The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

2291-1A

Joint ICTP-IAEA Course on Science and Technology of Supercritical Water Cooled Reactors

27 June - 1 July, 2011

OVERVIEW OF IAEA ACTIVITIES SUPERCRITICAL WATER-COOLED REACTORS(SCWRs)

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Overview of IAEA Activities on Supercritical Water-cooled Reactors (SCWRs)

Joint ICTP-IAEA Course on Science and Technology of SCWRs, Trieste, Italy, 27 June - 1 July 2011

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Objectives

Objectives of this Overview are to:

- Introduce IAEA's roles in area of nuclear power technology development;
- Describe SuperCritical Water-cooled Reactor (SCWR) concept briefly;
- Explain IAEA activities on facilitating R&D of SCWR; and
- Express Expectations to the Course.

Mission of IAEA
- Why does IAEA support SCWR R&D? -

- The International Atomic Energy Agency:
  - Is an independent intergovernmental, science and technology-based organization, in the UN family, that serves as the global focal point for nuclear cooperation;
  - Assist its Member States, in the content of social and economic goals, in planning for and using nuclear science and technology for various peaceful purposes, including the generation of electricity, and facilitate the transfer of such technology and knowledge in a sustainable manner to developing Member States;
  - …….

Mission Statement of the IAEA

How does IAEA support Member States for NPPs?

- Support near term deployment of NPPs in Member States (MSs) for their existing, expanding and new programs.
- Ensure information exchange and foster R&D collaboration among MSs for technology development through:
  - Technical Meetings;
  - Training Courses; and
  - Coordinated Research Projects (CRPs).

Coordinated Research Project (CRP)

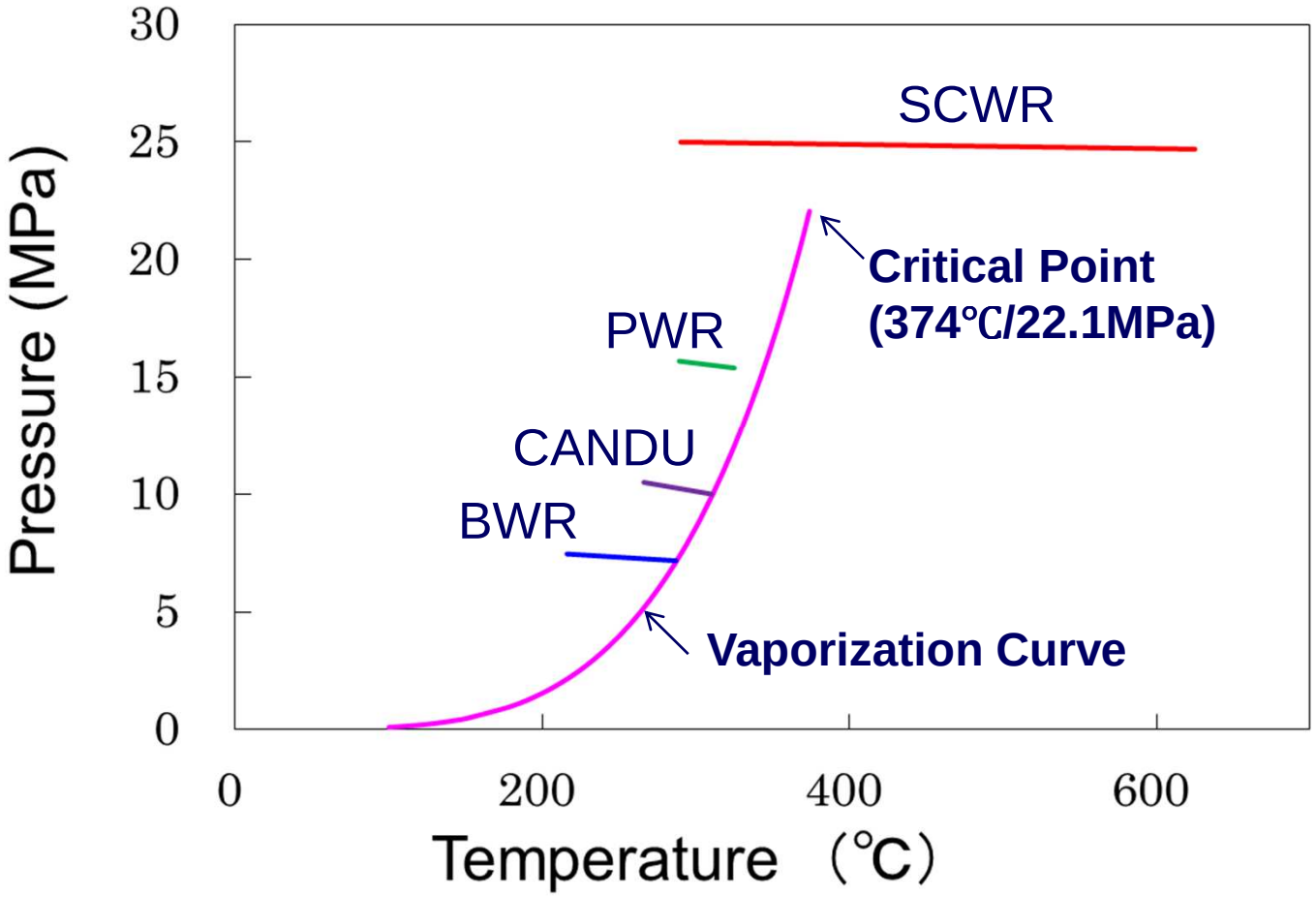
- The CRP:
  - Is an international cooperative research project established by the IAEA in areas that are of common interest to a number of Member States; and
  - Allows a sharing of efforts on an international basis, fosters team-building and benefits from the experience and expertise of researchers from all participating institutes.
- In the IAEA, 115 CRPs are active and 39 CRPs planned.

Technical Features of SCWR

- A Water-Cooled Reactor (WCR) concept that uses water pressurized above its critical pressure (P_c = 22.1 MPa) as reactor coolant
- Very high coolant temperature

  (500 – 625C @core outlet)
- Simple system
- Flexible design options:
  - Pressure vessel type / Pressure tube type
  - Thermal-spectrum / Fast-spectrum cores

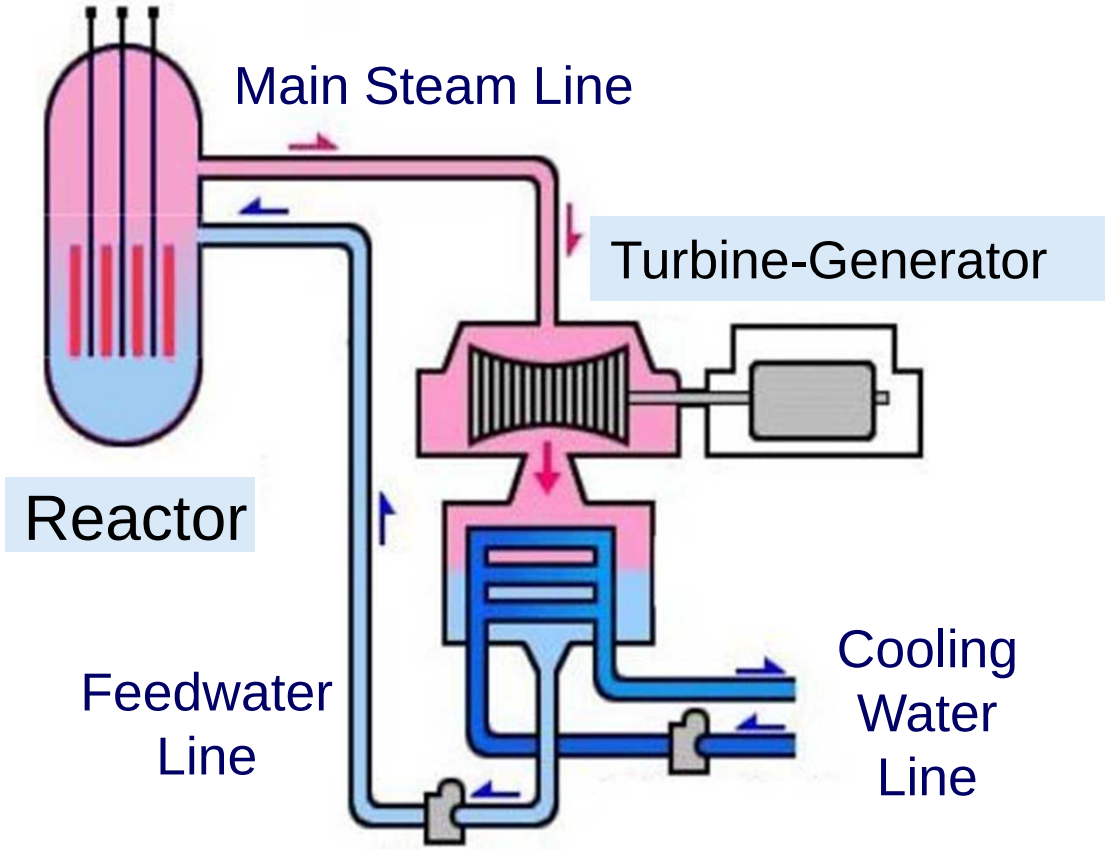
Operation Ranges of Core Pressure/Temperature



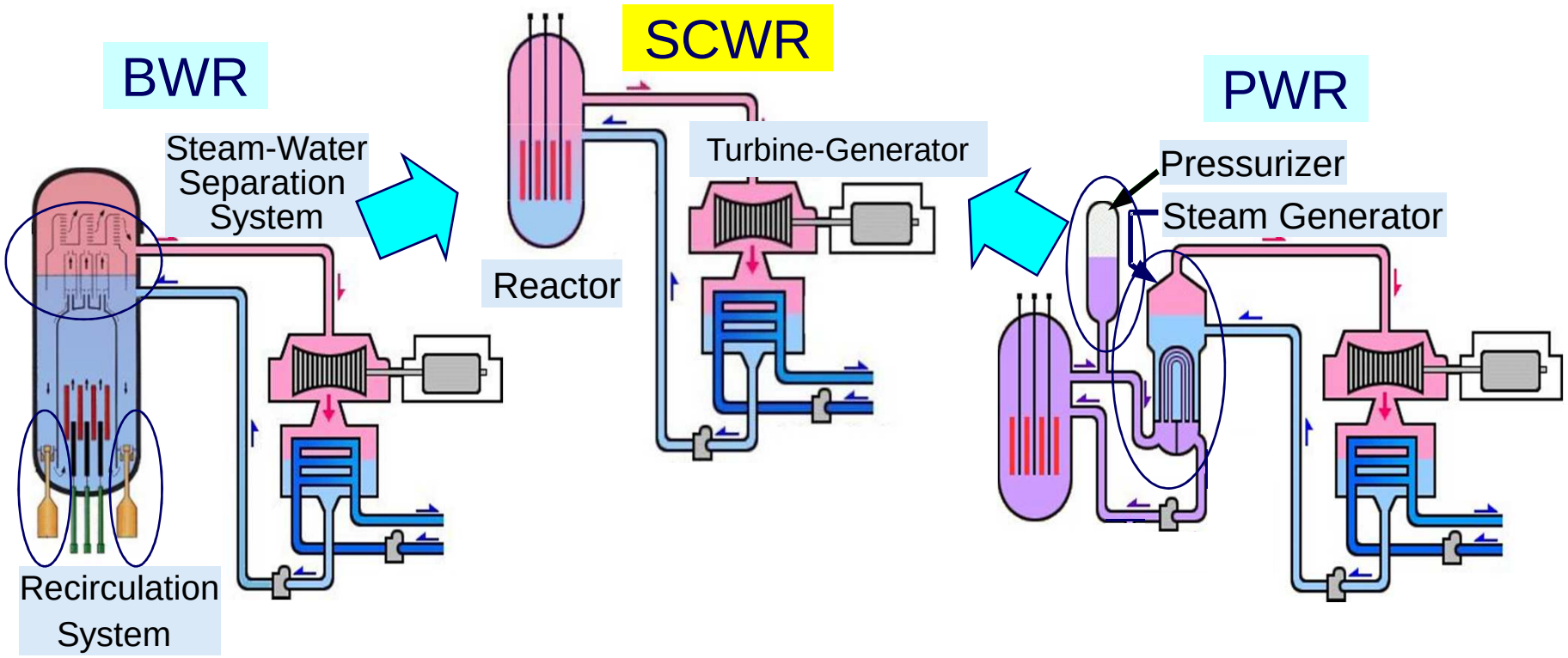
Primary System of SCWR

- Nuclear System
  - ➢ Once-through reactor like PWRs
- Turbine System
  - ➢ Direct cycle like BWRs

Simplest Combination



Comparison of Major System between SCWR and LWRs



Advantages of SCWR

- Coupling of existing WCR technologies extrapolated to higher P/T and supercritical fossil-fired power plant technologies

  => Main R&D are on the reactor systems limiting cost, time and risk

- Low capital cost due to higher thermal efficiency & simple systems than conventional WCRs

  => Economic competitiveness

High interest in a number of Member States

Challenges of SCWR

- Thermal-Hydraulics of supercritical water
  - ✓ Heat transfer in fuel bundles
  - ✓ Pressure drop across cores
  - ✓ Critical flow – blowdown flow rate
- Materials and chemistry under high temperature, high pressure, and irradiation conditions
  - ✓ Fuel cladding materials
  - ✓ Structural materials
  - ✓ Water chemistry

CRP on Thermal-Hydraulics of SCWRs

- Proposed to TWG-LWR of the IAEA Nuclear Energy Department (TWG: Technical Working Group).
- Jointly endorsed by TWG-LWR and TWG-HWR.
- Started in 2008 as “Heat Transfer Behaviour and Thermo-hydraulics codes testing for SCWRs”, and to complete at the end of this year.
- The CRP Plan was developed with:
  - advice from experts in various organizations conducting SCWR research and development; and
  - comments from Generation International Forum (GIF) SCWR System Steering Committee.
- Conducted officially in connection with the OECD-NEA.

Objectives of SCWR CRP

1. Establish a base of accurate data for heat transfer, pressure drop, blowdown, natural circulation and stability for conditions relevant to super-critical fluids.

2. Test analysis methods for SCWR thermo-hydraulic behaviour, and identify code development needs.

Organizations involved in SCWR CRP

- OECD-NEA
- Atomic Energy of Canada, Ltd. (Canada)
- University of Ontario Institute of Technology (Canada)
- China Institute for Atomic Energy (China)
- Shanghai Jiao Tong University (China)
- University of Manchester (UK) → Tsinghua University (China)
- VTT Technical Research Centre (Finland)
- Bhabha Atomic Research Centre (India)
- University of Pisa (Italy)
- Korea Atomic Energy Research Institute (Rep. of Korea)
- EC/JRC/Institute for Energy, Petten (Netherlands)
- Nuclear Research and Consultancy Group (Netherlands)
- Gidropress (Russia)
- Institute for Physics and Power Engineering (Russia)
- University of Wisconsin (USA)

Integrated Research Plan : 10 Tasks

1. Establishment of database
2. Collecting and sharing typical SCWR core design parameters
3. Collecting, sharing and analyzing existing heat transfer data
4. Collecting, sharing and analyzing existing pressure drop data
5. New experiments on heat transfer and pressure drop at SC conditions
6. Develop new correlations and prediction methods for heat transfer and pressure drop
7. Study of critical flow during blowdown at SC conditions
8. Study of instability and natural circulation in SCWR systems
9. Thermo-hydraulics code testing for SC conditions
10. Documentation of results

Expected Outcomes

- Supercritical heat transfer and pressure drop database
- IAEA reports synthesizing the results and technology advancements achieved by the CRP for dissemination to Member States
- Joint papers by CRP participants for international conferences/congresses/ symposia and technical journals

Additional CRP Outcomes

- Course on “Science and Technology of SCWRs” (This Course!)
- Conferences and Technical Meetings on SCWRs specific issues
- Development of a close network and a sense of community

Course on Science and Technology of SCWRs

- 1st IAEA Course on SCWRs
- Held jointly with and at ICTP
- 27 lectures, a special lecture and a topic on Fukushima accident
- 12 Lecturers and 24 Participants

The Abdus Salam
International Centre for Theoretical Physics

Joint ICTP-IAEA COURSE ON SCIENCE AND TECHNOLOGY OF SUPERCRITICAL WATER COOLED REACTORS

27 June - 1 July 2011
Miramare - Trieste, Italy

The "Abdus Salam" International Centre for Theoretical Physics (ICTP), Trieste, Italy, in co-operation with the International Atomic Energy Agency (IAEA), Vienna, Austria, is organizing a Course on the Science and Technology of Supercritical Water Cooled Reactors (SCWR), to be held at ICTP, Trieste, from 27 June – 1 July 2011.

There is high interest internationally in both developing and industrialized countries in innovative supercritical water-cooled reactors, primarily because such concepts will achieve high thermal efficiencies (44-45%) and promise improved economic competitiveness utilizing and building on recent developments for highly efficient fossil fueled power plants. The Supercritical Water Cooled Reactor (SCWR) is a Generation IV reactor concept that uses supercritical water as the working fluid. Therefore, SCWR systems are essentially water cooled reactors operating at high-temperature and high-pressure, above the thermodynamic critical point of water. Since this concept is based on the well known water cooled reactors currently in operation all over the world, it provides a good stepping stone for developing countries looking to deploy advanced nuclear power plant designs.

The course will provide a comprehensive and up-to-date review of the science and engineering of supercritical water cooled reactor concepts, including thermodynamics, thermohydraulics and heat transfer, neutronics and core design, materials requirements, system design and safety aspects, and a detailed description of the various supercritical water cooled reactor concepts currently under development. The course will also explore the opportunities and challenges associated with this reactor concept, and will unveil opportunities for research and development in this area.

In particular, the following topics will be addressed:

- Thermodynamics of systems at supercritical pressure
- Thermohydraulics and heat transfer in supercritical water cooled reactors
- Neutronics and core design for supercritical water cooled reactors
- Selection of materials for use in supercritical water cooled reactors
- System design and safety aspects for supercritical water cooled reactors
- Overview of the various SCWR concepts currently under development in the world.
- Opportunities and challenges associated with the development and deployment of SCWRsl
- Overview of on-going research and development activities in the area of supercritical water cooled reactors
- Experimental databases for the study of these phenomena
- Overview of advanced computational tools to study and simulate these phenomenologies

PARTICIPATION

Scientists and students from all countries, which are members of the United Nations, UNESCO or IAEA, may attend the Course subject to approval by the Course Directors. The course is intended for nuclear engineering faculty and students (at the university level), graduate engineers/physicists working in the nuclear field, post-graduate students, engineering designers, nuclear researchers and nuclear regulators. A basic knowledge in nuclear physics, thermohydraulics, fluid mechanics and heat transfer is required. Logistics limit the number of participants to 25. As the Course will be conducted in English, participants should have an adequate working knowledge of that language. Although the main purpose of the Centre is to help research workers from developing countries, through a programme of training activities within a framework of international cooperation, a limited number of students and post-doctoral scientists from developed countries are also welcome to attend.

As a rule, travel and subsistence expenses of the participants should be borne by the home institution. Every effort should be made by candidates to secure support for their fare (or at least half-fare). However, limited funds are available for some participants, who are nationals of, and working in, a developing country, and who are not more than 45 years old. Such support is available only for those who attend the entire activity. There is no registration fee.

REQUESTS FOR PARTICIPATION

The application form can be accessed at the activity website:

http://agenda.ictp.it/smr.php?2291

Once in the website, comprehensive instructions will guide you step-by-step, on how to fill out and submit the application form. The deadline for submitting applications is 25 February 2011

SECRETARIAT

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Course web page: http://agenda.ictp.it/smr.php?2291 ICTP Home Page: http://www.ictp.it/

Trieste, October 2010

International Atomic Energy Agency

Directors:
Katsumi YAMADA
Sama BILBAO Y LEON
(IAEA, Vienna, Austria)

Local Organizer:
Claudio TUNIZ
(ICTP, Trieste, Italy)

DEADLINE for submitting applications
25 February 2011

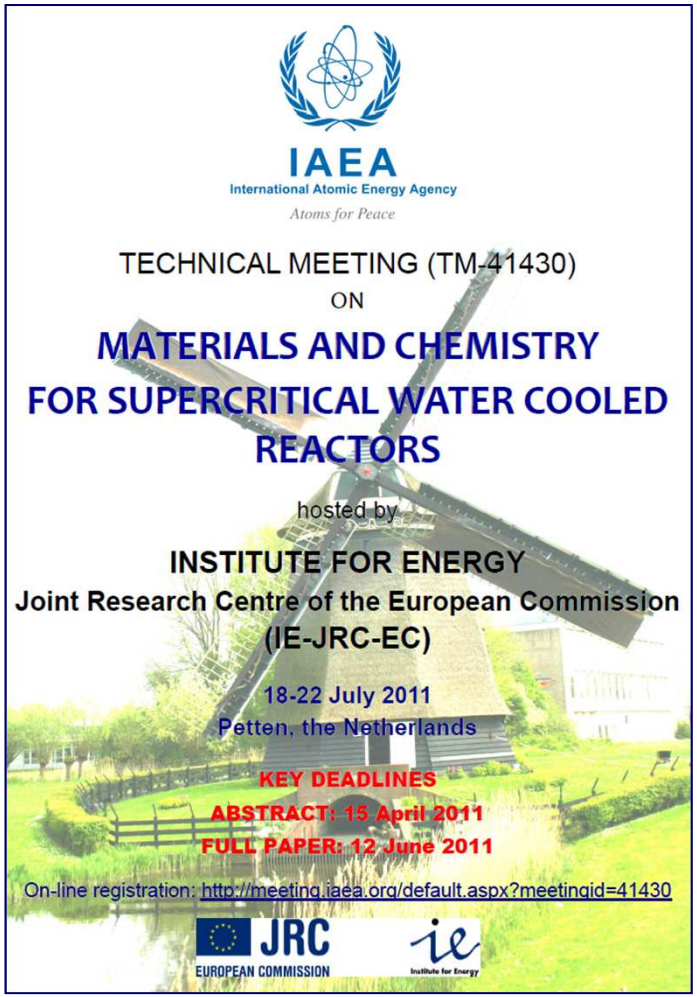
http://cdsagenda5.ictp.trieste.it/askArchive.php?base=agenda&categ=a10196&id=a10196/announcement

Technical Meeting on Heat transfer, Thermal-Hydraulics and System Design for Supercritical Water-cooled Reactors

- Held July 5-8, 2010, Pisa, Italy
- Hosted by the University of Pisa
- Embedded International Meeting of Specialists on Supercritical Pressure Heat Transfer and Fluid Dynamics
- 60 specialists from 20 Member States
- 38 papers

Technical Meeting on Materials and Chemistry for SCWRs

- Hosted by Institute for Energy, Joint Research Centre of the European Commission, Petten, the Netherlands, July 18-22, 2011
- More than 20 participants expected
- Collect and exchange information on R&D results of materials and chemistry



http://www.iaea.org/NuclearPower/Technology/Meetings/2011-July-18-22-TM.html

Expectation to the Course Participants

- Understand comprehensively the SCWR concept, especially:
  - Advantages over conventional WCRs; and
  - Challenges to realize the concept.
- Learn methodologies to develop a new reactor concept.
- Develop a close network among the participants and lecturers.

Summary

- SCWR is one of the key areas of common interest to Member States and has been followed by IAEA.
- CRP on thermal-hydraulics for SCWRs is on-going as planned and expected to complete successfully this year.
- Two major events in this year on SCWRs:
  - Joint ICTP-IAEA Course on Science and Technology of SCWRs
  - Technical Meeting on Materials and Chemistry for SCWRs

References

1. S. Bilbao y León and N. Aksan, “IAEA Coordinated Research Project on Heat Transfer Behavior and Thermo-Hydraulics Code Testing for Super Critical Water Cooled Reactors,” *Proc. of ICAPP 09*, Tokyo, Japan, May 10-14, 2009.
2. S. Bilbao y León and N. Aksan, “Improving the Understanding of Thermal-Hydraulics and Heat transfer for Super Critical Water Cooled Reactors,” *Proc. of ICAPP 10*, San Diego, USA, June 13-17, 2010.
3. S. Bilbao y León, N. Aksan and K. Yamada, “International Collaboration in Thermal-Hydraulics and Heat Transfer for Supercritical Water-Cooled Reactors”, *Proc. of ICAPP 11*, Nice, France, May 2-5, 2011.
4. K. Yamada, S. Sakurai et. al., “Overview of the Japanese SCWR Concept Developed under the GIF Collaboration”, *Proc. of ISSCWR-5*, Vancouver, Canada, March 13-16, 2011.

…Thank you for your attention!

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