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Management Consultants – Health Safety & Environment

Analysis of Work Health and Safety Data for the Use of Synthetic Greenhouse Gases and Substitutes in the Refrigeration and Air-Conditioning Industry

Final Report

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Glossary of Terms

ACCC	Australian Competition and Consumer Commission
A2L gases	A2L is a hazard rating to describe a gas that has low toxicity (A), mildly flammable (2L) that is currently used in the ISO for refrigerating systems. It is likely to be adopted by the updated equivalent to AS/NZS 1677.1. The flammability rating is defined by the lower explosive limit (LEL) for the gas, determined by the lowest concentration at which the gas will burn. Mildly flammable refrigerants require a concentration of >100 g/m3 to ignite, and have a burning velocity of less than 10 cm/s. R32 or 1234yf are examples of gases that are considered A2L. Until Australia adopts the new ISO standard these gases need to be handled according to the higher A2 rating.
AIRAH	Australian Institute of Refrigeration Air-conditioning and Heating
ARC	Australian Refrigeration Council
DMNR	Department of Mines and Natural Resources, Queensland
Drop In	Drop-in replacement is an alternative gas that can be used to replace the existing gas without any system modification or oil replacement.
Flammability Class 1	Refrigerants that do not show flame propagation when tested in air at 101 kPa (Standard atmospheric pressure) N21 ^{0}C.
Flammability Class 2	Refrigerants having a low flammability limit (LFL) concentration of more than 0.10 kg per cubic metre in air at 21 ^{0}C and 101 kPa.
Flammability Class 3	Refrigerants that are highly flammable as identified by an LFL concentration of less or equal to 0.1 kg per cubic metre at 21 ^{0}C and 101 kPa.
Gas classification	The capital letter indicates the toxicity and the numeral denotes the flammability.
Gas description	First letter—A or B relates to low or high toxicity; and number—1, 2 or 3 relates to flammability rating.
GWP	Global Warming Potential
HFO	Hydrofluoroolefin
HWSA	Heads of Workplace Safety Authorities
Industry Partners	This includes the government departments and industry associations: WHS, Gas and Electrical regulators, trade unions, suppliers and service companies, OEMs, technicians, ACCC, Insurance companies and training organisations. A full list of the industry partners consulted in this review is provided in Appendix 3.
ISO	International Organisation for Standardisation
MAC	Mobile air-conditioning and includes equipment found in non-commercial passenger vehicles.
MFB	Metropolitan Fire Brigade
NOLA	National Occupational Licencing Authority
NOLS	National Occupational Licencing System
ODS	Ozone Depleting Substances
OEM	Original Equipment Manufacturer
OHS	Occupational Health and Safety
RAC	Refrigeration and Air-Conditioning
RRA	Refrigerant Reclaim Australia
RTO	Registered Training Organisation

SGG	Synthetic Greenhouse Gases
Stationary RAC	Items of refrigeration and air-conditioning including cool stores, supermarkets, commercial and industrial buildings as well as domestic installations that are designed to operate as a fixed or stationary unit, as distinct from the MAC and TRAC sectors.
Substitute refrigerant	Refrigerant gas used as a replacement for the one recommended by the OEM.
Toxicity classification Class A	Refrigerants for which toxicity has not been identified in concentrations less than or equal to 400 ppm.
Toxicity classification Class B	Refrigerant for which there is evidence of toxicity in concentrations below 400 ppm.
TRAC	Transport Refrigeration and air-conditioning including light commercial vehicles, buses, trucks, and off road applications such as locomotives, passenger rail, mining equipment, harvesters and forklift trucks.
VACC	Victorian Automobile Chamber of Commerce
VASA	Automotive Air-conditioning, Electrical and Cooling Technicians of Australia
WHS	Work health and safety
WHS risk	Potential to cause harm to one or more people and breach of WHS legislation.

Executive Summary

This project was commissioned by the Department to gather and analyse current data on the issues and risks associated with the use of ozone depleting substances (ODS), synthetic greenhouse gases (SGGs) and their alternatives in the refrigeration and air conditioning (RAC) industry. The project has been undertaken during a period of global transition to the use of low, or no, global warming potential (GWP) refrigerant gases.

In 2012 the Department of the Environment commissioned a study to examine the risks associated with the introduction of the carbon tax and potential changes in Australia's gas industry sector. The 2012 report, *Baseline Analysis of Work Health and Safety Data and Information for the use of Synthetic Greenhouse Gases and Substitutes in the Australian Gas Industry Sector,* found that that the risk of an incident occurring was low, but future work health safety (WHS) incidents were most likely to occur in the refrigeration and air conditioning (RAC) industry. The potential for increased exposure to risk was considered a result of increasing take up of alternative gases.

This project included a critical review of actions taken in response to the recommendations of 2012 report; a comparative assessment of the current risk profile in the Australian RAC industry as well as an assessment of the risks faced in the RAC industries of other countries; developments in international and Australian / New Zealand Standards (AS/NZS); and whether there are focal points of risk in specific sectors of the RAC industry in Australia.

The methodology involved consultation with 69 groups including; government agencies, industry associations, suppliers, Registered Training Organisations (RTO), unions and international stakeholders between January and April 2015. Over 90 interviews were conducted by Brian Eva, Occupational Hygienist, and David Caple, Occupational Health and Safety (OHS) Consultant. A list of those consulted is provided in Appendix 3.

The key questions addressed through consultation and research related to the issues and recommendations raised in the 2012 report. Specifically, these were to identify changes in work health and safety (WHS) risk identification and management over the last three years.

Australia is largely an importer of RAC infrastructure and equipment and Australian engineers and technicians are dependent on the original equipment manufacturer (OEM) for guidance on the safe installation, operation, and maintenance of the RAC systems. It was evident in 2015 that the major changes in the RAC industry in Australia since 2012 are reflective of international changes as many manufacturers proactively transition to lower GWP gases and equipment technologies that are compatible with these gases. Since 2012, there have been two major industry changes in terms of WHS risk. There has been an expansion of the mid-range stationary RAC systems with the introduction of systems containing A2L (mildly flammable) gases, including consumer products such as split system air conditioners. More recently Australia has seen the commencement of imports of new vehicles from the United States (US), Japan and Europe which contain mildly flammable refrigerant as the new standard gas in car air-conditioning systems.

Feedback from gas reclaiming and destruction stakeholders indicated that there has been an increase in hydrocarbons in gas mixtures being returned in cylinders from the RAC sector. Feedback from the Victorian Automobile Chamber of Commerce (VACC) and the Automotive Air-Conditioning, Electrical and Cooling Technicians of Australia (VASA) indicates that less than 5 per cent of technicians in the mobile sector have access to refrigeration gas identification equipment. Consequently, the majority of technicians are recovering gas assuming the correct labelling is provided on the RAC equipment. In the event that there are substitute gases in the plant, the technicians may be at a WHS risk if the gas is flammable and there is a source of ignition during the servicing process. More attention is required, particularly in the automotive sector, about correct labelling of gas in cylinders to ensure technicians

and members of the community are not at risk.

An evaluation of WHS incidents was undertaken in consultation with state based WHS regulators and Comcare. This indicated there have been very few WHS notifiable serious incidents for the RAC industry since 2012. However, the interview process revealed the industry still has many challenges with WHS incidents involving flammable gases These include the knowledge and competency of designers of RAC systems to ensure safety integrity when using alternative gases and the variable level of knowledge and competency of technicians handling these gases. A focus on education and training in the safe use of alternative gases is required, including the use of flammable gases in systems that were not designed by the OEM for their use.

In reviewing WHS injury data,, it was identified that musculoskeletal injuries and slips, trips, and falls, are the most frequently reported workers compensation claims. The risk from potential flammable gases in the RAC sector is not represented in the WHS claims, incidents or injury data. The insurance premium paid by the RAC sector for workers compensation reflects a low risk level comparable to light manufacturing industries. However, it is possible that this data is affected by under reporting of incidents in this industry. There is a role for educators and the RAC industry to encourage a cultural change to improve the rate of reporting.

There was no evidence to suggest the WHS regulators, gas or electrical regulators have introduced any industry codes of practice, or communication plan to inform the community about WHS risks in relation to substitute gases as was recommended in 2012. It should be noted the RAC industry has, had in place industry codes of practice for stationary and mobile RAC applications which do address the use of alternative gases, since before the 2012 report.

It was also identified that many technicians are not conducting adequate risk assessments as required under the WHS Codes of Practice, or implementing controls as specified in Australian Standards when using substitute gases. A WHS communication and compliance enforcement plan is required to ensure these processes are implemented.

Currently, there is no national governance model in Australia that covers all A2, A2L or A3 gases. The Australian Refrigeration Council implements a nationally consistent environmental licensing scheme to regulate the use, sale, handling and disposal of ODS and SGGs scheduled under the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* to meet Australia's obligations under the Montreal Protocol on Substances that Deplete the Ozone Layer and the Kyoto Protocol to the United Nations Framework Convention on Climate Change.

Under this system, it is the emissions and not safety that is regulated. Only A2, A2L or A3 listed as scheduled substances under the Montreal Protocol or the Kyoto Protocol are regulated. There was unanimous support among those interviewed for a single national regulation model to cover all refrigerants. There is a role for WHS, gas and electrical regulators and the RAC industry to work together to establish the best mechanism for such a model.

Feedback from the European Union (EU) found that many parts of the RAC market currently make widespread use of non-flammable HFCs with high GWPs. To meet the requirements of the EU HFC phase down schedule, there will need to be a rapid switch in the selection of refrigerants used in new equipment from A1 refrigerants to lower GWP alternatives including hydrocarbons (A3), HFOs and lower GWP HFCs (A2L) and CO_2 as well as blends of these gases. RAC experts interviewed in the United Kingdom (UK) indicated that within five years these gases will be dominant in the EU.

Industry experts in the EU, USA and Japan indicated that in those jurisdictions there are tight controls placed on retrofitting equipment still within warranty. Similarly, in Australia, manufacturers place tight controls on maintenance, including refrigerant choice, in equipment under warranty.

The greatest risks for the Australian market are in older equipment that is outside of warranty. Greater cultural similarities between the USA and Australia indicated there are similar risks faced in the aftermarket sector, particularly in the automotive air conditioning sector, where people are more likely to use cheaper alternatives to the gases recommended by the manufacturer.
Representatives of the EU and Japanese RAC industries indicated that culturally their technicians tended to follow the manufacturer's recommendations and therefore the risk of incidents occurring is considered to be very low.

The main design standard for the RAC sector is Australian Standard AS1677 This is undergoing a process of review based on ISO5149. The Standard would then become the 'state of knowledge' from a WHS perspective. I was informed by the Chair of MEOO6 that ISO817 (Refrigeration Safety Designation) is proposed to be adopted in Australia. This will be an online Standard that will provide safety designations for refrigeration gases, including updates as new gases and designations are made. The industry associations and their members will need to collaboratively develop an education and awareness program – targeted to different groups within the industry – on the new Australian Standard once it is released.

Since the 2012 report a number of training modules have been developed to target the safe handling of flammable gases. Another module on the safe use of A2 and A2L gases in development needs to be progressed as a matter of priority. These modules should be mandated into RAC Certificate II and Certificate III courses for applications where these gases may be used. Further, Australia's RTO trainers need support to fully understand the content of the new modules to be well placed to teach them to new students.

This report has identified isolated WHS incidents in Australia during the last three years where flammable gases have resulted in explosions or fire with potential harm to technicians and members of the community. However, this is not a WHS risk which has been identified as a priority area by the WHS regulators, or the gas or electrical regulators in Australia. This project has identified the requirement for the industry to work to increase knowledge and competency, particularly with RAC designers and technicians for the safe handling of alternative gases within the global context of moving towards lower GWP products.

David C Caple
Project Leader
18th August 2015

Key Findings

On the basis of the information that has been collated from stakeholders during January and February 2015, the following key safety and regulatory challenges have been identified together with recommendations for implementing solutions.

WHS and Regulatory Challenge	***Key Findings***
1. A significant trend is now in place to move to low GWP gases in the RAC sector at a global level. Australia is represented on international bodies such as the Montreal Protocol and International Standards Committees to contribute and learn from the knowledge around the world. In relation to designing large engineering systems, mid-range systems including split system air conditioners, and in the automotive sector, Australia is largely an importer of technology. The responsibility of conducting the WHS risk assessment on these new designs rests with the OEM. Once these designs are imported and installed in Australia, the WHS risk profile is dependent on the technicians following the advice of the OEM. If this advice is not followed and modifications are made to the design or substitute gases not endorsed by the OEM are utilised, then the WHS risks will increase.	1.1 The Department should continue to participate at an international level to fully understand the WHS risks and the associated mitigation strategies that are required to ensure the OEM requirements are fully implemented. The OEM has the WHS legal duty to conduct a risk assessment on their product and to provide safety advice to technicians and consumers. 1.2 The industry associations and their members should clearly state that no substitute gases should be used in RAC equipment unless the modifications required to operate safely are within the servicing and warranty requirements stipulated by the OEM. If an equipment item is out of warranty and retrofit processes are used, the technician undertaking this work assumes the legal accountability that a WHS risk assessment has been undertaken and the retrofit processes are deemed to be safe. The individual employers and their technicians have the WHS legal accountabilities to ensure the safety of systems that are using retrofit processes. Industry associations should clearly inform their members of this accountability.
2. Global trends in RAC design have seen a range of new gases used in different product categories. These include: ● Domestic refrigeration and small freezers using hermetically sealed charges of hydrocarbon. These charges are less than 150 grams. ● Industrial systems requiring charges over 10 kg of gas are being designed to operate on a specific gas and for a particular requirement. These include systems designed to operate on charges of ammonia, carbon dioxide, hydrocarbon, as well as low GWP SGGs. ● The automotive sector is transitioning to the use of low GWP gases (primarily A2L gases) in systems.	2.1 The industry associations that represent the RAC sector should initiate a process to identify and assess the WHS risks associated with the introduction of new technology containing the new gases. They should also work with the education sector to integrate the knowledge into the training and professional development program for technicians. The industry associations and the training organisations should focus on the safe use of HFOs including R32, R1234yf, as well as hydrocarbons. The focus should also include other new RAC systems that are now designed for hydrocarbons. Where these systems have been specifically designed for hydrocarbons, they have been widely used safely. The training is to ensure the safety

● Split system air conditioners are also being designed to operate on different types and blends of gases. These systems are utilising pure gases and also blends. The WHS risks arise when gases are substituted in these equipment items that have not been tested or approved by the OEM or an engineer with equivalent knowledge of the equipment. This has the potential to increase WHS risks through the life cycle of servicing and decommissioning these RAC items. It also increases the risks for the equipment owners and by-standers.	integrity requirements are clearly articulated and communicated to the technicians. The training program should cover the supply chain elements from importing the gas; engineering systems for using the gas; maintenance and replacement of the gas as well as collection, transportation, storage and destruction. The WHS risks in this supply chain should be identified by the WHS Duty Holder at each stage of the gas handling process. They should identify where the sources of ignition could be present and the quantity of the flammable gas required that may result in a risk of a fire or explosion. 2.2 The industry associations should provide guidance on the use of 1234yf (another A2L gas) which is to be mainly used in automotive systems. These guidelines should cover the same supply chain elements to identify the WHS risks and controls. 2.3 The industry associations should develop a supply chain communications plan relating to the WHS risks in utilising new flammable gases and the associated risk controls. This should incorporate the existing guidance materials such as the AIRAH *Flammable Refrigerants Safety Guide* but extend to the new gases and their mixtures. This is to ensure that the technicians are competent in handling the gas through the importation, installation, maintenance and replacement of the gas as well as collection, transportation, storage and destruction. 2.4 The industry associations together with the state WHS regulators, electrical regulators and gas regulators should convene a forum to collectively identify WHS legal compliance requirements for this sector. This should ensure that a Materials Safety Sheet has been documented for all new gases and mixtures. This is the legal responsibility of the supplier to be provided to the consumer of the gas via their website or hardcopy. 2.5 The industry associations and regulators should clearly call for all gases used in the RAC sector be provided with an appropriate R rating for toxicity and number rating for flammability from a recognised authority such

	as ASHRAE.
3. Currently Australia has national governance of ODS and SGGs through the Department of the Environment. This is administered through the Australian Refrigeration Council with the licensing of technicians and businesses for the sale, use, handling and disposal of ODS and SGG gases. This licensing scheme only relates the environmental governance as outlined in legislation and not WHS governance. There is no national governance arrangement in place for the safe implementation and life cycle processes for all gases and their safe use in the RAC sector. As the dependence on high GWP SGG decreases and the use of the alternative gases and mixtures with increased hazard increases then the requirement to introduce a nationally consistent WHS governance process is more evident.	3.1 The RAC industry associations should work together with the WHS Regulators to identify the most appropriate governance model for the safe design, installation, operation, maintenance and decommissioning, of RAC equipment. They should also work on the safe transportation, storage, use, reclaiming, recycling and destruction of all gases including A1, A2, A2L and A3 gases and their mixtures.
4. There are nine jurisdictions in Australia each with WHS legislation governing the duty of care for participants in the supply chain of the RAC sector. There is little direct involvement of the WHS regulators in monitoring the WHS risks associated with the use of these gases and their mixtures. There is also little involvement in monitoring the WHS risks of using hydrocarbon gases in RAC systems. The WHS regulators prioritise risks to be regulated or inspected on the basis of notifiable incidents, as well as workers compensation claims. During this review, it was evident that neither of these measures have resulted in any of the WHS regulators identifying a need for closer compliance monitoring of this sector.	4.1 The WHS Regulators across all jurisdictions should consider a coordinated communication strategy that clearly outlines their role and expectations in the safe use and handling of gases in the RAC sector. This is consistent with the current approach taken through Safe Work Australia where one or more jurisdictions will take the lead in developing strategic guidance on behalf of all jurisdictions. This will enable a national approach to be maintained consistent with the harmonised WHS legislation model.
5. The proposed replacement Australian Standard for AS1677 is nearing completion. If adopted the new Standard will be known as AS/NZS5149. This new Standard contains four parts. It moves away from the current Standard which requires a process to be undertaken to identify the WHS risks and to implement controls that eliminate or reduce these risks. The new Standard will provide more direct advice relating to WHS in the design, installation, construction, and maintenance of the RAC systems.	5.1 The industry associations as well as their members will need to collaboratively develop an education and awareness program on the new Australian Standard once it is released. Different strategies will be required depending on the target skill group such as the professional design engineers compared with the technicians maintaining and servicing equipment. 5.2 The AIRAH *Flammable Refrigerants Safety Guide* and Fact Sheets provide practical

It is a large technical document that will become the 'state of knowledge' once it is released. In the absence of specific WHS regulations relating to the RAC sector, the technical documents produced by the industry itself such as the Australian Standards as well as guidance documents developed by the industry associations can be produced as evidence during WHS litigation proceedings as the 'state of knowledge'. In the context of the new AS/NZS being introduced there is an opportunity and a need for the industry to review Standards on the appropriate charge sizes of gases including the A2Ls.	resources for use in professional development workshops and seminars. They will need to be updated once the new Standard is introduced. Additional Guides and Fact Sheets need to be developed for the automotive sector relating to the new gases and mixtures. 5.3 WHS guidance needs to be developed by the WHS Regulators as well as the Gas Regulators and Electrical Regulators. Collaboration is required by these regulators to ensure national uniformity of the advice that they are providing to the RAC industry. This guidance is required to clearly articulate what WHS compliance looks like in relation to the hazards relevant to this sector. 5.4 Innovative methods to communicate with the sector should be used to maximize the access to WHS information. The WHS regulators provided hyperlinks from their websites during their interview with examples of social media such as LinkedIn networks and YouTube presentations, as well as participation in industry trade shows to disseminate WHS information. 5.5 The Australian standards process should include a review of charge sizes relevant to the A2L rating. The Department of the Environment should also consider supporting a review of charge sizes for new gases such as the A2Ls in relation to the international standard and incorporate the outcomes into the communications strategy.
6. Refrigeration Reclaim Australia (RRA) reports that there has been a measurable increase of hydrocarbons from 0.2% of all gas received to over 1.2% in the last two years. RRA has reported some containers are now being returned with up to 40% of hydrocarbon gas in a cylinder labelled as a SGG. This raises WHS risks through the supply chain. The collection, transportation and storage of the containers raises WHS risks if the contents of the container are not correctly labelled. The technicians may not be aware of the proportion of hydrocarbon gas in these containers. RRA noted that hydrocarbon gas in these containers result from the process of 'drop ins'. They indicated that hydrocarbons are now appearing together with SGG in the	6.1 The WHS risks associated with the safe decommissioning of equipment and disposal of low GWP gases needs greater attention by the RAC industry. Whilst there is little environmental value in destroying low GWP gases, there are WHS risks that need to be addressed if they are sent for destruction in SGG cylinders that are not accurately labelled. The RAC industry associations should develop guidance on the correct methods of gas recovery using appropriate equipment and the correct labelling of gas mixtures. This may include a standardised 'Warning' sticker for technicians to use on gas cylinders where they are recovering gases suspected of potentially containing a HC mix.

cylinders being reclaimed and sent to reprocessing points. As this trend has been evident since 2012, RRA has needed to construct a small intrinsically safe processing area once these mixed gases are identified.	It is noted that, at the time of writing, equipment rated to safely recover A3 refrigerants was not available in the Australian market. Therefore, industry guidance needs to continue to be updated as and when this situation changes. 6.2 The industry associations should investigate opportunities to identify and introduce cost effective gas analysing equipment for use by technicians. This is due to the risks related to the recovery of flammable gases, predominantly within the mobile sector, where refrigerant recovery often takes place without identifying the gas, on the assumption that the original gas is still housed within the equipment. This can result in unwittingly unsafe work practices, as well as a legacy of unidentified, unquantified gas mixtures being introduced to the end-of-life supply chain. Separately, there is currently a lack of equipment available in Australia to recover A3 refrigerants or mixtures including those refrigerants. This is being addressed by the Department of Environment and by industry, however, there is a need for such equipment to be developed and available as a matter of priority. 6.3 A communication program is then needed for technicians to adopt the guidance on correct labelling and handling of containers of gas mixtures.
7. Feedback from the majority of the technicians interviewed who have traditionally used, and have been trained in the use of SGGs indicated that they tended to not swap to alternative gases during the equivalent carbon tax period. Some indicated that the carbon tax did not raise the costs by enough of a margin to necessitate changes to business practices which incorporated alternative gases. The technicians who continued to use the SGGs were more diligent in the reclaiming and reprocessing of the SGGs. They were very dependent on information provided by the gas suppliers. The majority of technicians across all RAC sectors indicated they only worked on	7.1 There is a need for an industry led education program in relation to the new gases such as A2 and A2L including mixtures of these gases and A3 gases that are used in the RAC sector. This information should be based on the WHS guidance from the OEM. As is their primary WHS duty of care, the OEMs must continue to ensure that the equipment they manufacture and supply allows for a safe system of work for installers and servicing technicians.

particular cars, trucks, brands of appliances or for specific building owners where they have been trained in the OEM safe work procedures. They have continued to use the gases recommended by the OEM for the product. If new gases are introduced then they would expect training from the OEM on their safe use. The technicians who chose to continue using the SGGs were aware of the WHS risks associated with using flammable substitute gases. They were particularly concerned about the compatibility of the engineering design to safely use these alternative gases.	
8. The process of identifying and handling mixtures of gas that contain natural refrigerants introduces potential WHS risks if the safe systems of work are not clearly understood and implemented through the supply chain. It is evident that some technicians are unsure how to handle mixtures of SGGs with A3 gases that result in a flammability risk from a WHS perspective. Anecdotal evidence was provided that some technicians may vent these mixtures to atmosphere which is illegal under the ozone legislation where penalties exist for emitting SGGs. They may also place themselves and others at WHS risks if they do not handle the gases safely.	8.1 The industry bodies, wholesalers, suppliers and technicians should work together to develop systems to manage the potential hazard from contaminated gas. This should include suppliers of all refrigerant gases, not just ODS/SGGs. 8.2 The RAC industry needs to develop safe handling procedures to ensure the safe disposal of gases in cylinders that contain a mixture of A2, A2L and mixtures with A3 gases in accordance with the relevant WHS Regulations and Dangerous Goods legislation.
9. There is unanimous support across Australia from all stakeholders interviewed for a single, nationally consistent licensing scheme for RAC technicians working on stationary items. The industry is aware that the current ARC licence is only applicable to ODS and SGG equipment due to the legislative powers under which this scheme operates and is focused on reducing environmental impact. However, with the increasing proportion of low GWP gases being now utilised, the influence of the current licensing system will progressively diminish. In addition as more technicians utilise low GWP gases, they may not need to be licensed under the current licensing scheme. It is noted however that the specific skills required to handle each type of gas, regardless of whether it is an SGG or not, necessitates the introduction of a broader based licence program.	9.1 A nationally consistent approach to licensing requirements for technicians installing or maintaining RAC equipment is desired by the industry. Under the Ozone legislation, there is no requirement or head of power for the Department of the Environment to be involved in the licensing of technicians other than in relation to ODS/SGG purchasing and use. The current licensing process can continue for SGG purchasing and use whilst they remain the safest gas for specific technology and applications. The appropriate agency to oversee the licensing scheme was not identified in this review. The WHS regulators and the Gas regulators were the most likely agencies with oversight of the governance requirements. 9.2 This project did not form an opinion which option would be the most appropriate to oversee a single licensing scheme. A

It was also noted that the mobile sector has different competency requirements due to the equipment design and systems of work relevant to the auto sector. In 2012 and 2013, the NOLS process commissioned a Regulatory Impact Study[1] to assess the viability of national licensing options for the RAC occupation. This found that there was not a national licensing model that was viable under the current state legislation. The NOLS process was established to oversee such a scheme and was disbanded in 2014. The proposal for one National Occupational Licence Scheme for RAC has not been progressed after the NOLS process was completed. The recommendation arising from the NOLS project is that there is one licence that should be provided for stationary RAC work and another licence for RAC work in the automotive MAC and TRAC sector. Specialist areas of RAC work such as working with ammonia or carbon dioxide would require the RAC licence was well as additional requirements. A single licence for the stationary sector would greatly assist rural and regional Australia where a wide variety of RAC work is undertaken by a relatively small number of workers. This is due to the requirement for these workers to be competent to service equipment using a range of gas types across the spectrum of the RAC applications.	nationally consistent licensing arrangement could be developed by industry bodies that are in a position to stipulate that participants in the sector should be licensed through an industry led program. Input to the licensing program could be made by the WHS regulators and the Gas regulators.
10. The RTO sector has developed two training modules in the apprenticeship course to specifically address the WHS risks associated with the installation and service of natural refrigerants in the stationary RAC sector. These modules are Unit 174 'General Safety Relating to Hydrocarbon and Substituted Gases'. Unit 175 is 'Service and Repair – Self-contained Hydrocarbon Air-conditioning and Refrigeration Systems'. Currently, they are available at some RTOs as elective modules.	10.1 If a licensing program was introduced by the industry sector in consultation with the WHS Regulators and the Gas Regulators, it should stipulate that all apprentices should undertake the A3 natural refrigerant modules as mandatory units in their RAC courses. This needs to take into consideration the safe use of A3 gases in systems that have been designed for their use by the OEMs. 10.2 Within the context of the introduction of R1234yf to the mobile sector, and R32 in split system air-conditioning, there is a requirement for education Units to be developed on A2 and A2L gases by 2016 as

[1] A regulatory Impact Statement is required before changes in legislation to quantify the costs and benefits of the proposed changes.

There are no modules available yet in relation to A2 or A2L gases and their WHS requirements. There are also no modules available on natural refrigerants in the automotive sector. This is because the OEM currently stipulate the use of gases that are not natural including those of A3 designation. Anecdotal evidence provided by the industry associations identified that natural gases are used as substitutes or 'drop ins' in the MAC and TRAC sectors. This raises WHS risks across the whole sector.	part of the courses for the MAC and TRAC sector and also for the mid-range stationary RAC sector. The RTOs teaching these units should be equipped with appropriate equipment to ensure that competency based training outcomes can be achieved. 10.3 The RTO sector, in consultation with the RAC stakeholders, should run professional development programs for the RTO teachers to ensure they fully understand the content of the A3 natural refrigerant module and the A2 and A2L modules that they are teaching. This should be conducted as a 'Train the Trainer' strategy that has been used previously within this sector. This professional development program should be integrated as part of the NQF (National Quality Framework) which sets out the minimum qualification requirements for educators. 10.4 Industry mentors should be identified across Australia by the industry associations to assist local technicians implement safe systems of work and safe design of RAC systems. These could be experienced engineers nominated by the industry associations as well as representatives of the OEM and gas suppliers. This program could be included with the communications package with information from the WHS, Gas and Electrical regulators.
11. The professional engineers involved in designing RAC systems that use A2L and A3 gases need to be adequately trained to ensure they can demonstrate the competencies in designing systems for these gases. The introduction of the proposed AS/NZS5149 Standard would provide an opportunity to refocus the professional development opportunities for RAC engineers. RTOs should integrate competency based education programs for engineers on the safe design, installation, operation, maintenance and decommissioning of plant and equipment using substitute gases.	11.1 A series of professional development programs should be scheduled by the industry sector as part of launching the AS/NZS 5149. These programs could be conducted by the industry associations and universities teaching engineering disciplines across Australia. 11.2 Universities should extend their curriculum for professional engineers to ensure they have a full understanding of the design requirements for using substitute gases and blends of gas in RAC equipment. The course accreditation process should identify that the inclusion of the relevant curriculum is a requirement for these courses. The industry should work with the sector to provide the technical input to these processes.
12. NSW WorkCover recently finished	12.1 The RAC industry bodies should establish

collating data and evidence to determine the nature and extent of WHS risk in the RAC sector. This information will be provided to HWSA once the study is complete.	communication with NSW WorkCover and HWSA in relation to the findings of their research on WHS risks in this sector. Depending on the outcomes of this research, collaboration should occur in developing awareness and training opportunities using documents such as the AIRAH *Flammable Refrigerants Safety Guide*, Fact Sheets and materials that are developed by the WHS Regulators as part of a national package of communication resources. Resources will also be required for the MAC and TRAC sector suited to their requirements.
13. Currently the Electrical Standard 60335 series mention Electrical Safety Standards that include flammable refrigerants and their respective charge limits. They basically refer to the gas as A1 or flammable. With the introduction of the A2 and A2L gases there will be requirements for them to be addressed as part of the electrical safety requirements.	13.1 The Electrical regulators should consider the most appropriate way to address the safe introduction of A2 and A2L gases into their legislation for the RAC sector. This should be conducted in consultation with the WHS regulators.
14. There is currently little sharing of information between the main government departments who have legislative powers relevant to this sector from a WHS perspective. This includes the WHS, Electrical Safety and Gas Safety regulators in each jurisdiction.	14.1 The WHS Inspectors should participate in a gas industry workshop together with Inspectors from the Electrical Safety Regulator and the Gas Safety Regulators. This should be an opportunity to exchange knowledge and a common understanding of what compliance to WHS standards should be. These workshops should be part of the implementation of the proposed AS/NZS5149 Standard. They can also establish ongoing communication using links on their websites to relevant materials from the RAC sector. Opportunities to develop joint publications and enforcement programs should also be explored.
15. There is little evidence provided by the WHS Regulators to date of WHS incidents that have been notified to the Regulator or resulted in workers compensation claims. Jurisdictions such as Queensland, that have over 100,000 workers compensation claims including minor claims with only medical expenses a year, did not report any data attributed to WHS risks associated with gas handling and processing from the RAC sector.	15.1 Industry associations and RTO colleges should specifically encourage their members and students to report WHS incidents to their employer to enable the industry to have more data and better understanding of risk that has been discussed informally associated with unsafe events involving refrigerant gas. 15.2 The WHS Inspectors should be encouraged to target specific elements of the storage and handling requirements for compliance

Anecdotal stories indicate that there are minor incidents and near misses which are not reported to the Regulators. This was particularly mentioned in the automotive sector. In relation to the workers compensation insurance performance for this sector rate for the stationary RAC sector is 1.684% and for the automotive sector is 1.054%. This rate is determined by the claims experience over the preceding five years. The majority of this rating is based on reported claims such as musculoskeletal disorders, slip trips and falls, as well as psychological illness. These industry rates are equivalent to light manufacturing industry. The insurance rate for high-risk industries such as shearing, horse racing and tyre manufacturing are over 7%.	with the Dangerous Goods Act during site visits to this sector. A more proactive approach will provide a stronger database for understanding the current and emerging WHS risks. 15.3 Similarly, the Electrical Safety Regulators and the Gas Safety Regulators should also target this sector as part of their overall compliance requirements to ensure that safe systems of work and safety design is in place relevant to their respective technical areas of competence. This should be consistent with the WHS requirements as stipulated by the WHS regulators.

Project Introduction

The purpose of this project was to develop a report gathering and analysing information and data on the current issues and risks associated with synthetic greenhouse gases (SGGs), including ozone depleting substances (ODSs), and alternative gases, particularly in regard to the refrigeration and air-conditioning (RAC) industry's transition to low or no global warming potential (GWP) refrigerant gases. This includes a critical review of the 2012 report titled, *Baseline Analysis of Work Health and Safety Data and Information for the use of Synthetic Greenhouse Gases and Substitutes in the Australian Gas Industry Sector,* (and its recommendations.

The 2012 report concluded that the RAC industry in Australia had the potential for increased exposure to alternative gases and that future WHS incidents were most likely to occur in that industry, particularly in small to medium sized workplaces such as automotive servicing workshops. The report also noted the handling of alternative gases by unlicensed and untrained tradespeople who are not aware of the WHS risks to themselves or others as a major concern. This report will examine the original baseline analysis and assess whether the anticipated changes to the selection, use and handling of SGGs and alternative gases have occurred as projected.

As the US, Europe and Japan are major influencers of the Australian RAC industry, these countries and region were targeted for consultations. Since the 2012 report, the RAC industry, both in Australia and globally, has continued its transition towards lower GWP refrigerants. This includes the introduction into Australia of low GWP flammable SGG refrigerants that have not previously been available.

The Department of the Environment is aware that two WHS incidents involving RAC equipment have occurred in Australia since the 2012 report was published. The report includes an assessment of the causes of those and any other known incidents since 2012, involving SGGs or alternative refrigerants and the implications these may have for ongoing management of WHS risks. The investigation into incidents also tried to capture incidents involving equipment owners or by-standers.

The development of this report has included consultation with industry representatives, WHS regulators and other government agencies and also included international representatives to obtain a broad based perspective of the Australian issues within the international context.

The Department is currently undertaking a comprehensive review of the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989*. The review terms of reference provide for

consideration of the interaction and consistency of regulation with other Commonwealth, state and territory policies and legislation including work health and safety, dangerous goods and hazardous substances. This review has provided a timely opportunity to consider how regulatory and non-regulatory approaches could contribute to SGG emissions reduction in the future in line with international efforts. This report has been developed to inform the review.

The review has been undertaken by David Caple with the assistance of Brian Eva, an Occupational Hygienist. Both David and Brian have over 30 years experience in conducting WHS reviews in Australia. They were the same team who developed the previous report in 2012. A brief CV for David and Brian are provided as an Appendix to the report.

Scope of Work

The scope for this project was to develop a report on the current issues and risks associated with SGGs and alternative gases, particularly the RAC industry's transition to lower GWP refrigerant gases.

The issues in scope for the report included:

1. Consider how the risks, issues and recommendations identified in the 2012 report have been managed since 2012 in the RAC industry, including in the use of blended gases in mobile and stationary equipment.

2. Identify the current key WHS risks from the perspectives of WHS regulators, other relevant government agencies and relevant industry sectors. In doing so, the report will:

    (i) consider the specific SGGs and substitutes (in terms of hazard properties and handling requirements) used by the RAC industry sectors, including but not limited to the automotive sector, through the equipment life cycle

    (ii) provide information on any significant new or emerging changes or trends within industries relevant to WHS risks

    (iii) identify the current and predicted key health and safety risks to consumers.

3. Consider any developments in international standards and approaches of other countries to WHS risks relating to refrigerants gases, OEM and retrofit.

4. Identify what effect, if any, the introduction and subsequent repeal of the Australian Government's equivalent carbon tax has had on industry's use of SGGs and substitutes and on related WHS risks. This will include assessment of whether anticipated changes in the use and handling of SGGs and substitutes, and those gases' risk profile, have eventuated, whether WHS risk profiles have been affected, and whether the 2012 report's recommendations are affected.

5. Identify and examine details of significant WHS incidents occurring in Australia since the preparation of the 2012 report, and any implications or findings from those incidents relevant to the management of WHS risks posed by trends in use and handling of SGGs and substitutes. Relevant incidents include those occurring in Western Australia in April 2014 and Rochester, Victoria in June 2014.

6. Identify the key safety and regulatory challenges for Commonwealth and state and territory government , industry, WHS regulators and other stakeholders, and provide recommendations and suggestions for implementing solutions, including identification of which industry sectors, government agencies and other stakeholders would be responsible for their implementation.

Project Methodology

1. Consultation occurred with 69 organisations within the RAC industry, WHS, gas and electrical regulators, original equipment manufacturers (OEM), unions and registered training organisations to identify what WHS risks they have identified and what systems and standards they have implemented to address these risks. With multiple people consulted from some organisations over 90 experts in the industry were involved.

2. Each consultation was preceded by a phone call and sending a letter developed with the Department to provide the introduction to the project. Copies of the letter to the industry partners and also the letter to the WHS regulators are attached.

3. Consultation occurred with international experts to identify experiences in Europe, the UK, Japan, and North America regarding international use of alternative refrigerant gases to identify what WHS risks they have identified and what systems and standards they have implemented to address these risks. This included the processes being taken towards designing RAC systems to allow for the safe use of lower GWP gases. These were selected because they are some of the main manufacturers and suppliers of equipment and gases to Australia and their regulatory systems have some similarities as well. They are also leaders in policy development at a global level that integrates the WHS risks in the design and use of RAC equipment and gases.

   The international consultations included teleconferencing with Ray Gluckman from the UK who has been commissioned as a RAC technical advisor by the European Union. He has also provided consulting advice to the Australian Government prior to the introduction of the equivalent carbon tax. Teleconferencing also occurred with Richard Lord from Carrier UTS in the US. He is an active participant on government committees and industry groups for the RAC sector in the US.

   A workshop was conducted in Canberra with representatives from the Alliance for Responsible Atmospheric Policy in the US; the European Partnership for Energy and the Environment from Europe; and the Japanese Refrigeration and Air-Conditioning Industry Association from Japan.

4. Copies of documents provided by representatives of the industry in relation to the topic were also received and reviewed. These included personal statements and industry position documents in relation to the scope of the project.

5. Regular liaison was maintained with the Department to clarify issues arising during the course of the project.

Project Outcomes

1. *Consider how the risks, issues and recommendations identified in the 2012 report have been managed since 2012 in the Refrigeration and Air-Conditioning (RAC) industry, including in the use of blended gases in mobile and stationary equipment.*

1. **Have the WHS Regulators developed a communication plan to inform the community about:**

   1.1 **The potential WHS risks of using substitute gases in equipment designed for SGGs?**
   1.2 **Targeting sectors that may be least aware of their legal obligations including by using the supply chain?**
   1.3 **Outlining the legal requirements in respect to conducting risk assessments and correct labelling, storage and handling of gases in workplaces?**

1.1 The WHS Regulators across Australia have not developed a communication plan specifically to inform the community about potential WHS risks using substitute gases in equipment design for SGGs as part of a nationally coordinated initiative. Appendix 5 provides an overview of the WHS regulation requirements in Australia.

1.2 NSW WorkCover was nominated by the Heads of Workplace Safety Authorities (HWSA) to undertake a review of WHS risks relating to the use of gases in the RAC industry. This project was undertaken over a 12 month period to be completed by the end of June 2015. It is part of an overall focus on potential low likelihood and high consequence incidents. Safe Work Australia and NSW WorkCover are considering what communication strategy about WHS risks would be required.

This review has found that there is little reported evidence of incidents or workers compensation claims associated with the handling of these gases in the RAC sector. The general feedback to date is that the WHS regulators should consider developing awareness of potential WHS risks and support training for technicians working in this sector in collaboration with the RAC industry.

1.3 Each jurisdiction has been communicating separately using a range of documents. For example, the Department of Mines and Petroleum in Western Australia, has issued two Safety Bulletins. These include 'Flammable Refrigerants in Non-Refillable Gas Cylinders', Dangerous Goods Safety Bulletin, no. 0114, January 2014.
www.dmp.wa.gov.au/documents/bulletins/msh_sb_114.pdf

It has issued a combined Mines Safety Bulletin no.100 and Dangerous Goods Safety Bulletin no. 0312, August 2012, titled 'Safe Use of Flammable Refrigerants'. This referred to a significant incident on the 18 April 2012 when an employee received burns following the ignition of hydrocarbon gas that had leaked from a vehicle's air-conditioning system.
http://www.dmp.wa.gov.au/documents/Bulletins/MSH_SB100.pdf

1.4 The Department of Natural Resources and Mines in Queensland has issued a Petroleum and Gas Safety Alert 57 'Illegal Hydrocarbon Refrigerant usage', June 2013. It has a specific warning about illegal use of hydrocarbon gas in motor vehicle air-conditioning and other stationary devices that have not been approved by the Chief Inspector.

1.5 WorkSafe in Victoria and, Fair and Safe Work Queensland, have been providing WHS information to technicians relating to the use of ammonia in the RAC industry. Feedback from Fair and Safe Work Queensland, as well as NSW WorkCover, indicated a communication

strategy is required to increase awareness of WHS risks through the RAC supply chain. This strategy needs to minimise the use of complex technical documents and focus on engaging stakeholders with targeted information and could use a digital approach utilising social media and YouTube. WHS Regulators are already communicating with workplaces through digital media as this allows for a more targeted, simple and cost effective method. WHS Regulators have indicated that the delivery of targeted material through this medium is more effective than the development of detailed guidance material.

1.6 The major concern of the WHS Regulators relates to the low probability and high consequence potential of fire and/or exposure to toxic by-products as a result of fire with refrigerants used in the RAC industry. WHS Regulators indicate that the risk of an adverse outcome in using these refrigerants is still considered to be low, given the low number of incidents reported for investigation.

1.7 The general duties as outlined in the WHS legislation and associated Regulations and Codes of Practice are used by the WHS Regulators in determining legal compliance. Each jurisdiction has their own WHS legislation. The model WHS legislation has been adopted by all Australian jurisdictions except Victoria and Western Australia. They all contain the same duties that require persons who design, manufacture, import, supply, install, construct or commission plant, substances and structures to demonstrate a duty towards those who have potential WHS risks. Appendix 5 provides details of the wording from the respective sections of the legislation for each jurisdiction.

Each WHS Regulator would expect that the RAC industry guidance provided on safe use and handling of these gases would be the 'state of knowledge' that would be utilised in determining compliance. This is within a WHS legislative environment where the basic duties of hazard identification, risk assessment and risk control needs to be met by employers and employees. If the WHS Regulators develop Regulations, Codes of Practice or Guidance materials themselves then these would also form part of the legislative compliance model. In relation to the storage and transportation of the gases, the *Dangerous Goods Act 1985* would form the basis of the compliance requirements.

As part of the introduction of the A2L gases (mildly flammable refrigerants) Refrigerant Reclaim Australia conducted their own consultation process and risk assessment in determining the correct labelling, gas cylinder thread selection, and handling requirements of gas bottles being introduced into Australia. This was done independently of the WHS Regulators. Their primary interest was that a risk assessment had been undertaken and that the controls were able to be implemented across the RAC industry to eliminate or reduce the risk 'so far as is reasonably practicable'.

One of the major suppliers of the A2L gas R32, Heatcraft, has developed a gas cylinder with specific labels and left hand thread for this gas. It has also supplied an instruction tag on the safe handling and use of this gas attached to each cylinder. This cylinder provides specific guidance because R32 is a new A2L gas and the users of this gas need to be educated on the safe handling requirements.

The main RAC industry sector that received the most comments about emerging uncontrolled WHS risks by industry partners was the after-market MAC and TRAC sector. Key industry groups including VACC, VASA and Auto Skills Australia have all expressed concerns about the potential for WHS incidents associated with the use of gases including natural refrigerants and mixtures of gases including hydrocarbons.
This concern relates to the supply chain associated with the servicing and replacement of gas with unknown WHS characteristics in vehicle air-conditioning systems.

The VASA feedback indicated that the number of technicians who have access to refrigerant gas identification equipment would be less than 5%, maybe much less, in the mobile sector.

Without this type of equipment there is no way to identify the refrigerant contained in an air-conditioning system.

It would be widely assumed that the refrigerant in the system is the type recommended by the vehicle manufacturer and indicated on the label attached to the vehicle.

When a vehicle is manufactured the air-conditioning system is fitted with service access adaptors applicable to the refrigerant to be used in the system. This is to prevent equipment not dedicated to that refrigerant from being attached to the system, thus avoiding cross contamination.

When a technician charges the system with a hydrocarbon refrigerant, the service access adaptors are often not modified. These adaptors should be modified if a hydrocarbon refrigerant is being used in the system. Modified adaptors would give an instant indication to a technician that the system had been previously charged with a hydrocarbon, thereby removing some of the uncertainty of the systems refrigerant contents. Dedicated hydrocarbon fittings may not have been developed. This is an issue that could be addressed by the industry in their Code of Practice on safe use of hydrocarbons in the mobile sector.

Regulations administered by the Australian Refrigeration Council require licensed technicians to follow a mandatory code of practice to ensure correct service procedures are performed. One of these requirements is that vehicle air-conditioning systems are labelled to indicate the type and quantity of refrigerant the system contains. These same mandatory requirements are unable to be enforced by the ARC on unlicensed technicians who choose to use alternative refrigerants such as hydrocarbons. However these technicians have a duty under the WHS legislation which can be enforced by the WHS regulator if the safe use of the refrigerants is considered to be the ‘state of knowledge’.

1.8 The other industry sector that was most discussed in the interviews was the ‘mid-range’ stationary equipment sector. This is equipment that requires between 150 grams and 10 kg of gas. This sector is currently undergoing rapid change with new technology and gas products available on the market. The trend is seeing a combination of products such as R134a as well as the new A2L gases. The substitution of natural refrigerants in this sector was raised as a potential WHS risk during the interviews for this project where appropriate engineering and electrical systems are not in place.

1.9 There have been no specific changes to the legal requirements for the conduct of WHS risk assessments in this sector since 2012.

2. Have education programs been developed for engineers within universities and VET providers on safe design, installation, operation, maintenance and decommissioning of plant and equipment using substitute gases?

2.1 In relation to the governance of the training of technicians, the following information has been provided by E-Oz Energy Skills Australia.

Since 1999, Australia's national Vocational Education and Training (VET) system has been based on national qualifications made up of competency standard units. These VET qualifications range from Certificate I to Advanced Diploma, with most traditional trade qualifications being at Certificate III level. The qualifications are packaged together in industry sectors, into a document called a 'Training Package'.

For example, the RAC qualifications and the competency units they contain are in the UEE11 Electrotechnology Training Package, which is available on the Training.gov.au website at http://training.gov.au/Training/Details/UEE11
The Certificate III in Air-Conditioning and Refrigeration qualification is available at http://training.gov.au/Training/Details/UEE32211 and all the competency units are also available at http://training.gov.au

The national qualifications and competency standard units are delivered and assessed as courses to students by Registered Training Organisations (RTOs) both public (e.g. TAFE) and private organisations.
To deliver and assess a qualification, the RTO must apply to the Australian Skills Quality Authority (ASQA) for registration or approval. Details on ASQA are available at http://www.asqa.gov.au/

These national qualifications made up of competency standard units were developed in consultation with industry by Industry Skills Councils. There are 11 Industry Skills Councils, details are available at http://www.isc.org.au/
The main RAC qualifications are in the UEE11 Electrotechnology Training Package, which was developed and maintained by E-Oz Energy Skills Australia, details are available at http://www.e-oz.com.au/
When new or revised Training Packages are developed by an Industry Skills Council they were, until recently, submitted to National Skills Standards Council (NSSC) for endorsement/approval and once approved they are published on http://training.gov.au

However, in 2014 the Commonwealth Government announced that the National Skills Standards Council (NSSC) had been dissolved and its ongoing functions delegated to industry representatives and selected senior officials through a new Industry and Skills Council Advisory Committee. The Commonwealth Government is also introducing a new model for engaging Australian industry in the development of Training Packages. Specifically, the new model will form Industry Reference Committees (IRCs) as the conduit for industry intelligence into training policy and practice and to guide the development of training packages and support materials. The IRCs will be supported by new Skills Service Organisations (SSOs) to replace the existing ISCs, which will be funded by the Australian Government to provide administrative, technical and operational support to assist IRCs in their engagement with industries. These new arrangements are to be completely operational by January 2016.
For details of the proposed new Arrangements refer to http://vetreform.education.gov.au/news/new-arrangements-training-product-development-australian-industry

2.2 The major activity in the education sector has been by the AIRAH and the RTOs. This has

included commissioning the writing of two new Units dealing with natural refrigerants for use in the stationary RAC sector.
These are known as Units 174 (General Safety Relating to Hydrocarbon and Substituted Gases) and Unit 175 (Service and Repair – Self-contained Hydrocarbon Air-conditioning and Refrigeration Systems) that have been developed by E-Oz Energy Skills Australia. The writing of these Units has involved extensive consultation across the industry through the RAC Technical Advisory Committee (RACTAC). These Units have been available in those RTOs with the appropriate plant and equipment to teach the competencies since 2012. They include the broad area of flammable A3 natural refrigerants including hydrocarbons. The Units do not cover the use of ammonia. It is the intention that these Units would be utilised in the training of technicians in all RTOs across Australia that cover the RAC applications. The main difference between those RTOs interviewed was the amount of time and amount of theory and practical activity allocated to these units.

2.3 At this stage there are no educational units available for the A2 and A2L refrigerants. This work is currently being developed by the industry sector and should be introduced into TAFE courses by 2016. Hence the only WHS training available to the sector on these A2 and A2L gases is provided by companies such as Daikin and Fujitsu as well as industry associations. This training has been open to all technicians in the industry sector. When the training units are available the RTOs will need to equip their teaching areas with RAC equipment designed for using these gases to enable competency based learning outcomes.

2.4 There will be a requirement to commission the development of a unit on the safe use of A2L gases for the automotive sector. Currently they have no units involving hydrocarbon gases as the OEMs do not recommend them. However Auto Skills Australia will need to develop and introduce a unit on the use of A2L gases with the projected increased use in imported vehicles. A list of the gases known to be introduced in this and other RAC sectors is provided in Appendix 5.

2.5 In relation to professional engineers involved in the design and installation of medium to large RAC systems, there are insufficient skilled engineers across regional Australia in particular who are competent to work in the design, installation and operation of RAC equipment using the new gases and mixtures. For example, the Queensland Petroleum and Gas Inspectorate within the Department of Natural Resources and Mines, indicate that it has appointed three contractors to issue Certificates of Compliance before substitute gas can be utilised in a piece of RAC equipment originally designed with a different gas.

Feedback from Gas Inspectors approved by the Queensland DMNR indicates that there have been installations, including very large installations that have failed the compliance requirements due to inadequate understanding by the engineers involved in the design process. Examples were also provided from other jurisdictions where these same Inspectors provide independent advice around Australia to building owners as part of their due diligence requirements. It was noted by one of these Inspectors, that a project that was rejected by the DMNR Inspector for compliance to use hydrocarbons had already been approved by a WHS Regulator Inspector. This raises questions about the level of competency and different approaches that may be being taken across Australia with professional engineers fully understanding the requirements particularly if substitute gases are to be used in medium sized and large engineering installations.

2.6 Education is also provided by the industry associations. For example, AIRAH has been providing professional development courses for their members on a range of topics including the use of natural refrigerants. It has developed guidance material such as the Flammable Refrigerants Safety Guide, 2013. AIRAH has also developed Fact Sheets relating to the design, installation and maintenance of flammable base refrigerant systems. These were developed with extensive consultation across all aspects of the RAC industry. They have also delivered free national

seminars for technicians.

The general feedback in relation to professional engineers designing RAC systems, is that they will often 'catalogue engineer' projects. This means engineers will select items from existing product catalogues and then rely on the suppliers to assist in the safe installation of their components. Unless these engineers are fully aware of the risks in using natural refrigerants, it is possible that they are not stipulating sufficient safety controls into the installation design.

2.7 Another gap that has been identified though industry feedback relates to the level of understanding by RTO teachers who are now expected to train technicians on the safe use of natural refrigerants and substitute mixtures of gas, when the teachers themselves may not have used these gases whilst they were technicians. Feedback has been provided by RTO teachers that some of their teaching colleagues may not have kept pace with changing trends in RAC design and the new gases and mixtures being used in the RAC industry.

2.8 Communication with the RAC engineering sector is currently undertaken using different mediums. For example, there are now 1,500 members of the LinkedIn hosted by AIRAH.

AIRAH distributes a monthly magazine entitled HVAC and R Nation which has 15,000 copies distributed mainly to stationary RAC technicians via gas wholesalers. The ARC distributes a quarterly publication called Cool Change to ARCtick licensees and authorisations holders, and industry associations also produce newsletters for their members. There is a culture within this industry that technicians tend not to prioritise professional development. Consequently, they tend not to attend conferences or read publications. Attendance at these events is mainly by professional engineers.

Opportunities exist at trade days where wholesalers of RAC equipment items and retailers can showcase their products. These tend to be attended by technicians if they are hosted in their local areas.

2.9 Large companies such as Daikin and Fujitsu have conducted extensive education programs around Australia for technicians who are approved to install their systems. They are also retailing their product through outlet managers who, as a condition of selling the product, only refer customers to trained technicians to carry out the installation. This governance over the installation and servicing arrangements by the OEM could be linked to warranty arrangements and insurance coverage for the RAC system.

Daikin has participated in the consultation process with the RTO sector in the development of the new Unit specifically to cover A2L gases such as R32 and R1234yf. Currently, around 800 technicians have been trained across Australia by Daikin in installing and using R32 in their new range of split system air conditioners. Daikin's R32 split systems were introduced into the Australian market in 2014 and by the end of 2014, there were over two million R32 split systems introduced in Japan. Daikin products are manufactured in Japan and are they now exporting R32 systems to Europe, India and across Asia.

2.10 The major suppliers of products using these A2L gases are encouraging education of engineers and technicians to ensure that the gases are handled safely. In relation to design engineers, they need to learn the new rules for engineering systems to take new gases such as the mildly flammable A2L gases. When engineers are designing air-conditioning systems for specific room sizes and either a floor mounted or high wall mounted unit, they will need to understand the engineering requirements of these systems to optimise efficiency and safety. This is part of the training requirements in the UK which should be implemented in Australia.

2.11 As a consumer of new RAC technologies from around the world, Australia is potentially seeing more new technologies across the range of RAC applications than elsewhere in the world. Europe, Japan and the US have stricter governance systems controlling the introduction

of new technology than in Australia. As Australia does not have a central or national governance framework to oversee the RAC sector as a whole it is possible that there are greater potential WHS risks in Australia that are not encountered in the other countries surveyed. Australia does have close governance around the sale and use of ODS andSGGs in accordance with the requirements administered by the ARC. Australia has a national framework through the National Industrial Chemicals Notification and Assessment (NICNAS) for the introduction of new chemicals. As lower GWP gas technologies are imported into Australia there will be more equipment on the market that can be legally worked on by unlicensed technicians. There is an assumption that the WHS risks in using these gases are known by and enforced by the WHS regulators in workplaces where RAC technicians are working. Our consultation with the WHS regulators would indicate that their inspectors are not targeting an enforcement program in this sector at this time.

2.12 There has been no broadening of the approach in relation to licensing of technicians since 2012. In Queensland, the Department of Natural Resources and Mines has its own licensing for technicians using natural refrigerants in the RAC industry. No other jurisdiction has an equivalent licensing program in place.

2.13 The Department has investigated its potential role to oversee the whole RAC sector but the legislation that controls their coverage can only regulate scheduled ODS/SGGs and their applications. The legislation needs to be empowered by the Australian Constitution. Under the external affairs power it can only extend to the regulation of the gases listed under the Montreal Protocol and UNFCCC. There is no constitutional power to regulate all gases and/or all members of industry under the Ozone legislation. In 2012 the Department of Industry was involved with the establishment of NOLA to oversee the potential for a national licensing scheme for all RAC technicians. NOLA has since been disbanded and no other government department or agency has taken coverage of the entire RAC sector. To date no other government department or agency has been identified to provide the national governance for the entire RAC sector.

2.14 The unanimous view among all stakeholders interviewed was that Australia should adopt a national licensing program encompassing all refrigerants used in RAC systems.

With the progressive move away from high GWP SGGs to low GWP gases internationally, and consequently in Australia over the next five years, the industry is strongly encouraging the government to implement a broader licensing model to reflect the emerging reality of this industry sector. As the use of high GWP SGGs reduce and more technology is introduced to safely work with HFO or hydrocarbons then the number of technicians covered by the current ARC licence arrangements will progressively decrease. Whilst high GWP SGGs remain one of the main gases in use then the technicians will still need their ARC licence. Conversely, the number of technicians interfacing with low GWP RAC equipment will increase. With the exception of technicians in Queensland, technicians will not be required to undergo specified training nor be licensed.

The industry is aware of the Regulatory Impact Statement on adopting a national licensing scheme developed by PricewaterhouseCoopers (2013). This was commissioned as part of the NOLA review. It considered a range of alternative models for the establishment of a national licensing scheme and concluded that none of the options were viable under the current legislation.

2.15 The main issue of debate among the industry about the licensing of technicians was how this licensing program should be implemented as a consistent national model. The options that most frequently were mentioned included:

- Extend the coverage of the current RAC licence for stationary RAC equipment to include all refrigerant gases used in the RAC sectors. This would include the current requirement for the

purchasing and use of SGGs.

- A separate licence should be provided for the mobile and transport sectors.
- Work with Safe Work Australia and the Heads of Workplace Safety Authorities (HWSA) should reach an agreement that each jurisdiction WHS regulator would introduce a licensing scheme similar to that used in Queensland.
    - One concern with this option expressed by the industry was that two licences may be required by a technician if they work close to a state border. They strongly encouraged a single licence model to be introduced. This option was generally not supported by the WHS Regulators interviewed.
      They had not identified that the handling of gases in the RAC sector to be of sufficient risk to introduce a new licensing scheme. They were more focused on a strategy that focussed on WHS risk awareness and training.
- The State Gas regulators and Electrical regulators did not see a role for themselves in the governance of a licensing scheme for their jurisdiction. They are generally small departments and are more focussed on other risk areas. For example in Tasmania there are only four staff members for the state's gas regulator role and they mainly focus on applications where gas is consumed such as furnaces.
- The industry associations that represent the different RAC sectors could develop a generic licensing scheme that covers all technician but with application specific requirements. This could be administered by the associations in each jurisdiction to incorporate the requirements from their respective WHS legislation.

There was no agreement evident from this review if any of these licensing schemes would be viable. There was also no agreement if they would adequately meet the WHS needs as well and the environmental legal requirements for this sector.

3. Has a focus on licensing been retained to cover, not just the use of the gas, but a broader licence to cover the proposed category of plant and equipment where the gas will be used e.g. licence for tradespeople working in large cool rooms, fixed installations such as supermarkets, plug and operate installations such as refrigerators or split system air conditioners, or mobile plant such as cars?

3.1 In Australia, there are currently over 60000 individuals who have been issued a 'handling licence' by the ARC.

3.2 There are also more than 17,000 businesses that have been provided the authority to purchase SGGs. Around 95 percent of the licensed individuals work for these businesses.

3.3 There are around 20 types of licences that are provided for different stationary RAC equipment. These account for around 48.5 percent of persons who are licensed to handle stationery RAC equipment. The remaining 51.5 percent of licence holders are for automotive systems.

3.4 Due to the large geographical spread of RAC installations across Australia, there is significant concern that technicians in regional Australia still require training and capability to service the wide range of stationary RAC systems that use the new gases and blends in their regional or remote areas. Due to their geographical isolation from major teaching programs the opportunities for regional and remote technicians to be trained and have regular professional development are limited. A process of 'train the trainer' programs and mentoring to enable one or two technicians from these areas to bring back the knowledge and skills should be considered.

3.5 The introduction of a single base level RAC licence would give technicians the capacity to undertake the majority of the service work within their capabilities. A change to the structure of the licence could reduce the complexity and potentially excess formal training requirements.

3.6 There is general acceptance that a specialist skill set is required for the design, maintenance, and servicing of stationary systems using ammonia. Consequently, this should be seen outside the general RAC licence coverage. As ammonia is mainly used in large stationary systems it could be seen as a specialist area that would have its own training requirements over and above those currently provided for other refrigerant gases.

3.7 Specialist training is also required for systems involving carbon dioxide. These systems operate at significantly higher pressures than the other gases.

3.8 There is a global trend towards introducing A2L gases, particularly in the mid-range products of stationary RAC systems, and also in the MAC and TRAC sector, it is critical that Australia is prepared with technicians who understand the supply chain needs associated with using these gases as well as A1, A2 and A3 gases.

3.9 There is an emerging risk with component-based installations where technicians may re-engineer OEM systems. Changing systems by substituting compressors and condensers to take natural refrigerants is introducing an emerging WHS risk if the engineering and electrical systems are not correctly designed. Concerns have been raised during this project by OEM companies that provide integrated systems such as split system air conditioners. These concerns relate to technicians in Australia who remove the external hardware to enable alternative gas to be used.

This can occur without the OEM knowledge or endorsement. Apart from potential reputational damage to these OEM companies, they are expressing concern that such modifications to their product design will potentially increase WHS risks to the technicians, and also to the community

where these substitution modules have been implemented.

This is one example described by the industry supporting a broader approach to training and licensing of technicians.

3.10 An area still requiring clarification is the need to identify and isolate ignition sources as well as change seals, hoses, gaskets and valves as part of the safety requirements when substitute gases are used. There are currently potential WHS risks arising from leaks where technicians are not conducting WHS risk assessments and replacing gases in systems that may not be suitable for the safety requirements.

4. Have all Australian WHS regulators adopted the Code of Practice developed for Ammonia? Have they also adopted the Codes under development for safe handling and use of carbon dioxide and hydrocarbons as refrigeration gases used in plant and equipment?

4.1 Feedback from the WHS regulators across Australia was that there have been no WHS Codes of Practice developed or introduced for the safe handling and use of carbon dioxide or hydrocarbons as refrigeration gases used in plant and equipment. There have also been no changes to the level of adoption of the Code of Practice for Ammonia.

4.2 A review of WHS legislation for each jurisdiction indicates that all states and territories have adopted the same duties for manufacturers, importers, suppliers and installers. An example of these duties from ComCare is provided in Appendix 5. Hyperlinks to the other jurisdictions duties are also provided. It is evident that all of these jurisdictions have utilised the same duties from the harmonised WHS model legislation. It is noted that Victoria was not part of this legislation, but the harmonised model duties were based on the Victorian OHS Act 2004. Consequently, regardless of the jurisdiction in Australia, the duties applying to all of these stakeholders should be considered to be consistent.

4.3 The main relevant Standards relating to the RAC sector for gas include:

AS/NZS 1677.1: 1998 – Refrigerating Systems – Part 1: Refrigerant Classification

AS/NZS 1677.2: 1998 – Refrigerating Systems – Part 2: Safety requirements for fixed applications

AS 4332: 2004 – The Storage and Handling of Gases in Cylinders

AS 1894: 1997 – The Storage and Handling of non-flammable cryogenic and refrigerated liquids

AS/NZS 2022:2003 – Anhydrous ammonia – Storage and Handling

AS/NZS 1596: 2014 – The Storage and Handling of LP Gas

4.4 The main relevant Standards relating to the RAC sector for electrical safety include:

AS/NZS 3820: 2009 – Essential Safety requirements for electrical equipment.

AS/NZS 60335: 2011 – Household and similar electrical appliances – Safety, general requirements.

AS 4343: 2014 – Pressure equipment – hazard levels.

AS 1482: 1985 – Electrical equipment for explosive atmospheres – Protection by ventilation

AS/NZS 3000: 2007 – Electrical installations

AS/NZS 60079.10.1: 2009 – Explosive atmospheres – Classification of areas.

4.5 The WHS regulators have not developed any Guidelines or Codes of Practice since 2012 in relation to WHS risks for the RAC sector.

The major activity in developing guidance in this area has come between the Department of the Environment and AIRAH with the Flammable Refrigerants Safety Guide, together with three Fact Sheets. These have been developed after extensive consultation across the RAC industry and are available on a number of websites including the Australian Refrigeration Council. The other guidance has been developed by the Queensland Department of Natural Resources and Mines called Hydrocarbon Refrigerants, 2015.

This guide explains how to apply for a gas work licence (hydrocarbon refrigerants) and how to get Type B gas devices approved. It also provides an overview of safety standards and legislative requirements relating to hydrocarbon refrigerants.

4.6 HFO-1234yf has yet to be seen in large quantities in Australia. It was expected that it will be more widely used with imported cars that have been designed specifically for this A2L gas. We were informed that over 60 models of cars in the US are now being produced with this refrigerant gas.

4.7 At a more general level, it is evident that mildly flammable gases are now becoming more commonly used in Europe in a wide range of applications including cars as well as mid-size stationary air-conditioning systems. The discussion in the report relating to European experience provides more detail on this area.

4.8 Consequently, the awareness and education program in handling mildly flammable HFO gases as part of a broader trend towards A2L gases should be one of the major areas for consideration in the next year.

4.9 Feedback from the industry is supportive of mandating the use of left hand thread for gas containers with flammable contents.

4.10 Feedback from the interviews informing this project indicated that technicians use adaptors to enable left hand threads to be used on plant requiring right hand threads. This enables them to interface with containers of flammable gases or mixtures. Hence, the gas that may remain in a cylinder may be a flammable and non-flammable mixture.

4.11 The labelling of the cylinder is one source of information about the gas. The Safety Data Sheet for the gas provides more detailed WHS information that needs to be reviewed and understood by the technician. This is generally an accurate indication of the gas from the suppliers.

However if substitute gases are added during the supply chain the actual content of the equipment being reclaimed may be a mixture of various gases. This may occur as technicians add substitute gases during the servicing of equipment. Observations during site visits noted hand written comments on labels of what mixtures of gas may have been added. When this is identified by the technician or wholesaler the container is to be treated as an A3. We were also informed that some of these cylinders are vented to atmosphere which is illegal if it contains SGGs.

4.12 The designation of A2 as ‘moderately flammable’ and A2L gases as ‘mildly flammable’ remains an issue of confusion through the industry in relation to the safety requirements. Within this category, there are a range of measurable criteria such as the flame velocity and the ignition energy that varies between the A2L gases. Further information on the labels such as those provided by Heatcraft should be considered as an example of how to communicate with the user handling their specific gas bottles. A copy of the label attached to the bottle is provided in

Appendix 6.

5. What do we learn from international benchmarking of SGG policy and strategies for the safe use of substitute gases to ensure that Australian workplaces maintain their current high standards of WHS performance?

5.1 It is evident that the transition to lower GWP refrigerants and the associated changes to engineering design in the RAC industry is being driven at a global level. Australia is represented on many international committees with the most influential one being the Montreal Protocol on Substances that Deplete the Ozone Layer meetings. It is also evident that the majority of the OEMs around the world are not based in Australia. Consequently, Australia is a consumer of RAC system designs and needs to introduce safe work practices in relation to the various points in the supply chain when utilising these systems and equipment. This includes both stationary and mobile RAC systems. Since 2012 changes are evident across all RAC sectors as the move to lower GWP gases is driving changes to plant designs. The gaps that relate to WHS risks arise from technicians using substitute gases in RAC systems not designed for their use and modified engineering systems not integrating intrinsically safe designs for flammable gases. This requires the elimination of leaks and removal of potential sources of ignition for the gases.

5.2 Details of the authors' discussions in relation to international trends are provided as an appendix of this report, however, the major findings indicate that:

- Domestic refrigerators and small freezer units are currently being designed to use hermetically sealed hydrocarbon based systems. This was consistent around the world except in the US until 2015 when the SNAP Rules were changed to include hydrocarbons for this application. The SNAP program (Significant New Alternatives Policy) is the Environmental Protection Agency (EPA) program to evaluate and regulate substitutes for the ozone-depleting chemicals that are being phased out under the US Stratospheric Ozone Protection Provisions of the *Clean Air Act 1970*.

- For the large industrial applications such as supermarkets and cool rooms, Europe and the US continue to have specific designs utilising ammonia, carbon dioxide, or newer SGG gas formulations that have lower GWP.

- There are some medium sized and large installations that have been specifically designed for hydrocarbon use, but this is still an emerging technology area due to the wide range of variables required to ensure intrinsic safety for an A3 refrigerant.

- It is also noted that there is a trend against using hydrocarbon refrigerants in applications that expose a lot of people to risk in the event of a serious WHS incident such as inside shopping centres or for use within buses. The exception is very low charge applications in hermetically sealed equipment such as domestic refrigerators. Consequently, for those systems that are specifically designed for the use of hydrocarbons they tend to be located outside the building fabric and utilise products such as glycol to refrigerate the internal units.

- For mid-sized RAC plants such as small supermarkets, stores, as well as split system air-conditioning systems, there is a growing trend towards the A2L gases. This mid-sized range is based on safety calculations as used in ISO 5149: 2014 'Refrigerating systems and Heat Pumps.' This provides charges of A2L gases up to around 15 kg. This range of products is possibly the main growth area of change that is currently occurring around the world in the RAC industry.

- In relation to cars, the new models are now moving towards lower GWP gases which are now in the A2 or A2L range. There is ongoing reluctance around the world to use hydrocarbon gas in cars as a substitute gas in systems designed and manufactured to operate using a hydrofluorocarbon refrigerant. No major OEMs use a hydrocarbon refrigerant in automotive air-conditioning systems.

- For larger mobile plant such as buses or refrigerated trailers, there is a trend towards the A2L gases. With buses in particular, there is significant global concern against using A3 refrigerants due to the potential exposure of the large numbers of people in the buses in the event of an accident or leakage.

5.3 Whilst the major discussion internationally about the selection of gases relates to WHS risks and flammability, there is also some concern in relation to toxicity. Primarily, this is a concern if people are exposed to by-products of the gas in the event of a fire. The overall debate about this matter is that these toxicity risks have been present with SGG gases since their development and the risk has been adequately managed by the industry.

2. *Identify the current key work health and safety risks from the perspectives of WHS Regulators, other government agencies and relevant industry sectors.*

2.1 Governance of WHS risks by the WHS regulators is based on evidence of risks identified in workplaces across Australia. Evidence is generally based on notifiable incidents as well as workers compensation data arising from injured or illness reported by workers and their employers. Each jurisdiction also has WHS Inspectors who visit workplaces and assess compliance with WHS legislation requirements. These three sources of information are then used by the WHS regulators to prioritise those risks that form the basis for their targeted intervention programs.

The reporting requirements for workers compensation claims to the regulators vary between jurisdictions. For example in Queensland all claims are reported to Fair and Safe Work Queensland whilst in Victoria claims involving more than 10 days off work or claims greater than a nominated expense amount are reported to the WHS regulator. Hence the claims database in Queensland has over 100 000 entries whilst in Victoria it is around 30 000. It is therefore difficult to compare data between jurisdictions as part of the risk identification process.

2.2 Consultation with the WHS Regulators in relation to the RAC industry indicates that there is still little evidence to escalate a program of intervention with their Inspectors, or development of further guidance materials, Codes of Practice, or Regulations. They were unable to provide us with any workers compensation data analysis that specifically relates to WHS risks in the use of gas in this sector. Comcare reported that since 1 January 2013 there have been 11 incidents notified to Comcare from organisations that relate to refrigerant gas leaks from air-conditioning units. Other incidents reported to Comcare include fire or smoke coming from air-conditioning units in operation (10 incidents), electric shock during maintenance (6 incidents) and leakage of water during operation (2 incidents). No similar data could be obtained from the other WHS regulators.

2.3 Consultation with the Gas Regulator Technical Group indicates concerns relating to the use of alternative gases in systems which were designed for different class of refrigerant. This Group is an informal network of Gas Regulators from each jurisdiction. The major WHS concern relates to the lack of understanding on the integrated electrical safety systems that need to be in place when a SGG is substituted with an A2, A2L or A3 gas. Their main concern relates to the use of flammable gas in applications with direct exposure to the community such as buses or systems where there could be foreseeable risk to the community. There is national acceptance of low charge of hydrocarbon gas in hermetically sealed domestic refrigerators.

2.4 Another major concern of the industry relates to the end of life process of reclaiming and disposal of SGGs. There is an increasing amount of mixed gases that are now returning to wholesalers and subsequently to Refrigerant Reclaim Australia (RRA). RRA notes that A2, A2L or A3 gases are all classified as Class 2.1 under the Dangerous Goods Regulation. Consequently, the storage and handling, including transportation, of these gases must to be legally compliant with these Regulations. It is noted that this is the same classification that is required to be complied with for the transporting and storage of LPG. The safety procedures for decanting and pumping of the gas must also comply with the Dangerous Goods Class 2.1 requirements. The Dangerous Goods requirements must be met by the RAC sector during these processes.

2.5 It is evident that mixed gas (containing a mixture of original gas and ‘drop in’ substitute gas) that is being returned to the wholesalers introduces a range of potential non-compliance with this legislation.

RRA has been providing information relating to safe storage and handling of these gases. However, it appears that a broader level of awareness is required across the full supply chain of the RAC industry to prevent the contamination of gases.

There is a fundamental limitation in the sector in identifying cost effective and reliable gas analysis and identification instruments. As a result, technicians and wholesalers are often not aware of what is actually in the reclaimed gas bottles and transport them back for reuse or disposal with potential increase of WHS risk. It was estimated by VASA and the VACC that less than 5 percent of technicians in the mobile sector have access to gas analysis equipment.

It is noted that RRA is now anticipating a requirement to introduce a whole new engineering system for the destruction of gases due to the increased proportion of hydrocarbons being returned. There is currently a small specialised intrinsically safe system at Toxfree in Laverton, Victoria. However, in the future, there may be a need to treat all returning gases as flammable and utilise a new treatment equipment as well as new gas handling processes.

It is noted that there are reclaim cylinders that are available that can handle A2L refrigerants such as R32 and R1234yf. R32 is a higher pressure gas compared to commonly used refrigerants such as R22, R410A and requires a higher pressure 6.2MPa cylinder. For example the Heatcraft Gas2Go® is a dedicated R32 reclaim cylinder. The R32 reclaim cylinders are uniquely identifiable by a red collar with a yellow shoulder. A-Gas also has reclaim cylinders for R32. The interviews indicated that the A3 gas is vented to atmosphere.

It was suggested that the carbon footprint to reclaim and reprocess the A3 gases and potentially A2L gases, is greater than the environmental impact of releasing the gas. There are evident environmental risks if the substitute gas is mixed with SGG and they are vented to atmosphere. We were informed that some technicians in the MAC and TRAC after-market sector who mix SGG and substitute gas vent it to atmosphere which is illegal. The other risk relates to them reclaiming the gas including the mixes and not accurately labelling the container. This has consequent risks to others handling the container in the supply chain.

2.6 The majority of the observations relating to WHS risks in the 2012 report remain much the same. The major changes that have occurred in the last three years within industries that are relevant to WHS risks is the increased utilisation of A2, A2L and A3 refrigerant gases. This continues to be primarily driven by the manufacturers of stationary and mobile refrigeration and air-conditioning equipment. The main approach that now needs to be taken is a greater focus on consistent simple messages as part of a communication and awareness program. There is also a need for a greater focus on training and professional development of technicians to ensure they safely use and handle the new products and gases as the industry moves towards lower GWP gases.

2.7 Australia has a very strong advocacy group supporting the elimination of synthetic greenhouse gases particularly due to their potential environment impact, and a strong passion towards introducing natural refrigerants where safe to do so. This group is particularly concerned about the short and long term environmental impact whilst gases such as A1, A2 and A2L refrigerants continue to be used. Their desire would be for companies that are involved in designing stationary and mobile RAC systems would fast track their compatibility for natural refrigerants to be used where possible.

There continues to be ongoing debate in Australia about the level of WHS risks in using A3 gases in applications such as cars, buses and mid-sized systems as ‘drop ins’. This debate relates to the understanding of the risk management process to be followed and the quality of the risk assessment and risk controls that are implemented.

2.8 There continues to be a need in the automotive sector, and the mid-size stationary air-conditioning sector, that a focus on WHS risk assessment and risk control is required where A1 and A2 gases are replaced with A2L and A3 gases. The technicians should be the focus for this strategy to ensure that any replacement of parts such as compressors and substitution of gas is undertaken with appropriate engineering controls, labelling and systems that are based on the OEM requirements.

2.9 The major trend with systems using larger quantities of gas is the new engineering of designs using ammonia, carbon dioxide and hydrocarbon gases. With appropriate engineering expertise and quality installation and maintenance, there should not be an increased WHS risk in this sector. This is based on the assumption that there are consistent standards that are followed by the engineers. However, we were informed by the Queensland Chief Inspector for Natural Resources and Mines that there are not sufficient engineers with this expertise across metropolitan and regional Australia.

The major changes that are occurring in the RAC sector relates to the introduction of A2L gases, such as R32 and R1234yf in the large, mid-range and automotive sectors. There does not appear to be any change with the use of very small charge of sealed hydrocarbon systems in domestic refrigerators and small refrigerators and freezers in the retail sector.

2.10 The lack of evidence that the current systems have resulted in WHS incidents has informed assessments among WHS regulators that the risks to the health and safety of consumers is low. There is also an assumption that the OEMs manufacturing RAC systems using A2, A2L, and A3 gases are manufacturing these systems to adequate standards to ensure the life cycle safety, and integrity of these processes. However there are potential risks particularly in the automotive sector and domestic sector where inappropriate replacement gases are used in systems that leak and have potential sources for ignition.

Due to the minimal number of reported WHS incidents and limited media coverage, the author considers that the majority of consumers would be unaware of any residual WHS risks that may be present in these applications. Discussions with the industry associations and reviewing the industry newsletters and guidance materials we found that there is broad awareness of the environmental merits of reducing GWP of gas used in the RAC sector. This was also found with our consultations with the overseas technical experts. However, consultation with Australian industry associations indicates that there may be consumers who are unaware of the WHS risks that may be present within their vehicle, workplace, or home if technicians have not followed the correct maintenance procedures. Industry groups such as the VACC and VASA report anecdotal stories of small WHS incidents but these are not reported to the regulators possibly due to embarrassment or fear of prosecution. There are anecdotal cases of events involving retrofits that were not reported due to concerns of becoming a party to a WHS regulator investigation.

The assessment by NSW WorkCover that this is a low risk but potential high consequence issue would seem consistent with the feedback provided in this review. Under WHS legislation any risk identified in a workplace must be controlled as far as reasonably practicable. This takes into consideration the probability of an event; the potential harm; the alternative processes used in the sector; their suitability for the application; as well as the costs.

It was noted in consultation with the ACCC that the WHS risks to the consumer from exposure to RAC appliances is seen as a technical issue that should be managed by the RAC sector and the WHS regulators. The ACCC consider that potential consumer risks would arise from the poor technical management within the RAC sector. They consider that the responsibility to identify and manage WHS risks that impact on the consumer to rest within the sector itself. In the event that a WHS incident occurred impacting on the safety of consumers, they would consider that the relevant duty holder under the WHS legislation would be accountable.

3. Consider any developments in International Standards and approaches of other countries to WHS risks relating to refrigerant gases, OEM, and retrofit.

3.1 Although the 2012 report suggested that the revised AS1677 was nearly ready for release and would be introduced in 2013, this has actually not occurred due to delays in finalising ISO5149. ISO5149 now has international agreement. The Australian Standard Committee ME006 is very close to releasing a new draft Standard which will be called AS/NZS5149 Refrigeration Safety and Environment. This will be primarily based on the International Standard ISO5149, but with some changes. This draft will need to go through a process of consultation and feedback before it could be considered for acceptance.

The new Standard will be in four parts. These will cover:

- Design
- Construction
- Installation
- Maintenance, of RAC systems.

Automotive Systems are not covered in AS1677 and will not be covered in the revised standard.

It is understood to be over 500 pages long and is targeted towards design engineers. It will be important to have a communication strategy, together with simple Fact Sheets or similar to accompany the launch of this new Standard. This communication strategy should be the responsibility of the peak RAC industry associations to ensure that their members are aware of the content of the Standard as it applies to their respective work practices. It is not expected that the technicians will purchase and read the entire document due the length of the Standard and the cost. However they will have a legal responsibility to be aware of the content relevant to their work. This Standard would become the 'state of knowledge' for the RAC sector.

Unlike the previous Standard, the proposed AS/NZS5149 is likely to be much more prescriptive to ensure the WHS integrity of system design. This will become the 'state of knowledge' upon its release and regardless if the WHS regulators reference this standard in their documentation, the WHS legal process would recognize this as the current approach to address WHS risks. To add further legislative power towards compliance, it would be appropriate that the WHS Regulators reference this new Standard in their Regulations or Codes of Practice to assist compliance.

3.2 In relation to electrical Standards, the Electrical Standard 60335 series reference the Electrical Safety Standards. These include flammable refrigerants and their respective charge limits, and refers to the gas as A1 or flammable. With the introduction of the A2 and A2L gases there will be requirements for these gases to be addressed as part of the electrical safety requirements, which is under the control of the State Electrical Regulators. There are differences between the Electrical Safety regulators in Australia. The Electrical Regulatory Authorities Council (ERAC) was developed as a COAG initiative for national uniformity. However, it was commenced in Queensland in March 2013 and only Queensland, Tasmania, and Western Australia have recognised this Council. As new WHS guidance materials are developed by the RAC industry partners, there is a requirement to include the Electrical Safety Regulators in the consultation process.

It was noted during the consultation process with the other state electrical regulators that many are not aware of or involved in any WHS risk analysis of the RAC sector.

This review has spoken to many stakeholders with anecdotal stories about the introduction of substitute gases in the RAC sector and associated WHS risks but there is little documented evidence of how this is impacting on the overall WHS risk profile for the sector.

3.3 The focus of the ARC is on the sale, use and life cycle of ODS and SGGs in the RAC sector and this includes the requirement to record general gas usage and equipment servicing history although there is not currently a requirement to report this information. It is noted that Japan has a centrally controlled gas database that requires the importers, OEMs, technicians and others handling the gas to record the amount of gas being handled. In this way they are able to track if and where any gas is lost in the supply chain. Australia does not have a similar life cycle record system for SGGs or substitute gases. As a result, WHS risks may be arising in areas such as the automotive aftermarket sector and the industry associations together with the WHS regulators, may not be aware of the evidence and the extent of the risks that may be present. It is noted that in Japan there are differences in hazard classifications compared to the Australian market. For example, the R32 gas is not designated as flammable.

Japan is also going to release new HFC Regulations in April 2015 relating to the use of substitute gases as they support the global trend towards lower GWP gas in the RAC sector. This will cover a range of comprehensive measures relating to equipment design and technician certification. Japan is developing programs involving efficiency schemes for 28 different products. The major focus is on reducing leakage of refrigerant through the life cycle of the gases.

3.4 In the US, the Environment Protection Authority (EPA) sets the standards to control hydrocarbons due to their flammability and is responsible for issuing approvals. One of the controls on the use of flammable gases in US buildings is a requirement to regulate these gases through the Building Codes. The Building Codes provide responsibilities on the building owner in relation to the gases that can be used. The Building Codes are reviewed every three to five years and before the Building Codes can be modified there is a requirement for the Safety Codes to be updated with the new gases. Then each State and city adopts the Building Code to be implemented. Therefore it takes a long time before a new class of gas can be introduced into US buildings. In the RAC industry in the US, there is a gradual move towards A2L gases based on the OEM research processes.

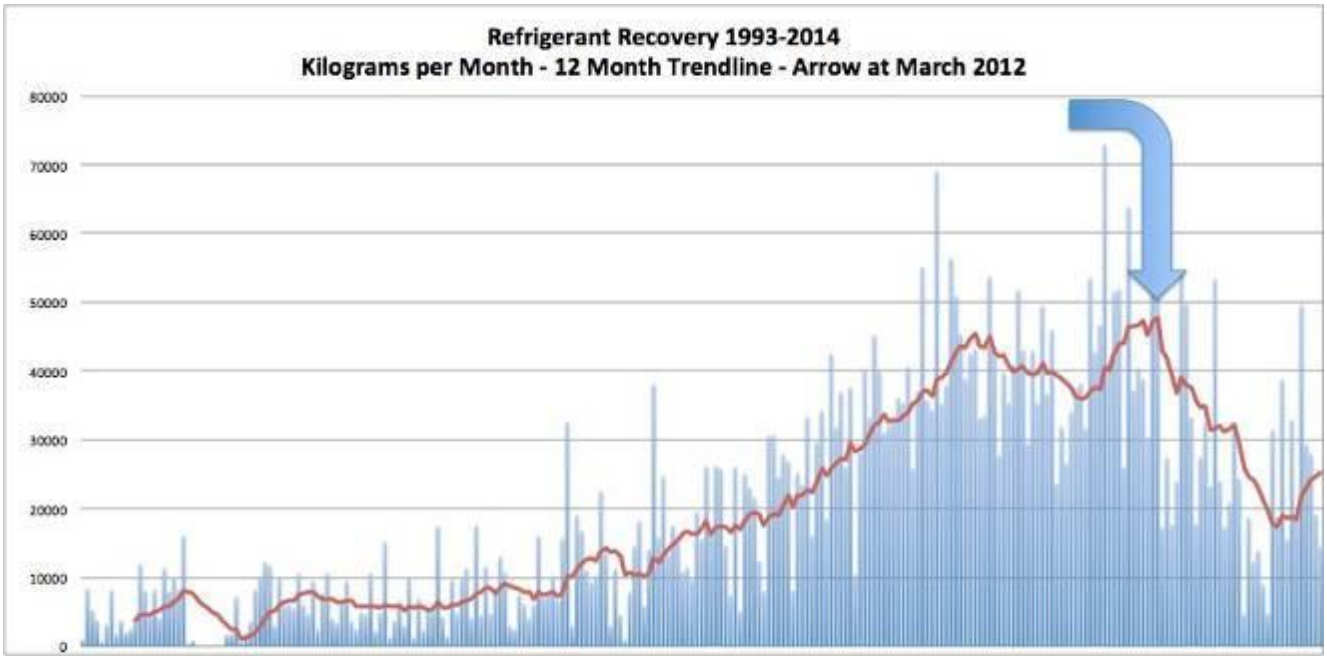
Compared to the stationary approvals, the mobile RAC sector in the US does not require as detailed process to approve a new gas. It is predicted that R1234yf will become the industry standard as this gas has been approved by the EPA for use in the auto sector and there are currently over 60 models of car already adopting this gas. The EPA requires that a technician needs to be certified to use any gas involved in these air-conditioning systems. There was a political issue where prohibition was introduced for purchasing self-service cans of gas to minimise inappropriate use. However, this was cancelled as it was seen to be ‘picking on the poor people’ who may use these cheaper alternatives in their cars. As a general principle, the US has identified further education and training as a primary requirement for technicians working in the RAC industry. The EPA has introduced the Significant New Alternatives Policy (SNAP) program to evaluate and regulate substitute gases. It has identified substitute gases for multiple refrigeration and air-conditioning applications as a replacement for ozone depleting products.

In Table 4 of its recommended substitute gases, the US EPA notes that all flammable refrigerants including hydrocarbon mixtures, except for HFC152a are unacceptable for use in motor vehicle air-conditioning, retrofit, and new vehicles. We were informed during the consultation process by industry contacts in the US that hydrocarbon mixtures are actually used in the aftermarket area contrary to the EPA approval process.

The EPA also prohibits the use of hydrocarbon mixtures in all end-uses except for new or refit industrial applications that have been designed for their safe use. The reason provided is ‘lack of adequate risk assessment that characterises incremental flammability risk’. It is noted that the 2015 SNAP announcement has extended the list of acceptable hydrocarbon gases and applications as part of the US government commitment to environmental policies involving low GWP gas.

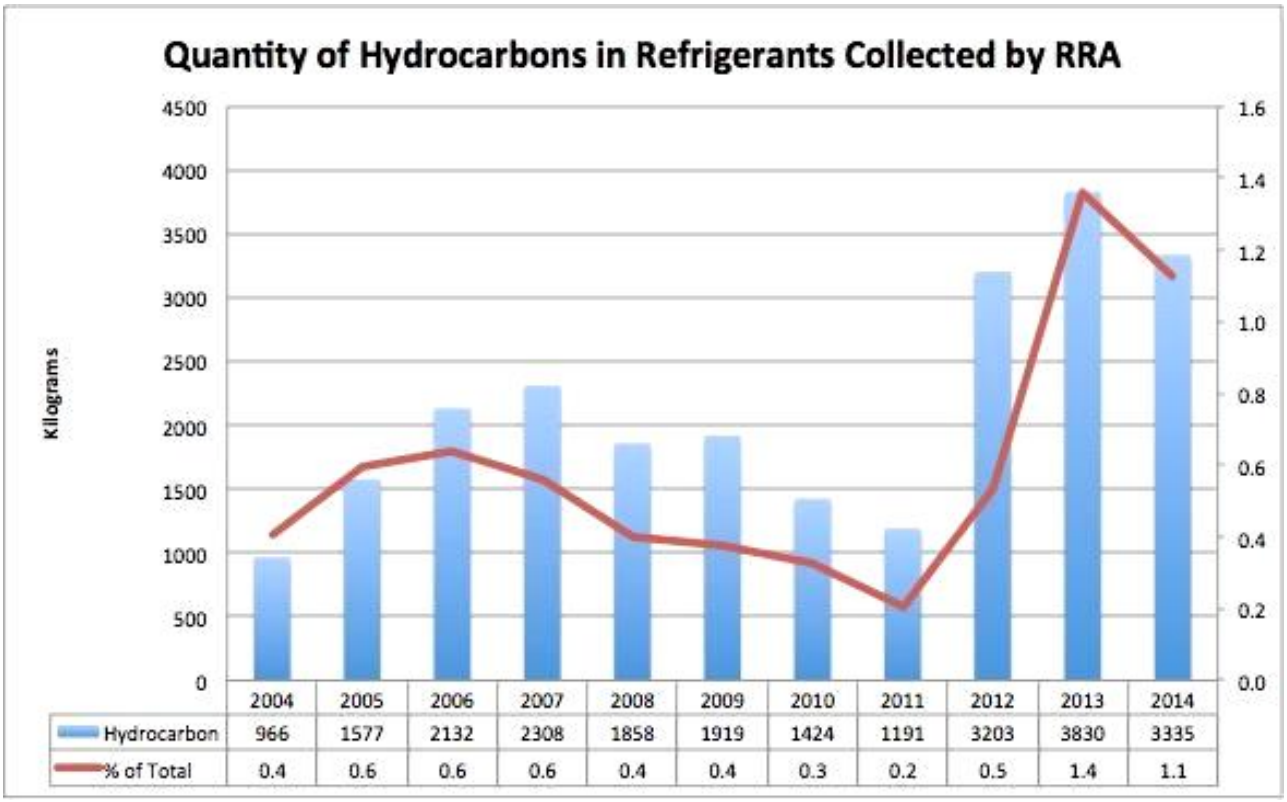
4. *Identify what effect, if any, the introduction and subsequent repeal of the Australian Government's equivalent carbon tax has had on industry's use of SGGs and substitutes and on related WHS risks. This will include assessment of whether anticipated changes in the use and handling of SGGs and substitutes, and those gases' risk profile, have eventuated; whether WHS risk profiles have been affected; and whether the 2012 report's recommendations are affected.*

   The most striking measurable impact during the period when the Australian equivalent carbon tax was in place, was that the quantity of gas received by Refrigerant Reclaim Australia for destruction reduced by half.



   The gas appears to have been reused and recycled, rather than sent for destruction. Since the repeal of this legislation, RRA has noted that the quantities of gas that are now being sent for destruction are returning to pre carbon tax levels.

   A major difference with the gas which is now being received by RRA, is the higher proportion of hydrocarbons that is now being found in gas cylinders. The quantity of hydrocarbons in the total gas collected by Refrigerant Reclaim Australia has risen from less than 0.5 percent in 2011 to 1.2 percent in 2014.



Data provided by Refrigerant Reclaim Australia indicates that every kilogram of hydrocarbon recovered represents an unfunded cost of approximately $23.00 per kilogram. This covers the cost of collection and destruction of the hydrocarbons by RRA. Thus, the cost in 2013 to process the hydrocarbon by RRA was in the order of $95,000. The RRA explain that transporting and processing hydrocarbons for destruction was an ‘unfunded liability’.

Feedback from suppliers and technicians indicated that the majority continued to use the same gas recommended by the OEM for their service requirements. They depended greatly on their gas supplier and industry association to inform them if alternative gases or mixtures would be safe to use. However it is evident that mixed messages were received and there is still ongoing debate in the sector about which substitute gases and mixtures are safe to use and what modifications to engineering systems are required. We were also informed that since the repeal of the equivalent carbon tax, some of the experienced technicians who had modified equipment and trialled hydrocarbon gases have reverted to using the original gas. This eliminated the need for re-engineering RAC equipment to cater for hydrocarbon refrigerant gases.

In relation to WHS risk profiles, Australia is similar to other parts of the world where substitute gases are being introduced to RAC systems primarily due to cost, efficiency and environmental benefits. It was noted in the US that the automotive RAC sector also discussed aftermarket users of substitute gas as a ‘drop in’ in the same way observed by some technicians in Australia. It appears that the technicians themselves are accepting the duty of care that adequate risk assessments have been undertaken to ascertain that the system is compatible for the drop in alternative gas. This is possibly due to the lack of prescriptive guidance such as an Australian Standard that forms the basis for determining safety in design using the new gases. The potential release of AS/NZS 5149 will provide a new baseline for this knowledge in the stationary air-conditioning sector however, it does not apply to the automotive sector.

The recommendations in the 2012 report still remain current in 2015.

5. *Identify and examine details of significant WHS incidents occurring in Australia since the preparation of the 2012 report, and any implications or findings from those incidents relevant to the management of WHS risks posed by trends in use and handling of SGGs and substitutes. Relevant incidents include those occurring in Western Australia in April 2014 and Rochester, Victoria in June 2014.*

5.1 Feedback from the Workers Compensation insurance sector indicates that the insurance rating for the refrigeration and air-conditioning sector is equivalent to the low risk manufacturing sector rates. For example, the WorkCover insurance industry rate in Victoria for automotive electrical services, that includes motor vehicle air-conditioning service, has an insurance rate of 1.054 percent. The rate for the air-conditioning and heating services sector, which includes the stationary air-conditioning and refrigeration equipment, is 1.684 percent.

This is within a context that the industry rate reflects the claims experience of the industry in which an employer operates calculated over five years of claims experience.

It is noted that the current industry rate for these sectors is similar to industry rates for much of the manufacturing sector which range between 1percent and 3 percent. There are industries such as brick laying, plastering, tyre manufacturing, and meat processing which have industry rates up to 8 percent.

The majority of the industry rate is dependent on the WorkCover claims experience. This is predominantly due to musculoskeletal disorders, slips trips and falls, and psychological illness. It is evident from the feedback from the WHS regulators that the risk rating for these sectors is not influenced by the potential WHS risks associated with working with the gas used in the installations.

5.2 In relation to significant WHS incidents that have occurred in Australia since the preparation of the 2012 report, the only two serious incidents that have been identified to us involving injury or fatality occurred in April 2014 in Western Australia and in June 2014 in Rochester, Victoria.

Both incidents are subject to investigation by multiple regulators and, by February 2015 neither investigation reports have been publicly released. The only information we are able to provide relates to conversations with regulators who have been involved in the investigation process from the electrical safety and Work Health and Safety perspective.

From what has been identified to date in relation to the incident in Western Australia, a fire in a van was attributed to ignition of a hydrocarbon refrigerant gas when the temperature and pressure resulted in a release of the gas from a safety valve. This gas subsequently came into contact with a source of ignition and the flames penetrated into the cabin of the vehicle resulting in the injuries to the occupants.

In relation to the Rochester incident in Victoria, where two fatalities occurred in the basement of a building when an explosion and fire occurred, little evidence has been released. Until such time as a full report is provided on this incident, it would be premature to speculate on the exact nature of the incident and causal factors.

5.3 Some information has been obtained from Metropolitan Fire Brigade (MFB) in Melbourne in relation to a fire in the refrigeration unit in a butchers shop in March 2015. It related to a hydrocarbon gas explosion flowing a leak in the system and an ignition source nearby. The Safety Alert from the MFB has been provided in Appendix 7.

5.4 We were informed by Comcare that since January 2013 there have been 11 incidents notified from organisations within their scheme relating to refrigerant gas leaks from air-conditioning units. These gas leaks occurred during operation or maintenance of the plant. No further information was able to be provided without a FOI request. Other potentially relevant incidents include fire or smoke coming from air-conditioning units in operation (10 incidents), electric shock during maintenance (6 incidents) and leakage of water during operation (2 incidents).

5.5 We were also informed by an RAC Inspector about near miss incidents in South Australia, and Queensland, where an experienced electrical safety inspector prohibited the commissioning of industrial sized air-conditioning plants due to their lack of safety integrity for the proposed use of hydrocarbon gas. In both cases, qualified mechanical engineers had been involved in the specification of the design but apparently lacked adequate knowledge and experience in understanding the level of electrical safety and gas safety systems that needed to be introduced at the design and installation process.

5.6 The implications of these incidents reported and the anecdotal information provided by the majority of the interviews conducted for this project indicates that Australia has a challenge to consistently record and investigate and learn from WHS incidents in the RAC sector. There is little information publically available about any of the incidents reported in this study. This is due to the time required to complete an investigation of serious incidents and privacy issues around the release of data and investigation reports.

There are implications for how Australia should manage the awareness of the key stakeholders in the supply chain to potential WHS risks in the RAC sector. Due to the small amount of data and investigation reports available to form the basis for policy and intervention strategies the primary input to the awareness is mainly based on technical input and anecdotal information of incidents. There is a requirement for the RAC industry partners to develop closer collaboration with the WHS regulators, as well as the electrical and gas regulators to develop a more coordinated approach to exchanging information that could impact the WHS risks to workers and members of the community. Part of this process is to encourage greater reporting of minor WHS incidents to enable more data to be available for monitoring trends and opportunities for early intervention. There are also implications for processes to coordinate awareness and education programs that include the knowledge and information from all agencies to ensure an integrated approach to manage WHS risks.

Appendices:

Appendix 1: Review of European Experience with SGG and Substitute Gases

Appendix 2: Review of the US Experience with SGG and Substitute Gases

Appendix 3: Consultation Contacts

Appendix 4: Letters of Introduction

Appendix 5: Legislation table

Appendix 6: Brochure on labels

Appendix 7: MFB Safety Alert

Enc. Brief CV – David C Caple
Brief CV – Brian Eva

Appendix 1: Discussion on the European Experience with SGGs and Substitute Gases

This Appendix has been developed in consultation with Ray Gluckman from the UK. Ray is a consultant who works with the Government in the UK and the European Union in relation to the RAC sector. He has previously consulted to the Australian Government prior to the introduction of the equivalent carbon tax legislation.

The EU has moved faster towards the phase out of ODS and the reduction in the emissions of SGGs than most other parts of the world. Note in Europe the term F-Gas (fluorinated greenhouse gas) is used for HFCs, PFCs and SF_6, referred to in Australia as synthetic greenhouse gases (SGGs).

In 1991, the UK government commenced its investigation of the Montreal Protocol as part of the EU phase out of CFCs and HCFCs. In 1995, the first inventory of F-Gas emissions was developed in the UK. The EU Ozone Regulations of 1995, 2000 and 2009 led to an accelerated phase out of all ODS, including CFCs and HCFCs, faster than for other developed nations under the Montreal Protocol.

In 2000, the European Commission initiated projects on all the varied uses of F-Gases. A consultation process was introduced with meetings scheduled each month over a one-year period to investigate the F-Gas applications. The outcomes of these meetings led to an agreement that Regulations should be developed in Europe in relation to the utilisation of these gases.

The EU F-Gas Regulations of 2006 and 2014 were the first pieces of legislation in the EU that addressed reducing emissions of SGGs.

In 2006, EU F-Gas Regulation (842/2006) came into force. The main policies in this Regulation related to reducing F-Gas emissions through improved containment (e.g. mandatory leak testing, F-Gas recovery, use of trained technicians etc.). There were end use bans applied in a few areas such as novelty aerosols, one component foam and magnesium smelting. There were no bans applied to stationary refrigeration and air-conditioning. The EU also introduced the MAC Directive (40/2006) which created a ban on the use of HFC-134a in car air-conditioning (MAC: mobile air-conditioning) in 2006. That ban applies to new vehicle types from 2011 and to all new vehicles from 2017. During the years following the 2006 EU F-Gas Regulation, a range of new technology was introduced into the refrigeration and air-conditioning industry in Europe.

In 2011, the European Commission reviewed the 2006 Regulations. By 2013, the new Regulations were drafted. After a year of negotiation between the Commission, EU Member States and the EU Parliament, a new F-Gas Regulation (517/2014) was agreed and came into force at the beginning of 2015.

The new EU F-Gas Regulation (517/2014) came into force in 2015 and is much more radical than the 2006 Regulation. It includes a phase down in HFC consumption, in a series of supply cuts starting in 2016. By 2030 there will be a 79% cut in GWP-weighted sales of HFCs in the EU (compared to a baseline, the average HFC consumption in 2009 to 2012). The new Regulation includes several other important features including a number of specific end use bans and a strengthening of various features of the 2006 regulation.

To help agree a suitable HFC phase down schedule, a computer modelling process was introduced to predict how the phase down of HFCs could be introduced across Europe for all end use sectors. This modelling was based on the six main RAC sectors and also other markets that were utilising HFCs.

These included:

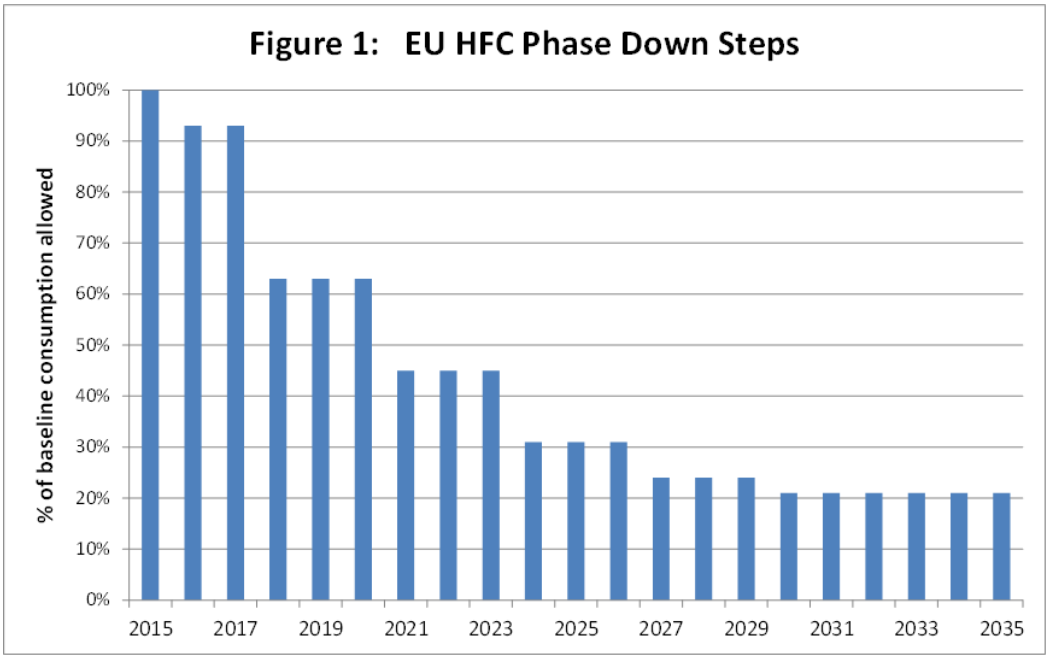
- Domestic refrigeration
- Commercial refrigeration
- Industrial refrigeration
- Transport refrigeration
- Air-conditioning and heat pumps (including split system air-conditioning and chillers)
- Aerosols (including medical inhalers and technical aerosols)
- Insulating foam
- Fire protection systems

Modelling was carried out by both the European Commission and by other industry stakeholders. The most comprehensive model was developed by SKM for an EU trade body the European Partnership for Energy and the Environment (EPEE). This used a total of 50 end use sub-markets, to provide sufficient granularity to predict future HFC consumption. For each sub-market, the model included forecasts for what types of refrigerants could be used in new equipment for systems being replaced between now and 2030. It also made forecasts of the level of consumption reductions that could be achieved through measures such as reduced leakage and use of reclaimed HFCs.

The negotiation of the 2014 EU F-Gas Regulation was complex as it involved 28 Member States, the EU Parliament and numerous stakeholders from industries affected and from environmental NGOs. Many stakeholders agree that the final text is a reasonable compromise and, most importantly, it provides a significant degree of certainty about the future cuts in HFC availability—this is very important as it enables technology providers to start making the required investments to supply low GWP alternatives and equipment based on these new gases.

The most important features of the 2014 EU F-Gas regulation are:

1) **The phase down in HFC supply**. This will operate via a quota system—only companies with a HFC quota from the European Commission are allowed to produce or import bulk supplies of HFCs. The rate of phase down is shown in Figure 1.



2) **Rules on the import of pre-charged equipment**. The HFC phase down would be prejudiced if large amounts of HFCs came into the EU inside pre-charged equipment (such as split system air-conditioning). There are new rules to ensure that pre-charged products are filled with HFCs sourced from the EU quota system.

3) **Various end use bans**. There are a number of bans specified for F-Gases used in new products and equipment. These are summarised in the table below.

New Products and Equipment: EU F-Gas Ban Summary Table

Market Sector	Product Description	Scope of banned F-Gases	Start Date[2]
Refrigeration	Non-confined direct evaporation systems	All HFCs and PFCs	2007
	Domestic refrigerators and freezers[3]	HFCs with GWP > 150	2015
	Refrigerators and freezers for commercial use (hermetically sealed)[4]	HFCs with GWP > 2,500	2020
		HFCs with GWP > 150	2022
	All stationary refrigeration equipment[5]	HFCs with GWP > 2,500	2020
	Multipack central systems for commercial use with a cooling capacity above 40kW [6]	F-Gases with GWP > 150	2022
Air-conditioning	Moveable, hermetically sealed air-conditioning	HFCs with GWP > 150	2020
	Single split systems containing 3 kg or less	F-Gases with GWP > 750	2025
Insulating foam[7]	One component foam aerosols	F-Gases with GWP > 150	2008
	Extruded Polystyrene foam (XPS)	HFCs with GWP > 150	2020
	Other foams (including polyurethane)	HFCs with GWP > 150	2023
Fire protection	Systems using PFCs	All PFCs	2007
	Systems using HFC 23	HFC 23	2016
Aerosols	Novelty aerosols[8] and signal horns	HFCs with GWP > 150	2009
	Technical aerosols[9]	HFCs with GWP > 150	2018
Other applications	Non-refillable containers for bulk product	All F-Gases	2007
	Windows for domestic use	All F-Gases	2007
	All other windows	All F-Gases	2008

[2] All start dates from 2015 onwards are January 1st of year specified

[3] This ban includes both refrigerant and foam blowing agent

[4] This ban includes both refrigerant and foam blowing agent

[5] Exemption for equipment cooling products below -50°C

[6] The primary circuit of cascade systems can use an HFC with a GWP up to 1,500

[7] Exemption where F-Gas is required to meet national safety standards

[8] For entertainment and decorative purposes as listed in Point 40, Annex XVII, Regulation EC/1907/2006

[9] Exemptions: (a) when required to meet national safety standards, (b) medical applications

	Footwear	All F-Gases	2006
	Tyres	All F-Gases	2007

4) **A 'service ban' for certain existing refrigeration equipment**. This ban affects maintenance of existing refrigeration plants using a refrigerant with a GWP above 2500 that contain more than about 10 kg of refrigerant (the precise amount depends on the GWP). The ban starts in 2020 and mainly targets the use of R-404A and R-507A in systems such as supermarket central systems and industrial systems. The service ban is important as it stimulates early cuts in HFC demand. There is an exemption for very low temperature systems (cooling products to below -50^{o}C).

   The service ban will require the replacement of existing high GWP refrigerants (mainly R-404A) with suitable lower GWP alternatives (they must have a GWP below 2500). In many cases existing equipment can be retrofitted with an alternative refrigerant. The retrofit gases that are predominantly utilised are R-407A and R-407F which have around 50% of the GWP of R-404A. These are both non-flammable gases. They often create better efficiency than R-404A, which provides a positive financial driver for the retrofit. Consequently, there are voluntary conversions occurring in the supermarket sector. For example, Marks and Spencer have now removed all R-404A from their refrigeration systems. During the period from 2015 to 2020, it is expected that the majority of supermarkets in Europe will convert to lower GWP gases.

   R-448A and R-449A have recently been introduced and may be used in the near future instead of R-407A or R-407F. They are mixtures that include new HFO refrigerants such as R-1234ze or R-1234yf. R-448A and R-449A have a lower GWP around 1,400 compared with R-404A which has a GWP of 3,922 and R-407F which has a GWP of 1825.

5) **Other features**. Various rules in the 2006 Regulation such as those on leak testing, gas recovery, record keeping, product labelling and technician training have been strengthened and increased in scope (e.g. there is now a requirement to carry out leak testing in refrigerated trucks and trailers).

The phase down will create a shortage of HFCs which will drive up the price of HFCs and create a strong driver to use lower GWP alternatives. The phase down is 'GWP-weighted'—this means that the highest GWP gases (such as R-404A) are likely to be replaced as soon as possible. In the short term gases such as R-407F (GWP 1825) and R-410A (GWP 2088) will still be used in new equipment. However, to meet the phase down it is expected that by 2017, R-410A and R-407F will not be used in new equipment, but will be replaced with alternative lower GWP gases. The development of these new gases for the refrigeration and air-conditioning sector are driven by market forces and also regional variation. For example, progressive regions such as Scandinavia, Germany and the UK, will transition to the alternative gases as their engineering systems are designed to cater for their requirements. However, countries like Spain, Portugal and Greece generally do not have the funding to enable new engineering systems to cater for their needs to be introduced.

In Europe it is noted that in 2012, the average GWP for all HFCs sold was around 2100. To achieve the EU phase down target of a 79% cut in HFCs by 2030, the average GWP for the lower GWP alternatives will need to be in the region of 400. In some markets much lower GWPs can be expected such as the use of ammonia in industrial systems, CO_2 in supermarket systems and use of the new HFOs (including R-1234yf and R-1234ze) in car air-conditioning and in chillers. Use of these 'ultra-low' GWP refrigerants in parts of the HFC market will allow some use of higher GWP gases (such as R-32 with a GWP of 675) whilst still achieving an overall average of 400.

The range of lower GWP alternatives to HFCs will be summarised in Fact Sheets for the United Nations in time for the Bangkok meeting of the Montreal Protocol in April 2015.

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Specific Trends in the Main Refrigeration and Air-Conditioning Markets

1. Domestic Appliances

Before 1990, the majority of refrigeration appliances were utilising CFC-12. This progressively moved to HFC134a. By 1995, isobutane hydrocarbon began to be used in Europe for the domestic refrigeration sector. This is a notable difference with the US, which does not currently use hydrocarbons for this application. HCs have high flammability. International safety codes allow the use of up to 150 grams of HC in domestic appliances.

It is now estimated that there are over 500 million refrigerators in the domestic market globally that are designed to work off small charges of hydrocarbon. This includes the vast majority of domestic refrigerators sold in Australia based on advice from AIRAH. These are factory produced electrically driven hermetically sealed systems using vapour compression refrigeration cycles. They are well designed with little leakage and contain between 50 grams and 300 grams of refrigerant. The majority of domestic units require less than 150 grams when working off hydrocarbon gas.

In February 2015, the US EPA's Significant New Alternatives Policy (SNAP) program expanded the list of approved substitutes to include more low-global warming potential gases. These included:

- Ethane in very low temperature refrigeration and non-mechanical heat transfer
- Isobutane in retail food refrigeration (stand-alone commercial refrigerators and freezers) and in vending machines
- Propane in household refrigerators, freezers, or combination refrigerators and freezers, in vending machines and in room air-conditioning units
- HFC-32 (Difluoromethane) in room air-conditioning units. HFC-32 has one third the GWP of the conventional refrigerants currently being used in room air-conditioning units.

In addition to approving these alternatives, the EPA is also exempting all of these substances, except HFC-32, from the Clean Air Act Prohibition on Venting. The current evidence suggests that their venting, release or disposal does not pose a threat to the environment.

Conditions are required by the EPA in relation to limiting charge sizes and for use only in new equipment designed specifically for the refrigerant, pipe colours, and markers being present.

2. Split Air-Conditioning Systems

It is noted that in the US, there is not a large market for the mini split systems which are more commonly seen in Europe, Japan and Australia.

Currently most new split systems use R-410A. In the Far East and in Europe new models of split systems are now being sold using R-32. In Europe, it is anticipated that in the next two years, the refrigerant gas R-410A (GWP of 2,100) will be replaced in split systems designed to be used with R-32 (GWP of 675). These GWP values are based on the UN Fourth Assessment report. Two new HFC/HFO mixtures with properties similar to R-410A have recently been announced. R-446A (GWP of 480) and R-447A (GWP of 600) may become important alternatives in the split system market.

It is important to note that R-32, R-446A and R-447A all have low flammability (unlike R-410A that is non-flammable). This small degree of flammability is acceptable for many small split systems, but may not be appropriate for large multi-splits, for Variable Refrigerant Flow (VRF) systems as well as those with larger charges of gas.

3. Supermarkets and Food Retail

Larger systems have a central rack of compressors with condensers outside the building. They typically have a charge of around 100 kg of gas. It is noted however, that all RAC systems have a record of leaking the gas over time. By locating the equipment outside the building then the potential WHS risks arising from the leaking gas close to a source of ignition is minimised. These systems in Europe have mainly used R-404A in the past.

In this sector, the European market is moving towards specially designed systems based on CO_2. This requires five times more pressure to be designed into the engineering system than those used for HFCs. The CO_2 systems have negligible GWP (1). Consequently, CO_2 is now becoming the standard long-term solution for these larger supermarket system designs.

For smaller refrigeration units such as ice-cream freezers, the hermetically sealed systems are being introduced with hydrocarbons in the same way as used in the domestic refrigeration market. For example, Unilever has distributed over one million ice-cream freezers across Europe with hydrocarbon as the refrigeration gas.

In contrast, in the US the majority of the small refrigeration units have utilised the SGG systems due to their reliability. The revised SNAP (2015) in the US has approved more substitute gases to be used under strict conditions with new appliances designed for their use.

For condensing unit refrigeration such as in small retail shops with various display refrigerators, there are different requirements. In these small facilities, the heat from these units cannot be ducted back into the shop. Hence, like a split system, there is an evaporative cooling system in the shop with the compressor and condenser outside. A solid piping mechanism is used to link the systems together.

The refrigerant gas used in this application requiring a charge of around 5 kg of gas is emerging as R-32 or new blends with similar characteristics as R-404A, but with lower GWP of 200. It is noted that experimentation has been occurring in this mid-size sector with CO_2 but it is difficult and expensive to implement.

4. Large Office Building Air-Conditioning Units

The majority of the larger office buildings utilise water chillers outside the building to drive their air-conditioning systems. These mainly use R-134a. The smaller chillers use R-410A. Various lower GWP options are becoming available such as HFO-1234ze. As chillers are located generally on the roof or in a machine room it is possible to use low or high flammability refrigerants including flammable HFOs, hydrocarbon, or ammonia based designs.

It is noted in the US, that a number of air-conditioning companies are now developing designs to use R1234ze.

5. Industrial Sector with Very Large Refrigeration Systems

In this sector, ammonia has been commonly used since the 1880s in purpose designed systems with steel piping and integrated engineering components. Large systems are also utilising CO_2 and chilled glycol. In recent times, there have been some big systems based on R1234ze. The level of training and experience required to work with these large systems would indicate that the level of risk would be less than the other sectors where more untrained and unlicensed technicians are employed.

6. Refrigerated Transport

This sector includes refrigeration systems on vehicles including vans, trucks, trailers, intermodal containers and ships. These refrigerated vehicles have mainly utilised R-404A and with some use of R134a. They are moving more slowly to alternative designs than other application areas. Some have trialled systems based on CO_2. The risk of using flammable refrigerants in the refrigerated transport sector is an area of concern. The reluctance to use flammable refrigerants is based on a range of risk factors such as travelling through tunnels, on ships, and through different countries with different safety rules relating to their acceptance.

If a non-flammable solution is required for the refrigerated transport sector, then CO_2 is the most likely refrigerant with an ultra-low GWP. A new blend R-452A has recently been introduced specifically for the transport sector. It is non-flammable, but it has a GWP of 2,100, which may be too high in the long term. R-448A and R-449A are also non-flammable gases and they have a GWP of 1,400. However, they may only be suited to transport systems operating in mild climates. In very hot weather they may be unsuitable.

7. MAC (Mobile Air-Conditioning)

MAC systems are used for air-conditioning of vehicles including cars, vans, trucks, buses and trains.

The 2006 EU MAC Directive bans gases with more than 150 GWP in all new cars and light vans by 2017. The rule already applies to new 'vehicle types' (i.e. a completely new model rather than a model upgrade).

When the MAC Directive was published in 2006 there was no available alternative to the globally used R-134a. EU car manufacturers started developing CO_2 based systems, but when HFO-1234yf was announced in 2009 the industry selected that refrigerant as a more effective way of complying with the MAC Directive.

There are now some vehicle models in Europe that incorporate the R-1234yf as the vehicle refrigerant. By 2017, all new vehicles must use a refrigerant with a GWP less than 150. This is likely to be R-1234yf, although some German manufacturers are still considering CO_2 due to concerns about the low flammability of R-1234yf. Most vehicle manufacturers believe that the safety tests already carried out prove that the use of R-1234yf is safe in cars and small vans.

For larger vehicles such as buses and trains, larger refrigerant charges are required. It is not yet clear if a low flammability refrigerant can be used in such vehicles.

8. Licensing in the European Union

Technicians working on refrigeration and air-conditioning systems require certificates in the same way as those in Australia require a licence. The technical requirements that must be included in an 'F-Gas handling certificate' are defined in the 2006 EU Regulation. The 2014 Regulation slightly extends the training requirements to include 'information on low GWP alternatives'. This is not a requirement for training—just a requirement for awareness of the safety issues associated with alternatives. Training that addresses all alternatives (including CO_2, ammonia, hydrocarbons and HFOs) is outside the scope of the EU F-Gas Regulation.

Information provided by Ray Gluckman (EU technical adviser on the RAC sector) indicates that teaching of technicians in Europe on using hydrocarbon gas indicates that it should not be used as retrofit for HFCs and should only be utilised in equipment specifically designed by the OEM for its use. Retrofit of a system designed for a non-flammable gas (A1) should not be done with a high flammability hydrocarbon (A3).

In the UK, the government approves training bodies and courses. There is a training authority that oversees the quality of the training centres to ensure that they cover the key information and competency requirements for the technicians.

In relation to design engineers, they need to learn the new rules for engineering systems to take new gases such as the mildly flammable A2L gases. For example, when engineers are designing air-conditioning systems for specific room sizes and either a floor mounted or high wall mounted unit, they will need to understand the engineering requirements of these systems to optimise efficiency and safety.

There are some fundamental safety design requirements such as the placement of the wall mounted unit. If the unit is located on the wall at ceiling height and the gas leaks, then the gas would disperse into the indoor space. In contrast, if it is a floor mounted system and the gas leaks, then a gas cloud at the floor level is more likely to occur with a higher safety risk closer to sources of ignition.

A Safety Code needs to be developed in Europe to cater for the new mildly flammable A2L gases such as HFC-32, and HFO-1234yf. They have a much lower safety risk than high flammability gases such as hydrocarbons, due to their low flame velocity and their high ignition energy. It is noted that many of the gases that contain a mixture of gas do have toxicity risks from by-products when they are ignited. These constituent gases have been in existence as part of mixtures used in the RAC sector and there is little evidence of WHS incidents resulting in illness or injury to workers as a result of exposure to these toxic by-products. The utilisation of these gases within the new generation of A2L gas mixtures will result in the same low level of WHS risk relating to human exposure to toxic by-products.
This is one of the next steps that must be taken to safely accommodate the A2L gases as they rapidly become the most likely choice for the split system applications and the automotive sector.

9. International HFC Phase Down

There are on-going discussions for a global HFC phase down under the Montreal Protocol. Under the Protocol (which is specific to ODS) amendment proposals to include a phase down of hydrofluorocarbons have been made each year since 2009. The amendments proposals have not been agreed to date but there is growing support. There is also discussion in relation to the phase down at other international forums such as the G20, 2014 UNGA as well as the US/China joint statement and the US/India joint statement. Four separate proposals were tabled in 2015.

With the EU now having an HFC phase down in place and recent support for a HFC phase down announced by the US and Chinese presidents, there is a reasonable chance that an international agreement can be reached.

A Montreal Protocol meeting in Bangkok in April 2015 discussed a number of technical issues but was unable to agree the final terms for negotiations to begin. These discussions continued during July and will continue again before the Montreal Protocol Meeting of the Parties in November 2015.

The Australian Government announced in August 2015 its intention to encourage all countries to agree to a global HFC phase-down and that it will look to fast track work to reduce its domestic HFC emissions by 85 per cent by 2036, in-line with the most ambitious phase-down proposals under the Montreal Protocol.

Appendix 2: Discussion on the US Experience with SGG and Substitute Gases

This Appendix has been developed in consultation with Richard Lord from UTS Carrier in the US. Richard is an ASHRAE Fellow in the US with extensive experience in US Government reviews of the stationary RAC sector.

The US, Canada, and Mexico are jointly proposing a phase down of high GWP gases under the Montreal Protocol. Progress in approving low GWP gases has been achieved by the EPA in the US in 2015 through the release of the new SNAP approved low GWP gases. The major department leading the implementation of the policies in the United States is the Environmental Protection Agency (EPA). The EPA has adopted a phase down towards lower GWP gases as its goal. The Significant New Alternatives Policy (SNAP) Program is utilised for the registration of new gases and delisting of gases that are banned in the US. The outcome of this process is forcing the designers of RAC equipment to adopt alternative gases and redesign their hardware accordingly. For example, there is a delisting of R404a to be replaced with alternative gases such as R452a and R448a.

In the automotive industry in the US, they use a process called 'Tail Pipe Credits'. This is based on the fuel efficiency of the vehicle from an environmental perspective. The EPA's Tier 2 program was finalised in 2000. This required treatment of vehicles and fuels as a system that needed to reduce sulphur emissions from the gasoline and exhaust emissions from the vehicle. In 2017, the Tier 3 new vehicle emission Standards with lower sulphur content with both the tailpipe and the evaporative emissions from passenger vehicles, light duty trucks, medium duty passenger vehicles, and some heavy-duty vehicles.

The adoption of A2L gases in the air-conditioning systems such as R1234yf in new vehicles being rolled out across the US is part of this broader strategy to reduce the environment impact from this sector.

In 2015, the United State's introduction of the new SNAP rules has enabled greater utilisation of hydrocarbons in hermetically sealed refrigerators, as well as specified commercial refrigerator systems.

Manufacturers will now be in a position to design and introduce into production products based on the new SNAP requirements in the US. It is acknowledged that the introduction of new technology in the US is within a climate where litigation is common. Manufacturers are extremely cautious in making changes towards hydrocarbon gases for fear of subsequent litigation in the event of a safety incident. As a result, hydrocarbons have not been used in the past in the US for large commercial or domestic refrigerators. It is evident that this will now change with the new SNAP rules. This is in direct contrast with the experience in Europe and Australia where hydrocarbons are the predominant gas that is used for these implications. In the US domestic refrigerators are currently using R134a as the main refrigerant gas.

Honeywell is constructing a new plant in Louisiana for the manufacturing of R1234ze. This is a new A2L gas that is used as an alternative in the manufacturing of refrigerator insulation foam.
The determination of gases in the US is based on the ASHRAE Codes. Currently, A2L gases are included in ASHRAE 34. There is a need to revise Standards in the US for incorporation of A2L gases.

To enable a new gas to be used in products in the US, there is a three-stage process required.

1. Utilise technical information and research to then include the gas as part of a Gas Safety Code.

2. Update the acceptable products and gases within the Building Code. It is noted that these are generally revised only every 3–6 years.

3. Each state of the US, and in some instances, major cities, then need to adopt the new Building Codes into their local laws. This can take a long time.

Consequently, changes of technology in the US particularly if there are any safety concerns, can take many years. However, it is evident from our interview outcomes that there are products that are on the market faster once the EPA approvals have been received without going through all of the additional approval processes.

It is noted that the A2L gases are being introduced as part of a global change towards lower GWP gases. Whilst they may be designated as mildly flammable, it is noted that an additive that would impact on the flammability would also impact on the efficiency. The focus in the US in using these gases is on eliminating the potential ignition sources.

The emergence of the A2L gases in the US is more strictly controlled in the stationary air-conditioning sector where Building Codes dictate the safety requirements. In contrast, the automotive sector is not regulated in the US in the same way as the stationary RAC sector.

The introduction of carbon dioxide systems for water heating continues to occur across the US. This product is better for use in colder climates. It provides good refrigeration for large areas but is not suitable for small domestic applications to provide 'comfort cooling'. One of the main applications that is growing in the US is to use carbon dioxide for refrigerated shipping containers.

The ASHRAE Standards provide specific requirements for different applications. For example, ASHRAE 90.1 relates to Building Approvals, whilst Standard 189 specifically relates to Green Building.

In relation to ammonia, it is only used in the US in industrial cool rooms and is banned from application where there is a risk that people could be exposed to gas. For trucks and buses, the predominant gas used in the US for the TRAC sector is R134a for air-conditioning and also refrigeration of the trailers.

From information provided to date, there have been no significant WHS incidents reported in the US as a result of the use of substitute gases in the RAC sector. We were informed that the US technical experts were aware of issues in other countries such as a major incident in China resulting in fatalities. However, these experts acknowledge that the circumstances involving this incident would not be allowable in the US due to the much tighter EPA rules. There are stricter design, maintenance, and operational management systems in place which makes it difficult to compare the level of risk in the US with events such as those described from China.

New refrigerant gases containing mixtures are becoming more common in the US.

The ASHRAE 34 is the process of approving new gases. There is a rigorous process to be followed before they are entitled to use 'R' before the gas number. This is basically the same process as the EU817 gas approval process.

Licensing of technicians in the US is a state based system. It is understood that there are roughly 700,000 technicians working in the stationary air-conditioning sector in the US with approximately 200,000 of them licensed. It is an industry that has an annual turnover rate of around 20%.

California has the tightest controls in this area due to the political environment in this state. For example, in the last 10 years less than 10% of building permits to replace air conditioners with alternative designs and gases have been approved in California, compared to over 90% in other states of the US. Whilst these controls are in place, the enforcement of the controls is dependent on the capacity of the regulator to visit installations to check compliance.

In identifying the emerging issues in this sector, the major challenge in the US is to redevelop the Standards and Codes to take into consideration the A2L refrigerants. This needs to embrace the adequacy of risk assessments that have been undertaken, and to ensure that the installation, maintenance and downstream supply chain processes are clearly understood and documented. If this

process is not followed and WHS incidents occur, then litigation will follow and the insurance rates in this sector would increase significantly.

As part of the change process for using new technologies, the procedures need to be fully documented and incorporated into safety Standards and then put into simple guidance material for training the technicians.

In relation to using substitute refrigerant gases, the US is more conservative and requires significantly more time for research and documentation compared with Europe. This is particularly evident for the stationary RAC sector. Within the US manufacturing sector for vehicles, there is a significant move towards the adoption of A2L gases in new models. These vehicles that will be manufactured in the US will be imported into Australia in forthcoming years.

Appendix 3: Participating industry members and regulators

Industry Organisations

Australian Refrigeration Council
Air Conditioning and Refrigeration Equipment Manufacturers Association (AREMA)
Australian Refrigeration Association (ARA)
Refrigerant Reclaim Australia
Refrigerants Australia (RA)
Refrigeration and Air Conditioning Contractors Association (RACCA)
Automotive Air-conditioning, Electrical and Cooling Technicians of Australia (VASA)
Kevin Lee - Previously of Heatcraft, Chair of ME-006 Standards Committee
Victorian Automobile Chamber of Commerce (VACC)
Air Conditioning and Mechanical Contractors Association (AMCA)
Australian Institute of Refrigeration, Air conditioning and Heating
The Master Plumbers and Mechanical Services Association of Aust
Australian Gas Association

Regulators

Heads of Workplace Safety Authorities (HWSA)
WorkSafe Victoria
WorkCover NSW Dangerous Goods and Electrical Safety
WorkSafe ACT
Workplace Standards Tasmania
Environment Protection Authority
WorkSafe NT
Fair and Safe Work Queensland
Qld Department of Mines and natural resources - Licences hydrocarbons
Worksafe WA
Safe Work SA
ComCare
ACCC - Australian Competition & Consumer Commission
Australian Government Department of Industry
NSW Workcover Authority
Country Fire Authority (CFA) (VIC)
Metropolitan Fire Brigade (MFB) (VIC)
Tasmanian Gas Standards and Safety

Electrical Regulators

NSW WorkCover Authority
Queensland Department of Natural Resources and Mines
Energy Safe Victoria
EnergySafety Division Department of Commerce WA

Training Organisations

E-Oz Energy Skills Australia
Construction and Property Services Industry Skills Council (CPSISC)
Nepean TAFE - Kingswood Campus
TAFE NSW, Hunter Institute
Automotive Training Solutions
Auto Skills Australia

TRACS WA
Tas TAFE

Suppliers and Services

Cooldrive
HyChill Australia Pty Ltd
Fujitsu
TECO Australia Pty Ltd
Refrigeration Parts (Vic) Pty Ltd
Carrier Transicold Australia
Daikin Australia Pty Ltd
Huntsman
Actrol – Reece Pty Ltd
V.S Refrigeration Services
Ricky Marr Refrigeration Murrabit
Gary and Warren Smith Holden dealership
IAQ Consulting
Scantec
Pioneer International
A-Gas
Robert Crnkovic, Consultant

Trade Unions

Australian Manufacturing Workers' Union (AMWU)

Insurance Groups

Insurance Council of Australia (ICA)

International Advice

Gluckman Consulting, UK
European Partnership for Energy and the Environment
Japanese Refrigeration and Air Conditioning Industry Association
Alliance for Responsible Atmospheric Policy, USA
Honeywell (formally the Alliance) Regulation, USA
Richard Lord from Carrier UTS, USA
Heating Refrigeration and Air Conditioning Institute of Canada

Appendix 4: Letters of Introduction

Australian Government
Department of the Environment

Dear Sir/Madam

New report analysing work health and safety data and information for the use of synthetic greenhouse gases and alternatives in the RAC industry.

In 2012, the Department of the Environment (the department) engaged Health, Safety and Environment consultants, David Caple and Associates P/L to provide an independent baseline analysis of the work health and safety (WHS) data and information for synthetic greenhouse gases (SGGs) and their alternatives. The report concluded that there was potential for future WHS incidents in the Refrigeration and Air conditioning (RAC) industry in Australia given the increased exposure to alternative gases with different hazard properties in that industry. The 2012 report is available on the department's website at: www.environment.gov.au/protection/ozone/publications/baseline-analysis-work-health-and-safety-data

The department has again engaged David Caple & Associates P/L to undertake a new report analysing WHS risks for the use of SGGs and alternative gases specifically in the RAC industry. The report will:

- examine the findings and recommendations of the 2012 report and assess whether changes to the selection, use and handling of SGGs and their alternatives have occurred
- consider any known incidents since 2012, involving SGG's or alternatives and the implications these may have for ongoing management of WHS risks
- identify the key safety and regulatory challenges for governments, industry, WHS regulators and other stakeholders
- consider Australia's situation and experience against the international experience and management strategies.

The department is seeking qualitative and quantitative data from a range of RAC industry sectors to establish information on the current use of SGGs and their alternatives. It will be important to understand WHS risks through the life cycle of these products, such as installation, operation, maintenance, and disposal.

If you have any information you would like to include in this project please contact David Caple at david@caple.com.au or via telephone on (03) 9499 9011. The consultants will be aggregating the information to maintain confidentiality and privacy for all individuals and organisations that are consulted. The consultant may also contact your agency in the coming weeks.

I would like to thank you in advance for any assistance you can provide in this project.

Yours sincerely

Ms Rachel Short
Director
Environment Standards Branch
Department of the Environment
January 2015

Australian Government
Department of the Environment

Dear Sir/Madam

New report analysing work health and safety data and information for the use of synthetic greenhouse gases and alternatives in the RAC industry.

In 2012, the Department of the Environment (the department) engaged Health, Safety and Environment consultants, David Caple and Associates P/L to provide an independent baseline analysis of the work health and safety (WHS) data and information for synthetic greenhouse gases (SGGs) and their alternatives. The report concluded that there was potential for future WHS incidents in the Refrigeration and Air conditioning (RAC) industry in Australia given the increased exposure to alternative gases with different hazard properties in that industry. The 2012 report is available on the department's website at: www.environment.gov.au/protection/ozone/publications/baseline-analysis-work-health-and-safety-data

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- consider any known incidents since 2012, involving SGG's or alternatives and the implications these may have for ongoing management of WHS risks
- identify the key safety and regulatory challenges for governments, industry, WHS regulators and other stakeholders,
- consider Australia's situation and experience against the international experience and management strategies.

Development of the report will include consultation with industry representatives, WHS regulators and other government agencies. As a WHS regulator in Australia, we seek cooperation from your agency to assist the consultants to access relevant information. We are seeking any information or advice relating to WHS risks and incidents within Australian workplaces or experienced by members of the public. It will be important to understand WHS risks through the life cycle of these products, such as installation, operation, maintenance, and disposal.

David Caple and Associates P/L will be contacting your agency over the coming weeks. If you prefer to have an agency representative contact the consultants directly please contact David Caple at david@caple.com.au or via telephone on (03) 9499 9011.

I would like to thank you in advance for any assistance you can provide in this project.

Yours sincerely,

Ms Rachel Short
Director
Environment Standards Branch
Department of the Environment
January 2015

Appendix 5: Legislation

This Appendix provides details about the stakeholder duties relating to persons conducting businesses or undertakings including designers, manufactures, importers, and suppliers of plant, structures and substances. This Appendix provides the wording summarised by Comcare in the Guide to the WHS Act *(*2012). Hyperlinks are also provided in this Appendix to the relevant legislation for these duty holders in the other Australian jurisdictions. It is noted that these duties were based on the Occupational Health and Safety Act 2004 from Victoria. The adoption of the National Harmonised Model Legislation in 2011 has resulted in the same wording basically being used by NSW, Queensland, Tasmania, South Australia, Northern Territory as well as Comcare. The duties outlined in the Western Australia legislation are also basically the same for these stakeholders.

The primary link to the publications is found on the SafeWork Australia website.

http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/guide-to-the-work-health-and-safety-act-

The Comcare Guide to the WHS Act (2012).

Further duties of upstream persons conducting business or undertakings (PCBUs) (designers, manufacturers, importers and suppliers)

Designers, manufacturers, importers and suppliers of plant, structures or substances can influence the safety of these products before they are used in the workplace. These businesses or undertakings have a responsibility to ensure, so far as is reasonably practicable, that their products are without risks to health and safety when used at a workplace—throughout their entire lifecycle.

Duty holder	**Duty to ensure health and safety in the workplace**	**Duty to test**	**Duty to provide information**
Designers of plant, structures or substances (section 22)	A PCBU who is a designer of a plant, structure or substance that is to be used, or could reasonably be expected to be used, at a workplace must ensure all workplace activity relating to it including its handling or construction, storage, dismantling and disposal is designed, so far as is reasonably practicable, to be without risks to health or safety when used for its intended purpose.	Designers of the plant, structure or substance must carry out tests and examinations sufficient to ensure that when used for its intended purpose the plant, structure or substance meets work health and safety requirements.	Adequate information must be given to those for whom the plant, structure or substance was designed about its intended purpose, test results and any conditions necessary to ensure that it is safe and without risks to health or safety, when used for its intended purpose. Current relevant information must also be provided, so far as reasonably practicable, to other end users at a workplace upon request.

Duty holder	Duty to ensure health and safety in the workplace	Duty to test	Duty to provide information
Manufacturers of plant, structures or substances (section 23)	A PCBU who is a manufacturer of any plant, structure or substance which is manufactured to be used, or could reasonably be expected to be used, at a workplace must ensure all workplace activity relating to it including its handling, storage and disposal or dismantling is so far as is reasonably practicable without risks to health or safety when used for its intended purpose.	Manufacturers must carry out or arrange tests and examinations sufficient to ensure that the plant, structure or substance is manufactured to meet work health and safety requirements when used for a purpose for which it was manufactured.	Adequate information must be given to any person to whom the product is provided about the purpose for which it was manufactured, test results and any conditions necessary to ensure that when used for its intended purpose it is safe and without risks to health or safety. Current relevant information must also be provided, so far as reasonably practicable, to other end users at a workplace upon request.
Importers of plant, substances or structures (section 24)	A PCBU who is an importer of any plant, substance or structure which is to be used, or could reasonably be expected to be used, at a workplace must ensure all workplace activity relating to it including its handling, storage and disposal or dismantling is, so far as is reasonably practicable, without risks to health or safety when used for its intended purpose.	Importers must carry out or arrange tests and examinations sufficient to ensure that the imported plant, structure or substance meets work health and safety requirements when used for its intended purpose. Alternatively importers must ensure that these tests and examinations have been carried out.	Adequate information must be given to any person who the importer supplies with the plant, structure or substance about its intended purpose, test results and any conditions necessary to ensure that when used for its intended purpose it is safe and without risks to health or safety. Current relevant information must also be provided, so far as reasonably practicable, to other end users at a workplace upon request.

Duty holder	Duty to ensure health and safety in the workplace	Duty to test	Duty to provide information
Duties of **suppliers** of plant, substances or structures (section 25)	A PCBU who is a supplier of any plant, substance or structure that is to be used, or could reasonably be expected to be used, at a workplace must ensure all workplace activity relating to it including its handling, storage and disposal or dismantling is, so far as is reasonably practicable, without risks to health or safety when used for its intended purpose.	Suppliers must carry out or arrange tests and examinations sufficient to ensure that the supplied plant, structure or substance meets work health and safety requirements when used for its intended purpose. Alternatively suppliers must ensure that these tests and examinations have been carried out.	Adequate information must be given to any person who the supplier supplies with the plant, structure or substance about its intended purpose, test results and any conditions necessary to ensure that when used for its intended purpose it is safe and without risks to health or safety. Current relevant information must also be provided, so far as reasonably practicable, to other end users at a workplace upon request.
Duties of people **installing, constructing or commissioning** plant or structures. (section 26)	A PCBU who installs, constructs or commissions plant or structures must also ensure, so far as is reasonably practicable, all workplace activity relating to the plant or structure including its decommissioning or dismantling is without risks to health or safety.	n/a	n/a

Victoria	*Occupational Health and Safety Act 2004* www.worksafe.vic.gov.au http://www.legislation.vic.gov.au/Domino/Web_Notes/LDMS/PubStatbook.nsf/f932b66241ecf1b7ca256e92000e23be/750e0d9e0b2b387fca256f71001fa7be/$FILE/04-107A.pdf
New South Wales	*Work Health and Safety Act 2011* www.workcover.nsw.gov.au http://www.legislation.nsw.gov.au/maintop/view/inforce/act+10+2011+cd+0+N
Queensland	*Work Health and Safety Act 2011* www.worksafe.qld.gov.au https://www.legislation.qld.gov.au/LEGISLTN/CURRENT/W/WorkHSA11.pdf
Tasmania	*Work Health and Safety Act 2012* http://www.thelaw.tas.gov.au/tocview/index.w3p;cond=;doc_id=1%2B%2B2012%2BAT%40EN%2B20150605000000;histon=;prompt=;rec=;term=
Western Australia	Department of Commerce www.workcover.wa.gov.au http://www.commerce.wa.gov.au/worksafe/occupational-safety-and-health-act-1984
South Australia	*Work Health and Safety Act 2012 SA* http://www.legislation.sa.gov.au/LZ/C/A/WORK%20HEALTH%20AND%20SAFETY%20ACT%202012.aspx
Northern Territory	*Work Health And Safety (National Uniform Legislation) Act 2014* www.worksafe.nt.gov.au http://notes.nt.gov.au/dcm/legislat/legislat.nsf/linkreference/work%20health%20and%20safety%20%28national%20uniform%20legislation%29%20act?opendocument

Appendix 6: Codes on bottles

Gas2Go®

your total gas management system

R32 Information

R32 is not a suitable replacement for other refrigerants in existing systems and must only be used in systems specifically designed for R32.

R32 is a flammable refrigerant

R32 is classified as a 2.1 flammable refrigerant with additional handling and storage requirements compared to 2.2 non-flammable refrigerants. When handling flammable gases, keep away from ignition sources, do not smoke and take precautions against static charges.

Reclaim Cylinders

R32 is a higher pressure gas compared to other refrigerants such as R22, R410A and requires a higher pressure 6.2MPa cylinder. Only use Heatcraft Gas2Go® dedicated R32 Reclaim cylinders.

Equipment

Due to the flammability and higher operating pressures of R32, service equipment compatibility (eg. manifolds, gauge, recovery units) must be checked and electrical equipment must not have any potential sources of ignition. All Gas2Go® R32 cylinder valves contain a left hand thread; adapters are available from your local Heatcraft store. Your local Heatcraft branch can assist with information on all compatible equipment.

Health and Safety

The Flammable Refrigerants Safety Guide developed by AIRAH outlines the OH&S risks associated for refrigeration and air conditioning equipment and systems that use a flammable refrigerant. Chapter 11 & 12 covers cylinder handling, storage and transport.

To download a copy of the guide, please log onto www.airah.org.au click on the "Resources" tab, and select "Technical Resources" from the drop-down menu or scan the QR code.

For R32 specific health and safety information and personal protective requirement please read the R32 Safety Data Sheet (SDS) available under the resources section of heatcraft.com.au or scan the QR code.

Please familiarise yourself with the product label, equipment manual, as well as relevant regulations and procedures before using R32 refrigerant.

For technical information please contact our Technical Excellence Centre on **1800 132 350**.

13 23 50
heatcraft.com.au

HEATCRAFT
Worldwide Refrigeration

David Caple & Associates Pty Ltd
PO Box 2135
Ivanhoe East
Victoria 3079, Australia
Tel: 3 9499 9011
Fax: 3 9499 9022

Appendix 7: MFB Safety Alert

SAFETY ALERT

Metropolitan Fire and Emergency Services Board

SAFETY ALERT: 05/2015

Author: Commander Operations Improvement

Authorised by: ACFO Capability Improvement

Issue date: 1 April 2015

Flammable Refrigerant Gases

BACKGROUND

Non-flammable, refrigerant gases used in refrigeration and air conditioning systems were mostly synthetic, with high global warming potential, and included chlorofluorocarbons (CFCs), hydro chlorofluorocarbons (HCFCs) and hydro fluorocarbons (HFCs). Due to concerns regarding the atmospheric effects of these gases, there has been increased use of alternative refrigerant gases with low global warning potential. Most of these alternative gases are hydrocarbons and are flammable.

Flammable refrigerant gases are now widely used in domestic refrigerators, standalone display fridges, fluid chillers and industrial refrigeration. Their use is expected to continue to grow in commercial and industrial areas as well as residential air conditioning.
Refrigerant gases have an odorising agent added although materials and components used within the refrigeration or air conditioning systems may react with the agent over time reducing its effectiveness.

SCENARIO

Recently crews responded to an explosion the cause of which was attributed to a refrigeration unit leaking within an enclosed area which had been established the previous day. This is one of a number of incidents both nationally and internationally being followed up to ascertain the specific dangers caused by the change to alternative refrigerant gases.

RISKS

The risks to fire crews in responding to gas leak incidents is heightened due to the change to flammable and potentially odourless gases used in refrigeration systems.

- Hydrocarbon refrigerants can be highly flammable at normal temperatures and pressures
- Containers of hydrocarbon refrigerants are explosive hazards when exposed to excessive heat
- Hydrocarbon vapours displace air and can cause asphyxiation in confined spaces
- At higher temperature, (>250oC), decomposition products may include Hydrochloric Acid, Hydrofluoric acid and Carbonyl Halides

ACTIONS

- Extreme caution needs to be exercised
- OIC to conduct Dynamic Risk Assessment
- Ensure personnel are wearing QRAE II detectors
- Eliminate ignition sources

Next Review: 01/04/2016
DocCentral: File #1004972

- Isolate supply if possible
- Ventilate the area
- Where appropriate LPG leak procedures should be followed (see below)

Liquid leak/spill/vapour release

- Eliminate ignition sources
- Consult on-site personnel/driver of vehicle to obtain quantity in tank
- Use thermal imaging camera to confirm leak site
- Use water spray or fog to disperse vapour clouds
- Isolate supply if possible
- Evacuate up to 800m
- If cylinder damaged/leak cannot be isolated consider emptying remaining contents using MFB gas flare off kit (carried on heavy rescue) or contacting container's supplier to arrange decanting
- Upright cylinder if safe to do so

Note:
Gas flare off kit can be used up to a maximum cylinder size of 200kg and requires 2 gas flare off operators to be responded with the heavy rescue.

Dangerous Goods Initial Emergency Response - Guide No. 04	
UN No: 1075	
HAZCHEM: 2YE	
Exp. Ratio: 270:1	
LEL 1.5% UEL 10%	
Heavier than air, will collect in low and confined areas	
LPG cylinders are silver, LPG bullets are white	

International symbol for flammable gas

REFERENCE

[Download the Flammable Refrigerants Safety Guide - Airah]

Emergency Response Guide page 133

CONSULTANT PROFILE

David Caple
Director
David Caple & Associates Pty Ltd
Melbourne, Australia

www.davidcaple.com.au
Tel: 61 3 9499 9011
Mobile: 0419 339 268
david@caple.com.au

Summary
David has been an independent OHS consultant with 31 years in private consulting plus 10 years in corporate and research employment.
His technical experience includes OHS and ergonomics/Human Factors research projects in Sweden, Hong Kong, the US, Singapore, Papua New Guinea, New Zealand and the UK, as well as OHS management projects in Australian funded by the Australian and state governments as well as the private sector. Activities primarily involve industry-level research and consulting as well as training, strategy development and legal briefings for a range of large and small companies. These projects involve collaborations with government, employers and trade unions.

Technical qualifications
BSc (Hons), DipEd, MSc (Erg) UK
Past President, International Ergonomics Association (IEA)
Fellow, IEA
Fellow, HFESA Australia
Fellow and Chartered Member, Institute of Ergonomics and Human Factors
Fellow, Ergonomics Society Sweden
Member, Human Factors Society US
Certified Ergonomist, Australia
Certified Professional Ergonomist, US
Senior OHS Auditor, Australia
Adjunct Professor, La Trobe University, Melbourne, Australia
Senior Research Fellow, Federation University, Ballarat, Australia

Experience
- Past President, International Ergonomics Association (IEA) 2006–2009; executive member 2006–2012
- Conducted industry-based OHS consulting in petrochemical, meat, automotive, retail, mining, health, banking, aged care, manufacturing, hospitality, communications, prisons, airlines and public sector industries
- Researched Australian OHS issues for NOHSC (Safe Work Australia) and state governments
- Evaluated OHS legislation, including cost benefit studies for state governments
- Trained OHS managers, supervisors, OHS representatives and employees in several industry sectors
- Provided expert witness advice in court cases and with Fair Work Australia
- Developed OHS strategy plans for major employers and government departments
- Provided technical OHS advice to European Union and United States Congress hearings
- Liaison Officer on ergonomics development with the International Labour Organisation, International Organisation for Standards and World Health Organisation
- Independent member of Victorian Government WorkSafe OHS Advisory committee since 2004 and judge of OHS Awards
- Author and reviewer of peer-reviewed journals
- Presenter at more than 30 international conferences
- Facilitator of public consultation for the Australian Work Health and Safety Strategy from 2012 to 2022
- Independent investigator on OHS Leadership for Singapore Government with top 20 CEOs
- Project leader for the Australian Government on OHS impacts of equivalent carbon tax for SGGs and OHS implications from the recycling of e-waste
- Conducted industry-based OHS risk assessments on emerging issues including bullying, manual handling, stress, working at heights, occupational violence, plant design, supply chains and development of OHS management systems.
- Conducted review for the Singapore Government on OHS leadership and management development.
- Independent ergonomics advisor for Activity Based Work projects for Government and private companies.

CONSULTANT PROFILE

Brian Eva
Director
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Melbourne, Australia

www.evaandassociates.com.au
Tel: 61 3 98223454
Mobile: 0412 465 315
brian_eva@evaandassociates.com.au

Summary
Brian has been an independent OHS consultant with 20 years in private consulting plus twelve years in corporate and research employment.
Extensive consultancy experience in the fields of environmental and workplace occupational health & safety assessments, training, audits and monitoring programmes within Australia and South East Asia. Consulting assignments include environmental compliance assessments, chemical hazard investigations and environmental impact, indoor air quality investigations and IMS preparation and implementation. Extensive experience in workplace hazardous materials risk management including workplace chemicals, asbestos, synthetic mineral fibre, polychlorinated biphenyls (PCB's) and chemical contamination.

Technical qualifications
Dip App Sci (App Chem), Grad Dip Occupational Hygiene
Certified Occupational Hygienist (COH)
Chartered Chemist, Australia (CChem Aust)
Member Australian Institute of Occupational Hygienists
Member Australian Radiation Protection Society
Member Clean Air Society of Australia & New Zealand
Associate Member American Conference of Governmental Industrial Hygienists
Environmental Auditor (Industrial Facilities) – EPA Victoria (re-appointment pending)
Auditor of Port Safety and Environment Management Plans – DOT Victoria
Lead Auditor Environment – RABQSA 005525
Lead Auditor OHS –RABQSA 005525
NATA Signatory Laboratory 14879
Member of WorkSafe Victoria WorkSafe Essentials Provider Panel

Experience
- Conduct of industry based OHS risk management programs in the chemical, petrochemical, forest products, retail, health care, automotive, water, Defence, rail and food industry sectors.
- Workplace risk assessment for new chemical substance introduction.
- Chemical substance/dangerous goods risk management for retail warehousing and trade supply including flammable and refrigerant gas storage and handling.
- Safety and Environment Management Plan Certification/Audit for Port of Melbourne Corporation, Geelong Port, Western Port and Bluescope Wharf.
- OHS/WHS Risk Assessment for theatrical performance: Grease, Lion King, War Horse, King Kong, Legally Blonde, Chitty Chitty Bang Bang, Love Never Dies, Rock of Ages, Wicked, Spamalot, Mary Poppins, Jersey Boys, Hairspray, Phantom of the Opera, Guys and Dolls, Avenue Q, Mary Poppins, Annie, Eat Pray Laugh and How to Train Your Dragon.
- Compliance Audit Team Leader – VCDF WHS Compliance Audits of 72 Joint Logistic Units and Joint health Centre facilities – Department of Defence.
- Project team member – Department of Defence Hazardous Materials Compliance Project.
- Expert Witness VCAT hearing – Odour complaint from food processing factory
- Expert Witness Supreme Court WA – Employee exposure claim to sulphur dioxide fume
- Odour assessment urban land development and impact from sewerage treatment plant – Devine Homes
- Statutory environmental audit and risk assessment of the Air Environment – Cranbourne Stevensons Road Landfill.
- Statutory environmental audit and risk assessment of the Air Environment – Clayton South Regional Landfill.
- OHS Risk assessment and hazardous substance management Bunzl Australia.
- Health Risk Assessment arising from the introduction of Spent Fluid Combustion Catalyst from the oil industry into concrete manufacture.
- Co-Author for SafeWork Australia research projects – Barriers and Enablers to Control Hazardous Chemicals in SME's and Asbestos Exposure and Compliance Study of Construction and Maintenance Workers
- Project team member to the Australian Government on a baseline Analysis of Work Health and Safety Data and Information for the use of Synthetic Greenhouse Gases and Substitutes in the Australian Industry Sector.