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# WORKING MATERIAL

**Forty-Fourth Meeting of the  
Technical Working Group on Fast Reactors (TWG-FR)**

**China Institute of Atomic Energy (CIAE)  
Beijing, China**

**23–27 May 2011**

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## **MEETING REPORT**

### **1. Introduction**

The 44<sup>th</sup> Annual Meeting of the Technical Working Group on Fast Reactors (TWG-FR) was held from 23 – 27 May 2011 in Beijing, China, hosted by the China Institute of Atomic Energy (CIAE).

The meeting was attended by the TWG-FR Members and Advisers from the following Member States (MS): Argentina (observer), China, France, Germany, India, Italy, Japan, Kazakhstan, the Netherlands, the Korea, Republic of, the Russian Federation, Ukraine, and the United States of America. Apologies for not being able to participate were received from Belgium (observer), Belarus and Sweden.

The objectives of the meeting were to:

- Exchange information on the national programmes on Fast Reactors (FR) and Accelerator Driven Systems (ADS);
- Review the progress since the 43<sup>rd</sup> TWG-FR Annual Meeting, including the status of the actions;

- Consider topical technical meeting arrangements for 2012-2013, as well as review FR-related activities included in the IAEA Project&Budget (P&B) biennium 2012-2013;
- Review the IAEA's ongoing information exchange and coordinated research projects in the technical fields relevant to the TWG-FR (FRs and ADS), as well as coordination of the TWG-FR's activities with other organizations and international initiatives (GIF, INPRO, NEA, ESNII, etc.).

Agenda of the meeting is in Annex I, list of participants is in Annex II.

The participants were welcomed by Mr. D. Zhang (CIAE, Director of CEFr), Mr. S. Ning (Project manager of the China Atomic Energy Authority) and Mr. H. Xia (Director of Department of Nuclear Physics at CIAE). In particular the Chinese delegation thanked the IAEA for promoting Innovation and R&D in the field of Fast Spectrum Nuclear Systems (FRs and ADS).

The participants were also welcomed by Mr S. Monti, TWG-FR Scientific Secretary, who took this occasion to introduce himself as new IAEA Team Leader of Fast Reactor Technology Development, since 16 May 2011.

After the self-introduction, the meeting participants appointed Mr D. Zhang as chairman of the 44<sup>th</sup> TWG-FR annual meeting and as chairman of the TWG-FR starting with the 44<sup>th</sup> till the 45<sup>th</sup> TWG-FR meeting in 2012.

## **2. National Presentations**

There were 15 presentations made by the representatives of 13 Member States in addition to the presentation on TWG-FR activities during the period May 2010 – April 2011 given by the IAEA Scientific Secretary. The papers and presentations are attached (Annex IV).

Each country representative presented updates on national nuclear policy even in light of the recent Fukushima accident; status of design, construction or operation (if any) of national fast reactors; prospects of fast reactor research and technology development; fast reactor concepts under consideration; and the progress and status of works related to ADS activities.

Lively discussions took place on the various specific topics addressed in the national presentations. The discussions contributed to the clarification of the points of view of the represented Member States with regard to the status and prospects of fast reactor research and technology programs and initiatives.

From a general view point, the most relevant news in the field of FR are:

- The continuous excellent performance of BOR-60 and BN-600 in Russian Federation;
- The on-going commissioning of the Chinese Experimental Fast Reactor (CEFR) which is expected to be connected to the grid by July 2011;
- The progressive construction of the Prototype Fast Breeder Reactor (PFBR) in India and of the BN-800 in Russian Federation;

- The Japanese recovery efforts to restart JOYO and MONJU as soon as possible;
- The *European Sustainable Nuclear Industrial Initiative* (ESNII) which includes the ASTRID GENIV-SFR prototype hosted by France, the MYRRHA Fast Spectrum Irradiation Facility hosted by Belgium, as well as the two GENIV DEMO Plants ALFRED (LFR) and ALLEGRO (GFR);
- The Russian Federation “*Federal Target Program (FTP): Nuclear power technologies of a new generation for the period 2010-2015 and with outlook to 2020*” which includes the realization of 4 FR plants: BN-1200 (SFR), BREST-OD-300 (LFR), SVBR-100 (LBE-cooled FR) and MBIR, a Sodium-cooled material test reactors;
- The development of the two GEN-IV SFRs: JSFR in Japan and KALIMER in Republic of Korea.

### **3. On-going and future TWG-FR Activities (CRPs, Topical Technical Meetings)**

The Scientific Secretary reviewed the status of TWG-FR publications under finalization/review, i.e.:

- Status Report on Accelerator Driven Systems: Energy Generation and Transmutation of Nuclear Waste;
- Status Report on Fast Reactor Research and Technology Development;
- Liquid Metal Coolants for Fast Reactors (reactors cooled by sodium, lead, and lead-bismuth eutectic);
- Proceedings of the International Conference on Fast Reactors and Related Fuel Cycles: Challenges and Opportunities (FR09).

All of these TECDOCs/publications are expected to be published by end 2011 / beginning 2012.

After a review of the state of the art of the on-going activities, all TWG-FR members stressed the need to enhance the role of TWG-FR. A number of specific proposals and suggestions on how to achieve this goal were made. Finally, several topics for future activities were identified.

In particular, the TWG-FR members agreed on the following list of specific proposals for collaborative research (CRP) and information exchange activities (large conferences, topical technical meetings, workshops and seminars) to be implemented within the framework of the TWG-FR in the period 2012 – 2013 and beyond:

#### **I. Coordinated Research Projects (CRPs)**

- a. Final report of the CRP on “Update Codes and Methods to Reduce the Calculation Uncertainties of Liquid Metal Fast Reactor Reactivity Effects: BN-600 MOX core benchmark analysis” (to be issued by 2011);
- b. Final report of the CRP on “Analytical and Experimental Benchmark Analyses of Accelerator Driven Systems” (to be issued by early 2012);

- c. Final report of the CRP on Analyses of and Lessons Learned from the Operational Experience with Fast Reactor Equipment and Systems (to be issued by early 2012);
- d. Completion of the CRP on “Benchmark Analyses of Sodium Natural Convection in the Upper Plenum of the Monju Reactor Vessel” (4<sup>th</sup> Research Coordination Meetings in 2012 in Tsuruga (Japan), publication of final report end of 2012);
- e. Completion of the CRP on “Control Rod Withdrawal and Sodium Natural Circulation Tests Performed During the Phénix End-of-Life Experiments” (4<sup>th</sup> Research Coordination Meetings in 2012, publication of final report end of 2012);
- f. Completion of the CRP on “Thermal Hydraulics, Code Benchmarking and Handling of Liquid Metal and Molten Salt Coolants at High and Very High Temperatures (in collaboration with the INPRO “COOL” collaborative project);
- g. New CRP on “Benchmark Analyses of an EBR-II Shut Down Heat Removal Test” ” (kick-off meeting in 2012, duration ~ 4 years);
- h. New CRP on “Source Term for Radioactivity Release Under Fast Reactor CDA Conditions” (kick-off meeting in 2012, duration ~ 3 years);
- i. New CRP on “Optimum Plant Parameters with Metallic and MOX Fuelled Fast Breeder Reactors” (2012 and beyond);
- j. New CRP on Sodium properties, Sodium facility design and operation, Sodium safety issues (to be started in 2013);
- k. New CRPs in the field of severe accidents in FRs with special emphasis on SBO and LOUHS (to be launched in 2013).

## II. Information exchange

- a. Large conferences, seminars, and workshops;
  - Institutionalize the IAEA international conference on “Fast Reactors and Related Fuel Cycles - Challenges and Opportunities” as a recurrent event (every 3 years);
  - Workshop on “Advanced Core and Structural Materials for Future Fast Reactors”;
  - Seminar on “Heavy Liquid Metal Cooled and Gas-cooled Fast Reactors Development”;
  - Workshop on Fast Reactor Decommissioning Experiences and Guidelines for Future Reactor Design”.
- b. Topical Technical Meetings (TMs)
  - IAEA Fast Reactor Knowledge Preservation (FRKP) initiative;
  - Fast Reactor Physics and Technology;
  - Status of, and Innovative Solutions for In-service Inspection and Repair of Liquid Metal-cooled Fast Reactors;
  - Innovative Heat Exchangers and Steam Generators for Fast Reactors;
  - Identifying Innovative Fast Neutron Systems Development Gaps and technology challenges, and providing coordinated responses and solutions;



- Impact of Fukushima event on current and future FR designs (March 2012, venue TBD);
- Fast reactor deployment issues (e.g. impact of institutional and regulatory issues, impact of industrial and manufacturing issues, societal issues and public acceptance of fast reactors, etc);
- Verification, validation and qualification (V&V&Q) methods and codes for analyzing and designing Fast Spectrum Nuclear Systems;
- Seismic design of fast reactors;
- TWG-FR annual meetings in 2012 and 2013.

#### **4. Discussion on impact of Fukushima accident on FR programs**

Taking also into account the lessons learned from the Fukushima accident by JAEA (presented by Mr. H. Ohira), a first brainstorming concerning impact of this event on national nuclear policy and FR programs as well as on TWG-FR activities took place at this meeting.

The general issues discussed by the participants were:

- Public Perceptions;
- Actions being taken by the member countries;
- Impact on FR strategy due to possible change in Nuclear Energy Policy;
- Safety Approach on FR and related Fuel Cycle;
- Future Actions to be taken by IAEA-TWG.

As a result of the broad discussion, examples of safety issues and impact on FR designs which could be considered as basis of CRPs to be launched within the TWG-FR in the near future were identified, as follows:

- Severe accidents / Core catcher;
- Post accidental cooling / DHR systems / Cold sources;
- Active vs. Passive systems;
- Containment;
- Methodologies for analysis of cumulative accidents;
- Instrumentation for post accidental situations;
- Accidents management;
- Comparison between LWR and FR in case of Loss of Heat Sink accident.

However, to better identify topics for new CRPs, the TWG-FR deems necessary to hold a Technical Meeting where the safety features of the present and future FR designs should be deeply discussed even in comparison with LWRs.

To this end a room document to be used as basis for discussion will be worked out as follows:

- Each country summarizes the general safety features of FRs as well as the specific safety characteristics of the different FR concepts;
- Mr. A. Vasile, French representative in the TWG-FR, with the support of the TWG-FR scientific secretary, will collect and homogenize the contributions;
- The draft document will be circulated for final comments and approval and then distributed also outside the TWG-FR.

## **5. Conclusions and Recommendations**

The 44<sup>th</sup> Meeting of the TWG-FR reached the following conclusions/recommendations:

- Despite the recent Fukushima accident which is going to affect the energy policies of some MS, most of the participating countries have confirmed their willingness to proceed with the present programs on Fast Reactors and their associated fuel cycles, recognizing that this technology is key for the future of nuclear energy and for enhancing sustainability of this energy source;
- It is agreed to prepare a document concerning general safety features of FRs at large, specific safety characteristics of the domestic present and future FR concepts, with special attention to safety features of the present and future FR designs, as well as plant behaviour in case of Station Black-Out and Loss of Ultimate Heat Sink;
- It is recommended to organize an IAEA Technical Meeting to be held on 1<sup>st</sup> quarter of 2012 where the safety features of the present and future FR designs should be deeply analyzed even in comparison with LWRs. As a follow-up, specific CRPs could be launched within the TWG-FR in the area of severe accidents in FRs;
- The TWG-FR should continue to (i) organize regular meetings to exchange information, (ii) carry out collaborative research projects of common interest to the TWG-FR Member States, (iii) be pro-active in the organization of large conferences on different aspects of fast reactor research and technology, and last but not least (iv) sustain the excellent platform for the fast reactor specialists to share the experience related to design, development, construction and operation of nuclear power plants with fast reactors;
- The TWG-FR should increase the efforts to make more countries participating in its activities;
- It is recommended that IAEA concentrate all research and technical activities related to fast reactor developments under the TWG-FR umbrella. An efficient and effective interface between INPRO and TWG-FR should be established to avoid duplication/overlapping of activities;
- Closer cooperation links should be established with FR-related activities implemented within the framework of other international programmes (e.g. GIF, INPRO, OECD/NEA, ESNI). From this point of view the TWG-FR should increase its efforts towards establishing a forum for broad exchanges on technical requirements for 4<sup>th</sup> generation fast reactor systems;

- The TWG-FR should continue to secure training and education in the field of “Fast Neutron System Physics, Technology and Applications”, and respective Schools/Workshops/Seminars should be held on a regular basis;
- It is recommended to finalize and publish the new Status Reports on Fast Reactor and ADS “ASAP”;
- It is recommended to organize the next IAEA International Conference on Fast reactors and Related Fuel Cycles: Challenges and Opportunities (FR013) not later than 2013. France has already volunteered to host this conference;
- It is recommended that the IAEA, with technical inputs from the TWG-FR, produce IAEA safety guides and standards relevant to fast reactors.

## **6 Miscellaneous**

The 45<sup>th</sup> TWG-FR meeting is tentatively scheduled for May 2012. Proposals for hosting this meeting are expected by the Secretariat within 2 months, otherwise the meeting will be held at IAEA in Vienna.

CIAE thanked the TWG-FR Scientific Secretary for accepting to organize the 44<sup>th</sup> TWG-FR meeting in Beijing, and also all the delegates from the TWG-FR Member States for accepting the invitation.

By the same token, all participants expressed their happiness and thanked for the excellent hospitality provided by CIAE.



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**ANNEX I: DRAFT AGENDA**

**Monday, 23 May 2011**

**09:30      Opening Remarks**

Welcome : China Atomic Energy Authority

Welcome : China Institute of Atomic Energy

Opening remarks: TWG-FR Scientific Secretary (Stefano Monti)

Meeting Chairperson

Chairperson's remarks

Self-introduction by the participants

Discussion and adoption of the agenda

**10:30      Break**

**11:00      Progress reports on national programmes on fast reactors and accelerator driven systems, and identification of areas and topics of interest for future cooperation within the TWG-FR framework [Approximately 20 – 30 minutes presentation including discussion by each Member State representative, in country name alphabetical order. *The delegates are kindly requested to bring along their full paper progress reports and the PowerPoint presentation (on electronic support) for publication in the meeting report.*]**

- 12:30      *Lunch*
- 14:00      Progress reports on national programmes ..., continued
- 18:30      *Dinner*

## **Tuesday, 24 May 2011**

- 09:00      Progress reports on national programmes ..., continued
- 12:30      *Lunch*
- 14:00      Report of the TWG-FR Scientific Secretary (summary of TWG-FR activities, status of the actions, etc)
- Discussion of the TWG-FR Scientific Secretary's report
- Benchmark Analyses of Sodium Natural Convection in the Upper Plenum of the Monju Reactor Vessel (2008 – 2012);
  - Phénix End-of-Life Tests (2009 – 2012);
- Status of the preparation of TWG-FR publications (Technical Reports, Status Reports, etc)
- Analytical and Experimental Benchmark Analyses of Accelerator Driven Systems (ADS);
  - Analyses of, and Lessons Learned from the Operational Experience with Fast Reactor Equipment and Systems (consultancy meeting to be convened with IPPE);
  - Status Report on Accelerator Driven Systems: Energy Generation and Transmutation of Nuclear Waste;
  - Status Report on Fast Reactor Research and Technology Development;
  - Status Report on Liquid Metal Coolants for Fast Reactors;
  - Proceedings of the International Conference on Fast Reactors and Related Fuel Cycles: Challenges and Opportunities (FR09).
- 18:00      *Adjourn*

## **Wednesday, 25 May 2011**

- 09:00      Departure by bus to CIAE
- 10:00      Arrival at CIAE
- 10:30      Technical visit#1: China Experimental Fast Reactor

11:15	Technical visit#2: National Tandem Accelerator Nuclear Physics Laboratory
12:00	<i>Lunch (in CIAE)</i>
13:30	Departure by bus
14:15	Summer Palace
16:15	Departure by bus
17:00	Arrival at Minzu Hotel

### **Thursday, 26 May 2011**

- 09:00 Discussion 1: the TWG-FR meetings planned within the framework of IAEA's Program and Budget 2011-2012:
- Back-to-back 4<sup>th</sup> RCMs of the CRPs on “Benchmark Analyses of Sodium Natural Convection in the Upper Plenum of the Monju Reactor Vessel” and on “Control Rod Withdrawal and Sodium Natural Circulation Tests Performed During the Phénix End-of-Life Experiments”;
  - Topical Technical Meetings (TMs) to “Identify Innovative Fast Neutron Systems Development Gaps and Technology Challenges and Provide Coordinated Responses and Solutions”;
  - Topical Technical Meeting (TM) on Innovative Fast reactor Designs with Enhanced Negative Reactivity Feedback Effects;
  - Topical Technical Meetings (TMs) on “IAEA's Fast Reactor Data Retrieval and Knowledge Preservation Initiative”;
  - Topical Technical Meeting (TM) on “In-service Inspection and Repair of Sodium Cooled Fast Reactors”;
  - Topical Technical Meeting (TM) on “Advanced Sodium Heated Steam Generators and Sodium/Gas Heat Exchangers for Fast Reactors”;
  - Topical Technical Meeting (TM) on “Design Features of Advanced Sodium Cooled Fast Reactors with Emphasis on Economics”;
  - Kick-off RCM of the new CRP on “The Source Term for Radioactivity Release Under Fast Reactor Core Disruptive Accident (CDA) Situations”;
  - Kick-off RCM of the new CRP on “Optimum Plant Parameters for Metallic Fuel and MOX Fuelled Fast Reactors”;
  - IAEA/ICTP “Workshop on Innovative Nuclear Energy System Concepts and Technologies for Sustainable Development”;
  - 45<sup>th</sup> Annual Meeting of the TWG-FR.

Discussion 2: new CRPs to be started in 2011-2012:

- The Source Term for Radioactivity Release Under Fast Reactor Core Disruptive Accident (CDA) Situations;
- Optimum Plant Parameters for Metallic Fuel and MOX Fuelled Fast Reactors;
- Analyses of Fast reactor Safety Tests Conducted in EBR-II;
- Analyses of primary Pump Seizure in Fast Reactor Under Seismic Excitations.

12:30 *Lunch*

14:00 Discussion 3: future (beyond 2011) TWG-FR activities:

- Proposals for new CRPs, TMs, symposia/seminars, identification of possible NE Series Documents on topics relevant to the TWG-FR work scope (*To ensure distribution among all participants, the delegates are kindly requested to inform the Scientific Secretary ahead of the meeting of intended proposals*).

18:00 *Adjourn*

18:30 *Dinner*

## **Friday, 27 May 2011**

09:00 Conclusions and recommendations of the 44<sup>th</sup> TWG-FR Meeting, and drafting of the Meeting Report

Date and venue of next TWG-FR Meeting

12:30 *Lunch*

14:30 *Adjourn meeting*

## ANNEX II: LIST OF PARTICIPANTS

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## ANNEX III: LIST OF ACTIONS, DECISIONS AND SHORT CONCLUSIONS

TABLE 1

<i>Active CRPs</i>	<i>Proposer</i>	<i>Participants</i>	<i>Next RCM tentative date, venue</i>	<i>Actions</i>
<b>Control Rod Withdrawal and Sodium Natural Circulation Tests Performed During the PHENIX End-of-Life Experiments</b>	France	China, India, France, Germany, Japan, R. of Korea, Russia, Switzerland, USA	To Be Decided within 3 months and in case to be held as back-two-back meeting with Monju RCM	Two different TECDOCs to be issued by the end of 2011. S. Monti to contact Bruno Fontaine & Denis Tenchine for reports finalization
<b>Benchmark Analyses of Sodium Natural Convection in the Upper Plenum of the MONJU Reactor Vessel</b>	Japan	China, India, France, Japan, R. of Korea, Russia, USA	4th RCM: 1st quarter of 2012, Tsuruga	Draft of Final Report to be issued by the end of 2012

TABLE 2

<i>New CRPs</i>	<i>Proposer</i>	<i>Interested Countries (preliminary list)</i>	<i>Actions + tentative dates and venue</i>
<b>Source Term for Radioactivity Release in Fast Reactor Core Disruptive Accident Conditions</b>	India		Within 1 month proposal from India to be circulated for EoI. EoI from interested countries within 4 months
<b>Benchmark studies on creep fatigue damage of SFR components</b>	India		As above.
<b>Benchmark analyses of an EBR-II Shut Down Heat Removal Test</b>	USA	India, France, Russia, Germany, China (TBC)	EoI to be collected in 3 months on the basis of the two-page Hill's proposal distributed at this meeting. Kick-off RCM: 1st quarter of 2012, Vienna
<b>Analyses of Primary Pump Seizure in Fast Reactor Under Seismic Excitations</b>	India		Chellapandi will distribute reference docs within 1 month. To be performed only if there is no parallel on-going project in Europe (secretariat to confirm)
<b>Sodium properties, Na facility design and operation safety</b>	France	Argentina, India, Russia, China, Netherland, USA, RoK, Germany, Japan, Italy (TBC)	Focal point is Christian Latge' (CEA); To be organized in three WPs: data + correlations; Facility design guidelines; safety aspects. Latge' in charge to prepare a short proposal to be distributed for EoI on specific WPs within 2 months. Member countries are invited to specify their contributions. EoIs are expected within 1 month from the proposal. Kick-off RCM: 1st quarter 2012. Venue: proposal by Latge'

TABLE 3

<i>Approved TMs</i>	<i>Proposer</i>	<i>Interested Countries</i>	<i>Tentative Date &amp; Venue</i>
<b>LM Fast Reactor In-service Inspection and Repair: Status and Innovative Solutions</b>	India		Vienna, Nov. 2011
<b>Innovative Heat Exchanger Designs of LM Fast Reactors</b>	India		Vienna, Nov 2011
<b>Innovative Fast Reactor Designs with Enhanced Negative Reactivity Feedback Effects</b>	India		Russia (TBC in 2 months), RoK (TBC). Back-up: Vienna. Spring 2012
<b>Identify Innovative Fast Neutron Systems Development Gaps</b>	India		As above
<b>Impact of Fukushima event on FR safety</b>	ALL		Spring 2012. Venue to be decided
<i>45th TWG-FR Meeting</i>	IAEA	All	<i>May 2012. Possible proposals from member countries within 2 months. If none: Vienna</i>
<i>FR Conference</i>	IAEA	All	<i>TWG-FR recommendation for holding the conference not later than 2013 in France. Monti to contact G. Dick and then French contact point to be provided by Vasile</i>

### **Discussion about the impact of the Fukushima accident on the TWG-FR activities**

Taking also into account the lessons learned from the Fukushima accident by Atomic Energy Society of Japan, a first brainstorming concerning impact of this event on national nuclear policy and FR programs as well as on TWG-FR activities has taken place at this meeting.

The general issues discussed by the participants were:

- Public Perceptions;
- Actions being taken by the member countries;
- Impact on FR strategy due to possible change in Nuclear Energy Policy;
- Safety Approach on FR and related Fuel Cycle;
- Future Actions to be taken by IAEA-TWG.

Examples of safety issues and impact on FR designs which could be considered as basis of TMs and CRPs to be launched within the TWG-FR in the near future are:

- Severe accidents / Core catcher;
- Post accidental cooling / DHR systems / Cold sources;

- Active vs Passive systems;
- Containment;
- Methodologies for analysis of cumulative accidents;
- Instrumentation for post accidental situations;
- Accidents management;
- LWR and FR performance in case of Loss of Heat Sink accident.

However, to better identify topics for new CRPs, the TWG-FR deems necessary to hold a Technical Meeting where the safety features of the present and future FR designs should be deeply discussed even in comparison with LWRs.

To this end a room document to be used as basis for discussion will be worked out as follows:

- With reference to Fukushima event, each interested country summarizes in a two-page document the general safety features of FRs at large as well as the specific safety characteristics of the domestic present and future FR concepts;
- Vasile with the support of the TWG-FR secretariat will collect and homogenize the contributions;
- The draft document will be circulated for final comments and approval and then distributed also outside the TWG-FR.

Monti will draft introduction with a short description of the reference accident scenario.

Each contribution should include the following information:

- Safety features of the design possibly affected by LOHS and station black out;
- Anticipated response of the present design in case of LOHS and station black out;
- Suggested provisions to improve the design;
- Identification of additional R&D needs.

**Country contributions to be sent to Messrs Vasile and Monti are due within 3 months with the aim to finalize the document by the end of the year. In parallel the Secretariat will take action to organize the related TM.**