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QUALITY AND SECURITY ON THE USES OF COBALT 60

SOURCES FOR INDUSTRIAL IRRADIATORS

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A B S T R A C T

The construction and operation of industrial irradiators using large quantities of Cobalt 60 give rise to an important problem of security. The CEA Radioisotope Department which manufactures and sells sources of Co60 has created an insurance Quality System which insures the maximum of security for the user.

The use in industry of radioactive sources gives rise to serious problems of security. Most of the countries have established a regulation on the use of radioactive products. Moreover, the international organizations such as ISO, AIEA, etc., have set up norms and recommandations on the specifications which these sources should have to withstand without damage the transports and utilisation in laboratories or industry.

What are the risks involved by using a batch of sources of many hundreds of thousands of curies in industry ?
Those risks are of two sorts : first of all the risk of accidental irradiation. The irradiator constructors - they can be trusted - have studied devices and multiplied security systems so that such accidents do not occur. This risk is therefore greatly reduced by the quality of the irradiation installation on the level of the project, the construction, the set up of development instructions with the supervision to carry them out strictly.
The risk of contamination, therefore of irradiation by contamination could appear or exist with leakage of the sources.

Before analysing the dangers related to the existence of radioactive sources, I must precise a few data concerning the level of tolerated contamination in the air and the water.
The maximum permissible concentration of Co60 in the air is of 10^{-7} ci per m^3 in the insoluble form.
In water, the maximum admissible concentration is of 5×10^{-4} ci/m^3 in the soluble form and 3×10^{-4} ci/m^3 in the insoluble form.
When considering that the specific activity of the cobalt 60 reaches 100 ci/g of metallic cobalt, this corresponds to a maximum weight of 5×10^{-3} mg per m^3 in water, which is extremely low.

Let us see now the reaction of the radioactive cobalt in contact with water.
Theorically the cobalt is insoluble in water; unfortunately the intense radioactivity of the Cobalt 60 produces a decomposition of water on contact with production of nascent oxygen which oxydes the metal and is much propitious to its transfer into the solution. The experiences which have been carried out in our laboratory prove this hypothesis : the Cobalt irradiated and immersed in water blackens and is transferred partly into a solution.
The immediate consequence of a leaking source is the contamination of the water of the irradiator with the necessity of treating this water on the spot or transferring it to a plant of radioactive wastes processing.
As an indication, in France, the processing of one cubic meter of water containing 1 curie of Co60 costs 1.746 FF (about 1000 DM), transport not included.
I would like to indicate in this connection that our Radioisotope Department has created a system for processing the water on the spot by using a device of fixation on - ion exchanging resin.

After having examined the risks subsequent to the use of radioactive sources, I shall now describe succinctly what contains a Cobalt 60 source and how it is manufactured.
For minimal self-absorption reasons, the Cobalt is irradiated in the reactor in the form of Cobalt plates actually 1,2mm thick (0,9mm shortly) 54mm long and 18mm wide and encapsulated in stainless steel 0,5mm thick and argon arc welded.
These elementary sources are mounted in a stainless steel tube of 27,8mm external diameter in a well defined geometry in layers of 6 plates. The complete source holds 6 or 8 piling up of 6 plates.
The tube is argon arc welded as usual and introduced in a second envelope of stainless steel 1mm thick and plugged at each end. These plugs are used as handling heads and are made leak-proof by argon arc welding. The handling head is made on the customer's request.

Now I will talk on the different stages of manufacturing. We shall see further on, how is organised the Quality Control and the different tests and controls which are carried out.
The "inactive" works are : supplying and engraving the tubes, plugs, probes having a rectangular or triangular section and stainless steel encapsulated cobalt plates.
After irradiation, in the shielded cells, the plates are measured, weighed and arranged in batches. They are decontaminated.
Then follows their mountings in the primary envelope. The plates are mounted in pairs along the four sides of an equilateral triangle.
Then comes the helium filling work and the primary envelope is sealed automatically by argon arc welding.
The helium spectrometer measuring permits to verify the non-leakage of the welding. The activity is also measured in the ion chamber.
The assembled plates are encapsulated in a secondary envelope welded and checked in the same way.
Before loading, the source is decontaminated and verified.

All this appears very simple but in order to obtain a source of very high quality, many measures of security have to be taken.
The Quality control takes place at the project level (in the case of a new design) on working out the specifications of material supply, of manufacturing and checking up.
In fact, the specifications or welding processings are established only after having qualified this processing which is perfected on test-tubes These test-tubes withstand various metallographic and radiographic tests The Quality Control is made on receipt of the material : dimensionnal control, chemical analysis, non-leakage test for the parts welded in the plant. Then follows all the manufacturing tests; some of them are part of the manufacturing process and are made by the manufacturing staff. All stages of verification are made by the Quality Control Group which is independant from the manufacturing Group.

The controls of the sources are performed on :

- the plates : weight, measurement in ion chamber, measurement of non-contamination.

- on the sources : verifying the conditionning of the operation.
  - verifying the welding parameters (on primary and secondary envelopes).
  - non-leakage test (1st and 2nd envelopes) by helium spectrometer.
  - non-contamination control by wipe-test or immersion into nitric acid.
  - measure in the ion chamber.

Just before shipment, the non-contamination of the transport container is verified and the loading process checked.
The sources are delivered along with two documents : a delivery note, a source certificate; moreover and on request, we can supply two supplementary documents : first, an insurance quality certificate giving the references and components of the source and certifying that the tests on manufacturing and material have been made.
Secondly, a waranty under which the CEA engage themselves to replace or repair free of charge all or part of the supply showing defects.
I must add that these sources are classified "special form" material simplifying thus transport and utilization authorization and that their classification under the norm ISO/DIS 2919 is 63446.

To conclude, I will give with a few figures the result of our work to obtain very high quality sources :

During 10 years our Radioisotope Department has selled more than 7 millions of curies of Co60 in 15 different countries with only two incidents due to the user's faulty operation. Both incidents resulted in an important distortion of the capsule without dispersion of the Co60.