Iran's Next Steps: Final Tests and the Construction of a Uranium Enrichment Plant

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On January 10, 2006, Iran started to remove 52 seals applied by the International Atomic Energy Agency (IAEA) for the purpose of verifying the suspension of Iran's P-1 centrifuge uranium enrichment program. The seals were located at Natanz, Pars Trash, and Farayand Technique sites. Iran plans to resume all its activities to build, research, develop, and test the P-1 centrifuge. In taking these actions, Iran has resumed enrichment related activities, crossing a well-established "red line" defined by the IAEA Board of Governors and the agreements between key members of the European Union and Iran. Iran's statements minimizing the significance of its actions divert attention from its renewed effort to enrich uranium and build a centrifuge plant able to make enriched uranium for power reactors or for nuclear weapons.

Iran's Last Technical Hurdle to Building a Centrifuge Plant

A key part of the development of Iran's gas centrifuge program is the operation of a 164-machine cascade at the Pilot Fuel Enrichment Facility (PFEP) at Natanz. The installation of the first such test cascade was finished in the fall of 2003 but it never operated with uranium hexafluoride prior to the start of the suspension in November of 2003. It was not operated during the suspension. Until the start of the suspension, Iran had used uranium hexafluoride in single machine tests and a small cascade of 19 machines. Several of these tests encountered problems.

To operate this cascade at the pilot facility, Iran needs to take several steps before it can introduce uranium hexafluoride into the system. It first has to repair or replace any damaged centrifuges. According to IAEA reports, about 30% of the centrifuges crashed or broke when the cascade was shut down at the start of the suspension. In addition, Iran disconnected some of the pipes and exposed the pipes to humidity which could have caused corrosion. After making necessary repairs, Iran then has to finish connecting all the pipes, establish a vacuum inside the cascade, start the process of turning on the centrifuges and then running them under vacuum for several weeks, and prepare the cascade for operation with uranium hexafluoride. Iran may start enriching uranium in a subset of this cascade sooner, but it could take two or more months to ready the whole cascade for the use of uranium hexafluoride. If Iran does not encounter any significant problems, such as excessive vibration of the centrifuges or leakage of the vacuum, Iran could then introduce uranium hexafluoride into the entire cascade and start enriching uranium. Iran would want to operate the cascade for several more months to ensure that no significant problems develop and gain confidence that it can operate the cascade with uranium hexafluoride. Absent major problems, Iran will need roughly six months to one year to demonstrate successful operation of this cascade.

Once Iran overcomes the last technical hurdle of operating its test cascade, it can duplicate it and create larger cascades. Iran would then be ready to build a centrifuge plant able to produce significant amounts of enriched uranium either for peaceful purposes or for nuclear weapons.

The PFEP can hold a total of six, 164-machine cascades for a total of about 1000 machines, although Iran may build fewer cascades or change the number of centrifuges per cascade. Without major modifications, this facility is unlikely to be used to make significant amounts of highly enriched uranium (HEU) for nuclear weapons.

The Fuel Enrichment Plant

Iran has indicated to the IAEA that it plans to start industrial scale operations soon, which likely means that it plans to install centrifuges or related equipment in the underground buildings of the main Fuel Enrichment Plant (FEP). Until the end of the suspension, Iran had not installed any centrifuges at the FEP, where it plans eventually to install about 50,000 machines. It plans to install the centrifuges in modules of 3,000 machines that would be designed to produce low enriched uranium for power reactors. In a case where just 1,500 of these centrifuges were installed and optimized to produce HEU, these centrifuges could produce enough highly enriched uranium for about one nuclear weapon per year. When completed, the FEP could be used to produce roughly 500 kilograms of weapon-grade uranium annually. At 15-20 kilograms per weapon, that would be enough for 25-30 nuclear weapons per year.

Time to the Bomb

It is difficult to estimate how long it would take Iran to be able to build its first nuclear weapon, assuming Iran makes such a decision. The key to predicting a timetable is understanding the pace and scope of Iran's gas centrifuge program. Prior to the November 2004 suspension, Iran had an estimated 700 assembled centrifuges that were in good condition and usable in centrifuge cascades[1]. Also, Iran has enough disassembled parts for more than a thousand additional P-1 centrifuges. At past rates of production, Iran can make and assemble about 70-100 centrifuges per month, and could therefore have a total of 1,300-1,600 centrifuges by late 2006, if they resume centrifuge manufacturing in January 2006. Combining all these centrifuges into cascades, installing control equipment, building feed and withdrawal systems, and testing the plant would take at least another year.

Given another year to make enough HEU for a nuclear weapon and a few more months to convert the uranium into weapon components, Iran could have its first nuclear weapon in 2009. By this time, Iran is assessed to have had sufficient time to prepare the other components of a nuclear weapon, although the weapon may not be deliverable by a ballistic missile.

This result reflects a worst case assessment, and thus is highly uncertain. Though some analysts at the IAEA believe that Iran could assemble centrifuges quicker, other analysts, including those in the US intelligence community, appear to believe that a date of 2009 would be overly optimistic. They believe that Iran is likely to encounter technical difficulties that would significantly delay bringing a centrifuge plant into operation. Factors causing delay include Iran having trouble making so many centrifuges in that time period or it taking longer than expected to overcome difficulties in operating the cascades or building a centrifuge plant.

[1] By spring 2004, Iran had assembled about 1,140 centrifuge rotors, a reasonable indicator of the number of centrifuges it could possess (see IAEA Director General, "Implementation of the NPT Safeguard Agreement in the Islamic Republic of Iran," International Atomic Energy Agency, June 1, 2004, GOV/2004/34, Annex 1, p. 11). However, only about 500 rotors were good enough to operate in cascades, according to knowledgeable IAEA officials.

According to the September 2004 IAEA safeguards report, after resuming centrifuge manufacturing in June 2004, Iran had assembled and tested about 70 centrifuge rotors by mid-August at the Natanz pilot plant. The November 2004 IAEA report stated that by October 10, 2004, Iran had assembled a total of 135 rotors, bringing the total number of rotors assembled to 1,274. As mentioned above, a large number of these rotors are not usable in an operating cascade.

Iran is believed to have assembled more centrifuges prior to the suspension that began on November 22, 2004. Without more specific information, it is assumed that Iran continued to assemble centrifuges at a similar rate, adding another 70 centrifuges, for a total of 1,345 centrifuges. However, the total number of good centrifuges is estimated as about 700 centrifuges.

With this information, the intelligence estimates can be understood. If Iran ended the suspension, and it made and tested about 70-100 centrifuges per month, it could assemble roughly 630-900 usable centrifuges in about nine months, for a total of 1,300-1,600 centrifuges.