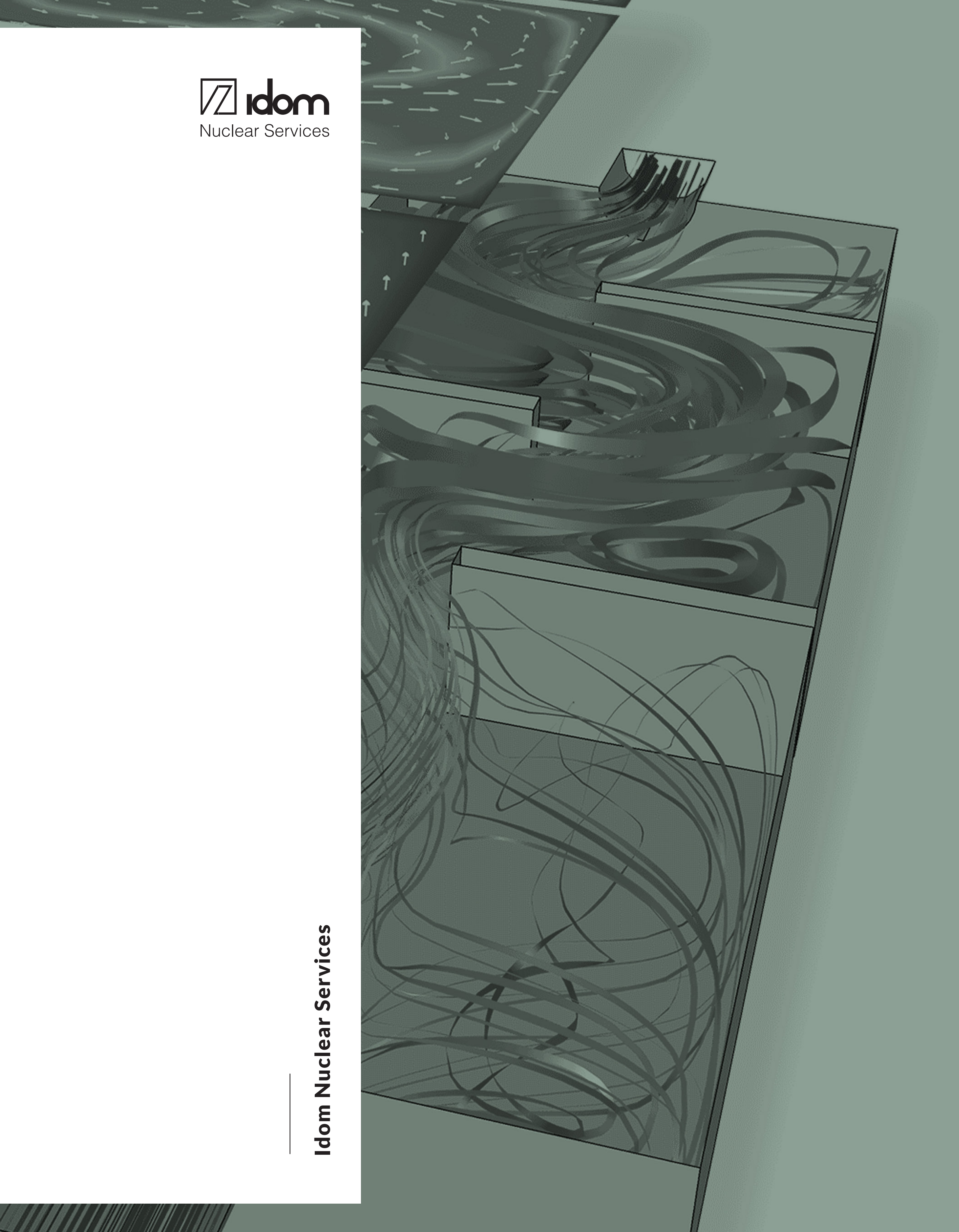


idom
Nuclear Services

Idom Nuclear Services

idom

Nuclear Services

Images in this brochure have the following copyrights:

(Cover) Image made using COMSOL Multiphysics® and provided courtesy of COMSOL® - modified; (PG05) ©alexdndz_shutterstock - modified; (PG07) ©Idom; (PG08-09) ©F4E; (PG10) ©F4E; (PG10-11) ©Nadezda Simunkova_shutterstock; (PG12) ©F4E; (PG13) ©Idom; (PG14) ©F4E; (PG15) ©Idom; (PG16) ©Idom; (PG17) ©Idom; (PG18-19) ©Idom - Photographer: Alfonso Calza.

Content developed by: Clara Colomer, Emili Martínez, Imanol Zamora, Jordi Salellas, Jorge Fradera, Marco Fabbri, Mathieu Ichard and Pierfederico Briani.

Editorial design: Belén Hermosa and Muak Studio. www.muak.cc

Computational Fluid Dynamics is a commercial brochure from the company Idom

Idom, Ingeniería y Consultoría, S.A.U.
Avenida Zarandoa, 23
48015, Bilbao - Spain

CONTENT

Idom 03
Idom Nuclear Services 04
CFD tools applied to nuclear technology 06
Thermal hydraulics analysis 08
Gas blast analysis 10
Neutronics - CFD coupling 12
Mass transport analysis 14
Fire engineering analysis 16
Conclusion 18
Scientific papers & studies 19

IDOM

Idom is an independent international company that delivers professional integrated services in engineering, architecture and consultancy. Excellency, innovation and commitment are the main basis on which Idom has built a solid group with offices distributed worldwide giving support to projects in more than 120 countries, accounting for 80 percent of the global turnover of Idom.

The market and new requirements of our clients mean that Idom is on a path of continuous growth in the scope of the services being offered as well as in the training of personnel.

At present, more than 2,500 people carry out their professional activities in the Company´s offices and projects all around the world.

THE GOAL

Providing the best possible service to each and every client

1957 Idom was founded in 1957, as a result of the effort and unifying work of the engineer Rafael Escolá (Barcelona 1919 - Bilbao 1995).

1995 Idom obtains accreditation of its quality management system to ISO-9001, awarded by Lloyd's Register Quality Assurance (LRQA).

2000 Idom obtains accreditation of its Environmental Management System to ISO 14001.

2011 Idom successfully gains accreditation to OHSAS 18001 of its Health and Safety Management System.

100% employee owned

The company is employee owned, with 100% of the capital of Idom distributed between staff currently working in the firm.

2500 employees | **12000** clients | **30000** projects

INDUSTRY & ENERGY

ARCHITECTURE & BUILDING

CONSULTING & SYSTEMS

NUCLEAR SERVICES

ADVANCED ANALYSIS

TURNKEY SERVICES

TELECOMMUNICATIONS

INFRASTRUCTURES

ENVIRONMENT

POLAND
BELGIUM
UK
ROMANIA

CANADA
USA
PORTUGAL
MEXICO

SPAIN
MOROCCO
COLOMBIA
UAE

LYBIA
INDIA
CHILE
BRAZIL

In recent years, Idom has expanded the range of its services, both technically and geographically.

IDOM NUCLEAR SERVICES

IDOM NUCLEAR SERVICES

Idom´s experience in the nuclear sector has its origins in the early nuclear generation projects in Spain in the late 70s and 80s, participating in the construction of Ascó and Vandellós II nuclear power plants (NPPs). Our relationship with these and other projects has continued throughout the lives of these facilities.

Working on these projects has enabled us to acquire technical abilities and experience in the fields of engineering technical support, industrial architecture, civil, mechanical, and structural engineering design and advanced analysis.

Our participation in the Energhia consortium, providing engineering services to Fusion for Energy (F4E) and the ITER organisation in the ITER fusion research project marks a milestone in the development of the nuclear services provided by Idom Nuclear Services (NS).

The spectrum of activities of the business unit covers a wide range of projects, from minor component or subsystems analysis to major design projects for new facilities.

Idom NS can offer nuclear engineering services working both as an integrated resource within the client's engineering team on site and as a resource from the various Idom offices.

Sustainability and innovation are valued aspects of Idom NS´ operations and, together with the knowledge acquired from our projects, we look forward to putting these aspects together to assist our clients on the path to a future with lower carbon emissions.

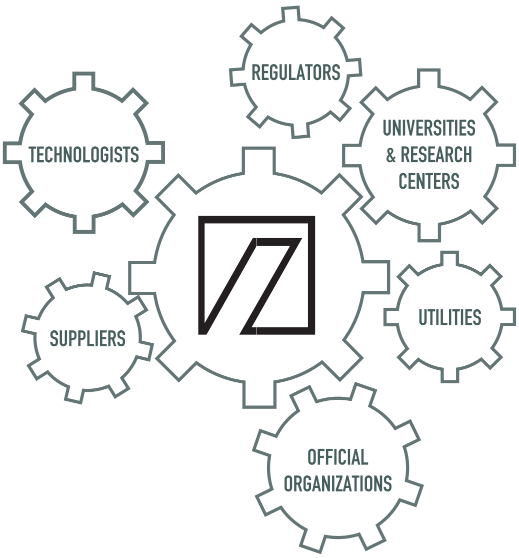
OUR TEAM

Idom NS offers a committed international and multidisciplinary team dedicated to high level performance, ensuring that projects are planned and delivered efficiently. By combining international experience and multidisciplinary expertise, Idom NS adopts a holistic approach to ensure the work is carried out to the client's satisfaction. When required, our core team will receive support from other highly skilled and experienced individuals within the company to ensure that momentum is maintained.

The Idom NS team manages the projects of Idom NS complementing their knowledge and expertise with people from other Idom technical areas working as a Task Force team.

In addition to the certified quality system of Idom, Idom NS operates according to its Nuclear Management and Quality Assurance System, based on UNE 73401, NQA–1 and KTA 1401.

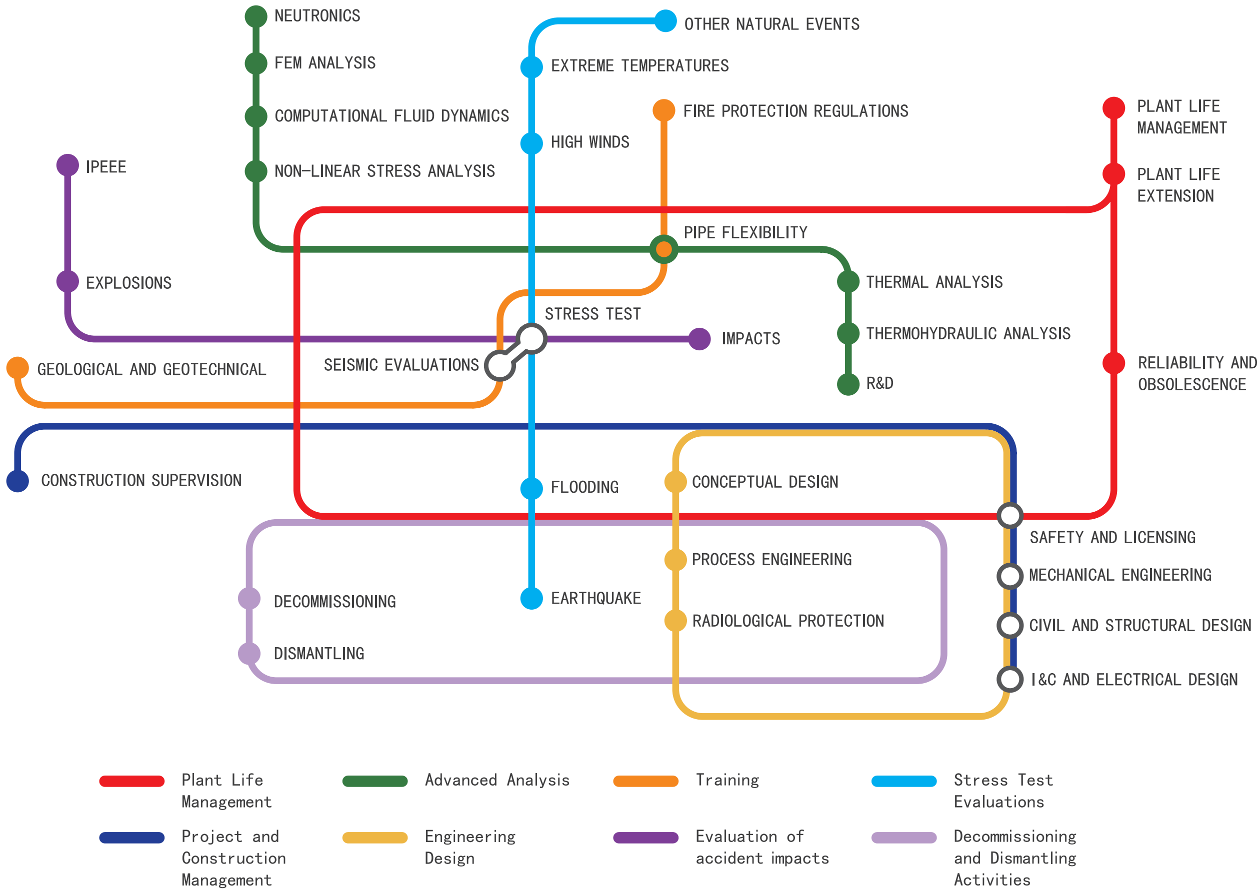
Idom NS is listed in the registry of the Spanish Nuclear Regulator (Consejo de Seguridad Nuclear, CSN), is an approved supplier of AREVA and of all Spanish NPPs and belongs to several communities of suppliers, such as UVBD (UK utilities), REPRO (Southern Europe Oil & Gas utilities industry) and SAGA 7 (Enel-Endesa).



Idom NS is member of the most relevant associations in the field in Spain and Europe: European Nuclear Society (ENS), Spanish Nuclear Society (SNE), United Kingdom Nuclear Industry Association (NIA), Sustainable Nuclear Energy Technology Platform (SNETP) and Spanish Nuclear Forum.

Idom NS is Centre of Reference of the Spanish NPPs for the Electric Power Research Institute (EPRI) projects.

SERVICES PROVIDED BY IDOM WITHIN THE NUCLEAR BUSINESS UNIT



SELECTED CURRENT TASKS RELATED TO THE SAFETY OF THE PLANTS

SAFETY SYSTEMS

Various Safety Related Systems projects have been carried out, from geological and technological studies and site evaluation against extreme natural events, to the development of basic and detailed engineering, equipment purchasing, construction, installation and commissioning of new safety systems of the plants.

Idom NS is also currently carrying out the evaluation of fire protection systems, based on the new Nuclear Safety Council (CSN) IS-30 Safety Instruction, as well as the analysis of emergency Heating, Ventilation and Air Conditioning (HVAC) systems and adequacy to the new regulations.

STRESS TESTS

Idom NS is conducting technical analyses to support the Western European Nuclear Regulators Association (WENRA) stress tests, including safety checks and risk analyses. Our tasks include assessment of the plants' defences against earthquakes, floods and other external events beyond the design basis of the plant, among other aspects.

Idom NS has participated in stress test related services for all the Spanish plants: Ascó, Vandellós II, Cofrentes, Almaraz, Trillo and Santa María de Garoña.

LIFETIME MANAGEMENT

Commencing in 2003 Idom NS developed the necessary studies and evaluations for the Santa María de Garoña NPP operating licence extension. Since 2006, Idom NS has also offered technical support in various areas including planning, development, implementation and monitoring to the Ascó, Vandellós II, Almaraz and Trillo NPPs' Lifetime Management plans.

This task is developed taking into account the considerations included in Safety Instruction IS-22 (CSN document) based on 10CFR54, NEI95-10, NUREG 1800 and NUREG 1801 NRC regulations.

CFD TOOLS APPLIED TO NUCLEAR TECHNOLOGY

Computational Fluid Dynamics (CFD) uses numerical algorithms to solve and analyze fluid flow problems in complex 3-D geometries. In the past years CFD has gained an excellent reputation as results have been validated and used to solve many real problems, therefore, saving a large amount of time and investment.

CFD analyses can be a key tool from the design, safety and operation standpoint that can dramatically lower costs. Moreover, CFD for nuclear reactor safety problems have been assessed in NEA/CSNI/R(2007)13 (*NEA. Assessment of Computational Fluid Dynamics (CFD) for Nuclear reactor Safety Problems. s.l.: OECD, 2008*) and NEA/CSNI/R(2007)5 (*Best Practice Guidelines for the use of CFD in Nuclear Reactor Safety Applications. 2007*) for 3-D flow and complex geometries, e.g. reactor primary components. Results show that CFD analyses bring real benefits and solutions to many problems.

Idom NS has the capability to carry out the aforementioned simulations for highly complex and complicated CFD cases, ensuring quality by following standards like NUREG-1781 (*U.S.NRC. CFD Analysis of 1/7th Scale Steam Generator Inlet Plenum Mixing During a PWR Severe Accident*), NUREG-1788 (*CFD Analysis of Full-Scale Steam Generator Inlet Plenum Mixing During a PWR Severe Accident. 2004*) or NUREG-1922 (*Computational Fluid Dynamics Analysis of Natural Circulation Flows in a Pressurized-WaterReactor Loop under Severe Accident Conditions. 2010*), and guidelines like NEA/CSNI/R(2007)5.

Computational resources at Idom NS have been dimensioned to allow multiple large cases, up to hundreds of millions of cells in a mesh, as seen in the figure, running at the same time. Hence, Idom NS can adapt to any case with its dedicated servers ensuring fast and reliable computations with high accuracy and resolution. Moreover, high quality data analysis is achieved with Idom NS' post processing servers giving a more comprehensive insight on all the simulated phenomena.

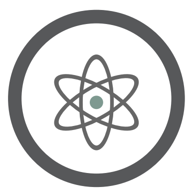
Highly skilled analysts with a specific knowledge not only in nuclear engineering, but also in CFD guarantee high quality results as well as time and investment saving analyses.

Following the terminology and concepts developed in IAEA Safety Standards Nº SSG-2 (*IAEA Safety Standards for protecting people and the environment. Deterministic Safety Analysis for Nuclear Power Plants. Specific Safety Guide. International Atomic Energy Agency. Vienna, 2009*), CFD computation together with conservative initial and boundary conditions provide best estimate analyses. As opposed to rigorous conservative approaches, a best estimate approach gives a more realistic information about the physical behavior of the plant components, assists in identifying the most relevant safety parameters and allows a more realistic comparison with acceptance criteria.

IDOM NS' MAIN CAPABILITIES REGARDING NUCLEAR TECHNOLOGY

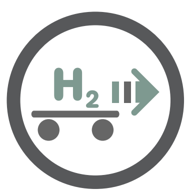
Thermal hydraulics

Gas blast analysis

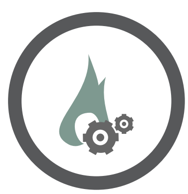


Neutronics - CFD coupling

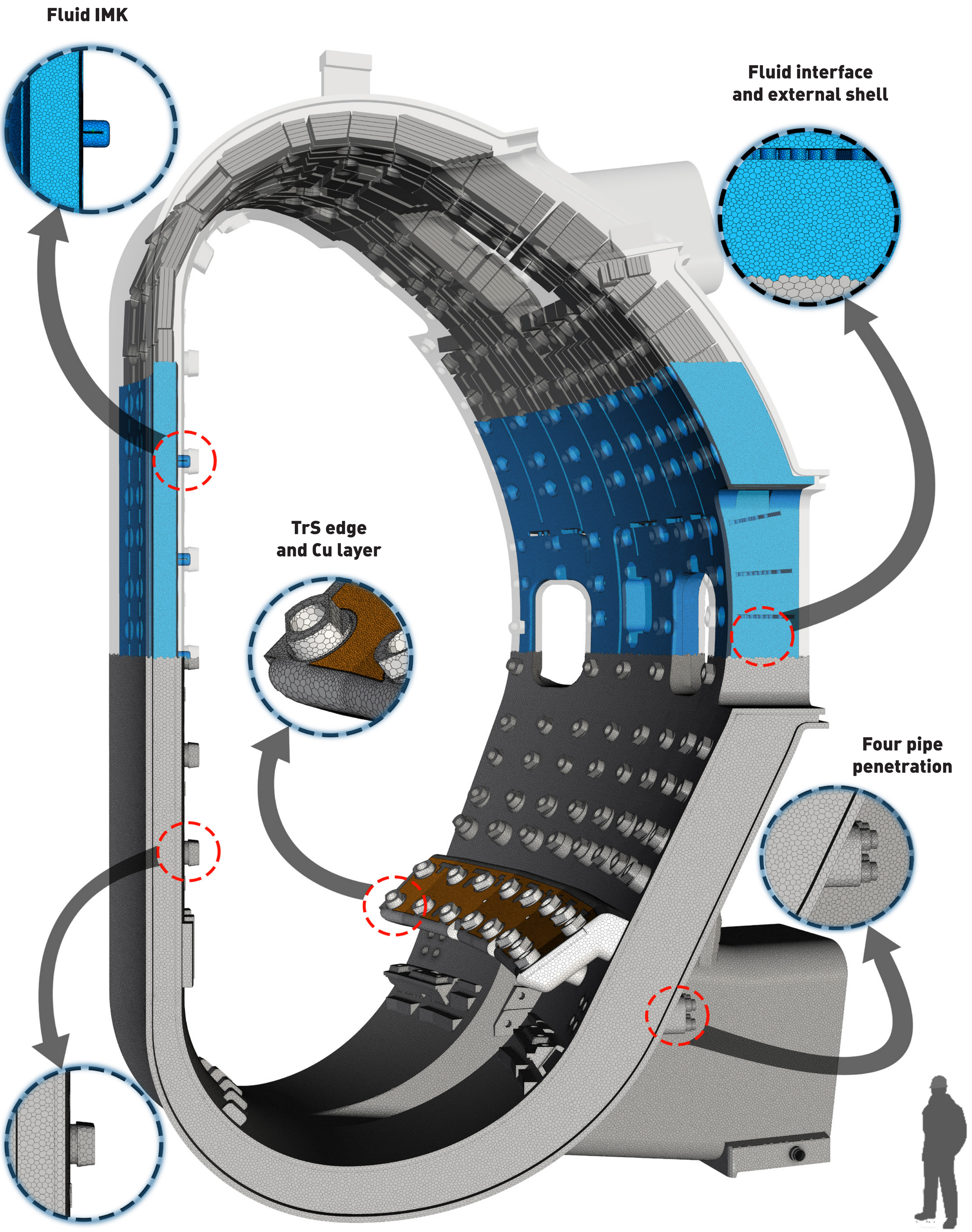
Mass transport analysis



Hidrogen transport CFD tools



Fire engineering analysis



Mesh of the ITER vacuum vessel irregular sector #02.
Polyhedral cell mesh for a shell and coolant coupled domains.

THERMAL HYDRAULICS ANALYSIS

Thermal hydraulics CFD cases were limited to in detail analysis of small geometries. Idom NS not only offers the aforementioned in detail analysis, but it offers the analysis of highly complex geometries and large computational domains such as reactor vessels or reactor cooling systems. Large-scale computer models allow the analysis of inlet/outlet flow distributions, fuel components integrity and heat transport coefficient determination among others.

Idom NS has an extensive knowledge and experience regarding thermal hydraulics and has the capability to solve any CFD case related to this field, following CFD for nuclear reactor safety guidelines and standards.

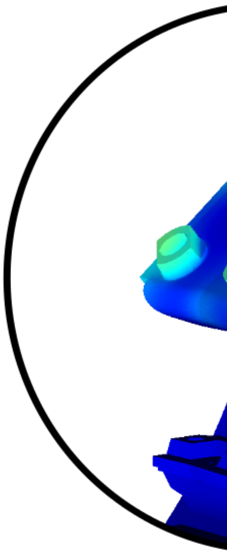
CFD studies applied to thermal hydraulics solve problems like temperature hot spots, determine heat transfer coefficient in order to optimize the performance of a system and detects possible safety related issues.

BENEFITS

- Numerical thermal hydraulic experiments for multiple scenarios.
- Detection of flow patterns, hot spots, stagnant regions.
- Quantification of pressure losses, temperatures, velocities and heat transfer coefficients.
- System optimization.
- Detection and solution of safety related issues like low heat transfer coefficient interfaces.
- Much lower cost and more flexibility than physical experiments.

CASE STUDY

ITER VACUUM VESSEL IRREGULAR SECTOR #2 THERMAL HYDRAULIC ANALYSIS



The thermal-hydraulic (TH) Analysis of ITER Vacuum Vessel (VV) Irregular Sector #02 (IrS#2) is a part of Fusion for Energy (F4E) fluid dynamic analysis procurement framework contract, assigned to Idom NS.

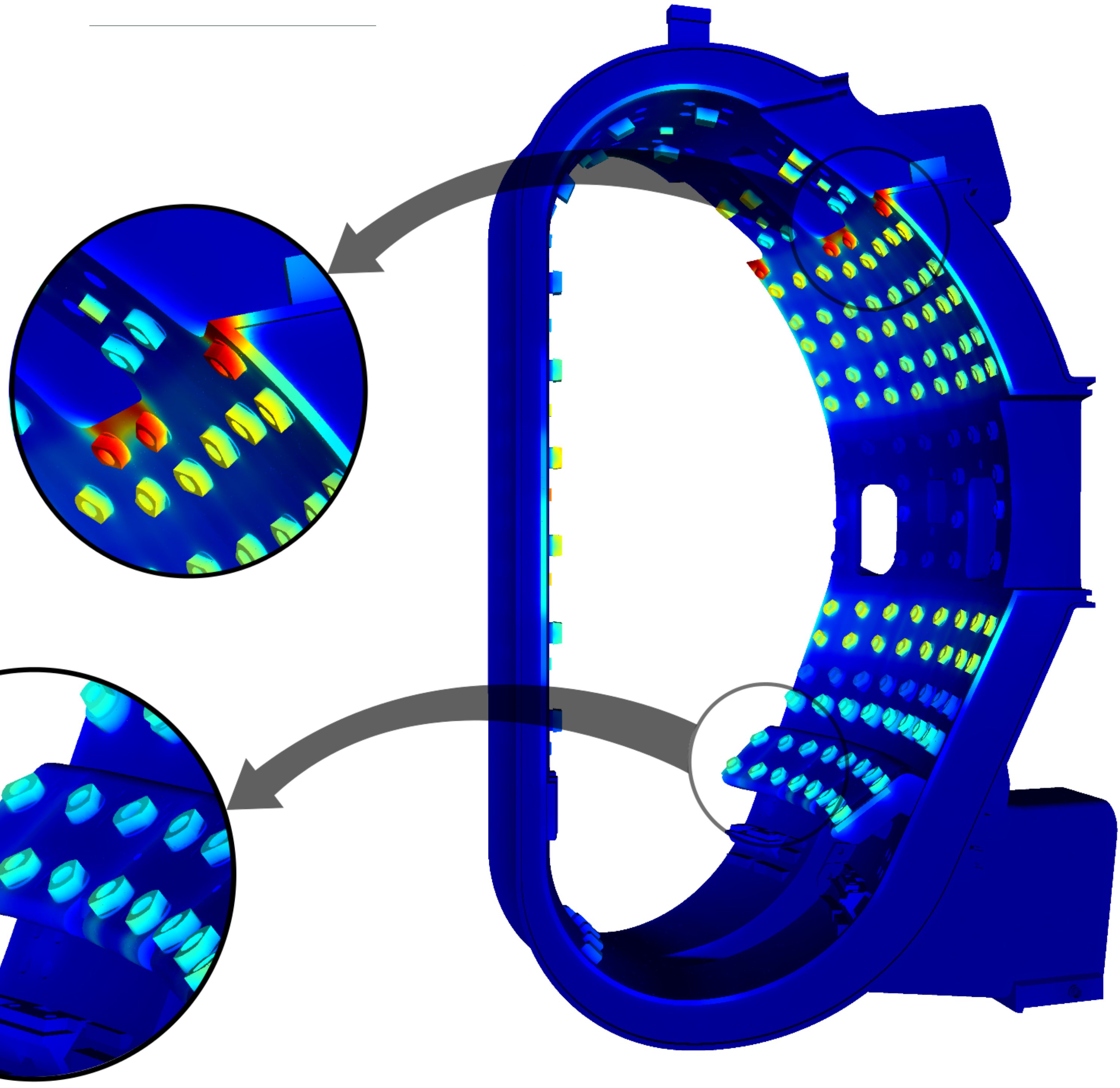
ITER is a large-scale scientific experiment intended to prove the viability of fusion as an energy source, and to collect the data necessary for the design and subsequent operation of the first electricity-producing fusion power plant.

The ITER VV, which is a critical component from the safety standpoint, is located inside the magnet system and inside the cryostat, and houses the In-Vessel components.

The TH analysis of the IrS#02 has identified the cooling performance of the system with special attention to the water mass flow rates distribution, temperature distributions and hot spots in solid and fluid domains. Note that Idom NS' neutronics to CFD coupling tool was used as a key application to complete the analysis. A whole set of reports, which include phenomena analysis, state of the art, results analysis, consistency analysis and safety implications were delivered to assess the TH behavior of the IrS#2.

The analysis was evaluated by Fusion for Energy with an excellent feedback that resulted in collaboration for scientific publication. This publication exposes the results of the analysis as well as the methodology that was adopted in order to make possible such a large CFD simulation. Heat transfer coefficient was calculated at the solid-fluid interface which gave rise to the detection of stagnant regions and hot spots. The results gave a significant insight on the behavior of the cooling system not only from the engineering standpoint, but also from the safety one.

Thermal hydraulic analysis can be improved with a CFD 3D simulation.



TH analysis of the ITER VV IrS #02.
Temperature map at the external shell (ANSYS® Fluent®).

Idom NS carries out gas blast CFD simulations to respond to the safety demands of society regulatory agencies and for the purposes of efficient plant design within an appropriate level of investment, saving time and dramatically reducing costs by, for example, evaluating safety measures in detail.

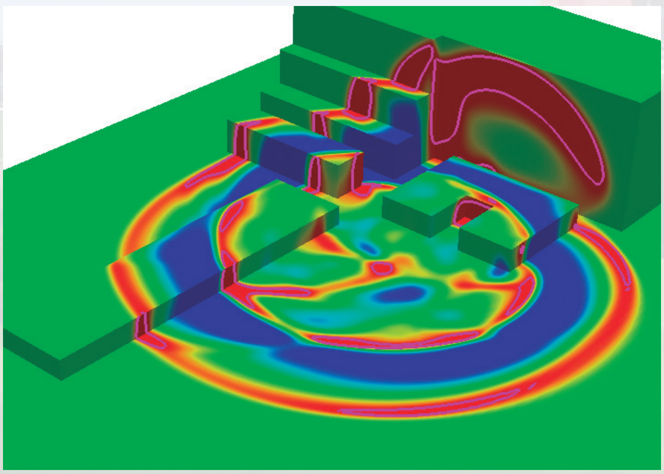
Gas blasts, e.g. helium gas storage blasts or hydrogen blasts, are a main concern regarding safety analysis of NPPs. Gas blast may have a severe impact on critical components that must be protected. Hence, blasts analyses are a key tool to determine not only the effects of a blast, but also for assessing current safety measures or gas tank locations.

CFD simulations of gas blasts were carried out in order to assess the impact on building and the generated damage. Idom NS has the capability to simulate large-scale models, like external blasts in a NPP, as well as detail analysis, like gas storage tanks in a room.

CFD simulations are utilized to predict gas dispersions, gas explosions, blast pressures and structural responses. Understanding the phenomena can help avoiding risks and to assess the safety of a NPP.

BENEFITS

- Numerical blast experiments for multiple scenarios.
- Detection of damage on building facades.
- Detection of the best location to place a pressurized gas tank.
- Gas blast shockwave impact assessment.
- Much lower cost and more flexibility than physical experiments.



Cryogenic He tank blast reflected overpressure on a set of buildings (OpenFOAM®).

CASE STUDY

ANALYSIS OF THE IMPACT OF A CRYOGENIC VESSEL BLAST SHOCK WAVE ON BUILDINGS

Helium storage tanks are present in many factories, e.g. natural gas plants, and will also be present in future fusion NPPs as a key component of cryogenic systems. Helium storage poses a safety issue regarding possible tank failures and subsequent gas blasts.

Blast of helium and nitrogen tanks in ITER is a part of F4E seismic, dynamic and structural analysis framework contract, assigned to Idom NS. A helium storage tank gas blast was simulated in order to address the limitations of the generalized methods based on thermodynamics used in the assessment of blast effects. Results show the impact of the shock waves and their reflection giving not only the pressures that the buildings have to withstand, but a valuable insight on the safest location to place the cryogenic tanks.

The analysis was evaluated by Fusion for Energy with an excellent feedback that resulted in collaboration for scientific publication. Results shows the evolution of a shockwave and were used to assess the best location for a pressurized gas tank, saving a large amount of time and lowering costs.

A CFD 3D simulation of a gas blast makes possible a thorough damage analysis.

NEUTRONICS - CFD COUPLING

During the past few years Idom NS has participated in several projects dealing with the interactions between neutronics (i.e. MCNP) and thermo-fluid dynamic (i.e. ANSYS® Fluent®).

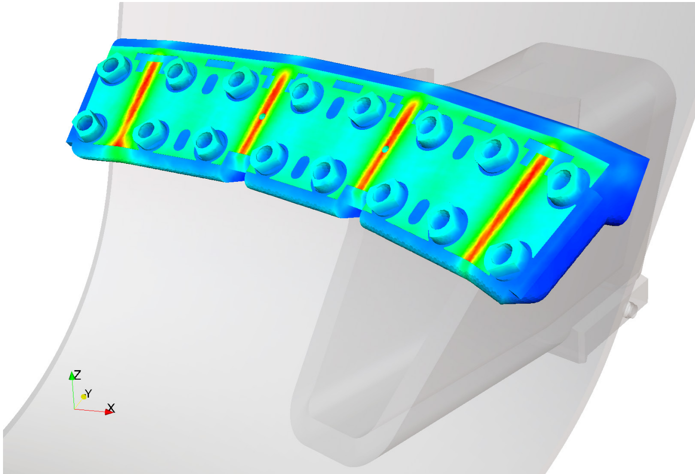
A two years research programme has allowed developing a semi-automated interface between MCNPX and ANSYS® Fluent®. Neutronics data can be automatically applied to a CFD reducing the analysis cycle and improving accuracy and resolution of simulations.

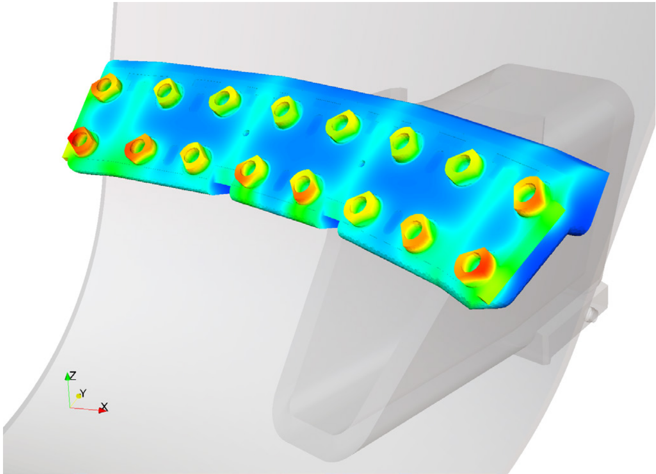
As a result of the aforementioned coupling tool, Idom NS can carry out CFD simulations with highly accurate nuclear data, which makes the analysis more reliable and improves the quality of the results. Moreover, the simulation process has been reduced and the flexibility of the tool allows more complete analyses with lower costs and more benefits for the clients.

BENEFITS

- Time saving automatic tool.
- Improved efficiency and accuracy.
- Coupled thermal hydraulic and neutronic analysis.
- Much lower cost and more flexibility than classic methods.

A coupling code can enhance CFD process efficiency





MCNP volumetric deposition mapped on a CFD mesh of a triangular support for the ITER vacuum vessel (left) and resulting temperature distribution (right) (ANSYS® Fluent®)

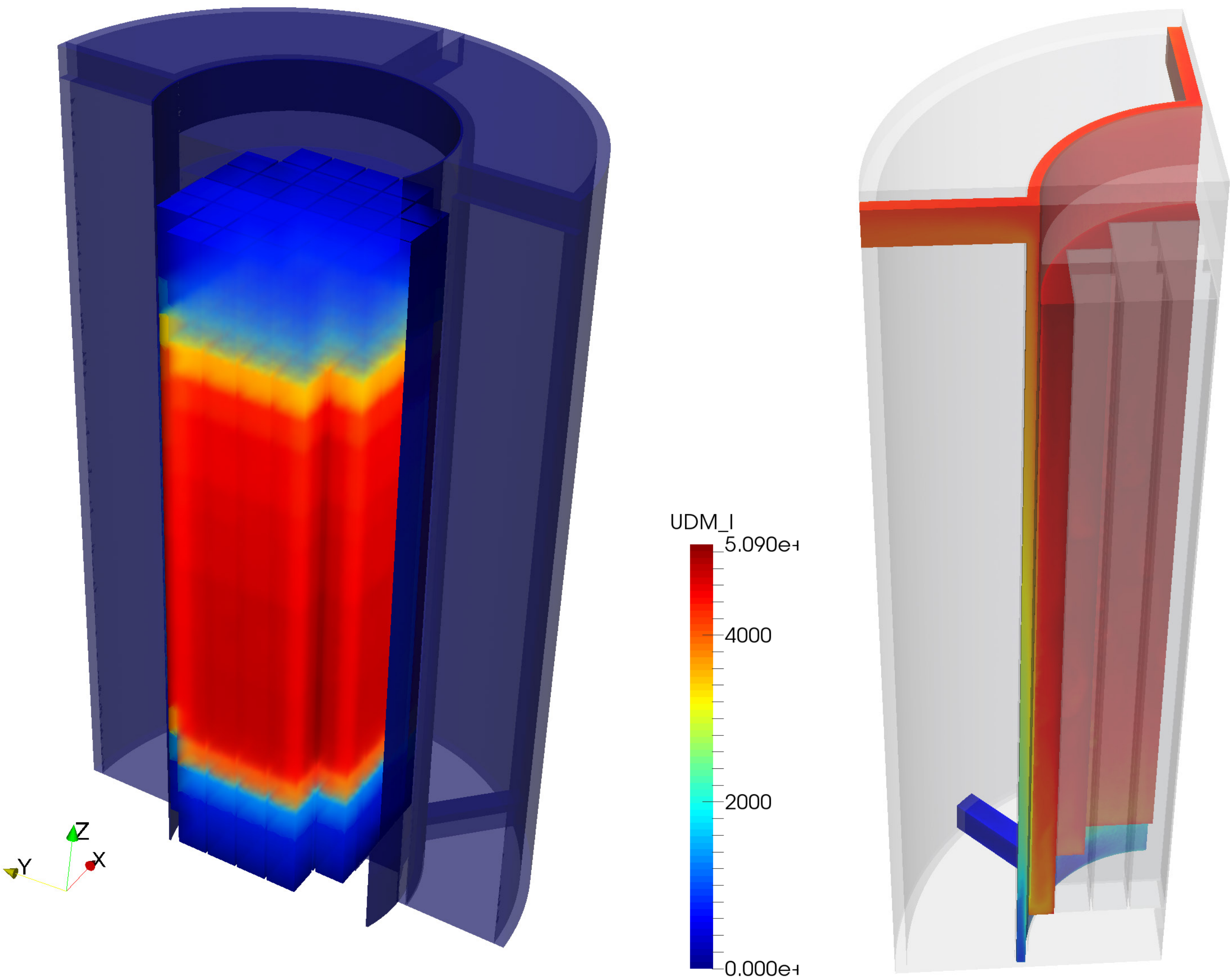
CASE STUDY

MCNP- ANSYS® FLUENT® COUPLING TOOL

This coupling software can be very useful in the design/optimization of many fusion/fission components where heat deposition is present. Possible applications include components of the fusion experiment ITER, DEMO and IFMIF or spallation sources such as the SNS/ESS, whereas wet storage systems of spent fuel racks, vessel shielding or fuel assembly can be areas of interest in fission.

For a dry storage system, we envisage that the coupling software could be used to determine the temperature field, the air flow and the presence of hot spots. In this way, the cask could be further optimized improving materials, thicknesses and other shielding mechanisms reducing costs and improving resulting design from the safety point of view.

Regarding fusion technology, several projects have required the application of the MCNPX-ANSYS® Fluent® tool. For instance, it was used in the TH analysis of the VV IrS #02 to import and map the MCNP Triangular Support (TrS) data on the CFD mesh.



Volumetric deposition (MCNPX) (left) and air temperature distribution (ANSYS® Fluent®) (right) of a dry spent fluent cask

MASS TRANSPORT ANALYSIS

CFD cases involving mass transport phenomena are a key issue regarding safety, design and operation in NPPs. Contaminant transport, corrosion, hydrogen permeation and accumulations among other phenomena can be simulated in order to assess the impact on critical areas. CFD simulations can be used to detect future problems and address possible solutions, including such solutions demonstration. Hence, this kind of simulations are a valuable tools for NPPs safety measure testing and improvement. Note that CFD tools not only can be used to verify that NPPs fall into applicable regulations, but also to implement new measures or improve existing ones.

Idom NS has the capability to carry out all types of mass transport simulations resulting in state of the art analysis useful for NPPs safety. Activation, accumulation zones, dispersion, habitability criteria and evacuation among others can be assessed in order to minimize the impact and dimension measures with more accuracy and lower costs.

CFD studies applied to mass transport solve problems like contaminant dispersion, extraction efficiencies and concentrations within systems in order to assess not only performance, but also safety.

BENEFITS

- Numerical mass transport experiments for multiple scenarios.
- Detection of flow patterns, contaminant accumulations and dispersion.
- Quantification of extraction efficiencies and concentrations.
- Detector location optimization.
- Detection and solution of safety related issues like limit concentrations.
- Much lower cost and more flexibility than physical experiments.

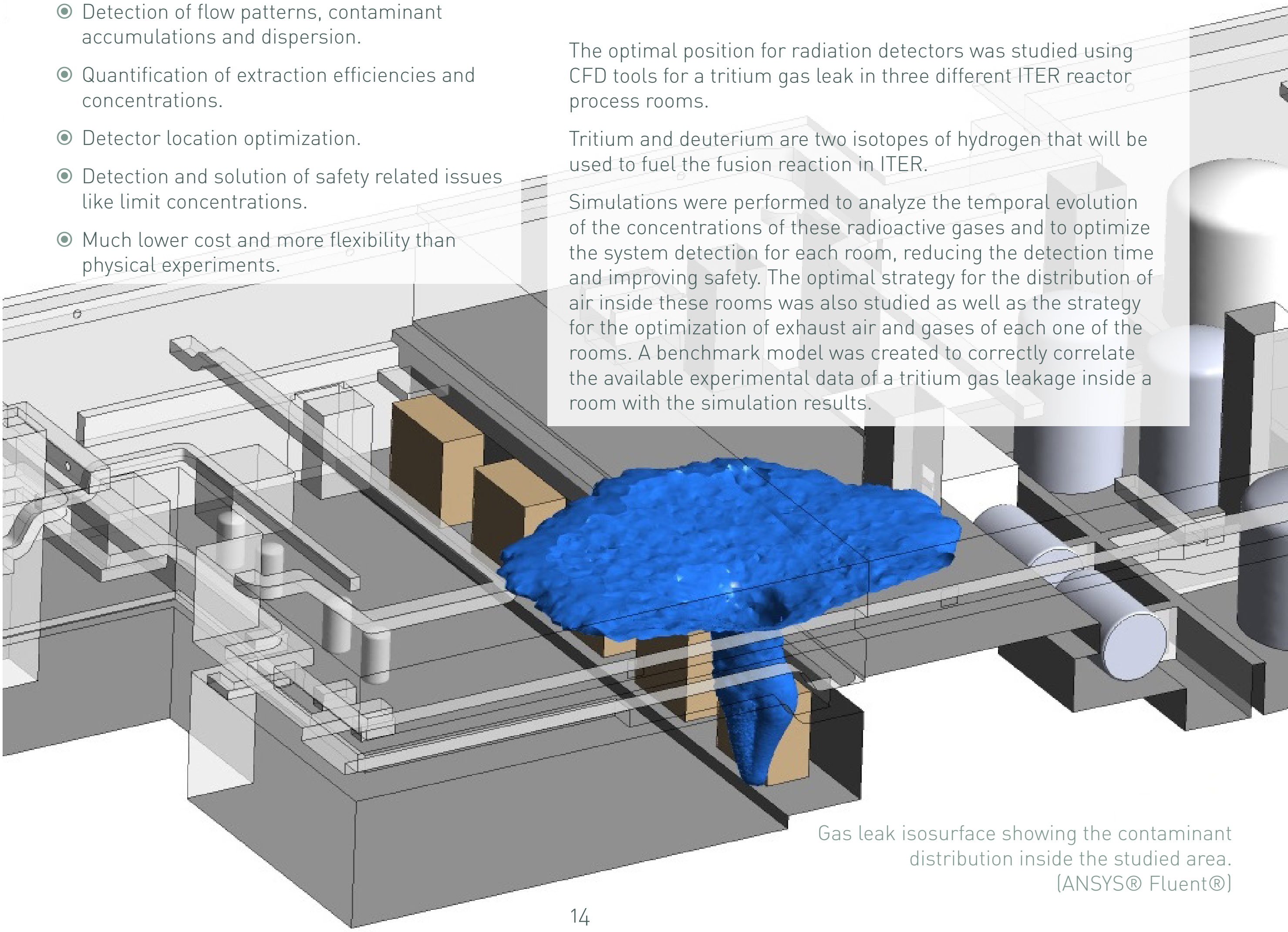
CASE STUDY

TRITIUM LEAKS WITHIN THE ITER PROCESS ROOMS

The optimal position for radiation detectors was studied using CFD tools for a tritium gas leak in three different ITER reactor process rooms.

Tritium and deuterium are two isotopes of hydrogen that will be used to fuel the fusion reaction in ITER.

Simulations were performed to analyze the temporal evolution of the concentrations of these radioactive gases and to optimize the system detection for each room, reducing the detection time and improving safety. The optimal strategy for the distribution of air inside these rooms was also studied as well as the strategy for the optimization of exhaust air and gases of each one of the rooms. A benchmark model was created to correctly correlate the available experimental data of a tritium gas leakage inside a room with the simulation results.



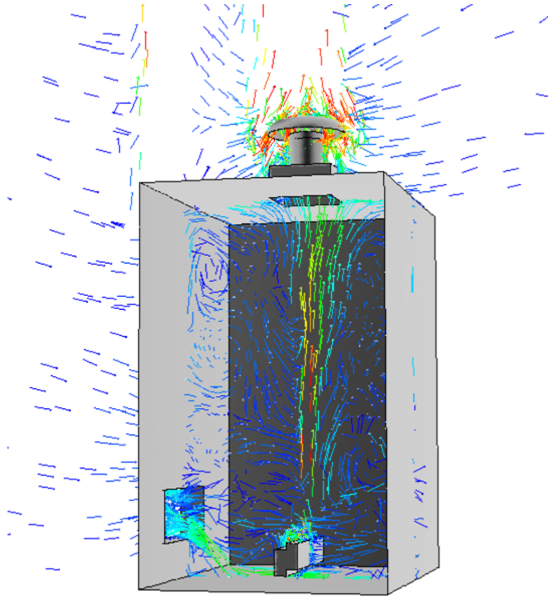
Gas leak isosurface showing the contaminant distribution inside the studied area. (ANSYS® Fluent®)

CASE STUDY

HYDROGEN EMISSION IN BATTERIES ROOM OF A NPP

A hypothetical hydrogen leak from batteries in different ventilation scenarios was studied. The analysis was aimed to verify that the hydrogen concentration would not exceed its Lower Explosive Limit (LEL).

The CFD model (ANSYS® Fluent®) was used to simulate hydrogen dispersion, heat transfer and fluid dynamics within a battery room. Hydrogen concentration evolution was studied in order to determine the steady state of the system under the year's worst meteorological scenario. Temperature distribution inside the room was also studied in order to assess safety parameters regarding battery performance and to ensure that temperature remained below danger limits.



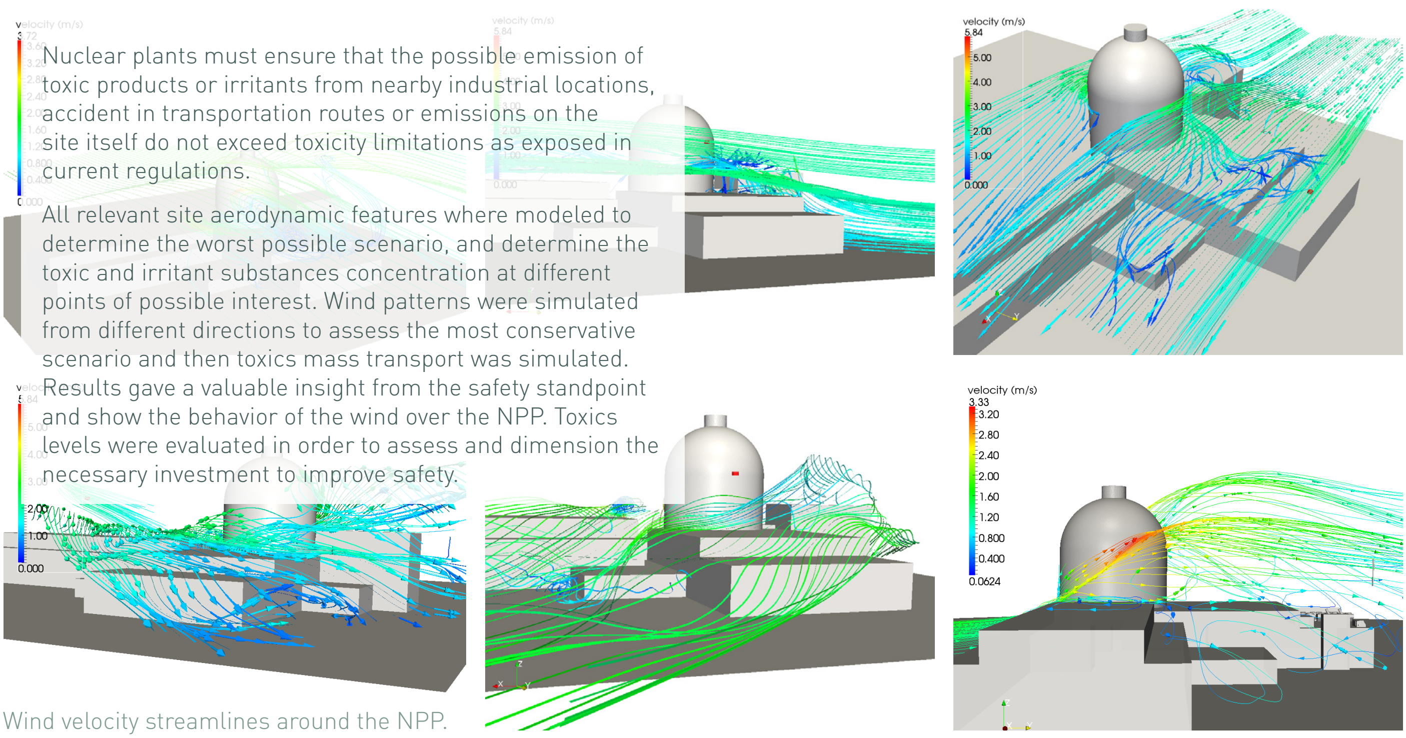
Hydrogen distribution due to a gas leak in a battery.

CASE STUDY

TOXICS DISTRIBUTION IN A NPP

Nuclear plants must ensure that the possible emission of toxic products or irritants from nearby industrial locations, accident in transportation routes or emissions on the site itself do not exceed toxicity limitations as exposed in current regulations.

All relevant site aerodynamic features where modeled to determine the worst possible scenario, and determine the toxic and irritant substances concentration at different points of possible interest. Wind patterns were simulated from different directions to assess the most conservative scenario and then toxics mass transport was simulated. Results gave a valuable insight from the safety standpoint and show the behavior of the wind over the NPP. Toxics levels were evaluated in order to assess and dimension the necessary investment to improve safety.



Wind velocity streamlines around the NPP.

FIRE ENGINEERING ANALYSIS

Fire simulation analysis allows knowing the evolution and spread of fire in areas of interest within a NPP such as control room, cable room and multi zone compartment among others. Fires are a main concern regarding safety analysis of NPPs.

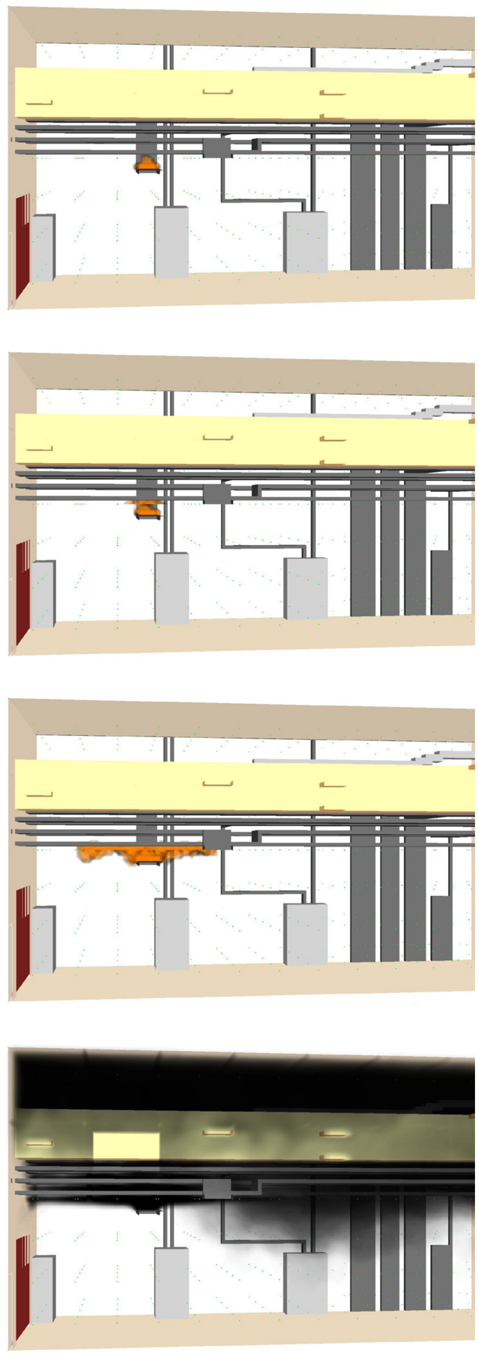
Idom NS has the capability to carry out fire simulations, taking into account smoke control, fire spread, toxicity levels and ventilation. As a result, appropriate fire protection measures and systems can be assessed for each scenario.

CFD tools applied to fire simulations can determine with higher resolution all damages caused during the fire. Furthermore, such tools can reduce costs due to a lower impact of design modifications.

BENEFITS

- Numerical fire experiments for multiple scenarios.
- Detection of fire spread patterns, smoke evolution and damage to components.
- Assessment of safety measures according to a detailed 3D analysis.
- Detector location optimization.
- Detection and solution of safety related issues like component damage habitability and evacuation.
- Much lower cost, non-destructive tests and more flexibility than physical experiments.

A fire scenario analysis can be improved with a CFD 3D simulation, showing detailed fire spread and smoke evolution.



Fire spread and smoke along trays in a room of a NPP.

CASE STUDY

SPREAD FIRE SIMULATION ANALYSIS IN FIRE AREAS OF A NPP

As a result of our experience, gained during diverse incidences in NPPs, a fire can severely compromise plant safety measures.

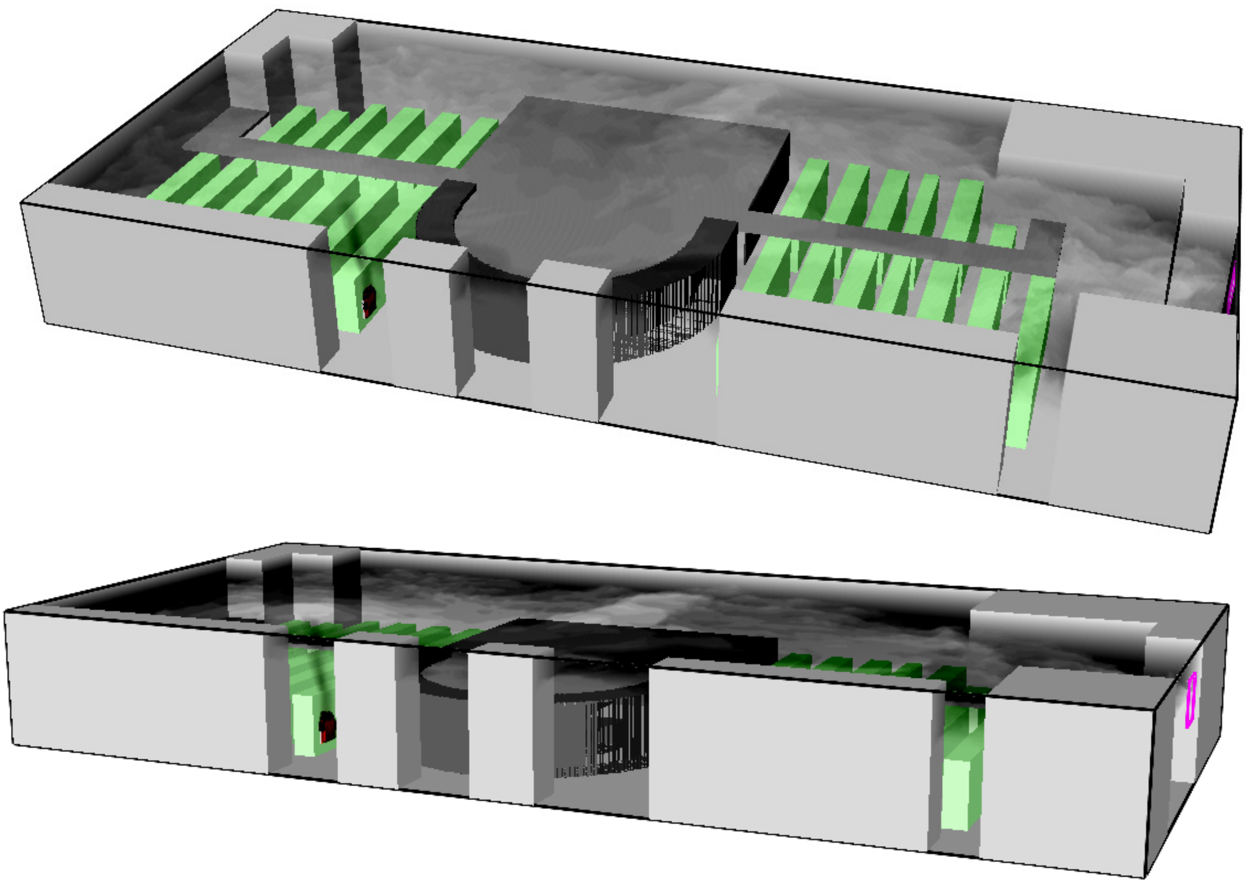
Idom NS has applied CFD tools like Fire Dynamics Simulator (FDS), developed by National Institute of Standards and Technology (NIST), in order to assess fire impact. It is worth mentioning that FDS is approved for analyzing fires at NPPs according to NUREG and NFPA rules.

Potential damage of electrical components and habitability has been analyzed for a NPP. This study has been carried out following NUREG-1934 (*U.S.NRC, EPRI. NUREG-1934 / EPRI 1023259 Nuclear Power Plant Fire Modeling Analysis Guidelines (NPP FIRE MAG). U.S.NRC, 2012*) and NUREG-1824 (*U.S.NRC, EPRI. NUREG-1824 / EPRI 1011999 Verification and Validation of Selected Fire Models for Nuclear Power Plant Applications. U.S.NRC, 2007*) methodology to guarantee reliable results from the conservative standpoint.

FDS has been used to simulate and analyze transient fire evolution, flame spread, smoke distribution and toxicity levels. Results show damage to key components like cable trays, electrical cabinets or paper stacks, as well as habitability, temperature and other related phenomena.

All this information gives an additional knowledge that allows to take more reliable decisions about the design of safety measures as well as to reduce safety measures implementation investment.

Damage analysis in critical components habitability was delivered to the client as well as a detailed assessment on the impact of fire on the NPP safety. Results were used to contribute to the assessment and implementation of safety measures in the NPP.



Smoke evolution example in a control room of a NPP.

CONCLUSION

CFD is a key tool for nuclear applications as it is fully recognized by its powerful, reliable and accurate results that solve complex problems reducing costs and investments as well as improving safety in NPPs. Simulations give the flexibility to study multiple scenarios with a reduced cost that allows the client to save time and money.

Idom NS has an extensive knowledge on CFD applied to nuclear applications, especially for nuclear reactor safety and thermal-hydraulics. Computational resources and necessary software, together with highly skilled analysts and a methodology in perfect alignment with current regulations, gives Idom NS the capability to carry out any CFD simulation despite the model size and the physics complexity.

Current and past CFD projects have given us the expertise and the know-how to successfully meet the client requirements. In addition our references show an excellent client feedback and have even been published as scientific and engineering relevant studies.

BENEFITS

- 3D highly detailed numerical experiments for multiple scenarios.
- Detection of key parameters under multiple conditions.
- Assessment, design and optimization of safety measures.
- Much lower cost than physical experiments.
- Much more flexibility than physical experiments.
- Time saving.
- Scalable analysis and easier and faster modifications as process or design evolves.

SCIENTIFIC PAPERS & STUDIES

Some scientific papers and studies developed by Idom NS include, as examples:

- *Thermal–hydraulic analysis of an irregular sector of the ITER vacuum vessel by means of CFD tools.* Fusion Engineering and Design. Volume 92 (Pages 69-74). March 2015.

  Authors: J. Fradera, C. Colomer, M. Fabbri, M. Martín, E. Martínez-Saban, I. Zamora, A. Alemán, J. Izquierdo, R. Le Barbier and Y. Utin.

- *Analytical and computational methodology to assess the overpressures generated by a potential catastrophic failure of a cryogenic pressure vessel.* SNE, 2014.

  Authors: I. Zamora, J. Fradera, F. Jaskiewicz, D. López, B. Hermosa, A. Alemán, J. Izquierdo and J. Buskop.

- *Estudio de un sistema out-core para la caracterización de elementos de combustible durante las operaciones de recarga de una central nuclear PWR.* SNE, 2012.

  Authors: C.Colomer, R. Ahmed, A. Alemán, M. Fabbri and J. Salellas.

- *Analysis by Computational Fluids Dynamics (CFD) of tritium leaks within the ITER process rooms.* ISFNT, 2013.

  Authors: C. Colomer, A. Alemán, X. Ariño, M. Martín and J. Salellas.

- *Análisis de simulación de la propagación de incendios mediante el programa Fire Dynamics Simulator FDS en áreas de fuego de centrales nucleares.* SNE, 2014.

  Authors: J. Salellas, I. Zamora, M. Fabbri, C. Colomer, B. Hermosa, R. Castillo and J. Fradera.

- *Multiscale integral analysis of tritium leakages in fusion nuclear power plants.* SOFE, 2015.

  Authors: J. Fradera, M. Velarde, J. M. Perlado, C. Colomer, P. Briani, E. Martínez-Saban, I. Zamora, M. Fabbri, A. Janés, A. Alemán.

Nuclear Services

Idom, Ingeniería y Consultoría, S.A.U.
www.idom.com

Avenida Zarandoa, 23
48015, Bilbao - Spain
T: +34 944 797 600
nuclear@idom.com

idom
Nuclear Services