EXCLUSIONS, EXEMPTIONS AND LOW SPECIFIC ACTIVITY MATERIAL IN THE 1996 EDITION OF THE IAEA REGULATIONS FOR THE SAFE TRANSPORT OF RADIOACTIVE MATERIAL

L. Baekelandt
Niras
Belgium

Abstract

Exclusions and exemptions, total as well as partial, have always been part of the IAEA transport regulations, but these provisions were dispersed over various sections. In the 1996 edition of these regulations, some of these exclusions and exemptions have been kept unchanged, others have been changed and also, new ones have been added.

This paper gives an overview of the exclusions and exemptions in the 1996 edition, the most important change with respect to the previous edition being the departure from the single exemption value of 70 Bq/g for all radionuclides to the radionuclide specific exemption values as specified in the IAEA Basic Safety Standards.

As a consequence of this change, a new category of Low Specific Activity (LSA) material has been introduced.

This paper also discusses the rationale of these changes to the regulations.

1. INTRODUCTION

Exclusions and exemptions (total and partial) have always been part of the transport regulations[1], but these provisions were dispersed over various sections, for instance:

- the regulations do not apply to shipments within regulated facilities, neither to radioactive material that is an integral part of the means of transport (such as ballast in aircraft or ships), nor to material having a specific activity lower than 70 Bq/g;
- excepted packages and Low Specific Activity (LSA) material are exempted from certain requirements of the regulations;
- objects with surface contamination lower than 0.4 Bq/cm^2 for beta and gamma emitters and low toxicity alpha emitters, and 0.04 Bq/cm^2 for all other alpha emitters, are not classified as Surface Contaminated Objects (SCO) and are therefore implicitly exempted from the requirements of the regulations.

Some of these exclusions and exemptions have been kept unchanged in the 1996 edition of the regulations, others have been changed and also, new ones have been added.

2. EXCLUSIONS

Whereas the exclusions in the 1985 edition were dispersed over several paragraphs, they have been grouped into one single paragraph (107) of the revised regulations:

The Regulations do not apply to:

(a) radioactive material that is an integral part of the means of transport;

(b) radioactive material moved within an establishment which is subject to appropriate safety regulations in force in the establishment and where the movement does not involve public roads or railways;

(c) radioactive material implanted or incorporated into a person or live animal for diagnosis or treatment;

(d) radioactive material in consumer products, which have received regulatory approval, following their sale to the end user;

(e) natural material and ores containing naturally occurring radionuclides which are not intended to be processed for use of these radionuclides provided the activity concentration of the material does not exceed ten times the appropriate exemption values.

The exclusions in subparas (a) and (b) are not new in the transport regulations. The exclusion in subpara. (c) has been extended to live animals.

The exclusion in subpara (d) applies for instance to smoke detectors containing relatively small amounts of radioactive materials; such articles are also exempted from the system of notification and authorization set forth in the Basic Safety Standards (BSS)[2].

The rationale behind subpara. (e) will be explained later in relation with the departure from the single exemption level of 70 Bq/g to a radionuclide specific approach in the definition of radioactive material.

3. PRINCIPLES FOR EXEMPTION

In 1988 an international (IAEA, NEA) consensus was reached on the general principles for exemption from radiological protection measures, and published as IAEA Safety Series No. 89[3].

The exemption of a practice or a source from regulatory control (notification, registration, licensing) must be seen in relation to the basic radiological protection principles: justification of a practice, optimisation of protection, individual risk and dose limits.

A "practice" is defined as "a set of coordinated and continuing activities involving radiation exposure which are aimed at a given purpose, or the combination of similar such sets".

The "source" is then defined as "the physical entity (e.g. radioactive material, nuclear installation) whose use, manipulation, operation, decommissioning and/or disposal are constituents of the coordinated set of activities defined as practice".

From a radiological protection standpoint, there are two basic criteria for determining whether or not a practice can be a candidate for an exemption :

- the individual risks must be trivial, i.e. sufficiently low as not to warrant regulatory concern;
- the radiological protection must be optimised, taking the cost of regulatory control into account.

A schematic view of the exemption procedure is given in figure 1.

An individual dose is likely to be regarded as trivial if it is of the order of some tens of microsieverts per year. Because an individual may be exposed to radiation from several exempt practices, it is reasonable to apportion a fraction to each exempt practice. This could lead to individual doses to the critical group of the order of 10 μSv in a year from a single practice (e.g. all shipments made in one year by one carrier).

In the optimisation assessment, the relevant quantity is the collective dose commitment per year of practice. A generic study of the available options should be made and the conclusion reached that exemption is the option that optimizes protection. If this generic study indicates that the collective dose commitment from one year of the unregulated practice will be less than about 1 man.Sv, it may be concluded that the total detriment is low enough to permit exemption without more detailed examination of other options.

In its 1990 recommendations, the International Commission on Radiological Protection (ICRP) recognizes "that the exemption of sources is an important component of the regulatory functions"[4]. The Commission reiterates the two basic criteria for exempting a source or an environmental situation from regulatory control. One is that the source gives rise to small individual doses and small collective doses in both normal and accident conditions. The other is that no reasonable control procedures can achieve significant reductions in individual and collective doses.

These principles have been endorsed and made more explicit in the revised IAEA Basic Safety Standards[2] as follows :

(a) the radiation risks to individuals caused by the exempted practice or source be sufficiently low as to be of no regulatory concern;

(b) the collective radiological impact of the exempted practice or source be sufficiently low as not to warrant regulatory control under the prevailing circumstances; and

(c) the exempted practices and sources be inherently safe, with no appreciable likelihood of scenarios that could lead to a failure to meet the criteria in (a) and (b).

4. APPLICATION OF EXEMPTION PRINCIPLES TO TRANSPORT

Unregulated practices give rise to small individual doses (10 or some tens of microsievert per year), which are not measurable in practice. Therefore, the exemption criteria in terms of dose must be converted to more practical and measurable quantities, such as activity concentration levels in Bq/g or total activity in Bq.

During the revision of the Basic Safety Standards an international consensus was reached on the various scenarios, models and exposure pathways to be considered for the derivation of exemption levels in terms of total activity and activity concentration[5]. The radiological criteria mentioned above were used for normal conditions; in addition to those, for accident scenarios a reference level of 1 mSv was used, on the basis that the probability of occurrence is less than unity, and a reference dose to the skin of 50 mSv was taken into account.

Such exemption levels were derived for the most common radionuclides. The exemption values for some selected radionuclides are given in table 1.
They range several orders of magnitude[2][5] : from 1 to 1 000 000 Bq/g in terms of activity concentration, from 1 000 to 1 000 000 000 Bq in terms of total activity.

The benefit of harmonization between the BSS and the transport regulations is obvious. Such harmonization would avoid problems at interfaces and legal and procedural complications. It was recognized that the single exemption level of 70 Bq/g has no dose basis and that it is unlikely that this level satisfies the general dose criterion of 10 μSv/y for all radionuclides.

A careful examination of the underlying scenarios and models used to derive the exemption levels for the BSS led to the conclusion that they had not been demonstrated to be appropriate for transport purposes. Therefore, a set of transport-specific scenarios were developed[6] which reflected various exposure situations (exposure times, distances, source geometries and shielding factors):

- a postman or courier delivers a package containing radioactive material to a laboratory or a hospital after having carried it during his delivery round (200 hrs/year);
- a driver transports bulk material or packages in a truck or van (400 hrs/year);
- a person loads bulk material or packages in a truck or van (200 hrs/year);
- a member of the public travelling in an aircraft is exposed to radioactive material being transported in the hold of the aircraft (200 hrs/year).

The accident scenarios (only those leading to exemption levels in terms of total activity) were analyzed following the so-called Q system exposure pathways, i.e. the exposure pathways that are considered in the derivation of the contents limit of a type A package[1].

Based on these scenarios both activity concentration and total activity (per consignment) values were calculated which would result in an annual dose of 10 μSv (or 1 mSv in the case of an accident). One of the most restrictive scenarios is the exposure of a truck driver transporting 20 m^3 of bulk material for a total duration of 400 hours per year.

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[1] A type A package is designed to withstand normal transport conditions, including minor mishaps. The radioactive content is limited such that the exposure of individuals in case of a severe accident does not exceed 50 mSv.

It was shown that the single exemption value of 70 Bq/g was not compatible with the dose criteria. For some radionuclides (e.g. Co-60, Ra-226, Th-232, U-238) it results in doses of the order of 1 mSv/year or more (see figure 2).

These transport derived values were generally more restrictive than the BSS values, but generally did not differ more than one order of magnitude (see figure 3). Taking into account the obvious advantages of having the same set of values to be applied to both fixed installations and transport operations, it was decided to adopt the BSS derived values also for transport purposes[7]. A comparison of the new exemption levels with the single value of 70 Bq/g is illustrated in figure 4.

For mixtures of radionuclides, the "ratio rule" must be applied so that the sum of the activities (or activity concentrations for each radionuclide divided by the applicable exemption value is less than or equal to 1.

It must be noted that, in the case of decay chains, the values explicitly refer to the parent nuclide. The radiological impact of the daughter nuclides has been taken into account in the calculations. The single value of 70 Bq/g in the current regulations is not unambiguous in this respect and leads to divergent interpretations.

Although some doubts were raised about the radiological justification of the exemption level in terms of surface contamination, the same definition of contamination was kept. Hence, objects with surface contamination lower than 0.4 Bq/cm^2 for beta and gamma emitters and low toxicity alpha emitters, and 0.04 Bq/cm^2 for all other alpha emitters, are not classified as Surface Contaminated Objects (SCO) and are implicitly exempted from the requirements of the regulations.

5. LOW SPECIFIC ACTIVITY MATERIAL

The scope of the Regulations includes those natural materials or ores which form part of the nuclear fuel cycle or which will be processed in order to use their radioactive properties. The Regulations do not apply to other ores which may contain naturally occurring radionuclides, but whose usefulness does not lie in the fissile, fertile or radioactive properties of those nuclides, as long as the concentration of the radionuclides has not been artificially enhanced. Were this not the case the Regulations would have to be applied to enormous quantities of material that present a very low hazard.

However, there are ores where the activity concentration is much higher than the exemption values. Since the regular transport of these ores may be of radiological concern, a need was felt to put a limit for the activity concentration, above which radiological protection measures need to be considered. A factor of 10 above the exemption values was chosen as a compromise between the radiological protection concerns and the practical inconvenience of regulating large quantities of material with low level activity concentration (see para. 107(e) of the transport regulations).

Materials containing radionuclides in concentrations above the exemption levels have to be regulated. It is reasonable that materials containing radionuclides with an estimated average activity up to 30 times the exemption level may be exempted from parts of the transport regulations. Such materials have been associated to the category of LSA-I materials (para.226). The factor of 30 has been selected to take account of the rounding procedure used in the derivation of the exemption levels and to give a reasonable assurance that the transport of such materials does not give rise to unacceptable doses.

6. PARTIAL EXEMPTION

It must be noted that some categories of material and packages are exempted from part of the requirements of the regulations.

LSA-I material and SCO-I are exempted from the requirement of packaging, provided some conditions are met (para. 523):

(a) all unpackaged material other than ores containing only naturally occurring radionuclides shall be transported in such a manner that under routine conditions of transport there will be no escape of the radioactive contents from the conveyance nor will there be any loss of shielding;

(b) each conveyance shall be under exclusive use, except when only transporting SCO-I on which the contamination on the accessible and the inaccessible surfaces is not greater than ten times the exemption level in terms of surface contamination; and

(c) for SCO-I where it is suspected that non-fixed contamination exists on inaccessible surfaces in excess of these values, measures shall be taken to ensure that the radioactive material is not released into the conveyance.

Excepted packages are subject only to part of the provisions of Section V, Requirements and controls for transport, and Section VI, Radioactive materials and packagings and packages (para. 515). In particular they are not required to be labelled on the external surface.

Table 1 - Exemption values for some selected radionuclides

Radionuclide	Activity Concentration (Bq/g)	Total Activity (Bq)
H-3	1 000 000	1 000 000 000
C-14	10 000	10 000 000
P-32	1 000	100 000
S-35	100 000	100 000 000
Cl-36	10 000	1 000 000
K-40	100	1 000 000
Co-60	10	100 000
Kr-85	100 000	10 000
Sr-89	1 000	1 000 000
Sr-90(*)	100	10 000
Mo-99	100	1 000 000
Tc-99m	100	10 000 000
I-125	1 000	1 000 000
I-131	100	1 000 000
Cs-137(*)	10	10 000
Ir-192	10	10 000
Au-198	100	1 000 000
Tl-201	100	1 000 000
Ra-226(*)	10	10 000
Th-nat(*)	1	1 000
U-nat(*)	1	1 000
Pu-239	1	10 000
Am-241	1	10 000

(*) parent nuclides and their progeny included in secular equilibrium :

Sr-90 Y-90
Cs-137 Ba-137m
Ra-226 Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210
Th-nat Ra-228, Ac-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212,Tl-208 (0.36), Po-212 (0.64)
U-nat Th-234, Pa-234m, U-234, Th-230, Ra-226, Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210

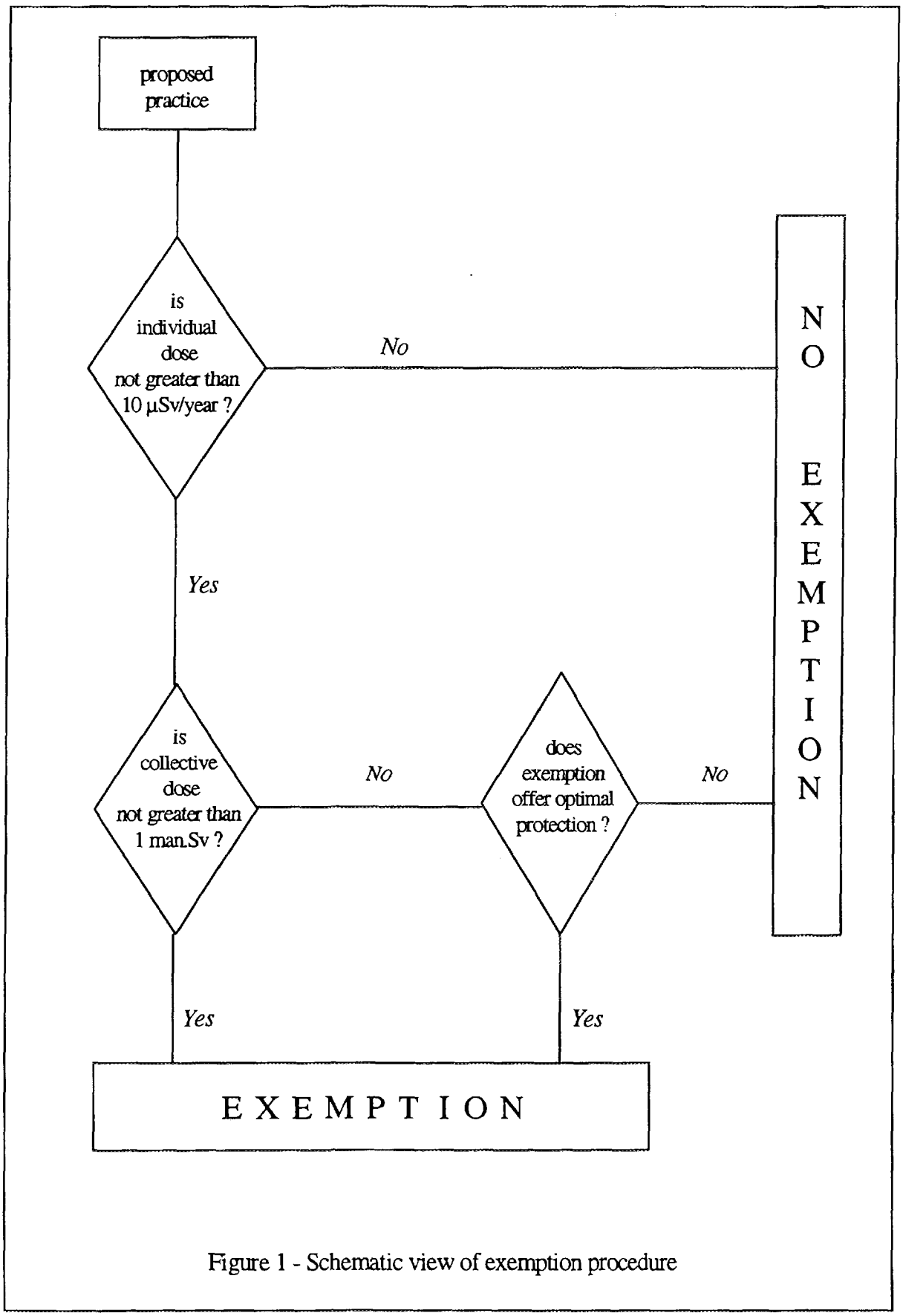


Figure 1 - Schematic view of exemption procedure

Figure 2 - Radiological Impact (μSv/year)
of material with activity concentration of 70 Bq/g

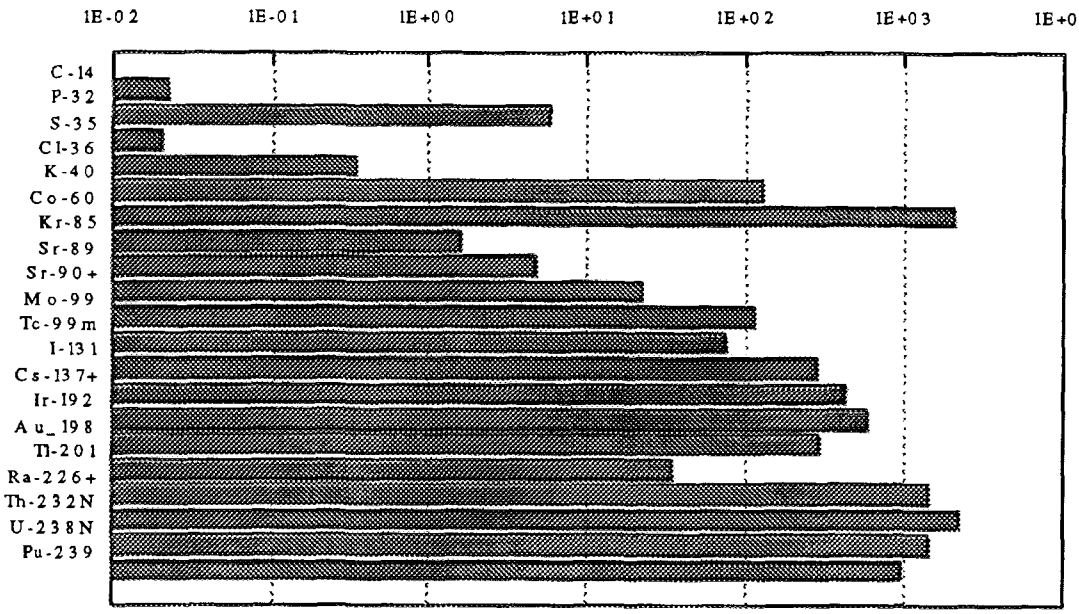


Figure 3 - Exemption values in terms of activity concentration (Bq/g)

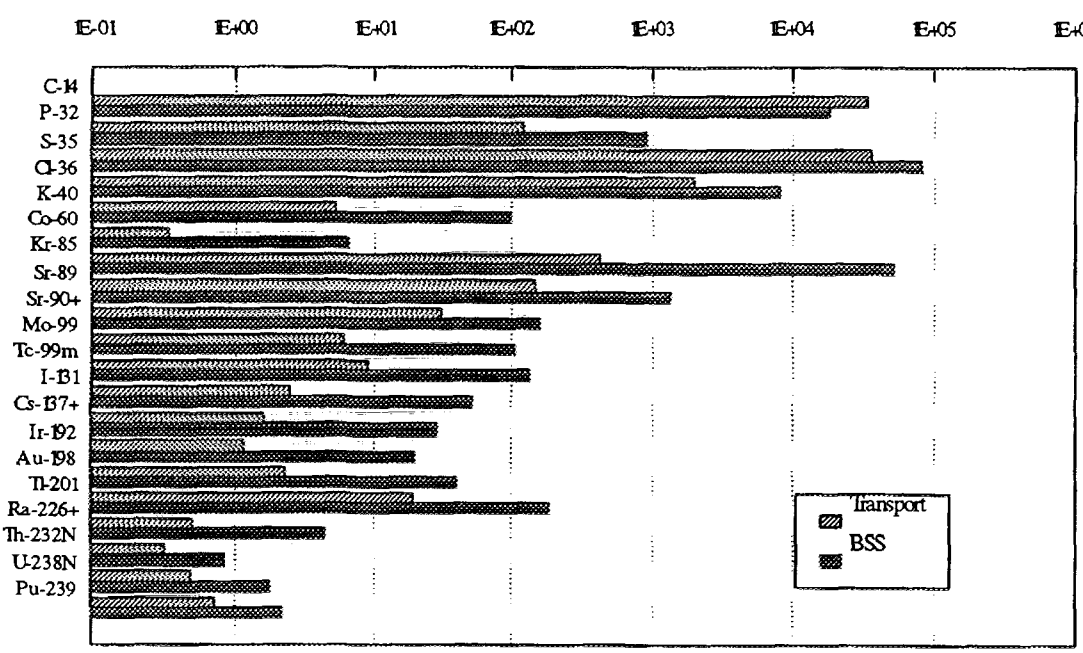
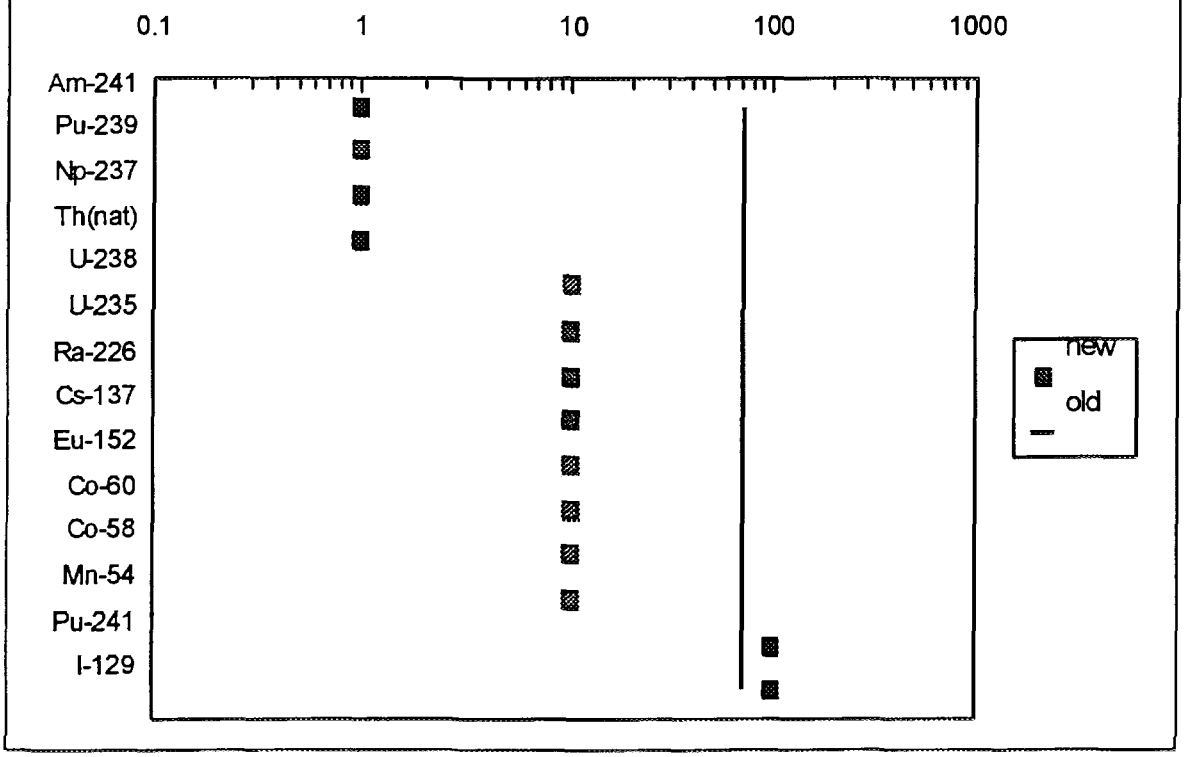


Figure 4 - Exemption levels in terms of activity concentration (Bq/g)



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