ADMINISTRATION OF RADIOISOTOPE PRODUCTION

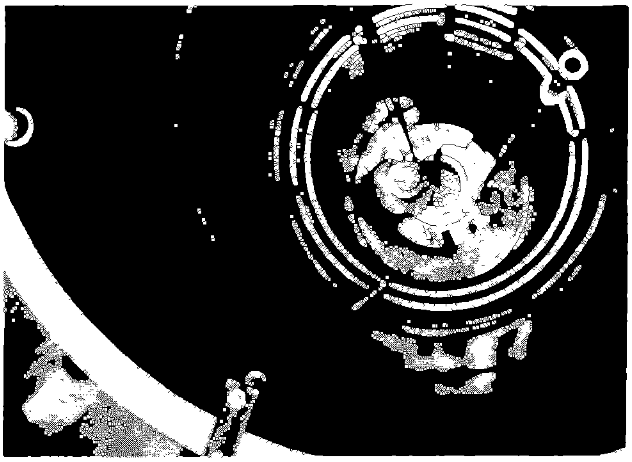
Current developments in atomic energy, and the administrative problems to which they give rise, were surveyed in a seminar on "Atomic Energy for Atomic Energy Administrators" held at IAEA headquarters from 30 September to 4 October 1963. The ground covered included protection against radiation, isotopes and radiation sources, research reactors, nuclear power, legal matters, technical and scientific administration, the role of the universities, and the Agency's part in assistance to developing countries.

The possibilities and limitations of radioisotope production from research reactors were discussed by Dr. G. B. Cook, of the Division of Research and Laboratories, IAEA; a report of his paper is given below. Another paper presented at the seminar was by Dr. U. V. Archangelski, USSR. This is dealt with in a separate article in this issue.

Dr. Cook introduced his subject by comparing radioisotope production in research reactors with the manner in which the large suppliers produce their radioisotopes. The majority of these isotopes are produced in graphite-moderated reactors with a neutron flux of the order of $10^{12}n/cm^2/sec$, the reactor being operated 24 hours a day for, usually, a six-day week. Can these conditions be met by research reactors? In most cases there is adequate space at $10^{12}n/cm^2/sec$ though usually not as much as in the normal isotope-producing reactors, but it is the operating schedule which is not normally based on 24 hours per day which constitutes a considerable difficulty. The reason is simply that it takes three times as long to produce the same specific activity of, say, cobalt-60 in a reactor operating eight hours per day as it does in one operating 24 hours a day. For radioisotopes of shorter half-life, the factor is more than three, because in the shut-down period the source decays appreciably. Regular production becomes difficult if neutrons are available only at irregular intervals, as is common with many research reactors.

In the initial years of development of radioisotopes, medical use has largely defined production. In general, industrial and other requirements can be met within the framework of medical requirements. The commonly-produced radioisotopes can be divided into sealed sources, which require no treatment after irradiation, and processed radioisotopes, which do.

Sealed sources may be medical (for internal application) or industrial. Medical sources are usually required with strengths of the order of 1 - 5 mc of such radioisotopes as gold-198 as "seeds", iridium-192, tantalum-182, and cobalt-60 as wires. The time taken to produce an activity of $2\frac{1}{2}$ mc of each at



Ten kilowatt research reactor, situated at the bottom of a 20-foot, water-filled pit. It has a rotary specimen rack for production of radioisotopes (Photo: General Atomic)

a neutron flux of $10^{12}n/cm^2/sec$ on a 24-hour, 6-day schedule, is respectively 4 hours, 4 hours, 1 week, and 2 weeks. With any research reactor schedule the first two constitute no problem, but the irradiation times of the other two will be considerably prolonged, according to the reactor programme.

Industrial sources will include those for radiography - commonly iridium-192, cobalt-60 and thulium-170. Strengths of the order of 500 mc and more are commonly required, with specific activities of the order of 1000 mc/g or more. Even at continuous operation at $10^{12}n/cm^2/sec$, cobalt requires about a year to attain this value. Iridium is more favourable, and under the same conditions requires an irradiation of less than a week. Thulium-170 is worse than iridium but better than cobalt. Whether the last two are practicable depends on the reactor schedule.

In an industrial programme, a variety of sources must be irradiated, many for activation analysis; for the latter, irradiation times are hours rather than weeks. The sources must be carefully sealed so that breakage or leakage does not damage the reactor.

In medicine, two radioisotopes - cobalt-60 and caesium-137 - are commonly used as large radiation sources for teletherapy. Since quantities of the order of 1000 curies are required, production of cobalt-60 in a research reactor is out of the question. Caesium-137 is also required in similar quantities, and is produced from large quantities of fission product wastes, available in very few countries.

The common requirements for processed radioisotopes are almost entirely for medical treatment. An important consideration is the quantity likely to be used. This is not easy to define, but from the figures of about five countries which are not primary producers of radioisotopes and which have been working with radioisotopes for a few years, the following figures of utilization per year per 10 million of population were compiled:

Iodine-131	5 - 10 curies
Gold-198 (colloidal)	5 - 10 curies
Phosphorus-32	1 - 2 curies
Chromium-51	100 - 150 millicuries
Sodium-24	~100 millicuries
Iron-59	~ 2 - ~ 5 millicuries
Sulphur-35	up to 200 millicuries
Carbon-14	up to 50 millicuries

The first three items are obviously the most important, and their production must be considered. Losses due to chemical treatment and decay are of the order of 50 per cent, so that about twice as much as required must be produced by irradiation to account for these losses. Taking an optimistic reactor operating schedule of 8 hours per day and 6 days per week, the quantities of target material for iodine-131 and phosphorus-32 are of the order of several hundred grams; since we have taken an optimistic schedule the actual quantities may be even larger, and the production is undoubtedly difficult. Gold is somewhat better because of its high cross-section, and can be considered practical. The processing of these radioisotopes also requires properly-designed radiochemical laboratories, which are expensive to build and operate.

It is in the production of short-lived activities which cannot be imported that the research reactor is particularly important. Production requiring only short irradiation times is readily possible in a research reactor schedule, and in general the chemical processing is relatively simple.

In addition to pure production problems, there are many considerations in a regular production programme. Supplies of suitable containers of all sorts for irradiation, storage and shipping must be always available; instruments must be at least duplicated so that failures do not hold up production; transport and customs arrangements must be made; books and records must be kept. Sources for human application must meet certain medical specifications, which can also be troublesome. In all this it is also desirable to keep paper work for the customer to a minimum, and to be as flexible as possible to allow for unusual requests.

The cost of importing all the items in the table from one of the large suppliers is about US $10 000, taking the lower amount, and assuming centralized ordering and a delivery distance of about 10 000 kilometres. It would be very difficult to produce this amount of material for the same cost, but there are other important considerations, such as the development of scientific manpower and techniques, fuller utilization of the reactor, and independence of foreign supplies which must be also considered in addition to the purely financial account.

The Agency is active in three aspects of isotope production:

A manual is being prepared on Production of Radioisotopes with Research Reactors.

In regional meetings on the utilization of research reactors, there is always a section on Isotope Production, with an expert in attendance.

The Agency is collecting information on the safety of experiments carried out with research reactors, which should be particularly useful in helping to decide, for instance, what chemicals and materials can be safely irradiated and what are likely to give trouble.