International
Specialised
Skills
Institute Inc

Australian Government
Department of Education, Science and Training

THE FUTURE USE OF CARBON DIOXIDE (CO_2)

A Natural Gas Alternative to Synthetic Gasses for the Australian Refrigeration Industry and the Training Needs for Installation, Service and Repair

Peter Moore
ISS Institute Overseas Fellowship

Fellowship supported by the
Department of Education, Science and Training,
Commonwealth of Australia

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1.0 Acknowledgments

It would not have been possible to undertake this project without the support of a number of organisations and individuals, sharing my belief that the identification of important skill gaps that are emerging in the Refrigeration industry here in Australia require appropriate and immediate rectifying by training practitioners in those skills. Therefore, I would like to acknowledge the following organisations and in particular a number of individuals for making this project possible.

1.1 Awarding body/s – individuals International Specialised Skills Institute (ISS Institute)

- Ms Carolynne Bourne - Chief Executive Officer
- Mr Franco Fiorentini - Chairman
- Sir James Gobbo AC CVO – Patron in Chief
- Mr. Michael Reardon (DEST) and Mr. David Wittner – the other selection panel members

1.2 Fellowship sponsor/s Department of Education Science and Training, Commonwealth Government

Other sponsors / supporters:

- Mr Greg Harper – Institute Director Logan Institute of TAFE

- Ms. Judy Thomson – Program Director Logan Institute of TAFE

1.3 Participating overseas individuals/ organisations

The following is a list of people and their respective organisations overseas who provided help and support which has made this fellowship study possible. I therefore wish to thank and acknowledge their assistance.

- Mr. Christian Bendtsen - Danfoss A/S
- Mr. Alexander Cohr Pachai – York Denmark ApS
- Dr. Bjarne Dindler Rasmussen - Danfoss A/S
- Mr. Rainer Grosse-Kracht – Bitzer Refrigeration
- Mr Ib Baek Jensen – Technical College of Jutland
- Mr. Bent Johansen – Birton Refrigeration
- Mr. Frank Lochel – Bitzer Refrigeration
- Mr. Kenneth Madsen - Danish Technological Institute
- Mr Andy Pearson – Star Refrigeration
- Mr. Hermann Renz – Director Bitzer Refrigeration
- Mr. Peter Schneider – Danish Technological Institute
- Dr. Christian Veje - Danfoss A/S
- Mr. Niels P. Vestergaard - Danfoss Industrial Refrigeration

1.4 Individuals and or organisations in Australia involved in assisting in identifying skills gaps

I wish to acknowledge the support of the following people who assisted me in identifying the skill gaps relating to the Australian Refrigeration industry and, in particular, the skill gaps which are emerging with the use of Carbon Dioxide as a refrigerant.

- Mr. Russell Ash – Bitzer Australia
- Dr. Michael Bellstedt – Natural Refrigerants Transition Board
- Mr. Pat Bourke – Bitzer Australia
- Mr. Frank De Jong – Danfoss Australia
- Mr. Don Griffiths – Coles Myer
- Mr. John Mott – Gordon Bros. Refrigeration
- Mr. Noel Munkman – NSW TAFE
- Mr. Ruediger Rudischhauser – Bitzer Australia
- Mr. Paul Sheahen – Frigrite Refrigeration
- Mr. Wayne Willis – Austral Refrigeration

2.0 Introduction

2.1 International Specialist Skills Institute

Since 1989, ISS Institute, an independent, national, innovative organisation has identified “skill deficiencies” through market research, then fills them through its Overseas Skill Acquisition Plan (Fellowship Program) and consultancy services.

ISS Institute provides opportunities for Australian Industry and commerce, learning institutions and public authorities to gain best - in - the - world skills and experience in traditional and leading edge technology , design (note, ISS Institute is a key driver of ‘design’ in Victoria), innovation and management.

From the beginning, ISS Institute has set itself the ambitious task of gaining skills and knowledge from overseas, then transposing those capabilities into an Australian context for innovative business development.

ISS Institute is known for providing exciting and unique opportunities for Australians to enhance their capabilities in – keeping with the world’s best. The ISS Institute Overseas Skills Acquisition (Fellowship Program) creates and supports significant international and cross cultural relationships.

Importantly, fellows must pass on what they have learnt through a Report and a wide range of ISS Institute education and training activities and events such as workshops, lectures, seminars, forums, exhibitions and conferences. The activities place these capabilities, plus insights (attitudinal change) into the minds and hands of those who use them
- trades and professional people alike – the multiplier effect.

The ISS Research Institute has been established to enable firms, government and non-government organisations, industry bodies, professional associations such as the MBA, education and training institutions access to the significant IP and insights gained over the past fifteen years of operation through consultancy services.

ISS Institute has a significant resource in the human capital it can draw upon (within ISS and through its networks here and overseas) to conduct programs and projects.

ISS Institute has no vested interest other than to see Australian talent flourish and in turn, businesses succeed in local and global markets.

Individuals gain; industry and business gain; the Australian community gains economically, educationally and culturally.

2.2 Major sponsor – Department of Education Science and Training

The Fellowship is funded by the Department of Education, Science and Training (DEST), Commonwealth of Australia.

Over fifteen years ago, Sir James Gobbo AC,CVO helped create a new body which sought to address a critical need in Australia – namely the retention and enhancement of skills and knowledge of artisans and tradesmen. There were increasing gaps appearing in many areas. No body, in particular no grant - making body was – indeed is – meeting this need. There are very admirable large organisations, but these make few if any, awards in this area. Music, the arts, science and medical research are well covered, but the trade skills are seldom assisted. There is plenty of evidence which shows the need for increasing skills in all parts of Australia. Artisans and tradespeople badly need the special support and status which is available through ISS Institute's overseas Fellowship programs" states Sir James.

Sir James and Carolynne Bourne AM, CEO, ISS Institute, presented this situation to The Hon Dr Brendan Nelson MP, Minister for Education, Science and Training. Minister Nelson enthusiastically agreed to support ISS Institute's work to enhance the skills and knowledge and to inspire our nation's talented artisans and tradespeople through ISS Institute's Overseas Skill Acquisition Plan – The Traditional Trade Fellowship Program.

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ISS Institute gratefully acknowledges the funding and support of Minister Nelson and the staff of the Industry Skills Section.

2.3 The Australian context -Current situation of the industry

2.3.1 Background

The refrigeration and air conditioning industry has seen great change over the last one hundred years. However the rate of change has accelerated in recent years. The impetus for this increasing rate of change has been environmental concerns surrounding the use of synthetic chemicals used as working fluids contained in refrigeration and air conditioning equipment. The term **"Refrigerants"** is commonly used in the refrigeration industry to describe the working fluids contained within the systems. Synthetic refrigerants, specifically Chlorofluorocarbons (CFC's) are acknowledged by both governments and the scientific community alike as having a detrimental effect on the earth's Ozone layer. The Ozone layer is a finely dispersed naturally occurring band of gas (O_3) which protects the Earth from harmful ultraviolet radiation from the sun. As a consequence, this issue proved to be of significant concern to governments around the world in the nineteen eighties and early nineteen nineties due to the widespread use and resultant emissions of these refrigerants to the atmosphere. Initially, both industry and government responded by adopting more stringent servicing practices and containment policies for existing equipment. This was followed by Industry's move away from the ozone depleting synthetic chemicals CFC's in new refrigeration and air conditioning equipment to ozone benign synthetic refrigerants known as Hydro fluorocarbons (HFC's)

As a result of this change there has been considerable impact on the training curriculum, particularly the apprenticeship program, with regard to service techniques of existing equipment. The curriculum was expanded to include modifying existing training programs to include training on CFC refrigerant containment techniques and equipment and the addition of new training modules and competencies relating to the use of these new HFC refrigerants in old equipment. The use of the new HFC's in old equipment designed for use on CFC's is known as "retrofitting". To properly retrofit a system required new knowledge and handling competencies, such as the application of new lubricants and the resultant material compatibility issues and the use of newly developed recovery equipment. This change also led industry to design and manufacture new refrigeration and air conditioning equipment designed to operate exclusively on the new HFC refrigerants.

The training for the acquisition of these new skill sets, borne out of this new technology, were significant but manageable, as the new HFC refrigerants were designed to emulate most of the characteristics displayed by the refrigerants they were replacing. However like the apprenticeship program the up skilling process continues with TAFE providing professional development programs for Refrigeration trades people – like the joint TAFE/Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) HFC R410 refrigerant course and the current refrigerant containment programs. **But these up skilling programs are only designed to address the skill gaps that are associated with HFC synthetic refrigerant technology.**

2.3.2 The current situation and the new skill gaps

Both industry and governments around the world continue to search for new refrigerant technologies that are:

1. Cost effective
2. Energy efficient and
3. **Safe to both the end user and to the environment.**

The United Nations Environment Program (UNEP 2002:21) Technical Options Committee report states:

> *For the long term, there remain, in fact only five important different refrigerant options for the vapour compressor cycle*[1] *in all refrigeration and air conditioning sectors, in alphabetical order*
> 1. *Ammonia (R717)*
> 2. ***Carbon dioxide CO_2 (R744)***
> 3. *Hydrocarbons and blends (HCs e.g. HC-290, HC-600 etc.) ;*
> 4. *Hydro fluorocarbons (HFC,s & HFC blends)*
> 5. *Water (R718)*

Water (no.5.) as a primary refrigerant has only very limited application and ammonia (no.1) which is somewhat toxic and is unlikely to have much impact outside of its current application i.e. industrial refrigeration. Currently this leaves 3 serious contenders for mainstream refrigeration applications.

- **Carbon Dioxide CO_2 (no.2) – natural**
- Hydrocarbons HC's (no.3) – natural
- Hydro fluorocarbons HFC's (no.4) – synthetic

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[1] *The vapour compression cycle is to date the most energy efficient refrigeration system and is by far the most prolific system in modern refrigeration and air conditioning applications*

Hydro fluorocarbons HFC (No4.) synthetic refrigerants – future use is now in doubt

Concerns regarding ozone depletion, while still significant, are rapidly being overshadowed by an equally foreboding environmental threat **– "Global Warming".** It has now been recognised that these new HFC's (no. 4), synthetic refrigerants, whilst being ozone depletion benign, are significant (through direct emission) global warming or greenhouse gas contributors. These gasses are referred to as "Synthetic Greenhouse Gases" and the Australian Federal Government has recently passed an amendment[2] to include these substances under a previous law aimed at controlling emissions of Ozone depleting refrigerants. However, many within government, the scientific community, and the industry consider these synthetic greenhouse gases or HFC's to be short term or "Transitional Refrigerants" only. There now appears to be an increasing chorus of concern regarding the use HFC refrigerants, concern based on this new environmental threat:

Bellstedt (2004a:12) points out:

> *European governments, including those of Denmark, Norway, Austria and Switzerland, has already passed laws banning the future use of HFC's in some applications and other countries such as Germany are in the process of finalising similar legislation.* Further*, "a new EURO regulation banning HFC 134a for automotive applications by 2008 has just come into effect.*

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[2] The new amendment is now known as the Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 formerly the Ozone Protection Act 1989

2.3.3 The future use of Natural Refrigerants in Australia

There are **natural** refrigerant gas alternatives to the synthetic HFC refrigerant technology which are both sustainable, affordable and energy efficient in some applications. These alternatives include “Hydrocarbons” **(HC)** (no.2) such as Propane and Butane. However, to date, the uptake of these refrigerants in Australia has been poor due to concerns, by many within the industry (ICF Consulting 2003: 4), over safety issues, particularly concerns regarding the flammability of these gases. It is interesting to note that this refrigerant technology is however popular in countries such as Denmark and Norway. But many see the significant uptake in the application of hydrocarbon refrigerants will in all likelihood be confined to very small refrigeration systems which have correspondingly small refrigerant charges[3].

Another natural refrigerant, one which is not flammable, which has received considerable industry attention, again in Europe, has been **“Carbon Dioxide” CO_2, (R744) (no.3) a gas which is both ozone benign and has a negligible direct global warming impact potential when compared to HFC refrigerants.** Global warming impact is defined as direct and indirect. Direct is when the substance is released into the atmosphere and indirect is the CO_2 released by the burning of fossil fuels in order to provide the electricity to run the equipment. When comparing direct global warming potential or GWP, CO_2 refrigerant to HFC refrigerants, HFC’s have a more substantial impact e.g. releasing 1kg of refrigerant R404A (a synthetic HFC refrigerant) is equivalent in atmospheric carbon loading of releasing approximately 3 tonnes of CO_2.

Bellstedt (2004b:14) argues Australia will follow a similar path to that followed by European countries which are now favoring CO_2 systems:

> *“Although in Australia the revised draft Ozone Layer Protection Act still lags well behind the legislation passed in Europe, such steps (*banning the use of HFC’s*) will eventually have to be implemented in Australia also”*

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[3] Australian Greenhouse Office report (ICF Consulting) into use of alternatives amongst HFC user Industries. RAC sector reported HC uptake in the future will most likely be in the automotive, domestic and transport refrigeration applications ***see appendix 1.*** *Further, both of the remaining domestic refrigerator manufacturers in Australia – Fisher & Paykel and Electrolux (formerly Email LTD.) have had some products designed to use or will use in the future, Hydrocarbon refrigerants and not* CO_2.

Whilst the application of Carbon Dioxide CO_2 as a refrigerant is not new[4] it is however receiving renewed interest, due to an increasing level of concern with the environment, this coupled with advances in manufacturing technologies will be one of the factors driving the application of this technology into the future. But a cautionary note – it has been identified by industry experts that before this technology finds its way into mainstream use, service personnel will require:

- Specific knowledge on the operating principles on e.g. "Transcritical" systems which are fundamentally different from the conventional vapour compression system and

- Practitioners will need education and training to develop skills in handling CO_2 as a refrigerant and new knowledge relating to equipment designed to operate exclusively on CO_2.

The concern for the environment is shared by all responsible, thinking people and people involved in the Australian refrigeration industry are no different as Pelvin (2004:4) cites a recent survey conducted in Victoria of HVAC&R consultants, service managers, installers and technicians:

> *"Cost was identified as a major factor in considering which refrigerant to use, although the cost of equipment, availability, performance, and reliability were also identified as important considerations. It was however, heartening that these commercial influences were often balanced with* ***environmental consideration and thought for the future"***

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[4] *Carbon Dioxide was used as a refrigerant as early as the late 1800's and peaked in the 1930's. CO_2 was the refrigerant of choice in the shipping industry as it was not toxic or flammable. However CO_2 eventually gave way to the "Modern" synthetic refrigerants. Source Danfoss article (pp.3) "CO_2 refrigerant for industrial refrigeration"*

2.3.4 The challenge ahead for Australia

The challenge for Australia is that the refrigeration industry simply cannot rely on the larger refrigeration companies to provide the handling, installation and servicing techniques which accompany the application and commercialisation of CO_2 refrigeration technologies.

TAFE has a role to play in supporting the refrigeration industry by way of training support for the practitioners involved in it. This translates into choice for the end users by giving them confidence in the knowledge that TAFE is supporting their refrigeration contractors in this type of refrigeration and air conditioning equipment.

Some of the larger refrigeration manufacturing companies who have the resources may train “in house”.

In the past this type of training has generally been directed at customers, contractors, dealers or distributors and this can lead to small to medium sized enterprises without access to new and emerging technology. TAFE needs to position itself to work, not in isolation, but co-operatively with these larger manufacturers where courses could be offered with a mix of training provided by both TAFE and the manufacturers. My colleagues and I within the TAFE system are focussed on assisting the Australian refrigeration and air conditioning industry and its skilled workforce to assist in raising the awareness of the industry to this alternative refrigerant technology pathway.

The way in which this can be done is by being proactive and striving to understand and gain these skills that will help support the application of natural refrigerant technology in Australia. The Australian community expects and should have access to choice in the type of refrigeration system that meets their needs.

2.3.5 What is so special about the training involved with Carbon Dioxide refrigerant?

The application of Carbon Dioxide as a refrigerant does have some technical drawbacks. For example, the operating pressures of CO_2 refrigeration systems - particularly transcritical systems are considerably different to that of conventional synthetic refrigerant systems. High side Pressures in the order of 70 – 110 Bar or 7000 – 10000 kilopascals (kPa) compared to 15 – 25 Bar or 1500 – 2500 kilopascals for conventional synthetic refrigeration systems. This places a greater emphasis on the level of safety, which needs to be observed and adhered to.

One approach is that the training on these systems should only be provided to existing practicing refrigeration tradespersons. Practitioners, who already possess skills and knowledge which will better enable them to grasp the fundamentals differences between CO_2 and conventional systems.

This I believe to be a sound and rationale approach. It will be unrealistic and potentially dangerous to expose new entrants into the refrigeration industry at the level required to competently handle CO_2 systems due to the increased operating pressures involved.

This alone or coupled with a number of additional specialist skills could ideally lead to a special class of refrigeration tradesperson, viz., "**Master Refrigeration"** tradesperson as proposed under ISS Institute's " A new model for skilling the Trades. Master Artisan Framework for Excellence".

2.4 Organisations which have impact on the refrigeration industry

The Refrigeration and Air Conditioning Contractors Association **(RACCA)** is an organisation that started in 1957 and has many hundreds of refrigeration contractor members in Australia. It is a peak industry group that has a guiding presence on standards committees, training and educational groups and government advisory panels. This organisation keeps its members informed through web sites and a trade journal entitled *Celsius* that is published monthly. It provides information on many issues affecting the industry including emerging technology.

The Australian Institute of Refrigeration Air Conditioning and Heating **(AIRAH)** is another peak industry group which has wide membership within the Refrigeration industry. The membership is largely made up of engineering professionals and consultants who are often the decision makers on behalf of building owners and managers. They also inform their members through a web site and a trade journal called *EcoLibrium*^{tm}. It is through this and similar journals which sparked my initial interest in the renewed use of Carbon Dioxide as a refrigerant. AIRAH also has an affiliation with the International Institute of Refrigeration (IIR) a well respected global network of researches, engineers and educationalists associated with this industry. AIRAH has and continues to be involved in advising Government and standards committees on issues such as industry codes of practice.

Governments including both State and Federal have a significant impact on this industry. This industry has been the focus of recent legislation for example the "*Ozone Protection and Synthetic Greenhouse Gas Management Amendment Regulations 2004"* which is designed to regulate and control the emissions of synthetic refrigerants commonly used in the refrigeration industry. Note this legislation does not include natural refrigerants as they are ozone benign and have a negligible direct global warming impact.

Finally, the TAFE system and particularly the refrigeration teacher's network have a major interest in this project. This project will provide valuable information from the worlds most respected and highly experienced practitioners developing and employing CO_2 refrigerant technologies.

It is intended that new competencies and training programs will be developed as an outcome of this project. This hopefully may act as a catalyst for change as there are many detractors of CO_2 refrigerant technology. This I believe is mainly due to the uncertainty relating to the elevated operating pressures associated with CO_2 refrigerant systems. But like any new technology all the components will be designed with adequate safety margins for safe use with this refrigerant. Further, the training on these systems should only be offered, as mentioned before, to existing trades people as a MASTER CLASS programme i.e. only qualified refrigeration technicians should be admitted for the programme.

2.5 Aim of the Fellowship

1. To investigate the current techniques relating to the safe handling and maintenance practices of Carbon Dioxide CO_2 refrigeration systems.

2. To investigate the operational benefits and diagnostic/repair techniques relating Carbon Dioxide CO_2 refrigeration systems and the compatibility of materials and chemical interaction.

3. To acquire the necessary skills and knowledge relating to the installation techniques associated with Carbon Dioxide CO_2 refrigeration systems.

4. To understand the attitudinal and cultural aspects surrounding the use of Natural Refrigerants and why they have been so enthusiastically embraced by both the people and industry in Europe.

5. To establish contacts with companies and training providers in Europe and to link them with similar organizations in Australia in order to keep abreast with future developments.

6. On return to Australia, to pass on this knowledge acquired from overseas experience to industry practitioners, industry associations and TAFE refrigeration teachers via the Australian National TAFE Refrigeration Teachers Network

2.6 The Skills Gap

The skill gaps identified

It is not a matter of 'if the technologies will be adopted' by Australian industry but more a matter of 'when and to what extent.' In a recent Australian Government commissioned report (ICF Consulting 2003) that surveyed key Industry experts and practitioners, it was revealed more than 50% expected the uptake of alternative refrigerants in the near future (CO_2 among them). The supermarket and cold storage sectors are currently trialling CO_2 refrigerant technology. Early trial reports are very pleasing as the systems are reported to be both reliable and energy efficient.

The skills gaps that will accompany the application of CO_2 refrigerant systems for the current and future Refrigeration Mechanics are:

- Installation techniques for CO_2 – new pipe connection techniques relating to CO_2 refrigerant systems because CO_2 refrigerant systems operate much higher system pressures compared to conventional synthetic refrigerant systems.
- Technical understanding associated with piping materials and the required standards of piping relating to CO_2 systems.
- Commissioning techniques for CO_2 systems.
- Fault finding and system diagnosis.
- System charging and discharging practices.
- Necessary precautions and standards for proper application.

- Compatibility of system materials, lubricants and contaminant tolerances and their chemical interactions with system materials.
- New service tools – proper use and care.
- New components – how they differ from conventional components.
- Knowledge of “Transcritical” or “supercritical” vapour compression system cycles.
- Cascade systems using CO_2 as the low temperature refrigerant

3.0 The fellowship program

3.1 Introduction

The program outlined below, involved both , meeting with individuals and organisations leading the development and application of CO_2 system technology and attendance at a peak industry conference which focussed on the very latest research and development of refrigeration system technology. Being the only delegate from Australia I was left wondering – are we turning our backs on new refrigeration technology ?

3.2 Educational institution/Host organisations.

Organisations and people visited included;

Mr. Rainer Gross-Kracht, Project Manager
e-Business Bitzer Group
Rottenburg, Germany

Mr. Frank Lochel, Applications Engineer
Bitzer Group
Leipzig, Germany

Bitzer Refrigeration Group is a major developer and manufacturer of refrigeration compressors and components for the commercial refrigeration industry. The company was foundered in Germany in 1934. The company prides itself on the manufacture of high quality "made in Germany" refrigeration products. These manufacturing standards are maintained in all Bitzer manufacturing plants including plants they have been established in other parts of the world. This company has a sales and marketing presence in Australia and includes contractor clients serving the refrigeration equipment needs of Coles and Woolworth's supermarket chains and other food retailers.

The Bitzer group has developed and brought to market compressors designed to operate on CO_2 for the commercial refrigeration sector but this is mainly centred in Europe.

Mr. Rainer Gross - Kracht

The facility in Rottenburg Germany was where I met with Rainer Gross-Kracht. We discussed Bitzer groups development of CO_2 compressors and the progress to date with these products as well as servicing and maintenance of CO_2 systems and discovered a number of interesting commissioning and servicing procedures. Some examples are given below:

1. Polyol Ester (POE) oil is used on all CO_2 products BSE 60k Sub critical & BSE 80k for Trans critical
2. Electronic oil return control system is available for CO_2 applications (sub critical applications only)
3. Oil foaming is more pronounced with CO_2 systems minimum 20^0 c at start up and 40^0 c discharge gas temp after start up
4. Liquid charging of systems must not be done – oil lubrication quality is already low with CO_2 – liquid charging dilutes oil further.
5. Superheat is critical with CO_2 never too low (more superheat is desirable)

The Bitzer factory in Rottenburg produces screw compressors and houses the research and development facility.

The Bitzer factory in Leipzig was where I met with Frank Lochel Applications Engineer Bitzer Group. Here I was shown the manufacture of the reciprocating compressor product which is similar in design to the compressor currently being developed for use on CO_2 systems.

Dr. Bjarne Dindler Rasmussen
Refrigeration Specialist
Central R&D controls
Danfoss, Nordborg, Denmark

Dr. Christian Veje
Central R&D
Danfoss, Nordborg, Denmark

Mr. Christian Bendtsen
Controls
Danfoss, Nordborg, Denmark

Danfoss is a global company based in Denmark. The company has three major divisions.

1. Refrigeration and Air conditioning
2. Motion control – Hydraulics
3. Heating and Water

The Refrigeration and Air Conditioning division consists of four product business units:

1. Refrigeration and Air Conditioning Controls
2. Commercial Refrigeration Compressor
3. Household Refrigerator Compressors
4. Industrial and Appliance Refrigeration controls

The product range is manufactured in 27 factories in 16 countries. The global market is organized in 4 regions Europe, Middle East and Africa, North America and Latin America, Asia Pacific. The Refrigeration and Air Conditioning division employs 9000 people globally.

The Danfoss group has joined the United Nations Global Compact Initiative. This commits the company to nine principles regarding human rights, labour rights and the environment.

> *"Global compact is one of the tools that Danfoss users to set our framework for activities relating to sustainable development."*

The nine United Nations Global Compact initiatives are a set of sound principles for companies to embrace for current and future manufacturing approaches but of particular interest is the ninth principle which discusses "Eco Design". The Eco Design principle sets out an emphasis on a “cradle to grave” responsibility for product manufacturers. This means that the highest possible volume of the product must be reused and when the product has reached the end of its serviceable life and is to be disposed of, it will still contain value, and therefore, is more likely to be recycled.

Danfoss has been a leader in the development of a new refrigeration compressor (light commercial) and component technology for use with CO_2 as the refrigerant.

Danfoss claims:

> *“Over the past 10 years, Danfoss has developed a new cooling technology based on environment – friendly CO_2 coolant as a replacement for synthetic coolants. The test results from this new technology have proven that lower energy consumption can be obtained than for corresponding systems using other coolants.”*

Mr Niels P. Vestergaard
Director Business Research
Danfoss, Hasselager, Denmark

In Denmark I met with a number of people but first met with Neils Vestergaard, Director Business Research Danfoss. Neils specialises in industrial refrigeration component products. Neils introduced me to their new products which have been developed for use on CO_2 large commercial/ Industrial systems such as the “ICV” Valve. Neils was also very kind in explaining the different service, repair and lubrication issues relating to large CO_2 systems.

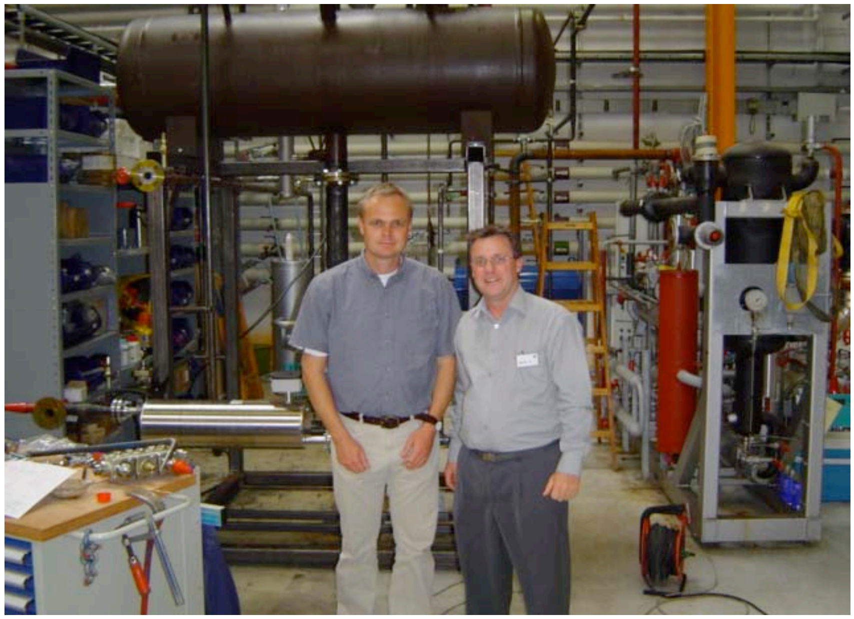
Later I Met with Bjarne Dindler Rasmussen refrigeration specialist Central R&D – controls. Bjarne has been involved in the controls of CO_2 systems along with Christian Veje and Christian Bendtsen and works with other design and development specialists developing such products as the “TN” compressor. Bjarne and his colleagues where very helpful in showing me many useful facts relating to the small to medium sized CO_2 systems stemming from both an R&D perspective and field trials. Bjarne and his colleagues were very helpful and demonstrated a very professional and profound knowledge of CO_2 systems. Bjarne and his colleagues also shared some presentation material with me for which I am very grateful.

Danfoss “TN” compressor

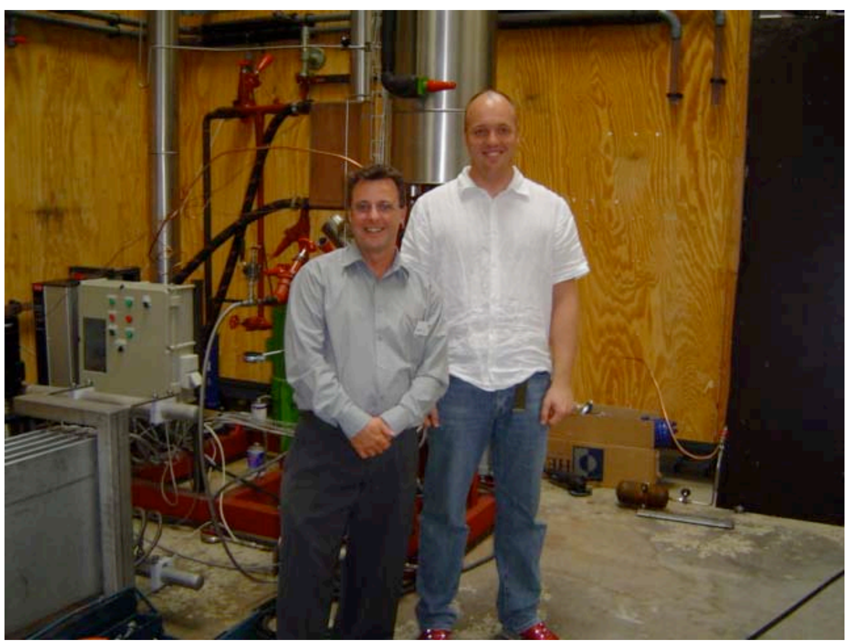
Mr Peter Schneider
Danish Technological Institute
Arhus, Denmark

Mr Kenneth Bank Madsen
Danish Technological Institute
Arhus, Denmark.

Danish Technology Institute DTI is an organisation located in Arhus Denmark. This institute has been involved in research and development working in partnership with companies such as Danfoss and Bitzer on CO_2 systems in Denmark. It has also delivered training courses on CO_2 applications. It is interesting to note that in Denmark the government has imposed additional tax on greenhouse gasses. This has been a major influence for companies to seek out alternatives to synthetic gasses for the refrigeration industry.



Mr. Peter Schneider



Mr. Kenneth Bank Madsen

At DTI I met with Peter Schneider and Kenneth Madsen. Here I gathered some additional facts about the installation and servicing of CO_2 systems.

Some examples include:

1. Safety valves need to be installed in any part of the system which can be isolated and there is a risk of hydraulic press.
2. Should be aware that CO_2 has a very high coefficient of expansion
3. Vapour lines also need to be considered with safety valves
4. If you release valves even with vapour only dry ice can form
5. Sublimation temp is very low and avoid contact with liquid CO_2 or dry ice (-56c)
6. Must not open refrigeration system – some parts under extreme pressure
7. Care needs to be exercised when welding an isolated part of the system and you need to be aware that heat transfer by conduction could result in very high pressure in other parts of the system which contain liquid CO_2
8. CO_2 is heavier than air and CO_2 will concentrate in these low points – this is where detectors need to be located
9. Vent should also be done from the lowest point in the system to ensure system is emptied
10. Safety valves can form ice plugs and this results in “ice bullets”

Mr. Bent Johansen
Birton a/s
Viby, Denmark

The Birton Company is a major refrigeration contracting firm based in Denmark. It specializes in installation contracting and service operations on commercial supermarket refrigeration. The organisation has had considerable experience in the installation of CO_2 systems, to date some 15 supermarkets in Denmark. The company is recognized as the pioneer in this field i.e. Commercial refrigeration. Currently the company through its successes with CO_2 applications is now at a stage where it is standardizing its design and pricing. This market maturation in Denmark is evidence by CO_2, at least in the commercial refrigeration sector, moving from the prototype phase to the more mainstream. It is now considered a standard system.

I met with Birton's director Bent Johansen who showed me a presentation that he has developed which details CO_2 refrigeration installation tips. Another interesting discussion we had was in relation to Hydrocarbon refrigeration systems which Birton also has considerable expertise in the design, installation and servicing.

Bent Johansen Birton a/s

Mr. Alexander Cohr Pachai
Senior Engineer
York Refrigeration
Hojbjerg, Denmark

The York Refrigeration (commercial refrigeration) division known as YORK ComRef is a major supplier of equipment to the supermarket segment in Europe. It also has a leading training facility for industry personnel to provide the most up to date advances in refrigeration technology. The person I met with was Alexander Cohr Pachai Senior Engineer Standards and Systems. Alex has extensive knowledge and experience with the larger industrial systems and was kind enough to show me the training facility where York conducts high level training programs. I also witnessed their mobile training rigs that are converted shipping containers which can be deployed anywhere in the world for training delivery. Alex and I inspected some of the systems in the factory that manufactures both CO_2 and Hydrocarbon systems for the Danish domestic and overseas markets. Alex discussed with me useful techniques and he also shared with me some of his presentation materials.

York CO_2 Refrigeration package

Mobile training facility which is deployed around the world

Mr. Andy Pearson
Star Refrigeration
Glasgow, United Kingdom

The Star Refrigeration Co. was founded in Glasgow Scotland in 1970. Star Refrigeration has grown to be the largest and one of the best known refrigeration engineering companies in the UK. The company employs over 250 people in a network of locations throughout the UK.

The company is primarily involved in the larger industrial refrigeration and air conditioning systems. The company proudly claims to be the first in recent times to have used Carbon Dioxide as a refrigerant in a new industrial refrigeration plant.

I met with Andy Pearson Managing Director contracts - Star Refrigeration. Andy and I visited one of two cold storage food distribution centres near Glasgow where the refrigeration system operates exclusively on natural refrigerants - a combination of Ammonia and Carbon Dioxide cascade systems. This was a very useful opportunity to witness first hand a large scale system utilising CO_2. While there we discussed and I was shown a number of innovative aspects about this system (appendix 2). The systems which have a combined cooling capacity of 7MW have been running for a couple of years and according to Star (case study No.8)

> *"The energy efficiency of the new CDC's (central distribution centres) is substantially better than had been achieved on previous sites, even those already achieving "best practice" performance"*

CO_2 / Ammonia cascade system
Star Refrigeration ASDA Distribution CentreGlasgow

The International Institute of Refrigeration (IIR) is an organisation which has its head office, including all staff, located in Paris France. The organisation and was constituted on December 1st 1954 and is a scientific and technical intergovernmental organization enabling the pooling of scientific and industrial know-how in all refrigeration fields on a world wide scale.

The IIR's mission is to:

> *" …promote knowledge of refrigeration technology and all its applications in order to address today's major issues, including food safety and protection of the environment (reduction of global warming, protection of the Ozone layer) and the development of the least developed countries (food, health). The IIR commits itself to improving quality of life and promotes sustainable development."*

The IIR membership ranges from **Member countries** (61) to corporate and benefactor **Members** (companies, laboratories, universities…) to private (individual) members.

This four day event was a showcase of the worlds leading scientists and researchers in the field of refrigeration. This conference was dominated by research surrounding CO_2 technologies. Some thirty (30) papers where presented on CO_2 and no other issue promoted as much interest. . I came away from this conference convinced that CO_2 is the leading alternative refrigerant for many applications for the foreseeable future.

The conference papers will serve as a very useful resource.

Mr. Ib Baek Jensen
Head of Refrigeration Department
Hadsten, Denmark

Technical College of Jutland[5] – Denmark

This institute is similar to the TAFE and is the only national institution delivering refrigeration training primarily to apprentices. This institute provides on site accommodation and training for apprentices in a boarding school type model. Refrigeration training is of the highest standard and the duration of apprentice training is four and a half (4.5) years, of which, 55 weeks of formal "off the job" training is provided in blocks throughout this period.

As the Technical College of Jutland is the only college training refrigeration apprentices, it has found it necessary to link with similar vocational training institutes outside of Denmark for moderation purposes and the like. This has led to the institute to be involved in the European Union - Leonardo Di Vinci Project "Service Refrigeration Education for the Future". This project is designed to, among other things , share resources in order to have a single training standard across Europe.

Ib Baek Jensen Head of Refrieration Department

[5] *Technical College of Jutland (equivalent to the Aust. TAFE system) was not on the original agenda and is not considered a centre focussing on CO_2 technology but may serve to be a valuable point of contact in the future. CO_2 technology training is still mainly provided by the companies directly involved.*

3.3 Program content - What was learnt

The following is a description of the types of systems that I learnt about through this study. The first – "Transcritical " describes a system that is very new and is significantly different to conventional refrigeration systems.

1.Transcritical or supercritical refrigeration systems operate very differently than the conventional vapour compression system - in particular the high side or the heat rejection side of the system. In the conventional system this side of the system rejects heat via a condenser and the heat is dissipated in a steady state[6] known as latent heat of condensation. Not so with the "Transcritical" system where the high side of the system is operating above the critical temperature and pressure point. Rasmussan (2005) while referring to a phase diagram[7] for (R744) CO_2 describes the critical point as the point that marks:

> *"…the upper limit for heat transfer processes based on evaporation and condensation. At temperature and pressures higher than those at the critical point no clear distinction can be made between what is called liquid and vapour. Thus there is a region extending indefinitely upward from, and indefinitely to the right of the critical point – and this region is known as the fluid region."*

Another unique aspect of transcritical systems is that optimal efficiency of the system can be improved by raising the high side or "head pressure" of the system during high ambient conditions. Again this concept is at variance with existing practices with conventional refrigeration systems i.e. when the ambient conditions rise, every attempt should be made to keep the high side pressure low and thus maintaining good system operational efficiency.

The many companies I visited are well advanced in the development of components used on these systems, many of which are quite unique. For example, Danfoss has developed or is in the process of still developing such products as the Thermal Back Pressure (TBR) valve. The understanding of system dynamics and operating characteristics, relating to the application of these new devices will be vitally important in any future training programme.

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[6] *The term steady state means the temperature and pressure remain stable as the heat is being transferred*

[7] *The phase diagram is a pressure/ temperature diagram illustrating the various physical states of* CO_2 under various conditions.

2. Cascade systems

This technology has been around for many years and is relatively well known. Its use is mainly confined to low temperature applications in medium to large scale plant or specialised very low temperature equipment. However what was new was the expanded use of cascade technology with CO_2. This has now been applied to the commercial sector i.e. Supermarket with a high level of success in some of the countries I visited.

The advantages of cascade systems with CO_2 are:

- **Substantial reduction of synthetic refrigerant use in the system when used on the low stage only**
- **Complete elimination of all synthetic refrigerants when using Hydrocarbon or Ammonia on the high stage.**

Advances using CO_2 is not only confined to the medium temperature refrigeration sector but advances have also been realised in the industrial sector as well. Star Refrigeration based in Glasgow has considerable expertise (as mentioned before) in the application of Industrial CO_2 systems. The advantages for the adoption of CO_2 over synthetic refrigerants was best explained to me by Andy Pearson (Star Refrigeration).

1. Few of the many available synthetic HFC refrigerants are suitable for large scale low temperature applications particularly those that have significant temperature glide. This makes them unsuitable for flooded systems typical in large industrial refrigeration plant.
2. The two most promising are R125 and R404A. R125 has a very low critical point and therefore tends to be inefficient. The second R404A is expensive (when compared to ammonia and CO_2) and requires an expensive lubricant which does not tolerate moisture.
3. When used in lieu of glycol as a pump circulated coolant the unique transport properties of CO_2 have realised substantial energy savings.
4. Finally CO_2 is the only non toxic, non ozone depleting, non global warming[8] refrigerant.

Other proven or emerging technologies I became aware of include Pump Circulated CO_2 for medium temperature, secondary volatile systems and two stage throttling with parallel compression.

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[8] *CO_2 is used as a baseline for comparison with other gases and is considered to have a negligible GWP rating on a direct emission basis*

3.4 Outcomes of the fellowship program (related to the skill gaps key issues and analysis)

After travelling to Europe It has now become clear that the Europeans are focussed on these technologies due to a number of influences **or "drivers".** The first and the most influential of these drivers is government environment policy, the outcome of which has resulted in the imposition of levies placed on synthetic refrigeration gasses e.g.

Denmark R404A – € 51 per kG
Norway R404A – € 70 per kG

The above are only the tax components, added to this is the cost of the refrigerant. In comparison, the cost of CO_2 is nominally 0.01 the cost of the synthetic gases. This is a considerable cost differential but it must be remembered that there are technical issues that need to be overcome when employing CO_2 – hence the need for research and development.

Some of the people I spoke to also mentioned that the "Global Warming" issue is as much a political issue as it was a scientific / environmental issue. The refrigeration industry has been the focus of political attention due to refrigeration equipment contributing significantly to the problem by being a major energy user and synthetic gas charged systems having Global Warming Potentials up to thousands of times higher than natural refrigerant alternatives.

Refrigerant	R134a	R404A	NH3	CO_2
Natural Substance	No	No	Yes	Yes
Ozone depletion Potential	0	0	0	0
Global Warming Potential[a]	1300	3260	-	1

Table 1

[a] *Global Warming potential is = 1 kG of R404A released has the equivalent global warming effect as releasing 3260 kG of CO_2 R404A is a commonly used refrigerant in modern systems : Source Danfoss A/S*

The imposition of such levies on the these materials used in the refrigeration industry is seen by some as, *"easy political points"* in the atmospheric carbon loading / global warming debate, because the transition to natural refrigerants in Europe thus far, has and will continue to cause, little or no real disruption to industry, the community, the end user, or the economy. In fact, in the case of Denmark it has real potential for benefiting their domestic economy because Denmark is the home of a number of companies which are major exporters of refrigeration equipment and components. Therefore by being at the forefront of design and of development of CO_2 specific components, these companies will enjoy (and rightly so given the resources invested) market advantage.

The second driver towards the adoption of natural refrigerants is corporate policy. Very large corporations obviously seek to promote positive environmental profile. For example the giant Coca Cola Corporation has reaffirmed its commitment for CO_2 refrigeration in its vending and display cabinets world wide. Jeff Seabright Coca Cola Vice President Environment & Water Resources (2004:3) adds:

> *"In 2004 we took a major step in reducing the potential climate impact of our cooling equipment (coolers and vending machines) by honouring our commitment to work with bottlers to transition our system toward hydro fluorocarbon – free refrigerants. As a result of extensive testing* **CO_2 *based refrigeration***, *has clearly emerged as the safest most reliable and energy efficient hydro fluorocarbon free cooling alternative for our business. We are now working toward full commercialisation of this technology and encouraging the wider industry to follow suit, an effort that is being conducted in close collaboration with other global corporations, along with the United Nations Environment Programme and Greenpeace International".*

In addition to these two very powerful influences there remains one more rudimentary driver influencing industry towards the uptake of CO_2 and that is first cost. CO_2 is a very cheap refrigerant compared to synthetic alternatives. This is a very positive driver especially when one considers the fact that it has been estimated for the commercial refrigeration sector (supermarket) current leakage rates range in the order of 30% of the entire charge per annum[9]. This is a significant cost in the operation of a modern supermarket. In order to minimise cost, systems can be more leak resistant but this in itself requires higher maintenance costs. Thus it appears contemporary practice is a trade off between higher labour costs and the cost of topping systems with sustained moderate leakage rates. Note these leakage rates combined with synthetic refrigerants powerful GWP is what has alarmed and motivated governments in Europe the legislate against HFC refrigerants.

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[9] *figure is an estimate mentioned in a paper "Mitigation of Greenhouse Gas Emissions from commercial Refrigeration systems" presented jointly by Petter Neksa (Senior Research Scientist SINTIF) and Per Lundqvist (Ass. Professor Royal inst. of Technology Stockholm Sweden) at the International Institute of Refrigeration conference* Vicenza Italy Sept.2005

4.0 Recommendations

- It is important that the Australian refrigeration industry be more receptive to this new technology surrounding the application of CO_2 as a refrigerant. Currently there are some who oppose CO_2 system technology in favour of the continued use of conventional synthetic refrigerants for the following reasons

    a) Moving away from the existing tried and proven technology (learning new techniques is perceived to be difficult and time consuming)
    b) The increased danger associated with higher pressures
    c) The additional costs of the new equipment - having to be more robust with additional safety components incorporated in the design
    d) The perceived increase in energy use by CO_2 systems

- Those companies, institutes and individuals whom I have been fortunate to meet in Europe have shown a willingness and technical expertise to overcome most of the abovementioned limitations with CO_2 in many of the common applications. Learning about and understanding the environmental, technical and commercial advantages and limitations of CO_2 systems are important in providing more choice to end users particularly those end uses seeking a greener public perception.

- Target groups for the dissemination of this information are :-

    a) End users who will be looking for a commercial advantage. CO_2 refrigerant offers considerable cost advantage to the equivalent synthetic refrigerant. Synthetics are produced by large chemical companies which are protected by patents and this has a major influence on price - natural gasses such as CO_2 on the other hand cannot be patented this combined with the fact that CO_2 is a simple gas and not complex artificial compounds makes them far cheaper.
    b) Consulting engineers who are now recognising that “environmentally sustainable systems” are also “well engineered systems”.
    c) TAFE teachers who are inculcating the tradespeople of tomorrow with the skills and knowledge to be responsible trade practitioners and finally current refrigeration tradespeople.

- As we move into the future, environmental concerns are becoming increasingly pervasive this will not change and Australia like all other countries are increasingly being pressured to comply with world environmental protocols. This impacts on many industries but the impact has been particularly influential on the refrigeration industry and, even though we don't currently have significant levies on synthetic refrigerant gasses, we may, be obligated soon into imposing levies similar to those found in those countries as mentioned earlier such as Denmark and Norway.

- By embracing an understanding CO_2 technology now, we may prevent a scramble for the knowledge and expertise when we may not have a choice in the immediate future as the rest of the world moves towards a more sustainable refrigeration industry.

- The Australian Government through the Australian Greenhouse Office is providing information but more needs to be done in raising the awareness of the availability of this and other technologies.

4.1 Government – Federal, State and Local government

The Australian government through the Department of Environment and Heritage is responsible for the administration for the control of emissions of harmful gasses into the atmosphere. These include synthetic greenhouse gasses particularly those used in the refrigeration industry as mentioned earlier. In a recent study commissioned by the Australian Greenhouse Office[10] (which surveyed a number industries using synthetic greenhouse gasses here in Australia) it was revealed that within the refrigeration sector the Australian Government could do more and that industry participants (ICF 2003:4) stressed :

> *"…the importance of improved training, information, and education on the use of natural refrigerants (e.g., ammonia, hydrocarbons and carbon dioxide) to overcome current attitudinal barriers to their use."*

Therefore if Government policy is to control these emissions as evidenced by the new *Ozone Protection and Synthetic Greenhouse Gas Management Amendments Regulations (2004)* and the accompanying licensing system, then it would seem reasonable to expect the Government to at least consider funding educational and marketing incentives to encourage the uptake of natural refrigerants in the Australian refrigeration market where CO_2 refrigeration technology is viable[11].

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[10] ICF Consulting produced a report into the Use of Alternatives to Synthetic Greenhouse gases in industries Regulated by the Montreal Protocol in Australia. RAC industry provided the greatest number of responses of the five sectors surveyed 44 in total.

[11] CO_2 technology has proven to match or even out perform synthetic refrigerant systems in most refrigeration applications but some air conditioning applications are proving difficult to match in terms of energy efficiency and therefore synthetic gasses will continue to be applied for some time.

4.2 Companies can contribute to the solution

One positive development in the use of CO_2 refrigerant technology has been the recent establishment by Bitzer Australia of a purpose built training facility in Sydney for the purpose of training Refrigeration technicians in CO_2 system technology. Bitzer Australia has signalled an intention to work collaboratively with the TAFE system in providing training programmes (N.B. the details of which have yet to be decided) . This will be an exciting venture and should provide quality training outcomes.

4.3 Professional Associations

Professional associations have an important role to play by providing an avenue for the distribution of information regarding CO_2 technologies as many associations have regular meetings and most publish journals. The following lists those associations (also mentioned before) which have the highest profile and significant membership. Further, these organisations also consult and advise Government on matters relating to the industry, such as environmental training, industrial relations and are also involved in the development of standards.

Australian Institute of Refrigeration Air Conditioning and Heating **(AIRAH)** has worked collaboratively with the TAFE system in the past. Example of this is the R410A update programme that continues to provide professional development for refrigeration mechanics. CO_2 technologies can and should be promoted through this organisation.

In addition to this AIRAH through its trade journal EcoLibrium[tm] has provided a very efficient means of raising awareness of advancements in this industry in the past. This journal is read by many within the design engineering fraternity, and I know this publication also reaches end users as well. Given the broad reach of this journal I recognise that the profile of CO_2 technologies will be advanced through this medium and this project and future training projects will need to be highlighted with the editor. I will be making the editor aware of this report.

The Refrigeration and Air Conditioning Contractors Association **(RACCA)** has chapters throughout Australia and has many members. This organisation has regular meetings which discuss among other matters new developments in the refrigeration industry. It is my intention with the co-operation of the president of RACCA to present a CO_2 seminar which I have prepared.

The Air Conditioning and Mechanical Contractors association **(AMCA)** represents contractors that are involved primarily in large projects such as hospitals, shopping centres and high rise commercial office towers. This organisation is in regular contact with not only Logan Institute of TAFE but also refrigeration departments of all TAFE institutes around Australia. This organisation has a well-established newsletter and website which provides a very efficient way of conveying information which affects this industry. AMCA also provides seminars and training programs to its members and in the past I have been asked to present information at meetings and provide training sessions to its members.

I will endeavour to promote information relating to CO_2 technologies through this professional organisation.

The Natural Refrigerants Transition Board **(NRTB)** in its charter states its goal is to promote the use of CO_2 and other natural refrigerant technologies within the wider community generally and the refrigeration industry specifically. NRTB actively pursues state and federal governments on policy relating to the implementation of natural refrigerant technologies. NRTB has also stated a desire to work collaboratively with the TAFE system in developing training programs for CO_2 technologies and other natural refrigerants.

4.4 Training providers

The refrigeration industry will be looking towards TAFE primarily, as it always has done, to provide training to fill the skills gap that has already opened up within the industries labour force.

The TAFE system will need to develop the skills of its refrigeration teaching staff by providing professional development opportunities through such activities like the introductory hands on course at BITZER's new training facility in Sydney. This will assist in the understanding of this new technology can then be passed on to the industry at large. Ongoing involvement with the refrigeration TAFE teachers network through regular meetings[12] so as to pool resources and expertise is one of the many strengths TAFE has as a training provider for this industry. This needs to continue to be supported by the TAFE system.

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[12] *Delivered a presentation at the Refrigeration and Air Conditioning Technical Advisory Committee (RAC TAC) meeting Rydges Hotel South Ban Brisbane Monday 7th November*

4.5 Community marketing

Targeting end users (supermarket chains and other food retailers) and consumers for the uptake of natural refrigerants is the role of environmental lobby groups and the Government through the Department of Environment and Heritage. However it is important for these organisations be made aware that TAFE can and will support industry by learning about the latest techniques (the purpose of the skill acquisition plan) and therefore supporting end users.

4.6 What the ISS Institute can do to help with the change

I have recently made an approach to the Department of Environment and Heritage for the possibility for Federal funding the development of training courses and awareness programs. The reply I received was to make a formal submission to the Australian Greenhouse Office for funding assistance.
I will be asking for the ISS Institute to assist me in writing this submission.

4.7 Further skill gaps

The range of Natural refrigerants extends beyond Carbon Dioxide and includes such refrigerants as Hydrocarbons. The use of these refrigerants is gaining popularity in Europe and I can see that these will also have some market impact here in Australia. In terms of further skill gaps it would be reasonable to assume that with the uptake of these refrigerants technicians will require specialist training in handling particularly given the fact that these refrigerants are flammable.

Conclusion

While the focus of this project was to investigate the need for specialised training in the handling of CO_2 and the newly developed equipment designed to operate efficiently on this gas, this project has served to put into perspective the challenges looming for the Australian refrigeration industry. As industry and the wider community embrace CO_2 and other emerging refrigeration technologies the consequential training needs that stem from these technologies will continue to put increased strain on the industry as it exists presently and particularly for current industry practitioners who are part of the ‘aging” baby boomer workforce.

The same is also true in the TAFE system that employs many ageing albeit highly experienced teachers who will be faced with these challenges in the near future.

The reasons for this increased strain on industry and the concurrent training system are many, including the introduction of the above mentioned technologies as well as :

- The need to respond to industry demands for the provision of fee for service training like the new Federal Licensing system for the handling of Synthetic Greenhouse Gasses and future programs - CO_2 training.

- Considerable growth within the industry sector and the resultant growth in the employment of apprentices (which is most desirable) but which has outstripped the supply side - the recruitment of trained trades people has not kept up with the demand in the industry resulting in the current shortage of highly skilled and experienced workers in the industry who are able to attract high salaries.

- Therefore, recruiting industry practitioners to a career in TAFE teaching is difficult (salaries and conditions available in industry are unable to be matched by TAFE)

- Quality of teaching can be compromised as well new teachers that are employed are engaged on casual contracts. This results in a mentoring role that is an added demand on the remaining tenured teachers.

Before the implementation of training for CO_2 technology can be conducted effectively to industry practitioners, the TAFE system needs to improve its capacity to deliver. Some of the possible solutions could be to provide :

- Improved career pathway for the more senior teachers to take up a more active role in the development of resources and curriculum (less time in the classroom/workshop). This would lead a pathway open for new teachers and provide an incentive for the retention of experienced TAFE teachers.

- The current system of training packages continues to cause uncertainty and poor outcomes, as the focus is on paperwork. Training packages are convoluted and open to many interpretations. This in turn leads to confusion and a waste of resources (auditing the paperwork instead of focussing on outcomes). A system that reduces the need for paper checks and focuses instead on quality outcomes is far more logical.

- Professional development of teachers is under funded. Incentives such as maintaining industry currency and the ability to attend seminars provided by companies both domestically and internationally would serve a number of purposes simultaneously. Teachers would see that the system is prepared to invest in them and the students and industry would benefit from the latest knowledge and skills that can best be communicated by professional teachers.

5.0 Appendices

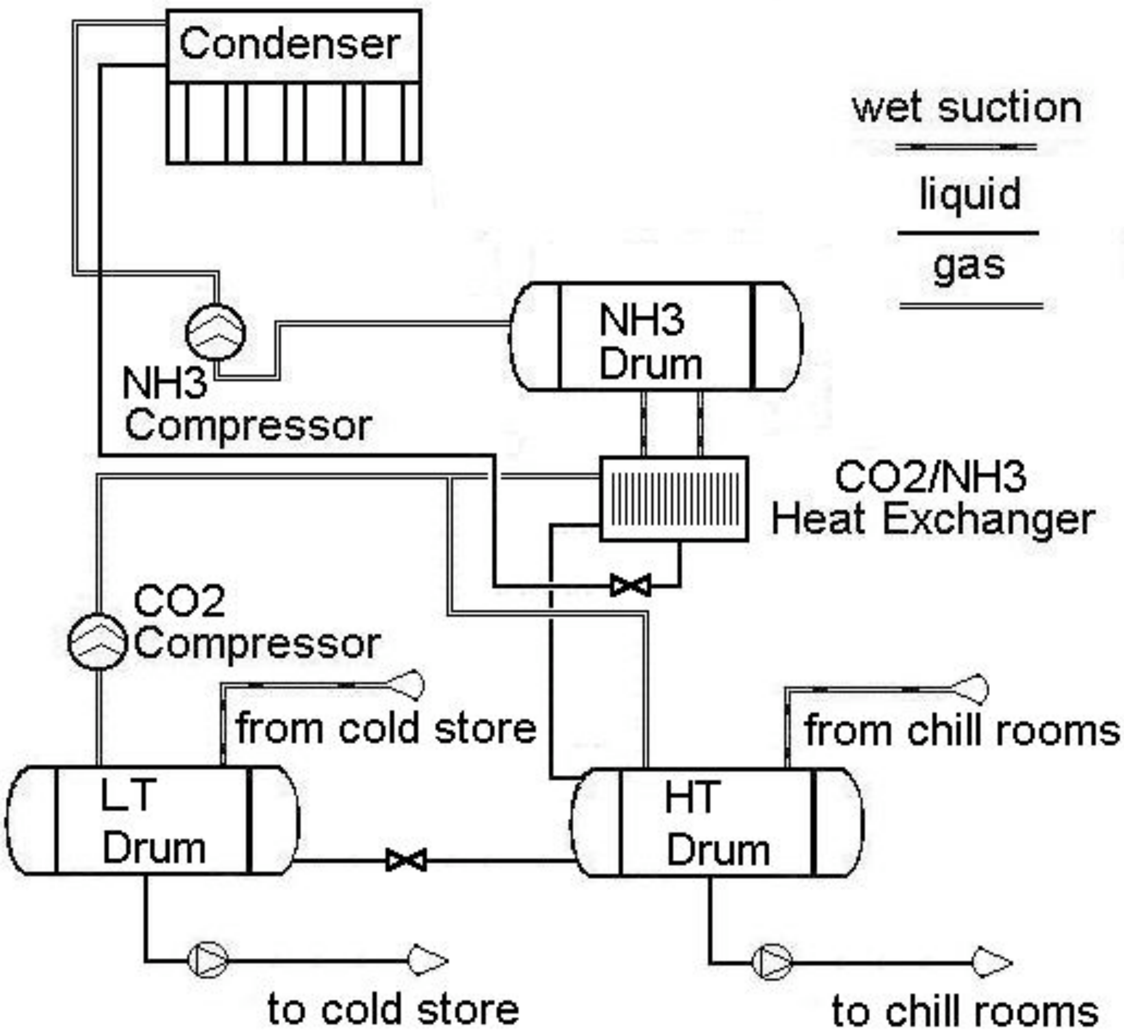
Appendix No.1

Table ES-1. Most Promising Options for Reducing Greenhouse Gas Emissions in 2020, as Indicated by Industry

Sector	Alternative	Expected Market Penetration
Refrigeration/Air-Conditioning[a]		
Commercial AC/ Chillers	Ammonia	11-20%
	Secondary loop systems[b]	> 10%
Cold Storage	Secondary loop systems	21-50%
	Carbon dioxide	21-50%
	Distributed systems[c]	> 10%
Retail Food	Secondary loop systems	21-50%
	Hydrocarbons	21-50%
	Carbon dioxide	11-20%
Industrial Process Refrigeration	Ammonia	> 50%
	Hydrocarbons	11-20%
	Carbon dioxide	11-20%
Household Refrigeration	Hydrocarbons	> 50%
MVACs (Motor vehicle air-conditioning)[d]	Hydrocarbons	> 50%
Transport Refrigeration	Hydrocarbons	21-50%

Source: (2003) ICF Consulting for the Australian Government report into "The use of alternatives to Synthetic Greenhouse Gases in industries Regulated by the Montreal Protocol"

Appendix No 2.



Source: (2004) Star Refrigeration Andy Pearson: example of industrial refrigeration system employing CO_2 as a refrigerant

References

Bellstedt, Dr. Michael (2004) 'Special features on Refrigerants'
Celsius Magazine June 2004 pp.12-15

Coca Cola Company (2004) 'Everyday around the Globe'
Environment Report

Commonwealth of Australia Legislation (1989) 'Ozone Protection and Synthetic Greenhouse Management Act'
Formerly the 'Ozone Protection Act 1989'

Commonwealth of Australia Legislation (2004) 'Ozone Protection and Synthetic Greenhouse Gas Management Amendment Regulations'

ICF Consulting (2003) 'The use of Alternatives to Synthetic Greenhouse Gasses in industries Regulated by the Montreal Protocol
Australian Greenhouse Office

Pelvin Jennifer (2004) 'AIRAH survey of refrigeration and air conditioning market awareness'
Ecolibrium[tm] Magazine October 2004 pp.4

Star Refrigeration (2004)
March 2004 Case study No.8 ASDA Distribution Centre. Skelmersdale Scotland
www.star-ref.co.uk

United Nations Environment Program (UNEP)
2002 Report of the Refrigeration, Air Conditioning and Heat Pump technical options committee 2002 assessment
www.teap.org