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energy &
technical
services
conference
FMI
FOOD MARKETING INSTITUTE

Leak Reduction Best Practices: Charge Your Bottom Line, Not Your Refrigeration System

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And

Jonathan Perry of

Farm Fresh, a division of Supervalu

Farm Fresh: Leak Reduction Best Practices using Hydrogen

By: Jonathan Perry

Director of Energy and Maintenance

Hydrogen Leak Detection

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

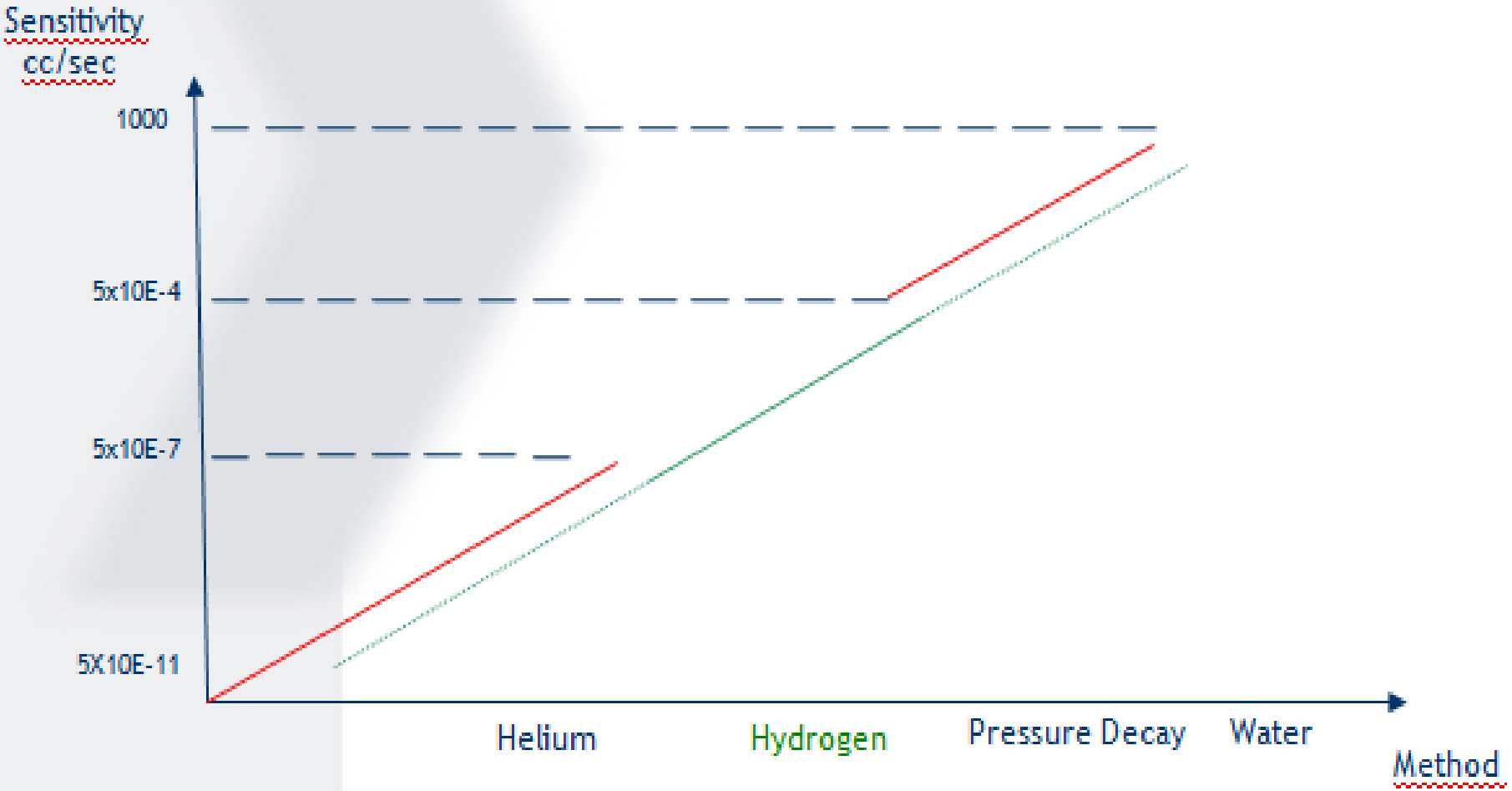
- ***Pure Hydrogen is explosive, Concentrations of 5% or less are not***
- ***"Hydrostar" is a mix of 95% dry nitrogen and 5% dry hydrogen***
- ***It comes with a dryness of 1-2 ppm of moisture***
- ***It is ISO 140001 and ISO 10156 (meaning it is Green and Safe)***

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



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°.

Std cc/sec	Time for lb of Freon to leak	Torr Liters/sec	Time for cc to leak	Bubble Time in Water
10^{-1}	10 Days	$7.6x10^{-2}$	10 seconds	INSTANT
10^{-2}	3 Months	$7.6x10^{-3}$	100 seconds	1.3 seconds
10^{-3}	2.7 Years	$7.6x10^{-4}$	16.67 minutes	13.3 seconds
10^{-4}	27 Years	$7.6x10^{-5}$	2.78 hours	14.5 minutes
10^{-5}	270 Years	$7.6x10^{-6}$	27.8 hours	24 minutes
10^{-6}	2,700 Years	$7.6x10^{-7}$	11.57 days	4 hours
10^{-7}	27,000 Years	$7.6x10^{-8}$	3.86 months	
10^{-8}	270,000 Years	$7.6x10^{-9}$	3.22 years	
10^{-9}	2,700,000 Years	$7.6x10^{-10}$	32 years	
10^{-10}	27,000,000 Years	$7.6x10^{-11}$	320 years	

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 lbs X 45 stores X 5.00 $/lb X 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 x 10-5 down to 1 x 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***

Large Leaks Start Out Small

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

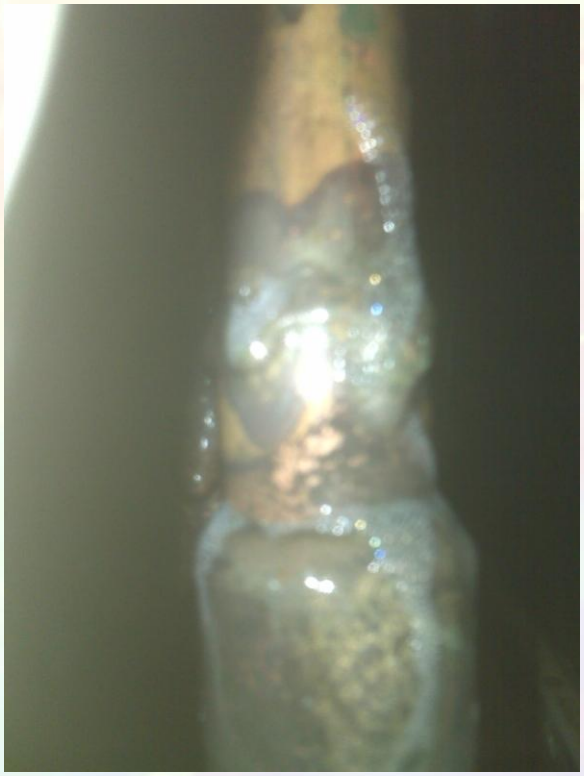
- ***We pressurized the system to 300 psi and let hold for 48 hours with taps on suction and liquid sides.***
  - ***The readings were dead on after 24 hours.***
  - ***At 48 hours we could tell there was almost 300 psi, but there was a slight hair difference***
- ***We then leak checked with the Hydrogen 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 & N_2***



Results of the test system

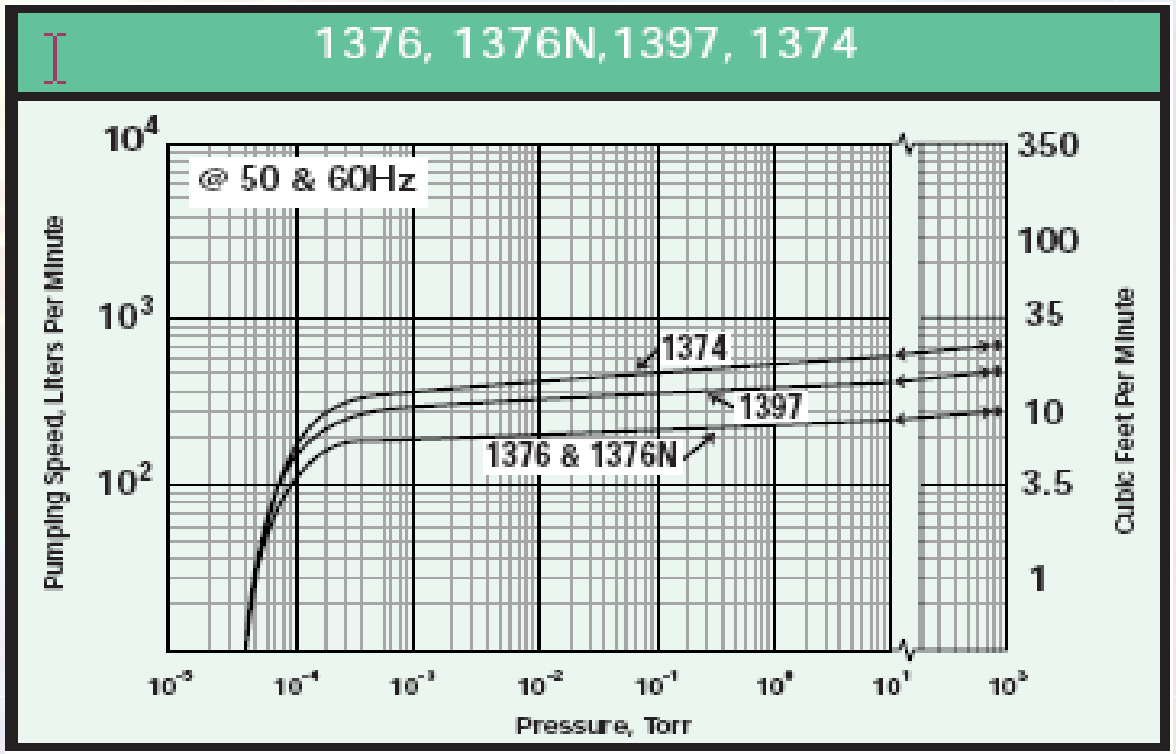
- *We found that using hydrogen allowed us to more consistently find all the leaks*
- *We were able to pull the test system consistently below 10 microns*
- *We were able to get 3 different Ritchie micron gauges to readings of zero and have them remain at zero for 4 to 5 minutes, maintaining microns 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

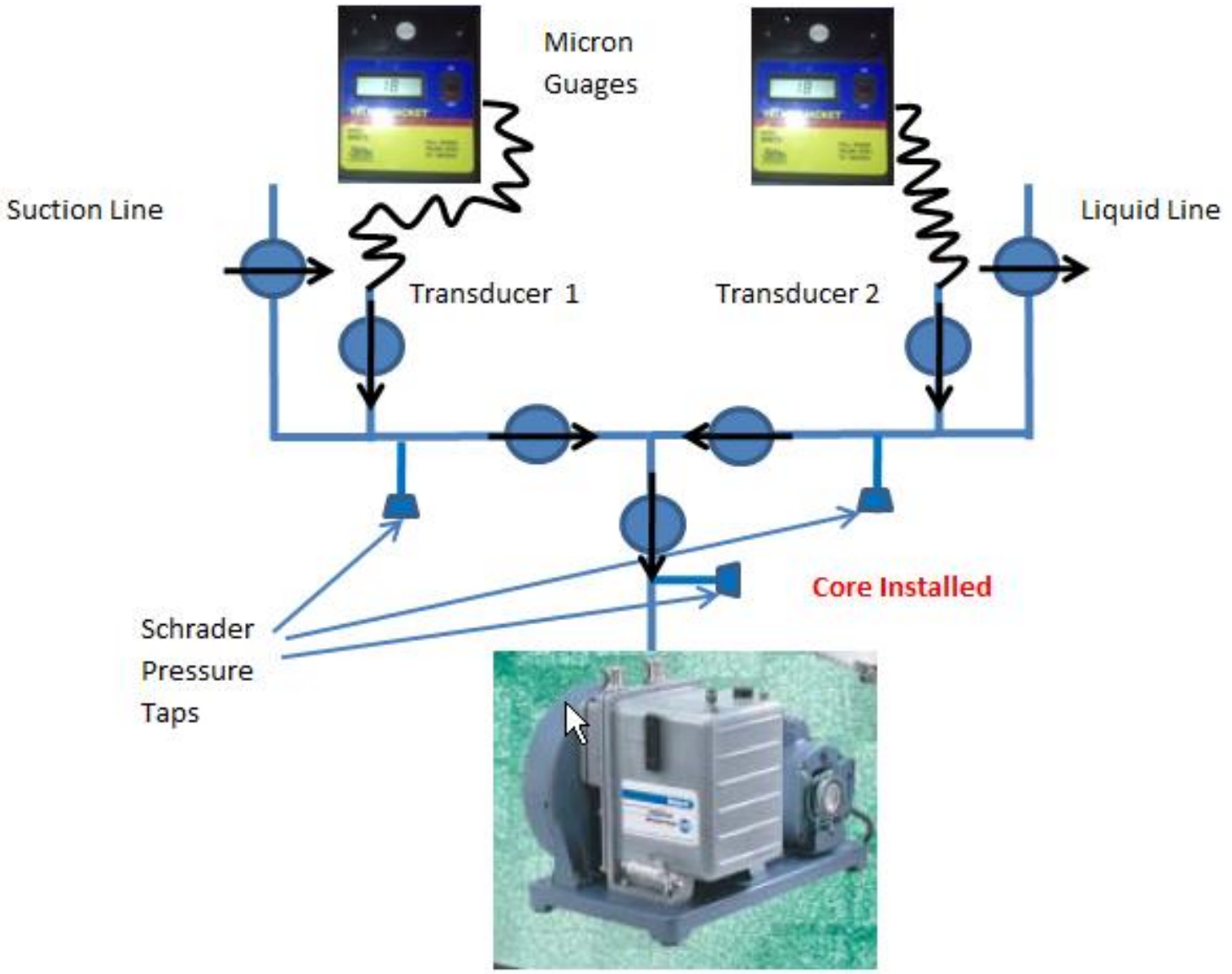
- *Use a "dynamic flow" manifold set up*
- *Verify the pump, oil, and micron gauges to start*
- *Solder in the manifold with all associated gauges before starting pressurization*
- *Use hydrostar and hydrogen leak testing equipment to test the entire system at full pressure*
- *Use as close to a "dynamic 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)***

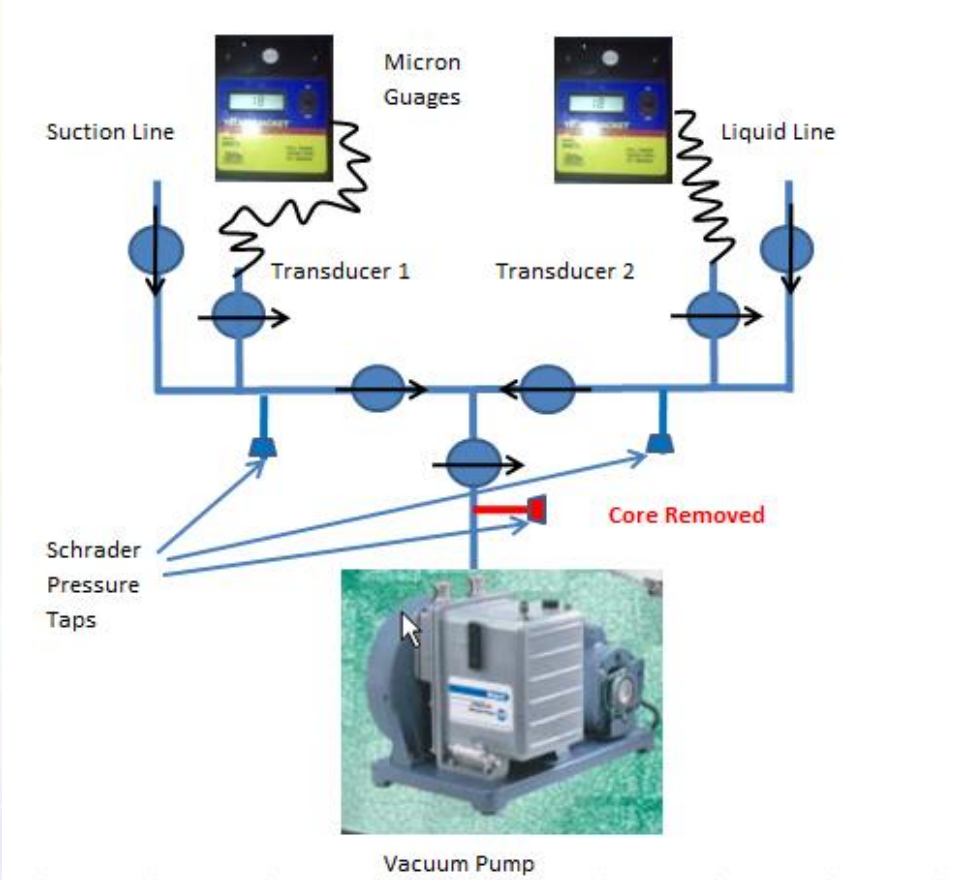


New Vacuum Manifold Setup



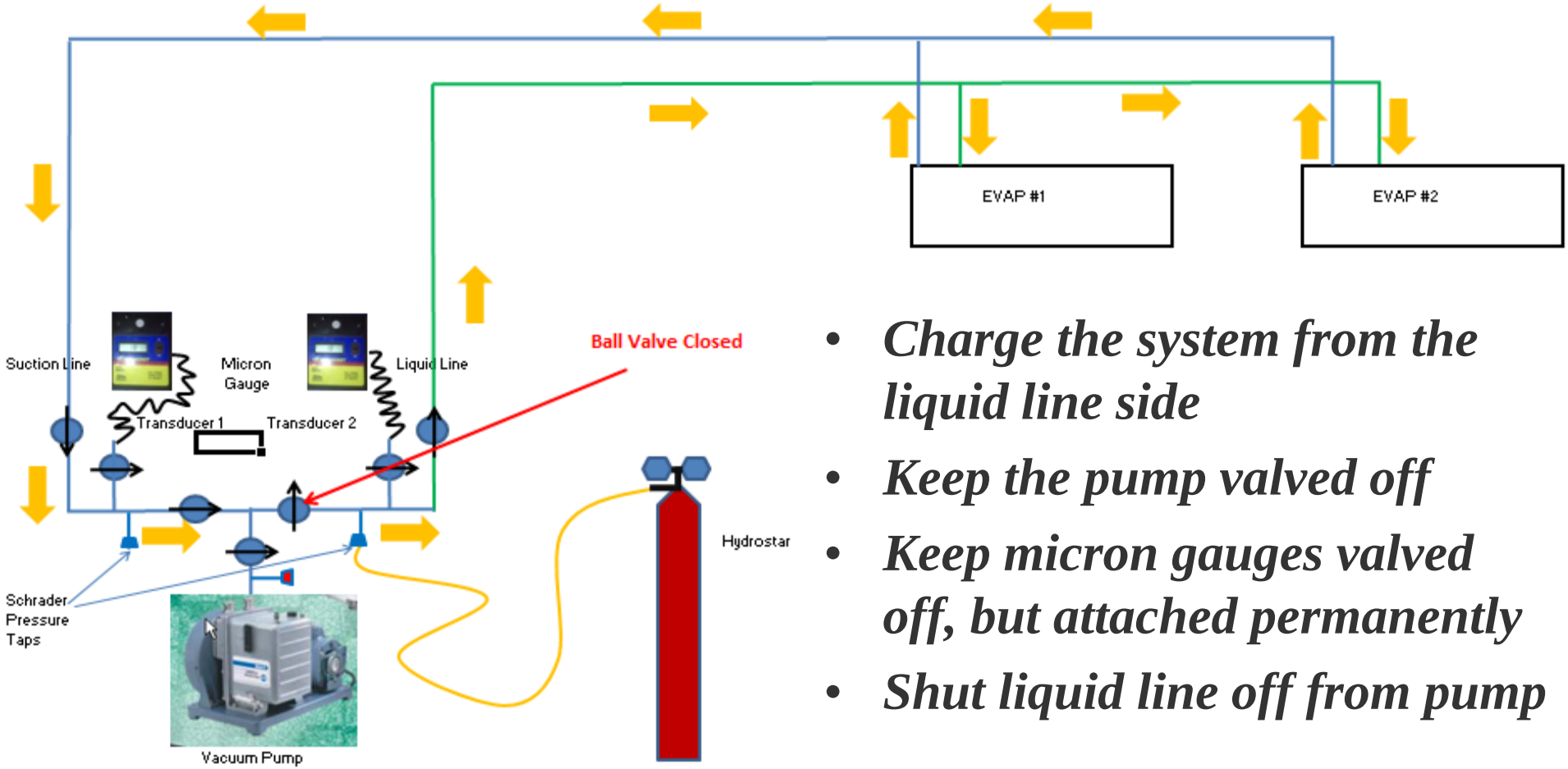
New Vacuum Procedure

- ***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*

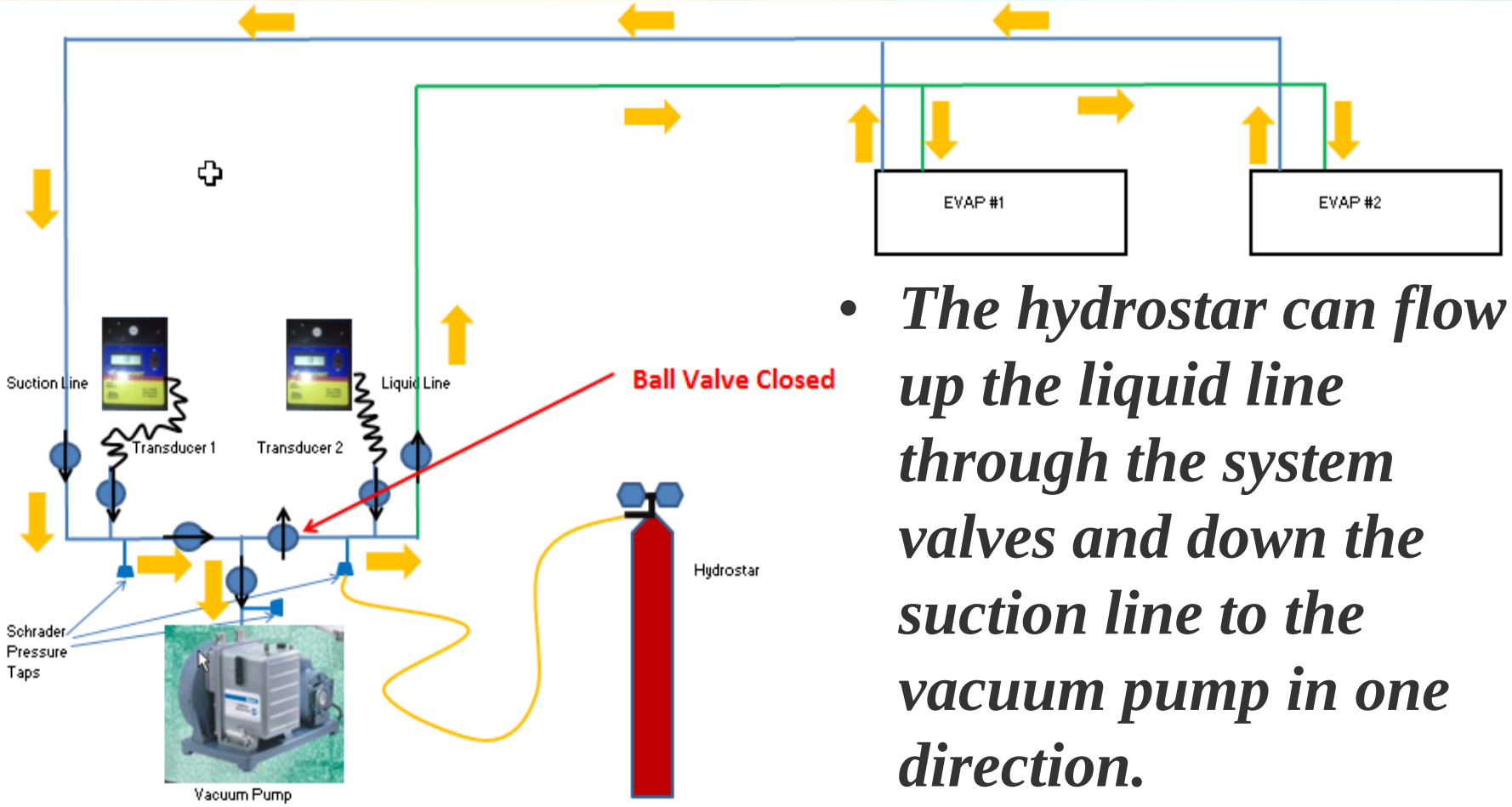
New Vacuum Procedure

- ***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.***

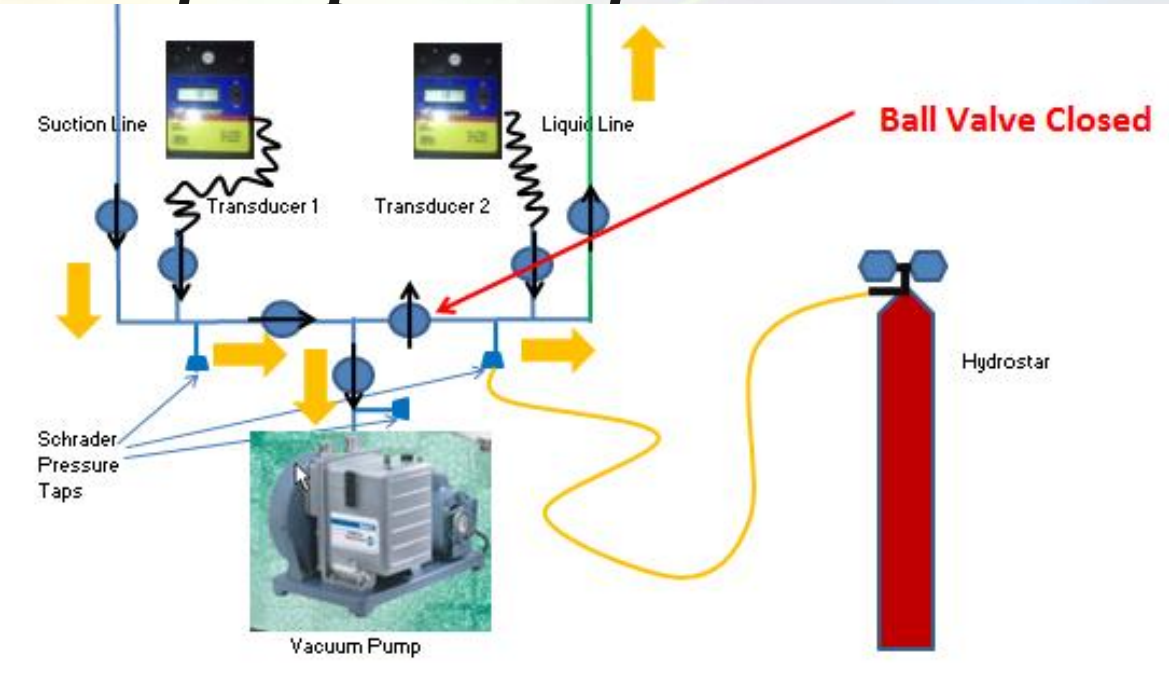
Dynamic Flow



- ***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.***



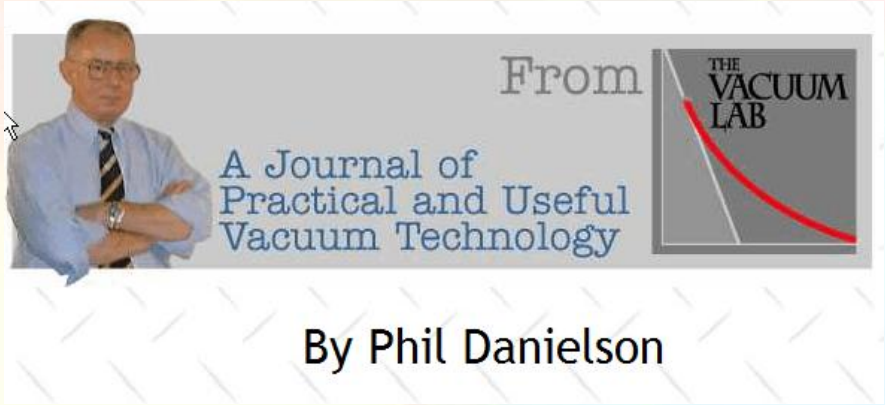
New Vacuum Procedure

- ***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***

Logic of the New Vacuum Procedure



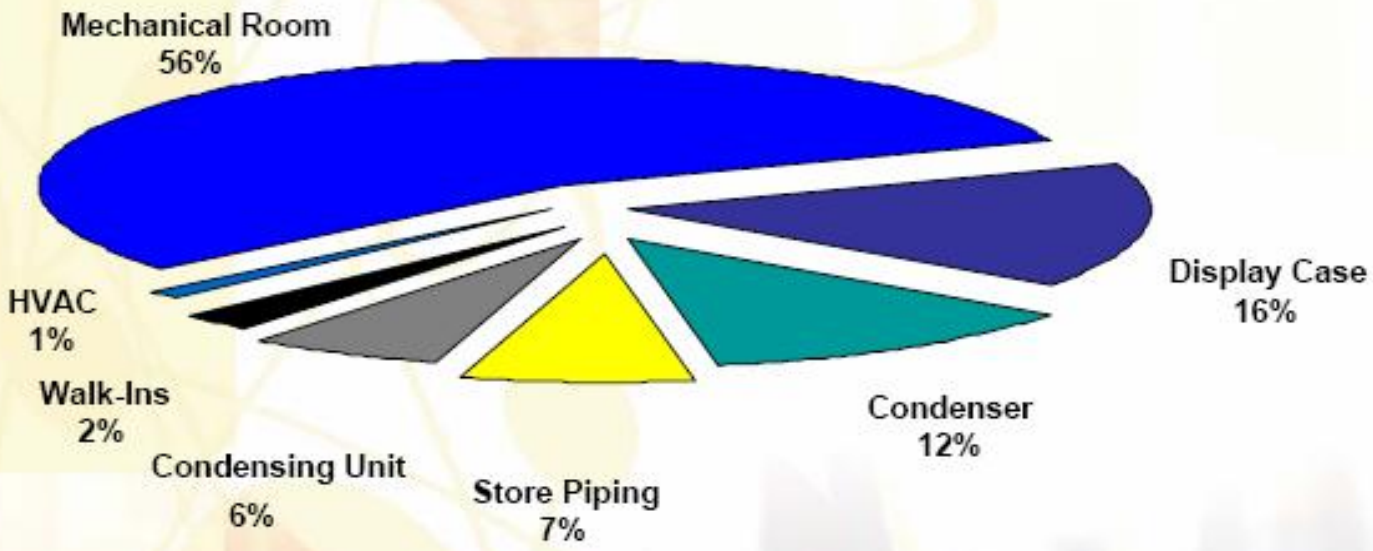
It is like swimming in a lake versus a river. If you try to swim to the edge of a raging river the current sweeps you to towards the ocean, but swimming to the edge of a lake is not difficult.

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

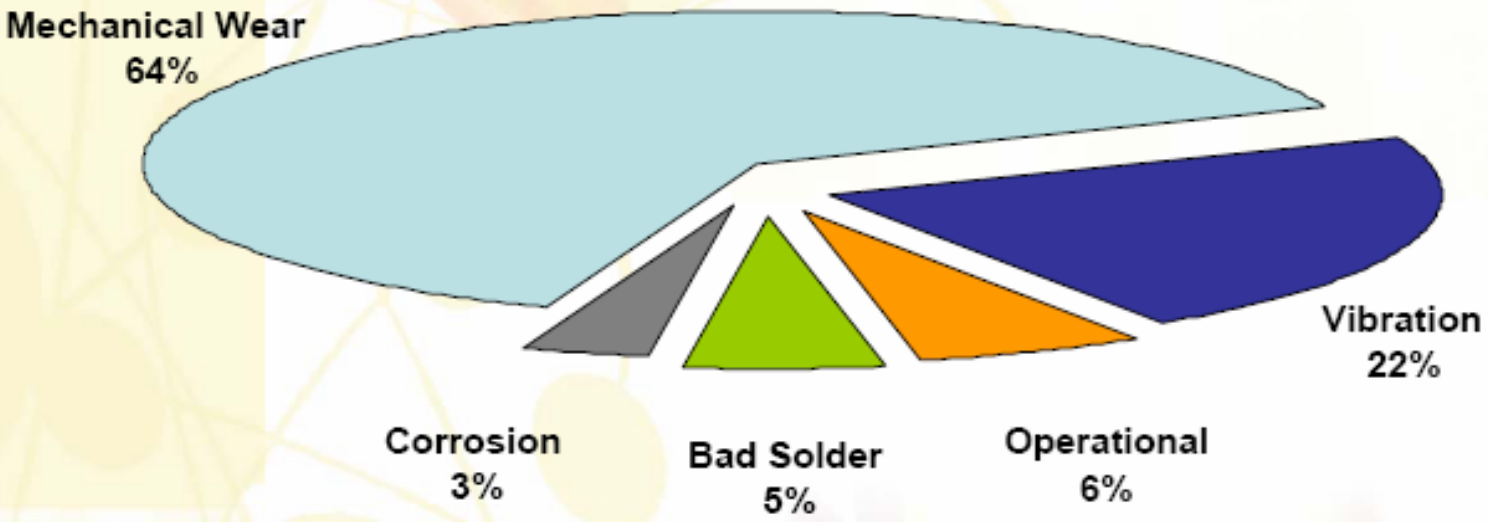
- ***When we use Hydrostar we have eliminated the use of diminimus gas (we do not use any refrigerant for leak testing)***
- ***Also, we are experiencing vacuum pump oil lasting many jobs. (In my testing of the test system over 4 weeks I never had to change the oil.)***

Locations for Refrigerant Loss



Mechanical Room is significant opportunity; however Display Cases, Condensers, Store Piping and Condensing Units are fertile ground.

Reports of Refrigerant Loss - Reasons



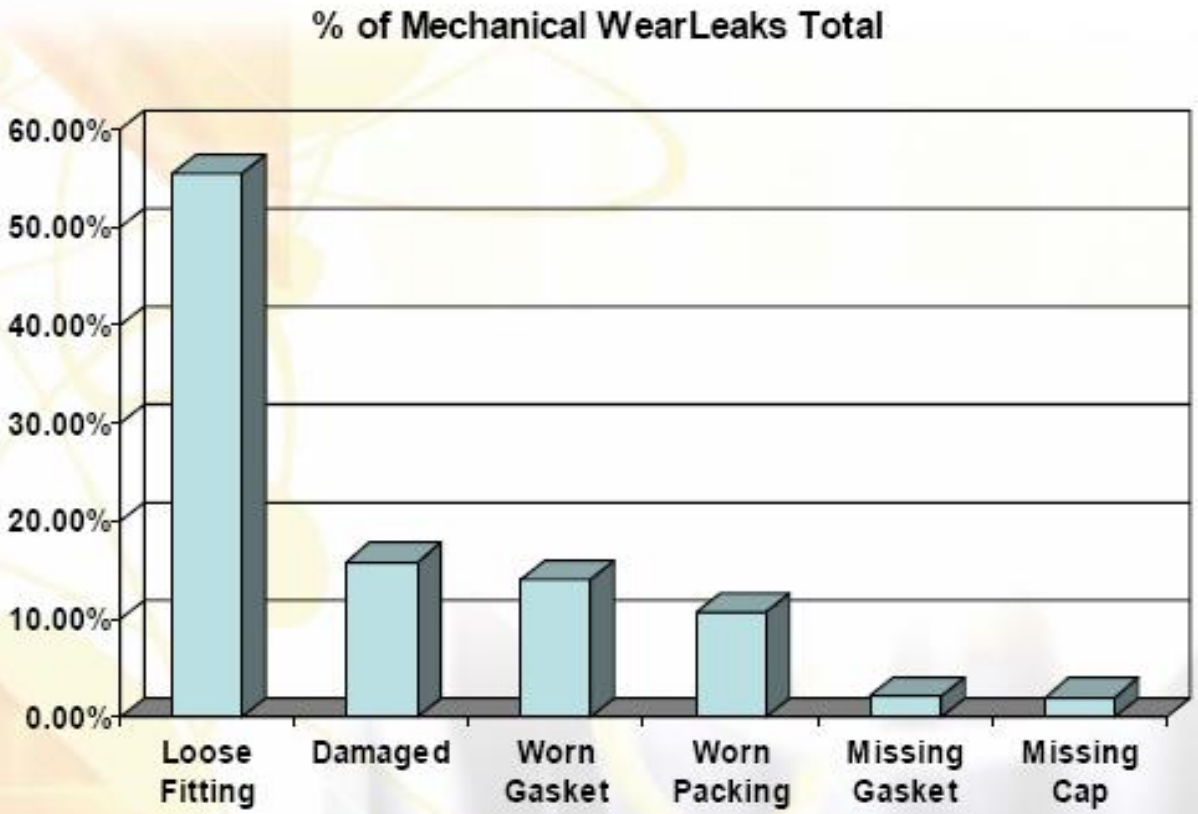
Mechanical Wear and Vibration produced 86% of refrigerant leaked.

Significant opportunity!

Not limited to any particular location.

2006 FMI Technical Slide

Leaks Due to Mechanical Wear



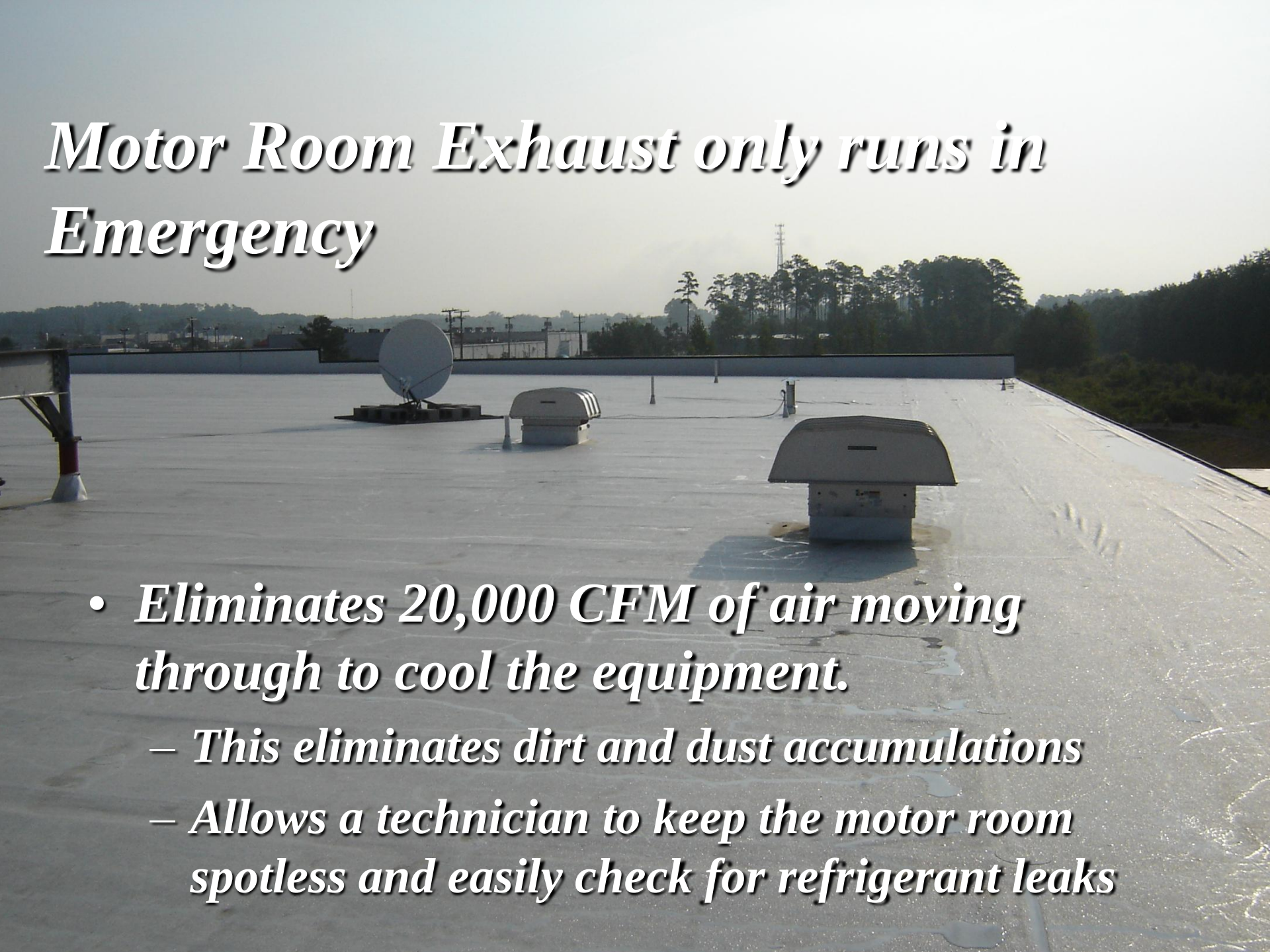
Loose Fitting included flare fittings, Schraeder caps, rotolock valves, service port caps and others.

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*

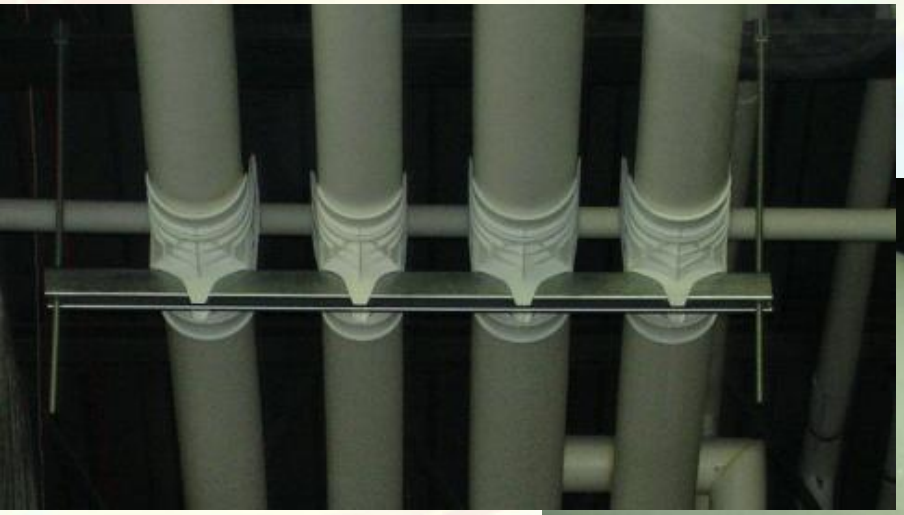
New Store Design and Reftrofits

- Spacious and Clear
- They are kept Clean

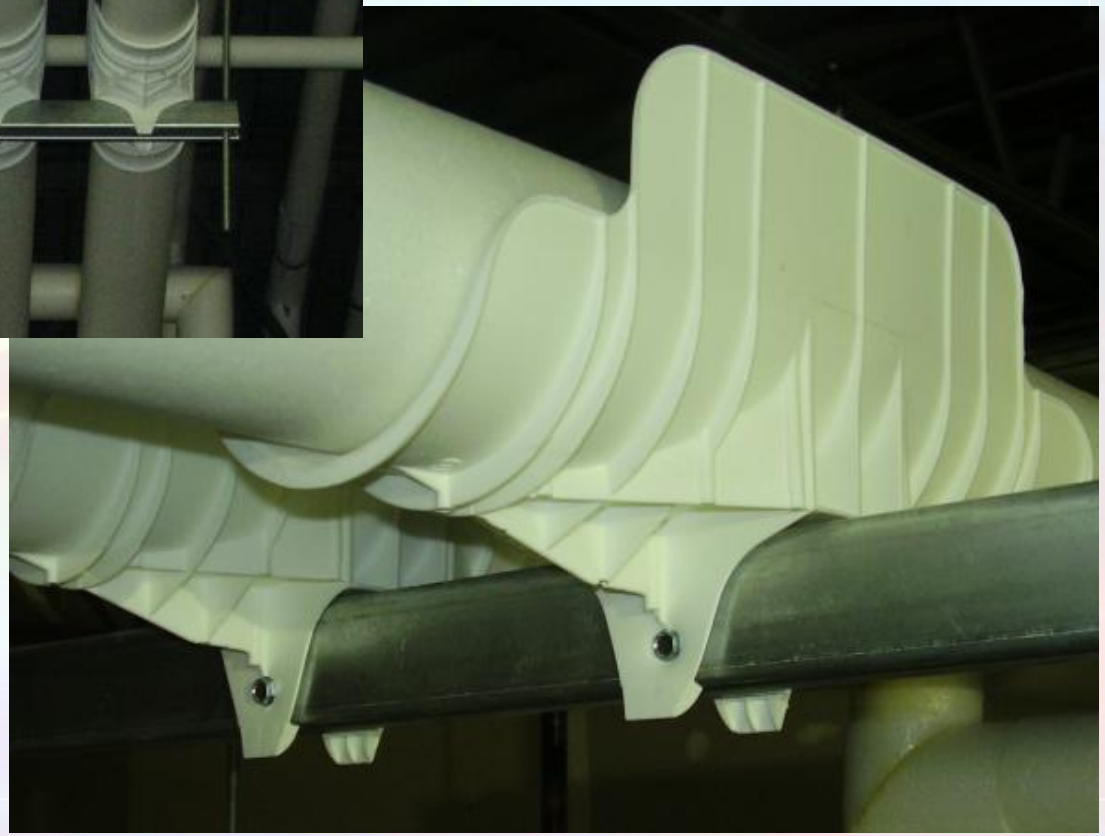
All Mechanical Areas are Remotely Alarmed for Entry

- *This ensures the doors stay shut to best help detect leaks*

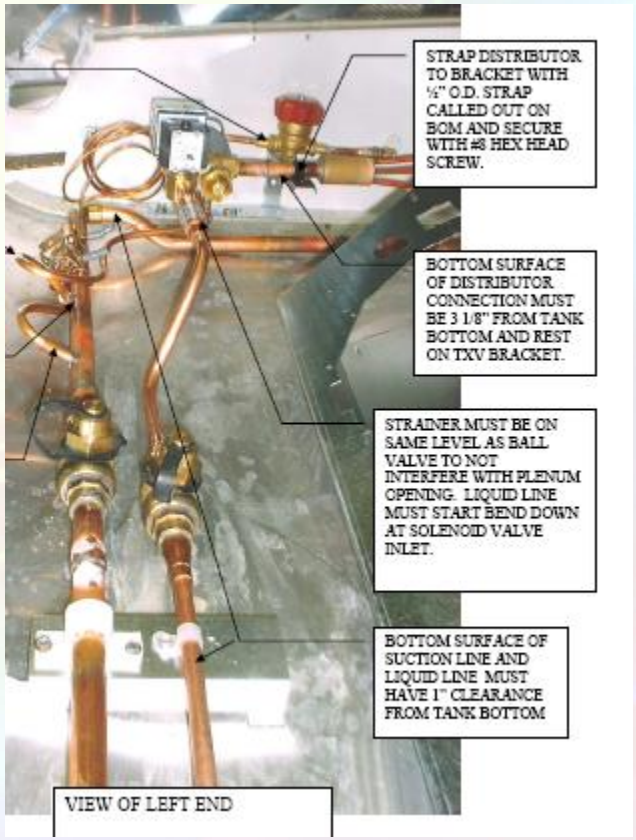
Better Pipe Support in the Overhead

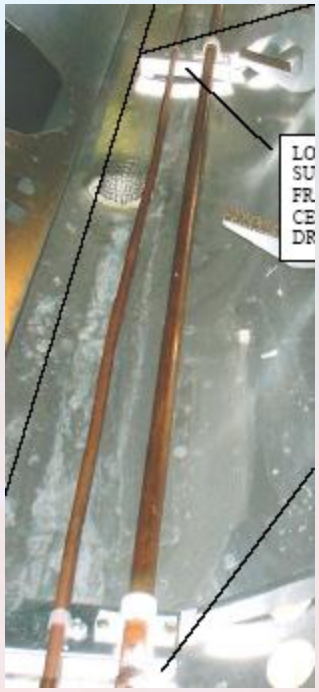


- *Insugaurd*



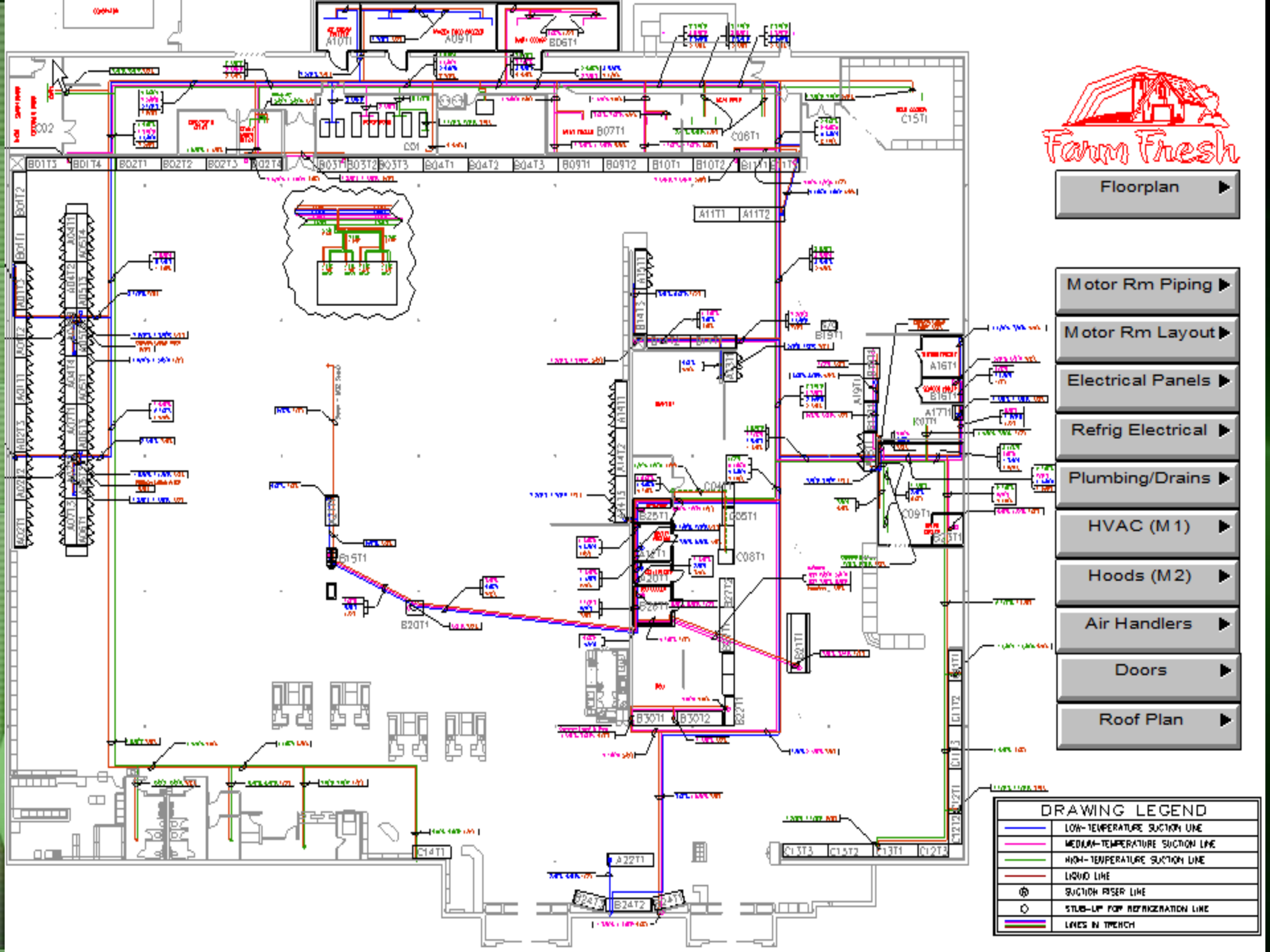
Superior Case Line Supports

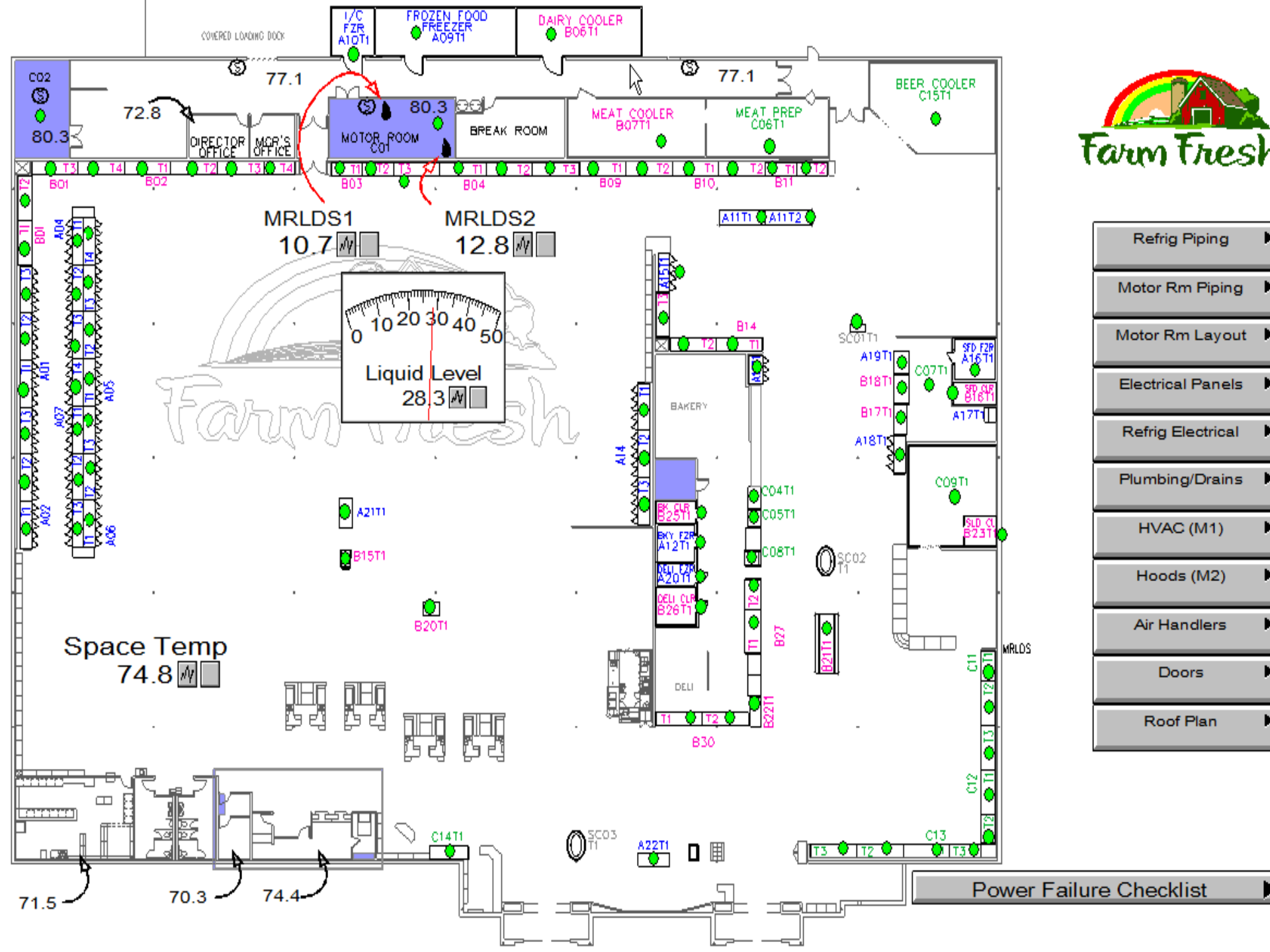




Assisting with Leak Checking

- ***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***


Farm Fresh
Floorplan
Motor Rm Piping
Motor Rm Layout
Electrical Panels
Refrig Electrical
Plumbing/Drains
HVAC (M1)
Hoods (M2)
Air Handlers
Doors
Roof Plan
DRAWING LEGEND
LOW-TEMPERATURE SUCTION LINE
MEDIUM-TEMPERATURE SUCTION LINE
HIGH-TEMPERATURE SUCTION LINE
LIQUID LINE
SUCTION RISER LINE
STUB-UP FOR REFRIGERATION LINE
LINES IN TRENCH


COVERED LOADING DOCK
I/C FZR A10T1
FROZEN FOOD FREEZER A09T1
DAIRY COOLER B06T1
BEER COOLER C15T1
CO2
80.3
77.1
72.8
DIRECTOR OFFICE
MGR'S OFFICE
MOTOR ROOM C01
80.3
BREAK ROOM
MEAT COOLER B07T1
MEAT PREP C06T1
77.1
B01
B02
B03
B04
B09
B10
B11
MRLDS1
10.7
MRLDS2
12.8
Liquid Level
28.3
0 10 20 30 40 50
Space Temp
74.8
A11T1
A11T2
B14
BAKERY
A14
A21T1
B15T1
B20T1
BK CLR B25T1
BKY FZR A12T1
DELI FZR A20T1
DELI CLR B26T1
C04T1
C05T1
C08T1
B27
B21T1
B22T1
B30
DELI
SC01T1
A19T1
B18T1
B17T1
A18T1
C07T1
SFD FZR A16T1
SFD CLR B16T1
A17T1
C09T1
SLD CL B23T1
SC02 T1
MRLDS
C11
C12
C13
C14T1
SC03 T1
A22T1
71.5
70.3
74.4
Refrig Piping
Motor Rm Piping
Motor Rm Layout
Electrical Panels
Refrig Electrical
Plumbing/Drains
HVAC (M1)
Hoods (M2)
Air Handlers
Doors
Roof Plan
Power Failure Checklist
Farm Fresh

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***

Other …

- *We have devoted more technicians to leak checking than ever*
- *A greater support and awarenes 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