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ANSTO Camperdown Decommissioning Licence Application

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Radiation Protection Plan for Decommissioning of the ANSTO Camperdown Facility

(Rev. 1)

Prepared By

Australian Nuclear Science and Technology Organisation

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1 Purpose and Scope

The purpose of this Radiation Protection Plan is to describe the organisational arrangements and procedures for the control of exposures to ionising radiation during all decommissioning activities at the ANSTO Camperdown facility. This includes decommissioning of the

- IBA "Cyclone 30" 30MeV Cyclotron (known as the National Medical Cyclotron) – a Prescribed Radiation Facility – and
- Radiopharmaceuticals Operations (Camperdown) – a Nuclear Installation

both facilities authorised under combined licence F0044-5A, 5B, 5C.

For convenience, these two facilities are referred to as "the facility" in this plan.

The plan outlines the systems and processes that ensure compliance with standards and regulatory requirements on radiation protection and the application of optimisation of protection measures at the facility.

This plan applies to all activities associated with the dismantling, disassembly and removal activities at the facility, its adjacent areas and the radiation protection of all personnel in the facility. This plan will interface with the relevant decommissioning, waste management, environmental management, and safety plans. It is consistent with international best practice in particular, with ICRP and IAEA standards and guidelines on protection against the effects of ionising radiation.

In addition to the outline of systems and processes for radiation protection, this plan provides details of processes and associated dose estimates and dose constraints in relation to the decommissioning (including dismantling, packaging, transport and storing) of contaminated and activated structures, equipment and materials in the

- Cyclotron Vault (room 0053);
- PET beam room (room 0059);
- GMP Area (rooms 0037 & 0038);
- Control Room (room 0043); and
- other non-active areas.

Details of processes and associated dose estimates and dose constraints in relation to the decommissioning of the North and South SPECT beam rooms (rooms 0051 and 0059 respectively) and the SPECT Laboratory (rooms 0048 and 0049) will be provided separately when more details are available.

Dose estimate data provided in this plan has been derived from cyclotron vault, PET beam room and other room survey data and the estimated exposure durations for staff. (Ref 14, 15)

2 Responsibilities

ANSTO's Major Project Delivery Office (MPDO), which is a part of the Engineering and Capital Programs (ECP) will manage the decommissioning activities at Cyclotron Camperdown Site. MPDO gained adequate experience in executing HIFAR safe enclosure projects (under the Possess or Control Licence) and the dismantling of Moata Reactor. The decommissioning team has demonstrated a strong radiation safety culture in all activities. Personnel from the MPDO, Campus Services and Waste Operations (WO) are trained and assessed for their specialist skills and take responsibility for ownership of radiation safety. Decommissioning of the facility will be undertaken under the guidance of the ECP.

The Facility Nominee and all individuals (staff and contractors) are responsible for applying the OHSE management system, procedures and instructions to ensure radiation exposures are as low as reasonably achievable (ALARA) and within limits and constraints.

2.1 The Nominee and Facility Officer

General Manager ECP is the Nominee of the Cyclotron Camperdown decommissioning. The Project Organisation for this dismantling, with roles and responsibilities of key personnel, are described in The Effective Control Plan AC-D-LA-EGa. The Camperdown Works Coordinator is the Facility Officer and responsible for ensuring systems, procedures and technologies are available to ensure compliance with radiation safety standards and optimised radiation protection of all individuals.

2.2 Radiation Protection Adviser (RPA)

The RPA advises the facility management/leaders, supervisors, contactors/consultants and others on radiation protection issues, safe working practices, standards and the optimisation of operational radiation protection measures. The RPA has professional qualifications and experience in applied health physics and radiation protection.

The RPA assists with improvements in radiation safety on a day-to-day basis through input into the Safe Work Method and Environmental Protection Plan (SWMS) and through changes to individual dose constraints and dose rate constraints. Monitoring programs and their implementation are advised and reviewed by the RPA. Advice on licensed source handling and storage, radioactive waste and transport of activated materials are given by the RPA and Health Physics Surveyors (HPS).

The RPA advises on the development, application and modification of Camperdown facility dismantling procedures, instructions and written work systems for all activities where radiological safety assessment is required.

The RPA is supported by Health Physics Surveyors (HPSs) who have been accredited in providing radiation protection and monitoring services. The RPA and HPS are empowered to advise the temporary suspension of work if the radiological dose rates or contamination levels are deemed to be in excess of the reference levels, constraints or not as planned.

3 Radiation Protection Principles

ANSTO is committed to maintaining standards of radiation safety recommended by the International Atomic Energy Agency, (IAEA), the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), and through the application of its radiation safety management systems. ANSTO Radiation Standard (AS 2310) applies to ANSTO controlled facilities and controlled sources. ANSTO is committed to keeping all radiological exposures to As Low as Reasonably Achievable (ALARA), social and economic factors being taken into account.

3.1 Radiation Dose Limits

Individual doses due to the combination of exposures from all ANSTO activities must not exceed the specified annual effective dose limits and equivalent dose limits recommended by ARPANSA and NOHSC: Recommendations for Limiting Exposure to Ionizing Radiation and National Standard for Limiting Occupational Exposure to Ionizing Radiation, ARPANSA Radiation Protection Series RPS No.1 2002. All personnel working in the classified radiation and contamination areas during facility decommissioning will be regarded as occupationally exposed. For occupational exposure, the effective dose must not exceed:

- 20 millisieverts (mSv) annually, averaged over five consecutive years
- 50 millisieverts (mSv) in any single year.

For occupational exposure, the equivalent dose must not exceed:

- 150 millisieverts to the lens of the eye
- 500 millisieverts to the hands and feet
- 500 millisieverts to the skin (average dose received by any one square centimetre of skin).

An annual dose constraint of 15 mSv (effective dose) is also to be applied. (AS 2310).

3.2 Optimisation of Radiation Protection and Safety

The magnitude of individual doses, the number of people who are exposed, and the likelihood of incurring exposures to radiation, must be As Low as Reasonably Achievable (ALARA), taking into account economic and social factors. (As per AS 2310 and related guides).

The ALARA principle will be applied by the use of dose constraints on individual or groups of tasks, or for day to day dose control. It also is intended that individual doses for the decommissioning process (estimated time period approximately 6 weeks) for the Cyclotron Vault components, PET beam room contents, the transport, unloading and storage of all these components will be well below the ALARA assessment value of 2mSv with the most exposed individual's potential dose between 0.9mSv and 1.0mSv.

A summary of individual dose and collective dose estimates for this phase is included in Appendix A including the dismantling, transfer and unloading of these components. As noted in Section 8, the doses to personnel due to long term storage are not significant. The tasks to be undertaken are grouped and estimates of exposure times and dose rates for the individuals involved in performing the tasks are given. The derived recommended dose constraints are also presented and reproduced for convenience in table 3.1 below.

The effects of engineering and administrative control and dose reduction methods have been taken into account in the assessment where possible.

As the most activated and highest dose rate components are removed, the hazards are progressively reduced. This has been considered in deciding the order of removal.

The potential collective dose from the identified tasks has been estimated at 3.0 man-mSv with an average individual effective dose to personnel of 0.37mSv. The highest potential individual dose for these tasks is estimated to be 984μSv (1mSv). These dose estimates are based on conservative estimates of dose fields, exposure times and numbers of personnel involved (8) and serve as a guide to radiation protection planning throughout the decommissioning. These potential doses are considered acceptable (and in fact are ALARA without further consideration of optimisation), and during the work where opportunities arise for further dose reductions these will be reviewed by staff including the RPA.

Table 3.1 – Summary of Recommended Decommissioning Dose Constraints (Phase 1)

Type	Recommended Constraint
Individual Effective dose constraint	1 mSv
Individual extremity (skin) dose constraint	10 mSv
Collective Dose	3 man.mSv

4 Radiological Hazards

The radiological hazards associated with the dismantling activities are mainly in the form of gamma dose rates from the activated material removed from Vault Rm G53, the cyclotron tank and connected beam line components and the beam rooms, G51, G59 and G61. These activation products have been identified as Co-57, 60, Zn-65, Mn54, and to a lesser degree Fe-59, Co-56, 58, Na-22. The hazards associated with dismantling, packing, storage, removal and transport activities are the external gamma dose rates from the activated components and to a lesser extent, from contamination.

Characterisation activities to take samples of activated materials to ascertain the specific activity in Bq per gram (Bq/g), together with measured dose rates allows best practical techniques and dose reduction techniques to be assessed and implemented. The measurements on individual components also allow the specific activity to be assessed for transport categorisation. Indications so far are that most of the activated components will be either exempt or Low Specific Activity-1 (LSA-1) as either unpackaged solid objects or in Industrial Package-1 (IP-1) categories.

Dose rates for some of the tank components range from several mSv/h at contact with the components to one or two µSv/h for less active pieces. Those metal activation product gamma emitters with higher energies are believed to be major contributors to the dose rates (radiological hazards) measured i.e. Co-60, Zn-65, Mn-54.

Time, distance and shielding will be adopted to reduce the radiation exposure while carrying out the decommissioning activities. .Detailed radiation dose estimates (both individual and collective doses) for the Stage 1 dismantling tasks are included in Appendix A. All personnel involved with the decommissioning tasks will be using appropriate monitoring and PPE as advised by the Radiation Protection Adviser (see section 6). To reduce external exposures, lifting equipment, trolleys and containers will be utilised. Some shielded containers will also be used for shielding smaller higher dose rate components.

5 Radiological Classification of Areas

AS 2310 and Classification of contamination and radiation areas (AG 2509) explains the system of radiological classification of areas employed to control or limit occupational exposure (actual or potential) to ionising radiation. Initial area classifications are based on measured values of radiation and contamination levels and the occupancy times of staff in those areas during decommissioning. Previous exposure data during shutdowns were also reviewed.

For the dismantling of the components in the cyclotron vault, G53, and PET beam room, G59, the areas will be blue contamination and red radiation. The SPECT beam rooms may be used for temporary storage of dismantled items. They are currently classified as red contamination and red radiation and are suitable for this storage. When no contamination hazard exists and higher dose rate items are removed, the areas maybe changed to white contamination and blue radiation and finally for the majority of rooms to white, white levels. A SWMS will describe the detailed operation, with identification of the hazard and the necessary controls to minimise the radiation hazards. Surveys have been undertaken at each stage to assess decay rates. Together with data on task durations and processes for dose reduction, estimates of individual and collective doses have been undertaken and used for effective planning and dose control. Appendix A summarises this data for Vault (Rm G53) and associated beam lines which link the vault with the adjacent beam rooms containing activated components (PET beam room G59 also included). Dose reduction options have been assessed and optimised.

The Area Supervisor, Responsible Officer and the RPA shall review the radiation and contamination classification of these areas during dismantling activities. Radiological data obtained from installed and portable monitoring, dosimetry results and occupancy factors will decide if any changes to area classifications are required during the decommissioning activities.

The Cyclotron basement will continue to be used for activated item segregation, handling and storage and is designated as a blue contamination, blue radiation area. The transfer routes between dismantling and storage areas in the building will be reclassified as advised by the RPA.

5.1 Barrier Procedures to Contamination Areas

Barrier procedures will be implemented to ensure contamination areas comply with AG 2510. Entry and exit by all persons will be via the appropriate change barrier. All persons must wear the appropriate personnel monitoring dosimeter and wear clothing and respiratory equipment appropriate for the contamination classification of the area. These barrier procedures force the checking of possible contamination prior to exit from the radiation and contamination areas.

Access routes will also be reviewed by the RPA from time to time and whenever a classification change is made, so as to minimise the chance of cross contamination.

6 Radiation Monitoring Programs

6.1 Introduction

Monitoring is the collection of information about radiological conditions in the workplace and the evaluation of this information (workplace/area monitoring). This, together with information on exposures to individuals (dosimetry results), assists in confirming that safe working practices and engineering standards are in place and radiological hazards are under effective control. Monitoring of the workplaces and individuals involved in this project will occur continuously throughout the facility decommissioning. The monitoring programs that demonstrate adequate protection and optimisation of the protection measures are described in two parts. The first is based on measurements or 'surveys' taken in the workplace. The second is based on measuring individual exposures to radioactive (activated) components and contaminated items/ waste; 'individual monitoring', also known as dosimetry using Thermo Luminescent Dosimeters (TLDs) and Electronic Personal Dosimeters (EPDs).

6.2 Workplace and Area Monitoring

The purpose of routine area monitoring during the decommissioning activities is:

- to confirm effective control of dose rates and contamination levels in classified areas as per SWMS and the specially designed engineering features (e.g. lifting equipment of activated large item, trolleys, containers and shielding).
- to confirm/review the area classifications of areas described in section 5 of this plan and any changes in radiological hazards and conditions;
- to evaluate actual and potential dose rates, potential surface and airborne contamination levels.

Instrumentation used to perform measurements is described in section 6.4. Dose rate monitoring of the containment ventilation filters and management of liquid and solid active wastes is continuing throughout maintenance and decommissioning.

Task-related area monitoring is any dose rate or surface contamination measurements using equipment that is similar to that described for routine area monitoring. Dose reduction assessment monitoring is being undertaken during the dismantling of tank, beam line and radioactive cell components as described in the plan.

6.3 Individual monitoring (dosimetry)

Individual monitoring (dosimetry) is the measurement, assessment and evaluation of radiological exposure information to an individual. Occupationally exposed workers are monitored as part of the routine dosimetry program, Personal Dosimetry (guide) AG2521. Monitoring may also be performed for reassurance purposes.

External monitoring using TLDs for effective (whole body) and extremity (wrist TLDs) dosimetry is employed in this decommissioning project. TLD issue/assessment periods are monthly. Individual monitoring using EPDs for immediate whole body dose assessment is also employed for task and day to day dose control. Specific task numbers are used to evaluate individual and collective doses against tasks and exposure times. EPD and TLD records may be used for incident/event investigations of exposures.

At the contamination area barrier, personnel leaving the area will remove protective clothing (e.g. coats, overshoes, gloves) and use monitoring equipment for detection of contamination as per *Entry to and exit from classified radiation areas (guide) AG 2510* (e.g. fixed and portable equipment). Individual monitoring for internal dosimetry is performed by whole body counting for gamma emitting contaminants, as required depending on the work type (AS 2310).

Reference levels for individual (occupationally exposed worker) values exist in the form of Investigation Levels. The investigation levels are set at 1mSv per month for effective dose, and 40mSv per month for skin or hand doses. Investigations are performed by an RPA, and the results are discussed with line management. It is planned that over the dismantling project (approx 6 weeks) individual doses will be lower than the investigation levels. For the Phase 1 work, dose constraints are given in section 3.2. These shall be reviewed regularly by the RPA and project management during the project. Appendix A gives a break down and summary of potential dose estimates. The estimated potential collective dose for 8 individuals is 3.0 man-mSv for the 6 weeks, with an overall average individual dose of 0.37mSv.

6.4 Radiation Monitoring Equipment

The radiation monitoring equipment that will be used in The Cyclotron Dismantling Project will consist of a combination of fixed and portable instrumentation designed to monitor the radiological conditions and the personnel throughout the facility.

The fixed radiation monitors indicate the dose rates in the work areas and alarm at specific levels indicating when action (e.g. evacuation of the area) needs to be taken. Fixed gamma dose rate (area gamma) monitors were used as part of the door interlock to rooms G 60, 61, 50, 51, 52, 53, 58 and 59. As these are not specifically suitable for decommissioning activities, portable area gamma monitors will be utilised. Portable radiation monitoring equipment has the ability to monitor gamma dose rates, and surface contamination levels from activated material containing Co-57, 60, Mn-54 and Zn-65 etc in and around the dismantling areas including items and individuals. Prior to and during removal of activated components and inside shielded enclosures long handled probes (Teletectors) will be used to measure dose rates from a safer distance. Gamma spectrometry equipment will be utilised to check on type and activity levels for several activated components to assess transport and handling options.

Personnel doses are monitored using TLD badges and EPDs. Dose rate exposure information may also be viewed using the data recorded by EPDs. Portable monitors are used to survey during specific tasks for gamma dose rate and surface contamination levels. Instruments will also be used to measure personnel and items leaving classified areas. Potentially contaminated surfaces are surveyed using portable instruments or applying smear sampling techniques and remote assessment.

7 Review and Audit

It is standard practice for dose results from such work to be periodically reviewed and compared to dose constraints and investigation levels. This practice will be adopted for the decommissioning work with daily, weekly and monthly reviews. Average and maximum individual effective dose values (mSv) for workers will be evaluated over the work period against the progress of the work, as performance indicators by the project team. In addition when doses (effective individual, collective or shallow (skin) doses) reach 50% and 75% of defined constraints a review by the project team will be conducted to ensure that the project can be completed within the defined dose constraints or the RPA will revaluate the dose constraints.

If events occur that are subsequently assessed as near-misses, abnormal events, events of interest, dangerous occurrences, incidents or accidents they will be reported (following safety response and assistance required) in accordance with the ANSTO Event System (AG 2372). The outcomes of radiological incident or accident events and the findings and recommendations maybe considered as an indicator of radiation safety in decommissioning activities. Indicators of the effectiveness of the Radiation Protection Plan and specifically the monitoring programs, dose minimisation and limitation are the dosimetry results, survey results, contamination events, and the number of investigations and the relevant actions following each investigation.

8 Packaging, Transport and Storage

All packaging and transport of materials designated as “radioactive material“ will be packed and transported as per Safe movement and transport of radioactive material (guide) AG 2515 and ARPANSA COP Safe Transport of Radioactive Material, RPS2 (ref 4).

The segregation of non-active and exempt items from “radioactive” items and materials will be performed by assessing the radionuclide inventory of activated components, estimates of specific and total activity for the radio-nuclides and the external gamma dose rates. Where possible samples of the materials activated have been taken for assessment to determine average specific activity levels for transport categorisation (internal cyclotron tank components).

Previously items assessed have indicated Co-57, 60, Mn -54 and Zn -65 as the dominant longer life activation radio-nuclides. Categorisation of items into reuse, storage and waste has also influenced transport and packaging components. The majority of active items will be categorised as LSA, Low Specific Activity material as Industrial Packages, IP-1 or LSA unpackaged. Please refer to the waste management plan (ref 11) and transport plan (ref 5) for details.

Cyclotron and beam line components from both the cyclotron vault and PET beam room that are to be dismantled will be stored in the basement. Exposure to staff will be managed by way of routine surveys and administrative controls. Components are to be positioned and shielded in accordance to advice provided by the RPA to minimise dose exposure. It is noted here that the basement is a low occupancy area and is classified as a blue radiation and contamination area. Relatively highly activated components are to be stored in the heavily shielded SPECT beam rooms, as advised by the RPA. Entry to the SPECT beam rooms will be controlled and radiological surveys will be performed with administrative controls in place to reduce or remove the risk of any unnecessary exposure.

With these controls and arrangements in place, the long term storage of these components will not result in a significant exposure to staff.

9 REFERENCES

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10 Appendix A – Decommissioning of NMC Vault Components

10.1 Description of Vault Decommissioning process

The components to be removed and a basic description of the associated tasks are;

Table 10.1: List and descriptions of Decommissioning tasks

Decommissioning vault, Room G53 components
Remove 3 vac valves to switching magnets and blank
Open cyclotron tank
Stripper rod assembly 1,2 removal from tank (sleeve, carousels, valves etc) & blank
Disassemble magnet wave guide assembly side 1+2
Remove tank RF components
Remove RF cabinet contents (tube)
Final checks of tank - inside
Close tank
Drain circuits (oil, water)
Disconnect all services from cyclotron
Decommissioning vault G53, PET Beam line 1.5
Remove vac pump
Remove diagnostic cube (finger assembly)
Remove variable quadrupole magnet
Disassemble and remove Faraday
Remove remaining diagnostic instruments and beam
Remove stand and fit plates to service trench
Decommissioning vault G53, SPECT Beam line 1.1 south
Remove vac pump
Remove diagnostic cube (finger assembly)
Remove permanent magnet quadrupole
Disassemble and remove Faraday
Remove remaining diagnostic instruments and beam
Remove stand and fit plates to service trench
Decommissioning vault G53, SPECT Beam line 2.2 north
Remove vac pump
Remove Faradays
Remove Perm. magnet quadrupole
Remove remaining diagnostic instruments and beam
Remove stand

Decommissioning vault G53, tank sides/top/bottom components
Remove stripper rod assembly stands etc
Remove main coil cooling lines from tank
Remove cryogenic and vac pumps from top tank
Remove ion source and injection assembly
Blank tank top penetrations
Install work platform/scaffolding + remove target transfer lines
Remove tank platforms/rails - top
Remove work platforms/scaffolding
Remove tank hydraulic jacks
Remove tank ladders
Remove 3 water manifolds
Remove plumbing from under tank
Remove cryo + helium pumps from under tank + fit blanks
G53 Cyclotron tank lifting (roof plug out)
Clear wiring looms, cabling
Remove internal ceiling crane
Pack, wrap and label tank
Lower + fit lifting cradle
Free cyclotron tank pedestals
Lift cyclotron tank out to transport
Clear trenches G53 to G51&G61 rooms (north & south SPECT) & remove 2.2 wall quadrupole
Disconnect & Clear wiring, cabling SPECT North
Disconnect & Clear wiring, cabling SPECT south
Disconnect beam line 2.2 quadrupole in SPECT beam room G51
Remove beam line 2.2 quadrupole from wall from G53 side
Final survey + Plug holes G53
Clear PET Beam Room active items, G59 **Transfer components to area for assessment and storage/ packing** Tank transported to LHSTC and unloaded to storage area Items to basement store at Camperdown following activity / dose rate assessments and packaging

Samples of the magnet steel, vacuum tank and external components were taken for analysis to determine specific activity. The cyclotron tank and upper structure was raised for this exercise to gain access to the cyclotron magnets. In addition, samples were taken from previously removed components now stored in the facility basement.

Computational analysis was also used to determine average specific activities for the cyclotron and major components to determine packaging requirements. All items except the cyclotron tank will be taken for an assessment of radioactivity content and dose rate and then taken for storage in basement room L 1001 and 1002. The tank will be wrapped and lifted in a frame through the Vault roof and placed on a truck and transported to LHSTC and stored.

10.2 Dose Estimates & Reduction Techniques for the Vault Decommissioning, Associated beam lines and the PET beam room

An evaluation of the potential exposure levels (collective and individual doses) for the dismantling tasks was performed and dose reduction techniques assessed. During this process tasks were identified and grouped for review. The expected duration for this work is approximately 6 weeks..

Data considered included;

- Tasks/work descriptions to be performed
- estimated exposure times during tasks
- estimated dose rates for workers during tasks (nominally dose rates at 0.5m from active items were used except for workers were inside tank or disconnecting the wave guide magnets and stripper rod assemblies when workers are leaning into the tank)
- estimated dose rates for extremities.
- number of workers involved with tasks
- dose rate data and activation data from previous surveys (It is estimated that by Dec 2010 the measured (in June 2010) dose rates quoted will have halved due to radioactive decay.

Dose reduction techniques have been planned and include, use of remote handling and lifting equipment and special tooling, trolleys and jigs and tables to support items and components with extended handles to increase distance (e.g. extended wrenches and other lifting devices). Assessments of previous dismantling tasks during shutdown maintenance have been reviewed in terms of doses, dose rates and task durations.

All engineered controls and dose reduction techniques have been reviewed to ensure optimisation in terms of personnel exposures. In addition administrative controls such as access restrictions, barriers, demarcation & classification of areas are planned as described in the plan. Together with the personal protective equipment, monitoring and dosimetry of individuals, these form the basis of the dose reduction and optimisation of all protection measures during decommissioning.

The following summary represents exposures (individual and collective doses) from external sources of radiation (gamma from activated materials embedded inside the mainly metal surfaces of activated components such as Co-60, 57, Zn-65 and Mn-54). It is assumed that the combination of good work practices, use of PPE and the generally very low levels of loose contamination present will ensure that doses from internal exposures will be nil. To date no loose contamination on surfaces has been observed. Previous experience during maintenance of activated components and dose rates at close range has indicated extremity (wrist) dosimetry is required. It is necessary during the dismantling to place the hands close to some components with dose rates of up to 350μSv/h outside the tank and up to 1000μSv/h inside the tank. Hand (Extremity) dose rates and potential doses will be assessed prior to each item removal for those items with dose rates >100μSv/h at contact. In general the ratio of extremity dose rate to effective dose rate is approximately 10 indicating that the limiting constraint will be on the effective dose, not on extremity dose.

There are groups of tasks summarised and it is anticipated that majority of vault and beam room work will be carried out by Engineering and workshop staff (4) and the movement, assessment, packing and storage handling will be performed by Waste operations staff (3). Other individual workers included in the calculations for estimated exposures are the Health Physics monitoring staff (HPS) and lifting contractor.

The number of workers to be utilised for the vault dismantling tasks may vary and this will have an impact on the individual dose but is not expected to change the overall collective dose. Workers individual doses will be monitored closely for each task and reviewed against the individual dose constraints as per the SWMS**.**

A total of 4 workers (fitters, electricians, engineers) with a Health Physics surveyor (HPS) providing health physics advice will be involved in the decommissioning of vault G53 as per task list above and also decommissioning the PET Beam room active target stations. The task will be performed usually working in pairs with worker 1 most exposed, then worker 2 and then 3 and 4 out of a pool of 4 persons. This is the worst case in terms of individual doses as some tasks will be shared amongst 4 or more individuals. Potential dose rates measured range from 1 to 100μSv/h at working distance of 0.5m, three or 4 items have contact dose rates up to 350μSv/h in the room and 1000μSv/h inside the tank.

It is estimated that this set of tasks will take about 7550 minutes (~126 hrs) in total over several days, possibly up to 6 weeks. Workers 1 and 2 are assumed to perform the tasks on above list; i.e. decommissioning/ dismantling some components inside the tank, and those that need access to tank interior by leaning over side, potentially the highest exposures during this task (1st group of tasks in list), then continue to dismantle the 3 beam lines 1.5, 1.1 and 2.2, then workers 3 and 4 remove top/ side items from tank, all room ancillaries, tank itself through the roof and then clear the vault trenches and remove quadrupole 2.2 from shield wall. Also small activated target station items from Pet beam room, G59 are removed also by workers 3 and 4.

The estimated individual and collective dose to personnel during these tasks is as follows;

Table 10.2 - Task Group 1; Dismantling and removal of beam lines and tank accessories in G53 and G59 (Decommissioning and clearing Vault, Room G53 and Pet Beam room G59)

Task Group 1 Personnel	Group 1 Estimated dose (μSv)
Worker 1	984
Worker 2	773
Worker 3	416.5
Worker 4	416.5
HPS 1	104
Estimated Collective dose (man-μSv)	**2694 (man-μSv)**

Assumptions: Worker 1 is most exposed, however workers 1 and 2 and 3 and 4 may interchange positions and collective dose will not be affected with individual doses being lower than estimated.

Lifting equipment and tables, trolleys will be used to increase distance during removal. Also administrative controls are used to reduce exposure levels. Extended dose rate probes will be used to measure contact and ambient dose rates. Several staff are available and trained to take the roles of workers 1 to 4 above and so individual doses may be lower if more than 4 staff are involved or tasks are shared between 4 more equitably, but the collective dose remains the same. The maximum potential individual dose for these tasks is estimated to be 984 μSv with the effective collective dose potentially at 2694 man-μSv (2.7 man-mSv).

10.3 Dose Estimates during Loading and Transfer of dismantled components in packaging to store

This task group will involve the packaged tank loading onto a truck, transporting and unloading in storage facilities at LHSTC. The majority of vault and PET beam room components will be transferred to the basement to be assessed, packed, labelled and stored in an allocated place in the basement area.

A total of 3 workers (waste operations personnel) with a Health Physics Surveyor providing health physics advice will be involved in this task. The task will be shared equally among the three workers. Workers 5, 6 and 7 represent the waste ops personnel which will be from a team of more than 3 persons. In addition HPS is considered as 1 person (most conservative assumptions on staffing and exposure times). Working dose rates are at distances of 0.5m.

Potential dose rates may range from 1 to 5μSv/h at working distances of 0.5m with several large unshielded items having surface dose rates up to 350μSv/h.

It is estimated that this group of tasks as listed in table above will take about 1460 minutes (24hrs). The estimated individual and collective dose to personnel involved in this task is as follows;

Table 10.3 - Task Group 2; Transfer active items from vault, assess and pack/ store

Task Group 2 Personnel	Group 2 Estimated dose (μSv)
Worker 5	79
Worker 6	66
Worker 7	66
HPS 1	41
Estimated Collective dose (man-μSv)	**252 (man-μSv)**

Assumptions: Items approximately numbering 32 will be moved, assessed, packed, labelled and stored (taking approximately 1460 minutes over several days, possibly up to 6 weeks). Higher dose rate components will be placed into shielded containers and be transferred specified storage area in the basement or possibly the SPECT beam rooms until the rooms are decommissioned.

Workers 5, 6 and 7 may interchange positions and collective dose will not be affected. Several staff are available and trained to take the roles of workers 5 to 7 above and so individual doses may be lower if more than 3 staff are involved but the collective dose remains the same. Trolleys and shielding will be utilised where possible during transfer and assessments. The maximum potential individual dose for these tasks is estimated to be 79μSv with the collective dose potentially at 252 man-μSv (0.3 man-mSv). The Health Physics Surveyor, HPS doses assume that only one person is exposed to all the doses during the tasks and this is a very conservative assumption. The HPS staff will be utilised from a pool of 10 or 11 in the Radiation Protection Services Section.

These numbers were calculated from adding potential doses from each separate task as described in table 10.1 (the detailed calculations with the breakdown of activities/ tasks and individual μSv doses and collective man-μSv are summarised in the tables of this appendix).

10.4 Summary of Dose Estimates (Phase 1 only)

The potential individual and collective doses for the Cyclotron Camperdown decommissioning tasks have been summarised in the Table below. The estimations are based on the assumptions stated within this plan particularly with the planned tasks and utilising available radiological data.

Time, distance and shielding techniques will be utilized to reduce the risk where appropriate and ensure ALARA. This is described above in detail for each task set. The use of remotely operated equipment and using distance between workers and activated items have been looked at and doses analysed. Where possible shielding materials or containers will be utilised to minimise exposure. The movement of activated items will be carried performed using lifting equipment, shielding, containers and trolleys. Radiation monitors will be utilised to help in reducing the risk of exposure. Electronic dosimeters (EPDs) will complement health physics monitoring in complying with set dose constraints.

The actual doses to personnel involved may vary depending on the tasks they perform. Ansto staff will perform these tasks together with contracting transport staff for tank movements. The times used for performing the tasks are estimates only and where applicable the maximum estimated time needed to perform the task has been used.

All worker individual doses will be monitored closely to ensure compliance with the individual effective dose constraint of 1.0 mSv for this project.

Table 10.3 – Summary of Decommissioning Dose Estimates

Personnel performing decommissioning tasks	Estimated dose (μSv)
Worker 1	984
Worker 2	773
Worker 3	416.5
Worker 4	416.5
Worker 5	79
Worker 6	66
Worker 7	66
HPS	145
Total Estimated Collective dose (man-μSv)	**Approx 2946 (man-μSv)**

The potential collective dose from the identified tasks has been estimated at 3.0 man-mSv with an average individual effective dose to personnel of 0.37mSv. The highest potential individual dose for these tasks is estimated to be 1.0mSv (984μSv). These estimates are based on conservative estimated of exposure times and numbers of personnel involved and serve as a guide to radiation protection planning throughout the decommissioning.

These potential doses are considered acceptable, and during the work where opportunities arise for further dose reductions these will be reviewed by staff including the RPA.

10.5 Recommended dose constraint (Phase 1)

Table 10.4 – Summary of Recommended Decommissioning Dose Constraints (Phase 1)

Type	Recommended Constraint
Individual Effective dose constraint	1 mSv
Individual extremity (skin) dose constraint	10 mSv
Collective Dose	3 man.mSv