

COOL INNOVATIONS

With the government under pressure to reduce harmful emissions, including from commercial vehicles, it's likely that transport refrigeration systems will come under the microscope, says Brian Tinham

Refrigerated trucks are significant hidden polluters, contributing to thousands of deaths and costing taxpayers across Europe some €2 billion a year, rising to €2.5 billion by 2025. That is among key findings of research published late in September on behalf of liquid air engineering firm Dearman. Its study also points the finger at European governments that continue to grant tax breaks for red diesel on auxiliary engines. That, it suggests, exacerbates the situation by acting as a disincentive to developers of alternative lower-emission refrigeration technologies.

The allegations are not altogether surprising, other than in terms of their scale and seriousness. Dearman's study claims that diesel TRUs (transport refrigeration units) operating throughout the EU lead directly to an air quality impact of 13 million tonnes of CO₂e (carbon dioxide equivalent), 40,000 tonnes of NO_x and 5,000 tonnes of dangerous particulate matter (PM) per year. This, it says, is equivalent to 56 million extra diesel cars.

Those figures are based on an

estimated 1 million TRUs across Europe, of which 84,000 are in the UK. They are also calculated on the basis that TRUs – often based on Euro 3 or similar engines – emit 29 times more PM and six times more NO_x than a Euro 6 diesel truck, or 165 times more PM and 93 times more NO_x than a Euro 6 car.

"Until now, nobody has given TRUs a thought," insists professor Toby Peters, CEO of Dearman and visiting professor of 'power and cold economy' at Birmingham University. "But they are unregulated, use outdated technology and are disproportionately polluting."

WORRYING POLLUTION

He adds: "What's worse, their pollution is concentrated on city streets where it does the most damage to our health. With 400,000 people dying prematurely every year in the EU as a result of air pollution, we simply cannot afford to ignore these hidden polluters any longer."

His is a convincing argument but what can we, in transport, do about it? Let's get some context. Peters does not have philanthropy as his sole motive. Dearman styles itself as the 'clean cold



and power' technology firm, and is well down the road to developing zero-emission, liquid air engines. So Peters hopes these will, in due course, replace auxiliary diesels in TRUs.

However, while the concept is attractive (see panel p12) and the first prototype is due to enter trials as we go to press on a mono-temperature rigid with an as yet unnamed UK operator, systems are nowhere near series production. What's more, they are unlikely to be so until late in 2017.

So, facing a two-year hiatus, what about other innovations capable of reducing the environmental impact of TRUs? Well, chief among the contenders must be BOC's Frostruise and Carrier Transicold's NaturaLine – the former in commercial production since its formal post-trial launch at this year's CV Show, and the latter currently the subject of a promising two-year trial with Sainsbury's.

As with Dearman's innovation,



Oliver Burston

Frostcruise harnesses liquid nitrogen, but in this case only for cooling – not for electrical power. That means it is disadvantaged in terms of overall efficiency to the tune of some 50%, according to Dearman. That said, this on-demand refrigeration system is available now and is simple in concept.

Essentially, Frostcruise uses nitrogen at -196°C stored in on-board cryogenic tanks to indirectly chill truck or trailer compartments via ceiling-mounted, fan-assisted vaporisers that boil off the gas. The system has been proven with Marks & Spencer and Starbucks to deliver accurate temperature control, even in multi-drop operations – and importantly, with or without the vehicle engine.

It also offers ultra-rapid cool down: trials by BOC demonstrated that the system could reduce trailer air temperature from 16°C ambient to 2°C within eight minutes, less than half the time for mechanical systems.

Additionally, Frostcruise also delivers zero emissions at the point of use and a claimed 64% reduction in total carbon footprint, compared to diesel TRUs. And it's quiet, with a PIEK certificate for near silent operation at 56dB, meaning that Frostcruise-equipped trucks can be used for deliveries around the clock, even in urban areas that limit noise to 60–65dB from 10pm to 6am.

NOT JUST A TRU

"BOC is committed to providing innovative, cost-effective solutions that minimise the impact and maximise the effectiveness of our customers' store deliveries," comments Nathan Palmer, BOC director of bulk and packaged gas. "We have worked with Marks & Spencer and Gist to evolve the product to where it is today, and I'm very pleased to say that M&S has purchased another 13 new trailers with Frostcruise."

Meanwhile, Carrier Transcold's NaturaLine is quite different. It leaves the diesel engine untouched, and serves instead to eliminate environmental risks due to HFC (hydrofluorocarbon) refrigerant leakage by substituting CO_2

(R744) for conventional F-gases, primarily R404A, which are aggressive greenhouse gases. And to gauge the value of that, note that R404A has a GWP (global warming potential) of 3,922: R744 stands at just 1. That's worth noting, given the new EU 517/2014 F-Gas regulation, which came into force on 1 January 2015 governing the use and maintenance of TRUs containing HFCs on vehicles plated above 3.5 tonnes – also presaging a planned phase down of HFCs.

The first trial unit – powered by the same E-Drive all-electric technology as Carrier's existing Vector range – entered service in the summer of 2013, mounted on a specially commissioned 10.8-metre Gray & Adams, single-compartment urban distribution trailer operating at -22°C . It has been running out of Sainsbury's Elstree depot delivering to stores across Greater London and has achieved 100% performance to date. This summer, Sainsbury's took delivery of a second, almost identical CO_2 -filled fridge, this time on a dual-temperature application (chilled and ambient), for its St Albans depot.



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Nick Owen

According to Sainsbury's operations support manager Gary King, next up will be a full multi-temperature version on a 13.6-metre semi-trailer. “Moving over to natural CO₂ as the refrigerant is an important step forward in reducing refrigerated transport's environmental impact,” he says. “Trials are progressing well and we continue to work with Carrier to develop the unit to offer identical cooling to traditional TRUs.”

Nevertheless, given the increased CO₂ pressure and the trials' timeframe, NaturaLine is probably some years from series production. Carrier Transicold president David Appel says only: “CO₂ as a natural refrigerant holds great promise across the cold chain as a preferred environmental choice.” And he adds that Carrier is committed to the commercialisation of natural refrigerants in road transport by 2020.


In the meantime, the company has

started making R452A available on new units and as a retrofit option to existing R404A-charged TRUs. R452A offers the same cooling capacity, fuel efficiency, reliability and charge as R404A, but yields a 45% GWP reduction, at 2,140. Carrier says the conversion does not require major component changes and can be done in customer workshops.

Finally, however, if you're after a sanity check, here's what Ryder's product director for refrigeration Justin Lochhead (former managing director of Euroway prior to its acquisition) has to offer. “The alternatives to diesel-driven RTUs, such as Dearman and Frostcruise, are very interesting. But, while both are positive steps to eliminating emissions and CFCs, neither is yet far enough down the road for us to recommend them to customers... We have to keep a sharp eye on residual values and be mindful of what's standard equipment.”

What does he recommend? “For now, we would look first at Carrier and Thermo King: they're both knocking on the door of efficiency, although there's only so much anyone can do with diesel engines. We're also looking seriously at trying to get operators to make more use of electric standby, which is sadly neglected at the moment.”

Lochhead is also a fan of the relatively new class of hermetically sealed electric fridges driven by auxiliary diesels, as championed by Carrier – not least for their “step change in reliability”. However, he also rates Thermo King's hybrid approach, where the diesel drives the compressor and an alternator.

His advice: “With any deep frozen application I would always consider an alternator-driven system. Also, any system that requires constant airflow – vegetables, flowers, etc – needs an independent system.” 

Dearman in perspective

At the heart of the Dearman technology portfolio is the Dearman engine – a novel piston engine that harnesses the rapid expansion of liquid air (or nitrogen) to yield powerful cooling and, importantly, also zero-emission power. For transport, applications might include air conditioning on PSVs (public service vehicles), where the combination of power for auxiliaries, cooling for the primary function and zero emissions is obviously attractive. But in the short term Dearman is focusing its efforts on temperature-controlled transport, where the benefits are equally clear.

How does it work? Dearman chief technology officer Nick Owen explains that at the heart of what amounts to a conventional piston engine modified to maximise heat exchange potential, is a Rankine cycle expander powered by liquid nitrogen. “As the very cold industrial gas is pressurised to 40–50bar and then vaporised, it drives the engine. That provides a combination of cooling, due to the vaporisation process, but also motive power.”

Looking at the stroke cycle, heat exchange fluid is first pumped into the engine, filling most of the cylinder volume. Liquid nitrogen is then introduced, which, on contact with the heat exchange fluid, starts expanding under near isothermal conditions. That forces the piston down and an exhaust valve then opens, allowing the mix of gas and heat exchange fluid to exit the engine. The latter is reclaimed, reheated and recycled, while the nitrogen is exhausted back to atmosphere.

“The power output drives a generator for auxiliary electrical equipment,” explains Owen. “And we also use some Dearman engine power to drive a

dramatically downsized conventional refrigeration cycle, which adds further heat pumping to aid its cooling efficiency. But the main point is that, whereas a conventional engine produces heat and power, this produces cold and power, so it is well suited to TRU (transport refrigeration unit) applications.”

Deputy chief executive Michael Ayres concedes that, in the absence of volume production, he can't yet give a list price. “However, we have been working with our partners Hubbard Products and Air Products in the [government-backed] Proving Factory environment, and we believe that above 1,000 units a year, we will be cost competitive with conventional TRUs,” he says.

In fact, current modelling suggests that running costs for Dearman's second-generation unit will be comparable to conventional auxiliary engined units, themselves buoyed by cheap red diesel, but £1,000–£2,000 cheaper per annum than direct drives, depending on duty cycle. And although on-costs are likely to be “a few hundred pounds including the cryogenic tanks”, these TRUs will have the advantages of zero emissions, very rapid cooling – a rigid will have circa 16kW of cooling power – and low noise, at some 60dBA.

“The current business plan is to get about 100 units into Europe and the US next year, to build experience and to extend our technology validation. Then in Q4 2017 we intend to start building, ramping up to 10,000 units per year.”

Ayres accepts that is ambitious, but counters that the investment is there, the new Croydon technology centre is fully functioning and potential customers can expect “maybe a couple of thousand units in 2017 at fully commercial prices and terms”.