



NUCLEAR FISSION AND  
RADIATION PROTECTION



## Severe Accident Research Network of Excellence (SARNET2 project)

SARNET2-SE-C01  
DIMNP 005 (11)

### SARNET2 Severe Accident Phenomenology Course January 2011

Authors: S. Paci (UNIFI), P. Piluso (CEA)

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WP N°2	WP leader: S. Paci	His organization name: UNIFI


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#### Dissemination Level

PU	Public	X
RE	Restricted to a group specified by the SARNET2 partners	
CO	Confidential, only for SARNET2 partners	
CR	Confidential, only for SARNET2 partners working on the same subject	

## SARNET2 Quality Assurance page

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<p><u>Summary</u></p> <p>The first SARNET2 "Severe Accident Phenomenology Short Course" was organized from 10 to 14 January 2011 by CEA and UNIPI and hosted by Pisa University, with the participation of about 100 students from 20 different countries. This was a 1-week course on phenomenology, focused on disseminating the knowledge gained on severe accidents in the last two decades to students, young engineers and researchers. The goal was also to refresh participants memories after 5 years and SARNET new outcomes, with a program covering severe accident phenomenology and progression in current water-cooled Gen. II NPPs, but also the different design solutions in Gen. III ones. Lecturers were experts from 8 different countries, with large skills and knowledge on Gen. II and III plants and on the progression of a severe accident. The course was open to university students with a discount fee and contributed for 3 ECTS with a strong link among SARNET2 and ENEN.</p>	

Visa grid			
	Main author(s)	Verification	Approval
Names	S. Paci	P. Piluso	
Date	November 2011	September 2012	
Signatures			

## 1. PRESENTATION

After the old EURO COURSE 1997 on the “*Analysis of Severe Accidents in Light Water Reactors*”, held in Madrid in October 1997, and EURO COURSE 2003 on “*Corium: Severe Accident R&D and Nuclear Power Plant Safety*”, held in Aix-en-Provence in January 2003, during the SARNET first phase in the Framework of EURATOM 6<sup>th</sup> program, three short courses (1 week) on Severe Accident technology were organized:

2006 SA Phenomenology including some description of Accident Management (AM). It was attended by about 100 students and researchers including many from outside of EU. The fee was only 500 € for students. It was organized by CEA and held in Cadarache with a huge success.

2007 SA Progression (analysis, data and uncertainties) to give the order of magnitude of physical phenomena occurring during a SA progression to researchers and engineers working in industry and regulatory organizations. It was organized by IRSN and held again in Cadarache, focused on:

- knowledge on the associated risks linked with SA situations for different types of nuclear reactors;
- knowledge on the deterioration mechanisms of the different safety barriers in case of SA;
- analysis of the possible recovery actions.

This 2007 short course was attended by 38 persons, 27 SARNET and 11 non-SARNET organizations, also from Canada and South Africa. No students were present but only Research organizations (5 participants), TSO (15), Safety Authorities (9) and Utilities & Vendors (9).

2008 Nuclear Reactor SA Analysis: Application and Management Guidelines, focused more on SA methodology (models, codes), analyses and Accident Management. This third SARNET course was held in Budapest in April 2008, organized by VEIKI and CEA. About 50 students and researchers attended the course. For the balancing of the budget (to go towards a self-sustainability of the SARNET Network) the participation fees were increased to about 1400 € for general participants and to 700 € for students. But these increasing fees resulted in a decreasing participation (one half of the 2006 Course).

The first SARNET2 “Severe Accident Phenomenology Short Course” was successfully organized from 10th to 14th January 2011 by CEA and Pisa University and hosted by Engineering Faculty of Pisa University. This new “Severe Accident Phenomenology Short Course” is part of the Excellence Spreading activities WP2 of the European Severe Accident Research Network of Excellence SARNET2 (project of the EURATOM 7th Framework programme).

This was again a 1-week course on phenomenology, focused on disseminating the knowledge gained on severe accidents in the last two decades to Master-PhD students, young engineers and researchers. The goal was also to refresh participants memories after 5 years and SARNET new outcomes, with a program covering severe accident phenomenology

and progression in current water-cooled Gen. II NPPs, but also the different design solutions in Gen. III ones (i.e. the “in-vessel” melt retention concept or the “ex-vessel” core catcher concept).

During the course, the severe accident phenomenology was described through its progression in the core and in the lower head up to vessel failure, followed by the ex-vessel accident progression, with the loadings which can cause early containment failure (i.e. Direct Containment Heating, hydrogen combustion in containment, steam explosion) and the late containment failure (i.e. MCCI, coolability, etc.) The source term with fission products release from the core and transport in the reactor coolant system and in the containment have been specially emphasized.

Lecturers were 18 experts from 6 different countries, with large skills and knowledge on Gen. II and III plants and on the progression of a severe accident. The presence of 2 lecturers from industry has allowed to describe how the different plants would react during an accident, keeping in mind that an introductory course would not allow lengthy discussions or computer simulations.

The course was open to university students with a strong discount fee and contributed for 3 ECTS (with a written work) as an advanced course for master students, with a strong link among SARNET2, ENEN & European Master of Science in Nuclear Engineering (EMSNE).

## **2. SEVERE ACCIDENT PHENOMENOLOGY SHORT COURSE: TOPICS AND LECTURES.**

The 2011 “Severe Accident Phenomenology Short Course” was presented in several International meetings and, as an highlight of the SARNET2 Education & Training program, also at the ENS NESTet Conference in May 2011 at Prague (the poster presented at this Conference is available on both SARNET2 web-sites), to promote the course itself. The SARNET2 public web-site has been also used (<http://www.sar-net.eu>) to announce the Course (see Appendix-1 for the final announcement) and to give practical information to participants.

A massive information campaign was also performed by e-mail and printed information brochures distributed in different international conferences or specific international meetings (see Appendix 2).

This 2011 course was aimed at disseminating the knowledge gained on Nuclear Reactor Severe Accident Research during the last two decades to master/PhD students and engineers and researchers from industry, utilities, regulatory bodies, Technical Safety Organizations, R&D laboratories and Universities.

The Pisa course was subdivided in 14 main sections (see Appendix-3 for the final programme), as in the skeleton of the 2006 one:

1. Invited lecture on ENEN activities
2. Introduction on safety of NPPs, including description of TMI-2 and Chernobyl accidents
3. Early In Vessel progression
4. Late In Vessel progression

5. Early containment failure, Direct Containment Heating
6. Hydrogen
7. Steam explosion
8. Ex Vessel, including MCCI and corium progression
9. Source Term
10. Safety assessment
11. SA Codes and ASTEC
12. SAM and mitigation
13. Gen. III Ex Vessel Retention
14. Closure lecture on status of SA studies

The lectures were given by 18 experts from major European institutes and Universities working on the different topics of SA phenomenology:

- Ansaldo Nucleare Italy M. Froghieri
- AREVA Germany M. Fisher
- CEA France P. Piluso, C. Journeau
- CIEMAT Spain L. Herranz
- ENEA Italy F. De Rosa
- KIT Germany A. Miassoedev
- GRS Germany W. Luther, T. Steinroetter
- IRSN France F. Fichot, C. Seropian, J.P. Van Dorsselaere
- JSI Slovenia I. Kljenak
- KTH Sweden B.R. Sehgal
- POLIMI Italy F. Campi
- RSE Italy F. Parozzi
- UNIPI Italy W. Ambrosini, M. Mazzini

Six of them came from 5 different Public R&D institutions, 5 from 2 Safety Institutes, 2 from 2 Industry and 5 from 4 Universities (even if many of the others are also part time lecturers in different universities). Only one lecturer was a lady, Dr. Monica Froghieri from Ansaldo Nucleare (I).

The course was coordinated by Dr. Pascal Piluso from CEA (France) and Prof. Sandro Paci of UNIPI, Italy with an **Organizing Committee** formed by Pascal Piluso (CEA), Sandro Paci (UNIPI) and Christophe Journeau (CEA).

A specific **Steering Committee** was in charged to provide guidance and an advice for the organizers on key issues such as objectives, budgetary control and other decisions involving course stakeholders. The SARNET2 Coordinator and the MT members were included in this Steering Committee, formed by:

- Jean-Pierre Van Dorsselaere      IRSN
- Roland Zeyen                            JRC
- Joseph Safieh                            ENEN
- Giuseppe Forasassi                    CIRTEN
- Raj Sehgal                                KTH
- Ari Auvinen                              VTT
- Christophe Journeau                CEA
- Ivo Kljenak                              JSI
- Sandro Paci                              UNIPI
- Pascal Piluso                            CEA
- Walter Tromm                          KIT

**Local organizers** of the Pisa Course were Sandro Paci of UNIPI and Davide Mazzini of Acta s.r.l., a spin-off society of UNIPI.

The course notes have been prepared and distributes to all the course participants and lecturers (plus to SARNET2 MT members) into two forms:

- Presentation material

The course presentation materials have been distributed during the week of the course as black and white printed hand-outs and, after the course, these notes and the presentations were distributed also as a final CD-ROM (see Fig. 1), including video and photos, plus the text materials described in the following.

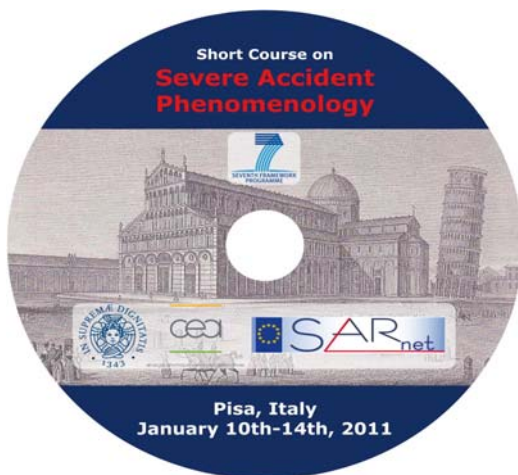


Fig. 1: Pisa 2011 CD-ROM.

- Text material

The text material was composed by some information papers on SARNET2 activities, the reference document *“SARNET Lecture Notes on Nuclear Reactor Severe Accident Phenomenology”*, edited by B.R. Sehgal and P. Piluso - SARNET-SPREAD-D-118 – that was released after the 2006 SARNET Course, and by the drafts of some chapters of the SA Book released in the SARNET framework.

### 3. SEVERE ACCIDENT PHENOMENOLOGY SHORT COURSE: ATTENDANCE AND EVALUATION

The 2011 Severe Accident Phenomenology Short Course was a real success: there were 87 students and researchers from the EU and other countries in the world, including 11 young master students from UNIPI, and 19 lecturers or organizers attending this course for a total of 106 participants.

No application for grants was received by the organizers but only few requests of reduction of the course fees, with the application of the very low student fee.

The 2011 course was endorsed by UNIPI and ENEN to contribute for 3 ECTS as an advanced course for Master and PhD students. To obtain these 3 ECTS, the preparation after the course attendance of a short document, respecting the following structure, was required:

- Severe accidents topic in which each student is more involved.
- Short overview to describe the topic
- Short bibliography- State of the Art
- Still opened questions- Consequence on safety of reactors

The different topics assigned by the 2 Coordinators according to the 8 student' requests were the following:

- Iodine behavior in containment-
- Ruthenium behavior in containment
- Corium Concrete Interaction
- Fuel Coolant Interaction
- Coolability of debris bed
- PSA-Level 2
- Comparison of Gen 3 mitigation concepts
- Codes employed in SA analysis

After 2 months from the topic assignments, only 3 PhD students have obtained the 3 ECTS.

The 2011 overall attendance was truly international (see Figure 2, not including the 11 Italian master students): participants came from 20 different countries, mostly European but there were also 8 participants from People's Republic of China (2), South Korea (5) and United Arab Emirates (1). The 64 participants from EU Members represented 84.1% of the total number, while the other European participants (4) were 5.3% and 10.5% for the rest of the world.

The attendance had a mixed background (see Fig. 3): safety authorities and technical safety organizations (21.1%), utilities (15.8%), industry (15.8%), research centers (32.9%) and universities (14.5%). It was mainly made of professionals but also with a large participation of PhD students (plus the 11 Pisa master students).

The gender balance for the 2011 participants is reported in Fig. 4 (25.6% F vs. 75.6% M).

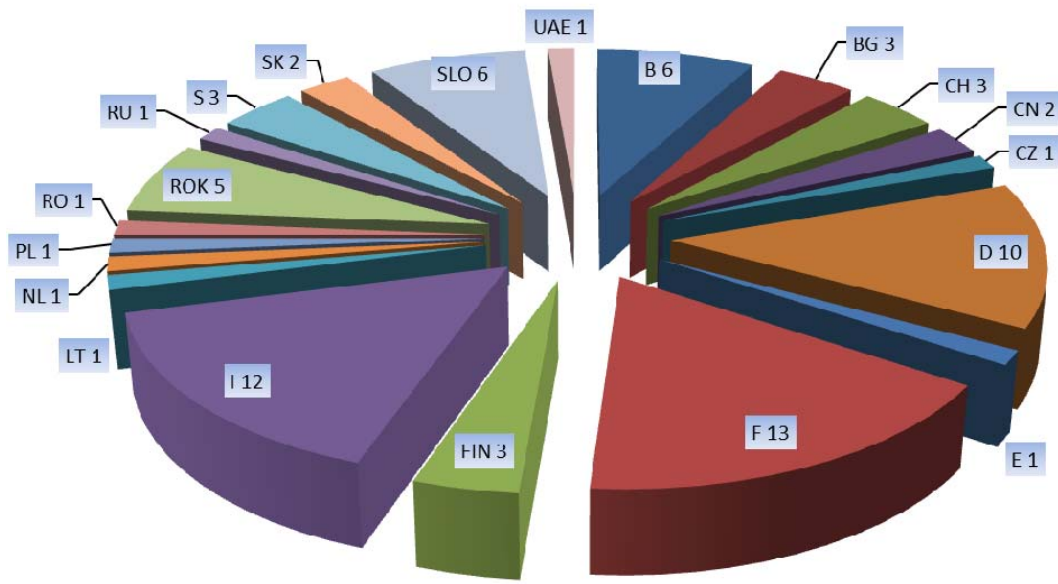


Fig. 2: Nationalities of the participants to the 2011 Course.

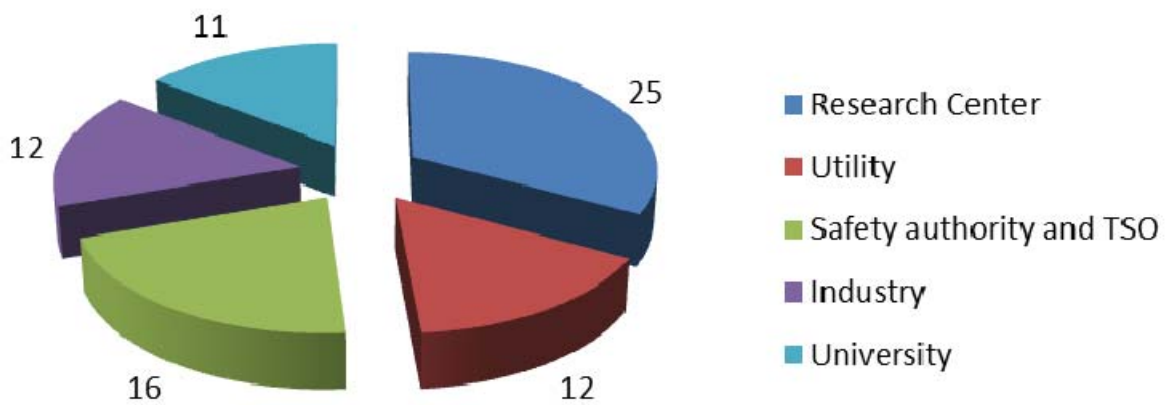


Fig. 3: Background of the participants to the 2011 Course.

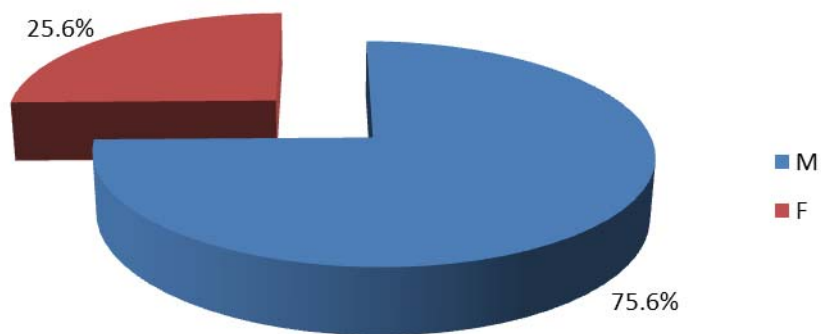


Fig. 4: Gender balance of the participants to the 2011 Course.



An evaluation form was distributed during the last days of the course week to the participants, except the lecturers. It is the tool used in this report to analyze the 2011 course and its impact. The evaluation was generally made on a scale from 1 (very bad) to 5 (very good) on the basis of 76 compiled forms.

The evaluation of the general organization of the 2011 course by the attendees was very good for the overall mark: 4.32/5. Also for coffee breaks and lunches, notwithstanding the contemporary strike in the Italian universities, the mark was quite good 3.87/5.

When registering for this 2011 SARNET2 Course, most of the participants probably were expecting to gain more knowledge of the Severe Accident Phenomenology and to obtain an overview of current severe accident research, having the following distribution (Fig. 5) for the question “Since when are you involved in Severe Accidents SA studies?”. The matters of the current involvement of participant in SA studies are reported in Fig. 6. It can be seen that about 80% of the participants have been recently involved in SA (less than 36 months).

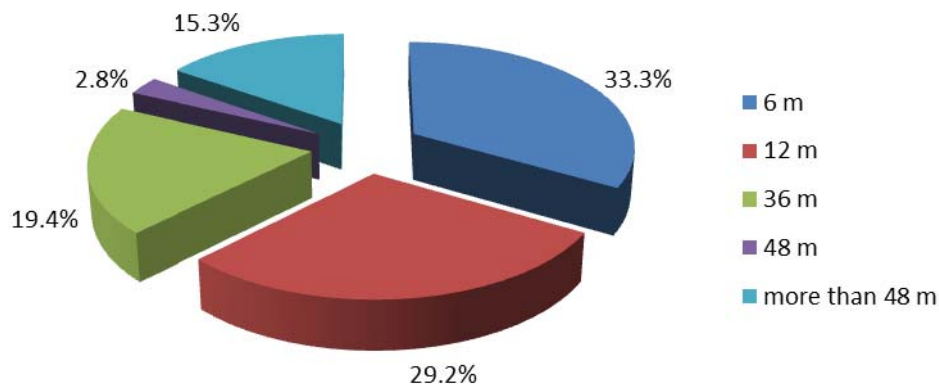


Fig. 5: Involvement time of the participants in SA studies.

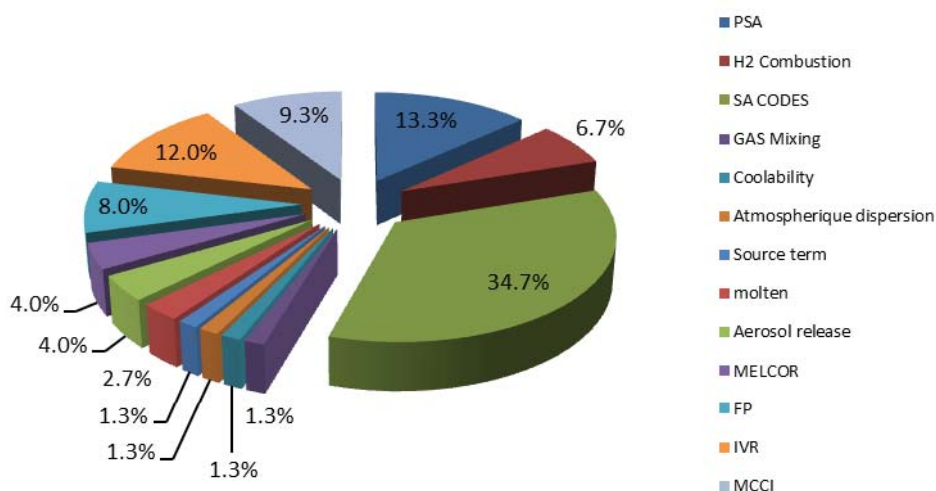


Fig. 6: Current involvement of the participants in SA studies.

Participants have not expressed a main field of interest for reactor applications, with a quite equilibrated distribution (reported in Fig. 7) of this interest between Gen. II and Gen. III reactor design. These figures reflect the fact that half of participants were participating to SARNET course for the future reactors to be built.

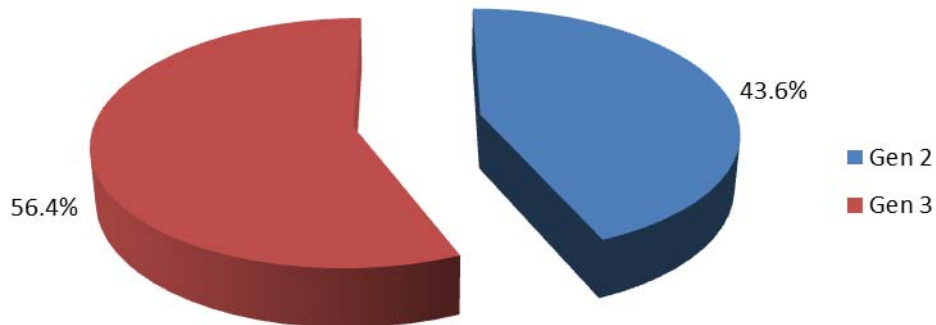


Fig. 7: Main field of interest for reactor application.

Also the time schedule (Fig. 8) of the 2011 Course was judged quite equilibrated for 79.5% of participants, not too short (3.8%) or too long (16.7%).

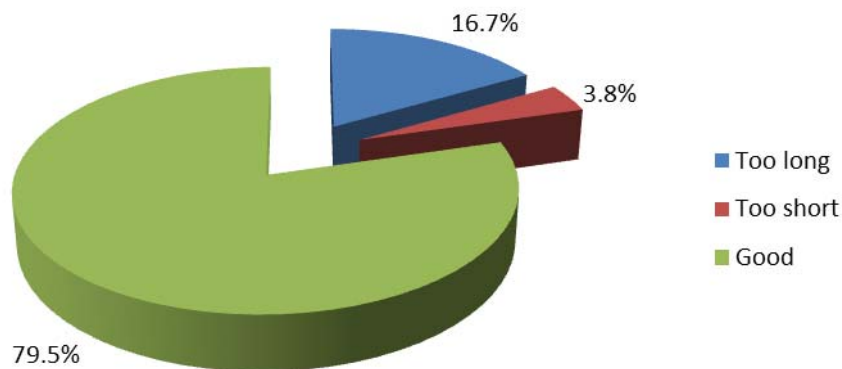


Fig. 8: Time schedule.

The average rate expressed by course participants on the power point presentations was quite high - 4.1 / 5 - while the black and white paper print of the lessons had a lower mark of 3.8 / 5, with an useful judgment of 89.7% for the course participants (there were some requests for color prints, that are however too expansive for the course financial balance). On the other side, the final CD-ROM was considered useful in 100% of the forms, with some requests to have available, in the future courses, and this kind of CD-ROM before the beginning of the course itself.

Finally, the 2011 lectures had an average mark of 3.86 / 5, with the answers distribution reported in Fig. 9. No BAD or VERY BAD marks were expressed by participants, with 18.2% of the mark VERY GOOD and 54.5% of the mark GOOD.

Concluding this review, it can be stated that the 2011 SARNET2 Course met very well the participant expectations and needs for nuclear industry in terms of personal objectives in the field of Severe Accident as can be highlighted from the distribution of answers at the main question *“You have participated to the 2011 course in order to reach your own objectives in the field of Severe Accident, after the course, do you estimate that these objectives have been reached?”* reported in Fig. 10. The MAINLY answer had 70.5% while the TOTALLY 17.9%, without NOT AT ALL mark.

Furthermore, the excellent results of the SARNET course has shown the increasing interest in nuclear safety, stressing the fact that the course has been held before the Fukushima events.

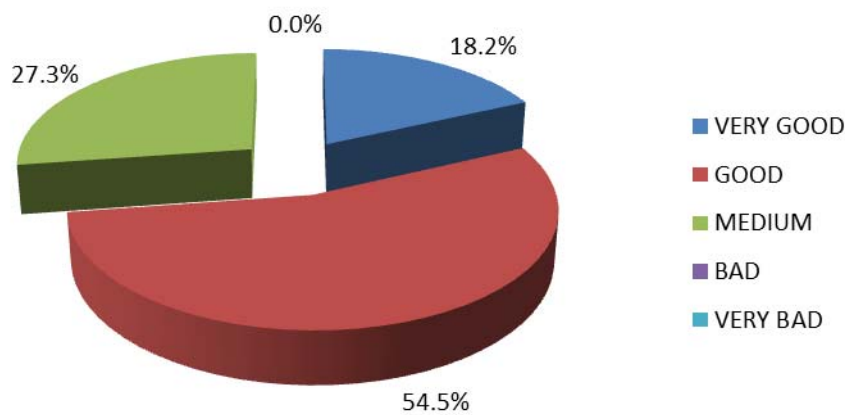


Fig. 9: Lectures quality.

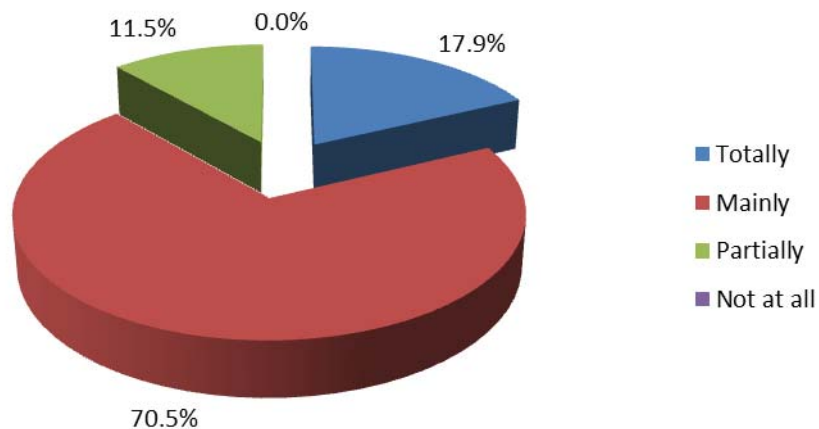


Fig. 10: Achievement of the 2011 Course objectives.

The suggestions reported in the 2011 Course evaluation forms also provide the following recommendations and indications for the planning of the future SARNET2 courses on severe accidents:

- Would you recommend, in your institute or company, a next SARNET2 course for people involved in Severe Accidents? The answer was YES for 100% of participants.
- Would you participate to a possible follow up of this 2011 course? Also for this question the answer was highly positive, YES for 94.9% of the forms.
- A new SARNET2 course similar to 2011 one, again on Severe Accidents phenomenology, has been indicated as useful, reducing the focus on codes (*more models, less codes*).

## Appendix-1: Severe Accident Phenomenology Short course Announcement



*This short course is a part of the Excellence Spreading activities of SARNET2 and it will focus on disseminating the knowledge gained on Severe Accidents in the last two decades to Master-PhD students, young engineers and researchers*

[www.sar-net.eu](http://www.sar-net.eu)

### I. INTRODUCTION

During SARNET1 three short courses (1 week) on Severe Accident technology were organized:

- 2006 SA Phenomenology including some description of Accident Management (AM). It was attended by about 100 students and researchers including many from outside of EU. The fee was only 500€ for students. It was organized by CEA and held in Cadarache with a huge success.
- 2007 SA Progression (analysis, data and uncertainties) to give the order of magnitude of physical phenomena occurring during a SA progression to researchers & engineers working in industry & regulatory organizations. Organized by IRSN and held again in Cadarache, it was focused on:
- knowledge on the associated risks linked with SA situations for different types of nuclear reactors;
  - knowledge on the deterioration mechanisms of the different safety barriers in case of SA;
  - analysis of the possible recovery actions.

The 2007 course was attended by 38 persons, 27 SARNET and 11 non-SARNET organizations, also from Canada and South Africa. No students - Research organizations (5 participants), TSO (15), Safety Authorities (9) and Utilities & Vendors (9)

- 2008 Nuclear Reactor SA Analysis: Application and Management Guidelines, focused more on SA methodology (models, codes), analyses and AM. This third course was held in Budapest in April 2008, organized by VEIKI and CEA. About 50 students and researchers attended the course.

For the balancing of the budget (to go towards a self-sustainability of the SARNET Network) the participation fees were increased to about 1400 € for general participants and 700 € for students. But the increasing fees resulted in a decreasing participation.

In SARNET2 again three courses are foreseen:

1. A one-week course on SA phenomenology, focus on Education (disseminating the knowledge gained on SAs in the last two decades to Master/PhD students and young/new researchers), with a strong link among SARNET2, ENEN & European Master of Science in Nuclear Engineering (EMSNE). The goal will be also to refresh older/previous participants after 5 years and SARNET1 outcomes.
2. A shorter course for staff & managers in regulatory authorities, TSOs & utilities: such shorter course was requested by the AC in SARNET1.
3. A one-week (or 2 weeks) course focused on code training, to learn models and to operate the different codes.

The first SARNET2 **"Severe Accident Phenomenology Short Course"** will be organized by CEA and Pisa University and will be hosted by Engineering Faculty of Pisa University.

Lectures will be from experts from different countries with large skills and knowledge on new Generation III NPPs and on the progression of a SA. The presence of lecturers from industry will be utilized to describe how the different plants would react during a SA, keeping in mind that an introductory course would not allow lengthy discussions or computer simulations. As referents in safety assessment, well known organizations (IRSN, GRS...) will be part to the course and will take the leadership of some activities.

Moreover, ASTEC code developers will be involved and will constitute a vehicle for applications.

It will be open to University students (discount fee). The course can contribute for 3 ECTS (with a written work or a presentation) as an advanced course for Master Students (through the European Nuclear Education Network ENEN).

A limited number of tuition grants for students/young researchers may be available for attendants from Central and Eastern European Countries. Application deadline: 30/10/2010.

## II. TOPICS

The program will cover SA phenomenology and progression in current water-cooled Gen. II Nuclear Power Plants, but also the different design solutions in new Gen. III Plants. The purpose will be to describe Gen. III designs addressing SA (i.e., the "in-vessel" melt retention concept or the "ex-vessel" core catcher concept).

Lectures will present the historical aspects of reactor safety and severe accidents (TMI-2 and Chernobyl-4). The phenomenology of a severe accident will be described through its progression in core and in the lower head up to vessel failure. The ex-vessel accident progression with the loadings which can cause early containment failure (i.e., DCH, H2 combustion, steam explosion) and the late containment failure (i.e., MCCI, coolability, etc) will be described.

The source term with the release and transport of fission products in the primary and containment systems will be specially emphasized.

### III. REGISTRATION

It includes the attendance at the course lectures and a copy of the course material (CD-ROM). It also covers coffee breaks, lunches and the social dinner. Accommodation and travel expenses are not included.

	Before 01/10/2010	After 01/10/2010
<b>General</b>	€ 900	€ 1,200
<b>Students</b>	€ 300	€ 400

(Plus VAT, if applicable)

Please send the registration fee (cheque payable to CEA) together with the registration form available in the SARNET2 public web site [www.sar-net.eu](http://www.sar-net.eu) to Pascal PILUSO - CEA Cadarache.

### IV. VENUE AND ACCOMMODATION

- Designated participants who require a **visa to enter** Italy should submit the necessary application form in due time to the nearest diplomatic or consular representative of Italy.



- Each participant is to make his own hotel reservation.
- A list of hotels not far from the Course location and practical info will be available on the SARNET2 public web site [www.sar-net.eu](http://www.sar-net.eu)

**Organizing Committee:**

Pascal Piluso (CEA)  
 Sandro Paci (UNIFI)  
 Christophe Journeau (CEA)

**Steering Committee:**

Jean-Pierre Van Dorsselaere (IRSN)  
 Roland Zeyen (JRC)  
 Joseph Safieh (ENEN)  
 Giuseppe Forasassi (CIRTEN)  
 Raj Sehgal (KTH)  
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 Ivo Kijenk (JSI)  
 Sandro Paci (UNIFI)  
 Pascal Piluso (CEA)  
 Walter Tromm (KIT)

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## Appendix-2: Severe Accident Phenomenology Short course Brochure

### Registration Form

**Short Course on  
Severe Accident Phenomenology  
Pisa, Italy - January 10-14, 2011**

NAME (FIRST, LAST):

AFFILIATION:

DEPARTMENT:

ADDRESS:

PHONE (including country and area codes):

FAX:

E-MAIL:

-----  
Your background:

- Student:  
 MSc  Engineer  PhD  Post doc
- University professor  Safety regulator  
 Electrical  Utility Industry  
 National R&D lab  TSO  
 Others:

-----  
Please send the registration form and the fees (cheque payable to CEA or bank transfer) to:

Pascal PILUSO  
CEA Cadarache



hosted by:  
**Facoltà di Ingegneria - Pisa**



Course Coordinators:

**Pascal PILUSO**

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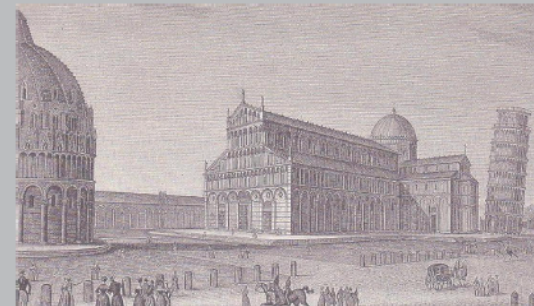
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Fax: +39 050 221 2065  
e-mail: [sandro.paci@ing.unipi.it](mailto:sandro.paci@ing.unipi.it)



Short Course on  
**Severe Accident  
Phenomenology**

Pisa, Italy  
January 10<sup>th</sup>-14<sup>th</sup>, 2011

Jointly organized by:  
CEA  
Università di Pisa



### Short Course on Severe Accident Phenomenology

January 10<sup>th</sup> – 14<sup>th</sup>, 2011  
Engineering Faculty - Pisa (I)

The Severe Accident (SA) Research Network of excellence **SARNET2** is sponsoring a new one-week Course entitled "**Severe Accident Phenomenology**". This course is a part of the Excellence Spreading activities of SARNET2 and it will focus on disseminating the knowledge gained on SA in the last two decades to Master-PhD students, young engineers and researchers. The SARNET2 project is co-funded by the EURATOM research program in the 7<sup>th</sup> Framework Programme of the European Commission.

**The Course will be organized by CEA and UNIPI and will be hosted by Engineering Faculty of Pisa University.**

This short Course is a sequel to the previous three SARNET SA Courses. The program will cover SA phenomenology & progression in current water-cooled Gen. II Nuclear Power Plants (NPP), but also the different design solutions in new Gen. III Plants. The purpose will be to describe Gen. III designs addressing SA (i.e., the "in-vessel" melt retention concept or the "ex-vessel" core catcher concept).

Lectures will be given by international experts from major Nuclear Institutes, Industries and Universities working on the topic. Lecturers from industry will be able to describe how the different NPPs would react during a SA, keeping in mind that an introductory short course would not allow lengthy discussions or computer simulations. Moreover, the integral codes, in priority ASTEC (but also MELCOR) will constitute a vehicle for applications, thus involving the code developers.

The Course will also describe applications of the codes to estimate consequences for the various SA scenarios. It will also include background lectures on NPP safety, SA scenarios and the events leading, respectively, to the early and late failure of containment.

It will be open to University students (**discount fee**). The course can contribute for 3 ECTS (with a written work) as an advanced course for Master students (through the European Nuclear Education Network **ENEN**). A limited number of tuition grants for students/young researchers may be available for attendants from Central and Eastern European Countries. Application deadline: 30/11/2010.

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Ari Auvinen (VTT)  
Christophe Journeau (CEA)  
Ivo Kljenak (JSI)  
Sandro Paci (UNIPI)  
Pascal Piluso (CEA)  
Walter Tromm (KIT)

#### Local Organizers:

Sandro Paci (UNIPI)  
Davide Mazzini (ACTA)

#### LOCATION: Pisa – Italy

Facoltà di Ingegneria, Università di Pisa  
Polo F (didactic building F)  
via Diotisalvi, 2 - 56126 Pisa (I)



#### Registration Fees

	Before 01/11/2010	After 01/11/2010
General	€ 900	€ 1,200
Students	€ 300	€ 400

(Plus VAT, if applicable)

It includes the attendance at the course lectures and a copy of the course material (CD-ROM). It also covers coffee breaks, lunches and the social dinner.

Accommodation and travel expenses are not included.

**WEBSITE:** <http://www.sar-net.eu>

**LANGUAGE:** English

**ACCOMMODATION:** A list of hotels not far from the course location will be available on the Course website. Participants will make directly their own hotel reservations.

### Appendix-3: Severe Accident Phenomenology Short course Schedule

Monday, Jan 10	Tuesday, Jan 11	Wednesday, Jan 12	Thursday, Jan 13	Friday, Jan 14
9:00-10:00	9:00-11:00	9:00-12:30	9:00-12:30	8:30-10:30
Registration – Coffee 10:00 -11:00 Opening Faculty Dean, P. Pilluso, S. Paci G. Forasassi (CIRTEN) DIMNP Director 1- Invited lecture (0.5 h) • European nucl.education and ENEN W. Ambrosini (ENEN)	4-Late In Vessel (2.0 h) • Focusing effect • External cooling • Gap cooling • Vessel failure W. Luther (GRS)	8-Ex Vessel (3 h) • Spreading • MCCI and basemat behaviour • Ex vessel FP and gas release • Coolability C. Journeau (CEA)	10a-Safety assessment (2 h) • PSA Level 1,2: Principles and overview of practices • Risk informed Analysis T. Steinroetter (GRS)	12-SAM and mitigation - IVR (2.0 h) • Passive and active systems • Existing plants, New designs • Generations II and III M. Froghlerl (Ansaldo Nucl.)
	11:00-11:30 Coffee Break	11:00-11:30 Coffee Break	11:00-11:30 Coffee Break	10:30-11:00 Coffee Break
11:00 -12:30	11:30-12:30		11:30-12:30	11:00-12:30
2a- Introduction (0.5 h) • SARNET, ASTEC J.P. Van Dorsselaere (IRSN) 2b- Safety of NPPs (1.0 h) • Defence in depth • WASH-1400 study M. Mazzini (UNIFI)	5-Early containment failure - DCH (1h) A. Miasoedov (KIT)		10b-Safety assessment (1 h) • Environmental impact and human health risk F. Campi (POLIMI)	13-Gen. III Ex Vessel Retention (1.5 h) • EPR, APWR, ESBWR.. M. Fischer (AREVA)
12:30-14:00 Lunch	12:30-14:00 Lunch	12:30-14:00 Lunch	12:30-14:00 Lunch	12:30-13:30 Lunch
14:00 -17:30	14:00-15:30	14:00-15:30	14:00-17:30	13:30-14:30
2c- Safety of NPPs (0.25 h) • TMI-2, Chernobyl • Classification of accidents J.P. Van Dorsselaere (IRSN) 3- Early In Vessel (3.0 h) • Fuel degradation and reflooding • H2 production	6- Hydrogen (1.5 h) • H2 risk • H2 distribution in the containment • H2 mitigation I. Kijenek (JSI)	9a-Source Term (1.5 h) • Transport in primary system / containment, containment bypass F. Parozzi (RSE)	11a-SA Code (1. h) • mechanistic and integral codes • validation process • benchmark F. De Rosa (ENEA)	14- Closure Lecture • Status on SA studies his view on future, especially for Gen.III B.R. Sehgal (KTM)
15:30-15:45 Break	15:30-16:00 Break	15:30-16:00 Break	15:00-15:30 Break	14:30-15:00 Break
• FP release from core • In vessel progression • Reactors/scenarios F. Fichot (IRSN)	7-Steam explosion (1.5 h) P. Pilluso (CEA)	9b-Source Term (1.5 h) • Chemistry effects (Iodine, Ru) • FP mitigation (sump, spray, filters) L. Herranz (CIEMAT)	11b- ASTEC Code (2.0 h) • ASTEC main features and demo C. Seropian (IRSN)	Feedback-Conclusion S. Paci (UNIFI) P. Pilluso (CEA)
		19.30 Official Dinner		