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INTERIM REPORT

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Subject of this Document: Travel of J. A. Thie, Consultant to ORNL,
to IAEA meeting in Czechoslovakia

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ORNL
FOREIGN TRIP REPORT
ORNL/FTR-1330

DATE: July 1, 1982

SUBJECT: Report of Foreign Travel of Joseph A. Thie, Consultant to
ORNL's Instrumentation and Controls Division

TO: Herman Postma

FROM: J. A. Thie, Consultant

- PURPOSE:
1. Serve as the U. S. Government-nominated participant in the "IAEA Specialists' Meeting on Early Diagnosis of Failures in Primary System Components of Nuclear Power Plants," held June 21-25, 1982 in Prague, including serving as chairman of the Diagnosis of Vibrations session.
 2. With the co-authorship of J. A. Mullens, present a paper of ORNL work entitled "Utilization of Pressure Noise for Reactor Anomaly Monitoring."
 3. Engage in technical discussions with other participants outside of the meeting time, emphasizing topics of interest to NRC-funded programs at ORNL primarily, but the general development of nuclear power as well.

SITES

VISITED: The meeting was held at the Hotel International in Prague, Czechoslovakia, June 21-25, 1982 and was sponsored by the IAEA and hosted by the Czechoslovak Atomic Energy Commission. Personnel individually contacted (see Appendix A) among the 48 participants for purposes of technical discussions were seven from five CMEA countries, and ten from six OECD countries.

ABSTRACT: From this conference, which was dominated by eastern European participants, summary information obtained from technical discussions and formal sessions is presented in four sections: (1) Items of a governmental, nuclear energy developmental/regulatory/safety, and IAEA-participational nature; (2) types of information obtained that are of value to the NRC's reactor surveillance and diagnostic programs - especially technical communications from participants directed specifically towards the ORNL pressure noise research presented in our conference paper; (3) a general survey of the conference technical content; and (4) a conclusion pointing out the value of participation in this type of conference, with recommendations for future participation.

COMPREHENSIVE REPORT

1. INFORMATION OF A GOVERNMENTAL, NUCLEAR ENERGY DEVELOPMENTAL/
REGULATORY/SAFETY, AND IAEA PARTICIPATIONAL NATUREUSNRC Participation in IAEA Activities

In the summing-up session of the meeting, there was constructive criticism regarding the absence of papers from regulatory and safety experts. Conference participants felt that these experts should be present to clarify their motives for promoting early diagnosis of power plant problems. When the chairman noted that only one regulatory expert (the Principal Inspector of Nuclear Installations in the UK) was in attendance, the group was informed that the traveler's participation was, in fact, sponsored by the USNRC because of its interest in supporting this IAEA safety activity.

At the next IAEA conference on this subject - perhaps in 1984 - there is likely to be a couple of invited papers to indicate safety interest in early diagnosis. It is the traveler's opinion that a joint USNRC-ORNL paper would be well received. Such a paper was informally volunteered from the UK by Her Majesty's Principal Inspector of Nuclear Installations.

CMEA* Countries' Participation in Conferences

The combination of IAEA sponsorship and a geographical location convenient for CMEA countries accounted for their predominant participation:

| | |
|---|-----------|
| 29 CMEA participants | 16 papers |
| 16 OECD participants | 9 papers |
| 1 developing country participant | |
| 2 international organizations' participants | |
| <u>48</u> | <u>25</u> |

Nevertheless, the papers and discussions were primarily in English. UN-style simultaneous interpretation was provided between Russian and English.

*CMEA (or COMECON) is the Council for Mutual Economic Assistance - an eastern European organization analogous to the OECD.

For individuals from these countries to participate in meetings, visits, and other activities outside their geographical area, they must receive an official invitation with ample advance notice. Moreover, as a Russian participant suggested, it is preferable that some mechanisms other than a formal paper (e.g., workshop sessions) be arranged for an informal exchange of information among participants who are unable to submit written papers due to cumbersome red tape.

UK Regulatory Environment: Regulations and Inspectors

In discussions with UK representatives, the traveler learned that the UK regulator-utility relationship is analogous to the following hypothetical US situation: (a) INPO with a couple of powerful safety committees setting regulations, with the government inspectorate as its conscience, and (b) government inspectors having a professionalism of the type one seeks in a consultant.

The industry and regulatory representatives in the UK gave no criticism of their regulatory environment - in contrast to criticisms sometimes voiced in analogous discussions in the US.

Plant Construction and Technical Support in CMEA Countries

With priority efforts, a 5-6 year construction time was mentioned as achievable in Bulgaria. A slightly longer time was envisioned as a lower bound for the plant currently being constructed in Poland, but the desire to use major Polish-fabricated parts for the first time may lead to substantial delays. At Swierk, Poland, a shift from nuclear to coal plant surveillance research has occurred.

Researchers in one country have difficulty obtaining design information from another country. Also, they are hampered by the unavailability of current state-of-the-art computer and reactor instrumentation equipment, as seen in the larger OECD countries. Further, limitations in the use of foreign exchange for purchases of foreign publications was a complaint from more than one research institution.

Future Meetings Pertinent to NRC Reactor Surveillance Programs

As part of the IAEA's program in nuclear safety research, a second meeting on early diagnosis is tentatively planned for 1984. It is expected that the times of two series of similar meetings involving the same specialists [i.e., the SMORN (Specialists' Meeting on Reactor Noise) series and the European series of annual informal reactor noise meetings] will be appropriately staggered in the future. The programmatic content of all three series is intimately related to many subtasks of the reactor surveillance programs being funded by the NRC. Characteristics of these meetings are summarized in Appendix B.

The traveler received two separate invitations coinciding with the time of the next scheduled meeting listed in Appendix B: (1) remain

for discussions at the Central Research Institute for Physics, Budapest, Hungary, after the meeting there; (2) give a lecture at the Institute of Nuclear Research, Swierk, Poland.

Conference Evaluation by Attendees

The following conclusions and recommendations were agreed upon by the participants in the final session and will be written into the IAEA's conference documents:

1. Thanks to the valuable organizational efforts by the IAEA and the excellent hosting services provided by the Czechoslovakian Atomic Energy Commission, the meeting was successful in its purpose of improving international cooperation in the subject technology selected.
2. Both the formality of written papers at an IAEA conference and the informality of oral presentations at related meetings held annually in Europe serve as useful vehicles for communicating advances in research and applications.
3. It will be fruitful to hold the second IAEA meeting of this type in about two years.
4. The OECD, IAEA, and organizers of informal meetings should communicate to avoid scheduling conflicts among the meetings in Appendix B.
5. Workshop oral discussion sessions should be a part of the next IAEA meeting, distinct from written paper sessions, especially to accommodate CMEA participants not providing written papers.
6. Safety needs in this area, not addressed in this meeting, should be a definite part of the next meeting - as by invited papers, possibly.

2. INFORMATION PERTAINING TO NRC-FUNDED PROGRAMS AT ORNL IN THE FIELD OF REACTOR SURVEILLANCE AND DIAGNOSTICS

Pressure Noise

In stimulating the accrual of information useful to ORNL's pressure noise research, contacts made prior to the conference proved beneficial: (a) the European trip of J. A. Mullens, ORNL, in May 1982; (b) mail, phone, and personal meeting contacts between the traveler and two European institutions performing similar research (Akademie der Wissenschaften der DDR at Dresden, GDR; and Gesellschaft für Reaktorsicherheit at Munich, FRG). As a result, individuals from both of these latter institutions not only spoke of their work but also transmitted internal memoranda specially written for ORNL's consumption a few of days before the conference (items j and k of Appendix D).

Within the last month a small-scale PWR loop was constructed at Dresden for purposes of studying low-frequency pressure noise. A loop at ORNL, now operating for purposes of studying pressure sensors, also obtains related information pertinent to unexplained pressure phenomena at LOFT. Information exchange here is most beneficial.

Research involving a computer program for computing acoustic pressure phenomena in reactor piping was conducted a year ago by the Munich group, but not published. Mentioned was information exchange involving explanations for certain LOFT pressure data and confirmatory calculations from the Munich group's computer program.

ORNL's paper was "Utilization of Pressure Noise for Reactor Anomaly Monitoring." In the formal discussion and especially subsequently in informal discussions, valuable suggestions were offered for ORNL's consideration in their recent investigations (of a dominating low-frequency pressure noise resonance common to all types of PWRs but still unexplained after 10 years of observations by others). The technical details of these suggestions, as well as those of the pressure noise loop and acoustic pressure in reactor piping calculations, will be conveyed by the traveler to ORNL personnel in detail.

Temperature Noise and Boiling Detection

Boiling detection was treated in various papers. In this connection, thermocouple noise in an instrumented assembly of the Rheinsburg WWER was studied. The French participants desire further information on ORNL's use of core exit thermocouple noise at TMI. For PWR boiling detection they prefer in-core neutron detectors. Nevertheless, the French might take core exit thermocouple noise data in a future pressure reduction test in a PWR where boiling is deliberately induced.

Pattern Recognition and System Modeling

Some advanced and sometimes rather general ideas on diagnostic aids, including parameter identification in models, were presented. Without practical examples of implementation given, their future merit remains unproven. One participant did show the practicality of extracting individual vibration resonance parameters by a different extraction method (involving autoregression) from that used in recent ORNL work.

Neutron Noise and Core Motions

Reviews of earlier work were given in some papers. Newly presented were noise measurements in a special controllable-flow WWER-type instrumented assembly; these had differences from usual BWR noise when boiling occurred. Special peculiarities of this assembly may be introducing effects not typical of PWR assemblies - a lesson that should be remembered for any special fuel assembly tests.

A few undiagnosed core anomalies seen in neutron noise were reported. A lack of ample and versatile data recordings at the times of the anomalies (in contrast to on-line data recording features used in loose-part detection systems) is preventing researchers from diagnosing and learning, according to reports from some participants.

3. TECHNICAL CONTENT OF THE CONFERENCE

Appendix C lists the session papers and topics treated. The list of reports brought from this meeting, Appendix D, includes a set of summaries, the papers presented, and a few additional reports received during private discussions.

Some repetition of the May 1982 informal noise meeting topics appeared in a few papers. However, with only a few of the participants attending both meetings, the papers are, by far, previously unpublished work.

From this latter class, the following items are deserving of note as being, to some extent, additions to currently in-vogue practices/methods - though in themselves not all necessarily intrinsically new:

1. Injecting and sensing ultrasound for diagnostic purposes, such as the detection of boiling.
2. A general system-analysis approach to diagnosis.
3. Topological aids borrowed from graphics theory that help in system modeling.
4. Using pressure noise for void detection, according to various mechanisms.
5. Use of an instrumented assembly with its own inlet flow control device.
6. A library of surveillance data anomalies, such as for pumps, being collected from now to 1985 in CMEA countries.
7. An acoustic pickup used to provide information on the tightness of coupling within a control rod mechanism.

4. CONCLUSIONS

1. The opinions stated here concerning the merit of participating in this type of conference reinforce those given in the trip report of last year's topically-related SMORN-III meeting (R. C. Kryter, ORNL/FTR-1219). Keeping current on related research avoids unknowing duplications of effort. Cooperative ventures in information exchange

result from the personal contacts made at conferences, such as this, which bring out common research interests.

2. As an isolated instance of cost effectiveness, this trip has provided ORNL pressure noise researchers with the techniques used and the problems encountered in a similar loop that was first put into operation in the GDR. Possibly more substantial, but more difficult to set a value on, is the information and specific suggestions pertinent to NRC's surveillance and diagnostic program. If maintained, contacts now established with the Munich and Dresden groups on the pressure noise program should bring about handsome payoffs.

3. Roughly one-half of the information in Sects. 1 and 2 above came from technical discussions that will never be documented in conference literature. Based on the traveler's experience, a suggestion is that future travelers establish contacts in some information exchange detail by mail and phone well in advance of the trip. The trip discussions can then be immediately productive rather than merely probing and preliminary in nature.

4. Finally, it is recommended that the Instrumentation and Controls Division of ORNL keep current on plans that organizers have for the three types of international meetings that address power plant surveillance and diagnostics. This is for purposes of participating in all three types. Moreover, a joint NRC-ORNL paper should be prepared for the next IAEA-sponsored meeting of this type.

APPENDIX A

LIST OF PARTICIPANTS

Specialists' Meeting on Early Diagnosis of Failures in Primary
System Components of Nuclear Power Plants,
June 21-25, 1982, Prague, CSSR

| <u>COUNTRY/NAME*</u> | <u>ORGANIZATION/ADDRESS</u> |
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| <u>CZECHOSLOVAKIA</u> | |
| J. Bahna | Nuclear Power Plants Research Institute, 919 31 Jaslovske Bohunice |
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| J. Kott | Skoda, 316 00 Pilsen |
| V. Krett | Nuclear Research Institute, 250 68 Rez |
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| K. Slama | same address |
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| V. Svoboda* | Sigma Modrany, 143 14 Praha 4 - Modrany |

*An asterisk indicates attendees with whom the traveler had technical discussions outside of the normal meeting hours.

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| V. Zeman | Technical University, Nejedleho sady 14, 306 14 Pilsen |
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| A. Brillon | Electricite de France Direction des Etudes et Recherches Departement Fonctionnement des Centrales 6, Quai Watier 78400 Chatou FRANCE |
| D. Goetsch | Commissariat a l'Energie Atomique Institut de Protection et de Surete Nucleaire B.P. no.6 92260 Fontenay-aux-Roses FRANCE |
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APPENDIX B

CHARACTERISTICS OF INTERNATIONAL MEETINGS INVOLVING
SPECIALISTS IN REACTOR SURVEILLANCE AND DIAGNOSTICS

| | <u>IAEA</u> | <u>SMORN</u> | <u>Informal</u> |
|--|------------------------------------|-----------------------|----------------------|
| Documentation: | written paper obtainable from IAEA | published proceedings | handouts (sometimes) |
| Interval between meetings: | ~2 years | ~4 years | ~1 year |
| Location: | anywhere | anywhere | Europe |
| Language: | English, Russian | English | English |
| Historical average recent USA participation: | 1 paper | ~2 papers | ~2 papers |
| Next meeting: | ~June 1984 | ~1985 | May 1983 |

APPENDIX C

PROGRAMME

Plant Diagnosis Systems Aspects

Opening (H. Andres, IAEA)

Application of noise diagnostic methods in LWRs in FRG
(D. Wach, FRG)

On-line noise analysis of BWR (J. Lorenzen, Sweden)

Integration of noise analysis into the control system of a nuclear power plant (F. P. Weiss, GDR)

Concept of in-service diagnostics system of selected NPPs of WWER 440 type in the Nuclear Power Plants Research Institute (J. Bahna, CSSR)

Concept of a diagnostic system design from the safety point of view using the pattern recognition method (J. Cech, CSSR)

Diagnosis of Vibrations

Activities of the Institute of Nuclear Research in the early diagnosis of failures (A. Mikulski, Poland)

On the possibility of in-service PWR control rod vibration diagnosis by neutron noise methods (Pazsit, Glockler, Hungary)

Experience with utilization of neutron noise in PWRs for monitoring the fuel and internal structures (Bernard, Cloue, Messainguiral - CEA; Puyal, Brillon, Vincent - EDF, France)

Detecting core barrel motion in the Rheinsberg PWR (Izsak, Pór, Budapest)

Diagnosis of vibrations and boiling WWER 440 experimental fuels assembly (V. Krett, J. Vavrin, J. Kott, J. Vlcek, CSSR)

A pattern recognition method for nuclear reactor core surveillance (M. Ivernizzi, France)

On-load condition monitoring of reactor gas circuit components using vibration signals (P. N. Whitton, UK)

Influence of variations in the operating and rigidity parameters on the steady-state induced vibrations of the pressure vessel internals in a WWER reactor (L. Pecinka, V. Zeman, CSSR)

Acoustic Emission

A review of acoustic emission for pressurized reactor applications (P. G. Bentley, UK)

Use of the cluster analysis technique to locate acoustic emission sources detected during hydrostatic tests of WWER reactor pressure vessels (J. Liska, M. Svetlik, K. Sláma, CSSR)

Application of acoustic emission method (K. Vakar, USSR)

Leakage monitoring by means of acoustic methods (Stipsitz, FRG)

French experience with loose part detection (C. Puyal, A. Brillon, A. Fernandes, France)

Experiments with Instrumented Fuel Assemblies

Integrated systems of in-core instrumentation in nuclear reactors (J. Kott, CSSR)

Noise investigations with an Experimental Fuel Assembly in a PWR (P. Liewers, GDR)

Utilization of pressure noise for reactor anomaly monitoring (J. A. Thie and J. A. Mullens, USA)

Vibration and vibro-acoustic control rod tests at test section (V. Fedorov, USSR)

Investigation of passive and active methods for coolant boiling monitoring in the core of a WWER reactor; application to NPP Rheinsberg, GDR (V. Bulavin, F. Karmanov, USSR)

Problems of diagnostic parameter selection for the design of diagnostic systems (P. Chvátal, CSSR)

Diagnostics of thermohydraulic anomalies in PWRs using neutron noise analysis (T. Katona, L. Meskó, Hungary)

Closing of Meeting

Discussion of conclusions and recommendations (E. V. Gilby, UK, as session chairman and discussion leader)

APPENDIX D

BIBLIOGRAPHICAL LIST OF LITERATURE ACQUIRED

1. Abstracts (all in English) of papers listed in Appendix C.
2. Written papers (most in English) for those listed in the first four sessions of Appendix C.
3. Written summaries (all in English) of the meeting from the session chairmen.
4. L. Mesko and T. Katona, Investigation of the Local Neutron Noise Caused by Subcooled Boiling, KFKI-1981-55, Central Research Institute for Physics, Budapest, Hungary (1981).
5. T. Katona and L. Mesko, A Simple Theoretical Model for the Interpretation of Temperature and Void Fluctuations Caused by Inlet Coolant Velocity Noise, KFKI-1981-88, Central Research Institute for Physics, Budapest, Hungary (1981).
6. L. Mesko and T. Katona, Ein Einfaches Theoretisches Model für das Neutronenrauschen bei Unterkühltem Sieden, Central Research Institute for Physics, Budapest, Hungary (1982).
7. N. N. Andryooshenkov et al., Method Kontrolya Vibratsee Konstrooktsee Vnootrec Korpoosa VVER, Atomnaya Energieya (1980).
8. N. N. Andryooshenkov et al., Esslyedovanie Vibratsee Organa Regooleerovaneeya Energeticheskogv Yadernogv Reaktora s Vodoe pod Davlennem v Kanale Geedrodeenameecheskogo Stenda, Atomnaya Energieya (1981).
9. P. G. Bentley and R. Rowley, Acoustic Vibration Measurements in PFR, B.N.E.S. Conference on Vibrations in Nuclear Plant, Keswick, UK (1978).
10. V. Bauernfeind, Programme für Untersuchung Stehender und Forschreitender Wellen in PWR-Primarkreis, Internal Memorandum at Gesellschaft für Reaktorsicherheit, Munich, FRG (June 16, 1982).
11. R. Breitenfeld and G. Grunwald, Erste Mesgergebnisse von Druckschwingungen in einem Kreislaufmodell, Internal Memorandum at JFK Rossendorf, Dresden GDR (June 17, 1982).

APPENDIX E

ITINERARY

| <u>Dates</u> | <u>Location/Activity</u> |
|------------------|---|
| June 19-20, 1982 | Travel from Chicago, IL, to Prague, Czechoslovakia, via plane |
| June 21-25, 1982 | IAEA Conference at the Hotel International, Prague, Czechoslovakia |
| June 25-26, 1982 | Travel from Prague, Czechoslovakia, to Chicago, IL, via plane with overnight stop at Heathrow, London, UK |

DISTRIBUTION

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40. L. C. Oakes
41. R. B. Perez
42. R. L. Shepard
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