619 Issue

# Studsvik Arbetsrapport - Technical Report

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Titel och författare – Title and author

Aerosol instrumentation for the Marviken Aerosol Transport Tests.


L Ström
J Mäkynen*
W Piispanen

* Author attending the conference


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|---|---|---|
| Jan Collén | | ☐ |

This report was presented at the 11 th conference of the Gesellschaft für Aerosolforschung (GAEF) on September 15, 16, 198_ and will also be published in the proceedings from the conference in 1984. Attached as an Appendix is a reduced copy of the poster that was on display during the conference.

TRCONF

## PURPOSE OF THE PROJECT

The primary purpose of the Marviken ATT (Aerosol Transport Tests) project is to create a data base from large scale facilities on the behaviour of vapours and aerosols produced from overheated core materials within typical Pressurized Water Reactor (PWR) primary systems and Boiling Water Reactor (BWR) pressure vessels. The data base is needed to verify theoretical methods which can be and are being used to predict results of postulated core melt accidents for a wide range of geometries and fluid conditions. The existing Marviken test facility has been modified to meet these objectives.

The program has a second objective which is to provide a large scale demonstration of the behaviour of aerosols in primary systems.

## SYSTEM DESIGN

The basic arrangement of the hardware components models a PWR with aerosol transport through the hot leg, pressurizer, and relief tank. A tank, simulating a reactor vessel, is designed to have vessel internals which are interchangeable to represent PWR and BWR components. Aerosol material is evaporated using electrical plasma heaters. Extensive instrumentation and multiple sampling stations are used to characterize the system conditions and to measure the composition and the transport of the aerosol and gaseous species. Of this instrumentation, only the large aerosol samplers are described in this paper.

## TEST CONDITIONS

The aerosol and gaseous species consist of simulated fission products ("fissium"), and in later tests also simulated structural materials ("corium"). The main tests is conducted by injecting the fissium and corium vapours through the bottom of the simulated reactor vessel. In the initial tests however, fissium is vaporized and fed directly into the pressurizer. The vaporized material condenses to an aerosol as the temperature falls during tranport through the system.

The resulting simulations produce the following conditions for aerosol sampling:

- Temperature of gas - up to 800°C
- Pressure - ambient pressure
- Gas flow rate - 0.04 to ≈ 0.5 kg/s, steam plus inert gas and hydrogen
- Particle concentration - up to ~ 500 $g/m^3$
- State of aerosol - liquid droplets and/or solid particles, hygroscopic, may be chemically reactive, highly corrosive, poisonous

## AEROSOL SAMPLING

Aerosol sampling include the following methods: sequential sedimentation sampler, deposition coupons, optical smoke density meter, total particle filter sampler, size fractionating particle sampler, and system wash for deposition pattern.

A sampling train has been designed to provide fractionated samples of the aerosol at various measurement locations. The sampling train is constructed entirely of stainless steel and is designed for sampling up to 800°C. A single piece nozzle/probe assembly is attached either to an 8 plate elutriator followed by a cyclone cascade, or directly to a 4 stage cyclone train. The elutriator is designed to sample particles above 15 µm ($D_{100}$) but is intended to be used only in later tests where these larger particles are expected. The first cyclone flow rate is set to produce a 15 µm ($D_{50}$) cut size. In the later cyclones, the cut sizes are then for example 8.4, 2.4, and 0.87 µm at the conditions of 25°C air, 14.2 l/min, flow, and 1.0 g/cm$^3$ particle density (Smith et al., 1979).

It should be noted that the test conditions provide a significantly different environment for the cyclones than the "as calibrated" conditions. Calibrations for higher temperature and viscosity are to be made in the near future.

## SAMPLING OPERATIONS

Each aerosol sampling station consists of one fractionating sampler and 2 total particle (filter plus probe) sampling units (Fig 1).

Each sampling unit is installed on a moving cradle inside a temperature controlled oven. The entire unit is connected to a drive mechanism which rotates at 2 rpm to provide continuous traversing along a single duct diameter. Samples are taken sequentially not simultaneously in order to provide samples over a longer test period. The gas exiting the filter passes first through an air cooled heat exhanger which is temperature controlled to maintain temperatures greater than 100°C (steam condensation) and less than 200°C (Teflon melts). A single flow monitoring station is connected to the three incoming heated lines and parallel switching valves allow sequential operation of samplers. Sampler flow control is monitored using a turbine flow meter in a temperature controlled cabinet. The temperature is maintained above 100°C to avoid condensation. The computer program determines duct velocity and probe velocity and relays a voltage set for isokinetic sampling. The flow control is then manually adjusted to meet the set point. Data is monitored as real time but activation of the program is by a user defined key at the measurement station computer terminal.

## OBSERVATIONS FROM THE FIRST FISSIUM TEST

In the first fissium test, steam flow was under 100 g/s and temperatures were less than ~ 400°C. Most of the aerosol material was found in the relief tank water.

Aerosol instrumentation functioned quite well. Measured aerosol concentration was ≈ 80 $g/m^3$ at the pressurizer outlet and the aerodynamical mass mean diameter was approximately 5 µm. The aerosol may have consisted of liquid droplets since at the temperatures of the gas sampled, the CsOH could be in a liquid state. This observation needs to be verified by further testing.

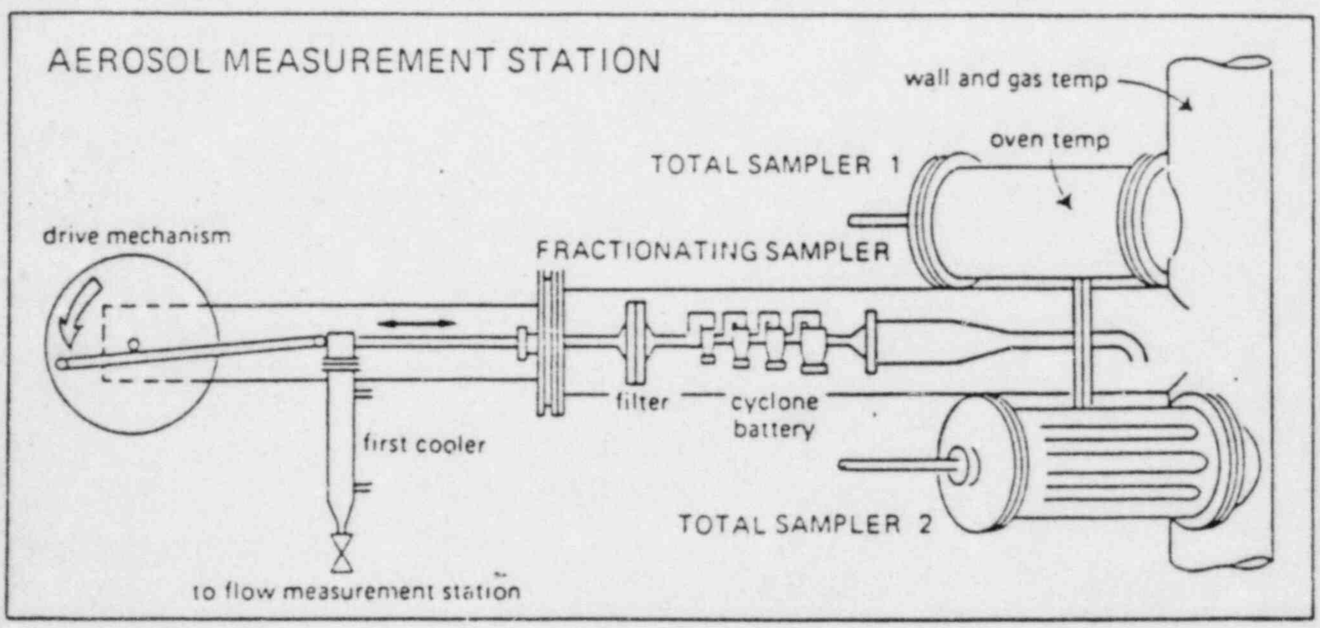
Problems of corrosion of the stainless steel were not severe but the sampling train was tarnished and extensive cleaning and polishing was required to prepare the train for the next test. The filter material was corroded by the aerosol sampled with the total particulate trains.

REFERENCES

1. Smith, W B, Wilson, R R Jr, and Harris, D B., A Five-Stage Cyclone System for in Situ Sampling, ES & T, 13, 11, November 1979.

FIGURE CAPTIONS

Fig 1 Schematic diagram of the aerosol measurement station.


AEROSOL MEASUREMENT STATION
wall and gas temp
oven temp
TOTAL SAMPLER 1
drive mechanism
FRACTIONATING SAMPLER
filter
cyclone battery
first cooler
TOTAL SAMPLER 2
to flow measurement station

# INSTRUMENTATION FOR THE MARVIKEN AEROSOL TRANSPORT TESTS

L. Strom
Studsvik Energiteknik AB
Nykoping, Sweden

J. Makynen
Technical Research Centre of Finland
Helsinki, Finland

W. Pospanen
Battelle Columbus Laboratories
Columbus, Ohio, USA

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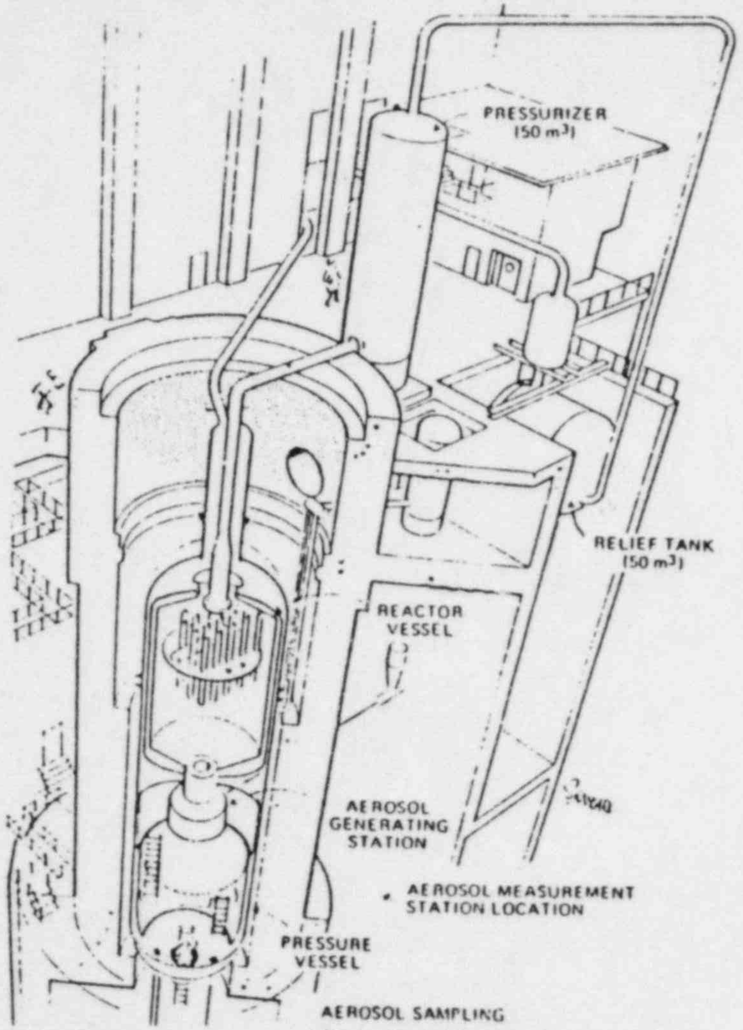


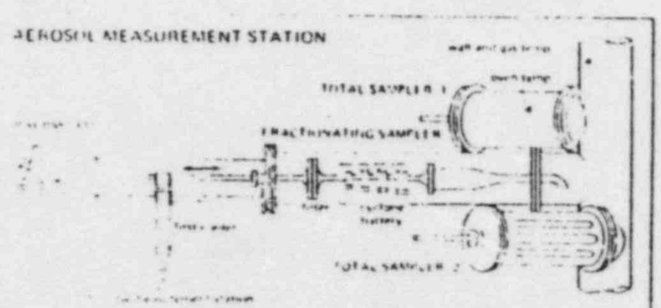


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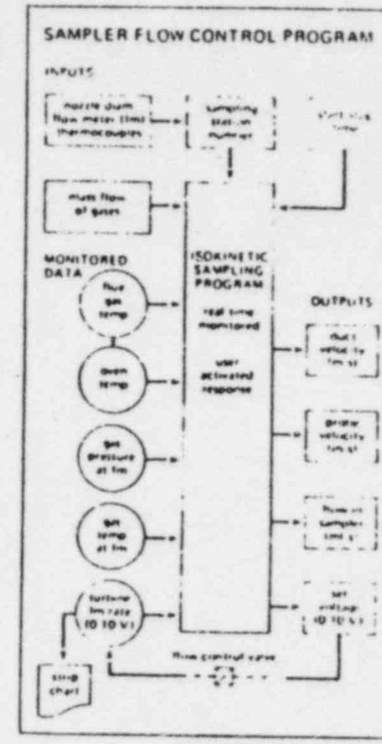


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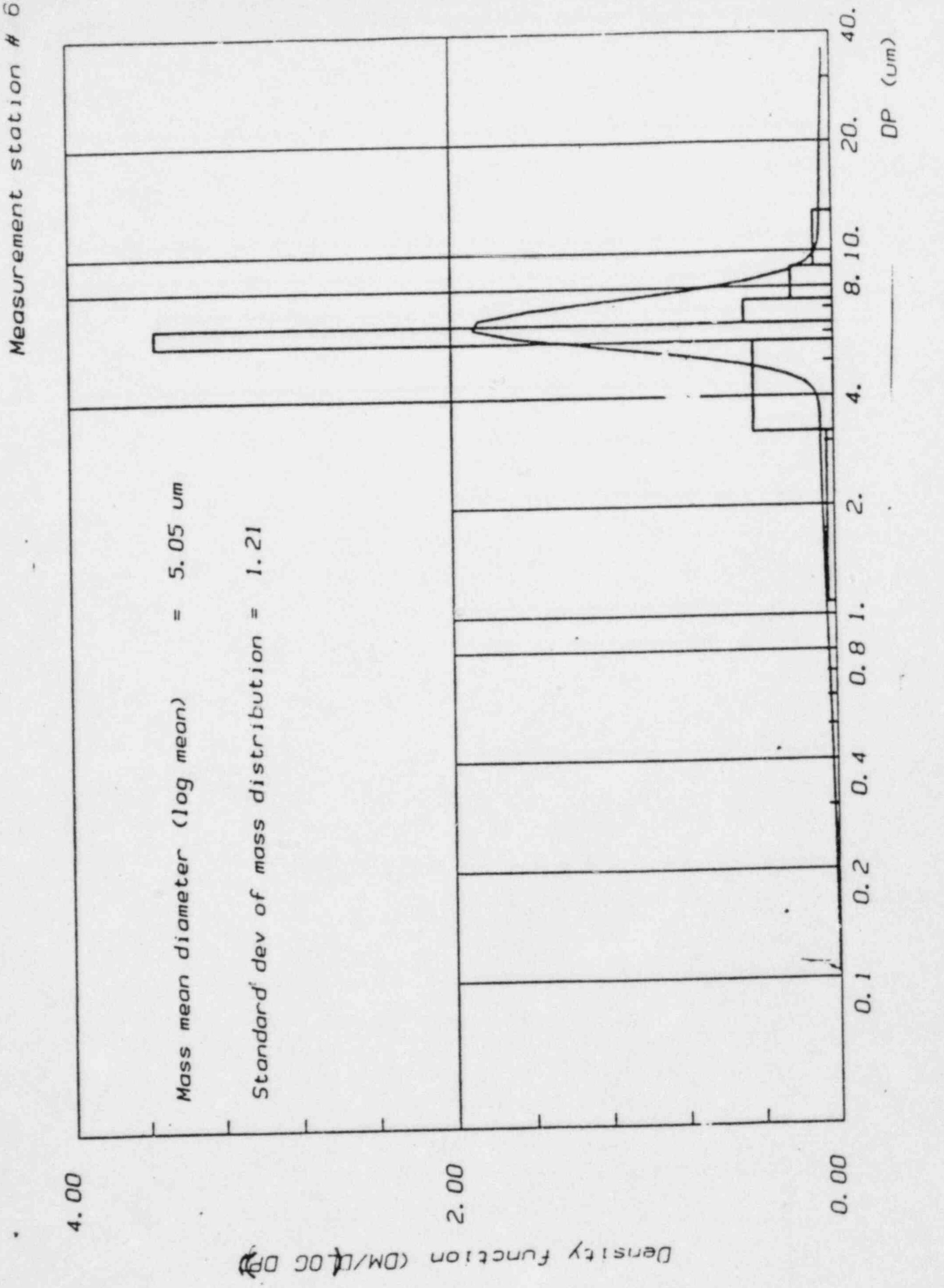



Fig 5:13 Particle size distribution

GE-NRC MEETING

GESSAR SOURCE TERM ANALYSIS

MARCH 20, 1984

BETHESDA, MD

# AGENDA

- BACKGROUND
- GE PROGRAM PLAN
- SOURCE TERM ISSUES
- SUPPRESSION POOL SCRUBBING
  - SPARC Code Data Comparisons
- PRELIMINARY PROGRAM RESULTS
- SCHEDULE

# GESSAR SOURCE TERM ANALYSIS

## BACKGROUND

o REASONS FOR STUDY

- VEHICLE TO CONCLUDE GESSAR LICENSING
  ( CONSISTENT WITH DISCUSSION IN DRAFT POLICY STATEMENT)
- FACTOR IN MOST RECENT SOURCE TERM INFORMATION
- HIGHLIGHT IMPORTANT PARAMETERS AND ADDRESS THEIR UNCERTAINTIES
- PROVIDE PERSPECTIVE ON PROPOSED DESIGN MODIFICATIONS

o PREVIOUS MEETINGS WITH NRC STAFF

| | |
|---|---|
| - FEBRURARY 9,1984 | DEFINE SPECIFIC SOURCE TERM ISSUES |
| - FEBRUARY 22,1984 | DISCUSS PROPOSED GE PROGRAM |
| - FEBRUARY 28,1984 | DISCUSS SPARC MODEL-DATA COMPARISONS |
| - MARCH 20,1984 | GE-NRC MANAGEMENT MEETING TO DISCUSS PROGRAM |
| | GE-NRC STAFF MEETING TO DISCUSS STUDY RESULTS |
| - APRIL , 1984 | DISCUSS PROPOSED DESIGN MODIFICATIONS |

## GE PROGRAM PLAN

- APPROACH

  - Perform Sensitivity Studies on Source Term Issues
  - Assess Impact on Fission Product Release and Containment Failure Modes and Timing
  - Assess Impact on Base Case Risk
  - Assess Impact of Design Modifications

- SENSITIVITY STUDY INPUTS

  - NRR Inputs (2/9/84 and 2/22/84 Meetings)
  - BMI-2104: Available Documentation, Peer Review
  - BNL Sensitivity Studies
  - New Experimental/Analytical Information
    - NRC-IDCOR Interaction Meeting
    - Recent Technical Meetings
    - Marviken
    - EPRI-BCL
  - NUREG-0772 and WASH-1400

## SCHEDULE

| | | |
|---|---|---|
| □ | GE-NRC MANAGEMENT REVIEW | 3/20/84 |
| □ | STAFF REVIEW OF SENSITIVITY STUDIES | 3/20/84 |
| □ | DISCUSS PROPOSED DESIGN MODIFICATIONS | 4/84 |
| □ | DOCUMENTATION OF DESIGN MODIFICATION EVALUATION | 4/84 |

# SOURCE TERM ISSUES

- CORE HEATUP PHENOMENOLOGY
  - Heatup Rates
  - Hydrogen Generation
- FISSION PRODUCT RELEASE
  - Fuel Release
  - Core-Concrete Release
- FISSION PRODUCT RETENTION
  - Primary System Retention
  - Suppression Pool Scrubbing
- SUPPRESSION POOL BYPASS
- SITE POPULATION

# SUPPRESSION POOL SCRUBBING
# (SPARC)

- ☐ MEETING AT PNL - 2/28/84 - GE/EPRI/PNL/NRR CONSULTANTS

- ☐ MEETING PURPOSE - REVIEW SPARC CODE EVALUATIONS OF EXISTING GE AND EPRI DATA

- ☐ PRINCIPAL GE CONCLUSIONS

  - SPARC Underpredicts Most Data
    - Confirmed by PNL Calculations
  - Identified Changes That Improve Model Predictions

- ☐ SATURATED POOL DATA

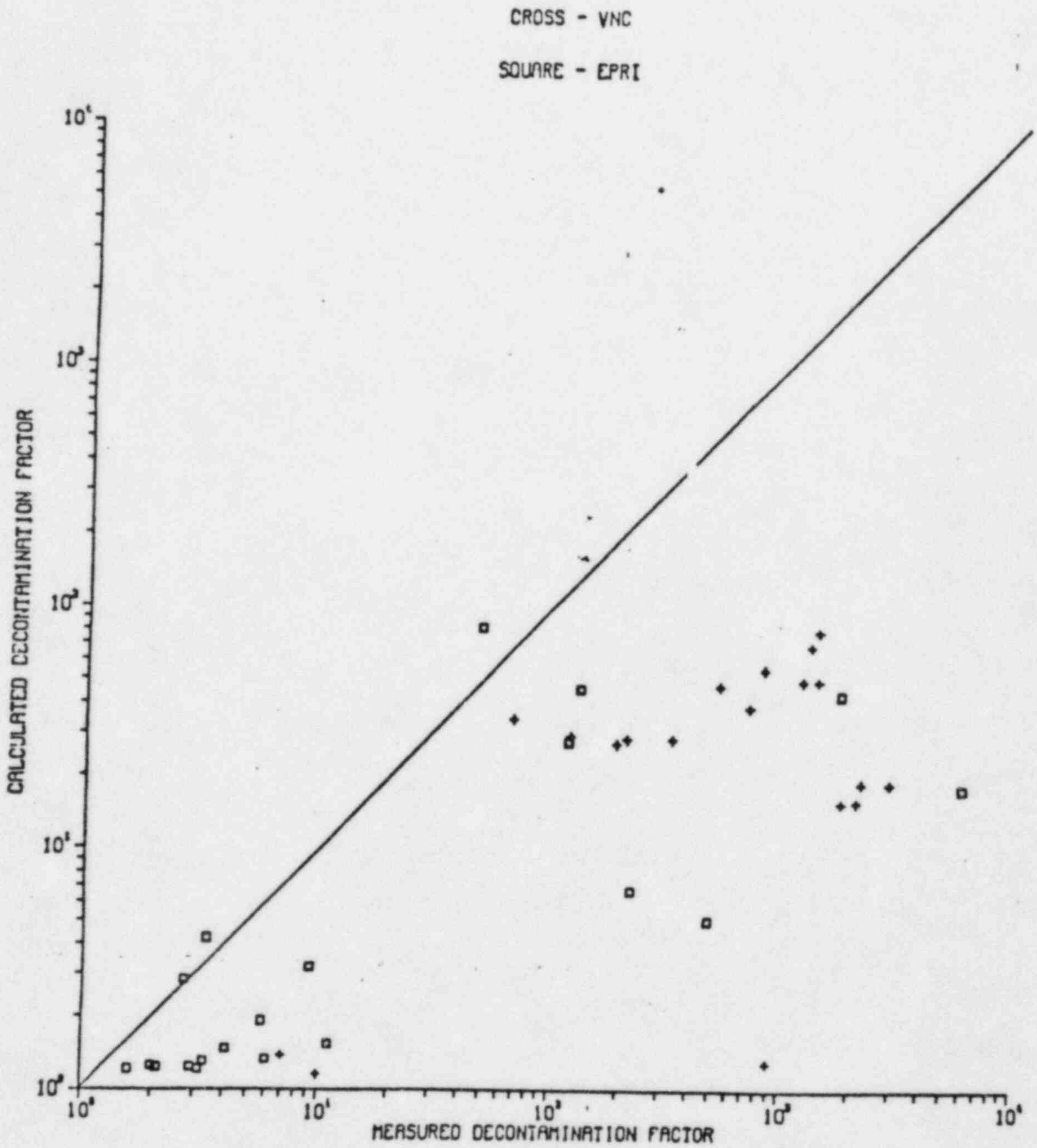
  - SPARC Predicts Little or No Scrubbing for Saturated Pools
  - Data Shows Saturated Pool Scrubbing as Good or Better Than Subcooled Pool Scrubbing
    - PNL Modeling Phenomena to Account for This Effect

- ☐ GE CONCERNS

  - SPARC Changes May Not be Reflected in GESSAR Review

# PNL CALCULATIONS

## SPARC MODEL VERSUS SCRUBBING DATA



# PRELIMINARY PROGRAM RESULTS

- o GESSAR RISK RELATIVELY INSENSITIVE ( < FACTOR OF 2 ) TO:
  - CORE HEATUP
  - HYDROGEN GENERATION/ OXIDATION MODELLING
  - PRIMARY SYSTEM RETENTION
  - EARLY RPV FAILURE
  - CONCRETE COMPOSITION
- o GESSAR RISK MODERATELY SENSITIVE ( FACTOR OF 2-10 ) TO:
  - LATE TELLURIUM RELEASE
  - HIGH POPULATION DENSITY SITE
  - SUPPRESSION POOL SCRUBBING
- o CONCLUSION:
  - UNCERTAINTIES IN SOURCE TERM ISSUES APPEAR UNLIKELY TO RESULT IN SURPRISES AFFECTING GESSAR