

## Comparison of the Export Control Methods for Deuterium and Heavy Water by Country

Hee-su Choe<sup>a</sup>, Su-hyeon Kim<sup>a</sup>, Seung-hyo Yang<sup>a\*</sup>

<sup>a</sup> Korea Institute of Nuclear Nonproliferation and Control(KINAC), 1418 Yuseong-daero, Yuseong-gu, Deajeon 34101

\*Corresponding author: shyang3220@kinac.re.kr

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### 1. Introduction

Nuclear Suppliers Group(NSG), one of the four major export control regimes, stipulates a trigger list and manages them under export control to prevent their diversion into weapons of mass destruction(WMD) and fulfill nuclear nonproliferation. NSG provides the general guidelines, and to the extent that they are complied with, each member state should incorporate the guideline into its domestic legislation, taking into account the characteristics of its industry, the efficiency of its export control organizational structure, and the effectiveness of the regulations. Although nuclear export control regimes in all member states are consistent with the guidelines, there are some differences between countries in controlling materials: deuterium and heavy water. This paper reviewed the current status of material export control in ROK. Also, this study aimed to summarize the detailed standards applied by other countries through a comparative analysis.

### 2. Current Status of Material Export Control in ROK

ROK controls trigger list items by implementing them under the Foreign Trade Act, Part 10 of Table 2 of the Public Notice of Exportation and Importation of Strategic Items. In particular, there are two main criteria for controlling the materials; quantity and end-use. The details are shown in Table 1.

Table 1: Control Limits for Materials

ECCN	Item	Nuclear -Use	Annual quantity	Threshold
0A001.f	Fuel cladding	O	-	10 kg
0C001	NU	-	O	500 kg
	DU, Th	-	O	1000 kg
0C002	Special fissionable material	-	O	50 Eg
0C003	Deuterium and Heavy water	O	O	200 kg
0C004	Nuclear grade graphite	O	-	1 kg

For certain items considered to have a low likelihood of diversion to WMD when held in small quantities, the regulations require cumulative control of the total amount exported over a year, either on a per-export basis or on an annual basis. In this case, the reference amount of the source material shall be 1/20 of 1 SQ, which is the significant level for nuclear proliferation. For example, 0C001(natural uranium, depleted uranium, and thorium), 0C002(special fissionable material), and 0C003(deuterium and heavy water) are representative cumulative quantity controlled items. At the same time, 0C004(reactor grade graphite) and 0A001.f(nuclear fuel cladding tube) have control criteria on the quantity for individual exports.

From the perspective of end-use, nuclear materials(NM), the raw materials for weapons are managed without distinguishing between uses. However, for items that are secondary materials required for producing NM and have high utilization in other industries, the control target is limited to “nuclear use”.

### 3. Necessity of systematizing deuterium and heavy water control standards

According to the previous studies, there is a need for different considerations to efficiently follow up on the exporting amount, status, and control standards for the items that require annual cumulative amount management[1]. Especially in the case of deuterium and heavy water, which require both the determination of the end-use and annual accumulation management, specific research on control standards and system is required. Recently, deuterium compounds and heavy water have been widely used for non-nuclear purposes, such as pharmaceuticals, semiconductors, displays, and fiber optic cables[2,3] as shown in Table 2.

Table 2: Some Non-Nuclear Uses of Deuterium

Industry	Applications
Semi-conductor	Remove physical/chemical stresses from wafers
Fiber Optic Cables	Reduce OH light absorption Remove contaminants from the fiber
OLED Displays	Achieving greater brightness Extend the lifetime Improve efficiency

Regarding the complexity of the material's characteristics, ROK currently classifies small quantities of deuterium compounds, heavy water exports for non-nuclear purposes, or issues export licenses for bulk heavy water exports for nuclear purposes on a case-by-case basis. The control standards for strategic items should not be set and applied by a single country, but rather by the entire supplier, which share similar control standards to a certain extent.

#### 4. Comparing heavy water management by country

The NSG guidelines define the criterion for reactor-grade heavy water as the atomic ratio of deuterium to hydrogen exceeding 1:5000 and recommend controlling 200 kg of deuterium atoms for any one recipient country within one calendar year(1 Jan.~31 Dec.) Two countries and an union reviewed in this paper(U.S., Canada, and EU) have different forms of reactor use and cumulative volume controls, which are summarized in Table 3.

##### 4.1 U.S.

The U.S. distinguishes between heavy water and deuterium hydride for nuclear applications. It imposes controls based on annualized export volumes, with different quantitative thresholds depending on the form of the material. At the same time, bulk exports are managed by limiting the maximum quantity per shipment. Even if the total annual export volume does not exceed the control threshold, licenses are needed for exports above a certain amount. However, general licenses are issued to some countries and for small amounts of exports, taking into account the final destination and volume of individual shipments.

Until 2021, the NRC did not distinguish the purpose of exported deuterium or heavy water. After 2021, NRC controlled exports for 'nuclear use' only, as the volume of exports for non-nuclear uses increased. The licensing authority has changed to DOC and the items with end-use were controlled according to EAR regulations[4].

##### 4.2 Canada

Canada issues export licenses for all heavy water and deuterium compounds, with no distinction between nuclear and non-nuclear uses or total quantities per export. However, three specific uses (deuterium lamps, deuterium as a contaminant, and deuterium compounds for labeling purposes) are excluded from the control[5].

For export of heavy water for non-nuclear purposes, the CNSC review the importer, the intended uses, the planned duration, and the total quantity at the contract or each end-user level, and provide information to the other country. This is not intended to impose additional obligations on importers and exporters, but rather to provide information in consideration of the complexity of heavy water export controls and the different

approaches in each country. Suppose a Korean company imports heavy water for non-nuclear purposes from Canada. In that case, Canada does not require a government-to-government assurance through the Ministry of Foreign Affairs or obligations under a cooperation agreement. However, it may require a confirmation of the purpose of the import between the companies.

##### 4.3 EU

The EU does not specify the cumulative amount within a calendar year in its regulation[6]. It means that EU controls deuterium and heavy water according to their specification and end-use, regardless of the amount exported. In the perspective of end-use control, similar to the U.S. and ROK, only the items used in nuclear reactors are controlled. In other words, deuterium and heavy water used in nuclear reactors, even in small quantities, are required the permits to meet the NSG Guideline's 200kg/year/country limit.

Table 3: Comparison Result of Control Methods

		U.S.	Canada	EU
End-use Control	Nuclear purpose	O (NRC)	O	O
	Non-nuclear	O (DOC)	O*	X
Quantity Control	Annual Quantity Limitation	<b>Deuterium compounds</b> 200kg/country <b>Heavy water</b> 1000kg/country	Quantity independent	
	Other	<b>Deuterium compounds</b> 10 kg/shipment <b>Heavy water</b> 50kg/shipment		
License Issuance Unit		Individual shipments*	Contract or each End-user	
Control Methods		General Licenses for specific destinations, within certain quantities	Exemption for 3 specific uses	

#### 5. Review for domestic application

##### 5.1 Approach to the purpose of end-use

In Canada, it is controlled regardless of the use, and the US and EU have different licensing authorities and control procedures depending on the expected purpose. Currently, ROK's Foreign Trade Act regulates heavy water subject to export licenses to "nuclear power plant use". Nevertheless, for the export of heavy water and deuterium for non-nuclear applications that meets the component ration, 1) the end user and 2) the end-use are identified at the classification stage. Moreover, in order

to track the end-use or changes in the trading conditions, authorities addressed the significance of the contract terms and using purpose and the possibility of change in the classification result.

However, there is a limitation that the use cannot be verified every time. Unlike other countries, Korea has a separated process between classification, which is to clarify if the item to be controlled, and licensing to export. It leads to the limitation, for the item that is not a trigger list item, the classification procedure is not mandatory.

In the future, if the domestic use and international exports of heavy water/deuterium for non-nuclear purposes continue to increase, a case-by-case review of the importance of controls in terms of proliferation perspective could be conducted. And new regulatory measures for 'non-nuclear' items could be developed based on the Canadian exclusions or other examples. As a first step, it is necessary to establish an implementation system by providing definitions and guidelines for non-nuclear uses. Internally evaluating the validity and effectiveness of controls and reflecting them in National legislation will also help operators to implement export control procedures with clear standards.

### *5.2 Management on Accumulative Quantities*

U.S. implements the controlling methods through shipment-by-shipment permits. On the other hand, in Canada and the EU, to reduce the loophole, export licenses for all items are required, even in small quantities, regardless of the annual counting per country, in order to bring them into the control system.

In ROK, small amounts of heavy water for nuclear reactors have never been exported, so export licenses are issued based on the total volume and timing of export, rather than managing the cumulative amounts by case. The annual planned export volume is reviewed at the time of classification and export licensing. In some cases, the license is issued with the transfer within the given year as a condition, and the export license have to returned if the export is not conducted. This may allow cumulative quantity management for large quantities of deuterium and heavy water.

Exporting small quantities of deuterium compounds for non-nuclear purposes, such as laboratory scales, is not subject to cumulative quantities calculation and export licensing. However, export plans for the year are submitted and reviewed during the classification process, similar as the above large scale case. In this aspect, it may be possible to refer to the case of the U.S. which stipulates different standards for deuterium compounds and heavy water, and the case of Canada, controls and issues export licenses regardless of the quantity of the exporting heavy water.

## **6. Conclusions**

Each country has different export control means due to the complexity of the criteria and the difficulty of calculating the total export quantity. U.S. and Canada have applied additional measures beyond the NSG guidelines to ensure effective control. These include differentiating between the control criteria for heavy water and deuterium compounds, controlling on a per-shipment basis rather than an annual cumulative basis, and providing specific examples for non-nuclear uses.

It is clear that heavy water and deuterium compounds are subject to case-by-case review depending on their use and trading terms. However, in order to systematize the control methods in ROK, it is expected that measures such as managing the end-use, the cumulative amount calculation, and shipment or contract basis controls in other countries' approaches can be utilized as described above.

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