Topics: TEC - Fusion Energy Technology

European ITER Vacuum Vessel procurement: the delivery of the first two sectors and overview of the overall production.

B. Bellesia[1], A. Bonito-Oliva[1,2], J. Caixas[1], A. Dans[1], M. Emidio[1] , M. Febre[1] , A. Fernandez[1], E. Fernandez[1], M. Gonzalez[1], C. Kostopoulos[1], K. Libens[1], D. Rossi[1]
B. Giraud[2] A, Martin[2], J-M. Martinez[2], P. Teissier[2], S. Yang[2]
M. Jenco[3], N. Verde[3], S. Batticci[3], G. Di Carlo[3], A. Petrocco[3], M. Parodi[3]
[1] Fusion for Energy, Josep Pla 2, 08019 Barcelona, Spain
[2] ITER Organization Team, CS 90 046, 13067 St. Paul lez Durance, France
[3]Ansaldo Nucleare-Mangiarotti Westinghouse-Walter Tosto Consortium
mailto:boris.bellesia@f4e.europa.eu

ITER (International Thermonuclear Experimental Reactor) is a global collaborative project aimed at demonstrating the feasibility of fusion energy as a large-scale and carbon-free source of power. Funded by seven members—China, the European Union, India, Japan, Korea, Russia and the United States—ITER represents one of the most ambitious scientific collaborations in history. Fusion for Energy (F4E) is the European agency (Joint undertaking) responsible for managing Europe's contribution to the ITER project, providing in-kind components, including the vacuum vessel.

The vacuum vessel is a critical nuclear component of ITER, serving as the first confinement barrier of the fusion plasma. It is a large, toroidal structure composed of nine individual sectors that, once completed, will be welded together to form the final toroidal shape having an outer diameter of about 20 m, an height of 11.4 m and an overall weight of 5200 t, Fig.1. The production of the nine sectors has been split between Europe (five sectors) and Korea (four sectors), with both parties following strict nuclear-grade manufacturing and quality assurance standards.

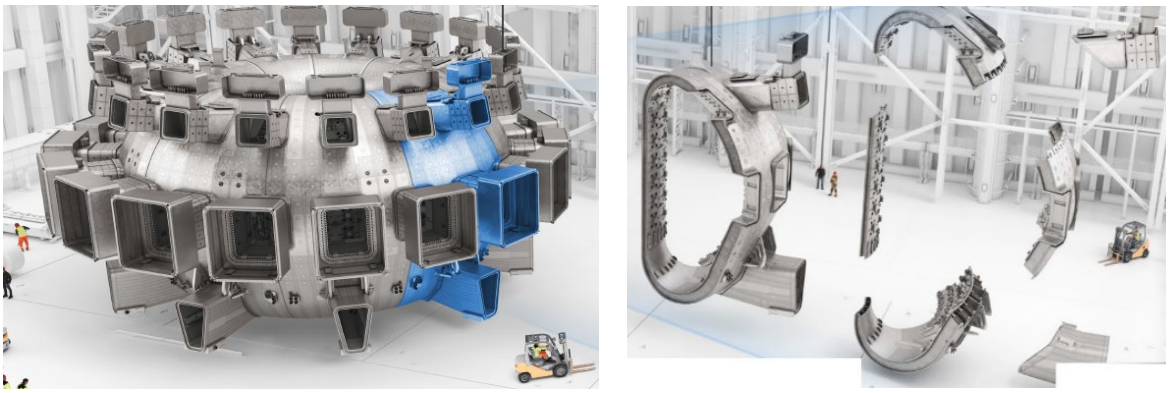

Figure 1: sketch of the assembled torus with 9 sectors – left. Single VV sector and segments and ports exploded view – right.

Each vacuum vessel sector represents a 40-degree slice of the torus and is fabricated through the assembly of four large, thick-walled segments. Additionally, each sector features two ports that connect the vacuum vessel to external systems serving as crucial interfaces for diagnostic, heating and fuel injection systems and ensuring the functionality of ITER's plasma confinement,

The procurement [1,2,3] of the five European sectors has been implemented through a contract signed in 2010 between Fusion for Energy and an Italian consortium composed of Ansaldo Nucleare, Westinghouse/Magiarotti and Walter Tosto. The production of these mechanically complex components has faced numerous challenges, including technical difficulties, supply chain issues and the development of novel welding and inspection techniques required to meet stringent nuclear safety and performance standards. Despite these obstacles, the European contribution to the ITER vacuum vessel has progressed significantly, incorporating lessons learned and innovative solutions to ensure the successful delivery of this essential component.

Ensuring compliance with nuclear safety regulations is a key aspect of ITER's construction. The French Nuclear Safety Authority (ASN) is responsible for overseeing nuclear safety and radiation protection, ensuring that ITER adheres to French nuclear regulations. Agreed Notified Bodies (ANBs) are designated by ASN to verify that nuclear pressure equipment (ESPN) meets regulatory requirements. ANB conduct conformity assessments, including material certifications, non-destructive testing (NDT) validations, welding qualifications and pressure tests. Resident inspectors are present in each of the vacuum vessel manufacturing workshops and the review of weld ultrasonic inspection files has been centralized due to the specialized skills required. ITER, as the Nuclear Operator, holds ultimate responsibility for implementing nuclear standards and the ANB contract is managed by ITER itself. As a Level 1 external intervener for ITER, Fusion for Energy ensures that all suppliers (Level 2) comply with ASN and ANB requirements. F4E also prepares and submits required documentation to ITER for ANB approval, coordinates inspections, testing and certifications and acts as a key interface between suppliers, ITER and regulatory bodies to resolve issues and ensure alignment among stakeholders.

This paper provides a comprehensive status update on the European procurement of the ITER vacuum vessel sectors, detailing the technical challenges encountered to meet the stringent requirements, the manufacturing processes adopted and the strategies implemented to overcome delays and improve efficiency. As ITER moves closer to full assembly, the completion of the vacuum vessel remains a critical milestone in achieving the project's ultimate goal of advancing fusion energy research and development.

One sector, Sector5, has been successfully delivered to the ITER site in October 2024 and a second one, Sector4, is scheduled for delivery in May 2025. The manufacturing of the remaining three sectors, is ongoing, with completion expected in the next future. The production process continues to benefit from lessons learned, technological advancements and close collaboration between stakeholders to ensure the timely and high-quality completion of the European vacuum vessel contribution.

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