Paper 27

10 years of feedback experience from expertise work on industrial gauges and irradiators

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1 Introduction

The continuous measurement of the thickness of laminated products in 1947 was one of the first recorded uses of radioactive sources in industry. Since then, the industrial applications of radioactive sources have enormously expanded. In 1992, there were 58000 users of medical X-ray generators (dental, radiodiagnostic applications, etc.) in France although only 800 users of X-ray generators in industry (diffractometers, etc.). The situation is reversed for sealed sources for which there are 5000 users in industry and 900 in medicine. Attention is drawn to the fact that 88% of industrial sources are used in conjunction with radioactive gauges. An interministerial body, ***« la Commission Interministerielle des Radioéléments Artificiels (CIREA) »*** is responsible for deciding whether (or not) new equipment items involving ionising radiation can be sold or marketed in France. ***CIREA*** consults the various competent French radiation protection authorities in order to make its decision.

Over the past 10 years, the ***Service de Radioprotection*** (**SPR**) of the CEA Saclay has provided ***CIREA*** with expertise hundreds of times. The large amount of data available on this subject incited us to set up a database giving access to the 10 years of practical feedback experience acquired.

2 An overview of the national situation and the expertise work performed by the SPR service at saclay

In 1996 there were 2658 recorded users of radioactive gauges in France corresponding to the existence of about 12000 gauges on national territory. The following table shows the percentage of radioactive sources used for different applications on national territory together with the percentage of users provided with expertise by our laboratory.

	« National » Users	SPR Laboratory Expertise
Density, weight and level measurements	67%	8%
Thickness and surface density mesurements	22%	57%
Hygrometer and hydrometer type measurements	9%	15%
X-ray fluorescence analysis	2%	20%

It can be seen that the highest proportion of expertise (relative to the national average) has been devoted to thickness and surface density determination (57% of the 22% of users) and X-ray fluorescence (20% of the 2% of users).

3 Expertise methodology

In view of the considerable variety of gauges likely to find their way onto the market and the many years of expertise experience already acquired, our laboratory developed a rigorous methodological approach, materialised by the elaboration of a format for a «standard» expertise report in 1991.

This report to be communicated to CIREA relates to radiological measurements (measurements in the beam with the shutter open and closed, isodoses etc.), radiography of the shutter mechanism, investigations into overall safety (including, if appropriate, special safety features), controls to ensure that there is no contamination, radiation protection recommendations, a source calibration certificate, checks for radiation leakages, photographs of the equipment and/or source holder, pertinent extracts from regulations, etc.

In order to be able to handle equipment with different geometry, sources and measurement conditions, an expertise laboratory must have the various measurement equipment required at its disposal: thermoluminescent

(TLD) measurement systems, dose rate meters, gamma, beta, and alpha detectors, rem counters, bubble detectors, spectral analysis systems, liquid scintillator analysis systems, etc... Such equipment must also be correctly calibrated and appropriate corrections applied. This is particularly important for expertise involving beta sources where energy dependent correction factors must be taken into considerations. These factors are presented in the report.

4 Making full use of experience gained from past expertise

Some 120 standardised format files were used to constitute a database which has enabled:

F feedback experience to be documented

Fassessments to be made on the differences observed between the results of measurements made on the same type of equipment

F anomalies to be identified (e.g. very different measurement results for two pieces of equipment of the same type)

Fan inventory to be made of the main causes of anomalies observed with different types of equipment and different manufacturers

Fimprovements to be made in equipment design

F etc...

4.1 Database structures

From 1991 onward, expertise files have been structured in a standard manner. The database was constituted through the extraction of the following information from 116 files:

1 nature and activity of source
2 dose rate in the direct beam,
3 type of shutter employed (mechanical, pneumatic, electrical or manual operation)
4 isodose distances,
5 exposure time, t, corresponding to the annual exposure limit
6 anomalies
7 etc...

Other indicators have been introduced e.g. the ratio between the does rates observed with the shutter open and the shutter closed, the equivalent dose rate in the beam for a nominal source activity of 1 GBq, etc..

Data corresponding to four measurement categories are defined: thickness determination, density and level determination, hygrometers/hydrometers and X-ray fluorescence analysis.

4.3 Example: thickness and surface density determination gauges

It is, in general, difficult to obtain accurate information about souse holders, the shapes and geometry of sources and on the nature and thickness of beam exit windows. For a beta source, a small variation in one of the above parameters can lead to large variations in beam characteristics. In general, the most significant variations in measured values have been observed with gauges employing this type of source.

As far as thickness and surface density measurement gauges are concerned, out of 67 types of gauge investigated 8 employed ^{147}Pm, 24 ^{85}Kr, 16 ^{90}Sr-^{90}Y, 4 ^{137}Cs, 1 ^{55}Fe and 1 ^{109}Cd.

a) Axial dose rates

The maximum and minimum beam dose rates generated by a nominal 1GBq source can vary considerably (see table). The beam dose rate generated by a beta source is 1000 to 10000 times higher than that generated by a gamma source of the same activity. It should also be noted that measurement dispersion becomes increasingly significant with decreasing energy.

Radionuclide	^{147}Pm n=8	^{85}Kr n=24	^{90}Sr-^{90}Y n=16	^{241}Am n=13	^{137}Cs n=4
Maxi (Gy/h)	4.1	73.0	70.,3	2.1E-3	7.6E-3
Mini (Gy/h)	1.3E-3	6.0E-2	1.1	9.5E-5	3.2E-3
R=Maxi/Mini	3044	1217	62	23	2.5

b) Shutter efficiency

Extreme shutter efficiency ratios varying between 10^{-1} and 10^{-8} have been observed for equipment from the same manufacturer.

c) Anomalies

Presence of source not indicated: 31 %
Absence of means to indicate the position of the source or shutter: 42%
Information not provided in the French language: 58%
Radiation leakage around the shutter : 9%
Absence of a fail safe mode for the shutter in the case of pneumatic system and/or electrical power supply failure : 22%

d) Potential risks

The duration of time, t, over which the annual exposure limit is reached through incidental radiation exposure conditions serves as an indicator. The following examples can be cited: t varies between 24 seconds and 700 minutes for ^{147}Pm, between 1 second and 6 minutes for ^{85}Kr and 40 seconds and 1 hour for ^{90}Sr-^{90}Y. For gamma sources, t values are generally of the order of tens of hours whereas for beta gauges the maximum dose rates observed are several hundred times higher than those observed with gamma gauges.

5 Conclusion

In order to provide radiation protection expertise for industrial equipment prior to its commercialisation various different types of measurement may be necessary involving gamma, beta and neutron sources etc... The number of measurements made should exceed the strict minimum laid down by regulations. In this way a safety culture can be developed taking possible equipment malfunctions into consideration. The application of this philosophy has led to modifications and consequential improvements to systems (and radiation protection conditions) on several occasions.

In addition to having acquired more than 20 years of experience in expertise, we defined a «standard» methodology in 1991 for radiation protection expertise, which enabled a database to be constituted. This tool allows maximum advantage to be drawn from past experience. The availability of such a database represents an important positive step forward in this field, enabling rational approaches to be made to problems such as flagrant errors in the declared activities of sources. The database also facilitates the constitution of an inventory of anomalies encountered (the same anomalies often being found in products from the same manufacturer) and provides ***a priori*** order-of-magnitude values facilitating the optimisation of measurement means to be employed, etc..

References

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