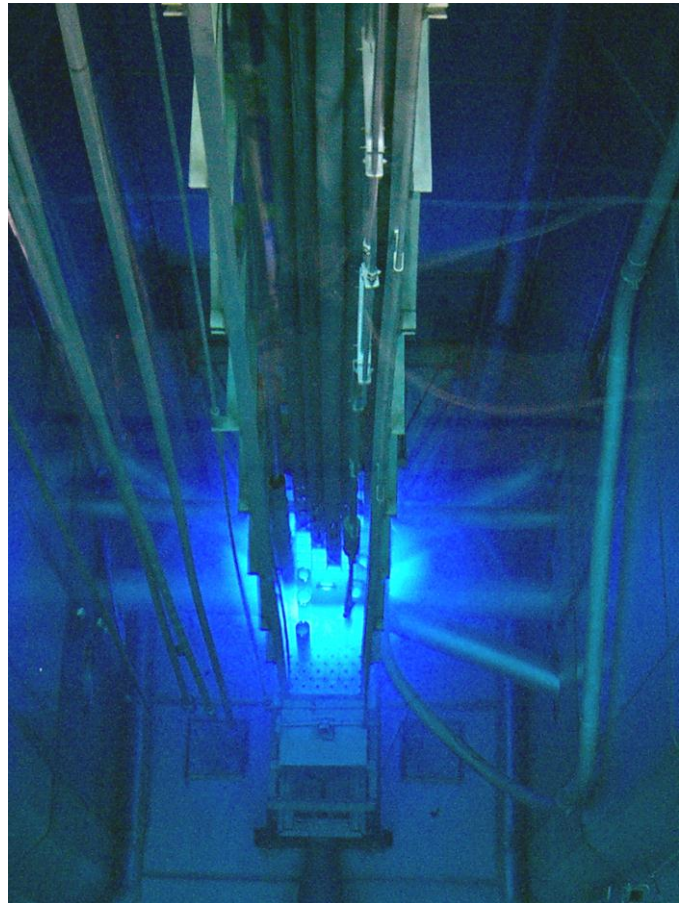


Reactors and Nuclear Safety Unit



Reactors and Nuclear Safety Unit

José Gonçalves Marques

The Research Unit on Reactors and Nuclear Safety includes the *Portuguese Research Reactor* (RPI), a unique infrastructure in the Iberian Peninsula, as well as the *Neutron Activation in Environment, Nutrition and Epidemiology* and *Applied Dynamics* groups. The RPI also supports activities for groups in the other Research Units of ITN, as well as in some Universities. Two new researchers were hired under the *Ciência* initiative during 2009, resulting in a total of 6 researchers hired in 2008 and 2009 in this research unit. This will have a significant impact in the near future, as the number of full-time researchers nearly doubled.

The staff involved in all aspects of the operation and use of the RPI presents its activities under the common headline of *Operation and Exploitation of the Reactor*. A strong effort was made in 2010 for the preparation of the replacement of the instrumentation and control of the RPI and the modernization of its radiological monitoring system.

The *Neutron Activation in Environment, Nutrition and Epidemiology* group uses the k_0 INAA technique in the RPI and was again the main Portuguese user of the reactor in 2010, accounting for nearly 30% of the total irradiation time. The group is dedicated to cycling and impact of trace elements in the

atmosphere. It addresses, specifically, the development and application of nuclear techniques, source apportionment and tracking in the atmosphere, chemical speciation, uptake and release of chemical elements in biomonitoring and monitoring, as well as health linkage through epidemiology and nutrition studies. These objectives are approached through research, included mostly in PhD theses. The activities are essentially financed by the Foundation for Science and Technology (FCT).

The research performed by the *Applied Dynamics* group is mostly concerned by vibration and acoustic problems displayed by components of nuclear and conventional power plants. As such, a significant part of their research results has been motivated and funded by the French *Commissariat à l'Energie Atomique (CEA)* and the Portuguese *Electricidade de Portugal (EDP)*. However, the techniques developed by this group can and have been used to solve problems, both of industrial and fundamental nature, outside the realm of power generation. In spite of continuing to be one of the smallest groups in terms of ITN staff, this fact is compensated by an active collaboration with Universities and Research Laboratories, both in Portugal and abroad. The vitality of this group is well demonstrated by their research contracts and publications.

Staff

Researchers

J. G. MARQUES, Princ.
M. C. FREITAS, Princ.
A. V. ANTUNES, Princ.
A. FALCÃO, Princ.
N. P. BARRADAS, Princ.
A. KLING, Aux. (Agreg.)
A. R. RAMOS WAHL, Aux.
S. M. ALMEIDA, Aux. (Contract)
D. BEASLEY, Aux. (Contract)
V. DEBUT, Aux. (Contract)
H. M. DUNG, Aux. (Contract)
A. C. FERNANDES, Aux. (Contract)
M. A. S. PEREIRA, Aux. (Contract)

Technical Personnel

J.P. SANTOS, Dosimetry
J. A. M. RIBEIRO, Reactor Operator
J. C. ROXO, Reactor Operator
R. SANTOS, Reactor Operator
N. SERROTE, Reactor Operator
F. B. GOMES, Radioprotection
R. POMBO, Radioprotection
A. RODRIGUES, Technician
I. DIONÍSIO, Laboratory Assistant

Administrative Personnel

T. FERNANDES, Secretariat

OPERATION AND EXPLOITATION OF THE REACTOR

José Gonçalves Marques

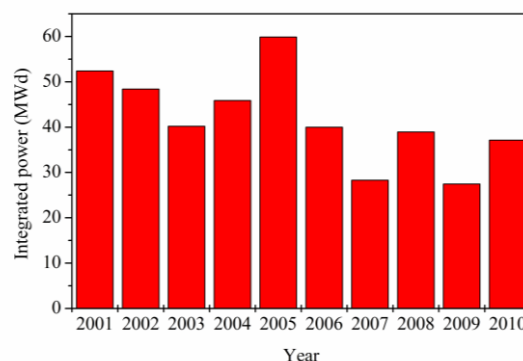
The main objective of the Operation and Exploitation of the Portuguese Research Reactor (RPI) is to be able to satisfy the users' needs while conducting all tasks with the assurance that the reactor is operated in a safe and reliable manner by a highly competent and motivated staff. The implementation of such objectives demands a variety of activities, some of which are repetitive in objective and variable in content, while others address specific aspects of the same end situation.

The main users of the reactor are described in the Table below.

User	Area	Time (%)
URSN	NAA	29.7
	Tomography	21.8
	Radiation effects	17.9
	Dosimetry and detector development	5.3
	Education and training	<0.1
UCQR	NAA	8.1
	Isotope Production	0.6
Univ. Lisboa	Isotope Production	13.8
IVIA	Radiation Effects	1.8
UPV	Isotope Production	0.9
IPFN	Isotope Production	0.1

The largest sustained activity supported by the RPI is neutron activation analysis (NAA) in the URSN and UCQR Research Units of ITN. Most other activities suffer large fluctuations – e.g., education and training

is very dependent on the number of students that attend courses that use the reactor in practical sessions. Neutron tomography was recently started in the RPI and already accounted for more than 20% of the reactor utilization in 2010. The integrated power in 2010 increased when compared with 2009, as shown in the figure below, where it is visible that 2005 continues to be the year with more activity.



The recent hiring of two researchers for the Operation team, under the *Ciência 2008* initiative, allowed to start an internal program to implement or optimize new techniques, such as neutron tomography and prompt gamma neutron activation analysis, as well as assess the status of experimental setups that had reduced use in the last years and that have the potential to attract new users in a sustained way.

Research Team

Researchers

J.G. MARQUES, Princ.
N.P. BARRADAS, Princ. (85%)
D. BEASLEY, Aux., (Contract)
A.C. FERNANDES, Aux. (Contract)
A. FALCÃO, Princ.
A. KLING, Aux. (85%)
M.A.S. PEREIRA, Aux. (Contract)
A.R. RAMOS WAHL, Aux. (85%)

Reactor Operators

J.A.M. RIBEIRO
J.C. ROXO
N. SERROTE
R. SANTOS

Technical Personnel

F.B. GOMES
R. POMBO
A. RODRIGUES
J.P. SANTOS

Students

M.A.F. COSTA, PhD Student, UNL,FCTgart

Collaborators

T. GIRARD, CFNUL
T. MORLAT, Post-doc., CFNUL

Neutron Tomography at the RPI

M. A. Stanojev Pereira, J. G. Marques

Objectives

The objective of this work is to have a neutron tomography setup with an image size of 30 by 30 cm for research and industrial applications at the Portuguese Research Reactor. The characterization of the prototype installed under project “Neutron Tomography at the Portuguese Research Reactor” (POCI/FIS/59287/2004) funded by FCT was finished and the setup was used to image historical tiles within project RADIART (PTDC/HIS-HEC/101756/2008) of the UQCR/ITN.

Results

Neutron radiography is a well known non-destructive technique. Compared with X-rays, neutrons have as specific advantages a high interaction probability with hydrogen and a lower attenuation in several heavy elements which are “black” for X-rays. Tomography requires a reasonably high number of 2D images in digital form of the observed object rotated over 180 degrees related to its central axis. With modern CCD cameras it is possible to obtain 2D images in a few minutes, even for modest neutron fluxes of 10^5 n/cm²/s.

A prototype setup for neutron tomography was implemented in the RPI under project POCI/FIS/59287/2004, funded by FCT. The prototype was installed in the horizontal access of the thermal column and is thus limited to a parallel beam with 5 cm diameter. During 2010 the characterization of the installation was finished. In the present conditions, the best irradiation time is 7 minutes and the spatial resolution in the current conditions is 323 μ m.

Even if the present conditions are not optimal, the setup started being used to image real objects, namely ceramic tiles within the RADIART project. Tiles are an important component of the cultural heritage in Portugal. They are composed of a ceramic base covered by a vitreous glaze which provides an impermeable glassy and brilliant surface. The porosity and permeability of the ceramic body are in the origin of the deterioration of ancient tiles. The main goal of these studies is to obtain information on the porosity of the tiles and how water can ingress and contribute to the degradation of the tile.

Figure 1 shows images of the fragment of a XVII century tile, imaged with conventional photography and with neutron tomography. The fragment was inspected in two distinct conditions: dried and moistened. For the first condition it was dried at room temperature for several days and a set of 200 individual images obtained in angular steps of 0.9° was taken. As can be seen, except for some dark spots, the sample shows homogeneity in terms of neutron transmission. For the second condition, the tile was partially immersed in water for some hours before irradiation and, as before, 200 individual images were taken. The water inside the tile is clearly visible by the darker regions of the image and the variations in water concentration are also easily visible by the gray level fluctuation in the image.

It is expected that the current setup will be transferred to a neutron beam line with a high neutron flux, with a parallel and a divergent beam, to increase the imaging area up to 30 cm by 30 cm, reduce the acquisition time and obtain images with better quality.

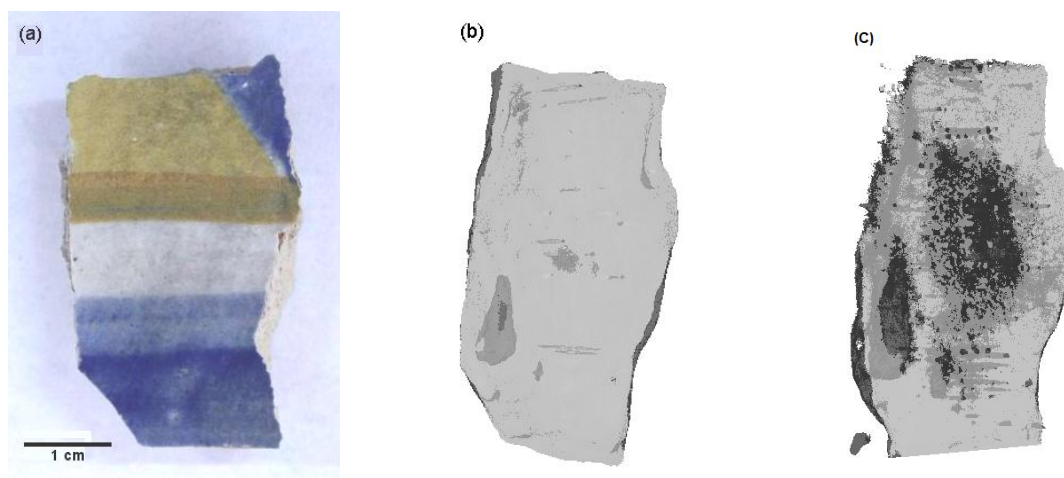
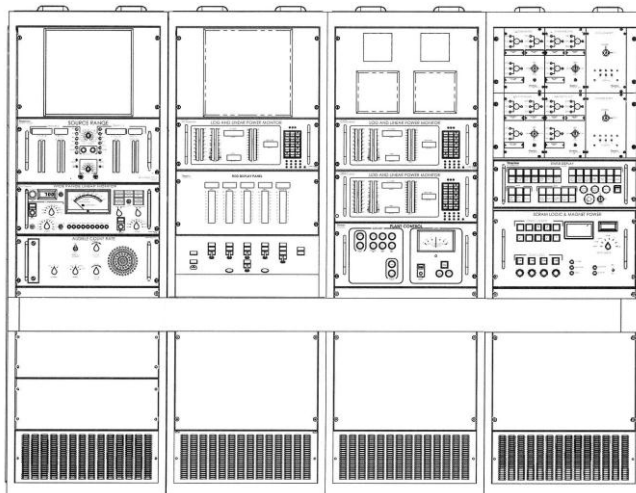


Fig 1. Fragment of a XVII century tile with (a) conventional photography, (b) neutron tomography of the dry fragment, (c) neutron tomography of the wet fragment.

Preparation for Replacement of the Instrumentation and Control of the RPI

J.G. Marques

The current instrumentation and control system of the RPI was installed in 1972. Its core results from a combination of analog modules of the Multibloc series of Merlin-Gerin (France) with modules made at the then Laboratory for Nuclear Physics and Energy. The replacement of obsolete and hard-to-maintain modules was initiated in the late nineties but the project for the complete replacement of the instrumentation and control system could only be started once it was decided that the RPI would be converted to low-enriched fuel and continue operating after 2006. The final shipment of analogic modules manufactured by Thermo Electron and GammaMetrics (USA) was received in early 2010. The console is being assembled next to the control room, with more than thirty modules received over five years. It is expected that the replacement can be done in 2011 once the tests are finished and regulatory permission is obtained.



Improvement of the RPI Radiation Protection Monitoring

A. Kling, A. R. Ramos, J. G. Marques

The monitoring of the radiation levels in the interior of the reactor hall and of radioactive gaseous effluents is of high importance for the safe operation of a research reactor. During the year 2010 the main focus was a further modernization of the monitoring within the reactor hall. The existing aging real-time noble gas monitor (Merlin-Gerin CAG-141) was replaced by a modern Mirion NGM204L monitoring system. The new system uses semiconductor detectors for the measurement of β - and γ -activity in the air allowing a wide range of activity concentration values and an easy calibration to a reference isotope (Kr-85 in our case). Also, new Si-detector based gamma radiation monitors (Mirion GIM204) were acquired and installed. The new monitors have a lower measurable minimum dose rate ($0.01\mu\text{Sv/h}$) than the Merlin-Gerin C/IEP51 ionization chambers ($1\mu\text{Sv/h}$) installed more than twenty years ago. During the test operation it was observed that the dose rates measured by the new monitors are significantly lower showing a more realistic situation. Both new radiation monitoring systems are fully compatible with the Merlin-Gerin RAMSYS data acquisition software used for most of the other monitoring system allowing an easier processing of the registered data.

Radiation Tolerance of Wireless Devices

I. López¹, J.A. Agapito¹, F. Franco¹, S. Gaillot², J. G. Marques

The performance of electronic components and systems under irradiation is a concern for the nuclear industry, the space community and the high-energy physics community. The use of wireless systems in nuclear installations is very attractive, as cabling is nearly reduced to zero, provided the devices can operate without significant degradation in radiation environments. Previous irradiations in the fast neutron facility of RPI and in the industrial Co-60 unit at ITN were focused on pt100 temperature sensors from Omega. Although these survived fast neutron fluences up to $4 \times 10^{12} \text{ n/cm}^2$ without measurable degradation, they showed degradation after a gamma dose of 200 Gy and were destroyed above 600 Gy. Since these sensors are highly integrated it was not possible to identify at which doses the different components were failing. In 2010 we irradiated wireless modules from Cypress (CYWM6935) and from Texas Instruments (CC2530). Their behavior under gamma irradiation was better than the one of the devices previously tested. However, the microprocessors were destroyed above 500 Gy, while other critical components such as logic gates, flash memories and multiplexers survived at least until 1 kGy. These results, a priori, restrict the use of wireless devices to 'soft' radiation environments.

¹University Complutense of Madrid, Madrid, Spain.

²CEA, Cadarache, France.

Software for Monitoring the Reactor Instrumentation and Control Systems

D. Beasley, J.G. Marques

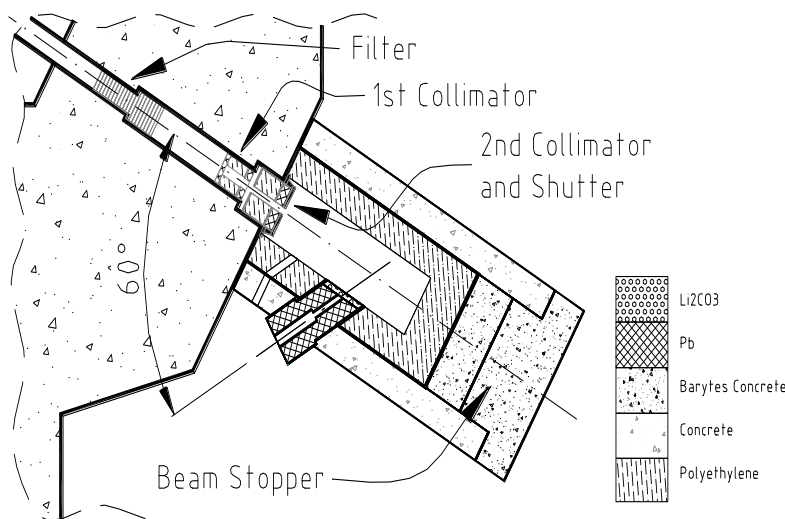
The new control system of the RPI will use paperless recorders from Yokogawa for data display in the operators' console. Although the control system is completely based on analog modules, the Yokogawa recorders when used as data acquisition platforms provide many of the advantages of a digital control system, at a fraction of the cost. LabView was used to develop dedicated software that can be run on multiple computers. The functions implemented include:

- Display operational variables (e.g., reactor power, temperature in cooling circuits) in custom-made screens, or from stored data.
- Automatic generation of daily log files and reports.
- Novel warning of any unusual behavior before triggering of conventional alarms, by analyzing data trends and comparison with normal data.

Monte Carlo Modeling of Modifications to the Epithermal Neutron Beam Line

D. Beasley, J.G. Marques

A beam irradiation facility with a neutron spectrum rich in the thermal and epithermal components was built ten years ago in the RPI. This facility was designed for multiple applications and for this reason it was provided with two openings with 2 cm and 5 cm diameter and the possibility of cutting the thermal component with a Cd filter. Multi-elemental 'Prompt Gamma Neutron Activation Analysis' (PGNAA) using a HPGe detector will now be implemented in this line. However, the high gamma background prohibits PGNAA in the current configuration. An MCNP model of the beamline was built, using realistic neutron and gamma components from the reactor core. Several modifications to the general arrangement and to the neutron and gamma filters were studied. A new design of a sample chamber extending from the current chamber was modeled and the new flux, signal to noise ratio and expected count rate were determined.



The SIMPLE Dark Matter Search Project

M. Felizardo, T.A. Girard¹, T. Morlat¹, A.C. Fernandes, F. Giuliani², A.R. Ramos, J.G. Marques, M. Auguste³, D. Boyer³, A. Cavaiillou³, C. Sudre³, J. Poupene³, H.S. Miley⁴, R.F. Payne⁴, J. Puibasset⁵

Project activity in 2010 centered on the completion of the Stage 1, and execution of the Stage 2, measurements of the 30 kgd measurement in the underground site (Laboratoire Souterrain Bas Bruit, LSBB). Shielding improvements between the two stages consisted of the addition of a 10cm thickness of PE below the detector water bath, and completion of the wood base to a full 20cm. These were implemented in new MCNP simulations, resulting in a neutron background estimate of 0.22 evt/kgd. Stage 1 was completed on 5 February, yielding a 14.1 kgd exposure the results of which have been published in Phys. Rev. Lett. and constitute the world's most restrictive exclusion of a SD WIMP-proton coupling to date. Stage 2, completed 22 July, preliminary analysis of the data yields zero candidate WIMP events for the 10.1 kgd exposure, and new spin-dependent exclusion contours surpassing that of the Stage 1 results. A publication of the Stage 2 results is in preparation.

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⁴Pacific Northwest National Laboratory, Richland, WA 99352 USA

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Applied Dynamics

José Antunes

The activities at Applied Dynamics Laboratory (ADL) are devoted to research in nuclear engineering, with an emphasis on the vibratory and acoustic behaviour of mechanical components. Our group started in 1986, with the following objectives: (1) Develop theoretical methods, computer tools and experimental techniques, to solve structural problems in nuclear power station components; (2) Use this state-of-the-art know-how, in order to solve structural problems arising in Portuguese power plants and other industrial facilities.

The first objective has been pursued through extensive international collaboration with our main scientific partner - the French Commissariat à l'Energie Atomique (CEA) / Département de Mécanique et Technologie (DMT). More than one decade of fruitful collaboration is attested by a significant number of published results. Important problems have been solved, such as nonlinear vibrations in steam-generators, flow-induced vibrations of nuclear fuel and stability problems in rotating machinery. Furthermore, new identification techniques have been developed and applied with success to nonlinear dynamical systems.

The second objective has been pursued by starting in 1990 a series of projects with (and for) the Portuguese power supplier Electricidade de Portugal / Companhia Portuguesa de Produção de Electricidade (EDP/CPPE), stemming from actual structural problems in power plants (Sines, Setúbal): These projects enabled us to model and solve vibratory problems arising in rotating machinery, vibro-acoustical problems in boilers and heat-exchangers, as well as structural identification problems. Several computer codes have been developed in connection with these projects.

In recent years we also developed research projects of more fundamental nature, mainly funded through the Portuguese Science Foundation (FCT) research programmes. These projects have been developed in partnership with several Portuguese institutions (Faculdade de Ciências de Lisboa, Instituto Politécnico do Porto, Instituto Politécnico de Setúbal, Instituto Superior Técnico, Universidade Nova de Lisboa), as well as the Université de Paris, Trinity College Dublin and Southampton University. This

work, developed in the context of fundamental physics – in particular addressing problems in music acoustics, optimization and structural geology – is centred in modelling nonlinear dynamics and flow-structure phenomena. The methods developed transcend the context of these projects and may be adapted to solve several aspects of industrial problems.

The Applied Dynamics team is mainly concerned with the following scientific fields: structural dynamics, flow-induced vibrations, nonlinear dynamics, vibro-acoustics, experimental methods, signal processing, system identification, structural and acoustical optimization. As a spin-off from our research activities, teaching has been actively pursued on structural dynamics and acoustics - ranging from university level courses in Portugal (Coimbra, Lisbon) to several post-graduation short courses abroad (Paris, Dublin, Cargèse). Also, student and post-doc training, as well as several university thesis (MSc and PhD) have been successfully supervised, for both Portuguese and foreign students. An extensive book on fluid-structure dynamics and acoustics, co-authored by two researchers from CEA and ITN/ADL was internationally published during 2006 and another volume on flow-induced vibrations is currently under completion.

Among the above-mentioned scientific fields one should stress those features which give this small group a distinct profile from others working in structural dynamics in Portugal. Those features are: (1) a proven expertise and output in flow-excited systems and nonlinear vibrations; (2) a complementary theoretical/experimental approach for every problem.

Most of the research projects pursued at ADL have been based on both industry and academic research contracts. Research activities at ADL were internationally recognized by two prizes from the American Association of Mechanical Engineers (ASME).

A new researcher, Vincent Debut, joined the permanent staff of the Applied Dynamics group in 2008, being involved since in most of our research activities.

Research Team

Researchers

J. ANTUNES, Princ.
V. DEBUT, Aux. (Contrat)

Collaborators

O. INÁCIO (15%), PhD, Adj. Professor (1)
L. HENRIQUE (10%), PhD, Adj. Professor (1)
M. MOREIRA (20%), PhD, Adj. Professor (2)
M. PAULINO (10%), MSc, Inv. Professor (3)
(1) IPP, Porto
(2) IPS, Setúbal
(3) IPL, Lisboa

Flow-induced vibrations of tubular nuclear components with vibro-impacting at support clearances

J. Antunes¹, P. Piteau², X. Delaune², V. Debut¹, L. Borsoi²

Objectives

In nuclear facilities, flow turbulence excitations and fluid-elastic phenomena may induce structural vibrations or instabilities, leading to fatigue failures and wear, which must be addressed with particular care for safety reasons. At ITN/ADL, in a long-term close collaboration with CEA-Saclay (contract TGV-ICE), we gained significant expertise in these areas. This project is aimed at the development at ITN/LDA of up-to-date software to compute turbulence-induced and fluid-elastically unstable vibrations of nuclear components, such as fuel rods or steam-generator tubes, with an experimental validation of the computational methods at the flow test-loop of CEA-Saclay. These experiments were performed by our French colleagues.

Results

The experimental setup shown in Figure 1 was used as a representative tube steam-generator bundle geometry for both the theoretical and the experimental work. A flexible tube, within a rigid bundle, was excited by the flow for two different configurations: (a) A linear system consisting on the clamped-free vibrating tube; (b) A vibro-impact nonlinear system, after two rigid clearance stops were positioned near the free-end of the tube. Configuration (a) was used for extracting the flow turbulence excitation spectrum from the linear tube responses, as well as the fluid-elastic coupling coefficients $C_f(V_R)$ and $K_f(V_R)$, as a function of the dimensionless flow velocity V_R . Then, the identified turbulence and flow-coupling data were used to predict the nonlinear tube responses after the clearance supports were installed.

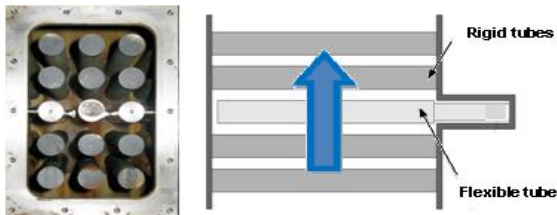


Fig.1 Test rig developed at CEA-Saclay for experimental validation of the software developed at ITN/ADL.

Figure 2 illustrates one such computation, showing the impulsive impact forces and the gap-limited tube vibrating motion, as well as an estimate of the "instantaneous" tube response frequency $f_r(t)$, which was needed for computing the reduced velocity V_R and hence the coupling coefficients. As illustrated in Figure 3, the computational and experimental results obtained constitute an overall validation of our approach to deal with gap-supported tubes subjected to fluid-elastic forces and turbulence. The main point successfully addressed was to assert the validity of computing the nonlinear and unsteady vibro-impact responses of fluid-elastically unstable tubes, knowing

that the fluid-elastic coupling coefficients are provided by tests performed under steady oscillatory conditions.

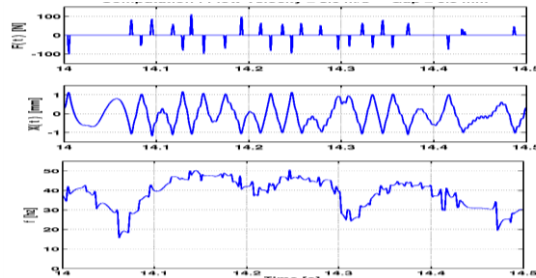


Fig. 2 Computations of a vibro-impact regime, showing the impact force and tube displacement at the gap-support, as well as the "instantaneous" response frequency.

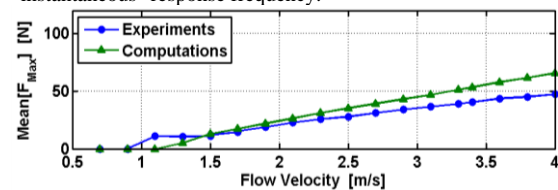


Fig. 3 Comparison between computed and experimental mean impact forces at the gap-support, for a series of tests.

Results connected with this work were already published at two international conferences and two journal papers, with a third journal paper in print.

Publications

P. Piteau, X. Delaune, J. Antunes, L. Borsoi, "Vibro-impact experiments and computations of a gap-supported tube subjected to single-phase fluid-elastic coupling forces", Paper FEDSM-ICNMM2010-30071, *Proc. 7th Int. Symp. Fluid-Structure Interaction, Flow-Sound Interaction, Flow-Induced Vibration & Noise*, 1-5 August 2010, Montreal, Canada.

X. Delaune, P. Piteau, V. Debut, J. Antunes, "Experimental validation of inverse techniques for the remote identification of impact forces in gap-supported systems subjected to local and flow turbulence excitations", Paper PVP2010-26133, *Proc. ASME 2010 Pressure Vessels & Piping Conference*, 18-22 July 2010, Bellevue, USA.

V. Debut, X. Delaune, J. Antunes, "Identification of nonlinear interaction forces acting on continuous systems using remote measurements of the vibratory responses", *Int. Journal of Mechanical Science*, Vol. 52, pp. 1419-1436 (2010).

X. Delaune, J. Antunes, V. Debut, P. Piteau, L. Borsoi, "Modal techniques for remote identification of non-linear reactions at gap-supported tubes under turbulent excitation", *ASME Journal of Pressure Vessel Technology*, Vol. 132, Paper 031801.

X. Delaune, P. Piteau, V. Debut, J. Antunes, "Experimental validation of inverse techniques for the remote identification of impact forces in gap-supported systems subjected to local and flow turbulence excitations", *ASME Journal of Pressure Vessel Technology* (in print).

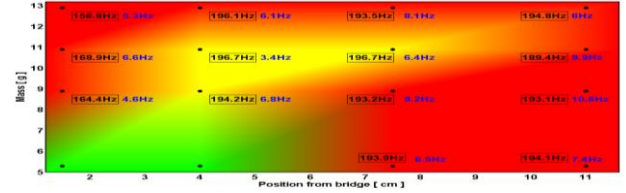
¹Instituto Tecnológico e Nuclear, Applied Dynamics Laboratory

²Commissariat à l'Énergie Atomique, DEN/DM2S/SEMT/DYN, CEN-Saclay, France

String/body coupling in string instruments

V. Debut¹, J. Antunes¹, O. Inácio², P. Serrão³, A. Ribeiro³

In the context of the FCT project PTDC/FIS/103306/2008, we pursued our study on the coupled body/string dynamics of bowed instruments. A common annoying phenomenon which arises is the so-called "wolf note", which is a warbling sound stemming from a severe interaction between the string and the body motions, coupled through the instrument bridge. We addressed the dynamical behavior of the string/body/wolf-eliminator coupled system, both theoretically and through experiments performed on a XIXth century cello. This study contributed to clarify the functioning of this anti-wolf device and provides guidelines for an effective use. Two conference papers were published as a result of this work.



Cello bridge and G2 string fitted with an anti-wolf device (left) and experimental "wolf-stability" chart (right), with normal sound domains in green, easily played wolfs in red and rarely sounding wolfs in yellow.

¹ Instituto Tecnológico e Nuclear, Applied Dynamics Laboratory

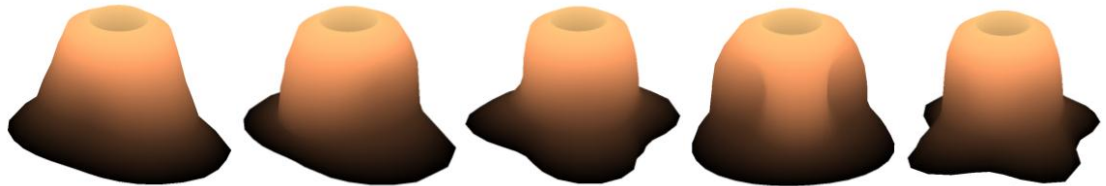
² Instituto Politécnico do Porto, Escola Superior de Música e Artes do Espectáculo, Laboratory of Music Acoustics, Porto

³ Instituto Superior Técnico, Lisbon

Dynamical analysis and tuning of carillon bells

J. Antunes¹, V. Debut¹, O. Inácio², J. Soeiro de Carvalho³

In the context of the FCT project PTDC/EAT-MMU/104255/2008, we have started a three-year project dealing on the physical and musicological aspects of the historical Mafra carillons, from the XVIIth century. As a first step on the work for asserting the current state of tuning (or mistuning) of the carillons, laboratory experiments were performed on a contemporary bell, in order to establish adequate procedures and techniques for the modal identification on a large number of bells. Following this study, the identification field-work will take place early in 2011. Then, the main task for ITN in this project - the development of optimal tuning procedures - will follow.



Experimentally identified modes of the laboratory bell: modal frequencies ranging from 643 Hz to 2675 Hz.

¹ Instituto Tecnológico e Nuclear, Applied Dynamics Laboratory

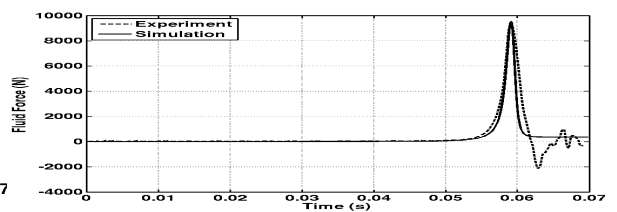
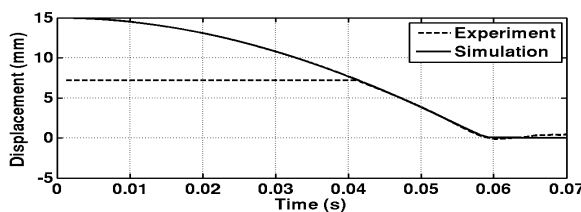
² Instituto Politécnico do Porto, Escola Superior de Música e Artes do Espectáculo, Laboratory of Music Acoustics, Porto

³ Universidade Nova de Lisboa, Faculdade de Ciências Sociais e Humanas, Lisbon

Nonlinear squeeze-film vibrations of planar structural components

J. Antunes¹, P. Piteau²

Squeeze film dynamical effects are relevant in many industrial components, including bearings and seals, as well as when dealing with the seismic excitation of spent nuclear fuel racks. The significant nonlinearity of the squeeze-film forces prevents the use of linearised flow models. In this project a simplified analytical model, based on gap-averaged Navier-Stokes equations and incorporating all relevant inertial and dissipative terms, was developed. The dependence of the flow friction coefficient on the local flow velocity is explicitly accounted for, so that it can be applied to laminar, turbulent and mixed flows. Following these theoretical developments, extensive experiments were performed at CEA/Saclay, on a test rig consisting on a gravity-driven instrumented rectangular plate colliding with a planar surface. The theoretical results were compared with the experimental measurements, with success. A conference paper and one journal paper were published as a result of this work.



Comparison between the theoretical and experimental motion (left) and squeeze-film fluid force (right) for a dropping plate (experimental displacement clipped beyond 7 mm).

¹ Instituto Tecnológico e Nuclear, Applied Dynamics Laboratory

² Commissariat à l'Énergie Atomique, Laboratory of Dynamical Studies, Saclay, France

Neutron Activation in Environment, Nutrition and Epidemiology

Maria do Carmo Freitas

The research is focused on development of methodologies in neutron activation analysis and their application to studies of atmospheric environment, nutrition and epidemiology. The investigation appeared as a natural application of the potentialities of k_0 -INAA (instrumental neutron activation analysis using the k_0 -method). The unit activities include the following scientific interests:

Development of Methodologies, Quality Control, Automatization, Data Handling

This line aims to optimize the analytical technique in order to facilitate the analysis of the samples of the different projects, to speed the calculation and to improve the handling of the data. It also aims to implement methodologies to improve the detection limits for important pollutant chemical elements such as cadmium, arsenic, nickel, and to determine lead and the light elements. Interlaboratory exercises are targets, aiming at analytical quality control.

Monitoring, Biomonitoring

This line aims to characterise areas of Portugal using biomonitors and air particulate matter collection. The data are analysed for factors aiming at identifying emission sources and the air mass trajectories, including local, regional and long-range transport. To assure the quality of the data, accuracy and precision studies are being performed. So-called conventional analytical techniques are applied to complement the research unit's results. Cooperation with Cabo Verde entities started in 2010 within a FCT project; the cooperation with Azores University continued aiming studies of long-range transport at Pico summit.

Epidemiological studies

The objective of this line is to link biomonitoring and monitoring to epidemiological studies. Children respiratory problems, cardiovascular diseases and carcinogenic incidence in the Portuguese population are being studied in association to chemical elements, pollutant gases and meteorological data. New

methodologies are suggested to smooth health and environment data.

Element Uptake Processes

Plant physiology is also one of the group aims, looking for effects on plants due to atmospheric chemical components. The underlying questions are related to the extent in which biomonitors may reflect the element contents of particulate matter. Bioremediation at mining abandoned areas is being studied aiming to select strong accumulators of arsenic.

Nutrition

So far, selenium has been the target. It is an essential element to humans and in Portugal its contents in diet is deficient. Therefore, we are supplementing it to cereals and studying its absorption in the cereal plant and the cereal grains. The experiments on foliar selenium spray performed in 2010 were a success, since selenium enriched wheat grains were cropped. We proceed with other two methods (soil and enriched seeds). Cooperation with INIA/Elvas strongly started.

Training

The research unit has a strong component in graduation and post graduation training (BSc, MSc, PhD, post-PhD). A training course was held for the research unit's newcomers, to uniform the basic knowledge. Courses are attended in order to improve and update the team's knowledge.

Participation in intercomparison exercises

Whenever offered, the group collaborates in intercomparison exercises, to improve its analytical quality.

Services

Analytical services are provided under request. Fluorine is being determined for a German company. Portuguese universities requested analysis. Services are being done for a private Portuguese company.

Research Team

Researchers

M. CARMO FREITAS, Princ. (Agreg), Group Leader
S.M. ALMEIDA, Aux. (Contract)
H.M. DUNG, Aux. (Contract)
A. HOSSAIN, Post-Doc. grant

Technical Personnel

I. DIONISIO
T. SITO, PTDC/AAC-CLI/100331/2008 fellow (since Aug. 2010)

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N. CANHA
A. SILVA,
M.A. SILVA, (since Aug. 2010), FCT PhD

Collaborators

A.M.G. PACHECO, Aux. Professor, CERENA/IST, Portugal
H.TH. WOLTERBEEK, Sen. Res., TUDelft, The Netherlands
M.M. FARINHA, ISQ-Portugal, PhD student
A. CRUZ, CERNAS/ESAC/IPC-Portugal, PhD student
B. VIEIRA, AmbiGovernance, PhD student
C. GALINHA, DEQ/IST

Impact of Atmospheric Indoor Aerosol in Human Health, (PTDC/SAU-ESA/65597/2006)

N. Canha, M. Almeida Silva, M.C. Freitas, S.M. Almeida, H.M. Dung, I. Dionísio, T. Siteo, C.A. Pio¹, M.A. Trancoso², H.Th. Wolterbeek³

Objectives

Most individuals spend about 80% of their time indoors and, consequently, the exposure to the indoor environment is much higher than to the outdoors. Furthermore, children spend most of their time at home or at school and study at these localities are important to evaluate their time-weighted exposure.

Due to their underdeveloped airways, children constitute a sensitive group with a higher risk than adults. The higher impact in health and educational performance of children reveals the importance of indoor air quality studies of schools.

The aim of this study was to assess the children exposure, at elementary schools of the Lisbon urban area (Fig. 1), to bioaerosols (fungi, bacteria and pollens) and to total particulate matter – TPM (its natural radioactivity, elemental and soluble ions composition) by using passive methods.

Fig. 1. Studied elementary schools at urban area of Lisbon.



Methods

Polycarbonate and quartz filters were passively exposed at two classrooms of each of the 14 Lisbon primary schools, for periods of 1-3 months (Fig. 2), to collect TPM. Three sampling campaigns were done: Spring 2009, Autumn 2009 and Winter 2010.



Fig. 2. Placement of the passive filters in the classrooms.

Bioaerosols were collected passively at the indoor of the classrooms of 3 schools and, for bacteria and fungi, as well at the outdoor to determinate the ratio indoor/outdoor and to assess the level of outdoor contamination of the indoor environment.

Results

Passive sampling showed its feasibility to evaluate TPM in a spatially large scale. Furthermore, it was demonstrated that passive sampling is an easier and cheaper method than the use of automatic samplers. Quartz and polycarbonate collected masses were significantly correlated (Fig. 3). Higher TPM mass values were obtained in autumn (0.97-4.55mg) and winter (0.81-4.42mg) than in spring (0.27-2.23mg) and a correlation between autumn and winter was found. This suggests a significant difference towards spring, probably due to insufficient ventilation, especially in winter.

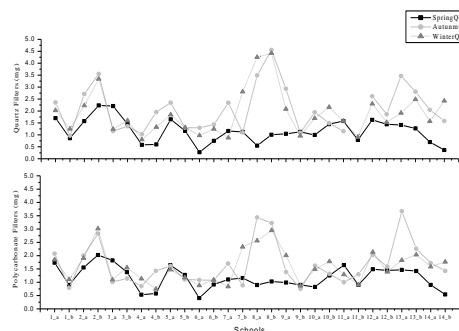


Fig. 3. TPM mass collected in schools.

Fungi levels were usually higher at outdoor environments. Seasonally, fungi were higher in spring and lower in winter due to the outdoor atmospheric conditions, especially temperature and relative humidity. Bacteria levels were higher indoors due to the children presence and a seasonal variation was not found. The indoor bacterial level was associated with the occupancy of the classroom.

TPM elemental composition was assessed by Instrumental Neutron Activation Analysis (INAA), natural radioactivity by gamma measurement using a HPGe detector and the soluble ions content (Ca^{2+} , Mg^{2+} , K^+ , Na^+ , NH_4^+ , PO_4^{3-} , Cl^- , SO_4^{2-} , NO_3^- , NO_2^-) by ionic chromatography, atomic absorption and UV spectroscopy.

Further work will evaluate TPM source apportionment, the correlation between the indoor parameters and the children allergenic symptoms (assessed by inquiries applied to the children).

Published work

N. Canha, M.C. Freitas, S.M. Almeida, M. Almeida Silva, M. Ribeiro, C. Galinha, H.Th. Wolterbeek. Indoor school environment: easy and low cost to assess inorganic pollutants. *J. Radioanal. Nucl. Chem.* 286 (2): 495-500.

N. Canha, M. Ribeiro, M. C. Freitas, S. M. Almeida, S. Cabo, H.Th. Wolterbeek, M. Almeida Silva, Fungi, bacteria and pollens seasonally quantified at 3 basic schools in Lisbon, 2010. ASHRAE, IAQ Conference, Malaysia 2010, CDROM.

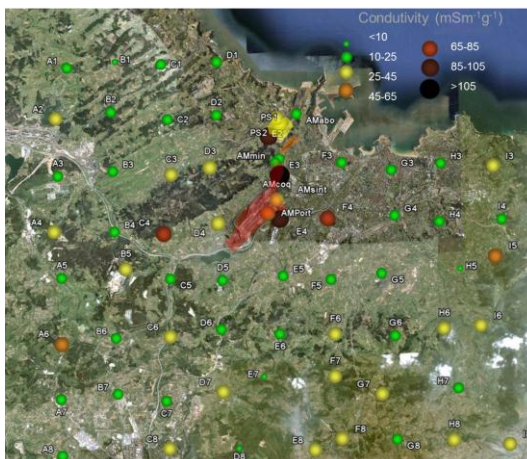
N. Canha, M. Almeida Silva, M.C. Freitas, S.M. Almeida, Seasonal variation of total particulate matter and children respiratory diseases at Lisbon basic schools using passive Methods, *Procedia Environmental Sciences* (in press).

¹CESAM/Aveiro University; ²LNEG; ³Dept. Radiation, Radionuclides & Reactors, Delft, The Netherlands

Biomonitoring of Metal Deposition in the Vicinity of a Spanish Steel Plant, RFSR-CT-2009-00029

S.M. Almeida, M.C. Freitas, A. Silva, N. Canha, M. Almeida Silva, C. Galinha, T. Siteo, I. Dionisio, J. Perim de Faria¹, V. Torre Suarez¹, S. Garcia², G. Domingues²

A biomonitoring study is being performed within the European Project “Assessment of Emissions and Impact of Steel Processes” in order to indicate geographical variances in trace-element air pollution around the Arcelor Mittal steelwork placed in Gijon, Spain. In 2010, lichens were transplanted from a clean background site, exposed in an industrial area in Gijon, and collected after 5 months 1) to verify membrane damage during the exposure by measuring the electric conductivity and 2) to determine trace element concentrations. The main objective was to relate variability in lichen vitality to variability in ambient conditions. Results showed that the values of conductivity from the transplants were significantly higher near the main industries (a steel plant, a power plant and a cement plant) revealing the existence of a physiological response to environmental stress.

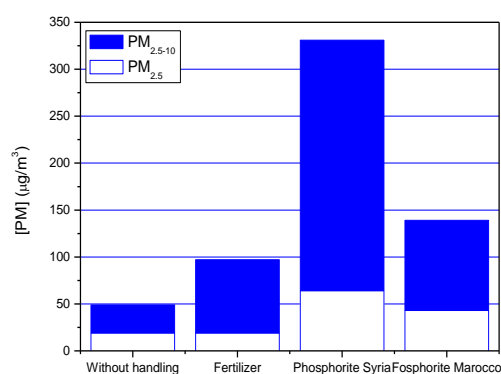


¹Arcelor Mittal Spain, ²ISQ

Characterization of Dust Material emitted during Setúbal Harbour Activities by INAA and PIXE, PTDC/AAC-AMB/098825/2008

S.M. Almeida, A. Silva, M.C. Freitas, T. Pinheiro, A.M. Marques¹, A.I. Silva², C.A. Ramos¹, S. Garcia³, G. Domingues³, I. Abreu dos Santos⁴

Activities in the Setúbal harbour such as loading, unloading and transport of materials may be an important source of Atmospheric Particulate Matter (APM). Depending on the materials, type of operation and meteorological conditions, these activities may have an impact on the levels of APM around harbour areas. The aim of this work was to characterize the emissions of dust originating from different handling operations. The techniques INAA and PIXE were applied as sensitive analytical tools for the determination of heavy metals and rare earth elements in the APM sampled in the harbour during the unloading operations. Results showed that manipulation of bulk materials during harbour operations resulted in high emissions of particles, principally from the coarse fraction. These emissions were enriched in rare earth elements and heavy metals and were very affected by the provenience of the material.

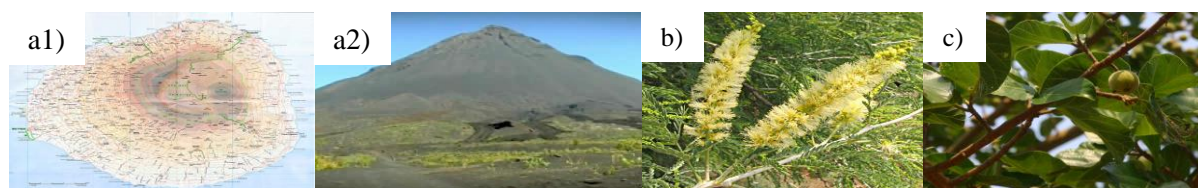


¹ESTeSL, ²ISEL, ³ISQ, ⁴SAPEC PI

CV-Dust - Atmospheric Aerosol in Cape Verde Region: Seasonal Evaluation of Composition, Sources and Transport, PTDC/AAC-CLI/100331/2008

M. Almeida Silva, M.C. Freitas, S.M. Almeida, H.M. Anawar, I. Dionísio, T. Siteo, J. Cardoso¹, C. A. Pio¹

A total of 100 filters of Nucleopore polycarbonate were weighed and sent to Aveiro University together with a Partisol (*Plus Sequential Air Sampler*). This equipment is used for sampling the particulate air matter in Cape Verde, Santiago island. The sampling is taking place at the Praia airport area. One sampling campaign of biomonitors was done in Fogo Island^{a1,a2}, Cape Verde. A total of 37 samples of 7 different biomonitors were collected from 23 sites. The main species found were *Acacia albida*^b, *Ficus sycomorus ssp. Gnaphalocarpa*^c, *Eucalyptus*, *Oleandro*, and *Apple Tree*. Bark from these species is being processed aiming site differentiation. Also the lichen *Usnea* sp. Was collected at one site.



¹CECESAM/Aveiro University

Selenium Distribution in Cereals and Portuguese Cultivation Soils. Interactions between Selenium and Iodine Uptake by Cereals - A case study, PTDC/QUI/65618/2006

C. Galinha¹, A.M.G. Pacheco¹, M.C. Freitas, H.M. Anawar, H.M. Dung, I. Dionísio, T. Siteo, A.S. Almeida², J. Coutinho², B. Maças²



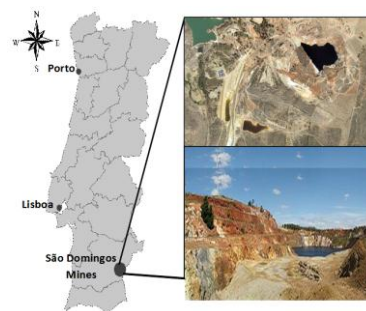
This project is a joint initiative of ITN and IST. Selenium in soil and cereal samples were analyzed by INAA. Due to the very low concentrations of selenium in several samples Radiochemistry was also done in Řež - Czech Republic. So far selenium results were within the range of 100-225ppb for soils; 3-55ppb for durum wheat; 6-80ppb for bread wheat and 4-30ppb for rye. Bread and durum wheat were seeded, grown and collected with the collaboration of INRB/INIA – Elvas. These crops were used to study the biofortification of selenium using foliar supplementation at different stages of plant growing. These supplemented samples are being analyzed by INAA on the fast pneumatic system (SIPRA). It was shown that Rye collected in Portugal has a Transfer Coefficient from soil (TC) above 10% for Zn and K and around 100% for Br. Also for wheat (bread and durum wheat) it was found a TC relative to soil above 10% for K. Some cereal cultivation soils near Elvas area showed a deficiency in zinc, below the detection limit of the analytical technique, around 20 mg/kg.

¹CERENA/IST; ²INRB/INIA - Elvas

(Hyper)accumulation of Arsenic and other Elements by Plants adapted to Sites impacted by Mining and Smelting Activities, PTDC/AMB/65462/2006

M.C. Freitas, H.M. Anawar, N. Canha, I. Dionísio, H.M. Dung, A.M.G. Pacheco¹, C. Pinto-Gomes², A. Bettencourt³

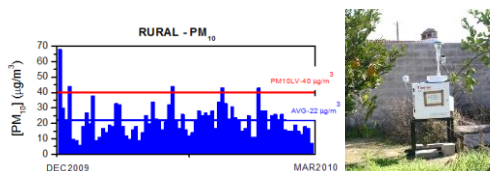
The objective was to characterize the elemental composition of mine tailings in order to evaluate the environmental hazards, and to identify the metal accumulation potential of native plant species from São Domingos mine, one of the oldest massive sulphide deposits of Portugal that belongs to the Iberian Pyrite Belt. The mine tailings are highly contaminated by As and Sb (main contaminants), Ag, Cr, Hg, Sn, Fe and Zn. Among the plant species, higher concentrations of all the metals were noted in *Erica andevalensis*, *Erica australis*, *Echium plantagium* and *Lavandula luisierrae*. Considering the tolerant behavior and abundant growth, the plant species *Erica australis*, *Erica andevalensis*, *Lavandula luisierrae*, *Daphne gnidium*, *Rumex induratus*, and *Juncus* are important for the rehabilitation and recovery of the degraded São Domingos mining area. Water flows are also highly contaminated with hazardous pollutants, the contamination decreasing with distance to the main well.



¹CERENA/IST; ²ICAM – Évora University; ³CMA-IMAR, Évora University

Characterizing Seasonal Variations in Elemental Particulate Matter Concentrations in European Urban and Rural Areas under Different Climatic Conditions, IAEA RER/2/005

N. Canha, M.C. Freitas, S.M. Almeida, H.M. Dung, I. Dionísio, T. Siteo, J. Cardoso¹, A. Caseiro¹, C.A. Pio¹, H.Th. Wolerbeek²



The aim was to characterize air particulate matter (APM) pollution, to identify the pollution sources and to prepare guidelines/recommendations to reduce APM. A Partisol sequential air sampler was put in a rural area (Fornos de Arrão, Ponte Sor - 39°10'39 N; 8°14'25 W) for 3 months (December 2009 – March 2010), the Portuguese colder winter months. In this area, burning wood for heating and cooking is a common practice and no other anthropogenic source is known except for small village traffic. PM₁₀ average concentration in the rural area was 22 µg/m³ (with values in a range of 6 – 68µg/m³), which did not exceed the limit values established by the EC legislation. High K concentrations were found in the APM probably due to the wood combustion. PM_{2.5} was sampled inside a classroom of a primary school at the rural area for 2 weeks (in March 2010). The obtained PM_{2.5} average concentration was 67 µg/m³ (range 13-201 µg/m³). Comparing with PM_{2.5} sampling performed at a classroom in the Lisbon urban area (average value of 10 µg/m³), it is obvious the higher concentrations of PM_{2.5} that children are exposed in the school located at the rural area, where wood is used to heat the classroom.

¹CESAM/Aveiro University; ²Dept. Radiation, Radionuclides & Reactors, Delft, The Netherlands

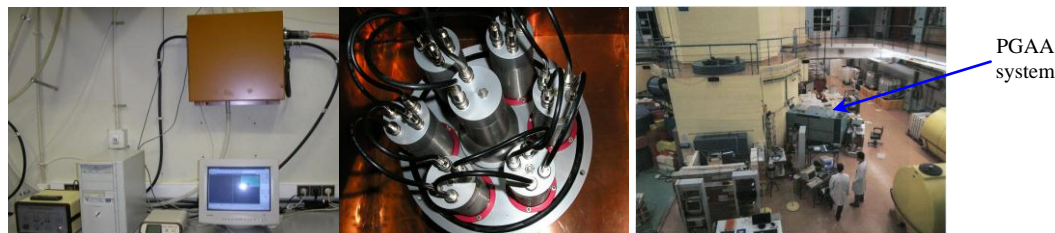
Enhancement of Capability of the NAA Techniques at RPI*H.M. Dung, M.C. Freitas, S.M. Almeida, N. Canha, C. Galinha, I. Dionísio, J. Marques*

Fig. 1. From left to right, the SIPRA, CSS and PGAA systems.

The capability of Neutron Activation Analysis (NAA) techniques at RPI (some of the equipment discussed is shown in Fig. 1) is based upon irradiation and measurement facilities that permit to utilize the entire neutron spectrum of the reactor, epithermal neutrons (ENAA), cyclic irradiations (CNAA), Compton suppression spectroscopy (CSS), automatic sample changers (ASCs) and prompt gamma (PGAA). The existing NAA techniques must be combined in order to improve the analytical capabilities for the intended applications. Three different modes of combination were studied: 1) Normal short and long irradiations; 2) ENAA counted with and without CSS; and 3) CNAA. Computer software NAA-PRO, in which a linear system of differential equations are solved to obtain the radionuclides in modelled gamma-ray spectrum, predicting the best conditions for the detection of radionuclides of interest prior to carrying out the experiments. The combination of NAA techniques allows to determine the elements: Ag, Al, As, Ba, Br, Ca, Cd, Ce, Cl, Co, Cr, Cs, Cu, Dy, Eu, Fe, Hf, Hg, I, K, La, Mn, Na, Nd, Rb, Sb, Sc, Se, Sm, Sr, Ta, Tb, Th, Ti, U, V, Yb, Zn and Zr by using the above mentioned first mode; by the second mode: As, Cu, I, K, La, Lu, Sm, Sr and U; and the third mode: F, Al, Ca, Cl, Cu, Se, Ti and V in biological, environmental and material (polymer) samples. The experimental results were in a good agreement with the certified or consensus values, with biases lower than 12% for most elements. The combination of Cyclic NAA with cumulative/replicate NAA was also studied, and the detection limits of selenium (^{77m}Se) in biological and fluorine (^{20}F) in polymer samples were improved by a factor of 1.7 and 1.9, respectively. The implementation of PGAA is being carried out within a regional IAEA project.

Enhancing the sustainability of Research Reactors and their safe operation through regional cooperation, networking and coalition, IAEA-TCR-05632 RER/4/032

N. Canha, M.C. Freitas, S.M. Almeida, H.M. Dung, J. Marques, Z. Révay¹

This project is supported by the IAEA - International Atomic Energy Agency and its main goal is to implement a PGNAA (Prompt Gamma Neutron Activation Analysis) facility at the RPI-ITN in order to enhancing its facilities and experimental techniques offer to the users. In January 2010, three members of the group went for one month training on this technique at the Budapest PGNAA facility at the Nuclear Research Department from the Institute of Isotopes and Surface Chemistry of the Hungarian Academy of Sciences. It was possible to learn about the technique and to understand the processes of irradiation, measurement, spectra analysis (by Hypermet-PC software) and the results calculations. PGAA analysis of soil samples allowed obtaining information for light elements, such as B and Si. Possibilities of setups for the future PGNAA facility at ITN were designed and the materials required were discussed. In October 2010, Dr. Zsolt Révay (IAEA specialist for PGAA technique) visited the RPI and several designs for the PGAA facility were evaluated by doing some experiments (different reactor power and different setups of the shielding material of the bunker proposed for the facility). The measured beam background was above 1000 cps (too high) which does not allow installing a versatile PGAA facility at the bunker, in which the facility was planned. It was proposed to position the detector at the end of the neutron beam line, aiming at a larger distance between the detector and the reactor wall. Further work will be developed where a new design of the facility will be created (with the detector located far away from the reactor face).



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