

APPENDIX C TO PART 110—ILLUSTRATIVE  
LIST OF GASEOUS DIFFUSION ENRICH-  
MENT PLANT ASSEMBLIES AND COM-  
PONENTS UNDER NRC EXPORT LI-  
CENSING AUTHORITY

NOTE—In the gaseous diffusion method of uranium isotope separation, the main technological assembly is a special porous gaseous diffusion barrier, heat exchanger for cooling the gas (which is heated by the process of compression), seal valves and control valves, and pipelines. Inasmuch as gaseous diffusion technology uses uranium hexafluoride ( $UF_6$ ), all equipment, pipeline and instrumentation surfaces (that come in contact with the gas) must be made of materials that remain stable in contact with  $UF_6$ . A gaseous diffusion facility requires a number of these assemblies, so that quantities can provide an important indication of end use.

The auxiliary systems, equipment and components for gaseous diffusion enrichment plants are the systems of plant needed to feed  $UF_6$  to the gaseous diffusion assembly to link the individual assemblies to each other to form cascades (or stages) to allow for progressively higher enrichments and to extract the “product” and “tails”  $UF_6$  from the diffusion cascades. Because of the high inertial properties of diffusion cascades, any interruption in their operation, and especially their shut-down, leads to serious consequences. Therefore, a strict and constant maintenance of vacuum in all technological systems, automatic protection for accidents, and precise automated regulation of the gas flow is of importance in a gaseous diffusion plant. All this leads to a need to equip the plant with a large number of special measuring, regulating, and controlling systems.

Normally  $UF_6$  is evaporated from cylinders placed within autoclaves and is distributed in gaseous form to the entry point by way of cascade header pipework. The “product” and “tails”  $UF_6$  gaseous streams flowing from exit points are passed by way of cascade header pipework to either cold traps or to compression stations where the  $UF_6$  gas is liquified prior to onward transfer into suitable containers for transportation or storage. Because a gaseous diffusion enrichment plant consists of a large number of gaseous diffusion assemblies arranged in cascades, there are many kilometers of cascade header pipework, incorporating thousands of welds with substantial amounts of repetition of layout. The equipment, components and piping systems are fabricated to very high vacuum and cleanliness standards.

The items listed below either come into direct contact with the  $UF_6$  process gas or directly control the flow within the cascade. All surfaces which come into contact with the process gas are wholly made of, or lined

with,  $UF_6$ -resistant materials. For the purposes of this appendix the materials resistant to corrosion by  $UF_6$  include stainless steel, aluminum, aluminum alloys, aluminum oxide, nickel or alloys containing 60 percent or more nickel, and  $UF_6$ -resistant fully fluorinated hydrocarbon polymers.

1. Assemblies and components especially designed or prepared for use in gaseous diffusion enrichment.

#### 1.1 Gaseous Diffusion Barriers

Especially designed or prepared thin, porous filters, with a pore size of 100–1000 Å (angstroms), a thickness of 5 mm or less, and for tubular forms, a diameter of 25 mm or less, made of metallic, polymer or ceramic materials resistant to corrosion by  $UF_6$ , and especially prepared compounds or powders for the manufacture of such filters. Such compounds and powders include nickel or alloys containing 60 percent or more nickel, aluminum oxide, or  $UF_6$ -resistant fully fluorinated hydrocarbon polymers having a purity of 99.9 percent or more, a particle size less than 10 microns, and a high degree of particle size uniformity, which are especially prepared for the manufacture of gaseous diffusion barriers.

#### 1.2 Diffuser Housings

Especially designed or prepared hermetically sealed cylindrical vessels greater than 30 cm in diameter and greater than 90 cm in length, or rectangular vessels of comparable dimensions, which have an inlet connection and two outlet connections all of which are greater than 5 cm in diameter, for containing the gaseous diffusion barrier, made of or lined with  $UF_6$ -resistant materials and designed for horizontal or vertical installation.

#### 1.3 Compressors and Gas Blowers

Especially designed or prepared axial, centrifugal, or positive displacement compressors, or gas blowers with a suction volume capacity of 1 m<sup>3</sup>/min or more of  $UF_6$ , and with a discharge pressure of up to several hundred kN/m<sup>2</sup> (100 PSI), designed for long-term operation in the  $UF_6$  environment with or without an electrical motor of appropriate power, as well as separate assemblies of such compressors and gas blowers. These compressors and gas blowers have a pressure ratio between 2/1 and 6/1 and are made of, or lined with, materials resistant to  $UF_6$ .

#### 1.4 Rotary Shaft Seals

Especially designed or prepared vacuum seals, with seal feed and seal exhaust connections, for sealing the shaft connecting the compressor or the gas blower rotor with the driver motor so as to ensure a reliable seal against in-leaking of air into the inner chamber of the compressor or gas blower

which is filled with UF<sub>6</sub>. Such seals are normally designed for a buffer gas in-leakage rate of less than 1000 cm<sup>3</sup>/min.

#### 1.5 Heat Exchangers for Cooling UF<sub>6</sub>

Especially designed or prepared heat exchangers made of or lined with UF<sub>6</sub> resistant materials (except stainless steel) or with copper or any combination of those metals, and intended for a leakage pressure change rate of less than 10 N/m<sup>2</sup> (0.0015 PSI) per hour under a pressure difference of 100 kN/m<sup>2</sup> (15 PSI).

2. Auxiliary systems, equipment and components especially designed or prepared for use in gaseous diffusion enrichment.

#### 2.1 Feed Systems/Product and Tails Withdrawal Systems

Especially designed or prepared process systems, capable of operating at pressures of 300 kN/m<sup>2</sup> (45 PSI) or less, including:

1. Feed autoclaves (or systems), used for passing UF<sub>6</sub> to the gaseous diffusion cascades;
2. Desublimers (or cold traps) used to remove UF<sub>6</sub> from diffusion cascades;
3. Liquefaction stations where UF<sub>6</sub> gas from the cascade is compressed and cooled to form liquid UF<sub>6</sub>;
4. "Product" or "tails" stations used for transferring UF<sub>6</sub> into containers.

#### 2.2 Header Piping Systems

Especially designed or prepared piping systems and header systems for handling UF<sub>6</sub> within the gaseous diffusion cascades. This piping network is normally of the "double" header system with each cell connected to each of the headers.

#### 2.3 Vacuum Systems

(a) Especially designed or prepared large vacuum manifolds, vacuum headers and vacuum pumps having a suction capacity of 5 m<sup>3</sup>/min or more.

(b) Vacuum pumps especially designed for service in UF<sub>6</sub>-bearing atmospheres made of, or lined with, aluminum, nickel, or alloys bearing more than 60 percent nickel. These pumps may be either rotary or positive displacement, may have fluorocarbon seals, and may have special working fluids present.

#### 2.4 Special Shut-Off and Control Valves

Especially designed or prepared manual or automated shut-off and control bellows valves made of UF<sub>6</sub> resistant materials with a diameter of 4 cm to 1.5 m for installation in main and auxiliary systems of gaseous diffusion enrichment plants.

#### 2.5 UF<sub>6</sub> Mass Spectrometers/Ion Sources

Especially designed or prepared magnetic or quadrupole mass spectrometers capable of

taking "on-line" samples of feed, product or tails, from UF<sub>6</sub> gas streams and having all of the following characteristics:

- (a) unit resolution for mass greater than 320;
- (b) ion sources constructed of or lined with nichrome or monel or nickel plated;
- (c) electron bombardment ionization sources;
- (d) having a collector system suitable for isotopic analysis.

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### APPENDIX D TO PART 110—ILLUSTRATIVE LIST OF AERODYNAMIC ENRICHMENT PLANT EQUIPMENT AND COMPONENTS UNDER NRC EXPORT LICENSING AUTHORITY

NOTE—In aerodynamic enrichment processes, a mixture of gaseous UF<sub>6</sub> and light gas (hydrogen or helium) is compressed and then passed through separating elements wherein isotopic separation is accomplished by the generation of high centrifugal forces over a curved-wall geometry. Two processes of this type have been successfully developed: the separation nozzle process and the vortex tube process. For both processes the main components of a separation stage included cylindrical vessels housing the special separation elements (nozzles or vortex tubes), gas compressors and heat exchangers to remove the heat of compression. An aerodynamic plant requires a number of these stages, so that quantities can provide an important indication of end use. Because aerodynamic processes use UF<sub>6</sub>, all equipment, pipeline and instrumentation surfaces (that come in contact with the gas) must be made of materials that remain stable in contact with UF<sub>6</sub>. All surfaces which come into contact with the process gas are made of or protected by UF<sub>6</sub>-resistant materials; including copper, stainless steel, aluminum, aluminum alloys, nickel or alloys containing 60% or more nickel and UF<sub>6</sub>-resistant fully fluorinated hydrocarbon polymers.

The following items either come into direct contact with the UF<sub>6</sub> process gas or directly control the flow within the cascade:

#### (1) Separation nozzles and assemblies.

Especially designed or prepared nozzles that consist of slit-shaped, curved channels having a radius of curvature less than 1 mm (typically 0.1 to 0.05 mm). The nozzles are resistant to UF<sub>6</sub> corrosion and have a knife-edge within the nozzle that separates the gas flowing through the nozzle into two fractions.

#### (2) Vortex tubes and assemblies.

Especially designed or prepared vortex tubes that are cylindrical or tapered, made of or protected by materials resistant to UF<sub>6</sub> corrosion, have a diameter of between 0.5 cm and 4 cm, a length to diameter ratio of 20:1