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# AUSTRALIAN ATOMIC ENERGY COMMISSION
## RESEARCH ESTABLISHMENT
## LUCAS HEIGHTS

# A FIVE YEAR PROGRAMME FOR RADIOISOTOPE PRODUCTION AT THE RESEARCH ESTABLISHMENT

by

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## ABSTRACT

This report summarises plans for radioisotope production at Lucas Heights over the period 1966-71 and indicates how these are based on present trends of demand for radioisotopes. The programme is discussed in terms of available staff and facilities; while some small staff increases will be required, the facilities presently being commissioned should be adequate over this period.

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(g) Fe 59

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## 1. INTRODUCTION

Production of radioisotopes at the Research Establishment began in 1960. Originally the emphasis was on the production of radioisotopes which required the minimum of chemical or other processing. With the gradual improvement of facilities it has been possible to increase the range of products. The completion of the extensions to the Isotope Production Building will enable a substantial increase in production of processed radioisotopes.

Long-term planning of radioisotope production has, during the initial period, been restricted largely to the field of radiography and teletherapy sources. The production of other radioisotope sources has necessarily been on a more ad hoc basis pending the development of facilities and assessment of demand.

The stage has now been reached where it is both possible and desirable to plan for the production of a much wider range of radioisotopes on a long-term basis. This report considers the programme for a five-year period ending in December 1971 and takes into account the experience of the first five years of radioisotope production at Lucas Heights. It also takes into account the policy as approved by the Commission, which was stated as follows:

"Radioisotopes may be produced at Lucas Heights in the following cases, where special circumstances exist or where they can be produced economically -

(i) where the radioisotope has a short half life and it is necessary to produce it locally in order to satisfy domestic requirements, for example sodium-24 and gold-198,

(ii) where importation is uneconomic, for example because of shielding, for example iridium-192 and cobalt-60,

(iii) where production in Australia is necessary in order to ensure continuity and convenience - primarily for medical purposes. These radioisotopes would generally have short lives, for example iodine-131 and phosphorus-32,

(iv) where there is reactor space and surplus reactivity available in the reactor and the cost of irradiations would be trivial in relation to the value of the radioisotopes produced. Examples are cobalt-60 and iridium-192,

(v) activation analysis - producing radioisotopes in situ for particular experiments, for example irradiation of copper in butter, manganese in ore, activation of superphosphate, etc.

(vi) labelling compounds - preparation of a particular radioisotope for

labelling purposes, for example labelling of silt with gold-198, where special factors are involved such as short half life, or the need to irradiate a local material, or cost".

It should be noted that where radioisotopes are produced within the policy stated above, there is generally an advantage to be gained by increasing the scale of production provided that adequate markets can be found for the product.

## 2. ASSUMPTIONS ON WHICH THIS PROGRAMME IS BASED

The proposed programme assumes the following:

(i) That during the next five years there will be an increased demand in Australia and New Zealand for the most commonly used radioisotopes. Justification for this may be found in:

(a) the increasing development and sophistication of Australasian industry, research and medicine,

(b) the world trend to advancing radioisotope technology, and

(c) the growing importance of radioisotopes in medical diagnosis and biological research. (The issue of supplementary regulations to the Therapeutic Substances Act to specify radioactive pharmaceutical preparations should lead to a marked increase in demand for certain items which were hitherto impossible or difficult to obtain).

(ii) That the A.A.E.C. will be able to some extent to penetrate the already existing radioisotope market in South East Asia.

(iii) That a well defined research and development effort by the Radioisotope Production Section is focused on improving routine products, on developing new processes, and, in general, maintaining a level of technical competence in step with that of other radioisotope producers.

(iv) That the present HIFAR irradiation facilities allocated to the Isotope Division will be increased by at least two hollow fuel element positions for fission spectrum neutron activation and possibly two 4V facilities (for bulk cobalt-60 production).

The future activities of the Isotope Production Section are considered under the following headings:

(a) Production of large sealed sources of cobalt-60.

(b) Production of radioisotopes of short and medium half-life which require little post-irradiation treatment.



(c) Radiochemical and radiopharmaceutical preparations.

(d) Service irradiations. (Neutron activation and post-irradiation handling of items supplied by customers).

(e) Other service work. (This includes loading operations of sources into containers and apparatus; the disposal of replaced sources and the examination, repackaging and dispensing of radioisotopes which have been imported in bulk or in units).

## 3. LARGE SEALED COBALT-60 SOURCES

It is expected that the sale of large sealed cobalt-60 sources will continue to provide a large proportion of the revenue from radioisotope trading. The emphasis will continue to be on the production of high specific activity material and of teletherapy sources. It is, however, anticipated that during this period a significant proportion of the cobalt-60 produced could be sold in the form of unsealed bulk sources.

Market assessments have shown that, although the demand for teletherapy sources was fairly constant in Australia, New Zealand, South East Asia, and India in the past three years, a steady increase in demand can be expected up to 1971. There has been an upward trend in other parts of the world, notably Japan, recently and the predicted slump in demand for cobalt-60 due to accelerator developments, did not eventuate. It is expected that the Australian share in world markets will increase as a result of active sales promotion now being carried out.

The present annual production of cobalt-60 at Lucas Heights is approximately 30,000 curies of teletherapy cobalt-60 and about 10,000 curies of low specific activity cobalt-60 for gamma radiation applications. It is proposed to increase this production level over the next five years; improved activation techniques will be used to increase the specific activity of teletherapy cobalt above the present maximum of 250 curies per gram. The feasibility of increasing production in HIFAR of high specific activity cobalt-60 has been examined. Additional cobalt will be irradiated in hollow-fuel-element rigs and this should approximately double the production of cobalt-60.

## 4. PRODUCTION OF RADIOISOTOPES OF SHORT OR MEDIUM HALF-LIFE WHICH REQUIRE LITTLE POST-IRRADIATION TREATMENT

The work involved with this type of radioisotope is only concerned with

target preparation and encapsulation (where necessary), irradiation, post-irradiation measurement and preparation for despatch. Table 2 shows that during the financial years 1964/65 and 1965/66 iridium-192 and cobalt-60 (as level gauge and radiography sources) and gold-198 and yttrium-90 (as medical implants) head the list of unprocessed radioisotopes required. The Table also shows an increase in demand for these products. Approximately sixty other unprocessed radioisotopes are offered in the radioisotope catalogue, but the demand for these is small. The financial return in relation to the effort and resources required for production is very good in the case of iridium-192 and cobalt-60 and it is expected that the demand for these and the other unprocessed radioisotopes, in particular thulium-170 and gadolinium-153, will rise steadily during the next five years. A conservative estimate would predict an increase in demand by a factor of 2 to 3, but very great flexibility in production capacity is now available.

## 5. RADIOCHEMICAL AND RADIOPHARMACEUTICAL PREPARATIONS

Preparation of radiochemical and radiopharmaceutical products involves post-irradiation chemical processing of various degrees of complexity. It is usually necessary to produce the radioisotope in solution in the particular chemical form required by the user. These radioisotopes are used extensively in scientific research, industrial and field tracer experiments, and in medical diagnosis and therapy. The latter applications frequently demand sterile, isotonic, pyrogen-free products. In general the specification for purity and radioactive content is more strict for this type of product than that described in Section 4. . Table 2 shows the pattern of demand for chemically processed radioisotopes in 1964/65 and 1965/66 and Table 3 summarizes some of the principal requirements for medical use.

The details for chemically processed radioisotopes during the financial year 1964/65, given in Table 2, refer only to materials for industrial scientific use. Medical preparations were not on the A.A.E.C. production schedule during that period. The demand for radiochemicals in the industrial and scientific fields is sporadic and highly variable in the quantities required per shipment. For this reason, there are insufficient statistics to predict the future pattern.

The previous pattern of demand for the more popular medical radioisotopes obtainable from overseas is presented in Figure 2. These statistics are taken from the annual report of the Commonwealth X-Ray and Radium Laboratories in Australia and also include the figures for New Zealand published by the National Radiation Laboratory.



Because of legal restrictions, the commencement of production of radiopharmaceutical solutions did not start in Australia until July 1965. Until that date, the medical profession in Australia and New Zealand was virtually without supplies of the short-lived hard gamma emitters, such as sodium-24, potassium-42 and bromine-82, which are very popular overseas. Consequently, there are no demand statistics to give a firm indication of a future requirement in this field. However, it is known definitely that they would be used if available. The long-term planning can therefore only be based on comparable consumption statistics from other countries of similar development. For those radioisotopes which have been used in previous years (Figure 2) it can fairly be assumed that demand will increase by a factor of 2 to 3 in the next five years.

Some of the nearer centres in Asia are also within economic range for supply of the shorter lived radioisotopes and are expected to have some demand for A.A.E.C. products.

In general terms, the radiochemical or radiopharmaceutical preparation requires the greatest effort in skilled manpower in radioisotope production. Therefore, standard stock solutions of a given activity are produced at regular intervals in a shielded facility equipped with apparatus to deal with one or a small number of chemical processes. The economic employment of staff made possible in this method of production far outweighs the incidental waste of radioactive material. All major radioisotope suppliers employ this technique for standard products.

Table 4 and Figure 3 present a production scheme for radiochemicals, based on predicted demands, which is possible with the design of the Radiochemical Wing, Block A, Building 23 at Lucas Heights. This production scheme for radiochemicals has been designed to be flexible enough to cope with credible variations in quantity and frequency of the standard products listed. It is also designed to accommodate production at irregular intervals of non-standard isotopes such as fluorine-18, magnesium-28, iodine-125, iodine-132, molybdenum-99, technetium-99m, and small amounts of fission products, and very large processed sources for industrial and scientific applications.

The preparation of labelled compounds, which are becoming important in scientific research, with a possible few exceptions, is outside the capacity of both the proposed plant and staff complement. Mercury-197 labelled neohydrin (half life 65 hours) is now in demand in Australia and is not satisfactorily available from overseas. Production at Lucas Heights should be possible after

a short period of production development. Commonwealth X-Ray and Radium Laboratory estimates an initial demand of approximately six shipments per week totalling 10-20 mCi. The demand for compounds labelled with other very short-lived radioisotopes is small at present, but demands may arise for medical uses.

## 6. SERVICE IRRADIATIONS

There is small demand for radioactivation of materials supplied by clients for various purposes such as activation analysis and industrial and scientific tracer work. In general, this is very similar to the products described in Section 4, with the client supplying the target material. Any anticipated demand in the future can be accommodated easily in present facilities.

## 7. OTHER SERVICE WORK

The principal service in this category is the importing of non-medical radioisotopes that for various reasons are best obtained from overseas. In general, this includes radioisotopes which cannot be produced in HIFAR, and labelled compounds of long-lived radioisotopes for which the small Australian demand does not at present justify local production. (See Table 5). Apart from the administrative aspects of procurement, all imported radioisotopes are inspected for safety reasons and to ensure that the import meets the customers' specification. A small part of the handling facilities available has been allocated for this service. Where sufficient demand exists it is anticipated that some of the radioisotopes will be imported in bulk and dispensed at the Research Establishment for distribution in small lots.

Other miscellaneous service work includes the loading of sources into clients' equipment, special encapsulations to order and the disposal of replaced or spent sources.

## 8. FACILITIES

### (a) Large Sources of Cobalt-60

The cobalt-60 handling cell and its necessary ancillaries are now in full-scale operation and it is unlikely that any major additions or alterations will be required over the next five years. The only facility demands for this aspect of the programme will involve new irradiation rigs and a small increase in the number of heavily shielded transport containers.

### (b) Non-Processed Radioisotopes of Short and Medium Half-Life, Service Irradiations and Miscellaneous Services

All facilities necessary to achieve the programme outlined in Sections 4, 6,



and 7 are either in existence or in an advanced state of design and construction. Figure 1 is a diagram of the materials flow when all these facilities are in operation. It demonstrates that the shielded cells on the northern part of the radioisotope handling bay in Building 23, presently used exclusively for the manufacture of unprocessed radioisotopes, will also be required for the initial post-irradiation handling of activated substances which will be chemically processed in Building 23A. This requirement must be accounted for in the assessment of the maximum activity allowable in the cells. In order to avoid undue handling problems some increase in the present shielding of these facilities must be incorporated in the building programme for the period under review.

These facilities will cope with practically all the demands made by service irradiations and the other miscellaneous service activities, including dispensing of gaseous radioisotopes which have been imported in bulk.

### (c) Radiochemical and Radiopharmaceutical Preparations

The radiochemical facilities in Building 23A will be capable of handling the programme envisaged for the next five years. Figure 3 relates shielded facilities in this laboratory and staff effort to this programme.

## 9. RESEARCH AND DEVELOPMENT

A definite proportion of staff effort, materials, and facilities of the Radioisotopes Production Section is set aside to improve the quality of present products and processes and develop new products for which demands arise and which can be made using local resources.

A general programme of research and development has been drafted and is now operational. In the development of new products the programme favours, in principle, the short-lived radioisotopes. It is divided into the following categories:

### (i) Chemistry

Projects in this field are directed towards the development of techniques to produce radiochemical compounds and control certain quality aspects on a routine basis. Rapid and reliable chemical separation methods with the object of producing carrier free radiochemicals, which are the product of other than $(n,\gamma)$ activation reactions or daughter products, are a highlight in this research.

### (ii) Physics

The physics research programme is devised to develop suitable activity

measurement techniques for the determination of the radioactive strength and radioisotopic purity of products. It also is concerned with a fuller understanding of activation processes and mechanisms in reactors or other activity inducing devices.

(iii) Engineering and Metallurgy

The effort in this field is directed towards the development of more efficient activation techniques in HIFAR, improvement of transport and handling-container designs for radioactive materials, safe and efficient encapsulation methods for radiation sources, (in particular those with low penetrating power), and shaping of metallic radiation sources, notably cobalt-60.

## 10. STAFF

The present staff allocation is shown in Table 1. It is difficult to make an accurate prediction of the staffing requirements for the Section over as long a period as five years. This is primarily because staff requirements are affected by the demand for various local radioisotope products. During the last year this demand rose sharply. If, as expected, the demand continues to increase steadily, further staff would be required to maintain the required production. Over the five year period under consideration, approximately five more staff would be needed, mainly to assist in the production of processed, short-lived radicisotopes.

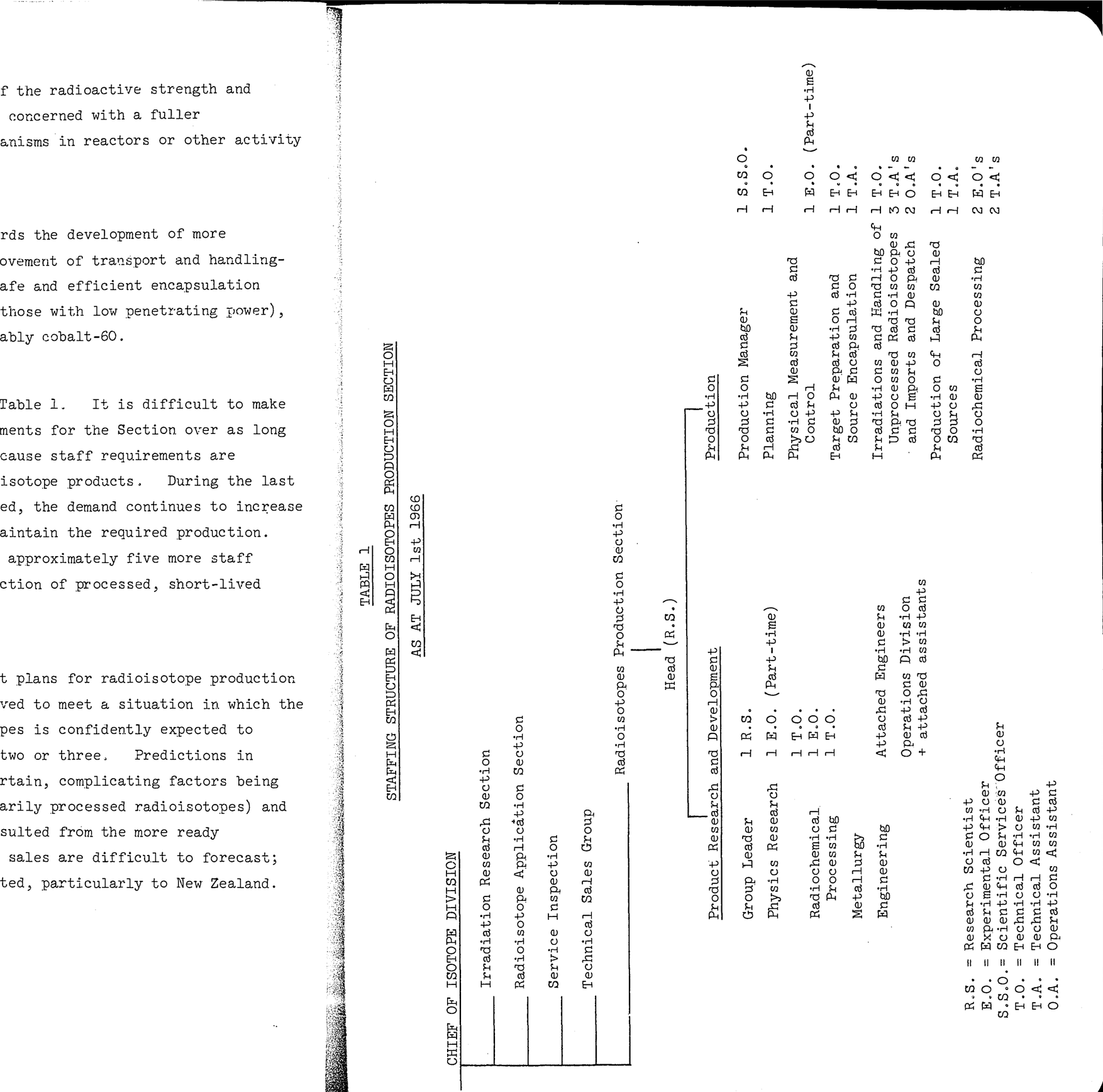
## 11. CONCLUSION

This report gives a summary of the current plans for radioisotope production at Lucas Heights. These plans have been evolved to meet a situation in which the overall demand for locally produced radioisotopes is confidently expected to increase by a factor of, on average, at least two or three. Predictions in relation to specific radioisotopes are less certain, complicating factors being changes in medical practice (this affects primarily processed radioisotopes) and the general stimulation of demand which has resulted from the more ready availability of the local products. Overseas sales are difficult to forecast; however, a steady increase in exports is expected, particularly to New Zealand.

TABLE 1

STAFFING STRUCTURE OF RADIOISOTOPES PRODUCTION SECTION

AS AT JULY 1st 1966




R.S. = Research Scientist
E.O. = Experimental Officer
S.S.O. = Scientific Services Officer
T.O. = Technical Officer
T.A. = Technical Assistant
O.A. = Operations Assistant

TABLE 2

SHIPMENTS OF RADIOISOTOPES IN SIGNIFICANT DEMAND PRODUCED BY THE RADIOISOTOPES PRODUCTION SECTION FROM JULY 1964 TO JUNE 1966 (EXCLUDING COBALT-60 TELETHERAPY AND LARGE GAMMA RADIATION SOURCES)

| RADIOISOTOPE | UNPROCESSED | | | | PROCESSED | | | |
|---|---|---|---|---|---|---|---|---|
| | Activity (mCi) | | No. of Units Consigned | | Activity (mCi) | | No. of Units Consigned | |
| | 1964/65 | 1965/66 | 1964/65 | 1965/66 | 1964/65 | 1965/66 | 1964/65 | 1965/66 |
| Ir-192 | 748,600 | 1,161,940 | 59 | 103 | - | - | - | - |
| Co-60 | 12,300 | 21,283 | 40 | 483 | - | - | - | - |
| Tm-170 | - | 2,131 | - | 5 | - | - | - | - |
| Au-198 | 3,100 | 2,270 | 47* | ø603 | 36,100 | 8,505 | 8 | 17 |
| Y-90 | 700 | 1,159 | 42* | ø267 | - | - | - | - |
| Cr-51 | 0.5 | - | 1 | - | +306,200 | 102,000+ | 19 | 65 |
| P-32 | - | - | - | - | - | 2,436 | - | 197 |
| Na-24 | 2,700 | - | 14 | - | 800 | 1,687 | 8 | 45 |
| K-42 | 40 | - | 2 | - | 120 | 825 | 6 | 10 |
| Br-82 | - | - | - | - | - | 41 | - | 51 |
| Gd-153 | - | 22 | - | 2 | - | - | - | - |
| Rb-86 | - | - | - | - | 20 | 108 | 4 | 10 |
| Ca-45 | - | - | - | - | 8 | 44 | 4 | 19 |
| Service Irradiations | | | 279 | 139 | | | | |
| TOTAL | | | 491 | 1503 | | | 49 | 414 |

* Refers to shipments

ø Refers to units. Unit system adopted with introduction of computer data storage. For example a shipment of Au-198 may contain up to 15 units - a shipment of Y-90 up to 5 or 6.

\+ Substantial proportion used by A.A.E.C. in hydrological studies.

TABLE 3

THE APPLICATION OF ARTIFICIAL RADIOISOTOPES IN MEDICINE AND BIOLOGY

| Application, or Suggested Application, in Medicine | Isotope | Application in Biological and Physiological Research |
|---|---|---|
| Therapy: whole body irradiation, erythropoeisis, polyglobuly. | Fluorine F-18 | Physiology and chemistry of bones and teeth. |
| Diagnosis: circulation measurements with Na-24 labelled plasma. Determination of the extravascular space according to the dilution method. Blood circulation in extremities and organs. Cardiac insufficiency. | Sodium Na-24 | (Also Na-22) Excretion resorption; permeability of capillaries, gastric mucosa, intestinal walls, placenta, organic cell walls. Distribution between plasma and tissue. Ion transport. |
| Therapy: surface therapy of deformities and malformations, skin lesions, eczema. Chronic leukaemia and polycythaemia. Selective irradiation with colloids containing P-32.<br>Diagnosis: blood volume determinations and circulation diagnosis with P-32 labelled erythrocytes. | Phosphorus P-32 | Mineral metabolism, intermediary metabolism. |
| Therapy: experiments with selective irradiation of the joints.<br>Diagnosis: recent investigations regarding sulphur accumulation in tumours. | Sulphur S-35 | Permeability studies. Intermediary metabolism. Metabolism of sulphur-containing amino-acids and peptides. S-35 labelled pharmaceuticals. Mineral metabolism. |
| | Chlorine Cl-36 Cl-38 | Mineral metabolism, permeability, ion transport through membranes. |
| | Potassium K-42 | Mineral metabolism, adrenal physiology. |
| | Calcium Ca-45 Ca-47 | Mineral metabolism, incorporation of Ca in the bones of rachitic and vitamin-D treated animals. Bone healing. |
| Diagnosis: blood volume and circulation studies with Cr-51 labelled erythrocytes. | Chromium Cr-51 | Plasma-albumin investigations with $^{51}CrCl_3$. |
| Therapy: local irradiation of lymph nodes. Distribution of colloidal $MnO_2$ in the reticuloendothelial system. | Manganese Mn-52 Mn-54 | Mineral metabolism. |

Continued.

TABLE 3 (Continued)

| Application, or Suggested Application, in Medicine | Isotope | Application in Biological and Physiological Research |
|---|---|---|
| Diagnosis: blood volume; lifetime of erythrocytes | Iron<br>Fe-55<br>Fe-59 | Mineral metabolism, blood physiology, resorption by gastric and intestinal mucosa. Distribution of Fe in the organism. Blood preservation. |
| Therapy: telecurie therapy external (high depth doses). Co-wire for local application. Intracavitary cobalt chloride solution in rubber bags as cavity applicator (bladder). | Cobalt<br>Co-60 | Mineral metabolism. |
| Therapy: intratumoral therapy. Zn-63 as insoluble sulphide and as sol: intraperitoneal and intrapleural application. Zn-63 in coarse-disperse sulphide form results in selective fixation in the lungs. | Zinc<br>Zn-63<br>Zn-65 | Mineral metabolism. Lifetime of leucocytes. |
| | Bromine<br>Br-82 | Electrolyte exchange. Thyroid physiology, distribution of brominated dyes. |
| Diagnosis: minute-volume determination | Krypton<br>Kr-85 | Respiratory gas exchange. |
| Therapy: therapy of bone sarcoma. | Strontium<br>Sr-89 | Absorption-distribution-excretion. Bone physiology. |
| Therapy: selective irradiation of the thyroid. Treatment of hyperthyroidism, thyroid carcinoma, diffuse and nodular struma.<br>Diagnosis: thyroidal dysfunction. Localization of tumours by means of I-131 diiodofluorescin. | Iodine<br>I-131 | Iodine metabolism. Thyroid physiology. |
| Therapy (i) in insoluble form (pectin sol) for intra-cavity treatment. Peritoneal and pleurocarcinosis. Intratumoral therapy.<br>Therapy (ii) as metallic gold seeds for tumour implantation. | Gold<br>Au-198 | Absorption-distribution-excretion; distribution in arthritis. |
| Diagnosis: as a labelled diuretic Neohydrin-Hg-197 in the scanning of brain tumours. | Mercury<br>Hg-197 | |
| Diagnosis: in various chemical forms for the visualisation and study of several organs. | Technetium<br>Tc-99m | |

Continued.



TABLE 3 (Continued)

| Application, or Suggested Application, in Medicine | Isotope | Application in Biological and Physiological Research |
|---|---|---|
| Therapy (i) as colloidal yttrium silicate - alternative agent to colloidal gold.<br>Therapy (ii) as ceramic yttria rods for pituitary gland ablation. | Yttrium<br>Y-90 | |
| | Magnesium<br>Mg28 | Mineral metabolism. |

TABLE 4

STANDARD RADIOCHEMICAL PRODUCTS TO BE PRODUCED AT LUCAS HEIGHTS BETWEEN 1966 AND 1971

| Radioisotope | Half Life | Production Process | Anticipated Regular Batch Size for Stock: Frequency. | Probable Chemical Forms (other demands may arise) | Field of Expected Usage |
|---|---|---|---|---|---|
| Potassium-42 | 12.5 hr. | $^{41}K(n,\gamma)^{42}K$ | 50 mCi/week | Isotonic chloride solution | Medical |
| Sodium-24 | 15 hr. | $^{23}Na(n,\gamma)^{24}Na$ | 100 mCi/week | (i) Solid carbonate<br>(ii) Isotonic chloride solution | (i) Industrial<br>(ii) Medical |
| Bromine-82 | 36 hr. | $^{81}Br(n,\gamma)^{82}Br$ | 100 mCi/week | $NH_4^+$, $Na^+$ or $K^+$ bromides, isotonic soln. if required. | Industrial and medical |
| Iodine-131 | 8 d | $^{130}Te(n,\gamma)^{131}Te \xrightarrow{\beta} {}^{131}I$ | 1000 mCi/week | (i) Iodide in NaOH<br>(ii) Iodide in $Na_2S_2O_3$<br>(iii) Iodide in isotonic buffer | (i) Protein labelling<br>(ii) Medical-oral administration.<br>(iii) Medical-parenteral administration |
| Phosphorus-32 | 14 d | $^{32}S(n,p)^{32}P$ | 1 Ci/month | (i) $PO_4$ in dilute HCl<br>(ii) $PO_4$ in isotonic buffer | (i) Scientific, indust'l and medical research<br>(ii) Medical-parenteral administration |
| Chromium-51 | 27.8 d | $^{50}Cr(n,\gamma)^{51}Cr$ | 100 mCi/month | (i) Aqueous chromic chloride<br>(ii) Isotonic chromic chloride<br>(iii) Isotonic potassium chromate | (i) Industrial<br>(ii) Medical-general protein labelling<br>(iii) Medical-red blood cell labelling |

Continued.



TABLE 4 (Continued)

| Radioisotope | Half Life | Production Process | Anticipated Regular Batch Size for Stock: Frequency | Probable Chemical Forms (other demands may arise) | Field of Expected Usage |
|---|---|---|---|---|---|
| Copper-64 | 12.8 hr. | $^{63}Cu(n,\gamma)^{64}Cu$ | 100 mCi/week | (i) Aqueous chloride soln.<br>(ii) Isotonic EDTA complex | (i) Industrial and Scientific Research<br>(ii) Medical |
| Yttrium-90 | 64.5 hr. | $^{89}Y(n,\gamma)^{90}Y$ | 100 mCi/week | (i) $YCl_3$ aqueous solution<br>(ii) Yttrium silicate colloid | (i) Industrial<br>(ii) Medical |
| Gold-198 | 2.7 d | $^{197}Au(n,\gamma)^{198}Au$ | 100 mCi/week | (i) Aqueous auric chloride<br>(ii) Gold colloid | (i) Industrial<br>(ii) Medical |
| Technetium-99m | 6.0 hr. | $^{98}Mo(n,\gamma)^{99}Mo \xrightarrow{\beta} {}^{99m}Tc$ | 2 Ci/week | (i) Pertechnetate generator<br>(ii) Colloidal heptasulphide<br>(iii) Labelled albumin | Medical |
| Magnesium-28 | 21.3 hr. | $^{26}Mg(t,p)^{28}Mg$ | 20 mCi/month | Isotonic chloride solution | Medical |
| Mercury-197 | 67 hr. | $^{196}Hg(n,\gamma)^{197}Hg$ | 50 mCi/week | Labelled neohydrin isotonic solution | Medical |
| Calcium-47 | 4.7 d. | $^{50}Ti(n,\alpha)^{47}Ca$ | 10 mCi/month | Isotonic chloride solution | Medical |
| Fluorine-18 | 1.7 hr. | $^{16}O(t,n)^{18}F$ | 20 mCi/month | Isotonic sodium fluoride solution | Medical |

TABLE 5

RADIOISOTOPES FOR WHICH PRODUCTION BY A.A.E.C. IS AT PRESENT NOT POSSIBLE OR DESIRABLE AND WHICH WILL NORMALLY BE IMPORTED

| | Radioisotope Preparation | Reason Not Produced by A.A.E.C. |
|---|---|---|
| 1. | Accelerator produced neutron deficient isotopes | Australian accelerator resources are very limited. |
| 2. | Fission products | Expensive and complex plant required, but may be justified in some instances, e.g. Tc99m . |
| 3. | Tritium and other radioactive gases | Supply assured from overseas - no transport problems. |
| 4. | Tritiated water | as 3 above. |
| 5. | Labelled compounds of carbon-14, tritium-3, sulphur-35, selenium-75, chlorine-36 and iodine-131 | Extensive resources and highly trained staff required, and not normally economic. |
| 6. | Special sources (e.g. tritium-3 targets, Mossbauer) | Very small Australian demand. |
| 7. | Processed radioisotopes not produced by A.A.E.C. | Many processed radioisotopes will be imported, especially those of long half-life. |

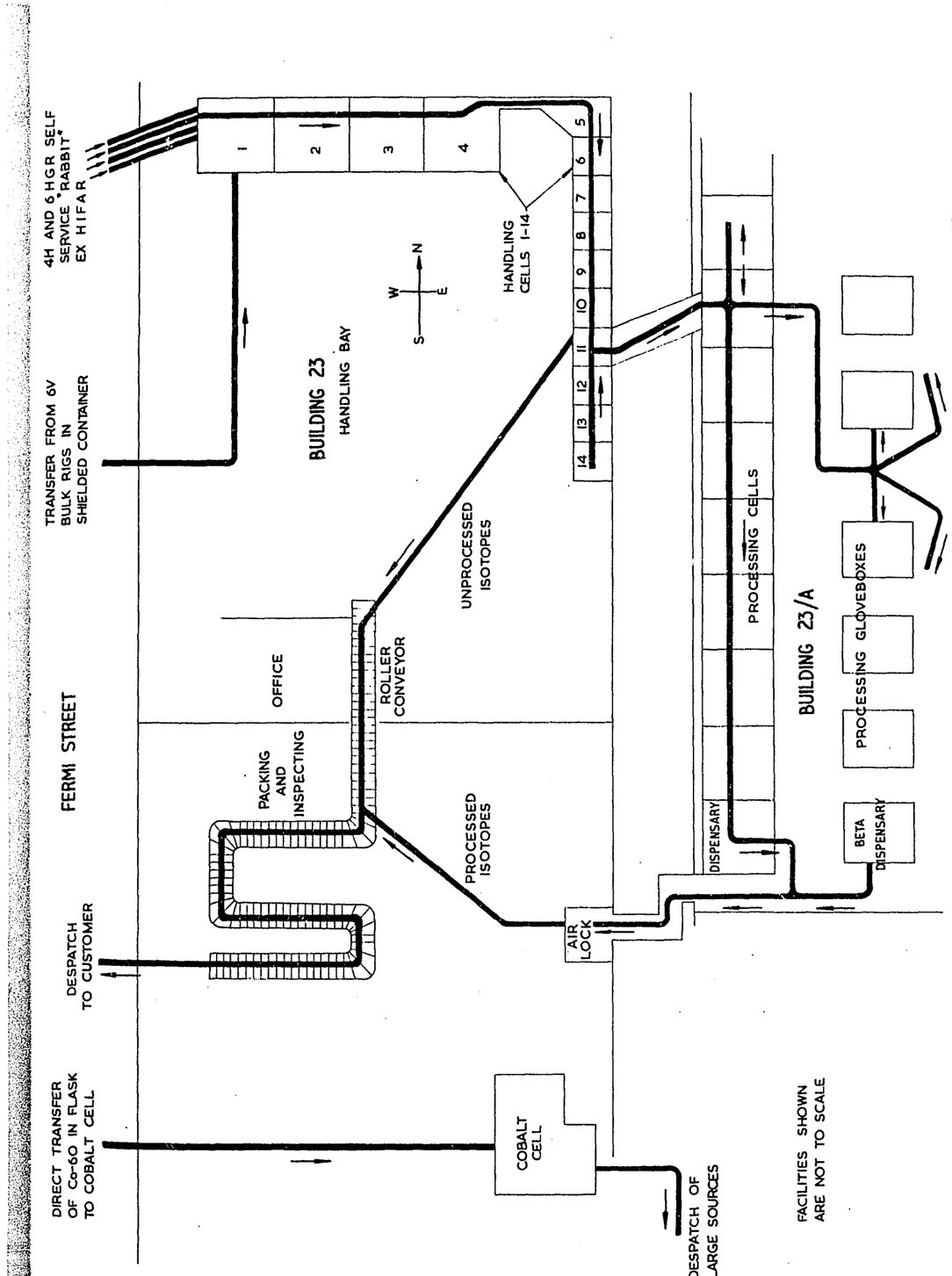
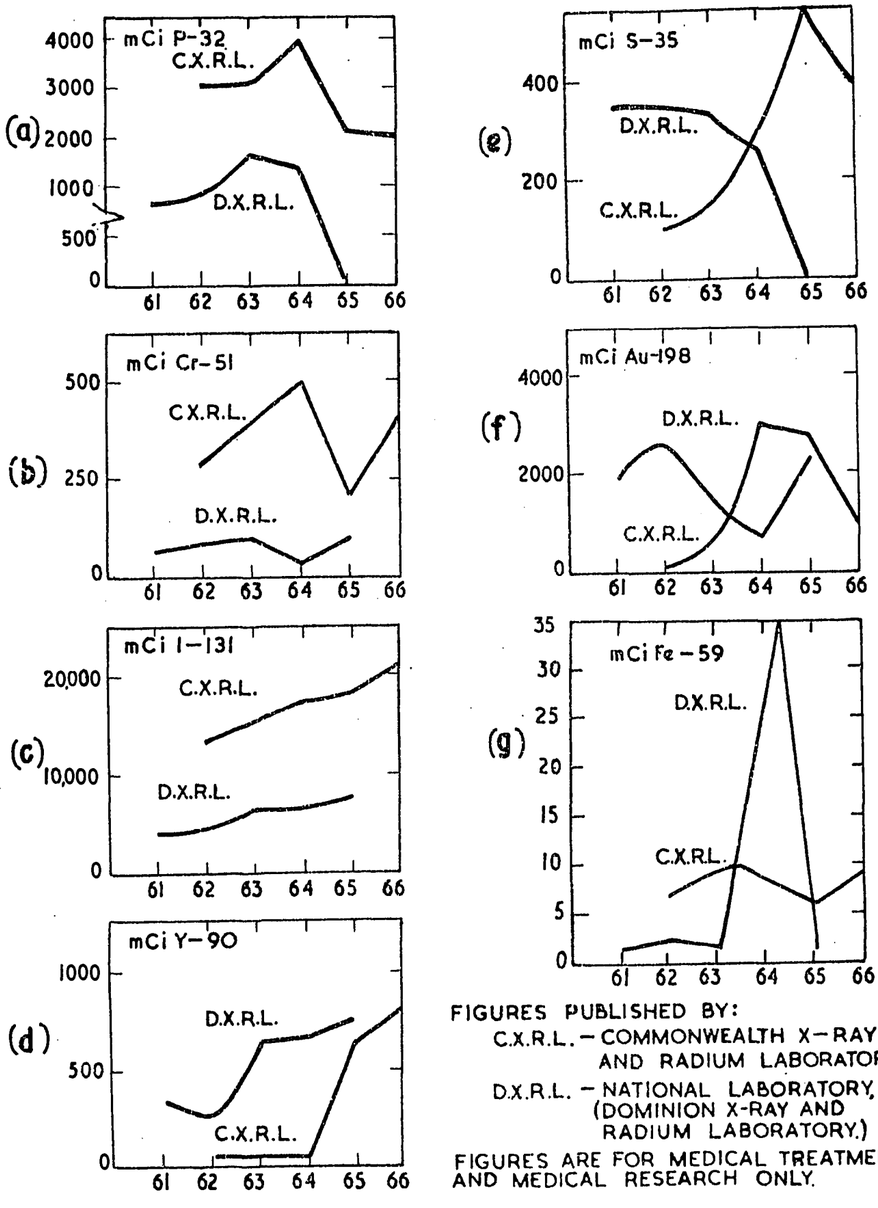



FIGURE 1. DIAGRAM OF MATERIAL FLOW IN THE PRODUCTION OF RADIOISOTOPES AT THE A.A.E.C. RESEARCH ESTABLISHMENT

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FIGURES ARE FOR MEDICAL TREATMENT AND MEDICAL RESEARCH ONLY.

# FIGURE 2. AUSTRALASIAN USAGE OF MEDICAL RADIOISOTOPES