

Transport of Radioactive Materials

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Abstract

Daily, transport of radioactive materials takes place from NRG facilities to clients or to other Petten site facilities. For instance, in 2001 a total of 739 containers were transported to external clients, not including internal transports.

In the Netherlands requirements are applicable to the transport of radioactive materials. These are laid down in a number of decrees, including attachments [1,2]. One of the attachments concerns the transportation by rail or over land of dangerous goods. Since 1985 these attachments are in agreement with the ADR (**A**ccord **E**uropéen **R**elatif au **T**ransport **I**nternational des **M**archandises **D**angereuses par **R**oute) [3]. At this moment 33 European countries accepted the ADR rules.

Next, regulations with respect to transport by air are set by ICAO (**I**nternational **C**ivil **A**viation **O**rganisation).

Transport of radioactive materials is closely related to safety. The safety aspects are a main concern within NRG. To identify safety issues internal auditing as part of the Management System is an excellent tool to get a first impression of these issues. However, active participation of the management is required. Recently, an update of the NRG Management System has been carried out and two new procedures with respect to transport of radioactive materials will be implemented.

In this report a summary is given of the requirements for transport of radioactive materials from and to NRG. Since a lot of aspects are involved not all related subjects will be discussed. The Dutch situation with respect to safety requirements and training requirements of persons involved, as well as the types of containerisation, allowable radiation and contamination levels will be highlighted. In this paper no specific values are mentioned with respect to activity and contamination level, or to labelling and identification standards. They are all referred to the ADR rules. Finally, some types of containers for internal use and internal transport are discussed briefly.

1. Introduction

1.1 General

The transport of dangerous goods takes place all over the world. In the end all transport branches dealing with this kind of transport are involved. All problems encountered have to be solved worldwide. The United Nations Committee of Experts on the Transport of Dangerous Goods is the leading authority in this field. This authority is assigned to co-ordinate all economic and social activities of international organisations. They also act as a contact for other specialised agencies and other international and non-governmental organisations dealing with the transport of dangerous goods, like manufacturers, transporters, and truck builders. In Europe road transport is co-ordinated by the Economic Commission of Europe (ECE).

The problems that can arise with regard to transport of dangerous goods can be very extensive. First of all it concerns the substance itself for which a solution must be found. A small amount of dangerous good can cause danger to the public and environment. One has to consider proper packaging, stowage, the way of transport itself, necessary paperwork and procedures covering the transport. Last but not least one has to consider the various international regulations and organisations, which can influence the transport, like environmental organisations, organisations dealing with working conditions or trading associations. In short, transport of dangerous goods is a multidisciplinary activity, which is covered by national and international rules and regulations.

More and more these rules and regulations are being harmonised. In 1993 the “Working Party on the Transport of Dangerous Goods” started to re-structure the complex ADR rules. User’s friendliness and more consistency were a main objective. Other international working parties and committees were involved, resulting in the revised version of the ADR rules by July 2001. Other branches revised their rules as well and a transitional arrangement was agreed. The old ADR rules are still valid until January 2003 (with the exception of Class 7 “Radioactive Material”, which is valid till January 2002) and by this time all other revisions have to be implemented.

1.2 ADR

The ADR dated from 1957 and became internationally effective in 1968.

Transport of dangerous goods can happen by road, rail, air, seas, or inland waterway. Each branch has its own specific requirements yielding to specific rules and regulations. In Europe this is co-ordinated by the Economic Commission of Europe (ECE). Part of this commission is the Inland Transport Committee, where the "Working Party on the Transport of Dangerous Goods" is responsible for the ADR.

1.3 European Union guidelines

In the field of transport of dangerous goods the European Commission plays an important role in assigning guidelines to realise one safety level for the transport of dangerous goods between European Union countries. One of these guidelines is 94/55/EU, known as the ADR guideline. A number of clauses are part of the Netherlands' regulations.

1.4 ADR guideline

This guideline has been recently revised in July 2001. On the basis of this guideline all member states are obliged to declare the ADR rules valid for transport between member states and national transport. This leads to the following three consequences:

- The ADR is valid for all international transport of dangerous goods within the European Union.
- The ADR is valid for all national transport. For the Netherlands this also has no effect since the complete ADR rules are effective for the national transport.
- The most important effect of the ADR rule is to maintain some national agreements for transport.

In the following chapters the Netherlands' situation with respect to safety and training requirements of persons involved, as well as the types of containerisation, allowable radiation and contamination levels will be highlighted. Finally, some types of containers for internal use and internal transport are discussed in short.

2. Safety requirements

2.1 General safety care

Organisations and their personnel involved in the transport of dangerous goods have to take measures according to the nature and magnitude of the foreseeable dangers to prevent damages, and if damages occur to limit the magnitude. In any case they shall comply with the ADR rules.

The organisations involved should immediately report a possible danger for the public safety to the respective authorities and provide them with the necessary information.

2.2 Duties

a. Sender

Offered dangerous goods shall meet the requirements in conformance to ADR rules.

Particularly, the sender:

- Makes sure that the goods are classified according to ADR rules and that transportation is allowed;
- Supplies the carrier with all necessary and required information as well as all the transport documents, including permissions, certificates;
- Only uses packages which are allowed and appropriate for transport of the goods involved and completed with the prescribed identifications;
- Complies with the regulations for transportation and limitations for transport.

The sender has to take measures to guarantee that the carrier meets the ADR requirements, if the sender does not transport the goods himself.

If sender acts under third party orders, then he shall inform the sender about the nature of the goods and provide him all necessary information and documentation to comply with the regulations.

b. Carrier

The primary responsibilities of the carrier are:

- Check if the offered goods are allowed to be transported;
- Make sure that the prescribed documents are included;
- Check by visual inspection that the truck and freight show no defects, no leakage or cracks and no relevant equipment is missing;
- Make sure that certification of equipment is still valid;
- Check that the truck is not overloaded;
- Make sure that all necessary identifications are fitted;
- Make sure that all personal protective equipment as mentioned in the driver's instruction, is present and ready for use. In some cases this is part of the transportation documents.

If the carrier notices that violation of the rules has taken place transportation shall be stopped until the requirements are met.

If during a transport a violation is observed, which possibly can lead to a reduction of safety, then the transport shall be detained with regard of the traffic regulations and public safety. The authorities responsible for the remaining route can approve continuation.

c. Receiver

At delivery of the goods the receiver has to verify and unload the freight as soon as possible as well as to check if all is in accordance with the ADR rules.

Next, the receiver has:

- If necessary, according to ADR rules, to clean and decontaminate the container and the truck;
- To take care that the unloaded, decontaminated and degassed container is free from any danger indications.

If the receiver makes use of other services (unloader, cleaner, or Decontamination Company) the receiver has to take appropriate measures to guarantee that the ADR rules are observed.

If during these checks a violation of the ADR rules is noticed, the receiver may not release the container until it complies with the rules.

3. Types of packages

Containers can be distinguished between containers for transport of radioactive materials and transport of fuel. With radioactive materials there is a risk for radiation of persons during transport and handling as well as a risk when the containment is damaged.

A possible risk during transportation of fuel is the chance of a chain reaction if the fuel comes into contact with sufficient water.

The requirements for containers are very stringent and dependent of the dangers connected to transport conditions. The following distinctions can be made:

- Normal transport conditions (without any incidents);
- Transport conditions with expected minor incidents;
- Conditions whereby accidents can occur during transport.

The types of containers for radioactive materials with increasing degree of allowable activities are:

- Exempted package

This is a container in which instruments, objects or substances with a limited amount of activity. The specifications are in conformance to ADR rules.

- Industrial package

This package is for objects with a Low Specific Activity (LSA) or Surface Contaminated Objects (SCO), which meets the ADR requirements. Three sub divisions can be distinguished, type 1, 2, and 3 (or IP-1, IP-2, and IP-3), each with increasing design and performance requirements.

- Container type A

This container can contain material of which the activity level is between A_1 and A_2 , depending on the specific condition of the material. A_1 and A_2 are defined as the boundary value of activity level (TBq) of radioactive material in a special condition or with the exception of material in a special condition

respectively, as incorporated in the ADR rules, and is used to determine the boundary values of the activity. In table 1 a number of A₁ and A₂ values are given for some elements.

- Container type B
This container can contain material of which the activity level can be higher than A₁ or A₂. A certificate limits the nature and amount of activity.
- Container type C
This type of container is specially designed to transport highly active material (>(3 x 10³) A₁ to (1 x 10⁵) A₂ by air.

table 1 A₁ and A₂ boundary values for some elements

Radio nuclide (Atomic number)	A ₁ value (TBq)	A ₂ value (TBq)
Al-26	1 x 10 ⁻¹	1 x 10 ⁻¹
Be-10	4 x 10 ¹	6 x 10 ⁻¹
C-14	4 x 10 ¹	3 x 10 ⁰
Co-60	4 x 10 ⁻¹	4 x 10 ⁻¹
Cr-51	3 x 10 ¹	3 x 10 ¹
Cs-134	7 x 10 ⁻¹	7 x 10 ⁻¹
Fe-59	9 x 10 ⁻¹	9 x 10 ⁻¹
I-131	3 x 10 ⁰	7 x 10 ⁻¹
Ir-192	1 x 10 ⁰	6 x 10 ⁻¹
Mn-54	1 x 10 ⁰	1 x 10 ⁰
Ni-63	4 x 10 ¹	3 x 10 ¹

4. Training requirements

For Class 7 ("Radioactive Materials") personnel shall have appropriate training with regard to radiation dangers as well as to take precautionary measures to limit their exposure and others. In table 2 the training requirements for drivers transporting Class 7 material is given.

table 2 Training requirements for drivers

Exempted packages			
LSA / SCO		General ADR certificate ¹⁾	Specialised training Class 7 ²⁾
Type A	No Fission Material < 10 containers and sum transport index (TI)<3 ⁴⁾	Appropriate ³⁾ training and instruction ³⁾	
	No Fission Material >10 containers or sum TI>3	General ADR certificate ¹⁾	
Type B		General ADR certificate ¹⁾	

^{1), 2)} Mandatory revision course every 5 years

³⁾ Employer shall demonstrate a certificate

⁴⁾ TI = Transportation Index; see paragraph 5.2

5. Allowable radiation and contamination levels

5.1 Dose rate

In table 3 the ADR requirements with respect to the maximum allowable dose rate (mSv/h) are given.

table 3 Allowable dose rate (mSv/h) according to ADR

			Surface mSv/h	1 meter mSv/h	2 meter mSv/h
Exempted packages		Package	0.005	-	-
Other packages	Normal use	Package	2	0.1	-
		Truck	2	-	0.1
	Exclusive use ¹	Package	10	-	-
		Truck	2	-	0.1

¹ Exclusive use means *that the receiving side is notified of the transport in advance and measures are taken to accommodate the package immediately upon arrival.*

5.2 Transport index

The transport index (TI) for a package, container, or unpacked LSA or SCO goods, is the figure which is derived according to the ADR rules using the following method:

- Determine the highest radiation level in mSv/h at a distance of 1 meter from the outer surfaces of the package, the container or unpacked LSA or SCO goods. The measured value is multiplied by 100, resulting in the transport index.
- The value obtained from a) has to be rounded up to one decimal point, except if the value is lower than or equal to 0.05.

The transport index for packages, containers, or trucks is determined by adding the TI's of all present packages or to measure the radiation level directly.

5.3 Contamination level

In conformance with the ADR rules the non-fixed contamination at the outer surfaces of each package has to be as low as possible and may not exceed under normal transport conditions the following values:

- 0.4 Bq/cm² for all other alpha emitters,
- 4 Bq/cm² for beta and gamma emitters, and alpha emitters of limited toxicity;

6. Internal transports at Petten site

6.1 Regulations

At the Petten site 4 companies are situated, ECN, JRC, NRG, and TYCO. In general, if a transport container has been certified following ADR requirements, the ADR directives are applicable and must be followed. This pertains to all classes of containers and or packaging.

The ADR prescribes tests on packaging that must be passed successfully. These tests are designed such that specific classes of accidents do not lead to unacceptable high radiation fields or leakage of radioactive material. The tests and class of accidents depend on the kind and quantity of radioactive materials. It is obvious that on the Petten site certain accidents are impossible like a collision with a train or falling from a bridge. Since the distance to be traversed and the speed of transport is limited the probability of accidents is reduced considerably.

The ADR rules are **not** applicable to internal transports over the company's area and to and from JRC or TYCO. Yet, the rules are applied as much as possible. However, a number of agreements are adjusted with respect to the use of not-ADR-certified containers (such as Graviner, Tonolli, WI, and WII), contamination standards, labelling of packages and transport documents.

Therefore, conditions and agreements between all the parties involved are laid down in a document "Transport Regulations for the Petten site" [4,5]. Requirements for the use of a transport container within the Petten site are as follows:

- The container must be on the list of admitted containers (table 4);
- The container may only be used for the purpose mentioned on this list;
- The responsibility for the correct procedure lies with the senders side;
- The ADR rules are applicable for the certified containers, with the exception of labelling and transport documents;
- The sender is responsible for the procedure;
- The dose rate (refers to effective dose as defined in ICRP-60) at the surface is lower than 2mSv/h. For "exclusive" transport this limit may be raised to 10 mSv/h;
- The dose rate at 1 m is lower than 0.1 mSv/h (for exclusive use 1 mSv/h);
- The dose rate for the driver shall be less than 0.02 mSv/h;
- Representative wipe tests (over 300 cm²) at the outer side of the package may not be higher than 0,4 Bq/cm² for α emitters and 4 Bq/cm² for α and γ emitters;
- The transport is accompanied by the following documents:
 - General Transport Document;
 - Request for Radioactive Waste Disposal or Treatment;
 - Request for Decontamination.

Any of the above mentioned regulations may be overruled by a specific exemption granted in writing by the Radiation Protection Officer of the sender and receiver on special request. The list of containers satisfying the Transport Regulations for the Petten site is shown in table 4.

table 4 List of transport containers satisfying the Transport Regulations for the Petten site

Name	Number	Useful space (mm)		Lead thickness (mm)	Weight (kg)	Purpose	Owner(s)
		length	diam.				
Tonolli	1	2150	160	275	14235	Experiments / capsules	NRG
Graviner	1	1037	124	150	2789	Experiments / capsules	NRG
Graviner	1	585	124	150	2040	Experiments / capsules	NRG
Waste container	4	856	292	200	5675	Waste transport	1 and 4 NRG / 2 and 3 JRC
Container	3	155	75	50	85	Multi purpose	NRG
STEK container	1	447	160	180	2220	Steel transports	NRG
Container	2	298	298	100	1424	Multi purpose	NRG
Container	2	298	196	150	1574	Multi purpose	NRG
Container	2	298	98	200	1642	Multi purpose	NRG
Container	1	860	630	90	4500	Multi purpose	NRG
Ilonka	1	2450	235	250	15000	Longer syntacs	JRC
Goslar container	1	856	235	300	12410	U-residue (Mo prod.)	TYCO
P-container	6	700	235	220	4800	Storage	NRG
Lemair	2	160	100	150	605	Multi purpose	NRG
Lemair	2	150	75	110	280	Multi purpose	NRG
Lemair	3	75	32	50	32	Multi purpose	NRG
Lemair	2	130	30	100	150	Multi purpose	NRG
Lemair	1	100	30	75	80	Multi purpose	NRG
Lemair	1	155	75	100	250	Multi purpose	NRG
Lemair	1	330	100	90	300	Multi purpose	NRG
KfK	1				4340	Waste (Mo prod. / research lab HCL)	TYCO
Petten	1				±350	General bulk quantities	NRG
Sample Container	1				<20	Samples ⁹⁹ Mo	TYCO
Rb / Kr	1				±150	Rb / Kr bulk	TYCO

6.2 Containers used at the Petten site

As can be seen from table 4, NRG, and more specific the Hot Cell Laboratories (HCL), can handle 24 types of containers. The dimensions of the containers vary from 75 mm to more than 2 meters in length and from 30 to nearly 300 mm in inner diameter. This also accounts for the weight of which the heaviest is 15 tons (Ilonka container). The enlisted containers are used for internal transports only. Some of these containers are used for special purposes, like the ones used by TYCO. Most of the containers are multi purpose. The choice of a container depends on the material to be transported. This can vary for example from solids to fluids or gaseous to non-gaseous materials. The maximum load and related contamination is equivalent to a dose rate at the surface of 2 mSv/h or less than 0.1 mSv/h at 1 m. This dose rate is based on a ^{60}Co source. However, for exclusive transports the dose rate might be higher but must never exceed 10 mSv/h and 1 mSv/h at 1 meter respectively. In these cases the receiver has to be notified of the deviating transport and has to accept it. In figures 1 to 5 some of the Petten site containers are shown. Some specific characteristics of these containers are given hereafter.

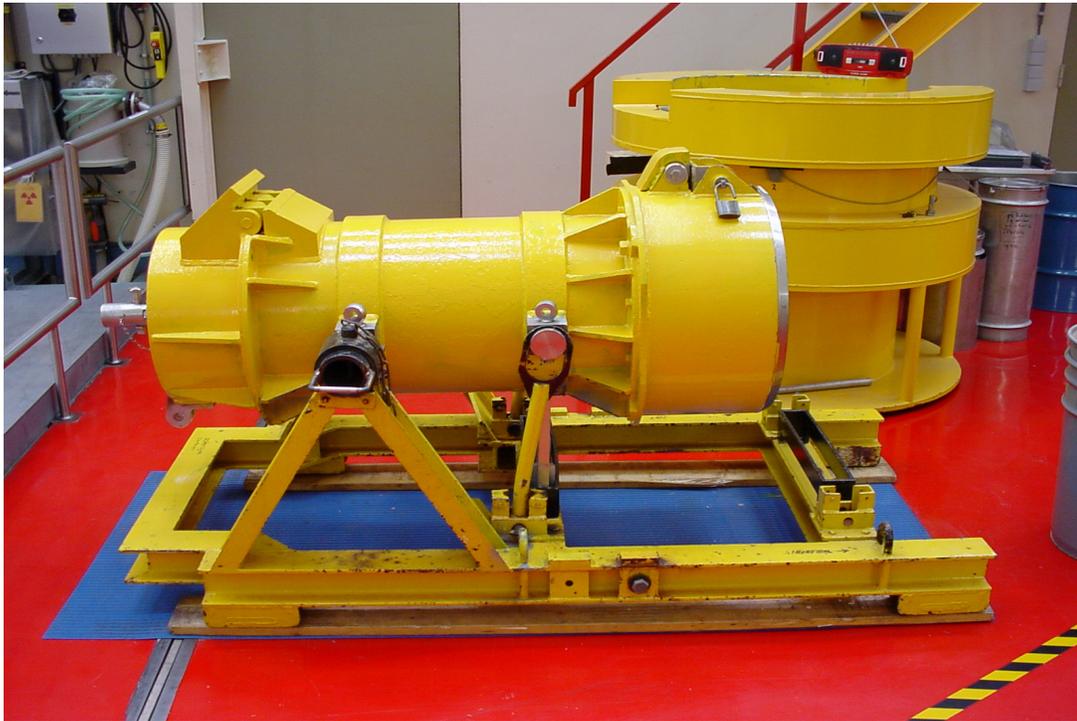


figure 1 Graviner container

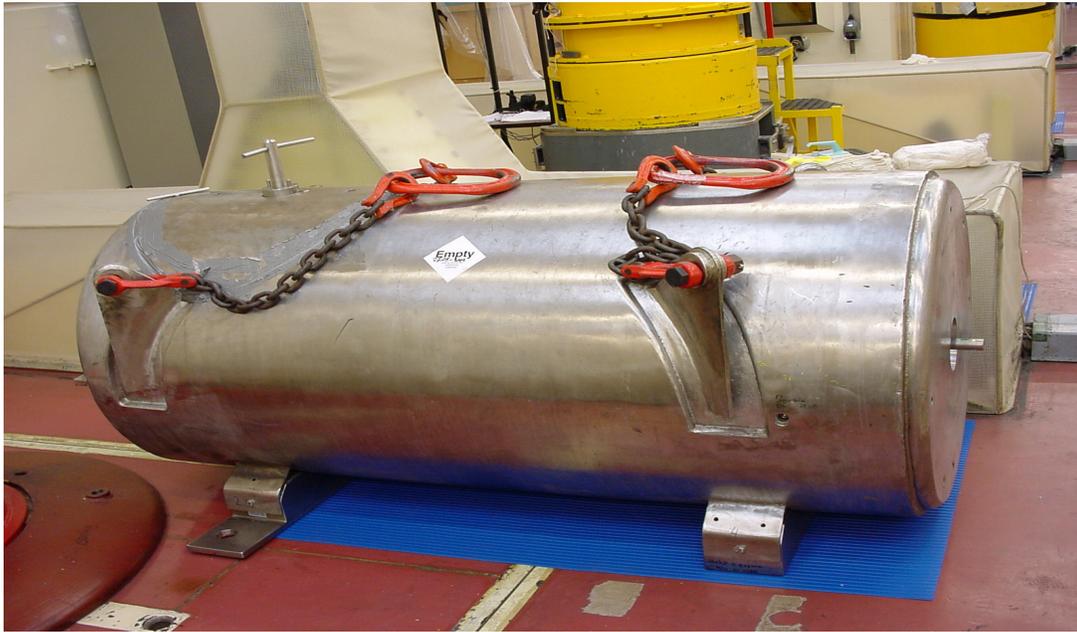


figure 2 Goslar container used for transport of U-residue from the Molybdenum production facility

The Gravier container

This container always needs a hoisting mechanism, because it has no own support. The middle part of the container can be extended. It is suitable for loading and unloading under water and the water drainage is done automatically by a labyrinth construction. Inside the container a shovel is available if loading is done outside the water, like the loading of isotope cans. It is provided with a vertically sliding shutter. Transports from and to the HFR are mostly done with this container.

The Goslar container

A "gastight" (Syntax 210) can, including a clamping device is a typical load for this container. During unloading in the cell the underpressure is maintained. Loading and unloading can only be done in a horizontal position. A ball valve is used as a shutter.

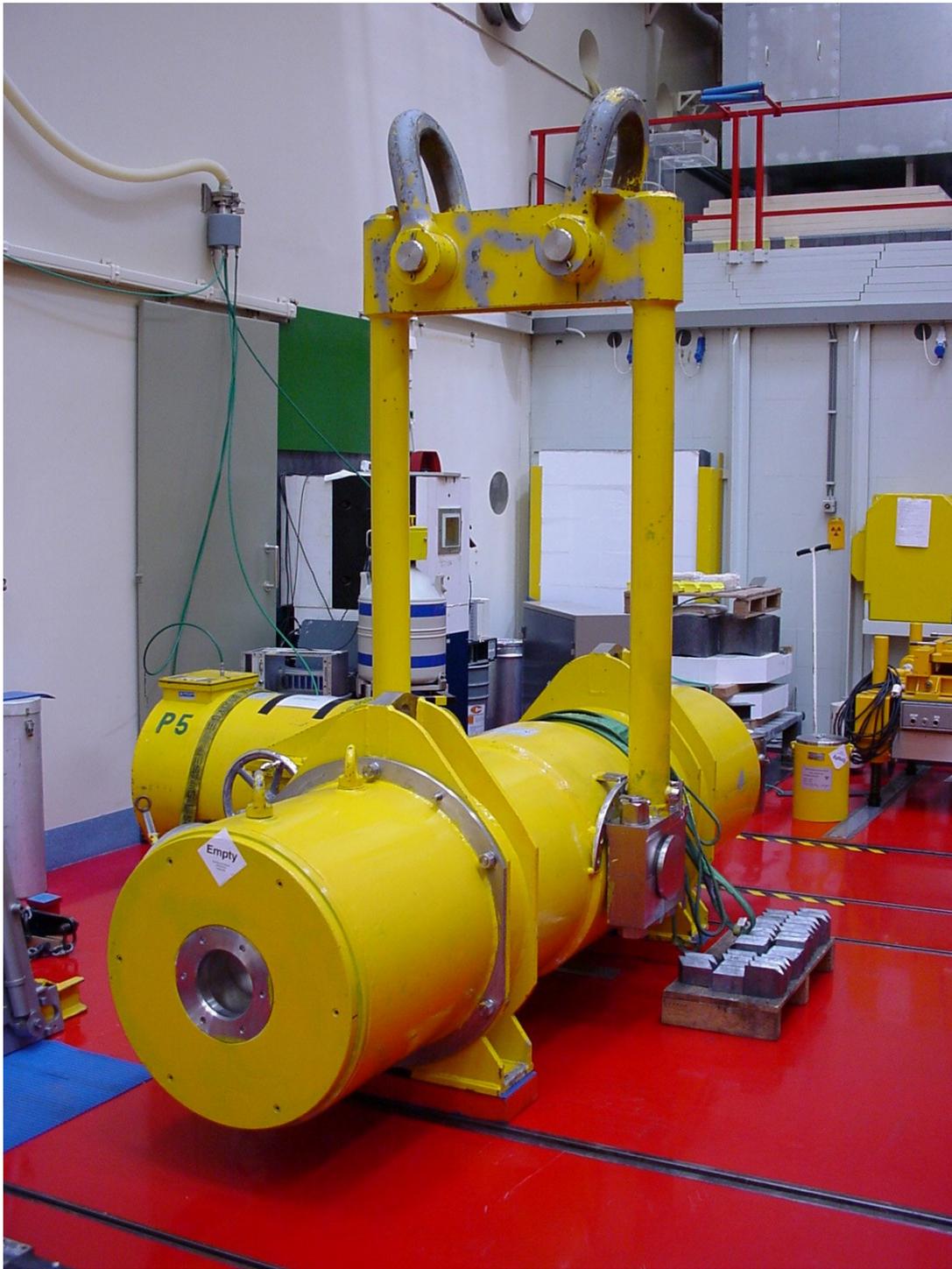


figure 3 Tonolli container to transport irradiation capsules from HFR to HCL



figure 4 JRC solid waste container

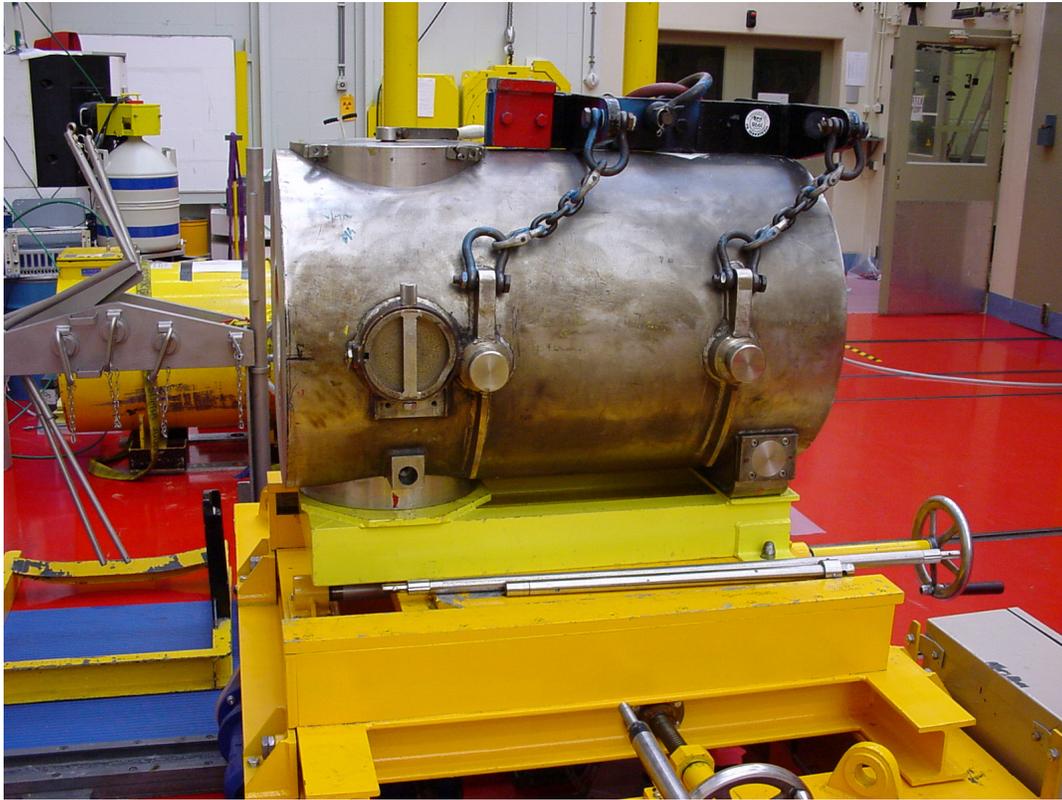


figure 5 STEK container for internal laboratory transports of steel samples from highly active to medium active hot cells

The Tonolli container

This container is suitable for loading and unloading under water. Loading and unloading can be done at a certain angle. It has a hoisting mechanism, which can be lowered down. A drain plug is used to drain the container. The shutter is of the cylindrical type with a horizontal hole.

The JRC solid waste container

This container is only suitable for vertical loading or unloading and it is equipped with a manual hoisting mechanism. Besides the hoisting mechanism, also a grabber and a vacuum nap are available. It is mostly used to transport vessels. The horizontal shutter consists of two sliding halves, which are moved and locked manually.

The STEK container

Interlaboratory transports of steel samples from the high active to the medium active hot cells are done with this container. It has its own hoisting mechanism, so that loading and unloading can be performed either horizontally or vertically. Inside the container a lockable can is available. The shutter is of the cylindrical type.

7. Conclusions

The transport of dangerous goods is a multidisciplinary activity, which is covered by international rules and regulations. Although these rules and regulations were harmonised recently the ADR is still complex, since a great number of parties are involved.

The old ADR rules are still valid until January 2003 (with the exception of Class 7 "Radioactive Material", which is valid till January 2002) and by this time all other revisions have to be implemented.

Transport of radioactive materials is a daily activity at the Petten site ever since the institute is dealing with nuclear research. These transports are closely related to safety, which is a main concern of the NRG Management. The active participation of the management resulted in the implementation of procedures regarding this subject as part of the Integrated Management System.

Experiences at NRG have learned that the ADR has been well implemented. Part of the implementation is to organise and provide training to all personnel involved.

In 2000 a total of 691 containers were transported, which increased to 739 containers in 2001. During the transports in 2000 only 5 ADR non-conformances were registered from **external** transports. Two of them had an administrative nature, such as a missing copy of the transport license, or not having a Dutch identification label. The others concern improper dose values on the documents or wrong storage of the goods. An overview for 2001 is not available yet.

In the last 5 years non-conformances with regard to **internal** transports of radioactive materials were not registered.

8. References

- [1] Regulations for the Safe Transport of Radioactive Material, 1996 Edition (revised) IAEA Safety Standards Series No. TS-R-1 (ST-1, Revised) Vienna, 2000.
- [2] Nederlandse Vereniging voor Stralingshygiëne (NVS) "Aanvulling bij NVS-Publicatie nr. 26 "Het Vervoer van Radioactieve Stoffen over de Weg in Nederland" (in Dutch).
- [3] Accord Europeen Relatif au Transport des Marchandises Dangereuses par Route (ADR).
- [4] A.S. Keveling Buisman "Transport Regulations for the Petten site", NRG Report 99.30576, 3 January 2000.
- [5] J.M. Lutgerink "Transporten met Radioactief Materiaal", NRG Report 02.47513/I, 1 September 2002.