energy & technical services conference
Leak Reduction Best Practices: Charge Your Bottom Line, Not Your Refrigeration System

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Farm Fresh: Leak Reduction Best Practices using Hydrogen

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Hydrogen Leak Detection is similar to electronic refrigerant leak detection, only the gas used as a tracer gas has a component of pure hydrogen.
Hydrostar for Leak Detection

• Pure Hydrogen is explosive, Concentrations of 5% or less are not

• “Hydrostar” is a mix of 95% dry nitrogen and 5% dry hydrogen

• It comes with a dryness of 1-2 ppm of moisture

• It is ISO 140001 and ISO 10156 (meaning it is Green and Safe)
Why use Hydrogen as a tracer gas?

- Traditional installations do not remain leak tight over time, costing refrigerant.
- New construction of non-traditional systems are significantly higher cost.
- Traditional systems can be the most energy efficient if we can keep them leak tight.
- Technicians are already trained to service the existing fleet of supermarkets.
Relative Leak Detection

Graph

Sensitivity (cc/sec)

Helium  |  Hydrogen  |  Pressure Decay  |  Water

1000
5x10E-4
5x10E-7
5x10E-11

Method
Relative Leak Detection

Std. cc/sec = One cubic centimeter of gas flow per second at 14.7 psi of pressure and a temperature of 77°.

<table>
<thead>
<tr>
<th>Std. cc/sec</th>
<th>Time for lb of Freon to leak</th>
<th>Torr Liters/sec</th>
<th>Time for cc to leak</th>
<th>Bubble Time in Water</th>
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<tbody>
<tr>
<td>$10^{-1}$</td>
<td>10 Days</td>
<td>$7.6 \times 10^{-2}$</td>
<td>10 seconds</td>
<td>INSTANT</td>
</tr>
<tr>
<td>$10^{-2}$</td>
<td>3 Months</td>
<td>$7.6 \times 10^{-3}$</td>
<td>100 seconds</td>
<td>1.3 seconds</td>
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<td>$10^{-3}$</td>
<td>2.7 Years</td>
<td>$7.6 \times 10^{-4}$</td>
<td>16.67 minutes</td>
<td>13.3 seconds</td>
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<td>$10^{-4}$</td>
<td>27 Years</td>
<td>$7.6 \times 10^{-5}$</td>
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<td>14.5 minutes</td>
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<td>$10^{-5}$</td>
<td>270 Years</td>
<td>$7.6 \times 10^{-6}$</td>
<td>27.8 hours</td>
<td>24 minutes</td>
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<td>$10^{-6}$</td>
<td>2,700 Years</td>
<td>$7.6 \times 10^{-7}$</td>
<td>11.57 days</td>
<td>4 hours</td>
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<tr>
<td>$10^{-7}$</td>
<td>27,000 Years</td>
<td>$7.6 \times 10^{-8}$</td>
<td>3.86 months</td>
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<tr>
<td>$10^{-8}$</td>
<td>270,000 Years</td>
<td>$7.6 \times 10^{-9}$</td>
<td>3.22 years</td>
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<td>$10^{-9}$</td>
<td>2,700,000 Years</td>
<td>$7.6 \times 10^{-10}$</td>
<td>32 years</td>
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<tr>
<td>$10^{-10}$</td>
<td>27,000,000 Years</td>
<td>$7.6 \times 10^{-11}$</td>
<td>320 years</td>
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</table>
Why use Hydrogen as a tracer gas?

• The best electronic handheld refrigerant detectors on the market cannot detect well enough
  – R404A tracer gas in concentrations of 5% at 100 psi of pressure, smaller than 2 oz/year
  – R404A tracer gas in concentrations of 100% at 100 psi of pressure smaller than 1/2 oz/year
Why try Hydrogen as a tracer gas?

• The average store has 3500 to 4000 lbs of refrigerant and leaks 25% of its charge each year. If the cost of refrigerant is 5$ per pound:

\[3500 \text{ lbs} \times 45 \text{ stores} \times 5.00 \$/\text{lb} \times 25\% = \]$196,875 per year

Add product losses, leak checking, repairs, lost sales, lost customers
What is the cost?

- Hydrogen leak detection equipment can be $5,000 to $15,000 per unit
- The gas is roughly 2 times the cost of dry nitrogen
- Handheld electronic refrigerant leak detectors can easily be found for around $300
- Labor is essentially the same for a pressure test
- Risk is higher with damaging equipment
How well does it work?

- Our first tested store was put to 300 psi of Nitrogen for 60 hours and did not lose 1 psi of pressure.
- With 125 psi of Hydrostar 8 small leaks were found (3 factory solder joints, 2 field solder joints, 3 flare nut fittings on pressure switches and oil lines).
- We achieved the lowest microns I had witnessed on a large system 125 microns after 24 hours.
- We used the most sensitive settings of hydrogen detector.
How well does it work?

• All of the leaks ranged from $1 \times 10^{-5}$ down to $1 \times 10^{-7}$.

• One of them was so noticeable with a bubble test, I could not believe the test. I had that compressor valved off from the system, re-pressurized with nitrogen, and R22 to recreate the original test leak. After bubble testing the same leak for 15 minutes a tiny bubble slowly appeared.

• These are leaks that would not leak 1 oz. of refrigerant in more than 20 years.
How well does it work?

- We refrigerant leak tested an existing lineup in preparation to installing an additional new case the following day.
- Upon installation of the new case, there were pinhole leaks found in one of the existing cases that did not pick up with the refrigerant leak detector. The pinhole leaks showed up immediately with hydrogen leak detector.
How well does it work?

• There are many examples like this
• However, the best proof is we have not had a leak on any system that we have tested with hydrostar to 300 psi and pulled vacuum.
• We are now consistently getting below 100 microns
How well does it work?

• Our first store hydrogen leak tested store was opened May 7th 2008

• Since this store we have done 3 other total gut remodels.

• Originally we had only one hydrogen detector

• We had logistic problems with only 1 detector and could not test a lot of work

• We now have 3 leak detectors and require all new systems to be hydrogen tested

• We still have some issues
Trying to improve the system

• I wanted to see what was feasible for pulling vacuums.
• I wanted to create a super tight typical reference system and find out how long it should take to pull vacuum
• I wanted to dispel or prove myths about vacuums
  – One being you can’t pull a good vacuum on old systems with oil present
  – One being that you can pull a vacuum too fast with an oversized vacuum pump
Initial Test Setup
Initial Test Setup

- 200 feet of suction 1-3/8”, 10 feet 7/8” risers and ½” liquid line piping with 2 Dairy Cooler evaporator coils (Bohn Model: ADT208)
Initial Test Setup

• We pressurized the system to 300 psi and let hold for 48 hours with taps on suction and liquid sides.
  – The readings were dead on after 24 hours.
  – At 48 hours we could tell there was almost 300 psi, but there was a slight hair difference

• We then leak checked with the Hydrogen detector and found 3 leaks
  – Both TXV packing nuts
  – One suction riser had a hairline factory defect
A Note on pressure readings

- We no longer allow gauge manifolds to be used for pressure testing
- We require stub gauges to be installed on suction lines and liquid lines to prove pressure throughout the system.
  - Some txvs limit pressure that can flow through them. So, we require both lines.
- We do not allow them to be taken off during the test.
- We require the original reading to be written in permanent ink on the pipe next to the gauges
The Suction Riser of the Leaking Evaporator Pressurized to 300 psi

Hydrostar vs. R22 & N₂
Results of the test system

- We found that using hydrogen allowed us to more consistently find all the leaks
- We were able to pull the test system consistently below 10 microns
- We were able to get 3 different Ritchie micron gauges to readings of zero and have them remain at zero for 4 to 5 minutes, maintaining microns as low as 20 microns for over a week
- Note: the system was 15 years old, R22 with mineral oil. We on purpose heated the oil in the system to burn it.
New Pressure and Vacuum Procedure

- Use a “dynamic flow” manifold set up
- Verify the pump, oil, and micron gauges to start
- Solder in the manifold with all associated gauges before starting pressurization
- Use hydrostar and hydrogen leak testing equipment to test the entire system at full pressure
- Use as close to a “dynamic flow” hydrostar purge as sensible.
- Pull the vacuum from the suction line to the far end of the liquid line in one direction
- Repeat purge until the vacuum is achieved
New Vacuum Procedure

• First, test the vacuum pump, the vacuum pump manifold, the micron gauges, and the oil of the pump can easily achieve a vacuum of 50 microns or better. (High end pumps will do 0.1 microns or better)
New Vacuum Procedure

• Before applying any pressure, remove the Schrader core just before the vacuum pump. Shut the ball valve closest to the pump and at each micron gauge.
New Vacuum Procedure

- We no longer break vacuums in the traditional method. We now break vacuum with what we term “dynamic flow.”
  - Charge the system from the liquid line side
  - Keep the pump valved off
  - Keep micron gauges valved off, but attached permanently
  - Shut liquid line off from pump
New Vacuum Procedure

• During this time the micron gauges should be reading the low microns from the pump test and they are not exposed to the pressure.

• Pressure test the entire system to a pressure of 50-100 psi Hydrostar, including the vacuum pump manifold. (Make sure to remove core of the Schrader cap at vacuum pump to not blow up the pump)

• If no huge leaks are found go to max pressure. (We are typically going to 300 psi.) Keep the Hydrostar fully connected and leak check it.

• Length of time depends on the job. We do 1 hour minimum and long enough to leak check entire system
New Vacuum Procedure

• Once the test has held at least 1 hour and no leaks were found on the entire system the pressure test is done. (longer is better)
• Crack the ball valve at the vacuum pump to relieve the pressure out the open Schrader core
• This achieves a one direction flush from the furthest point of the system on the liquid line towards the vacuum pump through the entire system.
• Replace the core and cap the opened Schrader valve
• Reduce the hydrostar regulator to 2 psi or lower
• You now have a system full of hydrostar at atmospheric pressure ready to pull a vacuum.
**Dynamic Flow**

- The hydrostar can flow up the liquid line through the system valves and down the suction line to the vacuum pump in one direction.
Dynamic Flow

- Now open the pump to the suction side of the system. Having all valves on the system wide open. The valve to the liquid side of the vacuum manifold should remain closed so the pump does not pull through the liquid line during any of the dynamic flow portion of the vacuum.
New Vacuum Procedure

• The system should rapidly pull to 1,000 microns or better for a single circuit. Both gauges should read below 5,000 microns

• To break open and close the Hydrostar valve quickly

• Watch the micron gauges. The liquid micron gauge will shoot up to about 20,000 to 80,000 and the suction will come up to a few thousand. In a matter of a minute or two you should be back to your earlier readings

• Repeat this about 5 times or more

• Disconnect the Hydrostar with it flowing so no atmosphere enters the system
New Vacuum Procedure

• Let the system pull either until you have the desired micron reading. Valve off the system and let it stabilize.

• I do recommend cycling solenoids and turning all valves if it is possible during deep vacuum.

• You can also open up the vacuum manifold to both sides after a reasonable time to pull less restricted once you have done the breaking completely, but when you read your microns you have to remember you will be reading close to the pump and not the far end of the system.
It is like swimming in a lake versus a river. If you try to swim to the edge of a raging river the current sweeps you to towards the ocean, but swimming to the edge of a lake is not difficult.

Breaking a system the old way is the lake concept there is not a push to the vacuum pump. Also, you are constantly contaminating the system if you remove the micron gauges.
Hydrogen may be Greener

• When we use Hydrostar we have eliminated the use of diminimus gas (we do not use any refrigerant for leak testing)

• Also, we are experiencing vacuum pump oil lasting many jobs. (In my testing of the test system over 4 weeks I never had to change the oil.)
Locations for Refrigerant Loss

- Mechanical Room: 56%
- Display Case: 16%
- Condenser: 12%
- Condensing Unit: 6%
- Store Piping: 7%
- Walk-Ins: 2%
- HVAC: 1%

Mechanical Room is significant opportunity; however Display Cases, Condensers, Store Piping and Condensing Units are fertile ground.
Reports of Refrigerant Loss - Reasons

- Mechanical Wear: 64%
- Vibration: 22%
- Corrosion: 3%
- Bad Solder: 5%
- Operational: 6%

Mechanical Wear and Vibration produced 86% of refrigerant leaked.
Significant opportunity!
Not limited to any particular location.
Leaks Due to Mechanical Wear

% of Mechanical Wear

Leaks Total

- Loose Fitting
- Damaged
- Worn Gasket
- Worn Packing
- Missing Gasket
- Missing Cap

Loose Fitting included flare fittings, Schraeder caps, rotolock valves, service port caps and others.
New Store Design Points and Retrofits

• Motor rooms are built on solid ground
• Contained Motor Room
• Infrared Leak Detection in the motor room, and we are experimenting on the sales floor
• All mechanical areas are alarmed for entry
• No Schraders outside the motor room
• Remote Analog liquid level sensors
• Better piping support
• Reduced Charge
• Non ODS / Low GWP
New Store Design (continued)

- Motor rooms are on the ground on solid concrete to stop vibration
- They are air conditioned. This enables them to be a confined space for improved leak detection
Motor Room Exhaust only runs in Emergency

- **Eliminates 20,000 CFM** of air moving through to cool the equipment.
  - This eliminates dirt and dust accumulations
  - Allows a technician to keep the motor room spotless and easily check for refrigerant leaks
New Store Design and Retrofits

- Spacious and Clear
- They are kept Clean
All Mechanical Areas are Remotely Alarmed for Entry

• This ensures the doors stay shut to best help detect leaks
Better Pipe Support in the Overhead

• Insugaurd
Assisting with Leak Checking

• **Live As-builts**
  – Access to building automation on a computer
  – There are live circuit drawings *(virtual walk-through drawings of electrical, mechanical, plumbing etc.)*
  – Site specific information specifically level indicators and leak detection sensors
Reduced Charge
• One central system with loop piping
• One Surge receiver / Roof mounted
• Extreme Sub-cooling reduces liquid line sizes
• Hydronic heat reclaim with flat plate heat exchangers
**Big View of Overhead piping**

**Loop piping**
- 8,980 linear feet
- $54,213
- 3,115 sq ft of surface area
- 8,837 lbs of copper
- 779 feet of solder circumference
- 2500 lbs refrigerant

**Manifolded**
- 24,800 linear feet
- $76,500
- 5,889 sq ft of surface area
- 12,673 lbs of copper
- 1472 feet of solder circumference
- 4400 lbs refrigerant
Farm Fresh Joined Green Chill

• Announcement March 26, 2008
• After that we worked on the Best Practices Guidelines for Refrigeration Installation
• **We have devoted more technicians to leak checking than ever**

• **A greater support and awareness with upper management**
  – *I personally am reviewing all vacuum tests*
  – *We do not do overnight case turn overs unless I have certified the microns*

• **If a leak is not found we move to pressure testing the entire rack with in a few days**

• **Infrared leak alarms are responded to immediately (about 1 hour)**
Where are we headed?

• We are watching secondary systems and CO2
• Removal of all Schrader's outside of motor room
• Better partnerships with suppliers focused on reducing leaks creating improved equipment (Case piping)
• We continue to reduce our charge (last store 1800 lbs for all equipment including HVAC)
• Improved installation techniques
  – Higher pressure testing for longer periods
  – Lower vacuums for longer periods
  – Hydrogen leak testing is now standard practice
Thank you