Australian Government | ANSTO

# HIFAR Safety Analysis Report

ACS248156

Public Consultation Version

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**Notes:**

1. Revision shall be verified in accordance with the Quality Plan for the job.

2. Revision to be agreed by the Client where relevant.

## EXECUTIVE SUMMARY

The High Flux Australian Reactor (HIFAR) is a nuclear facility that is operated by ANSTO and regulated by the system administered by ARPANSA.

The HIFAR reactor was permanently shut down in 2007 and shortly after the fuel, heavy water and primary reactor control components were removed from the facility. Some innocuous redundant systems were decommissioned, and safe enclosure upgrades were undertaken. A Possess or Control (PorC) licence (F0184) was issued on 15 Sep 2008, that provided time for the radiological hazards to reduce through radioactive decay, and for the facility to be characterised in preparation for decommissioning.

The decommissioning and dismantlement (D&D) of HIFAR will be undertaken in the following phases:

- Phase A – Removal of peripheral plant and equipment, which will be further broken down to the following sub phases:
    - Phase A-I – Removal of:
        - Utilisation equipment (Flasks, silicon storage blocks, handling equipment, tools etc.),
        - Neutron beam instrument shielding and platforms, and
        - Irradiation rig support equipment.
    - Phase A-II – Removal of the main ancillary circuits
    - Phase A-III – Removal of items stored in the No.1 Storage block
- Phase B – Removal of Reactor Block, Storage Block, remaining systems and the RCB.

This Safety Analysis Report substantiates the controls assuring safe operation of HIFAR during Phase A-I Decommissioning and Dismantlement (D&D) and ongoing Care and Maintenance (C&M). Phase A-II and A-III D&D will be undertaken as Section 63 submissions and if required this SAR will be updated. The over-arching Safety Principle for Phase A-I is to execute decommissioning tasks in a manner that minimises risk to human health and the environment.

There are no nuclear hazards associated with HIFAR, radiological hazards have been intentionally reduced and are well known. Non-radiological hazards associated with Phase A-I D&D are typical for the type of work required.

Most items being decommissioned in Phase A-I have been characterised as having low radiological activity as noted in the HIFAR Characterisation Report (ACS187819). Section 6 summarises these results and documents the waste volumes and safety implications. The management of project waste is detailed in the Decommissioning Plan (ACS248144) and summarised in Section 6.

Non radiological risks during Phase A-I include undertaking heavy lifts, working at heights, asbestos, and manual handling. Section 0 summarises the key controls in place to manage these risks.

Decommissioning Execution Plans (DEPs), which provide dismantlement sequences for each piece of equipment, have been individually safety assessed with key findings (material risks) of all hazards, consequences and likeliness summarised in Appendix B

The safety assessments conclude that the residual radiological risks of the various fault sequences during Phase A-I are 'low' or 'very low'. The residual risks of several scenarios involving non-radiological hazards were assessed to be 'medium' risk. These are summarised in Appendix B

To ensure adequate management of risks during Phase A-I, Critical Controls have been identified in Section 9.4 .

It is concluded that Phase A-I D&D can be safely undertaken with the risks to human health and the environment sufficiently mitigated by the identified controls.

This report should be read in conjunction with the HIFAR Decommissioning Plans and Arrangements (ACS261210) and the HIFAR Decommissioning Plan (ACS248144).

## Table of Contents

# 1. INTRODUCTION

The High Flux Australian Reactor (HIFAR) research reactor was a 10 MW heavy water moderated and cooled reactor, of the DIDO class. Initially, it used highly enriched XXXXX as fuel, but later it was converted to use low enriched XXXXX. HIFAR went critical for the first time on 26 January 1958. It was a multi-purpose nuclear reactor used for research; production of radioactive isotopes for Australian nuclear medicine and industry; materials testing; neutron beam experiments, and for silicon irradiation. HIFAR was permanently shutdown at 10:25 am on 30 Jan 2007, after 49 years of operation, when it was replaced by the OPAL reactor which was commissioned in 2006.

Following its shutdown, a program of closure works commenced, the reactor fuel was fully unloaded, heavy water drained, control arms removed, and operational staffing ceased. Additionally, several dismantling and refurbishment projects was undertaken to remove redundant non-radioactive items of plant and equipment from HIFAR to reduce maintenance overheads and allow the facility to be operated for a Possess or Control (PorC) period.

The facility was characterised during the PorC period, and a characterisation report produced. The information provided in the characterisation report (ACS187819), provides detailed information of radiological hazards allowing for risk informed planning, risk assessment and safety analysis.

## 1.1. Document Structure

The structure and format of this SAR has been developed by ANSTO following IAEA guidelines (1).

## 1.2. Purpose

This SAR substantiates the controls assuring safe operation of the facility during Phase A-I D&D and ongoing C&M. This document is a working document and will be revised as required if significant changes to the operation of the facility occur.

A decommissioning strategy is provided in the HIFAR Phase A-I Decommissioning Plan (ACS248144), To summarise, the final D&D of HIFAR will be conducted in two phases - Phase A and B.

The Phase A D&D of HIFAR will be split into Phase A-I, A-II and A-III and will require three submissions including the decommissioning licence application and two requests for approval under Section 63 of the ARPANS Regulation 2018 (2). These submissions will consist of:

- **Decommissioning Licence Application Phase A-I**: D&D of the Utilisation equipment, Neutron beam instruments and Irradiation rig support equipment.
- **Section 63 Phase A-II:** D&D of the main reactor ancillary circuits; and
- **Section 63 Phase A-III:** D&D of the items stored in the No.1 Storage block.

As the Section 63 submissions for phase A-II and A-III will each require their own respective safety assessments, this plan only includes the summaries of the safety assessments for phase A-I

This approach is commensurate with the level of safety analysis, decommissioning planning, documentation, and associated risks. It also accommodates government serial funding and the requirement for dedicated project resources.

The decommissioning of the reactor block is not in the scope of this SAR and will be undertaken at a later stage. The existing routine care and maintenance tasks which have supported the safety and monitoring of the facility through the recent Possess or Control phase will be continued throughout Phase A.

Phase A-II and A-III activities will be safety assessed under Section 63 request and included as a future update to this SAR.

## 1.3. Facility Background

Planning for the decommissioning of HIFAR extends as far back as 1992 with the decommissioning strategy 'deferred dismantlement' eventually being adopted. HIFAR was shut down on 30 Jan 2007, and a Possess or Control (PorC) licence (F0184) issued on 15 Sep 2008(3). A further 2005 options study (14) for HIFAR recommended its decommissioning be completed in three stages:

- De-fuel, removal of the heavy water inventory etc.
- Characterisation.
- Final dismantlement.

Given that decreases in radiation levels would be modest beyond 10 years post shutdown the study recommended early decommissioning. This would meet with international best practice, would ensure knowledge retention of the facility for its safe dismantlement, and would respect previously made public commitments.

A project to characterise the facility, under the PorC licence, was initiated in Nov 2014 and completed in Aug 2019 (ACS187819).

The D&D of HIFAR will be phased under multiple decommissioning licence applications and request for approval under Section 63 of the ARPANS Regulation 2018 (2). This approach is commensurate with the level of safety analysis, decommissioning planning, documentation, and associated risks. It also accommodates government serial funding and the requirement for dedicated project resources.

D&D of the reactor block (Phase B) will be undertaken at a later stage and will be dependent on the build schedule of the Australian National Radioactive Waste Management Facility (NRWMF).

## 1.4. Scope

This SAR covers the:

- Conduct of D&D activities and ongoing C&M activities of the facility during Phase A-I.
- Conduct of Waste Characterisation, processing, and waste storage; and
- Services areas and plant rooms that directly connect to the facility and are related to the planned D&D activities to be undertaken within the facility.

The SAR does not cover the:

- Transport of materials to and from the facility; or
- Waste processes or storage once materials have transferred to ANSTO Waste Management Services.

## 1.5. Interfaces

Key documents that interface with this SAR are:

- Waste management Services SAR (5) regarding the management and disposal of radioactive and nuclear materials waste.
- ARWA Generic Waste Acceptance Criteria (6).

The facility has arrangements in place with:

- ANSTO Radiation Protection Services to provide assurance area surveys, process surveys, clearance and consignment monitoring, and radiation protection advice from HPS and RPAs.
- ANSTO WHS to provide non-radiological safety advice and support.
- ANSTO Waste Management Services to provide advice on waste characterisation, processing, and storage.
- ANSTO Nuclear Stewardship provide radioactive environmental monitoring.
- ANSTO Nuclear Security, Government, and International Affairs to provide both security advice (Agency Security Advisor) and safeguards advice (ANSTO Manger Nuclear Safeguards); and
- ANSTO Support Services to provide Facilities Maintenance and IT support.

These arrangements are documented in the HIFAR P&A (ACS261210).

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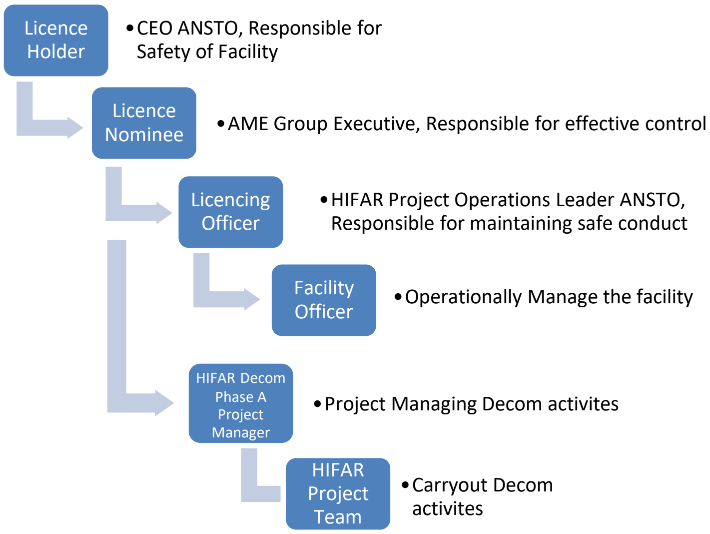
## 1.6. Responsibilities




The Licence Holder is the CEO of ANSTO and has ultimate responsibility for the safety of the facility.

The Licence Holder has appointed the Leader of AME as the Licence Nominee, and as the senior officer responsible for ensuring effective control and safe management within the facility.

The Licence Nominee has appointed a Licencing Officer responsible for ensuring that the licence basis for the facility is maintained and that the legislative and regulatory requirements for the conduct of a licenced Nuclear Installation are maintained. The Licence Nominee also appoints a Facility Officer to operationally manage the safe and effective control of all aspects of the facility.

The Licence Nominee is the client of the HIFAR Decommissioning Phase A Project Manager and is responsible for ensuring that all Decommissioning activities are carried out safely and according to the Decommissioning Licence.

The HIFAR Decommissioning Phase A Project Manager tasks the HIFAR project team to carry out decommissioning tasks.

For more detail review Guide on ARPANSA Requirements AG-5445.

# 2. SITE DESCRIPTION

## 2.1. Location

The ANSTO Lucas Heights Science and Technology Campus (LHSTC) is located on commonwealth land in the suburb of Lucas Heights some 35 - 40 km southwest of the centre of Sydney. HIFAR is located at the west end of the site, as shown in Figure 2 of Appendix A.

## 2.2. Site Characteristics

A detailed description of on-site characteristic including site geology, seismic characteristics, meteorology, and hydrology is provided in Section 4.2 of the ANSTO LHSTC – Site Descriptions AG-2430 Surrounding Land Use.

Vehicle access to HIFAR is via the vehicle air lock which exits onto Fermi St on the north-west end of B41. This will be used as the primary vehicle access point for the movement of equipment into or out of HIFAR. The production facility for ANSTO Health is located immediately across Fermi Rd. Immediately to the north and connected to B41 is Building 40 which has access to HIFAR.

## 2.3. Baseline Radiological Levels

The facility has recently been characterised and decluttered as part of the HIFAR Possess or Control licence. Baseline radiological levels are at background radiation levels which are given in LHSTC Site Description ACS060487.

# 3. DESIGN FOR DECOMMISSIONING SAFETY

The over-arching safety principle for Phase A-I is to manage the risks involved with D&D activities and ongoing safe enclosure C&M such that impact to human health and the environment is minimised.

Achievement of this safety principle will be through the application of safety functions supported by

**Table 1 Safety Principle, Safety Functions and Safety Functional Elements**

| Term | Definition | Example |
|---|---|---|
| Safety Principle | The project safety aims at the highest level. | Minimise human and environmental radiological exposure |
| Safety Functions | Functions designed to control the hazards | Containment of radiological inventory |
| Safety Functional Elements | The mechanism that delivers the identified Safety Functions | Static (RCB), Dynamic (HVAC dP), Filtration |

The main safety functions are identified below:

- Containment (static, dynamic, facility & portable task specific) for radiological and other toxic substances.
- Radiation shielding.
- Hazardous substances management.
- Exposure monitoring (radiological and other toxins).
- Lifting equipment integrity (cranes, beams & lifting gear).
- Fire prevention, detection & mitigation.
- Electrical safety (services, fixed & portable devices).
- Access to and work at heights.
- Emergency communication, access & egress.
- Safeguard's security (information & access security).

The safety functional elements are the features and controls that deliver the identified safety functions. Some examples include:

- Signage
- Radiation Monitors
- Smoke (VESDA) and heat detection systems
- Toolbox Talks
- SCADA control system
- Staff Licencing Requirements

Safety Functions and Safety Functional Elements are derived from the risk assessment listed in Appendix C .

## 3.1. Design For Containment

The potential for the release of contamination (toxic and radiological) during D&D activities has been identified as a primary hazard in terms of both worker exposure and secondary exposure of others due to airborne and contamination spread throughout the facility. Containment during decommissioning therefore is a key safety function to minimise this and is to be delivered through the combination of static and dynamic containment layers as summarised below and detailed in the Facility and Decommissioning Activities (Section 4) of this SAR.

Size reduction of the items being removed as part of the Phase A-I are required to minimise active waste volumes and facilitate handling and packaging of active wastes. A Deconstruction and Decontamination area will be utilised to provide local containment and prevent contamination migration when undertaking such work.

### 3.1.1. HIFAR Reactor Containment Building (RCB)

The HIFAR cylindrical steel dome roofed RCB provides the final barrier to reduce any released airborne radioactive material from accidentally entering the environment. Access and penetrations into the RCB are via controlled points to ensure containment is maintained. Containment integrity is demonstrated by monitoring and recording the pressure differential.

The existing HVAC system (refurbished during PorC) maintains a pressure cascade between the outside and inside environments, minimising transfer of contamination through confinement penetrations.

The Building HVAC system incorporates HEPA filtration to minimise the level of generated contaminants that are discharged to the external environment via the stack.

The RCB ductwork for the Active Ventilation System (AVS) is located around the perimeter of the RCB with flexible trunking feeding up through support columns. This protects the ductwork from the risk of impacts caused by crane lifted loads or other heavy trafficable items.

### 3.1.2. Deconstruction and Decontamination Area (DDA)

**DDA Structure**

For dismantling and decontamination tasks with the potential to generate mobile and airborne contamination (e.g., grinding), a Deconstruction and Decontamination Area (DDA), within the RCB, will be constructed to provide local containment and prevent contamination migration.

A local extract will be maintained within the DDA through an extract connected to the building AVS. To minimise the release of radiological and non-radiological contamination (particulates / gases) during hot works a local HEPA filtered extract system incorporating a mobile extract hood will be positioned directly at the cutting zone. This local extract system will discharge into the buildings AVS.

### 3.1.3. Liquid Containment

The wastewater from HIFAR is directed to delay tank systems. The delay tanks are part of the Waste Management Services Licence (F0260) and designed to capture any potential contaminated liquid wasted generated during D&D activities.

## 3.2. Design For Radiological Shielding

The biological shielding achieves low background dose rates throughout the facility. Section 9 provides a summary of the dose exposure assessment for Phase A-I activities and a historical review of the doses incurred over the past 6 years of C&M activities,

D&D activities are to be executed to optimise and minimise worker exposures. This has included the application of additional shielding where it is beneficial. In the main, worker exposures for the Phase A-I D&D activities have been assessed to be low and acceptable with the application of the following shielding elements:

- Utilisation of existing shielding (e.g., reactor beam shutters).
- Addition of shielding as required following instrument removal (e.g., where shutters are absent).
- Use of temporary shielding (e.g., during dismantling of highly activated instrument components).
- Maintaining shielding integrity is supported by access control to shield plugs and shutter mechanisms through physical locks and administrative access controls (Lock and Tag-out).

## 3.3. Design For Control of Chemical / Hazardous Substances

### 3.3.1. Decontamination

For Phase A-I, mechanical decontamination techniques only are proposed (no bulk chemical flushing/baths). The hazardous substances that will be utilised during Phase A-I D&D are small quantities of cleaning solvents. These are stored and used in accordance with ANSTO guidelines. Engineered controls include a separate chemical storage area in accordance with:

- ANSTO Standard AE-2302, Chemical Safety.
- ANSTO Guide, AG-2411 Storage of Chemicals.

## 3.4. Design For Control of Asbestos Containing Materials

Asbestos Containing Materials (ACM) are present as legacy items within HIFAR, and have been identified, labelled, and recorded. During removal of instruments in Phase A-I, remaining ACM (vinyl floor tiles under the instruments) will be revealed, however, because they are bonded, release of asbestos fibres during these tasks is unlikely. In terms of design to minimise asbestos exposure from these ACM's, they will be covered/sealed pending specialist removal once the area is clear to do so.

## 3.5. Design For Exposure Monitoring

As described in the previous three sections, several harmful substances present within HIFAR may become airborne during D&D activities. Substances identified include:

- Radiological Contamination (particulates and volatiles).
- Asbestos (Fibres).
- Heavy Metals (Particles & volatiles).
- Ionising Radiation Exposure.

Throughout Phase A-I contamination and radiation will be monitored to ensure exposure levels are optimised.

The specific arrangements for optimising exposures to ionising radiation are documented within the HIFAR P&A, Radiation Protection Plan section (ACS261210) which draws on the principles of protection outlined in the ANSTO Radiation Safety Standard (AE-2310).

Most relevant are the following standard and codes:

- ARPANSA Planned Exposure Code RPS-C1, December 2016 (7).
- NVF/DG001, An Aid to the Design of Ventilation of Radioactive Areas, (24) (Supersedes AECP 1054:1993, AEA Technology Code of Practice, Ventilation of radioactive areas)

AECP 1054 was regarded as the industry standard for the design of ventilation of radioactive areas. The document was owned by the United Kingdom Atomic Energy Authority (UKAEA) and supported by a committee within the industry.

The last revision of the AECP 1054 was produced in 1989. Following the resurgence of the nuclear industry in the early 2000s, a Nuclear Ventilation Forum (NVF) was convened in 2007 to review the principles of AECP 1054 and apply relevant good practice. The forum represents the views of industry and a new guide for the design of ventilation of radioactive areas has been developed. In January 2009, the forum issued NVF/DG001 which effectively supersedes AECP 1054. NVF/DG001 has been endorsed by the Safety Directors' Forum and is accepted within the nuclear industry as representing relevant good practice.

### 3.5.1. Contamination Monitoring

Radiological area classifications for HIFAR and the management of contamination monitoring within the facility are detailed in Section 4.6.

A characterisation of non-radiological toxins has identified several contaminants in low concentrations. Exposure to these toxins is expected to be at its most prevalent during hot works. As such, Personal Air Sampling with wearable monitors ensures an alarm is triggered warn workers at the time of exposure. When heavy metals and toxins are above threshold levels in proximity (breathing zone) to operators. Fixed and portable airborne monitors will be utilised, as well as change barriers for entry to the RCB and D&D area. The task will be closely monitored by Radiation Protection and Occupational Hygienist.

### 3.5.2. Radiation Monitoring

HIFAR has Radiation Monitors that are installed strategically around the building to measure and display gamma radiation levels. They incorporate visual and audible alarms at 10µsv/h. Each instrument consists of a detector/transmitter, local display unit and a main amplifier. During Decommissioning additional monitors maybe required as per Health Physics advice such as,

- Fixed Dose rate monitors – which provide constant assurance of area dose rates and alarm.
- Worker Whole Body and extremity TLD's – which provide lag indication of direct radiation exposure throughout the reporting period.
- Use of portable monitors (EPD's HP Survey and Worker during barrier exits).

## 3.6. Design for Structural Integrity

HIFAR was designed and built in the 1950s to the standards that applied then. Section 3 of the original HIFAR Safety document (August 1972) (8) and the HIFAR descriptive Manual (Sep 1972) (9) do not state any specific codes or practices apart from references to various engineering drawings and documents.

The RCB structure and cladding supports the following safety functions:

- Containment of contamination between the facility and the environment.
- Support of 20.5 tonne DGR RCB Polar Crane.
- Shielding for the facility and its occupants from external impacts (High winds, lightning, seismic event, smoke & fire, other projectiles).

The facility enclosure was deemed to provide acceptably safe protection from the impacts of external events during its operation and is maintained to achieve the same structural standard to this day.

The RCB external cladding is washed down every 3-5 years and inspected every year. Corrosion repairs and full repainting was last undertaken in 2017, and is scheduled every 10-15 years, based on the outcome of the inspections. The building's structural elements are inspected as part of the asset maintenance plan (10) every 5 years.

Section 8 of this SAR provides a review of the current facility condition.

## 3.7. Design For Electrical Safety

All electrical installations are designed to the AS 3000:2007 – Electrical Installations – Australia/New Zealand Wiring Rules. Electrical equipment introduced to support D&D activities will be reviewed as part of standard ANSTO procurement procedures to ensure they meet current Australian Electrical Safety Standards.

Electrical circuits associated with redundant instruments and experimental facilities have all been de-energised and isolated as part of the PorC activities. These circuits will be tested again to ensure they are not live prior to dismantling of the instrument.

## 3.8. Design For Mechanical Safety

The following codes will be applied to all mechanical equipment introduced into the facility to support D&D activities (e.g., local ventilation, mechanical lifting aids etc):

- AS/NZS 4024.1:2006, Safety of Machinery, Physical protection, safety covers, ergonomics and interlocking of mechanical systems
- AS/NZS 2243.6:2010, Safety in Laboratories, Plant and Equipment.

## 3.9. Design For Lifting Safety (Cranes & Other Lifting Equipment)

Lifting equipment to be utilised within HIFAR and associated buildings include:

- RCB Polar Crane.
- Installed Lifting Beams (e.g., RCB Platforms).
- Scissor lift
- Ladders

Maintenance, testing and certification of all lifting equipment is detailed in the Asset Management Plan (G-7543) and all lifting gear (bridges, chains, slings etc.) will be configured to provide the same SWL margin of safety required for a Dangerous Goods Lift. Prior to commencement of D&D (which will involve a significant number of lifts), a full inspection of the lifting equipment will be undertaken and the frequency of routine maintenance activities on the installed lifting equipment (cranes and hoists) will be reviewed by the Lifting Equipment Approvals Officer. This will ensure the planned maintenance and testing schedule reflects best practice.

The RCB Polar Crane has a Safe Working Load (SWL) of 20.5 tonnes and is a current certified Dangerous Goods Rated (DGR) crane. It was refurbished in 2019 to meet the AS 2550.1:2011, Cranes Hoists and Winches DGR requirements

It can be operated from a cab suspended from the bridge, or by remote pendant control and will be used for most of the heavy lifts.

During Phase A-I equipment out of reach from the Polar Crane (Under platforms and in auxiliary buildings) will be lifted with existing lifting beams and hoists; as during previous HIFAR shutdowns. These lifting beams will be inspected by an authorised engineer prior to use.

Load Cells will be used to provide feedback to the crane operator on the weight of the load / lifting force being applied. During crane lifts barriers will be used to prevent access to the drop / crush zones.

## 3.10. Design For the Prevention of Fire

During the PorC refurbishment the RCB fire protection system was upgraded and the following buildings (Building 42, Building 68, Building 73, AVS plant room) now have a fire protection system installed to current modern standards. These protection systems include smoke detection (in both occupied areas and within the ventilation system exhaust ducts), manual call points (at all personnel egress points and at the vehicular access point), a flame detector near the vehicular access, and audible and visual alarm indicators within the building.

HIFAR Fire Protection includes preventative and mitigative design elements that provide a significant level of defence in depth against both local fires and their escalation. Prevention includes the minimisation of combustibles (including selection of materials) and ignition sources (i.e., hot works etc.) and their isolation & separation within the building. Mitigation includes the layout and zoning of fire zones, fire barriers and detection systems.

Within the Reactor Building, there are eight fire zones which are supported by a VESDA system and smoke detectors adequately covering the building and in the ventilation system ductwork.

### 3.10.1. Design to prevent Electrical Ignition of Fires

All electrical installations are designed to the Australian / New Zealand Wiring Rules AS/NZS 3000 "Electrical Installations", with RCD provided on all circuits and wires protected by fire pillows. Where possible battery powered tools will be utilised during D&D.

### 3.10.2. Design to prevent Flammable Atmospheres

The configuration and safe storage of flammable, compressed gases will be the subject of WHS review in accordance with ANSTO guideline.

## 3.11. Design For Safe Work at Heights

Access to the polar crane cabin is via a non-compliant ladder with height exposure. Access is infrequent due to the use of the pendant controller and is mainly for maintenance and inspection.

The access steps pre-date current standards but have been upgraded over the years to improve their design and reduce the potential for slips and falls when utilising them - AS 1657:1992, Fixed platforms, walkways, stairways and ladders, Design, construction, and installation.

The access stairs down to the vehicle bay however is steep and has a fall exposure of approximately 3m.

For D&D tasks requiring access at heights away from existing facility platforms (e.g., removal of aerial services), elevated work platforms will be used. They will meet the below standard:

AS/NZS 5532:2013, Manufacturing requirements for single-point anchor device used for harness-based work at height.

## 3.12. Access, Emergency Egress & Response

Access to the RCB is via the Personnel or Vehicle Air Locks (PAL, VAL) with security access control which serves to restrict access to unauthorised persons but also expedite egress in the event of an emergency. The access control has recently been refurbished to meet current standards.

Lighting was refurbished during the PorC period and meets the Australian Standard (11) within the RCB, with some enhanced and supplementary lighting for specific areas and tasks. Emergency lighting to in the event of a loss of normal lighting is provided by battery-backed exit signs and spitfire units.

HIFAR's communication systems (Computer cabling, telephones, intercoms, and PA) were refurbished during PorC. In the event of a power failure, ANSTO's site standby diesel generator and dedicated uninterruptable power supplies (UPS's) provide power to instrumentation, monitoring, and communications equipment, all of which are subject to regular test, inspection, and maintenance by qualified technical personnel.

The HIFAR P&A - Emergency Plan (ACS261210) detail the response to events which are periodically exercised.

## 3.13. Safeguard Requirements

Safeguard requirements, defined in the Nuclear Non-Proliferation Treaty, (12) enable physical security for the prevention of theft or loss of nuclear materials.

All fissile material (fuel & targets) has been removed from HIFAR, and so no fissionable materials remain. Similarly, except for a small quantity of heavy water, potentially trapped in dead legs and hard to access parts of the reactor cooling circuit, all bulk $D_2O$ has been drained and removed from the facility.

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The graphite reflector lies in the space between the reactor aluminium tank (RAT) and the reactor steel tank and is sealed by the reactor top shield which would need to be removed before the graphite blocks could be removed (see **Error! Reference source not found.**).

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## 3.14. Classification and Qualification of Components

There are no above normal environmental conditions such as ambient temperatures, radiation fields, magnetic fields etc. remaining in the facility that warrant the qualification of equipment or components, particularly with respect to radiological safety. The classification of structures, systems, and components along with their criticality is discussed in Section 9.

## 3.15. Selection of Decommissioning Techniques

D&D techniques and technologies are detailed in DEP's. The purpose of the DEP is to define the dismantlement process including safety risks and controls, waste considerations and the disassembly sequence for each item to be decommissioned. Each DEP has involved detailed planning provided by WHS, radiological and HIFAR subject matter experts as well as other key members of the project team. They include:

- An estimate of the hours to complete the task,
- The equipment to be used and
- An understanding of the likely radiological hazards, allowing dose optimisation.

The DEPs for the Phase A-I work are listed below:

- Ausans (ACS248150)
- MRSCD (ACS248151)
- Longpol (ACS248155)
- TAS (ACS248153)

- MRPD (ACS248152)
- Neutron Reflectometer (ACS248154)
- X193 (ACS248148)
- Rigs (ACS248149)
- HIFAR Control Room (ACS256348)
- Fuel Assembly Station (ACS256345)
- Silicon Transfer Flasks (ACS256347)
- Silicon Storage Blocks (ACS261237)
- Fuel Element Transfer Flasks (N1 & N2) (ACS261236)

Much of the latter has been provided by data from the characterisation of HIFAR (ACS187819). Additionally, every DEP has undergone a rigorous radiological and WHS risk assessment process.

Further information is provided in the Decommissioning Plan (ACS248144).

# 4. FACILITY & DECOMMISSIONING ACTIVITIES

HIFAR consists of the RCB, its contents, and six other buildings/structures that either continue to support it or are attached to it.

## 4.1. Building And Structures

### 4.1.1. Reactor Containment Building

The RCB is a cylindrical steel building 21 m in diameter, 21 m high, with a low-profile conical roof and with walls generally of 21 mm thick steel. It houses the reactor block, No 1 storage block, $D_2O$ plant room, experimental plant room and other ancillary plant and experimental equipment. Access to the RCB is by way of access-controlled personnel air locks (PAL) or the vehicle air lock (VAL).

A schematic diagram of RCB and its contents is shown in Figure 1, the reactor block and $D_2O$ Plant Room in **Error! Reference source not found.**

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**Figure 1 Schematic Diagram of RCB and Contents**

### 4.1.2. The HIFAR Deconstruction and Decontamination Area (DDA)

The project proposes to decontaminate, or size reduce larger contaminated items in an area away from the operational location of the equipment. Where required and in consultation with a RPA, the team will setup a deconstruction and decontamination area (DDA):

**Deconstruction Area (DA)**

The DA is where items, not able to be deconstructed in situ, will be segregated into smaller parts. The DA will also be equipped for first step decontamination of items with low levels of radioactivity. Items that are still contaminated will be taken to the DCA.

**Decontamination Area (DCA)**

The DCA will be assembled for Phase A-II where chemical decontamination of some items will be required. Equipment required for the DCA includes:

- Existing local active extract.
- Bunded chemical and water flushing tanks with transfer baskets.
- Chemical preparation.
- Aqueous transfer/De-tritiation oven.

### 4.1.3. Reactor Block

The Reactor Block (**Error! Reference source not found.** and **Error! Reference source not found.**) is in the centre of the RCB and comprises barytes and steel shot concrete shielding around a steel tank containing a graphite reflector. This steel tank and graphite reflector surround the reactor aluminium tank (RAT) which contained the core and the heavy water ($D_2O$) moderator. On top of the reactor are shield rings and top plug and plate that provide biological shielding to personnel while working on the top plate area. Experimental rigs occupy either horizontal or vertical intrusions into the reactor core and graphite.

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### 4.1.4. Storage Block No 1

The Storage Block No 1 (SB1) (**Error! Reference source not found.**) is on the ground floor (basement level) inside the RCB. It provides storage for vertical and horizontal irradiation facility plugs and rigs, and vertical storage for fuel element plugs, assemblies, and liners. Access to the horizontal storage is from the ground floor. Access to the vertical storage is from 5m (operating) floor level.

Any items that are to remain in the Storage Block can be stored dry and do not require cooling.

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### 4.1.5. Auxiliary Plant Room

Connected to the Building 15 and Building 41 exterior walls is the APR, which houses HIFAR plant and equipment like the vehicle airlock hydraulics power pack, SCADA unit, HIFAR Operator office, effluent pumps, and ducting plus HIFAR electrical cabling and electrical penetrations through the Building 15 wall.

### 4.1.6. Other Buildings and Equipment

### 4.1.7. Building 42

Building 42 houses HIFAR administrative functions, ANSTO project activities and facility management instrument calibration workshop, and provides access to the RCB via a PAL and access tunnel on the upper level.

### 4.1.8. Building 68

Building 68 was the FANAL (Fast Access Neutron Activation Laboratory) in which samples were prepared and then fired into the reactor (rig X176) by way of a pneumatic conveyor tube. After irradiation, samples were returned by way of the same pneumatic conveyor tube for immediate analysis. The X176 pneumatic receiver station and a related fume cupboard are in this building.

### 4.1.9. AVS Plant Room

The AVS Plant Room is of brick construction and is situated adjacent to the RCB and below Building 73 (Section 4.1.10). It houses the fans and filters for the active ventilation system, and other fan control equipment.

This structure is structurally independent of the upper structure (Building 73), however, the floor of Building 73 forms the ceiling of the AVS Plant Room.

### 4.1.10. Building 73

Building 73 is a steel frame construction that is situated above the AVS Plant Room (Section 4.1.9) and houses the AUSANS detector vacuum tank. Building 73 is structurally independent of the lower structure.

### 4.1.11. Air Handling Unit (Building 41)

The air handling unit is attached to Building 41 and accommodates equipment for the RCB's air supply.

### 4.1.12. Emergency Control Room

The Emergency Control Room (ECR) is a thick-walled concrete bunker attached to Building 41, adjacent to the south delay tanks and pit. The ECR is no longer functional and most of the equipment was stripped out during the PorC licence stage of HIFAR. What remains is a ventilation plant room (attached to the ECR) and an underground services trench extending to the RCB and Building 70.

## 4.2. Plant And Equipment

### 4.2.1. Electrical Power System

HIFAR's power is supplied from Sydney's mains and, in the event of a power failure, ANSTO deploys a site standby diesel generator. Dedicated uninterruptable power supplies (UPS's) provide power to instrumentation, monitoring, and communications equipment.

HIFAR's electrical power system was simplified under the PorC Licence as the shutdown and de-fuelled facility requires significantly less power. Broadly, the simplification resulted in:

- Installation of a new mains switchboard in the auxiliary plant room which serves as the point of distribution to plant and equipment.

- Installation of a new moulded case circuit breaker (MCCB) capable of handling the demand of the new switchboard.
- Installation of new earth and mains cables; protected by the new MCCB.

### 4.2.2. Ventilation System

The RCB is ventilated by two SCADA controlled systems:

- Normal ventilation system (NVS).
- Active ventilation system (AVS).

Their operation creates a negative pressure of approximately 300 Pa (-30 mm H2O) inside the RCB and is powered by a UPS.

In the event of a ventilation system failure, a SCADA alarm will sound. There is no immediate risk to personnel inside the RCB, as the only potential source of airborne contamination is the slow desorption of tritium from the $D_2O$ Circuit. During normal operations, the AVS is configured to continuously purge air from the $D_2O$ Circuit.

**Ventilation system Maintenance**

The inner damper on each system can be physically closed by turning the shaft to the closed position. This allows maintenance of fans and other components as required.

**Redundancy**

The filtration system on each of the normal and active systems is comprised of HEPA filters and can be configured manually so that redundant fans have access to either Filter unit on their respective systems.

#### 4.2.2.1. Normal Ventilation

HIFAR's normal ventilation system is designed to:

- Provide an acceptable rate of air changes (one per hour) for personal comfort and removal of heat, odours etc, and to produce some degree of air conditioning.
- Provide control of input air temperature and humidity.
- Prevent a build-up of contamination within the ventilated space.
- Run on Normal and Standby power supply

The extracted air and gases are passed through filters before discharge to atmosphere through 15M stacks atop the RCB. These are constantly monitored by air samplers for radiological discharges.

#### 4.2.2.2. Active Ventilation

The active ventilation system is designed to extract air and gases from rigs, including the silicon irradiation facilities, the $D_2O$ and experimental plant rooms, the graphite reflector and other areas in the RCB where contamination may have originated during HIFAR operations. The extracted air and gases are passed through filters before discharge to the atmosphere through stack 15A at the top of the RCB. The filters trap 99.9% of particulate matter larger than 0.5 micron. The AVS is constantly monitored by air samplers for radiological discharges. Active ventilation fans and dampers are powered by normal and standby power supply.

### 4.2.3. Cranes

The Reactor Building Polar Crane has a DGR Safe Working Load (SWL) of 20.5 tonnes and will be used for most heavy lifting activities within the RCB.

The crane may be operated from a cab suspended from the bridge, or by remote pendant control. The drive motors operate on 415 V AC power from the line supply. Routine maintenance includes mechanical and electrical inspections monthly, quarterly, annually, and bi-annually. The crane operators also perform pre- checks.

The frequency of the routine maintenance activities on the crane will be reviewed during the preliminary dismantling based on the number and load of operations.

### 4.2.4. Auxiliary systems

#### 4.2.4.1. Lighting

The RCB's lighting provides a reliable and fire-safe illumination of the RCB. It meets the Australian Standard for plant rooms (11), with enhanced lighting to meet the standard for switchboards in appropriate areas and supplementary lights for special tasks.

Lighting in the RCB is by flood lights suspended from the ceiling to give general illumination to the reactor top and 5m floor. This is supplemented by fluorescent tube lights in the reactor gallery, control room and under the mezzanine levels. Ground floor lighting is by fluorescent tube lights.

Emergency lighting is provided by battery-backed exit signs and spitfire units.

#### *4.2.4.2.* Communication System

HIFAR's communications system includes:

- Computer cabling.
- Normal telephone system.
- Intercoms and the public address systems.

## 4.3. HIFAR Decommissioning Activities

Decommissioning tasks typically include the following:

- Decontamination
- Dismantlement techniques and technologies

These tasks have been documented in DEPs as part of planning with their applicability risk assessed.

Phase A-I D&D is intended to include removal of the following from HIFAR:

- Utilisation equipment (Flasks, silicon storage blocks, handling equipment, tools etc.)
- Neutron beam instrument shielding and platforms
- Irradiation rig support equipment.

During the Decommissioning phase of HIFAR. Facility Management will also continue to undertake routine C&M activities to ensure:

- The Ventilation System is operational.
- Containment and radiation classification is adhered to.

- The SCADA System is fully operational.
- WHS management system is adhered to.
- Housekeeping inspections are up to date.
- Surveillance requirements in accordance with remaining Operating Limits and Conditions are met.

## 4.4. Hazards In the Facility

Hazards in the facility including radiological and non-radiological hazards are identified in section 9 and their controls discussed in section 3.

There are no criticality hazards or inventory of fissile or fertile nuclear material within the facility.

## 4.5. Protection Systems

### 4.5.1. Fire Alarm and Suppression

The RCB's and Auxiliary Plant Room fire alarm systems include:

- A VESDA system.
- Manual call points at all personnel egress points and at the vehicular access point.
- A flame detector near the vehicular access.
- Smoke detectors located within the ventilation system exhaust ducts.
- Audible and visual alarm indicators within the building.

The following buildings each have a fire protection system installed:

- Building 42.
- Building 68.
- Building 73.
- AVS plant room.

### 4.5.2. Instrumentation, alarm, and control systems

#### 4.5.2.1. Monitoring System

HIFAR's monitoring system utilises a SCADA system which forms part of HIFAR's building management system. The main unit is in the Auxiliary Plant Room where it processes all data and distributes it to selected, password-protected SCADA clients. Key metrics the SCADA monitors are:

- Normal Ventilation status, air flow gamma and fire detection VESDA
- Active Ventilation status, air flow, gamma, and fire detection VESDA
- Supply Air status, air flow and inlet temperature
- Normal and Standby power
- All Area radiation monitors
- RCB Differential air pressure

A panel that displays of some of these metrics is located at the main PAL entry from Building 42. It is powered by an UPS.

### 4.5.3. Radiation Monitoring

HIFAR has real-time radiation monitoring in the form of

- Area radiation monitoring system.
- Tritium monitor.
- Airborne contamination sampling

Radiation monitors are installed to measure and display gamma radiation levels. They incorporate visual and audible alarms at 10µsv/hr. Each instrument consists of a detector/transmitter, local display unit and a main amplifier. They are connected to the HIFAR instrumentation power supply and are powered with a UPS. Documentation on the Function testing of the RCB Radiation monitors is contained with I-7292.

The RCB internal air quality is monitored for tritium and particulates via a dedicated Tritium monitor. Airborne contamination is monitored via a dedicated contamination sampler.

During Decommissioning portable radiation monitors maybe required as per Health Physics advice.

## 4.6. Designation Of Areas

The Classification of Contamination and Radiation areas is undertaken according to the process described in AG 2509 Classification of Radiation and Contamination Areas. These define the system of radiological classification of areas employed to control, prevent, limit and review occupational exposure (actual or potential) to ionising radiation. This system of radiological classification helps ensure that occupational dose limits are not exceeded and is part of the process of ensuring that doses to individuals are kept optimised in line with dose constraints.

The initial area classification for HIFAR working areas is determined by the Area Supervisor in consultation with the HP. These classifications are based on calculated results as well as operational experience obtained from similar activities. Where relevant, the planned occupancy times of staff in those areas during normal operation will be considered.

Area classifications may be changed if appropriate in consultation with the HP. This will be done by reviewing radiological data obtained from installed and portable monitoring equipment and the final occupancy factors and may result in changes in area classification to either higher or lower categories. Areas may be temporarily reclassified to reflect temporary changes in radiological conditions, with the changes in classifications and application of controls being commensurate with the temporarily changed conditions. Certain operations in radiological classified areas may raise or lower the hazard and potential radiation exposure for workers.

## 4.7. Security Arrangements

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# 5. SAFETY MANAGEMENT

The safety arrangements for HIFAR are discussed in the HIFAR P&A Safety Management Plan (ACS261210)

## 5.1. ANSTO Work Health, Safety and Environment Policy

The ANSTO Safety Policy documents listed below underpin the safety of D&D activities.

- The ANSTO Work Health Safety and Environment Policy (ACS46348)
- Work Health & Safety Risk Management Standard AE-2301.

## 5.2. Legal Requirements

ANSTO is considered “a person conducting a business or undertaking” for the purposes of the Work Health and Safety Act (2011) (12) associated regulations and the Safety and Rehabilitation and Compensation Act (1988) (13).

ANSTO is a controlled person for the purposes of the Australian Radiation Protection and Nuclear Safety Act (ARPANS) Act (1998), and ARPANS Regulation (2018) (2).

Under this legislation, HIFAR requires licencing by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) at all stages of the facility life.

## 5.3. ANSTO WHSE Standards, Practices and Procedures

ANSTO WHSE documents are available to all staff via the ANSTO Intranet. These cover the following aspects of safety.

- WHSE Management.
- Risk Management.
- Chemical Safety.
- Contractor Safety.
- Electrical Safety.
- Emergency Management.
- Hazardous Work.
- Nuclear Safety.
- Plant and Structure Safety
- Radiation Safety
- Workplace Health.

## 5.4. Organisational Management Structure

HIFAR is managed by AME and the organisation management structure for the Phase A-I is contained in the Effective Control Plan of HIFAR P&A (ACS261210).

## 5.5. HIFAR Facility Management Structure and Responsibilities

The responsibility for the safe operation of HIFAR is delegated by the Chief Executive Officer of ANSTO to the Chief Engineer – ANSTO Maintenance & Engineering, managers, and supervisors by requiring them to comply with ANSTO’s safety policies and ANSTO WHSE standards and practices.

The Effective Control Plan of HIFAR P&A details the chain of authority and responsibilities in more detail (ACS261210.)

## 5.6. Safety Approval System

ANSTO's Safety and Reliability Assurance (SRA) process is described in (AP-1094). WHS Risk Management Standard AE-2301 requires that no new activities (including changes to existing activities) may be undertaken without a hazard identification and risk assessment.

Activities are screened as per SRA screening process. This screening process will determine if safety control evaluation is required. The evaluation process is carried out by the process/activity owner in consultation with the subject matter experts (SME) which may include an RPA, WHS Adviser and System Safety and Reliability Adviser. The activity is approved or rejected based on the safety control evaluation by the General Manager.

For activities that have regulatory requirements, an independent review of the activity is performed by a selected team of SMEs.

The SRA process is co-ordinated by the SRA Manager.

## 5.7. Quality And Environmental Assurance Program

HIFAR follows the requirements of quality assurance system ISO 9001:2015. The HIFAR Business Management System (BMS) incorporates specific procedures and instructions for the planned D&D activities to be undertaken in the facility.

## 5.8. Control Of Normal Operations

This section summarises the way operations are controlled, who authorises planned D&D activities to be undertaken and who decides at what stage a modification is required. A description of the operating limits and conditions is also presented.

### 5.8.1. Overall responsibility

Overall responsibility is with the AME Group Executive. The Facility Officer and the Area Supervisor for HIFAR ensure the facility is operated safely.

### 5.8.2. Local control

Local control of the facility is the responsibility of the Facility Officer, Area Supervisor and their deputies or delegated persons.

### 5.8.3. Use of written procedures

All operating procedures and instructions for HIFAR are documented located on the ANSTO intranet HIFAR Instruction & Procedures.

### 5.8.4. Permits to work

HIFAR follows the ANSTO wide Safe Working Permit system (AP-2408).

### 5.8.5. Handing Over Responsibilities

HIFAR Operates in normal business hours and does not normally involve shift work. D&D activities will be undertaken as per a package of work, therefore handing over responsibilities is not applicable.

### 5.8.6. Training and authorisation of staff

All staff shall be trained according to their requirements. A General Access and Induction course exists for those requiring access to HIFAR without needing to perform any hands-on work.

Those who undertake hands-on operations to manage the safety of the Facility will be required to complete appropriate training.

Persons completing D&D activities will be required to complete appropriate training in accordance with the HIFAR Training Plan (ACS260821).

### 5.8.7. Minimum Staffing Level

There are no minimum staffing levels for HIFAR. The Facility Officer and Area Supervisor ensure that activities carried out in the facility meet the minimum staff levels approved in the relevant D&D activities and associated risk assessment.

## 5.9. Limits And Conditions (LC)

There are no additional LCs associated with the D&D activities beyond those detailed in the current HIFAR Limits & Conditions (ACS043989).

## 5.10. Radiation Protection Regime

The radiation protection regime is designed to limit radiation exposures to as low as reasonably achievable (ALARA) with the guidance on optimisation of radiation exposure from the Radiation Safety Standard AE-2310.

The radiation protection regime for HIFAR is discussed in the Radiation Protection Plan section of the HIFAR P&A (ACS261210).

## 5.11. Management of Health and Safety

The safety arrangements for HIFAR are discussed in HIFAR Safety Management Plan section of HIFAR P&A (ACS261210).

## 5.12. Control of Inspection and Maintenance Activities

ANSTO manages HIFAR as a strategic asset, as detailed in the HIFAR Asset Management Plan (ACS212921). This plan describes the level of maintenance required to meet the asset objectives.

The tasks required to meet this level of maintenance are detailed in the HIFAR Maintenance Strategy (ACS176055) and are implemented using AeSAP to manage delivery.

Unscheduled maintenance, including breakdowns, are also managed and documented using AeSAP.

## 5.13. Control of Abnormal Events and Emergency Arrangements

### 5.13.1. Incident Reporting systems

ANSTO Incident Management System shall be used for all significant incidents.

### 5.13.2. Experience Feedback

Opportunities for review of abnormal events include:

- Incident Investigations and follow up.
- Periodic Safety and Assurance reviews.
- Internal decommissioning planning workshops.
- Regular contact with international collaborators who work in similar facilities; and
- Close working relationships between staff.

### 5.13.3. Emergency Arrangements

Standard operating practice that are evacuated immediately following an emergency, and warning signs posted. In the event of a fire alarm the building should be immediately evacuated.

Instructions document the local arrangements for dealing with emergencies.

The emergency arrangements for HIFAR are discussed in the HIFAR P&A Emergency Management Plan (ACS261210)

## 5.14. Control Of Modifications

Modifications will be change assessed and screened for safety significance as per the Safety Approval System described in Section 5.6.

## 5.15. Control Of Contractors and Visitors

Personnel entering the ANSTO LHSTC site are classified according to the type of pass they hold which can be summarised as:

- Permanent pass holders.
- Contractor, temporary or business photo pass holder.

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## 5.16. Safety Monitoring and Review

Inspections and audits are described in Section 5.12, and safety review, in Sections. 5.13.2

### 5.16.1. Pro-active monitoring of safety performance

Within HIFAR there are several pro-active monitoring systems for monitoring safety performance as outlined in the following:

- The ANSTO Incident Management System.

- Radiation Protection oversight by RPA.
- Optimisation assessments.
- Personal dosimetry.
- Stack discharge monitoring (abnormal release would identify process failures or deficiencies).

### 5.16.2. Reactive monitoring of safety performance

ANSTO's policy on the reporting of accidents, injuries, incidents and abnormal events is detailed within ANSTO Event Response Process in ANSTO WHSE Standards and Practices (ACS060426). All accidents, injuries, illnesses and dangerous occurrences that occur in ANSTO are reported to WHS using the ANSTO Incident Management System.

All reported incidents are investigated with the aim of identifying the real and underlying causes and developing effective methods of preventing future similar occurrences. An appointed officer/s will perform these investigations.

# 6. WASTE MANAGEMENT

During D&D activities the radioactive solid and liquid wastes will be segregated, treated, analysed and stored in the approved packages in the controlled buildings. All solid radioactive waste generated directly or indirectly from ANSTO activities and projects are appropriately stored at licenced facilities at the Lucas Heights site.

Only wastes that meet the clearance level criteria defined by Waste Operations facility licence (F0260) are disposed to authorised landfills.

The HIFAR Waste Management Plan section of the P&A (ACS261210) provides describes the management of waste generated by D&D activities.

## 6.1. Policy And Requirements

ANSTO Radioactive Waste Management Policy (AB-0103) commits ANSTO to:

- Comply with all relevant legislative requirements ensuring that all discharges are within authorized limits and regularly monitoring and reporting radioactive releases to the environment.
- Ensure that radiation exposures are optimised.
- Dispose of wastes when appropriate disposal routes are available; and
- Accord with international best practice.

ANSTO requires, amongst other things, that waste production is minimised by good management and housekeeping and that radioactive wastes are managed and stored safely, with due regard for radiation exposures and economic factors.

## 6.2. Airborne Discharges

HIFAR is currently discharging tritium into the environment at a rate of 181 GBq per year, on average, for the last 5 years.

Planned tritium decontamination activities may increase this environmental discharge. Any proposed increase will be assessed by ARPANSA under a planned future section 63 amendment to the decommissioning licence (Submission A-II).

During some D&D activities, plasma cutting techniques may be employed. Any smoke generated from this technique will be ventilated via local extract into the RCB AVS.

## 6.3. Solid Wastes

Most of the waste generated from Phase A D&D will be solid waste with the estimated total amounts for each classification tabled in Table 2. Waste will be transferred via the roads on the Lucas height Site to Waste management Services (

Figure 3).

**Table 2 ILW, LLW and Free Release volumes**

| Total Volume | Packaged ILW ($m^3$) | Packaged LLW ($m^3$) | Free Release Waste ($m^3$) |
|---|---|---|---|
| HIFAR Phase A-I Decommissioning | Redacted | Redacted | Redacted |
| | | | |

## 6.4. Liquid Wastes

In accordance with ANSTO WMS procedures liquid waste may be discharged to the appropriate waste line or collected in suitable vessels for treatment at Waste Operations facilities.

## 6.5. Baseline Radiological Levels

HIFAR is no longer an operational reactor. All fissile material has been removed and the cooling systems drained. Background radiation readings determined by regular health physics surveys reveal negligible radiation and contamination levels confined within the RCB.

# 7. Review of Operating Experience

A review of HIFAR operations was undertaken during characterisation of the Facility (ACS187819).

The review considered abnormal occurrence reports (AORs) and operational history that occurred whilst HIFAR was operational and during the C&M period. This review was considered relevant to the characterisation of HIFAR because they had the potential to affect radiological characteristics of the Facility and helped with the methodology to be undertaken to decommissioning HIFAR.

# 8. REVIEW OF PLANT CONDITION

The RCB was designed to house an operating reactor, its condition is sound and there are no life-limiting features in the facility.

## 8.1. Building Condition

The buildings that constitute HIFAR are in good condition, consistent with their age. The RCB is structurally inspected every 5 years. Corrosion repairs and full repainting was last undertaken in 2017, and is scheduled every 10-15 years, based on the outcome of the inspections.

## 8.2. Security Systems

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## 8.3. Comparison With Regulatory Expectations

The facility in its existing condition meets regulatory requirements with respect to design for radiological, chemical, and industrial safety and housekeeping. This is covered in Section 3.

## 8.4. Results Of Facility Inspections

ANSTO manages HIFAR as a strategic asset, as detailed in the HIFAR Asset Management Plan (ACS212921). This plan describes the level of maintenance required to meet the asset objectives, including the objectives of effective control, serviceability, and good housekeeping of the facility.

The tasks required to meet this level of maintenance are detailed in the HIFAR Maintenance Strategy (ACS176055) and are implemented using AeSAP to manage delivery.

Unscheduled maintenance, including breakdowns, are also managed and documented using AeSAP. This approach is modern and compares well to standards used for similar applications.

## 8.5. Comparison With Modern Housekeeping and Maintenance Standards

ANSTO have undertaken a number or housekeeping operations to improve the working area in HIFAR in readiness for decommissioning. This program involves but not limited to:

- Regular housekeeping audits using a well thought out audit protocol.
- A schedule for prompting to carry them out through SAP.
- A system to record the results and to follow-up on the actions.
- A comprehensive characterisation program.

## 8.6. HIFAR Identification of Any Life-Limiting Features

There are no life-limiting features in the facility that would affect its ability to safely support the planned D&D or return to a PorC licence.

# 9. SAFETY ANALYSIS

This Chapter summarises the safety assessments that have been conducted to support Phase A-I and ongoing C&M activities. The assessment is divided into the following sections:

- Safety during Normal Operations (planned radiological exposures & controls)
- Identified Internal Initiators leading to Exposures
- Identified External Initiators leading to Exposures

## 9.1. Normal Operational Exposures

General background gamma levels have been consistently between 0.3 and 0.8 µsv/hr and contamination levels consistently less than 3 Bq. Tritium levels were measured over 16 days achieved 0.0041 DAC. Over the past six years all results have revealed negligible background radiological levels.

The average collective dose over the past six years was 1.26 mSv. With the average dose for each year listed in Table 3.

**Table 3 Dose in HIFAR for the past six years courtesy of ANSTO's Dosimetry Service**

| Year | Collective Dose in mSv | Avg Individual Dose in mSv | Maximum Individual dose in mSv |
|---|---|---|---|
| 2016 | 2.37 | 0.296 | 0.55 |
| 2017 | 2.07 | 0.259 | 0.53 |
| 2018 | 0.82 | 0.091 | 0.34 |
| 2019 | 0.50 | 0.056 | 0.14 |
| 2020 | 1.19 | 0.132 | 0.22 |
| 2021 | 0.63 | 0.060 | 0.16 |

### 9.1.1. Decommissioning Tasks - Radiological Exposure Estimates

The Radiation Protection Plan section of the HIFAR P&A (ACS261210) details the overall approach to ensuring that radiological exposures during D&D activities are minimised by reducing:

- the likelihood of incurring a radiological exposure.
- the magnitude of individual doses.
- the number of people exposed (collective dose).

The potential direct radiation whole body exposures during D&D activities have been estimated in a Preliminary Dose Assessment (15). This is based on maximum measured dose rates, contamination levels and the estimated task times for the number of workers required. This is detailed in each specific DEP. The estimated collective dose for Phase A-I activities is approximately 2.78mSv.

Phase A-I D&D activities will not result in any direct radiation exposure to members of the public.

### 9.1.2. Care & Maintenance Activities - Radiological Exposure

Described in Section 6.5, the background radiation readings determined by regular health physics surveys reveal negligible radiation and contamination levels confined within the RCB.

As identified in Table 3, routine radiological exposures over the years 2016 – 2021 serve as a conservative estimate for future exposures during C&M activities. This will be confirmed by regular health physics surveys.

Additionally, if there is a build-up of tritium in the RCB, an alarm will sound, and an orderly evacuation of the building will take place.

### 9.1.3. Phase A-I Airborne Discharges

As described in Section 6.2, airborne contamination is likely to be generated because of planned Phase A-I D&D activities. These will mainly be due to fumes generated during hot works (plasma-arc and Oxy-acetylene cutting of components).

Cutting sequences are planned to minimise the level of radiological airborne discharges.

Where possible, hot cutting is to be conducted within the D&D Area which includes a local extract, discharging via a spark arrestor and HEPA filter. Sampling of any fume discharged via the HEPA filtered stack will be used to verify that aerial discharges are within authorisation limits.

As per ANSTO's Stack Monitoring Program (P-3976), the Stack Emissions and Environmental Monitoring team carries out sampling, monitoring and the reporting of stack discharge levels.

### 9.1.4. Liquid Discharges

In accordance with ANSTO WMS procedures (ACS008048) liquid waste will be discharged to the appropriate waste line or collected in suitable vessels for treatment at waste operations facilities prior to release from the site.

## 9.2. Safety Analysis for Internal and External Abnormal Events

During the evaluation stage of the project, workshops and risk assessments were conducted on each of the DEPs to identify and document hazards and risks associated with the Phase A-I work. A summary of the safety assessments for Phase A-I work is provided in Table 4 below:

**Table 4 Summary of Safety Assessments**

| D&D Equipment | Safety Assessment Associated with HIFAR Phase A-I work |
|---|---|
| AUSANS | ANSTO/T/TN/2021-08 rev 0, (ACS248162)<br>Dismantling and decommissioning of AUSANS beam instrument involves the dismantling of 21 interlocking blocks which formed the main shielding of the instrument. Shielding materials include lead, steel, borated paraffin wax, and borated rubber sheets. Other equipment to be removed include a rotating beam selector, collimator rig, monochromator, and a detector vessel. |
| MRSCD | ANSTO/T/TN/2021-09 rev 0, (ACS248163)<br>Dismantling and decommissioning of the MRSCD involves the dismantlement of the biological shield (principally consisting of three interlocking shield blocks and integrated plugs) which are constructed from steel, lead, and borated paraffin wax. |
| LONGPOL | ANSTO/T/TN/2021-12 rev 0, (ACS248167)<br>Dismantling and decommissioning of LONGPOL involves the dismantlement of the biological shield (principally consisting of four interlocking shield blocks and integrated plugs). These components are constructed from steel, lead, and borated paraffin wax. |
| TAS | ANSTO/T/TN/2021-10 rev 1, (ACS248165)<br>Dismantling and decommissioning of TAS involves the dismantlement of the biological shield (principally consisting of upper and lower interlocking shield blocks), monochromator plug, dummy collimator plug, axis drive rail and |

| | |
|---|---|
| | residual internal brackets. residual internal brackets. These components are constructed from steel, lead, borated paraffin wax, borated rubber sheets, and XXXX |
| MRPD | ANSTO/T/TN/2021-13 rev 0, (ACS248164)<br><br>Dismantling and decommissioning of the MRPD involves the dismantlement of the biological shield (principally consisting of interlocking shield blocks and integrated plugs) which are constructed from steel, lead, and borated paraffin wax. |
| Neutron Reflectometer | ANSTO/T/TN/2021-11 rev 0, (ACS248166)<br><br>Dismantling and decommissioning of the Neutron Reflectometer involves the dismantlement of the biological shield (principally consisting of shield blocks, lead blocks, lead shot and integrated plugs) and residual internal brackets. These components are constructed from steel, lead, and borated paraffin wax. |
| XXXXX Analysis Rig | ANSTO/T/TN/2021-14 rev 0, (ACS248160)<br><br>Dismantling and decommissioning of the XXXXX Analysis Rig involves the dismantlement of the biological shielding and sample transport tubing, measuring station, loading station and contamination filtration system. These components are constructed from steel, paraffin wax and lead. |
| Rig Support Equipment | ANSTO/T/TN/2021-31 rev 0, (ACS248161)<br><br>Dismantling and decommissioning of the rig support equipment involves the dismantlement of the various control panels, loading stations, unloading stations, piping, active ventilation fans and ducting, delay stations, biological shielding, valves, and field instruments. These components are constructed of various materials including polymers, steal, lead and copper. |
| Utilisation Equipment | ANSTO/T/TN/2021-32 rev 0, (ACS261238)<br><br>Dismantling and decommissioning of the utilisation equipment involves the dismantlement of the fuel element transfer flasks, fuel assembly station, silicon storage blocks, transfer flasks which are items constructed of various materials including polymers, steal, lead and copper. Decommissioning of the reactor control room is also included. |

The safety assessments referenced in Table 4 were conducted in accordance with ‘WHS Hazard Identification and Risk Assessment Guide’ (AG-2390) and the associated ‘Risk Analysis Matrix’ (AG-2395). Hazardous scenarios were analysed to assess the inherent and residual risk.

In addition, the safety critical controls relevant to each scenario were identified following the critical control identification methodology (22) employed by ANSTO Systems, Safety and Reliability (SSR). Residual impacts and likelihoods were then estimated considering the identified safety critical and safety related controls.

Seven categories of likelihood and six categories of consequence (i.e., impacts) were used to enable the hazardous scenarios to be plotted onto the risk evaluation tables.

Hazards assessed as major (or above) and associated with work activities undertaken for Phase A-I are discussed in sections 9.2.1 to 9.2.9 and summarised in Appendix B . In addition, a summary of the safety assessments undertaken for Phase A-I is provided in Appendix C

### 9.2.1. Direct Radiation Exposure when undertaking Decommissioning Activities

Low levels of direct radiation are anticipated during the ongoing conduct of the dismantling and decommissioning activities. A number of direct radiation exposure scenarios have been identified and assessed in the AUSANs and TAS safety assessments for decommissioning. The task of removing beam instrument components, requires workers to be around the instrument for a significant amount of time. While working on these instruments it is credible that the workers may be working with an open beam shutter if the shutter was left open in error while removing the monochromator or the beam selector. This could result in the workers remaining in a shine path for a prolonged period without realising that they are being exposed to the radiation due to the open beam shutter. The worst-case dose rate has been measured to be 30 mSv/h from an open shutter on the AUSANS collimator. This is detailed in the Risk Assessment of the HIFAR Decommissioning Phase A – AUSANS Beam Instrument, (ACS248162). The inherent impact assumes that an operator is exposed to a dose rate of 30mSv/h for an hour dismantling in the direct shine path of the beam, a whole body dose of **Major** (20 – 100mSv) impact.

#### 9.2.1.1. Controls

The key controls to prevent exposures to radiation during the removal and dismantling of these instruments is the secure closure of the beam shutters. These have been locked closed during the PoC period and are subject to a two-person Lock-Out/Tag-Out (LOTO) authorisation procedure to unlock. The drives to open the shutters have been disabled and manual operation of the shutter is an onerous 34 turns. Through these actions it is considered that the opening of the shutter in error is unlikely. These shutters are protected as they sit internally within the reactor face and therefore damage during dismantling is considered to be highly unlikely. The application of the LOTO authorisation procedure to these shutters has been nominated as a safety critical control (CC01) and reduces the high inherent whole-body exposure risk.

The following administrative controls ensure that the shutter is closed prior to commencing any instrument dismantling and it remains closed throughout the dismantling process to reduce the risk of radiation exposure.

- The DEP for each of the instruments stipulates that before commencing any dismantling work the shutter should be closed and locked.
- The shutter should be Locked using the Lock Out Tag Out (LOTO) process to ensure that the shutter is closed and locked.

Health Physics Monitoring will be conducted throughout the D&D activities. HP Surveyors will closely monitor radiation and contamination levels during dismantling processes. The DEPs require that after the monochromator is separated from the instrument, the workers are required to move a safe distance away from the work area, this step in the dismantling process will limit the radiation exposure to the operators. A HP survey (CC02) will monitor the area to determine if the dose rates around the instrument is high and unsafe for workers and will advise on appropriate actions required to meet dose constraints.

The use of electronic personal dosimeters (EPDs) provide further defence in depth in terms of revealing any event which leads to an increased rate of whole-body radiation exposure.

There are several area radiations monitors (ARM) which will reduce the risk of radiological incident and exposure. These monitors will activate and alarm if there is an increase in the radiation level in the building. These monitors are regularly checked and maintained as per ANSTO Guide AG-5795. Activation of the alarms will result in evacuation of the HIFAR building as per the HIFAR evacuation procedure. The alarms will also initiate an emergency response from ASOC.

Other additional controls are identified in Appendix B to reduce the risk further.

#### 9.2.1.2. Residual Risk

The above controls in combination provide a high level of defence in depth to detect and enable mitigation of a potential Major radiation exposure to an operator. As a result of the application of the critical controls, the residual risk of the operators incurring a Major whole-body radiation exposure is reduced to a Low level. These proposed controls are considered sufficient to enable the risk of accidental exposure discussed to be ALARP.

The residual risk associated with this scenario is assessed as follows:

| Impact | Likelihood | Risk |
|---|---|---|
| **Major**<br>(20 – 100 mSv effective dose to an occupationally exposed person) | **Highly Unlikely**<br>($10^{-5}$ pa to $10^{-4}$ pa) | **Low** |

### 9.2.2. Heavy Load Crane Lifts / Loss of Security

During HIFAR Phase A-I activities, regular crane lifts of heavy loads will be required. These will include lifting of shielding blocks, shutters and whole instruments, etc. The Polar Crane will be the primary crane used for most heavy lifts, however there are several lifting beams and hoists located, in areas where the Polar Crane cannot service the lifts. Lifts utilising beams and secondary hoists will be subject to the same WHS controls, as described in the following analysis. The scenario for heavy crane lifts considers the causes for a loss of stability of the load, leading to load impacts with people, structures and equipment.

In the event of a loss of load stability, the following inherent impacts have been assessed:

- Potential damage to shielding (beam shutters, reactor block / No.1 Storage Block (SB1)) has been assessed in AUSANs as credible, resulting in a loss of shielding that could cause **Moderate** exposure.
- Damage to AVS ductwork leading to a release of contamination into the general RCB area is assessed as potentially **Minor** inhalation exposure.
- Worker injured due to contact with dropped / swung/ sprung load is inherently assumed to lead to permanent disability / death (**Severe**).
- Drop of load onto Waste Package / Item – Contamination / Asbestos release (**Severe**).

#### 9.2.2.1. Controls

The following critical control have been identified to reduce the risk.

**CC03 - Dangerous Goods Rated Crane (Polar Crane)**

The HIFAR 20.5 tonne crane is a certified DGR crane, which meets the Australian Standard AS1418; it is designed and manufactured with safety factors for crane components and additional safety features including dual ropes and drum over-speed emergency brakes. These additional features are considered to improve the reliability of the crane. The DGR crane will reduce the probability of failure on demand (PFD) of the crane by two orders of magnitude compared to a regular crane. A risk reduction factor of 0.01 is factored in for this critical control.

**CC04- Exclusion Zones and ANSTO Standard Industrial Practice**

The process of planning the lift in terms of identifying the load mass, lifting points, rigging method, checking lifting gear and identifying additional controls is undertaken. Difficult lifts will be authorised following a supervisory check of the Lift Plan by the ANSTO Lifting Equipment Authorised Officer (LEAO). Physical exclusion zones will be implemented during all lifts. It is assumed that the probability of severe physical injury in the case of a drop load will be reduced by 0.1 per demand.

Other additional controls are identified in Appendix B to reduce the risk further.

#### 9.2.2.2. Residual Risk

Critical controls CC03 and CC04 reduce the risk of severe physical injury and radiological exposure. The residual risk associated with this scenario is assessed as follows:

| Impact | Likelihood | Risk |
|---|---|---|
| **Severe**<br>(Death, permanent disability or permanent ill health) | **Highly Unlikely**<br>($10^{-5}$ to $10^{-4}$ p.a.) | **Medium** |
| **Minor**<br>Whole body dose<br>(0.1-1 mSv) | **Highly Unlikely**<br>($10^{-5}$ to $10^{-4}$ p.a.) | **Very Low** |

### 9.2.3. Physical injury or dose from fire or heat application

Scenarios potentially leading to the ignition of a fire within the RCB during D&D activities have been identified for assessment. In the event of a fire being initiated within the RCB, the inherent outcomes and impacts include:

- Localised fire causing worker injury including smoke inhalation / heat injury
- Building AVS (inc HEPA filter) fire resulting in a stack release and public dose
- Escalation of an AVS fire to the graphite reflector potentially resulting in off-site release, public dose, worker injury or dose during fire-fighting.

Potential worker injury due to heat injury, smoke inhalation from a local fire ignited within the RCB has been assessed as a potentially **Major** impact. It is inherently considered credible that a local fire from proposed hot works could ignite the local HEPA filter or the TAS wax resulting in a release of potentially contaminated fume into the D&D area / local RCB area. Since no intentional cutting of activated or contaminated items are proposed, the level of contamination that would be released has been assessed as low, resulting in a **Minor** worker inhalation dose.

Five scenario types potentially leading to a fire during D&D activities have been considered:

- Hot work (Plasma Arc, Oxyacetylene, Grinding)
- Electrical equipment fault ignites combustibles in workplace
- Wiring fault / damage during dismantling
- Stored/utilised chemicals reaction
- Graphite Wigner Energy release.

Of the above identified causes, the dominant contribution to a fire is considered to be during the proposed hot cutting of the TAS instrument. Fires due to electrical or wiring faults are inherently considered to be low initiation likelihoods. Further controls such as the de-energising of instrument cabling, testing prior to work, compliance with electrical codes and removal / management of combustibles within the workplace maintain these causes as residual low contributors to the top event. The amount of stored Wigner Energy in HIFARs graphite moderator has been conservatively estimated to be 60 cal.$g^{-1}$ which could potentially result in a 250C temperature rise if released. This release of energy would be insufficient to ignite the graphite.

During Hot Work (Plasma Arc/Welding/Grinding), there is the possibility of generated hot fumes or sparks igniting combustibles in the work area. It is conservatively assumed that Hot Work may be undertaken twice a week and an inherent probability of ignition of fire of 0.1 per demand is applied generating an inherent initiating event frequency of 10 p.a. As detailed in the TAS DEP (ACS248153), located in the centre of the instrument is a section of XXXX which needs to be removed. Removal of the XXXX first requires the removal of the borated paraffin wax located around the XXXX. The wax will be removed by using heating blankets to heat the shielding and melt the wax. This wax removal process will improve the access required for XXXX removal. During the melting process, there is the potential of fire and the potential to spread loose contamination from the use of pressurised firefighting techniques resulting in an inhalation dose from airborne contamination.

#### 9.2.3.1. Controls

Controls that have been identified to prevent a fire being ignited and escalated during Hot Work include minimising combustibles, housekeeping during decommissioning minimising any build-up of combustibles in the area and any necessary residual combustibles to be segregated from the Hot Work area. Fire Curtains or Barriers may also be used if required. Acetylene cylinders for plasma arc will be segregated and stored in accordance with hazardous materials codes. During plasma arc cutting a large amount of fume and hot particulates are generated. To control these and prevent their transport through the working area, a purpose designed local extract will be located at the cutting zone to extract the fume and sparks from the working area. The extract will incorporate a spark arrestor and fire-retardant HEPA filter.

In the event of a fire commencing in HIFAR, existing fire extinguishers and hose reels are available for utilisation to extinguish the fire and prevent fire escalation. All workers are trained in their utilisation and a frequency reduction of 0.1 has been applied for their use.

Smoke detectors are installed through the various zones within the HIFAR RCB. The VESDA system will detect low concentrations of smoke and generate an alarm to prompt workers to stop work and evacuate awaiting the Site Emergency response.

The building AVS HEPA filters are a nuclear grade (fibreglass) fire retardant material and hence a reduction factor of 0.1 has been applied. There is a low probability of ignition from sparks of flames entering the building extract reaching the HEPA filters due to the distance of the filters from building extract points. A reduction factor of 0.1 has been applied for this.

#### 9.2.3.2. Residual Risk

Due to preventative controls, the likelihood of a fire initiating or escalating through the facility have been controlled to the point where residual risk levels (Workers, Public and Environment) are managed to Low or below and are considered tolerable without further mitigation.

The residual risk associated with the scenarios described above are assessed as follows

| Impact | Likelihood | Risk |
|---|---|---|
| **Major** (>5 days Lost Time Injury)<br>Worker heat injury / inhalation | **Not credible**<br>($<10^{-6}$ p.a.) | **NA** |
| **Minor** (First aid)<br>Heated Blanket Injury | **Unlikely**<br>($10^{-3}$ to $10^{-2}$ p.a.) | **Very low** |
| **Moderate** (<5 days Lost Time Injury)<br>Injury due to pressurisation of Paraffin wax | **Very Unlikely**<br>($10^{-4}$ to $10^{-3}$ p.a) | **Low** |

### 9.2.4. Worker radiation exposure during cutting

Hot Works such as plasma cutting and grinding have the potential to generate fumes and a large amount of fine particulate. Aerosols in the breathable / respirable size range (micron) are buoyant in the air and not visible and can therefore remain as a hazard in the area for many hours after their generation ceases. As well as the potential for exposure to radiological activity, toxic fumes are also generated during the utilisation of hot cutting techniques. It is possible also that during the use of plasma arc cutting that metals can be volatilised in the high temperature cutting zone and be released as part of the fume. Hot cutting will either be undertaken in the D&D area to be established within HIFAR, or if unavailable, within the existing dedicated waste management services decontamination facility.

Routine hot cutting or grinding of items generates radioactive airborne particulates and the erroneous cutting through XXXX shielding are cause lines examined.

Hot cutting of the TAS instrument has the following inherent outcomes and impacts.

- Worker inhalation exposure (toxic or radiological) from routine hot cutting
- General building occupancy worker inhalation exposure
- Stack discharge, public radiological exposure
- Worker inhalation exposure, erroneous cut through XXXX / Pb.

It is inherently considered credible that a worker undertaking routine Hot Cutting could be exposed to airborne particulates and fume including toxic and radiological contaminants which could result in a **Moderate** radiological inhalation exposure and **Major** WHS impact (Serious Illness). For the postulated erroneous hot cutting through XXXX and Pb, it has been assessed that this could result in a **Severe** radiological inhalation exposure and a **Severe** toxic inhalation exposure.

This scenario could cause a very small amount of airborne XXXXX to be released, which according to the XXXXX SDS (24) is assessed as a Category 2 'acute toxicity'[1]. This could potentially cause a **Severe** (Death or permanent ill health) to a worker.

[1] Note that 'Acute toxicity' is terminology as per AG-2395 but is not referred to as such in this report and simplified as 'toxicity'.

#### 9.2.4.1. Controls

The application of hot cutting to an item will be informed through characterisation results, HP Surveys and the application of the hierarchy of techniques and as indicated within the Detailed Execution Plan (DEP). This is a key preventative control in reducing medium radiological exposure risk. A dedicated mobile welding fume extraction and filtration system will be used to collect fume and particulate created during cutting (ACS248153).

In the highly unlikely event that an operator erroneously cuts through the DU/Pb shielding on the TAS instrument, a series of mitigative controls will act to reduce the impact and likelihood. These include the application of a local filtered extract positioned at the cutting zone, all generated fumes will be extracted and filtered prior to discharge. Operators undertaking the hot cutting will utilise air flow hoods. The use of a portable air monitor will provide warning if airborne radiological contamination is detected.

#### 9.2.4.2. Residual Risk

With implementation of the critical controls, the residual risks associated with this scenario is assessed as follows:

| Impact | Likelihood | Risk |
|---|---|---|
| **Moderate** (1mSv-20mSv)<br>Worker inhalation exposure from routine hot cutting | **Extremely Unlikely** ($10^{-6}$ to $10^{-5}$p.a.) | **Very Low** |
| **Severe**<br>XX Toxicity Exposure | **Extremely Unlikely** ($10^{-6}$ to $10^{-5}$p.a.) | **Low** |

As the radiological and related WHS residual risks are assessed as **Low,** with the controls in place, no further actions are necessary.

### 9.2.5. Exposure to Asbestos

Asbestos Containing Material (ACM) remains in a few areas within HIFAR. No sources of friable asbestos have been identified within HIFAR.

The floor tiles are a non-friable (bonded) asbestos fibre and therefore pose a minimal hazard until disturbed. Similarly, fibrous boards behind electrical boxes and electrical insulation are non-friable. Due to the age of these non-friable materials, there is the potential loose fibres may be present due to previous works, degradation with age or other abrasive processes. If fibres are released, their inhalation could cause a significant health risk. For asbestos exposure, airborne fibre concentrations >TWA (0.1ppm) is conservatively assumed to result in a **Severe** impact (Death or permanent ill health).

Prior to the D&D of any space or structure, an intrusive hazardous materials survey will be conducted. Identified ACM will be protected pending access for remediation. Removal of ACM will be undertaken by specialists under ANSTO AP2522. All decommissioning team members will undertake asbestos awareness training. If any potential ACM is identified, work will be stopped prompting sampling / protection / specialist removal (as detailed in DEP, toolbox talk and SWMES). As these controls are managing a **Severe** impact (WHS material risk) and all three are required to reduce risks levels below a high level. No further mitigative controls have been identified.

The combination of the controls listed above reduces the inherent risk to a **Low** residual level. This residual medium risk is a result of the potentially Severe health impact from exposure to asbestos which cannot be downgraded to a lower category. As the residual impact remains 'Severe' for a physical injury, the AR-7455 High Risk Escalation Process is to be followed for WHS risks.

### 9.2.6. Work at Heights

The dismantling work requires use of stairs to access the upper and lower floors of the RCB.

If a worker falls while climbing up or down or when trying to place the slings and harness to lift the shielding and instrument components, it could result in the worker sustaining fatal injury or suffering permanent disability. Therefore, the consequence of this scenario has been assessed as **Severe**. The likelihood of worker falling while accessing different floors of the building or working on the instrument, is conservatively estimated as **Highly Unlikely** ($10^{-5}$ to $10^{-4}$ per year), considering that workers are experienced and well trained to perform this task and use appropriate PPE (i.e., fall arrester etc.).

The residual risk associated with the scenario described above is assessed as follows:

| **Impact** | **Likelihood** | **Risk** |
|---|---|---|
| **Severe**<br>(Death, permanent disability, or permanent ill health) | **Highly Unlikely**<br>($10^{-5}$ to $10^{-4}$ p.a.) | **Medium** |

With the existing safety precautions, this risk is considered tolerable according to AG-2395.

### 9.2.7. Slip, Trip or Fall

Dismantling work requires increased movement of personnel in the RCB. It will also require the use of tools and equipment, which if left on the floor could become a trip hazard. The increased movement of workers and equipment on the floor in the building could result in physical injury to the workers, which could require medical attention or result in lost time injury.

Therefore, the consequence of this scenario has been assessed as **Moderate**. The likelihood of worker slipping or tripping while dismantling the TAS instrument, is conservatively estimated as **Unlikely** ($10^{-3}$ to 0.01 per year), taking into account that workers are experienced and well aware of the risks involved in the dismantling work, access will be controlled to the area, housekeeping will be maintained and use of appropriate PPE by workers (ACS248153).

The residual risk associated with the scenario described above is assessed as follows:

| **Impact** | **Likelihood** | **Risk** |
|---|---|---|
| **Moderate**<br>(Medical attention / up to 5 days off (LSI)) | **Unlikely**<br>($10^{-3}$ to 0.01 p.a.) | **Low** |

With the existing safety precautions, this risk may be tolerable as per (AG-2395).

### 9.2.8. Manual Handling - Work Demands Beyond Individual Capacity

Dismantling work involves removal of heavy shielding blocks, plugs and instrument components. There is the potential that manual handling activities could cause workers to suffer sprains, fatigue and exhaustion. Careful planning of the work, rotation of staff, sharing of the workload will minimise the likelihood of an injury. Also, careful monitoring and supervision will identify any worker health issues before they could become more serious.

The residual risk associated with the scenario has been assessed as follows:

| Impact | Likelihood | Risk |
|---|---|---|
| **Moderate**<br>(Medical attention/up to 5 days of LTI) | **Likely**<br>(0.01 pa to 0.1 p.a.) | **Medium** |

With the existing safety precautions, utilisation of the hierarchy of controls methodology, the manual handling risk are considered to be tolerable as per AG-2395.

### 9.2.9. Electrocution

The work during decommissioning requires the use of electrical equipment. The electrical tools could be used to unbolt the instrument shielding and other tasks. There is therefore a risk of electrocution while using power tools. This risk is managed by using standard ANSTO precautions against electrical hazard, such as isolation, use of certified electricians for wiring, use of RCDs, and battery powered tools where possible etc.

Additionally, if there are any undetected energised cables present in the instrument and these cables are severed during the instrument dismantling, then it could lead to electrocution of the worker. The equipment has been electrically isolated, and all electrical cables connected to the instrument have been physically disconnected. It is therefore, considered that the risk of electrocution by the electrical tools or by unidentified energised cables is **Highly Unlikely** ($10^{-5}$ to $10^{-4}$ per year).

The risk associated with this scenario is assessed as follows:

| Impact | Likelihood | Risk |
|---|---|---|
| **Severe**<br>(Death, permanent disability, or permanent ill health) | **Highly Unlikely**<br>($10^{-5}$ to $10^{-4}$ per year) | **Medium** |

As the residual risk is assessed as **Medium**, further work will be undertaken to comprehensively review all electrical connections to the instruments and equipment to ensure that they are isolated prior to commencing any dismantling work as such this would reduce the risk to a tolerable level as per AG-2395.

## 9.3. Safety Analysis for External Events

External accidents considered include:

- high winds
- bushfire
- earthquake
- lightning strike
- flooding
- military impact
- aircraft impact and
- transport accident.

Each of these hazards was analysed when the reactor was operational, and the risks shown to be extremely low. No proposed dismantling works will alter the vulnerability of HIFAR or its associated services to these events and hence these pre-existing assessments remain valid.

Potential changes in assessment due to impacts from the loss of off-site power, a seismic event and aircraft crash are discussed below.

### 9.3.1. Loss of Off-Site Power

In the event of a power failure, ANSTO's site standby diesel generator, would power instrumentation, monitoring, security and communications equipment will maintain power.

Battery backed emergency lighting would permit safe evacuation of the building. The polar crane is equipped with a drum brake which halts the descent of any load being lifted coincident with a loss of power event. There are no nuclear safety-related issues related to the loss of offsite power

#### 9.3.1.1. Loss of Ventilation

This scenario considers the failure of the RCB ventilation system due to failure of the extraction fan or accidental closure of the damper. It is assumed that the failure of the fan or damper occurs in both normal and active ventilation systems. These failures could occur due to power or mechanical failure or fault in the control system.

The failure of the ventilation system will result in loss of extraction and cause loss of negative pressure in the RCB.

If the failure occurs for an extended period, it could also result in build-up of tritium in the building, but as the tritium concentration in the building air is very low (currently averaging 0.1 DAC) the consequence of this scenario is conservatively assessed as **Minor** (>0.1 - 1 mSv). The above inherent impact rating is reinforced by the B15 (HIFAR) tritium stack release data, which is historically far below the prescribed limits. Dose incurred to workers from tritium build-up in this scenario within the 6800$m^3$ HIFAR containment volume, estimating by historical data, is bound by the above assessment. It is expected to be a revealed event through ongoing monitoring and alarms. It is estimated to take a long period of time (weeks of working with failed ventilation) to increase the impact rating and thus is considered not credible.

The likelihood of a worker being exposed to contaminants or tritium in the RCB during dismantling work or Care and Maintenance work without considering any controls is conservatively estimated as Likely (0.01 pa to 0.1 pa).

The inherent risk associated with the scenario described above is assessed as **low**.

In the event of loss of power, Monitoring equipment such as the air sampling unit (radioactive contamination) and the SCADA (building ventilation system) are on a UPS with a 45-minute battery life. This would further reduce any potential operator exposure.

### 9.3.2. Seismic Event During Decommissioning

Given the reactor is no longer operational and has been de-fuelled and cooling circuits drained, no significant mobile sources of radiological materials exist and hence the biological shields are the only identified structures whose failure could lead to exposure to significant direct radiation from the retained stored radiological activity (Reactor core & storage block contents).

The Storage Block 1 (SB1) has been previously assessed to withstand ground motions of up to 0.23g (avg return frequency 1 in 33,000 yrs., 3.3 x $10^{-5}$p. a). An earthquake could result in damage to biological shield structures, however due to their mass, any damage is likely to be slight resulting in only minor loss of shielding.

The Reactor Block and support columns have been assessed to withstand ground motions of up to 0.23g but modelling has shown the structures likely to survive much higher ground motions. Failure of the columns could, in the worst case, cause the reactor block to topple but major structural failure of the block itself is considered incredible (i.e., < $10^{-6}$ pa). A **Major** Dose to a Worker (20-100 mSv) due to shielding damage has been assessed, but no credible mechanisms for a radiological release outside the facility have been identified. No dismantling works will alter the vulnerability of these biological shield structures and hence these pre-existing assessments remain valid.

The combination of a **Major** Dose impact with a frequency of 3.3. x $10^{-5}$ p.a. generates a **Medium** inherent radiological risk to workers.

The DGR rated Polar Crane and other lifting beams will be used for most heavy item lifts. During heavy lifts, it is postulated that a 1 in 500yr seismic event may be sufficient to lead to a loss of stability of a load leading to damaged shielding (reactor block/ shutter or storage block) and a **Major** dose to operators or a **Severe** injury due to impact. The residual risks associated with a seismic event are acceptable.

### 9.3.3. Aircraft

The airspace directly over the LHSTC is Restricted RA3 Airspace (Radius of 1.6km (1 mile) from ground level to 2000ft), which means that all civil and military aircraft are prohibited from entering it and therefore exposure from overflying aircraft is limited. ANSTO is the Controlling Authority for this airspace and therefore pilots cannot be granted access by Air services. If an aircraft enters this airspace and impacts HIFAR (e.g., an aircraft loss of control event), no vulnerable inventories or services have been identified that if damaged could lead to a radiological release from the building. Due to the non-operational, de-fuelled and drained status of the reactor, all significant residual radiological inventory is static and protected by massive seismic rated biological shields as well as the reactor containment building. Loss of ventilation (due to potential impact with external ventilation components) would not result in a significant release event. No activities or services being planned during Phase AI activities will increase the vulnerability of the remaining radiological inventory from an aircraft impact. It is concluded therefore that an aircraft impact on HIFAR would result in negligible consequences and poses an Inherent Very Low Risk to workers, the public and the environment.

## 9.4. Summary of Critical Controls and Related Controls

As a result of this review and all risk assessment in support of HIFAR Phase A-I Decommissioning. Critical controls and other controls which reduce the risk have been identified respectively in Table 5 and Table 6 below.

**Table 5 Summary of Critical Controls**

| ID | Critical Control | Main Safety Functions | Control Type | Safety Category | Control Description | Claimed Likelihood Reduction/ Failure Rate | Monitoring and Surveillance |
|---|---|---|---|---|---|---|---|
| CC01 | Administrative control to ensure that the shutter remains closed during dismantling. Reactor Beam Shutters Lock-Out / Tag Out (LOTO) Procedure | To ensure that the collimator shutter remains closed before commencing the dismantling work. | Administrative control | NA | This administrative control prevents workers from commencing work without ensuring that the shutter is closed. | 0.1 | |
| CC02 | Decommissioning Procedure/Health Physics Survey. | To prevent workers from undertaking work before confirming that the radiation level is within acceptable limits. | Administrative control | NA | HP surveyors monitor the area to determine the dose rate around the instrument to highlight potentially high level of radiation. | 0.01 | |
| CC03 | Dangerous Goods Rated Crane (Polar Crane) | To prevent failure of the crane during heavy lifting activates. | Engineered | 1 | The DG rated crane has the additional safety features of dual rope and emergency braking. | 0.01 | Routine maintenance<br>Review and approval by the lifting approval officer. |
| CC04 | Lifting Exclusion Zones and ANSTO Standard Industrial Practice | Prevention of personnel under or close to a lifted or centre of gravity shifted load | Administrative | - | A temporary physical barrier underneath or close to the lifted or potentially hazardous load. Complimented by this is the standard ANSTO safety guidelines on lifting. | 0.1 | Shift supervisor to maintaining temporary exclusion zones |
| CC05 | Fume Hood Extraction | To mitigate purposeful and accidental cutting through toxic and radiological materials that become airborne | Engineered | 2 | A portable fume hood that extracts airborne particulates and aerosols and captures these into a filter. | 0.1 | |

**Table 6 Summary of additional Controls**

| Related Control | Description |
|---|---|
| Change Barrier & Exit Radiological Monitoring | Change Barriers and radiological monitoring will be utilised to minimise spread of contamination during dismantling and decontamination tasks commensurate with the area classification as advised by Health Physicist. |
| Combustibles to be minimised around Hot Works | Combustible inventories (e.g., wax) will be removed prior to Hot works cutting.<br>Housekeeping will be undertaken to minimise any build-up of combustibles in the area and Fire Curtains, or Barriers will be used if required.<br>Flammable liquids will be segregated and stored in accordance with hazardous materials codes. |
| Fire Extinguishers and Hose Reels | Local firefighting equipment suitable for the works will be available throughout the facility. |
| Polar Crane Access Ladder Fall Restraint System | A fall restraint is utilised when accessing the Polar Crane Cabin. |
| First Responders - First Aid | Rapid Response from trained First Aiders to stabilise injuries reduces the injury category. |
| Fixed Real-Time Dose Rate Monitor | Fixed Area Radiation Monitors (ARMs) are located throughout the RCB to detect any increase in radiation levels. In such an event they will initiate alarms and the emergency response from ASOC |
| Electronic Personal Dosimeter (EPD) Alarm | The use of EPD's provide further defence in depth in terms of by indicating radiation exposure near the operator |
| HIFAR NVS & AVS filtered Discharge via Stack | Effective filtration to be used in reducing particulates discharge. |
| VESDA prompts Local & SCC Evacuation Alarm & Site ER | Installed Fire Detectors (VESDA) - Local and SCC alarm & site ER response.<br>The VESDA system will detect low concentrations of smoke and generate an alarm (local and SCC) to prompt workers to stop work, fight an obvious small fire or evacuate awaiting the Site Emergency Response |
| VESDA prompts Ventilation Closure | On detection of smoke in the AVS duct, the inlet fans automatically shut down and inlet dampers close, the extract fans switch to half extract speed, and an alarm is sounded to prompt investigation and corrective action which may include further isolation / extinguishing and to prompt an evacuation of the building / site ER. |
| Building AVS HEPA Filters – Fire Retardant | The Building AVS HEPA filters are a nuclear grade (fibreglass) fire retardant material |
| Breathing Air /RPE | Operators undertaking the hot cutting will utilise positive air flow hoods. |
| Portable Air Monitor | The use of a portable air monitor will provide warning if airborne radiological contamination is detected |
| Task informed by Surveys, Exposure Assessment & Detailed Execution Plan | Selection of Technique based on Characterisation, Radiological Survey, Hierarchy of techniques and indicated in DEP. Specific controls may include the temporary sealing of openings during handling & prior to crane lifts. |
| Pre-decommissioning Intrusive Survey & Specialist ACM removal | Prior to the decommissioning of any space or structure, an intrusive hazardous materials survey will be conducted. Identified ACM will be protected pending access for remediation. Removal of ACM will be undertaken by specialists under ANSTO AP2522. |
| Stop Work if unexpected ACM detected | Asbestos Awareness training will form part of the training manual for HIFAR Decommissioning.<br>If any potential ACM is identified, work will be stopped prompting sampling / protection / specialist removal (as detailed in DEP, toolbox talk and SWMES). |

| | |
|---|---|
| Personnel Exclusion Zones & Barriers | Set up exclusion zones to prevent potential injury to operator. Communication between work groups across the multiple working levels in HIFAR is important. |
| Lift Plan identifies appropriate method & controls | Lift plans will be utilised for nonstandard lifts and will be assessed by the Lifting approval officer (LEAO) and WHS prior to undertaking the work, to ensure Worker Physical wellbeing, Skilled & Conditioned for lifting and ergonomic Study for repetitive task has been undertaken and reviewed. |
| Appropriate use of access ladders / stairs | Work at Heights training will form part of the training manual and be undertaken by personnel.<br>- 3 point of contact.<br>- no transfer of tools or materials by hand on ladders<br>- Awareness of steep stairs within HIFAR<br>- utilises stable & protected work platform<br>- Fall Prevention Barriers |

## 9.5. Reference Accident

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## 9.6. Emergency Preparedness Category

The IAEA GSR-Part 7 (17) requires that all controlled facilities are assigned Emergency Preparedness Categories to determine the appropriate level of preparedness and response for a nuclear or radiological emergency. The application of these requirements is intended to mitigate the consequences of a nuclear or radiological emergency if an emergency occurs despite all efforts made to prevent it.

ANSTO is committed to ensuring compliance with IAEA GSR Part 7: Preparedness and Response for a Nuclear Radiological Emergency (17), and the ARPANSA RPS G-3 Guide for Radiation Protection in Emergency Exposure Situations (26).

In accordance with ANSTO WHS Management System (19), and under the guidance of the ANSTO Emergency Management Plan: Lucas Heights Campus Emergency Plan (20), all ANSTO facilities (including the HIFAR facility) operate under a common framework. In addition, the most likely emergency situations and actions are described in the Emergency Management Plans of the HIFAR P&A ACS261210.

As considered in the risk assessment and the reference accident (Section 9.5), there are no credible reference accidents that could present risk of harm to persons outside of the facility. However, the security initiator prudently assumes people outside of the facility but still on site may be exposed. As detailed in Radiation Protection Services Technical Note ANSTO/RPS/TN/2022-03 (21), the HIFAR facility is assessed as Emergency Preparedness Category III.

# 10. CONCLUSIONS

This section sets out the rationale for acceptability of Phase A-I D&D and C&M. It takes the information provided within previous sections of the SAR and compares it with industry best practices and safety objectives.

## 10.1. Acceptability Of Normal Operation

The facility is in an adequate condition for its intended purpose and that there are no life limiting components that may affect the safety of the facility over the next 5 years, whilst undertaking decommissioning.

The safety management systems used to control operations in the facility have been described in Section 0 and have shown to provide appropriate levels of control. Planned D&D activities and C&M in the facility pose no hazard to the public. The external dose rates are not sufficient to present any hazard at the site boundary. Normal operations in the facility pose an acceptable risk to operators.

## 10.2. Acceptability of Residual Risk Associated with Abnormal Operation

has described the risks associated with accidents that may occur within HIFAR during decommissioning has been discussed in Section 9. This shows that residual risks of radiological consequence of the potential abnormal events are very low or low. These affect only staff and not the public.

The residual risks of non-radiological accidents resulting in physical injury or health effects were assessed as very low, low or medium. The medium level risks were assessed as low as reasonably practicable (ALARP).

There is no risk to members of the public due to normal or abnormal operations of this facility during decommissioning.

## 10.3. Emergency Arrangements, Procedures and Exercises

The various risk assessments identified several credible scenarios which could cause above normal radiation exposure and/or personal injury. The most likely emergency situations and actions are described in the Emergency Management Plans of the HIFAR P&A ACS261210.

## 10.4. Maintenance, Inspection and Testing of Safety Related Items

HIFAR is currently in a good condition that enables and facilitates decommissioning as well as all future maintenance operations.

## 10.5. Action Plan

Several risk assessments have recommended safety improvements. These refer to operational improvements during decommissioning and have been given due consideration for implementation within the DEP and tracked via GRC.

## 10.6. Justification For Continued Operations

This safety analysis report demonstrates that the facility can be operated safely and in compliance with all the relevant regulations. The management systems and responsibilities to ensure that this is achieved have been described.

## 10.7. Facility Hazard Categorisation

The HIFAR facility is assessed as Emergency Preparedness Category III.

# 11. Acknowledgments

The Licence Nominee acknowledge with thanks the input to this SAR provided by everyone involved in the ANSTO Decommissioning Project Team.

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# 13. DEFINITIONS

The site SAR document will define the general terms such as the acronym SAR. Avoid the use of acronyms as far as possible.

| Term/Abbreviation | Definition |
|---|---|
| AC | Alternating Current |
| ACM | Asbestos Containing Materials |
| AeSAP | ANSTO Enterprise SAP |
| AOR | Abnormal Occurrence Report |
| APR | Auxiliary Plant Room |
| ARWA | Australian Radioactive Waste Agency |
| ASNO | Australian safeguards and non-proliferations Office |
| AVS | Active Ventilation System |
| Bounding Case | A selected case that represents potential accidents for other cases in the group |
| CCA | Corse Control Arm |
| C&M | Care and Maintenance |
| D2O | Deuterium |
| DA | Deconstruction Area |
| DAC | Derived Air Concentration |
| DCA | Decontamination Area |
| DDA | Deconstruction and Decontamination Area |
| DGR | Dangerous Goods Rated |
| DU | XX XX XX XX XX |
| ECR | Emergency Control Room |
| EPD | Electronic Personal Dosimeters |
| FANAL | Fast Access Neutron Activation Laboratory |
| HEPA Filter | High Efficiency Pleated Air Filter |

| | |
|---|---|
| HIFAR | High Flux Australian Reactor |
| HP | Health Physics or Health Physicist |
| HPS | Health Physics Surveyor |
| IAEA | International Atomic Energy Agency |
| Inherent Impact | The consequence that an event would have without controls in place |
| ILW | Intermediate Level Waste |
| LHSTC | Lucas Heights Science and Technology Centre |
| LOTO | Locked Out Tagged Out |
| Material risk | Risk that has serious consequences regardless of probability of occurrence |
| MCCB | moulded case circuit breaker |
| Mitigative controls | A control the reduces the severity of an event |
| Non radiological hazard | Any hazard that does not involve ionising radiation from radioactive material or controlled apparatus; or non-ionising radiation from controlled apparatus or naturally occurring. |
| NRWMF | National Radioactive Waste Management Facility |
| Nuclear hazard | Hazard that involves nuclear material |
| NVS | Normal Ventilation System |
| OLC | Operational Limits and Conditions |
| PAL | Personnel Airlock |
| PFD | Probability of Failure on Demand |
| PorC | Possess or Control |
| Preventative controls | A control that reduces the likelihood of an event occurring |
| RAT | Reactor Aluminium Tank |
| RCB | Reactor Containment Building |
| Radiological hazard | Hazard that involves ionising radiation from radioactive material or controlled apparatus; or non-ionising radiation from controlled apparatus or naturally occurring. |
| RCD | Residual Current Device |
| Residual impacts | The consequence that an event would have after controls are in place |
| RF | Reduction Factor |
| RPA | Radiation Protection Adviser |
| SAR | Safety Analysis Report |
| SB1 | Storage Block No 1 or Number 1 Storage Block |
| SCADA | Supervisory control and data acquisition |
| SSC | Systems, Structures, Components |
| Fissionable Materials | Material that is capable of undergoing fission reaction after absorbing either thermal (slow or low energy) neutron or fast (high energy) neutron |
| SRA | Safety and Reliability Assurance |
| SSR | Systems, Safety and Reliability |
| SWL | Safe Working Load |
| TLD | Thermo Luminescent Dosimeter |
| UPS | Uninterruptable power supply |
| VAL | Vehicle air lock |

# Appendix A - LUCAS HEIGHTS CAMPUS

**Figure 2 Lucas Heights Campus Aerial Image**

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**Figure 3 HIFAR Decommissioning Zone and route to Waste Management Services**

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# Appendix B – RISK ASSESSMENT SUMMARY TABLE

| HIFAR Decommissioning Phase A-I Risk Assessment Summary Table | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Scenario** | **Impact** | **Category description** | **Inherent Impact** | **Inherent Frequency (p.a.)** | **Inherent Risk** | **Critical Controls** | **Other Controls** | **Residual Impact** | **Residual Frequency (p.a.)** | **Residual Risk** |
| 9.2.1. | Exposure to gamma radiation during Direct Radiation Exposure when undertaking Decommissioning Activities Removal of the monochromator or rotating beam selector, if the collimator shutter is left open in error. | Radiation shine of 30 mSv/h exposed for more than 30 minutes (assuming 1 hour) if the task of removing the monochromator was delayed due to error or crane failure, which could result in an effective does to the worker of greater than 20 mSv. | 30 mSv/hr | Major | Likely | High | CC01 Administrative control to ensure that the shutter remains closed during dismantling<br>CC02 Procedure/Health Physics (HP) survey of the work area at the completion of each step | • Oversight of the task by an RPA<br>• Fixed area radiation monitoring and alarms<br>• Individual dose monitoring, using EPDs or TLDs<br>• Detailed decommissioning procedures<br>• Daily toolbox talks to plan out each day's work<br>• Radiation surveys, prior to commencement of work<br>• Dose assessment planning prior to the work based on the radiation survey<br>• Oversight by RPA<br>• Planned activity<br>• Adequately training for the dismantling crew | Major | Highly Unlikely | Low |
| 9.2.2 | Dropping Instrument or components during instrument lifting | Physical Injury | Death, permanent disability or permanent ill health | Severe | Likely ($10^{-2}$ to $10^{-1}$ p.a.) | High | CC03 Dangerous Goods Rated Crane (Polar Crane) | • Certified crane and lifting devices<br>• Active ventilation system<br>• Crane maintenance<br>• Certified crane operators and dogmen<br>• Airborne contamination monitoring | Severe | Highly Unlikely ($10^{-5}$ to $10^{4}$ p.a.) | Medium |
| | | Whole body dose | (0.1-1 mSv) | Minor | Likely | Very Low | | | Minor | Highly Unlikely | Very Low |

| HIFAR Decommissioning Phase A-I Risk Assessment Summary Table | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Scenario** | **Impact** | **Category description** | **Inherent Impact** | **Inherent Frequency (p.a.)** | **Inherent Risk** | **Critical Controls** | **Other Controls** | **Residual Impact** | **Residual Frequency (p.a.)** | **Residual Risk** |
| | | | | | ($10^{-2}$ to $10^{-1}$ p.a.) | | CC04 Lifting Exclusion Zones and ANSTO Standard Industrial Practice | • Evacuation procedures and drills<br>• Individual dose monitoring, using EPDs.<br>• Health physics surveys<br>• Hand and body PPE, gloves, overcoat eye protection, P3 masks. | | ($10^{-5}$ to $10^{-4}$ p.a.) | |
| 9.2.3 | Physical injury or dose from fire or heat application | Molten Wax or fire Injury | >5 days Lost Time Injury | Major | Not credible (<$10^{-6}$ p.a.) | Not Assessed | - | • Wax removal procedure-inspection<br>• Wax removal procedure-even heating application<br>• Appropriate firefighting equipment<br>• PPE- Fire retardant | Moderate | Not credible (<$10^{-6}$ p.a.) | Not Assessed |
| | | Heated Blanket Injury | First aid | Minor | Unlikely ($10^{-3}$ to $10^{-2}$ p.a.) | Very Low | | | Minor | Unlikely ($10^{-3}$ to $10^{-2}$ p.a.) | Very Low |
| | | Injury due to pressurisation of Paraffin wax | <5 days Lost Time Injury | Moderate | Very Unlikely ($10^{-4}$ to $10^{-3}$ p.a.) | Low | | | Moderate | Very Unlikely ($10^{-4}$ to $10^{-3}$ p.a.) | Low |
| 9.2.4 | Worker Radiation exposure during cutting | XX release airborne inhalation dose | 20mSv-100mSv | Moderate | Highly Unlikely ($10^{-5}$ to $10^{-4}$ per year) | Very Low | CC05 Fume Extraction | • Positive pressure mask PPE<br>• Detailed decommissioning procedures<br>• Fixed Area Radiation Monitoring<br>• Health physics surveys<br>• Individual dose monitoring, using EPDs.<br>• Detailed decommissioning procedures<br>• Daily toolbox talks<br>• Dose assessment<br>• Dose constraints | Moderate | Extremely Unlikely ($10^{-6}$ to $10^{-5}$ p.a.) | Very Low |
| | | XX Exposure | Toxicity Category 2 | Severe | Highly Unlikely ($10^{-5}$ to $10^{-4}$ per year) | Medium | | | Severe | Extremely Unlikely ($10^{-6}$ to $10^{-5}$ p.a.) | Low |

| HIFAR Decommissioning Phase A-I Risk Assessment Summary Table | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Scenario** | **Impact** | **Category description** | **Inherent Impact** | **Inherent Frequency (p.a.)** | **Inherent Risk** | **Critical Controls** | **Other Controls** | **Residual Impact** | **Residual Frequency (p.a.)** | **Residual Risk** |
| | | | | | | | | • Review of DEPs by RPA.<br>• Hand and body PPE, gloves, overcoat eye protection, P3 masks. | | | |
| 9.3.1 | Loss of Site Power - Ventilation system failure exposing workers to airborne contamination | Effective dose to an occupationally exposed person During extended outage | >0.1 - 1 mSv | Minor | Likely (0.01 pa to 0.1 pa) | Low | - | • DGR crane (for dropped load scenario)<br>• Automatic PA announcement, and evacuation of the building, low pressure/ low airflow switch generating alarm<br>• Redundant fan with site backup supply<br>• Triton instrument installed in the HIFAR building will raise an alarm on high tritium level in the building<br>• The air damper to the ventilation system is locked open.<br>• PPE eye protection, P3 masks. | Minor | Likely (0.01 pa to 0.1 pa) | Low |
| 9.3.2 | Seismic event during decommissioning | Load drop | (Death, permanent disability or permanent ill health) | Severe | Extremely Unlikely ($10^{-6}$ to $10^{-5}$ p.a.) | Low | - | • DGR rated crane<br>• Exclusion zone/ barricades.<br>• Safe work practices.<br>• Trained/Certified/Authorised crane operators and dogmen<br>• RCB evacuation | Severe | Extremely Unlikely ($10^{-6}$ to $10^{-5}$ p.a.) | Low |
| 9.2.5 | The asbestos tiles on the floor and under the instrument | Exposure to asbestos fibres | (Death, permanent disability or | Severe | Very Unlikely ($10^{-4}$ pa to $10^{-3}$ pa) | Medium | - | • Dangerous Goods Rated Crane HIFAR building ventilation system | Severe | Highly Unlikely ($10^{-5}$ pa to $10^{-4}$ pa) | Low |

| HIFAR Decommissioning Phase A-I Risk Assessment Summary Table | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Scenario** | **Impact** | **Category description** | **Inherent Impact** | **Inherent Frequency (p.a.)** | **Inherent Risk** | **Critical Controls** | **Other Controls** | **Residual Impact** | **Residual Frequency (p.a.)** | **Residual Risk** |
| | could be damaged during the dismantling process if a suspended load is dropped on it. This could result workers being exposed to asbestos fibres. | | permanent ill health) | | | | | • ANSTO WHS guidelines will be followed during TAS instrument dismantling process<br>• The task will make use of certified crane, chain, and other lifting equipment<br>• The crane operators and dogmen deployed for the task are experienced, trained, and certified<br>• PPE- P3 Masks | | | |
| 9.2.8 | Manual handling Incidents | Physical injury could occur if heavy items lifted without following proper procedure or due to awkward positions | Medical attention/up to 5 days of LTI | Moderate | Likely (0.01 pa to 0.1 p.a.) | Medium | - | • Operator experience<br>• Safe work practices | Moderate | Likely (0.01 pa to 0.1 p.a.) | Medium |
| 9.2.9 | Electrocution Risk | Faulty equipment or misuse could lead to electric shock or electrocution. | Death, permanent disability or permanent ill health | Severe | Highly Unlikely ($10^{-5}$ to $10^{-4}$ per year) | Medium | -<br>- | • Use of RCD's<br>• Electrical work performed by licensed electricians<br>• Isolation of electrical connection prior to commencement of work | Severe | Highly Unlikely ($10^{-5}$ to $10^{-4}$ per year) | Medium |
| | | Faulty equipment or misuse could lead to | Death, permanent disability or | | | | | | | | |

| HIFAR Decommissioning Phase A-I Risk Assessment Summary Table | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Scenario** | **Impact** | **Category description** | **Inherent Impact** | **Inherent Frequency (p.a.)** | **Inherent Risk** | **Critical Controls** | **Other Controls** | **Residual Impact** | **Residual Frequency (p.a.)** | **Residual Risk** |
| | | electric shock or electrocution. | permanent ill health | | | | | | | | |
| 9.2.6 | Working at Heights | Falls-physical injury | Death, permanent disability or permanent ill health | Severe | Highly Unlikely ($10^{-5}$ to $10^{-4}$ p.a.) | Medium | - | • Safe work practices | Severe | Highly Unlikely ($10^{-5}$ to $10^{-4}$ p.a.) | Medium |
| 9.2.7 | Slip, trip or fall | Falls-physical injury | Medical attention / up to 5 days off (LSI) | Moderate | Unlikely ($10^{-3}$ to 0.01 p.a.) | Low | - | • Hard hat, Steel cap boots (PPE)<br>• Safe work practices | Moderate | Unlikely ($10^{-3}$ to 0.01 p.a.) | Low |

# Appendix C PHASE A-I WORK ASSOCIATED LIST OF RISK ASSESSMENT

| D&D Equipment | Safety Assessment Associated with HIFAR Phase A-I work |
|---|---|
| AUSANS | ANSTO/T/TN/2021-08 rev 0, (ACS248162)<br><br>Dismantling and decommissioning of AUSANS beam instrument involves the dismantling of 21 interlocking blocks which formed the main shielding of the instrument. Shielding materials include lead, steel, borated paraffin wax, and borated rubber sheets. Other equipment to be removed include a rotating beam selector, collimator rig, monochromator, and a detector vessel.<br><br>Identified potential safety hazards due to decommissioning activities are asbestos exposure, manual handling, electrical hazards, dropping of detector vessel and working at heights. These risks have been assessed as medium and all radiological events are low or very low.<br><br>Dismantlement will be undertaken using various techniques/methods such as polar crane, exclusion zones, barricades, SWMES, dose monitoring and radiation monitoring on the active extract |
| MRSCD | ANSTO/T/TN/2021-09 rev 0, (ACS248163)<br><br>Dismantling and decommissioning of the MRSCD involves the dismantlement of the biological shield (principally consisting of three interlocking shield blocks and integrated plugs) which are constructed from steel, lead, and borated paraffin wax.<br><br>Identified potential safety hazards due to decommissioning activities are exposure to asbestos, manual handling, electrical hazard and working at heights. These risks have been assessed as medium and all radiological events are low or very low.<br><br>Dismantlement will be undertaken using various techniques/methods such as hand tools, polar crane, exclusion zones, barricades, SWMES, dose monitoring and radiation monitoring on the active extract |
| LONGPOL | ANSTO/T/TN/2021-12 rev 0, (ACS248167)<br><br>Dismantling and decommissioning of LONGPOL involves the dismantlement of the biological shield (principally consisting of four interlocking shield blocks and integrated plugs). These components are constructed from steel, lead, and borated paraffin wax.<br>Identified potential safety hazards due to decommissioning activities are exposure to asbestos, manual handling, electrical hazard and working at heights. These risks have been assessed as medium and all radiological events are low or very low.<br>Dismantlement will be undertaken using various techniques/methods such as hand tools, polar crane, exclusion zones, barricades, SWMES, dose monitoring and radiation monitoring on the active extract. |
| TAS | ANSTO/T/TN/2021-10 rev 1, (ACS248165)<br><br>Dismantling and decommissioning of TAS involves the dismantlement of the biological shield (principally consisting of upper and lower interlocking shield blocks), monochromator plug, dummy collimator plug, axis drive rail and residual internal brackets. These components are constructed from steel, lead, borated paraffin wax, borated rubber sheets, and XX XX XX XX XX (DU).<br><br>Identified potential safety hazards due to decommissioning activities are manual handling, electrical hazard, working at heights, slips, trips and |

| | |
|---|---|
| | falls, and physical injury during cold cutting and airborne XX inhalation. These risks have been assessed as medium and all radiological events are low or very low.<br><br>Dismantlement will be undertaken using various techniques/methods such as hand tools, cold cutting, polar crane, exclusion zones, barricades, SWMES, dose monitoring and radiation monitoring on the active extract. |
| MRPD | ANSTO/T/TN/2021-13 rev 0, (ACS248164)<br><br>Dismantling and decommissioning of the MRPD involves the dismantlement of the biological shield (principally consisting of interlocking shield blocks and integrated plugs) which are constructed from steel, lead, and borated paraffin wax.<br><br>Identified potential safety hazards due to decommissioning activities are manual handling, electrical hazard and working at heights. These risks have been assessed as medium and all radiological events are low or very low.<br><br>Dismantlement will be undertaken using various techniques/methods such as hand tools, polar crane, exclusion zones, barricades, SWMES, dose monitoring and radiation monitoring on the active extract. |
| Neutron Reflectometer | ANSTO/T/TN/2021-11 rev 0, (ACS248166)<br><br>Dismantling and decommissioning of the Neutron Reflectometer involves the dismantlement of the biological shield (principally consisting of shield blocks, lead blocks, lead shot and integrated plugs) and residual internal brackets. These components are constructed from steel, lead, and borated paraffin wax.<br><br>Identified potential safety hazards due to decommissioning activities are asbestos exposure, manual handling, electrical hazard and working at heights. These risks have been assessed as medium and all radiological events are low or very low.<br><br>Dismantlement will be undertaken using various techniques/methods such as hand tools, polar crane, exclusion zones, barricades, SWMES, dose monitoring and radiation monitoring on the active extract |
| XXXXX Analysis Rig | ANSTO/T/TN/2021-14 rev 0, (ACS248160)<br><br>Dismantling and decommissioning of the XXXXX Analysis Rig involves the dismantlement of the biological shielding and sample transport tubing, measuring station, loading station and contamination filtration system. These components are constructed from steel, paraffin wax and lead.<br><br>Identified potential safety hazards due to decommissioning activities are electrical hazard, working at heights, manual handling and slips, trips and falls. These risks have been assessed as medium and all radiological events are low or very low.<br><br>Dismantlement will be undertaken using various techniques/methods such as hand tools, polar crane, exclusion zones, barricades, SWMES, dose monitoring and radiation monitoring on the active extract. |
| Rig Support Equipment | ANSTO/T/TN/2021-31 rev 0, (ACS248161)<br><br>Dismantling and decommissioning of the rig support equipment involves the dismantlement of the various control panels, loading stations, unloading stations, piping, active ventilation fans and ducting, delay stations, biological shielding, valves, and field instruments. These components are constructed of various materials including polymers, steal, lead and copper. |

| | |
|---|---|
| | Identified potential safety hazards due to decommissioning activities are electrical hazard, working at heights, manual handling, slips and trips and falls. These risks have been assessed as medium and all radiological scenarios are low inherent risks.<br>Dismantlement will be undertaken using various techniques/methods such as hand tools, polar crane, exclusion zones, barricades, SWMES, dose monitoring and radiation monitoring on the active extract |
| Utilisation Equipment | ANSTO/T/TN/2021-32 rev 0, (ACS261238)<br>Dismantling and decommissioning of the utilisation equipment involves the dismantlement of the fuel element transfer flasks, fuel assembly station, silicon storage blocks, transfer flasks and the reactor control room. These items are constructed of various materials including polymers, steal, lead and copper.<br>Identified potential safety hazards due to decommissioning activities are dropped load, manual handling, electrical hazard and working at heights. These risks have been assessed as medium and all radiological events are low or very low.<br>Dismantlement will be undertaken using various techniques/methods such as hand tools, polar crane, exclusion zones, barricades, SWMES, dose monitoring and radiation monitoring on the active extract |