If you wouldn't give a XXXX for anything else, then you might be surprised to know that the iconic beer is now being chilled by ammonia, following a refrigeration plant upgrade at the Castlemaine Perkins Milton brewery in Brisbane last year. Sean McGowan reports.

XXXX GIVES THE NOD TO AMMONIA

The Castlemaine Perkins brewery, easily identifiable by its iconic XXXX sign, is one of the most recognisable landmarks of Brisbane, and among a handful of traditional breweries left standing in Australia.

Originally a distillery, the site, located alongside the Ipswich rail line in Milton, was purchased and converted into a brewery in 1877 by brothers Nicholas and Edward Fitzgerald, who named it after their brewery in Castlemaine, Victoria, which had served the goldfields at the time.

Brewing commenced at Milton shortly after, and the first XXXX-branded sparkling ales were released (the Xs refer to the traditional system used to grade the strength of beer). By the end of the following decade, it became the first brewery in Queensland to produce lager-style beers.

However, it was not until 1924 that the iconic XXXX Bitter was first introduced, coinciding with the famous branding the company still carries today, including the Mr Fourex character that remains featured on the city-side of the brewery walls.

Four years later, a takeover made Castlemaine Perkins Ltd the largest brewery in Queensland. Such was the company's success over the ensuing 60 years that it was eventually bought by food and beverage company Lion Nathan in 1992. Lion Nathan was then bought by Japanese beverage giant Kirin in 2009.

CHANGING TIMES

Despite changes in ownership over the brewery's 90-year history, the XXXX brand and product have remained resolute – as much a symbol of the sunshine state as any other. However, just as tastes change, so too has the brewing process.

Devastating floods hit Brisbane in 1974, and in that same year a major fire broke out in the brewery. It resulted in more than $1.25 million in damages, and a new brew house was installed to meet growing demand.

Around this time, a refrigeration system comprising of four chiller packages with centrifugal compressors was installed. These may well have originally run on CFC12, but in the past 30 years were converted to HFC 134a.

This system supplied a 24 per cent by weight ethanol and water mixture at -6°C to all areas within the brewery requiring refrigeration, including the maturing of the company's famous product during the brewing process.

Although the system served its purpose for many years, it increasingly presented many problems including excessive condensing pressures and refrigerant leaks.

Stefan Jensen, F.AIRAH

Perhaps even more concerning was that the HFC 134a-based refrigeration system consumed 40 per cent of the electrical energy consumed by the entire site. With carbon pricing being mooted, the company sought an energy-efficient replacement to its aging, energy-hungry system.

While attending the IIR-Gustav Lorentzen Conference on Natural Working Fluids in 2010 (GL 2010), two representatives of the Castlemaine Perkins Milton brewery were introduced to Stefan Jensen, F.AIRAH, of Scantec Refrigeration Technologies. The relative merits of ammonia versus HFCs were discussed.

Following the introduction, Scantec was invited to tender on the refrigerant conversion by engineering consultancy Beca; this it subsequently won.

According to Jensen, the brief was to replace the four existing R134a centrifugal chillers with four speed-controlled, low-NH_3 charge packaged industrial ethanol/water chillers with a unit capacity of 1500kW. In addition, new ethanol/water buffer tanks, cooling water pumps, primary ethanol pumps and new secondary ethanol pumps were also part of the brief.

The objective was to eliminate the refrigeration system's exposure to the impacts of environmental legislation in relation to HFCs, rising energy costs and general equipment upgrades and replacements.

"Perseverance with HFC 134a was considered, but the considerable energy efficiency advantages of ammonia could not be ignored," Jensen says.

"Although the carbon-equivalent HFC levy was not a reality when it was decided to upgrade the plant, the levy became a serious consideration later in the project. As the previous centrifugal chillers had a unit R134a charge of around 3,500kg, the replacement cost per charge at current post-levy prices for R134a is around $20,000."

BACK TO THE FUTURE

Despite the replacement ammonia system being specified as including four individual chillers, the new ammonia system was designed as a central plant.

According to Jensen, this was in the interest of energy savings, particularly at part load.

Scrubbers on the brewery's exterior.

Inside the Castlemaine Perkins Brewery.

The plant room prior to the upgrade.

He says this is because all heat exchanger surfaces are fully engaged in the refrigeration process at all times, with only the compressor capacity being varied. This compares favourably to individual chillers where the heat exchanger surface area engaged is varied, with the number of chillers operational.

Along with being selected due to having no global warming impact or ozone-depletion potential, ammonia features thermophysical and transport properties that inherently deliver higher cycle efficiencies than HFC refrigerants. It also has the lowest molecular weight of any common refrigerant (17.03kg/kmol), resulting in minimised pressure drops in pipe lines, valves and compressor ports.

"The thermal conductivity of NH_3 in the liquid phase is six to eight times higher than for HFC refrigerants," Jensen says. "This improves heat transmission coefficients in all heat exchangers."

However, for all its advantages, the introduction of a central ammonia plant presented significant challenges, not least of which were the greater ammonia charge and the toxicity of the fluid – both of particular concern given the brewery's inner-city location.

Just as there were issues of safety for operators, owners and the public to address, an ammonia-based system also requires the use of ferrous materials or aluminium in the plant's construction. This placed high demands on the quality of the welds – and the welders.

It is for this reason, Jensen says, that central ammonia plant design is not a discipline mastered by a large percentage of stakeholders within the refrigeration industry.

Great care was taken during the design phase of the project to address the safety concerns associated with the installation, including extensive HAZOP (hazard and operability) analysis.

As well as complying with all modern safety standards, the resulting design introduced additional scrubbers and duplicated ammonia detection devices. The plant was also designed to be installed within an appropriate engine room enclosure to minimise the safety risks associated with an accidental ammonia release.

Having been involved in the first large-scale HCFC22-to-ammonia conversions on large cold store facilities in the mid-1990s, Jensen says the Castlemaine Perkins conversion was relatively simpler.

He says the biggest challenge was the short period of time available to complete the changeover from the old plant to the new ammonia plant. With few periods of the year available where production shuts down, a four-day long weekend was targeted. During this time the old plant was taken off-line and the new plant installed.

Jensen says despite the short time-frame, the ammonia refrigeration system is conceptually simple and relatively straightforward to install.

"It comprises four compressors, two condensers, two evaporators, a high-pressure receiver and a surge drum," he explains, adding that such conversions require extensive familiarity with ammonia refrigeration system design and the associated safety requirements.

With little time to finetune the system before production recommenced and the new ammonia system began providing refrigeration to all areas of the brewery, a few minor control issues were subsequently identified.

It was soon found that the ethanol/water mixture, following the conversion, became too cold for the processes in some cases.

For example, the maturing stage of the brewing process requires that the beer be chilled to a low temperature to precipitate remaining yeast and protein. It is then stored for up to two weeks at a temperature just below 0°C. During this time the beer is stabilised to refine the flavours; yeast and haze materials settle out of the beer; and carbon dioxide is locked in.

According to Jensen, the ethanol/water mixture became too cold due to an improvement in ammonia plant response to heat-load changes.

"The effect was that the control set-point for the ethanol had to be raised marginally," he says. "Of course, this further improves energy efficiency."

With the aging R134a refrigeration system responsible for 40 per cent of the site's electrical consumption in the past, the change-over to the new central ammonia plant reduced this figure to around 30 per cent.

Jensen says this will likely translate into a simple pay-back period for the new ammonia plant of around three to four years.

Despite the safety concerns surrounding the use of ammonia as a refrigerant, he says industrial refrigeration associations world-wide have developed and refined safety standards over a long period of time, such that ammonia now has an admirable safety record.

"The probability of fatalities has statistically been reduced to less than two per one billion citizens, per annum. This is significantly less than the probability of fatal road accidents, of which there are around 3,000 daily, worldwide."

With no global warming or ozone-depletion impact, and therefore no carbon-equivalent levy attached to it, it is not surprising to see ammonia being considered for a wide range of refrigeration solutions, including super-low-charge installations in commercial applications.

Nearly 90 years after it brewed its first ale, the Castlemaine Perkins brewery in Milton has likely gone full circle by returning to the use of ammonia in its refrigeration process.

Give it some thought when next you crack open a XXXX can or stubby, and raise your glass to this century-old refrigerant. ▲

Inside the plant room.