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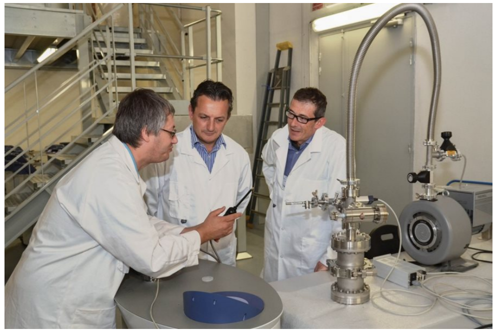
Featured

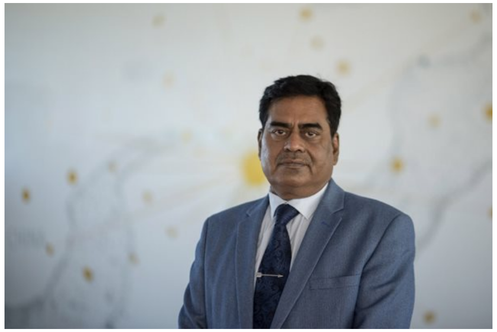
Vacuum | The art and science of cleanliness in a fusion reactor



(https://www.iter.org/newsline/-/3470)

Just as a few dust particles in a semiconductor fabrication plant can limit manufacturing yield, dust and other impurities inside a tokamak can limit fusion output. The ITER vacuum team is instituting a range of cleanliness protocols and processes at such an unprecedented scale that they are likely to inform the choices made for future reactors. Creating and maintaining the plasma in a fusion reactor requires not only an ultra-high vacuum, but also ultra-clean surfaces. Contamination present on vacuum-facing surfaces can be released through a process known as outgassing. When vacuum facing surfaces are heated—either intentionally (for cleaning) or unintentionally (when the plasma touches walls)—the outgassing process accelerates. The challenge is to keep vacuum facing components so clean that the impurities released through unintentional outgassing do not significantly reduce fusion output. The right materials and the right processes The first step in achieving the required level of cleanliness is choosing the right materials—an exercise that began more than a decade ago at ITER during the design phase of vacuum-important components. 'Each material has its own characteristics in vacuum,' says Liam Worth, Group Leader for Vacuum Transverse Activities. 'Vacuum-compatible materials that are suitable for semiconductor fabrication are not necessarily suitable for fusion—and vice-versa. We look for materials with very low outgassing rates, very low vapor pressures and compatibility with machine operations.' 'In order to characterize materials and ensure compatibility with ITER operations we run outgassing tests almost continuously on the materials. We also do dry wipe and wet wipe tests on large components to check for gross contamination—we simply rub the surface with a lint-free cloth and see what comes off. To the untrained eye, the cloth may seem relatively clean. But even the slightest speck of gray represents hundreds of millions of particles.' Selecting the right materials is important, but so is controlling the processes that those materials have been subjected too. All installed surfaces facing the vacuum and any constituent parts must be kept free of contaminants, such as oils, greases, and packing residues. Vacuum-important components must be kept clean during the transport, unpacking and assembly phases. 'We work to a philosophy of continual cleanliness,' says Robert Pearce, Section Leader of the Vacuum Delivery & Installation Section. 'For instance, our Assembly Hall is a clean room, so that when we assemble vacuum components, we assemble them in a clean environment. Then we put controls on the actions that people take on those components. It's not super high-tech stuff. It's more about procedures and routines, including requiring people to wear coveralls, gloves, and clean overshoes.' A different focus for cleanliness after assembly Once components are assembled, a number of techniques will be used to ensure the cleanliness of the vacuum vessel—a set of processes known as conditioning. One technique is simply baking: heating the walls of the vacuum vessel at 200 °C for several days will significantly reduce moisture and hydrocarbons on the surfaces. 'In addition to heating we pump the vacuum vessel to remove the outgassing species,' says Pearce. 'If you don't pump, the dirt comes off one surface, and then sticks to any cooler surface it might hit. As outgassing rate is strongly dependent on temperature, when we drop the temperature of the surfaces the outgassing rate also drops.' 'We will also likely use a technique called glow discharge cleaning, which involves bombarding the walls with cold plasma. Beyond glow discharge cleaning, we can also use a higher energy tokamak plasma for cleaning. Normally when you run, you try to confine particles so they stay away from the walls. But if you want to clean the wall, you can actually run plasma along the surface.' 'Another technique is to create radiofrequency-excited discharges to clean the walls,' says Pearce. 'These discharges desorb impurities that can then be pumped out.' From experimental reactors to commercial fusion One can never be too obsessive when it comes to keeping a tokamak clean. Two incidents at one of ITER's predecessors highlight how a seemingly small mistake can have a huge impact. The first case involved a small piece of cable left inside a vacuum chamber, which prevented the reactor from operating for several weeks. In the second case, a piece of tape was left on a wall in the vacuum vessel. It took months to identify the issue and to get the reactor operating again at full performance. 'When you find the piece of tape, the problem is obvious,' says Worth. 'But when you have a vacuum problem, especially one that is associated with contamination, you have various pieces of evidence from different sources—for example, a pump doesn't work or you see a bit of titanium where it shouldn't be. It's like a detective story. You know you will find the answer eventually. Sometimes you get it right away; other times it might take months to find.' 'One of the most sensitive measurements of contamination is the plasma itself,' says Worth. 'Different diagnostic instruments look at the radiation from the plasma for example. But we also have our own vacuum instrumentation where we can look at what we call the residual gas, gas that is present in the vacuum vessel after pumping and conditioning. We can do this in between pulses to determine the cleanliness of the vacuum.' Ultimately, the goal of the vacuum team is to learn what it takes to achieve the required level of cleanliness and to drive cleaning processes towards industrial application. Much has already been gained from the experiences at JET and other fusion reactors. But because ITER is a different machine (it is pumped differently and it lends itself to different cleaning techniques), there is still more to learn. 'What we learn now can positively impact DEMO and commercial reactors,' says Pearce. 'Sustainable fusion will come faster if we learn and apply the lessons from the past and present, including simple things like cleanliness.'

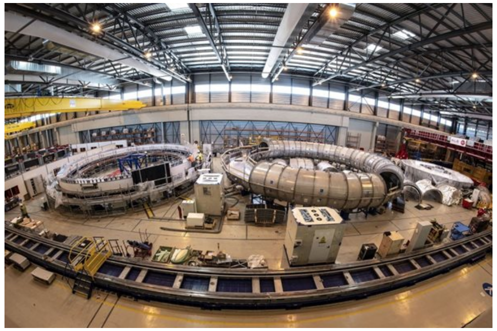
Top management | Nalinish Nagaich, Head of Corporate



(https://www.iter.org/newsline/-/3471)

For the past six decades, Nalinish Nagaich and the Indian nuclear power program have followed a parallel timeline: Nalinish, who was recently appointed Head of the ITER Corporate Domain, was born in 1959 when India completed the definition of its nuclear road map for the second half of the century, and he began working as a nuclear engineer when India faced the immense challenge of developing its own 'indigenous reactor' in the early 1980s . Nalinish defines himself as 'a nuclear professional who moved from one functional area to another' throughout the whole of his career in India's nuclear establishment. A young chemical engineer at the Rajasthan Atomic Power Station (a CANDU reactor) in 1981, he quickly rose through the ranks, playing an important role in the construction, commissioning and operation of another plant at Narora in Uttar Pradesh, before going back to the Rajasthan site to lead training and technical services in the early 2000s and moving, in the following decades, to high-level corporate functions at the Nuclear Power Corporation of India Ltd (NPCIL). 'I was fortunate to work in many different fields, both technical and managerial, and I guess it has made me 'compatible' with people and new environments.' The career of this engineer-turned-technocrat culminated in 2015 with a position as director of human resources, corporate planning and corporate communication—the 'number two' job at NPCIL. And then came ITER. 'I've always had a passion for working in frontier technology. Forty years ago, the frontier was fission and I've explored it with passion. Today, it is fusion, with its formidable intellectual and technological challenges.' To ITER, Nalinish brings wide and diverse experience, accumulated over forty years in commercial nuclear power plant development and management. But more than competencies, the new Head of the ITER Corporate Domain brings to his present position an approach and a philosophy. 'I believe in learning, even when the learning curve is quite steep. And for a fission man in a fusion environment, it certainly is.' The fission man however instantly 'felt at home' when he passed the gates of ITER. 'I was elated,' he confides. 'Of course I had seen photos, but being here, in this first-of-a-kind fusion facility... to see it with my own eyes, to watch the cryostat base travel through the assembly and crane halls... These are visions you only have in your dreams.' Nalinish's portfolio at ITER is a particularly large one, as he oversees human resources, finance, procurement and contracts, information technology, and project control. But he is confident that his journey from fission to fusion will be a rich, exciting and intellectually rewarding one. 'In a way, ITER is a lot like India. Both are multicultural societies that achieve unity through diversity. And this is a tremendous asset.'

Ring coils | A fisheye view



(https://www.iter.org/newsline/-/3472)

Three poloidal field coils are now present in Europe's on-site winding facility. To the far left of this fisheye image, poloidal field coil #5 (PF5), whose fabrication was launched in August 2017, has entered the final assembly phase and is being equipped with helium piping and electrical cables prior to cold test operations. At the opposite end of the frame, half-hidden under the red gantry crane, the recently delivered PF6 is being readied for a cold test campaign that is scheduled to begin in August. A cryogenic chamber for cold testing, partly open, is visible to the right. Cold testing consists in bringing down the coil's temperature to 80 K (minus 193 °C) in order to verify that the insulation is robust and that the component can be cooled to superconducting temperatures without incurring the formation of cracks. The same diameter (17 metres) as PF5 but considerably lighter (204 tonnes versus 342 tonnes), PF2 occupies the centre of the image. Workers are presently assembling a tight mould around the coil for the resin impregnation phase, set to begin in the coming weeks. Once impregnated, PF2 will be fitted with additional equipment (joints, clamps, etc.) and also cold tested. In addition to the three fully formed poloidal field magnets visible in this image, work has begun far to the left on the preparatory activities for

PF4 (24 metres in diameter, 350 tonnes). A dummy double pancake must be completed before actual fabrication is launched this summer. Also see this report on the Fusion for Energy website.

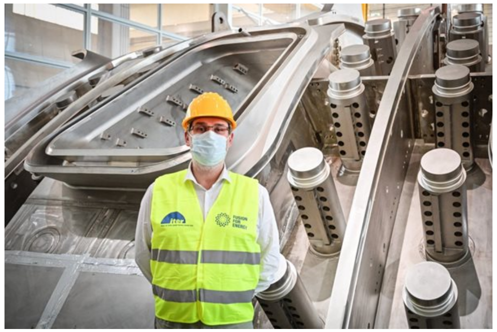
ITER kicks off assembly | President Macron to host virtual celebration

(https://www.iter.org/newsline/-/3473)

On Tuesday 28 July, French President Emmanuel Macron and government leaders from China, Europe, India, Japan, Korea, Russia and the United States will celebrate the start of assembly at ITER. As Newsline readers well know, massive and complex first-of-a-kind components have been arriving at the ITER construction site in recent months from all over the world. The Tokamak Building and Assembly Hall are united. The cryostat base is installed. The cryostat lower cylinder and poloidal field coils #5 and #6 are on hand. The requisite assembly tools are largely in place. This week, the first sector of the ITER vacuum vessel will arrive in France from Korea. Together with two toroidal field coils and sections of the silver-coated protective thermal shield, all components needed to create the first Tokamak sub-assembly will now physically be in France. Machine assembly can begin. The event will be live-streamed, in three parts (all times listed are French local times):- 10:00 a.m. — Tour of the ITER worksite and large components on site- 11:00 a.m. — Ceremony, including statements by world leaders- 12:30 a.m. (or following the ceremony) — Press conference We will have a full report in Newsline on 29 July. On Tuesday 28 July, 10:00 a.m. (local French time) the livestream will begin below.

Of-Interest

Making headway on the vacuum vessel in Europe



(https://www.iter.org/of-interest/933)

In a report published this month, the European Domestic Agency for ITER, Fusion for Energy, explains how progress was maintained on the fabrication of five ITER vacuum vessel sectors despite some factory shutdowns due to Covid-19. 'We had to analyze the impact of the pandemic on our production plants, figure out which tasks could be performed in line with the instructions issued by the Italian authorities, and adopt measures of health and safety in line with this new reality. Therefore, we re-arranged the planning of activities, prioritised some critical ones. We put forward a short-term plan to keep up the progress, while ensuring full compliance with protocols,' explains Max Febvre, Fusion for Energy Manufacturing Project Manager for the vacuum vessel. As a result, the impact of the pandemic was not as disruptive as expected. See a full report plus recent photos here.

European Fusion Teacher Day 2020

(https://www.iter.org/of-interest/932)

Secondary school teachers across Europe are invited to participate virtually in the 2020 European Fusion Teacher Day, hosted by FuseNet, the European Fusion Education Network. Registration for the event on 2 October is free of charge and open now. The European Fusion Teacher Day will premiere new education materials for the classroom, offer a behind-the-scenes look at international fusion experiments such as ITER, JET and GOLEM, and host a live connection with teachers throughout Europe. At the end of the event you will be able to tell your students all about nuclear fusion: from the cutting-edge research that is going on, to how to make fusion a career! For the first part of the event, participants will join video calls in the language of their choice, hosted by fusion institutes in Austria, Bulgaria, the Czech Republic, France, Germany, the Netherlands, Portugal, Slovenia, Spain, Sweden, Ukraine, and the United Kingdom. An introductory lecture followed by a presentation of newly developed classroom materials will be the highlights of this part of the program. Then, all participants will tune into a livestream (in English) with fusion students and scientists located on site at three tokamak facilities: ITER, JET and GOLEM. For more information on how to participate, see FuseNet.

Publication

ITER Organization 2019 Annual Report

(https://www.iter.orghttp://e.issuu.com/embed.html?d=2019_iter_annual_report&u=iterorganization)

Press

Experts measure the tritium retained inside dust particles produced in a tokamak

(https://www.iter.orghttps://fusionforenergy.europa.eu/news/experts-measure-the-tritium-retained-inside-dust-particles-produced-in-a-tokamak/)

Self-healing fusion components could lead to better reactor designs

(https://www.iter.orghttps://ccfe.ukaea.uk/self-healing-fusion-components-could-lead-to-better-reactor-designs/)

РФ продолжает отправку оборудования для ИТЭР

(https://www.iter.orghttp://energo-news.ru/archives/158232)

Massive ITER magnets in full production

(https://www.iter.orghttps://fusionforenergy.europa.eu/news/massive-iter-magnets-in-full-production/)

The Mammoth Magnets That Could Help Make Nuclear Fusion A Reality

(https://www.iter.orghttps://www.forbes.com/sites/mitsubishiheavyindustries/2020/07/13/the-mammoth-magnets-that-could-help-make-nuclear-fusion-a-reality/#4add19a45eb5)

All port cell doors installed inside the ITER castle

(https://www.iter.orghttps://fusionforenergy.europa.eu/news/all-port-cell-doors-installed-inside-the-iter-castle/)

В ИТЭР из Кореи отправлен сектор вакуумной камеры с российским верхним патрубком

(https://www.iter.orghttp://www.atominfo.ru/newsz01/a0864.htm)

Iter / Final Segments Of Key Component Ready For Shipping From India

(https://www.iter.orghttps://www.nucnet.org/news/final-segments-of-key-component-ready-for-shipping-from-india-7-2-2020)

Indian firm completes ITER cryostat manufacture

(https://www.iter.orghttps://www.world-nuclear-news.org/Articles/India-completes-ITER-cryostat-manufacture)

皖产"超导线圈"越洋赴法国 国际热核聚变实验堆ITER迎来核心部件

(https://www.iter.orghttp://www.pinlue.com/article/2020/07/0711/4810984184241.html)

Europe's industrial partners of ITER Vacuum Vessel stand up to coronavirus

(https://www.iter.orghttps://fusionforenergy.europa.eu/news/europes-industrial-partners-of-iter-vacuum-vessel-stand-up-to-coronavirus/)