Riskcon engineering

Dangerous Goods Design Report

83 Missenden Road, Camperdown

Royal Prince Alfred Hospital
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83 Missenden Road, Camperdown

Royal Prince Alfred Hospital

Prepared by

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Quality Management

Rev	Date	Remarks	Prepared By	Reviewed By
A	12 July 2023	Draft issued for comment	Renton Parker	Steve Sylvester
B	26 September 2023	Issued final		
C	16 February 2024	Changed storage layout		
D	1 May 2024	Design review		
E	25 February 2025	Additional oxygen tanks		

Executive Summary

Background

The Royal Prince Alfred Hospital (RPA) has several gas cylinder stores and bulk gas tanks supplying liquid oxygen and nitrogen for use in the hospital. It has been proposed to install two (2) new 32 kL liquid oxygen tank whilst retaining the existing liquid oxygen tank such that there is sufficient back up. It has also been proposed to optimise the cylinder storages in the compound to achieve compliance with the Work Health and Safety Regulation 2017 (Ref.) and applicable standards.

CPB Contractors (CPB) has been engaged to design and construct the new tank installation and undertake the design optimisation for the gas cylinders. To assist with the project, CPB has engaged Riskcon Engineering Pty Ltd (Riskcon) to undertake a review of the storages and outline the design requirements that need to be included for each storage location to achieve compliance with the applicable regulations and standards. This document represents Riskcon's assessment and recommendations for the DG storage(s) at the site.

Conclusions

A review of the proposed DG storage and operations at the RPA gas compound was conducted to determine compliance with the Work Health and Safety Regulation 2017 (Ref.) and all relevant design standards.

A review of the standards determined that the following standards should be used to govern the storage requirements in the respective areas:

- Liquid oxygen / nitrogen - AS 1894-1997
- Gas cylinders – AS 4332-2004

Each of these standards was used to construct a series of requirements to inform the design and storage of each of the storages at the RPA gas compound.

Recommendations

The following recommendations have been made based on the assessment within this report:

DG Storage Requirements:

Each DG storage area has different requirements based on the particular substances which are being stored. Detailed summaries of the items to be included in the design of each DG store are provided in the following sections:

- Liquid oxygen (new 32 kL): Table 4-2
- Liqui doxygen (new 32 kL): Table 4-5
- Emergency liquid oxygen: Table 4-8
- Liquid nitrogen: Table 4-10
- Store A/B: Table 4-12
- Store 4/5/7/F: Table 4-14

Specific Recommendations

- Separating fire wall between tanks and existing stores to be a minimum of 4.5 m high.

DG Documents:

Ensure the following documentation is supplied on site in accordance with the Work Health and Safety Regulation 2017 (Ref.):

- A Dangerous Goods Register, indicating the type of chemical, any notations that may be required from the risk assessment and the Safety Data Sheet for the chemical.
- A Manifest.
- A DG Risk Assessment of the storage and handling area.
- A Placard Schedule.
- An Emergency Response Plan (ERP).
- Emergency Services Information Pack (ESIP).
- A Hazardous Area Classification (HAC).
- Hazardous Area Verification Dossier (HAVD).

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Abbreviations

Abbreviation	Description
AQR	Aggregate Quantity Ratio
CBD	Central Business District
DGs	Dangerous Goods
ERP	Emergency Response Plan
ESIP	Emergency Services Information Pack
HAC	Hazardous Area Classification
HAVD	Hazardous Area Verification Dossier
LPG	Liquefied Petroleum Gas
RPA	Royal Prince Alfred Hospital
WHS	Work Health and Safety

1.0 Introduction

1.1 Background

The Royal Prince Alfred Hospital (RPA) has several gas cylinder stores and bulk gas tanks supplying liquid oxygen and nitrogen for use in the hospital. It has been proposed to install two (2) new 32 kL liquid oxygen tank whilst retaining the existing liquid oxygen tank such that there is sufficient back up. It has also been proposed to optimise the cylinder storages in the compound to achieve compliance with the Work Health and Safety Regulation 2017 (Ref. [1]) and applicable standards.

CPB Contractors (CPB) has been engaged to design and construct the new tank installation and undertake the design optimisation for the gas cylinders. To assist with the project, CPB has engaged Riskcon Engineering Pty Ltd (Riskcon) to undertake a review of the storages and outline the design requirements that need to be included for each storage location to achieve compliance with the applicable regulations and standards. This document represents Riskcon's assessment and recommendations for the DG storage(s) at the site.

1.2 Objectives

The objective of the DG design report is to assist CPB design compliant storages for the bulk gases and the gas cylinder stores to achieve compliance with the Work Health and Safety Regulation 2017 (Ref. [1]) and all applicable DG standards.

1.3 Scope of Work

The scope of the work is to prepare a comprehensive design assistance document for the bulk gas and cylinder compound at RPA. The assessment does not include any other sites, nor additional work which may be identified in the course of the assessment.

2.0 Methodology

2.1 General Methodology

The following methodology was applied:

- The existing site operations were inspected to familiarize the project team with the scope of the project.
- The proposed design of the storages was reviewed, including details of dangerous goods (DGs) which will be stored and handled on site.
- Compliance Assessment – the design of the proposed warehouse was assessed against the requirements of the relevant standards for each store. Recommendations were made to ensure the proposed storage design achieved the requirements of the applicable clauses of the standards.
- Draft Reporting – On completion of the assessment, a draft report was prepared for review and comment by the project team.
- Final Report – On completion of the review of the draft report, any comments were incorporated into the finalised version.

3.0 Site Description

3.1 Site Location and Layout

RPA is located at 83 Missenden Road, Camperdown which is approximately 34 km west of the Sydney Central Business District (CBD). **Figure 3-1** shows the regional location of the site in relation to the Sydney CBD. Provided in **Figure 3-3** is the proposed layout of the warehouse within the site, with the DG storage areas marked on the image.

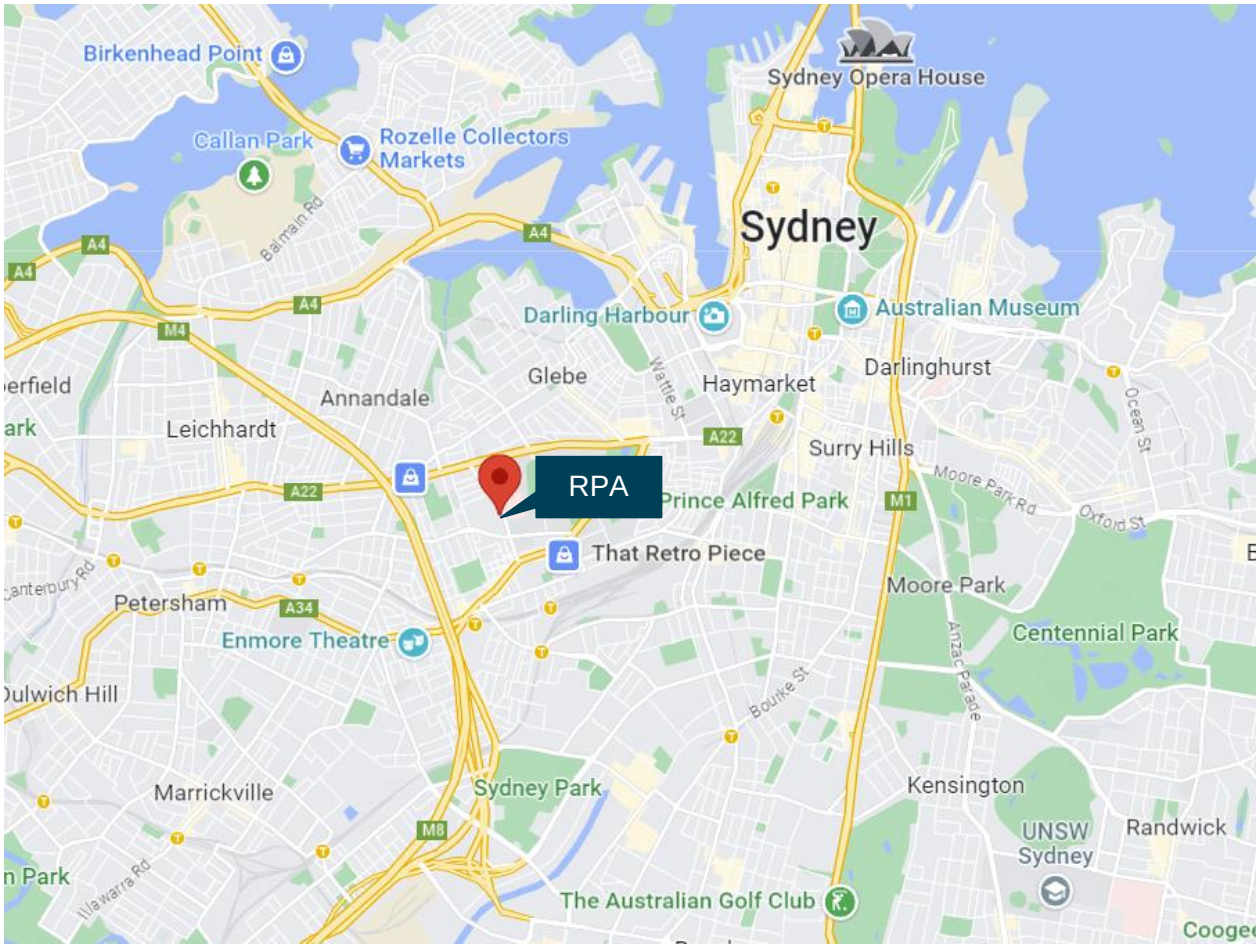

Figure 3-1: Site Location

3.2 General Area Description

The bulk gas and cylinder compound is located off Rochester Street in the western campus of the Hospital. To the west of the store is the radiation oncology department and to the north is the Chris O'Brien Lifehouse. The site currently has an existing 30,000 L liquid oxygen and nitrogen tanks and several discrete storages for gas cylinders which are open fronted to provide natural ventilation. The location of the gas cylinder compound is provided in **Figure 3-2**.

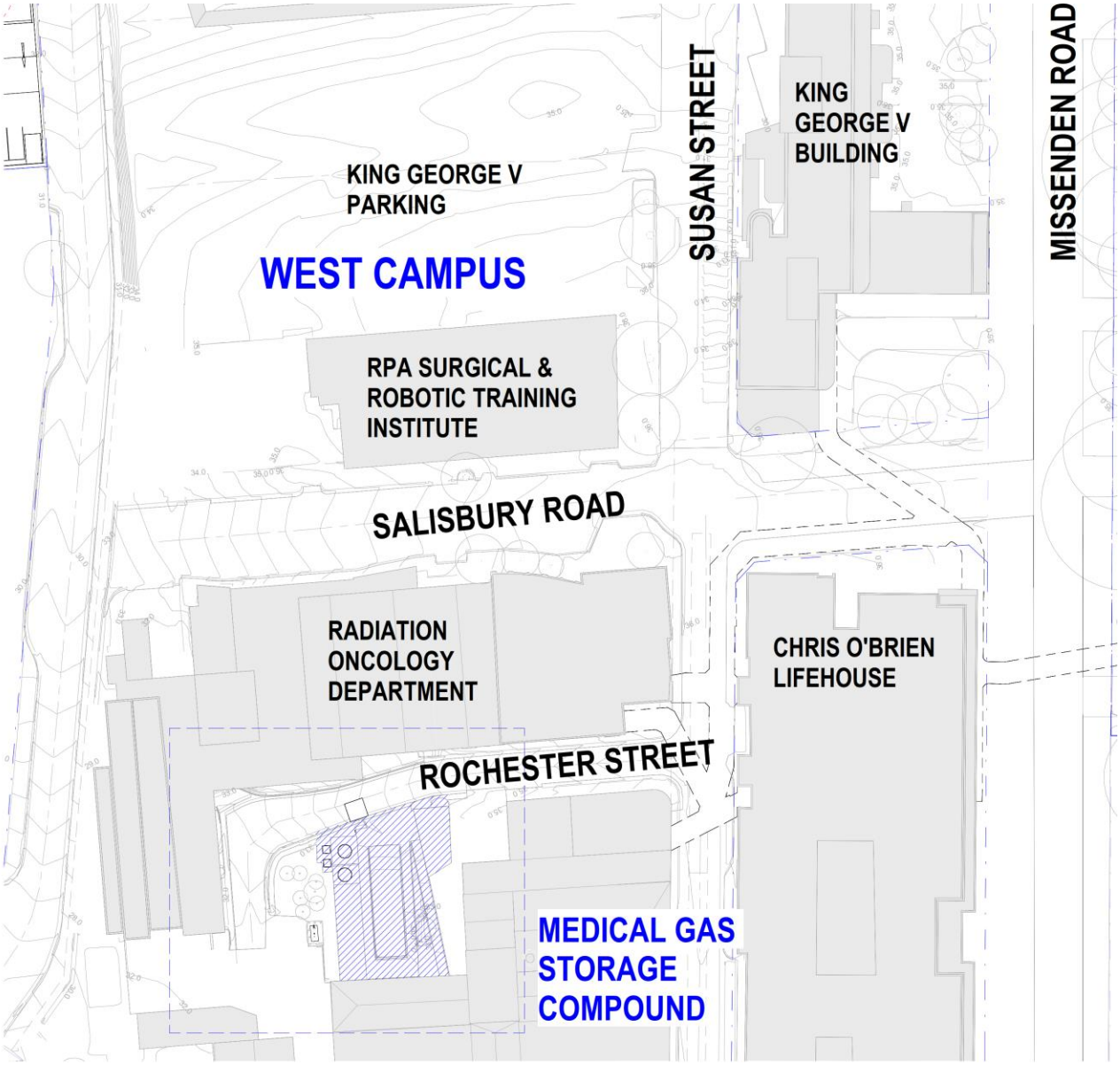

Figure 3-2: Gas Compound Location

3.3 Proposed Project

It has been proposed to install a two (2) new 32,000 L liquid oxygen tank and retain the existing 30,000 L tank. The existing liquid nitrogen tank will remain, and the gas cylinder stores will be optimised to ensure there is sufficient storage for the hospital operations and that the stores are able to comply with AS 4332-2004 (Ref. [2]). An existing 20,000 L diesel tank is proposed to be removed as part of the project.

3.4 Quantities of Dangerous Goods Stored and Handled

The classes and quantities of DGs proposed to be stored is provided in **Table 3-1**. The location referred to in the table can be identified on **Figure 3-1**.

Table 3-1: Quantities of DGs Stored and Handled

Storage Location	Class	PG	Description	Quantity (L)
A	2.2(5.1)	n/a	Nitrous oxide	1,500

Storage Location	Class	PG	Description	Quantity (L)
B	2.1	n/a	LPG, Acetylene, etc.	1,000
C	-	-	Vacant	-
D	-	-	Future Use	-
E	-	-	Future Use	-
4	2.2	n/a	Carbon dioxide	700
5	2.2	n/a	Argon dewars	400
7/F	2.2	n/a	Air & carbon dioxide	500
8	2.2	n/a	Liquid nitrogen	20,000
9	2.2(5.1)	n/a	Liquid oxygen (existing)	30,000
H	2.2(5.1)	n/a	Liquid oxygen (new)	32,000
			Liquid oxygen (new)	32,000

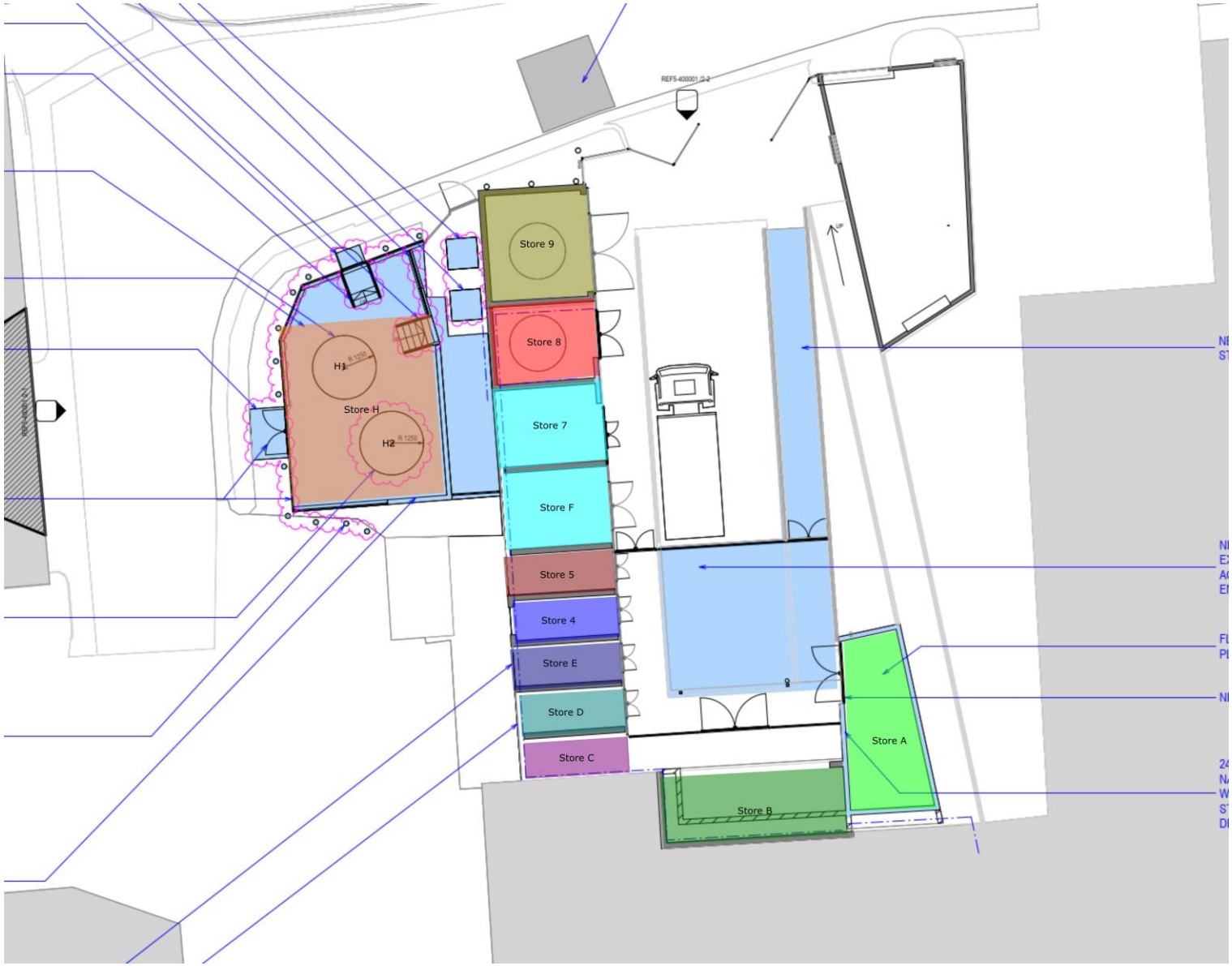

Figure 3-3: Proposed Layout

4.0 Dangerous Goods Design Requirements

4.1 Introduction

The following sections outline the design requirements for each DG storage. The storage areas assessed in the following sections include:

- 32,000 L oxygen tank (new vessel - **Section 4.2**).
- 32,000 L oxygen tank (new vessel - **Section 4.3**).
- 30,000 L oxygen tank (existing vessel (retained) – **Section 4.4**).
- 30,000 L nitrogen tank (existing)
- Store A/B (existing)
- Store 4/5/7/F (Existing)

4.2 32,000 L Oxygen Tank – New Vessel (H1)

4.2.1 Introduction

The 32,000 L liquid oxygen tank has been proposed to be stored in the western portion of gas compound area. The design standard that covers the storage and handling of liquid oxygen is AS 1894-1997 (Ref. [3]). A summary of the quantity of liquid oxygen to be stored is provided in **Table 4-1**.

Table 4-1: Liquid Oxygen Tank (New) Storage Quantity (H1)

Class	PG	Description	Quantity (L)
2.2(5.1)	n/a	Liquid oxygen	32,000

4.2.2 Design

The design points to be included within the design have been summarised in **Table 4-2**. The tank will be supplied by a 3rd party; hence, it is assumed that the supplier will provide a compliant vessel with valves, equipment, etc. as necessary.

Table 4-2: Liquid Oxygen Tank (H1 New) Storage Requirements in accordance with AS 1894-1997

Item	Requirement
Foundations	• The design load of the supports and foundation shall be the total mass when the storage vessels is full of either water of the product, whichever is greater. • The slab shall be sloped such that any spills of oxygen will flow away from sensitive receptors.
Impact protection	• The tank shall be protected from vehicular impact (i.e. cars, forklifts, etc.). This may be achieved by guard rails, bollards, or walls. • The protection shall be located a minimum of 1 m away from the vessel.
Transfer area	• The transfer area shall be adjacent to the fill coupling of the installations. • The location shall be such that in the event of an emergency the tanker has a means of quick, direct and unobstructed exit. • The area shall be designated as “No Parking” area on delivery days. • The area shall be level.

<table>
<tr><th>Item</th><th>Requirement</th></tr>
<tr><td></td><td>• The area shall be in open air.
• The transfer area shall have a hard standing area of 2.5 m x 2.5 m of non-porous concrete upon which the tanker's pipework and couplings can stand.</td></tr>
<tr><td>Storage Location</td><td>The tank shall be stored outside and have a minimum distance to points of interest as follows:
<table>
<tr><th>Description</th><th>Distance (m)</th></tr>
<tr><td>Pipework containing flammable gases or liquids</td><td>6</td></tr>
<tr><td>Sprinklered buildings or structures with non-combustible exterior</td><td>6</td></tr>
<tr><td>Property boundary</td><td>6</td></tr>
<tr><td>Street, road, or car park</td><td>6</td></tr>
<tr><td>Smoking area, open flames, sources of ignition</td><td>6</td></tr>
<tr><td>Fixed installations of gas cylinders</td><td>6</td></tr>
<tr><td>Other DG storages</td><td>6</td></tr>
<tr><td>Medium or high voltage equipment</td><td>6</td></tr>
<tr><td>Building or structure with combustible exterior</td><td>6</td></tr>
<tr><td>Process equipment that is not part of the installation</td><td>6</td></tr>
<tr><td>Openings to underground drains, pits, ducts, etc.</td><td>6</td></tr>
<tr><td>Openings in walls of adjacent buildings or structures</td><td>6</td></tr>
<tr><td>Areas where personnel can congregate (offices, lunchrooms).</td><td>8</td></tr>
<tr><td>Openings in walls of adjacent buildings or structures</td><td>8</td></tr>
<tr><td>Places of public assembly</td><td>13</td></tr>
<tr><td>Areas of buildings where patients are confined to bed</td><td>13</td></tr>
<tr><td>Solid combustible materials</td><td>13</td></tr>
<tr><td>Flammable liquid storages</td><td>15</td></tr>
<tr><td>Flammable gas storages</td><td>15</td></tr>
</table>
A review of the separation distances indicates these are predominantly complied with. The only exceptions are to the MRI waiting area in the oncology department and the cylinder storages / non-combustible structures. An assessment has been conducted in Section 4.2.3 which identified that this distance is considered adequate from a risk perspective and would therefore comply with the WHS Regulation.
The diesel tank is proposed to be demolished and removed.</td></tr>
<tr><td>Ventilation</td><td>The tank is located in open air which provides adequate ventilation</td></tr>
<tr><td>Fire Protection</td><td>No specific fire protection requirements</td></tr>
</table>

4.2.3 Separation to DG Stores

Provided in **Table 4-3** is a review of the separation distances of the oxygen tank (H1) to the closest DG stores.

Table 4-3: DG Separation Distance from H1

Store	Class	Description	Distance (m)		Comment
			Required	Measured	
A	2.2(5.1)	Nitrous oxide	6	>8.8	Compliant
B	2.1	LPG, Acetylene, etc.	6	>8.8	Compliant
C	-	Vacant	6	>8.8	Compliant
D	-	Future Use	6	>8.8	Compliant
E	-	Future Use	6	>8.8	Compliant
4	2.2	Carbon dioxide	6	>8.8	Compliant
5	2.2	Argon dewars	6	8.8	Compliant
7/F	2.2	Air & carbon dioxide	6	5 / 6.6	Fire wall required to achieve 6 m separation to Store F
8	2.2	Liquid nitrogen	6	6.3	Compliant
9	2.2(5.1)	Liquid oxygen (existing)	-	6.6	Compliant
H2	2.2(5.1)	Liquid oxygen (new)	-	1	Compliant

The separation distances for H1 are less than those of H2; hence, the wall height separation has been based on H2 as documented in **Section 4.3.3**.

4.2.4 Separation Distance Review

Provided in the following subsections is a review of the separation distances between the liquid oxygen tank and the MRI waiting area MRI. The separation requirements for the oxygen tank indicates that 13 m is required to where the general public may assemble. The standard does not provide a clear definition of what public assembly is; hence, there is the potential that the MRI waiting area may be considered an area of public assembly which is only 11 m from the tank and would therefore not comply.

The MRI waiting area is located within the radiation oncology department and is not directly open to the storage tank; hence, in the event of an uncontained oxygen release the gas will be unable to penetrate into the building preventing exposure of the patients to the gas. Due to the presence of the building wall, it is considered that this would provide a greater level of protection than an addition 2 m of separation. Subsequently, it is considered that the risks posed by the oxygen tank on the MRI waiting are considered to be as low as what would be afforded by strict adherence to the separation distances or lower as required by the WHS Regulation 2017 (Ref. [1]).

4.3 32,000 L Oxygen Tank – New Vessel (H2)

4.3.1 Introduction

The 32,000 L liquid oxygen tank has been proposed to be stored in the western portion of gas compound area. The design standard that covers the storage and handling of liquid oxygen is AS 1894-1997 (Ref. [3]). A summary of the quantity of liquid oxygen to be stored is provided in **Table 4-4**.

Table 4-4: Liquid Oxygen Tank (New) Storage Quantity (H2)

Class	PG	Description	Quantity (L)
2.2(5.1)	n/a	Liquid oxygen	32,000

4.3.2 Design

The design points to be included within the design have been summarised in **Table 4-5**. The tank will be supplied by a 3rd party; hence, it is assumed that the supplier will provide a compliant vessel with valves, equipment, etc. as necessary.

Table 4-5: Liquid Oxygen Tank (H2 New) Storage Requirements in accordance with AS 1894-1997

<table>
<tr><th>Item</th><th>Requirement</th></tr>
<tr><td>Foundations</td><td>• The design load of the supports and foundation shall be the total mass when the storage vessels is full of either water of the product, whichever is greater.
• The slab shall be sloped such that any spills of oxygen will flow away from sensitive receptors.</td></tr>
<tr><td>Impact protection</td><td>• The tank shall be protected from vehicular impact (i.e. cars, forklifts, etc.). This may be achieved by guard rails, bollards, or walls.
• The protection shall be located a minimum of 1 m away from the vessel.</td></tr>
<tr><td>Transfer area</td><td>• The transfer area shall be adjacent to the fill coupling of the installations.
• The location shall be such that in the event of an emergency the tanker has a means of quick, direct and unobstructed exit.
• The area shall be designated as “No Parking” area on delivery days.
• The area shall be level.
• The area shall be in open air.
• The transfer area shall have a hard standing area of 2.5 m x 2.5 m of non-porous concrete upon which the tanker’s pipework and couplings can stand.</td></tr>
<tr><td>Storage Location</td><td>The tank shall be stored outside and have a minimum distance to points of interest as follows:
<table>
<tr><th>Description</th><th>Distance (m)</th></tr>
<tr><td>Pipework containing flammable gases or liquids</td><td>6</td></tr>
<tr><td>Sprinklered buildings or structures with non-combustible exterior</td><td>6</td></tr>
<tr><td>Property boundary</td><td>6</td></tr>
<tr><td>Street, road, or car park</td><td>6</td></tr>
<tr><td>Smoking area, open flames, sources of ignition</td><td>6</td></tr>
<tr><td>Fixed installations of gas cylinders</td><td>6</td></tr>
<tr><td>Other DG storages</td><td>6</td></tr>
<tr><td>Medium or high voltage equipment</td><td>6</td></tr>
<tr><td>Building or structure with combustible exterior</td><td>6</td></tr>
<tr><td>Process equipment that is not part of the installation</td><td>6</td></tr>
<tr><td>Openings to underground drains, pits, ducts, etc.</td><td>6</td></tr>
<tr><td>Openings in walls of adjacent buildings or structures</td><td>6</td></tr>
<tr><td>Areas where personnel can congregate (offices, lunchrooms).</td><td>8</td></tr>
<tr><td>Openings in walls of adjacent buildings or structures</td><td>8</td></tr>
</table></td></tr>
</table>

Item	Requirement	
	Places of public assembly	13
	Areas of buildings where patients are confined to bed	13
	Solid combustible materials	13
	Flammable liquid storages	15
	Flammable gas storages	15
	A review of the separation distances indicates these are predominantly complied with. The only exceptions are to the MRI waiting area in the oncology department and the cylinder storages / non-combustible structures. An assessment has been conducted in **Section 4.3.4** which identified that this distance is considered adequate from a risk perspective and would therefore comply. A diesel tank is located adjacent to the proposed location of the tank and would not comply. Therefore, the diesel tank should be relocated greater than 10 m from the oxygen tank.	
Ventilation	The tank is located in open air which provides adequate ventilation	
Fire Protection	No specific fire protection requirements	

4.3.3 Separation to DG Stores

Provided in **Table 4-6** is a review of the separation distances of the oxygen tank (H2) to the closest DG stores.

Table 4-6: DG Separation Distance from H2

Store	Class	Description	Distance (m)		Comment
			Required	Measured	
A	2.2(5.1)	Nitrous oxide	6	>6.9	Compliant
B	2.1	LPG, Acetylene, etc.	6	>6.9	Compliant
C	-	Vacant	6	>6.9	Compliant
D	-	Future Use	6	>6.9	Compliant
E	-	Future Use	6	>6.9	Compliant
4	2.2	Carbon dioxide	6	6.9	Compliant
5	2.2	Argon dewars	6	5.3	Fire wall required to achieve 6 m
7/F	2.2	Air & carbon dioxide	6	3 / 3.4	Fire wall required to achieve 6 m
8	2.2	Liquid nitrogen	6	4.6	Compliant - Liquid nitrogen tank enclosed by fire wall
9	2.2(5.1)	Liquid oxygen (existing)	-	7.1	Compliant
H2	2.2(5.1)	Liquid oxygen (new)	-	1	Compliant

The closest non-compliant separation is 3 m; hence, a fire wall will be required to achieve the necessary separation. The separation is either a total of 6 m from the valves / fittings and attachments or 3 m from the tank shell. The tank shell achieves the required 3 m separation; hence, the height of the wall will be based on the separation from the valves and fittings on the tank.

It is assumed that the valves / fittings are a maximum of 1.5 m above ground. Therefore, the FRL wall would require a total height of 4.5 m to achieve the required separation as shown in **Figure 4-1**.

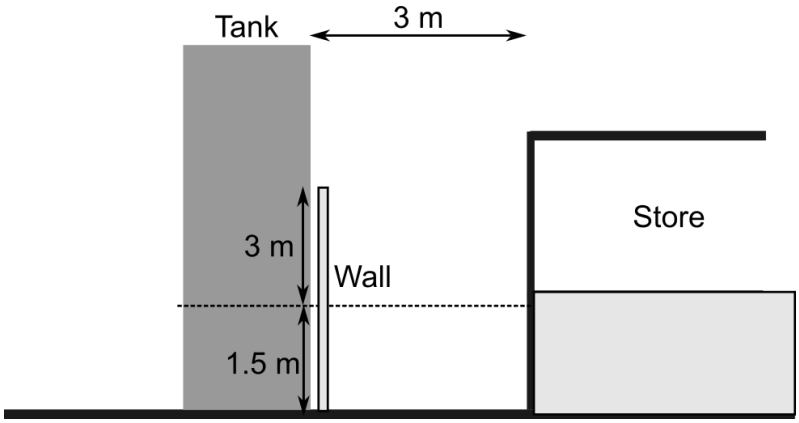

Figure 4-1: FRL Wall Height

4.3.4 Separation Distance Review

Provided in the following subsections is a review of the separation distances between the liquid oxygen tank and the MRI waiting area MRI. The separation requirements for the oxygen tank indicates that 13 m is required to where the general public may assemble. The standard does not provide a clear definition of what public assembly is; hence, there is the potential that the MRI waiting area may be considered an area of public assembly which is only 12.6 m from the tank which is essentially 13 m and is considered close enough to achieve compliance within the context of a risk framework.

The MRI waiting area is located within the radiation oncology department and is not directly open to the storage tank; hence, in the event of an uncontained oxygen release the gas will be unable to penetrate into the building preventing exposure of the patients to the gas. Due to the presence of the building wall, it is considered that this would provide a greater level of protection than an addition 0.4 m of separation. Subsequently, it is considered that the risks posed by the oxygen tank on the MRI waiting are considered to be as low as what would be afforded by strict adherence to the separation distances or lower as required by the WHS Regulation 2017 (Ref. [1]).

4.4 30,000 L Oxygen Tank – Existing Vessel (Retained)

4.4.1 Introduction

A 30,000 L liquid oxygen tank has been proposed to be retained with a supplementary new 30,000 L vessel which provides a total capacity of 60,000 L. The design standard that covers the storage and handling of liquid oxygen is AS 1894-1997 (Ref. [3]). A summary of the quantity of liquid oxygen to be stored is provided in **Table 4-7**.

Table 4-7: Emergency Liquid Oxygen Tank (Retained) Storage Quantity

Class	PG	Description	Quantity (L)
2.2(5.1)	n/a	Liquid oxygen	30,000

4.4.2 Design

The design points to be included within the design have been summarised in **Table 4-8**. The tank will be supplied by a 3rd party; hence, it is assumed that the supplier will provide a compliant vessel with valves, equipment, etc. as necessary.

Table 4-8: Emergency Liquid Oxygen Tank (Retained) Storage Requirements in accordance with AS 1894-1997

<table>
<tr><th>Item</th><th>Requirement</th></tr>
<tr><td>Foundations</td><td>• The design load of the supports and foundation shall be the total mass when the storage vessels is full of either water of the product, whichever is greater.
• The slab shall be sloped such that any spills of oxygen will flow away from sensitive receptors.</td></tr>
<tr><td>Impact protection</td><td>• The tank shall be protected from vehicular impact (i.e. cars, forklifts, etc.). This may be achieved by guard rails, bollards, or walls.
• The protection shall be located a minimum of 1 m away from the vessel.</td></tr>
<tr><td>Transfer area</td><td>• The transfer area shall be adjacent to the fill coupling of the installations.
• The location shall be such that in the event of an emergency the tanker has a means of quick, direct and unobstructed exit.
• The area shall be designated as “No Parking” area on delivery days.
• The area shall be level.
• The area shall be in open air.
• The transfer area shall have a hard standing area of 2.5 m x 2.5 m of non-porous concrete upon which the tanker’s pipework and couplings can stand.</td></tr>
<tr><td>Storage Location</td><td>The tank shall be stored outside and have a minimum distance to points of interest as follows:
<table>
<tr><th>Description</th><th>Distance (m)</th></tr>
<tr><td>Pipework containing flammable gases or liquids</td><td>4</td></tr>
<tr><td>Sprinklered buildings or structures with non-combustible exterior</td><td>4</td></tr>
<tr><td>Property boundary</td><td>4</td></tr>
<tr><td>Street, road, or car park</td><td>4</td></tr>
<tr><td>Smoking area, open flames, sources of ignition</td><td>4</td></tr>
<tr><td>Fixed installations of gas cylinders</td><td>4</td></tr>
<tr><td>Other DG storages</td><td>4</td></tr>
<tr><td>Medium or high voltage equipment</td><td>4</td></tr>
<tr><td>Building or structure with combustible exterior</td><td>4</td></tr>
<tr><td>Process equipment that is not part of the installation</td><td>4</td></tr>
<tr><td>Openings to underground drains, pits, ducts, etc.</td><td>4</td></tr>
<tr><td>Openings in walls of adjacent buildings or structures</td><td>4</td></tr>
<tr><td>Areas where personnel can congregate (offices, lunchrooms).</td><td>7</td></tr>
<tr><td>Openings in walls of adjacent buildings or structures</td><td>7</td></tr>
<tr><td>Places of public assembly</td><td>12</td></tr>
<tr><td>Areas of buildings where patients are confined to bed</td><td>12</td></tr>
</table></td></tr>
</table>

Item	Requirement	
	Solid combustible materials	12
	Flammable liquid storages	10
	Flammable gas storages	10
	A review of the separation distances indicates these are predominantly complied with. The only exceptions are to adjacent DG storages. An assessment has been conducted in **Section 4.4.3** which identified that this distance is considered adequate from a risk perspective and would therefore comply.	
Ventilation	The tank is located in open air which provides adequate ventilation	
Fire Protection	No specific fire protection requirements	

4.4.3 Separation Distance Review

The liquid oxygen tank is located in an enclosure that is adjacent to a nitrogen tank. A masonry wall is provided between the two tanks which results in a separation of 3.4 m between tanks when measuring around the walls; however, as the fire rating of the wall is not known the distance has been measured directly between the tanks which results in a 1.4 m separation distance. This does not comply with the separation requirements between DG stores.

Nitrogen is a very stable gas and does not readily react with gases or chemicals without an external reaction (i.e. combustion). In addition, nitrogen composes 78% of the atmosphere; hence, if oxygen were to be released from the tank it would be in contact with nitrogen prior to impacting the nitrogen tank.

As nitrogen is already present in the atmosphere at high concentrations, the required separation distance to the liquid nitrogen tank is non-sensical and does not provide an increased level of safety. Therefore, it is considered that the risks posed by non-compliance with the separation distance are not increased to an unacceptable level; hence, the location of the tank is considered acceptable as required by the WHS Regulation 2017 (Ref. [1]).

4.5 30,000 L Nitrogen Tank

4.5.1 Introduction

The 30,000 L liquid nitrogen tank is existing and is not proposed to be altered. The design standard that covers the storage and handling of liquid nitrogen is AS 1894-1997 (Ref. [3]). A summary of the quantity of liquid nitrogen to be stored is provided in **Table 4-9**.

Table 4-9: Liquid Nitrogen Tank Storage Quantity

Class	PG	Description	Quantity (L)
2.2	n/a	Liquid nitrogen	30,000

4.5.2 Design

The design points to be included within the design have been summarised in **Table 4-10**. The tank will be supplied by a 3rd party; hence, it is assumed that the supplier will provide a compliant vessel with valves, equipment, etc. as necessary.

Table 4-10: Liquid Nitrogen Tank Storage Requirements in accordance with AS 1894-1997

<table>
<tr><th>Item</th><th>Requirement</th></tr>
<tr><td>Foundations</td><td>• The design load of the supports and foundation shall be the total mass when the storage vessels is full of either water of the product, whichever is greater.
• The slab shall be sloped such that any spills of oxygen will flow away from sensitive receptors.</td></tr>
<tr><td>Impact protection</td><td>• The tank shall be protected from vehicular impact (i.e. cars, forklifts, etc.). This may be achieved by guard rails, bollards, or walls.
• The protection shall be located a minimum of 1 m away from the vessel.</td></tr>
<tr><td>Transfer area</td><td>• The transfer area shall be adjacent to the fill coupling of the installations.
• The location shall be such that in the event of an emergency the tanker has a means of quick, direct and unobstructed exit.
• The area shall be designated as “No Parking” area on delivery days.
• The area shall be level.
• The area shall be in open air.</td></tr>
<tr><td>Storage Location</td><td>The tank shall be stored outside and have a minimum distance to points of interest as follows:
<table>
<tr><th>Description</th><th>Distance (m)</th></tr>
<tr><td>Pipework containing flammable gases or liquids</td><td>1</td></tr>
<tr><td>Sprinklered buildings or structures with non-combustible exterior</td><td>1</td></tr>
<tr><td>Property boundary</td><td>2</td></tr>
<tr><td>Street, road, or car park</td><td>2</td></tr>
<tr><td>Smoking area, open flames, sources of ignition</td><td>2</td></tr>
<tr><td>Fixed installations of gas cylinders</td><td>2</td></tr>
<tr><td>Other DG storages</td><td>2</td></tr>
<tr><td>Medium or high voltage equipment</td><td>2</td></tr>
<tr><td>Building or structure with combustible exterior</td><td>2</td></tr>
<tr><td>Process equipment that is not part of the installation</td><td>2</td></tr>
<tr><td>Openings to underground drains, pits, ducts, etc.</td><td>2</td></tr>
<tr><td>Openings in walls of adjacent buildings or structures</td><td>2</td></tr>
<tr><td>Areas where personnel can congregate (offices, lunchrooms).</td><td>2</td></tr>
<tr><td>Openings in walls of adjacent buildings or structures</td><td>2</td></tr>
<tr><td>Places of public assembly</td><td>3</td></tr>
<tr><td>Areas of buildings where patients are confined to bed</td><td>3</td></tr>
<tr><td>Solid combustible materials</td><td>3</td></tr>
</table>
A review of the separation distances indicates these are predominantly complied with. The only exceptions are to adjacent DG storages. An assessment has been conducted in Section 4.5.3 which identified that this distance is considered adequate from a risk perspective and would therefore comply.</td></tr>
<tr><td>Ventilation</td><td>The tank is located in open air which provides adequate ventilation</td></tr>
<tr><td>Fire Protection</td><td>No specific fire protection requirements</td></tr>
</table>

4.5.3 Separation Distance Review

The liquid nitrogen tank is located in an enclosure that is adjacent to a liquid oxygen tank. A masonry wall is provided between the two tanks which results in a separation of 3.4 m between tanks when measuring around the walls; however, as the fire rating of the wall is not known the distance has been measured directly between the tanks which results in a 1.4 m separation distance. This does not comply with the separation requirements between DG stores.

Nitrogen is a very stable gas and does not readily react with gases or chemicals without an external reaction (i.e. combustion). In addition, nitrogen composes 78% of the atmosphere; hence, a release of nitrogen into the atmosphere within the vicinity is unlikely to make an observable impact with respect to chemical reactions or impact on the oxygen tank.

As nitrogen is already present in the atmosphere at high concentrations, the required separation distance to the liquid oxygen tank is non-sensical and does not provide an increased level of safety. Therefore, it is considered that the risks posed by non-compliance with the separation distance are not increased to an unacceptable level; hence, the location of the tank is considered acceptable as required by the WHS Regulation 2017 (Ref. [1]).

4.6 Store A

4.6.1 Introduction

Store A/B is proposed to contain nitrous oxide which is an oxidising gas and flammable gases (LPG, hydrogen, acetylene, etc.) in the adjoining space. The design standard that covers the storage and handling of oxidising gases is AS 4332-2004 (Ref. [2]). A summary of the quantity of gases to be stored is provided in **Table 4-11**.

Table 4-11: Store A/B Storage Quantity

Class	PG	Description	Quantity (L)
2.2(5.1)	n/a	Nitrous Oxide (oxidising gas)	3,000
2.1	n/a	Flammable gases (LPG, acetylene, hydrogen, etc.)	1,000

4.6.2 Design

The quantity of gases contained in Store A/B would result in the storage being classified as a cylinder store. The design points to be included within the design have been summarised in **Table 4-12**.

Table 4-12: Store A/B Storage Requirements in accordance with AS 4332-2004

<table>
<tr><th>Item</th><th>Requirement</th></tr>
<tr><td>Separation</td><td>The cylinders shall have a minimum distance to points of interest as follows:
<table>
<tr><th>Description</th><th>Distance (m)</th></tr>
<tr><td>Protected place (i.e. offices on adjacent sites)</td><td>5</td></tr>
<tr><td>Onsite protected place (i.e. offices, areas people congregate)</td><td>3</td></tr>
<tr><td>Other DG storages</td><td>5</td></tr>
</table></td></tr>
</table>

Item	Requirement	
	Filling / decanting points, bulk DGs	5
	All separation distances are complied with	
Construction	• Doors shall be outward opening or perforated roller that can be opened from inside the store.	
Ventilation	Ventilation may be provided via natural means provided the following is complied with: • The length of the store is twice the depth of the store. • The long side of the store is constructed of mesh to enable air flow.	
Electrical Equipment	• All electrical equipment shall be installed in accordance with AS/NZS 3000:2018 (Ref. [4]) • Electrical equipment with a hazardous area rating as required by hazardous area zoning per AS/NZS 60079.10.1:2022 (Ref. [5]). • Electrical equipment installed per the requirements of AS/NZS 60079.14:2022 (Ref. [6]). • Electrical equipment installed by an appropriate qualified/certified hazardous area electrician. • Hazardous area verification dossier prepared documenting all hazardous area equipment.	
Fire Protection	• Hose reel coverage to all parts of the store • 1 x fire extinguishers	
Placarding	The store shall be placarded in accordance with the WHS Regulation.	

4.7 Store 4/5/7/F

4.7.1 Introduction

Store 4/5/7/F is proposed to contain a range of non-flammable, non-toxic gases. The design standard that covers the storage and handling of these gases is AS 4332-2004 (Ref. [2]). A summary of the quantity of gases to be stored is provided in **Table 4-13**.

Table 4-13: Store 4/5/7/F Storage Quantity

Class	PG	Description	Quantity (L)
2.2	n/a	Air, carbon dioxide, argon dewars	1,600

4.7.2 Design

The quantity of gases contained in Store 4/5/7/F would result in the storage being classified as a minor store. The design points to be included within the design have been summarised in **Table 4-14.**

Table 4-14: Store4/5/7/F Storage Requirements in accordance with AS 4332-2004

Item	Requirement	
Separation	The cylinders shall have a minimum distance to points of interest as follows:	
	Description	Distance (m)
	Other DG storages	3
	Doors, windows, openings	1

Item	Requirement
	A review of the separation distances indicates these are complied with the exception of Store I in relation to Store J which contains liquid nitrogen. Store I contains air and carbon dioxide which are non-flammable, non-toxic and are compatible with liquid nitrogen. Therefore, the risk of non-compliance is considered to be low and acceptable. A diesel tank is located adjacent to the proposed location of the tank and would not comply. Therefore, the diesel tank should be relocated greater than 3 m from Store G/H/I.
Construction	• Non-combustible walls.
Ventilation	Ventilation shall be adequate to maintain exposure to gases below exposure thresholds. The stores are open mesh which would provide ventilation to disperse gases as required.
Electrical Equipment	• All electrical wiring and lighting within the store shall comply with IP 65 in accordance with AS 60529 • All electrical equipment shall be installed in accordance with AS/NZS 3000:2018 (Ref. [4])
Fire Protection	• Hose reel coverage to all parts of the Store G/H/I
Placarding	The store shall be placarded in accordance with the WHS Regulation.

5.0 Work Health and Safety Requirements

5.1 Introduction

In addition to the requirements of the relevant standards, a Person Conducting a Business or Undertaking (PCBU) must also satisfy several obligations outlined in Chapter 7 of the NSW Work Health and Safety (WHS) Regulation 2017 (Ref. [1]). The relevant requirements are dependent on the quantities of DGs stored on site. The DG quantities and the placard and manifest thresholds are outlined in **Table 5-1**. As the DG stores exceed the manifest threshold, the site is classified as a manifest site.

Table 5-1: Manifest and Placard DG quantities

Class	PG	Description	Quantity (L)	Threshold Quantity (L)		Classification
				Placard	Manifest	
2.1	n/a	Flammable gases	1,000	200	5,000	Placard
2.2	n/a	Nitrogen	30,000	1,000	10,000	Manifest
2.2	n/a	Non-toxic, non-flammable	1,600	1,000	10,000	Placard
2.2(5.1)	n/a	Nitrous oxide	3,000	1,000	10,000	placard
2.2(5.1)	n/a	Oxygen	60,000	1,000	10,000	Manifest

5.2 Applicable WHS Clauses

The applicable clauses for a manifest site are outlined in **Table 5-2**.

Table 5-2: Relevant WHS clauses and requirements

Clause	WHS Requirement
346	A Hazardous Chemicals [*Dangerous Goods*] register shall be prepared which must include; • A list of hazardous chemicals stored, used or handled • The current Safety Data Sheet (SDS) for DGs stored, used or handled, unless the hazardous chemical is a consumer product (e.g. hand sanitiser). The register must be readily accessible to workers involved in handling or storing the chemicals, and anyone who is likely to be affected by the chemicals.
347	A manifest of chemicals stored on site shall be prepare in accordance with Schedule 11 and Schedule 12 of the regulation. The manifest shall be kept in a place determine in agreement with the primary emergency service organisation (Fire and Rescue NSW). It must be readily accessible to emergency service organisation and be available for inspection.
348	A notification shall be made to the regulator of the DGs that exceed the manifest quantities detailed in Schedule 11 of the Regulation. Notice must also be given after the DGs are no longer used, stored, or handled on site
349 & 350	PCBU shall ensure placards are displayed for all chemicals which exceed placard quantity of Schedule 11, and that placards comply with Schedule 13, as shown **Figure 5-1** to **Figure 5-3**. A Placard Schedule shall be prepared to indicate the placard requirements. A PCBU shall ensure an outer warning placard shall is prominently displayed at the site. The placard is to show the words “HAZCHEM” in red lettering on white or silver background and

Clause	WHS Requirement
	shall have minimum dimensions 120 mm x 600 mm, in compliance with Schedule 13, as shown in **Figure 5-4.**
351 & 354	A PCBU must manage the risk to health and safety associated with using and storing a hazardous chemical [*Dangerous Good*] and have regard of the following: • Hazardous properties of the chemical • Reactions between chemicals (physical) or between the chemical and other substances/materials; • The nature of the work to be carried out with the hazardous chemical; • Any structure, plant or system of work used in the handling, generation or storage of the hazardous chemical [Dangerous Good] or that could react with the hazardous chemical [Dangerous Good] at the workplace. In order to comply with this requirement, it is necessary to conduct a risk assessment and to identify those hazards and risks associated with the storage and handling of the hazardous chemicals [*Dangerous Goods*]. The following recommendation has been made: • A risk assessment of the hazardous chemical [*Dangerous Good*] storage areas be conducted, including the use of the chemicals in the manufacturing areas; or • If there is an existing risk assessment, it should be reviewed.
353	A PCBU must display safety signs required to control an identified risk in relation to using, handling or storing hazardous chemicals. The safety signs must warn of a particular hazard associated with the hazardous chemical, and be located next to hazard, clearly visible to a person approaching the hazard.
355	A PCBU must ensure ignition sources are not introduced to areas which where there is a possibility of fire or explosion in a hazardous area. In the flammable liquids containers, there is potential for vapours to accumulate and ignite. Therefore, the following recommendation has been made: • A Hazardous Area Classification (HAC) report and associated drawings should be prepared for flammable liquid in accordance with AS/NZS 60079.10.1:2022 (Ref. [5]). • A Hazardous Area Dossier shall be prepared prior to occupation in accordance with AS/NZS 3000:2018 (Ref. [4]).
357	A PCBU must ensure, SFAIRP, that where there is a risk from a spill or leak of a hazardous chemical, a spill containment system contains the resulting effluent within the workplace. • The containment system must not create a hazard by bringing together incompatible chemicals. The containment system must provide for the clean-up and disposal of hazardous chemicals.
358	A PCBU must ensure containers of hazardous chemicals are protected against impact damage and damage from excessive load.
359	A PCBU shall ensure that a workplace is provided with fire protection and firefighting equipment that is designed and built for the types of hazardous chemicals at the workplace. • The PCBU shall have regard to the fire load of the hazardous chemicals and from other sources, and the compatibility of the hazardous chemicals with other substances on site. • The equipment shall be compatible with firefighting equipment used by Fire and Rescue NSW

Clause	WHS Requirement
	Fire protection and firefighting equipment shall be properly installed, tested and maintained, and a dated record shall be kept of the latest testing results.
361 & 360	A PCBU shall prepare an emergency response plan (ERP) and submit it to the primary service organisation (Fire and Rescue NSW). A PCBU must ensure that emergency equipment is always available for use in an emergency.
364	A PCBU must ensure that containers in which hazardous chemicals are used, handled, or stored in bulk shall have stable foundations and supports, and be secured to the foundations and supports to prevent movement and subsequent damage to the container.

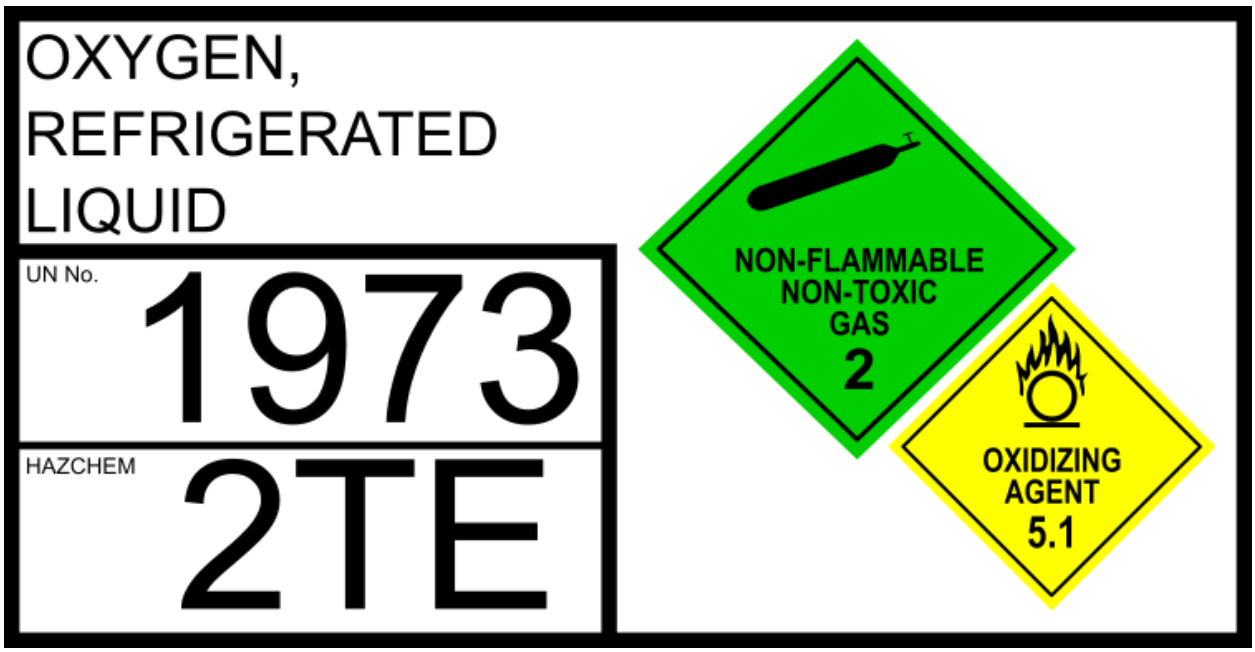

Figure 5-1: Bulk Oxygen Placard

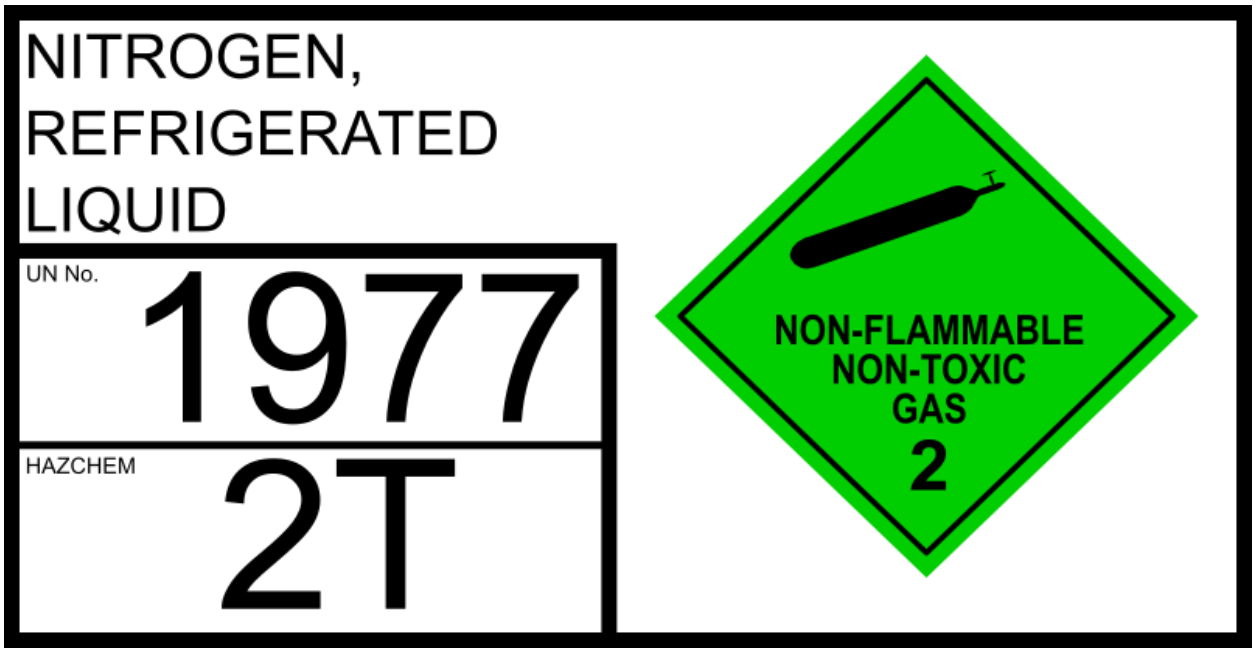

Figure 5-2: Bulk Nitrogen Placard

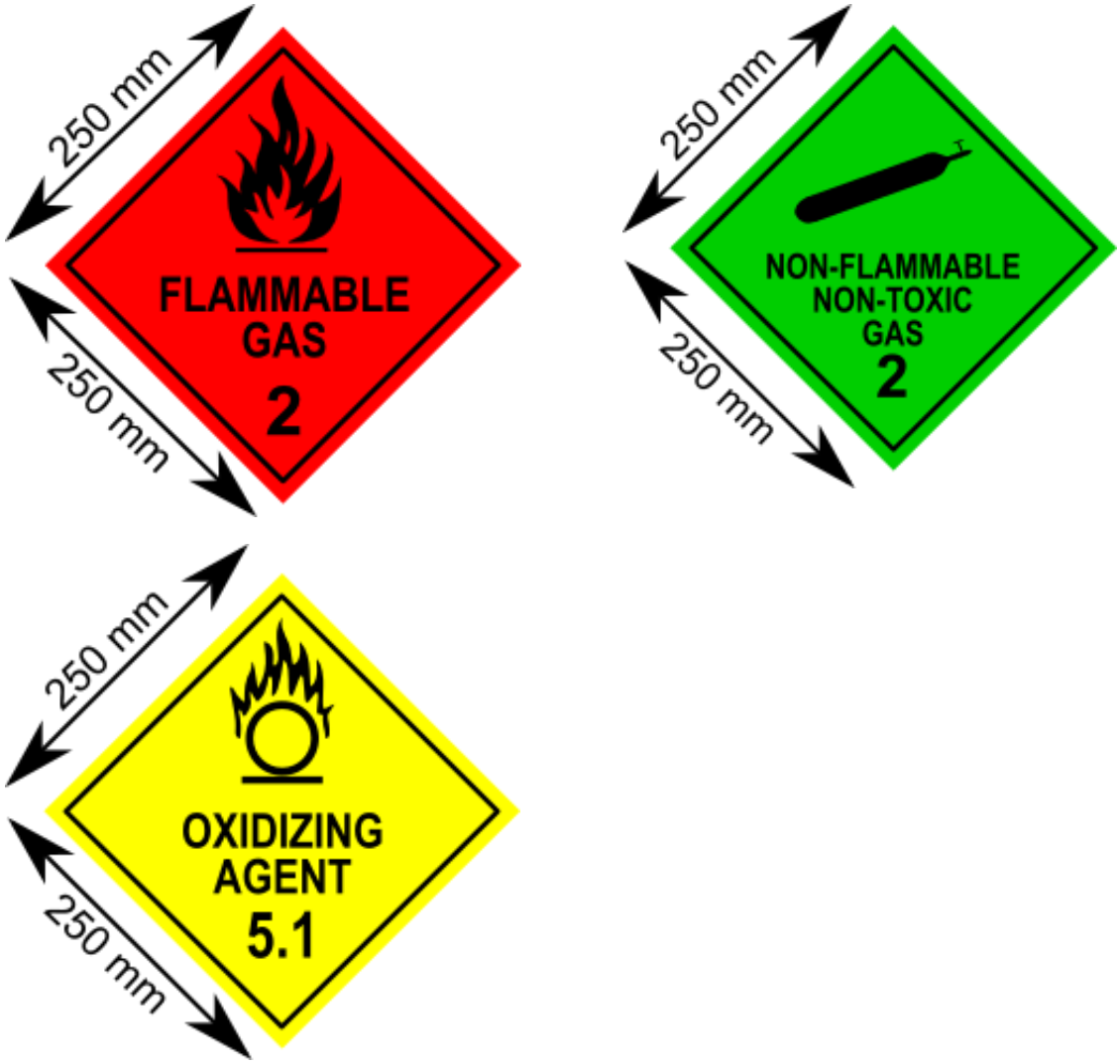

Figure 5-3: Gas Cylinder Placards

Figure 5-4: HAZCHEM Placard

5.3 Summary of Requirements

In summary, the site will require the following:

- A Dangerous Goods Register, indicating the type of chemical, any notations that may be required from the risk assessment and the Safety Data Sheet for the chemical.
- A Manifest.
- A DG Risk Assessment of the storage and handling area.

- A Placard Schedule.
- An Emergency Response Plan (ERP).
- Emergency Services Information Pack (ESIP).
- A Hazardous Area Classification (HAC).
- Hazardous Area Verification Dossier (HAVD).

6.0 Conclusions and Recommendations

6.1 Conclusions

A review of the proposed DG storage and operations at the RPA gas compound was conducted to determine compliance with the Work Health and Safety Regulation 2017 (Ref. [1]) and all relevant design standards.

A review of the standards determined that the following standards should be used to govern the storage requirements in the respective areas:

- Liquid oxygen / nitrogen - AS 1894-1997
- Gas cylinders – AS 4332-2004

Each of these standards was used to construct a series of requirements to inform the design and storage of each of the storages at the RPA gas compound.

6.2 Recommendations

The following recommendations have been made based on the assessment within this report:

DG Storage Requirements:

Each DG storage area has different requirements based on the particular substances which are being stored. Detailed summaries of the items to be included in the design of each DG store are provided in the following sections:

- Liquid oxygen (new 32 kL): Table 4-2
- Liqui doxygen (new 32 kL): Table 4-5
- Emergency liquid oxygen: Table 4-8
- Liquid nitrogen: Table 4-10
- Store A/B: Table 4-12
- Store 4/5/7/F: Table 4-14

Specific Recommendations

- Separating fire wall between tanks and existing stores to be a minimum of 4.5 m high.

DG Documents:

Ensure the following documentation is supplied on site in accordance with the Work Health and Safety Regulation 2017 (Ref. [1]):

- A Dangerous Goods Register, indicating the type of chemical, any notations that may be required from the risk assessment and the Safety Data Sheet for the chemical.
- A Manifest.
- A DG Risk Assessment of the storage and handling area.
- A Placard Schedule.
- An Emergency Response Plan (ERP).

- Emergency Services Information Pack (ESIP).
- A Hazardous Area Classification (HAC).
- Hazardous Area Verification Dossier (HAVD).

7.0 References

[1] SafeWork NSW, “Work Health and Safety Regulation,” SafeWork NSW, Lisarow, 2017.

[2] Standards Australia, “AS 4332-2004 - The Storage and Handling of Gases in Cylinders,” Standards Australia, Sydney, 2004.

[3] Standards Australia, “AS 1894-1997 Storage and Handling of Non-Flammable Cryogenic and Refrigerated Liquids,” Standards Australia, Sydney, 1997.

[4] Standards Australia, “AS/NZS 3000:2018 - Wiring Rules,” Standards Australia, Sydney, 2018.

[5] Standards Australia, AS/NZS 60079.10.1:2022 - Explosive Atmospheres Part 10.1: Classification of Areas, Explosive Gas Atmospheres, Sydney: Standards Association of Australia, 2022.

[6] Standards Australia, AS/NZS 60079.14:2022 - Explosive Atmospheres Part 14: Electrical Installations, Design, Selection and Erection, Sydney: Standards Australia, 2022.