# New studies on passive and active systems towards enhanced severe accident source term mitigation– The PASSAM Project

*T. Albiol[1]*, L. Herranz[2]*, E. Riera[3]*, S. Guieu[4]*, T. Lind[5]*, G. Manzini[6]*,*
*A. Auvinen[7]*, N. Losch[8]**

[1]* IRSN, Centre de Cadarache, BP3, 13115 Saint Paul les Durance Cedex, France
[2]* CIEMAT, Avda. de la Complutense, 22, Madrid 28040, Spain
[3]* CSIC, Serrano 144, Madrid28006, Spain
[4]* EDF, 12 - 14 avenueDutriévoz, 69628 VilleurbanneCedex, France
[5]* PSI, 5232 Villigen, Switzerland
[6]* RSE, viaRubattino 54, 20134 Milano, Italy
[7]* VTT, BI7, Biologinkuja 7, P.O. Box 1000, FI-02044 VTT, Finland
[8]* AREVA NP GmbH, Kaiserleistrasse 29, 63067 Offenbach, Germany

**Abstract:**

The PASSAM project has been mounted in the frame of the 7th framework programme of the European Commission. Coordinated by IRSN, this four years project (2013 – 2016)involveseight partners from six countries having a strong experience on severe accidents.

It will be focused on mitigation systems in case of severe accident,and more specifically, on Filtered Containment Venting Systems intended for reducing potential radioactive atmospheric releases to the environment.

The PASSAM project is of R&D experimental nature, aiming at:

- exploring potential enhancement of existing source term mitigation devices,
- demonstrating the ability of innovative systems to achieve larger source term attenuation.

The project's outcomes will constitute a valuable database which may be strategic for helping the utilities on the decision of implementing and/or enhancing mitigation systems on their reactors and for improving severe accident management. Robustness features for each type of mitigation system studied will be evaluated to increase the reliability of operation insevere accident conditions.

Simple models and/or correlations will result from in-depth analysis of PASSAM experimental results. Once implemented in accident analysis codes, these modelsshould allow enhancing the capability of modelling Severe Accident Management scenarios and developing improved guidelines.

## 1 GENERAL CONTEXT

The "Passive and Active Systems on Severe Accident source term Mitigation" (PASSAM) project has been proposed to the European Commission in the frame of the seventh framework program, and more particularly in answer to the call of early 2012.The project, coordinated by IRSN, involves eight organizations from six countries: IRSN and EDF (France), CIEMAT and CSIC (Spain), PSI (Switzerland), RSE (Italy), VTT (Finland) and AREVA NP GmbH (Germany). It represents a total effort of 390 persons.months and an associated total cost of more than 5 million Euros. It was accepted in July 2012 by the European Commission for the so-called "negotiation phase" and, except in case of unidentified major problem, it should start in January 2013 for a four year period.

## 1.1 PASSAM concept and objectives

In case of a Severe Accident (SA) in a Nuclear Power Plant (NPP) fission products are released from the degraded fuel and may reach the environment if the containment building is damaged and/or bypassed. Given the high radio-toxicity of fission products for environment and population, it is absolutely necessary to avoid - or to drastically reduce - their release. This highlights the importance of relying on efficacious mitigation systems capable of reducing as much as possible any accidental release. This overall statement becomes even stronger after the accident of March 2011 at the Fukushima Daiichi NPP.

Current NPPs are furnished with safeguards based on the Design Basis Accident (DBA) and some extensions to cope with accidents beyond the design bases. This applies, in particular, to mitigation systems. There are a number of mitigation systems within a NPP both to accommodate the energy release and to deplete most of potential radioactive emission to the environment.

The PASSAM project focuses on R&D experimental activities aimed to:

- explore potential enhancement of existing source term mitigation devices,
- demonstrate the ability of innovative systems to achieve an even larger source term attenuation.

The current knowledge on existing mitigation systems should be complemented by considering aspects that need to be investigated as:

- their performance under degraded conditions of operation (loss of electrical current; flooding; loss of ultimate heat sink; etc.),
- their efficiency regarding other potential source term compositions than those originally considered, i.e. beyond aerosols and inorganic iodine,
- long term behaviour of the trapped elements (i.e., potential for revaporization and/or reentrainment of radioactive material, in particular due to radioactive environment).

So, the PASSAM project aims at experimentally demonstrating the capability and reliability of a number of existing or innovative systems related to Filtered Containment Venting Systems (FCVS) under anticipated conditions during a severe accident, including long term conditions. The understanding gained from in-depth analysis of experimental results will make possible to produce simple models and/or correlations easy to be implemented in accident analysis codes. Then, the use of these codes will allow enhancing the capability of modelling Severe Accident Management scenarios and developing improved guidelines.

Note that conducting any industrial device qualification is not an objective of PASSAM; it is the vendors' duty.

## 1.2 Expected progress beyond the state-of-the-art

Research on severe accidents has been performed for the last thirty years. Many aspects on severe accident phenomenology and severe accident progression are considered as rather well understood. Nevertheless, some specific topics arestill considered as outstanding issues by international projects or networks of excellence, in particular SARNET and SARNET2 networks of excellence[2].

Once released from the fuel in case of a severe accident, fission product transport to the environment depends on a number of phenomena of different nature that can act either as sources (aerosol resuspension, iodine (and other fission products)revolatilization, etc., …), as sinks (aerosol deposition, iodine trapping in the sump, iodine deposition on painted surface, etc., …) or just as conditioning mechanisms (particle-particle agglomeration, etc., …). Many of these phenomena are driven by the action of natural forces, whereas some others are caused by the action of engineering systemsthat, although originally designed to keep the pressure inside the containment at acceptable values, are effective also at removing particles and,toa lesser extent, volatile iodine from the containment atmosphere in much shorter times. Examples are containment sprays, steam suppression pools and fan coolers.

Beside the above safeguard systems, for preventing severe damage of the containment building if the pressure increases anyway, many European reactors have been equipped with complementary systems to vent the containment building atmosphere to the environment once filtered. So, the risk of containment failure is avoided while release of radioactivity to the environment is kept at a reasonably low level.

These industrial Filtered Containment Venting Systems (FCVS)are essentially based on two approaches: gravel beds (particles deposit in the large surface provided by gravel) and water pools (particles get absorbed in the water bulk as a consequence of several particle removal mechanisms which efficiency depends on thermal-hydraulic conditions). These, sometimes called dry/wet approaches, can be enhanced by including venturi scrubbers (water droplets injected in the gas stream capture aerosol particles and make them more easily scrubbed by water pools or gravel beds).

These systems, which some of them are put up on several reactors, have been well characterised as regards aerosol retention efficiency, but to a far lesser extent as regards volatile iodine retention. In this context the Advanced Containments Experiment (ACE) can be cited as the largest international test programme[3]. Since then, additional tests have been performed, and improvements of the systems have been proposed for organic iodide retention in water pools, although the research on this specific aspect needs to be complemented. A lack of knowledge also appears clearly for organic iodine retention in dry systems. Finally, gaps may also remain in the investigation of systems performance that have not been properly addressed, either because evolution of anticipated working conditions and/or because of new insights coming from recent research on fission product behaviour. Hence, some specific experiments could provide meaningful insights into the systems performance that could result in an optimisation of their working conditions.

In parallel, several alternative and innovative approaches are appearing in the literature or are even already proposed by some vendors. Electric filtration systems are already widely used in industry, out of the nuclear field, for separation of particles, for instance,from flue gases of coal-fired power plants or from product gases in iron manufacturing or in cleaning indoor air applications. There are also a number of proposed solutions based on molecular sieves (improved zeolites, metallic organic filters, etc…) that are widely used as filter in many industrial processes. Many kinds of zeolite exist; the key point would be to find the more efficient zeolite for iodine species in severe accident relevant conditions. Another promising innovative solution consists of the combination of wet and dry filter systems. Besides, as it is well known that, generally speaking, the filtration systems are less efficient for aerosol particles of some tenths of microns, some systems are being developed, aiming at agglomerating aerosol particles in order to get bigger particles which will be better filtered.Implementing such a device upstream of the filtration system would overcome the decrease of filtration efficiency of sub-micron particles.

Another subject which has poorly been studied is the long term behaviour of the trapped fission products (i.e., potential for re-vaporisation and/or re-entrainment of radioactive material) due to surrounding conditions relevant to an accident and more especially, due to continuous irradiation, coupled to continuous flow-rate (if the venting system remains open), temperature, humidity, etc… Indeed the re-entrainment of trapped aerosols was tested in different small scale facilities and, at larger scale, in the international ACE programme where the aerosol loaded filters (dry and wet filters) were operated with clean gas and the aerosol concentrations of the gas downstream of the filters were measured. Nevertheless long term re-vaporisation under irradiation, both for aerosols and for gaseous iodine forms, has not been investigated yet.

The PASSAM project will start by a literature survey and the drafting of a state-of-the-art report on all the existing and innovative containment venting systems which can be applied in case of a severe accident on a NPP. The pending issues will be clearly identified and the lack of knowledge will be investigated through experimental studies resulting in the establishment of correlations and/or simple models to be implemented in a second step - but out of the scope of the PASSAM project - in general severe accident codes as ASTEC[1]. An assessment of advantages and drawbacks of the studied systems will also be provided. Without waiting for the outcomes of the state-of-the-art report, we can assert that:

- the lack of knowledge is important as regards retention efficiency of gaseous fission products (with major interest for molecular iodine and organic iodine),especially under actual conditions relevant to severe accidents,

- interesting innovative approaches are promising and need to be deeper investigated,
- the long term behaviour of trapped fission products in filtration systems needs to be investigated.

These domains are the ones which will be studied by the PASSAM project in order to go beyond the state of the art. The main outputs of the project will be:

- a relevant extension of the current database on these existing or innovative mitigation systems,
- a deeper understanding of the phenomena underlying their performance and models/correlations that allow feasible modelling of the systems in accident analysis codes, like ASTEC,
- an estimation of the order of magnitude for source term reduction for each filtration system and suggestions for improved filtration systems.

# 2METHODOLOGY AND ASSOCIATED WORK PLAN

## 2.1 Overall strategy

To achieve the here-above objectives, the PASSAM project will be organized into 5 Work Packages (WP): the 1$^{st}$ one on project management; the 2$^{nd}$ one on drafting a state-of-the-art report, and performing in depth analysis of experimental results up to proposing correlations and/or simple models; the 3$^{rd}$ one on experimental studies of existing filtration systems; the 4$^{th}$ one on experimental studies of innovative filtration systems and the 5$^{th}$ one on dissemination of knowledge and project synthesis.

### *2.1.1 WP1: (MANAG) PROJECT MANAGEMENT (leader: IRSN)*

This WP will deal with the project scientific coordination and with administrative, financial and quality management aspects. It will make the links with the European Commission and with the necessary decision-making bodies (Steering Committee and Management Team).

### *2.1.2 WP2: (THEOR) STATEOFTHEART AND MODELLING (leader: CIEMAT; participants: all PASSAM partners)*

This WP will concern two scientific parts of the project which are not directly experimental studies and which will benefit from a real shared work between the partners. It will be divided into two sub work packages.

#### 2.1.2.1WP2.1 (SOAR): State-of-the-art report (leader: CIEMAT)

The work will consist of performing a comprehensive literature survey and writing a state-of-the-art report on filtration systems used (pool scrubbing; sand filters plus metallic pre-filters), or potentially usable (agglomerators to be mounted upstream a filtration system; electrostatic precipitators; improved zeolites; combination of several systems…) for source term mitigation of severe accidents. This state-of-the-art report will allow highlighting both the existing knowledge and gaps in this field. From that step, the remaining needs will be identified and they will allow a precise definition of the experiments to be performed to improve the knowledge. For each type of filtration system the following questions will be answered:

- What has been tested (aerosols, molecular iodine, organic iodine, other gaseous species)?
- Under which conditions (more or less relevant as regards severe accident conditions)?
- What filtration efficiency has been assessed?

- What is the understanding of the trapping phenomena?
- Are there models and/or correlation to pre-estimate the filtration efficiency of a specific system during an accident?
- When considering the long term behaviour following an accident, will the trapped fission products remain in the filtration system or is there a significant risk that, due to the surrounding conditions (thermal-hydraulics, radioactivity), these fission products be released by re-entrainment or revaporisation or any other physical-chemical phenomenon?

Also, based on available literature and on other data coming from partners pre-existing knowledge,the ranges of major parameters determining FCVS operation will be included in the state-of-the-art report. This last point is of utmost importance to outline suitable test matrices within the PASSAM project. So, as a result of this work, tests to be performed will be clearly identified and test matrices will be defined for each type of system to be experimentally studied in WP3 and WP4.

#### 2.1.2.2 WP2.2 (MODEL): Development of simplified models/correlations (leader: RSE)

The partners will share the experimental results of the project and will proceed to a common detailed analysis of the experimental results obtained through WP3 and WP4 in order to understand the major phenomena which allow the trapping of the fission products and their long term behaviour under accident conditions. This analysis will allow deriving simplified models and/or correlations for each type of system studied, that will be easy to implement - but not included in the PASSAM project - in accident analysis codes, as ASTEC.

Such a detailed analysis of experimental results in a collaborative project provides a major advantage. From each set of experimental data gained through one series of experiments, several participants will share their analysis and so the quality of the analysis will be really improved.

### *2.1.3 WP3: (EXIST) EXPERIMENTAL STUDIES OF EXISTING FILTRATION SYSTEMS (leader: PSI; participants: IRSN, CIEMAT, PSI, RSE, AREVA NP GmbH)*

This WP will concern experiments to be performed on existing filtration systems as resulting from the lacks identified through the state-of-the-art report. It will be divided into two sub work packages dealing respectively with pool scrubbing systems and with sand bed filters plus metallic pre-filters.

Note that for this work package (and for WP4), the precise studies to be performed will result from the corresponding parts of the state-of-the-art report (WP2.1). Nevertheless, the main fields of research needed can be anticipated from the current knowledge of the participants to the PASSAM project, who are specialists in the domain.

#### 2.1.3.1WP3.1 (POOL): Experimental studies of pool scrubbing systems (leader: PSI)

The precise understanding of fission product trapping in pools corresponds in fact to two situations. First, specific pool scrubbing systems are designed in nuclear power plants to operate under severe accident conditions as a FCVS. Second, some BWR and PWR severe accident scenarios involve transport paths of radioactive aerosols which include passages through stagnant pools of water where particles can be retained.

Pool scrubbing efficiency tests were performed in the eighties and nineties, using different experimental systems and different aerosols, mostly reproducing prototypical conditions. Indeed, those tests produced a large data scattering. A number of state-of-the-art reports (e.g.: Ref. [3]) tried to summarize their results and define the uncertainties affecting the interpretation of the involved phenomena. However, there is no experimental set available for a systematic validation under accident relevant conditions. Therefore, a systematic experimental campaign to build a sound database for validation purposes appears as necessary. Particular attention will be given to aspects hardly explored to date.

One of the reasons for the scattering observed in previous experiments was the actual size distribution of the particles entering the water pool, the bubble size and shape, in particular near the injection orifice. As nothing else exists, the produced data are presently used as reference for model validation, although their generation was not made in a systematic way and they are comparable with some difficulties. So, the state-of-the-art report of WP2 should confirm that complementary experiments overcoming these difficulties (several tests with repeatability, use of mono-disperse particles with well-defined density and shape, etc…) remain relevant.

The present pool scrubbing codes for calculation of retention of aerosols and gas-phase radionuclides have been developed for bare pool conditions where a jet of gas is discharged from a nozzle into a stagnant water pool. Under these conditions, the jet behaviour and development is relatively well-characterized. However, in the presence of additional structures in the pool, the codes significantly under-predict the aerosol retention. One of the reasons is that the hydrodynamics of the pool under these conditions is not fully understood. Especially under high jet flow velocities, the jet interacts with the structures in the pool and creates a complex two-phase flow. The characterization of the resulting flow is necessary for any understanding of the aerosol and radionuclide behaviour under such geometries and conditions. It is anticipated that the state-of-the-art report to be produced through WP2 will confirm that very few data exist that can support model development and/or validation, and so experiments on these hydrodynamics topics are quite relevant.

Finally, the state-of-the-art report of WP2 should point out the relevance of complementary research on organic iodine retention in pool. In particular the effect of various additives may need additional experiments that will be proposed in the PASSAM project.

#### 2.1.3.2WP3.2 (SAND): Experimental studies of sand bed filters plus metallic pre-filters (leader: IRSN)

Sand bed filters plus associated metallic pre-filters are installed on all French PWRs in operation. They have been tested in the late eighties and in the early nineties as regards their efficiency for aerosol filtration and, probably, no further experimental study is needed. In full scale tests of sand bed filters, molecular iodine retention was also tested. Nevertheless – to be confirmed by the state-of-the-art report – complementary tests on molecular iodine retention are probably needed as well as tests with organic iodides. Finally the long term retention of filtered fission products also needs to be tested under postulated severe accident conditions (temperature, flow-rate, humidity, irradiation). These last topics will be investigated in the PASSAM project.

### *2.1.4 WP4: (INNOV) EXPERIMENTAL STUDIES OF INNOVATIVE FILTRATION SYSTEMS (leader VTT;participants: IRSN, CIEMAT, CSIC, RSE, VTT, AREVA NP GmbH)*

This WP aims at investigating innovative systems which look promising for source term mitigation in severe accident conditions, as described in part 1.2 of this paper.

The investigation will focus on five new methods and devices that the partners consider as having potential for enhanced mitigation of the release during severe accidents: two types of agglomeration systems (acoustic agglomerator and spray agglomerator), electric precipitator, improved zeolites and combination of wet and dry filtration systems.

#### 2.1.4.1WP4.1 (ACOU): Acoustic agglomeration systems (leader CIEMAT)

Enhancement of particle agglomeration by sound waves would have the potential of enhancing mitigation. On one side, if installed in containment, agglomeration of sub-micron particles would result in much larger ones that would be much faster depleted by sedimentation (settling velocity is proportional to aerodynamic diameter squared). On the other side, if implemented in the venting line to a wet/dry containment filter, they would largely improve the performance of the filtration devices by enlarging particles, since efficiency of those systems show a minimum in the range of 0.1 to 0.3 microns. The efficiency of such a system has been demonstrated in a variety of conditions. In PASSAM, the challenge would be to extend the already proven working domain to those conditions characterizing the accident scenarios and to optimise its operation accordingly.

The generic objective will be to investigate the performance of an acoustic agglomerator under the anticipated severe accident conditions. The specific objectives will be as follows:

- to measure aerosol lifetime with and without fostering acoustic agglomeration,
- to find out the best working conditions for the equipment.

#### 2.1.4.2WP4.2 (SPRAY): Spray agglomeration systems (leader RSE)

This sub work package is focused on the improvement of aerosol growth by spray. Traditional spray agglomeration systems are well known, but aerosol removal may be improved by non–traditional sprays. Different possible types of sprays may be envisaged, leading to improved efficiencies, and the associated mechanisms are not yet fully understood. The focus will be, mainly, on water additives, water with electrical charging and studies of injection axis configurations.

#### 2.1.4.3WP4.3 (ELEC): Electric filtration systems (leader VTT)

Potential of electric filtration systems were discovered early 19$^{th}$century, when corona discharge was found to remove particles from gas streams. Today many types of these filters exist including electro-static precipitators, air ionizers and ion wind devices. Typically they are very efficient filtration systems with minimal resistance to the gas flow. They are applied for reduction of many industrial emissions, including coal and oil fired power plants, salt cake collection from black liquor boilers in pulp mills, and catalyst collection from fluidized bed catalytic cracker units in oil refineries. Wet electrostatic precipitators operate with saturated gas streams and are used to remove liquid droplets from industrial processes. Plate precipitators are commonly applied as household as well as industrial air purifiers. As a side-effect of electrostatic precipitation devices they produce ozone and NOx, which can transform gaseous iodine to iodine oxide particles.

In characterisation of the novel electric filtration systems iodine containing species will be used: gaseous molecular iodine and organic iodide species as well as iodine containing aerosols or mixtures of them. The ability of both dry and wet electric filters to trap various iodine compounds will be tested in various conditions expected in the containment. Also the most efficient strategy of using the electric filters will be determined (it is not yet clear, whether it would be better to place the filters within the containment or applied in the filtered venting system).

#### 2.1.4.4WP4.4 (ZEOL): Improved zeolite filtration systems (leader IRSN)

Several innovative devices have been imagined and more or less tested. The literature survey should lead to a consensus among the project partners to choose one very promising innovative system (in addition to the ones to be studied in WP4.1 to WP4.3). This system will be tested in accident conditions in order to complement the available studies. So, in particular for this sub work package, the precise test conditions will have to be defined after the state-of-the-art report.

Indeed, except if the state-of-the-art report of WP2 shows that there is a much more promising candidate, focus should be put on zeolite capabilities that are widely used as filter in many industrial processes. Many kinds of zeolite exist, the key point is to find the more efficient zeolite for iodine species and if possible for other gases like ruthenium tetroxide in severe accident relevant conditions (temperature, pressure, humidity, gas flow rates …).

#### 2.1.4.5WP4.5 (COMB): Combined Filtration Systems (Leader AREVA)

The combination of wet and dry filters as well as adsorptive filters shall be investigated in this work package. The feasibility and the potential benefits shall be assessed. The interaction between the retention stages shall be analysed in order to evaluate if the respective strong point of each retention principle can be accumulated. In this context the operation range of the single retention stages as well as the combined system shall be investigated. The performance of the system shall finally be accessed by experimental works. Besides the retention efficiency for gaseous volatile species such as organic iodine, the robustness of the retention process shall also be evaluated.

### *2.1.5 WP5: (DKS) DISSEMINATION OF KNOWLEDGE AND SYNTHESIS (leader: IRSN; participants: all PASSAM partners)*

This work package will encompass the creation of a web site, education and training aspects relative to the PASSAM project, scientific publications to be produced along the project, organization of two workshops and writing of the final synthesis report of the project. It will be divided into two sub work packages.

#### 2.1.5.1WP5.1 (DISK): Dissemination of knowledge (leader IRSN)

Among other points, the main points of general interest about this activity are:

- Publication of several papers in scientific journals or conferences,
- Organization of two open workshops mainly targeted toR&D organizations, National Safety Authorities and their Technical Support Organizations, to the utilities and to the vendors:
  - one workshop after writing the state-of-the-art report to present the outcomes of this report and the envisaged test programme,
  - oneworkshop at the end of the project to present the major outcomes of the project.

#### 2.1.5.2WP5.2 (SYNTH): Project synthesis (leader IRSN)

The work will consist in writing the final synthesis report of the project, which will be made available in open literature. This final synthesis report will summarize the main outputs of the project (extension of the current database on the existing or innovative mitigation systems; deeper understanding of the phenomena underlying their performance; models/correlations easy to implement in accident analysis codes, as ASTEC). It will contain a comparison of advantages and drawbacks of all the systems studied (efficiencies for the different compounds to be mitigated; more or less passive behaviour; long term retention; etc...). Finally, a last part will be devoted to extrapolating the models developed to real accident conditions (as defined in the state-of-the-art report of WP2). It will allow to estimate the order of magnitude for source term reduction for each filtration system, including on the long term, and to provide hints for improved filtration systems.

### 2.2 The experimental facilities

For carrying out the PASSAM project, several existing facilities, owned and operated by the PASSAM partners will be used.

The IRSN EPICUR facility containing a $^{60}Co$ irradiator and allowing working with labelled iodine ($^{131}I$), will be used for testing the long term stability of trapped materials on various types of filtering devices. The IRSN PERSEE facility will allow some large scale retention efficiency tests, while bench scale tests should be used for better understanding trapping phenomena for iodine compounds.

The CIEMAT PECA facility will be used for studying hydrodynamic aspects (jet injection regime effect) in pool scrubbing systems and for conducting tests on acoustic agglomerators.

Pool scrubbing system hydrodynamics in the presence of structures (study of submerged structures effect) will be investigated in the PSI TRISTAN facility.

RSE will carry out lab-scale experiments in its SCRUPOS facility both to improve the pool scrubbing efficiency understanding (including the use of additives and bubble breaking devices) and for investigating spray systems efficiency.

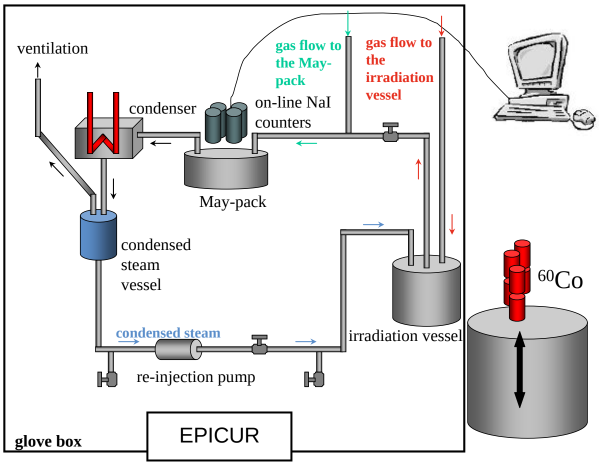
In characterisation of the novel electric filtration systems, VTT will use its EXSI CONT facility as the source of iodine containing species

AREVA NP GmbH owns and operates the JAVA large scale test facility which will be used as necessary for large scale retention tests.

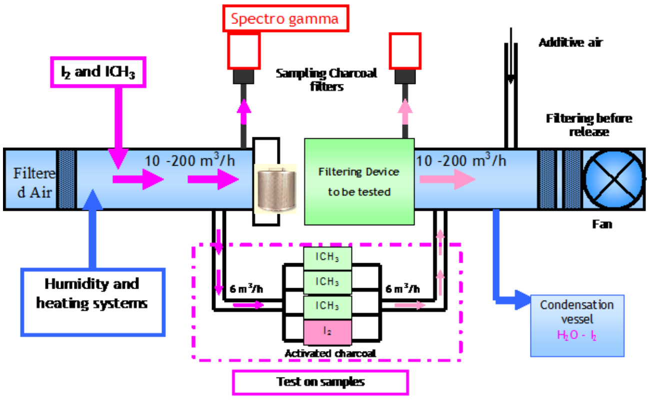
Details on these various facilities can be found in specific papers dealing with previous experiments performed using these facilities, or on request to the authors. Some views and schemes are provided in Figure 1 for illustration purpose.

It is worth noticing that the PASSAM project has been built in order to provide a real complementarity between the partners' activities and the use of the different available experimental facilities.

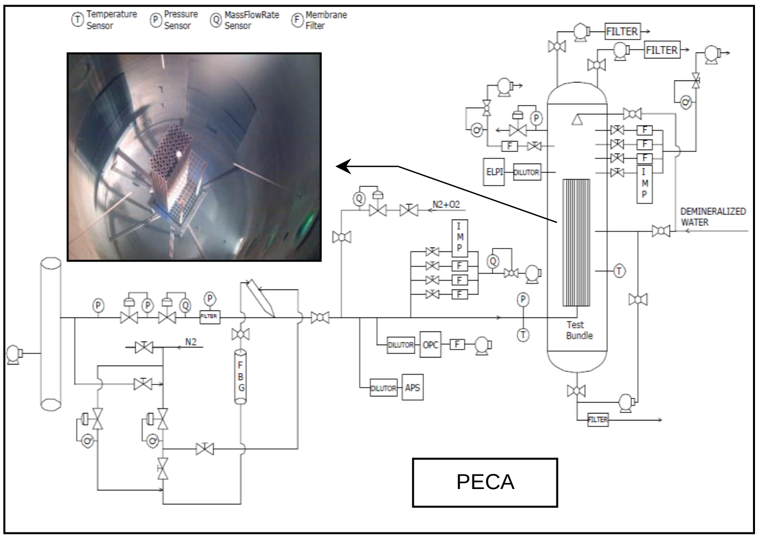
Figure 1: selected views and schemes of the facilities to be used in PASSAM project



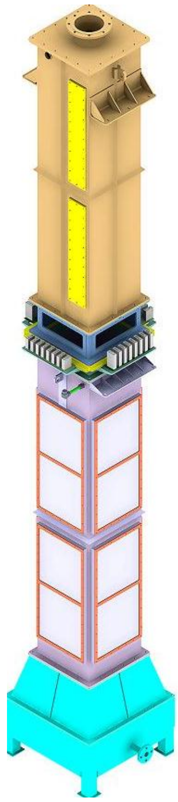

EPICUR



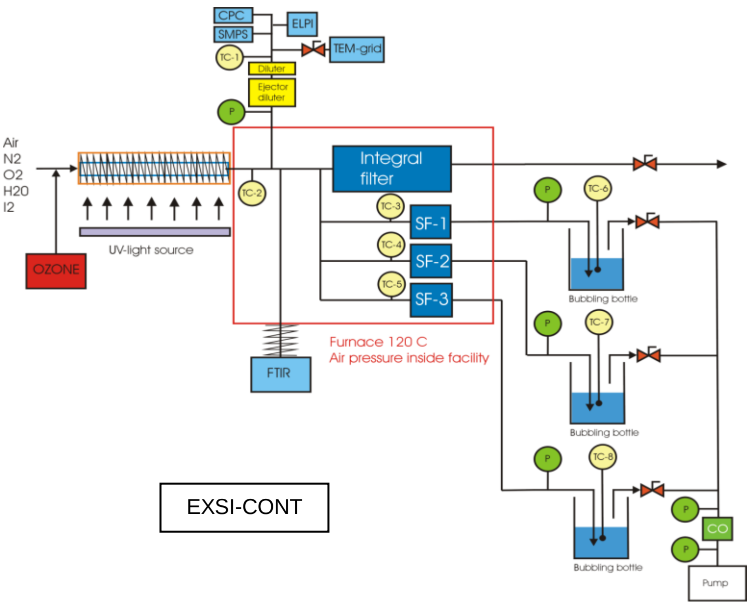

PERSEE



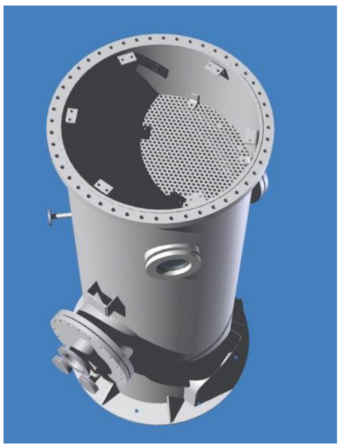

PECA



TRISTAN




EXSI-CONT

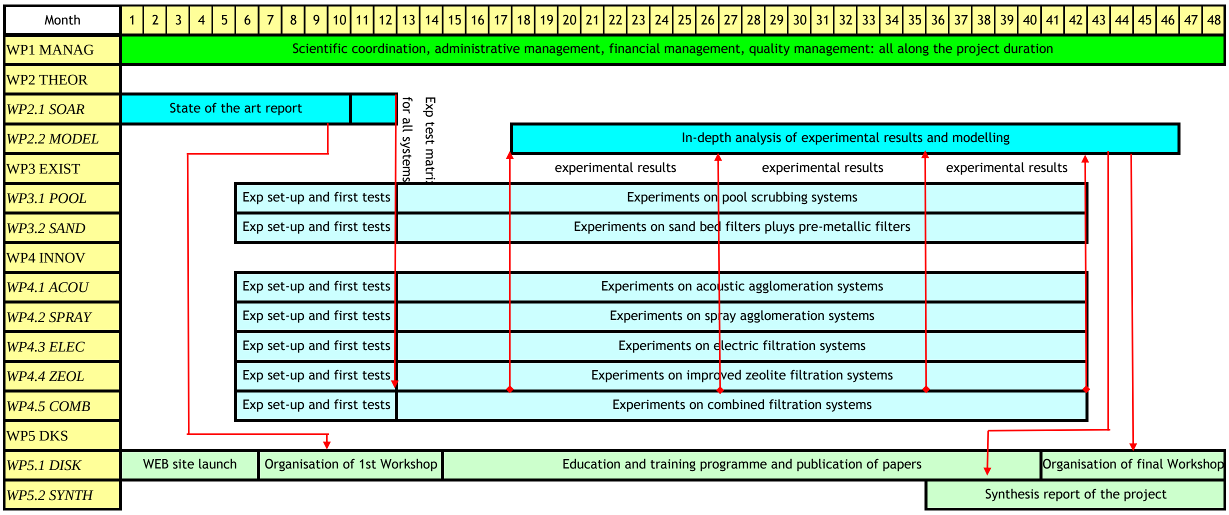


JAVA

## 2.3 Summary of the different WorkPackages and of major milestones

Figure 2 provides an overview of the timing of the PASSAM work packages (month 1 is January 2013 and month 48 is December 2016) and shows the links between them.

Figure 2: Timing and major links between the PASSAM work packages




Besides the links between the PASSAM work packages, there will be links between PASSAM and other international projects and with national projects (projects conducted by the partners in their national frame, but also, for instance, a forthcoming work on the FCVS to be undertaken by the US-NRC). There will be also links with the universities through direct collaborations by the various partners and through the performance of some parts of work in the frame of PhD theses.

The major milestones of the project are listed in Table 1 here-under.

Table 1: List of major milestones of the PASSAM project

| Milestone name | WP(s) N° | Expected date (months) |
|---|---|---|
| State-of-the-art report on current knowledge on existing and innovative filtration systems for nuclear power plants | 2 | 10 |
| Test matrices, with associated planning (including the connected analysis/modelling phase), defined for each type of system to be tested and all series of tests started or ready to start | 2, 3 and 4 | 12 |
| Workshop on the state of the art | 5 | 14 |
| All experimental programmes and experimental reports completed | 3 and 4 | 42 |
| Report on development of models/correlations | 2 | 46 |
| Final synthesis report | 5 | 48 |
| Final workshop | 5 | 48 |

## 3CONCLUSION

The PASSAM project, built up in the frame of the 7$^{th}$ framework programme of the European Commission, is mainly of experimental nature. Coordinated by IRSN (France), it involves eight partners from six countries. It takes into account complementarity between existing facilities and precise domains of excellence of each partner.All partners will share the same initial knowledge, to decide a quite consistent test matrix for the whole programme. Then they will share the experimental results and their analyses with the aim of optimising and comparing all the data resulting from the project in view of a final project synthesis report.

The studies about existing mitigation systems will focus on their performance under degraded conditions of operation, on their efficiency regarding other potential source term compositions than those originally considered (i.e. beyond aerosols and inorganic iodine), on long term behaviour of the trapped elements.Innovative methods and devices that are considered as having potential for enhanced mitigation of the radioactive release during severe accidents will bealso studied.

The project's outcomes will constitute a valuable database which may be strategic for helping the utilities on the decision of implementing mitigation systems on their reactors and for improving severe accident management. Robustness features for each type of mitigation system studied will be evaluated in the aim to increase the reliability of operation and reduce the risk for environmental impact in case of severe accident.

The understanding of major retention phenomena, for each type of mitigation system studied, will lead to determination of correlations and models, which should be easy to implement in severe accident computer codes as ASTEC. The models proposed by PASSAM could be used for evaluating the effect in real plant calculations of some mitigation systems on the source term ("Fukushima-like" scenarios or any other accident scenario).

Of course, the outcomes of the project will be of direct interest for the National Safety Authorities and their Technical Support Organizations in their respective roles and in link with the vendors and utilities.

For an efficient dissemination of knowledge, the state-of-the-art report to be drafted at the beginning of the PASSAM Project will be an open document and an associated workshopwill be organised, widely open to stakeholders interested by mitigation measures for severe accidents. Then, the final synthesis report of the project will be also an open document and a final project workshop will be also organised and widely open. Furthermore, several scientific papers will be written and published in scientific journals all along the project. They will be presented in conferences and during the two workshops here-above mentioned.

## ACKNOLEDGEMENTS

The authors thank the European Commission for showing a strong interest in the proposed PASSAM Project, and for being now on the way to propose a contract in order to fund it in the frame of their 7th framework programme for nuclear research and training activities.

## REFERENCES

[1] Chatelard P., Arndt S., Atanasova B., Bandini G., Bleyer A., Brähler T., Buck M., Kljenak I., Kujal B. - Overview of the ASTEC V2.0 and V2.0-rev1 validation – 5thEuropean Review Meeting on Severe Accident Research (ERMSAR 2012), Cologne (Germany), 21-23March 2012.

[2] Albiol T., Van Dorsselaere J.-P., Chaumont B., Haste T., Journeau C., Meyer L., Sehgal B. R., Schwinges B., Beraha D., Annunziato A. and Zeyen R. - SARNET: Severe Accident Research Network of Excellence –Transactions of. International Topical Meeting on Safety of Nuclear Installations (TOPSAFE), Dubrovnik (Croatia), 30 September. – 3 October 2008.

[3] Allelein H.-J., Auvinen A., Ball J., Güntay S., Herranz L. E., Hidaka A., Jones A. V., Kissane M., Powers D. and Weber G. - State-of-the-art on nuclear aerosols (pages 248-255) – OECD/NEA/CSNI/R(2009)5 – November 2009.