

Get**COMFORTABLE**

A Thermo King publication for the mobile climate control industry

2010 Is Almost Here... Will You Be Ready?



T-Series Rear-Mount



LRT-HP Roof-Mount

As of January 1, 2010, bus operators will be affected by two significant new EPA regulatory statutes: the 2010 engine emissions standards and the ban on R-22 refrigerant for use in new equipment (see R-22 articles in this issue). These two regulations will affect everything from new bus specifications to how fleet maintenance is done. The biggest and most dramatic change operators will see are the new EPA engines that will begin appearing on new buses sometime in 2010. The new engines must comply with lower emissions standards as set forth by the EPA, and to meet these standards bus builders and engine manufacturers will be adding Diesel Particulate Filters (DPFs) to the buses.

"While many of you are aware of this change, you may not be aware that the configuration and location of the HVAC unit could be affected," explained Steve Johnson, product manager for large bus at Thermo King. "In the United States, the most commonly used HVAC in the transit industry is mounted at the rear of the bus above the engine. As bus OEMs are forced to find space to accommodate the DPF, they are re-arranging the components in the rear of the bus. The available space for the traditional rear-mount HVAC unit is being reduced or eliminated. The robust, one piece, compact design is the most reliable configuration available today and is easy to install and service. Will it go away permanently? As of now we don't know, but we do know that some type of change is inevitable."

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Each bus builder will have its own approach as to how to best deal with the space issue. Fundamentally, if the space for the conventional rear-mount HVAC unit is not available, the most logical place for the unit is on the roof. "This is not a novel concept," continued Johnson. "Some U.S. transit properties already have experience with roof-mount HVAC, particularly on articulated buses where two cabins have to be cooled. Also, in all markets outside of the U.S., roof-mount HVAC is the standard configuration. "For the most part, the rear-mount HVAC is preferred in the transit industry, and in fact, more than 80 percent of what Thermo King supplies has been rear-mount over the years."

So what are the differences between rear-mount and roof-mount systems? For installation of roof-mount systems, holes have to be cut in the roof for the air openings, and sealing of the HVAC unit to the roof becomes critical. The refrigerant, water lines and some harnesses have to be routed within the body of the bus to connect the roof-top unit, to the compressor in the engine compartment. To realize the same capacity, the roof-mount unit will be heavier, mainly due to the configuration of the coils and the addition of covers, which are not needed on the rear-mount system. Some roof-mount configurations have separate condenser and evaporator modules that have to be connected after they are on the roof, an additional step in the installation process not required for rear-mounted units. In addition, some maintenance and repair work has to be done from the roof of the bus instead of from the ground or on a short ladder.

According to Johnson, there are several advantages of the roof-mount system as well. "The roof-mount configuration allows the operator to have a rear window if they choose, and there are more opportunities to manage air distribution, weight distribution and noise because the location of the unit can be anywhere from the back to the front of the bus."

"What all of this means for the primary stakeholders: the bus builder, the HVAC supplier and the operator is that the industry has to come up with some valid, cost-effective solutions," said Johnson. "Traditional roof- and rear-mount systems are not the only options -- there can be integrated solutions where the components are placed in various parts of the bus and connected, similar to what is done in some coach and small bus applications. The unit could also be integrated into the roof of the bus and eliminate the need for expensive covers."

Martin Duffy, general manager for HVAC at Thermo King, summarizes Thermo King's approach to the upcoming design challenge: "We have never been a 'one-size-fits-all supplier' and we will work with each of our customers to provide the best custom solution for their business."

R-407C, the R-22 Replacement: A Truly Green Technology

The Global Warming impact of any refrigerant is a function of two things. First, there is the direct global warming potential of the gas. This occurs only when a leak arises. Many climatologists believe the most important contributor to global warming is the so-called indirect global warming, caused by the consumption of fossil fuels like those used to drive the A/C system. The use of fossil fuels produces carbon dioxide (CO₂), the output of which is measured in tonnes. This indirect global warming occurs every time the unit operates. More efficient systems use less fuel, so they produce less CO₂ for reduced global warming.

Adding the direct global warming to the indirect global warming produces what is known as the Total Equivalent Warming Impact (TEWI). Using the standard refrigerant loss factors as set out in the British Refrigeration Association (BRA) TEWI Calculation Guidelines (2000 edition), assuming a system operating lifetime of 10 years, one can calculate the following system TEWI values:

	TEWI (Tonnes CO ₂)	
	R-134a	R-407C
System operating 100% of year	498.3	428.2
System operating 50% of year	251.5	216.8

This data clearly shows that R-407C has a 14 percent lower environmental impact than R-134a. These results are illustrated by Thermo King field data in many parts of the world.

Streetcar Ready to Roll Again in New Orleans with Help from Thermo King

The New Orleans Regional Transit Authority (NORTA) has added a special streetcar to its fleet thanks to the dedication of Thermo King service employees in Europe and the United States. Streetcar 2008, the first Katrina-damaged vehicle to be rebuilt, returned to service on Canal Street in mid-September.

Most of NORTA's trains were damaged during the flooding that followed Hurricane Katrina in late August 2005. In the aftermath of the hurricane, the authority was unable to retain more than 75 percent of its skilled service technicians, and most of its tools and equipment were damaged or destroyed. For help, NORTA turned to supplier Thermo King, which had provided the air conditioning units used by the trains.

"Thermo King felt compelled to step in not only to support a customer in need, but as a gesture of support to the people of New Orleans," said Magdi Sayegh, global service manager, rail.

Sayegh coordinated the effort and gathered the necessary team members from European-Served Area engineering and local U.S. dealerships. A team of Thermo King technicians went to New Orleans to assist NORTA in rebuilding the Light Rail Vehicles (LRV).

Luckily, the floodwater did not reach the rooftop air conditioning units. Nevertheless, the Thermo King team faced a difficult task as every wire and connector had to be checked for damage and functionality. The team also had to conduct a class in order to instruct the new NORTA service employees on how to use Thermo King's service software.

"Upon our arrival for a visit to the NORTA depot, we could see the devastation and the difficult conditions that the NORTA technicians and engineers had to endure in working round-the-clock to get the first car ready," said Sayegh. "Seeing the first car being readied brought our team almost to tears."

NORTA was the first transit authority in the United States to install Thermo King units on its LRV fleet. To further support this special customer, Thermo King is extending the warranty on the rebuilt units by one year.

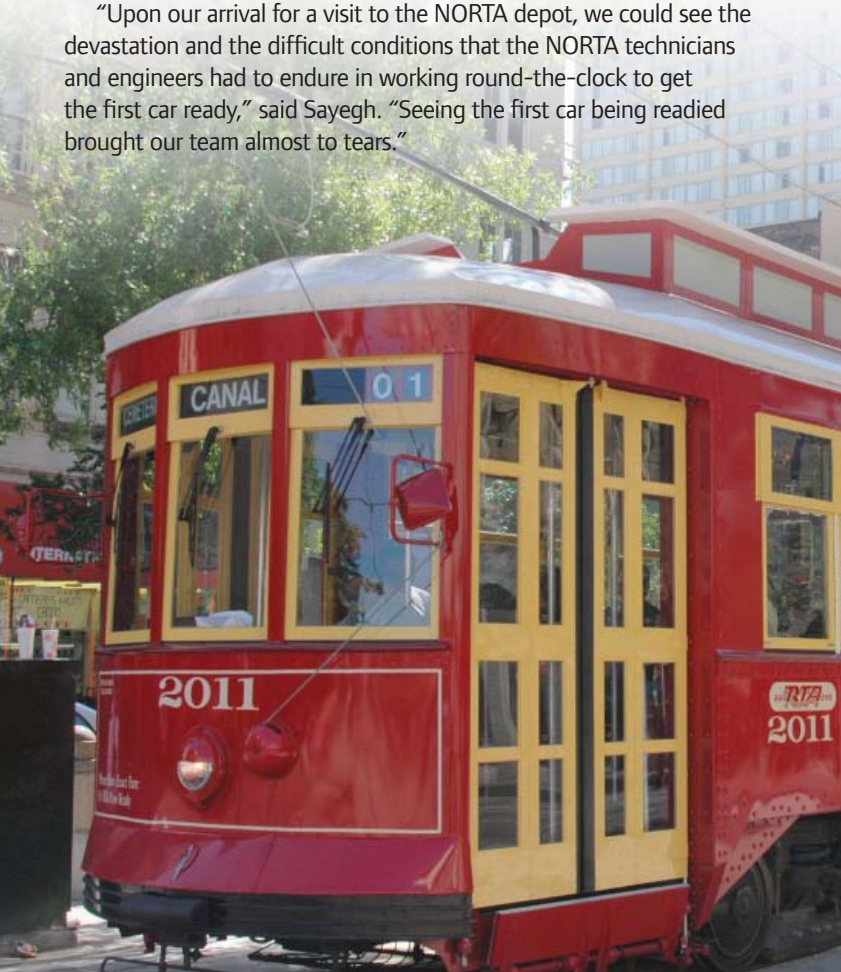


Streetcar 2008 on a test run on Canal Street. The Thermo King air conditioning unit is visible on the roof.

"On behalf of NORTA, please accept our appreciation for the assistance you and the entire Thermo King team has shown us during this time of our rebuilding," wrote Wil Mullet, Regional Transit Authority superintendent of rail, in a letter to Sayegh.

"Hurricane Katrina was devastating to our agency, and for you and your group to come in on request and assist us with the repairing of streetcar 2001, checking the rest of the cars and then performing training on streetcar 2008, our first rebuilt car, truly demonstrates your commitment to customer service."

So, if you visit New Orleans, be sure to ride the street cars and tell the drivers how supportive you are of NORTA and that you enjoy the legendary Canal Street and Charles Street cars.



Jan Havel, Thermo King engineering, Wil Mullet, NORTA light rail manager, Magdi Sayegh, Thermo King global service manager.

Saying Goodbye to an Old Friend

R-407C is Ready to Replace R-22

As of January 1, 2010, R-22 refrigerant can not be used in new equipment, and the most logical replacement choice is R-407C, which was designed specifically to replace R-22.

“We’ve known that this date was coming since 1992, when the Montreal Protocol was amended to establish a phase-out schedule for HCFCs,” explained Steve Johnson, product manager at Thermo King. “In 1992, Thermo King was already testing R-22 replacements and chose to use R-407C. This choice was based on the facts that 1) the chemical producers said it was a direct replacement for R-22, 2) successful performance testing in Thermo King equipment was completed, and 3) certain segments of the bus industry would always require a high-performance refrigerant. The transit air conditioning application, in particular, can benefit from the properties of R-407C as it did with R-22. With a need for high capacity at low rpms, coupled with a need for efficient use of energy and quick recovery times from door openings, R-407C is ideally suited to transit applications.”

Refrigerant Background

The modern era of refrigeration began in the 1930s, with the development of CFCs and HCFCs. Dr. Thomas Midgley developed many chemicals, two of which showed particular promise as refrigerants. These were R-12, which soon became the mainstay of refrigeration, and R-22, which became the primary fluid for air-conditioning. R-22 was seen to have higher efficiency at air conditioning temperatures than R-12, and could also provide more capacity in a given system. The refrigerant R-12 was used in transit applications until the advent of the Houston Pull-down performance test. “This test required that the temperature inside a 110 degrees F bus be reduced down to 70 degrees F in 30 minutes at engine idle (with an outside ambient temperature of 110 degrees F), explained Johnson. “In those days, you needed R-22 to pass this test.”

The environmental pressure resulting from the discovery of the ozone hole and the signing of the Montreal Protocol in 1987 lead to the phase-out of R-12 and the scheduled phase out of R-22 by 2010 in the U.S. Replacement products that did not harm the ozone layer were developed: R-134a to replace R-12 and R-407C to replace R-22. However, because R-22 could potentially damage the ozone layer, many transit users switched to R-134a to demonstrate environmental responsibility. There were other R-22 users that did not make the switch: Some to maintain consistency in their fleets and others because of R-22’s superior capacity and efficiency. Since 1994, Thermo King has been advising R-22 users that when the time came to switch refrigerants, R-407C would be the logical choice. And since 1994, many R-22 users have switched to R-407C.

R-407C: The Clear Choice

Since 1993, Thermo King has put R-407C to the test, and in each and every situation R-407C has proven itself to be more efficient than R-134a and equal to R-22 in performance. “R-407C is the industry replacement for R-22,” explains Steve Johnson, product manager at Thermo King. “We now have 15 years of experience with R-407C. As a solutions provider, we always offer our customers choices. Through the first eight months of this year, nearly 40 percent of our production has been R-22 or R-407C. When trying to help customers understand the efficiency difference between the two refrigerants, I often ask why we don’t see R-134a in home central air conditioning systems. We don’t because it would cost more to run, and the same reasoning is true for any application. In heavy duty transit, a system equipped with R-407C is smaller, has 20-35 percent more capacity and requires less energy to operate. We’re confident in offering it to our customers.”

Chlorine-Free R-22 Replacements

	R-134a	R-407C	R-410A
Glide	0	5.4°C	.11°C
HGWP	.28	.37	.44
Pressure at 54.4°C	1476 (KPA)	2262 (KPA)	3406 (KPA)
Compressor EER			
(%R-22)	101%	95-101%	92-100%
Capacity (%R-22)	65%	98-105%	149-155%
Heat Transfer	Slightly Less	Same	Higher
Tubing Size	Larger	Same	Smaller
System Performance	Slightly Less	95-100%	8-100%
System Cost	Slight Increase	Same	Slightly Lower
Redesign Required	Significant	Minor	Significant

R-22 Replacement R-407C:

Greater Efficiency than R-134a in Transit Applications

When compared to R-134a, R-407C is clearly the more efficient choice. Data from DuPont suggests that R-407C is around 15 percent more efficient than R-134a, when used in a correctly designed and balanced system. When applied to a system where the compressor sees widely varying rpms due to vehicle speed, the benefit of R-407C grows to around 20 percent.

These results are borne out in theoretical and practical work done by Thermo King. As the world's largest manufacturer of mobile temperature control systems and the leading supplier of R-407C systems for bus and coach applications, Thermo King has extensive experience in the use and application of R-407C. Typically, a fuel savings of around 1.3 gallons per 100 miles is seen by changing from an R-134a bus air-conditioning system to a correctly specified R-407C system. The chart "Chlorine-Free R-22 Replacements" illustrates the key differences between R-134a and R-407C.

Comparing Energy Efficiency

Because of the pressure difference between R-134a and R-407C, it's generally agreed that R-407C takes more horsepower from the engine when the engine is turning the compressor. However, R-407C provides more BTU per hour of cooling for each horsepower used. To be meaningful, any comparison must be based on the same amount of cooling. For example: An R-134a system would use less fuel if it was only providing 65,000 BTU per hour when compared to an R-407C system that was delivering 90,000 BTU per hour at the same conditions. The chart titled "R-134a vs. R-407C for the Same Capacity" shows, using actual test data, how different the operating conditions must be to get 60,000 BTU per hour in the same system. So, how do you get an R-134a system to deliver the same capacity at all operating conditions as the R-407C system? For starters, the system must be larger and it must have a compressor at least 600cc in size.

Early China Testing Verifies Efficiency of R-407C

The rest of the developed world started to ban the use of R-22 as early as 1994, and not all R-22 users switched to R-134a. In 2002, China's Guangzhou City Bus company believed that R-407C provided the best cooling because it used more horsepower from the engine when the compressor was running, but wanted to know if it consumed more fuel than R-134a. In cooperation with Thermo King, Guangzhou City Bus conducted a test using one Thermo King Citi RT unit running R-407C against two competitor units using R-134a. The buses were from the same body builder and ran the same routes with the same loads.

Test results showed that Thermo King's unit saved approximately 2.09 gallons of fuel for every 100 miles compared to one competitor's unit and about 2.9 gallons compared to the second competitor. "Our fuel test proves the efficiency of R-407C," says Guangzhou bus technical manager Kong Jun Liang. "The bottom line is that R-407C is 35 percent more efficient than R-134a."

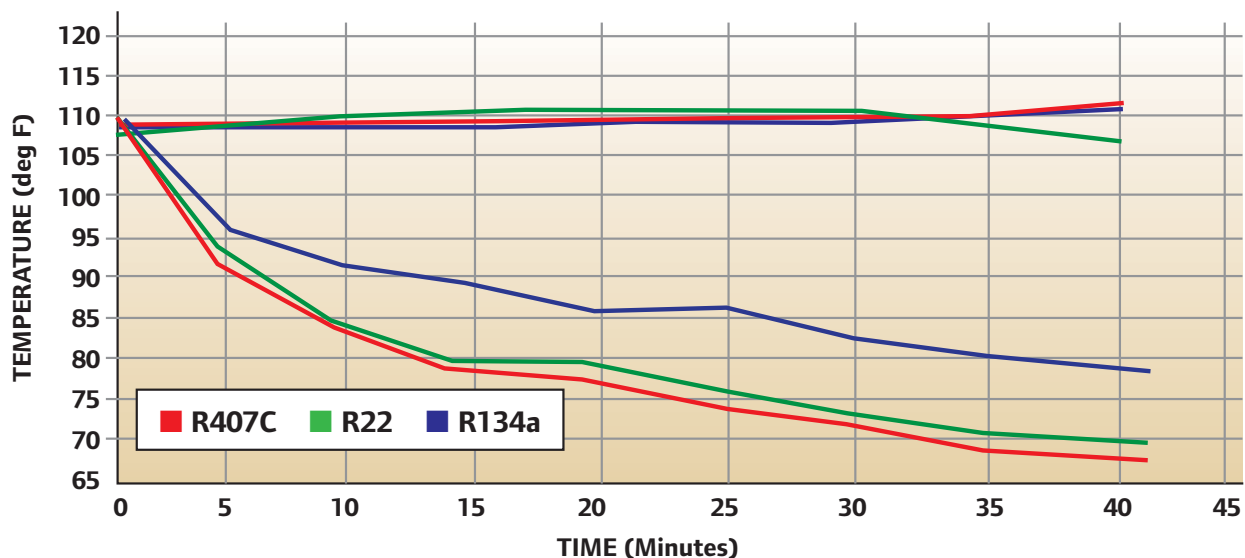
R-134a vs R-407C

Power Requirements For the Same Capacity

	R-134a	R-407C
Capacity BTU/HR (kW)	59056 (17.3)	60378 (17.7)
RPM	2000	1000
HP	8.6	7.5
BTU/HP	6860	8050
SSP/SST	47.9 psi / 37.5° F	84.2 psi / 41° F
SDP/SDT	210.9 psi / 128° F	278.7 psi / 121° F

Pulldown Comparison Test of R-407C, R-22 & R-134a

Thermo King r6-m1 roof mounted unit



From Paper to Pavement – Part II

Alternator-Powered All-Electric HVAC Gets Put to the Test in Portland

The weather report says the temperature is 98 degrees F. The pavement must be at least 115 degrees F. You're stuck in traffic – maybe you've moved a mile in the last 10 minutes. What's wrong with this air conditioner anyway? It's set to maximum but doesn't seem to be working very well. The traffic starts moving and you feel the air conditioning begin to cool down the car. Maybe the air conditioning doesn't need servicing after all? If this sounds familiar, you are familiar with what happens when air conditioning capacity is dependent on engine speed.

So knowing that potential problem, how does a conventional bus that idles 50 percent of the time with an engine-driven compressor keep passengers comfortable? The answer is that it takes a very large air conditioner with a very large compressor to provide ample cooling at engine idle speeds. Place an undersized air conditioner on a bus in Houston, Phoenix or Las Vegas and there will soon be complaints about the heat from passengers.

So what is the ideal solution to this problem? It would be an air conditioner that is not dependent on engine speed for capacity. An air conditioner with electric compressors. An air conditioner with the same capacity all of the time. This "dream system" is exactly what Thermo King offered to TriMet in Portland, Oregon more than a year ago. The idea of having an all-electric air conditioner on a conventional diesel engine-driven bus was exciting for bus maintenance director Tony Bryant, who believed that there would be fuel savings from such a system. With these potential benefits in mind, TriMet agreed to test the unit and compare the results to 20 other units from the same fleet.

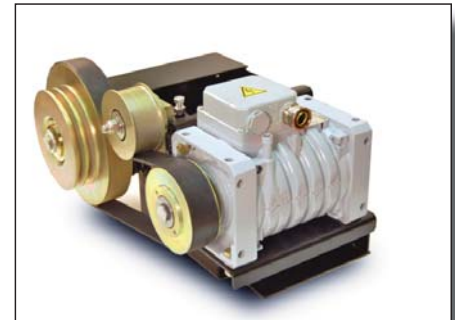
After one year of monitoring and recording, Bryant said "Like a lot of transit

maintenance managers, we're about getting results. The Thermo King system has had negligible maintenance costs and given us a 2-3 percent average yearly fuel savings to boot."

"Part of what we do at Thermo King is to make sure our customers are comfortable with new technology. We allow them to see the actual benefits in a fleet environment prior to making any major decisions," says Don Nielsen, engineering manager at Thermo King. "No one wants to be stuck with 'it sounded good but didn't work very well' technology."

Of course, with any testing there are issues and challenges to overcome. Aside from some normal tweaks and upgrades at the beginning of the test, the fuel mileage on the test unit was not as good as on the rest of the fleet. "Although the test was somewhat skewed by measuring one sample against the average of 20, we felt that we should be seeing better results," said Nielsen. "The test unit was delivering more capacity than the conventional unit and it was delivering it all the time, even when the engine was idling." Once software was installed to provide better capacity control on the electric HVAC, the fuel economy improved dramatically, exceeding the fleet average by as much as 7 percent in some months.

After the testing in Portland, two facts became obvious; the electric air conditioner could be smaller and still deliver the same amount of cooling as the conventional air conditioner and that there is a cost for cooling. "When comparing systems and refrigerants, it's very important for customers to understand that the comparison must be based on the same amount of cooling," says Nielsen. "When you do that, efficiency will win every time."



Alternator-Powered All-Electric HVAC



Rear Mount All-Electric



Bill Pratt, TriMet HVAC tech, Tony Bryant, TriMet bus maintenance director, Brian Fryer, service manager at TK Northwest and Bill Gall, Thermo King regional sales manager.

FAQs About the R-22 Replacement R-407C

Don't believe everything you've heard!

Q: Are there any concerns regarding cross-contamination with the R-134a used in the smaller units within a fleet? Will I need two sets of servicing equipment?

A: As R-134a and R-407C are both HFC refrigerants and R-134a is actually a component of R-407C, accidental mixing can be detected and is not a major concern. The same recovery, evacuation and charging equipment can be used for both refrigerants.

Q: Is the glide that occurs when the individual components condense and evaporate at different temperatures and pressures as the refrigerant moves through the heat exchangers a concern with R-407C?

A: This is a known characteristic of certain blends that does not affect the performance of a properly designed system.

Q: When a leak exists with R-407C, does flammability increase?

A: If a leak were to occur, the flammable component is the first of the three present to escape the system (in minute doses), so flammability is not a concern. The last component present is R-134a.

Q: Can fractionation (when the individual components of a blended refrigerant leak out at different rates if a leak exists in the HVAC system) have a significant impact on system performance?

A: Independent tests by the chemical manufacturers and laboratory tests by Thermo King show that fractionation has minimal impact on system performance. The test procedure was to allow a system to leak 50% of the refrigerant charge and then top the system off with virgin refrigerant. After repeating this procedure three times, the system performance was measured and showed a drop of only 5 to 7 percent. A dirty air filter could easily cause greater system degradation. Additionally, a typical maintenance program would never allow a system to operate with those kinds of leaks.

Q: Does the higher pressure of R-407C affect the system in a negative way?

A: The higher pressure of R-407c, which is related to its higher efficiency, has been presented as a negative. Pressure is far less detrimental to the system than operating temperatures, and the operating temperatures for R-407C are lower than R-134a at the same demand conditions. When properly designed and maintained, systems are not affected by the higher pressures. The benefits gained by R-407c outweigh the negatives.

Q: Why has the migration to R-407C been slower than that to R-134a?

A: R-134a was developed early for use in autos and was pushed due to the early ban on R-12, which it replaced. Many users switched because they believed it was the right thing to do environmentally. The ban on R-22, which R-407C is replacing, allowed R-22 be used until 2010 in the U.S., which has led to a more gradual rate of adoption.

Performance of R-407C After 5 Leaks

	R-407C Initial Recharge	1st Leak/ Recharge	2nd Leak/ Recharge	3rd Leak/ Recharge	4th Leak/ Recharge	5th Leak/ Recharge
Cooling Capacity (Relative to R-407C)	1	0.95	0.93	0.92	0.91	0.91
Energy Efficiency (Relative to R-407C)	1	1	1.01	1.01	1.01	1.01
Discharge Temperature (F)	166	164	163	162	162	
Discharge Pressure	257	244	238	235	234	234
Composition Change (WT. %)						
HFC-32	23	19.6	18.2	17.5	17.3	17.2
HFC-125	25	22.5	21.2	20.5	20.1	20
HFC-134a	52	57.9	60.6	62	62.7	62.8

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Thermo King Bus and Rail HVAC Under New Leadership

In an effort to further strengthen its customer focus and market presence, Thermo King introduced, in early 2008, Martin Duffy as general manager, HVAC Americas.



During his first nine months on the job, Duffy has provided valuable support and leadership to an already experienced team. "Martin's presence has quickly taken Thermo King's customer focus to new heights," says Chuck Rodman, a product sales manager with over 39 years at Thermo King.

Duffy is responsible for providing leadership to all facets of Thermo King's transit, shuttle, rail and coach businesses, including sales, marketing, service and product management, with matrix responsibility for engineering. "I look forward to continuing Thermo King's long tradition of excellence in the transit bus market segment through relentless focus on innovation, quality and customer service. In addition, we intend to apply our strength in these key areas to expand our presence in all market segments," says Duffy.

Joining Ingersoll Rand's Hussmann business unit in 1989, Duffy has held senior positions in manufacturing, engineering and sales. Duffy's most recent position was sales director, western region for Thermo King.

Preventing Connector Corrosion

Corrosion results in poor electrical connections and can cause the malfunction or failure of electrical components. Generally, corrosion is caused when the electrical connections are exposed to road salts, ice-dissolving agents and dirt buildup. Also, the harsh bus wash detergents and cleaning chemicals can have a corrosive effect.

To prevent corrosion, apply Super Lube to all exposed connectors, input studs and bus wiring power lugs. This provides a protective barrier for the connectors and prevents direct exposure from potential corrosion risks. Preventive action helps avoid electrical malfunctions that can result in bus downtime, and extends the life of electrical assemblies. Applying Super Lube also helps to protect the input studs and bus wiring power lugs from moisture resulting from cleaning procedures and/or exposure to dirt and debris buildup.

Super Lube must be applied with a clean, dry brush. The Super Lube must completely encapsulate the terminals on electric connectors. It is very important to coat BOTH the top and the exposed metal underside of the bus wiring power lugs. Apply twice a year under normal conditions. Also apply when the electrical assemblies are replaced or serviced, and when terminals or nuts have been loosened for any reason. Make sure to remove all coatings, dirt and corrosion before applying. This preventative step will result in longer equipment life and better performance of the HVAC equipment during the life of the bus.



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