in particular adapted so as to avoid criticality and radiation effects and to minimize toxicity hazards.

(7) Process control instrumentation specially designed or prepared for monitoring or controlling the processing of material in a reprocessing plant.


APPENDIX J TO PART 110—ILLUSTRATIVE LIST OF URANIUM CONVERSION PLANT EQUIPMENT AND PLUTONIUM CONVERSION PLANT EQUIPMENT UNDER NRC EXPORT LICENSING AUTHORITY

NOTE—Uranium conversion plants and systems may perform one or more transformations from one uranium chemical species to another; including: conversion of uranium ore concentrates to UO3, conversion of UO3 to UO2, conversion of uranium oxides to UF4 or UF6, conversion of UF4 to UF6, conversion of UF6 to UF4, conversion of UO3 to uranium metal, and conversion of uranium fluorides to UO2. Many key equipment items for uranium conversion plants are common to several segments of the chemical process industry, including furnaces, rotary kilns, fluidized bed reactors, flame tower reactors, liquid centrifuges, distillation columns and liquid-liquid extraction columns. However, few of the items are available "off-the-shelf"; most would be prepared according to customer requirements and specifications. Some require special design and construction considerations to address the corrosive properties of the chemicals handled (HF, F2, ClF3, and uranium fluorides). In all of the uranium conversion processes, equipment which individually is not especially designed or prepared for uranium conversion can be assembled into systems which are especially designed or prepared for uranium conversion.

(a) Uranium Conversion Plant Equipment.

(1) Especially designed or prepared systems for the conversion of uranium ore concentrates to UO3.

Conversion of uranium ore concentrates to UO3 can be performed by first dissolving the ore in nitric acid and extracting purified uranyl nitrate using a solvent such as tributyl phosphate. Next, the uranyl nitrate is converted to UO3 either by concentration and delustration or by neutralization with gaseous ammonia to produce ammonium diuranate with subsequent filtering, drying, and calcining.

(2) Especially designed or prepared systems for the conversion of UO3 to UF6.

Conversion of UO3 to UF6 can be performed directly by fluorination. The process requires a source of fluorine gas or chlorine trifluoride.

(3) Especially designed or prepared systems for the conversion of UO3 to UO2.

Conversion of UO3 to UO2 can be performed through reduction of UO3 with cracked ammonia gas or hydrogen.

(4) Especially designed or prepared systems for the conversion of UO2 to UF4.

Conversion of UO2 to UF4 can be performed by reacting UO2 with hydrogen fluoride gas (HF) at 300–500 °C.

(5) Especially designed or prepared systems for the conversion of UF4 to UF6.

Conversion of UF4 to UF6 is performed by exothermic reaction with fluorine in a tower reactor. UF6 is condensed from the hot effluent gases by passing the effluent stream through a cold trap cooled to −10 °C. The process requires a source of fluorine gas.

(6) Especially designed or prepared systems for the conversion of UF6 to UO2.

Conversion of UF6 to UO2 can be performed by one of three processes. In the first, UF6 is reduced and hydrolyzed to UO2 using hydrogen and steam. In the second, UF6 is hydrolyzed by solution in water, ammonia is added to precipitate ammonium diuranate, and the diuranate is reduced to UO2 with hydrogen at 820 °C. In the third process, gaseous UF6, CO2, and NH3 are combined in water, precipitating ammonium uranyl carbonate. The ammonium uranyl carbonate is combined with steam and hydrogen at 500–600 °C to yield UO2. UF6 to UO2 conversion is often performed as the first stage of a fuel fabrication plant.

(7) Especially designed or prepared systems for the conversion of UF6 to UF4.

Conversion of UF6 to UF4 is performed by reduction of UF6 with cracked ammonia gas or hydrogen.

(8) Especially designed or prepared systems for the conversion of UF4 to U metal.

Conversion of UF4 to U metal is performed by reduction with magnesium (large batches) or calcium (small batches). The reaction is carried out at temperatures above the melting point of uranium (1130 °C).

(9) Especially designed or prepared systems for the conversion of UF4 to UF6.

Conversion of UF4 to UF6 is performed by one or more transformations from one plutonium chemical species to another; including: conversion of plutonium nitrate to PuO2, conversion of PuO2 to PuF4, and conversion of PuF4 to plutonium metal. Plutonium conversion plants are usually associated with reprocessing facilities, but may also be associated with plutonium fuel fabrication facilities. Many of the key equipment items for plutonium conversion plants are common to several segments of the chemical process industry. For example, the types of equipment employed in these processes may include the following items: furnaces, rotary kilns, fluidized bed...
reactors, flame tower reactors, liquid centrifuges, distillation columns and liquid-liquid extraction columns. Hot cells, glove boxes and remote manipulators may also be required. However, few of the items are available off-the-shelf; most would be prepared according to the requirements and specifications of the customer. Particular care is essential in designing for the special radiological, toxicity and criticality hazards associated with plutonium. In some circumstances, special design and construction considerations are required to address the corrosive properties of some of the chemicals handled (e.g., HF). Finally, it should be noted that, for all plutonium conversion processes, items of equipment which individually are not especially designed or prepared for plutonium conversion can be assembled into systems that are especially designed or prepared for use in plutonium conversion.

(b) Plutonium Conversion Plant Equipment

(1) Especially designed or prepared systems for the conversion of plutonium nitrate to oxide.

The main functions involved in this process are: process feed storage and adjustment, precipitation and solid/liquor separation, calcination, product handling, ventilation, waste management, and process control. The process systems are particularly adapted so as to avoid criticality and radiation effects and to minimize toxicity hazards. In most reprocessing facilities, this process involves the conversion of plutonium nitrate to plutonium dioxide. Other processes can involve the precipitation of plutonium oxalate or plutonium peroxide.

(2) Especially designed or prepared systems for plutonium metal production.

This process usually involves the fluorination of plutonium dioxide, normally with highly corrosive hydrogen fluoride, to produce plutonium fluoride, which is subsequently reduced using high purity calcium metal to produce metallic plutonium and a calcium fluoride slag. The main functions involved in this process are the following: fluorination (e.g., involving equipment fabricated or lined with a precious metal), metal reduction (e.g., employing ceramic crucibles), slag recovery, product handling, ventilation, waste management and process control. The process systems are particularly adapted so as to avoid criticality and radiation effects and to minimize toxicity hazards. Other processes include the fluorination of plutonium oxalate or plutonium peroxide followed by reduction to metal.

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