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Systems
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Safety Assessment of the Interim Waste Store at Lucas Heights

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1	22 July 2014	Revised as per SAC comments
2	22 July 2014	Revised to include detail of the waste returning from the UK.
3	18 July 2014	Revised for the operating licence application of the Interim Waste Store. Included the analyses and findings of the TSAR.

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EXECUTIVE SUMMARY

Following the authorisation from ARPANSA to site and construct, ANSTO has commenced the construction of the radioactive waste store, called the *Interim Waste Store (IWS*), for housing Australia's Intermediate Level Waste (ILW) returned from France where it was reprocessed from HIFAR used fuel assemblies. This report covers the safety assessment of the activities to be undertaken during the operational phase of the IWS. The assessment includes a hazard identification followed by risk assessment in accordance with the ANSTO Work Health and Safety Management System (WHSMS). The report took into account the analysis and findings of the various accident scenarios that are analysed by AREVA TNI in the Topical Safety Analysis Report (TSAR) of the TN 81 Transport/Storage Container.

The ILW package containers that will be stored in the IWS are of robust design and construction, verified by independent third parties. The waste packages are tested and certified for transport by the Competent Authorities in France in compliance with the radioactive material transport regulation [4]. The risk of various hazardous scenarios considered in this report were assessed as 'Low' or 'Very Low', except for the electrical, manual handling and working at heights risk which are considered 'as low as reasonably practicable' (ALARP) since good safety practices are followed in ANSTO against these hazards,.

Where deemed necessary, the report made recommendations to reduce the risk, ensure good safety practices are followed and in some cases, to implement cost-effective improvements (even if the risk is Low or Very Low).

The risks considered in this report were assessed taking into account satisfactory implementation of the recommendations. Therefore, since this report is intended (amongst other uses) to support ANSTO internal safety approval of the proposed ILW Return project and also regulatory / licensing approval it is expected that the client will prepare a document outlining the disposition of these recommendations. The disposition of the recommendations should be made in consultation with the author of this report.

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1. INTRODUCTION

This report documents a safety assessment of the operation of the Interim Waste Store (IWS) at ANSTO. The objective of the study is to assess potential safety issues of the facility during its operational phase and to demonstrate that they are adequately addressed, with the view of facilitating safety approval for the facility and the application for an operating licence for this facility from the regulatory authority, Australian Radiation Protection and Nuclear Safety Agency (ARPANSA).

2. BACKGROUND

The IWS has been constructed at the Lucas Heights Science and Technology Centre (LHSTC) after obtaining siting and construction licences and will be used for the storage of solid intermediate level wastes (ILW).

Used fuel assemblies from HIFAR were sent to the United Kingdom (UK) in 1996 and France (between1999 and 2004) for reprocessing on the basis that the waste from the reprocessing operations would be returned to Australia. Under intergovernmental agreements the Australian Government signed in the 1990's, Australia is obliged to ensure that the intermediate level waste is removed from France by December 2015.

Under French Law, the La Hague reprocessing facility is not permitted to reprocess spent fuel from another country unless arrangements are in place for that country to take back the waste. ANSTO does not currently have a national facility to accommodate the ILW returning from France.

Australian nuclear fuel has also been reprocessed in the UK. ANSTO has negotiated a waste substitution agreement with the UK Nuclear Decommissioning Authority to take ownership of 3-4 canisters of low incorporation vitrified waste rather than the 51 drums of concrete encapsulated waste originally planned. The timescale for return is yet to be determined, but is unlikely to be before 2020. If Australia's National Radioactive Waste Management is not operational by the time of the UK return the UK waste could be temporarily stored in the proposed IWS, subject to a separate Regulation 51 approval by the CEO of ARPANSA [1].

The IWS will constitute a Nuclear Installation (a type of Controlled Facility) under the ARPANS Act and Regulations and ANSTO intends to make a Licence Application to ARPANSA to operate the facility.

The operating licence application for this facility is seeking approval to store the intermediate level solid wastes arising from French reprocessing of used HIFAR fuel (return in 2015). However, for the waste arising from the reprocessing of HIFAR used fuels in the UK, ANSTO will seek regulatory approval from ARPANSA later in the decade when the detailed information about the UK waste inventory and its timing of return are known to ANSTO.

2.1 Waste reprocessed in France

Waste reprocessed in France is vitrified meaning it is immobilised in a glass matrix inside stainless steel canisters. This process provides for a conditioned waste-form that is stable for thousands of years. The canisters are then placed inside a highly shielded container called the TN 81 Transport/Storage Container. The container is a dual purpose transport and storage container and licensed for use in France and Switzerland. It weighs about 115T and will store the vitrified ILW for at least 40 years (design life).

In addition to the reprocessed waste, ANSTO is also obliged to accept a share of the waste that arises from the reprocessing itself. This waste is known as the technological waste. This waste will include such items as disposable personal protective equipment (gloves, coveralls), paper, swabs, equipment, equivalent to that which would have been produced during the reprocessing of the HIFAR spent fuel. The technological waste is packed and cemented in steel drums each of which is in turn placed in a shielded transport/storage concrete container called a CBFC type 2 (CBF-C2). The shell of this container is made of fibre concrete and once filled with waste, it is then filled with a cement slurry and put aside to allow the slurry to set. There will be six CBF-C2 concrete containers housed in a metal rack and shipped to Australia in an ISO 20 foot IP2 container. The ISO container will arrive in the same shipment as the TN 81 Transport/Storage Container.

Both the technological and vitrified wastes will be repatriated to Australia under the contract between ANSTO and AREVA of France –"Contract for the Management of ANSTO's Research Reactors Spent Fuel" signed on 22 January 1999. The waste reprocessed in France must leave France by 31 December 2015.

3. SCOPE

The scope of this report is to perform a hazard identification and risk assessment of the storage of Australia's ILW (i.e. TN 81 Transport/Storage Container containing vitrified waste and the six technological wastes in cemented waste drums, also known as CBF-C2 containers) to be shipped from France in the IWS which is built at LHSTC.

The safety assessment of the transport of the TN 81 Transport/Storage Container and the CBF-C2 containers (i.e. both maritime and road transport of the wastes) is not part of this report. This will be subject to a separate assessment.

The assessment took into account the analysis and findings of the TN 81 package Topical Safety Analysis Report (TSAR) prepared by AREVA [26, 27, 28].

The risk assessment of the crane operation is performed separately and the analysis is in Appendix D.

The study focussed on the potential safety aspects of the facility during its operational phase and it included the routine normal operations of the facility and abnormal occurrences due to both internal and external events. Environmental aspects are outside the scope of the study.

The main consequence analyses (those undertaken by AREVA in the TSAR and cited in this report) were carried out using detailed computational analyses and in some cases, comparison with experimental work. The remaining assessments in this safety document were assessed semi-quantitatively using engineering judgement and no formal assessment of frequency or consequence for those sequences was undertaken. According to the graded approach to risk assessment only scenarios that can lead to 'major' or 'severe' radiological consequences are addressed by formal assessment, and no such scenarios were identified.

The study did not include the safety assessment of the waste returning from the UK because, the timing of return and its detailed radioactive inventory are not known to ANSTO at this stage.

4. FACILITY DESCRIPTION

ANSTO has constructed* an interim storage facility, the IWS, for the storage of the ILW returning from France (and possibly from the UK at later stage). The IWS building has a floor area of 28.2 m x 30m with a height of 21m and will contain a 140 Tonne Dangerous Goods Rated (DGR) crane to enable vertical lifting of the tallest container (i.e. the TN 81 Transport/Storage Container). The crane will also be used to unload the TN 81 Transport/Storage Container from the transport truck and place it at a desired location inside the store.

The building design includes fitted all necessary electrical and mechanical services, such as power, lighting, ventilation, fire detection, lifting devices, security systems etc.

The building has a natural ventilation system with an added feature of mechanical ventilation. No active ventilation is required as there will be no airborne contamination in the facility. Further description of the system is provided in the *Description of the Structures, Components, Systems and Equipment* document [24].

* **Note:** *This report is written with the view of describing and analysing the operation of the facility when it is installed and commissioned although the facility is currently being constructed. Therefore, some of the descriptions given below are written as if the facility is already in existence.*

There will be no additional shielding in the building at this stage as all of the waste items will be stored in shielded containers i.e. (a) a large shielded TN 81 Transport/Storage Container, which is approved and certified by the French regulatory authority for the vitrified waste and an IP2 ISO container for the technological waste.

4.1 The TN 81 Transport/Storage Container

There will be one TN 81 Transport/Storage Container in the store containing the waste residues reprocessed in France. The TN 81 is designed and constructed to provide structural containment and adequate shielding to the vitrified waste canisters (called CSD-U) to be stored within the container [26,21]. There will be up to 28 vitrified ILW canisters in this container. In fact the TN 81 Transport/Storage Container is designed and capable of holding 28 canisters of High Level Waste (HLW) with a maximum thermal load of 56 kW whilst the ANSTO waste is classified as ILW with a maximum thermal load of 15.4 kW. ANSTO does not have any HLW. The container has the following technical specifications:

The overall outside dimensions of the TN 81 Transport/Storage Container are [26]:

- Height: 6,454 mm (including the anti-crash cover); and
- External diameter: 2,780 mm.

The gross mass of the TN 81 Transport/Storage Container loaded for transport is about 118 Tonne [26, 13] when loaded with 28 canisters of verified wastes.

The TN 81 Transport/Storage Container is a forged steel cylindrical vessel with a forged steel bottom-end welded in. It has two lids (primary and secondary) which are also of forged steel. The thickness of the cylindrical shell is about 200 mm [8, 9 and 7]. There is an annular space called 'Aluminium Profile' [8] around the shell filled with lead (67 mm thick) and neutron shielding (using a high density resin compound). The gamma shielding is provided by the forged steel shell (of 200 mm thick) and lead installed in the 'Aluminium Profile' around the shell [9]. The neutron shielding is achieved by the resin compound which is poured into the 'Aluminium Profile. Figure 1 shows the configuration of the TN 81 Transport/Storage Container [12]. The confinement of the vitrified waste stored in the TN 81 Transport/Storage Container is achieved by the steel shell, the primary lid and its metallic gasket and the orifice tape with its metallic gasket [11]. Secondary containment is achieved by the secondary lid and its gaskets.

The TN 81 Transport/Storage Container is a certified Type B(U)F type transport package and thus it has undergone drop tests with different configurations and a missile impact test representative of an F-18 plane crash [16, 27]. The TN81 design is being separately assessed by ARPANSA as the competent Authority with a view to validate the certification for transport and to re-certify the package design for storage. Also, the radiological assessment undertaken by AREVA in the TSAR shows that the dose rate in the vicinity of the package under the normal and accident conditions remains below the acceptable limits [37]. In Germany, for the purpose of storage of the TN 81 Transport/Storage Container, an additional drop test was performed to demonstrate that, even after a drop of more than 3 m without shock absorbing covers, the leak-tightness was better than 10^{-8} Pa.m^{3}.s^{-1} [13].

The TN 81 Transport/Storage Container will be safely transported with a primary lid covered with a top shock-absorber, the bottom shock absorber and two aluminium transport rings (T1 configuration). After arriving at the IWS at LHSTC, the top shock-absorber will be removed from the TN 81 Transport/Storage Container and replaced by the secondary lid fitted on top of the primary lid. The bottom shock absorbing cover will also be removed.

4.1.1 Monitoring System

A gas monitoring system will be installed to the TN 81 Transport/Storage Container when it arrives in the IWS. This system monitors the inter-lid helium gas pressure (i.e. the space between the primary and secondary lid) and is used to test the integrity of the seals on a routine basis. The monitoring system has a small pressurised tank fixed to the secondary lid and connected to the space between the lids via the coupling orifice on the secondary lid [26]. There are three pressure sensors, each of which detect the inter-lid pressure independently and send the signal to the display unit located in the IWS control room. This information is also accessible via ANSTO intranet that allows online monitoring.

A further description of the monitoring system is provided in the TSAR [26].

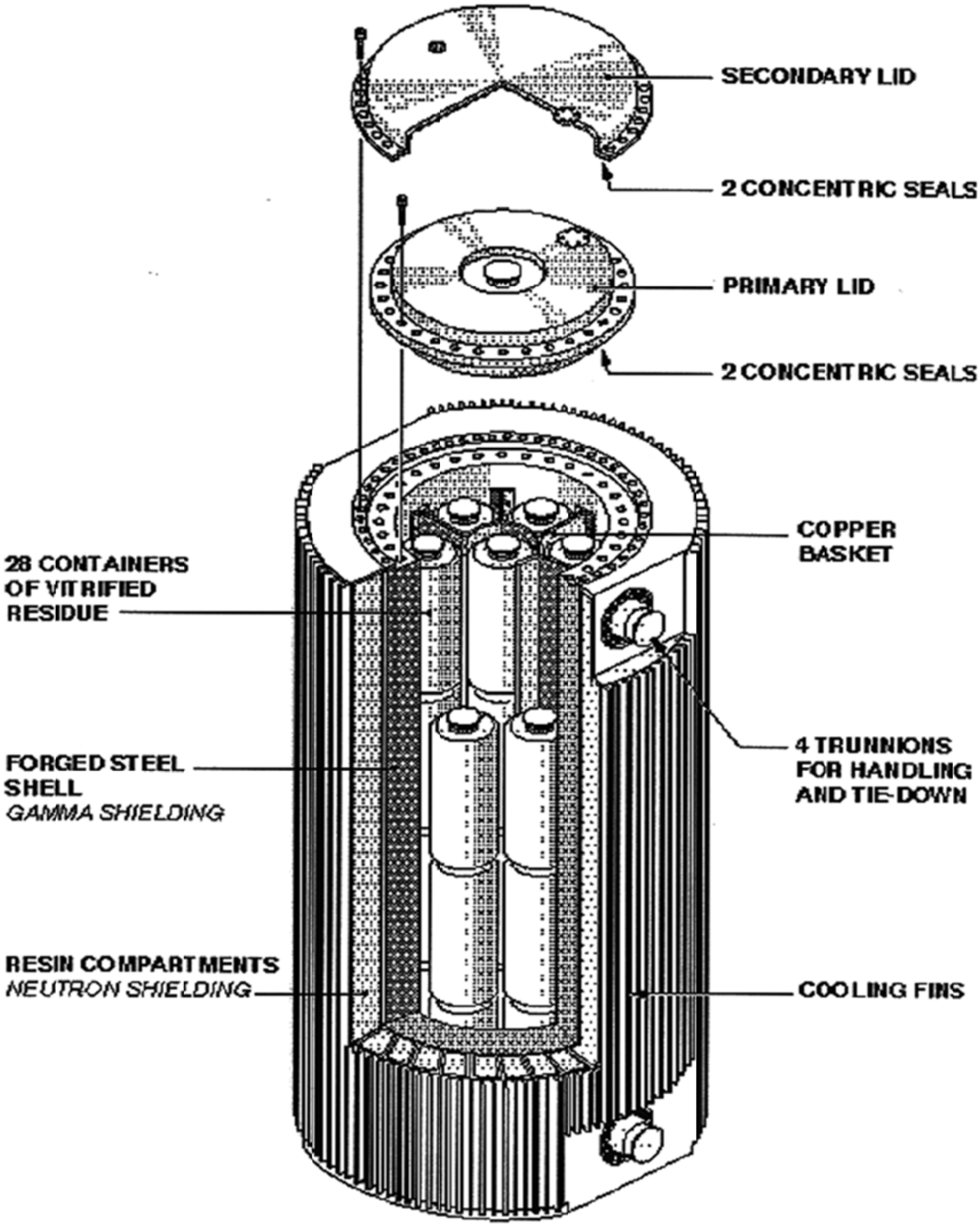

Fig.1. The TN 81 Transport/Storage Container

4.2 The CSD-U Canisters

The vitrified waste, CSD-U, is contained in a stainless steel canister (1,340 mm height and 440 mm in diameter) containing 380 kg of glass contents [26, 21]. Up to twenty eight canisters of vitrified waste are placed in a copper basket which is fixed inside the cavity of the TN 81 Transport/Storage Container.

4.3 The Technological Waste (CBF-C2 Fibre Concrete Containers)

The technological wastes are generated from the activities/services required to support the spent fuel reprocessing operations. It includes any of the following [14]:

(a) Process material and equipment, such as contaminated pumps, valves, ejectors, etc.
(b) Protective clothing, such as, gloves, overalls, overshoes etc.
(c) Laboratory equipment such as, glassware, beakers etc.
(d) Various annex waste material, such as, plastic sheets, cardboards, rag etc.

They are placed in a waste drum which is then placed in a fibre-concrete (CBF-C2) container which is made of a mixture of cement, sand, aggregate, cast-iron chips, water and other filler (See Fig 2). The CBF-C2 container is filled with a fibre-concrete mixture of the same composition as that of the CBF-C2 container shell [14]. The six CBF-C2 containers have different contact dose rates and it varies from 0.5 µSv/h to 1.3 mSv/h [40].

Each CBF-C2 container has the following characteristics [15]:

(a) Overall dimensions: Diameter 1,000 mm x height 1,500 mm
(b) Gross mass: 4,000 kg

The gross mass of the ISO container loaded with six CBFC containers is about 18,000 kg.

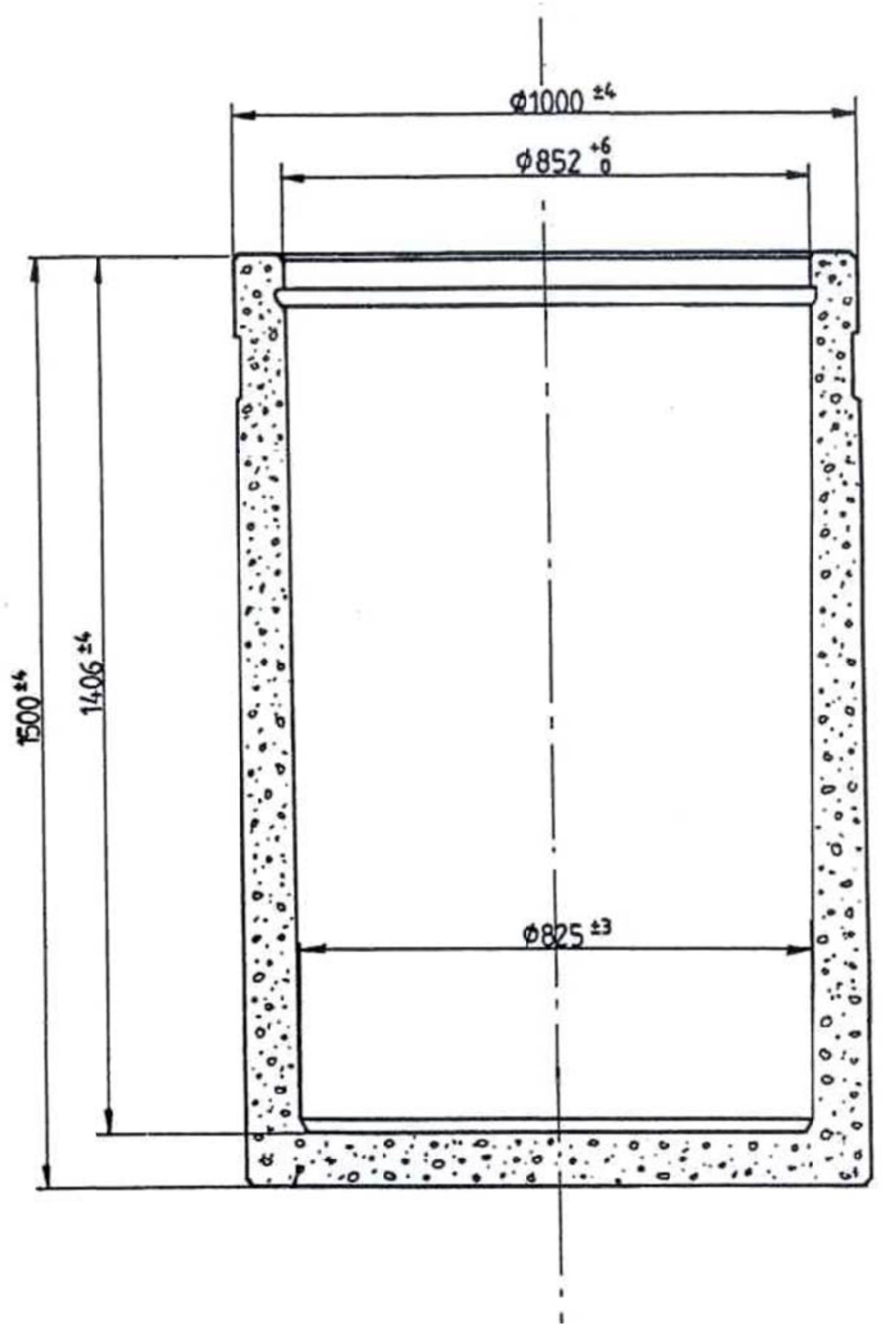

Fig 2. Fibre Concrete Container for Technological Wastes (CBF-C2)

Six (6) CBF-C2 packages are placed in a metal rack (see Fig. 3) which is transported to Australia in a 20 foot IP2 certified ISO shipping container (see Fig. 4). The ISO container will be unloaded from the transport truck and placed in the store with the six packages inside, and will be stored in this way.

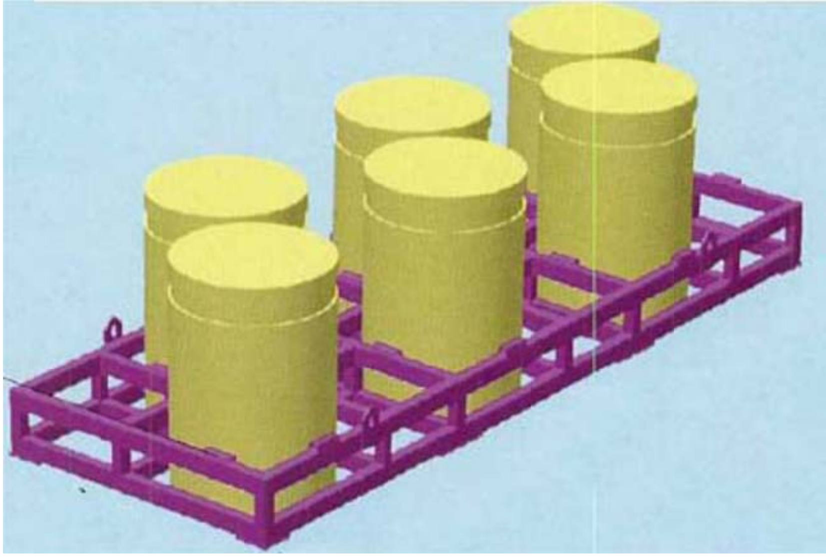

Fig 3. Technological Wastes drums (CBF-C2)

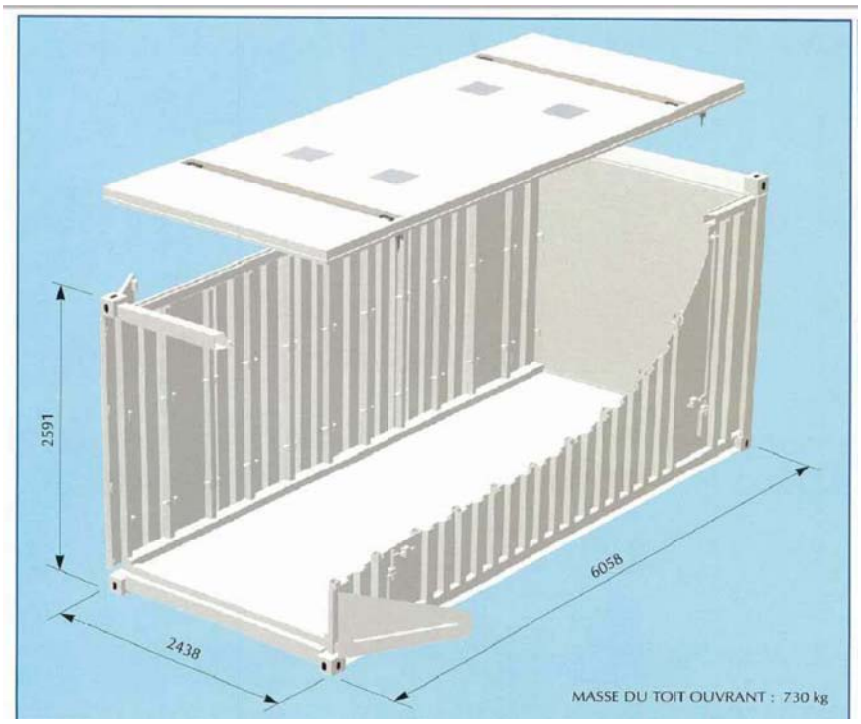

Fig 4. ISO container for Technological Wastes

4.4 Building services

4.4.1 Crane

The main building overhead crane is designed to the requirements of Australian Standards *1418 - Cranes Hoists and Winches* and it is rated to safely lift the heaviest container in the store (i.e. TN 81 Storage/Transport Container) as a dangerous goods rated (DGR) crane (140 tonne). The crane features double girder, end carriages and the main crab. The main crab contains the main hoist complete with a primary brake and a secondary brake which are mounted directly onto the gear box. The secondary brake is engaged by the speed encoder which is also mounted on the drum. The hoist drum supports a single rope.

The vertical travel of the hoist is controlled by the limit switches. Crane will also be supplied with an electronic data logger which keeps records of lifting frequency, loads and durations of crane usage. The crane will be operated via a remote control with an additional pendent (backup).

The secondary brake is an additional safety feature added by ANSTO which exceeds the requirements for the Dangerous Goods cranes according to the AS1418. This crane has been designed to withstand seismic event with following peak accelerations of 0.19g (vertical) and 0.28g (horizontal).

The crane has coverage of approximately 2.5 m from the southern and northern side walls (i.e. cross travel) and approximately 5 m from the eastern and western side walls (i.e. long travel).

A risk assessment of the operation of the crane is provided in the Appendix D.

4.4.2 Building ventilation system

IWS has both natural and mechanical ventilation systems. During normal conditions (i.e. when the room ambient temperature is below 28° C), it will be ventilated naturally. In this mode, the outside air will enter the store via the wall-mounted louvres and leave the building via the roof mounted turbine ventilators (8 off). The louvres (4 off) are installed at the floor level and fitted with cleanable electrostatic air filters.

When the room ambient temperature is above 28° C, the mechanical ventilation system will automatically activate. In this mode, the booster fans (8 off), which are mounted on each of the turbine ventilators, will automatically start. The booster fan(s) can be operated manually at any time from the switchboard mounted inside the IWS.

The layout of the roof-mounted ventilators with booster fans and the louvres are shown on the mechanical services drawing [29, 30, 31, 32].

4.4.3 Other building services

The following services have been provided in the facility:

(a) Water supply has been provided to the IWS for firefighting equipment (i.e., fire hydrants and fire hose reels);
(b) Sewerage and active drainage system is connected to the site wide B line;
(c) Electrical power supply is provided for systems and equipment, including lighting, the crane, area radiation monitoring, emergency and exit lighting, automatic fire detection and occupancy warning/PA system;
(d) Telecommunications/data service is provided for the computer network;
(e) Security and alarm system is provided to interface with the existing ANSTO site-wide system including ASOC ~~SCC~~; and
(f) Compressed Air is supplied from the site air supply system.

4.5 Activities during operational phase

4.5.1 Initial setup

Upon arrival to ANSTO, the following setup tasks will be undertaken on the TN 81 Storage/Transport Container. These tasks are necessary to alter its configuration from transport mode to the storage mode.

(a) Remove the bottom and top shock absorbers;
(b) Place secondary lid;
(c) Install the pressure monitoring device;
(d) Fill the inter-lid space with Helium gas;
(e) Install the anti-crash cover; and
(f) Connect the cables to the display unit for monitoring the inter-lid gas pressure.

These tasks will be performed with the assistance and supervision of experienced personnel from the Zwilag facility in accordance with the instruction manual provided by AREVA [33] and also in full compliance with the requirements of ANSTO WHS Management System. The tasks will be undertaken with advice from the Radiation Protection and WHS advisors.

There is no setup tasks required for the technological waste packages when it arrives in the IWS.

4.5.2 Routine tasks during storage

Both the TN 81 Storage/Transport Container and the technological wastes drums (i.e. CBF-C2) are low-maintenance waste packages. There are no routine tasks for the CBF-C2 package except the visual inspection of the ISO container and waste drums to be carried out on a regular basis.

For the TN 81 Storage/Transport Container, following routine mainantence tasks need to be performed in accordance with the instruction manual provided by AREVA [34]

(a) Routinely monitor the inter-lid gas pressure;
(b) Replace silicone between profiles/fins bolted on the outer surface of the Container;
(c) Repair paint damages, if any;
(d) Visual inspection of the waste items; and
(e) Undertake routine HP survey in the store.

5. METHOD

5.1 Hazard Identification

The method adopted in this study was to conduct a hazard identification workshop using a set of guidewords (see Appendix A) suitable for the activities that are expected to be carried out in the IWS. Using engineering judgement, these guidewords were drawn from a larger list by the author of this report, in consultation with the reviewer. The guidewords were then agreed with the workshop participants as being appropriate for the IWS. The guidewords were used to prompt the discussion and to identify the potential hazardous scenarios, which were then considered for the risk assessment. The hazard identification workshops took place on 20 February 2012, 12 February 2013 and 08 April 2014, with the participants as shown in the following Table 1. The findings of the hazard identification are attached in Appendix C.

Table 1: Workshop participants.

Team Member	Role/Expertise	20/02/2012 Duration 1.5 hr	12/02/2013 Duration 1.0 hr	08/04/2014 Duration 1.5 hr
	HAZOP Leader	√	√	√
	Senior Project Manager – ILW Project	√	√	√
	Specialist- ILW Project	√	x	x
	Project Manager – Logistic and waste transport	√	x	√
	RPA	√	√	√
	OHS Adviser	√	√	x
	Leader - NucMech	√	x	x
	Responsible Engineer – Transport packaging	√	x	
	Manager, Systems Safety and Reliability	x	√	√
	Leader, Compliance Management, WO	x	√	x
	Group Leader, ILW	x	√	√
	Project Engineer and Lifting Equipment Approval Officer,	x	√	x
	IWS Project Manager	x	x	√

5.2 Risk Assessment Method

After the hazard identification workshop, a risk assessment was carried out on the various hazardous scenarios identified during the workshop and in subsequent discussions with the facility officer and various safety personnel. The risk assessment was performed according to the WHSMS Guide [22]. The risk assessment, including the recommendations, was reviewed comprehensively by the participants of the workshop.

Seven categories of likelihood and six categories of consequence (i.e. impacts) are used to enable the hazardous scenarios to be plotted onto the risk evaluation tables. The likelihood and consequence of the hazardous scenarios were also assessed as per the Frequency Evaluation Table and the Risk Matrix given in Appendices G and H of the Guide [22]. These are reproduced in Appendix B of this report.

Recommendations are made to reduce the risk, ensure good safety practices are followed and in some cases, to implement cost-effective improvements (even if the risk is Low or Very Low).

Details of the residual risk (post-control) treatment actions are given in page 4 of the Guide [22].

6. ROUTINE RADIATION EXPOSURE

As part of the routine inspection and maintenance tasks of the waste items (e.g. TN-81 Transport/Storage Container and the CBF-C2 containers) and building services, ANSTO

Waste Operations (WO), Radiation Protection Services and Facilities Management staff would make visits to the store to undertake inspections and surveillance activities.

The TN 81 Transport/Storage Container has 67 mm of lead as gamma shielding (in addition to the 200 mm steel) and high-density resin as neutron shielding. The area(s) in the building will be radiologically classified in full consultation with the Radiation Protection Adviser (RPA) and therefore, WO staff will take necessary precautions for radiation protection before entering the store. Since the contact dose-rate of TN-81 is expected to be very low (i.e., close to background), the operators would receive negligible amount of gamma dose which would be managed in accordance with the ALARA principle.

An estimate of routine radiation exposure to the WO staff for the waste items has been prepared and included in the Radiation Protection Plan [41]. The routine dose to the operators during the operation phase of the store is very low and it is considered ALARA.

7. RESULTS OF THE RISK ASSESSMENT

The following sections document the assessments of hazardous scenarios. The risk assessment of the 140T DGR crane operation is performed separately and the outcome the assessment is appended in Appendix C.

7.1 Risks of Radiological Consequence

The assessment of radiological consequences performed in the following subsections is based on the information and assessments undertaken by AREVA in the TSAR of the TN 81 Transport/Storage Container [27, 28, 35, 36, 37, 38].

7.1.1 Accidental dose from possible damage to TN 81 Transport/Storage Container

The TN 81 Transport/Storage Container is of robust design and construction (see section 4.1). The waste inside the TN 81 Transport/Storage Container is in vitrified form placed in sealed (i.e., welded) stainless steel canisters and thus the waste is immobilised (see section 4.2).

Therefore damage to the shielding is not credible under foreseeable accident conditions.

7.1.2 Damage to the seals of the TN 81 Transport/Storage Container

The TN 81 Transport/Storage Container is of robust design and construction (see section 4.1). The waste inside the TN 81 Transport/Storage Container is in vitrified form placed in sealed (i.e., welded) stainless steel canisters and thus the waste is immobilised (see section 4.2).

The TN 81 serves as both a shielding and containment vessel. The seals provide an additional assurance should there be any loose radioactive material inside the TN 81 Transport/Storage Container.

Should the lid seals of the TN-81 be compromised through damage or deterioration, two potential scenarios need to be considered:

1. A shine path could be created and
2. Release of radioactive material.

There are two lids and each lid has two seals. These seals are metallic and therefore not subject to radiation damage or deterioration over time. Therefore, compromise of the seal is extremely unlikely.

The lids have lapped edges and therefore a shine path could not occur unless the hold-down bolts of both lids were somehow to come loose. At this stage, there is no intention to have any operation whereby the lid bolts are loosened or removed. Therefore, this would be a gross violation or operator error. Furthermore, the seals do not perform a shielding function but a containment function should containment in one or more canisters somehow become compromised.

Because the waste is in vitrified form and inside sealed stainless steel canisters [26], there is no credible scenario whereby radioactive waste material could be released even if all seals were compromised. The canisters will have been checked for external contamination prior to loading, therefore there is no loose radioactive material inside the TN 81 Transport/Storage Container that could escape even if all seals were compromised.

The integrity of the seals is verified through a specified procedure on departure from France and on arrival in the IWS facility. Therefore, there are no foreseeable circumstances under which any gamma shine or loss of containment could occur [39].

Notwithstanding all the above defences, even if a shine path were to occur, the fixed radiation monitor installed inside the store would alert personnel if such an event were to occur. Also, according to the mechanical and thermal analysis undertaken by AREVA in the TSAR show that the integrity of the container is not breached under the accident conditions of fire, aircraft crash, burying, earthquake and tipping over of the package [36, 37.38].

The scenario of radiation dose (shine) or radioactive release due to failure of the seals is assessed as **not credible** (<10^{-6} per year).

7.1.3 TN 81 Transport/Storage Container tip over

The TSAR considered a scenario of TN 81 container tip over and performed a stability analysis of the package under earthquake conditions at Lucas Heights [27, 28]. The finite element analysis was performed with two different loading conditions of the package, i.e. 24 and 20 vitrified canisters and the analysis was based on the following parameters:

(a) Total mass of the package with 24 and 20 canisters were 116.45 tonne and 114.25 tonne respectively;
(b) The centre of gravity height was taken as 3.3 m from the ground; and:
(c) The maximum ground accelerations in three directions were as follows:

Acceleration	**Load of 24 canisters**	**Load of 20 canisters**
a_x	0.351g	0.513g
a_y	0.351g	0.513g
a_z	0.234g	0.342g

The seismic analysis shows that there is no risk of tipping over (stability safety factor of 3.9 for a loading of 24 canisters and 5.7 for a loading of 20 canisters). The maximum sliding displacement compared to the ground is negligible (0.002° only) at the bottom or at the top of the package [28].

7.1.4 Burying of TN 81 Transport/Storage Container

The TN 81 package could be buried under debris in the event of collapse of the building due to an earthquake or aircraft crash. The TSAR included an assessment of such scenario and analysed the thermal behaviour of the package under three different levels of burial: 50%, 75% and 100%.

In all three cases, based on the results of section 7.1.3, it was assumed that the package remained vertical after the building collapse.

The three different levels of burial were modelled by taking the corresponding reduction of heat exchange coefficients between the outer surface of the package and the environment by 50%, 75% and 100% respectively.

The analysis showed that, in the case of burying to 50%, all the criteria were satisfied (i.e. the temperature of the vitrified canister, gaskets and lead shielding were less than 510°C, 370°C and 325°C respectively) [36] for an indefinite period (i.e. the equilibrium temperature met the constraints).

For the burying scenarios of 75% and 100%, all the criteria were also satisfied i.e., the containment of the package remains unaffected for a period of 7 days and 2.1 days for 50% and 100% burials respectively.

Thus the assessment concluded that there is no risk of radiological consequence due to the accidental burial of the package and these periods (7 and 2.1 days) were considered adequate to uncover the package from burial [27]. However, this assessment, as made in the TSAR, is conservative because [36]:

(a) It assumed that the debris are of thermally insulated material and thus it did not give any credit for heat transfer into the debris or into air spaces in the debris;
(b) In particular, this means there is no heat transfer from the TN 81 in the case of 100% burial; and
(c) The analysis is bounded by the thermal power of the CSD-V (i.e. vitrified waste from HLW) which generates about 3.7 times more heat than CSD-U.

Given that the modelling described above is for the CSD-V heat load, even under 100% burial, considerably more time that 2.1 days would be available to respond to this scenario before any damage occurred to shielding or containment of the TN 81.

In a worst case scenario, if the shielding and/or primary lid seals are damaged or degraded under such accident condition, the radiation exposure during recovery could be around 0.1-1.0 mSv in a planned and well controlled recovery process, However, there will be no release of radioactivity from the package because the waste items are in vitrified form and sealed in a stainless canisters.

The scenario of burial of the TN 81 container is assessed as **extremely unlikely** (10^{-6} to 10^{-5} per year) with **minor** (less than 0.1- 1.0 mSv) consequence and therefore the risk is assessed as **very low**.

7.1.5 Accidental radiation exposure from the technological waste (CBF-C2)

The technological waste is the waste generated during the reprocessing and the quantity of this waste (in terms of radioactivity) is extremely small compared to the vitrified waste. There are six CBF-C2 waste containers and the contact dose-rate of these waste containers varies from 0.5 μSv/h to 1.3 mSv/h [40]. Operator(s) could receive higher than normal dose if, due to an external event, the concrete container(s) is damaged and the wastes becomes unshielded. However, any accidental exposure to the operators will be detected by the EPD they use. However, the Project should investigate, in consultation with the RPA, whether the area where technological wastes are stored requires shielding to reduce the radiation exposure to the operators inside the store and/or personnel outside the store.

The fibre-concrete container for the technological waste will be transported and stored in an ISO container rated as an Industrial Package Type 2 (IP-2). Such package designs are extensively tested and robust and are capable of withstanding a drop test and stacking test without a loss of containment and dispersal of the radioactive contents.

The required height of the drop test is dependent on the mass of the package but is 1.2 m or less.

Robust testing of the Technological Waste Transport/Storage Container demonstrates that even in the unlikely scenario where an impact or drop of the container increased the dose rate by up to 20%, this would have no effect on people outside the facility and even inside the facility, no additional precautions would need to be taken.

It is also credible that impact or drop equivalent to more than 1.2 m could cause a minor release and somewhat greater increase in dose rate. The release would at worst be small amounts of radioactive dust and would be confined to the facility.

It is understood that these packages would not normally need to be handled or moved other than to place in the store and later removal to the Radioactive Waste Management Facility (NRWMF). Therefore the frequency of movements would be very low (<2 per 10 years). Furthermore, the TN 81 Transport/Storage Container is not to be stored near the ISO container so there is little likelihood of a collision when unloading or loading the TN 81 Transport/Storage Container.

The scenario of radiation dose due to accidental exposure to technological wastes is assessed as **extremely unlikely** (10^{-6} to 10^{-5} per year) with **minor** (0.1-1mSv) consequence and therefore the risk is assessed as **very low**.

Recommendation R1: The Project, in consultation with the RPA, should investigate whether the area where technological wastes are stored requires barricading and/or shielding to reduce the radiation exposure to the operators inside the store and/or personnel outside the store.

Status of Recommendation R1: ANSTO commenced this assessment in late 2013 and currently, it is being updated with the revised CBF-C2 characteristics information received from AREVA at the time of writing this report. More information is in the Radiation Protection Plan [41].

7.1.6 Inter-lid gas pressure monitoring failure

The inter-lid pressure of the TN 81 container is continuously monitored to ensure the integrity of the primary and secondary lid seals. There are three pressure sensors that detect the inter-lid pressure independently and displayed on a display unit. Any change in pressure in the inter-lid space could be due to one of the following causes:

(a) Monitoring system components failure (i.e. pressurised tank, display unit, cabling etc.) or
(b) One or more of the three pressure sensors failures.

The TSAR describes the possible failure scenarios and the consequences of the monitoring system failure. A set of diagnostic procedures is provided in the TSAR to identify the fault(s) involving the monitoring equipment, pressure sensors and/or lid seals. The TSAR concluded that there is no impact on the package containment due to such failure [27].

The pressure is monitored using three independent sensors and failure of all sensors simultaneously is assessed **extremely unlikely** (10^{-6} to 10^{-5} per year). But there is no radiological consequence of such failure as the package containment remains intact even if all the sensors and/or other components of the monitoring system fail [27].

The scenario of gas pressure monitoring device failure is assessed as **extremely unlikely** (10^{-6} to 10^{-5} per year) but, during replacement of the sensor(s), operators could receive a **negligible** (less than 0.1 mSv) dose and therefore the risk is assessed as **very low**.

Due to the failure of the lid gaskets (i.e. primary and/or secondary lid gaskets), the gas pressure result could be abnormal, however, such failure is assessed incredible (see Section 7.1.2).

However, according to the TSAR [27], if the lid gaskets are damaged in an extremely improbable event, replacement of the gaskets needs to be undertaken.

Replacement of the secondary gasket and/or seal can be undertaken in the IWS.

7.1.7 Vehicular incident causing radiological hazard

There will be routine inspections and maintenance works performed on the IWS building services by the ANSTO Support Services team. Maintenance vehicles, such as utes, fork-lifts, trucks, scissor lift etc., may very occasionally require to access the building. Due to human error, an incident involving vehicles could occur inside the building and cause damage to the technological wastes packages (i.e. CBF-C2 cemented drums) resulting in an increased radiation hazard inside the store. However, the TN 81 is extremely robust and the IP-2 is an industrial transport package and is reasonably robust and damage to either is considered incredible and extremely unlikely respectively.

The consequence of such incident would be bounded by the crane drop scenario onto the CBF-C2 package which was assessed to have a **minor** radiation exposure to personnel (see Appendix D).

The scenario of radiation dose due to a vehicular incident inside the IWS is assessed as **extremely unlikely** (10^{-6} to 10^{-5} per year) with **minor** (0.1-1mSv) consequence and therefore the risk is assessed as **very low**.

7.1.8 Failure of radiation monitor(s)

The store is fitted with gamma radiation monitor(s) to alert personnel in the event of a higher than normal dose-rate inside the store. Each operator carried an Electronic Personal Dosimeter (EPD) and in the unlikely event that the radiation monitors were to fail to detect any above normal radiation exposure inside the store under an accident condition, the operator would be immediately alerted and personnel would evacuate from the store in accordance with ANSTO procedures. Appropriate Health Physics (HP) support will be then requested to confirm the safety of the facility prior to operator re-entry.

Furthermore, there will be more than one radiation monitor and will be set up during the commissioning when waste items arrive in the IWS. It is unlikely that one monitor does not function and extremely unlikely that no monitor is functional.

Furthermore, there would need to be a significant and coincident increase in the dose rates in the facility, and it is difficult to postulate this other than damage to the technological waste ISO container and CBF-C2 drums within it and this has already been assessed as extremely unlikely. Furthermore, such damage would be revealed as soon as operators entered the facility or as soon as it occurred if operators were present at the time. Elevated doses to operators are not credible in this scenario.

If the failure of the monitors occurred prior and was not revealed and not noticed for some time, and while failed, damage occurred to the technological waste packages, a credible but extremely unlikely elevated dose to operators could occur. This requires

(a) Prior undetected failure of the monitors;
(b) Remains unnoticed for some period long enough in which it becomes credible that a subsequent damage could occur to the ISO container;
(c) Operator somehow not noticing the damage or not recognising that shielding could be compromised by the damage; and
(d) Operator not wearing an EPD or the EPD switched off, flat battery or otherwise not working.

The scenario of radiation monitor failure with coincident higher radiation levels leading to above normal radiation doses to personnel is conservatively assessed as **extremely unlikely** (10^{-6} to 10^{-4} per year) with **moderate** (1-20 mSv) consequence and therefore the risk is assessed as **low**.

7.1.9 Radiological contamination hazard

The TN 81 Transport/Storage Container is checked numerous times before and during transport and storage. Prior to loading the vitrified waste canisters (i.e. CSD-U) into the TN 81 Transport/Storage Container, AREVA will check the canisters for external contamination as per the requirements of the French Regulator and international regulations [33, 39]. Suitable facilities are available to ensure the canisters can be cleaned before they leave France if necessary. Prior to being unloaded at an Australian port and being transported within Australia the TN 81 Transport/Storage Container will be fully checked again [39]. ANSTO will conduct its own safety assessments prior to the container being unloaded into the IWS.

In the unlikely event that contamination was undetected, despite the extensive, ongoing monitoring only a minor radiation dose (0.1-1.0 mSv) which is conservatively estimated for the purpose of this safety assessment would be evident. This dose could only be received if an operator were to come into direct contact with the contamination; it poses no risk to the community.

Nevertheless, there could be some undetected contamination on the outer surface of the TN 81 Transport/Storage Container or the technological waste packages, due to human error. The nature of the contamination is such that it could only cause a **minor** radiation dose. However, the waste packages will undergo several HP checks starting from the loading of canisters in the TN 81 Transport/Storage Container at AREVA Plant in France up until the receiving point of TN 81 Transport/Storage Container at the Lucas Heights site. Also, the store will be regularly inspected by the HP surveyors [34] and no operations are to be undertaken in which contamination could be generated or spread. The areas within the

IWS will be radiologically classified depending on the extent of the hazard present, in consultation with the RPA.

The possibility of spreading contamination inside the store if the water pipework leaks/bursts inside the store and thus the floor becomes flooded with water has been assessed as **extremely unlikely.** Risks associated with the extremely unlikely scenario of the technological waste becoming wet and spreading contamination within the store have been mitigated by the following measures:

(a) As with the TN 81 Transport/Storage Container, these packages also must have been cleared for surface contamination on departure from France and again on receipt.
(b) These packages have an inner stainless steel or plastic drum and so the only way contamination could evolve from the technological waste would be via migration from contamination that was in or on the drum when originally loaded into the fibre-cement shell. Such evolution would need to migrate through the cement grout and would therefore be a very slow and insignificant release and would need continual wetting.
(c) The cemented waste packages are to be kept inside the ISO container which would protect them from any water spray.
(d) The building has an active drainage system (i.e. B-line) connected to the delay tank located outside the store.
(e) The floor is epoxy coated. The store floor needs to be bunded to prevent any spillage of contaminated water to the soil.

The scenario of contamination hazard is assessed as **extremely unlikely** (10^{-6} to 10^{-5} per year) with **minor** (0.1 to 1.0 mSv) consequence and therefore the risk is assessed as **very low**.

Recommendation R2: The store floor should have bunds around its perimeter to prevent the spread of contamination.

Status of Recommendation R2: This has been incorporated into the detailed design specification for the IWS and its construction is underway at the time of writing this report.

7.1.10 Fire in the store

Fire loading in the store is very low. There will be no combustible material stored in the building. The TN 81 Transport/Storage Container is of metal construction and is massive (115 tonne) and therefore would need a very severe and prolonged fire before any significant elevation of temperature would occur inside the cavity of the TN 81 Transport/Storage Container. The TSAR considered a fire scenario under which the thermal performance of the container was studied using accident conditions created by the crash of an aircraft with fuel tanks containing 6000 L of kerosene [27]. It was assumed that this fire caused the same level of damage as a fire of 800°C burning for 30 minutes which is the test requirement for this package according to the international transport regulation [4]. The study concluded that the containment vessel remains leak-tight because, the temperatures of the metallic gaskets on the lids do not exceed their maximum admissible ranges [27,36]. However, the TSAR indicated that the resin in the aluminium profile (i.e. neutron shielding) would undergo superficial burning under such fire but, it would not cause any significant rise in dose rate [37]. Therefore, the dose consequence of a fire in the vicinity of the container remains below the permissible limit [27, 37].

As discussed in Section 7.1.4, heat generation from the CSD-U is very low (i.e., 15.4 kW when TN 81 package is loaded with 28 canisters) therefore, the overheating of the TN 81 Transport/Storage Container due to the heat generation is not credible.

The technological waste drums have cement encasement. There is no credible scenario whereby a fire of the magnitude required to compromise the integrity of the TN 81 Transport/Storage Container, its shielding, or other ILW described in this application stored in the IWS, could occur in the facility. Furthermore, there is no significant heat load or credible source of ignition inside the building except for the electrical systems for lighting and crane which are properly designed and installed in accordance with the Australian

Standards (AS-3000) and some small specialised vehicles (*scissor lift and fork lift as mentioned in Section 7.1.7*) but, such vehicles are not stored in the IWS. The building will be fitted with fire detection devices and alarms system which, in the event of a fire, would raise an alarm locally and to the Site Control Centre (SCC). Therefore, it is **very unlikely** that a sustained fire in the store could cause an extensive damage to the technological waste packages or other ILW waste forms, which could then lead to release of active particulates and gases to the atmosphere and thus could cause excessive dose to the workers and members of the public.

Hence, because of the nature of the waste packages and absence of any heat load or credible source of ignition and fire loading in the store, no further radiological consequences analysis is performed. On this basis we conclude that fire suppression in the building is not required.

The scenario of fire in the store causing elevated radiation dose to workers is assessed as **very unlikely** (10^{-4} to 10^{-3} per year) with **minor** (0.1 to 1.0 mSv) consequence and therefore the risk is assessed as **very low**. It is not credible that any release could arise that would cause a dose to a member of the public.

7.2 RISKS OF PHYSICAL INJURY OR ADVERSE HEALTH EFFECT

7.2.1 Working at heights

Upon arrival in the IWS, initial setup works will be carried out on the TN 81 Transport/Storage Container. The works include the removal of bottom and top shock absorbers, installation of helium gas pressure monitoring device, secondary lid and the anti-aircraft crash cover. These works will be carried out at heights using ladder/scaffolding and/or the building crane. Also, from time to time, operations may need to be performed on the top of the TN 81 Transport/Storage Container (while in the upright position) and therefore, workers would be required to work at heights using a ladder or scaffolding. There is a risk of fall which could cause physical injury to the personnel involved. Also, access to the crane for repair and maintenance will be done using a ladder mounted on the wall of the building. Also, for accessing all sides of the TN 81 Transport/Storage Container, a dedicated moveable set of steps should be considered if this is expected to be a routine operation.

The scenario of working in heights that could cause physical injury is assessed as **unlikely** (10^{-3} to 10^{-2} per year) with **major** consequence (long term illness or serious injury but recovery probable) and therefore the risk is assessed as **medium**.

Recommendation R3: The project should consider providing a dedicated moveable set of steps which will help access to all sides of the TN 81 Transport/Storage Container during these tasks and also during routine operation.

Current Status of Recommendation R3: The project has undertaken to provide such steps.

The initial setup tasks are one-off activity to prepare the package for storage in the IWS. The tasks will be performed according to the instruction manual provided by the AREVA [34] with the proper supervision and expertise of the experienced personnel from Zwilag facility. Also, according to the WHS Guides (AG-2406 and AF-3005), all persons working at heights above 1.8 metres are fully accredited and also a risk assessment of the task is carried out.

7.2.2 Manual Handling

The top and bottom shock absorbing covers fitted to the TN 81 Transport/Storage Container would require removal upon arrival in the store for its interim storage. The anti-air crash cover and the secondary lid with the gas monitoring system would also need to be installed for interim storage of the TN 81 Transport/Storage Container. Bolts are heavy and sometimes, it may involve manual handling although the building cranes will be used in most cases. The frequency of such operation is very low. Operators are trained and experienced.

The scenario of manual handling causing physical injury is assessed as **likely** (0.01 to 0.1 per year) with **moderate** consequence (medical attention, several lost time days) and therefore the risk is assessed as **medium**.

These tasks will be performed as per the instruction manual provided by the AREVA [34] with the proper supervision and assistance from the experienced personnel from Zwilag facility.

7.2.3 Electrical hazard

The electrical systems are designed and will be installed in accordance with the Australian Standards (AS-3000). Any repair/maintenance works carried out on any electrical equipment will be performed by an accredited/qualified tradesperson in compliance with the WHS Management System for electrical safety and in compliance with the Australian Standards for Wiring Rules (AS 3000).

There are a suite of industry practices which make electrical work safe. The ANSTO tagging and isolation procedures will be followed.

The likelihood of electrocution is assessed as being **extremely unlikely** (frequency of 10^{-6} to 10^{-4} per year) and having a **severe** consequence (death or permanent illness). The risk of this scenario is **medium**.

The electrical risk is considered ALARP since a good safety practice is followed in ANSTO.

7.2.4 Building ventilation failure

The ventilation system for the waste store is designed to meet the IAEA guideline – WS-G-6.1 (2006) (Ref 5). There is no potential for creating airborne radiological hazard or any other hazardous gases to be produced during the life-time of storage of the wastes. Since the waste stored in the TN 81 Transport/Storage Container is intermediate level waste (ILW), the heat load dissipated from the TN 81 Transport/Storage Container would be minimal (less than 11 kW – compared to 56 kW [23] for the TN 81 Transport/Storage Container loaded with HLW in Zwilag facility in Switzerland). The store is designed for a natural ventilation system with an added feature of mechanical ventilation system which will provide adequate amount of air flow to maintain desired ambient temperature in the store.

Therefore, the natural ventilation system (with the added feature of mechanical ventilation system) using the thermostat control is considered adequate in this case (see Section 4.4.2). Failure to operate the fan on demand could result in store ambient temperature to rise to an uncomfortable level during hot/warm days. Personnel may get heat exhaustion if they continue to work under such conditions. If the booster fans (8 off) do not work, there will be an alarm. The area supervisor would stop work. The consequence of such an incident is assessed conservatively as '**moderate'** which may require medical attention and cause several lost time days. However, the IWS is a tall building (about 20.5 m) with a relatively small footprint. It will be mostly unmanned and will have personnel inside it only very infrequently and hence this scenario is extremely unlikely.

The scenario of ventilation failure causing heat exhaustion to the workers is assessed as **extremely unlikely** (10^{-6} to 10^{-5} per year) with **moderate** (requiring medical attention. Several lost time days) consequence and therefore the risk is assessed as **very low**.

7.2.5 Helium leakage

Helium gas bottles and the associated pipework is designed and approved by the ANSTO Piped Gas Approval Officer and in compliance with Australian Standards. The gas is non-toxic but could cause asphyxiation if released in a confined area with little or no extract ventilation [6]. The store is not a confined space and it is well ventilated and thus, the scenario of oxygen deficiency due to a release of Helium gas in the store is considered extremely unlikely. However, if such incident were to occur, it may have a '**major**' adverse health consequence to the operator.

The likelihood of Helium gas exposure to operators causing oxygen depletion is assessed as **extremely unlikely** (frequency of 10^{-6} to 10^{-5} per year) and having **major** consequence (long term illness or serious injury, recovery probable). The risk of this scenario is **low**.

7.2.6 Slips, trips and fall

While working inside the building, an operator could trip and may suffer physical injury. This could happen due to the lack of proper house-keeping in the store.

There is no slip hazard in the building since there is no process operations/activities to be performed in the building which could make the floor wet. Therefore no specific issues on slip hazard in the building are envisaged. For some routine inspection work tools and equipment, and power leads will be required and it is possible that they could temporarily be left in a position where they could be a trip hazard.

The scenario of trip hazard causing physical injury to the operators is assessed as **likely** (0.01 to 0.1 per year) with **moderate** consequence (medical attention, several lost time days) and therefore the risk is assessed as **medium**.

7.3 OTHER EXTERNAL EVENTS

7.3.1 Loss of Offsite Power

All process activities would be ceased when there is an off-site power failure and although there would be no immediate safety implications of such an event, it is likely that procedures will call for the store to be evacuated. Therefore, there would be no safety implications to the operators due to an external power outage.

7.3.2 Seismic Event

The current Australian seismic loading code is AS 1170.4, 2007 and the IWS is designed to this standard. Therefore it will withstand at least the ground motion specified in that standard for the Sydney region.

Since the safety of the ILW vitrified and cemented wastes is assured by its immobilised condition and packaging, e.g. the robust TN 81 Transport/Storage Container for vitrified waste, there would be no nuclear or radiological implications even if the building were to be damaged or if the flask were to topple (see also section 7.1.3 and [28]).

It is very unlikely that a seismic event could have catastrophic consequence in terms of safety of personnel/staff member since the occupancy rate of the store is very low. The IWS is a storage facility and accessed only when it requires routine inspection of the waste items.

7.3.3 High Winds

The store is designed in accordance with the requirements set out in the Australian Standards AS-1170.2. The building occupancy is very low and therefore, it is very unlikely that someone could be inside the building at the time of such extreme event and be severely injured (or cause fatality).

7.3.4 Flooding

There is no specific issue of water inundation of IWS due to a regional flooding. However, localised flooding due to a damage of the water supply pipework inside the store could occur. The waste items are stored in TN 81 Transport/Storage Container which is sealed gas tight,. Also, the technological wastes are immobilised as cemented waste and stored in an ISO container and therefore, flooding due to water pipe damage is not expected to cause any major contamination hazard.

The TSAR considered a flooding scenario whereby the TN 81 package is submerged in a depth of 200 m and analysed the (a) critical buckling pressure and circumferential stress of the forged shell and (b) stress and displacement of the secondary lid. The analysis concluded that the immersion of the package in a depth of 200 m will not cause any damage to its containment [27].

7.3.5 Lightning Strike

A lightning strike could cause damage to the building and, in an extreme case, it could cause harm to a person inside the building. According to the Lightning Protection standard (AS/NZS 1768:2007), between six and ten people are killed by lightning in Australia each year. Such incidence of fatalities is considered to be applicable mostly for persons staying outdoors at the time of the lighting strike.

In the event of a lightning strike to the IWS, it is very unlikely that a person inside the building would be present and suffer serious injury or fatality, or cause any significant radiological consequence. The site for the IWS is not far from Building 19 stack which would overshadow the IWS.

7.3.6 Aircraft Crash

All civil and military aircraft are prohibited from entering the restricted airspace above LHSTC unless a prior air traffic clearance has been obtained. It was estimated that the likelihood of the crash of a commercial jet or a general aviation aircraft on OPAL as $1.1x10^{-8}$ per year using the DOE method (DOE, 1996) [2, 3]. This is an extremely low likelihood event and would be even lower for the IWS since it presents a smaller projected target area. Therefore for the IWS the potential hazard of an aircraft crash does not need to be assessed further.

The TSAR included an assessment of aircraft crash scenario where an F-18 (mass- 20.5 tonne) impacts the package with a speed of 215 m/s. The study concluded that the package containment was not breached and there was no radiological consequences due to the impact [27, 35]. Moreover, the TN 81 Transport/Storage Container is tested for a 9.0 m drop as part of the Type B(U)F transport package [16]).

Similar robust Transport/Storage Containers have also undergone tests simulating a fighter aircraft crash. This was done by firing a steel annular rod at the Transport/Storage Containers at approximately 900km/h. The rod simulates the engine rotor of the aircraft. No significant damage or damage to seal integrity was observed [17, 18 and 19].

Similar robust flasks have also undergone rail-car crash tests, including a fire. Again no significant damage or damage to seal integrity was observed although in the case of the Dounreay flask, a small volume of the water inside was ejected through the seal [20].

7.3.7 External Fire

The location of the LHSTC is such that bushfires can be expected every 8 to 12 years. These fires have the potential to burn to the site boundary. The fire intensity and duration is dependent on several meteorological factors including the prevailing wind direction and strength, temperature and humidity. Generally the site is on relatively flat ground with sparse vegetation and this would reduce the intensity of fires reaching the boundary. Hazard reduction by 'burning-off' is normally undertaken annually external to the site perimeter fence to minimise fuel loads and therefore the potential bush-fire intensity in proximity to nearby structures on the site. Burning off is also sometimes undertaken inside the fenced area.

The proposed site for the IWS is well within the site, and is surrounded by other buildings. Damage by bushfire would be extremely unlikely.

The site emergency response team along with the NSW Fire & Rescue would respond to bush fire scenario at LHSTC. The store will be constructed in a location which is away from the vegetation and there are access roads outside the fence which provide a safe separation from the proposed IWS.

Even if a bushfire were to engulf the building and destroy it, it is not credible that it could heat the massive TN 81 Transport/Storage Container to a temperature that exceeds the fire test requirement according to the international transport regulation [4] and damage the confinement of the package(see further discussion in Section 7.1.10). In such a scenario, it is then possible but extremely unlikely that the technological waste packages (CBF-C2) could be compromised in such a fire, however given the fact that it is stored inside an ISO container and negligible fire load inside or around the building. However, given the two unlikely situations, that need to occur, a scenario leading to release is considered not credible.

7.3.8 Transport Accidents

The Site Description and General Arrangement Report [3] considered all types of transport accidents for the entire site. The only bulk hazardous substances regularly transported along roads near the LHSTC are petrol and diesel. The road transport of explosives is by a route away from the site. The OPAL Siting Safety Assessment (RRP-SL-02) reports on an analysis of possible transport accidents at the nearest road (New Illawarra Road) and the nearest railway line (approximately 3000 metres away). The analysis generally concluded that these events presented a low risk to the LHSTC.

7.3.9 Industrial Activities

The Site Description and General Arrangement Report concluded [3)] that the inventories of hazardous materials used in industrial activities near the LHSTC are very small. A review of the list of sites for the storage of dangerous goods licensed under the NSW Dangerous Goods Act, 1975 within an 8 km radius of the LHSTC has revealed that there are no sites that handle large quantities of hazardous materials. Therefore there are no major issues in relation to the industrial activities for low level solid waste management processes.

7.3.10 Military Activities

According to the HIFAR Probabilistic Safety Assessment (PSA), the chance of shelling a building on HIFAR was shown to be incredible [10]. The location of the IWS is further from the Holsworthy gunnery range.

8. CATEGORISATION OF SAFETY SYSTEMS

The safety systems of the IWS Facility that are used to reduce the likelihood or the consequence of accidents involving radiological consequence are identified based on the analysis of scenarios in section 7 above. These safety systems are categorised based on the methodology presented in the Guidance on Categorisation of Structures, Systems and Components ANSTO/T/TN/2008-11 Rev 1.

Table E.1 in Appendix E provides a table of the safety systems and their categorisation.

9. CONCLUSIONS

A hazard identification and risk assessment study was conducted for the proposed IWS and recommendations made in the following section.

The ILW package containers that will be stored in the IWS are of robust design and construction. The waste packages are tested and certified by the Competent Authority in France in compliance with the radioactive material transport regulation [4[. The risk of various hazardous scenarios considered in this report were assessed as 'Low' or 'Very Low', except for the electrical risk , working in heights and manual handling which is considered 'as low as reasonably practicable' (ALARP) since a good safety practice is followed in ANSTO.

The risks considered in this report were assessed taking into account satisfactory implementation of the recommendations. Therefore, since this report is intended (amongst other uses) to support ANSTO internal safety approval of the proposed ILW IWS and also regulatory approval, it is expected that the client will prepare a document outlining the disposition of these recommendations. The disposition of the recommendations should be made in consultation with the author of this report.

10. RECOMMENDATIONS

The recommendation of the study is listed below for convenience.

Recommendation R1: The Project, in consultation with the RPA, should investigate whether the area where technological wastes are stored requires barricading and/or shielding to reduce the radiation exposure to the operators inside the store and/or personnel outside the store.

Recommendation R2: The store floor should have bunds around its perimeter to prevent the spread of contamination.

Recommendation R3: The project should consider providing a dedicated moveable set of steps which will help access to all sides of the TN 81 Transport/Storage Container during these tasks and also during routine operation.

11. REFERENCES

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APPENDIX A - GUIDEWORDS FOR THE HAZARD IDENTIFICATION OF THE IWS

The following guidewords were used to identify hazards associated with the activities in the IWS. Using engineering judgement, these guidewords were drawn from a larger list by the author of this report, in consultation with the reviewer. The guidewords were then agreed with the workshop participants as being appropriate for the IWS. The guidewords prompted the relevant discussion on radiological and industrial hazards during the hazard identification workshops

- Radiation
- Contamination
- Electrical
- Ventilation
- Drainage
- Water
- Compressed air operated tools
- Fire/explosion
- Asbestos
- Chemical
- Toxicity
- Bio-hazard
- Manual handling
- Drop load
- Crane/Fork lift/walkie stacker operation
- Slips, trips and fall
- Transport events/accidents – speed, road condition, weather.
- Seismicity

APPENDIX B - RISK ASSESSMENT EVALUATION TABLES

B.1 Frequency Evaluation Table

Likelihood

Likelihood Levels	Likelihood Description	*Probability Intervals* *(for general risk assessments)*	Nominal frequency *(for specific risk assessments)*	Range *(for specific risk assessments)*	Likelihood Explanation
L7	**Almost Certain**	*90% - 100%*	3/year	> 1 / year (> 1 pa)	# *The event is expected to occur in most circumstances* / happens quite frequently (significant chance) # Historical records of greater than one occurrence per year at ANSTO in a similar situation # Well publicised occurrences in other similar facilities # Mathematically, the expected (or mean) frequency f is such that f ≥ 1 y^{-1} (i.e. happens more often than once each year)
L6	**Very Likely**	*75% - 90%*	1/3 years	1/10 years to 1 / year (0.1 pa to 1 pa)	# *The event will probably occur in most circumstances (very good chance)* / central estimate is once every 3 years # Has occurred a couple of times at ANSTO # Mathematically, the expected (or mean) frequency f is such that f ≥ 1 y^{-1} (i.e. happens more often than once each year).
L5	**Likely**	*55% - 75%*	1/30 years	1/100 years to 1/10 years (0.01 pa to 0.1 pa)	# *The event could occur at some time (realistic chance)* / central estimate is once every 30 years # Has occurred at ANSTO # Known in similar facilities and industries # Mathematically, the expected (or mean) frequency f is such that 0.1 > f ≥ 0.01 y^{-1} (i.e. happens less often than once each ten years, but more than once each hundred years)
L4	**Unlikely**	*35% - 55%*	1/300 years	1/1,000 years to 1/100 years (10^{-3} pa to 0.01 pa)	# *The event could occur (reasonable chance)* # Mathematically, the expected (or mean) frequency f is such that 0.01 > f ≥ 0.001 y^{-1} (i.e. happens less often than once each hundred years, but more than once each thousand years)
L3	**Very Unlikely**	*15% - 35%*	1/3,000 years	1/10,000 years to 1/1,000 years (10^{-4} pa to 10^{-3} pa)	# *The event could occur in certain circumstances (moderate chance)* / central estimate is once every thousand years # Mathematically, the expected (or mean) frequency f is such that 0.001 > f ≥ 10^{-4} y^{-1} (i.e. happens less often than once each 1000 years, but more than once each 10,000 years)
L2	**Highly Unlikely**	*5% - 15%*	1/30,000 years	1/100,000 years to 1/10,000 years (10^{-5} pa to 10^{-4} pa)	# *The event could occur in exceptional circumstances (remote chance)* # Mathematically, the expected (or mean) frequency f is such that 10^{-4} > f ≥ 10^{-5} y^{-1} (i.e. happens less often than once each 10,000 years, but more than once each 100,000 years)
L1	**Extremely Unlikely**	*0% - 5%*	1/300,000 years	1/million years to 1/100,000 years (10^{-6} pa to 10^{-5} pa)	# *The event could occur in very exceptional circumstances only (very remote chance* # Mathematically, the expected (or mean) frequency f is such that 10^{-5} > f ≥ 10^{-6} y^{-1} (i.e. happens less often than once each 100,000 years, but more than once each 1,000,000 years)

B.2 Consequence Evaluation Table

Consequence

Impact Level	Impact Description	Financial	Project Schedule	Operations	Injury or Disease	Patient Safety	Radiation (whole body - worker dose)	Radiation (whole body - public offsite dose)	Environment	Security	Legal / Compliance	Reputation	Government Relations	Human Resources
I6	Catastrophi c	>$15m	>18 months	Total loss of production / operations untenable in near to mid term	Multiple fatalities or serious permanent injuries	Death of a patient	>1000mSv or severe dose to multiple people	>50mSv or severe dose to multiple people	Long term damage (>10 yrs.) with effects beyond the Buffer Zone	Cessation of all operations / multiple fatalities / major criminal or terrorist event	Cancellation, permanent suspension of site license / repeal of ANSTO Act / Board and/or CEO removal / senior officers barred from office under CAC Act	Prolonged international and national condemna-tion	Loss of government support for agency operations as a whole	Agency-wide strike action
I5	Severe	$5m - $15m	12 - 18 months	Critical operations seriously affected > 6 months	Death, permanent disability or permanent ill health	General customer health problem that could attract public interest	100 mSv - 1000mSv	10 - 50 mSv	Long term damage (3 - 10 yrs.) with effects beyond the Buffer Zone	Impact on all operations (>24 hours) / shutdown / single fatality / crime or terrorism attempt	Prolonged regulatory suspension of operating license/s / major restriction of core activities / major compensation payable / prosecution (civil/criminal) or other serious administrative action for legislative breaches / large fines	International and national criticism	Extraordinary government enquiries called or examination into agency operations as a whole	Strikes at several facilities
I4	Major	$2m - $5m	8 - 12 months	Critical operations seriously affected 1 - 6 months	Long term illness or serious injury, but recovery probable	Customer/ community health problem causing significant backlog of patients or non- treatment / Possible adverse drug reaction due to a product quality issue	20 - 100 mSv / >500 mSv (skin extremity dose)	1 - 10 mSv	Medium term damage (1 - 3 yrs.) but confined to the Buffer Zone	Impact on some operations (>24 hours) / regulatory impact / injuries / negative media attention	Medium compensation / work suspension orders / regulatory directions	Very negative national criticism	Loss of government support for specific agency operations or projects	Strike at one facility
I3	Moderate	$500k - $2m	4 - 8 months	Limited damage to equipment and/or facility / loss of production < 1 month / Report to Regulator	Medical attention / several lost time days	Customer/ community health problem causing significant delay of treatment / Possible product recall situation	1 - 20 mSv / 40 - 500 mSv (skin extremity dose)	0.05 - 1 mSv	Short term (<1 yr.) effects confined to site, but breaching statutory requirements	Impact on some operations (>24 hours) / regulatory impact	Limited compensation / minor fines / major administrative complaint	Adverse national public attention	Extraordinary government enquiries called or examination of specific agency operations or projects	Organised stay aways
I2	Minor	$20k - $500k	2 - 4 months	Insignificant damage to equipment / short interruption to some operations (hours)	First aid	Customer/ community health problem causing delay/rebooking of some treatments	0.1 - 1 mSv / 4 - 40 mSv (skin extremity dose)	0.02 - 0.05 mSv (20 - 300 µSv)	Effects confined to work area, but is anomalous and/or exceeds guidelines	Impact on some operations (<24 hours)	Civil litigation / arbitration / minor administrative complaint / regulatory compliance notices	Local attention from media / NGO / public	Minister called on to publicly support agency	Disputes / Grievances
I1	Negligible	<$20k	<1 month	Superficial damage to equipment / no loss of production	Minimal effects / very small injury not requiring treatment	No delay in treatment	< 0.1 mSv / <4 mSv (skin extremity dose)	<0.02 mSv (< 20 µSv)	Within routine operational conditions, but may be an aspect with potential for improvement	No regulatory or operational impact	Reportable minor incident / minor breach of legal duty/obligation	Public concern restricted to local complaints	Additional oversight of operations required by Department	Complaints / dissatisfaction amongst staff

This table should not be construed to mean that different consequences at the same level are equivalent. For example, it is not meaningful or desirable to attempt to equate serious injury or death to financial costs.

B.3 RISK MATRIX (Risk Evaluation Table)

Risk Analysis Matrix

Medium	High	High	Very High	Very High	Very High	Very High	I6	Catastrophic	Impact
Low	Medium	Medium	High	High	Very High	Very High	I5	Severe	
Low	Low	Medium	Medium	High	High	Very High	I4	Major	
Very Low	Very Low	Low	Low	Medium	Medium	High	I3	Moderate	
Very Low	Very Low	Very Low	Very Low	Low	Low	Medium	I2	Minor	
Very Low	Very Low	Very Low	Very Low	Very Low	Low	Low	I1	Negligible	
L1	L2	L3	L4	L5	L6	L7			
Extremely Unlikely	Highly Unlikely	Very Unlikely	Unlikely	Likely	Very Likely	Almost Certain			
Likelihood									

APPENDIX C - HAZARD IDENTIFICATION WORKSHOP

ILW Return Project

Venue: Huxlin Training Room, B1

Date: 20 February 2012 (duration :1.5 hours), 12 February 2013 (duration: 1.0 hour) and 08 April 2014 (duration 1.5 hr)

Present: See the Table 1.

Area/Room and activity(s)	Hazard (and/or operational issues)	Scenario(s)	Consequences	Safeguards/controls	Consequence Type	Consequence Score	Likelihood Score	Risk	Actions/Recommendations	Comments
Waste Storage – TN 81 Transport/Storage Container, and Technological Wastes	Radiation	Failure of primary and secondary seal could cause gamma shine	Dose to operator	Fixed Radiation monitor and alarm. EPD Inter-lid pressure monitoring Evacuate	Radiation dose		**Incredible**			Risk tolerable.
		Drop or tip over of TN 81 Transport/Storage Container – vertical to horizontal due to external event(s), eg. Earthquake..	Dose to operator	Fixed Radiation monitor and alarm. Robust design and construction of the casks. EPD Evacuate	Radiation dose		**Incredible**			Risk tolerable.
		Burying of the TN 81 container with debris of the collapsed building following a severe seismic event	Dose to operator during recovery	Robust design and construction of the building. Recovery plan, i.e. uncover the container within 2.1 days for conservatively assumed 100% burial.	Radiation dose	**Minor**	**Extremely unlikely**	**Very Low**		
		Inter-lid gas pressure monitoring system failure.	Dose to operator(during recovery operation)	Three independent pressure sensor Routine inspection.	Radiation dose	**Negligible**	**Extremely unlikely**	**Very Low**		
		Radiation exposure from the tech waste	Dose to operator (less than 2 mSv/h at contact)	Cemented wastes Radiation monitor EPD and evacuate during an alarm.	Radiation dose	**Minor**	**Extremely unlikely**	**Very Low**	If required shielding to be provided to reduce the dose to background.	Risk tolerable.
		Vehicular accident causing damage to the technological waste drums	Dose to operator	CBFC-2 packages are insdie the ISO container Radiation monitor Training and experience.	Radiation dose.	**Minor**	**Unlikely**	**low**		
	Contamination	surface contamination on TN-81 or on technological wastes while loading canisters/drums due to human error	Dose to operator (minor)	HP checks at several points. Regular HP checks Training and experience.	Radiation dose	**Minor**	**Extremely unlikely**	**Very low**		Risk tolerable
		Water leak in the store could spread contamination	Dose to operator (minor)	Design and construction of the pipework Regular inspection	Radiation dose	**Minor**	**Unlikely**	**low**	Bunded floor should be needed to contain any contamination.	Risk tolerable

Area/Room and activity(s)	Hazard (and/or operational issues)	Scenario(s)	Consequences	Safeguards/controls	Consequence Type	Consequence Score	Likelihood Score	Risk	Actions/Recommendations	Comments
				Epoxy coated floor. Drains to active B-line						
	Mechanical or electrical failure	Radiation monitor failure due to mechanical or electrical fault	Dose to operator (minor)		Radiation dose	**Moderate**	**Extremely unlikely**	**Low**		Risk tolerable
	Fire	Fire in the store	Fire damage to the building and to the waste items (very unlikely) dose to operator and the public (very unlikely))	Very or no fire loading. TN 81 Transport/Storage Container designed/constructed as Package B(U)F and tested accordingly. No credible scenario of fire identified	Radiation dose	**Minor**	**Very unlikely**	**Very low**		Risk tolerable. Note: *Over-heating due to heat generation from the CSD-U is considered incredible – see Section 7.1.10.*
	Ventilation	Failure to operate the fan on demand.	Store ambient temp may rise to an uncomfortable level in hot/warm days. Personnel may get heat exhaustion.	Alarm Regular inspection Stop work on hot days. Evacuate No major works to carried out in the store.	Injury or disease	**Moderate**	**Extremely unlikely**	**Very Low**		Risk tolerable.
	Electrical	Electrocution	Electrical shock or even electrocution	Design as per AS Qualifications and accreditations of tradespersons Isolation and tagging procedure	Injury or disease	**Severe**	**Extremely unlikely**	**Medium**		
	Drainage	Drains to active B-line. No issues.								
	Water	Water on floor causing contamination hazard-discussed above								
	Helium	Release of Helium gas inside the store.	Asphyxiation	Design and construction of the pipework is approved by ANSTO Piped Gas Approval Officer. Store is well ventilated. Large open area in the building	Injury or disease	**Major**	**Extremely unlikely**	**low**		Risk tolerable.
	Compressed air	No issues								
	Chemical	No issues								
	Toxicity	No issues								
	Manual handling	Heavy bolts (of impact limiter) may need manual handling	Back injury if heavy items lifted without following proper procedure.	Very low frequency activity. Use of building crane. Training and experience	Injury or disease	**Moderate**	**Likely**	**Medium**	Follow WHS Guides. Use AREVA Instruction Manual	Risk tolerable.
	Working at heights	Worker may fall while working at height with the TN 81 Transport/Storage Container or using the building crane ladder.	Worker could be injured due to the fall.	Very low frequency operation Training and experience.	Injury or disease	**Major**	**Unlikely**	**Medium**	Consider dedicated moveable set of steps to access to the top of the TN 81 Transport/Storage Container.	Risk tolerable.

Area/Room and activity(s)	Hazard (and/or operational issues)	Scenario(s)	Consequences	Safeguards/controls	Consequence Type	Consequence Score	Likelihood Score	Risk	Actions/Recommendations	Comments
	Slips, trips, fall	While working inside the store, an operator could trip and could be injured.	Worker could be injured due to a slip, trip or fall	No process operations in the store and thus the floor is not wet. Training and experience	Injury or disease	**Moderate**	**Likely**	**Medium**	Follow WHS Guides	Risk tolerable.
	Seismicity	Discussed in section7.3.2. No major issues.								

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MEMORANDUM

APPENDIX D - CRANE RISK ASSESSMENT

To	Project Manager, ILW Return Project	Date	15 April 2014
cc:	Alamgir Kabir		
From	Joy Perera	Ref/File No.	**Error! Unknown document property name.**
Subject	Risk Assessment		

INTRODUCTION

This memo documents an updated risk assessment conducted of the operation of the 140T DGR crane for handling the Intermediate Level Wastes to be returned to ANSTO after reprocessing in France, in the new Interim Waste Store (IWS) of ANSTO. This risk assessment is intended to serve the following purposes.

1. To identify any ongoing safety issues relevant to the operation of the 175 tonne (140T DGR) overhead (OH) crane at the facility.
2. To facilitate the safety and licensing approval for the operation of the facility following its construction, installation and commissioning.

BACKGROUND

The IWS facility is being constructed at Lucas Heights Science and Technology Centre (LHSTC) and will be used for the storage of intermediate level solid wastes to be transferred from France which forms the waste products of spent fuel reprocessing carried out in that country. The facility is considered an interim storage because the final storage of the waste will be in a National Radioactive Waste Management Facility (NRWMF) to be constructed in the future in Australia.

The facility constitutes a Nuclear Installation in terms of ARPANSA Act and Regulations.

A preliminary risk assessment was conducted in April 2012 based on the ANSTO's past experience on overhead Gantry Cranes using the collective knowledge and experience of a multi-disciplinary team of officers involved in the project. A construction licence for the IWS facility has been issued by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA).

More detailed information on the cranes as well as the returned ILW is now available, which enables the risk assessment to be revised and updated. This memo provides a record of the updated and revised risk assessment conducted on 11 April 2014.

The crane is currently being installed and is expected to be commissioned in August 2014.

SCOPE

The scope of this memo is limited to the 175 tonne (DGR 140T) operation of the overhead crane to be provided for the IWS.

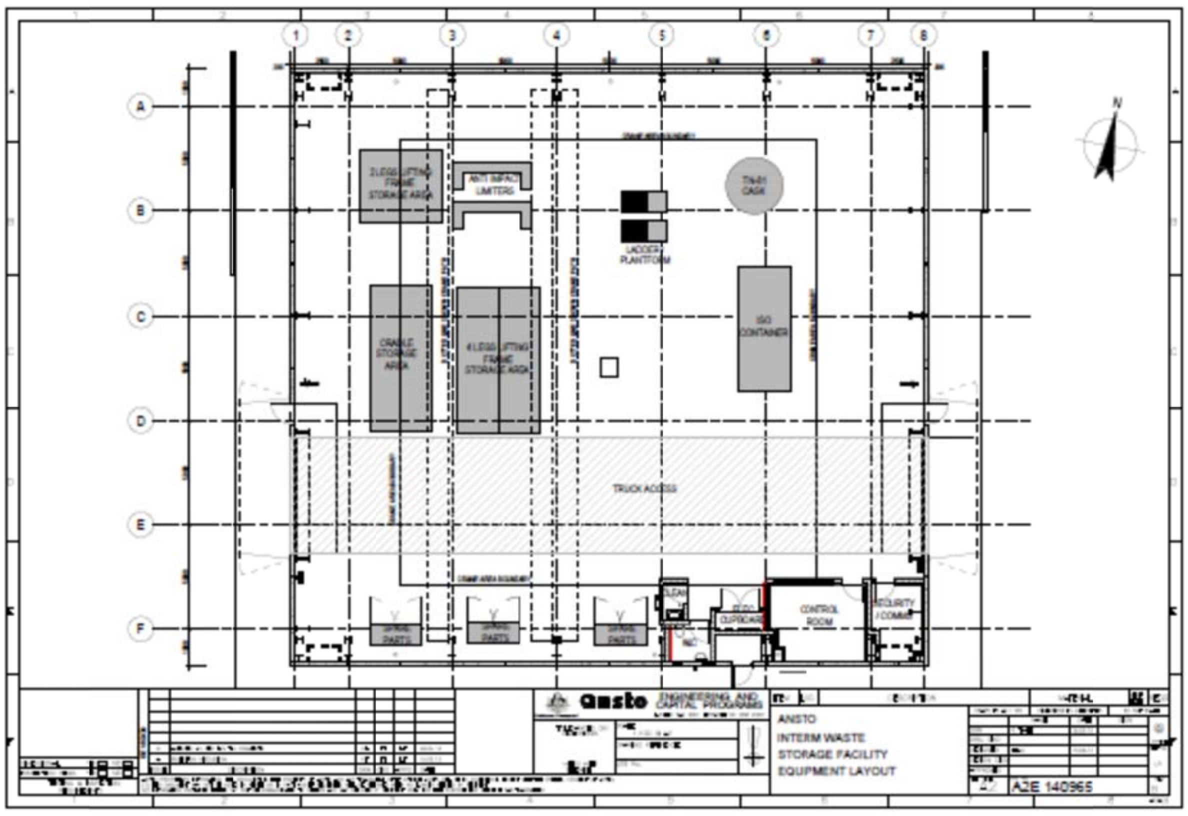

Figure 1: Layout Plan of the IWS Facility (from Dwg A2E 140965).

FACILITY DESCRIPTION

The facility is housed in a new building constructed at LHSTC. Figure 1 shows a layout plan of the facility. The facility consists of the following items of plant and equipment.

1. The building of approximate dimensions 30 mx 28.2 m x 21 m constructed with a steel structural frame and prefabricated concrete walls and a metal roof. It has roller shutter doors for the entry and exit of a truck or a low loading trailer to bring in the shielded TN 81 Transport/Storage Container into the facility, or to take away the shielded TN 81 Transport/Storage Container from the facility if the need arises.
2. An OH gantry crane with a Dangerous Goods Rating (DGR) of 140 tonnes (175 T crane de-rated by 20% to 140 DGR).
3. Shielded TN 81 Transport/Storage Container containing vitrified radioactive wastes stored in TN 81 Transport/Storage Container in the building.
4. A set of six concrete packages of technological wastes from the reprocessing activities shipped and stored in an ISO-shipping container. This refers to indirect wastes from contaminated equipment and materials, but not direct wastes of the spent fuel reprocessing.
5. Demarcated areas for the storage of various tools and equipment associated with the Transport/Storage containers.
6. A control room (mostly unmanned) which houses a PC monitor for local monitoring of Helium gas pressure inside the space between two lids of the TN-81 cask, whenever required. This information is also accessible for online monitoring via the ANSTO intranet.

The above items are further described below.

The Building

The building floor slab will be of robust design and construction to take the maximum expected floor load and the walls will be constructed to take the crane load whilst meeting the design requirements of

AS 1170 for wind and earthquake loads. The building will have fire/smoke detection systems and local fire suppression facilities (fire extinguishers and fire hose reels).

The Overhead Crane

The overhead crane complies with AS 1418.1: 2002 and has a DGR rating of 140 tonnes (i.e. a crane with a maximum design load of 175 tonnes with 20% de-rating for dangerous goods). The crane will have all lifting accessories required for the various types of loads to be handled in the facility.

TN 81 Transport/Storage Container containing radioactive waste generated form reprocessing spent fuel

TN 81 Transport/Storage Container containing ILW from reprocessing of spent fuel will be received from AREVA's LA Hague plant in France. The shipment will be one TN 81 Transport/Storage Container, containing vitrified waste from France. This TN 81 Transport/Storage Container, weighing 118T is to be stored in the IWS.

Although the TN 81 Transport/Storage Container to be handled by the crane have radioactive material, these are vitrified (bound and immobilised in a glass matrix) which would prevent any possible release of radioactivity even under extreme impacts imposed on the TN 81 Transport/Storage Container. The TN 81 Transport/Storage Container that contains the ILW is designed to withstand extreme mechanical impacts and it is not credible that they could be damaged in any of the foreseeable accidents in the facility.

Fibre Concrete container for technological wastes (CBF-C2)

In addition to the ILW from HIFAR spent fuel reprocessing waste from France, ILW generated from contaminated PPE, swabs, consumable, and/or damaged equipment, tools and materials used in the processes are packed into waste drums and compacted and then encased in shielded concrete containers [Ref 1] and loaded in a specially-designed rack and then into an ISO-shipping containers for transport and storage. Six such concrete packages are to be stored.

RADIOACTIVE INVENTORY

Currently, the actual radioactive inventories of the ILW in each vitrified canister, cemented shell/drum or technological waste container is not available, although conservative estimates of the inventory and the dose rates with shielding are available (based on a standard AREVA specification)..

The actual inventory and dose rates will be available from AREVA prior to transport of the waste to Australia. The dose rates on the outside surface of the TN 81 Transport/Storage Container is expected to be not significantly above background.

The vitrified waste contained in the TN 81 Transport/Storage Container is physically bound in a glass matrix and encased in stainless steel canisters. Thus the radioactivity in the TN 81 Transport/Storage Container is immobilised and cannot be released under any credible accident scenario during transport, handling or storage.

The technological wastes are compacted, cemented and contained in waste drums which in turn are enclosed in shielded concrete containers, then backfilled with concrete and the lid grouted into position [Ref 1]. Damage to concrete containers and waste drums during transport, handling and storage is possible, although extremely unlikely due to the engineered and administrative controls that will be in place. In the event of damage to the shielded containers, radiation exposure to personnel in the vicinity in the range of (0.1-1mSv) i.e. **minor** radiological consequence would be possible. However it is very unlikely to result any release of radioactivity to the environment. There will be no release of radioactivity that would cause any off site dose.

METHOD

The approach adopted in this updated and revised risk assessment consisted of the following steps.

1. Review, revise and update where necessary the risk assessment conducted in April 2012, in the light of the new information available on the crane as well as of the facility and the nature and the magnitude of the loads, with the participation of the project team,
2. Document the findings of the study.

The following officers participated in the updated risk assessment on 11 April 2014.

- Kristian Veronika – Project Engineer for the installation of the Crane and Lifting Equipment Approvals Officer
- Lynn Tan – Waste Operations.
- Alamgir Kabir – Systems Safety and Reliability
- Joy Perera – Systems Safety and Reliability.

RISK ASSESSMENT

Appendix D.1 provides a record of the risk assessment of potential accidents and failures based on the Risk Analysis Matrix AG-2395..

The following accident scenarios were considered in the risk assessment and a summary is provided below.

- Failure of the crane (or power failure) causing the load (radioactive) to be held suspended for an extended period – No radiological consequence.
- Spurious operation of the crane hoist, with potential for collision and consequent injury to personnel or damage to the crane or the crane load. No radiological consequence.
- Spurious operation of the crane longitudinal or cross travel with potential for collision and consequent injury to personnel or damage to crane or crane load. No radiological consequence.
- Drop of TN 81 Transport/Storage Container. Damage to the TN 81 Transport/Storage Container in the event of a drop is not considered credible due to the robust mechanical design and construction confirmed by testing.
- Collision of TN 81 Transport/Storage Container during handling by crane. Damage to the TN 81 Transport/Storage Container is not considered credible due to the robust mechanical design and construction confirmed by testing.
- Collision of a crane load with the technological waste container and the shielded waste containers resulting in some damage and consequent **minor** radiation exposure to personnel. No radioactivity release.
- Drop of the ISO container of the technological waste whilst being unloaded off the truck or being loaded for transport to the NRWMF in subsequent years resulting in some damage and consequent **minor** radiation exposure to personnel. No radioactivity release.
- Drop of a crane load on to the ISO container containing technological waste resulting in some damage and consequent **minor** radiation exposure to personnel. No radioactivity release.
- A major seismic event causing the crane bridge to drop and resulting in damage to the technological waste containers and consequent **minor** radiation exposure to personnel (assuming personnel present in the building). No off site release of radioactivity. The risk of physical injury/fatality would dominate in this scenario.

The risks of radiological consequence, injury to personnel or plant damage were assessed as low in all cases.

There is no credible possibility of radioactivity releases identified in any of the potential accident scenarios although the possibility exists for minor radiation exposure (0.1-1mSv) from some accidents due to the failure of the CBF-C2 containers of the technological waste due to a crane load drop or a collision.

CONCLUSION

Based on the risk assessment conducted and the consideration of the worst case radiological consequence of potential accidents, it is concluded that an OH crane for the facility complying with AS 1418.1 and related Australian Standards with DGR rating not less than 140T would meet the safety and operational requirements of the facility.

(Senior Safety and Reliability Adviser)

ANSTO Systems Safety and Reliability (SSR) Section

REFERENCES:

1. Cogema Branche Retraitement, Specification for Cement-Wrapped Technological Waste (Cylindrical Fibre Concrete Container Type C2). Document No. 300AQ 044 Rev 2A.
2. AREVA NC, Specification for Standard CSD-U Vitrified Waste Residues Produced at La Hague, Document No. 300AQ 059a 0A.

D.1 Risk assessment table- Operation of the 140 Tonne DGR rated crance in the IWS.

(Hazard Identification and Risk Assessment Form)

ansto **Hazard Identification and Risk Assessment Form**

Operation of the 140 Tonne (DGR rating) Crane of the IWS Facility

Hazard	Scenario	Mitigation	Consequence Type	Consequence	Consequence Score	Likelihood Score	Risk	Acceptability
Crane load (radioactive)	Crane Load (TN 81 Transport/Storage Container) dropped due to: rope snapped; slings failed; motor gear/coupling broken; or brake failed, resulting in damage to the TN 81 Transport/Storage Container	Safety factors of crane components Certified lifting devices DGR rating Regular inspection, testing and maintenance of crane. Crane load movements over other flasks avoided by administrative control Height of lift should be the minimum required. The TN 81 Transport/Storage Container used for transfer of is a robust container certified to withstand the shock of a drop or impact Extremely low usage (around once per year).	Radiation	Not Assessed	Not Assessed	Incredible (< 10^{-6} per year)	N/A	N/A
		Vitrified waste	Radioactivity release		None	Incredible (< 10^{-6} per year)	N/A	N/A
		Extremely infrequent usage Personnel stay clear of the load Crane operator/dogman can in most cases move out and not get injured. Lift height is minimised.	Physical injury	Potential for serious injury from secondary effects of the drop	Moderate/ Major/ Severe	Extremely Unlikely (10^{-5} to 10^{-4} per year)	Low	Tolerable risk
Crane load and radioactivity	Uncontrolled lowering of load (TN-81) due to brakes slip or control failure.	Emergency stop button. Height of lift should be the minimum required. The TN 81 Transport/Storage Container used for transfer of is a robust container certified to withstand the shock of a drop or impact	Radiation	Not assessed	Not assessed	Incredible	N/A	N/A
		Same as above	Plant/equipment damage and economic loss	Plant damage	Moderate	Very Unlikely	Low	Tolerable risk.
		Extremely infrequent usage Personnel stay clear of the load Lift height is minimised.	Physical injury	Potential for significant injury form secondary effects of the drop	Moderate/Major	Highly Unlikely (10^{-5} to 10^{-4} per year)	Low	Tolerable risk

ansto Hazard Identification and Risk Assessment Form

Operation of the 140 Tonne (DGR rating) Crane of the IWS Facility

Hazard	Scenario	Mitigation	Consequence Type	Consequence	Consequence Score	Likelihood Score	Risk	Acceptability
Crane load (radioactive)	TN-81 Crane load collision with the ISO container and consequent damage to shielded containers of Technological waste (Damage to TN 81 Transport/Storage Container considered not credible)	Certified crane operators and dogmen Operator in control; Emergency Stop switches.	Possible equipment damage	Significant plant damage	Moderate	Unlikely (10^{-3} to 10^{-2} per year)	Low	Tolerable risk.
		Same as above; and Technological waste drums are designed to withstand some degree of mechanical impact.	Radiation	Potential Radiation exposure in the range 0.1-1mSv	Minor	Very Unlikely (10^{-4} to 10^{-3} per year)	Very Low	Tolerable risk.
Crane load (radioactive)	Drop of the ISO container carrying the technological wastes.	Extremely infrequent usage Lift height is minimised. Technological waste drums are designed for mechanical impact from a drop height of 1 metre.	Radiation	Potential radiation exposure in the range of 0.1-1mSv	Minor	Highly Unlikely (10^{-5} to 10^{-4} per year)	Very Low	Tolerable risk
Crane load	Drop of the ISO Container	Extremely infrequent usage Personnel stay clear of the load Crane operator/dogman can in most cases move out and not get injured. Lift height is minimised.	Physical injury	Potential for serious injury from secondary effects of the drop	Moderate/Major	Extremely Unlikely (10^{-6} to 10^{-5} per year)	Low	Tolerable risk
Crane load and radioactivity	Uncontrolled lowering of load (ISO Container due to brakes slip or control failure.	Emergency stop button. Height of lift should be the minimum required. Technological waste drums are designed for mechanical impact from drop height of 1 metre.	Radiation	Potential radiation exposure in the range of 0.1-1mSv	Minor	Highly Unlikely (10^{-5} to 10^{-4} per year)	Very Low	Tolerable risk
		Same as above	Plant/ equipment damage and economic loss	Crane damage	Moderate	Very Unlikely (10^{-4} to 10^{-3} per year)	Low	Tolerable risk.
		Extremely infrequent usage Personnel stay clear of the load Lift height is minimised.	Physical injury	Potential for serious injury form secondary effects of the drop	Moderate/Major	Highly Unlikely (10^{-5} to 10^{-4} per year)	Low	Tolerable risk
Crane load (radioactive)	Crane (with a load in it) fails to operate. i.e. the hoist, trolley or the crane bridge fail to move as directed.	Load height kept as low as possible. Controlled brake release should be possible to lower the load.	Operational delays	Operational Delays	Minor	Likely (0.01 to 0.1 per year)	Low	Tolerable risk.

ansto **Hazard Identification and Risk Assessment Form**

Operation of the 140 Tonne (DGR rating) Crane of the IWS Facility

Hazard	Scenario	Mitigation	Consequence Type	Consequence	Consequence Score	Likelihood Score	Risk	Acceptability
Crane load (radioactive)	Inadvertent/ Spurious operation of crane hoist with a load resulting in some damage	Operator presence; Emergency stop Over travel limit switch and over travel cut off device minimise possibility of damage to crane or the load.	Plant/equipment damage	Crane damage	Moderate	Unlikely (10^{-3} to 10^{-2} per year)	Low	Tolerable risk.
Crane load (radioactive)	Spurious operation/ travel of the crane bridge or the hoist trolley resulting in some damage.	Operator presence; Emergency stop 2 stage Over travel limit switch (slowing down and then stopping) minimise possibility of damage to crane No go zones specified for the control room area. Speed is limited to 4metres /minute.	Possible equipment damage	Plant damage	Moderate	Unlikely (10^{-3} to 10^{-2} per year)	Low	Tolerable risk.
Crane load and its movement	Crane bridge or trolley over-travel.	Accreditation of crane operators and dogmen. Regular maintenance and inspection to ensure integrity and reliability of : Over travel protection Stops and buffers	Plant/equipment damage and economic loss	Crane damage and potential safety impact	Moderate	Unlikely (10^{-3} to 10^{-2} per year)	Low	Tolerable risk.
			Physical injury	Injury	Moderate	Unlikely (10^{-3} to 10^{-2} per year)	Low	Tolerable risk.
Seismic Event	Crane bridge dropping down and damaging the waste containers.	Facility is normally unmanned. It is very unlikely that a person is present in the facility during a major seismic event. TN 81 Transport/Storage Container is designed to withstand extreme mechanical impact. Technological wastes are cemented and contained in steel containers and shielded concrete containers Crane designed for seismic loading (as part of AS 1418.1 DGR requirements)	Physical injury	Severe injury /fatality	Major/Severe	Incredible	N/A	N/A
			Radiation	Radiation exposure (0.1-1mSv)	Minor	Incredible	N/A	
Crane drive mechanism and other moving parts	Maintenance worker suffers physical injury: falls, cuts, bruises, crushing injury	Training and experience; supervision.	Physical injury	Injury to maintenance personnel	Moderate	Unlikely (10^{-3} to 10^{-2} per year)	Low	Tolerable risk.

ansto **Hazard Identification and Risk Assessment Form**

Operation of the 140 Tonne (DGR rating) Crane of the IWS Facility

Hazard	Scenario	Mitigation	Consequence Type	Consequence	Consequence Score	Likelihood Score	Risk	Acceptability
	etc.				Major	Highly Unlikely (10^{-5} to 10^{-4} per year)	Low	Tolerable risk..
Electrical	Possibility of electrical shock during maintenance work.	Electrical work performed by licensed electricians. Isolation prior to work.	Physical injury	Electrical shock /Electrocution	Major/Severe	Highly Unlikely (10^{-5} to 10^{-4} per year)	Medium	Tolerable. Risk is considered as ALARP with standard ANSTO precautions and safeguards in place.

APPENDIX E - SAFETY CATEGORISATION OF STRUCTURES, SYSTEMS AND COMPONENTS

E.1 Introduction

This appendix provides safety categorisation of structures, systems and components (in terms of radiological safety) of the ANSTO Camperdown Facility as per following system of categorisation described in ANSTO/T/TN/2008-11 REV 1 - Guidance on Safety Categorisation of Structures, Systems and Components.

Category	Description
1	Items whose failure could lead to a radiological exposure exceeding 100mSv (for occupationally exposed individuals) or 5mSv (for a member of the public), taking into account other protective measures, with some degradation.
2	Items, other than category 1 items, whose failure could lead to a radiological exposure exceeding 20mSv (for occupationally exposed individuals) or 1.0 mSv (for a member of the public) taking into account other protective measures, with some degradation.
3	Any system, structure or component that is not allocated to Safety Category 1 or Safety Category 2.

E.2 The Safety Systems and their Categorisation.

Safety systems that are claimed as preventive or mitigation measures in the accident scenarios considered in this report are categorised as tabulated below:

Table E.1 Safety Systems Categorisation

Systems	**Worst credible case (Radiological Consequence) protected against**	**Safety Category**	**Remarks**
TN 81 Transport/Storage Container shielding	1-20 mSv	3	Due to an external event, the vitrified waste shielding could become compromised and could cause elevated dose to operators. See the risk assessment in Section 7.1. Although this has been assessed as **incredible**, it nevertheless requires such a categorisation in order to maintain the necessary quality levels and possible Operating Limits and Conditions (OLCs).
Technological waste drums (cemented waste)	0.1-1 mSv	3	Due to an external event, the technological waste could become unshielded. See the risk assessment in Section 7.1.
Inter-lid gas pressure monitoring system	Less than 0.1 mSv	3	Due to an electrical system fault, the inter-lid gas pressure monitoring system could fail. The dose consequence is assessed as minor less than 0.1mSv. See Section 7.1.

Systems	Worst credible case (Radiological Consequence) protected against	Safety Category	Remarks
Ventilation alarms	<0.1 mSv	3	Ventilation alarms alert operators to the failure of ventilation, to enable them to take appropriate action (evacuate). However, there is no credible scenario by which there could a release due to ventilation failure. The ventilation system in the IWS store is for comfort cooling and the booster fan(s) operation is controlled by thermostat.
Radiation monitor	1-20 mSv	3	Due to mechanical/electrical fault, radiation monitor could fail and its failure with coincident higher radiation levels in IWS leading to elevated doses could cause an exposure in the range of 1-20 mSv to operator. See the risk assessment in Section 7.1.
Building crane	1-20 mSv	3	Drop load onto the TN 81 Transport/Storage Container could cause radiological consequence in the range of 1-20 mSv.
Fire detection system	0.1-1 mSv	3	No credible fire scenario identified for the store. However, worst case radiological consequence is assessed as minor 0.1-1 mSv.
Fire hose reels and portable fire extinguishers	0.1-1 mSv	3	No credible fire scenario identified for the store. However, worst case radiological consequence is assessed as minor 0.1-1mSv.

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