Safety and security measures during transportation of dangerous goods class 7 (radioactive materials), taking into account the requirements of ADN

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Abstract: *One of the main continuous processes occurring in the operation of a nuclear power plant (NPP) is the normal provision of the Nuclear Fuel Cycle (NFC). The NFC includes all activities performed with Nuclear Fuel (NF) from the time of uranium mining and includes enrichment, fabrication of fuel assemblies, transportation, operation in a reactor plant as well as processing, disposal, storage or disposal of Spent Nuclear Fuel (SNF). The storage and reprocessing or disposal of SNF is the subject of a national strategy for the use of nuclear fuel. In most versions of the nuclear fuel strategies, transport of certain quantities of SNF from the reactor to the designated storage, processing or disposal site is envisaged. This transport may range from a few hundred meters to thousands of kilometers. In practice, land and water transport are mainly used. In both cases, the transport must be carried out in strict compliance with all safety and security requirements*

KEYWORDS: NUCLEAR FACILITIES, PROTECTION OF NUCLEAR INSTALLATIONS, SPENT NUCLEAR FUEL (SNF), INTERNATIONAL CARRIAGE OF DANGEROUS GOODS BY INLAND WATERWAYS (ADN)

1. Introduction

According to the definitions in the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN), SNF is dangerous goods (radioactive material class 7), as it contains substances which are only permitted for carriage by inland waterways under certain safety conditions. Inland waterways in this case means all stretches of navigable rivers in the European Community that are used for navigation. The ADN Agreement does not apply to sea and ocean waterways used for navigation.

The European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN) [1,2] was done at Geneva on 26 May 2000 under the auspices of the United Nations Economic Commission for Europe and the Central Commission for Navigation on the Rhine. It entered into force on 29 February 2008.

The Regulations applied to the ADN contain provisions relating to dangerous substances and articles, their carriage in packages and in bulk on board inland waterway vessels or tankers, and also provisions relating to the construction and operation of these vessels.

Member States of the United Nations Economic Commission for Europe (UNECE) in whose territories inland waterways are situated (excluding coastal routes) may also become Contracting Parties to the Agreement by joining it, provided that these inland waterways form part of the network of waterways of international importance as defined by the European Agreement on Main Inland Waterways of International Importance (AGN).

2. Organizational and technical safety measures when transporting radioactive materials.

2.1. Purpose of the ADN

The purpose of the ADN agreement is to ensure the protection of people, property and the environment from the effects of radiation when transporting dangerous goods of Class 7 (containing radioactive substances). This protection is achieved by:

- sealing the radioactive contents;

- control of external radiation levels;

- prevention of a state of criticality;

- prevention of damage caused by thermal effects.

The transportation of radioactive material must be carried out in accordance with a radiation protection program, which consists of systematic prescriptions aimed at due compliance with radiation protection measures.

The nature and extent of the measures provided for in the program must be related to the degree and likelihood of radiation exposure. The following requirements form an integral part of the program:

- the individual radiation doses must be below the permissible limit;

- the individual dosimetry monitoring of workplaces and/or personnel must be appropriately documented;

The workers must undergo appropriate radiation protection training, including the precautions they need to take to limit occupational exposure of personnel and others who may be affected by their actions.

2.2. Carriage of dangerous goods

Any enterprise whose activities involve the carriage of dangerous goods by inland waterways or related activities of packing, loading, filling or unloading of dangerous goods, must appoint one or more dangerous goods transportation safety consultants whose task is to help prevent the risks, inherent in these activities, to the public, to the various types of property or to the environment. The safety consultant's duties more specifically are as follows:

- to monitor the compliance with the requirements governing the transportation of dangerous goods;

- to monitor the existence of a Security Program (Plan);

- to consult its enterprise on the transportation of dangerous goods;

- to submit to the management of the enterprise or to the local public authority an annual report on the enterprise's activities involving the transportation of dangerous goods.

This report shall be kept for five years and made available to the national authorities upon request;

- to monitor the procedures for compliance with the requirements concerning the identification of the transported dangerous goods;

- to provide appropriate training of the employees and the workers in the enterprise and the keeping of records of this training;

- to monitor the enterprise's practice, when purchasing new vehicles, of taking in to account the special requirements for transporting dangerous goods;

- to monitor the procedures for the inspection of equipment used for the transportation, loading and unloading of dangerous goods;

- to implement emergency procedures in the event of an accident and/or incident;

- to investigate and, if necessary, to report any serious accident, incident or serious violation documented during the transportation, loading or unloading of dangerous goods;

- to take appropriate measures to prevent the recurrence of accidents, incidents or serious infringements;

- to comply with the regulatory provisions and special requirements for the transportation of dangerous goods when selecting and using subcontractors or third parties;

- to check that all employees and workers involved in the transportation, loading and unloading of dangerous goods have detailed working instructions;

- to introduce measures to increase the knowledge on the risks inherent in the transportation, loading and unloading of dangerous goods;

- to introduce procedures for checking that vehicles carry the safety documentation and equipment which must accompany transport shipments and that these documents comply with the regulatory requirements;

- to monitor the availability of a security Program (Plan).

2.3. Technical measures for transportation of Spent Nuclear Fuel (SNF).

The transportation of the SNF for the VVER- 1000 type Nuclear Reactor System (NRS) is usually carried out using transport packaging containers (TPK) of the TUK-13/1B type.

According to the TPK certificate, the package identification is RUS/3014/IF-96 and the UN classification cargo designation is UN 3328 Radioactive Material, type B (U) package, fissile.

According to paragraph 2.2.7.2.4.6.2. of ADR, the content of a type B (U) package shall be as specified in the certificate of approval.

The package must not contain:

- materials with activities greater than those authorized for the package design and specified in the certificate of approval;

- radionuclides other than those authorized for the package design and specified in the certificate of approval;

- ingredients in a form or in a physical and chemical state other than those authorized for the package design and specified in the certificate of approval.

In this particular case, the TUK-13/1B package was designed for maximum activity values of $2.44.10^{17}$Bq[5], when filled with 12 spent fuel cassettes. The radioactive contents could be heat-separating spent fuel cassettes (HSSFC) from VVER-1000 reactors. The HSSFC must meet the technical conditions "Heat-separating spent fuel cassettes from nuclear power reactors VVER-1000 of Kozloduy NPP."

In the table below is given the average activity by isotopes and the total activity of 12 pcs. HSSFCs from VVER-1000 containing U^{235} over isotope enriched on average to 3.3%, after having worked over four operating campaigns and then aged about ten years in a wet storage facility [6].

The weight of the metal in an HSSFC is approximately 420 kg and its average activity is about $5.02.10^{15}$Bq [3,4].

Therefore, the total activity is less than the maximum allowable activity value for which the package is designed ($0.602.10^{17}<2.44.10^{17}$) and the radioactive material under consideration (Spent Nuclear Fuel) can be transported safely in the proposed transport package TUK-13/1B according to the requirements of ADR.

Isotope	Ratio of activity relative to the total one	Relative activity. [Bq]
Am241	$1.04.10^{-02}$	$6.24.10^{14}$
Ba137	$2.18.10^{-01}$	$1.31.10^{16}$
Ce144	$1.22.10^{-07}$	$7.35.10^{09}$
Cm244	$5.03.10^{-03}$	$3.03.10^{14}$
Cs134	$8.46.10^{-04}$	$5.09.10^{13}$
Cs137	$2.31.10^{-01}$	$1.39.10^{16}$
Eu154	$4.93.10^{-03}$	$2.97.10^{14}$
Eu155	$8.26.10^{-04}$	$4.97.10^{13}$
H3	$2.61.10^{-07}$	$1.57.10^{10}$
Kr85	$1.12.10^{-02}$	$6.77.10^{14}$
Pm147	$3.36.10^{-03}$	$2.02.10^{14}$
Pr144	$1.22.10^{-07}$	$7.35.10^{9}$
Pu238	$8.99.10^{-03}$	$5.41.10^{14}$
Pu239	$1.16.10^{-03}$	$7.00.10^{13}$
Pu240	$1.74.10^{-03}$	$1.05.10^{14}$
Pu241	$1.94.10^{-01}$	$1.17.10^{+16}$
Rh106	$3.77.10^{-06}$	$2.27.10^{11}$
Ru106	$3.77.10^{-06}$	$2.27.10^{11}$
Sb125	$2.33.10^{-04}$	$1.40.10^{13}$
Sm151	$8.77.10^{-04}$	$5.28.10^{13}$
Sr90	$1.54.10^{-01}$	$9.30.10^{15}$
Te125	$5.70.10^{-05}$	$3.43.10^{12}$
Y90	$1.54.10^{-01}$	$9.30.10^{15}$
Total activity: $6.02.10^{16}$Bq		

3. Measures to ensure transportation security

3.1. Security program (plan).

Carriers, freight forwarders and other participants in the transportation of high-risk dangerous goods (including radioactive material) are required to adopt and effectively implement security-related plans that cover at least the following elements:

- specific assignment of security-related responsibilities to persons equipped with knowledge and qualifications and having the necessary powers;

- recording and reporting of the relevant dangerous goods;

- assessment of the current operations and the resulting security risks, including stoppages and instances of the dangerous goods remaining in the transport vehicles due to the conditions of the transportation and/or the specific road conditions;

- a clear presentation of the measures to be taken to reduce security risks;

- effective and up-to-date procedures for reporting and countering threats, security breaches and other incidents;

- procedures for evaluating and verifying security plan, as well as the procedures for periodical reviews and updating of the programs;

- measures to ensure the physical protection of the transportation information contained in the security plan;

- measures to guarantee that access to the shipping information contained in the security plan is allowed only to persons who need that information.

For the purpose of exchanging information on possible threats, the carriers, consignors and consignees should cooperate with each other and be prepared to implement appropriate security measures and to respond to security threats.

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3.2. Safety measures for water transportation of SNF

Prior to the water transportation of the spent radioactive material, it is necessary to ensure:

- Documents proving the serviceability and seaworthiness of the vessel as well as of the cargo facilities of the ports involved in the transport;

- Documents indicating that the vessel is authorized to carry Class 7 cargo (radioactive materials);

- Documents indicating the capability of specific ports to handle Class 7 cargo;

- Existence of an emergency plan to deal with emergencies on board the vessel carrying class 7 radioactive materials;

- Document certifying that all crew members are familiar with the emergency plan in force;

4. Risk associated with the use of nuclear material and nuclear facilities

There are well known risks associated with the use of nuclear material and nuclear facilities. From a nuclear security perspective the two primary risks are those associated with unauthorized removal of nuclear material, for potential use in a nuclear explosive device, and with sabotage of the material and/or facility resulting in Unacceptable Radiological Consequences (URC).

The management of these risks is the primary basis for nuclear security in relation to nuclear material and nuclear facilities.

If a country has made the decision to accept nuclear material and nuclear facilities within its borders, it is also accepting the responsibility to protect those materials from unauthorized removal and the facilities and materials from sabotage resulting in a release of radionuclides.

The country's physical protection regime should be reviewed and updated regularly to reflect changes in the threat and advances made in physical protection approaches, systems, and technology, and also the introduction of new types of nuclear material and nuclear facilities.

Nuclear facilities have often been designed without giving sufficient consideration to nuclear security until late in the design stage or after operational and safety features had already been determined.

Nuclear security measures were added later, often resulting in the application of measures that were not integrated or fully compatible with measures relating to safety, safeguards, and operations.

Moreover, implementing new or additional security measures after a nuclear facility is in operation may be difficult and costly. Considering security requirements early in new designs, partial redesigns and modifications can result in nuclear security that is more efficient and effective as well as better integrated with other measures in the facility.

4. Conclusions

The carriage of Class 7 dangerous goods according to the requirements of ADN on the inland waterways of Europe is a highly responsible activity where compliance with the regulatory requirements of ADN is mandatory.

First and foremost come the technical safety measures, such as the availability of properly selected package for the transportation of the specific material, availability of a certificate of intended use and shelf life of the package and details of the design algorithm and tests carried out on the package during manufacture.

Secondly, but no less important, is the existence and the implementation of a program (plan) for security during transportation.

The development of such a program is a specific activity requiring competences in the fields of security management, public order protection, traffic control, and operational combat training and police systems organization.

A professionally prepared security program is a good prerequisite for securing the transportation on the inland waterways of Europe of Class 7 materials (according to the requirements of ADN) in normal and emergency situations related to natural disasters, malicious acts or the threat of radioactive (nuclear) terrorism.

Bibliography

[1]. United Nations. European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways – AND, Vol. 1, Geneva, 2008.
[2]. United Nations. European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways – ADN, Vol. 2, Geneva, 2008.
[3]. В.Д. Шмелев, Ю.Г. Драгунов, В.П. Денисов, Активные зоны ВВЭР для атомных электростанции, ИКЦ "Академкнига", 2004г., Москва
[4].] В.К. Резепов, Н.А. Кирилюк, В.П. Денисов, Активные зоны ВВЭР для атомных электростанции, ИКЦ "Академкнига", 2004г., Москва
[5]. Certificate-approval for packag's construction and for transportation. Transport equipment TUK-13/1B for spent nuclear fuel from VVER-1000 reactors.
[6]. Съхраняване на ядрено гориво-технология и опит. Е. Вапирев, И. Христосков