iter magazine

In this issue

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Where are we at?

Editorial

With this new magazine we aim to bring you inside ITER and share the enthusiasm of those working around the globe toward its realization with the widest possible audience.

ITER is a vast subject that will take time to explore. Every few months we hope you'll look forward to receiving news from the frontiers of ITER science and technology, the enterprising world of high-precision industry, and from the hilltop in Provence where it's all coming together.

This magazine is for you. We'd be happy to receive your suggestions and remarks for its improvement at the email address listed below.

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See more at: http://www.iter.org/fr/mag/1/in english

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Who does what?

The ITER Project and its division of tasks between multiple actors can be confusing. Below are some elements of response to the question: "Who does what at ITER?"

ITER Organization (IO) is responsible for the design of the ITER Tokamak and its auxiliary systems. The ITER Organization will be responsible for machine installation and assembly beginning in 2015, and operations, beginning in 2020. Like other international organizations such as Unesco or the World Health Organization, the ITER Organization was established by international treaty.

On 21 November 2006 in Paris, France, the seven ITER Members signed the ITER Agreement. On site in Saint Paul-lez-Durance, ITER directly employs approximately 500 staff members representing 30 nationalities.

Domestic Agencies (DAs) were created by each ITER Member. There is thus an ITER Domestic Agency in China, India, Japan, Korea, Russia, the United States and Europe (the European Domestic Agency is located in Barcelona, Spain). These agencies, on behalf of their governments, are charged with procuring the ITER components, systems or buildings that fall under each Member's procurement responsibilities to ITER. Europe, with the largest percent of the Project, contributes 45% (including nearly all site buildings), while each of the other Members contributes 9%. The reason for this disparity is that Europe, as Host to the ITER Project, benefits from the largest amount of economic impact.

Agence Iter France (AIF) is an agency of the French Atomic Energy and Alternative Energies Commission (CEA). Created to manage the French financial contribution to ITER, it supervised the clearing and levelling activities for the ITER site (2007-2009) and the public works on the ITER Itinerary. It collects the contributions pledged to ITER by local governments and plays a role in welcoming international ITER staff members and their families. Agence Iter France is the interface between the ITER Project and French authorities and in this capacity oversees, for example, the organization of ITER component transport. It has also organized land acquisition measures to compensate for the clearing of the ITER site. When the ITER Project comes to the end of 20 years of operation in the early 2040s, Agence Iter France will be in charge of site decommissioning and dismantling.

A successful journey... to be replicated 200 times

After successfully navigating the ITER Itinerary for four consecutive nights, the test convoy reaches the ITER site.

4:45 a.m., Friday 20 September 2013: The 800-ton trailer rolls to a slow stop on the ITER site in the early morning hours. Under the light of the full moon, those gathered around the enormous 352-wheel vehicle – 46 metres long, 9 metres wide and 11 metres high – break into spontaneous applause. The test operation for the ITER Itinerary can be considered a complete success.

Four nights earlier on the banks of the *Étang de Berre*, a small inland body of water west of Marseille near the Mediterranean Sea, a long procession of men and machinery had started off at measured pace. The goal: to carry out a full-size test of the transport of an exceptionally-sized ITER component. At critical points along the 104 kilometre ITER Itinerary from Berre to the ITER site – for example at bridges, highway crossings and villages – measurements were taken to assess the stress imposed on the structures by the exceptional weight and dimensions of the test convoy.

At approximately 4:00 a.m. on 20 September, the ITER test convoy crosses the roundabout in front of the ITER site. ©ITER Organization

Over one hundred people participated in the test operation. It was the culmination of years of preparation, from the large-scale public works carried out by France to ready the Itinerary for ITER loads, to the administrative machinery set into place to plan for every contingency. Before the test convoy could take place, an enormous technical, administrative and regulatory machine had to be fine-tuned. Organizing the transport of an ITER component is infinitely more complex than transporting a container or a load of wood…

When, in 2005, the ITER partners chose a site near the French research installation CEA in southern France over a site proposed by Japan (Rokkasho-Mura, on the Pacific Ocean), they knew they would have one major obstacle to overcome. With a location fully 100 kilometres from the nearest coast, how would it be possible to transport the large ITER components shipped to the Project from factories all over the world with every guarantee of safety for the material and security for local residents?

The choice was soon made to create a dedicated Itinerary by carrying out work to adapt routes, reinforce bridges and, when necessary, create deviations. The responsibility fell to France as Host to the ITER Project. Between 2006 and 2010, the technical studies and necessary adaptations were carried out, financed in part by the local *département* (Conseil général des Bouches-du-Rhône) and in part by the French state.

As they travel the 104 kilometres of the ITER Itinerary, the ITER convoys will cross 16 villages, negotiate 16 roundabouts, cut across the motorway in three locations and cross 35 bridges. The Itinerary is the ITER "lifeline," permitting the most exceptionally sized ITER components to be transported to the assembly workshops of the ITER site from their point of disembarkation on the Mediterranean Sea.

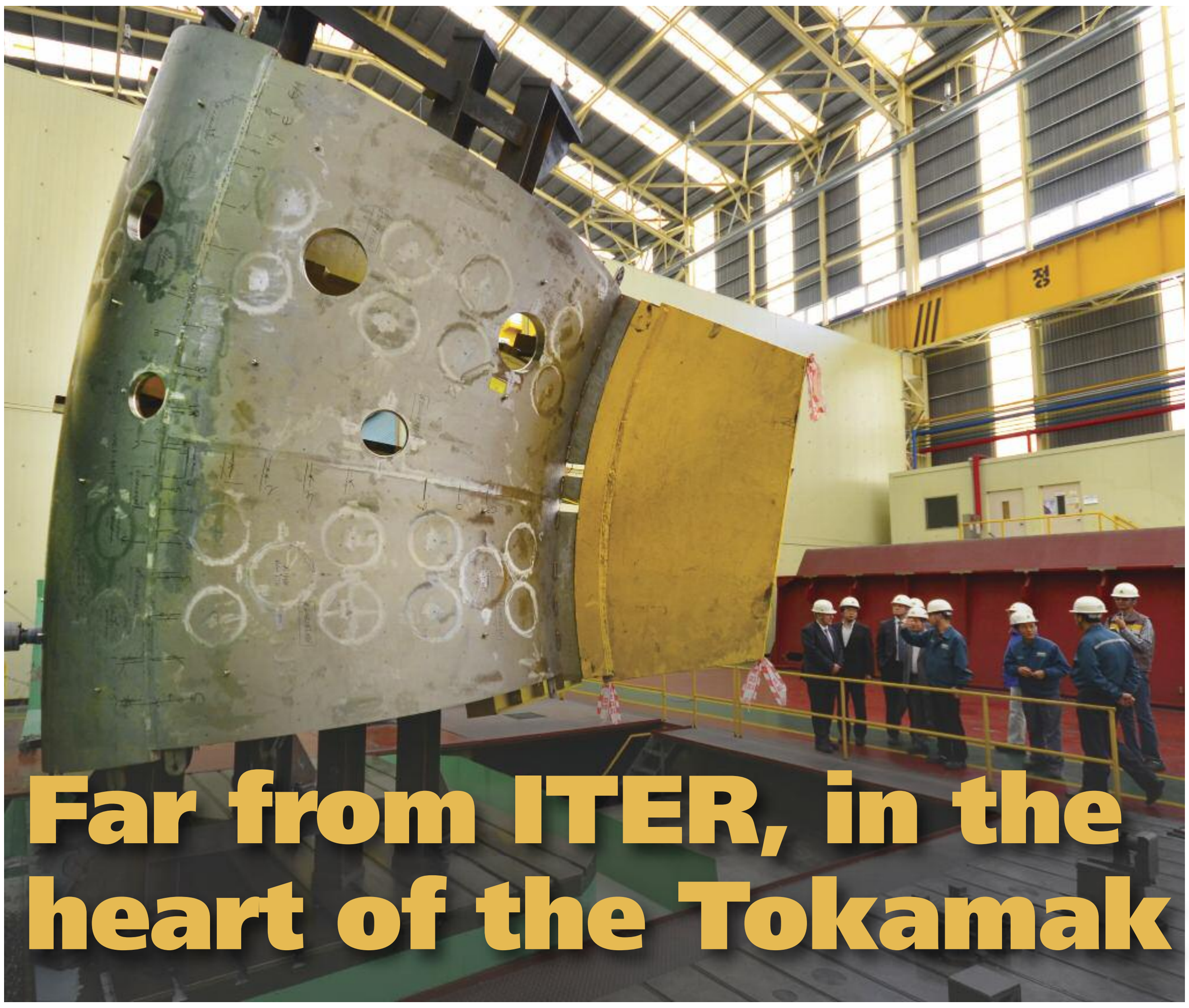
352 wheels, 46 metres long, 9 metres wide, 11 metres high… and 800 metric tons of concrete blocks. ©ITER Organization

The test operation held from 16 to 20 December was the occasion for the public, crowded along the roadside during the four nights of the maiden convoy, to get a sense of the size and weight of the future ITER loads. Not every load will be as impressive as this first, of course – of 230 the convoys that will begin to arrive at ITER starting in the summer of 2014, only 30 will replicate one of the exceptional dimensions of the test convoy (weight, height, width or length), without cumulating them all.

An ITER convoy will not just be a motorized vehicle and its squadron of police escort and technical vehicles snaking along the cordoned-off Itinerary. Several dozen kilometres of deviations will have to be organized; traffic on the motorway will be halted in the middle of the night; hundreds of road signs will be removed, then replaced; and unexpected situations will have to be managed as they arise.

All of these operations were "practiced" from 16-20 September 2013 during the full-scale ITER Itinerary test convoy operation. A second test, this time dedicated exclusively to logistics and organization, will take place in April 2014.

All participants – Agence Iter France, the logistics service provider Daher, the European Domestic Agency for ITER, the French authorities (prefecture, gendarmerie), and ITER Organization – can be congratulated on a job well done. A truly successful maiden journey that must be replicated more than 200 times in the years to come.



Far from ITER, in the heart of the Tokamak

In ITER Member factories on three continents, manufacturing has begun for the components of the ITER Tokamak. Here's a look inside the Hyundai shipyard in Korea where two of the nine ITER vacuum vessel sectors are under construction.

We find ourselves in South Korea. But we could just as well be in China, India, Japan, Europe, Russia or the United States – everywhere that ITER components are coming off of manufacturing lines in the factories of the ITER Members.

In Ulsan, South Korea, an industrial city of 1.5 million inhabitants on the south east coast of the peninsula, Hyundai Heavy Industries (HHI) is owner of a vast shipyard, one of the three largest in the world. Several hundred ships of all sizes and shapes (supertankers, gas carriers, luxury liners, container ships…) are produced here annually.

Not far from the stocking area for the vessels under construction is a vast workshop where a unique piece of equipment is taking shape, unlike anything the company has fabricated previously. Under the tall ceilings of the well-ordered workshop is a large steel structure nearly six metres tall: one of the elements of the ITER vacuum vessel.

The vacuum vessel will be the heart of the ITER machine where, in just a few years, a little Sun will be born within its walls. Not unlike the sections of an orange, the ITER vacuum vessel will be fabricated in nine sectors that, once assembled, will form a torus-shaped structure. Two ITER Members are participating in its fabrication – Korea for two sectors and Europe for nine.

As impressive as the metallic piece before us is, it is only a small upper segment of one of the vacuum vessel sectors under Korean responsibility (see image at right). Once all the completed pieces are welded together, each sector will be 17 metres tall. These giant components will leave Korea by sea, before travelling to the inland ITER site in southern France by self-propelled transporter.

All of the largest ITER components will follow a similar path before their final assembly in the ITER machine: a long ocean voyage followed by three or four nights of transport between the arrival port on the Mediterranean and the ITER site (see article in this issue: "A successful journey…").

For Hyundai Heavy Industries, as for all the industrial companies involved with ITER component fabrication, participating in the ITER adventure is both an organizational and a technical challenge. Much is novel about fabrication for ITER, from the special grade of steel produced especially for the Project, to specialized welding techniques, infinitesimal tolerances and drastic quality control procedures.

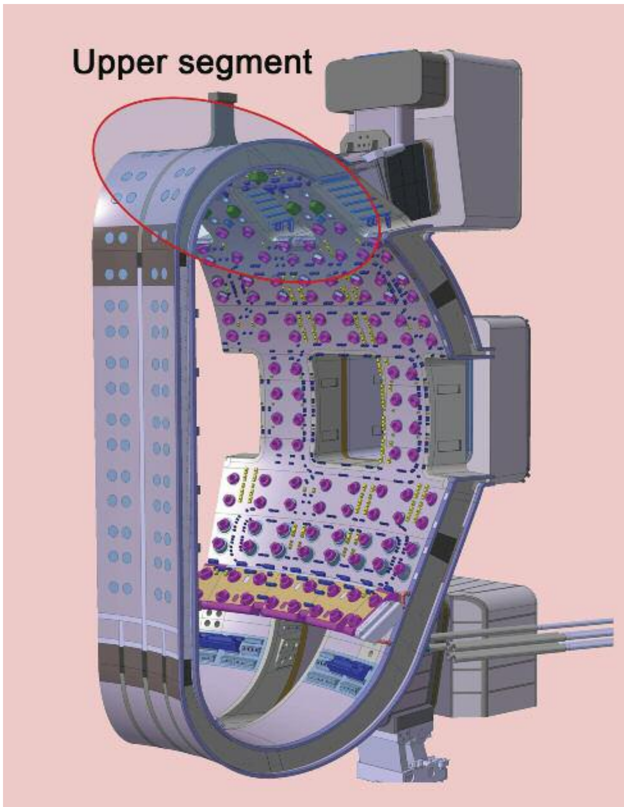
ITER components are high-technological objects with particularly demanding specifications. Those falling under the category of "Safety Important Component" (like the ITER vacuum vessel) must be the object of particular attention and control. Components will have to pass several levels of quality control procedures. In addition to procedures that are part of the suppliers' fabrication processes, the components will be inspected and controlled by representatives of the Members' Domestic Agencies, the ITER Organization, and – as the machine will operate in France – experts authorized by French nuclear authorities. (Representatives from the French Nuclear Safety Agency, ASN, will visit Hyundai's Ulsan plant in January 2014.)

Fabricating a "piece" of ITER requires submitting to a certain number of obligations for the supplier. But the benefits are clear: by participating in the fabrication of high-tech ITER components, companies have the opportunity to acquire a knowledge base and experience that is precious for its other areas of their activity as well as for future contracts in the domain of fusion.

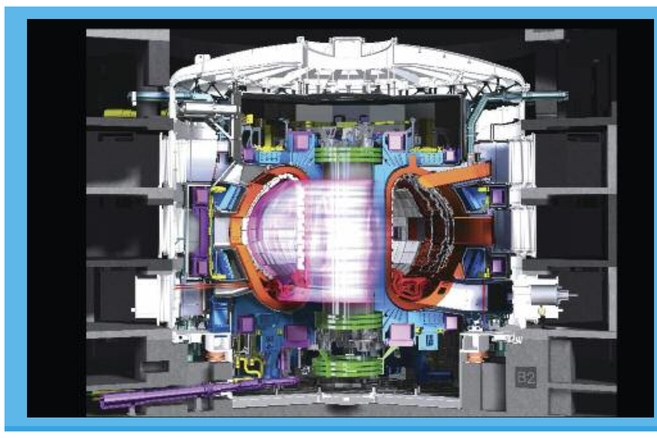
Byung-Ryul Roh, director of Hyundai's Nuclear Energy Department, agrees: "For our company the ITER contract can be considered 'small,' even if it represents the value of two supertankers. But for the knowledge acquired and the prestige of participating in ITER fabrication, it is a very important contract."

Nearly 10,000 kilometres separate the banks of the Durance River, near ITER, and the Sea of Japan, which the South Koreans call the East Sea. The ITER Project has built a bridge between the two, just as it builds other bridges with China, India, Japan, Russia, the United States and the different nations of Europe where components as technically challenging as the vacuum vessel are currently being fabricated.

Soon, the pieces of this gigantic puzzle will be assembled in Saint Paul-lez-Durance, France. ITER will have then accomplished the first part of its mission – reuniting a large number of the world's nations around a common project – before opening the way to a new source of energy, one that is capable of satisfying, for centuries to come, the energy needs of humanity.



The six-metre-tall structure currently on the shop floor in Ulsan is only the small upper segment of one of the nine ITER vacuum vessel sectors. © ITER Organization



Welcome to the machine!

Tokamak: the name is an acronym from the Russian "toroidal chamber, magnetic coils." It describes a type of particularly efficient fusion machine that was developed by Soviet research in the late 1960s and adopted worldwide during the following decade.

ITER will be the largest and most powerful tokamak ever built. It is an assembly of 15 major systems, one million components and some 10 million individual parts (each one identified by a unique number for assembly purposes).

The assembly of the ITER Tokamak will begin in 2015 as the first components are delivered to the ITER site. The delicate process of installing and aligning parts weighing up to 1,250 tons, within absolutely minimal tolerances, will last about five years.

Where are we at?

On this elevated 42-hectare platform in southern France, 35 nations are pooling their resources to build ITER. © ITER Organization

On a vast plot of land in southern France, the ITER scientific installation is taking shape. Let's take stock of construction progress, three years after works began.

Saint Paul-lez Durance, France, 4 August 2010: A giant excavator scrapes at the hard earth on the exact location where the ITER Tokamak and its supporting facilities will be constructed. This first day of digging is followed by hundreds of others: some 230,000 cubic metres of rock must be dug out or dynamited and removed in order to make room for the reinforced concrete box that will protect the ITER machine.

Only a few hundred metres away, worksite vehicles are levelling a 14,000 square metre area for the foundations of the huge Poloidal Field Coils Winding Facility (257 metres long, 49 metre wide and 20 metres tall). This factory will house the on-site manufacturing line for four of ITER's poloidal field coils – huge, annular coils that, with diameters ranging from 8 to 24 metres, are too bulky to be transported from any off-site facility. (Two other poloidal field coils are small enough to be manufactured in Russia and China and shipped.)

Three years and several months later, the lunar landscape of the ITER platform of 2008-2009 is a thing of the past. In its place: a busy construction site, crisscrossed by cranes, cement trucks, loaders, bulldozers and other heavy machinery in continuous motion.

The 17-metre-deep Seismic Pit is now equipped with two concrete "floors": the first, completely covering the raw rock surface, shoulders the 493 seismic columns and pads the will protect the ITER scientific installation in the case of an earthquake. The second, anchored on top of the seismic pads, forms the floor of the Tokamak Complex, a suite of three buildings estimated at 360,000 metric tons – nearly the weight of the Empire State Building.

The Poloidal Field Coils Winding Facility, completed and handed over in February 2012, will soon be equipped with tooling and equipment for the different stages of poloidal field coil fabrication (winding, insulation, assembly). Produced in Europe, China and Russia, dozens of kilometres of niobium-titanium superconductor – the raw material for the coils – will be delivered on large spools to the southern entrance of the building. When the annular-shaped coils exit from the opposite end 18-24 months later, they will weigh between 200 and 400 metric tons.

Like the other ITER components, the poloidal field coils will pass through the Assembly Building before being integrated into the machine. This 6,000 square-metre hall will house specialized tooling for the manipulation and pre-assembly of the Tokamak components. The building's concrete basemat has now set; over two metres thick in some places, it was sized to support the weight of the very heavy tooling and overhead cranes that will be required to manipulate loads of up to 1,500 metric tons.

The largest single load of Tokamak assembly will be the base of the cryostat. The cryostat is a large vacuum container that will completely surround the Tokamak and its magnet systems, providing the cold environment necessary for operation (-269 °C). This key component will be installed in four large segments; the heaviest of the four, the cryostat base, will weigh 1,250 metric tons.

The four cryostat segments will be assembled from 54 smaller sections in an on-site workshop that is under construction on the northeast corner of the ITER platform. Situated in direct sight of the Assembly Building at a distance of only a hundred metres, the mammoth cryostat segments will leave the workshop on a tractable platform along rails. The Cryostat Workshop, unlike the other platform buildings that are supplied by Europe as part of its contribution to the ITER Project, falls under the responsibility of India, part of the Indian procurement of the cryostat.

As the year 2013 draws to a close, the completed Seismic Pit, the Poloidal Field Coils Winding Facility, the Assembly Building and the Cryostat Workshop are the four emblematic construction projects on the ITER platform in southern France. Before the end of ITER Construction, there will be a total of 39 buildings on the 42-hectare platform.

Beginning in 2015, the assembly and installation of the ITER Tokamak will mobilize a considerable workforce in addition to the numbers required for continued construction activities. It is estimated that at the peak of activities (2015-2017), over 3,000 workers, technicians and engineers will work for the realization of ITER.

Two of the emblematic construction projects on the ITER platform in late 2013: a winding facility for the massive poloidal field coils (in red) and the Cryostat Workshop (at right). © ITER Organization

Serving science, serving peace

ITER has always been more than an international research project. When in the early 1980s scientists urged for the construction of a large machine that would demonstrate the feasibility of fusion energy – the energy of the Sun and stars – world leaders were looking for a project that would unite the nations of the world in a common, enthralling and peaceful venture.

A decisive political initiative, in 1985, opened the way for the realization of this double aspiration. At their first meeting in Geneva, Ronald Reagan and Mikhail Gorbachev agreed to launch an international effort to develop fusion energy research *"as an inexhaustible source of energy for the benefit of mankind."*

Soon, the original ITER members (the US; the Soviet Union; the European Union plus Switzerland; and Japan) were joined by China, Korea and India. By 2005, ITER reunited 34 countries representing more than half the world's population and 80% of the planet's industrial product.

On 28 June 2005, the ITER Members unanimously agreed to build ITER in southern France, 75 kilometres north of Marseille. A little more than two years later, an international treaty formally established the ITER Organization.

Over the six years of its existence, the ITER Organization has realized the double aspiration of the 1980s: the scientific installation that will open the way to an unlimited source of energy is now under construction, and the men and women of some 30 nations are inventing, day after day, a unique form of collaboration – one that serves science as much as it serves peace.

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