

## Appendix 1 Centrifuge R&D Limitations

Based on discussions at ISIS workshops, several limitations on centrifuge research and development (R&D) were identified that should be placed on an Iranian centrifuge R&D program.

- The speed of the rotor assembly should be limited to no more than 500 m/s
- The total effective rotor assembly length should be no more than 1.2 meters
- The limit on total separative work for a centrifuge is difficult to define in an unambiguous manner. It could also involve data that Iran may view as sensitive or proprietary, complicating a comparison. As an alternative, or a supplement to the approach in the first two bullets, it is possible to define a limit via a theoretical maximum separative capacity, or power, calculation (see appendices 2 and 3). These values would fundamentally depend on rotor speed and length and provide a method of comparison. However, it must be kept in mind that the actual separative capacity could be significantly less, as is the case of the IR-1 centrifuges deployed at Natanz and Fordow. Based on the formula in appendix 2, and the values in the first two bullets, the cap under this approach would be 6.8 swu per year.
- The size of test cascades would be limited; the allowed maximum number of centrifuges in a test cascade would be a small fraction of the number of centrifuge in a cascade designed to produce 5 percent low enriched uranium (LEU). This fraction would account for more advanced machines possibly needing fewer enrichment stages, and thus fewer centrifuges, to produce 3.5-5 percent LEU. In the case of the IR-1 centrifuges, Iran produces 3.5-5 percent LEU in production-scale cascades containing 164-174 centrifuges organized in 15-17 stages, respectively. Test IR-1 cascades typically have involved about 20 or fewer IR-1 centrifuges. The ratio of centrifuges in test cascades (20 IR-1's) to the number in a production-scale cascade (164-174) is about 0.11-0.12. A similar ratio would be developed for advanced centrifuges and would serve to define the maximum number of centrifuges in test cascades.
- The agreement on centrifuge R&D would include a review and adjustment condition that could modify the limits, subject to mutual agreement.
- Iran would declare all nuclear-related centrifuge R&D facilities, including those not using nuclear material, and subject those facilities and activities to additional, agreed upon monitoring.