THE RADIOLOGICAL TESTING OF PRODUCTS WHICH IRRADIATE THE PUBLIC

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1. INTRODUCTION

Radiological protection tests play an important part in the work of the National Radiological Protection Board in advising manufacturers, distributors and government departments on the acceptability of products which can lead to exposure of the public to ionising radiations. The Board's approach to testing and two examples of its application are described in this paper.

2. THE ROLE OF TESTING IN DECISION - MAKING

Radiation doses from any product which irradiates the public must not exceed appropriate ICRP Dose Limits. This is an overriding requirement but the proper application of the ICRP system of dose limitation to decisions on whether a product is acceptable involves two processes: justification by risk-benefit analysis and optimisation so that doses from the product are as low as is reasonably achievable. An acceptable product is one which has been both justified and optimised. Risk-benefit analysis involves assessments of the doses expected from the product when it is in normal use and when it is accidentally damaged or abused. Consumer products are effectively outside any form of centralised control after sale to the public; for this reason potential doses as a result of some form of recovery after disposal by their original user must also be considered. Rigorous but realistic testing provides the basic information needed for these assessments. The principal role of testing in optimisation is to obtain information on a range of comparable products. Data of this kind can indicate the design features necessary to minimise risks, and are thus useful when formulating radiological protection standards for products.

3. APPROACH TO TESTING

In addition to measurements of external radiation dose rates and source leakage in normal conditions, tests should include evaluation of a product's performance under adverse temperature, mechanical and corrosion conditions. These tests can be designed in two ways: they can either simulate the damage likely to be suffered by a product in the environment in which it is used, or they can simulate the environment itself. There are problems inherent in both methods and usually a combination of the two is used. Where little or no information is available it is necessary to make some assumptions about the types of accident which could occur, and the adverse environmental conditions which are likely to be encountered. The Board's approach is to develop tests on a case-by-case basis since flexibility is essential when dealing with a wide range of products and environments.

4. TEST PROGRAMMES AND RESULTS

4.1 Ionisation Chamber Smoke Detectors

The test programme for ionisation chamber smoke detectors (ICSDs) can be divided into two parts; three tests are related to normal use and the remainder to credible accidental damage or abuse (1). The tests intended to simulate adverse environmental conditions and accidental damage are summarised in Table 1. Each test is carried out on a separate detector or

source/holder combination to avoid the difficulty of interpreting the results of combined tests.

Type of test	Parameters	Part of detector tested	Damage or environment simulated
1. Temperature	-25°C to +100°C	Source and holder	Damage due to ambient temperature variations
2. External pressure	25 kPa to 100 kPa	Source and holder	Pressure variations during air transport
3. Impact	0.5 kg from 0.5 m	Whole ICSD	Damage from accidental blows
4. Drop	From 10 m	Whole ICSD	Accident during installation or servicing
5. Puncture	1 g from 1 m	Source and holder	Damage due to tampering with source
6. Vibration	5 - 60 Hz	Whole ICSD	Damage due to ceiling vibration
7. SO_2 Corrosion	16 days exposure	Source and holder	Corrosion in industrial atmosphere
8. Humidity	10 days exposure	Source and holder	Corrosion in non-industrial atmosphere
9. Special test: Fire	1. 600°C 2. 1200°C	Source, holder and parts of detector housing	1. Typical domestic fire 2. Hot industrial fire

TABLE 1 Test Programme for ICSDs

The majority of ICSDs now available use ^{241}Am foil sources. Measurements have confirmed that external radiation levels are very low, even for the highest activity detectors (100 μCi ^{241}Am). Preliminary wipe tests of sources and inactive parts of ICSDs have shown that amount of removable contamination are very small if suitable precautions are taken during manufacture. In general, the temperature and mechanical tests caused no increase in the amounts of removable activity on sources and their surroundings. After exposure to sulphur dioxide only the high activity ICSDs gave more than 5 nCi on wiping.

In the 600°C fire test the results of wipes over the sources range from an undetectable amount of activity to several hundred nanocuries (see Table 2). There is a clear correlation between the amounts of removable activity and the source holder material, stainless steel and aluminium holders giving much more satisfactory results than brass or tin-plated ones. In most cases the ICSD debris was not contaminated and no activity became airborne.

The results of this exploratory test programme have provided information which will be valuable in establishing criteria for acceptance of ICSDs. The 600°C fire test, with a requirement that not more than 5 nCi activity should be detectable in the debris and removed by wiping the source and

Holder material	Pre-test wipe (nCi)	Post-test wipe (nCi)	Comments
Stainless	NDA - 1.0 NDA	NDA - 3.0 97 - 345	Fire retardant ABS plastic housing caused higher leakage
Aluminium	NDA - 1.3	0.01 - 4.3	
Tin plated mild steel or brass	NDA - 0.2	10 - 409	
Brass	NDA - 0.06 0.08	12 - 15 120	Solder used for fixing foil contributed to higher leakage

NDA = no detectable activity ie, less than 10 pCi

TABLE 2 Results of 600°C Fire Test on ICSDs with ^{241}Am Foil Sources

holder after the test, has become one of the bases used by the Board for acceptance of ICSDs and is recommended for general use.

4.2 Radioluminous Compasses

In contrast to the extensive testing programme devised for ICSDs, when the Board carried out a systematic survey of compasses which are or have been available to the United Kingdom public, only external dose rates and removable activities were measured. The results of these simple tests were sufficient to enable the Board to make a number of recommendations on design features of compasses which would reduce doses to the public from these devices in both normal and accident conditions. These recommendations are:

a If radioluminous paint is used it should be sealed (with varnish) and covered with transparent material. This reduces dose rates and prevents loss of activity (the latter can be a problem with paints containing ^{3}H).

b In the case of paints containing ^{147}Pm the transparent cover should have a thickness equivalent to at least 50 mg cm^{-2} (0.4 mm perspex). This thickness is sufficient to reduce dose rates to acceptable levels.

c Luminising with gaseous tritium light sources (GTLSs) is preferable to using radioluminous paints. If GTLSs are used they should be inaccessible. Covering GTLSs reduces the external dose rate and minimises the possibility of accidental breakage.

d Paints containing ^{226}Ra should no longer be used. Because of the external γ-radiation and high radiotoxicity of ^{226}Ra, it should no longer be used in radioluminous paints.

e The use of non-radioactive luminous paints should be encouraged.

REFERENCES

(1) HILL, M.D., WRIXON, A.D. and WILKINS, B.T., Radiological Protection Tests for Products which can lead to Exposure of the Public to Ionising Radiation, National Radiological Protection Board, NRPB R42 (1976)