

INTERIM REPORT

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Report of Foreign Travel of A. P. Malinauskas
to Germany and France

Foreign Trip Report

A. P. Malinauskas

December 4, 1980



Robert B. Minogue, Director
Division of Reactor Safety Research

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Oak Ridge, Tennessee 37830

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INTERIM REPORT

NRC Research and Technical
Assistance Report

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ORNL

FOREIGN TRIP REPORT

ORNL/FTR-1006

DATE: December 4, 1980

SUBJECT: Report of Foreign Travel of A. P. Malinauskas, Head,
Chemical Development Section, Chemical Technology Division

TO: Herman Postma

FROM: A. P. Malinauskas

PURPOSE: To attend KFK-PNS Colloquium, Karlsruhe; participate
in USA/FRG Core-Melt Information Exchange Meeting; and
engage in technical discussions of LWR safety programs
with staffs at KFK-PNS and at CEN, Grenoble.

SITES VISITED: 11/24-27/1980 KFK Karlsruhe, Germany H. Albrecht
11/28/1980 CEN Grenoble, France J.-C. Janvier

ABSTRACT: Summaries are presented of the KFK-PNS Colloquium; of
the USA/FRG Core-Melt Information Exchange Meeting;
and of technical discussions that were held with
KFK-PNS staff in Karlsruhe and with CEN staff in
Grenoble on physicochemical forms and mechanisms of
release and transport of radiologically toxic fission
products under LWR accident conditions.

NRC Research and Technical
Assistance Report

1. Introduction

The purpose of this trip was to attend the Seventh Jahreskolloquium des Projekts Nukleare Sicherheit (PNS), participate in the Core-Melt Research Program review and information exchange, and conduct discussions on fission product release and transport in light water reactor (LWR) systems with the PNS staff. These activities were performed at Kernforschungszentrums Karlsruhe (KFK) in Karlsruhe, Federal Republic of Germany (FRG). In addition, a visit was made to the Centre Etudes Nucléaires (CEN) in Grenoble, France, to exchange results of recent research in the area of fission product release and transport in pressurized water reactor (PWR) systems.

Although not presented in chronological order, subsequent sections of this report involve the following: Section 2 is a summary of observations made during the presentations at the Jahreskolloquium. The agenda of the colloquium is presented in the Appendix, and copies of the German papers are available from the author. Section 3 summarizes highlights of the Core-Melt Research Program review and technical exchange, and the agenda of this meeting is also presented in the Appendix. Viewgraphs used during the presentations and the minutes of the meeting will be available from the author of this report when they are distributed. Section 4 is a resumé of private discussions held with the PNS staff, whereas Section 5 reports key aspects of technical discussions with CEN staff. Individuals contacted and the attendees at the Jahreskolloquium are identified in the Appendix. The final section reports general observations that were made in the course of this trip.

2. Seventh Jahreskolloquium des Projekts Nukleare Sicherheit

The program consisted of three policy- or overview-type presentations and five papers that were more technically oriented. A highlight was the presentation by D. Smidt of KFK, "Human Failure: A Basic Problem of Nuclear Power Plants?" This was followed by an overview of current PNS work by its present director, H. Rininsland, and an overview of the NRC Core-Melt Research Program by T. E. Murley. These and the more technical presentations were well presented and generally evoked interesting discussions.

3. Core-Melt Research Program

In his introductory remarks, D. Lummerzheim (BMFT, Bonn) pointed out that the U.S. and German programs were similar, but that studies of are currently not being conducted in the German program.

Much of the work presented generally indicated favorable progress since the last Core-Melt Research Program meeting; the results were as anticipated except in two areas. The first area was an apparent discrepancy between observations made by H. Kottowski (Euratom, Ispra) and those by D. Mitchell (Sandia Laboratories) concerning the

triggering of steam explosions. Kottowski indicated there was a threshold in the mass of core melt below which it was not possible to trigger a steam explosion. After much discussion, it was agreed that the statement is correct if it is limited to considerations of *practical* triggering mechanisms as opposed to triggers of unlimited energy input. All agreed there was a point at which energy input by the trigger would exceed energy output by the steam explosion.

The second area concerned the presentation of the work of Malinauskas, Campbell, and Stratton on the chemical forms of iodine in reactor accidents. The presentation, which was made by the author of this trip report, elicited many questions afterward.

4. Private Discussions with PNS Staff

Many discussions were held between the author and various FRG scientists concerning the chemical forms of iodine during LWR accidents. These contacts, which generally ended with a request to send additional information, are identified in the Appendix. In the course of the discussions it became clear that the question of iodine behavior was being seriously considered in the FRG, and that the German Reactor Safety Study was still in a state of development. When the author indicated to one of the FRG scientists involved in the study that his review of the fission product treatment left him with the impression that new work beyond that presented in the U.S. Reactor Safety Study (the Rasmussen Report) had not been considered, the reply was that the consideration of newer results was not possible because of the schedule involved. However, such new work would be considered during Phase II, which is now in progress, and involves an update of the published Phase I report.

P. Halleck of PNS is conducting thermodynamics studies of fuel-fission product-cladding interactions in LWR fuel-rod systems using thermogravimetric techniques. The approach involves beginning with selected one-component systems (e.g., CsI) to determine the characteristics of the individual species, then gradually adding additional components until finally "fissium" (a simulated fuel-fission product-cladding mixture) is examined. Several interesting observations have been made to date. These include:

1. CsI begins to show an appreciable vapor pressure at about 640°C regardless of whether inert or oxidizing conditions are employed.
2. In the system 90% U-5% Cs-5% Mo-O, some loss of uranium is noted at 1100°C in both air and an inert atmosphere.
3. At 1500°C, fissium corresponding to 13% burnup exhibits a 25% weight loss in an inert atmosphere and a 35% weight loss in an oxidizing atmosphere under otherwise identical conditions.
4. Unusually high releases of zirconium are observed even at temperatures as low as 1200°C.

Because the weight losses are determined as the temperature is ramped at a specific rate, more detailed information is required so that the implications of these observations can be fully understood. Additional correspondence with Halleck will be pursued when he has had more opportunity to analyze his data.

Discussions with H. Albrecht and H. Wild focused on their studies of fission product release from fissium using the SASCHA facility and on their experience with SASCHA as it relates to the ORNL conceptual design of a similar facility for use with irradiated fuel. With regard to the latter subject, a series of questions was prepared by the ORNL staff and was submitted to Albrecht and Wild. They were pleased to answer these questions and frequently provided advice beyond the points under discussion. The 5 to 6 years of experience that Albrecht and Wild have gained during the design and operation of SASCHA is invaluable to the proposed ORNL effort. When more tangible apparatus designs are developed, additional discussions with these scientists should most definitely be conducted.

Since Albrecht later presented his SASCHA results at the Core-Melt Research Program technical exchange, they need not be elaborated here. Three observations do require additional comment, however. The first of these is the observed increase in fission product releases in steam relative to air for virtually all fission product species monitored. Albrecht is still uncertain of the cause of this behavior, but proposes that the steam shocks the system thermally, thereby causing more fracturing to occur. The second is the very large release of silver in steam. This, he postulates, is due to CsI decomposition (by H_2O ?) and the subsequent reaction of the iodine to form AgI, which is more volatile than elemental silver. This mechanism is difficult to accept. Thirdly, Albrecht quoted very preliminary results which indicate that fission product releases increase with increasing pressure in air, but the reverse behavior occurs in a steam atmosphere. This he ascribes to increasing UO_2 oxidation with air pressure. It is clear that the Albrecht and Wild data require further study.

5. Discussions with CEN Staff

The Centre Etudes Nucléaires at Grenoble is the focus of in-pile studies of fission product release from PWR fuel rods using the SILOE research reactor. Two types of investigations are being made. One of these, which involves the BOUFFON loop, concerns the characteristics of release from defected fuel rods during normal operation; a summary of the tests to date will be presented at an ANS Topical Meeting at Sun Valley, Idaho, in August 1981. The second involves a new loop, FLASH, which concerns fission product release during the loss-of-coolant phase of a controlled LOCA, and the subsequent reflood period. Results of the first FLASH test are to be presented in Helsinki.

A brief tour of the in-pile facilities was sufficient to determine the high quality of the work being performed at CEN. Because these are the *only* in-pile facilities dedicated exclusively to fission product release studies, it seems essential to maintain close contact with this work. The facilities are impressive and the staff is extremely competent and cooperative.

The French currently have no programs in core-melt research, but are very interested in the U.S. studies. A French report was given to me by J. J. Seveon of the Service d'etudes de Surete Radiologique et des Sites, which is an extended (69 pp.) summary of the ORNL fission product release studies.

6. General Observations

The U.S. delegation to the meetings in Germany apparently was rather large relative to attendance at such previous meetings. This was noted by the Germans and was no doubt partially responsible for the enthusiasm with which both formal and informal information exchange occurred. It is recommended that delegations of about the same size be sent to these meetings on a regular basis.

The personal interaction with colleagues previously contacted only by mail was refreshing. The opportunity to pursue ideas and clarify points of confusion in an unhurried manner, unencumbered by the limitations and inherent problems in exchanging concepts by mail was most useful. Frequent contacts of this nature (perhaps semiannually) should be encouraged. The Core-Melt Research Program review and technical exchange meetings, if held on a semiannual basis, would provide an excellent vehicle for maintaining these contacts.

The water reactor safety research branches of the NRC Office of Reactor Regulatory Research have been especially aggressive in promoting staff exchanges with the corresponding European communities. Moreover, after a period of maturation with senior U.S. staff, NRC appears to favor appointments involving younger scientists and engineers. This writer can only commend the NRC for its foresight in this regard, and I strongly recommend not only the continuation, but also an extension, of the staff exchange idea especially since so many favorable comments were heard from the PNS staff. At CEN in particular, there is a desire to exchange staff in the area of fission product behavior. In view of the excellent facilities and staff at Grenoble, this should be pursued expeditiously.

There is no question about the very favorable cost effectiveness of my visit to PNS and CEN, nor is there reason to believe this experience is at all atypical.

Appendix A

Persons Contacted

*Haider - GRS/Cologne
*H. G. Friederichs - GRS
*R. D. von Dincklage - Dornier System GmbH, Friedrichshafen
*M. Fischer - Past director of PNS;DFVLW/ITP Stuttgart
H. Albrecht - PNS
P. Halleck - PNS
H. Wild - PNS
*H. Nickel - KFA Jülich
*M. Peehs - KWU Erlangen
*K. Hassman - KWU Erlangen
G. Ivens - AVR GmbH Düsseldorf
W. Schikarski - PNS
W. Schöck - PNS
A. Fiege - PNS
Israel - CEN
P. Chenebault - CEN
J.-C. Janvier - CEN
R. Delmas - French NRC
M. Bruet - CEN
Sainforth - CEN
Y. Kauffmann - CEN
J. J. Seveon - SESRS

*Discussions specific to fission product iodine behavior

Appendix B

7. Jahreskolloquium des Projekts Nukleare Sicherheit des Kernforschungszentrums Karlsruhe

Programm — Program

Montag, 24. November 1980

19.00 h **Empfang**
Reception
Gastdozentenhaus "Heinrich Hertz",
Karlsruhe, Engesserstr. 3

Dienstag, 25. November 1980

9.00 h **Eröffnung und Einführung**
Welcome and Opening Address
H. H. Hennies, KfK

Sitzung 1 — Session 1

Vorsitzender — Chairman: H. H. Hennies

9.15 h **Menschliches Fehlverhalten: Ein**
Kernproblem der Kernkraftwerke?
Human Failure: A Basic Problem of Nuclear
Power Plants?
D. Smidt, KfK

10.00 h **Fortschritte der**
Reaktorsicherheitsforschung im
Projekt Nukleare Sicherheit
Recent Advances of Reactor Safety
Research in the Nuclear Safety Project
H. Rininsland, KfK

10.45-11.15 h **Kaffeepause — Coffeebreak**

11.15 h **NRC's Core Melt Research Program and its**
Relation to Current Regulatory Activities
T. E. Murley, U. S. Nuclear Regulatory
Commission

12.00 h **US Steam Explosion Research: Risk**
Perspective and Experimental Results
M. Berman, Sandia Laboratories;
R. Sherry, U. S. Nuclear Regulatory
Commission

12.45-13.45 h **Mittagessen — Lunch**

Sitzung 2 — Session 2

Vorsitzender — Chairman: H. Rininsland

13.45 h **Analyse des Ablaufs hypothetischer**
Kernschmelzenunfälle
Analysis of the Course of Hypothetical Core
Meltdown Accidents
K. Hassmann, Kraftwerk Union Erlangen;
M. Reimann, Institut für Reaktorbau-
elemente, KfK

14.15 h **Zweiphasenmassenstrom-Messungen:**
Ein Vergleich verschiedener
Meßverfahren
Two-Phase Mass Flow Measurements:
Comparison of Different Methods
J. Reimann, H. John, U. Müller,
Institut für Reaktorbauelemente, KfK

14.45 h **Methoden zur Fluid- und**
Strukturdynamik bei der Analyse von
Störfällen in LWR
Methods of Fluid and Structural Dynamics
Applied to Postulated LWR Accidents
R. Krieg, U. Schumann,
Institut für Reaktorentwicklung, KfK

15.15 h **Messung der Brennstab-**
Hüllrohrtemperatur mit LOFT-
typischen Thermoelementen unter
Blowdown-Bedingungen in COSIMA
Measurements of Clad Temperatures with
LOFT-typical Thermocouples in the
COSIMA Facility under Blowdown Conditions
G. Class, R. Meyder, Institut für
Reaktorentwicklung, KfK;
K. Hain, Hauptabteilung Ingenieurtechnik, KfK

15.45 h **Schlußwort — Closing Remarks**

Diskussion nach jedem Vortrag
Discussion after each paper

POOR ORIGINAL

Appendix C

Agenda - Information Exchange Meeting BMFT/NRC
Common Review Group Meeting, Core-Melt Research

November 26, 1980

TOP. 1	9.00 h	On going activities in FRG core melt research	BMFT
TOP. 2	9.20 h	Status of NRC-research program "Severe Fuel Damage and Core Melt Research"	NRC, R. Sherry
Coffee Break	9.40 h		
TOP. 3	9.55 h	Steam explosions theore- tical and experimental in- vestigations in steam explosions, overview	EURATOM, Dr. Kottowski
TOP. 4	10.25 h	Summary of FITS-experiments	NRC D. Mitchell, SANDIA
TOP. 5	10.55 h	New investigations in code development: - Thermal detonation model - New code development and calculations in USA	Unger/Schwalbe, IKE NRC M. Corradini, SANDIA
Lunch	11.55 h		
TOP. 6	14.00 h	Analysis of MARCH-KESS comparison calculations	NRC, P. Cybulskis, BC Dr. Hassmann, KWU
TOP. 7	14.40 h	New results of the ZIP study - H ₂ -deflagration and pressure build-up - alternative containment concepts	NRC, M. Berman, SANDIA
Coffee Break	15.20 h		

TOP. 8	15.30 h	Melt-concrete-interactions	
		- Status of the BETA-experiments	Dr.Hosemann, PNS
		- Model description of the melt-concrete-interaction with CORCON	NRC, J. Muir, SAND
		WECHSL	Dr. Reimann, KfK
		KAVERN	Dr.Hassmann, KWU
TOP. 9	17.00 h	EPRI-Core melt activities	Ritzmann, EPRI
	17.15 h	End	
		Transfer by busses	
	19.30	Heinrich Hertz-Haus	

November 27, 1980

TOP.10	9.00 h	Status of SASCHA experiments	Dr.Albrecht,KfK
Coffee Break	9.40 h		
TOP.11	9.55 h	High temperature fission product release	A. Malinauskas,ORNL
		- planned ORNL-tests	
TOP.12	10.25 h	Status of NAUA code - analysis and development	Dr.Schöck, KfK
TOP.13	10.55 h	Status of TRAP-MELT code further code development plans	J.Gieseke, BCL
TOP.14	11.20 h	Chemical forms of Cs and I under severe accident conditions	NRC, FRG
		- discussions -	
	11.50	Discussion	
	12.30	Lunch	

Appendix D

7. Jahreskolloquium 1980 des Projekts Nukleare Sicherheit
List of Attendees

Name	Institution
Abramson, P.	Argonne National Laboratory / USA
Albrecht, H.	KfK / IRCH
Alsmeyer, H.	KfK / IRB
Anderko, K.	KfK / IMF II
Angelow, G.	Öko-Institut Freiburg
Armbruster, H.	KKW Philippsburg
Bachmann, E.	BBR Mannheim
Bäro, G.	BBR Mannheim
Bauer, A.	KfK / Bauabteilung
Bauer, H.	RWE Essen
Baukal, W.	Battelle Institut Frankfurt
Becker, H.J.	GWK Leopoldshafen
Becker, S.	Karlsruhe
Becker, W.	TÜV Mannheim
Behrendt, V.	Dornier System GmbH Friedrichshafen
Berman, M.	Sandia Lab. / USA
Bernard, R.	Badenwerk Karlsruhe
Bernhardt, S.	GKN Neckarwestheim
Bertsch, G.	Öko-Institut Freiburg
Bielmeier, M.	IKE Stuttgart
Birkhofer, A.	GRS Garching
Bisanz, R.	IKE Stuttgart
Blume, H.	AGF-Arbeitsgruppe Köln
Bocek, M.	KfK / IMF II
Bodenbender, H.H.	Hess. Min. f. Wirtschaft u. Technik Wiesbaden
Böhm, H.	KfK / Vorstand
Böttcher, D.	Preuß. Elektrizitäts-AG Hannover
Boffo, W.	Pfalzwerke Ludwigshafen
Bohl, W.R.	delegiert von Los Alamos zum INR
Bojarsky, E.	KfK / IMF III
Borgwaldt, H.	KfK / INR
Bork, G.	KfK / PNS-PL

Name	Institution
Bowers, Ch.	NSAC / USA
Bracht, K.-F.	GRS Köln
Braun, W.	KWU Erlangen
Brosche, D.	Bayernwerk München
Brudermüller, G.	KBG Leopoldshafen
Bünemann, D.	GKSS Geesthacht
Bürger, M.	IKE Stuttgart
Bunz, H.	KfK / LAF I
Caspar, P.	BBR Mannheim
Class, G.	KfK / IRE
Corradini, M.	Sandia Lab. / USA
Cybulskis, P.	Battelle Columbus Lab. / USA
Dagbjartsson, S.	Fichtner Stuttgart
Dearien, J.A.	EG&G Idaho Falls / USA
Dienst, W.	KfK / IMF I
Diepold, W.	Battelle Institut Frankfurt
Dillmann, H.G.	KfK / LAF II
Dincklage v., R.-D.	Dornier System GmbH, Friedrichshafen
Dirkx	Colonia Versicherung Köln
Distler, K.	Rhein.-Westf. Elektrizitäts-AG Biblis
Dittmar, H.	Preuß. Elektrizitäts-AG Hannover
Dluzniewski, E.	GRS Köln

Name	Institution
Eberle, R.	KWU Erlangen
Eglin, W.	Badenwerk Karlsruhe
Ehnis, L.	IKE Stuttgart
Ehrenstein von, D.	Universität Bremen
Eickelpasch, N.	KBG Gündremmingen
Emrich, F.	GWK Leopoldshafen
Erbacher, F.J.	KfK / IRB
Erle, G.	Badenwerk Karlsruhe
Esßmann, J.	Preuß. Elektrizitäts-AG Hannover
Eyink, J.	KWU Erlangen
Fendler, H.-G.	TÜV Mannheim
Fernandjian, J.	CEN Fontenay-aux-Roses / Frankreich
Feser, A.	Min. f. Soz., Gesundheit u. Umwelt, Mainz
Fiege, A.	KfK / PNS-PL
Fischer, M.	DFVLR / ITP Stuttgart
Föglein, F.	VEW Dortmund
Franke, H.	TÜV Stuttgart
Friedrich, H.-J.	Interatom Bergisch-Gladbach
Fritz, P.	Universität Hannover
Friz, G.	Euratom Ispra / Italien
Fröhlich, R.	KfK / INR
Füger, M.	KBG Leopoldshafen
Funke, O.	EVS Stuttgart
Gabriel, H.W.	DGB Weinheim
Gehrhardt, H.-J.	BMI Bonn
Geiger, W.	Battelle Institut Frankfurt
Gieseke, J.	BCL / USA
Gottlob, P.	KfK / PAL
Großerichter, R.	TÜV Bayern München
Grünhagen, A.	KfK / HIT
Gulden, W.	IKE Stuttgart
Gundermann, D.	Pfalzwerke Ludwigshafen

Name	Institution
Häfner, H.	KfK / IMF III
Hagen, S.	KfK / HIT
Hahn, L.	Öko-Institut Freiburg
Hain, K.	KfK / HIT
Hannappel, J.	NUKEM Hanau
Hartwig, S.	Battelle Institut Frankfurt
Hassmann, K.	KWU Erlangen
Haury, G.	BBR Mannheim
Heil, J.	BMFT Bonn
Heinz, W.	KfK / ITP
Helmers, H.	TÜV Hannover
Hennies, H.H.	KfK / Vorstand
Hermann, H.	KfK / PEK
Herrmann, F.J.	GWK Leopoldshafen
Herrmann, G.	GWK Leopoldshafen
Hicken, E.	GRS Garching
Hille, R.	KFA Jülich
Hindle, E.	UKAEA England
Hoensch, V.	Min. f. Arbeit, Gesundheit u. Soz. Stuttgart
Hörmann, E.	Dornier System GmbH, Friedrichshafen
Hörning, H.	Interatom Bergisch-Gladbach
Hoffmann, Heinz	BBR Mannheim
Hoffmann, Helmut	Pfalzwerke Ludwigshafen
Holleck, H.	KfK / IMF I
Holtbecker, H.	G.F.S. Ispra / Italien
Homma, H.	KfK / LA
Hoppe, H.-Ch.	TÜV Stuttgart
Horsch, F.	KfK / PNS-PL
Hosemann, J.P.	KfK / PNS-PL
Huber, A.	SDK Ingenieuruntern. Lörrach
Hübschmann, W.	KfK / HS
Humbach, W.	Inst. f. Reaktortechnik, TH Darmstadt

Name	Institution
Ihle, P.	KfK / IRB
Inabe, T.	JAERI / Japan
Ivens, G.	AVR GmbH Düsseldorf
Junge, R.	BBC Baden / Schweiz
Kadlec, J.	KfK / IRE
Kammerer, U.	RWTÜV Essen
Kanzleiter, T.	Battelle Institut Frankfurt
Kapulla, H.	KfK / HIT
Karb, E.	KfK / HIT
Keil, D.	Min. f. Arbeit, Gesundheit u. Soz. Stuttgart
Keller, C.	KfK / SKT
Kellner, G.	Öko-Institut Freiburg
Kemmerich, M.	KfK / LA
Kerr, W.	USNRC/ACRS / USA
Kerwin, D.	EG&G Idaho z.Z. KfK / IMF I
Kessler, G.	KfK / INR
Keusenhoff, J.	GRS Köln
Kiefer, H.	KfK / HS
Kietzer, K.	RWTÜV Essen
Klein, K.W.	Badenwerk Karlsruhe
Köberlein, K.	GRS Garching
Körber, H.	Berat.Büro f. Angew. Physik, Gechingen
Körting, K.	KfK / OEA
Kolodziej	KfK / IRB
Kraus, W.	TÜV Mannheim
Kreisel, W.	Hess. Landesanstalt f. Umwelt, Wiesbaden
Krieg, R.	KfK / IRE
Krüger, W.	KfK / LEOPOLDSHAFEN
Küchle, M.	KfK / INR
Kühn, W.	KfK / LEOPOLDSHAFEN
Kummerer, K.	KfK / IMF III
Kutsch, W.	RWE Essen

Name	Institution
Laermann, K.-H.	Universität Wuppertal
Ledermann, H.	Ingenieurberatung Ketsch
Leichsenring, C.H.	KfK / PWA-PL
Lienhart, W.	Min. f. Arbeit, Gesundheit u. Soz. Stuttgart
Lindow, W.	Kraftanlagen Heidelberg
Lummerzheim, D.	BMFT Bonn
Majewski, I.	Niedersächs. Soz.Min., Hannover
Malang, S.	KfK / IRB
Malinauskas, A.	Oak Ridge National Lab. / USA
Marchese, A.	USNRC/NRR / USA
Merz, E.	KFA Jülich
Mitchell, D.	Sandia Lab. / USA
Müller, H.H.	AEG-Elotherm, Remscheid
Müller, U.	KfK / IRB
Muir, J.	Sandia Lab. / USA
Murley, T.	USNRC / USA
Munz, D.	KfK / IRB
Naff	GRS Köln
Nagel, K.	KfK / IDT
Neck, E.	KfK/HF
Neff, N.	RWTÜV Essen
Nickel, H.	KFA Jülich
Niessalla, G.	TÜV Hannover
Nikodem, H.	Battelle Institut Frankfurt
Nikolopoulos, P.	KfK / IMF I
Nixdorf, J.	Wiss.-Techn. Beratungen Frankfurt
Nowak, K.	TÜV Rheinland Köln
Olles, T.	KBG Leopoldshafen
Orth, K.H.	KWU Erlangen

Name	Institution
Palmowski, J.	Kraftanlagen Heidelberg
Faul, K.D.	RWTÜV Essen
Peck, S.	EG & G Idaho z.Z. KfK / IRE
Peehs, M.	KWU Erlangen
Perinic, D.	KfK / HIT
Perzl, F.	GSF Neuherberg
Pförtner, H.	Fraunhofer-Gesellschaft Berghausen
Preußner, T.	TH Darmstadt
Quirrenbach, F.J.	VdTÜV Essen
Quittschreiber, G.	USNRC/ACRS Staff / USA
Rautenberg, J.	HRB Mannheim
Reimann, J.	KfK / IRB
Reimann, M.	KfK / IRB
Reineke, H.H.	Ing. Büro für Berechnung und Entwicklung verfahrenstechnischer Anlagen, Seelze
Reuschenbach, F.	GRS Köln
Reuter, H.-J.	Öko-Institut Freiburg
Riegel, B.	GRS Garching
Riem, P.	GKN Neckarwestheim
Ringot, C.	CEA Paris / Frankreich
Rininsland, H.	KfK / PNS-PL
Risse, D.	GRS Köln
Rittig, D.	GRS Köln
Ritzman, R.	SAI / USA
Rödler, P.	Bonnenberg & Drescher Aldenhoven
Rohde, D.	Pfalzwerke Ludwigshafen
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