The BG18, a B(U)F type package used for the transport of irradiated fuel rods Return of experience

Sperlich Jürgen, Sannen Herman

Transnubel, Dessel, Belgium

1. Introduction

The purpose of this presentation is to share the return of experience of Transnubel after a period of nearly 3 years operation of the BG18 package in several nuclear power plants and hot cell facilities.
This package has been used mainly for the shipment of full scale as well as samples of irradiated fuel rods – UOX or MOX, PWR or BWR.

2. Historical review

The BG18 has been built in the beginning of the 1980's by "Goslar Bleiwerke" at the demand of the SCK-CEN. The package has been used a first time in 1984 in Belgium (Tihange1 NPP to SCK-CEN)

After about 15 years of sleeping period of the package, TNB and SCK-CEN decided to put it again in activity. Some improvements have been integrated on the package and its tooling. A revised safety file has been elaborated on this basis and presented by TNB to the German licensing authorities.

The package has been put again in service in the beginning of 2002.

3. Short description of the package BG18 and of its operation

The BG 18 transport package has a cylindrical form and is equipped with a steel/lead/steel double envelope and with a 225 mm thick lead shielding in all directions. In the body cylindrical zone the package has a 15 mm thick thermal isolation layer embedded in a supplementary steel envelope.

The cavity is shielded and closed axially, in the front side by a turning lock and on the rear side by a massive plug equipped with an embedded draining spiral pipe. Each side is foreseen with a closure tight lid.

The containment system is formed by a tube of large thickness with a welded bottom. It is closed with a tight bolted lid at the front side and a tight plug at the bottom side.

The transport package BG 18 is equipped with a rear side and a front side shock absorber, which belong to the package.
The package is shipped on a steel transport frame, which also serves for the tilting to the vertical position of the package around the pair of trunnions located on the rear side of the body. Two pairs of trunnions can be fixed on the front side of the body and used for the handling of the package with the help of lifting beams.
The main dimensions and masses are given on figure 1 here under.

The particularity of this package is the inner containment system, called "dichte Umschliessung" which makes the conditioning different in comparison with single cavity packages. The advantage of the double containment barrier is not negligible.
The lower plug of the containment system is operated through the orifice tooling to be mounted on the rear side.
The upper lid of the containment is operated with the help of a shielded block installed on the package head. This equipment is provided with a grip for the lid and with 4 keys for the fixation bolts. The mounting/dismounting of the lid when the package is loaded occurs thus blindly.

The package can be loaded / unloaded:

- Vertically in a pool – in wet condition
- Horizontally when docked against a hot cell – in dry condition.

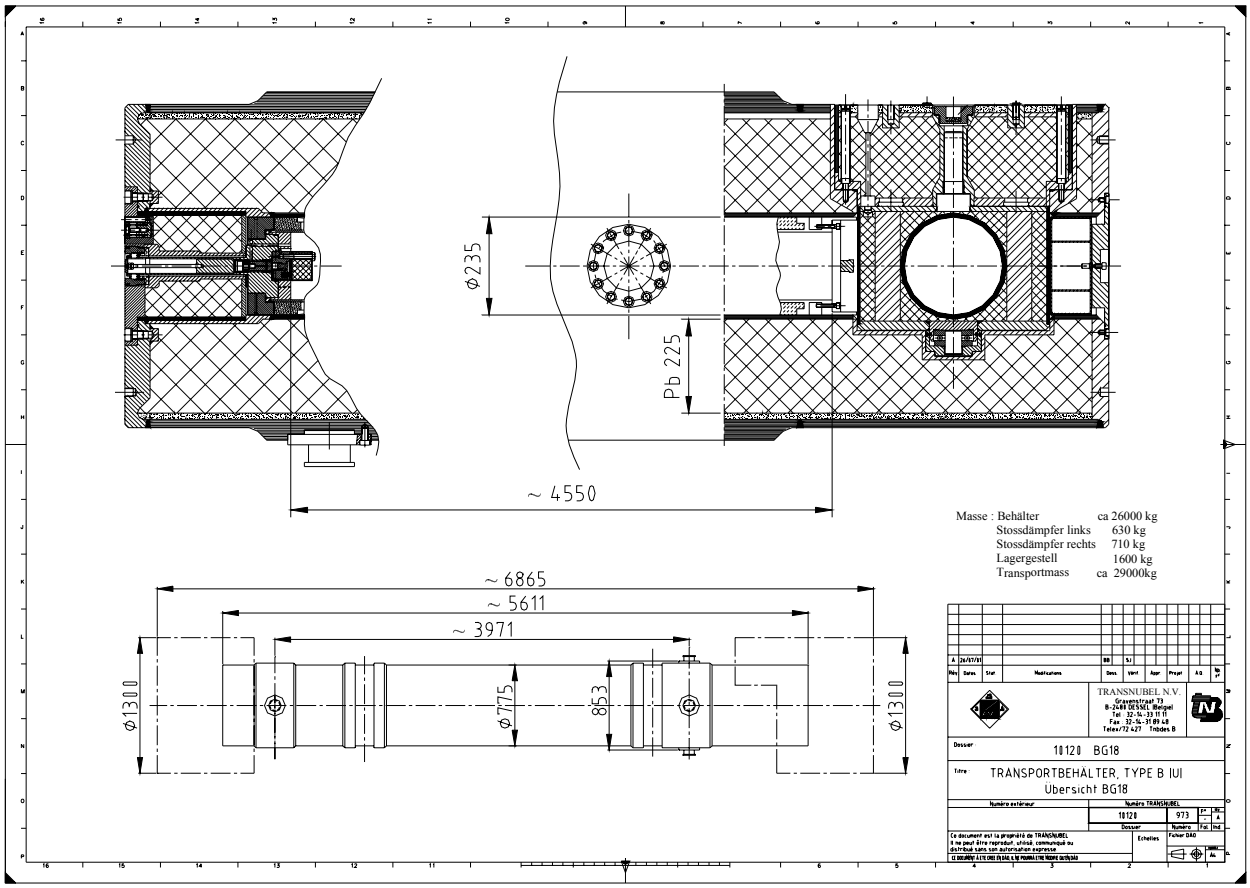


Fig. 1: BG-18 package overview

4. Agreement and validations

The German approval certificate in accordance to the IAEA regulations 1985 (As amended 1990) has been delivered in august 2001 with a validity period of 3 years.
A validation certificate has been obtained in other European countries where the use of the package was foreseen.
A request for prolongation of the German agreement has been introduced by TNB beginning of 2004.

5. Applications

The BG18 has been used for several shipments between nuclear power plants and hot cell laboratories or inversely as well as between hot cell laboratories:

- from the Gundremmingen NPP (D) to the SCK-CEN (B) hot cells
- from the Tihange 1 NPP (B) to the SCK-CEN hot cells
- from the Neckarwestheim (D) NPP to the SCK-CEN hot cells
- from the SCK-CEN hot cells to the Studsvik (S) hot cells
- from the SCK-CEN hot cells to the ITU (D) hot cells
- between the Gösgen NPP (CH) and the PSI (CH) hot cells
- between the PSI hot cells and the SCK-CEN hot cells
- from the ITU hot cells to the Gundremmingen NPP

The table 1 in appendix gives the main technical features of the performed shipments.

6. Return of experience

6.1. Transport administrative aspect

Each shipment of irradiated fuel rods or samples requires an important preparation work which has to be started several months before the foreseen transport date.
Among the numerous documents which have to be prepared or to be available in order to make the transport possible we can point out:

- pro-forma bill to be established by the sender
- end user statement to be established by the consignee
- declaration of acceptance of the goods by the consignee
- import, transit, export licenses in case of international transport
- insurances : nuclear liability insurance and loss and damage insurance for cargo and package
- transport licenses to be obtained from the competent authorities in each country concerned by the transport
- heavy load permit if necessary

Taking into account the rather long delay necessary for some documents and the number of interveners involved in this process, the success of a shipment depends very much from the organization and the narrow follow up assured by the company in charge of the organisation of the transport.

We can mention that for most of the realized shipments the documents were available just in time. It is also to be noted that a few shipments had to be postponed some weeks until all documents were available.

6.2. Transport technical aspect

Since the start of the activities a dedicated lorry and a dedicated support frame for the BG18 have been put into service. The reproducible tie-down system composed of 4 tender chains placed between the twist-lock devices of the lorry and the fixation points on the transport frame fulfils the IAEA requirements concerning packages stowage.

During the shipment the whole package and transport frame lies in a so called drip pan and is covered by a tarpaulin. This latter is designed and fixed in such a way to collect in the drip pan any possible condensation or sweat water.

The accessories necessary for the handling and for the conditioning of the package are transported in stainless steel boxes under UN2910, i.e. limited quantities of radioactive material in excepted package.
These boxes can be handled by means of an overhead crane or by means of a lift truck.
Among the main accessories we can enumerate:

- the support plate for the package in vertical position
- the lifting beam with pairs of lifting arms of different lengths
- the shielded block for the head of the package
- the drying and test module with the flexible hoses
- the orifice tooling

Much care is taken to avoid or to eliminate any contamination of the outer surfaces of the package with respect to the applicable IAEA regulations.
For all the shipment performed up to now no contamination of the conveyances used for the BG18 and for the accessories has been measured.
The same care is taken to clean as far as possible after use all the metallic accessories and in particular those having been in contact with the package and with the water of the loading pond.
The drying module equipped with a filter and the related connection hoses are more difficult to be maintained clean.
But in case of necessity the contaminated element which lead to higher dose rates than those acceptable (5 µSv/h at contact with the transport boxes) are replaced or shielded.

6.3. Handling in Nuclear Power Plant

6.3.1. Basically conditions

1) A practice generally applied for containers intended to be handled inside the controlled area of a NPP for loading/unloading operations is that cold tests must be performed with satisfaction prior to any application in that NPP.

This requirement of cold testing is quite comprehensive and is motivated by the safety. It is a repetition allowing the control that all the necessary handling steps and operations are feasible and a demonstration that a safe situation is maintained during the whole process or can be achieved in case of anomalies. For example, after a loading operation it must be possible to unload the content if necessary.

Before the first use of the package in a NPP, which was also the first application of the package, the cold tests have revealed some mechanical difficulties; we resume here after the three major difficulties encountered:

- Leak at the area of the bottom shielded plug

The leak has been observed after transfer in the loading pool of the package in vertical position and the transfer back in horizontal position on the support frame, during the drying process.
The investigation showed that the plug was not tightened to block on its shoulder and the metallic gasket between the plug and the seat was thus leaking.
The gasket has been replaced and the correct assembling of the plug has been guaranteed through tightening of the fixation bolts with predefined controlled torque.
After that intervention, no more difficulty has appeared after nearly 3 years of operation.

- Blocking of the turning lock

The turning lock is operated under water with the help of cords attached to the key of the lock. After an opening of the turning lock it was no more possible to close it manually with these cords.

The investigation showed that the end stop pin on the fix body was blocked at the extremity of the circular groove in the mobile drum with a slight overrun. The turning lock has been dismounted in order to repair. Damages due to the impacts of the end stop pin have been observed. It could also be concluded that the height of the pin was not optimal.
After the replacement of the damaged pin by a new one with optimal dimension and validation tests, a blocking of the turning lock never occurred again since.

- Mounting the lid of the inner containment

During the cold tests this operation took too much time and too much hesitations and it was judged unacceptable on an ALARA point of view. The improvement of the working method and a sufficient training of the operators led to a better control.

We can consider that these non repetitive difficulties are related to “youth illness” or initial fabrication defect or due to a long period of inactivity. We add also that since that time the operation of the package has become more and more familiar and controlled by the operators so that the risks of malfunction is minimized.

2) Another important condition is that the handling accessories such as lifting beam for the package, handling tool for the basket and the basket grip must be approved according to the requirements of the site or of the related competent authority; in the case of Germany for instance it implies that these equipment must be in accordance with the safety rules of the KTA (Kerntechnischer Ausschuss)
The supply of such equipment has to be planed early enough as the whole process of design, manufacturing and testing of the equipment requires the approval of the competent authorities.

6.3.2. Handling of the package in NPP

The NPP are designed and equipped in order to insure the evacuation of spent fuel.
So in the case of specific packages like the BG18 one has to follow the available handling itineraries and to interface with the existing handling equipment such as cranes and carriages.
The kinematics of the handling must be studied in detail for each site. This study belongs to the preparation works starting with a detailed visit to the site and discussion meetings with responsible of the plant operation.
In particular the handling interfaces and the required space for the movements of the material must be examined with the greatest attention.

For the conditioning of the package (ventilation, drying, testing), the necessary electrical and fluids connections must be foreseen.
Detailed working instructions are written for each application and submitted to the approval of the site and eventually of competent authorities. The measures foreseen regarding the radioprotection are defined along the whole process.

Following specific aspects of the handling are highlighted:

- Transfer of the package to the area of the loading pond

The different handling steps of the package starting from the lorry up to the preparation area prior to go into the pond are to be analysed in detail case par case in function of the environment specific to each NPP.
The lifting beam of the BG18 can be easily adapted according to the hook size of the crane (between 40 and 100 tons capacity) and is submersible as it is a full stainless steel construction.

- Transfer of the package in the loading/unloading pond

According to the site the hook of the crane may or may not be submerged; if not the lifting arms of the BG18 lifting beam must be long enough and the use of prolongation arms may be required. Due to the weight of such components their assembling and the needed handling means and place must be well defined.

- Handling of the basket

The basket is a light structure designed for the holding and spacing of the shipped fuel rods. A grip is foreseen at the upper end for the hooking with the handling tool.
According to the height of water in the pond, the height of the BG18 standing on the bottom of the pond, the height of the basket and the max handling height of the crane hook used in the plant, a handling tool with a well defined length has to be assembled. Indeed, a main safety concern during the handling in the pond of the basket containing irradiated fuel rods is to guarantee at any moment a minimum of water shielding above the rods.

6.4. Handling in hot cell laboratories

The family of packages able to forward full scale irradiated fuel rods, thus rather long and heavy packages, and to which the BG18 belongs can be accepted by most of the hot cell facilities. It may however represent the upper limit regarding the handling capacity and the required space for manoeuvring.

The main heavy handling operation is the transfer of the package from its transport lorry to the carriage used for the docking against the hot cell wall.
In most of the case something must be foreseen on the carriage in order to adapt the level of the package axis so that it fits exactly the level of the loading channel axis.
Indeed the inner containment of the BG18 has to be pushed partly inside the hot cell through this channel; due to the generally limited existing gap a quasi perfect alignment is required.

The lid of the inner containment can be removed inside the hot cell or outside the hot cell (using the shielded device) which is the most used solution.

A partial extraction of the basket outside the containment system is necessary in order to see and to have access to the fuel rods or samples to be unloaded. The same is also valid for the loading of the fuel rods or samples into the basket.
The containment displacements in both directions are performed by means of the package orifice tooling and the pushing bars system.
The basket displacements in the hot cell are performed by means of the available tooling such as remote manipulator or a crane.

The use of the package in hot cell facilities takes less time in comparison with the loading in pool because there are nor drying neither dryness control to be performed and because the handling ways are shorter.
No major difficulties occurred during the different applications of the package in the four hot cell facilities visited up to now.

6.5. Dose rates on package and conveyance

Due to its design the BG18 package is particularly well shielded against gamma radiations.
The calculation made in the frame of the safety file elaboration, with the allowable foreseen contents, showed that the greatest amount (> 95 %) of the dose rates is due to the neutrons. This feature is confirmed with abundance by the dose rates measurements performed during the shipments.

The BG18 package was not specially designed for strong neutron sources.
No neutron shielding material is present, except the 15 mm thick layer of thermal insulation at the periphery of the envelope, which participates slightly as neutron shielding.
The limit for the neutron source strength is fixed to 1.E+8 n/s in the agreement certificate, taking into account some conservatism as it is usual.

The regulatory dose rate limit in transport at 2 m distance from the vehicle is 100 µSv/h. This limit can be considered as the most restrictive one in comparison with the dose rate limit in contact with the vehicle (2000 µSv/h), the limit in contact with the package (2000 µSv/h or 10000 µSv/h under exclusive use) and the limit at 1m distance from the package (100 µSv/h or 500 µSv/h under exclusive use)
This is confirmed by the chart n° 1 in appendix where the results of measurements available for some representative transport have been grouped.
The chart n° 2 in appendix gives the linear regression between the neutron source strength and the dose rate measured at 2m from the vehicle for the concerned shipments.
We can see that there exists some margin with regard to the limitation of the content. The conservatism or the safety margins taken in the calculations are obvious.
On a proportional basis the allowable limit of neutron source strength could theoretically be increased by at least 50%, i.e. 1.5E+8 n/s instead of 1E+8 n/s.

6.6. Contamination control

Due to its use in nuclear power plants, in particular the immersion of the package in the loading pond and the transfer of the basket in areas where irradiated fuel are stored, a contamination of the surfaces of the package is practically unavoidable. Before immersion the most sensible areas of the outer surface of the package, such as tapped holes or grooves, can be protected by coating them with tight adhesive band.

The outer accessible surfaces of the package can more or less easily be decontaminated up to the criteria applicable for transport before leaving the site. The accessible surfaces of the package are the object of many control points by wipe test. The results of measurements are duly recorded by the sender as well as by the receiver.

It is of course not possible to avoid a contamination of the inner surfaces of the package, such as the cavity wall, the inner containment or the basket which are not accessible after loading. Those surfaces can only be inspected and decontaminated, if deemed necessary, after unloading of the content.
That aspect is an important point to be taken into account when establishing the cost of such transports. Indeed the shipper may not be held for responsible for the contamination of the package by the content and by the related handlings performed in the installations of the sender. In any case the costs of any necessary decontamination operations may not be supported by the shipper.

The contamination question concerns also the handling equipment and tooling but is less critical way.
Moreover the use of dedicated packaging boxes for their transport allows limited quantities of contamination to be present.
One sensible point which can be mentioned is the higher risk of contamination for the support plate of the package which comes into contact with the pool bottom surface. This risk can be minimized through the use, when it is possible, of a protection plate between the support plate and the pool floor.

It seems obvious that the use of the package in hot laboratories is less critical than the use in NPP. It necessitates however that care has to be taken, when connecting to the hot cell, to insure a connection of the package cavity to the ventilation system.

7. Maintenance

The regulatory maintenance of the package and of the handling equipment is performed according to the applicable rules, as defined in the safety file for what concerns the package itself and according to the KTA rules for what concerns the classified handling tools.
An important point to be noted is that the maintenance in good condition of the package is performed through the many controls and inspections made before and during each use of the package, such as the visual examination of the closure and fixation elements (bolts, lids, stops…), of the O-rings and of the tightness surfaces.

8. "Upgrade" of the package or conveyance

The trend is an increased need of the fuel vendors to ship fuel samples with higher burn up or enrichment and short cooling times. This means in fact that the contents have higher neutron source strengths, particularly for the MOX fuel.
On another side the wish to forward so much fuel rods as possible per shipment in order to reduce the number of shipments and, consequently also the cost of the investigation programmes seems legitimate.

In order to increase the capacity of the BG18 regarding the neutrons, two kinds of modifications could be envisaged:

- to add a neutron shielding/absorbing system inside the package itself
- to add a neutron shielding/absorbing system on the lorry around the package during the transport

The first solution is probably more restrictive because the addition of such a system should be justified with regard to the safety criteria applicable to the package, such as thermal behaviour, mechanical behaviour, criticality safety, but the positive result would be that no additional doses would be induced to the operators.
The second solution has the great advantage to leave the package unmodified for an equivalent result regarding the dose rate during transport. On the other hand, the dose rates directly around the package are higher. The operation of the package should be optimized in order to maintain the ALARA condition for the operators.
So we can imagine a reduction of the dose rate at 2m distance from the conveyance if we foresee an adequate shielding on the transport lorry. The advantage is to allow the transport of more fuel rods in on time.

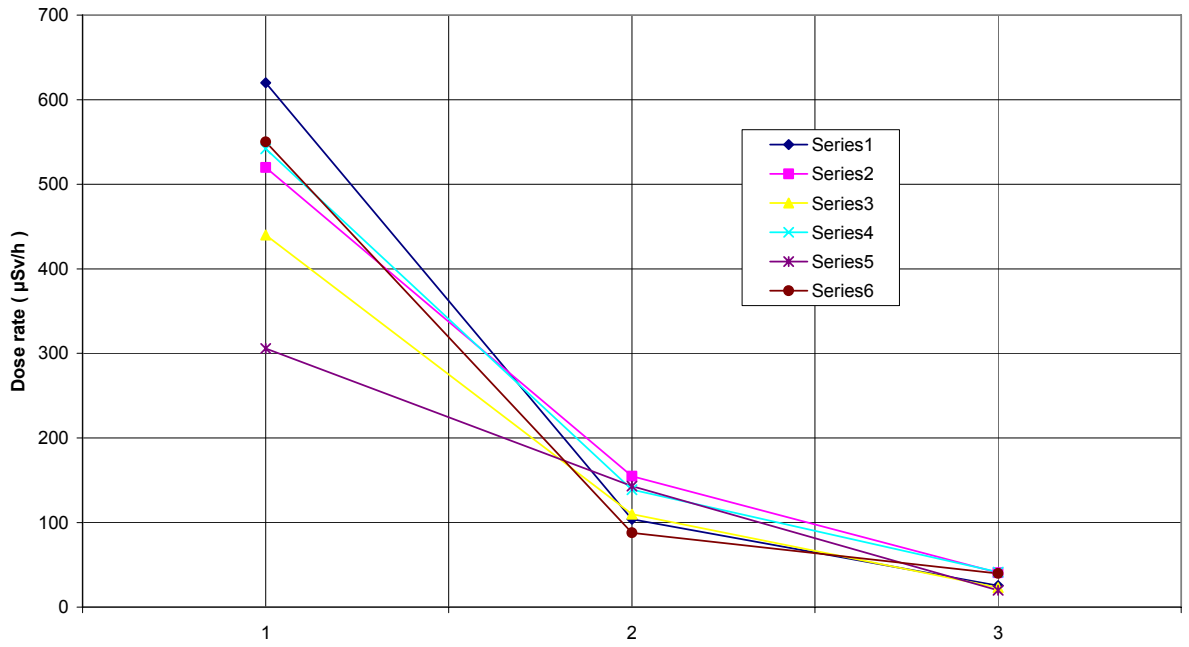
9. Conclusions

The BG18 package is a useful tool as it allows the shipment of full scale irradiated fuel rod or encapsulated fuel rods between the power production sites and the laboratories where the analysis of the fuel characteristics can be performed.
After some mechanical difficulties at the start up of its activity, which have been resolved with satisfaction, the package has fulfilled its function without problems and in accordance with the applicable rules.
The present general condition of the package and of its operational accessories is quite satisfying in order to allow further uses of it.

Transport n°	From	To	Date	Fuel rods or samples characteristics						
				Quantity	Type	Enrichment	Burnup	Cooling time	Total activity	Neutron source
						(w/o)	(GWd/tM)	(months)	E+14 Bq	E+7 n/s
1	NPP	Hol cell	April 2002	3 rods	MOX - BWR	5,5	45,4 to 57,2	33 and18	7,03	5,41
2	NPP	Hot cell	April 2002	3 rods	MOX - BWR	5,5 - 2,6	40,8 to 55,5	33 and18	6,54	6,58
3	NPP	Hot cell	Sept. 2002	3 rods	MOX - BWR	5,5	28,7 to 67,4	18 and 14	< 8,1	< 5,18
4	NPP	Hot cell	Sept. 2002	2 rods	MOX - BWR	2,6 - 5,5	57,1 to 65,9	14	< 7,0	< 7,7
5	NPP	Hot cell	Jan. 2003	2 rods	UO2 - PWR	4,25	51,6	22	4,17	
6	NPP	Hot cell	Febr. 2003	3 rods	MOX - BWR	5,5	57	31	< 6,6	< 6,9
7	NPP	Hot cell	July 2003	16 rods	UO2 - PWR	3,8	49,9 to 51	25	7,68	3,36
8	Hot cell	Hot cell	Oct. 2003	3 samples	MOX	4,1	49	>> 6	< 0,28	< 0,29
9	Hot cell	Hot cell	Dec. 2003	4 samples	MOX			>> 6	< 0,25	
10	Hot cell	NPP	April 2004	14	UO2 - PWR	3,8	13 to 51,2	> 60	< 7	<5,5
11	NPP	Hot cell	April 2004	7	UO2 - PWR	4,3 – 4,94	30,5 to 75,8	11	< 20,2	< 2,8
12	Hot cell	Hot cell	May 2004	4 samples	MOX - PWR			>> 6	< 0,4	
13	Hot cell	Hot cell	May 2004	3 samples	MOX - PWR			>> 6	< 0,3	
14	Hot cell	NPP	June 2004	8	UO2 - BWR	3,9	43 to 70,5	39	6,85	8,01

Table 1 Main data of the performed shipments

BG18 Dose rates **Chart n° 1**



Position of measure **1 = in contact package** **2 = 1 m from package** **3 = 2m from vehicle**

Dose rate as a function of neutron source strength **Chart n° 2**