Contract Program
or Project Title:

Surveillance Data Bases, Analysis, and
Standardization Program

Subject of This Document:

Report of Foreign Travel of F. B. K.
Kam, Leader, Radiation Effects,
Shielding, and Dosimetry Group,
Computing and Telecommunications
Division

Type of Document:

ORNL Foreign Trip Report

Author:

F. B. K. Kam

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September 21, 1990

Responsible NRC Individual
and NRC Office or Division:

Alfred Taboada, Division of
Engineering, U.S. Nuclear Regulatory
Commission
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ORNL

FOREIGN TRIP REPORT

ORNL/CSD/FTR-3758

DATE: September 26, 1990

SUBJECT: Report of Foreign Travel of F. B. K. Kam

TO: Alvin W. Trivelpiece

FROM: F. B. K. Kam

PURPOSE: To participate in the Seventh ASTM-EURATOM Symposium on Reactor Dosimetry at Strasbourg, France; to participate in technical discussions on nuclear safety with the Nuclear Research Institute, Czechoslovakia, and Budapest Technical University, Hungary.

SITES

VISITED:	8/26-31/1990	Symposium	Strasbourg, France	
	9/3-5/1990	NRI	Rez and Prague, Czechoslovakia	B. Osmera M. Tichy
	9/10-11/1990	Budapest Technical University	Budapest, Hungary	E. Zsolnay E. Szondi

ABSTRACT

The traveler presented a paper at the Seventh ASTM-EURATOM Symposium on Reactor Dosimetry and co-chaired an oral session on Computer Codes and Methods. Papers of considerable interest to the NRC Surveillance Dosimetry Program involved statistically based adjustment procedures and uncertainties. The information exchange meetings with Czechoslovakia and Hungary were very enlightening. Lack of large computers have hindered their surveillance program. They depended very highly on information from their measurement programs which were somewhat limited because of the lack of sophisticated electronics. The Nuclear Research Institute at Rez had to rely on expensive mockups of power reactor configurations to test their fluence exposures. Computers, computer codes, and updated nuclear data would advance their technology rapidly, and they were not hesitant to admit this fact. Both eastern-bloc countries said that IBM is providing an IBM 3090 for educational purposes but research and development studies would have very limited access. They were very apologetic that their currencies were not convertible, and any exchange means that they could provide services or pay for U.S. scientists in their respective countries, but funding for their scientists in the United States, or expenses that involved payment in dollars, must come from us.

REPORT OF FOREIGN TRAVEL TO FRANCE, CZECHOSLOVAKIA AND HUNGARY

BACKGROUND

The Nuclear Regulatory Commission, Materials Engineering Branch, Division of Engineering, is supporting work at ORNL to validate and to improve procedures and assumptions used in neutron fluence determination, to compile and verify the quality of data bases used in the above procedures, and to determine uncertainty estimates for the fluences in reactor pressure vessels. In addition to this work, NRC is fostering cooperative exchange programs in Civilian Nuclear Reactor Safety (CNRS) with different countries that would be mutually beneficial to both parties. The bottom-line result is to provide the technical basis for voluntary consensus standards that can be used in Codes, Regulatory Guides, Standard Review Plans, and future plant-life extension evaluations.

As part of this overall program, a series of ASTM-EURATOM symposia was initiated to bring together specialists from many countries to provide a forum for the exchange of ideas, techniques, and applications of reactor dosimetry to power reactor surveillance and to materials irradiation studies.

The visits to Czechoslovakia and Hungary were made in response to an invitation from the U.S. Nuclear Regulatory Commission (NRC) to explore what specific programs of exchange in the area of materials irradiation and reactor surveillance dosimetry can be effected as part of NRC's information exchange program.

SEVENTH ASTM-EURATOM SYMPOSIUM Strasbourg, France August 26-31, 1990

The traveler presented a paper titled "U.S. Power Reactor Embrittlement Data Base," at the Seventh ASTM-EURATOM Symposium on Reactor Dosimetry, co-chaired a session on Computer Codes and Methods, participated in joint meetings between members of the ASTM and EURATOM program committees, participated in workshops on LWR surveillance monitoring and adjustment codes and data bases, and held discussions with several participants on current status and future directions of the surveillance program. All papers presented at the symposium have been shipped back to ORNL for future references. Attendance at this symposium was sponsored by NRC to represent their interests.

There were several papers of interest to the NRC Surveillance Program. The western countries have been addressing the statistically based adjustment procedures more rigorously than eastern-bloc countries.

The availability of high-speed computers is probably the principal reason. Westinghouse and Babcock and Wilcox discussed their Integrated Surveillance Programs. Cavity dosimetry and gamma-ray dosimetry techniques to determine heat-generation rates were discussed as part of their overall tasks. There were many papers dealing with measurements using the solid state track recorders, niobium monitors, damage monitors, and gamma detectors. The development of these detectors will be helpful for NRC's surveillance Program.

After my presentation of the U.S. Power Reactor Embrittlement Data Base, N. P. Kocherov of IAEA indicated that he was interested in establishing an Embrittlement Data Base for all power reactors in the world. He would like to call a specialists' meeting in Vienna for just that purpose. It appears that he wanted help to compile this data base, but did not know whom to contact or who could do the work. He was informed that V. N. Lyssakov of IAEA was approached in June 26, 1987, about such a program. At that time Mr. Lyssakov indicated that he had neither the personnel nor the funding for such a task. Dr. Kocherov was informed that he should approach C. Z. Serpan of NRC if he wants to pursue this matter further.

It was interesting to note that a couple of European papers on transport calculations in the cavity of power reactors showed that the calculated to experimental (C/E) ratios were about 1.2. They were eager to get the ENDF/B-VI to obtain some improvement. N. P. Kocherov of IAEA told them it would be about a year before that data will be processed. The calculators were informed that recent studies sponsored by NRC indicated that the ENDF/B-VI cross sections will make their ratios even higher. The most significant change in ENDF/B-VI is the lowering of iron total inelastic cross sections. The effect of this change is to increase the flux with increasing iron penetration.

Albert Fabry of Mol, Belgium, was discussing the VENUS experiments and indicated that there are discrepancies between the water measurements at 45 degrees with calculations. He wanted to know if the ENDF/B-VI cross sections for oxygen have changed. He was reluctant to do more experiments until the past water measurements were resolved. However, he indicated that at least one more benchmark experiment needs to be done, but he did not elaborate. This problem is being investigated currently since the light water reactor configurations consist of water and steel.

Finally, there was a discussion of gamma-ray dosimetry and heat-generation rates in mixed fields. The question of heat-generation rates and temperature distributions in power reactors will have to be addressed in time.

Nuclear Research Institute (NRI)
Rez, Czechoslovakia
September 3-5, 1990

Discussions with Reactor Dosimetry Group

B. Osmera of NRI gave a detailed report of their current neutron dosimetry program that was dependent only on measurements. He did not discuss their previous comparisons with calculations, but he did provide a report of the work. The calculations used the ANISN and DOT 3.5 codes and DLC-23/CASK cross-section library. They did have the VITAMIN-C and the EURLIB-4 fine group libraries, but not VITAMIN-E. J. Rataj is currently responsible for performing their calculations, but was not available for discussions. The calculations of the neutron field parameters were not always calculated with sufficient accuracy so that measurements in benchmark fields and low-power mockup configurations were necessary. The calculations are all relative and are normalized to the measurements.

The experimental programs depend on the LR-0 reactor that was designed and built for research activities related to the VVER-type reactors. The thermal power of the reactor is limited to 5 kW for 1 hour, and the thermal neutron fluence rate in the center of the reactor core is about $1.0 \text{ E}+13 \text{ m}^{-2} \text{ s}^{-1}$. B. Osmera said that after about eight years of operation, the decision was a good one. Many projects were done under contract from IAE, Moscow, and Skoda, Czechoslovakia, to study various configurations of the VVER-400 and, lately, the VVER-1000. He indicated that they were having trouble with the VVER-1000 configurations but did not elaborate.

Full-scale modeling in the radial direction, from the core to the biological shielding of the VVER-type reactors, were simulated at the LR-0 reactor. The active length of the fuel elements were 1250 mm, and the fuel enrichment varied from 1.6 to 4.4% uranium-235. The neutron spectra were measured within the energy range of 10 keV to 10 MeV. A scintillation counter with a 10-by-10-mm stilbene crystal and two 40-mm-diameter spherical proportional counters were used. The energy range for the scintillation counter was 0.5 to 10 MeV, and 10 keV to 1.4 MeV for the proportional counters. The measurements were performed on the reactor midplane at the surveillance chain, the pressure vessel (PV) inner surface, the 1/4 PV thickness, and the PV outer surface. The detector counters were very similar to the benchmark experiments performed at UKAEA Winfrith, and B. Osmera said that they obtained their counters from the United Kingdom. He indicated that some improvements were made. A definitive response to a question regarding the overlapping energy range between the two counters or how the counters were calibrated was not answered. It was impressive that their experiments actually measured neutron spectra, and not integral responses from activation monitors. As a result, they obtained measured lead factors for the power reactor mockup (11.74 for the inner surface and

15.04 for the 1/4 PV thickness for neutron energies greater than 0.1 MeV). This type of measurements would be of significant importance in the validation of the shape of our calculated group fluxes (above 0.1 MeV) as part of any cooperative agreement with NRI, Czechoslovakia. The dosimetry group did very little in the way of gamma-ray dosimetry. About two hours was spent touring the LR-0 reactor. The mockup for the VVER configurations was in place, and they had just shut the reactor down to make a change. B. Osmera indicated the electronics were old, but they were still reliable.

Discussions with Reactor Materials Research Division

Jiri Zdarek, Head of the Reactor Materials Research Division, wanted a short discussion related to the work he was doing. He said that he was one of three evaluators for the nuclear safety of one of the Slovak power plants. He was responsible for the piping and corrosion studies, M. Brumovsky was responsible for the pressure vessel, and a third person had responsibility for the leak before break studies. He wanted to convey to C. Z. Serpan the work he was doing and what his findings were currently. A request was made that he put things down in a letter to Serpan, and it would be delivered. He indicated that this work was a subcontract to Skoda and NRI from the Slovakian ministry.

He turned his discussion to the irradiation capabilities of NRI. A 15-MW thermal test reactor will be ready by December 1990. They expect that the irradiation parameters for users will be available shortly after that date. He said that they could test small specimens at NRI, and large specimens could be done at Skoda. He was informed that Mr. Taboada of NRC and Bill Corwin of ORNL are the persons to discuss this work. The areas of reactor dosimetry, shielding, and the U.S. Power Reactor Embrittlement Data Base were part of the traveler's project.

He mentioned that many changes have occurred in the top echelon of NRI and the CAEC since the last meeting with the U.S. delegation. He indicated that more changes will occur in the next few months. He also mentioned that Skoda had bought the license from the USSR for the manufacture of the VVER-1000 reactors, and if demand for the VVER-1000 reactors does not materialize, the company will suffer losses. He mentioned that the new head of the CAEC is Wagner from Skoda.

Mr. Zdarek asked a personal question about the people at the U.S. National Laboratories doing consultant work. He was informed that there must be no conflict of interest with the work at the Laboratory, and the employee must get approval in advance. The traveler was not aware of additional information on the subject.

T. Pav informed me that he had a subcontract with IAE, Moscow, to put together an embrittlement data base for the VVER-440 reactors, and was interested to show me what he had compiled. He had a copy of the NRC report titled "PR-EDB: Power Reactor Embrittlement Data Base, Version 1,"

NUREG/CR-4816, June 1990. He spent a few minutes discussing the format of the data base. He indicated that he was using dBASE III plus for the personal computer, but it appeared that the architecture was a bit different from the U.S. version. It was surprising that he had a copy so quickly. He was informed that Mr. Kocherov of IAEA would be interested in his data base.

Institute of Radiation Dosimetry

M. Tichy of this Institute informed the traveler that he was interested in discussing his work on benchmark experiments of 14 MeV neutrons transmitted through iron. He felt that some of his work could be used to verify the new iron total inelastic cross sections in ENDF/B-VI. He spent about half an hour discussing his experimental setup, and then he turned to the topic of calculations. He mentioned that after about three years he received a copy of the Monte Carlo code, MCNP. However, he did not have a computer large enough to run the code. He said that IBM is furnishing an IBM 3090 to the University for education purposes, and he hopes to have a little time to test MCNP. Prior to this code, he was using 05R, a Monte Carlo code that was written at ORNL over 30 years ago by Coveyou and Sullivan. He was interested in knowing what discrete ordinates code to request from the Radiation Shielding Information Center (RSIC), and whether the latest nuclear cross-section data will be available to them. He was informed that his request should be made directly to the RSIC, and to let them process the paper work through the Department of Energy. The two-dimensional code, DORT, was recommended because it will be compatible with the IBM 3090.

Technical University of Budapest
Institute of Nuclear Technics
Budapest, Hungary
September 10-11, 1990

Dr. E. Zsolnay and Mr. E. Szondi started out the discussions with a description of their 100-kW, light-water-moderated, graphite reflected research reactor located at the university. The fuel elements were square rods containing 16 fuel pins and were about 10% enriched U-235. The fuel elements were more like the Buffalo reactor than the Material Test Reactor elements at Oak Ridge Research Reactor. The reactor had five beam tubes and an irradiation tunnel where shielding experiments were performed. Although the reactor is devoted primarily to educational purposes, research and development activities also were performed. Many of their surveillance dosimetry practices at the Paks Nuclear Power Plants (NPP) were investigated here. Proton recoil measurements were performed to measure the energy spectrum between 15 keV and 1.3 MeV behind different shield assemblies.

Their surveillance program for neutron dosimetry in the Paks NPP depends on activation monitors (Fe, Cu, and Nb) for the determination of fluence exposure. However, they have already completed preliminary work to insert dosimetry capsules in the reactor cavities and to increase the energy coverage of their threshold dosimeters. A test run was inserted into the second Paks reactor, and the results were very good. Plans are under way to put both surveillance and cavity dosimetry sets in all four reactors, and insert the new sets every four to five years when the last capsule is withdrawn. The reason for this procedure is their high lead factor of 11.7 from the surveillance capsule to the PV inner surface. Their calculational capabilities are very limited due to the lack of large computers, computer codes and nuclear data. They have been using a ten-group flux set calculated by IAE, Moscow. Their lead factors were obtained from Finland. The design of the Paks plants are fundamentally identical with Loviisa 1 and 2 in Finland. E. Szondi said that IBM will be furnishing the university with an IBM 3090 computer for educational purposes, and was interested in the two-dimensional code, DOT 4.3, and the nuclear data. The traveler informed him that his request should go to the Radiation Shielding Information Center, but must be approved by the Department of Energy.

P. Trampus, head, Material Testing Department, at the Paks NPP discussed their materials testing program. He emphasized that although the main contractor for the power plants was the Soviet company Atomenergosexport, the reactor pressure vessels (RPV) were manufactured by the Czechoslovakia Skoda Power Machinery Plant with low copper and phosphorus content. A circumferential weld is located near the core that receives 66 to 68 percent of the maximum flux. Each RPV at Paks has six Loviisa-type sets of surveillance specimens consisting of base metal, heat-affected-zone and weld materials. Each set consists of 12 Charpy-V specimens, 12 Charpy-size three-point-bend specimens, and six tensile specimens. The capsule contains the dosimetry mentioned above and diamond powder to measure the irradiation temperature. He mentioned that he did not think the diamond powder gave very accurate results. The temperature in their capsules were $260-270^{\circ}\text{C} \pm 15$ degrees. The specimens were located between the core and the PV and welded to the outside of the core barrel. He handed out papers summarizing the results of the materials test results. Based on the surveillance testing results, the ultrasonic examinations and the fracture mechanics calculations, the RPVs at Paks will not endanger the brittle fracture safety margins of the vessels during their lifetime.

F. Gillemot of the Central Research Institute for Physics spoke about their material damage studies. He mentioned that they do ultrasonic testing of the PV outer surface every year and of the PV inner surface every four years. Their future studies include thermohydraulics investigations, noise diagnostics, reactor instrumentation for power plants, nondestructive testing, and acoustic emission to look at embrittlement. He was aware that much of these studies were already in

advanced stages in the U.S., and was interested in any cooperative type of agreement. He indicated that life-extension studies must begin now for Hungary, that unirradiated and irradiated testing of specimens are performed in separate institutes, and quality assurance for welds is also done by a separate institute. He ended his discussion by informing me that a "Specialists Meeting on Radiation of Nuclear Reactor Pressure Vessel Steels," will be held near the Paks site, September 25-28, 1990, and will be chaired by Len Steele.

The last speaker was G. Csom, Director of the Institute of Nuclear Technics. Although he understands English, he spoke Hungarian, and E. Zsolnay translated. He stated that beginning this year, a master's program in nuclear engineering will be initiated at the university, and will be followed by a bachelor's program in the following year. His interest was in starting an exchange of some sort to obtain nuclear educators from the National Laboratories or U.S. universities to teach courses even for a couple months. He indicated that the Mellon Foundation is sponsoring some educators from the U.S. to Hungary. If the Mellon Foundation does not sponsor this exchange, he inquired whether exchanges of personnel can be effected whereby he pays for people there and the U.S. institution pays for his people in America. The nonconvertibility of the Hungarian currency was the reason. The courses will be given in English. The traveler informed him that inquiries will be made upon his return to the United States.

APPENDIX A

Itinerary

August 23-24, 1990	Travel from Oak Ridge, Tennessee, to Strasbourg, France
August 25, 1990	Saturday in Strasbourg, France. No cost to government
August 26-31, 1990	Attended the Seventh ASTM-EURATOM Symposium on Reactor Dosimetry, Strasbourg, France
August 31- September 2, 1990	Weekend travel to Prague, Czechoslovakia
September 3-5, 1990	Discussions at the Nuclear Research Institute, Rez, Czechoslovakia, and Institute of Radiation Dosimetry, Prague, Czechoslovakia
September 6, 1990	Travel to Budapest, Hungary
September 7-9, 1990	Discussions at the Budapest Technical University postponed to Monday, September 10, 1990, at request of Dr. P. Trampus, Head of Material Testing Department, Paks Nuclear Power Station, due to unanticipated troubles. Traveler took vacation to accommodate request.
September 10-11, 1990	Discussions at Budapest Technical University. An additional 1/2 day was added to the discussions to accommodate Dr. F. Gillemot and the Director of the Institute of Nuclear Technologies
September 12-13, 1990	Travel from Budapest to Frankfurt and from Frankfurt to Oak Ridge, Tennessee

APPENDIX B

LITERATURE ACQUIRED

Seventh ASTM-EURATOM Symposium on Reactor Dosimetry

Over one hundred papers were acquired at the symposium. The titles are listed in a document, "Abstracts of The Seventh ASTM-EURATOM Symposium on Reactor Dosimetry, Strasbourg, France, 27-31 August 1990," retained in the office of the traveler. The complete symposium proceedings will be published as a peer-reviewed document by the D. Reidel Publishing Company, P. O. Box 17, 3300 AA Dordrecht, Holland.

Nuclear Research Institute
Rez, Czechoslovakia

1. B. Osmera et al., "Studies of VVER Physics on IR-0 Experimental Reactor," presented at the PHYSOR 90 Conference, Marseille, France, April 23-24, 1990.
2. B. Osmera, "Experimental and Theoretical Investigations for VVER Pressure Vessel Neutron Exposure Evaluation in Czechoslovakia," presented at the IAEA Advisory Group Meeting on the Status and Requirements of Nuclear Data for Radiation Damage and Related Safety Aspects, Vienna, Austria September 19-22, 1989.
3. B. Osmera et al., "The Activity of the Czechoslovakia Working Group on Reactor Dosimetry in the Period from 1980 to 1983," presented at the Fifth ASTM-EURATOM Symposium on Reactor Dosimetry, Geesthacht, FRG, September 24-28, 1984.

Budapest Technical University
Budapest, Hungary

1. F. Gillemot et al., "Evaluations of VVER-440 Surveillance at Paks, NPS," ASTM STP 1011, Phila., PA, 1989.
2. P. Trampus, "Paks Surveillance Shows Reactor Vessels Safe from Embrittlement," Nuclear Engineering International, July 1990.
3. F. Gillemot and P. Trampus, "Survey of Post Irradiation Testing in Hungary," unpublished.
4. E. J. Szondi, "Temperature Fields and Thermal Stress Fields in Radiation Shielding," Periodical Polytechnica, Vol. 26, Nos. 1-2, 1982.

5. E. Zsolnay et al., "New Aspects in Least Squares Adjustment Methods," presented at the Fifth ASTM-EURATOM Symposium of Reactor Dosimetry, Geesthacht, FRG, September 24-28, 1984.
6. F. Divos and E. M. Zsolnay, "Neutron Spectrum Measurement in the Reactor Cavity of the Paks NPP," BME-TR-RES-14/86, Feb. 1986.
7. E. M. Zsolnay and F. Divos, "Surveillance Neutron Dosimetry at the Hungarian Nuclear Power Plant," presented at the Sixth ASTM-EURATOM Symposium on Reactor Dosimetry, Jackson Hole, WY, May 31 to June 5, 1987.
8. E. J. Szondi, "Some Limits to the Accuracy of the Radiation Damage Estimate," presented at the Czechoslovakia National Seminar on Reactor Dosimetry, October 20-22, 1987.

APPENDIX C

CONTACTS

ASTM-EURATOM Symposium

The attendees of the Symposium are listed below for completeness.

Dr. H. Ait Abderrahim, SCK/CEN, Belgium
 Mr. A. Alberman, CEA/CEN, France
 Dr. W. G. Alberts, PTB, Fed. Rep. of Germany
 Mr. A. V. Alevra, PTB, Fed. Rep. of Germany
 Dr. M. Angelone, ENEA, Italy
 Mr. S. C. Apple, Arkansas Tech. University, Russellville, AR
 Dr. L. B. Baers, Technical Research Center of Finland, Finland
 Mr. A. Ballesteros, Tecnatom, Spain
 Mr. M. F. Banham, AEA Technology, United Kingdom
 Dr. P. Batistoni, Italy
 Dr. N. P. Baumann, Westinghouse Savannah River Co., Aiken, SC
 Dr. Barak Ben-Shahar, NRC-NEGEV, Israel
 Mr. D. Beretz, CEA, France
 Mr. A. Bevilacqua, CEA, France
 Mr. J. J. Bonnin, CEA, France
 Mr. L. Bourdet, CEA, France
 Mr. G. S. Carter, B&W Nuclear Service Co., Lynchburg, VA
 Mr. C. A. Casado, ENUSA, Spain
 Dr. E. T. Cheng, TSI Research, Rancho Santa Fe, CA
 Dr. F. Cleri, ENEA, Italy
 Dr. N. C. Coursol, CEA, France
 Mr. F. Curran, Ohio State Univ., Columbus, OH
 Dr. R. Dierckx, Italy
 Mr. J. R. Dumais, Tohoku University, Japan
 Mr. C. Ertek, IAEA, Austria
 Mr. A. Fabry, SCK/CEN Reactor Physics, Belgium
 Dr. H. Farrar, Rockwell International, Canoga Park, CA
 Dr. T. M. Flanders, Nuclear Effects Laboratory, NM
 Mr. M. Fourgoux, CEA, France
 Mr. W. E. Freudenreich, ECN, The Netherlands
 Dr. C. Y. Fu, ORNL, Oak Ridge, TN
 Dr. A. J. Fudge, AEA Technology, United Kingdom
 Dr. Uzi Gherman
 Dr. G. Gorini, ENEA, Italy
 Dr. L. R. Greenwood, Battelle Pacific Northwest Lab., Richland, WA
 Dr. P. J. Griffin, Sandia National Lab., Albuquerque, NM
 Dr. F. H. Haggag, ORNL, Oak Ridge, TN
 Dr. F. W. Hasing, KFA Julich, Fed. Rep. of Germany
 Dr. P. J. Heffer, Berkeley Nuclear Laboratories, United Kingdom
 Mr. Hofmann, Siemens AG UB KWU, Fed. Rep. of Germany

Mr. Heimbach, Aberdeen Proving Ground, MD
 Dr. F. Hegedus, Paul Scherrer Institute, Switzerland
 Pr. Helm, New York, NY
 Dr. A. G. Holmes-Siedle, R.E.M., United Kingdom
 Pr. L. M. Hodgson, Arkansas Technical University, Russellville, AR
 Dr. P. D'Hondt, SCK/CEN-Reactor Physics, Belgium
 Mr. C. A. Hrabel, NRC, Washington, DC
 Dr. C. D. Ingelbrecht, CBNM, Belgium
 Mr. C. Hickman, CEN, France
 Mr. S. Iwasaki, Tohoku University, Japan
 Dr. J. Kalline, Uppsala University, Sweden
 Mr. F. B. K. Kam, ORNL, Oak Ridge, TN
 Mr. S. O. King, Nuclear Service Company, Lynchburg, VA
 Dr. N. P. Kocherov, IAEA, Austria
 Dr. K. Kobayashi, Kyoto University, Japan
 Dr. G. P. Lamaze, NIST, Gaithersburg, MD
 Mr. R. Lloret, CEA, France
 Dr. E. P. Lippincott, Westinghouse Electric Corporation, Pittsburgh, PA
 Dr. M. C. Lopes, Institute of Nuclear Sciences & Engineering, Portugal
 Mr. A. L. Lowe, Jr., B&W Nuclear Service Company, Lynchburg, VA
 Dr. T. F. Luera, Sandia National Laboratories, Albuquerque, NM
 Dr. R. E. Maerker, ORNL, Oak Ridge, TN
 Dr. W. N. McElroy, Consultant & Technology Services, Richland, WA
 Pr. P. Manahan, Penn State University, University Park, PA
 Mr. A. Marcault, CEA, France
 Dr. G. C. Martin, General Electric Company, Pleasanton, CA
 Dr. M. Matzke, PTB, Fed. Rep. of Germany
 Mr. Mehner, Fed. Rep. of Germany
 Mr. G. Minsart, SCK/CEN, Belgium
 Mr. E. D. McGarry, NIST, Gaithersburg, MD
 Dr. Mason, Technology Transfer Center, England
 Mr. C. Morin, CEA, France
 Dr. M. Najzer, J. Stefan Institute, Yugoslavia
 Mr. H. J. Holthenius, ECN, The Netherlands
 Mr. N. Odano, Tohoku University, Japan
 Mr. P. M. Ortego, ENUSA - Nuclear Fuel Division, Spain
 Mr. R. L. Perel, Hebrew University of Jerusalem, Israel
 Dr. M. Petilli, ENEA, Italy
 Ms. L. Petrusha, B&W Nuclear Service Company, Lynchburg, VA
 Mr. J. B. Paire, CEA, France
 Mr. A. N. Polle, ECN, The Netherlands
 Mr. S. W. Power, U.K. Atomic Energy Authority, United Kingdom
 Dr. K. M. Pytel, Institute of Atomic Energy, Poland
 Mr. U. Quade, Interatom GMBH, Fed. Rep. of Germany
 Mr. C. M. J. De Raedt, SCK/CEN, Belgium
 Mr. I. Remec, J. Stefan Institute, Yugoslavia
 Mr. C. Rieg, EDF/SEPTEN, France
 Mr. J. W. Rogers, EG&G Idaho Inc., Idaho Falls, ID
 Dr. F. H. Ruddy, Westinghouse Science & Technology Center, Pittsburgh, PA

Dr. K. E. Sale, Lawrence Livermore National Laboratory, Livermore, CA
 Dr. G. Sandrelli, ENEL - Thermal & Nuclear Research Centre, Italy
 Pr. V. Sanjust, Politecnico di Milano, Italy
 Mr. T. O. Seren, Technical Research Centre of Finland, Finland
 Mr. W. L. Server, Tenera Engineering Services, Berkeley, CA
 Dr. N. H. Shafir, Technion Israel Institute of Technology, Israel
 Dr. Mary H. Sparks, Nuclear Effects Laboratory, NM
 Dr. F. W. Stallmann, ORNL, Oak Ridge, TN
 Dr. M. Tichy, Institute of Radiation Dosimetry, Czechoslovakia
 Dr. G. Tsotridis, Commission des Communautés Europeennes, The Netherlands
 Dr. D. W. Vehar, Sandia National Laboratories, Albuquerque, NM
 Ms. T. Vergnaud, CEA, France
 Mr. W. P. Voorbraak, ECN, The Netherlands
 Pr. J. J. Wagschal, Hebrew University of Jerusalem, Israel
 Dr. C. D. West, ORNL, Oak Ridge, TN
 Dr. J. G. Williams, University of Illinois, Urbana, IL
 T. G. Williamson, Westinghouse Savannah River Lab., Aiken, SC
 Dr. Peter Wille, GKSS, Fed. Rep. of Germany
 Dr. E. M. Zsolnay, Technical University of Budapest, Hungary
 Mr. P. Zyromski, CEA, France

Czechoslovakia

B. Osmera, Section Head, NRI
 T. Pav, Reactor Materials Research Division, NRI
 J. Zdarek, Head, Reactor Materials Research Division, NRI
 V. Vesely, Head, International Office, NRI
 M. Tichy, Physicist, Institute for Radiation Dosimetry, Prague

Hungary

P. Trampus, Head, Material Testing Dept., Paks Nuclear Power Station
 F. Gillemot, Senior Research Associate, Central Research-Institute for Physics
 E. Zsolnay, Technical University of Budapest, Institute of Nuclear Technics
 E. Szondi, Technical University of Budapest, Institute of Nuclear Technics
 G. Csom, Technical University of Budapest, Director, Institute of Nuclear Technics

APPENDIX D

DISTRIBUTION

1. John J. Easton, Jr., Assistant Secretary for International Affairs and Energy Emergencies (IE-1), DOE, Washington, DC 20585
2. L. C. Shao, Director, Division of Engineering, NRC, Washington, DC 20555
3. E. S. Beckjord, Director, Office of Nuclear Regulatory Research, NRC, Washington, DC 20555
4. E. J. McCallum, Director, Division of Safeguards and Security (DP-34), DOE, Washington, DC 20585
5. A. Bryan Siebert, Director, Office of Classification and Technology Policy, DOE, Washington, DC 20585
6. James A. Reafsnyder, Deputy Assistant Manager, Energy Research and Development, DOE/ORO, P. O. Box E, Oak Ridge, Tennessee 37831
7. James R. Shea, Director of International Programs, NRC, Washington, DC 20555
8. A. L. Hiser, Division of Engineering, NRC, Mail Stop NL/S-217C, Washington, DC 20555
9. M. E. Mayfield, Division of Engineering, NRC, Mail Stop NL/S-217C, Washington, DC 20555
- 10-11. A. Taboada, Division of Engineering, NRC, Mail Stop NL/S-217C, Washington, DC 20555
- 12-13. C. Z. Serpan, Jr., Division of Engineering, NRC, Washington, DC 20555
- 14-15. P. N. Randall, Division of Engineering, NRC, Washington, DC 20555
- 16-17. R. J. Bosnak, Deputy Director, Division of Engineering, NRC, Washington, DC 20555
- 18-19. D. J. Cook, Director, Safeguards and Security Division, DOE/ORO, Federal Building, Room 37830, Oak Ridge, Tennessee 37830
20. T. E. Murley, Director, Office of Nuclear Reactor Regulation, NRC, Washington, DC 20555
21. Executive Secretary, Advisory Committee on Reactor Safeguards, NRC, Washington, DC 20555
22. D. J. McGoff, Associate Deputy Assistant Secretary for Reactor Deployment, DOE, NE40, A439/GTN, Washington, DC 20585
23. E. Purvis, DOE, Washington, DC 20585
24. M. L. Williams, Nuclear Science Center, Louisiana State University, Baton Rouge, Louisiana 70803-5820
- 25-26. U.S. Department of Energy, Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831
- 27-31. R. K. Nanstad
32. E. R. Bowers
33. R. D. Cheverton
34. W. R. Corwin
35. J. E. Jones Jr.
36. F. B. K. Kam
37. W. E. Pennell

- 38. C. E. Pugh
- 39. R. Roussin
- 40. K. R. Thoms
- 41. D. B. Trauger
- 42. A. W. Trivelpiece
- 43. R. M. Westfall
- 44. G. E. Whitesides
- 45. A. Zucker
- 46-47. Laboratory Records Department
- 48. Laboratory Records Department - RC
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- 50. ORNL Patent Section
- 51. ORNL Public Relation Office

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