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WORKING MATERIAL

Consultancy on

"Knowledge Preservation in the Area of Fast Reactor Technology"

Argonne National Laboratory-West, Idaho Falls, USA

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Fast Reactor Technology Knowledge Preservation

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Argonne National Laboratory
Idaho Falls, Idaho, USA

1 Introduction

The fast reactor, which can generate electricity and breed additional fissile material for future fuel stocks is a resource that will be needed when economic uranium supplies for the advanced light water reactors or other thermal-spectrum options diminish.

Further, the fast-fission fuel cycle in which material is recycled offers the flexibility needed to contribute decisively towards solving the problem of growing 'spent' fuel inventories by greatly reducing the volume of high-level waste that must be disposed of in long-term repositories. This is a waste management option that also should be retained for future generations.

The fast reactor has been the subject of research and development programs in a number of countries for upwards of 40 years. Now, despite early sharing and innovative worldwide research and development, ongoing work is confined to China, India, Japan, the Republic of Korea, and Russia. Information generated worldwide will be needed in the future. Presently, it is in danger of being lost even in those countries continuing the work.

Some countries have already taken the issue of knowledge preservation seriously: Japan, France, Britain, and Russia, in particular. At worst, valuable contributory information elsewhere will be lost and would have to be regenerated when needed.

2 The IAEA initiative

The IAEA initiative seeks to establish a comprehensive, international inventory of fast reactor data and knowledge, which would be sufficient to form the basis for fast reactor development in 20 to 40 years from now.

The Agency is in a good position to provide the framework for knowledge preservation efforts. Under Article III of its Statute, the IAEA is mandated to "encourage and assist research on, and development and practical application of atomic energy for peaceful uses throughout the world". Obviously, an important aspect of this mandate is maintaining and increasing the knowledge that is necessary for the technological development. More specifically, as regards the fast reactor technology area, many Member States have repeatedly underscored the importance of knowledge preservation and transmission to the young generation (e.g., the Advisory Group Meeting on "Evaluation of Fast Reactor Core Physics Tests", convened by the Agency in Vienna, from 22 to 24 November 1999)

This knowledge base is intended to provide access to the national guardians of assured quality information in the basic research, design, safety, fabrication, construction, operation, and in the decommissioning of fast reactors. "Access" here means a portal to the information. The free release of some of the information between nations may still require negotiation on a case-by-case basis.

The main objectives of the consultancy were to define the scope of the fast reactor knowledge preservation efforts (what should be preserved), and to produce a road map for the implementation of these efforts (work plan, funding sources, national and international coordination), eventually leading to the mentioned knowledge base.

3 What are the most important disciplines/topical areas in which fast reactor technology knowledge preservation is needed?

Fast reactor knowledge preservation can be considered in two ways. One would be the collection and analysis of all information pertaining to a particular reactor, the other would be a disciplinary crosscut for all reactors. The latter means was chosen as a basis for the current initiative. Then it became a matter of which set of disciplines would adequately encompass the principle aspects of the fast reactor technology for early preservation.

The following set of disciplines, if defined broadly enough, was thought to typify the most important aspects of fast reactor technology:

1. Fuels and Materials
2. Reactor Physics and Core Design
3. Operations
4. The Demonstration of Safety

It was recognized that some knowledge preservation activities, already in progress in some countries, address the problem according to a specific reactor. Moreover, the demonstration of safety could also be related more easily to specific reactors. However, the establishment of an interface between a topical preservation system with that of preservation of knowledge associated with a specific reactor should not present great difficulties.

4 How can these disciplines/topical areas be prioritized?

The question of prioritization of topical areas to be given preservation attention must be addressed by each participating member state. A general process by which this may be accomplished is suggested below.

For each technical discipline, an experts group should be selected and convened. This group should review the state of knowledge preservation within the particular country, and determine which technical areas are most important to future development of fast reactors and which technical areas are most endangered or vulnerable to loss of knowledge and expertise. Based on the experts group's evaluation, in-country preservation activities should focus on the most important and endangered areas.

As a second step in the prioritization effort, within each country, a conscientious effort to prevent the loss of technical information and facility components until an assessment of their potential value to future technical advancement should be made. If, in the opinion of the experts group, the item is of considerable value, the information/components should be preserved for documentation or further examination. If the experts group thinks the information/components has little value, then it may be discarded without further preservation effort.

5 Identification of the real "fast reactor technology treasures"

A wealth of experience has matured over the 40+ years of fast reactor technology development. From a general point of view, "treasures" can be found in the theoretical work (e.g., data, methods development), the experimental testing work (e.g., mock-ups, irradiation experiments) and the accumulated operating experience. Out of the full spectrum of topical areas, four have been selected to initiate the process (see Attachment 1). Within each of these, a number of "treasures" exist, namely:

- In the fuels and materials area, the "treasures" to be preserved are the performance data related to the most mature and/or best performing concepts within each fuel/cladding category. It is also important to record the process that lead to discarding concepts, as well as the data needed to produce the "best choices."
- In the reactor physics and core design area, the most valuable (and at the same time, most endangered) data are related to zero power critical and power reactor experiments.
- In the reactor operations area, it is essential to preserve the performance data and related measures, as well as the contributions towards performance (discriminating between positive and negative ones). It is also important to track the main operating events and relate to the corresponding design implications.
- In the safety area, consensus was reached that preserving the safety analysis reports of the major reactor facilities is the most urgent issue.

For each of the topical areas, Attachments 2, 3, 4, and 5:

- summarize the information and/or knowledge base constituting the respective discipline,
- attempt a first prioritization of the information and/or knowledge,
- give a first assessment of the status in the respective topical area (how endangered or vulnerable to loss is the information and/or knowledge, how much – if any – profit can be drawn from ongoing reactor technology development activities, what is already being done to preserve knowledge),
- outline a possible road map for the implementation of the IAEA initiative.

6 What is already being done to preserve these "treasures"?

In France, CEA, EDF and Framatome ANP have initiated a liquid metal cooled fast reactor knowledge preservation project that centers on two lines: R&D aspects, on the one hand, and the Superphenix design on the other. The approach followed is to have summary documentation, drafted by specialists in the respective areas, for R&D and Superphenix design aspects. In addition, all the relevant references are preserved.

Zero power critical experimental data obtained within the framework of the European fast reactor collaboration (MASURCA, SNEAK, ZEBRA) is preserved in the SNEDAX database. SNEDAX also includes SEG data.

Japan, which has an active fast reactor program, has initiated a comprehensive knowledge preservation program, including the capture of "human knowledge" based on interviews. JNC puts forward an international knowledge preservation proposal that would share information over the Internet.

In, Russia, some fast reactor knowledge preservation work is being done (e.g., zero power criticals BFS-1, BFS-2 and KOBR, and post-irradiation experience). However, lack of funding is seriously affecting this work in Russia.

In the UK, a Super Archive was prepared at the close of the UK government funding to provide a convenient access to fast reactor technology. The coverage of R & D material was intended to be comprehensive. This could be confirmed against the scope of the IAEA knowledge preservation initiative. The Super Archive is intended as an important link to the standard archiving within the UKAEA. The level/type of the information retained in the Super Archive and the detailed UKAEA archive also needs to be established.

The UKAEA is transferring the archive to electronic form. BNFL has an interest in preserving the "fuels" information and has the right for commercial exploitation of that information. The fast reactor intellectual property rights are owned by AEA-T and NNC who formed FASTEC as a single entity which is a counterpart of SERENA (France, Germany representing DeBeNe) for the SERENA/FASTEC agreement.

In the USA, TREAT and ZPPR data are currently on magnetic tape and hard copies with some transfer to electronic files. It is therefore subject to loss. Selected ZPR and ZPPR log books are being scanned and selected critical configurations are being evaluated and preserved by the International Criticality Safety Benchmark Evaluation Project. EBR II plant data is on CDs but design knowledge is needed for its interpretation. EBR II design information, and 80% of the system design descriptions, are all in electronic form and on CDs.

In the fuel area, while complete subassembly information (design, safety documentation, post irradiation X-rays and gamma-scans) exists as hard copies in filing cabinets all blanket region characterization has been lost.

OECD/NEA has preserved, in electronic form, the archive of primary documents from ZEBRA, SNEAK, and selected documents associated with the FCA.

As far as the IAEA is concerned, the participants in the already mentioned IAEA Advisory Group Meeting on "Evaluation of Fast Reactor Core Physics Tests", convened by the Agency in Vienna, from 22 to 24 November 1999, recommended to start fast reactor physics knowledge preservation with an exhaustive review of all available sources of fast reactor experimental data, including data from critical facilities. A list of the existing data, including the publicized benchmarks, should be established, with reference to the relevant documents, computer files, etc. Access restrictions, if any, should be identified and listed. From this inventory, a subset consisting of the most valuable (in terms of contents, quality, representativity, retrievability, etc.) experimental data should be identified by a group of experts. The most relevant data should be conserved in a systematic format, to serve as reference benchmarks, so as to ensure the continued quality of new developments. The experts should also identify the complete set of information required to provide a valuable and consistent record of the experiment, as well as its interpretation and analysis. Quality assurance requirements are an important issue in this context. These efforts would contribute to similar OECD/NEA propagated initiatives focused on thermal reactors (e.g., the International Criticality Safety Benchmark Experiments Project (ICSBEP), and the project on Preservation of Experimental Integral Reactor Physics Data (IRPhE)).

7 How can the IAEA initiative make best use of what is already being done, and what would be the road map to implementation?

As already mentioned, there are efforts to preserve knowledge already underway, particularly in France, Japan, Russia, and the United Kingdom. There is also an international initiative that is supported by OECD/NEA, to preserve very specific data from critical assemblies.

These extensive efforts can be viewed as preserving some parcels of an inventory of knowledge from which other parcels of information and knowledge have been, and are continuing to be lost.

The IAEA initiative, therefore, seeks to develop a knowledge base into which existing knowledge preservation "systems" will fit and within which new efforts to preserve data and knowledge will complement the prior work. It also seeks to assure that the data and knowledge are quality information by encouraging that the ever-diminishing group of international experts be used in reviewing and interpreting information for the future.

Therefore, the following general process is proposed in commencing this work:

1. Initiate a moratorium on the disposal of any further fast reactor records at fast reactor facilities or technology centers related to fast reactor experience.

2. Information preservation should be conducted primarily on a national basis as contributions to this international initiative.

3. National activities should include the identification of what information exists, where, and to what degree of completeness. These activities should also judge the value for future fast reactor development of the information/knowledge, as well as the degree to which it is endangered.

4. National activities should include the identification of a responsible guardian or guardians for the information.

5. National activities should include conversion of the information into a robust and secure form, including quality verification, electronic conversion, and redundant storage with permanent addresses.

6. National activities should include the development of interpretive documents for this information. These documents should define the final state of affairs and its rationale. This may include the retrieval of tacit information presently held by retiring experts.

7. National activities should include provision of access-information (not necessarily open release) within a combined international knowledge inventory administered and preserved by the IAEA.

8 Which experts will be able to join the initiative and do the job?

Each Member State should identify at least one individual to represent their technology preservation activities to the IAEA initiative.

Each Member State should select experts within each discipline or topical area to perform the tasks on the national level.

9 Funding of the initiative

Needed resources have to be determined and provided within each Member State. Due to the closing window of opportunity, each Member State should recognize the urgency to act and provide adequate funding while experts remain available.

10 List of actions

- The IAEA Technical Working Group on Fast Reactors (TWG-FR) is asked to endorse the Knowledge Preservation Initiative Work Plan.

- Representatives of each Member State should explore methods of implementing the recommendations of this Consultancy including the identification of resources and the prevention of further loss of information (see section 7).

11 Next Meeting

Assuming endorsement of the plan by the TWG-FR, IAEA will convene the next meeting within one year, possibly in conjunction with the 2003 Annual Meeting of the TWG-FR. At this meeting, it is expected that participating Member States will be in a position to present progress on the national level according to the recommendations in section 7.

Attachment 1

INFORMATION/KNOWLEDGE BASE REQUIRED TO DEVELOP AND TO OPERATE A LIQUID METAL FAST REACTOR

RESEARCH AND DEVELOPMENT
- Fuel and Materials *
- Heat Transfer Systems testing
- Safety Systems testing
- Piping Integrity testing
- Seismic design
- Accident analysis
- Sodium Fire testing
- Beyond Design Basis Events

DESIGN
- General System Criteria
- Standards
- Reactor Physics and Core Design *
- Dynamic Analysis
- System Design Descriptions
- Demonstration of Safety *
- Project Cost Analysis

FABRICATION AND CONSTRUCTION
- Site
- Plant
- Balance of Plant

OPERATIONS *
- Cold Start-up
- Low-Power Commissioning
- Fuel Power Operation
- Maintenance
- Off-Normal and Emergency operation

DECONTAMINATION AND DECOMMISSIONING
- Planning
- Experience

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* Those four disciplines were selected for immediate attention.

Attachment 2

FUELS AND MATERIALS

The scope of fuels and materials considerations was limited to core components, which include fuel and control assemblies. Information/knowledge preservation beyond the duct boundary would be the purview of other programs. Thus, materials in the remainder of the primary system and balance of plant were excluded from consideration.

The scope of preservation includes gas-cooled fast reactor fuel types as well as the traditional liquid metal cooled fast reactors. In addition, it could be argued that transmutation concepts (more specifically, in this area, "transmutation type" fuels and materials) could benefit from knowledge gained from fast reactor technology.

Because the scope was limited to the duct boundary there is not a great deal to be learned from thermal reactor technology.

To derive criteria to discriminate which information to preserve, it was thought useful to imagine what a fuel designer would need 30 years from now. He would want all information pertinent to the most mature, best-performing fuels. He would want to know how to fabricate the fuel, how it performed, and what improvements were in the conceptual stage when the program ended. He would also want to know what improvements were tried that failed and why. He would not want to be confused by extraneous information and he would want some assurance that the information provided to him was credible.

The current state of information preservation in the United States with respect to fuels and materials is varied. There are examples such as the "Nuclear System Materials Handbook" and supporting information that are in a good state. There are many other examples where the information may already be impossible to retrieve. In all cases the existing information is scattered at a number of sites under a wide array of storage conditions. There has been no systematic attempt to consolidate and preserve the data. The situation in other countries was not determined but France and Japan, and possibly now Russia, have committed to formally preserve important information and make it readily available for future applications.

Focus is on the fast reactor primary fuel types including the materials compromising fuel and control-type assemblies. The fuel types include oxide, carbide, nitride, metal, coated particle and dispersion matrix. The assembly components include the cladding materials, the duct materials and associated control materials.

The specific fuel and cladding/duct materials types would be addressed within the topics of fabrication and performance as outlined below:

1. Fuel Fabrication, including control assemblies
(a) Cladding alloy development and procurement
(b) Fabrication techniques

(c) Procedures and specifications
(d) Fabrication statistics

2. Fuel, Cladding/Duct, and Control Materials Performance
(a) Thermal-physical properties
(b) Steady-state performance
(c) Whole core/Subassembly performance (e.g. bowing)
(d) Off-normal performance
(e) Performance models
(f) Handbook information with supporting data

The elements of the discipline that would be most important for preservation are:

1. Fuel performance information[1] related to the most mature/best performing concepts within each fuel/cladding category,

2. What must be done to further improve and understand these 'best' choices,

3. What concepts were discarded and why, and

4. Information needed to procure the 'best' choices.

In general, at least in the U.S., there has been no organized attempt to systematically preserve the most important of the fuels and materials data.

It appears that France and Japan, and possibly Russia, have committed formally to preserve important information and make it readily available for future applications.

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[1] Particular consideration must be given to irradiation experiments and the associated PIEs, both for fuels under normal operating conditions and for fuels under transient or accident conditions (in Europe, e.g., irradiation experiments performed at BR2/Mol, HFR/Petten, CABRI/Cadarache, ...)

Attachment 3

REACTOR PHYSICS AND CORE DESIGN

The scope of reactor physics and core design comprises 11 basic areas as follows:

1. Basic data: cross-sections, reaction-rates, delayed neutron physics, decay heat

2. Zero power experiments and shielding tests: geometry, composition, and measurements including reaction rates, reactivity states, and experimental methods used to obtain data.

3. Power reactor experiments – same information as above.

4. Multi-group cross-section processing

5. Steady-state flux distribution

6. Core deformation models, e.g., reactivity effect of duct bowing

7. Shielding codes

8. Thermal-hydraulics models for liquid metal cooled cores

9. Optimized core feedback effects

10. Reactor control
    - Control rod physics characteristics
    - Instrumentation physics characteristics

11. Fuel management
    - In-core component shuffling
    - Blanket management
    - Physics related to fuel material selection

The most important elements for preservation

Whether the information would be preserved by ongoing reactor technology development work, the importance of the information for future fast reactor development, and how well the existing information was being preserved at present determined the highest priority of information. This was determined to be the information in items 2 and 3: Zero power experiments and power reactor experiments.

The details of the assessment are shown in the table below:

Item	Physics area	What information would be preserved by ongoing thermal-reactor programs?	The importance of this area to future fast-reactor development	The quality of existing preservation efforts
1	Basic data: cross-sections, reaction rates, delayed neutron physics, decay heat	Nearly all; current on-going programs support the full array of data needed for fast reactors.	High	High
2	Zero power experiments and shielding tests information	None, except for a limited number of critical configurations for selected critical experiments (A)	High	Medium/Low
3	Power reactor experiments information	None	High	Low
4	Multi-group cross-section processing	Nearly all; existing processing methods remain general enough to handle fast reactors	Low	Low
5	Steady-state flux distribution	All	Medium	High
6	Core deformation models: reactivity effect of duct bowing	None	Medium	Medium/Low
7	Shielding codes	Mostly all	Medium	High/Medium
8	Thermal-hydraulics models for liquid metal cooled cores	None	High	High/Medium
9	Optimized core feedback effects	None	Medium	Medium
10	Reactor Control information and Instrumentation physics characteristics	Partly; some information has unique aspects which must be addressed outside of ongoing thermal-reactor programs.	Low	Medium
11	Fuel management information and physics related to fuel material selection	Very little	Low	Low

Note *A*: The limited number of critical configurations for selected critical experiments (International Criticality Safety Benchmark Evaluation project (ICSBE)) and documentation of shielding tests (Radiation Shielding Experiments Database project). In addition, some preservation projects have started to need continuing support under IAEA/OECD programs.

Zero power experiments

A list of Zero Power Facilities is given in the following table.

Fast Reactor - Zero Power Facilities		
Reactor	**Country**	**National Agency**
Harmonie	France	CEA
Masurca	France	CEA
STEK	The Netherlands	ECN
SEG	Germany	FZR
SNEAK	Germany	FZK
FCA	Japan	JAERI
ZEBRA	United Kingdom	AEA-T
ZPR III,VI,IX	USA	US DOE
ZPPR	USA	US DOE
LANL Criticals	USA	US DOE
BR-1	Russia	IPPE
BFS-1	Russia	IPPE
BFS-2	Russia	IPPE
KOBR	Russia	IPPE
?	India	?

Power reactor experiments

A list of Fast Power Reactors is shown in the table below:

Fast Power Reactors		
Reactor	**Country**	**Responsible Agency**
JOYO	Japan	JNC
MONJU	Japan	JNC
FBTR	India	BARC (?)
BOR-60	Russia	Institute for Atomic Reactors (NIIAR)
BR-10	Russia	IPPE
BN-350	Russia	IPPE
BN-600	Russia	IPPE
KNK	Germany	FZK
RAPSODIE	France	CEA
PHENIX	France	CEA
SUPER PHENIX	France	EdF
DFR	United Kingdom	AEA-T
PFR	United Kingdom	AEA-T
EBR-I	USA	USA-DOE
EBR-II	USA	USA-DOE
FERMI -I	USA	Detroit Edison
FFTF	USA	USA-DOE
SEFOR	USA	General Electric

NOTE: For power reactor, the data should include the following
Operating Physics Data
Startup Physics Data
Reactor Physics Tests
Test Vehicle Data

The steps to identify and preserve zero and power reactor experimental data should include:

1. Development of an inventory of experiments for fast reactors; this inventory should merge with the reactor physics experiment inventory currently being compiled

2. The assessment of location and status of available documents and data

3. Documentation by a national technical experts group

4. Evaluation by a national technical experts group – including a peer review

5. A review and evaluation by an external experts group of each item referred to by the national team, and, if the quality is appropriate, the inclusion of that item in the IAEA knowledge base.

Attachment 4

OPERATIONS

For the following categories, standards, selection criteria, fabrication and quality testing, testing, operational parameters and operating experience are all included in the information that should be preserved.

1. Whole Plant and major system performance
   (a) plant availability,
   (b) forced outages and their cause and recovery times,
   (c) planned maintenance frequency and duration,
   (d) other measures of plant and system reliability.
   (e) emphasis on systems unique to sodium-cooled reactors, e.g. sodium purification systems, cover gas cleanup systems, electromagnetic pumps
   (f) Implications for future designs

2. Significant off-normal or anomalous events during startup, testing, maintenance, or operation
   (a) diagnosis
   (b) how recovery was accomplished
   (c) changes in operation, maintenance, or design required to prevent recurrence
   (d) how the event reflected on the plant or system/component design characteristics

3. Preparations for major maintenance activities
   (a) cool down of systems
   (b) draining coolant
   (c) freezing coolant in place, etc.
   (d) implications for future design

4. Average radiation doses received by plant operators and maintenance technicians
   (a) during normal operations and maintenance;
   (b) during major maintenance activities such as removal of a primary pump.
   (c) design implications

5. Significant plant/system tests,
   (a) Initial system and plant startup testing
   (b) preparation for and conduct of startup and tests,
   (c) results with operational and design implications,
   (d) recovery to normal. This will cross-cut safety, fuels, etc.

6. Staffing levels: operators, maintenance technicians, technical support engineers, core physicists, others.

7. Periodic inspections and tests
   (a) regulatory requirements (if any)
   (b) performance testing

(c) implications for design

8. Design/Cost: Design information and Information collected during the life-cycle of the facility that relates to design or cost implications for a follow-on design.

What would be preserved in on-going Thermal Reactor Technology?

Little information relevant to sodium-cooled fast reactors (SFRs) is being preserved as part of ongoing thermal-reactor technology development. However, development of the next SFR design will take advantage of continuing advances in the following areas:

- Control system philosophy and design
- Sensor technology
- Signal transmission technology
- Surveillance monitoring techniques
- Design technology incorporating modularity/replace-ability features to take advantage of advances in technology
- Materials

The most important elements for preservation are:

1. Performance measures
   - Whole plant
   - System/component (Priority to systems/components unique to sodium systems)

2. Design description, key design characteristics

3. Contributors to performance (positive and negative)
   - Design
   - Maintainability
   - Operability (including human factors)

4. Significant operating events
   - Cause
   - Recovery actions
   - Design implications

The information relevant to these elements is contained in:

Reactor Run Reports or equivalent (formal internal documents in hardcopy, microfiche)
- System Design Descriptions (hardcopy, CD)
- Safety Analysis Reports (hardcopy, CD)
- Engineering Modification files (formal internal documents in hardcopy, microfiche)
- Experiment Plans and Data Packages (formal internal documents in hardcopy, microfiche)

- System/Component History Logs (typically informal documents in personal files)
- Plant system data (magnetic tape, CDs)
- Internal published reports (in personal files and internal libraries)
- Open literature publications (books, transactions, journals)

The types of documents and information media identified above are located in facility files, informal document storage areas, formal records retention areas, personal files, internal libraries, technical libraries, and federal repositories. In many cases, the files may not be easily located. In some cases, responsibility for the files has been passed through several contracting organizations and, therefore, may be difficult to locate.

Attachment 5

The Demonstration of Safety

There was consensus that this category of information is applying to the demonstration of safety (in a regulatory sense). The following list that constitutes the information in this category addresses the probability of accident initiators and the consequences of accidents beyond normal operation:

1. Fuel Failure Propagation Issues

(a) Fuel-clad interaction
(b) External gas induced failures
(c) Fuel-coolant interaction
(d) Failure propagation mechanisms

2. Shut-down reliability

(a) Aging
(b) Deformed geometry
(c) Dormant conditions
(d) Seismic conditions

3. Heat-removal reliability (also in decay heat mode)

(a) Specific system experience
(b) Auxiliary cooling
(c) Sodium-freezing issues
(d) Influence of aerosols
(e) Natural circulation

4. Instrumentation and monitoring reliability

(a) Thermocouples
(b) Flow-meters
(c) Flux measurement
(d) Neutron monitors
(e) Fission product detection
(f) Safety circuit separation

5. Safety of Operation with Sodium

(a) Pool fires
(b) Spray fires
(c) Explosive ejection

6. Piping and vessel integrity

(a) Material quality controls
(b) Age effects
(c) Doubled-ended rupture dynamics

7. Heat exchanger and Steam Generator integrity
(a) Sodium-water reaction
(b) Interface material integrity

8. Restraint and support system reliability
(a) Vessel supports
(b) Core supports
(c) Piping supports
(d) Age effects
(e) Seismic conditions

9. Fault Analysis
(a) Two-dimensions
(b) Three-dimensions
(c) Other analyses (common cause, risk, etc.)

10. Beyond the Design Basis Margins of Safety (Design Extension)
(a) Progressive interaction of failures
(b) Energy release
(c) Mechanical energy conversion effects

11. Containment Building issues
(a) Integrity margin for high pressure
(b) Integrity margin for high temperature
(c) Age effects

The only part of the above information that will be preserved in a continuing thermal-reactor industry is that concerning the effect of external hazards on the containment building. In view of the thin wall design of the low-pressure fast reactor and the high thermal differences, the seismic analysis of in system structural components will be different. However, seismic and stress analysis codes will be preserved.

Since the Demonstration of Safety consists of demonstrating safety in **all** operating modes and under all conditions, it was not possible to prioritize this information in a regulatory environment. However, there was a feeling that Sodium behavior was so unique to the fast reactor that the items relating to operation with sodium may have higher priority if time and funding were at a premium.

Further, it is important to leave future generations, not only data, but an understanding of and application of the data. Therefore, no better interpretive documents exist than the safety analysis reports of major reactor facilities (JOYO, KNK, MONJU, RAPSODIE, PHENIX, SUPERPHENIX, BN-350, BN60, BN-600, DFR, PFR, EBRII, FFTF, CRBRP, SNR-300), and commercial planned facilities (EFR, BN-800, DFBR). The Safety Analysis Reports (together with their supporting documents) of these facilities represent the culmination and interpretation of fast reactor work.

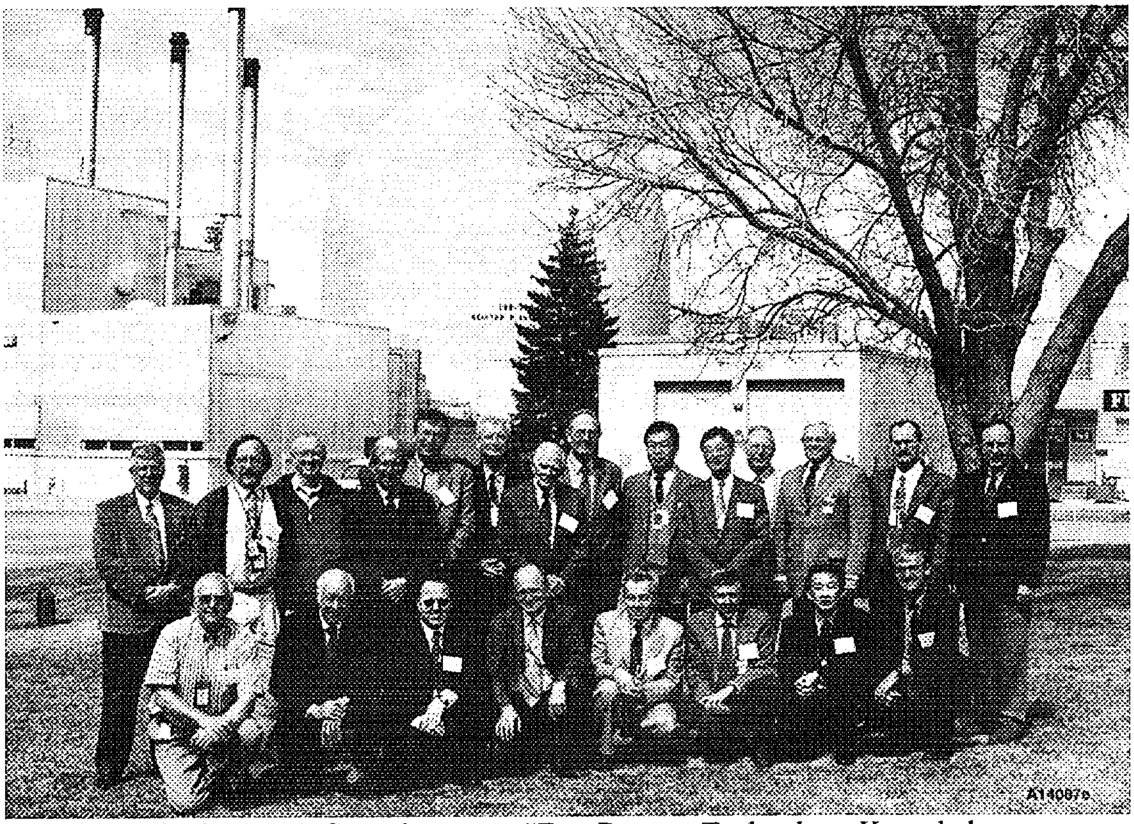
The preservation of basic information varies from nation to nation. The following are merely examples:

In the UK, a Super Archive was prepared at the close of the UK government funding to provide a convenient access to FR technology. The coverage of R & D material was intended to be comprehensive. The UKAEA are transferring the archive to electronic forms.

In the USA, as an example, TREAT and ZPPR data is currently on magnetic tape and hard copies with some transfer to electronic files. It is therefore subject to loss. EBR-II plant data is on CDs but design knowledge is needed for its interpretation. While complete subassembly information (design, safety documentation, post irradiation X-rays and gamma-scans) exists in file cabinets all blanket region characterization has been lost. EBR II design information, and 80% of the system design descriptions, are all in electronic form and on CDs.

Rocketdyne sodium data exists all in the form of library retention of published documents and would require an expert search to determine its value and completeness. Westinghouse information is in the same condition. General Electric company information preservation is presently unknown. CRBRP information retention is unknown at present.

The seventeen identified Safety Analysis reports and their supporting documents should be available at least in hard copy.



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