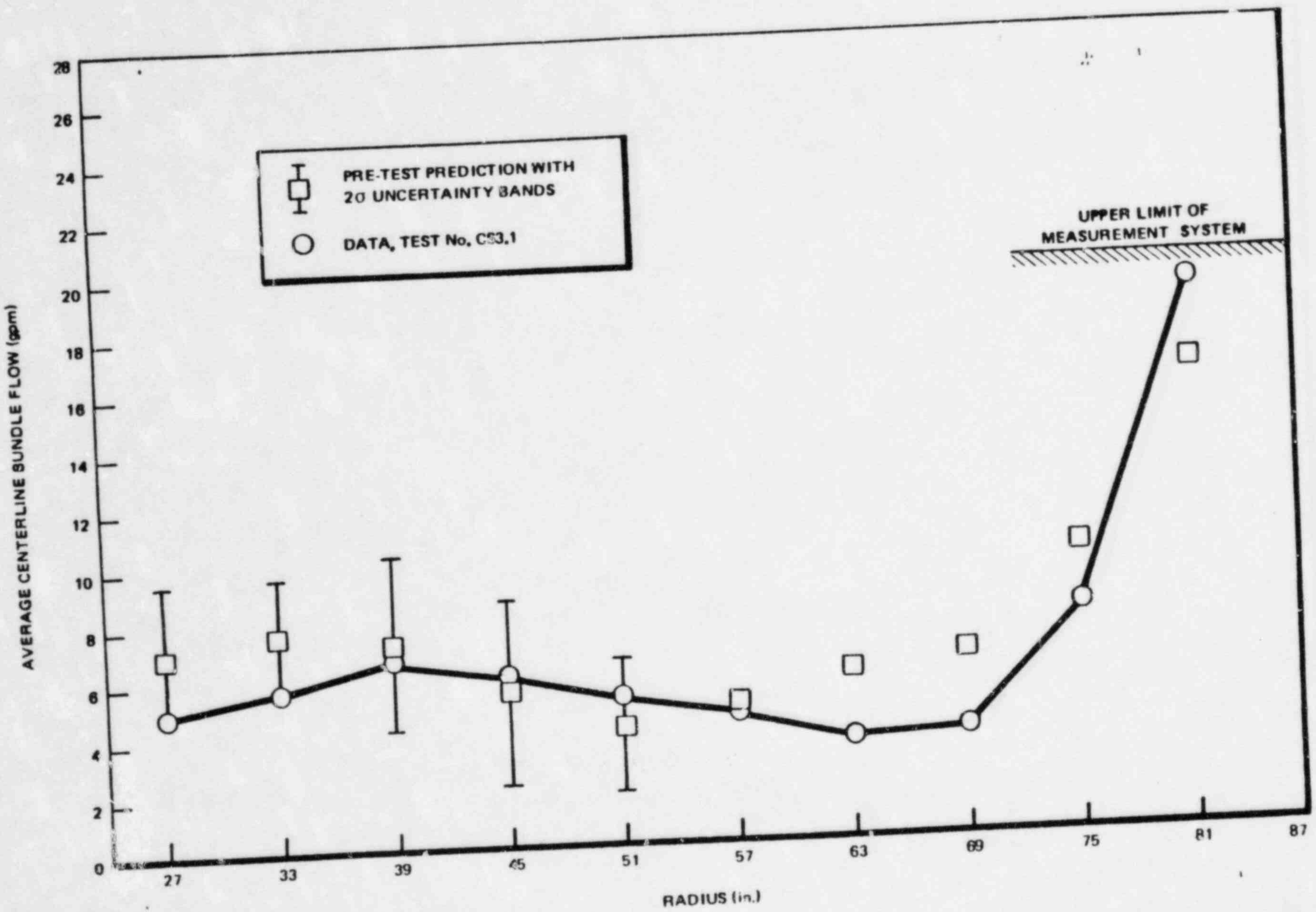

Figure 2 Comparison of SSTF Data to Pre-Test Prediction for LPCS Operation

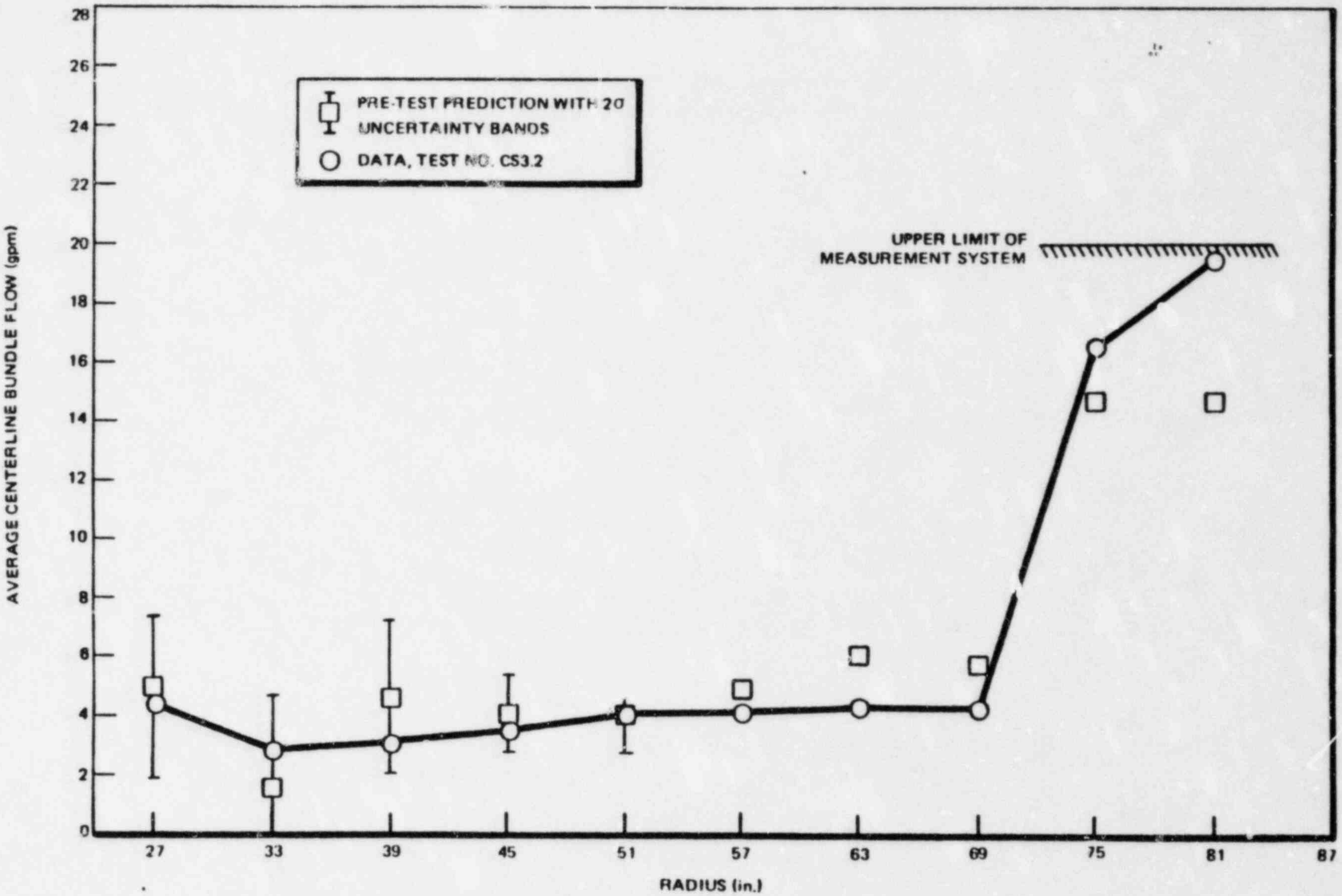

Figure 3 Comparison of SSTF Data to Extended Prediction for HPCS Operation