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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

Final Report

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Executive summary

This project has reviewed the Work Health and Safety (WHS) baseline data and incidents that have been reported to WHS regulators across Australia from 2007 to 2011. It has also reviewed baseline data available from the major industry associations where synthetic greenhouse gases (SGGs) are currently in use. In addition, it has reviewed data associated with the use of substitute gases including ammonia, carbon dioxide and hydrocarbon gases.

It is evident that there is little data that directly relates to workplace injuries, incidents and workers' compensation claims directly attributed to the use of these gases. However, there have been two major incidents in New Zealand and one in South Australia, including one fatality in New Zealand, where hydrocarbon gases were substituted in refrigeration and air conditioning equipment in workplaces without adequate safety controls. It was also evident from the feedback from industry partners that there may be unrecorded incidents that may occur particularly in the unlicensed 'backyard' refrigeration and air conditioning sector handling gases. These relate particularly to the servicing of smaller refrigeration and air conditioning units, as well as to automotive air conditioning servicing.

It is concluded that there has been a long history of using replacement gases, including ammonia, carbon dioxide and hydrocarbons, in the refrigeration and air conditioning sector in workplaces across Australia for more than 100 years. While there have been some tragic incidents, there has also been extensive experience of safely using these gases in workplaces in systems that have been appropriately designed, constructed and maintained by competent workers.

The feedback from the refrigeration and air conditioning sector would indicate that increased use of the substitute gases can be anticipated in those systems that are designed particularly for use with hydrofluorocarbons after the introduction of the equivalent carbon price for SGGs. This is due to the expected increase in the price of SGGs. There are also changes to production systems being introduced in foam manufacturing and to different products used in fire-suppressant systems. Little change is expected in the aerosol and electrical insulation industries.

It is in the refrigeration and air conditioning sector where the potential for increased exposure to alternative gases and probability for WHS incidents may occur. Of major concern is the handling of these substitute gases by unlicensed and untrained tradespeople who are not aware of the WHS risks to themselves or others. A further risk relates to tradespeople not using appropriate labelling when substitute gases have been installed. This will potentially increase the WHS risks for subsequent technicians who will interact with these items of technology.

The impending introduction of new Australian Standard 1677 and a code of practice on hydrocarbons will form a baseline for improved knowledge and enforcement criteria for the refrigeration and air conditioning sector. This will need to be considered within the context of the current model of national refrigeration and air conditioning licensing of more than 50,000 technicians and 17,000 businesses relating to the use of SGGs, and the licensing model that would be most appropriate into the future.

The most frequently recommended options arising from this review related to the consideration to extend the refrigeration and air conditioning licensing model to include the use of any gases to be used in defined items of plant and equipment. The exact nature and details of the future licensing model is outside the scope of this review other than to note that the existing WHS legislation has requirements for the provision of safe plant and equipment, safe systems of work and that workers are to be provided with information, instruction, and training associated with these safe systems of work.

This review has identified that industry stakeholders need to recognise that each of the WHS regulators operates under a WHS or occupational health and safety Act that stipulates the duties of care for the employers or persons in control of the business or undertaking (PCBU) and the employees or workers. There are specific duties assigned to each of these parties, as well as to importers, designers, suppliers, manufacturers and other duty holders, which would be relevant to the ongoing management of WHS risks involving SGG and substitute gases.

Recommendations

The Commonwealth, state and territory governments will need to implement a range of strategies to address potential WHS risks associated with the use of substitute gases in systems that are not safely designed for their use and where risk controls are not in place for safely handling these gases. There is also a role for them to work through the gas industry supply chain to encourage the suppliers to provide WHS information and support to their clients on safe systems and work practices.

These strategies should include the following.

1. Develop a communication plan in consultation with WHS regulators to inform the community and particularly workplaces, which:
   a. highlights the potential WHS risks of using substitute gases in equipment that was designed for SGGs
   b. targets the sectors that may be least aware of their legal obligations, including by using the supply chain
   c. outlines the legal requirements with respect to risk assessments and correct labelling, storage and handling of gases that are used in workplaces.

2. Promote the development of education programs for engineers with universities and vocational education and training (VET) providers on the safe design, installation, operation, maintenance and decommissioning of plant and equipment using substitute gases. While there are competent engineers already designing large systems based on hydrocarbon use, they are mainly located in the large cities and there are not many available in regional and rural Australia.

3. Broaden the existing Commonwealth, state and territory governments' approach to the licensing of technicians who are working on plants or equipment that contain gases, or expand on the proposed National Occupational Licensing System, to include the safe use of refrigerants including substitute gases.

4. Retain a focus on licensing to cover not just the use of the gas but a broader licence to cover the proposed category of plant or equipment where the gas will be used. For example, the licence could be for tradespeople to work on large coolrooms, fixed installations such as supermarkets, plug-and-operate installations such as refrigerators or split-system air conditioners, or mobile plants such as cars.

5. Ensure that all Australian WHS regulators adopt the Code of Practice developed for ammonia. They should also adopt the codes under development on the safe handling and use of carbon dioxide and hydrocarbons as refrigeration gases used in plant and equipment, through the Safe Work Australia process. This will enable their inspectors to enforce the legal responsibilities under the relevant WHS Act in their state or territory.

6. Consider the requirements for the use and handling of the substitute gas hydrofluoroolefin (HFO-1234yf) if it is registered for use in Australia. This will enable greater knowledge of the potential WHS risks by the users in workplaces.

7. Explore the potential to mandate the use of a left-hand thread on all gas containers that contain a flammable gas, to align the system with that used with industrial gases. This would assist as a secondary indicator of the flammable contents of the container if the labelling is not correct.

8. Monitor the policies and regulations developed by the European Aerosol Association to ensure that the selection of propellants used in Australia and their labelling include the potential WHS risks relating to flammability as well as health impacts identified by that Association.

9. Review the data relating to SGGs and substitute gases with the WHS regulators within the next 12 months to monitor incidents or injuries and outcomes of WHS inspector visits to workplaces, to determine whether the WHS risk profile has changed.

10. Use international benchmarking of SGG policy and safe use of substitute gases to ensure that Australian workplaces maintain their current high standards of WHS performance.

Background

Under the Australian Government's Clean Energy Future Plan, synthetic greenhouse gases (SGGs) listed under the Kyoto Protocol have an equivalent carbon price applied through the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* and related legislation.

As part of the due diligence prior to the introduction of this levy, our company was contracted by the Department of Sustainability, Environment, Water, Population and Communities (the department) to consult with the Work Health and Safety (WHS) regulators and major industry partners to develop a baseline analysis relating to the potential impact this levy may have on Australian workplaces.

The SGGs listed under the Kyoto Protocol that will have the equivalent carbon price applied are:

- hydrofluorocarbons (HFCs)
- perfluorocarbons (PFCs) (excluding gases produced from aluminium smelting)
- sulfur hexafluoride (SF_6).

The price per tonne of SGG is based on the carbon price and on the global warming potential for each gas relative to carbon dioxide. Applying an equivalent carbon price to SGGs will create an incentive to reduce emissions by placing a pricetag on every tonne of SGGs. The equivalent carbon price will encourage:

- increased recycling of SGGs
- improved servicing of existing equipment to reduce leakage of refrigerant gases
- a switch to purpose-designed equipment using lower global-warming-potential refrigerants (only where this is appropriate and meets relevant safety standards and legislative requirements)
- innovation by manufacturers to develop safe, low global-warming-potential refrigerants and suitably designed equipment for those refrigerants.

The equivalent carbon price applies to bulk gas and all equipment and products that contain these gases, unless the product or use is exempted by the Minister for Sustainability, Environment, Water, Population and Communities. These arrangements commenced on 1 July 2012, with a levy applied at the point of import or manufacture.

The policy intent of the equivalent carbon price is to create an incentive to reduce the emissions of SGGs by increasing recovery and recycling, improving installation and maintenance, and developing technology that uses low or no global-warming-potential alternative gases. These substitute gases differ depending on the industry sector. Many of the substitute gases in the refrigeration sector of the industry are generally known as 'natural' refrigerants. These natural refrigerants have the capacity, in the appropriately designed equipment, to achieve the same or better performance and equivalent or greater energy efficiencies.

It was established in this review that there is currently no substitute gas or system that has been identified to replace SF6 as a cover gas in high-voltage electrical switchgear. There is potential to introduce new vacuum technology into this sector which would eliminate the use of gases. Hence it is expected that there will be no new risks associated with this specific SGG in the foreseeable future.

Natural refrigerant gases include:

- hydrocarbons such as butane (R600), isobutane (R600a), propane (R290) and ethane (R1270)
- ammonia
- carbon dioxide.

In moving to substitute gases and technologies, safety issues need to be considered so that they can be managed effectively in order to realise the environmental benefits without increasing the risks to human health and safety.

The objective of this review was to identify data relating to WHS incidents involving SGGs and substitute gases within Australia from industry and other sources for the period 2006 to 2011.

The holistic nature of this review meant that it included as many examples as possible of gas-handling activities along the supply chain. These include:

- importation and distribution of gases
- equipment design and installation of gas systems
- maintenance and servicing of the equipment containing the gas
- reclaiming and recycling of the gas
- disposal of the gas.

In cooperation with the department, our company consulted with the WHS regulators in all nine Australian jurisdictions, including the Commonwealth (Comcare), states and territories. Each was requested to provide any data available on incidents, injuries, investigations and prosecutions involving the use of SGGs or substitute gases.

Consultation also occurred with major industry partners representing the different employer groups and trade unions involved in this industry sector. We also contacted representatives of the different industries and trade groups involved in using SGGs and substitute gases. These included the refrigeration and air conditioning sector as well as the aerosol, foam manufacturing, fire suppressant and electrical industries. Contact was also made with retailers of SGGs and substitute gases, as well as with a sample of tradespeople.

Information was also obtained in relation to the licensing of tradespeople who have completed the vocational education and training (VET) qualifications relevant to their industry sector. This also involved details of the trading authorisation requirements for the handling of SGGs. An invitation was sent to all members of the Australian Institute of Occupational Hygienists to offer their contributions to the review. No formal responses were received from the Institute.

Information was also obtained from major national and international companies that have already begun using hydrocarbon gases or other substitutes for SGGs in their operating systems. It was evident that large international companies such as Coca-Cola, Unilever and Aldi have been using replacement gases for SGGs as part of their ‘green’ corporate profile. It was also evident that large national companies such as supermarket chains are including purpose-built refrigeration and air conditioning systems using carbon dioxide as a replacement for SGGs. This is a reflection of their policy to reduce their greenhouse gas emissions by reducing the use of SGGs and designing systems that use substitute gases that are energy efficient and effectively achieve refrigeration requirements.

Consequently, the background in developing a baseline profile for SGGs would indicate that we are already working within an industry where there are a number of drivers towards greater diversity in gases being used within workplaces. With the implementation of the equivalent carbon price for SGGs, there will be a further driver associated with the price differential between gases for those applications where the substitute gases will have equivalent or better refrigeration qualities and energy efficiency. These alternative gases have been in use, due to their energy efficiencies and environmental benefits, for many years.

It is evident that, while hydrocarbons in particular are already used extensively in the community – for example, LPG as a fuel source – they may also be more frequently used in refrigeration systems. The suitability for retrofitting these gases is dependent on the design of the equipment and selection of other items such as oils. While ammonia and carbon dioxide require specialist engineering designs to enable them to work, it may be possible to use hydrocarbons in some systems designed for SGGs. However, this may introduce WHS risks unless a risk assessment is undertaken to determine whether the substitution is appropriate. This includes considering the chemical properties of the replacement gas, such as its flammability, and assessing the risks associated with controlling leaks of the gas from equipment. The background to this project would indicate that there is potential for substitutions to occur even where this knowledge and appropriate safety controls may not be in place, resulting in risks to workers and members of the community.

The potential for increased use of substitute gases will correspondingly increase the potential scale of risk across workplaces. This in turn raises the requirements for management to ensure awareness of potential WHS risks from unsafe use of substitute gases and to ensure that safe work practices are in place, including adequate training of tradespeople.

Section 1: Data and information provided by WHS regulators

Overview of baseline incident data from WHS regulators

From the consultations that have been conducted with all of the jurisdictions in Australia as well as some feedback from New Zealand, the following observations have been made. This analysis would indicate that there is little quantitative data available from WHS regulators to indicate that the use of SGGs or substitute gases have been identified as a major WHS risk. Further analysis will need to be undertaken in consultation with WHS regulators to determine whether the WHS risk profile of SGGs or substitute gases changes in the future.

1. There have been some notable incidents including one fatality and several serious injuries when substitute flammable gases ignited. In all instances it was evident that the systems had been designed for use with SGGs and appropriate risk controls were not in place. The WHS requirements for the identification of hazards and the conducting of risk assessments and implementation of risk controls were not consistently followed, resulting in these incidents. The required risk-management process is outlined by Safe Work Australia as illustrated below.

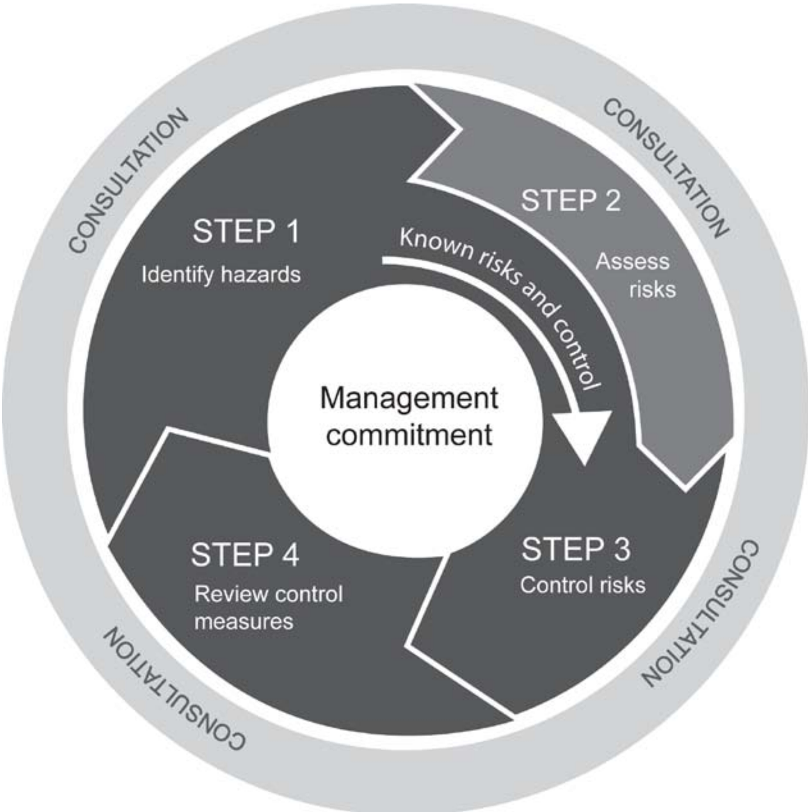


Figure 1: The risk-management process

2. There have also been some notable incidents involving the handling and use of LPG or acetylene industrial gas. These incidents are outside the scope of this review, but the community may associate them as part of a broader WHS risk profile in the use of such gases. It is evident that acetylene and LPG are used by many people in the community. For example, the use of gas bottles for barbecues is common, and incidents of burns from the gas have been reported (Khalessi et al., 2008).

3. The information that has been provided to date on the WorkCover incident databases would indicate that there are very few workers' compensation claims arising directly from the use of SGGs or substitute gases.

4. It was noted by WHS regulators that the specifics associated with their incident reporting information is confidential, and that they were therefore unable to provide details to us as part of this study.

5. Anecdotal information provided by tradespeople interviewed as part of this project would indicate that there have been unreported incidents where a gas leak or minor incident involving ignition of gas has occurred. These stories come predominantly from users of small amounts of gas. This typically involves gases used in automotive workshops and in smaller refrigeration and air conditioning units. The reasons for their decisions not to report these incidents to the WHS regulator could range from embarrassment to fear of being found in breach of the law. It is possible that an increase of reported incidents may occur when greater awareness relating to the mandatory reporting of incidents and injuries is promoted through the WHS regulators, employer associations and trade unions.

6. As a result of known major incidents, the WHS regulators tend to widely circulate details through Safety Alerts. For example, the explosion of a refrigerant gas during the repair of an air conditioning unit in a campervan in South Australia resulted in Safety Alert 84A (available on the Safe Work SA website).

   The WHS regulators also produce guidance material. For example, WorkSafe Victoria, WorkCover NSW and the Division of Workplace Safety and Health in Queensland have all produced significant guidance materials associated with the use of anhydrous ammonia refrigerant systems. They have also undertaken inspector visits to worksites specifically to inspect ammonia use. Each of these jurisdictions visited more than 400 workplaces using ammonia as part of their industry inspection programs, and issued many notices for compliance. WorkSafe Victoria has also produced a handbook for workers titled *Safe operation of cold storage facilities.*

7. The WHS Act and occupational health and safety (OHS) Acts require a risk-management approach to be followed to address workplace hazards. These Acts are supported by regulations and codes of practice relating to dangerous goods and hazardous substances, among other things. All of the gases relevant to this review would need to be managed in accordance with these regulations and codes of practice.

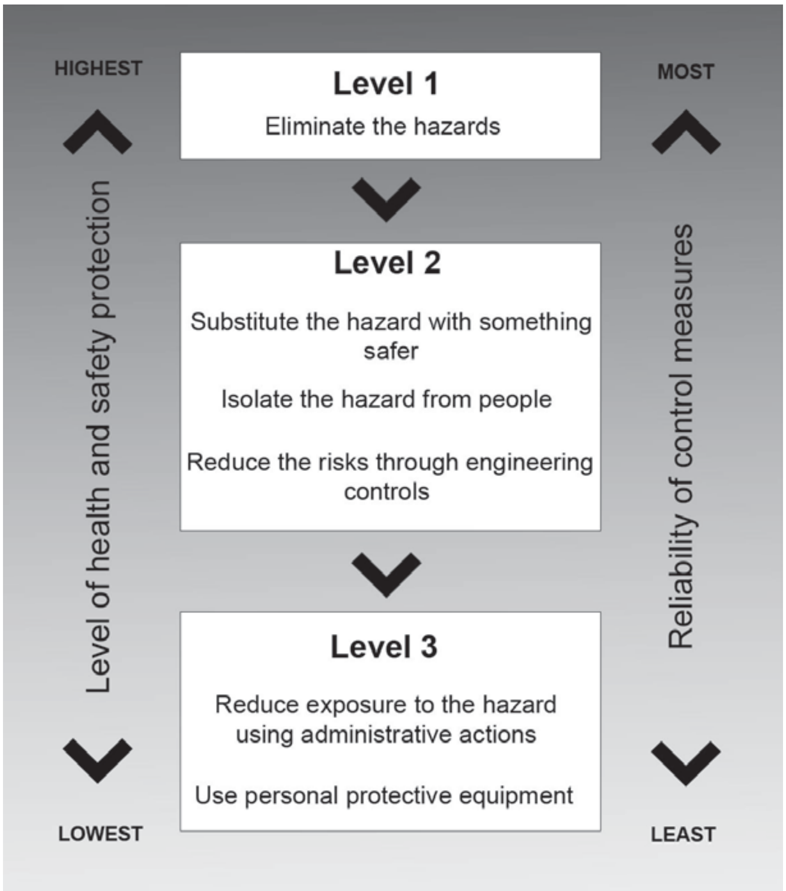
   The inspectors within these regulators have the powers to enforce the obligations outlined in the relevant Acts and regulations, including issuing fines, enforcement notices and prosecutions.

8. Major hazard facilities (MHFs) within each jurisdiction have their own WHS compliance and audit requirements. Many of these facilities contain large quantities of hydrocarbons and are specifically designed, managed and operated in accordance with strict safety procedures.

9. The environmental monitoring and investigation of gas leaks is handled by multiple government agencies and regulators. The impact of gas leaks on workplace health and safety comes under the jurisdiction of the WHS regulators. Other agencies, such as fire services and environmental departments, also have jurisdiction to investigate such gas leaks from the perspective of fire prevention and environmental control, respectively.

10. Gas leaks within workplaces are deemed to be notifiable incidents and as such must be notified to the WHS regulator. WHS inspectors would then investigate such leaks, even if no injury or ill health has been reported. These leaks may also result in fines or prosecutions.

11. Compliance with the WHS legal requirements is based on a risk-assessment approach, with the expectation that the hierarchy of control illustrated below would be followed in determining the risk mitigation actions to be implemented.



This hierarchy requires any identified hazard to be eliminated or a safer substitute used. If these are not reasonably practicable actions, then the hazard needs to be isolated from people, or engineering controls need to be used to reduce the risk. The lowest levels of risk control for WHS compliance involve dependence on safe work practices and training.

It is therefore essential that the focus of WHS risk management should be on achieving the higher levels of WHS protection by using equipment that has the appropriate engineering design and controls in place to minimise leakage of hazardous gases and to reduce the potential for incidents such as fire and explosion to occur within workplaces. This legislative compliance model is not based on the assumption of safe work practices and training alone. Consequently, the focus on licensing of individuals is an issue of current debate within the gas industry but would not be deemed an appropriate compliance strategy by WHS regulators in isolation of higher-level controls being considered.

Section 2: Use of SGGs and SGG substitutes in the refrigeration and air conditioning sector

It is understood that the use of hydrofluorocarbons as refrigerants and in air conditioning applications accounts for approximately 90 per cent of all SGGs imported into Australia (Energy Strategies Pty Ltd, 2008). As a result, a major focus of this review has been the investigation of WHS risks in the refrigeration and air conditioning sector.

Feedback from the WHS regulators would indicate that the risk profile and associated safety hazards involved with the use of SGGs are low, and hence no incident data or compliance guidance have been developed on SGG use.

Four main sub-sectors were reviewed due to their different risk profiles and application requirements. These were:

1. large commercial and industrial installations, such as refrigeration in cold stores for food processing and meatworks and large air conditioning systems for multi-storey buildings

2. fixed installation units, such as refrigerators and display cabinets in supermarkets, which may be installed and subsequently transported to different locations

3. mobile plants fitted with air conditioning, such as cars, buses, trains and trucks

4. domestic refrigeration and air conditioning systems.

The specific details identified through this review are as follows.

1. Large commercial and industrial installations involving refrigeration and air conditioning units

Large refrigeration systems have used hydrofluorocarbons or anhydrous ammonia as refrigerant gases for many years. There have been no specific WHS issues identified with the use of hydrofluorocarbon as a refrigerant gas. Cold stores have been specially designed to suit the gas that is used. Ammonia requires a range of specific components, including safety systems for the detection and management of leaks. Ammonia operates in a liquid state in the refrigeration system but can become a WHS risk when it is released and becomes a gas. As ammonia gas has a pungent odour, ammonia leaks are more easily detected by humans than leaks from other less noticeable substitute gases. Stenching agents are added to substitute gases to enable them to be smelt; however, these can dissipate over time.

Carbon dioxide is also frequently used in large refrigeration systems. Due to the high pressure required in pipework using carbon dioxide, these systems also need dedicated designs and materials. It was noted that there are specialist technicians in Australia with proven competency to design large-scale refrigeration and air conditioning systems using these refrigerant gases. Most of these specialist designers and technicians are located in the capital cities, but there are also many refrigeration and air conditioning systems in rural and remote regions that are not so well serviced. The lack of sufficient competent expertise of such designers and installers with coverage across Australia, particularly with older or smaller-scale installations, raises potential WHS risks. As one stakeholder commented, ‘The safety of any refrigeration system is only as good as the person who welds the pipe and the person who operates and maintains the plant.’

As noted previously, jurisdictional WHS regulators have identified potential hazards, particularly those relating to the handling of ammonia. The program outlined by WorkSafe Victoria would indicate that they continue to focus on this gas as a potential WHS risk. The development of more WHS guidance notes relating to the safe handling of gases in targeted industry sectors and the conduct of their targeted site inspections would reflect the concerns that previously resulted in the issuing of a guidance note relating to ammonia by Victoria, NSW and Queensland.

A major incident in New Zealand involving the use of a natural refrigerant was the Tamahere Cool Store fire and explosion, which resulted in the death of a firefighter and serious injuries to seven others. It would appear that a hydrocarbon gas was substituted into a refrigeration system that had been installed with a fluorocarbon refrigerant. The replacement gas had not been labelled and the system had not been designed for its use. It was evident from the coroner's report that a site assessment was not conducted prior to the changeover of gases and that there was ongoing leakage of the gas from this system, which may have contributed to the explosion. It was also evident that the business's owner and employer were unaware of the WHS risks that existed prior to this explosion.

Dedicated design systems have been implemented for large installations containing ammonia, carbon dioxide and hydrofluorocarbons. They require specialist designers and contractors for installation and maintenance. Systems that use hydrocarbon gases also require specialist designers and maintenance contractors. The WHS risks associated with the use of hydrocarbons appear to be higher when the quality of the design and installation is poor, potentially resulting in leakages. It would also be evident that WHS risks increase when the systems of monitoring and maintaining the gas do not meet safe work requirements. If specialist designers and maintenance contractors are available, then the existing trend to use hydrocarbon gases as a substitute within these facilities may occur within a safe work environment.

2. Fixed installation units such as refrigerators and display cabinets in supermarkets

There is a difference between the selection of gases to be used in new 'greenfield' supermarkets and distribution centres where the refrigeration and air conditioning system has been specifically designed for the building, and the use of substitute gases as discussed above. These designs often use hydrofluorocarbons or, more recently, carbon dioxide as the primary refrigerant gas. This move to carbon dioxide reflects the policy of larger companies such as Aldi and Woolworths to incorporate environmentally sensitive practices in their business plans. One example of a refrigeration system that uses carbon dioxide or ammonia in large supermarkets is the Echo Chill system from New Zealand. In this system, a refrigeration unit containing the gas is mounted on the roof and the system vents into the atmosphere. Consequently, if there was a leak of the substitute gas it would vent directly to the atmosphere. These units are designed to chill water or glycol, which then circulates to the refrigeration display units via pipework.

Many existing refrigeration and air conditioning systems in the commercial and retail sectors use hydrofluorocarbons or hydrochlorofluorocarbons (HCFCs) as the refrigeration gas. Hydrofluorocarbons have been used more extensively, as a result of the phase-out of hydrochlorofluorocarbons under the Montreal Protocol. The use of hydrochlorofluorocarbons in air conditioning equipment has been banned from importation into Australia since 2010, and its import in bulk form will cease by 2016, apart from a small tail of imports allowed to service remaining equipment until 2030. There are no plans to limit the use of hydrofluorocarbons in the workplace, although they are subject to the equivalent carbon price for SGGs. This levy has been introduced to encourage the consideration of gases with a lower global-warming potential. It is this additional financial disincentive that may result in a progressive move towards substitute gases. It has been noted that hydrocarbons perform well as refrigerant gases and also introduce potential energy efficiencies compared with SGGs through the life cycle of the refrigeration process.

One feature of older and often smaller refrigeration systems is that they are prone to leaks, especially if they are poorly maintained. This leakage generally occurs through the pipework and at the interface between the pipework and the air conditioning unit. It has been estimated that the leakage rate can vary from 0.3 per cent for domestic refrigerators to up to 18 per cent for centralised supermarket refrigeration systems. The highest leakage rates, at 40 per cent, are found in marine refrigeration systems (Department of Energy and Climate Change, UK, 2011). The amount of leakage is dependent on the age and condition of the system, as well as on the operating conditions. As a result, the repair and re-gassing of plant and equipment is a standard service element within this industry sector.

Of particular concern from a WHS perspective is the extent of leakage and re-gassing that may occur with older refrigeration and air conditioning systems. This may occur more often in smaller supermarkets and corner stores that use larger old refrigeration units. Apart from the safety hazards and environmental impacts of leakage, there is also the potential for a tradesperson to use a hydrocarbon in place of a hydrofluorocarbon or to retrofit the system without undertaking all the necessary technical procedures. As hydrocarbons are flammable, this introduces potential risks to the tradesperson and to the store in the event that the gas leaks, or that the subsequent servicing of the equipment wrongly assumes that it is a non-flammable hydrofluorocarbon. If a source of ignition is present then the gas can catch fire. This fire risk with hydrocarbon gases is different from the use of hydrofluorocarbon gases, which poses little risk of fire in the event of a leak.

Without appropriate safety precautions in place, the potential for ignition of this gas during subsequent servicing is foreseeable. These precautions include the use of appropriate labelling, redesign of the engineering system for the substitute gas, and the adoption of safe operating procedures. WHS laws require that before any servicing work is undertaken it must be identified whether any WHS hazards are present. If hazards are identified, then a risk assessment should be undertaken and reasonably practicable controls put into place before the servicing is commenced. Further, while the servicing is underway there is a need for dynamic risk assessment to continue to monitor the system of work and to identify whether any additional hazards arise.

It is also noted that the original equipment manufacturer will use labelling indicating what gas is to be used in their equipment. However, subsequent servicing by unlicensed or inadequately trained technicians may increase the probability of inadequate or incorrect labelling if a different gas is used. A new risk factor is introduced when a substitute gas is used and is unlabelled.

It is noted that in Queensland the *Petroleum and Gas (Production and Safety) Act 2004* requires any device that uses hydrocarbon as a refrigerant to be approved before it is sold, installed or used.

3. Mobile plants fitted with air conditioning, including cars, buses, trains and trucks

Mobile plants include any item of machinery that is powered to move, such as cars, trucks, buses and trains. It is estimated that around 10 per cent of cars in Australia are currently using a hydrocarbon refrigerant gas in their air conditioning system (HyChill, 2012; VACC, 2012). The majority of mobile plants would have been using hydrofluorocarbon134a or similar in their air conditioning systems. The majority of these air conditioning systems would have been fitted by the original equipment manufacturer and would have been labelled accordingly.

The servicing of these air conditioning systems in mobile plants should be undertaken by technicians who are licensed to handle hydrofluorocarbon gases. However, there is no licensing requirement for any individual who may be using a substitute hydrocarbon gas, except in Queensland where this is illegal, and in New South Wales where the Motor Industry Repair Industry Authority has a licensing scheme that includes a category for a mechanic licensed to handle natural gases in motor vehicles.

Due to the flexible parts and movement of the hardware in a vehicle or other mobile plant, there is greater potential for damage or leaks to occur compared to a fixed item of plant. Although there is pipework into the cabin of a car, the risk of leakage is minimal. The most likely location of leaks would be in the engine compartment of the vehicle. Larger vehicles such as trains and buses have stand-alone systems that are fitted away from the engine bay.

In Queensland, hydrocarbon gases are banned from use as air conditioning gases in cars. This ban has been in place for more than 10 years, and was introduced primarily to address the WHS risks related to the use of flammable substances. A similar ban was in place in New South Wales between 2004 and 2006, but is no longer in force. It is understood that it was overturned due to changes in the New South Wales trade practice laws.

As with other refrigeration and air conditioning applications, the aftermarket where gases are 'topped up' or substitutes may be used is not regulated for hydrocarbons, except in Queensland. It is noted that there are additional difficulties in enforcing these laws in the small business sector, where the aftermarket tradespeople mainly operate. Consequently, unlicensed handlers of gases may be involved in this work practice.

A primary concern across the industry sector is that these individuals will be unaware of or ignore the WHS risks associated with the use of substitute hydrocarbon gases in the mobile plant sector, placing themselves, the public and other technicians at risk.

While these WHS risks were identified by multiple respondents to this review, it is also noted that hydrocarbon gas has been used in these applications for many years without evidence of such incidents occurring or resulting in damage to plant or injury to people.

Despite the lack of formally reported data relating to such incidents, anecdotal stories were related during this review by tradespeople who indicated that minor incidents had occurred but were not reported to the WHS regulators. It is therefore possible that there have been instances where the use of such hydrocarbon gases in mobile plants has resulted in damage and minor injury, but that these do not appear in any of the WHS regulators' databases.

From a design perspective, it was proposed that if hydrocarbons were to be used within mobile plants, then a method of venting the chamber containing the gas to external air should be part of the design, to reduce the potential for any leakage into the engine compartment or cabin of the vehicle.

Feedback with respect to new cars, particularly from Europe, the US and Asia, would indicate that a replacement gas is currently being proposed for the hydrofluorocarbons. The gas most frequently discussed is a hydrofluoroolefin (HFO-1234yf). It is manufactured by Honeywell and DuPont and has been approved in the European Union, the US and Japan for use in vehicle air conditioning systems. It is also expected to be used in new cars in Australia. Hydrofluoroolefins are a type of hydrofluorocarbon that have a very low global-warming potential compared with the commonly used hydrofluorocarbon refrigerants such as 134a. A range of environmental issues have been raised in relation to this gas due to its manufacturing method and the associated greenhouse impacts (Greenpeace, 2009).

It is noted that this gas is mildly flammable, but significantly less flammable than the hydrocarbon gases. One concern about this hydrofluoroolefin is that a fire involving this gas can release hydrogen fluoride, which can be highly corrosive and toxic. The new vehicles that will be imported into Australia in coming years will potentially contain this hydrofluoroolefin refrigerant gas. With appropriate training and labelling, technicians should continue to handle this gas in a safe manner during the re-gassing and reclaiming processes. As the hydrofluoroolefin is a fluorocarbon refrigerant, there should be a requirement for licensed technicians to handle the gas, although this is not currently a requirement of the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989*.

One respondent indicated that up to 1.5 million cars, refrigeration and air conditioning units may be shredded or sent to landfill each year without being degassed. As well as having potential environmental consequences, this also poses WHS risks for those individuals working within the landfill and recycling industry sectors if flammable gases are contained within these devices.

The Australian Automotive Code of Practice 2008 *Control of refrigerant gases during manufacture, installation, servicing or de-commissioning of motor vehicle air conditioners* stipulates a set of requirements for retrofitting and servicing. This is enforceable through the refrigeration and air conditioning permit scheme. The Refrigerant Handling Code of Practice 2007 also requires the following labelling if a stationary system is retrofitted:

- name of the service organisation
- name and refrigerant handling licence number of the technician conducting the service
- date of the air conditioning service
- date of the last filter change
- type of refrigerant in the system
- type of oil in the system
- type of dye added, if any.

In the Victorian Automobile Chamber of Commerce (VACC) submission to this review, VACC commented that technicians and business owners are faced with the situation where they may not be able to determine what refrigerant gas they are working with, and therefore cannot correctly assess the associated risks. This is particularly the case with hydrocarbons, which can be volatile and explosive substances.

VACC also outlined that the risks are potentially exacerbated when testing the system for leaks. Some leak testers are designed only to detect certain gases, and have in-built protection only with regard to the gas type they are designed for. For example, a digital leak tester that is solely designed for detecting the hydrofluorocarbon 134a may not be able to detect hydrocarbons.

VACC indicated that if a system is not accurately labelled, and if a leaking hydrocarbon-based system is exposed to an ignition source, then a ‘flash’ or explosion may occur. VACC was unaware of any formal reports of this occurring but expressed concern particularly if unlicensed or inexperienced tradespeople were working with these gases in the aftermarket sector. The fundamental recommendation was not to ban the use of hydrocarbons in the automotive sector but to ensure that labelling systems are in place to identify which refrigerant gas is being used.

This concern was also raised in other industry discussions, where the potential for a flash of a quickly burning small quantity of gas was reported from leaking hoses in vehicle air conditioning systems.

It was also noted that there are international industry standards covering the mobile sector. These are released by the Australasian Society of Automotive Engineers (SAE). SAE is a member of, and is represented on the council of, the worldwide International Federation of Automotive Engineering Societies (FISITA). Examples of relevant SAE international standards include the following.

- J2772 *Measurement of passenger compartment refrigerant concentrations under system refrigerant leakage conditions*
  This standard was developed to provide a standard method for measuring refrigerant concentration in a motor vehicle. This is needed to provide consistent inputs to any risk assessment that is done on new refrigerants being developed for mobile air conditioning.

- J2773 *Standard for refrigerant risk analysis for mobile air conditioning systems*
  This standard became necessary due to the introduction of new alternative refrigerants for mobile air conditioning, leading to new requirements for the proper handling of these refrigerants being required.
  The standard states that the potential impacts of unintended refrigerant discharges resulting in high refrigerant concentrations must be investigated and considered. All reasonable hazards affecting people inside the vehicle and in the close proximity of the vehicle, as well as the effects of long-term exposure, must be considered. Possible failure scenarios and safety targets must also be considered.

- J2842 R-1234yf and R744 *Design criteria and certification for OEM mobile air conditioning evaporator and service replacements*
  This standard provides a testing and certification framework for evaporators used in the passenger compartments of vehicles as part of a mobile air conditioning (MAC) system. It is intended to minimise the potential risks to people during normal use or servicing of a MAC system using R-744 or R-1234yf refrigerants.

In addition to these standards, there are others that are specific to leak detection and servicing of particular refrigerants. Should a hydrocarbon refrigerant be used in a mobile air conditioning system, all of these standards are needed to protect the consumer and the service technician.

The main risk factors to be addressed by the mobile air conditioning sector are associated with:

- undetected leaks that have the potential for ignition; it is noted that while the charge size in cars is very small, this increases with buses, trains and trucks

- unlicensed technicians handling the gases without adequate awareness of the associated WHS risks to themselves and others.

4. Domestic refrigeration and air conditioning systems

The WHS risks associated with domestic refrigeration and air conditioning in residential dwellings are low, primarily due to the small amounts of gas contained within sealed refrigeration units. This risk would increase if the maximum charge sizes were exceeded. It is noted that there has been a trend in Europe towards the use of hydrocarbons as the preferred refrigerant gases in refrigeration appliances, due to their qualities as refrigerant gases as well as their energy efficiency. These appliances are now being imported into Australia, and no WHS incidents have been reported to the WHS regulators as a result of their use.

It is noted that Australian Refrigeration Council–licensed technicians for domestic refrigerators require a Certificate II qualification to handle SGG gases. However, they do not need an Australian Refrigeration Council licence to handle hydrocarbons, as this system is limited to the handling of fluorocarbon refrigerants.

There is a need for an Australian Refrigeration Council licence for those who would be involved in the servicing of split-system air conditioning units containing a fluorocarbon refrigerant. Most of the common brands of split systems, such as Fujitsu and Sanyo, comprise basically a simple plug-in system in which all of the technology is fully contained and installed by the manufacturer. These systems comprise an indoor and an outdoor unit. They are connected by pipework that requires installation and servicing by a technician. This technician needs to be licensed if hydrofluorocarbons are used in the system.

There is the potential for subsequent substitution of gases in domestic refrigerators and air conditioners in the future, with associated WHS risks. These risks would be similar to those described above for mobile plants such as cars. However, at this stage, there is no WHS data to suggest that there are any significant WHS risks within this sector.

Section 3: Use of SGG and substitutes in aerosols

The main propellant gases used in aerosols are hydrocarbons. An alternative propellant gas used in aerosols is hydrofluorocarbon 134a, which tends to be used where safety reasons limit the use of hydrocarbons.

The main applications of aerosols include:

- contact cleaning sprays for electrical circuit systems
- aircraft insect sprays
- marker sprays and blast bag inflators used in the mining industry
- propellants for consumer aerosol products such as hairsprays, disinfectants and so on.

The majority of these products are manufactured overseas and imported into Australia.

The Australian Aerosol Association expects that the primary replacements for the commonly used hydrofluorocarbons, such as 134a, in aerosols will be hydrofluoroolefin gases. These have been discussed at international aerosol industry conferences during the past three years. However, large-scale commercial availability and use of hydrofluoroolefins within the aerosol sector is not anticipated until after 2013. The Australian Aerosol Association suggests that the Australian Government should monitor the policies and regulations developed by the European Aerosol Association for guidance on the flammability and health impacts of propellants.

A range of approval processes would need to be in place before substitute gases could be used in many of the aerosol applications. For example, aircraft insect sprays would need to have approvals provided by the World Health Organization (WHO). Current WHO specifications relate to the use of hydrofluorocarbon gases.

Further, any replacement gas would need to be registered for the aircraft insect spray application by the appropriate pesticide regulators.

In the US, the use of gases in the electrical cleaning application was restricted by the Californian Air Resource Board on 1 January 2011. The board restricted the use of any product with a global warming potential above 150 unless it was used in ‘energised’ or ‘live’ circuits. Hence, a blend of hydrofluorocarbons134a and152a (which is flammable) was introduced to achieve an adequate global-warming-potential rating.

One of the main concerns for aerosol users relates to the replacement of the hydrofluorocarbon 134a with more flammable products without appropriate information and education about their risk profile. The application of particular concern relates to mining industry operations in remote communities, which need to know whether the reformulation of gases is more flammable.

It is noted that exemptions from the equivalent carbon price for SGGs have been provided for aerosol applications known as metered dose inhalers (MDIs), commonly used in asthma treatment.

Within the global context, the Australian Aerosol Association indicated that Australia is a very small market, with less than 250 million units per year. This compares with 5 billion units in Europe and 3.5 billion units in the US, within a total global context of 12 billion units per year. Within this global market, many of the decisions relating to gas use in aerosols are made in other parts of the world.

Section 4: Use of SGG gases or substitute gases in fire suppressant systems

The main extinguishing gas used in the fire suppressant industry is a SGG known as FM200 (100% hydrofluorocarbon 227ea). This is filled into cylinders for use in fire suppressant systems and then pressurised with nitrogen.

With respect to baseline WHS incidents, the Fire Protection Industry (ODS and SGG) Board indicates that while there have been incidents overseas regarding the use of pressurised cylinders containing SGGs, no incidents have been identified within Australia. However, it should be noted that it is not the board's role to monitor and record such incidents.

Substitute gases used in fire suppressant applications have included carbon dioxide since the early 1990s, Argonite (a blend of the inert gases argon and nitrogen) since the early 1990s, and Novec 1230 (a synthetic fluorinated hydrocarbon) since around 2001. These gases operate with different processes. For example, Novec 1230 is distributed in the fire protection system as a liquid, and then flashes to vapour on release through the nozzle. FM200 is 'gasified' by being pressurised with nitrogen, and is distributed through the fire protection system in vapour form.

The major driver of these changes was the suppliers' desire to improve their environmental profile by moving to environmentally friendly alternatives. However, it is noted that some of these alternative gases are not as efficient for putting out a fire as FM200 and other SGGs, unless the system has been designed for these gases. This relates to the volume of the alternative gas required compared to the volume of FM200 required. This is also true when comparing SGGs with the older-generation halons. The SGGs, which replaced the halons, were less efficient than the halons.

Feedback from the industry indicates that different gases and systems, including those using SGGs, must have detailed specifications developed in order to address the requirements and potential risks identified for the installed system. For example, consideration must be given to technical factors such as the number of cylinders that may be required, and the capacity for cylinder storage within the workplace may limit the selection process.

It is expected that there will be a move away from SGGs due to the introduction of the equivalent carbon price, and that companies will suggest that clients consider the alternatives, such as Novec 1230, inert gas blends (such as IG541 or IG55) or water mist. The water mist system uses a fine water spray of small droplet sizes that quickly turns to steam to eliminate oxygen from the fire and to wet the fuel source.

Under the Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995 (see Section 6), there is a national permit system administered by the Fire Protection Industry (ODS and SGG) Board on behalf of the Australian Government. The system provides for Extinguishing Agent Handling Licences for technicians handling ozone-depleting substances or SGG extinguishing agents. Businesses that acquire, possess, or dispose of these agents must use a licensed technician and have an Extinguishing Agent Trading Authorisation licence.

There are six different categories of experienced person licences. These are:

- portable fire extinguisher maintenance licence
- fixed system installation and decommissioning licence
- fixed system testing and maintenance licence
- recovery, reclamation, fuel and recycling licence
- warehouse maintenance licence
- control systems installation and decommissioning licence.

When the permit scheme was first implemented, no national training material existed for the above categories and handling licences were issued to those technicians who could show they were experienced. However, training material and assessments are now available from several registered training organisations. As competencies can now be obtained through coursework, recognition of prior learning or assessment of the technician's competency, the Fire Protection Industry (ODS and SGG) Board is progressively transitioning licensees from experienced person's licences to qualified licences for these categories.

Within these competencies, there are units specific to WHS requirements. These include:

- Safely remove materials and loads in the workplace
- Prepare for installation and servicing operation
- Participate in workplace safety arrangements
- Receive and dispatch ozone depleting substances and synthetic greenhouse gas containers.

In Queensland there is a specific requirement for a Building Services Authority Occupational Licence.

It is noted that a technician does not need to hold an Extinguishing Agent Handling Licence if they are using non–SGG or ozone-depleting substances; this licence is for environmental protection.

Companies that are registered with the Fire Protection Industry (ODS and SGG) Board are subject to audits to ensure compliance with handling processes and risk management requirements.

The Fire Protection Industry (ODS and SGG) Board has developed a code of practice to help technicians better understand the regulations. The code of practice also provides other information in the safe handling of SGGs and ozone-depleting substances, as well as environmental controls.

The major concern from this industry sector is that training and licensing are not required for the use of substitute gases such as inert gases and Novec 1230. Training and licensing are currently only required for SGG and ozone-depleting substances.

Section 5: Use of SGGs and substitute gases within the foam manufacturing sector

The foam manufacture industry uses SGG agents in the foaming process for the manufacturing of products such as insulation for hot-water systems and refrigeration equipment. In the past, foaming agents such as the hydrochlorofluorocarbon gas HCFC141b were used as primary gases in foam. However, hydrochlorofluorocarbons are an ozone-depleting substance now being phased out under the Montreal Protocol. Hydrofluorocarbons are often used as replacement foaming agents for hydrochlorofluorocarbons, and can be readily used in production systems that were designed for hydrochlorofluorocarbons. The major Australian supplier of foam agents recently exhausted its stock of HCFC141b. The replacement foaming agent will be the new M1 (or similar proprietary) system, which is a blend of the hydrofluorocarbon gases HFC 245fa and HFC 365mfc. These gases (HFC 245fa and HFC 365mfc) are not currently subject to the equivalent carbon price. The change to the M1 blend is expected to occur with most manufacturers, due to the cost of conversion to a system designed to handle hydrocarbon gas. The cost of a new facility and equipment to safely run a hydrocarbon system is not very high. However, retrofitting existing equipment and buildings due to the need for additional safety features is more problematic and expensive. This cost may limit the possibility of retrofitting being viable.

One of the major foam manufacturers in Australia has built a new facility to use hydrocarbons (pentane) as the foam blowing agent. This facility has integrated a range of design features to address WHS risks that may be present as a result of using the hydrocarbons.

The management system in the workplace comprises comprehensive programs, including:

- development of safe operating procedures
- training for operators and contractors
- equipment that is specifically designed for the use of the gases
- records of all training being kept by the OHS department.

One of the major manufacturers of polyurethanes and polyol systems uses the M1 system for the manufacturer of polyurethane foam products.

Large downstream customers have completed the transition from using chlorofluorocarbons (CFCs) (ozone-depleting substance phased out under the Montreal Protocol) to using hydrocarbons (isopentane) many years ago. For example, for Electrolux this transition occurred in the late 1990s. Also, Electrolux, Rheem and Dux are now equipped to run hydrocarbon systems for the foaming of insulation for refrigerators and hot-water units. Isopentane and cyclopentane are commonly used. The type of gas used will depend on the thermal properties required from the foam, and will vary depending on the application of the foam.

For small-volume users with limited access to technician and WHS support, a supply chain model is in place. The major suppliers of the raw materials, such as Huntsman, supply literature and safe-handling information to their customers. This includes safe handling of the M1 gases. The cost of upgrading plant and equipment to handle the additional safety requirements for hydrocarbons may result in some users ceasing manufacture of the foaming products in Australia, and potentially importing the finished goods from cheaper suppliers in other countries.

The option of cheaper gases such as carbon dioxide or alcohol-based products used in foam insulation is not considered to be a viable alternative, as foams blown with these substances do not provide the thermal properties required and more agents may be used, therefore decreasing overall efficiency while increasing costs.

Spray foam used in insulation, for example in residential roof spaces, requires a non-flammable agent for safety reasons. This situation would be the case for any application where spray foam is applied in a confined area. Consequently, substitute products would need to be non-flammable for use in these applications.

Other substitute products for hydrochlorofluorocarbons, such as hydrofluoroolefins and hydrofluoroalkanes (HFAs), may potentially be suitable for use in the foam industry. The suitability of both products is yet to be assessed in Australia. They are still under development for this application and are unlikely to be available in Australia until 2014.

Section 6: Training and licensing of gas use

The Commonwealth *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* (the OPSGGM Act) controls the manufacture, import and export of all ozone depleting substances and their SGG replacements. It also controls the importing of refrigeration and air conditioning equipment containing fluorocarbon refrigerants such as hydrofluorocarbons, and fire protection systems containing hydrofluorocarbons. The OPSGGM Act grants the Commonwealth the power to create a nationally consistent system to control the end uses of these harmful gases. The Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995 (the OPSGGM Regulations) support the OPSGGM Act and affect people who buy, sell or handle ozone-depleting substances or SGGs. The following discussion addresses the regulations first as they apply to the refrigeration and air conditioning industry, and then as they apply to the fire protection industry, as the regulations have similar but not identical requirements in each industry.

People working in the refrigeration and air conditioning stationary and automotive industries who handle these substances in bulk or in equipment are required to hold a Refrigerant Handling Licence. Companies or people who acquire, possess or dispose of these substances are required to hold a Refrigerant Trading Authorisation (see Section 2). The Australian Refrigeration Council has been appointed as the RAC Industry Board to administer these regulations.

The Regulations do not cover ‘natural’ refrigerants such as hydrocarbons. However, any individual (including a repairer or dismantler) who removes fluorocarbon refrigerant from a refrigeration or air conditioning system, including for the purpose of replacing this gas with hydrocarbons, must hold as a minimum a Restricted Refrigerant Recoverer’s Transitional Licence. Individuals who handle scheduled fluorocarbon refrigerants without a licence are committing an offence.

Currently there are more than 50,000 technicians and 17,000 businesses in Australia licensed by the Australian Refrigeration Council. The Australian Refrigeration Council has 11 field officers who visit authorised agents to conduct audits. They are located in each state and territory of Australia except for Tasmania and Northern Territory, which are covered by other state/territory offices.

Depending on the application area, different certificates are required by technicians. For example, there is a Certificate II course relating to automotive air conditioning and another Certificate II course relating to split-system air conditioning. There is also a Certificate III course relating to full air conditioning and refrigeration. These are all conducted through vocational education and training providers around Australia and are endorsed through the National Qualifications Training Framework.

These courses involve theory, which is taught in the classroom, as well as on-the-job training with designated mentors overseeing the practical work.

There is also an expectation that apprentices will undertake the one-day Construction Induction course to provide them with the White Card or its equivalent from the relevant jurisdiction in Australia. This course specifically covers WHS issues relating to working on construction or construction-like worksites. Apprentices are also expected to complete Level 2 first aid training.

Within these vocational education and training programs, there are modules relating to WHS practices in the workplace. These cover responsibilities for health and safety and risk management processes in line with the WHS Act, regulations and codes of practice. It also covers safe work practices relevant to specific tasks that would be undertaken. The Standards for Heating Ventilation and Air Conditioning and Refrigeration (HVACR) professional training is available from the Electro Comms and Energy Utilities Industry Skills Council Ltd, trading as EE-Oz. This training includes a significant emphasis on WHS and legal requirements of the OPSGGM Act. Work is being conducted by EE-Oz to address these needs for hydrocarbon, ammonia and carbon dioxide refrigerants. The associated training is almost entirely provided by vocational education and training providers.

There is a notable lack of degree-level training focused on the engineering design of systems to use substitute gases. Feedback provided by the industry associations indicates a lack of sufficiently qualified and experienced engineers across Australia with the competence to design systems using substitute gases. While those who are qualified and competent have been designing systems using hydrocarbons for many years, there are too few engineers across Australia where this expertise is required.

With respect to the risks involved in refrigeration and air conditioning, specific documentation components are included in the training. These include:

- occupational work hazard identification
- identifying health and safety risks to workers
- classification of risks
- documenting control measures intended to eliminate or reduce the risk that could potentially arise during the conduct of work activities
- consultation processes with those involved in refrigeration and air conditioning work.

At vocational education and training (VET) providers in NSW, a ‘train the trainer’ program has been delivered since 2008, with a range of programs scheduled for 2012. It has focused on the use of hydrocarbon gases in refrigeration systems.

This course involves a theory unit that covers the following topics:

- the differences between synthetic and ‘natural’ gases
- applications and uses of ‘natural’ gases
- different types of hydrocarbons and their physical and chemical properties
- compatibility between different gases in working systems
- OHS legislation obligations in NSW and nationally
- other legislation and requirements including those relating to dangerous goods, the OPSGGM Act and Regulations and Australian Standard AS 1677.

The course also involves a demonstration of how to service refrigeration equipment involving natural gases. Participants also undertake a competency assessment program in which they must demonstrate how to correctly service refrigeration equipment. The total duration of the course is 10 contact hours.

These courses are being conducted in 12 NSW vocational education and training providers: three in Sydney and nine in regional NSW.

It is noted that the uptake of these courses has been slow, primarily due to the costs of travel and accommodation to attend the program for regional-based trainers.

From an education perspective, there do not appear to be many opportunities currently offered through the vocational education and training providers to transition knowledge and competence of the technicians who are licensed to handle hydrofluorocarbon gases to also safely handle hydrocarbon gases in the refrigeration and air conditioning sectors. The Australian Government has provided some funding to assist in the conduct of this training. The primary WHS concern relates to those people who do not attend these training courses and are untrained in relation to safe use of the substitute gases. Further, they are not required to hold a licence to handle hydrocarbon gases within this sector.

Our consultation process with technicians working in this sector indicated that they regard the Australian Refrigeration Council licensing process highly. They also indicated that they would expect to receive information from the Australian Refrigeration Council and their industry association if there were any particular advice in relation to WHS risks associated with their work duties. The technicians noted that there has been limited specific advice provided prior to the introduction of the equivalent carbon price for SGGs with respect to any particular hazards that may be faced by the technicians working in this sector. An article was published in the industry newsletter *Cool Change*, sent to all licensed technicians, and a WHS factsheet was published on the department's website before 1 July 2012.

The technicians also indicated that they would expect advice to be coming from their WHS regulators, who may have more technical knowledge as to what the hazards might be and how they should be mitigated for their industry application.

The technicians further noted that those who are licensed are more likely to be audited by the Australian Refrigeration Council in relation to their work practices. This audit process is part of the governance of compliance from the Australian Refrigeration Council. However, there is no such auditing undertaken of worksites where unlicensed technicians may be undertaking the same work duties. This is because these workplaces would be unknown to the Australian Refrigeration Council. It is noted that the Australian Refrigeration Council undertakes 'drive-by' visits to businesses premises where unlicensed work may be occurring.

People working in the fire protection industry who handle ozone-depleting substances or SGGs in bulk or in equipment are required to hold an Extinguishing Agent Handling Licence (see Section 2). Companies or people who acquire, possess or dispose of these substances are required to hold an Extinguishing Agent Trading Authorisation. The Fire Protection Association of Australia has been appointed by the Australian Government as the Fire Protection (ODS and SGG) Industry Board to administer the OPSGGM Regulations.

A licence granted under the OPSGGM Regulations includes the condition that the licensee carries out work, to which the licence relates, in accordance with any standard set out in the regulations. There are industry codes of practice for the refrigeration and air conditioning, automotive and fire industries designed to provide a guide for technicians to reduce emissions and comply with relevant Commonwealth legislation.

Section 7: Australian Standards and Codes of Practice

At international level, it was noted that the Climate and Clean Air Coalition of countries has been formed to promote climate-friendly alternatives and technologies, minimise hydrofluorocarbon leaks and encourage recovery, recycling, reclamation and destruction of hydrofluorocarbons. Norway and Sweden are reducing the amount of these gases by restricting the quantities allowed to be imported into their countries. In 2006 Denmark instituted a general ban on their use in refrigeration and air conditioning systems requiring more than 10 kg of refrigerant, as well as household cooling and freezing appliances.

The predominant Australian Standard that has been the basis of guidance in the refrigeration and air conditioning industry has been AS 1677:1998 *Refrigeration systems – safety requirements for fixed applications*.

Standards Australia has established a working party known as Committee ME006. This is a mechanical and electrical sub-committee for the refrigeration and air conditioning sector. The committee is updating AS 1677:1998 to align with the new draft international standard ISO 5149. It is primarily focused on commercial installations of both fixed (shop displays) and stationary (cool rooms) applications. It includes mobile trucks but specifically excludes passenger vehicles.

The revised AS 1677:1998 would be based on the International Standard ISO 5149. It is envisaged that Committee ME006 will add a series of appendices to ISO 5149 and release it as a draft Australian Standard. This standard will most likely become known as AS 1677:2012. These appendices are necessary where local regulation or legal requirements conflict with the content of the International Standard. It is envisaged that there will be only minor changes required.

The new AS 1677:2012 is expected to be released for public comment around October 2012. It is unlikely to become a recognised Australian Standard until some time in 2013.

One of the main issues of disagreement within the industry in Australia relates to the charge limits for hydrocarbons that will be specified in this new standard. Under the proposed draft standard these limits will be reduced from those currently acceptable. It is understood that the reduction in limits has occurred internationally, and in particular within the British Standards. Feedback from suppliers and users of hydrocarbons in the refrigeration sector would indicate that they do not see any benefits to be gained from more restrictive limits. If they were to be put in place, it would limit the exposure of hydrocarbon use in air conditioning such as large ducted systems in buildings that may use chillers containing around 150 kg of gas. Such an installation has already been commissioned in Perth (Wallace & Taylor, 2012).

A new feature of the revised standard would be the recommendation for leak testing. This may include more frequent testing and potentially the installation of mandatory leak detectors in larger systems. Mandatory leak testing and requirements for leak detectors would be a decision at government level. Currently there are no proposals before the government for mandatory leak testing in Australia.

AS 1677:1998 is primarily based on controls for the use of SGGs. It does not cover the full spectrum of WHS issues. The new ISO 5149 does provide details on the safe application of hydrocarbons, carbon dioxide and ammonia.

Apart from the current initiative with Australian Standards, the industry is also developing a code of practice relating to hydrocarbons. A code of practice for ammonia has been developed and code of practice for carbon dioxide will be developed in the future. The draft code of practice for hydrocarbons will be based on the requirements outlined in ISO 5149 and the existing British code of practice. Currently, there are no Commonwealth, state or territory regulations that cover the safe use of hydrocarbon gas as a refrigerant except in Queensland where there are specific restrictions on the use of hydrocarbon gases in equipment and prohibition from their use in vehicles. The proposed code of practice is intended to include information on the transportation, storage and signage required for the use of hydrocarbons. There is state and territory regulations relating to the use of hydrocarbon gas as a fuel gas, such as in gas cylinders for barbecues.

Consultation in the development of the code of practice on hydrocarbon has included representatives from the Commonwealth, major regulators in Victoria, NSW and Queensland, and other stakeholders from the industry associations, major companies, fire services and the education sector.

Under state and territory WHS legislation there are specific regulations and codes of practice that must be complied with relating to the storage, handling, transportation and use of dangerous goods and hazardous substances. These requirements require a risk-management approach to be taken to identify the hazards and assess the level of risk. The hierarchy of control must then be followed to eliminate the hazard or, if this is not reasonably practicable, reduce the risk using substitution or engineering controls. The use of training and safe work practices is seen as the least reliable form of risk control. Compliance with the WHS regulations and codes of practice is overseen by the WHS regulator in each jurisdiction, which has the power to prosecute with fines and prison terms if significant breaches are determined by the courts.

One of the primary requirements under AS 1677:1998 is to conduct a site assessment when a change of refrigerant occurs. It is envisaged that this will continue to be a requirement when refrigeration contractors are exchanging refrigerants. Such information would be included as part of an appendix to the new Australian Standard and will be elaborated within the code of practice on hydrocarbons.

Section 8: Reclaiming and/or recycling of gases

As part of their trade training and in accordance with the licensing requirements for the use of SGGs, licensed refrigeration and air conditioning technicians are trained on how to reclaim these gases. The reclamation process involves safe removal of the gases from equipment, return to a gas wholesaler and transfer to consolidated vessels for return for destruction.

For fire protection, with the application of the equivalent carbon price, the industry sector is moving to reclaim/recover and then recycle the FM200 back to the manufacturer's specifications. No Australian Standards have been developed yet but the industry is working on a code of practice. This would be adopted by the Fire Protection Association of Australia. FM200, unlike refrigerants, is likely to be recovered without too much contamination and will simply require drying, filtering and then separating of the nitrogen from the FM200.

Holders of import licences under the OPSGGM Act who import hydrofluorocarbons and perfluorocarbons in bulk or in refrigeration and air conditioning equipment are required to meet product stewardship obligations by joining an approved product stewardship scheme before being granted a licence. Importers of sulfur hexafluoride and equipment other than refrigeration and air conditioning equipment are currently not required to be members of an approved product stewardship scheme before being granted a licence.

The only SGG product stewardship scheme in Australia is Refrigerant Reclaim Australia. The major site for destruction of waste SGGs has, until recently, been in Tottenham, Victoria. This will soon move to a site operated by Chemsal at Laverton, Victoria. The destruction facility operator will remain as BCD Technologies. The technology and operator is approved by the Minister under the OPSGGM Act.

In relation to the destruction of the particular gases that are substitutes for SGG, the following feedback has been provided.

- **Carbon dioxide:** It is unlikely that carbon dioxide would be processed through the destruction facility as it has a global warming potential of 1, hence there would be no climate benefit to its destruction, given the energy input involved in the recovery and destruction process.

- **Ammonia:** There are no specific changes expected in the use of this gas. The equipment that has been specially designed to handle ammonia will not be compatible with any substitute hydrocarbon gases. There are potential issues with respect to the willingness of the suppliers of ammonia to take back and recycle this product.

- **Hydrocarbon:** It is expected that the use of hydrocarbons may increase in those systems that have been designed and constructed to be compatible with hydrofluorocarbons. The reprocessing of these gases has been in place for over 100 years, particularly in the petrochemical industry and on industrial sites. These workplaces have very stringent controls in place to mitigate the WHS risks.

It is interesting to note that in the industrial sector, flammable gases are only stored in containers that have a left-hand thread, while non-flammable gases are stored in containers with a right-hand thread. This is used as a direct indicator to the service technician rather than depending on a label. There is currently no such requirement within the refrigeration sector.

The Refrigerant Reclaim Australia recovery centre accepts large cylinders which often contain a blend of gases. A technician may remove a gas from piece of equipment, and add it to a small cylinder containing other waste gases and take it to a collection centre. These gases are then mixed further and eventually sent to the recovery centre. Typically, the cylinders sent to the recovery centres are around 0.5 tonnes in capacity.

Although currently the refrigerant gases are predominantly hydrofluorocarbons and hydrochlorofluorocarbons, some hydrocarbons are included in the mixed refrigerants sent for destruction. Typically this is less than 5 per cent of the blended gases composition. The gas processing centre has been designed to destruct gas cocktails that contain a mixture of gases. If there is increased use of hydrocarbons within this cocktail of blended gases, then potential processing risks may arise without appropriate changes to technology and work practices.

In relation to non-recycled goods that end up in landfill, there are rules implemented by local government authorities to prohibit the acceptance of gas cylinders or products containing untapped gas. Despite this policy, the feedback from this review would indicate that there are still many products that contain gas which are dumped at these local government managed landfill sites. There are also sometimes cylinders contained within the waste stream which can potentially be pierced during the crushing and compressing processes. Based on the responses obtained, the number of incidents where this has resulted in a WHS risk has been minimal. It was indicated that the workers within these landfill facilities are alert to dumped gas cylinders and refrigerators and are educated on the risks associated with handling them.

The local government authorities indicated that they have protocols in place for the removal and transfer of gas within these cylinders and refrigerators by a licensed gas disposal contractor.

One possible consequence of the increased price of SGGs as a result of the equivalent carbon price for SGGs is the potential for theft of the gas due to its higher value, particularly when stored in large containers. One of the major retailers has indicated that it has plans to store containers of these SGGs in a more secure location inside its store due to potential thefts from storage containers in its yard. This highlights the potential that SGGs may be seen as a product worth stealing.

On behalf of myself and of our Occupational Hygiene Associate Brian Eva, I thank you for the opportunity to conduct this review and for the support and contributions of the many industry partners who have openly and freely participated.

Yours sincerely,

Professor David C Caple
Director
David Caple & Associates Pty Ltd
BSc(Hons), DipEd, MSc (Erg) UK
Past President, International Ergonomics Association (IEA)
Fellow, IEA
Fellow, HFESA Australia
Fellow, Ergonomics Society UK
Fellow, Ergonomics Society Sweden
Member, Human Factors Society USA
Certified Ergonomist, Australia
Certified Professional Ergonomist, USA
Senior OHS Auditor, Australia
Adjunct Professor, La Trobe University, Melbourne, Australia
Senior Research Fellow, University of Ballarat, Australia
www.davidcaple.com.au

References

The majority of referenced information in this report was extracted from interviews conducted in confidence with individuals and organisations from the SGG industry and WHS regulators. Out of respect for the privacy of these discussions, the full text has not been included here. The following external publications were cited in this report.

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Enc. *Consultant profile – Professor David Caple*

Appendix 1: Participants in the review

Appendix 2: Questions to regulators

Appendix 3: Questions to industry partners

Appendix 4: Letter of introduction to regulators

Appendix 5: Letter of introduction to industry partners

CONSULTANT PROFILE

Adjunct Professor David Caple
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Summary

David has been an independent OHS consultant with 29 years in private consulting plus seven years in corporate and research employment.

His technical experience includes OHS and ergonomic research projects in Sweden, Hong Kong, the US, Singapore, Papua New Guinea 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, Ergonomics Society UK
Fellow, Ergonomics Society Sweden
Member, Human Factors Society USA
Certified Ergonomist, Australia
Certified Professional Ergonomist, USA
Senior OHS Auditor, Australia
Adjunct Professor, La Trobe University, Melbourne, Australia
Senior Research Fellow, University of Ballarat, Australia

Experience

- Past President, International Ergonomics Association (IEA) 2006–2009; executive member 2006–2012
- Conducted industry-based OHS consulting in meat, automotive, retail, mining, health, banking, manufacturing, hospitality, telecommunications, correctional facilities, 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 personal injury 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 US Congress hearings
- Liaison Officer on ergonomics development with the International Labour Organization, International Organisation for Standards and World Health Organization
- Independent member of Victorian Government WorkSafe OHS Advisory committee and judge of OHS Awards
- Author and reviewer of peer-reviewed journals
- Presenter at more than 30 international conferences
- Facilitator of public consultant for the Australian National OHS Strategy in 2012
- Independent investigator on OHS Leadership for Singapore Government with top 20 CEOs
- Project leader for the Australian Government on OHS impacts of equivalent carbon price for SGGs and e-waste
- Conducted industry-based OHS risk assessments on emerging issues including bullying

Appendix 1: Participants in the review

1. OHS regulators

- Comcare
- WorkSafe Victoria
- WorkCover NSW
- Safe Work SA
- WorkSafe ACT
- NT WorkSafe
- Division of Workplace Health and Safety Queensland
- Workplace Standards Tasmania
- WorkSafe WA

2. Industry partners

Associations

Aerosol Association
Australian Refrigeration Association
Fire Protection Industry (ODS and SGG) Board
Air Conditioning and Refrigeration Equipment Manufacturers Association of Australia (AREMA)
Australian Refrigeration Council
Victorian Automobile Chamber of Commerce (VACC)
Vehicle Air Conditioning Specialist Association

Companies

Arkema Pty Ltd	Garry and Warren Smith Oakleigh
Hychill Australia Pty Ltd	Mazda Dealership Mulgrave
A-Gas	Huntsman Polyurethanes
Super Cool Asia Pacific Pty Ltd	Northern Auto
Refrigerant Reclaim Australia Ltd	Rhodes Smash Repairs Ferntree Gully
Heatcraft Pty Ltd	Caron Automotive
Huntsman Pty Ltd	AG Coombs Air Conditioning
KAV Consulting Pty Ltd	Barry Thomas Air Conditioning
Orica Pty Ltd	Burson Automotive
Sanden International Australia	Commercial Refrigeration Services
Vocational education and training providers NSW	Ferntree Gully Radiators Pty Ltd
4Build Project Engineering	Mitsubishi Heavy Industries Air conditioners Australia Pty Ltd (MHIAA)
Cool Drive	Nucleus Engineering
PJM Engineering	Reece Pty Ltd HVAC
GWA Group - Foaming	TROX Australia Pty Ltd
GWA Group – Heat Pump	Coolline Industries
GWS Clayton Landfill	Ricky Marr Refrigeration Murrabit
	Toyota Motor Corporation Australia Ltd.

• Site visits – Improvement Notices relating to: o SGG hazards o replacement gases hazards	
• Prosecutions launched re SGG or alternative gases	
• Major incidents – fire, explosions, spills/leaks of SGG or alternatives	
• Major hazard facilities – SGG management requirements	
• Injured/ill workers/contractors o Exposure to SGG o Alternative gases	
• Existing guidance, codes, regulations relating to SGG or alternatives	
• Proposed guidelines re SGG or alternatives	

Appendix 3: Questions to industry partners

1. SGG use

• Briefly describe how SGG are used by the company.	
• How many years have SGGs been used?	
• What was used before SGGs by the company?	
• What was the motivation to change to SGGs?	
• Details any incidents or injuries involving SGG?	

2. Alternative gas use

• What alternatives to SGG have been used or considered?	
• How many years have the alternative gases been used?	
• What was the motivation to move from SGG to alternatives?	
• Do you propose to swap to alternatives after the implementation of the carbon tax?	
• Detail any incidents or injuries involving the alternative gases.	

3. Hazard identification and risk control

• List the OHS hazards you have identified with your use of SGGs. o .... o .... o	
• Describe how you have controlled these risks to: o your workers............................... o your supply chain partners	
• What support have you received by your suppliers of SGG products?	

• Are there any continuing OHS risks relating to SGG or alternatives that you identify for your company or through your supply chain?	
• Can you provide an example of how OHS risks from SGG or alternatives have been eliminated or controlled by your company or through your supply chain?	

4. Guidance and training

• What OHS guidance has been the basic for SGG or alternative gas risk management program?	
• Who receives OHS training relating to SGG or alternatives? Detail the main training content competencies covered.	

5. Audits and Inspections

• Describe what audits and inspections are undertaken. Include checking for leaks as well as adherence to procedures.	

6. Decommissioning and disposal

• Describe how SGG or alternatives are handled during decommissioning or disposal of products.	

7. Quantities

• Describe quantities of SGG currently used per year. When alternatives are used, do these quantities increase or decrease to maintain process effectiveness?	

8. Customers

• What OHS issues do you anticipate/experienced for your customers if you move to alternative gas?	

Appendix 4: Letter of introduction to industry regulators

Dear Sir/Madam,

Review of Work Health and Safety Incidents involving Synthetic Greenhouse Gases

On 1 July 2012, the Australian Government will introduce a levy based on an equivalent carbon price on synthetic greenhouse gases (SGGs) as part of its Clean Energy Future Plan. As part of a due diligence process in assessing the potential impact of this legislation on the Australian community, the Department of Sustainability, Environment, Water, Population and Communities (the department) is investigating qualitative and quantitative data on the use of SGGs in products and supply chains.

The department has engaged independent Occupational Health and Safety consultants, David Caple & Associates Pty Ltd, to assist them in consultation with key stakeholders who may provide information and data on Work Health and Safety (WHS) incidents involving SGGs, including WHS risks arising from the use of substitute gases.

As you are one of the WHS regulators in Australia, we seek cooperation from your Occupational Hygiene/Dangerous Goods Division to assist our consultants in accessing relevant information. We are seeking any information or advice relating to WHS incidents or non-compliance that may represent baseline data on how SGGs or SGG alternative products may be used within Australian workplaces and by members of our community.

In particular, we are interested in following through supply chains where these gases are used in products that may be used in Australian workplaces, but also throughout the Australian community. We are seeking to understand WHS risks through the life cycle of these products, such as installation, operation, maintenance, and disposal.

It would be greatly appreciated if one of your department representatives could make contact with our consultants within the next few days to set up an appropriate teleconference.

The contact details for the independent project consultant are David Caple at david@caple.com.au.

More information on the project is available at www.environment.gov.au/equivalentcarbonprice.

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

Yours sincerely,

Dr David Swanton
Director
Synthetic Greenhouse Gas Communications Team
Environment Quality Division
23 May 2012

Appendix 5: Letter of introduction to industry partners

Dear Sir/Madam

Review of Work Health and Safety Incidents involving Synthetic Greenhouse Gases

On 1 July 2012, the Australian Government will introduce a levy based on an equivalent carbon price on synthetic greenhouse gases (SGGs) as part of its Clean Energy Future Plan. As part of a due diligence process related to the new regulatory system, the Department of Sustainability, Environment, Water, Population and Communities (the department) is investigating qualitative and quantitative data on the use of SGGs in products and supply chains.

The department has engaged independent Occupational Health and Safety consultants, David Caple & Associates Pty Ltd, to assist them in consultation with key stakeholders who may provide information and data on Work Health and Safety (WHS) incidents involving SGGs, including WHS risks arising from the use of substitute gases.

We are seeking qualitative and quantitative data from a range of industry sectors to establish baseline information on the current use of SGGs and their alternatives. In particular, we are interested in following through supply chains where these gases are used in products that may be used in Australian workplaces, but also throughout the Australian community. We are seeking to understand WHS risks through the life cycle of these products, such as installation, operation, maintenance, and disposal.

We would appreciate if you could provide information in relation to your experience in this area to our project consultants so that the government is well informed of the WHS risks relating to SGGs and their alternatives.

The consultants will be aggregating the information to maintain confidentiality and privacy for particular individuals and organisations that are consulted.

More information on the project is available at www.environment.gov.au/equivalentcarbonprice

If you are willing to discuss this topic with our consultants, please feel free to contact David Caple at david@caple.com.au.

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

Yours sincerely

Dr David Swanton
Director
Synthetic Greenhouse Gas Communications Team
Environment Quality Division
23 May 2012