Final Preservation of Mummies by Gamma Irradiation

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Final preservation of four mummies was achieved by means of gamma irradiation in a Cobalt 60 plant designed for radiation sterilization of medical products. The radiation dose was between 1.71 and 2.31 megarads.

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At the request of the National Museum in Denmark the final preservation of four Greenlandic mummies was carried out by means of gamma irradiation in the Cobalt 60 plant, Nuncatom, a plant designed for radiation sterilization of medical products.

Given the size of the boxes containing the sealed mummies it was not possible to use the normal procedures for sterilizing medical products. However, owing to the way in which the plant (AECL-Type J6000) was constructed, it was possible to use the excess gamma radiation in an area close to and parallel to the product conveyor system, surrounding the cobalt source (Fig. 1).

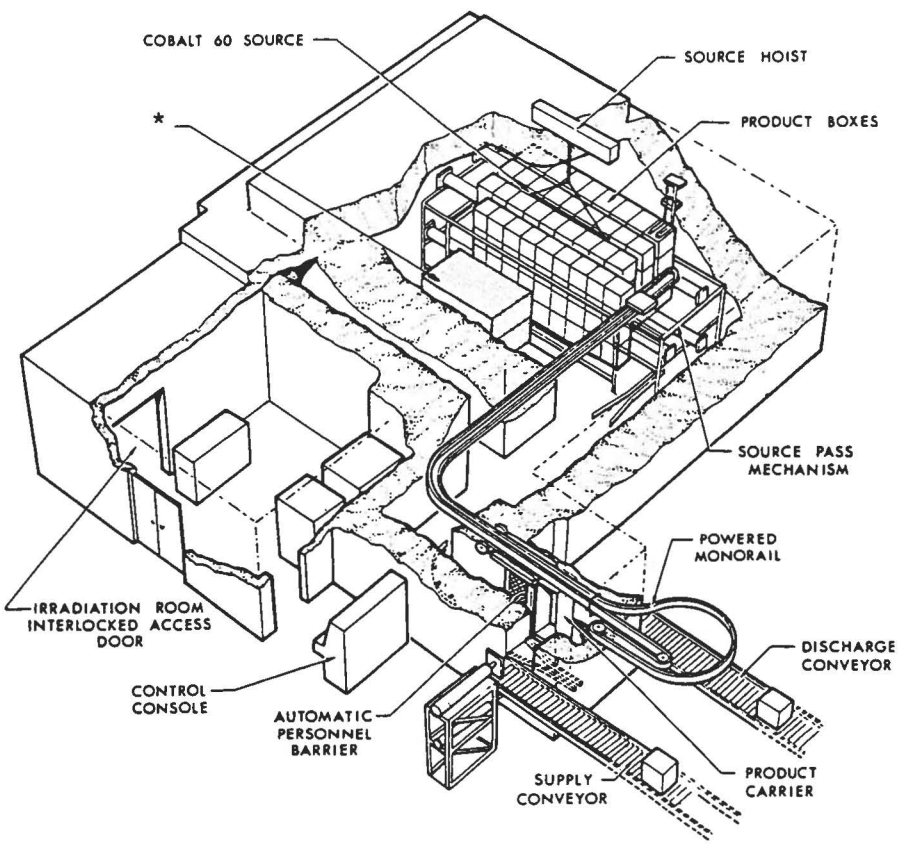

Fig. 1. Cobalt 60 irradiation plant. * The arrow indicates the position of the boxes containing mummies.

Table 1. Sterilizing effect of various doses on pieces of mummy skin

Sample No.	Dose megarads	Weight g	Result of 14 days' incubation
1	0	1.33	Growth
2	0.25	1.81	Growth
3	1.01	2.62	No growth
4	1.75	1.23	No growth
5	1.94	1.71	No growth
6	2.45	1.67	No growth
7	3.33	1.35	No growth

To assess the level of irradiation as well as the uniformity over the desired irradiation area the dose at nine different positions was measured using three Red Perspex 4034 at each position. The result of the dosimetry was dose rates between 39 krad/hour and 47 krad/hour. The above doses were obtained within an area of 170 × 120 cm, enough to cover the boxes containing the mummies.

As the irradiation varies over the required area because of variation in the density of the products in the normal process, the above dose rates were considered to be guidelines only, and it was decided to perform extensive dosimetry during the irradiation of the mummies.

The choice of dose to be applied to the mummies was partly based on results obtained from the gamma irradiation of the mummy of Ramses II (Brouqui *et al.* 1978). The estimated inactivation of various microorganisms was also considered, and test irradiation of various samples of mummy skin, clothing etc. played a substantial part in the decision.

Based on the above considerations and tests it was decided to irradiate the mummies with a dose between 1.8 and 2.5 megarads. As it was impossible to perform any microbiological examination of the mummies before and after the irradiation, it was further decided to perform a simple microbiological test on skin pieces from another mummy found in the same place.

Given the structure of the mummy skin it was not possible to determine the number of microorganisms present in the material, so the piece of skin was divided into seven smaller pieces, weighing from 1.34 to 2.62 g. These pieces were soaked in sterile growth medium (Heart Infusion Broth) and incubated for 14 days. The result of this investigation can be seen from Table 1.

Irradiation procedure

The mummies, hermetically sealed in polyethylene film and packed in shock-resistant cardboard boxes, were taken manually to the irradiation chamber and placed in the desired area. On the basis of the predosimetry, the total irradiation time was calculated at approximately 45 hours. In order to make the irradiation as uniform as possible the boxes were rotated after approximately 20 hours.

To monitor the applied dose a number of dosimeters were taped to the outside of the boxes and measurements of the obtained doses were taken at short intervals. After irradiation the complete set of dosimeters, placed in a pattern corresponding to the profile of the mummies inside the boxes, were measured.

The results obtained can be seen from Figs. 2–5, showing the position of the dosimeters as well as the dose in megarads. All doses indicated are mean values of 2 dosimeters and none of the measurements varied more than 2 per cent from the mean value.

The radiation preservation of the four mummies was of course a minor part of the total conservation process, but in spite of limited experience with the use of gamma irradiation for final preservation, it is a method which should be further elaborated. The clear advantage of the radiation process is the high penetration of the gamma rays, allowing preservation to take place in a sealed environment.

From the experiments with the test material it appears that no damage is done to the material at dose levels up to 2.5 megarads. The radiation degradation of organic material is probably related to the water content of the material, and this is one of the factors which

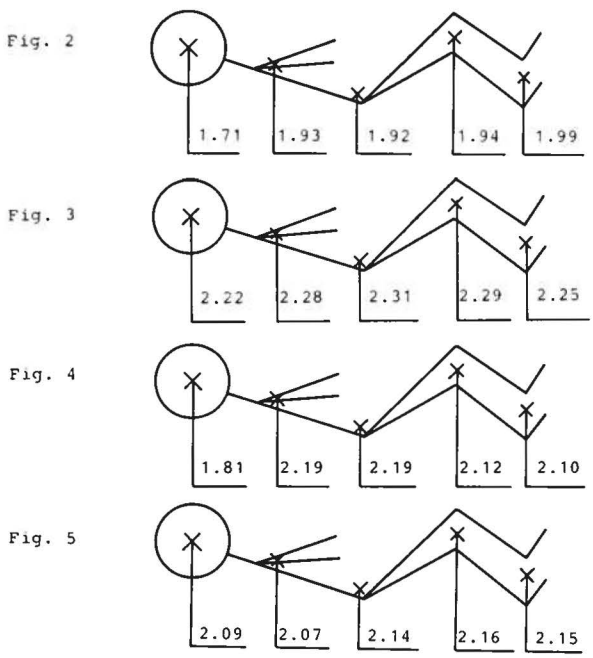

Fig. 2.–5. Location of the dosimeters. Dosimeters were placed outside the boxes containing the mummies in a pattern corresponding to the profile of the mummies. All values indicated are mean doses in megarads.

needs further investigation. The water content of the mummies was approximately 7 per cent, which in organic material is regarded as very low.

Finally, irradiation is one of the most intensively investigated methods for microbial inactivation, allowing accurate determination of the probability of microorganisms surviving the process, provided that the material to be preserved can be microbiologically examined. In the case in question, it was impossible to disintegrate the skin pieces to a degree where all the microorganisms present could be isolated for counting, but further investigations may lead to a solution.

References

Brouqui, M., Cornuet, R. & Tassigny, C. de. 1978: Traitement par rayonnements gamma, de la momie de Ramses II. – Revue Générale Nucléaire 1: 10–14.