

Definition of Nuclear Material in terms of Nuclear Nonproliferation and Security

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Nuclear Safety

- **Human from Radiation**
 - Nuclear safety accidents directly affect human health
 - More attention

Nuclear Security

- **Material from Human**
 - Nuclear security incidents indirectly influence human
 - Less attention

Objective

- Since nuclear terrorism is indeed one of the most dreadful threat humanity faces, we need a **better understanding of the nuclear material** which should be protected under the objective of nuclear security

• 효과적인 안전조치 및 물리적방호 이행

- 법을 통한 우선순위 (priority) 부여
- 기계적 이행이 아닌 능동적 규제
- 원자력통제 관점의 일관성있는 정의

• 국제적 노력 기여

- FMCT : International Panel on Fissile Materials

Fissile material	i) Plutonium of any isotopic composition except plutonium that contains 80 percent or more plutonium-238
	ii) Uranium containing uranium-235 and/or uranium-233 in a weighted concentration equivalent to or greater than 20 percent uranium-235
	iii) Any other fissile material suitable for the manufacture of nuclear weapons as agreed to in a protocol to this treaty
	iv) Material containing any combination of the foregoing

• 향후 핵비확산법 대비

- The definition of terminology on nuclear material within the highest-level legislation on the safeguards and physical protection
 - Korean legislation
 - International instruments
 - Case studies
 - International efforts (IAEA)
- A draft of definition on nuclear material in aspects of safeguards and physical protection

The Definitions in Korean Legislation



Provided Term	Definition Text of Act	Definition Text of Presidential Decree
Nuclear materials (NSA)	Nuclear fuel materials and nuclear raw materials;	-
Nuclear fuel materials (NSA)	Materials capable of producing nuclear energy, such as uranium and thorium, as prescribed by <u>Presidential Decree</u> ;	<ol style="list-style-type: none"> 1. Uranium with same ratio of the isotope 235 to isotope 238 as the ratio occurring in nature and its compounds 2. Uranium with lower ratio of the isotope 235 to isotope 238 than the ratio occurring in nature and its compounds 3. Thorium and its compounds 4. Materials containing at least one material specified in 1~3, which can be used as fuel for reactors 5. Uranium with higher ratio of the isotope 235 to isotope 238 than the ratio occurring in nature and its compounds 6. Plutonium and its compounds 7. Uranium 233 and its compounds 8. Materials containing at least one material specified in paragraph 5~7
Nuclear raw materials (NSA)	Uranium ore, thorium ore, and other materials used as raw materials for nuclear fuel materials, as prescribed by <u>Presidential Decree</u> ;	Materials containing uranium and its compounds, and thorium and its compounds excluding the “nuclear fuel materials”
Nuclear materials (APPRE)	Materials capable of producing nuclear energy, such as uranium and thorium and uranium ore, thorium ore, and other materials used as raw materials for nuclear fuel materials, as prescribed by <u>Presidential Decree</u> ;	<ol style="list-style-type: none"> 1. Uranium 233 and its compounds 2. Uranium 235 and its compounds 3. Thorium and its compounds 4. Plutonium (except that with isotopic concentration exceeding 80 percent in plutonium-238) and its compounds 5. Materials containing at least one material specified in paragraph 1~4 6. Materials containing uranium and its compounds, or thorium and its compounds besides 1~5

*Nuclear Safety Act (NSA), Act on Physical Protection and Radiological Emergency (APPRE)

The Definitions in Korean Legislation



용어	법령 정의	시행령 정의
핵물질 (NSA)	핵연료물질 및 핵원료물질을 말한다	-
핵연료물질 (NSA)	우라늄·토륨 등 원자력을 발생할 수 있는 물질로서 <u>대통령령으로 정하는 것을</u> 말한다	<ol style="list-style-type: none"> 1. 우라늄 238에 대한 우라늄 235의 비율이 천연혼합물과 같은 우라늄 및 그 화합물 2. 우라늄 238에 대한 우라늄 235의 비율이 천연혼합물에 미달하는 우라늄 및 그 화합물 3. 토륨 및 그 화합물 4. 제1호부터 제3호까지의 규정에 해당하는 물질이 하나 이상 함유된 물질로서 원자로의 연료로 사용할 수 있는 물질 5. 우라늄 238에 대한 우라늄 235의 비율이 천연혼합물을 초과하는 우라늄 및 그 화합물 6. 플루토늄 및 그 화합물 7. 우라늄 233 및 그 화합물 8. 제5호부터 제7호까지의 규정에 해당하는 물질이 하나 이상 함유된 물질
핵원료물질 (NSA)	우라늄광·토륨광과 그 밖의 핵연료물질의 원료가 되는 물질로서 <u>대통령령으로 정하는 것을</u> 말한다	우라늄 및 그 화합물 또는 토륨 및 그 화합물을 함유한 물질로서 핵연료물질 외의 물질을 말한다.
핵물질 (APPRE)	우라늄, 토륨 등 원자력을 발생할 수 있는 물질과 우라늄광, 토륨광, 그 밖의 핵연료물질의 원료가 되는 물질 중 <u>대통령령으로 정하는 것을</u> 말한다	<ol style="list-style-type: none"> 1. 우라늄 233 및 그 화합물 2. 우라늄 235 및 그 화합물 3. 토륨 및 그 화합물 4. 플루토늄(플루토늄 238의 농축도가 80퍼센트 초과한 것을 제외한 플루토늄을 말한다) 및 그 화합물 5. 제1호 내지 제4호의 물질이 1 이상 함유된 물질 6. 우라늄 및 그 화합물 또는 토륨 및 그 화합물이 함유된 물질로서 제1호 내지 제5호의 물질외의 물질

*Nuclear Safety Act (NSA) : 원자력안전법

Act on Physical Protection and Radiological Emergency (APPRE) : 원자력시설 등의 방호 및 방사능 방재 대책법

- Nuclear Safety Act
 - Fuel material and raw material
 - radiological harm on human health
 - Effectiveness of the definition
- Act on Physical Protection and Radiological Emergency
 - Relatively clear, however prioritization needed
- Not just radiation,
how easily the material can be used to develop nuclear weapon is of importance
 - Quantity, concentration, physical and chemical form, isotopic composition, irradiation status and quality
 - Most important factor : Material type (element contained and degree of enrichment)

Other Definitions of NM : Int'l Regime



Regime	Term	Definition Text
<ul style="list-style-type: none"> •IAEA Statute •CSA •AP 	Special fissionable material	<ol style="list-style-type: none"> 1. The term "special fissionable material" means plutonium-239; uranium- 233; uranium enriched in the isotopes 235 or 233; any material containing one or more of the foregoing; and such other fissionable material as the Board of Governors shall from time to time determine; but the term "special fissionable material" does not include source material. 2. The term "uranium enriched in the isotopes 235 or 233" means uranium containing the isotopes 235 or 233 or both in an amount such that the abundance ratio of the sum of these isotopes to the isotope 238 is greater than the ratio of the isotope 235 to the isotope 238 occurring in nature. 3. The term "source material" means uranium containing the mixture of isotopes occurring in nature; uranium depleted in the isotope 235; thorium; any of the foregoing in the form of metal, alloy, chemical compound, or concentrate; any other material containing one or more of the foregoing in such concentration as the Board of Governors shall from time to time determine; and such other material as the Board of Governors shall from time to time determine.
<ul style="list-style-type: none"> •ICSANT •CPPNM 	Nuclear material	<p>"Nuclear material" means plutonium, except that with isotopic concentration exceeding 80 percent in plutonium-238; uranium-233; uranium enriched in the isotope 235 or 233; uranium containing the mixture of isotopes as occurring in nature other than in the form of ore or ore residue; or any material containing one or more of the foregoing;</p> <p>Whereby "uranium enriched in the isotope 235 or 233" means uranium containing the isotope 235 or 233 or both in an amount such that the abundance ratio of the sum of these isotopes to the isotope 238 is greater than the ratio of the isotope 235 to the isotope 238 occurring in nature.</p>
INFCIRC/ 225/Rev.5	Nuclear material	<ol style="list-style-type: none"> 1. Unirradiated* plutonium (All plutonium except that with isotopic concentration exceeding 80% in plutonium-238) 2. Unirradiated* uranium-235 3. Unirradiated* uranium-233 4. Irradiated fuel <p>*Material not irradiated in a reactor or material irradiated in a reactor but with a radiation level equal to or less than 1 Gy/h. (100rad/h) at 1m unshielded.</p>

*Comprehensive Safeguards Agreement (CSA), Additional Protocol (AP)
 International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT)
 Convention on the Physical Protection of Nuclear Material (CPPNM)

TABLE 1. CATEGORIZATION OF NUCLEAR MATERIAL

Material	Form	Category I	Category II	Category III ^c
1. Plutonium ^a	Unirradiated ^b	2 kg or more	Less than 2 kg but more than 500 g	500 g or less but more than 15 g
2. Uranium-235 (²³⁵ U)	Unirradiated ^b – Uranium enriched to 20% ²³⁵ U or more – Uranium enriched to 10% ²³⁵ U but less than 20% ²³⁵ U – Uranium enriched above natural, but less than 10% ²³⁵ U	5 kg or more	Less than 5 kg but more than 1 kg 10 kg or more	1 kg or less but more than 15 g Less than 10kg but more than 1 kg 10 kg or more
3. Uranium-233 (²³³ U)	Unirradiated ^b	2 kg or more	Less than 2 kg but more than 500 g	500 g or less but more than 15 g
4. Irradiated fuel (The categorization of irradiated fuel in the table is based on international <i>transport</i> considerations. The State may assign a different category for domestic use, storage and <i>transport</i> taking all relevant factors into account.)			Depleted or natural uranium, thorium or low enriched fuel (less than 10% fissile content) ^{d, e}	

Note: This table is not to be used or interpreted independently of the text of the entire publication.

^a All plutonium except that with isotopic concentration exceeding 80% in plutonium-238.

^b Material not irradiated in a reactor or material irradiated in a reactor but with a radiation level equal to or less than 1 Gy/h. (100 rad/h) at 1 m unshielded.

^c Quantities not falling in Category III and natural uranium, depleted uranium and thorium should be protected at least in accordance with prudent management practice.

^d Although this level of protection is recommended, it would be open to States, upon evaluation of the specific circumstances, to assign a different category of physical protection.

^e Other fuel which by virtue of its original fissile material content is classified as Category I or II before irradiation may be reduced one category level while the radiation level from the fuel exceeds 1 Gy/h (100 rad/h) at one metre unshielded.

Table 1. Categorization of Nuclear Material from Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Rev.5)

Other Definitions of NM : Case Studies



Country	Act	Definition Text
Canada	Nuclear Safety and Control Act	<p>“Nuclear substance” means</p> <ul style="list-style-type: none"> (a) deuterium, thorium, uranium or an element with an atomic number greater than 92; (b) a derivative or compound of deuterium, thorium, uranium or of an element with an atomic number greater than 92; (c) a radioactive nuclide; (d) a substance that is prescribed as being capable of releasing nuclear energy or as being required for the production or use of nuclear energy; (e) a radioactive by-product of the development, production or use of nuclear energy; and (f) a radioactive substance or radioactive thing that was used for the development or production, or in connection with the use, of nuclear energy.
Japan	<ul style="list-style-type: none"> • Atomic Energy Basic Act • Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors 	<ul style="list-style-type: none"> • The term "Nuclear Fuel Materials" means materials that emit high energy in the process of nuclear fission, such as uranium and thorium which are specified by Cabinet Order; • The term "Nuclear Source Materials" means materials that are used as the raw materials of nuclear fuel materials, such as uranium ore and thorium ore, which are specified by Cabinet Order; • The term "specified nuclear fuel material" as used in this Act means plutonium (excluding that having an isotopic concentration of plutonium 238 exceeding 80 percent), uranium 233, uranium with a ratio of uranium 233 and uranium 235 to uranium 238 exceeding the ratio of natural composition and other nuclear fuel material specified by Cabinet Order.

Other Definitions of NM : Case Studies



Country	Act	Definition Text
France	<ul style="list-style-type: none"> •Defense Code Article L1333-1 •Defense Code Article R1333-1 	<ul style="list-style-type: none"> •The nuclear material fusible, fissile or fertile materials and any material containing one or more fusible, fissile or fertile elements, excluding ores whose list is specified by Order in Council of State •The list of fusible material, fissile or fertile mentioned in Article L1333-1 of the Code includes plutonium, uranium, thorium, deuterium, tritium and lithium 6
Russian Federation	Federal Law No.170 of the Russian Federation on the Use of Atomic Energy	Nuclear materials – materials which contain or are capable of generating fissile(fissionable) nuclear substances;
United Kingdom	<ul style="list-style-type: none"> •Energy Act 2013 •Anti-terrorism, Crime and Security Act 2001 	<ul style="list-style-type: none"> • “nuclear material” means any fissile material in the form of— <ul style="list-style-type: none"> (i) uranium metal, alloy or compound; or (ii) plutonium metal, alloy or compound; or any other fissile material prescribed by regulations made by the Secretary of State; • “nuclear material” means— <ul style="list-style-type: none"> (a) any fissile material in the form of— <ul style="list-style-type: none"> (i) uranium metal, alloy or chemical compound; or (ii) plutonium metal, alloy or chemical compound;
United States	Atomic Energy Act of 1954	The term "special nuclear material" means <ol style="list-style-type: none"> (1) plutonium, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of section 51, determines to be special nuclear material, but does not include source material; or (2) any material artificially enriched by any of the foregoing, but does not include source material.

Other Definitions of NM : Other Int'l Efforts

IAEA Safe- guards Glossary	•Special fissionable material	•Plutonium-239; uranium-233; uranium enriched in the isotopes 235 or 233; any material containing one or more of the foregoing
	•Fissionable material (Fissile material)	•In general, an isotope or a mixture of isotopes capable of nuclear fission. Some fissionable materials are capable of fission only by sufficiently fast neutrons (e.g. neutrons of a kinetic energy above 1 MeV). Isotopes that undergo fission by neutrons of all energies, including slow (thermal) neutrons, are usually referred to as fissile materials or fissile isotopes. For example, isotopes 233U, 235U, 239Pu and 241Pu are referred to as both fissionable and fissile, while 238U and 240Pu are fissionable but not fissile.
	•Fertile material	•A nuclear material which can be converted into a special fissionable material through capture of one neutron per nucleus. There are two naturally occurring fertile materials: 238U and 232Th. Through the capture of neutrons followed by two beta decays, these fertile materials are converted to fissionable 239Pu and 233U, respectively.
	•Direct use material	•Nuclear material that can be used for the manufacture of nuclear explosive devices without transmutation or further enrichment. It includes plutonium containing less than 80% 238Pu, high enriched uranium and 233U. Chemical compounds, mixtures of direct use materials (e.g. mixed oxide (MOX)), and plutonium in spent reactor fuel fall into this category. Unirradiated direct use material is direct use material which does not contain substantial amounts of fission products; it would require less time and effort to be converted to components of nuclear explosive devices than irradiated direct use material (e.g. plutonium in spent reactor fuel) that contains substantial amounts of fission products.
	•Indirect use material	•All nuclear material except direct use material. It includes: depleted, natural and low enriched uranium, and thorium, all of which must be further processed in order to produce direct use material.

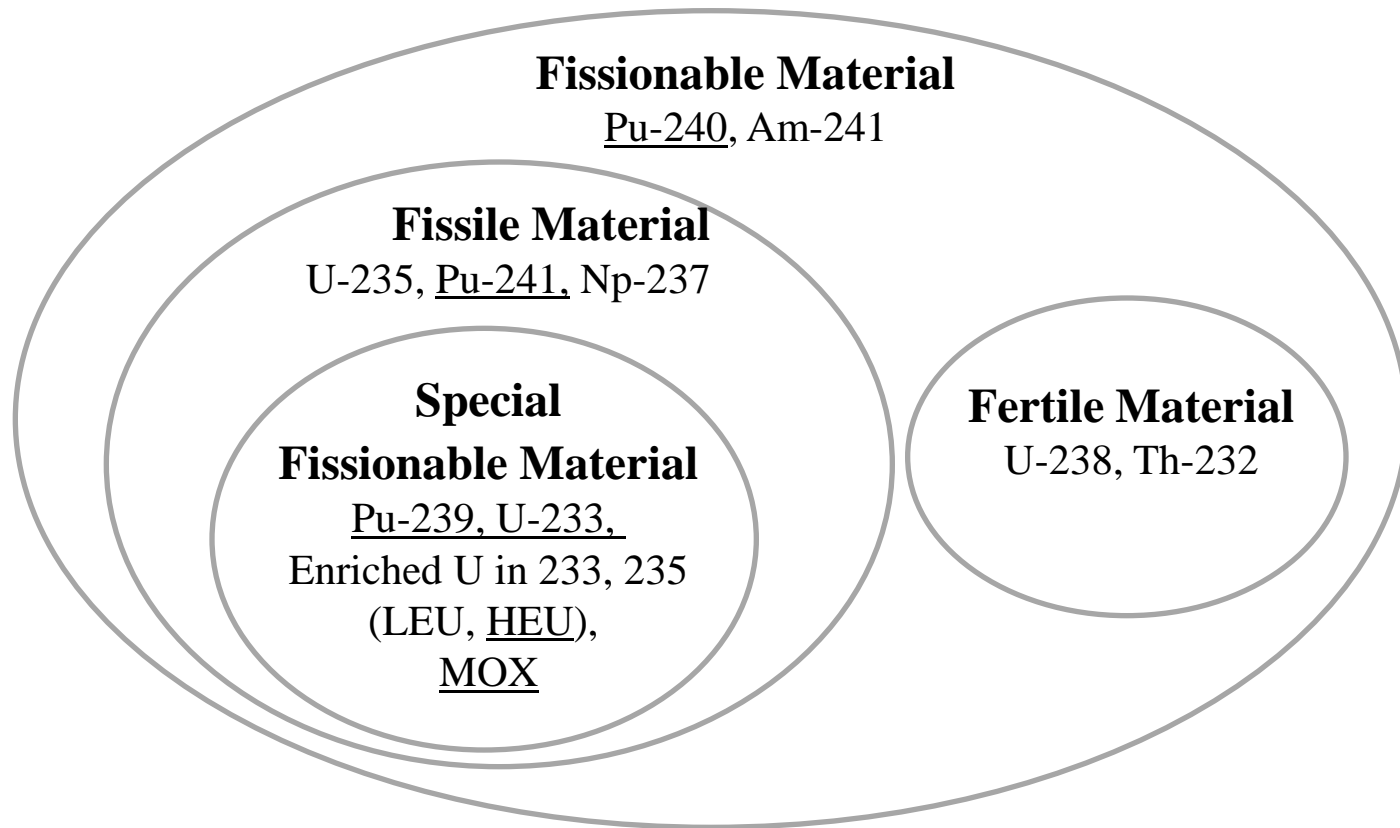


Fig. 1. Categorization of Nuclear Material based on IAEA Safeguards Glossary (underlined materials are 'direct use material')

[DRAFT]

Article XX.

1. Nuclear material of question in this act means nuclear fissionable material which includes fissile and fertile material.
2. Fissionable material is an isotope or a mixture of isotopes capable of nuclear fission, including fissile and fertile material.
 - I. Fissile material is isotopes or a mixture of isotopes that undergo fission by neutrons of all energies, including slow (thermal) neutrons such as special fissionable materials, uranium-235, plutonium-241, and neptunium-237.
 - a. Special fissionable materials aforementioned are plutonium-239, uranium-233, uranium enriched in the isotopes 235 or 233(including low enriched uranium and high enriched uranium), and mixed oxide (MOX).
 - b. Mixed oxide (MOX) is a mixture of the oxides of uranium and plutonium used as reactor fuel for the recycling of plutonium in thermal nuclear reactors and for fast reactors.
 - II. Fertile material is a nuclear material which can be converted into a special fissionable material through capture of one neutron per nucleus such as U-238 and Th-232.
3. The nuclear material might include other fissionable material as the Chairman of Nuclear Safety and Security Commission shall from time to time determine.

- The draft will facilitate the understanding of nuclear material in the context of nuclear nonproliferation and security
 - Provision for future legislation in consistent manner
- States-specific material should be considered
 - Canada and France
- For further studies
 - Multi-dimensional approach is required on the degree of efforts to diversion including material engineering
 - Direct use material and indirect use material
 - Diverse aspects of NM should be examined for further studies
 - Quantity concentration, physical and chemical form, isotopic composition, irradiation status and quality of nuclear material

Thank you!

Any Questions?