

INTERIM REPORT

**NRC Research and Technical  
Assistance Report**

Accession No.

ORNL/ENG/FTR-1034

Contract Program  
or Project Title: Advanced Instrumentation for Reflood Studies

Subject of this Document: Report of Foreign Travel of J. E. Smith, ETD  
Task Leader, and L. V. Wilson, Department  
Superintendent, ORNL Engineering

Type of Document: ORNL Foreign Trip Report

Authors: J. E. Smith and L. V. Wilson

Date of Document: March 20, 1981

Responsible NRC Individual  
and NRC Office or Division: W. S. Farmer, Division of Reactor Safety  
Research, NRC - FTS 427-4272

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Prepared for the  
U.S. Nuclear Regulatory Commission  
Washington, D. C. 20555  
Under Interagency Agreements DOE 40-551-75 and 40-552-75  
NRC FIN No. B-0413

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Oak Ridge, Tennessee 37830  
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**NRC Research and Technical  
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# NRC Research and Technical Assistance Report

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**ORNL**

## **FOREIGN TRIP REPORT**

ORNL/ENG/FTR-1034

DATE: March 20, 1981

SUBJECT: Report of Foreign Travel of J. E. Smith, ETD Task Leader, and L. V. Wilson, Department Superintendent, ORNL Engineering.

TO: Herman Postma

FROM: J. E. Smith and L. V. Wilson

PURPOSE: To discuss the design criteria, final design, and interfacing details of ORNL drag body transducers for the Upper Plenum Test Facility (UPTF) and the state-of-the-art of high-temperature strain measurements.

SITE VISITED: February 23-27, 1981 KWU, Erlangen, Germany Hr. Kiehne  
Dr. Melchior  
March 2-3, 1981 G.V. Planer Limited L. S. Phillips  
(J. E. Smith only) London, England

### ABSTRACT

The travelers, with a representative of the USNRC, attended a meeting at Kraftwerk Union (KWU) in Erlangen, Germany, on behalf of the USNRC in relation to drag body transducer instrumentation for the Upper Plenum Test Facility (UPTF). This facility will be a part of the International 2D/3D Program to study the behavior of a pressurized water reactor following a loss-of-coolant accident (LOCA). ORNL is assisting USNRC in fulfilling its commitments to provide two-phase instrumentation for the UPTF.

The participants reached tentative agreement on the final design of a four-post drag body transducer configuration for measuring forces on a fixed body caused by pressure differences and fluid impact in the UPTF and the mechanical and electronic details of interfacing the drag body transducer with regard to fabrication, installation, operation, and maintenance requirements.

J. E. Smith also visited G.V. Planer Limited in London, England to discuss high-temperature strain measurements relative to nuclear safety applications.

NRC Research and Technical Assistance Report

## INTRODUCTION

The travelers, J. E. Smith and L. V. Wilson, attended a five-day meeting with representatives of some of the German organizations involved in the International 2D/3D Program on pressurized water reactor safety.

In accordance with an agreement between the United States, the Federal Republic of Germany (FRG), and Japan on studies related to the behavior of a pressurized water reactor following a loss-of-coolant accident (LOCA), the Upper Plenum Test Facility (UPTF) will be designed and constructed in the FRG. The U.S. Nuclear Regulatory Commission (USNRC) has agreed to provide special two-phase flow instruments to acquire data during operation of the facility, which in turn will be used to analyze the behavior of the system. The Oak Ridge National Laboratory (ORNL), on behalf of the USNRC, will design and fabricate these special instruments that will be used to characterize fluid behavior in the region of the upper core support plate.

In a meeting at Los Alamos, the Tripartite Coordinating Committee's Decisions and Recommendations, dated November 6, 1980 stated:

"To resolve the adequacy of structural support of the drag body on the UPTF tieplate, ORNL/MPR/KWU/GRS engineers will separately perform load analyses and communicate to each other in writing for comparison before January 1981. In case of a design change additional tests are contemplated. A meeting to discuss these will be held in Germany in January 1981."

Due to problems in developing criteria, the meeting was rescheduled to the last week in February. More specifically, the purpose of the meeting was to reach agreement on the suitability of the ORNL four-post transducer configuration.

The original proposed agenda (Appendix A) for the meeting was for four days, but due to difficulties in establishing new criteria, five days were needed. The meeting was at Kraftwerk Union in Erlangen, Germany, with representatives of the FRG and USNRC present. The FRG was represented by personnel from Gesellschaft für Reactorssicherheit (GRS), KWU, and Battelle-Institut (Frankfurt). The USNRC was represented by personnel from ORNL and MPR Associates, a private consulting firm under contract with USNRC. A list of the participants and their affiliations is given in Appendix B and the itineraries are given in Appendix C.

## MEETING SUMMARY

The meeting at KWU, Erlangen, opened with a presentation of the ORNL mechanical and thermal design analysis of the four-post transducer configuration. The analysis showed that the design was adequate for the proposed ORNL design criteria. For the maximum up-flow condition, the ORNL criteria was approximately equivalent to that resulting from the KWU analysis of the TRAC-GPWR computer calculations as performed by LASL. Although the Germans accepted ORNL's calculation methods, they thought there was insufficient conservatism in the ORNL criteria and chose to include a 50% safety margin on the drag body forces and factors of 2-6 on the number of cycles. New ORNL calculations were performed which again showed the adequacy of the four-post design. Later, the force distribution between the drag body and the spider was questioned and again new ORNL calculations were performed based on conservative approximations to the new criteria. These results also showed the adequacy of the four-post design. The participants agreed that the results should be qualified as preliminary and a final ORNL analysis would be performed and transmitted to the Germans to document the results. If subsequent TRAC-UPTF calculations do not show more severe values than those presented at the meeting, the design will be considered as final.

There were some discussions about the mechanical design in other areas:

1. Columnar design of the four-post guide thimble posts that support each end box.
2. Design interface between the end box and the fuel bundle.
3. A design proposal for assembling the drag body transducer configuration from the top of the end box.

A proposal for "scope of supply" was discussed which, in general, delineates responsibilities for design, supply, and assembly for parts and assemblies. Some of the details will require further communication and agreement. The proposal and its specifics must, however, be approved by the authorized agencies in the USA and Germany.

Concerning the transducer electronics the following items were agreed on:

1. Length of hard (sheathed) cable, including details of the brazing sleeve.
2. Length of soft cable
3. A six-wire system from transducer to power supply
4. The d.c. amplifier specifications
5. Power supply requirements
6. Need for further clarification of signal conditioning equipment.



At G.V. Planer Ltd., Sunbury-on-Thames, Middlesex, United Kingdom, discussions were conducted on the current status of the use of strain gauges under in-service conditions in electric power plants. Capacitive strain gauges have been used to measure strains in an air environment to temperatures exceeding 600°C for approximately 10 years. One such device used is the CERL-Planer capacitive strain transducer manufactured by G.V. Planer Ltd.

The discussions initially focused on recent advancements and qualifications of the CERL-Planer gauge. Tests of this gauge, conducted by the writer at ORNL, were summarized. References of recent usage of capacitive strain gauges for successful, long term, monitoring of strains on primary power plant piping systems were presented and discussed.

Instrumentation for use with capacitive strain gauges was discussed with personnel from ASL Ltd., located at nearby Leighton Buzzard in Bedfordshire. All participants in the meeting agreed on the need and utility of a set of guidelines for high-temperature strain measurement.

The writer was shown facilities and methods for calibration and qualification of strain gauges and instrumentation.

#### Summary and Evaluation

The KWU meeting was characterized by the understanding and acceptance of the mutual problems and concerns of the participants in providing an instrument that would perform reliably in the UPTF environment. The value of the meeting was in the acceptance by the Germans of the ORNL calculational methods and development of criteria that is presently acceptable to the participants. Although there was no formal acceptance of the four-post design, it seemed to be a foregone conclusion that it would be accepted once the final design analysis using the new German criteria was submitted.

G.V. Planer Ltd., has been involved in the significant advancement of the state-of-the-art in high temperature strain measurements in recent years. Creep behavior, surface crack growth and stresses under transient conditions have been continuously monitored since 1977 on ferritic and austenitic steel piping under service conditions in thermal power plants in England to a temperature of 540°C. Results to date have shown good sensitivity of the capacitive gauges, low failure percentage, and acceptable drift rates. It can be concluded that long-term monitoring of strain on primary piping systems in nuclear power plants is an acceptable and feasible candidate for consideration when the information to be obtained is useful for verification of the structural adequacy of the piping system. However, the techniques involved would require specialist personnel for installation.

## APPENDIX A

Agenda, KWU Meeting

2D/3D KWU-ORNL Drag Body Design Meeting, February 23-27, 1981

Feb. 23

1. Status of ORNL calculations
2. Status of KWU calculations.
3. Review of loads and stress calculations (4 & 12 posts,

Feb. 24

1. Specification of loads.
2. Discussion and determination of design details.

Feb. 25

1. Interface problems (electronics, mounting, scope of supply).

Feb. 26

1. Conclusions and recommendations.

Agenda, G.V. Planer Ltd MeetingMar. 3

1. Advances in capacitive strain measurements.
2. In-service applications of capacitance strain gages relating to nuclear safety applications.

Mar. 4

1. Instrumentation for capacitive gage systems.

## APPENDIX B

KWU Meeting Participants

The following is a list of the participants in the UPTF - drag body transducer design meeting of February 23-27, 1981.

Damerell	MPR Assoc., USA
Engel	KWU, Erlangen
Ghazanfari	GRS, Köln
Hampel	Battelle Institut, Frankfurt
Kiehne	KWU, Erlangen
Mattis	KWU, Erlangen
Melchior	KWU, Frankfurt
Puelshen	KWU, Erlangen
Riegel	GRS, Munich
Roberts	ORNL/KWU/NRC, Erlangen
Smith	ORNL, USA
Strobel	KWU, Erlangen
Wilson	ORNL, USA

G.V. Planer Ltd. Meeting Participants

L. S. Phillips	G.V. Planer Ltd., U.K.
R. M. Dixon	ASL Ltd., U.K.
P. Wolfendale	ASL Ltd., U.K.
J. E. Smith	ORNL, USA

## APPENDIX C

Itineraries

Itineraries for the UPTF Drag Body Transducer Meeting of February 23-27, 1981.

Traveler: J. E. Smith

February 20-21	Travel - Knoxville to Erlangen, Germany
February 23-27	UPTF Drag Body Transducer Meeting at KWU, Erlangen, Germany
February 28	Travel - Erlangen to London, England
March 2-3	Strain measurement discussions with G. V. Planer Ltd in London
March 4-5	Vacation
March 6	Travel - London, England to Knoxville

Traveler: L. V. Wilson

February 20-21	Travel - Oak Ridge to Erlangen, Germany
February 23-27	UPTF Drag Body Transducer Meeting at KWU, Erlangen, Germany
February 28	Travel - Erlangen, Germany to London, England
March 2	Travel and vacation - London, England to Oak Ridge



## APPENDIX D

Literature AcquiredKWU Meeting

1. Conclusions of the Drag Body Meeting, Erlangen, Feb. 23-27, 1981
2. UPTF End Box Drag Body Loads (Mech.), Erlangen KWU/R114, Kiehne, Dec. 18, 1980 (Revised Feb. 6, 1981)
3. Preliminary Loads for the Drag Body Design (Mech. and Thermal, Kiehne, Feb. 27, 1981)

G.V. Planer Ltd.

B. Downe et al., "Performance of the CERL-Planer Strain Transducer" (Draft) To be presented at BSMS Conference, Glasgow, Scotland, UK. (Sept. 1981)

S. Ghia et al., "Monitoring of High Temperature Steam Piping with Capacitance Strain Gauges," C193/80 ENEL, Italian Electricity Board, Milana (1980)

C.K.V. Owen "Capacitive Strain Gauges for Monitoring Cracks" CBI-GAL The Welding Institute, Abington, Cambridge, U.K. (1976)

M. C. Coleman et al., "The Deformation Behavior of Thick Walled Pipe At Elevated Temperatures," Third International Conference on Mechanical Behavior of Materials, University of Cambridge, U.K., (Aug. 1979)

DISTRIBUTION

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