

## Introduction

BNEN, the Belgian Nuclear higher Education Network organizes a interuniversity program for Master of Science in Nuclear Engineering. This program is organized in a highly modular way and taught in English to facilitate and enhance participation of foreign students in the frame of the European Master of Science in Nuclear Engineering within the ENEN-association. The BNEN program makes full use of the laboratory facilities and infrastructure of the Belgian Nuclear Research, the SCK•CEN.

The course on "Nuclear Thermal Hydraulics" is free of charge for university registered students. Travel, lodging and other incurring cost are at own expenses. Participants from industry should contact the registration office.

## Students

The course is open for graduate and post-graduate students. Knowledge of Physics and higher Mathematics are a prerequisite.

## Application

Applicants should fill in the annexed Application Form and provide it with the requested additional information to the registration.

The number of participants is limited to 20. The applications are subject to a selection procedure.

## Application deadline

The application deadline is January 13, 2005.

## Venue

The course will take place at the SCK•CEN Club-House, Boeretang 200, B-2400 Mol, Belgium.

## Registration & Information

### Technical programme

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### Registration

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## Travel Information

SCK•CEN is in Mol, Belgium, about 100 km northeast of Brussels and about 50 km east of Antwerp.

For a roadmap and itinerary: [www.sckcen.be](http://www.sckcen.be)

By taxi from Brussels Airport to Mol: 1,5 h drive (*indicative rate* € 150)

By public transport from Brussels Airport:

Take the intercity train to Brussels North Station. Change to Antwerp Station. Change to Mol railway Station. (*indicative rate*: € 15) (app. 2h total travel time)

For more information please check the website of the Belgian Railways: [www.b-rail.be](http://www.b-rail.be)

## Accommodation

The course is organised in residential form. Dormitories or hotelrooms on SCK•CEN domain are available.

- Dormitories without hotel service (only sheets, no cleaning) € 76,95 for 2 weeks
- Dormitories with hotel service: towels, soap, cleaning € 263,47 for 2 weeks
- Club-House hotel (breakfast included)  
single: € 50 /night double: € 70 /night

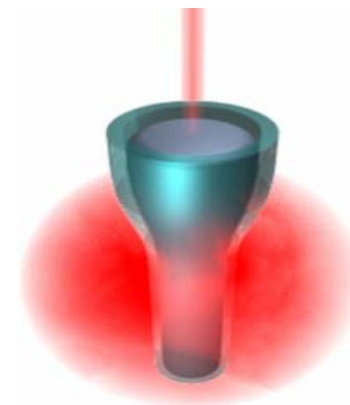
SCK•CEN guarantees 10 dormitories on a "first come, first served" base. Deadline for registration is December 13, 2004.

For all reservations of dormitories, a cash warranty of € 135 must be payed upon arrival.

## Meals

Meals can be taken at the

- cafeteria (self service) (lunch from € 4)
- the Club-House restaurant (lunch/dinner from € 10)
- the pub of the sportsclub (snack from € 2)
- the dormitory building has a communal kitchen



# Course on Nuclear Thermal Hydraulics

Mol, Belgium, February 8 - 26, 2005

Organised by BNEN:



BNEN is a consortium of the Belgian universities

- Katholieke Universiteit Leuven,
- Université Catholique de Louvain,
- Université de Liège,
- Universiteit Gent,
- Vrije Universiteit Brussel,

in collaboration with SCK•CEN, the Belgian Nuclear Research Centre

[www.sckcen.be/BNEN](http://www.sckcen.be/BNEN)



BNEN courses are proffered within the ENEN association. ENEN is a non-profit organisation to preserve and develop higher nuclear education and expertise.

[www.enen-assoc.org](http://www.enen-assoc.org)

## Introduction – Scope of the Course

The main objectives of the Nuclear Thermal Hydraulics course are:

- To get familiarised with various reactor types and their main design and operational characteristics
- To learn how to estimate the volumetric heat generation rate in fission reactor cores under normal operation and shutdown conditions
- To learn how to analyse the thermal performance of nuclear fuel elements
- To learn the basic fluid mechanics of single phase reactor cooling systems
- To learn to calculate pressure drop in reactor systems, including tube bundles, and spacer grids
- To learn to analyse the heat transfer characteristics of single phase reactor cooling systems
- To learn the basic fluid mechanics of two-phase systems, including flow regime maps, void-quality relations, pressure drop and critical flow
- To learn the fundamentals of boiling heat transfer and its implications for reactor design
- To learn the fundamentals of core thermal design, with attention to design uncertainty analysis and hot channel factors.

## Organisation of the Course

The course includes 27 lectures of 1h30 each, and 8 laboratory sessions & demonstrations of 3 hours each, i.e. 64,5 contact hours organised in a three week period.

The course starts on Tuesday February 8 at 08.30 a.m. and will be concluded on Saturday February 26 at 05.00 p.m.

Some visits of the research facilities of SCK•CEN are foreseen.

## Programme

### Theoretical course

The theoretical course is based on

1. Todreas, N.E. and Kazimi, M.S., Nuclear System I: Thermal Hydraulic Fundamentals, Hemisphere Publishing Corp., New York, 1990
2. Todreas, N.E. and Kazimi, M.S., Nuclear System II: Elements of Thermal Hydraulic Design, Hemisphere Publishing Corp., New York, 2001

### Laboratory sessions & demonstrations

- To recall conductive and single phase convective heat transfer by means of a practical application i.e. the temperature profile optimisation of a BR2 experiment rig. See 1, chapters 8, 9, 10
- To teach how the pressure is controlled in a LWR and to get familiar with the pressurizer behaviour in a PWR. See 1, chapters 4 and 7.
- To demonstrate the hydraulic design of an irradiation experiment i.e. to calculate the temperature profile in an existing irradiation rig. See 1, chapters 4 to 12.
- To demonstrate the theory of "thermal analysis of fuel elements", by performing the preliminary design of a fuel rod of the subcritical core of an accelerator driven system (ADS). See 1, chapters 1 to 3.
- To demonstrate the theory of "single phase fluid mechanics" by taking a hexagonal fuel assembly of the subcritical core of an accelerator driven system. See 1, chapters 1 to 3 and 9.
- To perform a practical application of the theory on "Flow loops", in calculating the natural convection flow regime in a simplified ADS configuration. See 2, chapter 3.
- To apply the RELAP code to the BR2 Reactor in case of a LOCA to demonstrate the methodology and capabilities of an advanced, best-estimate reactor thermal hydraulics simulation code. See 1 and 2.
- A demo of the use of the FLOW-3D code in the frame of an ADS-design project gives an impression of the methodology and capabilities of computational fluid dynamics codes, in comparison with best-estimate reactor thermal hydraulics simulation codes.  
See 1 and 2

## Examination

A written examination, prepared by the course staff, is foreseen on April 18, 2005; 08.30 – 12.00.

## Course credit

The course is rated 6 ECTS within the Belgian interuniversity programme for Master of Science in Nuclear Engineering (BNEN)

## Lecturer

### Professor Michel Giot

Michel Giot is professor at the Université catholique de Louvain (Louvain-la-Neuve, Belgium). His main research field is multiphase fluid flow and heat transfer with applications to nuclear and chemical engineering. He is a member of the Editorial Boards of the International Journal of Multiphase Flow, Archives of Thermodynamics, and Multiphase Science and Technology

The teaching assistants are research fellows and doctoral students of the SCK•CEN.