Canada's Nuclear Regulator

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# Proposal to Amend the *Nuclear Non-proliferation Import and Export Control Regulations*

Discussion Paper DIS-15-01

March 2015

Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

Canada

**Proposal to Amend the Nuclear Non-proliferation Import and Export Control Regulations**
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## Document availability

This document can be viewed on the CNSC website at nuclearsafety.gc.ca. To request a copy of the document in English or French, please contact:

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# Preface

Discussion papers play an important role in the selection and development of the regulatory framework and regulatory program of the Canadian Nuclear Safety Commission (CNSC). They are used to solicit early public feedback on CNSC policies or approaches.

The use of discussion papers early in the regulatory process underlines the CNSC's commitment to a transparent consultation process. The CNSC analyzes and considers preliminary feedback when determining the type and nature of requirements and guidance to issue.

Discussion papers are made available for public comment for a specified period of time. At the end of the comment period, CNSC staff review all public input, a 'what we heard' response will then be placed on the CNSC website.

The CNSC considers all feedback received from this consultation process in determining its regulatory approach.

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## Executive Summary

The Canadian Nuclear Safety Commission (CNSC) regulates the use of nuclear energy and materials to protect the health, safety and security of Canadians and the environment, and to implement Canada's international commitments on the peaceful use of nuclear energy. As part of accomplishing this mandate, the CNSC controls the import and export of nuclear and nuclear-related dual-use substances, equipment and technology under the *Nuclear Non-proliferation Import and Export Control Regulations* (NNIECR). This discussion paper lays out proposed amendments to the NNIECR, along with a related change in the *General Nuclear Safety and Control Regulations* (GNSCR), in order to solicit comments from those potentially impacted by the changes.

In 2009, the *Nuclear Suppliers Group* (NSG) began an extensive review of all entries in its Trigger List and Nuclear-related Dual-use List. In June 2013, 53 changes to these lists were agreed to. The changes were made to reflect developments in technology that increased, decreased or changed the nature of the proliferation threat posed by the items. By common custom, these revised lists were published by the International Atomic Energy Agency (IAEA) in November 2013. With the publication of the revised lists, the CNSC proposes to amend the corresponding entries in the NNIECR schedule to reflect these changes. Canada's trading partners within the NSG are also taking the appropriate steps to reflect these changes in their national legislation.

The CNSC is also proposing several additional amendments to the NNIECR that would clarify schedule entries, provide exemptions for items deemed to be of low proliferation risk, provide for additional application information, and specify record-retention requirements.

This discussion paper is intended to seek feedback from licensees, the Canadian public and other stakeholders on these proposals to amend the NNIECR and GNSCR. The CNSC will consider all feedback received during this consultation process. This pre-consultation process will then feed into the formal consultation process during which the proposed amendments will be published in the *Canada Gazette, Part I* for further public comment.

# Proposal to Amend the *Nuclear Non-proliferation Import and Export Control Regulations*

## 1. Introduction

The *Nuclear Non-proliferation Import and Export Control Regulations* (NNIECR) provide for the regulatory control of imports and exports of nuclear and nuclear-related dual-use substances, equipment and technology. These controls assist the CNSC in implementing Canada's international and bilateral commitments to the peaceful use of nuclear energy. The NNIECR set out regulatory requirements for the licensing of the import and export of items deemed to be of proliferation significance. The schedule of items controlled under the NNIECR is derived principally from lists agreed by the Nuclear Suppliers Group (NSG), with some modifications to ensure that Canada's nuclear non-proliferation policy is fulfilled.

In 2009, the Participating Governments of the NSG, of which Canada is an adherent, initiated a comprehensive review of the export control list entries appearing in INFCIRC 254 Part 1 and Part 2, respectively known as the Trigger List and the Nuclear-related Dual-use List. These are items of nuclear and nuclear-related substances, equipment and technology (information) that are exported internationally in accordance with supply guidelines agreed by the NSG. CNSC staff participated in the review. The review led to 53 amendments to the control lists that were approved by NSG Participating Governments in June 2013.

The NSG Guidelines, including control lists, are implemented by each Participating Government in accordance with its national laws and practices. While the mechanisms vary, there is an understanding that best efforts be made to effect implementation as soon as practicable, in order to avoid discrepancies or differences among export controls and possible proliferation risk. In Canada, implementation is done via incorporation into the schedule of the *Nuclear Non-proliferation Import and Export Control Regulations*, and into the *Export Control List* administered by the Department of Foreign Affairs, Trade and Development (DFATD).

The CNSC proposes that the amendments to the NSG control lists approved in June 2013 by NSG Participating Governments, including Canada, be incorporated into the NNIECR by amending these regulations. The CNSC is also proposing additional changes to the NNIECR, along with a related change to the *General Nuclear Safety and Control Regulations* (GNSCR), to clarify certain entries, reduce regulatory burden for items deemed to be of low proliferation significance, and to provide additional information for use in assessing applications and licensee compliance. The proposed amendments are described within this document.

In accordance with the Government of Canada's Red Tape Reduction Action Plan announced in 2012, the CNSC is interested in hearing from licensees about the impact of these proposals on their cumulative levels of administrative burden. This information will be used to analyze the impacts of the regulatory proposal on Canadian businesses.

Activities that impose administrative burden include planning, collecting, processing and reporting information, completing forms and retaining data required by the federal government to comply with a regulation. This includes filling out licence applications and forms, as well as finding and compiling data for audits and routinely scheduled reports submitted to the CNSC.

In many cases, the proposals contained in this discussion paper involve new definitions or clarifications for which the CNSC does not anticipate any impact on the administrative burden experienced by licensees. The CNSC encourages validation of these assumptions.

The CNSC will never compromise safety and the Government of Canada has said that the Red Tape Reduction Action Plan must be implemented in a way that ensures protection of the public, environment and economy is preserved. In this context, the CNSC is interested in lessening administrative burden where possible. Feedback from stakeholders on the impacts of proposals in this document and mechanisms to reduce administrative burden is welcome.

## 2. Description of Proposed Amendments

As described above, the bulk of the proposed amendments to the NNIECR are the result of changes to the Nuclear Suppliers Group lists from which the NNIECR schedule is principally derived. These changes are the outcome of a comprehensive review of the NSG Trigger List (so-called because the export of nuclear items on the list triggers nuclear safeguards considerations) and the Nuclear-related Dual-use list. The latter identifies materials, equipment and technology that are widely used in non-nuclear applications, but that may also be used in the production of weapons and weapons-usable material, and are therefore subject to export control. These proposed amendments to the NNIECR schedule, which are significant in number, are described in tabular form in Appendix A.

In addition to the NSG-related changes, the CNSC is proposing several changes to address issues identified by staff since the 2010 amendments to the NNIECR and a related change to the GNSCR. These issues include:

- lack of NSG explanatory notes in the schedule entries reduces clarity of the NNIECR
- lack of clarity in certain schedule entries and in an exemption found in Section 4 may cause licensee confusion and unnecessary administrative burden
- controls on certain items of low proliferation significance may place an unnecessary burden on licensees
- additional information in licence applications is required to assist in assessing applications for proliferation risk
- lack of a requirement for written compliance procedures hinders CNSC efforts to ensure that CNSC licensees comply with CNSC licensing requirements
- the requirement to present an import or export licence to a Customs officer for prescribed information is not always possible

The one-year default record retention requirement found in the GNSCR is deemed insufficient to meet CNSC's needs with respect to verification of compliance.

Subsections 2.1-2.5 below outline in detail the proposed amendments to the NNIECR and GNSCR which would address these issues.

### 2.1 Proposed corrections/clarifications to schedule entries

#### 2.1.1 Addition of technical notes

The technical notes found in the NSG control lists, currently not included in the NNIECR, will be added to the schedule to assist in clarifying the applicability of the regulatory controls.

### 2.1.2 Exemption for nuclear grade graphite

Section 4(1)(f) currently has no link between the exemption for exports of graphite and the related reporting requirements found later in section 4(3), which has potential for licensee confusion. The CNSC proposes to clarify the exemption for exports of graphite and the related reporting requirements found in section 4 of the NNIECR by adding a cross-reference in 4(1)(f) as follows:

*(f) export the controlled nuclear substance referred to in paragraph A.1.4 of the schedule that is not for use in a nuclear reactor to any Participating Government of the Nuclear Suppliers Group. Use of this exemption requires submission of Annual Reports as described in 4(3).*

### 2.1.3 Description of technology

The CNSC proposes to clarify the description of technology found in A.4.1 and B.3.1 to address intangible technology transfer. This clarification would assist exporters in determining when they require an export licence for a technology transfer. The new definition would read as follows:

*Technical data for the design, production, construction, operation or maintenance of any item in this part, except data available to the public (e.g.in published books or periodicals, or that which has been made available without restrictions on its further dissemination), including, but not limited to, technical drawings, models, instructions (written or recorded), working knowledge, design drawings, models, technical and operational manuals, skills training and parts catalogues. NOTE (a) Technical data as described above is subject to control under both tangible and intangible modes of transfer.*

### 2.1.4 Correction to vacuum pump entry

The CNSC proposes to correct an error in the measurement of *torr* found in the vacuum pump entry B.2.2.11 where the measurement should be $10^{-4}$ instead of $10^{4}$ Torr. The corrected entry would read as follows:

*Vacuum pumps with an input throat size of 38cm (15 in.) or greater with a pumping speed of 15,000 L/s or greater and capable of producing an ultimate vacuum better than $10^{-4}$Torr ($1.33x10^{-4}$mbar)*

### 2.1.5 Description of end-use controls

The CNSC proposes to clarify that the end-use controls also apply to exports to unsafeguarded nuclear activities, and to strengthen the existing end-use controls found in B.1.1.20 and B.2.7.6. The revised entries would read as follows:

*Any substance [equipment] not otherwise included in paragraph B.1[B.2] if the substance [equipment] is intended, or there are reasonable grounds to suspect that it is intended, in whole or in part, for use in connection with an unsafeguarded nuclear fuel cycle activity or the design, development, production, handling, operation, maintenance, storage, detection, identification or dissemination of nuclear weapons or other nuclear explosive devices, or of materials or equipment that could be used in such weapons or devices.*

### 2.2 Proposed exemptions to schedule entries

In order to reduce unnecessary regulatory burden on licensees, the CNSC proposes to provide exemptions for the following items deemed to be of low proliferation risk:

- The import or export of source material (entry A.1.2(b)) used in civil non-nuclear applications such as shielding, radiation devices, packaging, ballasts, counter-weights or the production of alloys and ceramics.
- The import or export of thorium (entry A.1.2(c)) used in civil non-nuclear applications, including thorium contained in lamps, lights, welding rods and engine coatings. This exemption would not apply to bulk imports or exports of thorium for the manufacture of these items.
- The import of nuclear grade graphite (A.1.4.) that is not for use in a nuclear reactor.
- The import or export of tritium (entry A.1.5) contained in signs, for illumination, which have been installed in aircraft, ships or vehicles (conveyances); and tritium contained in watches, compasses, musical instruments or used as biological tracers. This exemption would not apply to bulk imports or exports of tritium for the manufacture of these items.

### 2.3 Proposed additional application information requirements

The CNSC proposes to add the following items to section 3(1), the most significant of which would be a requirement for an applicant to include their written compliance procedures in an application for a licence to import or export:

> *3(1)(a)* The provision of the applicant's *Canada Revenue Agency-assigned business number* in addition to their name, address and telephone number;

New entries as follows:

- *3(1)(i) the name of the anticipated place of entry or exit*
- *3(1)(j) the name(s) of any anticipated transit states*
- *3(1)(k) the applicant's written procedures to ensure compliance with import and export regulatory requirements, including those associated with the allocation of management functions and responsibilities, internal tracking and compliance verification procedures, internal audit procedures, staff training programs and record management procedures*

With regard to the addition of 3(1)(k), the intention is that applicants shall have in place written procedures to ensure compliance with import and export controls under the NSCA. The first application for a licence to import or export should contain a copy of the compliance procedures referenced in the proposed 3(k). These procedures will be assessed as part of the licence application and, if they meet the requirements, the licensee will be notified as such in the cover letter to the relevant licence. For subsequent applications – assuming there are no extenuating circumstances – the licensee will only need to make reference to the previously submitted procedures.

### 2.4 Proposed record retention requirement

The CNSC proposes to add a requirement which would specify a six year record retention period versus the GNSCR default of one year. This would be specified as follows:

Records to be kept and retained

> *Every licensee shall keep, for a period of six years after the date of import or export pursuant to these Regulations, all records relevant to any import or export pursuant to a CNSC licence, including (i) the application and supporting information submitted to the CNSC (ii) the licence; (iii) the Customs Declaration and associated documentation submitted at the time of import or export; (iv) shipping manifests and associated documentation; (v) any purchase order or certification of manufacture; and, (vi) notification and other reporting submissions made pursuant to licence conditions.*

### 2.5 Proposed amendment to the *General Nuclear Safety and Control Regulations*

In response to licensee concerns raised over the past few years on the practical constraint on the ability of a licensee to comply with Section 18 of the GNSCR when importing or exporting prescribed information through intangible means (e.g., downloads, e-mail), the CNSC proposes to remove the requirement to present an import or export licence to a Customs officer for prescribed information. The revised entry would delete the term ‘prescribed information’ and read as follows:

> *18. On importing or exporting a nuclear substance or prescribed equipment, the licensee shall present the required import or export licence to a customs officer*.

## 3. Conclusion

The proposed amendments would ensure that the CNSC’s regulations remain up-to-date and ensure a level playing-field for industry within the Participating Governments of the Nuclear Suppliers Group. Further, these amendments would ensure that Canada is able to fulfill its international commitments in the area of non-proliferation while reducing unnecessary burden on industry by controlling only those items which are deemed to pose the greatest proliferation risk.

In addition, several of the proposed amendments would provide relief for Canadian importers and exporters dealing in items with very low proliferation significance by providing a licensing exemption for those items. Similarly, the clarifications provided for other existing entries should reduce industry administrative burden and increase efficiency by reducing the number of requests for clarification and submission of unnecessary applications.

While the proposed amendments do include new requirements, they require the provision of information and documents readily available for most importers and exporters. The requirement to provide information on compliance procedures formalizes existing CNSC expectations of licensee compliance and, in most cases, will entail a one-time submission with an initial application. Finally, the proposal to require applicants to provide additional information at the time of application on business number, transit states, and port of entry/exit is assessed not to add any significant burden in the application process, and will serve to facilitate more timely completion of risk assessments.

## 4. Public Input

The CNSC welcomes feedback on the proposed changes to the NNIECR as outlined in this discussion paper.

In addition to feedback on proposed changes, the CNSC would also appreciate receiving the following information from licensees, which will aid in the calculation of the cumulative costs or savings of any administrative burden change:

- How many employees in your business would be subject to a change in administrative activities resulting from this proposal? What are the generic position titles of those employees? (e.g. technician, manager, clerk, etc.)
- How many hours would it take those employees to perform any new administrative tasks over a 1-year period?
- How many hours would be saved through licensing exemptions or clarifications?
- What is the approximate salary cost per hour?
- Do you have any suggestions on how these costs could be reduced, while continuing to fulfil the objective of the proposal and without compromising safety?

The CNSC expects that this proposal will result in minimal overall change to current level of administrative burden experienced by licensees.

The CNSC will use this input in preparing regulatory amendments for pre-publication in the *Canada Gazette, Part I*. After due process, the amendments would proceed to publication in *Canada Gazette, Part II* and then, with the approval of the Governor in Council, the amendments would enter into force.

## 5. How to Participate

Please submit your comments or feedback to:

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Please indicate clearly which discussion paper you are commenting on.

## Appendix A: List of NSG-Related Amendment Proposals

| Part | Current NNIEC Regulations (SOR/2000-210) | Proposed Revision to the NNIEC Regulations | Substantive Change?[1] |
|---|---|---|---|
| **A.1.4** | *Nuclear grade graphite* | *Nuclear grade graphite* | No |
| | Graphite having a purity level better than 5 ppm boron equivalent and with a density greater than $1.50 g/cm^3$ | Graphite having a purity level better than 5 parts per million boron equivalent and with a density greater than 1.50 $g/cm^3$, in quantities exceeding 1 kilogram.<br><br>EXPLANATORY NOTE<br>Boron equivalent (BE) may be determined experimentally or is calculated as the sum of $BE_Z$ for impurities (excluding $BE_{carbon}$ since carbon is not considered an impurity) including boron, where:<br>$BE_z$ (ppm) = CF x concentration of element Z (in ppm);<br>CF is the conversion factor: ($\sigma_z$ x $A_B$) divided by ($\sigma_B$ x $A_z$);<br>$\sigma_B$ and $\sigma_z$ are the thermal neutron capture cross sections (in barns) for naturally occurring boron and element Z respectively; and $A_B$ and $A_Z$ are the atomic masses of naturally occurring boron and element Z respectively. | Yes |
| **A.2.1** | *Nuclear reactors and especially designed or prepared equipment and components therefor, including:* | *Nuclear reactors and especially designed or prepared equipment and components therefor, including:*<br><br>INTRODUCTORY NOTE<br>Various types of nuclear reactors may be characterized by the moderator used (e.g., graphite, heavy water, light water, none), | No |

[1] A substantive change is a change in which at least one requirement is altered. Non-substantive changes are changes which do not alter a requirement (e.g., grammatical or formatting changes, the addition of explanatory or introductory notes, or using different units for a measurement that doesn't result in a change to the actual value)

| Part | Current NNIEC Regulations (SOR/2000-210) | Proposed Revision to the NNIEC Regulations | Substantive Change?[1] |
|---|---|---|---|
| | | the spectrum of neutrons therein (e.g., thermal, fast), the type of coolant used (e.g., water, liquid metal, molten salt, gas), or by their function or type (e.g., power reactors, research reactors, test reactors). It is intended that all of these types of nuclear reactors are within scope of this entry and all of its sub-entries where applicable. This entry does not control fusion reactors. | |
| **A.2.1.1** | *Complete nuclear reactors* | *Complete nuclear reactors* | No |
| | Nuclear reactors capable of operation so as to maintain a controlled self-sustaining fission chain reaction. | Nuclear reactors capable of operation so as to maintain a controlled self-sustaining fission chain reaction.<br><br>EXPLANATORY NOTE<br>A “nuclear reactor” basically includes the items within or attached directly to the reactor vessel, the equipment which controls the level of power in the core, and the components which normally contain or come in direct contact with or control the primary coolant of the reactor core. | No |
| **A.2.1.2** | *Nuclear reactor vessels* | *Nuclear reactor vessels* | No |
| | Metal vessels, or major shop-fabricated parts therefor, especially designed or prepared to contain the core of a nuclear reactor as well as relevant reactor internals as defined in paragraph A.2.1.8 below. | Metal vessels, or major shop-fabricated parts therefor, especially designed or prepared to contain the core of a nuclear reactor as defined in paragraph A.2.1.1 above, as well as relevant reactor internals as defined in paragraph A.2.1.8 below.<br><br>EXPLANATORY NOTE<br>Item A.2.1.2 covers nuclear reactor vessels regardless of pressure rating and includes reactor pressure vessels and calandrias. The reactor vessel head is covered by item A.2.1.2 as a major shop-fabricated part of a reactor vessel. | No |

| Part | Current NNIEC Regulations<br>(SOR/2000-210) | Proposed Revision to the NNIEC Regulations | Substantive Change?[1] |
|---|---|---|---|
| **A.2.1.3** | *Nuclear reactor fuel charging and discharging machines* | *Nuclear reactor fuel charging and discharging machines* | No |
| | Manipulative equipment especially designed or prepared for inserting or removing fuel in a nuclear reactor. | Manipulative equipment especially designed or prepared for inserting or removing fuel in a nuclear reactor as defined in paragraph A.2.1.1 above.<br><br>EXPLANATORY NOTE<br>The items noted above are capable of on-load operation or at employing technically sophisticated positioning or alignment features to allow complex off-load fueling operations such as those in which direct viewing of or access to the fuel is not normally available. | No |
| **A.2.1.5** | *Nuclear reactor pressure tubes* | *Nuclear reactor pressure tubes* | No |
| | Tubes which are especially designed or prepared to contain fuel elements and the primary coolant in a nuclear reactor at an operating pressure in excess of 50 atmospheres. | Tubes which are especially designed or prepared to contain both fuel elements and the primary coolant in a reactor as defined in paragraph A.2.1.1 above.<br><br>EXPLANATORY NOTE<br><br>Pressure tubes are parts of fuel channels designed to operate at elevated pressure, sometimes in excess of 5 MPa. | Yes |
| **A.2.1.6** | *Zirconium tubes* | *Nuclear fuel cladding* | No |
| | Zirconium metal and alloys in the form of tubes or assemblies of tubes, especially designed or prepared for use in a nuclear reactor and in which the relation of hafnium to zirconium is less than 1:500 parts by weight. | Zirconium metal tubes or zirconium alloy tubes (or assemblies of tubes) especially designed or prepared for use as fuel cladding in a reactor as defined in paragraph A.2.1.1 above.<br>N.B.: For zirconium pressure tubes see A.2.1.5. For calandria tubes see A.2.1.8.<br><br>EXPLANATORY NOTE | No |

| Part | Current NNIEC Regulations (SOR/2000-210) | Proposed Revision to the NNIEC Regulations | Substantive Change?[1] |
|---|---|---|---|
| | | Zirconium metal tubes or zirconium alloy tubes for use in a nuclear reactor consist of zirconium in which the relation of hafnium to zirconium is typically less than 1:500 parts by weight. | |
| **A.2.1.7.** | *Primary coolant pumps* | *Primary coolant pumps or circulators* | Yes |
| | Pumps especially designed or prepared for circulating the primary coolant for nuclear reactors. | Pumps or circulators especially designed or prepared for circulating the primary coolant for nuclear reactors as defined in paragraph A.2.1.1 above.<br><br>EXPLANATORY NOTE<br>Especially designed or prepared pumps or circulators include pumps for water-cooled reactors, circulators for gas-cooled reactors, and electromagnetic and mechanical pumps for liquid-metal-cooled reactors. This equipment may include pumps with elaborate sealed or multi-sealed systems to prevent leakage of primary coolant, canned-driven pumps, and pumps with inertial mass systems. This definition encompasses pumps certified to Section III, Division I, Subsection NB (Class 1 components) of the American Society of Mechanical Engineers (ASME) Code, or equivalent standards. | Yes |
| **A.2.1.8.** | *Nuclear reactor internals* | *Nuclear reactor internals* | No |
| | Nuclear reactor internals especially designed or prepared for use in a nuclear reactor including support columns for the core, fuel channels, thermal shields, baffles, core grid plates, and diffuser plates. | "Nuclear reactor internals" especially designed or prepared for use in a nuclear reactor as defined in paragraph A.2.1.1 above. This includes, for example, support columns for the core, fuel channels, calandria tubes, thermal shields, baffles, core grid plates, and diffuser plates.<br><br>EXPLANATORY NOTE<br>"Nuclear reactor internals" are major structures within a reactor | Yes |

| Part | Current NNIEC Regulations (SOR/2000-210) | Proposed Revision to the NNIEC Regulations | Substantive Change?[1] |
|---|---|---|---|
| | | vessel which have one or more functions such as supporting the core, maintaining fuel alignment, directing primary coolant flow, providing radiation shields for the reactor vessel, and guiding in-core instrumentation. | |
| **A.2.1.9** | *Heat exchangers* | *Heat exchangers* | No |
| | Heat exchangers (steam generators) especially designed or prepared for use in the primary coolant circuit of a nuclear reactor. | (a) Steam generators especially designed or prepared for the primary, or intermediate, coolant circuit of a nuclear reactor as defined in paragraph A.2.1.1 above.<br><br>(b) Other heat exchangers especially designed or prepared for use in the primary coolant circuit of a nuclear reactor as defined in paragraph A.2.1.1 above.<br><br>EXPLANATORY NOTE<br><br>Steam generators are especially designed or prepared to transfer the heat generated in the reactor to the feed water for steam generation. In the case of a fast reactor for which an intermediate coolant loop is also present, the steam generator is in the intermediate circuit.<br><br>In a gas-cooled reactor, a heat exchanger may be utilized to transfer heat to a secondary gas loop that drives a gas turbine.<br><br>The scope of control for this entry does not include heat exchangers for the supporting systems of the reactor, e.g., the emergency cooling system or the decay heat cooling system. | Yes |
| **A.2.1.10.** | *Neutron detection and measuring instruments* | *Neutron detectors* | No |
| | Especially designed or prepared neutron detection and measuring instruments for determining neutron flux within the core of a nuclear reactor. | Especially designed or prepared neutron detectors for determining neutron flux levels within the core of a reactor as defined in paragraph A.2.1.1 above.<br><br>EXPLANATORY NOTE | Yes |

| Part | Current NNIEC Regulations (SOR/2000-210) | Proposed Revision to the NNIEC Regulations | Substantive Change?[1] |
|---|---|---|---|
| | | The scope of this entry encompasses in-core and ex-core detectors which measure flux levels in a large range, typically from $10^4$ neutrons per $cm^2$ per second to $10^{10}$ neutrons per $cm^2$ per second or more. Ex-core refers to those instruments outside the core of a reactor as defined in paragraph A.2.1.1 above, but located within the biological shielding. | |
| **A.2.1.11** | | *External thermal shields* | Yes |
| | | "External thermal shields" especially designed or prepared for use in a nuclear reactor as defined in paragraph A.2.1.1 for reduction of heat loss and also for containment vessel protection.<br><br>EXPLANATORY NOTE<br>"External thermal shields" are major structures placed over the reactor vessel which reduce heat loss from the reactor and reduce temperature within the containment vessel. | Yes |
| **A.2.2** | *Plants for the reprocessing of irradiated fuel elements, and equipment especially designed or prepared therefor, including:* | *Plants for the reprocessing of irradiated fuel elements, and equipment especially designed or prepared therefor, including:* | No |
| | | INTRODUCTORY NOTE<br>Reprocessing irradiated nuclear fuel separates plutonium and uranium from intensely radioactive fission products and other transuranic elements. Different technical processes can accomplish this separation. However, over the years Purex has become the most commonly used and accepted process. Purex involves the dissolution of irradiated nuclear fuel in nitric acid, followed by separation of the uranium, plutonium, and fission products by solvent extraction using a mixture of tributyl phosphate in an organic diluent.<br>Purex facilities have process functions similar to each other, including: irradiated fuel element chopping, fuel dissolution, | No |

| Part | Current NNIEC Regulations (SOR/2000-210) | Proposed Revision to the NNIEC Regulations | Substantive Change?[1] |
|---|---|---|---|
| | | solvent extraction, and process liquor storage. There may also be equipment for thermal denitration of uranium nitrate, conversion of plutonium nitrate to oxide or metal, and treatment of fission product waste liquor to a form suitable for long term storage or disposal. However, the specific type and configuration of the equipment performing these functions may differ between Purex facilities for several reasons, including the type and quantity of irradiated nuclear fuel to be reprocessed and the intended disposition of the recovered materials, and the safety and maintenance philosophy incorporated into the design of the facility.<br><br>A "plant for the reprocessing of irradiated fuel elements", includes the equipment and components which normally come in direct contact with and directly control the irradiated fuel and the major nuclear material and fission product processing streams.<br><br>These processes, including the complete systems for plutonium conversion and plutonium metal production, may be identified by the measures taken to avoid criticality (e.g. by geometry), radiation exposure (e.g. by shielding), and toxicity hazards (e.g. by containment). | |
| **A.2.2.1** | *Irradiated fuel element chopping machines* | *Irradiated fuel element chopping machines* | No |
| | Remotely operated equipment especially designed or prepared for use in a reprocessing plant as identified above and intended to cut, chop or shear irradiated nuclear fuel assemblies, bundles or rods. | Remotely operated equipment especially designed or prepared for use in a reprocessing plant as identified above and intended to cut, chop or shear irradiated nuclear fuel assemblies, bundles or rods.<br><br>EXPLANATORY NOTE<br><br>This equipment breaches the cladding of the fuel to expose the irradiated nuclear material to dissolution. Especially designed metal cutting shears are the most commonly employed, although advanced equipment, such as lasers, may be used. | No |

| Part | Current NNIEC Regulations (SOR/2000-210) | Proposed Revision to the NNIEC Regulations | Substantive Change?[1] |
|---|---|---|---|
| **A.2.2.2.** | *Dissolvers* | *Dissolvers* | No |
| | Critically safe tanks (e.g. small diameter, annular or slab tanks) especially designed or prepared for use in a reprocessing plant as identified above, intended for the dissolution of irradiated nuclear fuel and which are capable of withstanding hot, highly corrosive liquid, and which can be remotely loaded and maintained. | Critically safe tanks (e.g. small diameter, annular or slab tanks) especially designed or prepared for use in a reprocessing plant as identified above, intended for dissolution of irradiated nuclear fuel and which are capable of withstanding hot, highly corrosive liquid, and which can be remotely loaded and maintained.<br><br>EXPLANATORY NOTE<br>Dissolvers normally receive the chopped-up spent fuel. In these critically safe vessels, the irradiated nuclear material is dissolved in nitric acid and the remaining hulls removed from the process stream. | No |
| **A.2.2.3.** | *Solvent extractors and solvent extraction equipment* | *Solvent extractors and solvent extraction equipment* | No |
| | Especially designed or prepared solvent extractors such as packed or pulse columns, mixer settlers or centrifugal contactors for use in a plant for the reprocessing of irradiated fuel. Solvent extractors must be resistant to the corrosive effect of nitric acid. Solvent extractors are normally fabricated to extremely high standards (including special welding and inspection and quality assurance and quality control techniques) out of low carbon stainless steels, titanium, zirconium or other high-quality materials. | Especially designed or prepared solvent extractors such as packed or pulse columns, mixer settlers or centrifugal contactors for use in a plant for the reprocessing of irradiated fuel. Solvent extractors must be resistant to the corrosive effect of nitric acid. Solvent extractors are normally fabricated to extremely high standards (including special welding and inspection and quality assurance and quality control techniques) out of low carbon stainless steels, titanium, zirconium, or other high quality materials.<br><br>EXPLANATORY NOTE<br>Solvent extractors both receive the solution of irradiated fuel from the dissolvers and the organic solution which separates the uranium, plutonium, and fission products. Solvent extraction equipment is normally designed to meet strict operating parameters, such as long operating lifetimes with no maintenance requirements or adaptability to easy replacement, simplicity of | No |

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| | | operation and control, and flexibility for variations in process conditions. | |
| **A.2.2.4.** | *Chemical holding or storage vessel* | *Chemical holding or storage vessel* | No |
| | Especially designed or prepared holding or storage vessels for use in a plant for the reprocessing of irradiated fuel. The holding or storage vessels must be resistant to the corrosive effect of nitric acid. The holding or storage vessels are normally fabricated of materials such as low carbon stainless steels, titanium or zirconium, or other high-quality materials. Holding or storage vessels may be designed for remote operation and maintenance and may have the following features for control of nuclear criticality:<br>(*a*) walls or internal structures with a boron equivalent of at least 2%;<br>(*b*) a maximum diameter of 175 mm (7 in.) for cylindrical vessels; or<br>(*c*) a maximum width of 75 mm (3 in.) for either a slab or annular vessel. | Especially designed or prepared holding or storage vessels for use in a plant for the reprocessing of irradiated fuel. The holding or storage vessels must be resistant to the corrosive effect of nitric acid. The holding or storage vessels are normally fabricated of materials such as low carbon stainless steels, titanium or zirconium, or other high quality materials. Holding or storage vessels may be designed for remote operation and maintenance and may have the following features for control of nuclear criticality:<br>(1) walls or internal structures with a boron equivalent of at least two per cent, or<br>(2) a maximum diameter of 175 mm (7 in) for cylindrical vessels, or<br>(3) a maximum width of 75 mm (3 in) for either a slab or annular vessel.<br><br>EXPLANATORY NOTE<br>Three main process liquor streams result from the solvent extraction step. Holding or storage vessels are used in the further processing of all three streams, as follows:<br>(a) The pure uranium nitrate solution is concentrated by evaporation and passed to a denitration process where it is converted to uranium oxide. This oxide is re-used in the nuclear fuel cycle.<br>(b) The intensely radioactive fission products solution is normally concentrated by evaporation and stored as a liquor concentrate. This concentrate may be subsequently evaporated | No |

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| | | and converted to a form suitable for storage or disposal.<br>(c) The pure plutonium nitrate solution is concentrated and stored pending its transfer to further process steps. In particular, holding or storage vessels for plutonium solutions are designed to avoid criticality problems resulting from changes in concentration and form of this stream. | |
| **TBD** | | *Neutron measurement systems for process control* | Yes |
| | | Neutron measurement systems especially designed or prepared for integration and use with automated process control systems in a plant for the reprocessing of irradiated fuel elements.<br><br>EXPLANATORY NOTE<br>These systems involve the capability of active and passive neutron measurement and discrimination in order to determine the fissile material quantity and composition. The complete system is composed of a neutron generator, a neutron detector, amplifiers, and signal processing electronics.<br>The scope of this entry does not include neutron detection and measurement instruments that are designed for nuclear material accountancy and safeguarding or any other application not related to integration and use with automated process control systems in a plant for the reprocessing of irradiated fuel elements. | Yes |
| **A.2.3.** | *Plants for the fabrication of nuclear reactor fuel elements, and equipment especially designed or prepared therefor including equipment which:* | *Plants for the fabrication of nuclear reactor fuel elements, and equipment especially designed or prepared therefor* | No |
| | *Plants for the fabrication of nuclear reactor fuel elements, and equipment especially designed or prepared therefor* | INTRODUCTORY NOTE | Yes |

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| | *including equipment which:*<br>(*a*) normally comes in direct contact with, or directly processes, or controls, the production flow of nuclear material;<br>(*b*) seals the nuclear material within the cladding;<br>(*c*) checks the integrity of the cladding or the seal; or<br>(*d*) checks the finish treatment of the sealed fuel. | Nuclear fuel elements are manufactured from one or more source or special fissionable materials. For oxide fuels, the most common type of fuel, equipment for pressing pellets, sintering, grinding and grading will be present. Mixed oxide fuels are handled in glove boxes (or equivalent containment) until they are sealed in the cladding. In all cases, the fuel is hermetically sealed inside a suitable cladding which is designed to be the primary envelope encasing the fuel so as to provide suitable performance and safety during reactor operation. Also, in all cases, precise control of processes, procedures and equipment to extremely high standards is necessary in order to ensure predictable and safe fuel performance.<br><br>EXPLANATORY NOTE<br>Items of equipment that are considered to fall within the meaning of the phrase “and equipment especially designed or prepared” for the fabrication of fuel elements include equipment which:<br>(a) normally comes in direct contact with, or directly processes, or controls, the production flow of nuclear material;<br>(b) seals the nuclear material within the cladding;<br>(c) checks the integrity of the cladding or the seal;<br>(d) checks the finish treatment of the sealed fuel; or<br>(e) is used for assembling reactor fuel elements.<br><br>Such equipment or systems of equipment may include, for example:<br>1) fully automatic pellet inspection stations especially designed or prepared for checking final dimensions and surface defects of the fuel pellets; | |

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| | | 2) automatic welding machines especially designed or prepared for welding end caps onto the fuel pins (or rods);<br>3) automatic test and inspection stations especially designed or prepared for checking the integrity of completed fuel pins (or rods);<br>4) systems especially designed or prepared to manufacture nuclear fuel cladding.<br>Item 3 typically includes equipment for: a) x-ray examination of pin (or rod) end cap welds, b) helium leak detection from pressurized pins (or rods), and c) gamma-ray scanning of the pins (or rods) to check for correct loading of the fuel pellets inside. | |
| **A.2.4.** | *Plants for the separation of isotopes of natural uranium, depleted uranium or special fissionable material and equipment, other than analytical instruments, especially designed or prepared for that purpose, including* | *Plants for the separation of isotopes of natural uranium, depleted uranium or special fissionable material and equipment, other than analytical instruments, especially designed or prepared therefor* | No |
| | | INTRODUCTORY NOTE<br>Plants, equipment and technology for the separation of uranium isotopes have, in many instances, a close relationship to plants, equipment and technology for isotope separation of “other elements”. In particular cases, the controls under A.2.4. also apply to plants and equipment that are intended for isotope separation of “other elements”. These controls of plants and equipment for isotope separation of “other elements” are complementary to controls on plants and equipment especially designed or prepared for the processing, use or production of special fissionable material covered by the Trigger List. These complementary A.2.4 controls for uses involving “other elements” do not apply to the electromagnetic isotope separation process, which are addressed in Part B of the schedule.<br>Processes for which the controls in A.2.4 equally apply whether | No |

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| | | the intended use is uranium isotope separation or isotope separation of "other elements" are: gas centrifuge, gaseous diffusion, the plasma separation process, and aerodynamic processes.<br><br>For some processes, the relationship to uranium isotope separation depends on the element being separated. These processes are: laser-based processes (e.g. molecular laser isotope separation and atomic vapour laser isotope separation), chemical exchange, and ion exchange.<br><br>Items of equipment that are considered to fall within the meaning of the phrase "equipment, other than analytical instruments, especially designed or prepared" for the separation of isotopes of uranium include those described in entries A.2.4.1. to A.2.4.9.3. | |
| **A.2.4.1.** | *Gas centrifuges and assemblies and components especially designed or prepared for use in gas centrifuges, including:* | *Gas centrifuges and assemblies and components especially designed or prepared for use in gas centrifuges* | No |
| | | INTRODUCTORY NOTE<br><br>The gas centrifuge normally consists of a thin-walled cylinder(s) of between 75 mm and 650 mm diameter contained in a vacuum environment and spun at high peripheral speed of the order of 300 m/s or more with its central axis vertical. In order to achieve high speed the materials of construction for the rotating components have to be of a high strength to density ratio and the rotor assembly, and hence its individual components, have to be manufactured to very close tolerances in order to minimize the unbalance. In contrast to other centrifuges, the gas centrifuge for uranium enrichment is characterized by having within the rotor chamber a rotating disc-shaped baffle(s) and a stationary tube arrangement for feeding and extracting the $UF_6$ gas and featuring at least three separate channels, of which two are connected to scoops extending from the rotor axis towards the periphery of the | No |

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| | | rotor chamber. Also contained within the vacuum environment are a number of critical items which do not rotate and which although they are especially designed are not difficult to fabricate nor are they fabricated out of unique materials. A centrifuge facility however requires a large number of these components, so that quantities can provide an important indication of end use. | |
| **A.2.4.1.1.** | *Rotating components* | *Rotating components* | No |
| | (*a*) complete rotor assemblies: | (a) Complete rotor assemblies: | No |
| | thin-walled cylinders, or a number of interconnected thin-walled cylinders, manufactured from one or more of the high strength to density ratio materials. If interconnected, the cylinders are joined together by flexible bellows or rings as described in paragraph (*c*). The rotor is fitted with an internal baffle(s) and end caps, as described in paragraphs (*d*) and (*e*), if in final form. However the complete assembly may be delivered only partly assembled; | Thin-walled cylinders, or a number of interconnected thin-walled cylinders, manufactured from one or more of the high strength to density ratio materials described in the EXPLANATORY NOTE to A.2.4.1.1. below. If interconnected, the cylinders are joined together by flexible bellows or rings as described in paragraph (c) below. The rotor is fitted with an internal baffle(s) and end caps, as described in paragraphs (d) and (e) below, if in final form. However the complete assembly may be delivered only partly assembled. | No |
| | (*b*) rotor tubes: | (b) Rotor tubes: | No |
| | especially designed or prepared thin-walled cylinders with thickness of 12 mm (0.5 in.) or less, a diameter of between 75 mm (3 in.) and 400 mm (16 in.), and manufactured from high strength to density ratio materials; | Especially designed or prepared thin-walled cylinders with thickness of 12 mm or less, a diameter of between 75 mm and 650 mm, and manufactured from one or more of the high strength to density ratio materials described in the EXPLANATORY NOTE to A.2.4.1.1. below. | Yes |
| | (*c*) rings or bellows: | (c) Rings or Bellows: | No |
| | components especially designed or prepared to give localized support to the rotor tube or to join together a number of rotor tubes. The bellows is a short cylinder of wall thickness 3 mm (0.12 in.) or less, a diameter of | Components especially designed or prepared to give localized support to the rotor tube or to join together a number of rotor tubes. The bellows is a short cylinder of wall thickness 3 mm or less, a diameter of between 75 mm and 650 mm, having a | Yes |

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| | between 75 mm (3 in.) and 400 mm (16 in.), having a convolute, and manufactured from high strength to density ratio materials; | convolute, and manufactured from one of the high strength to density ratio materials described in the EXPLANATORY NOTE to A.2.4.1.1. below. | |
| | (*d*) baffles: | (d) Baffles: | No |
| | disc-shaped components of between 75 mm (3 in.) and 400 mm (16 in.) diameter especially designed or prepared to be mounted inside the centrifuge rotor tube, in order to isolate the take-off chamber from the main separation chamber and, in some cases, to assist the $UF_6$ gas circulation within the main separation chamber of the rotor tube, and manufactured from strength to density ratio materials; and | Disc-shaped components of between 75 mm and 650 mm diameter especially designed or prepared to be mounted inside the centrifuge rotor tube, in order to isolate the take-off chamber from the main separation chamber and, in some cases, to assist the $UF_6$ gas circulation within the main separation chamber of the rotor tube, and manufactured from one of the high strength to density ratio materials described in the EXPLANATORY NOTE A.2.4.1.1. below. | Yes |
| | (*e*) top caps/bottom caps: | (e) Top caps/Bottom caps | No |
| | disc-shaped components of between 75 mm (3 in.) and 400 mm (16 in.) diameter especially designed or prepared to fit to the ends of the rotor tube, and so contain the $UF_6$ within the rotor tube, and in some cases to support, retain or contain as an integrated part an element of the upper bearing (top cap) or to carry the rotating elements of the motor and lower bearing (bottom cap), and manufactured from high strength to density ratio materials. | Disc-shaped components of between 75 mm and 650 mm diameter especially designed or prepared to fit to the ends of the rotor tube, and so contain the $UF_6$ within the rotor tube, and in some cases to support, retain or contain as an integrated part an element of the upper bearing (top cap) or to carry the rotating elements of the motor and lower bearing (bottom cap), and manufactured from one of the high strength to density ratio materials described in the EXPLANATORY NOTE to A.2.4.1.1. below.<br>EXPLANATORY NOTE:<br>The materials used for centrifuge rotating components include the following:<br>(a) Maraging steel capable of an ultimate tensile strength of 1.95 GPa or more;<br>(b) Aluminium alloys capable of an ultimate tensile strength of 0.46 GPa or more;<br>(c) Filamentary materials suitable for use in composite structures | Yes |

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| | | and having a specific modulus of 3.18 X $10^6$ m or greater and a specific ultimate tensile strength of 7.62 X $10^4$ m or greater ('Specific Modulus' is the Young's Modulus in $N/m^2$ divided by the specific weight in $N/m^3$; 'Specific Ultimate Tensile Strength' is the ultimate tensile strength in N/ $m^2$ divided by the specific weight in N/ $m^3$). | |
| **A.2.4.1.2.** | *Static components* | Static components | No |
| | (*a*) magnetic suspension bearings: | (a) Magnetic suspension bearings: | No |
| | especially designed or prepared bearing assemblies consisting of an annular magnet suspended within a housing containing a damping medium. The housing will be manufactured from a $UF_6$-resistant material. The magnet couples with a pole piece or a second magnet fitted to the top cap described in paragraph A.2.4.1.1(*e*). The magnet may be ring-shaped with a relation between outer and inner diameter smaller or equal to 1.6:1. The magnet may be in a form having an initial permeability of 0.15 H/m (120,000 in CGS units) or more, or a remanence of 98.5% or more, or an energy product of greater than 80 kJ/$m^3$ (107 gauss-oersteds). In addition to the usual material properties, it is a prerequisite that the deviation of the magnetic axes from the geometrical axes is limited to very small tolerances (lower than 0.1 mm or 0.004 in.) or that homogeneity of the material of the magnet is specially called for; | 1. Especially designed or prepared bearing assemblies consisting of an annular magnet suspended within a housing containing a damping medium. The housing will be manufactured from a $UF_6$-resistant material (see EXPLANATORY NOTE to A.2.4.2.). The magnet couples with a pole piece or a second magnet fitted to the top cap described in A.2.4.1.1(e). The magnet may be ring-shaped with a relation between outer and inner diameter smaller or equal to 1.6:1. The magnet may be in a form having an initial permeability of 0.15 H/m or more, or a remanence of 98.5% or more, or an energy product of greater than 80 kJ/$m^3$. In addition to the usual material properties, it is a prerequisite that the deviation of the magnetic axes from the geometrical axes is limited to very small tolerances (lower than 0.1 mm) or that homogeneity of the material of the magnet is specially called for.<br>2. Active magnetic bearings especially designed or prepared for use with gas centrifuges.<br><br>EXPLANATORY NOTE:<br>These bearings usually have the following characteristics:<br>• Designed to keep centred a rotor spinning at 600 Hz or more, and | Yes |

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| | | • Associated to a reliable electrical power supply and/or to an uninterruptible power supply (UPS) unit in order to function for more than one hour. | |
| | (*b*) bearings/dampers: | (b) Bearings/Dampers: | No |
| | especially designed or prepared bearings comprising a pivot/cup assembly mounted on a damper. The pivot is normally a hardened steel shaft with a hemisphere at one end with a means of attachment to the bottom cap described in paragraph A.2.4.1.1(*e*) at the other. The shaft may however have a hydrodynamic bearing attached. The cup is pellet-shaped with a hemispherical indentation in one surface. These components are often supplied separately to the damper; | Especially designed or prepared bearings comprising a pivot/cup assembly mounted on a damper. The pivot is normally a hardened steel shaft with a hemisphere at one end with a means of attachment to the bottom cap described in section A.2.4.1.1(e) at the other. The shaft may however have a hydrodynamic bearing attached. The cup is pellet-shaped with a hemispherical indentation in one surface. These components are often supplied separately to the damper. | No |
| | (*c*) molecular pumps: | (c) Molecular pumps: | No |
| | especially designed or prepared cylinders having internally machined or extruded helical grooves and internally machined bores. Typical dimensions are as follows: 75 mm (3 in.) to 400 mm (16 in.) internal diameter, 10 mm (0.4 in.) or more wall thickness, with the length equal to or greater than the diameter. The grooves are typically rectangular in cross-section and 2 mm (0.08 in.) or more in depth; | Especially designed or prepared cylinders having internally machined or extruded helical grooves and internally machined bores. Typical dimensions are as follows: 75 mm to 650 mm internal diameter, 10 mm or more wall thickness, with the length equal to or greater than the diameter. The grooves are typically rectangular in cross-section and 2 mm or more in depth. | Yes |
| | (*d*) motor stators: | (d) Motor stators: | No |
| | especially designed or prepared ring-shaped stators for high speed multiphase AC hysteresis (or reluctance) motors for synchronous operation within a vacuum in the frequency range of 600 Hz to 2 000 Hz and a power range of 50 VA to 1 000 VA. The stators consist of multiphase windings on a laminated low loss iron core comprised of thin layers typically 2 mm (0.08 in.) thick or less; | Especially designed or prepared ring-shaped stators for high speed multiphase AC hysteresis (or reluctance) motors for synchronous operation within a vacuum at a frequency of 600 Hz or greater and a power of 40 VA or greater. The stators may consist of multi-phase windings on a laminated low loss iron core comprised of thin layers typically 2.0 mm thick or less. | Yes |

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| | (*e*) centrifuge housing/recipients: | (e) Centrifuge housing/recipients: | No |
| | components especially designed or prepared to contain the rotor tube assembly of a gas centrifuge. The housing consists of a rigid cylinder of wall thickness up to 30 mm (1.2 in.) with precision machined ends to locate the bearings and with one or more flanges for mounting. The machined ends are parallel to each other and perpendicular to the cylinder's longitudinal axis to within 0.05° or less. The housing may also be a honeycomb type structure to accommodate several rotor tubes. The housings are made of or protected by materials resistant to corrosion by $UF_6$; and | Components especially designed or prepared to contain the rotor tube assembly of a gas centrifuge. The housing consists of a rigid cylinder of wall thickness up to 30 mm with precision machined ends to locate the bearings and with one or more flanges for mounting. The machined ends are parallel to each other and perpendicular to the cylinder's longitudinal axis to within 0.05 degrees or less. The housing may also be a honeycomb type structure to accommodate several rotor assemblies. | Yes |
| | (*f*) scoops: | (f) Scoops: | No |
| | especially designed or prepared tubes of up to 12 mm (0.5 in.) internal diameter for the extraction of $UF_6$ gas from within the rotor tube by a Pitot tube action (that is, with an aperture facing into the circumferential gas flow within the rotor tube, for example by bending the end of a radially disposed tube) and capable of being fixed to the central gas extraction system. The tubes are made of or protected by materials resistant to corrosion by $UF_6$. | Especially designed or prepared tubes for the extraction of $UF_6$ gas from within the rotor tube by a Pitot tube action (that is, with an aperture facing into the circumferential gas flow within the rotor tube, for example by bending the end of a radially disposed tube) and capable of being fixed to the central gas extraction system. | Yes |
| **A.2.4.2.** | *Especially designed or prepared auxiliary systems, equipment and components for gas centrifuge enrichment plants, including:* | *Especially designed or prepared auxiliary systems, equipment and components for gas centrifuge enrichment plants* | No |
| | | INTRODUCTORY NOTE<br>The auxiliary systems, equipment and components for a gas centrifuge enrichment plant are the systems of plant needed to feed $UF_6$ to the centrifuges, to link the individual centrifuges to each other to form cascades (or stages) to allow for progressively higher enrichments and to extract the 'product' and 'tails' $UF_6$ | No |

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| | | from the centrifuges, together with the equipment required to drive the centrifuges or to control the plant.<br><br>Normally $UF_6$ is evaporated from the solid using heated autoclaves and is distributed in gaseous form to the centrifuges by way of cascade header pipework. The 'product' and 'tails' $UF_6$ gaseous streams flowing from the centrifuges are also passed by way of cascade header pipework to cold traps (operating at about 203 K (-70ºC)) where they are condensed prior to onward transfer into suitable containers for transportation or storage. Because an enrichment plant consists of many thousands of centrifuges arranged in cascades there are many kilometers of cascade header pipework, incorporating thousands of welds with a substantial amount of repetition of layout. The equipment, components and piping systems are fabricated to very high vacuum and cleanliness standards.<br><br>EXPLANATORY NOTE<br><br>Some of the items listed below either come into direct contact with the $UF_6$ process gas or directly control the centrifuges and the passage of the gas from centrifuge to centrifuge and cascade to cascade. Materials resistant to corrosion by $UF_6$ include copper, copper alloys, stainless steel, aluminium, aluminium oxide, aluminium alloys, nickel or alloys containing 60% or more nickel and fluorinated hydrocarbon polymers. | |
| **A.2.4.2.1** | *Feed systems/product and tails withdrawal systems* | *Feed systems/product and tails withdrawal systems* | No |
| | Especially designed or prepared process systems including: | Especially designed or prepared process systems or equipment for enrichment plants made of or protected by materials resistant to corrosion by $UF_6$, including: | Yes |
| | (*a*) feed autoclaves (or stations), used for passing $UF_6$ to | (a) Feed autoclaves, ovens, or systems used for passing $UF_6$ to | Yes |

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| | the centrifuge cascades at up to 100 kPa (15 psi) and at a rate of 1 kg/h or more; | the enrichment process; | |
| | (*b*) desublimers (or cold traps) used to remove $UF_6$ from the cascades at up to 3 kPa (0.5 psi) pressure. The desublimers are capable of being chilled to 203 K (-70°C) and heated to 343 K (70°C); and | (b) Desublimers, cold traps or pumps used to remove $UF_6$ from the enrichment process for subsequent transfer upon heating | Yes |
| | (*c*) product and tails stations used for trapping $UF_6$ into containers. | (c) Solidification or liquefaction stations used to remove $UF_6$ from the enrichment process by compressing and converting $UF_6$ to a liquid or solid form; | Yes |
| | This plant, equipment and pipework is wholly made of or lined with $UF_6$-resistant materials and is fabricated to very high vacuum and cleanliness standards. | (d) 'Product' or 'tails' stations used for transferring $UF_6$ into containers. | Yes |
| **A.2.4.2.2.** | *Machine header piping systems* | *Machine header piping systems* | No |
| | Especially designed or prepared piping systems and header systems for handling $UF_6$ within the centrifuge cascades. The piping network is normally of the triple header system with each centrifuge connected to each of the headers. There is thus a substantial amount of repetition in its form. It is wholly made of $UF_6$-resistant materials and is fabricated to very high vacuum and cleanliness standards. | Especially designed or prepared piping systems and header systems for handling $UF_6$ within the centrifuge cascades. The piping network is normally of the 'triple' header system with each centrifuge connected to each of the headers. There is thus a substantial amount of repetition in its form. It is wholly made of or protected by $UF_6$-resistant materials (see EXPLANATORY NOTE in A.2.4.2.) and is fabricated to very high vacuum and cleanliness standards. | Yes |
| **A.2.4.2.3.** | *Special shut-off and control valves* | *Special shut-off and control valves* | No |
| | Especially designed or prepared bellows-sealed shut-off and control valves, manual or automated, made of or protected by materials resistant to corrosion by $UF_6$, with a diameter of 10 mm to 160 mm (0.4 in. to 6.3 in.), for use in main or auxiliary systems of gas centrifuge enrichment plants. | (a) Shut-off valves especially designed or prepared to act on the feed, product or tails $UF_6$ gaseous streams of an individual gas centrifuge.<br>(b) Bellows-sealed valves, manual or automated, shut-off or control, made of or protected by materials resistant to corrosion by $UF_6$, with an inside diameter of 10 to 160 mm, especially designed or prepared for use in main or auxiliary systems of gas | Yes |

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| | | centrifuge enrichment plants.<br><br>EXPLANATORY NOTE<br>Typical especially designed or prepared valves include bellow-sealed valves, fast acting closure-types, fast acting valves and others. | |
| **A.2.4.2.4.** | *$UF_6$ mass spectrometers/ion sources* | *$UF_6$ mass spectrometers/ion sources* | No |
| | Especially designed or prepared magnetic or quadrupole mass spectrometers capable of taking on-line samples of feed, product or tails, from $UF_6$ gas streams and having all of the following characteristics: | Especially designed or prepared mass spectrometers capable of taking on-line samples from $UF_6$ gas streams and having all of the following: | Yes |
| | (*a*) unit resolution for atomic mass unit greater than 320; | 1. Capable of measuring ions of 320 atomic mass units or greater and having a resolution of better than 1 part in 320; | Yes |
| | (*b*) ion sources constructed of or lined with nichrome or monel or nickel plated; | 2. Ion sources constructed of or protected by nickel, nickel-copper alloys with a nickel content of 60% or more by weight, or nickel-chrome alloys; | Yes |
| | (*c*) electron bombardment ionization sources; and | 3. Electron bombardment ionization sources; | No |
| | (*d*) having a collector system suitable for isotopic analysis. | 4. Having a collector system suitable for isotopic analysis. | No |
| **A.2.4.2.5.** | *Frequency changers* | *Frequency changers* | No |
| | Frequency changers (also known as converters or invertors) especially designed or prepared to supply motor stators as defined in paragraph A.2.4.1.2.(*d*), or parts, components and sub-assemblies of such frequency changers having all of the following characteristics: | Frequency changers (also known as converters or inverters) especially designed or prepared to supply motor stators as defined under A.2.4.1.2.(d), or parts, components and sub-assemblies of such frequency changers having all of the following characteristics: | No |
| | (*a*) a multiphase output of 600 Hz to 2 000 Hz; | 1. A multiphase frequency output of 600 Hz or greater; and | Yes |
| | (*b*) high stability (with frequency control better than 0.1%); | 2. High stability (with frequency control better than 0.2%). | Yes |

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| | (*c*) low harmonic distortion (less than 2%); and | | Yes |
| | (*d*) an efficiency of greater than 80%. | | Yes |
| **A.2.4.3.** | *Especially designed or prepared assemblies and components for use in gaseous diffusion enrichment, including:* | *Especially designed or prepared assemblies and components for use in gaseous diffusion enrichment* | No |
| | | INTRODUCTORY NOTE<br>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. | No |
| **A.2.4.3.1.** | *Gaseous diffusion barriers* | *Gaseous diffusion barriers and barrier materials* | Yes |
| | (*a*) especially designed or prepared thin, porous filters, with a pore size of 100 Å to 1 000 Å (angstroms), a thickness of 5 mm (0.2 in.) or less, and for tubular forms, a diameter of 25 mm (1 in.) or less, made of metallic, polymer or ceramic materials resistant to corrosion by $UF_6$; and | (a) Especially designed or prepared thin, porous filters, with a pore size of 10 - 100 nm, 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 $UF_6$ (see EXPLANATORY NOTE to A.2.4.4.), and | No |
| | (*b*) especially prepared compounds or powders for the manufacture of such filters. Such compounds and powders include nickel or alloys containing 60% or more nickel, aluminium oxide, or $UF_6$-resistant fully fluorinated hydrocarbon polymers having a purity of 99.9% or more, a particle size less than 10 microns, and a high degree of particle size uniformity, which are especially prepared for | (b) especially prepared compounds or powders for the manufacture of such filters. Such compounds and powders include nickel or alloys containing 60% or more nickel, aluminium oxide, or $UF_6$-resistant fully fluorinated hydrocarbon polymers having a purity of 99.9% by weight or more, a particle size less than 10 µm, and a high degree of particle size uniformity, which are especially prepared for the manufacture of | No |

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| | the manufacture of gaseous diffusion barriers. | gaseous diffusion barriers | |
| **A.2.4.3.2.** | *Diffuser housings* | *Diffuser housings* | No |
| | Especially designed or prepared hermetically sealed cylindrical vessels greater than 300 mm (12 in.) in diameter and greater than 900 mm (35 in.) in length, or rectangular vessels of comparable dimensions, which have an inlet connection and two outlet connections all of which are greater than 50 mm (2 in.) in diameter, for containing the gaseous diffusion barrier, made of or lined with $UF_6$-resistant materials and designed for horizontal or vertical installation. | Especially designed or prepared hermetically sealed vessels for containing the gaseous diffusion barrier, made of or protected by $UF_6$-resistant materials (see EXPLANATORY NOTE to A.2.4.4.). | Yes |
| **A.2.4.3.3.** | *Compressors and gas blowers* | *Compressors and gas blowers* | No |
| | Especially designed or prepared axial, centrifugal, or positive displacement compressors, or gas blowers with a suction volume capacity of 1 $m^3$/min or more of $UF_6$, and with a discharge pressure of up to several hundred kPa (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 $UF_6$. | Especially designed or prepared compressors or gas blowers with a suction volume capacity of 1 $m^3$ per minute or more of $UF_6$, and with a discharge pressure of up to 500 kPa, designed for long-term operation in the $UF_6$ environment, as well as separate assemblies of such compressors and gas blowers. These compressors and gas blowers have a pressure ratio of 10:1 or less and are made of, or protected by, materials resistant to $UF_6$ (see EXPLANATORY NOTE to A.2.4.4.). | Yes |
| **A.2.4.3.4.** | *Rotary shaft seals* | *Rotary shaft seals* | No |
| | 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 $UF_6$. Such seals are normally designed for a buffer gas in-leakage rate of less | 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 $UF_6$. Such seals are normally designed for a buffer gas in-leakage rate of less than 1000 $cm^3$ per minute. | No |

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| | than 1 000 $cm^3$/min (60 $in.^3$/min). | | |
| **A.2.4.3.5.** | *Heat exchangers for cooling $UF_6$* | *Heat exchangers for cooling $UF_6$* | No |
| | Especially designed or prepared heat exchangers made of or lined with $UF_6$-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 Pa/h (0.0015 psi/h) under a pressure difference of 100 kPa (15 psi). | Especially designed or prepared heat exchangers made of or protected by $UF_6$-resistant materials (see EXPLANATORY NOTE to A.2.4.4.), and intended for a leakage pressure change rate of less than 10 Pa per hour under a pressure difference of 100 kPa. | Yes |
| **A.2.4.4.** | *Especially designed or prepared auxiliary systems, equipment and components for use in gaseous diffusion enrichment, including:* | *Especially designed or prepared auxiliary systems, equipment and components for use in gaseous diffusion enrichment* | No |
| | | INTRODUCTORY NOTE<br>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 from 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.<br>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 | No |

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| | | compression stations where the $UF_6$ gas is liquefied 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.<br><br>EXPLANATORY NOTE<br>The items listed below either come into direct contact with the $UF_6$ process gas or directly control the flow within the cascade. Materials resistant to corrosion by $UF_6$ include copper, copper alloys, stainless steel, aluminium, aluminium oxide, aluminium alloys, nickel or alloys containing 60% or more nickel and fluorinated hydrocarbon polymers. | |
| **A.2.4.4.1.** | *Feed systems/product and tails withdrawal systems* | *Feed systems/product and tails withdrawal systems* | No |
| | Especially designed or prepared process systems, capable of operating at pressures of 300 kPa (45 psi) or less, including: | Especially designed or prepared process systems or equipment for enrichment plants made of or protected by materials resistant to corrosion by $UF_6$, including: | Yes |
| | (*a*) feed autoclaves (or systems) used for passing $UF_6$ to the gaseous diffusion cascades; | (a) Feed autoclaves, ovens, or systems used for passing $UF_6$ to the enrichment process; | Yes |
| | (*b*) desublimers (or cold traps) used to remove $UF_6$ from diffusion cascades; | (b) Desublimers, cold traps or pumps used to remove $UF_6$ from the enrichment process for subsequent transfer upon heating; | Yes |
| | (*c*) liquefaction stations where $UF_6$ gas from the cascade is compressed and cooled to form liquid $UF_6$; and | (c) Solidification or liquefaction stations used to remove $UF_6$ from the enrichment process by compressing and converting $UF_6$ to a liquid or solid form; | Yes |
| | (*d*) product or tails stations used for transferring $UF_6$ into | (d) ‘Product’ or ‘tails’ stations used for transferring $UF_6$ into | No |

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| | containers. | containers. | |
| **A.2.4.4.2.** | *Header piping systems* | *Header piping systems* | No |
| | Especially designed or prepared piping systems and header systems for handling $UF_6$ within the gaseous diffusion cascades. This piping network is normally of the double header system with each cell connected to each of the headers. | Especially designed or prepared piping systems and header systems for handling $UF_6$ within the gaseous diffusion cascades.<br><br>EXPLANATORY NOTE<br><br>This piping network is normally of the "double" header system with each cell connected to each of the headers. | No |
| **A.2.4.4.3.** | *Vacuum systems* | *Vacuum systems* | No |
| | (*a*) especially designed or prepared large vacuum manifolds, vacuum headers and vacuum pumps having a suction capacity of 5 $m^3$/min (175 $ft.^3$/min) or more; and | (a) Especially designed or prepared vacuum manifolds, vacuum headers and vacuum pumps having a suction capacity of 5 $m^3$ per minute or more. | No |
| | (*b*) vacuum pumps especially designed for service in $UF_6$-bearing atmospheres made of, or lined with, aluminium, nickel, or alloys bearing more than 60% nickel. These pumps may be either rotary or positive, may have displacement and fluorocarbon seals, and may have special working fluids present. | (b) Vacuum pumps especially designed for service in $UF_6$-bearing atmospheres made of, or protected by, materials resistant to corrosion by $UF_6$ (see EXPLANATORY NOTE in A.2.4.4.). These pumps may be either rotary or positive, may have displacement and fluorocarbon seals, and may have special working fluids present. | Yes |
| **A.2.4.4.4.** | *Special shut-off and control valves* | *Special shut-off and control valves* | No |
| | Especially designed or prepared manual or automated shut-off and control bellows valves made of $UF_6$-resistant materials with a diameter of 40 mm to 1 500 mm (1.5 in. to 59 in.) for installation in main and auxiliary systems of gaseous diffusion enrichment plants. | Especially designed or prepared bellows-sealed valves, manual or automated, shut-off or control, made of or protected by materials resistant to corrosion by $UF_6$, for installation in main and auxiliary systems of gaseous diffusion enrichment plants. | Yes |
| **A.2.4.4.5.** | *$UF_6$ mass spectrometers/ion sources* | *$UF_6$ mass spectrometers/ion sources* | No |
| | Especially designed or prepared magnetic or quadrupole mass spectrometers capable of taking on-line samples of | Especially designed or prepared mass spectrometers capable of taking on-line samples from $UF_6$ gas streams and having all of | Yes |

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| | feed, product or tails, from $UF_6$ gas streams and having all of the following characteristics: | the following: | |
| | (*a*) resolution for atomic mass unit greater than 320; | 1. Capable of measuring ions of 320 atomic mass units or greater and having a resolution of better than 1 part in 320; | Yes |
| | (*b*) ion sources constructed of or lined with nichrome or monel or nickel plated; | 2. Ion sources constructed of or protected by nickel, nickel-copper alloys with a nickel content of 60% or more by weight, or nickel-chrome alloys; | Yes |
| | (*c*) electron bombardment ionization sources; and | 3. Electron bombardment ionization sources; | No |
| | (*d*) collector system suitable for isotopic analysis. | 4. Having a collector system suitable for isotopic analysis. | No |
| **A.2.4.5.** | *Especially designed or prepared systems, equipment and components for use in aerodynamic enrichment plants, including:* | *Especially designed or prepared systems, equipment and components for use in aerodynamic enrichment plants* | No |
| | | INTRODUCTORY NOTE<br>In aerodynamic enrichment processes, a mixture of gaseous $UF_6$ 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 include 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. Since aerodynamic processes use $UF_6$, all equipment, pipeline and instrumentation surfaces (that come in contact with the gas) must be made of or protected by materials that remain stable in contact with $UF_6$. | No |

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| | | EXPLANATORY NOTE<br>The items listed in this section 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 protected by $UF_6$-resistant materials. For the purposes of the section relating to aerodynamic enrichment items, the materials resistant to corrosion by $UF_6$ include copper, copper alloys, stainless steel, aluminum, aluminum oxide, aluminum alloys, nickel or alloys containing 60% or more nickel by weight and fluorinated hydrocarbon polymers. | |
| **A.2.4.5.1.** | *Separation nozzles* | *Separation nozzles* | No |
| | Especially designed or prepared separation nozzles and assemblies thereof. The separation nozzles consist of slit-shaped, curved channels having a radius of curvature less than 1 mm (typically 0.1 mm to 0.05 mm), resistant to corrosion by $UF_6$ and having a knife-edge within the nozzle that separates the gas flowing through the nozzle into two fractions. | Especially designed or prepared separation nozzles and assemblies thereof. The separation nozzles consist of slit-shaped, curved channels having a radius of curvature less than 1 mm, resistant to corrosion by $UF_6$ and having a knife-edge within the nozzle that separates the gas flowing through the nozzle into two fractions. | No |
| **A.2.4.5.2.** | *Vortex tubes* | *Vortex tubes* | No |
| | Especially designed or prepared vortex tubes and assemblies thereof. The vortex tubes are cylindrical or tapered, made of or protected by materials resistant to corrosion by $UF_6$, having a diameter of between 0.5 cm and 4 cm, a length to diameter ratio of 20:1 or less and with one or more tangential inlets. The tubes may be equipped with nozzle-type appendages at either or both ends. | Especially designed or prepared vortex tubes and assemblies thereof. The vortex tubes are cylindrical or tapered, made of or protected by materials resistant to corrosion by $UF_6$, and with one or more tangential inlets. The tubes may be equipped with nozzle-type appendages at either or both ends.<br><br>EXPLANATORY NOTE<br>The feed gas enters the vortex tube tangentially at one end or through swirl vanes or at numerous tangential positions along the periphery of the tube. | Yes |

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| **A.2.4.5.3.** | *Compressors and gas blowers* | *Compressors and gas blowers* | No |
| | Especially designed or prepared axial, centrifugal or positive displacement compressors or gas blowers made of or protected by materials resistant to corrosion by $UF_6$ and with a suction volume capacity of 2 $m^3$/min or more of $UF_6$/carrier gas (hydrogen or helium) mixture. | Especially designed or prepared compressors or gas blowers made of or protected by materials resistant to corrosion by the $UF_6$/carrier gas (hydrogen or helium) mixture. | Yes |
| **A.2.4.5.9.** | *Vacuum systems and pumps* | *Vacuum systems and pumps* | No |
| | (a) especially designed or prepared vacuum systems having a suction capacity of 5 $m^3$/min or more, consisting of vacuum manifolds, vacuum headers and vacuum pumps, and designed for service in UF6-bearing atmospheres; and | (a) Especially designed or prepared vacuum systems consisting of vacuum manifolds, vacuum headers and vacuum pumps, and designed for service in UF6-bearing atmospheres, | Yes |
| | (*b*) vacuum pumps especially designed or prepared for service in $UF_6$-bearing atmospheres and made of or protected by materials resistant to corrosion by $UF_6$. These pumps may use fluorocarbon seals and special working fluids. | (b) Vacuum pumps especially designed or prepared for service in $UF_6$-bearing atmospheres and made of or protected by materials resistant to corrosion by $UF_6$. These pumps may use fluorocarbon seals and special working fluids. | No |
| **A.2.4.5.10.** | *Special shut-off and control valves* | *Special shut-off and control valves* | No |
| | Especially designed or prepared manual or automated shut-off and control bellows valves made of or protected by materials resistant to corrosion by $UF_6$ with a diameter of 40 mm to 1 500 mm for installation in main and auxiliary systems of aerodynamic enrichment plants. | Especially designed or prepared bellows-sealed valves, manual or automated, shut-off or control, made of or protected by materials resistant to corrosion by $UF_6$, with a diameter of 40 mm or greater, for installation in main and auxiliary systems of aerodynamic enrichment plants. | Yes |
| **A.2.4.5.11.** | *$UF_6$ mass spectrometers/ion sources* | *$UF_6$ mass spectrometers/Ion sources* | No |
| | Especially designed or prepared magnetic or quadrupole mass spectrometers capable of taking on-line samples of feed, product or tails, from $UF_6$ gas streams and having all of the following characteristics: | Especially designed or prepared mass spectrometers capable of taking on-line samples from $UF_6$ gas streams and having all of the following: | Yes |

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| | (*a*) unit resolution for mass greater than 320; | 1. Capable of measuring ions of 320 atomic mass units or greater and having a resolution of better than 1 part in 320; | Yes |
| | (*b*) ion sources constructed of or lined with nichrome or monel or nickel plated; | 2. Ion sources constructed of or protected by nickel, nickel-copper alloys with a nickel content of 60% or more by weight, or nickel-chrome alloys; | Yes |
| | (*c*) electron bombardment ionization sources; and | 3. Electron bombardment ionization sources; | No |
| | (*d*) collector system suitable for isotopic analysis. | 4. Having a collector system suitable for isotopic analysis. | No |
| **A.2.4.5.12.** | *$UF_6$/carrier gas separation systems* | *$UF_6$/carrier gas separation systems* | No |
| | | EXPLANATORY NOTE<br>These systems are designed to reduce the $UF_6$ content in the carrier gas to 1 ppm or less and may incorporate equipment such as:<br>(a) Cryogenic heat exchangers and cryoseparators capable of temperatures of 153 K (-120°C) or less, or<br>(b) Cryogenic refrigeration units capable of temperatures of 153 K (-120°C) or less, or<br>(c) Separation nozzle or vortex tube units for the separation of $UF_6$ from carrier gas, or<br>(d) $UF_6$ cold traps capable of freezing out $UF_6$. | No |
| **A.2.4.6.** | *Especially designed or prepared systems, equipment and components for use in chemical exchange or ion exchange enrichment plants, including:* | *Especially designed or prepared systems, equipment and components for use in chemical exchange or ion exchange enrichment plants.* | No |
| | | INTRODUCTORY NOTE<br>The slight difference in mass between the isotopes of uranium causes small changes in chemical reaction equilibria that can be used as a basis for separation of the isotopes. Two processes have been successfully developed: liquid-liquid chemical | No |

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| | | exchange and solid-liquid ion exchange.<br><br>In the liquid-liquid chemical exchange process, immiscible liquid phases (aqueous and organic) are countercurrently contacted to give the cascading effect of thousands of separation stages. The aqueous phase consists of uranium chloride in hydrochloric acid solution; the organic phase consists of an extractant containing uranium chloride in an organic solvent. The contactors employed in the separation cascade can be liquid-liquid exchange columns (such as pulsed columns with sieve plates) or liquid centrifugal contactors. Chemical conversions (oxidation and reduction) are required at both ends of the separation cascade in order to provide for the reflux requirements at each end. A major design concern is to avoid contamination of the process streams with certain metal ions. Plastic, plastic-lined (including use of fluorocarbon polymers) and/or glass-lined columns and piping are therefore used.<br><br>In the solid-liquid ion-exchange process, enrichment is accomplished by uranium adsorption/desorption on a special, very fast-acting, ion-exchange resin or adsorbent. A solution of uranium in hydrochloric acid and other chemical agents is passed through cylindrical enrichment columns containing packed beds of the adsorbent. For a continuous process, a reflux system is necessary to release the uranium from the adsorbent back into the liquid flow so that ‘product’ and ‘tails’ can be collected. This is accomplished with the use of suitable reduction/oxidation chemical agents that are fully regenerated in separate external circuits and that may be partially regenerated within the isotopic separation columns themselves. The presence of hot concentrated hydrochloric acid solutions in the process requires that the equipment be made of or protected by special corrosion-resistant materials. | |

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| **A.2.4.6.1.** | *Liquid-liquid exchange columns (chemical exchange)* | Liquid-liquid exchange columns (Chemical exchange) | No |
| | Countercurrent liquid-liquid exchange columns having mechanical power input (*i.e.*, pulsed columns with sieve plates, reciprocating plate columns, and columns with internal turbine mixers), especially designed or prepared for uranium enrichment using the chemical exchange process. For corrosion resistance to concentrated hydrochloric acid solutions, these columns and their internals are made of or protected by suitable plastic materials (such as fluorocarbon polymers) or glass. The stage residence time of the columns is designed to be short (30 s or less). | Countercurrent liquid-liquid exchange columns having mechanical power input, especially designed or prepared for uranium enrichment using the chemical exchange process. For corrosion resistance to concentrated hydrochloric acid solutions, these columns and their internals are normally made of or protected by suitable plastic materials (such as fluorinated hydrocarbon polymers) or glass. The stage residence time of the columns is normally designed to be 30 seconds or less. | No |
| **A.2.4.6.2.** | *Liquid-liquid centrifugal contactors (chemical exchange)* | Liquid-liquid centrifugal contactors (Chemical exchange) | No |
| | Liquid-liquid centrifugal contactors especially designed or prepared for uranium enrichment using the chemical exchange process. Such contactors use rotation to achieve dispersion of the organic and aqueous streams and then centrifugal force to separate the phases. For corrosion resistance to concentrated hydrochloric acid solutions, the contactors are made of or are lined with suitable plastic materials (such as fluorocarbon polymers) or are lined with glass. The stage residence time of the centrifugal contactors is designed to be short (30 s or less). | Liquid-liquid centrifugal contactors especially designed or prepared for uranium enrichment using the chemical exchange process. Such contactors use rotation to achieve dispersion of the organic and aqueous streams and then centrifugal force to separate the phases. For corrosion resistance to concentrated hydrochloric acid solutions, the contactors are normally made of or protected by suitable plastic materials (such as fluorinated hydrocarbon polymers) or glass. The stage residence time of the centrifugal contactors is normally designed to be 30 seconds or less. | No |
| **A.2.4.6.3.** | *Uranium reduction systems and equipment (chemical exchange)* | *Uranium reduction systems and equipment (chemical exchange)* | No |
| | (*a*) especially designed or prepared electrochemical reduction cells to reduce uranium from one valence state to another for uranium enrichment using the chemical exchange process. The cell materials in contact with process solutions must be corrosion resistant to | (a) Especially designed or prepared electrochemical reduction cells to reduce uranium from one valence state to another for uranium enrichment using the chemical exchange process. The cell materials in contact with process solutions must be corrosion resistant to concentrated hydrochloric acid solutions. | No |

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| | concentrated hydrochloric acid solutions; and<br>(*b*) especially designed or prepared systems at the product end of the cascade for taking the $U^{+4}$ out of the organic stream, adjusting the acid concentration and feeding to the electrochemical reduction cells. | EXPLANATORY NOTE<br>The cell cathodic compartment must be designed to prevent re-oxidation of uranium to its higher valence state. To keep the uranium in the cathodic compartment, the cell may have an impervious diaphragm membrane constructed of special cation exchange material. The cathode consists of a suitable solid conductor such as graphite.<br>(b) Especially designed or prepared systems at the product end of the cascade for taking the $U^{+4}$ out of the organic stream, adjusting the acid concentration and feeding to the electrochemical reduction cells.<br><br>EXPLANATORY NOTE<br>These systems consist of solvent extraction equipment for stripping the $U^{+4}$ from the organic stream into an aqueous solution, evaporation and/or other equipment to accomplish solution pH adjustment and control, and pumps or other transfer devices for feeding to the electrochemical reduction cells. A major design concern is to avoid contamination of the aqueous stream with certain metal ions. Consequently, for those parts in contact with the process stream, the system is constructed of equipment made of or protected by suitable materials (such as glass, fluorocarbon polymers, polyphenyl sulfate, polyether sulfone, and resin-impregnated graphite). | |
| **A.2.4.6.4** | *Feed preparation systems (chemical exchange)* | *Feed preparation systems (chemical exchange)* | No |
| | Especially designed or prepared systems for producing high-purity uranium chloride feed solutions for chemical exchange uranium isotope separation plants. | Especially designed or prepared systems for producing high-purity uranium chloride feed solutions for chemical exchange uranium isotope separation plants. | No |

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| | | EXPLANATORY NOTE<br>These systems consist of dissolution, solvent extraction and/or ion exchange equipment for purification and electrolytic cells for reducing the uranium $U^{+6}$ or $U^{+4}$ to $U^{+3}$. These systems produce uranium chloride solutions having only a few parts per million of metallic impurities such as chromium, iron, vanadium, molybdenum and other bivalent or higher multi-valent cations. Materials of construction for portions of the system processing high-purity $U^{+3}$ include glass, fluorinated hydrocarbon polymers, polyphenyl sulfate or polyether sulfone plastic-lined and resin-impregnated graphite. | |
| **A.2.4.6.5.** | *Uranium oxidation systems (chemical exchange)* | *Uranium oxidation systems (Chemical exchange)* | No |
| | Especially designed or prepared systems for oxidation of $U^{+3}$ to $U^{+4}$ for return to the uranium isotope separation cascade in the chemical exchange enrichment process. | Especially designed or prepared systems for oxidation of $U^{+3}$ to $U^{+4}$ for return to the uranium isotope separation cascade in the chemical exchange enrichment process.<br><br>EXPLANATORY NOTE<br>These systems may incorporate equipment such as:<br>(a) Equipment for contacting chlorine and oxygen with the aqueous effluent from the isotope separation equipment and extracting the resultant $U^{+4}$ into the stripped organic stream returning from the product end of the cascade,<br>(b) Equipment that separates water from hydrochloric acid so that the water and the concentrated hydrochloric acid may be reintroduced to the process at the proper locations. | No |
| **A.2.4.6.6.** | *Fast-reacting ion exchange resins/adsorbents (ion exchange)* | *Fast-reacting ion exchange resins/adsorbents (ion exchange)* | No |
| | Fast-reacting ion-exchange resins or adsorbents especially designed or prepared for uranium enrichment using the ion | Fast-reacting ion-exchange resins or adsorbents especially designed or prepared for uranium enrichment using the ion | No |

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| | exchange process, including porous macroreticular resins, and pellicular structures in which the active chemical exchange groups are limited to a coating on the surface of an inactive porous support structure, and other composite structures in any suitable form including particles or fibres. These ion exchange resins/adsorbents have diameters of 0.2 mm or less and must be chemically resistant to concentrated hydrochloric acid solutions as well as physically strong enough so as not to degrade in the exchange columns. The resins/adsorbents are especially designed to achieve very fast uranium isotope exchange kinetics (exchange rate half-time of less than 10 s) and are capable of operating at a temperature in the range of 100°C to 200°C. | exchange process, including porous macroreticular resins, and/or pellicular structures in which the active chemical exchange groups are limited to a coating on the surface of an inactive porous support structure, and other composite structures in any suitable form including particles or fibres. These ion exchange resins/adsorbents have diameters of 0.2 mm or less and must be chemically resistant to concentrated hydrochloric acid solutions as well as physically strong enough so as not to degrade in the exchange columns. The resins/adsorbents are especially designed to achieve very fast uranium isotope exchange kinetics (exchange rate half-time of less than 10 seconds) and are capable of operating at a temperature in the range of 373 K (100°C) to 473 K (200°C). | |
| **A.2.4.6.7.** | *Ion exchange columns (ion exchange)* | *Ion exchange columns (ion exchange)* | No |
| | Cylindrical columns greater than 1 000 mm in diameter for containing and supporting packed beds of ion exchange resin/adsorbent, especially designed or prepared for uranium enrichment using the ion exchange process. These columns are made of or protected by materials (such as titanium or fluorocarbon plastics) resistant to corrosion by concentrated hydrochloric acid solutions and are capable of operating at a temperature in the range of 100°C to 200°C and pressures above 0.7 MPa (102 psi). | Cylindrical columns greater than 1000 mm in diameter for containing and supporting packed beds of ion exchange resin/adsorbent, especially designed or prepared for uranium enrichment using the ion exchange process. These columns are made of or protected by materials (such as titanium or fluorocarbon plastics) resistant to corrosion by concentrated hydrochloric acid solutions and are capable of operating at a temperature in the range of 373 K (100°C) to 473 K (200°C) and pressures above 0.7 MPa. | No |
| **A.2.4.6.8.** | *Ion exchange reflux systems (ion exchange)* | *Ion exchange reflux systems (ion exchange)* | No |
| | (*a*) especially designed or prepared chemical or electrochemical reduction systems for regeneration of the chemical reducing agent(s) used in ion exchange uranium enrichment cascades; and<br>(*b*) especially designed or prepared chemical or electrochemical oxidation systems for regeneration of the | (a) Especially designed or prepared chemical or electrochemical reduction systems for regeneration of the chemical reducing agent(s) used in ion exchange uranium enrichment cascades.<br>(b) Especially designed or prepared chemical or electrochemical oxidation systems for regeneration of the chemical oxidizing agent(s) used in ion exchange uranium enrichment cascades. | No |

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| | chemical oxidizing agent(s) used in ion exchange uranium enrichment cascades. | EXPLANATORY NOTE<br>The ion exchange enrichment process may use, for example, trivalent titanium ($Ti^{+3}$) as a reducing cation in which case the reduction system would regenerate $Ti^{+3}$ by reducing $Ti^{+4}$.<br>The process may use, for example, trivalent iron ($Fe^{+3}$) as an oxidant in which case the oxidation system would regenerate $Fe^{+3}$ by oxidizing $Fe^{+2}$. | |
| **A.2.4.7.** | *Especially designed or prepared systems, equipment and components for use in laser-based enrichment plants, including:* | *Especially designed or prepared systems, equipment and components for use in laser-based enrichment plants.* | No |
| | | INTRODUCTORY NOTE<br>Present systems for enrichment processes using lasers fall into two categories: those in which the process medium is atomic uranium vapour and those in which the process medium is the vapour of a uranium compound, sometimes mixed with another gas or gases. Common nomenclature for such processes include:<br>• first category - atomic vapour laser isotope separation;<br>• second category - molecular laser isotope separation, including chemical reaction by isotope selective laser activation.<br>The systems, equipment and components for laser enrichment plants embrace:<br>(a) devices to feed uranium-metal vapour (for selective photo-ionization) or devices to feed the vapour of a uranium compound (for selective photo-dissociation or selective | No |

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| | | excitation/activation);<br>(b) devices to collect enriched and depleted uranium metal as ‘product’ and ‘tails’ in the first category, and devices to collect enriched and depleted uranium compounds as ‘product’ and ‘tails’ in the second category;<br>(c) process laser systems to selectively excite the uranium-235 species; and<br>(d) feed preparation and product conversion equipment. The complexity of the spectroscopy of uranium atoms and compounds may require incorporation of any of a number of available laser and laser optics technologies.<br><br>EXPLANATORY NOTE<br>Many of the items listed in this section come into direct contact with uranium metal vapour or liquid or with process gas consisting of $UF_6$ or a mixture of $UF_6$ and other gases. All surfaces that come into direct contact with the uranium or $UF_6$ are wholly made of or protected by corrosion-resistant materials. For the purposes of the section relating to laser-based enrichment items, the materials resistant to corrosion by the vapour or liquid of uranium metal or uranium alloys include yttria-coated graphite and tantalum; and the materials resistant to corrosion by $UF_6$ include copper, copper alloys, stainless steel, aluminium, aluminium oxide, aluminium alloys, nickel or alloys containing 60% or more nickel by weight and fluorinated hydrocarbon polymers. | |
| **A.2.4.7.1.** | *Uranium vaporization systems (AVLIS)* | *Uranium vaporization systems (atomic vapour based methods)* | No |
| | Especially designed or prepared uranium vaporization systems which contain high-power strip or scanning electron beam guns with a delivered power on the target of | Especially designed or prepared uranium metal vaporization systems for use in laser enrichment. | Yes |

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| | more than 2.5 kW/cm. | EXPLANATORY NOTE<br>These systems may contain electron beam guns and are designed to achieve a delivered power (1 kW or greater) on the target sufficient to generate uranium metal vapour at a rate required for the laser enrichment function. | |
| **A.2.4.7.2.** | *Liquid uranium metal handling systems (AVLIS)* | *Liquid or vapour uranium metal handling systems and components (atomic vapour based methods)* | Yes |
| | Especially designed or prepared liquid metal handling systems for molten uranium or uranium alloys, consisting of crucibles and cooling equipment for the crucibles. | Especially designed or prepared systems for handling molten uranium, molten uranium alloys or uranium metal vapour for use in laser enrichment or especially designed or prepared components therefore.<br><br>EXPLANATORY NOTE<br>The liquid uranium metal handling systems may consist of crucibles and cooling equipment for the crucibles. The crucibles and other parts of this system that come into contact with molten uranium, molten uranium alloys or uranium metal vapour are made of or protected by materials of suitable corrosion and heat resistance. Suitable materials may include tantalum, yttria-coated graphite, graphite coated with other rare earth oxides (see INFCIRC/254/Part 2 - (as amended)) or mixtures thereof. | Yes |
| **A.2.4.7.3.** | *Uranium metal product and tails collector assemblies (AVLIS)* | *Uranium metal 'product' and 'tails' collector assemblies (atomic vapour based methods)* | No |
| | Especially designed or prepared product and tails collector assemblies for uranium metal in liquid or solid form. | Especially designed or prepared 'product' and 'tails' collector assemblies for uranium metal in liquid or solid form.<br><br>EXPLANATORY NOTE<br>Components for these assemblies are made of or protected by materials resistant to the heat and corrosion of uranium metal | No |

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| | | vapour or liquid (such as yttria-coated graphite or tantalum) and may include pipes, valves, fittings, ‘gutters’, feed-throughs, heat exchangers and collector plates for magnetic, electrostatic or other separation methods. | |
| **A.2.4.7.4.** | *Separator module housings (AVLIS)* | *Separator module housings (atomic vapour based methods)* | No |
| | Especially designed or prepared cylindrical or rectangular vessels for containing the uranium metal vapour source, the electron beam gun, and the product and tails collectors. | Especially designed or prepared cylindrical or rectangular vessels for containing the uranium metal vapour source, the electron beam gun, and the ‘product’ and ‘tails’ collectors.<br><br>EXPLANATORY NOTE<br>These housings have multiplicity of ports for electrical and water feed-throughs, laser beam windows, vacuum pump connections and instrumentation diagnostics and monitoring. They have provisions for opening and closure to allow refurbishment of internal components. | No |
| **A.2.4.7.5.** | *Supersonic expansion nozzles (MLIS)* | *Supersonic expansion nozzles (molecular based methods)* | No |
| | Especially designed or prepared supersonic expansion nozzles for cooling mixtures of $UF_6$ and carrier gas to 150 K or less and which are corrosion resistant to $UF_6$. | Especially designed or prepared supersonic expansion nozzles for cooling mixtures of $UF_6$ and carrier gas to 150 K (-123°C) or less and which are corrosion resistant to $UF_6$. | No |
| **A.2.4.7.6.** | *Uranium pentafluoride product collectors (MLIS)* | *‘Product’ or ‘tails’ collectors (molecular based methods)* | No |
| | Especially designed or prepared uranium pentafluoride ($UF_5$) solid product collectors consisting of filter, impact, or cyclone-type collectors, or combinations thereof, and which are corrosion resistant to the $UF_5/UF_6$ environment. | Especially designed or prepared components or devices for collecting uranium product material or uranium tails material following illumination with laser light.<br><br>EXPLANATORY NOTE<br>In one example of molecular laser isotope separation, the product collectors serve to collect enriched uranium pentafluoride ($UF_5$) | Yes |

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| | | solid material. The product collectors may consist of filter, impact, or cyclone-type collectors, or combinations thereof, and must be corrosion resistant to the $UF_5$/ $UF_6$ environment. | |
| **A.2.4.7.7.** | *$UF_6$/carrier gas compressors (MLIS)* | *$UF_6$/carrier gas compressors (molecular based methods)* | No |
| **A.2.4.7.8.** | *Rotary shaft seals (MLIS)* | *Rotary shaft seals (molecular based methods)* | No |
| **A.2.4.7.9.** | *Fluorination systems (MLIS)* | *Fluorination systems (molecular based methods)* | No |
| | Especially designed or prepared systems for fluorinating $UF_5$ (solid) to $UF_6$ (gas). | Especially designed or prepared systems for fluorinating $UF_5$ (solid) to $UF_6$ (gas).<br><br>EXPLANATORY NOTE<br>These systems are designed to fluorinate the collected $UF_5$ powder to $UF_6$ for subsequent collection in product containers or for transfer as feed for additional enrichment. In one approach, the fluorination reaction may be accomplished within the isotope separation system to react and recover directly off the 'product' collectors. In another approach, the $UF_5$ powder may be removed/transferred from the 'product' collectors into a suitable reaction vessel (e.g., fluidized-bed reactor, screw reactor or flame tower) for fluorination. In both approaches, equipment for storage and transfer of fluorine (or other suitable fluorinating agents) and for collection and transfer of $UF_6$ are used. | No |
| **A.2.4.7.10.** | *$UF_6$ mass spectrometers/ion sources (MLIS)* | *$UF_6$ mass spectrometers/ion sources (molecular based methods)* | No |
| | Especially designed or prepared magnetic or quadrupole mass spectrometers capable of taking on-line samples of feed, product or tails, from $UF_6$ gas streams and having all of the following characteristics: | Especially designed or prepared mass spectrometers capable of taking on-line samples from $UF_6$ gas streams and having all of the following: | Yes |
| | (*a*) unit resolution for mass greater than 320; | 1. Capable of measuring ions of 320 atomic mass units or greater and having a resolution of better than 1 part in 320; | Yes |

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| | (*b*) ion sources constructed of or lined with nichrome or monel or nickel plated; | 2. Ion sources constructed of or protected by nickel, nickel-copper alloys with a nickel content of 60% or more by weight, or nickel-chrome alloys; | Yes |
| | (*c*) electron bombardment ionization sources; and | 3. Electron bombardment ionization sources; | No |
| | (*d*) collector system suitable for isotopic analysis. | 4. Having a collector system suitable for isotopic analysis. | No |
| **A.2.4.7.11.** | *Feed systems/product and tails withdrawal systems (MLIS)* | *Feed systems/product and tails withdrawal systems (molecular based methods)* | No |
| | Especially designed or prepared process systems or equipment for enrichment plants made of or protected by materials resistant to corrosion by $UF_6$, including: | Especially designed or prepared process systems or equipment for enrichment plants made of or protected by materials resistant to corrosion by $UF_6$, including: | No |
| | (*a*) feed autoclaves, ovens, or systems used for passing $UF_6$ to the enrichment process; | (a) Feed autoclaves, ovens, or systems used for passing $UF_6$ to the enrichment process; | No |
| | (*b*) desublimers (or cold traps) used to remove $UF_6$ from the enrichment process for subsequent transfer upon heating; | (b) Desublimers (or cold traps) used to remove $UF_6$ from the enrichment process for subsequent transfer upon heating; | No |
| | (*c*) solidification or liquefaction stations used to remove $UF_6$ from the enrichment process by compressing and converting $UF_6$ to a liquid or solid form; and | (c) Solidification or liquefaction stations used to remove $UF_6$ from the enrichment process by compressing and converting $UF_6$ to a liquid or solid form; | No |
| | (*d*) product or tails stations used for transferring $UF_6$ into containers. | (d) 'Product' or 'tails' stations used for transferring $UF_6$ into containers. | No |
| **A.2.4.7.12.** | *$UF_6$/carrier gas separation systems (MLIS)* | *$UF_6$/carrier gas separation systems (molecular based methods)* | No |
| | Especially designed or prepared process systems for separating $UF_6$ from carrier gas. The carrier gas may be nitrogen, argon, or other gas. | Especially designed or prepared process systems for separating $UF_6$ from carrier gas.<br><br>EXPLANATORY NOTE<br>These systems may incorporate equipment such as:<br>(a) Cryogenic heat exchangers or cryoseparators capable of | No |

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| | | temperatures of 153 K (-120°C) or less, or<br>(b) Cryogenic refrigeration units capable of temperatures of 153 K (-120°C) or less, or<br>(c) $UF_6$ cold traps capable of freezing out $UF_6$.<br>The carrier gas may be nitrogen, argon, or other gas. | |
| **A.2.4.7.13.** | *Laser systems (AVLIS, MLIS and CRISLA)* | *Laser systems* | No |
| | Lasers or laser systems especially designed or prepared for the separation of uranium isotopes. | Lasers or laser systems especially designed or prepared for the separation of uranium isotopes.<br><br>EXPLANATORY NOTE<br>The lasers and laser components of importance in laser-based enrichment processes include those identified in Part B of the schedule. The laser system typically contains both optical and electronic components for the management of the laser beam (or beams) and the transmission to the isotope separation chamber. The laser system for atomic vapour based methods usually consists of tunable dye lasers pumped by another type of laser (e.g., copper vapour lasers or certain solid-state lasers). The laser system for molecular based methods may consist of $CO_2$ lasers or excimer lasers and a multi-pass optical cell. Lasers or laser systems for both methods require spectrum frequency stabilization for operation over extended periods of time. | No |
| **A.2.4.8.** | *Especially designed or prepared systems, equipment and components for use in plasma separation enrichment plants, including:* | *Especially designed or prepared systems, equipment and components for use in plasma separation enrichment plants.* | No |
| | | INTRODUCTORY NOTE<br>In the plasma separation process, a plasma of uranium ions passes through an electric field tuned to the $^{235}U$ ion resonance frequency so that they preferentially absorb energy and | No |

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| | | increase the diameter of their corkscrew-like orbits. Ions with a large-diameter path are trapped to produce a product enriched in $^{235}U$. The plasma, which is made by ionizing uranium vapour, is contained in a vacuum chamber with a high-strength magnetic field produced by a superconducting magnet. The main technological systems of the process include the uranium plasma generation system, the separator module with superconducting magnet (Part B of this schedule) and metal removal systems for the collection of 'product' and 'tails'. | |
| **A.2.4.8.3.** | *Uranium plasma generation systems* | Uranium plasma generation systems | No |
| | Especially designed or prepared systems for the generation of uranium plasma, which may contain high-power strip or scanning electron beam guns with a delivered power on the target of more than 2.5 kW/cm. | Especially designed or prepared systems for the generation of uranium plasma for use in plasma separation plants. | Yes |
| **A.2.4.8.4.** | *Liquid uranium metal handling systems* | Entry to be deleted | Yes |
| | Especially designed or prepared liquid metal handling systems for molten uranium or uranium alloys, consisting of crucibles and cooling equipment for the crucibles. | | Yes |
| **A.2.4.8.5.** | *Uranium metal product and tails collector assemblies* | *Uranium metal 'product' and 'tails' collector assemblies* | No |
| | Especially designed or prepared product and tails collector assemblies for uranium metal in solid form. These collector assemblies are made of or protected by materials resistant to the heat and corrosion of uranium metal vapour, such as yttria-coated graphite or tantalum. | Especially designed or prepared 'product' and 'tails' collector assemblies for uranium metal in solid form. These collector assemblies are made of or protected by materials resistant to the heat and corrosion of uranium metal vapor, such as yttria-coated graphite or tantalum. | No |
| **A.2.4.8.6.** | *Separator module housing* | *Separator module housing* | No |
| | Cylindrical vessels especially designed or prepared for use in plasma separation enrichment plants for containing the | Cylindrical vessels especially designed or prepared for use in plasma separation enrichment plants for containing the uranium | No |

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| | uranium plasma source, radio-frequency drive coil and the product and tails collectors. | plasma source, radio-frequency drive coil and the 'product' and 'tails' collectors.<br><br>EXPLANATORY NOTE<br>These housings have a multiplicity of ports for electrical feed-throughs, diffusion pump connections and instrumentation diagnostics and monitoring. They have provisions for opening and closure to allow for refurbishment of internal components and are constructed of a suitable non-magnetic material such as stainless steel. | |
| **A.2.4.9.** | *Especially designed or prepared systems, equipment and components for use in electromagnetic enrichment plants including:* | *Especially designed or prepared systems, equipment and components for use in electromagnetic enrichment plants* | No |
| | | INTRODUCTORY NOTE<br>In the electromagnetic process, uranium metal ions produced by ionization of a salt feed material (typically $UCl_4$) are accelerated and passed through a magnetic field that has the effect of causing the ions of different isotopes to follow different paths. The major components of an electromagnetic isotope separator include: a magnetic field for ion-beam diversion/separation of the isotopes, an ion source with its acceleration system, and a collection system for the separated ions. Auxiliary systems for the process include the magnet power supply system, the ion source high-voltage power supply system, the vacuum system, and extensive chemical handling systems for recovery of product and cleaning/recycling of components. | No |
| **A.2.4.9.1.** | *Electromagentic isotope separators* | *Electromagnetic isotope separators* | No |
| | Electromagnetic isotope separators especially designed or prepared for the separation of uranium isotopes, and | Electromagnetic isotope separators especially designed or | No |

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| | equipment and components therefor, including:<br>(*a*) ion sources:<br>especially designed or prepared single or multiple uranium ion sources consisting of a vapour source, ionizer, and beam accelerator, constructed of suitable materials such as graphite, stainless steel, or copper, and capable of providing a total ion beam current of 50 mA or greater;<br>(*b*) ion collectors:<br>collector plates consisting of two or more slits and pockets especially designed or prepared for collection of enriched and depleted uranium ion beams and constructed of suitable materials such as graphite or stainless steel;<br>(*c*) vacuum housings:<br>especially designed or prepared vacuum housings for uranium electromagnetic separators, constructed of suitable non-magnetic materials such as stainless steel and designed for operation at pressures of 0.1 Pa or lower; and<br>(*d*) magnet pole pieces:<br>especially designed or prepared magnet pole pieces having a diameter greater than 2 m used to maintain a constant magnetic field within an electromagnetic isotope separator and to transfer the magnetic field between adjoining separators. | prepared for the separation of uranium isotopes, and equipment and components therefor, including:<br>(a) Ion sources<br>Especially designed or prepared single or multiple uranium ion sources consisting of a vapour source, ionizer, and beam accelerator, constructed of suitable materials such as graphite, stainless steel, or copper, and capable of providing a total ion beam current of 50 mA or greater.<br>(b) Ion collectors<br>Collector plates consisting of two or more slits and pockets especially designed or prepared for collection of enriched and depleted uranium ion beams and constructed of suitable materials such as graphite or stainless steel.<br>(c) Vacuum housings<br>Especially designed or prepared vacuum housings for uranium electromagnetic separators, constructed of suitable non-magnetic materials such as stainless steel and designed for operation at pressures of 0.1 Pa or lower.<br>EXPLANATORY NOTE<br>The housings are specially designed to contain the ion sources, collector plates and water-cooled liners and have provision for diffusion pump connections and opening and closure for removal and reinstallation of these components.<br>(d) Magnet pole pieces<br>Especially designed or prepared magnet pole pieces having a diameter greater than 2 m used to maintain a constant magnetic field within an electromagnetic isotope separator and to transfer | |

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| | | the magnetic field between adjoining separators. | |
| **A.2.5.** | *Plants for the production or concentration of heavy water, deuterium and deuterium compounds and equipment especially designed or prepared therefor, including:* | *Plants for the production or concentration of heavy water, deuterium and deuterium compounds and equipment especially designed or prepared therefor* | No |
| | | INTRODUCTORY NOTE<br>Heavy water can be produced by a variety of processes. However, the two processes that have proven to be commercially viable are the water-hydrogen sulphide exchange process (GS process) and the ammonia-hydrogen exchange process.<br>The GS process is based upon the exchange of hydrogen and deuterium between water and hydrogen sulphide within a series of towers which are operated with the top section cold and the bottom section hot. Water flows down the towers while the hydrogen sulphide gas circulates from the bottom to the top of the towers. A series of perforated trays are used to promote mixing between the gas and the water. Deuterium migrates to the water at low temperatures and to the hydrogen sulphide at high temperatures. Gas or water, enriched in deuterium, is removed from the first stage towers at the junction of the hot and cold sections and the process is repeated in subsequent stage towers. The product of the last stage, water enriched up to 30% in deuterium, is sent to a distillation unit to produce reactor grade heavy water; i.e., 99.75% deuterium oxide.<br>The ammonia-hydrogen exchange process can extract deuterium from synthesis gas through contact with liquid ammonia in the presence of a catalyst. The synthesis gas is fed into exchange towers and to an ammonia converter. Inside the towers the gas flows from the bottom to the top while the liquid ammonia flows from the top to the bottom. The deuterium is stripped from the hydrogen in the synthesis gas and concentrated in the ammonia. The ammonia then flows into an ammonia cracker at the bottom | No |

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| | | of the tower while the gas flows into an ammonia converter at the top. Further enrichment takes place in subsequent stages and reactor grade heavy water is produced through final distillation. The synthesis gas feed can be provided by an ammonia plant that, in turn, can be constructed in association with a heavy water ammonia-hydrogen exchange plant. The ammonia-hydrogen exchange process can also use ordinary water as a feed source of deuterium.<br><br>Many of the key equipment items for heavy water production plants using GS or the ammonia-hydrogen exchange processes are common to several segments of the chemical and petroleum industries. This is particularly so for small plants using the GS process. However, few of the items are available "off-the-shelf". The GS and ammonia-hydrogen processes require the handling of large quantities of flammable, corrosive and toxic fluids at elevated pressures. Accordingly, in establishing the design and operating standards for plants and equipment using these processes, careful attention to the materials selection and specifications is required to ensure long service life with high safety and reliability factors. The choice of scale is primarily a function of economics and need. Thus, most of the equipment items would be prepared according to the requirements of the customer.<br><br>Finally, it should be noted that, in both the GS and the ammonia-hydrogen exchange processes, items of equipment which individually are not especially designed or prepared for heavy water production can be assembled into systems which are especially designed or prepared for producing heavy water. The catalyst production system used in the ammonia-hydrogen exchange process and water distillation systems used for the final concentration of heavy water to reactor-grade in either process are examples of such systems. | |

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| | | The items of equipment which are especially designed or prepared for the production of heavy water utilizing either the water-hydrogen sulphide exchange process or the ammonia-hydrogen exchange process include those found in A.2.5.1 to A.2.5.9. | |
| **A.2.5.1.** | *Water-hydrogen sulphide exchange towers* | *Water - hydrogen sulphide exchange towers* | No |
| | Exchange towers fabricated from fine carbon steel (such as ASTM A516) with diameters of 6 m (20 ft.) to 9 m (30 ft.), capable of operating at pressures greater than or equal to 2 MPa (300 psi) and with a corrosion allowance of 6 mm or greater, especially designed or prepared for heavy water production utilizing the water-hydrogen sulphide exchange process. | Exchange towers with diameters of 1.5 m or greater and capable of operating at pressures greater than or equal to 2 MPa (300 psi), especially designed or prepared for heavy water production utilizing the water-hydrogen sulphide exchange process. | Yes |
| **A.2.5.9.** | | *Ammonia synthesis converters or synthesis units* | Yes |
| | | Ammonia synthesis converters or synthesis units especially designed or prepared for heavy water production utilizing the ammonia-hydrogen exchange process.<br><br>EXPLANATORY NOTE<br>These converters or units take synthesis gas (nitrogen and hydrogen) from an ammonia/hydrogen high-pressure exchange column (or columns), and the synthesized ammonia is returned to the exchange column (or columns). | Yes |
| **A.2.6.1** | *Plants for the conversion of uranium and equipment especially design or prepared for that purpose, including* | *Plants for the conversion of uranium and equipment especially design or prepared for that purpose, including* | No |
| | | INTRODUCTORY NOTE<br>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 | No |

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| | | $UO_3$, conversion of $UO_3$ to $UO_2$, conversion of uranium oxides to $UF_4$, $UF_6$, or $UCl_4$, conversion of $UF_4$ to $UF_6$, conversion of $UF_6$ to $UF_4$, conversion of $UF_4$ to uranium metal, and conversion of uranium fluorides to $UO_2$. Many of the key equipment items for uranium conversion plants are common to several segments of the chemical process industry. For example, the types of equipment employed in these processes may include: 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 the requirements and specifications of the customer. In some instances, special design and construction considerations are required to address the corrosive properties of some of the chemicals handled (HF, $F_2$, $CIF_3$, and uranium fluorides) as well as nuclear criticality concerns. Finally, it should be noted that, in all of the uranium conversion processes, items of equipment which individually are not especially designed or prepared for uranium conversion can be assembled into systems which are especially designed or prepared for use in uranium conversion. | |
| **A.2.6.1.1** | *Especially designed or prepared systems for the conversion of uranium ore concentrations to $UO_3$* | *Especially designed or prepared systems for the conversion of uranium ore concentrations to $UO_3$* | No |
| | | EXPLANATORY NOTE<br>Conversion of uranium ore concentrates to $UO_3$ 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 $UO_3$ either by concentration and denitration or by neutralization with gaseous ammonia to produce ammonium diuranate with subsequent filtering, drying, and calcining. | No |

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| **A.2.6.1.2.** | *Especially designed or prepared systems for the conversion of $UO_3$ to $UF_6$* | *Especially designed or prepared systems for the conversion of $UO_3$ to $UF_6$* | No |
| | | EXPLANATORY NOTE<br>Conversion of $UO_3$ to $UF_6$ can be performed directly by fluorination. The process requires a source of fluorine gas or chlorine trifluoride. | No |
| **A.2.6.1.3.** | *Especially designed or prepared systems for the conversion of $UO_3$ to $UO_2$* | *Especially designed or prepared systems for the conversion of $UO_3$ to $UO_2$* | No |
| | | EXPLANATORY NOTE<br>Conversion of $UO_3$ to $UO_2$ can be performed through reduction of $UO_3$ with cracked ammonia gas or hydrogen. | No |
| **A.2.6.1.4.** | *Especially designed or prepared systems for the conversion of $UO_2$ to $UF_4$.* | *Especially designed or prepared systems for the conversion of $UO_2$ to $UF_4$* | No |
| | | EXPLANATORY NOTE<br>Conversion of $UO_2$ to $UF_4$ can be performed by reacting $UO_2$ with hydrogen fluoride gas (HF) at 300-500°C. | No |
| **A.2.6.1.5.** | *Especially designed or prepared systems for the conversion of $UF_4$ to $UF_6$.* | *Especially designed or prepared systems for the conversion of $UF_4$ to $UF_6$.* | No |
| | | EXPLANATORY NOTE<br>Conversion of $UF_4$ to $UF_6$ is performed by exothermic reaction with fluorine in a tower reactor. $UF_6$ 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. | No |
| **A.2.6.1.6.** | *Especially designed or prepared systems for the conversion of $UF_4$ to U metal.* | *Especially designed or prepared systems for the conversion of $UF_4$ to U metal.* | No |
| | | EXPLANATORY NOTE<br>Conversion of $UF_4$ to U metal is performed by reduction with | No |

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| | | magnesium (large batches) or calcium (small batches). The reaction is carried out at temperatures above the melting point of uranium (1130 °C). | |
| **A.2.6.1.7.** | *Especially designed or prepared systems for the conversion of $UF_6$ to $UO_2$.* | *Especially designed or prepared systems for the conversion of $UF_6$ to $UO_2$.* | No |
| | | EXPLANATORY NOTE<br>Conversion of $UF_6$ to $UO_2$ can be performed by one of three processes. In the first, $UF_6$ is reduced and hydrolyzed to $UO_2$ using hydrogen and steam. In the second, $UF_6$ is hydrolyzed by solution in water, ammonia is added to precipitate ammonium diuranate, and the diuranate is reduced to $UO_2$ with hydrogen at 820°C. In the third process, gaseous $UF_6$, $CO_2$, and $NH_3$ are combined in water, precipitating ammonium uranyl carbonate. The ammonium uranyl carbonate is combined with steam and hydrogen at 500-600°C to yield $UO_2$ .<br>$UF_6$ to $UO_2$ conversion is often performed as the first stage of a fuel fabrication plant. | No |
| **A.2.6.1.8.** | *Especially designed or prepared systems for the conversion of $UF_6$ to $UF_4$.* | *Especially designed or prepared systems for the conversion of $UF_6$ to $UF_4$.* | No |
| | | EXPLANATORY NOTE<br>Conversion of $UF_6$ to $UF_4$ is performed by reduction with hydrogen. | No |
| **A.2.6.1.9.** | *Especially designed or prepared systems for the conversion of $UO_2$ to $UCl_4$.* | *Especially designed or prepared systems for the conversion of $UO_2$ to $UCl_4$.* | No |
| | | EXPLANATORY NOTE<br>Conversion of $UO_2$ to $UCl_4$ can be performed by one of two processes. In the first, $UO_2$ is reacted with carbon tetrachloride ($CCl_4$ ) at approximately 400ºC. In the second, $UO_2$ is reacted at approximately 700ºC in the presence of carbon black (CAS | No |

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| | | 1333-86-4), carbon monoxide, and chlorine to yield $UCl_4$. | |
| **A.2.6.2.** | *Plants for the conversion of plutonium and equipment especially designed or prepared for that purpose, including* | *Plants for the conversion of plutonium and equipment especially designed or prepared for that purpose, including* | No |
| | | INTRODUCTORY NOTE<br>Plutonium conversion plants and systems perform one or more transformations from one plutonium chemical species to another, including: conversion of plutonium nitrate to $PuO_2$, conversion of $PuO_2$ to $PuF_4$, and conversion of $PuF_4$ 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: 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 in designing for the special radiological, toxicity and criticality hazards associated with plutonium is essential. In some instances, 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 which are especially designed or prepared for use in plutonium conversion. | No |

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| **A.2.6.2.1.** | *Especially designed or prepared systems for the conversion of plutonium nitrate to oxide.* | *Especially designed or prepared systems for the conversion of plutonium nitrate to oxide.* | No |
| | | EXPLANATORY NOTE<br>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. | No |
| **A.2.6.2.2.** | *Especially designed or prepared systems for plutonium metal production.* | Especially designed or prepared systems for plutonium metal production. | No |
| | | EXPLANATORY NOTE<br>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 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 a reduction to metal. | No |
| **B.1.1.1.** | Alpha-emitting radionuclides having an alpha half-life of 10 days or greater but less than 200 years, compounds or | Radionuclides appropriate for making neutron sources based on alpha-n reaction: | Yes |

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| | mixtures containing any of these radionuclides with a total alpha activity of 1 Ci/kg (37 GBq/kg) or greater, and products or devices containing any of the foregoing, except a product or device containing less than 3.7 GBq (100 mCi) of alpha activity. | Actinium 225, Actinium 227, Californium 253, Curium 240, Curium 241, Curium 242, Curium 243, Curium 244, Einsteinium 253, Einsteinium 254, Gadolinium 148, Plutonium 236, Plutonium 238, Polonium 208, Polonium 209, Polonium 210, Radium 223, Thorium 227, Thorium 228, Uranium 230, Uranium 232<br><br>In the following forms:<br>a. Elemental;<br>b. Compounds having a total activity of 37 GBq per kg or greater;<br>c. Mixtures having a total activity of 37 GBq per kg or greater;<br>d. Products or devices containing any of the foregoing, except a product or device containing less than 3.7 GBq of activity. | |
| **TBD** | | Rhenium, and alloys containing 90% by weight or more rhenium; and alloys of rhenium and tungsten containing 90% by weight or more of any combination of rhenium and tungsten, having both of the following characteristics:<br>a. In forms with a hollow cylindrical symmetry (including cylinder segments) with an inside diameter between 100 and 300 mm; and<br>b. A mass greater than 20kg. | Yes |
| **B.1.1.2** | Aluminium alloys capable of an ultimate tensile strength of 460 MPa (0.46 x $10^9$ N/$m^2$) or more at 293 K (20°C), in the form of tubes or cylindrical solid forms (including forgings) with an outside diameter of more than 75 mm (3 in.).<br>NOTE | Aluminium alloys having both of the following characteristics:<br>a. 'Capable of' an ultimate tensile strength of 460 MPa or more at 293 K (20 °C); and<br>b. In the form of tubes or cylindrical solid forms (including forgings) with an outside diameter of more than 75 mm.<br>NOTE | No |

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| | The phrase "capable of" encompasses aluminium alloys before or after heat treatment. | *In Paragraph B.1.1.2. the phrase 'capable of' encompasses aluminium alloys before or after heat treatment.* | |
| **B.1.1.4.** | High-purity (99.99% or greater) bismuth with very low silver content (less than 10 ppm). | Bismuth having both of the following characteristics:<br>a. A purity of 99.99% or greater by weight; and<br>b. Containing less than 10 ppm (parts per million) by weight of silver. | No |
| **B.1.1.8** | *Crucibles made of materials resistant to liquid actinide metals, as follows:*<br>(*a*) crucibles with a volume of between 150 ml and 8 L and made of or coated with any of the following materials having a purity of 98% or greater:<br>(1) calcium fluoride ($CaF_2$)<br>(2) calcium zirconate (metazirconate) ($Ca_2ZrO_3$)<br>(3) cerium sulfide ($Ce_2S_3$)<br>(4) erbium oxide (erbia) ($Er_2O_3$)<br>(5) hafnium oxide (hafnia) ($HfO_2$)<br>(6) magnesium oxide (MgO)<br>(7) nitrided niobium-titanium-tungsten alloy (approximately 50%Nb, 30%Ti, 20%W)<br>(8) yttrium oxide (yttria) ($Y_2O_3$)<br>(9) zirconium oxide (zirconia) ($ZrO_2$);<br>(*b*) crucibles with a volume of between 50 ml and 2 L and made of or lined with tantalum, having a purity of 99.9% or greater; and<br>(*c*) crucibles with a volume of between 50 ml and 2 L and made of or lined with tantalum (having a purity of 98% or | *Crucibles made of materials resistant to liquid actinide metals, as follows:*<br>a. Crucibles having both of the following characteristics:<br>1. A volume of between 150 $cm^3$ (150 ml) and 8000 $cm^3$ (8 l (litres)); and<br>2. Made of or coated with any of the following materials, or combination of the following materials, having an overall impurity level of 2% or less by weight:<br>a. Calcium fluoride ($CaF_2$);<br>b. Calcium zirconate (metazirconate) ($CaZrO_3$);<br>c. Cerium sulfide ($Ce_2S_3$);<br>d. Erbium oxide (erbia) ($Er_2O_3$);<br>e. Hafnium oxide (hafnia) ($HfO_2$);<br>f. Magnesium oxide (MgO);<br>g. Nitrided niobium-titanium-tungsten alloy (approximately 50% Nb, 30% Ti, 20% W);<br>h. Yttrium oxide (yttria) ($Y_2O_3$); or<br>i. Zirconium oxide (zirconia) ($ZrO_2$);<br>b. Crucibles having both of the following characteristics:<br>1. A volume of between 50 $cm^3$ (50 ml) and 2000 $cm^3$ (2 liters); and<br>2. Made of or lined with tantalum, having a purity of 99.9% or | No |

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| | greater) coated with tantalum carbide, nitride, or boride (or any combination of these). | greater by weight;<br>c. Crucibles having all of the following characteristics:<br>1. A volume of between 50 $cm^3$ (50 ml) and 2000 $cm^3$ (2 liters);<br>2. Made of or lined with tantalum, having a purity of 98% or greater by weight; and<br>3. Coated with tantalum carbide, nitride, boride, or any combination thereof. | |
| **B.1.1.9.** | *Fibrous or filamentary materials, prepregs and composite structures, as follows:*<br>(*a*) carbon or aramid fibrous or filamentary materials having a specific modulus of 12.7 x $10^6$ m or greater or a specific tensile strength of 23.5 x $10^4$ m or greater, except aramid fibrous or filamentary materials having 0.25% or more by weight of an ester based fibre surface modifier;<br>(*b*) glass fibrous or filamentary materials having a specific modulus of 3.18 x $10^6$ m or greater and a specific tensile strength of 7.62 x $10^4$ m or greater; and<br>(*c*) thermoset resin impregnated continuous yarns, rovings, tows or tapes with a width no greater than 15 mm (prepregs), made from carbon or glass fibrous or filamentary materials specified in paragraph (*a*) or (*b*).<br>NOTE<br>The resin forms the matrix of the composite.<br>(*d*) composite structures in the form of tubes with an inside diameter of between 75 mm (3 in.) and 400 mm (16 in.) made with any of the fibrous or filamentary materials specified in paragraph (*a*) or carbon prepreg materials specified in paragraph (*c*).<br>NOTE | *"Fibrous or filamentary materials", and prepregs, as follows:*<br>a. Carbon or aramid "fibrous or filamentary materials" having either of the following characteristics:<br>1. A "specific modulus" of 12.7 x $10^6$ m or greater; or<br>2. A "specific tensile strength" of 23.5 x $10^4$ m or greater;<br>NOTE: Paragraph B.1.1.9(a) does not control aramid "fibrous or filamentary materials" having 0.25% or more by weight of an ester based fiber surface modifier.<br>b. Glass "fibrous or filamentary materials" having both of the following characteristics:<br>1. A "specific modulus" of 3.18 x $10^6$ m or greater; and<br>2. A "specific tensile strength" of 7.62 x $10^4$ m or greater;<br>c. Thermoset resin impregnated continuous "yarns", "rovings", "tows" or "tapes" with a width of 15 mm or less (prepregs), made from carbon or glass "fibrous or filamentary materials" specified in Paragraph B.1.1.9(a) or Paragraph B.1.1.9(b).<br>*Technical Note: The resin forms the matrix of the composite.*<br><br>*Technical Notes:*<br>*1. In Paragraph B.1.1.9 "Specific modulus" is the Young's modulus in $N/m^2$ divided by the specific weight in $N/m^3$ when measured at a temperature of 296 ± 2 K (23 ± 2 °C) and a relative humidity of 50 ± 5%.* | No |

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| | (*a*) "fibrous or filamentary materials" means continuous monofilaments, yarns, rovings, tows or tapes.<br>(*b*) "specific modulus" is the Young's modulus in $N/m^2$ divided by the specific weight in $N/m^3$ when measured at a temperature of 23 ± 2°C and a relative humidity of 50 ± 5%.<br>(*c*) "specific tensile strength" is the ultimate tensile strength in $N/m^2$ divided by the specific weight in $N/m^3$ when measured at a temperature of 23 ± 2°C and a relative humidity of 50 ± 5%. | *2. In Item B.1.1.9 "Specific tensile strength" is the ultimate tensile strength in $N/m^2$ divided by the specific weight in $N/m^3$ when measured at a temperature of 296 ± 2 K (23 ± 2 °C) and a relative humidity of 50 ± 5%.*<br><br>d. Composite structures in the form of tubes having both of the following characteristics:<br>a. An inside diameter of between 75 and 400 mm; and<br>b. Made with any of the "fibrous or filamentary materials" specified in Paragraph B.1.19(a) or carbon prepreg materials specified in Paragraph B.1.1.9(c). | |
| **B.1.1.14.** | Maraging steel capable of an ultimate tensile strength of 2 050 MPa (2.050 x $10^9$ $N/m^2$) (300,000 lbs./sq.in.) or more at 293 K (20°C), except forms in which no linear dimension exceeds 75 mm.<br><br>NOTE<br>The phrase "capable of" encompasses maraging steel before or after heat treatment. | Maraging steel 'capable of' an ultimate tensile strength of 1950 MPa or more at 293 K (20 °C).<br><br>Note: Paragraph B.1.1. does not control forms in which all linear dimensions are 75 mm or less.<br>Technical Note: the phrase 'capable of' encompasses maraging steel before or after heat treatment. | Yes |
| **B.1.1.17.** | Titanium alloys capable of an ultimate tensile strength of 900 MPa (0.9 x 109 $N/m^2$) (130,500 lbs./sq.in.) or more at 293 K (20°C) in the form of tubes or cylindrical solid forms (including forgings) with an outside diameter of more than 75 mm (3 in.).<br><br>NOTE<br>The phrase "capable of" encompasses titanium alloys before or after heat treatment. | Titanium alloys having both of the following characteristics:<br>a. 'Capable of' an ultimate tensile strength of 900 MPa or more at 293 K (20 °C); and<br>b. In the form of tubes or cylindrical solid forms (including forgings) with an outside diameter of more than 75 mm.<br><br>NOTE<br>The phrase **'**capable of**'** encompasses titanium alloys before or after heat treatment. | No |

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| **B.2.1.1** | *Flow-forming machines and spin-forming machines capable of flow-forming functions, and mandrels, as follows, and specially designed software therefor:* | *Flow-forming machines and spin-forming machines capable of flow-forming functions, and mandrels, as follows, and specially designed software therefor:* | No |
| | (*a*) having three or more rollers (active or guiding) and, according to the manufacturer's technical specification, can be equipped with numerical control units or a computer control; and<br>(*b*) rotor-forming mandrels designed to form cylindrical rotors of inside diameter between 75 mm (3 in.) and 400 mm (16 in.).<br><br>NOTE<br>This paragraph includes machines which have only a single roller designed to deform metal plus two auxiliary rollers which support the mandrel, but do not participate directly in the deformation process. | a. Machines having both of the following characteristics:<br>1. Three or more rollers (active or guiding); and<br>2. Which, according to the manufacturer's technical specification, can be equipped with "numerical control" units or a computer control;<br>b. Rotor-forming mandrels designed to form cylindrical rotors of inside diameter between 75 and 400 mm.<br><br>NOTE<br>B.2.1.1(a) includes machines which have only a single roller designed to deform metal plus two auxiliary rollers which support the mandrel, but do not participate directly in the deformation process. | No |
| **B.2.1.2.** | *Machine tools and specially designed software as follows:* | *Machine tools, as follows, and any combination thereof, for removing or cutting metals, ceramics, or composites, which, according to the manufacturer's technical specifications, can be equipped with electronic devices for simultaneous "contouring control" in two or more axes, and specially designed software therefor as follows:* | No |
| | (*a*) machine tools, as set out below, and any combination of them, for removing or cutting metals, ceramics or composites, which, according to the manufacturer's technical specifications, can be equipped with electronic devices for simultaneous contouring control in two or more axes:<br>(1) machine tools for turning, that have positioning accuracies with all compensations available better | a. Machine tools for turning, that have "positioning accuracies" with all compensations available better (less) than 6 µm according to ISO 230/2 (1988) along any linear axis (overall positioning) for machines capable of machining diameters greater than 35 mm;<br>NOTE: Item B.2.1.2(a) does not control bar machines (Swissturn), limited to machining only bar feed thru, if maximum bar diameter is equal to or less than 42 mm | No |

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| | (less) than 0.006 mm according to ISO 230/2 (1988) along any linear axis (overall positioning) for machines capable of machining diameters greater than 35 mm;<br>NOTE<br>Paragraph B.2.1.2.(*a*)(1) does not include bar machines (Swissturn) limited to machining only bar feed thru, if the maximum bar diameter is equal to or less than 42 mm and there is no capability of mounting chucks. Machines may have drilling and/or milling capabilities for machining parts with diameters less than 42 mm.<br>(2) machine tools for milling having any of the following characteristics:<br>(i) positioning accuracies with all compensations available are better (less) than 0.006 mm according to ISO 230/2 (1988) along any linear axis (overall positioning);<br>(ii) two or more contouring rotary axes; or<br>(iii) five or more axes that can be coordinated simultaneously for contouring control;<br>NOTE<br>Paragraph B.2.1.2.(*a*)(2) does not include milling machines having the following characteristics:<br>(*a*) x-axis travel greater than 2 m; and<br>(*b*) overall positioning accuracy on the x-axis worse (more) than 0.030 mm according to ISO 230/2 (1988).<br><br>(3) machine tools for grinding having any of the following characteristics:<br>(i) positioning accuracies with all compensations | and there is no capability of mounting chucks. Machines may have drilling and/or milling capabilities for machining parts with diameters less than 42 mm.<br>b. Machine tools for milling, having any of the following characteristics:<br>1. "Positioning accuracies" with all compensations available better (less) than 6 µm according to ISO 230/2 (1988) along any linear axis (overall positioning);<br>2. Two or more contouring rotary axes; or<br>3. Five or more axes which can be coordinated simultaneously for "contouring control".<br>NOTE: Paragraph B.2.1.2.b. does not control milling machines having <u>both</u> of the following characteristics:<br>1. X-axis travel greater than 2 m; and<br>2. Overall "positioning accuracy" on the x-axis worse (more) than 30 µm according to ISO 230/2 (1988).<br>c. Machine tools for grinding, having any of the following characteristics:<br>1. "Positioning accuracies" with all compensations available better (less) than 4 µm according to ISO 230/2 (1988) along any linear axis (overall positioning);<br>2. Two or more contouring rotary axes; or<br>3. Five or more axes which can be coordinated simultaneously for "contouring control".<br>NOTE: Item B.2.1.2.c does not control grinding machines as follows:<br>1. Cylindrical external, internal, and external-internal grinding machines having all the following characteristics:<br>a. Limited to a maximum workpiece capacity of 150 mm outside diameter or length; and<br>b. Axes limited to x, z and c.<br>2. Jig grinders that do not have a z-axis or a w-axis with an | |

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| | available are better (less) than 0.004 mm according to ISO 230/2 (1988) along any linear axis (overall positioning);<br>(ii) two or more contouring rotary axes; or<br>(iii) five or more axes that can be coordinated simultaneously for contouring control; and<br>NOTE<br>Paragraph B.2.1.2.(*a*)(3) does not include the following grinding machines:<br>(*a*) cylindrical external, internal and external-internal grinding machines having all of the following characteristics:<br>(i) limited to a maximum workpiece capacity of 150 mm outside diameter or length; and<br>(ii) axes limited to x, z and c; and<br>(*b*) jig grinders that do not have a z-axis or a w-axis with an overall positioning accuracy less (better) than 0.004 mm (positioning accuracy is according to ISO 230/2 (1988)).<br><br>(4) non-wire type electrical discharge machines that have two or more contouring rotary axes and that can be coordinated simultaneously for contouring control; and<br>NOTE<br>Paragraph B.2.1.2.(*a*) does not include special purpose machine tools limited to the manufacture of any of the following parts:<br>(*a*) gears;<br>(*b*) crankshafts or camshafts;<br>(*c*) tools or cutters; and<br>(*d*) extruder worms. | overall positioning accuracy less (better) than 4 microns. Positioning accuracy is according to ISO 230/2 (1988).<br>d. Non-wire type Electrical Discharge Machines (EDM) that have two or more contouring rotary axes and that can be coordinated simultaneously for “contouring control”.<br>e. Software:<br>1. Software specially designed or modified for the development, production or use of equipment referred to in paragraph B.2.1.2.; and<br>2. Software for any combination of electronic devices or systems enabling those devices to function as a numerical control unit capable of controlling five or more interpolating axes that can be coordinated simultaneously for contouring control.<br>NOTE<br>1. Software is controlled whether exported separately or residing in a numerical control unit or any electronic device or system.<br>2. Software specially designed or modified by the manufacturers of the control unit or machine tool to operate an uncontrolled machine tool is not controlled.<br>Notes:<br>Item B.2.1.2 does not control special purpose machine tools limited to the manufacture of any of the following parts:<br>a. Gears<br>b. Crankshafts or cam shafts<br>c. Tools or cutters<br>d. Extruder worms<br><br>*Technical Notes:*<br>*1. Axis nomenclature shall be in accordance with International* | |

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| | (*b*) software:<br>(1) software specially designed or modified for the development, production or use of equipment referred to in paragraph B.2.1.2.(*a*); and<br>(2) software for any combination of electronic devices or systems enabling those devices to function as a numerical control unit capable of controlling five or more interpolating axes that can be coordinated simultaneously for contouring control.<br>NOTE<br>1. Software is controlled whether exported separately or residing in a numerical control unit or any electronic device or system.<br>2. Software specially designed or modified by the manufacturers of the control unit or machine tool to operate an uncontrolled machine tool is not controlled. | *Standard ISO 841, "Numerical Control Machines - Axis and Motion Nomenclature".*<br>*2. Not counted in the total number of contouring axes are secondary parallel contouring axes (e.g., the w-axis on horizontal boring mills or a secondary rotary axis the centerline of which is parallel to the primary rotary axis).*<br>*3. Rotary axes do not necessarily have to rotate over 360 degrees. A rotary axis can be driven by a linear device, e.g., a screw or a rack- and-pinion.*<br>*4. For the purposes of B.2.1.2. the number of axes which can be coordinated simultaneously for "contouring control" is the number of axes along or around which, during processing of the workpiece, simultaneous and interrelated motions are performed between the workpiece and a tool. This does not include any additional axes along or around which other relative motions within the machine are performed, such as:*<br>a. Wheel-dressing systems in grinding machines;<br>b Parallel rotary axes designed for mounting of separate workpieces;<br>c. Co-linear rotary axes designed for manipulating the same workpiece by holding it in a chuck from different ends.<br>*5. A machine tool having at least 2 of the 3 turning, milling or grinding capabilities (e.g., a turning machine with milling capability) must be evaluated against each applicable entry, B.2.1.2.a., B.2.1.2.b, and B.2.1.2.c.*<br>*6. Items B.2.1.2.b.3. and B.2.1.2.c..3. include machines based on a parallel linear kinematic design (e.g., hexapods) that have 5 or more axes none of which are rotary axes.* | |
| **B.2.1.3.** | *Dimensional inspection machines, instruments or systems, as follows, and software specially designed for them:* | *Dimensional inspection machines, instruments, or systems, as follows, and specially designed software therefor:* | No |

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| | (a) computer controlled or numerically controlled dimensional inspection machines having both of the following characteristics:<br>(1) two or more axes; and<br>(2) a one-dimensional length measurement uncertainty equal to or better (less) than (1.25 + L/1000) µm tested with a probe of an accuracy of better (less) than 0.2 µm (L is the measured length in millimeters) (Ref. VDI/VDE 2617, parts 1 and 2);<br>(*b*) linear displacement measuring instruments, as follows:<br>(1) non-contact type measuring systems with a resolution equal to or better (less) than 0.2 µm within a measuring range of up to 0.2 mm;<br>(2) linear variable differential transformer systems having both of the following characteristics:<br>(i) linearity equal to or better (less) than 0.1% within a measuring range of up to 5 mm; and<br>(ii) drift equal to or better (less) than 0.1% per day at a standard ambient test room temperature of ± 1 K; or<br>(3) measuring systems that have both of the following characteristics:<br>(i) contain a laser; and<br>(ii) maintain for at least 12 hours over a temperature range of ± 1 K around a standard temperature and a standard pressure:<br>(A) a resolution over their full scale of 0.1 µm or better; and<br>(B) a measurement uncertainty equal to or better (less) than (0.2 + L/2 000) µm (L is the measured length in millimeters); | a. Computer controlled or numerically controlled coordinate measuring machines (CMM) having either of the following characteristics:<br>1. Having only two axes and having a maximum permissible error of length measurement along any axis (one dimensional), identified as any combination of $E_{0x\ MPE}$, $E_{0y\ MPE}$ or $E_{0z\ MPE}$, equal to or less(better) than (1.25 + L/1000) µm (where L is the measured length in mm) at any point within the operating range of the machine (i.e., within the length of the axis), according to ISO 10360-2(2009); or<br>2. Three or more axes and having a three dimensional (volumetric) maximum permissible error of length measurement ($E_{0,\ MPE}$ equal to or less (better) than (1.7 + L/800) µm (where L is the measured length in mm) at any point within the operating range of the machine (i.e., within the length of the axis), according to ISO 10360-2(2009).<br>Technical Note: The $E_{0,\ MPE}$ of the most accurate configuration of the CMM specified according to ISO 10360-2(2009) by the manufacturer (e.g., best of the following: probe, stylus length, motion parameters, environment) and with all compensations available shall be compared to the 1.7 + L/ 800 µm threshold.<br>b. Linear displacement measuring instruments, as follows:<br>1. Non-contact type measuring systems with a “resolution” equal to or better (less) than 0.2 µm within a measuring range up to 0.2 mm;<br>2. Linear variable differential transformer (LVDT) systems having both of the following characteristics:<br>a. 1. “Linearity” equal to or less (better) than 0.1% measured from 0 to the full operating range, for LVDTs with an operating range up to 5 mm; or<br>2. “Linearity” equal to or less (better) than 0.1% | Yes |

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| | NOTE<br>Paragraph B.2.1.3.(*b*)(3) does not include measuring interferometer systems, without closed or open loop feedback, containing a laser to measure slide movement errors of machine tools, dimensional inspection machines or similar equipment.<br>(*c*) angular measuring instruments having an angular position deviation equal to or better (less) than 0.00025°; and<br>NOTE<br>Paragraph B.2.1.3.(*c*) does not include optical instruments, such as autocollimators, using collimated light (*e.g*. laser light) to detect angular displacement of a mirror.<br>(*d*) systems for simultaneous linear-angular inspection of hemishells, having both of the following characteristics:<br>(1) measurement uncertainty along any linear axis equal to or better (less) than 3.5 µm per 5 mm; and<br>(2) angular position deviation equal to or less than 0.02°.<br>NOTE<br>Specially designed software for these systems includes software for simultaneous measurements of wall thickness and contour.<br>NOTE<br>With respect to paragraph B.2.1.3.:<br>(*a*) machine tools that can be used as measuring machines are included if they meet or exceed the criteria specified for the machine tool function or the measuring machine function;<br>(*b*) machines are included if they exceed the control | measured from 0 to 5 mm for LVDTs with an operating range greater than 5 mm; <u>and</u><br>b. Drift equal to or better (less) than 0.1% per day at a standard ambient test room temperature ± 1 K;<br>3. Measuring systems having both of the following characteristics:<br>a. Contain a laser; and<br>b. Maintain for at least 12 hours, over a temperature range of ± 1 K around a standard temperature and a standard pressure:<br>1. A "resolution" over their full scale of 0.1 µm or better; and<br>2. With a "measurement uncertainty" equal to or better (less) than (0.2 + L/2000) µm (L is the measured length in millimeters);<br>NOTE: Paragraph B.2.1.3.b.3. does not control measuring interferometer systems, without closed or open loop feedback, containing a laser to measure slide movement errors of machine tools, dimensional inspection machines, or similar equipment.<br>*Technical Note: In Paragraph B.2.1.3.b. 'linear displacement' means the change of distance between the measuring probe and the measured object.*<br>c. Angular displacement measuring instruments having an "angular position deviation" equal to or better (less) than 0.00025°;<br>NOTE Paragraph B.2.1.3.c. does not control optical instruments, such as autocollimators, using collimated light (e.g., laser light) to detect angular displacement of a mirror.<br>d. Systems for simultaneous linear-angular inspection of hemishells, having both of the following characteristics: | |

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| | threshold anywhere within their operating range;<br>(*c*) the probe used in determining the measurement uncertainty of a dimensional inspection system shall be as described in VDI/VDE 2617, parts 2, 3 and 4; and<br>(*d*) all parameters of measurement values in paragraph B.2.1.3. represent plus/minus, *i.e.* not total band. | 1. "Measurement uncertainty" along any linear axis equal to or better (less) than 3.5 µm per 5 mm; and<br>2. "Angular position deviation" equal to or less than 0.02°.<br>NOTE<br>Specially designed software for these systems includes software for simultaneous measurements of wall thickness and contour.<br>Notes:<br>1. Paragraph B.2.1.3. includes machine tools that can be used as measuring machines if they meet or exceed the criteria specified for the measuring machine function.<br>2. Machines described in Paragraph B.2.1.3. are controlled if they exceed the threshold specified anywhere within their operating range.<br>Technical Note: All parameters of measurement values in this item represent plus/minus, i.e., not total band. | |
| **B.2.1.5.** | Isostatic presses capable of achieving a maximum working pressure of 69 MPa or greater having a chamber cavity with an inside diameter in excess of 152 mm and specially designed dies, molds, controls or specially designed software therefor.<br>NOTE<br>1. The inside chamber dimension is that of the chamber in which both the working temperature and the working pressure are achieved and does not include fixtures. That dimension will be the smaller of either the inside diameter of the pressure chamber or the inside diameter of the insulated furnace chamber, depending on which of the two chambers is located inside the other.<br>2. The term "isostatic presses" means equipment capable of pressurizing a closed cavity through various media (gas, liquid, solid particles, etc.) to create equal pressure in all | "Isostatic presses", and related equipment, as follows:<br>a. "Isostatic presses" having both of the following characteristics:<br>1. Capable of achieving a maximum working pressure of 69 MPa or greater; and<br>2. A chamber cavity with an inside diameter in excess of 152 mm;<br>b. Dies, molds, controls, and software specially designed for the "isostatic presses" specified in Item B.2.1.5.a.<br>*Technical Notes:*<br>*1. In Paragraph B.2.1.5 "Isostatic presses" means equipment capable of pressurizing a closed cavity through various media (gas, liquid, solid particles, etc.) to create equal pressure in all directions within the cavity upon a workpiece or material.*<br>*2. In Paragraph B.2.1.5. the inside chamber dimension is that of* | No |

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| | directions within the cavity upon a workpiece or material. | *the chamber in which both the working temperature and the working pressure are achieved and does not include fixtures. That dimension will be the smaller of either the inside diameter of the pressure chamber or the inside diameter of the insulated furnace chamber, depending on which of the two chambers is located inside the other.* | |
| **B.2.1.6.** | Robots or end-effectors having either of the following *characteristics; and specially designed software or specially designed controllers therefor:*<br>(*a*) specially designed to comply with national safety standards applicable to handling high explosives (for example, meeting electrical code ratings for high explosives); or<br>(*b*) specially designed or rated as radiation hardened to withstand greater than 5 x 104 Gy (Silicon) [5 x 106 rad (Silicon)] without operational degradation.<br><br>NOTES<br>1. "Robot" means a manipulation mechanism, which may be of the continuous path or of the point-to-point variety, may use sensors, and has all of the following characteristics:<br>(*a*) is multifunctional;<br>(*b*) is capable of positioning or orienting material, parts, tools, or special devices through variable movements in three-dimensional space;<br>(*c*) incorporates three or more closed or open loop servodevices which may include stepping motors; and<br>(*d*) has user-accessible programmability by means of teach/playback method or by means of an electronic | 'Robots', 'end-effectors' and software and control units as follows:<br>a. 'Robots' or 'end-effectors' having either of the following characteristics:<br>1. Specially designed to comply with national safety standards applicable to handling high explosives (for example, meeting electrical code ratings for high explosives); or<br>2. Specially designed or rated as radiation hardened to withstand a total radiation dose greater than 5 x $10^4$ Gy (silicon) without operational degradation;<br>Technical Note: The term Gy (silicon) refers to the energy in Joules per kilogram absorbed by an unshielded silicon sample when exposed to ionizing radiation.<br>b. Control units and software specially designed for any of the 'robots' or 'end-effectors' specified in Item B.2.1.6.a.<br>Note: Item B.2.1.6. does not control 'robots' specially designed for non-nuclear industrial applications such as automobile paint-spraying booths.<br><br>*NOTE*<br>*1. 'Robots'*<br>*In Item B.2.1.6. 'robot' means a manipulation mechanism, which may be of the continuous path or of the point-to-point variety, may use "sensors", and has all of the following characteristics:* | No |

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| | computer which may be a programmable logic controlled, *i.e.*, without mechanical intervention.<br>The above definition does not include the following devices:<br>(*a*) manipulation mechanisms which are only manually/teleoperator controllable;<br>(*b*) fixed sequence manipulation mechanisms which are automated moving devices operating according to mechanically fixed programmed motions. The program is mechanically limited by fixed stops, such as pins or cams. The sequence of motions and the selection of paths or angles are not variable or changeable by mechanical, electronic, or electrical means;<br>(*c*) mechanically controlled variable sequence manipulation mechanisms which are automated moving devices operating according to mechanically fixed programmed motions. The program is mechanically limited by fixed, but adjustable, stops such as pins or cams. The sequence of motions and the selection of paths or angles are variable within the fixed program pattern. Variations or modifications of the program pattern (*e.g.*, changes of pins or exchanges of cams) in one or more motion axes are accomplished only through mechanical operations;<br>(*d*) non-servo-controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The program is variable but the sequence proceeds only by the binary signal from mechanically fixed electrical binary devices or adjustable stops; or | (a) is multifunctional;<br>(b) is capable of positioning or orienting material, parts, tools, or special devices through variable movements in three-dimensional space;<br>(c) incorporates three or more closed or open loop servo-devices which may include stepping motors; and<br>(d) has “user-accessible programmability” by means of teach/playback method or by means of an electronic computer which may be a programmable logic controller, i.e., without mechanical intervention.<br>*N.B.1:*<br>*In the above definition “sensors” means detectors of a physical phenomenon, the output of which (after conversion into a signal that can be interpreted by a control unit) is able to generate “programs” or modify programmed instructions or numerical “program” data. This includes “sensors” with machine vision, infrared imaging, acoustical imaging, tactile feel, inertial position measuring, optical or acoustic ranging or force or torque measuring capabilities.*<br>*N.B.2:*<br>*In the above definition “user-accessible programmability” means the facility allowing a user to insert, modify or replace “programs” by means other than:*<br>*(a) a physical change in wiring or interconnections; or*<br>*(b) the setting of function controls including entry of parameters.*<br>*N.B.3:*<br>*The above definition does not include the following devices:*<br>*(a) Manipulation mechanisms which are only manually/teleoperator controllable;*<br>*(b) Fixed sequence manipulation mechanisms which are* | |

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| | (*e*) stacker cranes defined as Cartesian coordinate manipulator systems manufactured as an integral part of a vertical array of storage bins and designed to access the contents of those bins for storage or retrieval.<br><br>2. "End-effectors" include grippers, active tooling units, and any other tooling that is attached to the baseplate on the end of a robot manipulator arm. | *automated moving devices operating according to mechanically fixed programmed motions. The "program" is mechanically limited by fixed stops, such as pins or cams. The sequence of motions and the selection of paths or angles are not variable or changeable by mechanical, electronic, or electrical means;*<br><br>*(c) Mechanically controlled variable sequence manipulation mechanisms which are automated moving devices operating according to mechanically fixed programmed motions. The "program" is mechanically limited by fixed, but adjustable, stops such as pins or cams. The sequence of motions and the selection of paths or angles are variable within the fixed "program" pattern. Variations or modifications of the "program" pattern (e.g., changes of pins or exchanges of cams) in one or more motion axes are accomplished only through mechanical operations;*<br><br>*(d) Non-servo-controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The "program" is variable but the sequence proceeds only by the binary signal from mechanically fixed electrical binary devices or adjustable stops;*<br><br>*(e) Stacker cranes defined as Cartesian coordinate manipulator systems manufactured as an integral part of a vertical array of storage bins and designed to access the contents of those bins for storage or retrieval.*<br><br>*2. 'End-effectors'*<br><br>*In Item B.2.1.6. 'end-effectors' are grippers, 'active tooling units', and any other tooling that is attached to the baseplate on the end of a 'robot' manipulator arm.*<br><br>*N.B.:*<br><br>*In the above definition 'active tooling units' is a device for* | |

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| | | *applying motive power, process energy or sensing to the workpiece.* | |
| **B.2.1.7.** | *Vibration test systems, equipment, components and software therefor, as follows:*<br>(*a*) electrodynamic vibration test systems, employing feedback or closed loop control techniques and incorporating a digital controller, capable of vibrating at 10 g RMS or more between 20 Hz and 2 000 Hz and imparting forces of 50 kN (11,250 lbs.) measured bare table, or greater;<br>(*b*) digital controllers, combined with specially designed software for vibration testing, with a realtime bandwidth greater than 5 kHz and being designed for use with the systems referred to in paragraph (*a*);<br>(*c*) vibration thrusters (shaker units), with or without associated amplifiers, capable of imparting a force of 50 kN (11,250 lbs.), measured bare table, or greater, which are usable for the systems referred to in paragraph (*a*);<br>(*d*) test piece support structures and electronic units designed to combine multiple shaker units into a complete shaker system capable of providing an effective combined force of 50 kN, measured bare table, or greater, which are usable for the systems referred to in paragraph (*a*); and<br>(*e*) specially designed software for use with the systems referred to in paragraph (*a*) or for the electronic units referred to in paragraph (*d*). | *Vibration test systems, equipment, and components and software therefor, as follows:*<br>a. Electrodynamic vibration test systems, having all of the following characteristics:<br>1. Employing feedback or closed loop control techniques and incorporating a digital control unit;<br>2. Capable of vibrating at 10 g RMS or more between 20 and 2000 Hz; and<br>3. Capable of imparting forces of 50 kN or greater measured "bare table";<br>b. Digital control units, combined with "software" specially designed for vibration testing, with a real-time bandwidth greater than 5 kHz and being designed for a system specified in Item B.2.1.7.a.<br>c. Vibration thrusters (shaker units), with or without associated amplifiers, capable of imparting a force of 50 kN or greater measured "bare table", which are usable for the systems specified in Paragraph B.2.1.7.a.<br>d. Test piece support structures and electronic units designed to combine multiple shaker units into a complete shaker system capable of providing an effective combined force of 50 kN or greater, measured "bare table", which are usable for the systems specified in Paragraph B.2.1.7.a.<br>*e.* specially designed software for use with the systems referred to in paragraph B.2.1.7.*a.* or for the electronic units referred to in paragraph B.2.1.7.*d.*<br>*Technical Note: In Item B.2.1.7. "bare table" means a flat table, or surface, with no fixtures or fittings.* | No |

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| **B.2.1.8.** | Vacuum and controlled atmosphere metallurgical melting and casting furnaces as follows, and specially configured computer control and monitoring systems and specially designed software therefor:<br>(a) arc remelt and casting furnaces with consumable electrode capacities between 1 000 $cm^3$ and 20 000 $cm^3$ and capable of operating with melting temperatures above 1 700°C; and<br>(b) electron beam melting and plasma atomization and melting furnaces with a power of 50 kW or greater and capable of operating with melting temperatures above 1200°C. | *Vacuum or other controlled atmosphere metallurgical melting and casting furnaces and related equipment, as follows, and specially designed software therefor:*<br>a. Arc remelt and casting furnaces having both of the following characteristics:<br>1. Consumable electrode capacities between 1000 and 20 000 $cm^3$; and<br>2. Capable of operating with melting temperatures above 1973 K (1700 °C);<br>b. Electron beam melting furnaces and plasma atomization and melting furnaces, having both of the following characteristics:<br>1. A power of 50 kW or greater; and<br>2. Capable of operating with melting temperatures above 1473 K (1200 °C);<br>c. Computer control and monitoring systems specially configured for any of the furnaces specified in B.2.1.8.a. or B.2.1.8.b. | Yes |
| **B.2.2.2.** | *Rotor fabrication and assembly equipment and bellows-forming mandrels and dies, as follows:*<br>(*a*) rotor assembly equipment for assembly of gas centrifuge rotor tube sections, baffles, and end caps. Such equipment includes precision mandrels, clamps, and shrink fit machines;<br>(*b*) rotor straightening equipment for alignment of gas centrifuge rotor tube sections to a common axis; and<br>(*c*) bellows-forming mandrels and dies for producing single-convolution bellows (bellows made of high-strength aluminium alloys, maraging steel, or high-strength filamentary materials). The bellows have all of the following dimensions:<br>(1) 75 mm to 400 mm (3 in. to 16 in.) inside diameter; | *Rotor fabrication or assembly equipment, rotor straightening equipment, bellows-forming mandrels and dies, as follows:*<br>a. Rotor assembly equipment for assembly of gas centrifuge rotor tube sections, baffles, and end caps;<br>NOTE<br>Paragraph B.2.2.2(a) includes precision mandrels, clamps, and shrink fit machines.<br>b. Rotor straightening equipment for alignment of gas centrifuge rotor tube sections to a common axis;<br>*Technical Note: In Paragraph B.2.2.2(b) such equipment normally consists of precision measuring probes linked to a computer that subsequently controls the action of, for example, pneumatic rams used for aligning the rotor tube sections.* | No |

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| | (2) 12.7 mm (0.5 in.) or more in length; and<br>(3) single convolution depth more than 2 mm (0.08 in.). | c. Bellows-forming mandrels and dies for producing single-convolution bellows.<br>*Technical Note: The bellows referred to in Paragraph B.2.2.2(c) have all of the following characteristics:*<br>1. Inside diameter between 75 and 400 mm;<br>2. Length equal to or greater than 12.7 mm;<br>3. Single convolution depth greater than 2 mm; and<br>4. Made of high-strength aluminium alloys, maraging steel, or high strength "fibrous or filamentary materials". | |
| **B.2.2.4.** | Filament winding machines in which the motions for positioning, wrapping, and winding fibres are coordinated and programmed in two or more axes, specially designed to fabricate composite structures or laminates from fibrous and filamentary materials and capable of winding cylindrical rotors of diameter between 75 mm (3 in.) and 400 mm (16 in.) and lengths of 600 mm (24 in.) or greater; coordinating and programming controls therefor, precision mandrels; and specially designed software therefor. | *Filament winding machines and related equipment, as follows, and specially designed software therefor:*<br><br>a. Filament winding machines having all of the following characteristics:<br>1. Having motions for positioning, wrapping, and winding fibers coordinated and programmed in two or more axes;<br>2. Specially designed to fabricate composite structures or laminates from "fibrous or filamentary materials"; and<br>3. Capable of winding cylindrical tubes with an internal diameter between 75 and 650 mm and lengths of 300 mm or greater;<br>b. Coordinating and programming controls for the filament winding machines specified in Item B.2.2.4(a);<br>c. Precision mandrels for the filament winding machines specified in Paragraph B.2.2.4.a. | Yes |
| **B.2.2.5.** | *Frequency changers (also known as converters or inverters) or generators having all of the following characteristics:*<br>(*a*) multiphase output capable of providing a power of 40 W or more; | *Frequency changers or generators, usable as a variable frequency or fixed frequency motor drive, having all of the following characteristics:*<br><br>a. Multiphase output providing a power of 40 VA or greater; | Yes |

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| | (*b*) capable of operating in the frequency range between 600 Hz and 2 000 Hz;<br>(*c*) total harmonic distortion better (less) than 10%; and<br>(*d*) frequency control better (less) than 0.1%.<br><br>NOTE<br>Frequency changers and generators especially designed or prepared for the gas centrifuge process are controlled under paragraph A.2.4.2.5. | b. Operating at a frequency of 600 Hz or more; and<br>c. Frequency control better (less) than 0.2%.<br><br>NOTE<br>Paragraph B.2.2.5. only controls frequency changers intended for specific industrial machinery and/or consumer goods (machine tools, vehicles, etc.) if the frequency changers can meet the characteristics above when removed.<br><br>*Technical Notes:*<br>*1. Frequency changers in Paragraph B.2.2.5 are also known as converters or inverters.*<br>*2. The characteristics specified in Paragraph B.2.2.5. may be met by certain equipment marketed such as: Generators, Electronic Test Equipment, AC Power Supplies, Variable Speed Motor Drives, Variable Speed Drives (VSDs), Variable Frequency Drives (VFDs), Adjustable Frequency Drives (AFDs), or Adjustable Speed Drives (ASDs).* | |
| **B.2.2.6.** | *Lasers, laser amplifiers, and oscillators as follows:* | *Lasers, laser amplifiers and oscillators as follows:* | No |
| | (*a*) copper vapour lasers with 40 W or greater average output power operating at wavelengths between 500 nm and 600 nm;<br>(*b*) argon ion lasers with greater than 40 W average output power operating at wavelengths between 400 nm and 515 nm;<br>(*c*) neodymium-doped (other than glass) lasers with an output wavelength of between 1 000 nm and 1 100 nm having either of the following characteristics:<br>(1) pulse-excited and Q-switched with a pulse duration | a. Copper vapor lasers having both of the following characteristics:<br>1. Operating at wavelengths between 500 and 600 nm; and<br>2. An average output power equal to or greater than 30 W;<br>b. Argon ion lasers having both of the following characteristics:<br>1. Operating at wavelengths between 400 and 515 nm; and<br>2. An average output power greater than 40 W;<br>c. Neodymium-doped (other than glass) lasers with an output wavelength between 1000 and 1100 nm having either of the following: | Yes |

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| | equal to or greater than 1 ns, and having either of the following characteristics:<br>(i) single-transverse mode output having an average output power exceeding 40 W; or (ii) multiple-transverse mode output having an average output power exceeding 50 W; or<br>(2) frequency doubling incorporated to give an output wavelength of between 500 nm and 550 nm with an average output power at the doubled frequency (new wavelength) of greater than 40 W;<br>(*d*) tunable pulsed single-mode dye laser oscillators having all of the following characteristics:<br>(1) operation at wavelengths of between 300 nm and 800 nm;<br>(2) average output power greater than 1 W;<br>(3) repetition rate greater than 1 kHz; and<br>(4) pulse width less than 100 ns;<br>(*e*) tunable pulsed dye laser amplifiers and oscillators, except single mode oscillators, having all of the following characteristics:<br>(1) operation at wavelengths of between 300 nm and 800 nm;<br>(2) average output power greater than 30 W;<br>(3) repetition rate greater than 1 kHz; and<br>(4) pulse width less than 100 ns;<br>(*f*) alexandrite lasers having all of the following characteristics:<br>(1) operation at wavelengths of between 720 nm and 800 nm;<br>(2) average output power greater than 30 W;<br>(3) repetition rate greater than 125 Hz; and | 1. Pulse-excited and Q-switched with a pulse duration equal to or greater than 1 ns, and having either of the following:<br>a. A single-transverse mode output with an average output power greater than 40 W; or<br>b. A multiple-transverse mode output with an average output power greater than 50 W; or<br>2. Incorporating frequency doubling to give an output wavelength between 500 and 550 nm with an average output power of greater than 40 W;<br>d. Tunable pulsed single-mode dye laser oscillators having all of the following characteristics:<br>1. Operating at wavelengths between 300 and 800 nm;<br>2. An average output power greater than 1 W;<br>3. A repetition rate greater than 1 kHz; and<br>4. Pulse width less than 100 ns;<br>e. Tunable pulsed dye laser amplifiers and oscillators having all of the following characteristics:<br>1. Operating at wavelengths between 300 and 800 nm;<br>2. An average output power greater than 30 W;<br>3. A repetition rate greater than 1 kHz; and<br>4. Pulse width less than 100 ns;<br>Note: Paragraph B.2.2.6(e) does not control single mode oscillators.<br>f. Alexandrite lasers having all of the following characteristics:<br>1. Operating at wavelengths between 720 and 800 nm;<br>2. A bandwidth of 0.005 nm or less;<br>3. A repetition rate greater than 125 Hz; and<br>4. An average output power greater than 30 W; | |

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| | (4) bandwidth of 0.005 nm or less;<br>(*g*) pulsed carbon dioxide lasers having all of the following characteristics:<br>(1) operation at wavelengths of between 9 000 nm and 11 000 nm;<br>(2) average output power greater than 500 W;<br>(3) repetition rate greater than 250 Hz; and<br>(4) pulse width less than 200 ns;<br>NOTE<br>Paragraph B.2.2.6.(*g*) does not include the higher power (typically 1 kW to 5 kW) industrial CO2 lasers used in applications such as cutting and welding, as those lasers are either continuous wave or are pulsed with a pulse width of more than 200 ns.<br>(*h*) pulsed excimer lasers (XeF, XeCl, KrF) having all of the following characteristics:<br>(1) operation at wavelengths of between 240 nm and 360 nm;<br>(2) average output power greater than 500 W; and<br>(3) repetition rate greater than 250 Hz; and<br>(*i*) para-hydrogen Raman shifters designed to operate at 16 µm output wavelength and at a repetition rate greater than 250 Hz. | g. Pulsed carbon dioxide lasers having all of the following characteristics:<br>1. Operating at wavelengths between 9 000 and 11 000 nm;<br>2. A repetition rate greater than 250 Hz;<br>3. An average output power greater than 500 W; and<br>4. Pulse width of less than 200 ns;<br>Note: Paragraph B.2.2.6(g) does not control the higher power (typically 1 to 5 kW) industrial $CO_2$ lasers used in applications such as cutting and welding, as these latter lasers are either continuous wave or are pulsed with a pulse width greater than 200 ns.<br>h. Pulsed excimer lasers (XeF, XeCl, KrF) having all of the following characteristics:<br>1. Operating at wavelengths between 240 and 360 nm;<br>2. A repetition rate greater than 250 Hz; and<br>3. An average output power greater than 500 W;<br>i. Para-hydrogen Raman shifters designed to operate at 16 µm output wavelength and at a repetition rate greater than 250 Hz.<br>j. Pulsed carbon monoxide lasers having all of the following characteristics:<br>1. Operating at wavelengths between 5 000 and 6 000 nm;<br>2. A repetition rate greater than 250 Hz;<br>3. An average output power greater than 200 W; and<br>4. Pulse width of less than 200 ns.<br>Note: Item B.2.2.6(j) does not control the higher power (typically 1 to 5 kW) industrial CO lasers used in applications such as cutting and welding, as these latter lasers are either continuous wave or are pulsed with a pulse width greater than 200 ns. | |

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| **B.2.2.7.** | *Mass spectrometers capable of measuring ions of 230 atomic mass units or greater and having a resolution of better than 2 parts in 230, and ion sources therefor as follows:* | *Mass spectrometers capable of measuring ions of 230 atomic mass units or greater and having a resolution of better than 2 parts in 230, as follows, and ion sources therefor:* | No |
| | (*a*) inductively coupled plasma mass spectrometers (ICP/MS);<br>(*b*) glow discharge mass spectrometers (GDMS);<br>(*c*) thermal ionization mass spectrometers (TIMS);<br>(*d*) electron bombardment mass spectrometers which have a source chamber constructed from or lined with or plated with materials resistant to UF6;<br>(*e*) molecular beam mass spectrometers as follows:<br>(1) which have a source chamber constructed from or lined with or plated with stainless steel or molybdenum and have a cold trap capable of cooling to 193 K (-80°C) or less; or<br>(2) which have a source chamber constructed from or lined with or plated with materials resistant to UF6; and<br>(*f*) mass spectrometers equipped with a microfluorination ion source designed for use with actinides or actinide fluorides; except specially designed or prepared magnetic or quadrupole mass spectrometers<br>capable of taking on-line samples of feed, product or tails from UF6 gas streams and having all of the following characteristics:<br>(1) unit resolution for mass greater than 320;<br>(2) ion sources constructed of or lined with nichrome or monel or nickel-plated;<br>(3) electron bombardment ionization sources; and<br>(4) having a collector system suitable for isotopic | a. Inductively coupled plasma mass spectrometers (ICP/MS);<br>b. Glow discharge mass spectrometers (GDMS);<br>c. Thermal ionization mass spectrometers (TIMS);<br>d. Electron bombardment mass spectrometers having both of the following features:<br>1. A molecular beam inlet system that injects a collimated beam of analyte molecules into a region of the ion source where the molecules are ionized by an electron beam; and<br>2. One or more cold traps that can be cooled to a temperature of 193 K (-80 °C) or less in order to trap analyte molecules that are not ionized by the electron beam;<br>e. Mass spectrometers equipped with a microfluorination ion source designed for actinides or actinide fluorides.<br><br>*Technical Notes:*<br>*1. Paragraph B.2.2.7(d) describes mass spectrometers that are typically used for isotopic analysis of $UF_6$ gas samples.*<br>*2. Electron bombardment mass spectrometers in Item B.2.2.7(d) are also known as electron impact mass spectrometers or electron ionization mass spectrometers.*<br>*3. In Paragraph B.2.2.7(d)(2), a 'cold trap' is a device that traps gas molecules by condensing or freezing them on cold surfaces. For the purposes of this entry, a closed-loop gaseous helium cryogenic vacuum pump is not a cold trap.* | Yes |

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| | analysis. | | |
| **B.2.2.8.** | *Pressure transducers which are capable of measuring absolute pressure at any point in the range 0 kPa to 13 kPa, with pressure sensing elements made of or protected by nickel, nickel alloys with more than 60% nickel by weight, aluminium or aluminium alloys as follows:* | *All types of pressure transducers capable of measuring absolute pressures and having all of the following characteristics:* | Yes |
| | *Pressure transducers which are capable of measuring absolute pressure at any point in the range 0 kPa to 13 kPa, with pressure sensing elements made of or protected by nickel, nickel alloys with more than 60% nickel by weight, aluminium or aluminium alloys as follows:*<br>(*a*) transducers with a full scale of less than 13 kPa and an accuracy of better than ± 1% of full scale; and<br>(*b*) transducers with a full scale of 13 kPa or greater and an accuracy of better than ± 130 Pa.<br>NOTE<br>1. Pressure transducers are devices that convert pressure measurements into an electrical signal.<br>2. For the purpose of this paragraph, "accuracy" includes non-linearity, hysteresis and repeatability at ambient temperature. | All types of pressure transducers capable of measuring absolute pressures and having all of the following characteristics:<br>a. Pressure sensing elements made of or protected by aluminium, aluminium alloy, aluminium oxide (alumina or sapphire), nickel, nickel alloy with more than 60% nickel by weight, or fully fluorinated hydrocarbon polymers;<br>b. Seals, if any, essential for sealing the pressure sensing element, and in direct contact with the process medium, made of or protected by aluminium, aluminium alloy, aluminium oxide (alumina or sapphire), nickel, nickel alloy with more than 60% nickel by weight, or fully fluorinated hydrocarbon polymers; and<br>c. Having either of the following characteristics:<br>1. A full scale of less than 13 kPa and an "accuracy" of better than ± 1% of full scale; or<br>2. A full scale of 13 kPa or greater and an "accuracy" of better than ± 130 Pa when measuring at 13 kPa.<br>*Technical Notes:*<br>*1. In Paragraph B.2.2.8. pressure transducers are devices that convert pressure measurements into a signal.*<br>*2. In Paragraph B.2.2.8. "accuracy" includes non-linearity, hysteresis and repeatability at ambient temperature.* | Yes |
| **B.2.3.4.** | *Hydrogen-cryogenic distillation columns having all of the following applications:*<br>(*a*) designed to operate with internal temperatures of | Hydrogen-cryogenic distillation columns having all of the following characteristics:<br>a. Designed for operation at internal temperatures of 35 K | Yes |

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| | -238°C (35 K) or less;<br>(*b*) 0.5 MPa to 5 MPa (5 to 50 atmospheres);<br>(*c*) constructed of fine-grain stainless steels of the 300 series with low sulphur content or equivalent cryogenic and H2-compatible materials; and<br>(*d*) with internal diameters of 1 m or greater and effective lengths of 5 m or greater.<br>NOTE<br>Fine-grain stainless steels in this paragraph are defined to be fine-grain austenitic stainless steels with an ASTM (or equivalent standard) grain size number of 5 or greater. | (-238 ºC) or less;<br>b. Designed for operation at internal pressures of 0.5 to 5 MPa;<br>c. Constructed of either:<br>1. Stainless steel of the 300 series with low sulfur content and with an austenitic ASTM (or equivalent standard) grain size number of 5 or greater; or<br>2. Equivalent materials which are both cryogenic and $H_2$-compatible; and<br>d. With internal diameters of 30 cm or greater and 'effective lengths' of 4 m or greater.<br>*Technical Note: The term 'effective length' means the active height of packing material in a packed-type column, or the active height of internal contactor plates in a plate-type column.* | |
| **B.2.3.5.** | Ammonia synthesis converters or synthesis units in which the synthesis gas (nitrogen and hydrogen) is withdrawn from an ammonia/hydrogen high-pressure exchange column and the synthesized ammonia is returned to said column. | Entry to be deleted. | Yes |
| **B.2.4.2.** | *Multistage light gas guns or other high-velocity gun systems (coil, electromagnetic, electrothermal, or other advanced systems) capable of accelerating projectiles to 2 km/s or greater.* | High-velocity gun systems (propellant, gas, coil, electromagnetic, and electrothermal types, and other advanced systems) capable of accelerating projectiles to 1.5 km/s or greater.<br>NOTE<br>This item does not control guns specially designed for high velocity weapon systems. | Yes |
| **B.2.4.3.** | *Mechanical rotating mirror cameras, as follows; and specially designed components therefor:*<br>(*a*) framing cameras with recording rates greater than 225 | *High-speed cameras and imaging devices and components therefor, as follows:*<br>a. Streak cameras, and specially designed components therefor, | Yes |

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| | 000 frames/s; and<br><br>(*b*) streak cameras with writing speeds greater than 0.5 mm/μs.<br><br>NOTE<br><br>Components of such cameras include their synchronizing electronics units and rotor assemblies consisting of turbines, mirrors, and bearings. | as follows:<br>1. Streak cameras with writing speeds greater than 0.5 mm/μs;<br>2. Electronic streak cameras capable of 50 ns or less time resolution;<br>3. Streak tubes for cameras specified in B.2.4.3(a)(2);<br>4. Plug-ins specially designed for use with streak cameras which have modular structures and that enable the performance specifications in B.2.4.3(a)(1) or B.2.4.3(a)(2);<br>5. Synchronizing electronics units, rotor assemblies consisting of turbines, mirrors and bearings specially designed for cameras specified in B.2.4.3(a)(1).<br><br>b. Framing cameras and specially designed components therefor as follows:<br>1. Framing cameras with recording rates greater than 225,000 frames per second;<br>2. Framing cameras capable of 50 ns or less frame exposure time;<br>3. Framing tubes and solid-state imaging devices having a fast image gating (shutter) time of 50ns or less specially designed for cameras specified in B.2.4.3(b)(1) or B.2.4.3(b)(2);<br>4. Plug-ins specially designed for use with framing cameras which have modular structures and that enable the performance specifications in B.2.4.3(b)(1) or B.2.4.3(b)(2);<br>5. Synchronizing electronics units, rotor assemblies consisting of turbines, mirrors and bearings specially designed for cameras specified in B.2.4.3(b)(1) or B.2.4.3(b)(2).<br><br>c. Solid state or electron tube cameras and specially designed components therefor as follows:<br>1. Solid-state cameras or electron tube cameras with a fast image gating (shutter) time of 50 ns or less; | |

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| | | 2. Solid-state imaging devices and image intensifiers tubes having a fast image gating (shutter) time of 50 ns or less specially designed for cameras specified in B.2.4.3(c)(1);<br>3. Electro-optical shuttering devices (Kerr or Pockels cells) with fast image gating (shutter) time of 50 ns or less;<br>4. Plug-ins specially designed for use with cameras which have modular structures and that enable the performance specifications in B.2.4.3(c)(1).<br>*Technical Note: High speed single frame cameras can be used alone to produce a single image of a dynamic event, or several such cameras can be combined in a sequentially-triggered system to produce multiple images of an event.* | |
| **B.2.4.4.** | *Electronic streak and framing cameras and tubes, as follows:*<br>(*a*) electronic streak cameras capable of 50 ns or less time resolution and streak tubes therefor;<br>(*b*) electronic (or electronically shuttered) framing cameras capable of 50 ns or less frame exposure time; and<br>(*c*) framing tubes and solid-state imaging devices for use with cameras controlled in paragraph (*b*) as follows:<br>(1) proximity focused image intensifier tubes having the photocathode deposited on a transparent conductive coating to decrease photocathode sheet resistance;<br>(2) gate silicon intensifier target (SIT) vidicon tubes, where a fast system allows gating the photoelectrons from the photocathode before they impinge on the SIT plate;<br>(3) Kerr or Pockels cell electro-optical shuttering; or<br>(4) other framing tubes and solid-state imaging devices having a fast image gating time of less than 50 ns specially designed for cameras controlled by | Entry to be deleted. | Yes |

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| | paragraph (*b*). | | |
| **B.2.4.5.** | *Specialized instrumentation for hydrodynamic experiments, as follows:* | *Specialized instrumentation for hydrodynamic experiments, as follows:* | *No* |
| | (*a*) velocity interferometers for measuring velocities in excess of 1 km/s during time intervals less than 10 µs (VISARs, Doppler laser interferometers, DLIs, etc.);<br>(*b*) manganin gauges for pressures greater than 100 kilobars; and<br>(*c*) quartz pressure transducers for pressures greater than 100 kilobars. | a. Velocity interferometers for measuring velocities exceeding 1 km/s during time intervals of less than 10 µs;<br>b. Shock pressure gauges capable of measuring pressures greater than 10 GPa, including gauges made with manganin, ytterbium, and polyvinylidene bifluoride (PVBF, $PVF_2$);<br>c. Quartz pressure transducers for pressures greater than 10 GPa.<br>NOTE<br>Paragraph B.2.4.5(a) includes velocity interferometers such as VISARs (Velocity Interferometer Systems for Any Reflector), DLIs (Doppler Laser Interferometers) and PDV (Photonic Doppler Velocimeters) also known as Het-V (Heterodyne Velocimeters). | Yes |
| **B.2.5.3.** | *Firing sets and equivalent high-current pulse generators (for controlled detonators), as follows:* | *Firing sets and equivalent high-current pulse generators, as follows:* | No |
| | *Firing sets and equivalent high-current pulse generators (for controlled detonators), as follows:*<br>(*a*) explosive detonator firing sets designed to drive multiple controlled detonators covered in paragraph B.2.5.1.; and<br>(*b*) modular electrical pulse generators (pulsers) designed for portable, mobile, or ruggedized-use (including xenon flash-lamp drivers) having all the following characteristics:<br>(1) capable of delivering their energy in less than 15 µs;<br>(2) having an output greater than 100 A;<br>(3) having a rise time of less than 10 µs into loads of | a. Detonator firing sets (initiation systems, firesets), including electronically-charged, explosively-driven and optically-driven firing sets designed to drive multiple controlled detonators specified in Paragraph B.2.5.1;<br>b. Modular electrical pulse generators (pulsers) having all of the following characteristics:<br>1. Designed for portable, mobile, or ruggedized-use;<br>2. Capable of delivering their energy in less than 15 µs into loads of less than 40 ohms;<br>3. Having an output greater than 100 A;<br>4. No dimension greater than 30 cm;<br>5. Weight less than 30 kg ; and<br>6. Specified to operate over an extended temperature range of | Yes |

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| | less than 40 ω. (Rise time is defined as the time interval from 10% to 90% current amplitude when driving a resistive load);<br>(4) enclosed in a dust-tight enclosure;<br>(5) no dimension greater than 25.4 cm (10 in.);<br>(6) weight less than 25 kg (55 lbs.); and<br>(7) specified for use over an extended temperature range (-50°C to 100°C) or specified as suitable for aerospace use. | 223 to 373 K (-50 ºC to 100 ºC) or specified as suitable for aerospace applications.<br>c. Micro-firing units having all of the following characteristics:<br>1. No dimension greater than 35 mm;<br>2. Voltage rating of equal to or greater than 1 kV; and<br>3. Capacitance of equal to or greater than 100 nF.<br><br>NOTE<br>Optically driven firing sets include both those employing laser initiation and laser charging. Explosively-driven firing sets include both explosive ferroelectric and explosive ferromagnetic firing set types. Paragraph B.2.5.3(b) includes xenon flashlamp drivers. | |
| **B.2.5.4.** | *High explosives or substances or mixtures containing more than 2% of any of the following:*<br>(*a*) cyclotetramethylenetetranitramine (HMX);<br>(*b*) cyclotrimethylenetrinitramine (RDX);<br>(*c*) triaminotrinitrobenzene (TATB);<br>(*d*) any explosive with a crystal density greater than 1.8 $g/cm^3$ and having a detonation velocity greater than 8 000 m/s; or<br>(*e*) hexanitrostilbene (HNS). | *High explosive substances or mixtures, containing more than 2 % by weight of any of the following:*<br>a. Cyclotetramethylenetetranitramine (HMX ) (CAS 2691-41-0);<br>b. Cyclotrimethylenetrinitramine (RDX) (CAS 121-82-4);<br>c. Triaminotrinitrobenzene (TATB) (CAS 3058-38-6);<br>d. Aminodinitrobenzo-furoxan or 7-amino-4,6 nitrobenzofurazane-1-oxide (ADNBF) (CAS 97096-78-1);<br>e. 1,1-diamino-2,2-dinitroethylene (DADE or FOX7) (CAS 145250-81-3);<br>f. 2,4-dinitroimidazole (DNI) (CAS 5213-49-0);<br>g. Diaminoazoxyfurazan (DAAOF or DAAF) (CAS 78644-89-0);<br>h. Diaminotrinitrobenzene (DATB) (CAS 1630-08-6);<br>i. Dinitroglycoluril (DNGU or DINGU) (CAS 55510-04-8);<br>j. 2,6-Bis (picrylamino)-3,5-dinitropyridine (PYX) (CAS 38082- | Yes |

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| | | 89-2);<br>k. 3,3′-diamino-2,2′,4,4′,6,6′-hexanitrobiphenyl or dipicramide (DIPAM) (CAS 17215-44-0);<br>l. Diaminoazofurazan (DAAzF) (CAS 78644-90-3);<br>m. 1,4,5,8-tetranitro-pyridazino[4,5-d] pyridazine (TNP) (CAS 229176-04-9);<br>n. Hexanitrostilbene (HNS) (CAS 20062-22-0); or<br>o. Any explosive with a crystal density greater than 1.8 $g/cm^3$ and having a detonation velocity greater than 8000 m/s. | |
| **B.2.6.2.** | High-speed pulse generators with output voltages greater than 6 V into a less than 55 ω resistive load, and with pulse transition times less than 500 ps (defined as the time interval between 10% and 90% voltage amplitude). | *High-speed pulse generators, and pulse heads therefor, having both of the following characteristics:*<br>a. Output voltage greater than 6 V into a resistive load of less than 55 ohms; and<br>b. ‘Pulse transition time’ less than 500 ps.<br>*Technical Notes:*<br>*1. In Paragraph B.2.6.2(b) ‘pulse transition time’ is defined as the time interval between 10% and 90% voltage amplitude.*<br>*2. Pulse heads are impulse forming networks designed to accept a voltage step function and shape it into a variety of pulse forms that can include rectangular, triangular, step, impulse, exponential, or monocycle types. Pulse heads can be an integral part of the pulse generator, they can be a plug-in module to the device or they can be an externally connected device.* | Yes |

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| **TBD** | | High explosive containment vessels, chambers, containers and other similar containment devices designed for the testing of high explosives or explosive devices and having both of the following characteristics:<br>a. Designed to fully contain an explosion equivalent to 2 kg of TNT or greater; <u>and</u><br>b. Having design elements or features enabling real time or delayed transfer of diagnostic or measurement information. | Yes |
| **B.2.7.1.** | Neutron generator systems, including tubes, designed for operation without an external vacuum system and utilizing electrostatic acceleration to induce a tritium-deuterium nuclear reaction. | Neutron generator systems, including tubes, having both of the following characteristics:<br>a. Designed for operation without an external vacuum system; and<br>b. 1. Utilizing electrostatic acceleration to induce a tritium-deuterium nuclear reaction; or<br>2. Utilizing electrostatic acceleration to induce a deuterium-deuterium nuclear reaction and capable of an output of $3 \times 10^9$ neutrons/s or greater. | Yes |
| **TBD** | | Striplines to provide low inductance path to detonators with the following characteristics:<br>a. Voltage rating greater than 2 kV; and<br>b. Inductance of less than 20 nH. | Yes |
| **B.2.7.2.** | *Equipment related to nuclear material handling and processing and to nuclear reactors, as follows:*<br>(a) remote manipulators that can be used to provide remote actions in radiochemical separation operations and hot cells, as follows:<br>(1) having a capability of penetrating 0.6 m or more of hot cell wall (through-the-wall operation); or<br>(2) having a capability of bridging over the top of a hot cell wall with a thickness of 0.6 m or more (over-the- | *Equipment related to nuclear material handling and processing and to nuclear reactors, as follows:*<br>(a) Remote manipulators that can be used to provide remote actions in radiochemical separation operations or hot cells, having either of the following characteristics:<br>a. A capability of penetrating 0.6 m or more of hot cell wall (through-the-wall operation); or<br>b. A capability of bridging over the top of a hot cell wall with a thickness of 0.6 m or more (over-the-wall operation). | No |

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| | wall operation);<br>NOTE<br>Remote manipulators provide translation of human operator actions to a remote operating arm and terminal fixture. They may be of a "master/slave" type or operated by joystick or keypad.<br>(*b*) high-density (lead glass or other) radiation shielding windows greater than 0.09 $m^2$ on cold area and with a density greater than 3 $g/cm^3$ and a thickness of 100 mm or greater; and specially designed frames therefor; and<br>(*c*) radiation-hardened TV cameras, or lenses therefor, specially designed or rated as radiation hardened to withstand greater than 5 x $10^4$ Gy (Silicon) (5 x $10^6$ rad (Silicon)) without operational degradation. | *NOTE*<br>*Remote manipulators provide translation of human operator actions to a remote operating arm and terminal fixture. They may be of a master/slave type or operated by joystick or keypad.*<br>(b) High-density (lead glass or other) radiation shielding windows, having all of the following characteristics, and specially designed frames therefor:<br>a. A 'cold area' greater than 0.09 $m^2$;<br>b. A density greater than 3 $g/cm^3$; and<br>c. A thickness of 100 mm or greater.<br>*NOTE*<br>*The term 'cold area' means the viewing area of the window exposed to the lowest level of radiation in the design application.*<br>(c) Radiation-hardened TV cameras, or lenses therefor, specially designed or rated as radiation hardened to withstand a total radiation dose greater than 5 x $10^4$ Gy (silicon) without operational degradation.<br>*NOTE*<br>*The term Gy (silicon) refers to the energy in Joules per kilogram absorbed by an unshielded silicon sample when exposed to ionizing radiation.* | |
| **B.2.7.5.** | *Lithium isotope separation facilities, plants and equipment, as follows:*<br>(*a*) facilities or plants for the separation of lithium isotopes; and<br>(*b*) equipment for the separation of lithium isotopes, as follows:<br>(1) packed liquid-liquid exchange columns specially | *Lithium isotope separation facilities or plants, and systems and equipment therefor, as follows:*<br>N.B.: Certain lithium isotope separation equipment and components for the plasma separation process (PSP) are also directly applicable to uranium isotope separation and are controlled under Part A of the schedule.<br>a. Facilities or plants for the separation of lithium isotopes; | Yes |

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| | designed for lithium amalgams;<br>(2) mercury and lithium amalgam pumps;<br>(3) lithium amalgam electrolysis cells; and<br>(4) evaporators for concentrated lithium hydroxide solution. | b. Equipment for the separation of lithium isotopes based on the lithium-mercury amalgam process, as follows:<br>1. Packed liquid-liquid exchange columns specially designed for lithium amalgams;<br>2. Mercury or lithium amalgam pumps;<br>3. Lithium amalgam electrolysis cells;<br>4. Evaporators for concentrated lithium hydroxide solution;<br>c. Ion exchange systems specially designed for lithium isotope separation, and specially designed component parts therefor;<br>d. Chemical exchange systems (employing crown ethers, cryptands, or lariat ethers) specially designed for lithium isotope separation, and specially designed component parts therefor. | |
| **TBD** | | *Bellows-sealed scroll-type compressors and bellows-sealed scroll-type vacuum pumps having all of the following characteristics:*<br>a. Capable of an inlet volume flow rate of 50 $m^3$/h or greater;<br>b. Capable of a pressure ratio of 2:1 or greater; and<br>c. Having all surfaces that come in contact with the process gas made from any of the following materials:<br>1. Aluminium or aluminium alloy;<br>2. Aluminium oxide;<br>3. Stainless steel;<br>4. Nickel or nickel alloy;<br>5. Phosphor bronze; or<br>6. Fluoropolymers.<br>*Technical Notes:*<br>*1. In a scroll compressor or vacuum pump, crescent-shaped pockets of gas are trapped between one or more pairs of intermeshed spiral vanes, or scrolls, one of which moves while the other remains stationary. The moving scroll orbits the* | Yes |

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| | | *stationary scroll; it does not rotate. As the moving scroll orbits the stationary scroll, the gas pockets diminish in size (i.e., they are compressed) as they move toward the outlet port of the machine.*<br>*2. In a bellows-sealed scroll compressor or vacuum pump, the process gas is totally isolated from the lubricated parts of the pump and from the external atmosphere by a metal bellows. One end of the bellows is attached to the moving scroll and the other end is attached to the stationary housing of the pump.*<br>*3. Fluoropolymers include, but are not limited to, the following materials:*<br>*a. Polytetrafluoroethylene (PTFE),*<br>*b. Fluorinated Ethylene Propylene (FEP),*<br>*c. Perfluoroalkoxy (PFA),*<br>*d. Polychlorotrifluoroethylene (PCTFE); and*<br>*e. Vinylidene fluoride-hexafluoropropylene copolymer. .* | |