



Is Iran Mass Producing Advanced Gas Centrifuge Components?

Can we even know with the way the Iran deal has been structured and implemented so far?

By David Albright and Olli Heinonen^{1,2}

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The head of Iran's nuclear program says Iran has the capability to initiate mass production of advanced centrifuges on short notice. The mass production of these centrifuges (or their components) would greatly expand Iran's ability to sneak-out or breakout to nuclear weapons capability or surge the size of its centrifuge program if the deal fails or after key nuclear limitations end. If Salehi's statement is true, Iran could have already stockpiled many advanced centrifuge components, associated raw materials, and the equipment necessary to operate a large number of advanced centrifuges. The United States and the International Atomic Energy Agency (IAEA) need to determine the status of Iran's centrifuge manufacturing capabilities, including the number of key centrifuge parts Iran has made and the amount of centrifuge equipment it has procured. They need to ensure that Iran's centrifuge manufacturing is consistent with the intent of the nuclear deal as well as the deal's specific limitations on advanced centrifuges. Moreover, the Iranian statement illuminates significant weaknesses in the Iran deal that need to be fixed.

In early April 2017, Ali Akbar Salehi, the head of the Atomic Energy Organization of Iran, stated in a recorded interview that Iran is in a condition that it can mass produce IR2-M, IR-4 and IR-6 centrifuges "at will" if it decides to snapback should "the other side violate its commitment."³ Iranian print media subsequently reported him as stating that mass production of advanced centrifuges has already been initiated. In our original report, we used the Iranian print media translation of Salehi's statements.⁴ This mistranslation of Salehi's comment in the recorded interview is also found in the written transcript of his interview prepared by *Tasnim*

¹ Olli Heinonen is a Senior Advisor on Science and Nonproliferation at the Foundation for Defense of Democracies (FDD), and former Deputy Director General of the International Atomic Energy Agency, head of its Department of Safeguards.

² We would like to thank Annie Fixler of FDD for helpful review and editorial comments. We also thank Amir Toumaj at FDD for translating Salehi's comments as part of revising our original report.

³ The full interview with Salehi in Persian is available at Telewebion:

<http://www.telewebion.com/#!/episode/1603388/>

⁴ "AEOI Chief Underscores Nuclear Progress," *Financial Tribune*, April 10, 2017.

<https://financialtribune.com/articles/national/62153/aeoi-chief-underscores-nuclear-progress>

News, where the text can be read as Iran already reaching mass production.⁵ Whatever the actual situation with respect to centrifuge manufacturing, Salehi's comments in the recorded video highlight the need for more rigorous IAEA scrutiny of Iran's centrifuge manufacturing efforts and critical shortcomings in the nuclear deal that need to be remedied.

The mass production of any of these advanced centrifuges (or their components) would greatly expand Iran's ability to sneak-out or breakout to nuclear weapons or surge the size of its centrifuge program if the deal fails or after key nuclear limitations end. Therefore, Salehi's statements deserve careful scrutiny to determine their veracity, and if true, a determination of: where all these components could be made and in what number; how many critical advanced centrifuge components Iran has made; and how much key equipment for advanced centrifuge cascades Iran has stockpiled. Furthermore, the international community needs to understand whether the IAEA is able to verify or disprove whether Iran is mass producing centrifuge components under current arrangements.

JCPOA Centrifuge Limits

The JCPOA limits Iran's capability to make centrifuges. In particular, Iran has committed:⁶

"Consistent with its enrichment and enrichment R&D plan, Iran will only engage in production of centrifuges, including centrifuge rotors suitable for isotope separation or any other centrifuge components, to meet the enrichment and enrichment R&D requirements of this Annex."

Given that Iran's centrifuge program is limited to the operation of tens of advanced centrifuges during the first ten years of the agreement, the manufacturing limitation above would rule out mass production of advanced centrifuge components. It should also rule out any preparation

⁵ The *Tasnim News* written transcript is available at:

<https://www.tasnimnews.com/fa/news/1396/01/20/1374089/%D8%B5%D8%A7%D9%84%D8%AD%DB%8C-%D9%85%D9%88%D9%81%D9%82%DB%8C%D8%AA-%D8%B3%D8%A7%D9%86%D8%AA%D8%B1%DB%8C%D9%81%DB%8C%D9%88%DA%98%D9%87%D8%A7%DB%8C-%D9%81%D8%B1%D8%A7%D8%AA%D8%B1-%D8%A7%D8%B2-%D8%A7%D9%86%D8%AA%D8%B8%D8%A7%D8%B1-%D9%85%D8%A7-%D8%A8%D9%88%D8%AF-5-%D8%B3%D8%A7%D9%84-%D8%AF%DB%8C%DA%AF%D8%B1-%D8%B9%D8%B6%D9%88-%D9%BE%DB%8C%D9%88%D8%B3%D8%AA%D9%87-%D9%BE%D8%B1%D9%88%DA%98%D9%87-%D8%A7%DB%8C%D8%AA%D8%B1-%D9%85%DB%8C-%D8%B4%D9%88%DB%8C%D9%85-%D8%A8%D8%B2%D9%88%D8%AF%DB%8C-%D9%82%D8%B1%D8%A7%D8%B1%D8%AF%D8%A7%D8%AF-%D8%A8%D8%A7%D8%B2%D8%B7%D8%B1%D8%A7%D8%AD%DB%8C-%D8%B1%D8%A7%DA%A9%D8%AA%D9%88%D8%B1-%D8%A7%D8%B1%D8%A7%DA%A9-%D9%86%D9%87%D8%A7%DB%8C%DB%8C-%D9%85%DB%8C-%D8%B4%D9%88%D8%AF> See also "AEOI Chief Underscores Nuclear Progress," *Financial Tribune*, April 10, 2017.

<https://financialtribune.com/articles/national/62153/aeoi-chief-underscores-nuclear-progress>

⁶ JCPOA, Annex 1, Section K. Iran's centrifuge R&D plan can be found in: *Iran's Long-Term Centrifuge Enrichment Plan: Providing Needed Transparency*, Institute for Science and International Security, August 2, 2016. http://isis-online.org/uploads/isis-reports/documents/Irans_Long_Term_Enrichment_Plan_Breakout_2Aug2016_Final.pdf

for the mass production of centrifuges, particularly any activities that involve stockpiling parts, raw materials, and equipment for advanced centrifuges. Iran may argue it is preparing for the post 10-year period when it will be able to produce and install between 2500 to 3500 IR-2m or IR-4 centrifuges (combination of these two models) by the end of year 13, but that argument is at best ridiculous.

Furthermore, prior to the JCPOA, Iran already made at least 1,000 IR-2m centrifuges and installed at Natanz infrastructure for 3,000 IR-2m centrifuges. Iran has also stated in its enrichment R&D plan that redeploying these 1,000 centrifuges, which Iran dismantled and stored at the Natanz Fuel Enrichment Plant pursuant to the JCPOA, will be the first priority when the centrifuge limitations sunset. Iran does not need to prepare to mass produce advanced centrifuges today, and any such effort should be investigated and blocked.

Iran is known to have manufactured more centrifuge rotor assemblies than it is allowed to use in mechanical testing and feed with uranium hexafluoride under the JCPOA. For example, while Iran is currently allowed to operate one IR-8 centrifuge under the JCPOA and Iran's enrichment R&D plan, it is known to have put together more than half a dozen IR-8 rotor assemblies at the Kalaye Electric facility in north Tehran, and it perhaps manufactured rotor tubes and bellows for more. (Figure 1 shows an Iranian rotor tube and bellows made from carbon fiber. Figure 2 shows commercial satellite images of the Kalaye Electric site in 2005 and 2017.) Iran has also reportedly been making more IR-6 and IR-6s centrifuge rotor assemblies than it can operate. These numbers are excessive and inconsistent with the JCPOA. Moreover, in light of Salehi's comments, the excessive production of rotors may be part of a plan to lay the basis for mass production. For example, Iran could be using the more than expected or allowed number of centrifuges to establish a quality assurance program for the mass production of advanced centrifuges. Any such plan is not included in Iran's enrichment plan under the JCPOA.

Another pressing question is whether the IAEA knows the total number of centrifuge rotor assemblies and, most importantly, the true total number of centrifuge rotors and bellows Iran has manufactured or may be making today. Under the JCPOA⁷:

- "Iran and the IAEA will take the necessary steps for containment and surveillance on centrifuge rotor tubes and bellows for 20 years.
- Iran will provide the IAEA with an initial inventory of all existing centrifuge rotor tubes and bellows and subsequent reports on changes in such inventory and will permit the IAEA to verify the inventory by item counting and numbering,⁸ and through containment and surveillance, of all rotor tubes and bellows, including in all existing and newly produced centrifuges.
- Iran will declare all locations and equipment, namely flow-forming machines, filament-winding machines and mandrels **that are used for production of centrifuge rotor tubes or bellows**, and will permit the IAEA to implement continuous monitoring, including

⁷ JCPOA, Annex 1, section R.

⁸ Iran has not stamped the rotors with a number, complicating the IAEA's monitoring of rotor assemblies.

through containment and surveillance on this equipment, to verify that this equipment is being used to manufacture centrifuges only for the activities specified in this JCPOA (emphasis added).”

These commitments are by themselves insufficient to exclude the possibility that Iran simply did not declare all its centrifuge-capable flow forming machines and filament winding machines. It may have declared only those dedicated to current manufacturing of centrifuges. Iran declared centrifuge manufacturing activities at the TABA centrifuge production site near Karaj (see figure 3). The operational status and output of this facility is not reported in the IAEA reports on Iran. Such flow forming and filament winding machines are used in military industries that are present in Iran, and Iran has acquired many of them. Thus, a key question is whether Iran is secretly making centrifuge rotor tubes and bellows at unknown locations, in violation of the JCPOA, and if it takes place, what the probability is that it goes without detection. A related question is whether Iran’s suspicious activities concerning carbon fiber mask secret efforts to procure material abroad for use in undeclared centrifuge rotor tube and bellows manufacturing or for stockpiling to allow a rapid breakout if the deal fails.⁹

The IAEA has the authorities under the JCPOA and the Additional Protocol to investigate these propositions, although it is not known from the IAEA reports whether it has done so. It is known that the IAEA has recently visited the new expanded, albeit not yet operational, centrifuge assembly facility at Natanz which is located near the pilot enrichment plant (see figure 4). However, in the past, key centrifuge manufacturing occurred at Iranian military sites. During 2003-2005 the IAEA conducted short notice inspections at some military workshops to ensure that equipment was not used to produce centrifuge rotor tubes. It is not clear if the IAEA can now access military locations in practice, given that Iran has stated it will not allow the IAEA to access military sites. But to address the concern’s raised by Salehi’s statement, access to military sites is likely necessary. Yet, if the IAEA exercises its rights and asks to go to a military site, will a major confrontation with Iran erupt?

⁹ See for example, *Iranian Atomic Energy Organization Attempted Carbon Fiber Procurement*, by David Albright and Andrea Stricker, Institute Report, July 7, 2016. <http://isis-online.org/isis-reports/detail/iranian-atomic-energy-organization-attempted-carbon-fiber-procurement/8>

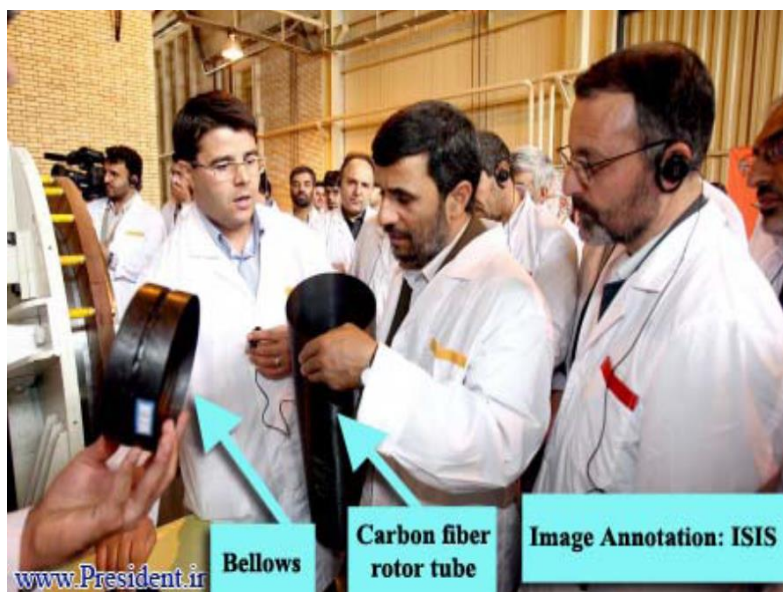


Figure 1 Then President Mahmoud Ahmadinejad holds a carbon fiber rotor tube at the Natanz enrichment site; visible is also a centrifuge bellows, which also appears to have been made from carbon fiber. Credit: Iran's Presidential web site.

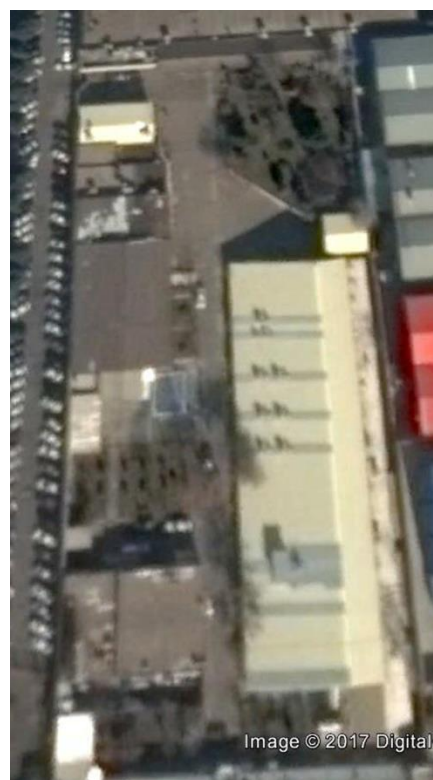


Figure 2 Kalaye Electric facility in Tehran. On right is a close up of most of this facility (minus administration building for example). Here, Iran makes advanced centrifuge rotor tubes and conducts initial testing of rotor assemblies. In particular, the assembly of the rotor of IR-8 centrifuge occurs here. Image sources. Left: Digital Globe and Institute for Science and International Security (ISIS), January 30, 2005. <http://isis-online.org/publications/iran/kalayeelectric.html> Image on the right: Google Earth, April 17, 2017.



Figure 3 In 2011, the People's Mojahedin Organization of Iran revealed the location of one of Iran's centrifuge manufacturing sites, near the city of Karaj, referred to as the TABA site. The components are reportedly made in the three workshops marked in the image on the right.

<http://www.globalsecurity.org/wmd/library/report/2011/iran-secret-site-110407.htm> Image Source: Google Earth, September 26, 2015



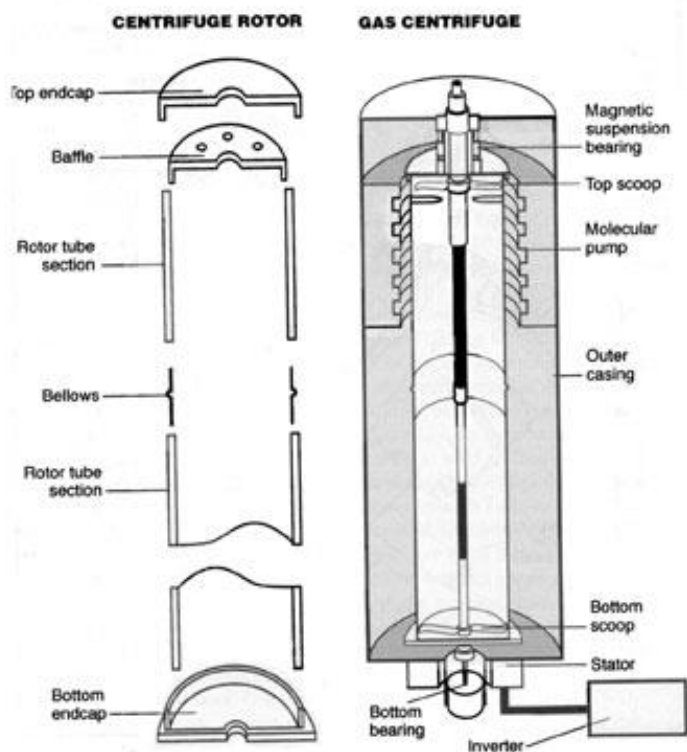
Figures 4 The Natanz enrichment site showing a reported new workshop for rotor assembly and other major centrifuge components near the pilot enrichment plant. The underground cascade halls of the Fuel Enrichment Plant are nearby. Images courtesy Google Earth. See <http://isis-online.org/uploads/isis-reports/documents/Analysis of IAEA Fifth JCPOA Report 3Mar2017 Final.pdf>

What about other centrifuge components?

An advanced centrifuge has roughly 100 components, either made in dedicated centrifuge manufacturing operations or procured from suppliers. The rotor tubes and bellows are critical components. Annex 1 of the Additional Protocol requires Iran to declare the scale of operations for each location engaged in the manufacture of rotor tubes and the assembly of centrifuges; the JCPOA has added bellows to the list of monitored activities. However, the rotor tube and bellows are only two of many components that must be made or procured. Iran must also make the other critical components of the rotor assembly, such as the end caps and baffles

(see figure 5). It must also make the top and bottom bearings, the motor and its housing, the outer casing and molecular pump, and the feed and withdrawal system. Furthermore, Iran must also procure from industrial suppliers in Iran and likely abroad many subcomponents, such as ring magnets and specialized O-rings, frequency converters or their subcomponents, vacuum equipment, such as roots pumps, pressure transducers, subcomponents of valves, and flow meters necessary to operate centrifuges (see figures 6, 7, and 8).

According to the terms of the JCPOA, however, only two components, namely the rotor tubes and bellows, are monitored explicitly by the IAEA. Thus, Salehi is stating that Iran is able to mass produce or rapidly acquire many other centrifuge components in large quantities in addition to the rotor tubes and bellows. The concern is that Iran is making and has already stockpiled many of these components, the raw materials necessary to make components, and/or the equipment required to run a large number of advanced centrifuge cascades.



Source: Albright, D. and Hibbs, M., 'Iraq's shop-till-you-drop nuclear program', *Bulletin of the Atomic Scientists*, vol. 48, no. 3 (Apr. 1992), pp. 32 and 33.

Figure 5 Schematics of a gas centrifuge of the type used by Iran. A rotor assembly is on the left, and a complete centrifuge is represented on the right, where it is illustrated that the bellows connect the rotor tubes together and allow the entire rotor assembly to be flexible and escape destructive resonant vibrations. The IR-8 centrifuge has four rotor tubes and 3 bellows. The IR-2m and IR-6 centrifuges each have two rotor tubes and a single bellows. The IR-6s may have just one rotor tube.



Figure 6 Then-President Mahmoud Ahmadinejad standing by an Iranian advanced centrifuge with a U.S.-manufactured pressure transducer, acquired by Iran illegally several years earlier. Iran cannot make reliable pressure transducers and acquired thousands of them abroad illegally. A critical question is determining how many of these and similar pressure transducers Iran acquired abroad and stockpiled. Credit: Iran's Presidential web site.



Figure 7 A ring magnet used in the top bearing of a centrifuge. Each top bearing uses two ring magnets. Iran obtained tens of thousands of ring magnets for its centrifuges abroad, particularly in Europe and China. It is unknown if Iran makes ring magnets for its centrifuges today or buys them abroad. The P5+1 and the IAEA should learn where Iran obtains ring magnets today and how many it has stockpiled for advanced centrifuges.



Figure 8 A vacuum bellows sealed valve showing subcomponents. On right is a convoluted tube, also called a bellows (which should not be confused with the bellows that is part of a rotor assembly). Iran's centrifuge program had thousands of these bellows made in China, in addition to vacuum valve housings, for its centrifuge program. After receiving the subcomponents, Iran assembled them into vacuum valves, including welding the bellows to the valve top. It is unknown if Iran continues to buy valve subcomponents abroad. The P5+1 and the IAEA should learn how and where Iran makes vacuum valves today and how much it depends on buying subcomponents from abroad.

Conclusion: What to do?

Iran's mass production of advanced centrifuges would allow for a substantial reduction in the time needed to break out and to have a capability to build nuclear weapons. Salehi's statement implies that Iran can rapidly reduce the breakout timeline, if it decides to do so. His comments also serve to highlight profound weaknesses in the JCPOA which include lack of inspector access, highly incomplete knowledge of Iran's centrifuge manufacturing capabilities and output, and too few centrifuge components being accounted for and monitored. As such, several steps should be taken.

The IAEA should on a priority basis carefully determine if Salehi's statement is correct. It should report its findings to the member states of the IAEA. First, the inspectors should address the issue of whether Iran is secretly making rotor tubes and bellows. It should obtain (and verify) a declaration from Iran of all its centrifuge capable flow forming machines and filament winding machines, not just the ones dedicated to centrifuge manufacturing. It needs to do this to develop confidence that Iran is not secretly making centrifuge rotor tubes and bellows.

The United States should request the IAEA to produce more detailed quarterly reporting on its activities. Such information should include whether the IAEA has been able to verify in a timely and conclusive manner the production of centrifuges and their components. The IAEA should also report on assurances it can provide on the absence of clandestine production of such items. It should also include information on where centrifuge components are manufactured, assembled, and tested.

As soon as possible, the United States should raise this issue at the Joint Commission, insisting on stricter accountability of Iran's production of centrifuge rotor tubes and bellows and on the monitoring of additional key centrifuge components identified in Part 1 list of the Nuclear Suppliers Group or subcomponents, raw materials, or equipment known to be critical to the Iranian centrifuge program.¹⁰ The current arrangement is inadequate.

The United States should interpret the JCPOA as currently banning mass or industrial production of any centrifuge components or the procurement of equipment or materials necessary for such deployment of centrifuges. It should also insist that more components be monitored. Between 2003 and 2005, the IAEA monitored many more centrifuge components and centrifuge manufacturing equipment in Iran than the agency is monitoring now. The current provisions of the Additional Protocol do not give tools for full monitoring of such activities, but the Joint Commission should establish caps on centrifuge component manufacturing and assign the monitoring to the IAEA. This monitoring should include determining Iran's inventory of centrifuge components, associated raw materials, and equipment needed to run centrifuges. Those new provisions should be established with the clear recognition that the IAEA will access all manufacturing sites including military workshops. These should also include those used in the past to make centrifuge components to confirm the absence of production of key centrifuge components.

Iranian proposals to the Procurement Working Group for exports to Iran's nuclear and non-nuclear civil industries should be carefully scrutinized as to their potential use in a plan to mass produce centrifuges. If the proposals involve goods or quantities of goods that could contribute to excessive centrifuge production, they should be rejected.

The United States and its allies should boost their efforts to detect and thwart Iran's illicit procurement schemes related to nuclear, missile, or conventional weapons programs. A focus should be on detecting Iranian overseas procurements of centrifuge-related goods, including those that typically are not on control lists but are known to be sought by Iran.

A strict interpretation of the JCPOA is that Iran should not only stop making more advanced centrifuges or their components but also destroy its excess advanced rotor assemblies and components beyond a relatively small number of extra ones that can be used if a centrifuge fails during operation. Such a policy would ensure that Iran cannot commit violations of the JCPOA limits and stockpile the fruits of these violations. For the one IR-8 centrifuges that is currently operating, that may mean having only one extra centrifuge rotor assembly. For the IR-6 and IR-6s centrifuge, which are mostly in small cascades, Iran should stockpile no more than a couple of extra ones.

U.S. and IAEA action is long overdue on tightening the enforcement and monitoring of Iran's centrifuge manufacturing. Iran has a long history of non-compliance on its international

¹⁰ Annex II of the Additional Protocol is a mid-1990s version of the Part 1 list of the Nuclear Suppliers Group, or an earlier of version INFCIRC/254/Part 1. The Joint Commission should use a current version on this INFCIRC.

nuclear commitments and illegally buying centrifuge-related goods abroad. Today, these activities raise concern that Iran can too quickly and easily shorten its breakout time. Salehi's comment provides a way to begin addressing this deficiency in the JCPOA.