PACKAGE TYPE A AND SHIELDING FOR 226Ra NEEDLES TRANSPORTATION

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ABSTRACT

In this work we projected and constructed packages Type A for transportation of ^{226}Ra needles. The package was tested to provide a safe transportation of these needles and to the maintenance of the quality assurance for the packaging procedure. These needles container, namely, the shielding itself, it has a maximum leakage rate of 10^{-7} torr.l.s^{-1} for the ^{226}Ra needle with leakage, so the adequate radiological protection is assured to the workers and general public. The shield have the capacity to absorb 18,5 GBq (100 mCi) independent of needle integrity. The package transport is projected for category III. It was also developed a computer program in an IBM computer 4381 for the shield calculation assuming a cilindrical source and the obtained results will be presented. This kind of program can be adapted to personal computers with 640 KBytes and 16 bites or bigger than.

INTRODUCTION

The ^{226}Ra is an alfa emitter with energies 4,78 MeV (95%) and 4,60 MeV (6%) and a gamma emitter having 14 different energies among 0,05 MeV and 2,44 MeV with mean energy of 0,662 MeV. Its half-life is 1602 y and it decays to ^{222}Rn which is a noble gas. ^{222}Rn is an alfa emitter with energy of 5,49 MeV (100%) and with 3,8229 d of half-life.
The ^{222}Rn decays to ^{218}Po with 3,0 min of half-life but now in the solid state. The ^{226}Ra is classified by IAEA (1) as having a very high radiotoxicity, while the ^{222}Rn as moderate radiotoxicity.
When the ^{226}Ra is sealed in a special form, the limits admited for its transportation are based only in the exposure rate. However, when a leakage occurs in a capsule, in a unsealed source or in a non special form, we are faced with an accidente caused by the inhalation of one of its daughters, i.e, ^{222}Rn.
The objective of this shielding project is due to the fact that ^{226}Ra is largely used in Brasil by medical personnel and in industrial facilities. In medicine it is used in teletherapy, brachiterapy and as needles. In industrial facilities it is used in the construction of lightining-conductor, radioluminous devices and other things.
Taking into account that presently the ^{226}Ra was substituted by either radioisotopes with less radiotoxicity and less exposure rate (^{3}H, ^{147}Pm

and others in the industrial facilities; ^{60}Co source, Linear Acelerator and ^{137}Cs needles in medical facilities), our National Nuclear Authority (CNEN) must collect the radioactive wastes.
The designed shielding, subject of this paper, is used in the transportation of ^{226}Ra source in any physical form, i.e., in a sealed, unsealed and in special forms.
For design purposes, the container is also the shielding of the source.

CRITERIA OF DESIGN

The package was designed to comply with the criteria proposed by IAEA, which allows 1,85 GBq (50 mCi) as the maximum value for transportation. IAEA also classifies this package as being of Type A.
In the shielding design we used 10^{-7} torr.l.s^{-1} as the major leakage, to be sure that a member of the public is adequatly protected. The limit used by IAEA is 10^{-5} torr.l.s^{-1}, i.e., 100 times higher than our limit. Our value was assumed taking into account the presence of the daughters of ^{226}Ra that, according to the ICRP (2), have a very high restrictive limit.
To estimate the shielding thickness we used the parameters obtained by Rockwell (3) and calculated it by using an IBM 155/370 computer programed in FORTRAN. We assumed the container having a cilindrical form with 7,5 cm of diameter and 9,8 cm of height having a volume of 0,4 l.
This calculation showed us that a thickness of 4,5 cm of lead will give an exposure rate of 30,96 μC.Kg^{-1}.h^{-1} (120 mR/h) in the external surface and 0,9 μC.Kg^{-1}.h^{-1} (3,5 mR/h) at one meter of the external surface of this package (fig.1).

PACKAGE STANCHING

We performed a leakage test using a VEECO leak detector model MS-17AB, calibrated by VEECO, according their certificate number SC-4. The sensibility limit is $6,0 \times 10^{-11}$ mbar.l.s^{-1}.
In any point surrounding the shielding did not found a leakage higher than $3,5 \times 10^{-08}$ mbar.l.s^{-1}.

PACKAGE TEST

The container was submitted to a specific tests before approving it for safe transportation of radioactive material as proposed by IAEA. The tests were: spray, free drop, compression and penetration.
The shielding and container integrity were verified before and after the tests. The results meet all the requirements proposed and the shielding was approved.

QUALITY ASSURANCE AND CONTROL

A quality assurance program is essencial during the manufacture of the needle container to insure that production meets the required standards.

The main planned and systematic actions necessary to provide confidence that needle container will perform satisfactory in service are:

MATERIALS

All the materials used for the manufacture of the shielding housing stainless steel should be submitted to a check analysis of chemical composition.

DIMENSIONAL CONTROL

All machined parts, specialy position A and B (fig.1), should have their dimensions controlled. The contact surface of O'rings must heve a roughness less than 1,0 micron. After welding and filling of the housing with lead, the planimetry of the surface A and B must be less than 0,08 mm, i.e., the tolerance field is delimited for two paralel planes equidistant by 0,08 mm.

WELDING PROCEDURE

Welding must be made by gas-shielded tungsten-arc process (TIG). The qualification standard for welding procedure and welding operator must follow the ASME section IX.
The welded parts must be examinated for cracks by the liquid penetration method prescribed in ASME section VIII.

SHIELDING EFFICIENCY

A radiographic inspection is necessary to insure that the lead inside the housing contains no porosity. This inspection is made using a ^{60}Co source.

LEAKAGE TEST

The body and cover of the needle container is submitted separately to a leakage measurement using an appropriated dispositive. The leakage measurement technique is dynamic by using helium as tracer gas. The leakage of each part should not exceed 10^{-8}torr.l.s^{-1}.

RESULTS

We introduced in the shielding cavity several different sources with activities up to 1,85 GBq (50 mCi) and we measured the exposure rate at the external surface and at one meter away from the external surface of the package. At any point of the package we found exposure rates not higher than 25,5 μC.Kg^{-1}.h^{-1} (99 mR/h) on the external surface and 0,97 μC.Kg^{-1}.h^{-1}(3,75 mR/h) at one meter away of the external surface (fig. 2 e 3). From this result we can introduce 18,5 GBq (100 mCi) of ^{226}Ra source complying with the requirement for label Category III.

DISCUSSION

This shielded was designed and constructed to comply with IAEA regulations in force by the time it was manufactured.
After 1985, IAEA increased the quantity of ^{226}Ra that can be introduced in a shielded package from 1,85 GBq (50 mCi) to 18,5 GBq (500 mCi) for package Type A. In this case, we intend in the near future to design a new shielded package complying with IAEA new estipulated value because it will

be more economic and will reduce the occupied space for transportation. The package presently in use will continue to be used only to transport ^{226}Ra source until 18,5 GBq (100 mCi), and for this reason it will not be eliminated.

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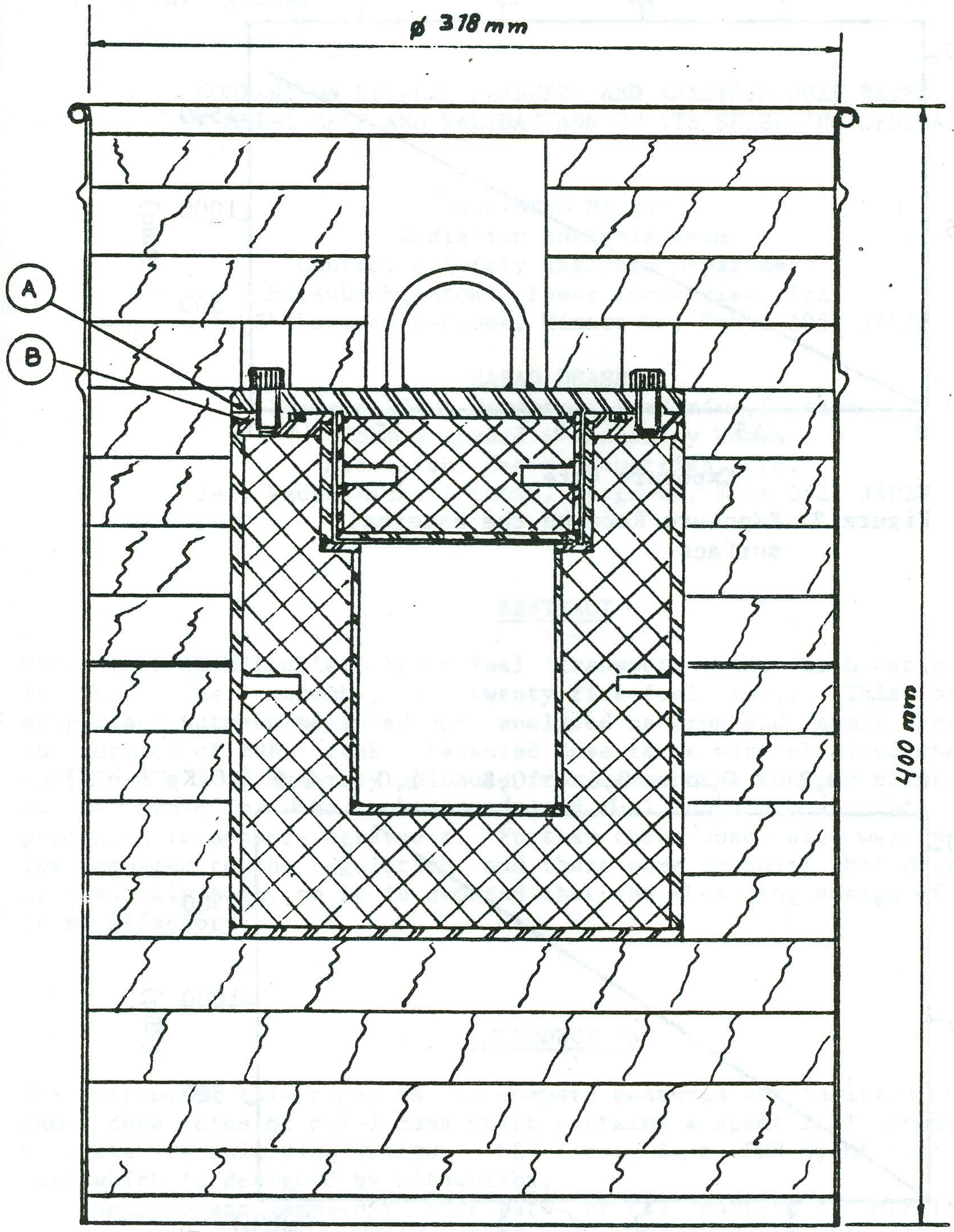

Figure 1

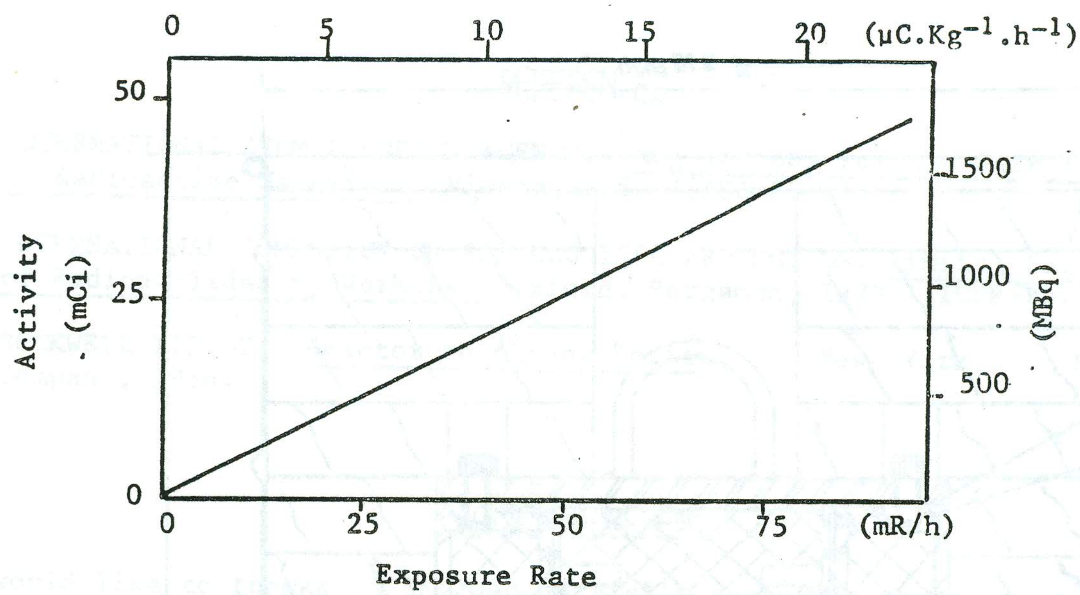

Figure 2. Exposure Rate on the external surface

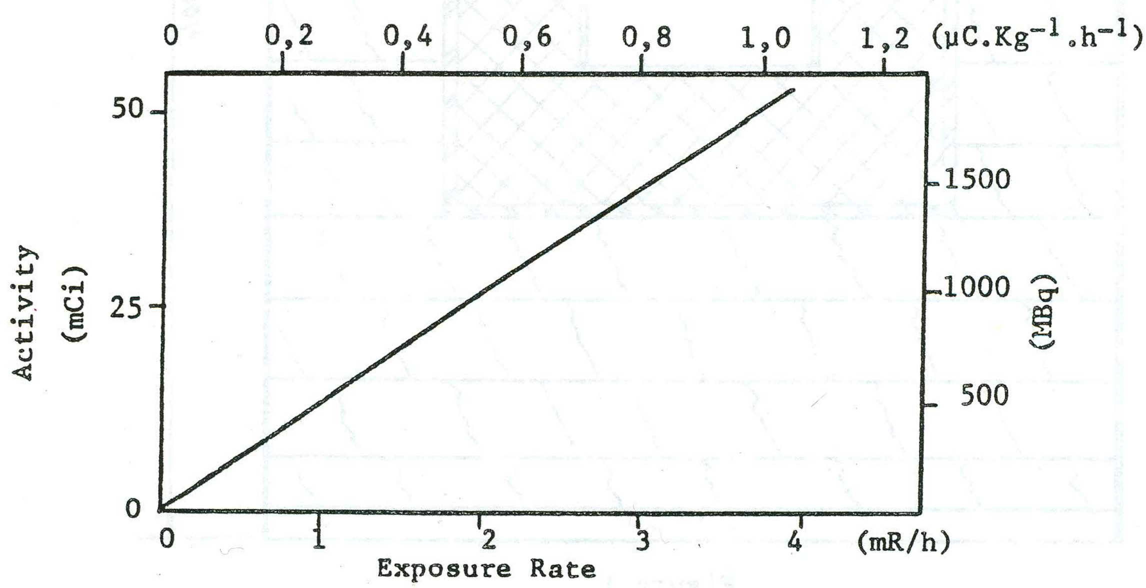

Figure 3. Exposure Rate at one meter away from the external surface