CASE STUDY

RCC-MRx: how CEA and Octave collaborate for safe, innovative nuclear power

Key facts:

Company: Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA)

Website: cea.fr

Industry: Nuclear

Country: France

Octave products used: Aspect Nuclear Pipe Stress *(PIPESTRESS)*

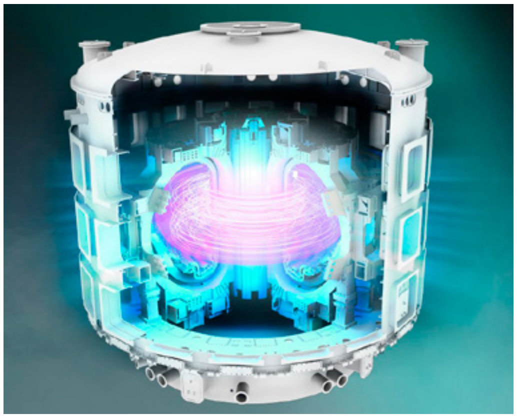
Writing rules and standards for building nuclear plants is a constant act of balance between two opposing forces.

On one side, a code must rest on proven operating experience to guarantee a sufficient level of safety. On the other, nuclear power is a field where new concepts and technologies are emerging, such as small modular reactors (SMRs), Generation IV reactors and fusion facilities. These installations have features not found in today's fleet. Very high temperatures, new materials, new coolants and modular configurations create operating conditions outside the domains covered by existing codes.

Identifying goals

Managing that balance is a core mission for France's AFCEN. Founded in 1980, the association develops technical codes grounded in industrial practice, operating feedback and scientific progress, to uphold the quality and safety demanded by nuclear reactors. Among these codes is RCC-MRx, the rulebook for the design and construction of mechanical equipment in nuclear installations, updated in a new 2025 edition.

AFCEN's members include the sector's key players, including the CEA (the French Alternative Energies and Atomic Energy Commission). As both an operator of research reactors and a client for innovative projects, CEA contributes actively to code evolution and practical deployment.



For novel concepts, the task is complex: because of the lack of industrial operating experience, design rules can only rely on preliminary studies and qualification tests. The critical challenge is to apply the right amount of conservatism to ensure safety and reliability without penalizing the design with overly restrictive requirements.

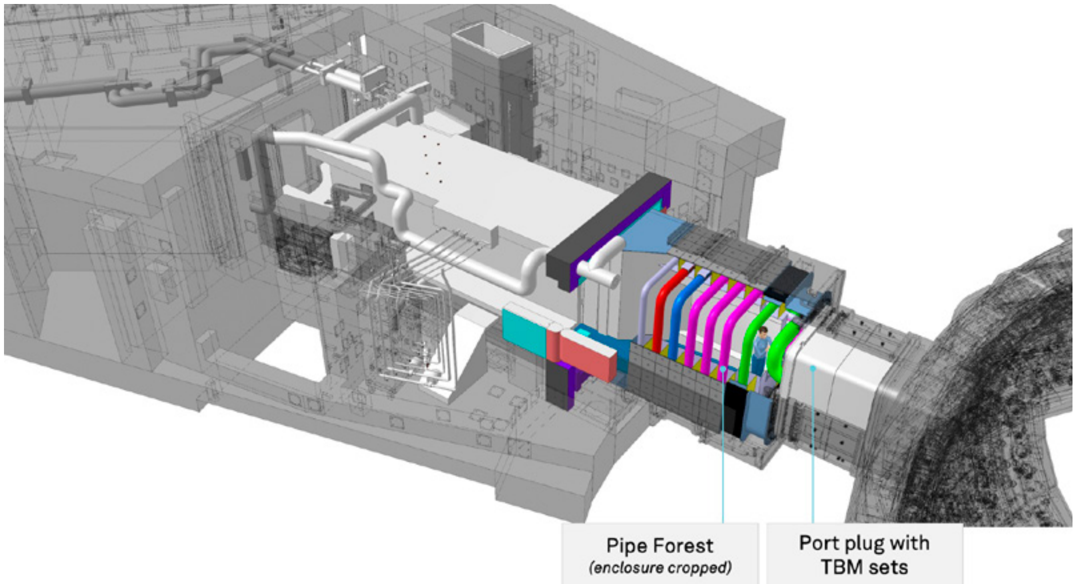
Steering rules and materials toward extreme conditions

CEA, as a public research body running many advanced reactor programs, brings essential input to guide technical rulemaking. RCC-MRx is a prime example of this continuous adaptation.

Created by merging two earlier codes, RCC-MRx today covers fast neutron reactors, research reactors and fusion facilities. Its first edition appeared in 2012 with its latest in 2018, each one folding in fresh experience.

Key benefits:

- The native integration of RCC-MRx and RCC-MX codes, using exactly the coefficients prescribed by the codes to calculate pipe stresses, allows CEA to run code-compliant pipe stress checks without workarounds
- Nuclear-QA qualification and fully text-editable models create a clear audit trail for reviews and approvals
- Faster modeling of, and iteration on, large, complex pipe networks, allowing for simultaneous calculation of all



The code now serves as a reference for European Generation IV prototypes and for leading research facilities.

Material integration has also been a special focus. RCC-MRx now includes extensive property data, such as stainless steel 316L with data extended into the creep range. It has also incorporated materials specific to new lines such as Eurofer steel for fusion structures.

These additions, validated by test campaigns in laboratories and reactors, give the code a framework suited to the extreme environments of these projects (high neutron flux, high temperatures). CEA has frequently taken the lead or played a coordinating role in these qualification efforts, such as spearheading the NUCOBAM European project focused on additive manufacturing for nuclear components.

Overcoming challenges

Applying RCC-MRx in a fusion project demonstrates the need for dedicated tools and methods. That means robust software tailored to nuclear demands, as well as partners able to bring high-level expertise and bespoke support.

Octave is one such partner. Its Aspect Nuclear Pipe Stress software has been maintained under nuclear quality assurance procedures for more than 40 years and has been used by engineering organizations worldwide to analyze piping in more than 50 nuclear plants.

A concrete example lies within ITER (International Thermonuclear Experimental Reactor), the international nuclear fusion research and engineering megaproject aimed at creating energy through a fusion process. Inside its vacuum vessel sit Test Blanket Modules (TBMs), experimental modules that test tritium production and structural material behavior in a fusion environment. Each TBM connects through a complex network of pipework known as the “Pipe Forest” to auxiliary equipment outside the machine. These lines will carry extreme fluids and withstand severe thermo-mechanical loads.

Yet detailed assessment of such pipework under RCC-MRx ran into a gap. There was no ready-to-use post-processing tool able to use flexibility analysis results directly. As Stéphane Gazzotti (CEA), the lead author on the subject notes: “No RCC-MRx post-processing tool existed as-is, which led CEA, in collaboration with ITER and Assystem, to develop a specific flexibility analysis methodology.”

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Stéphane Gazzotti
XR and Computational Modelling Research Engineer, CEA

Realizing results

Here CEA can rely on Octave Aspect Nuclear Pipe Stress. Designed for piping network analysis, Aspect Nuclear Pipe Stress offers built-in modules aligned with the main piping codes (including RCC-MRx/ RCC-MX formulae) and is qualified for nuclear applications.

Stéphane Gazzotti explains: "Unlike other tools, Aspect Nuclear Pipe Stress natively integrates RCC-MRx and RCC-MX, using exactly the coefficients prescribed by the codes to calculate pipe stresses. Purpose-built for this mission, it is more ergonomic than generalist tools. It allows modeling of large networks with easy iteration and simultaneous calculation of all pipe elements. You can also import geometries quickly via macros, modify routing, supports and components on the fly, edit the whole model in .txt format and run spectral analyses with ease."

From a management perspective, the solution delivers clear efficiency gains, improved traceability and the ability to monitor key performance indicators.

Moving forward

The evolution of RCC-MRx shows that engineering mastery sits at the heart of adapting technical standards to innovation. Building a code for unprecedented reactors remains a permanent challenge, which demands close tracking of scientific and technological advances. Bodies like CEA play a crucial testbed and reference role in this process, accumulating unique data that underpin continuous code improvement. Thanks to these contributions, RCC-MRx has broadened and strengthened. It's now at the point of being recognized beyond France as a reference code, notably in the European framework for innovative reactors.

Lastly, the internationalization of codification is visible in harmonization efforts, such as within CEN Workshop 64, where RCC-MRx incorporates expectations from stakeholders in several countries. This collaborative work, involving industry, operators, regulators and research centers, is key to producing robust shared rules. By sharing results, methods and operating experience, actors such as CEA help drive collective progress toward ever more exacting standards suited to the technologies of the future.

This article draws in part on:

Gazzotti, S., Tata, F., Ahossy, A., Di Paolo, C., Hausseguy, V., Le Cann, C., Lebarbe, T., Petesh, C., Friconneau, J.-P., & Martins, J.-P. (2024).

Test blanket modules piping systems calculation method according to RCC-MRx code. Fusion Engineering and Design, 203, 114452.

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The views and opinions expressed herein do not necessarily reflect those of the ITER Organization.

About Octave

Octave is a leader in enterprise software, turning data into decisive action and intelligence into your edge. Our software solves for and simplifies complexity, from the design and build to operations and protection of people, property, and assets– for any scope, at any scale. For decades, we've partnered with customers to sharpen performance, elevate efficiency, and amplify results. From factory floors to entire cities, our solutions are tuned to scale up what's possible from day one onward.