Designing for Reduced Refrigerant Leak Rates

- ***Joining GreenChill***
- ***Freon Documentation***
- ***Freon Purchasing***
- ***Central Monitoring (Mlrds/Levels/Load Cells)***
- ***New store design***
- ***Hydrogen Leak Detection***

Farm Fresh Joined GreenChill

- *Announcement March 26, 2008*
- *After that we worked on the Best Practices Guidelines for Refrigeration Installation*
- *I discussed that I had just started testing Hydrogen leak detection*

Why did Farm Fresh Join?

- *We want to be good environmental Stewards*
- *We know by joining and sharing we will reach our goals more effectively*
- *We have a duty to our customers*
- *We also are hoping to help guide an industry in the correct direction by being active contributors*

Documentation of Refrigerant

- ***All of our refrigerated equipment is done electronically at computers in the stores at the time of each incident and is networked together***
- ***All Refrigerant is purchased by Farm Fresh, not subcontractors***

Central Monitoring

- *Local Staff of 5 associates monitoring and programming all building automation alarms*
- *24 hours a day 365 days per year*
- *Electronic As-builts of stores*
- *7 network computers with dispatch, call booking, and alarm monitoring software*

Central Monitoring

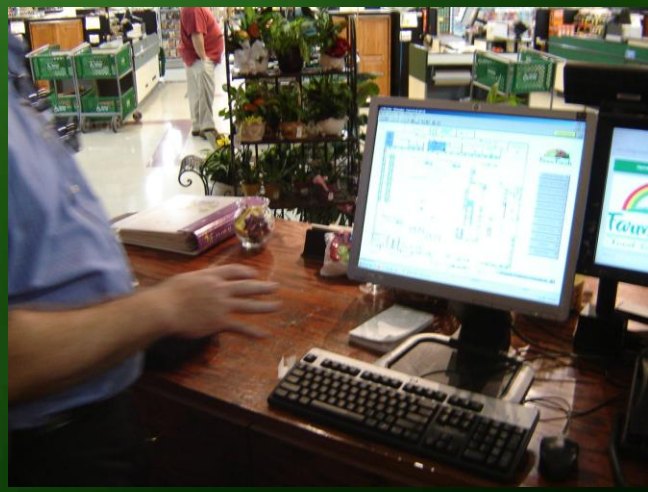
- *Advanced notification of refrigerant leaks MLRDS sensors*
- *Contained Motor room*
- *Rapid response with technicians*
- *Innovation in leak detection and refrigerant management*

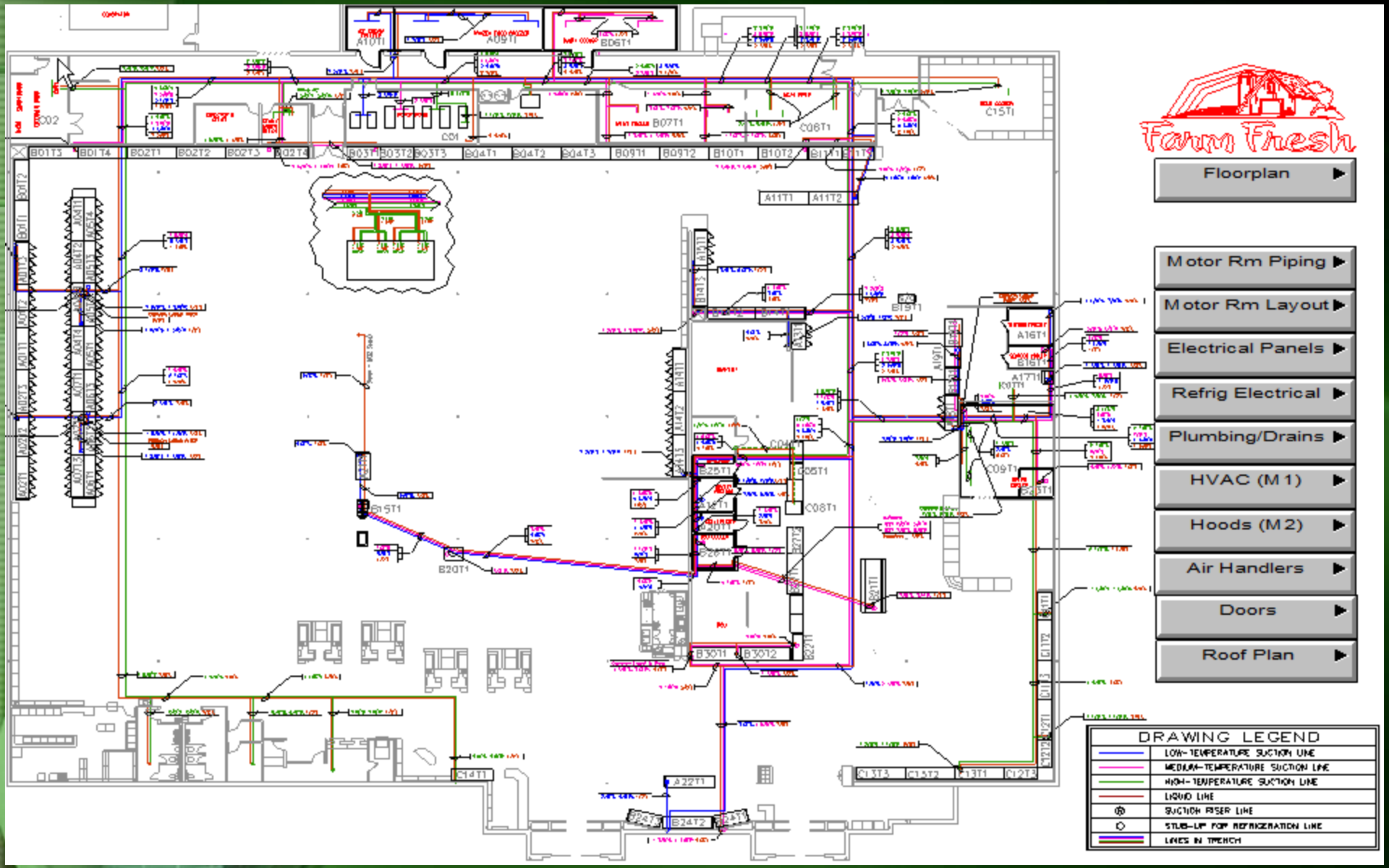
All Mechanical Areas are Remotely Alarmed for Entry

Refrigerant Leak Monitor

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*



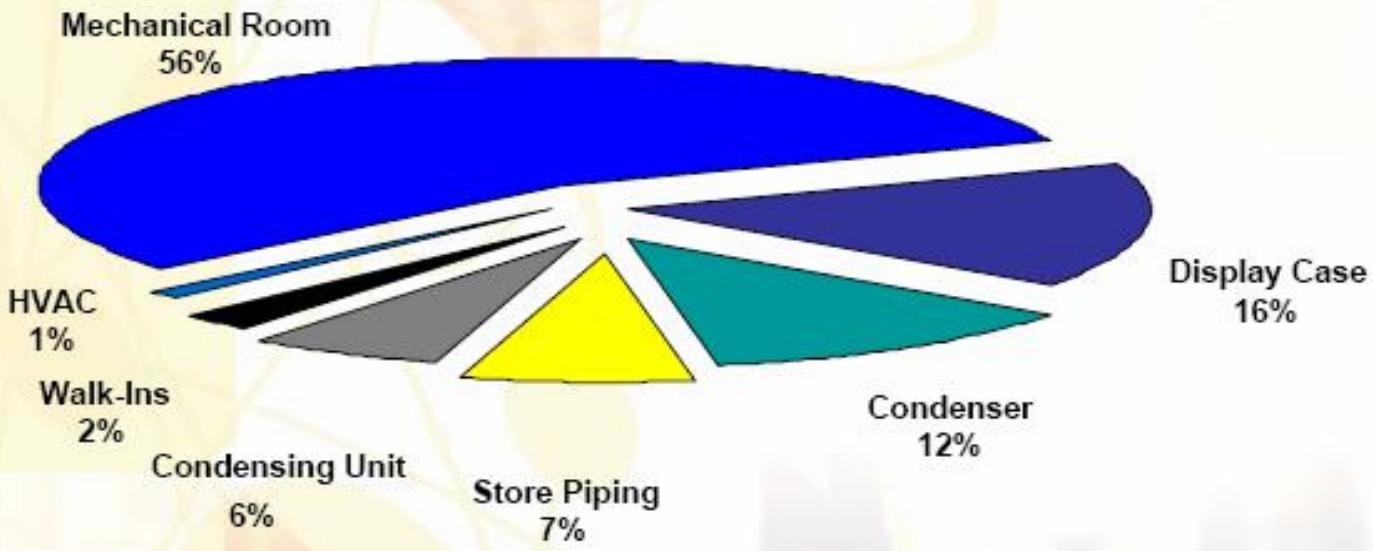

Farm Fresh
Floorplan
Motor Rm Piping
Motor Rm Layout
Electrical Panels
Refrig Electrical
Plumbing/Drains
HVAC (M1)
Hoods (M2)
Air Handlers
Doors
Roof Plan
DRAWING LEGEND
LOW-TEMPERATURE SUCTION LINE
MEDIUM-TEMPERATURE SUCTION LINE
HIGH-TEMPERATURE SUCTION LINE
LIQUID LINE
SUCTION RISER LINE
STUB-UP FOR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

On Call

- *Seasoned techs are more capable of maintaining a store than a journeymen*
- *They get to a point in their life where they still would like to work with their hands, but don't want to be on call because it is disruptive to their personal life. (They now are not single and have kids. They make good money and want quality of life.)*
- *So, they start looking for somewhere else to advance where they can work standard hours.*
- *The experienced technicians are older and don't like to climb up and down ladders all day.*

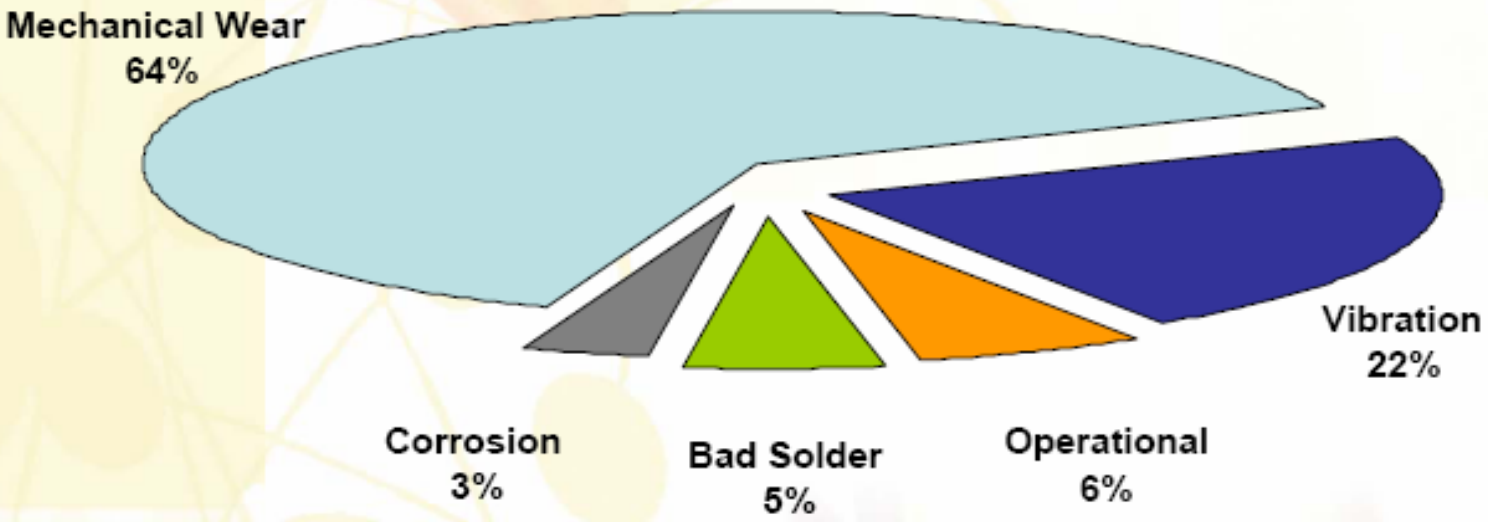
New Store Design

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

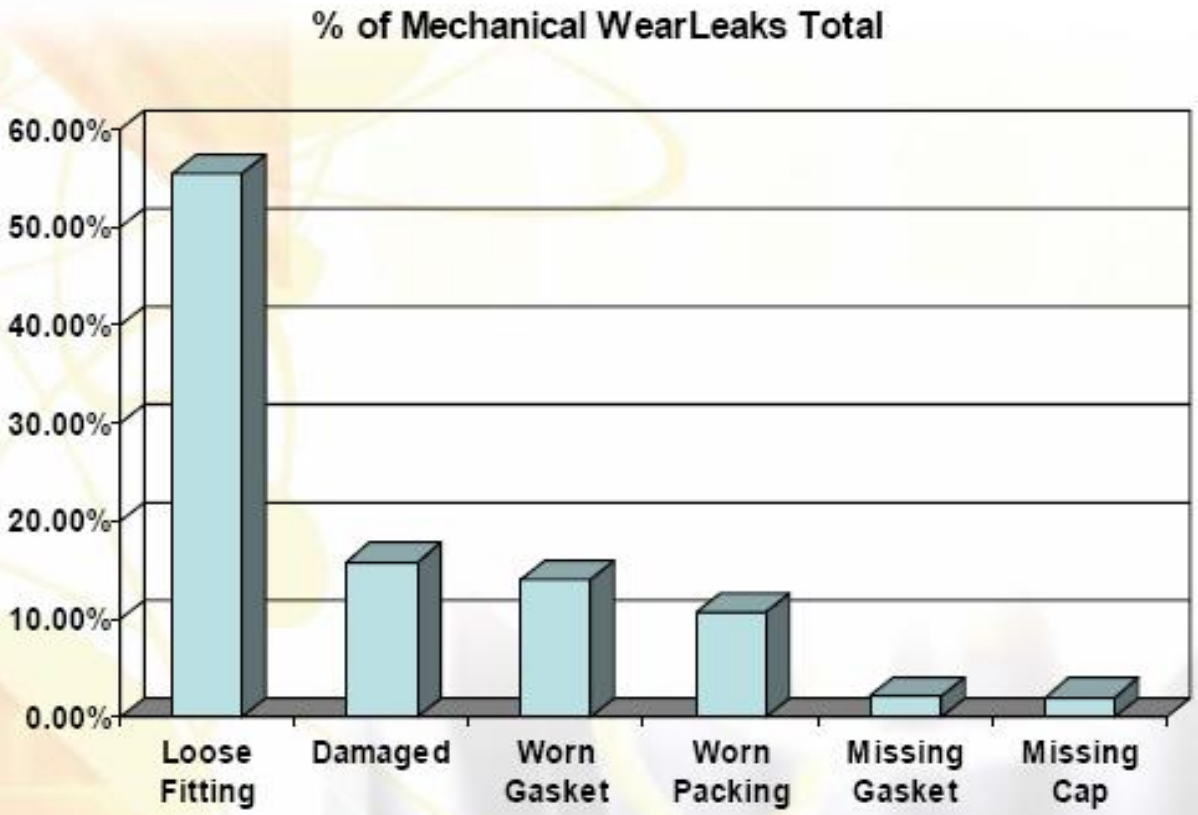


Mechanical Wear and Vibration produced 86% of refrigerant leaked.

Significant opportunity!

Not limited to any particular location.

Leaks Due to Mechanical Wear

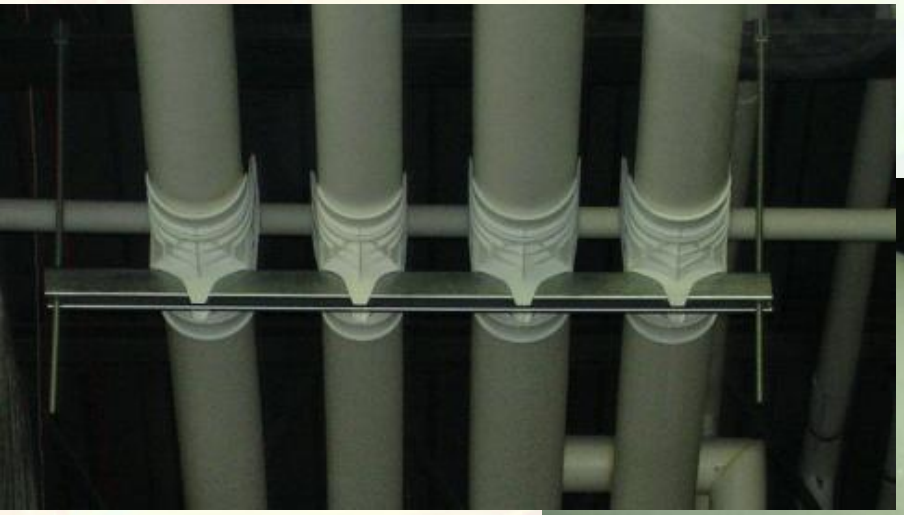


Loose Fitting included flare fittings, Schraeder caps, rotolock valves, service port caps and others.

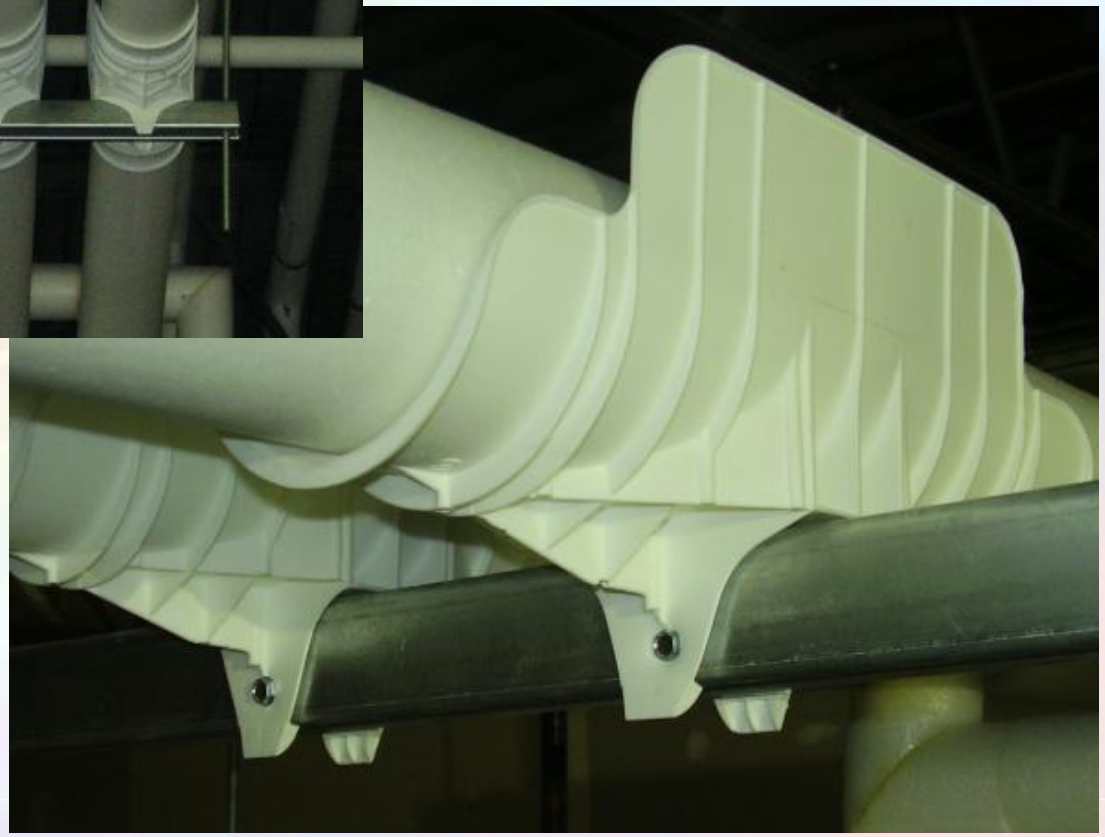
New Store Design

- ***Better piping support***
- ***Contained Motor Room***
- ***No Schraders outside the motor room***
- ***All mechanical areas are alarmed for entry***
- ***Infrared Leak Detection in the motor room, experiment on sales floor***
- ***Remote Analog liquid level sensors***
- ***Reduced Charge***
- ***Non ODS / Low GWP***

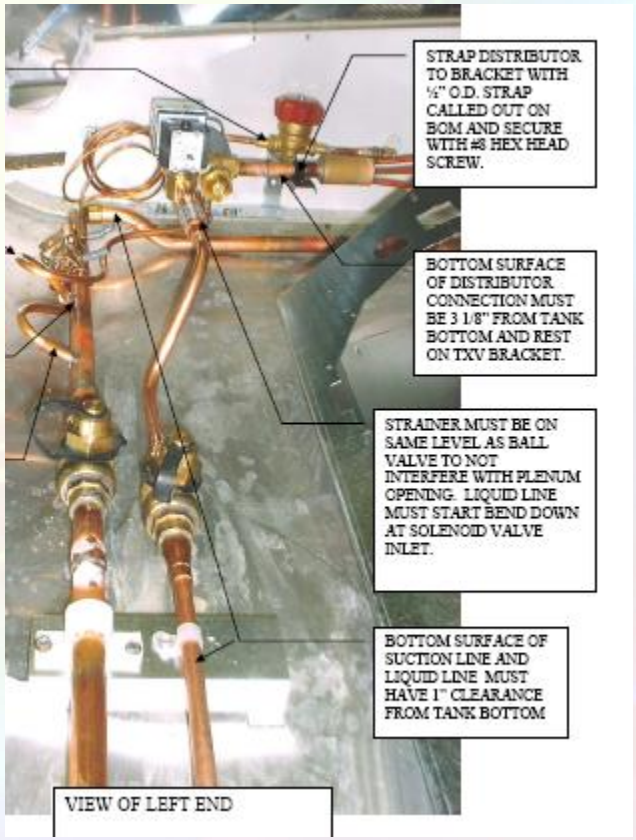
Better Pipe Support in the Overhead

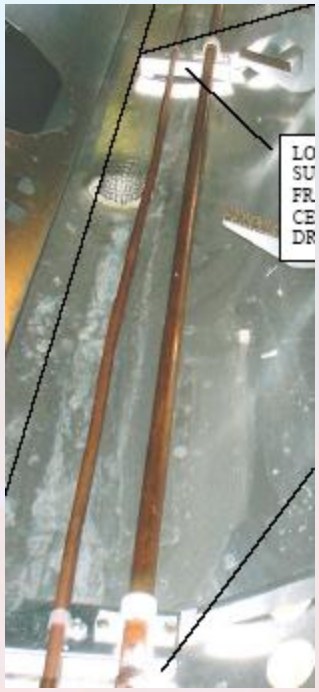


- *Insugaurd*



Superior Case Line Supports





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***

New Store Design (continued)

- *Spacious and Clear*
- *They are kept Clean*

Confined Space -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*

Refrigerant Management

- *Non ODS (R-404A vs R-22)*
- *Reduced Charge*

  4400 lbs to 1800 lbs
- *Reduced Leak Potential*
- *Reduced oil waste*

R-404A vs. R407A vs. R-22

- *Zero ODS*
- *3900 GWP*
- *Hard to detect*
- *Higher pressure*
- *Low grade waste heat*
- *good for oil temperature and desuperheating*

- *Zero ODS*
- *2100 GWP*
- *Hard to detect*
- *Middle pressure*
- *Mid grade waste heat*
- *bad for oil temperatures and requires desuperheating*

- *0.05 ODS*
- *1810 GWP*
- *Easy to detect*
- *Low pressure*
- *High grade waste heat*
- *bad for oil temperatures and requires desuperheating*

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*

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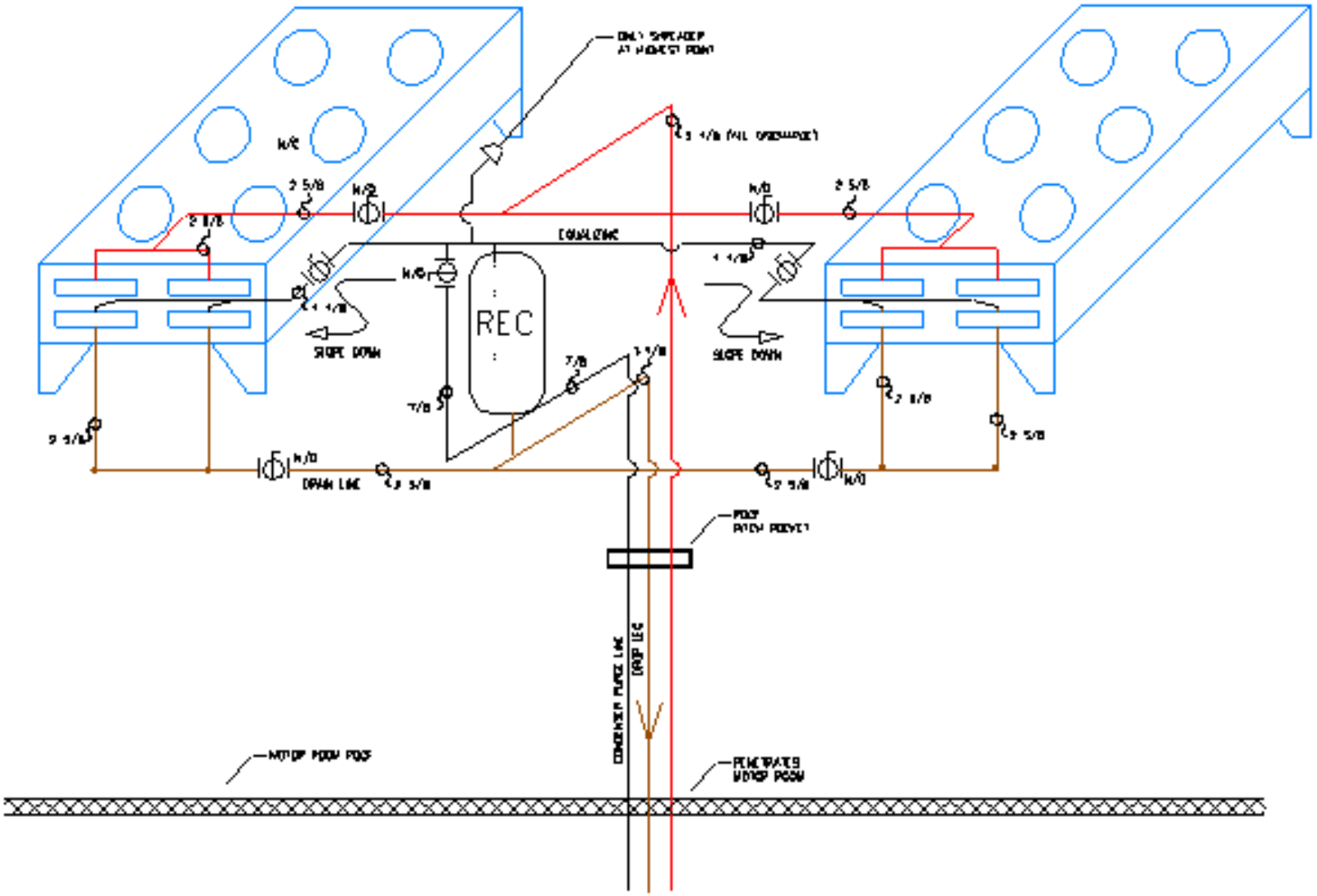
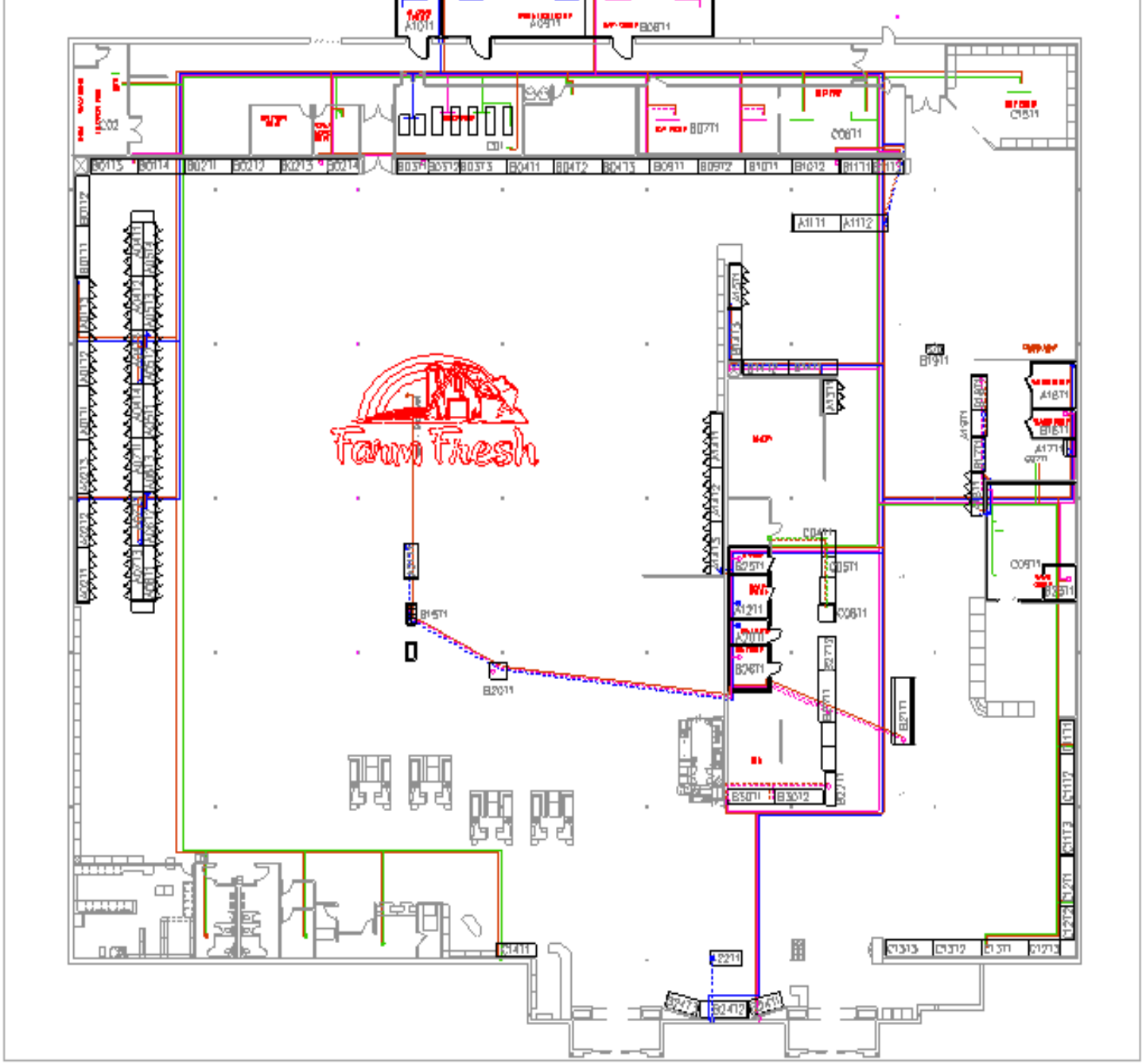
Surge Receiver Roof Mounted



Reduced Leak Potential

- *Less Pipe Surface area*
- *Less Pipe footage*
- *Less Solder Joints*
- *Less components*
- *Better piping supports*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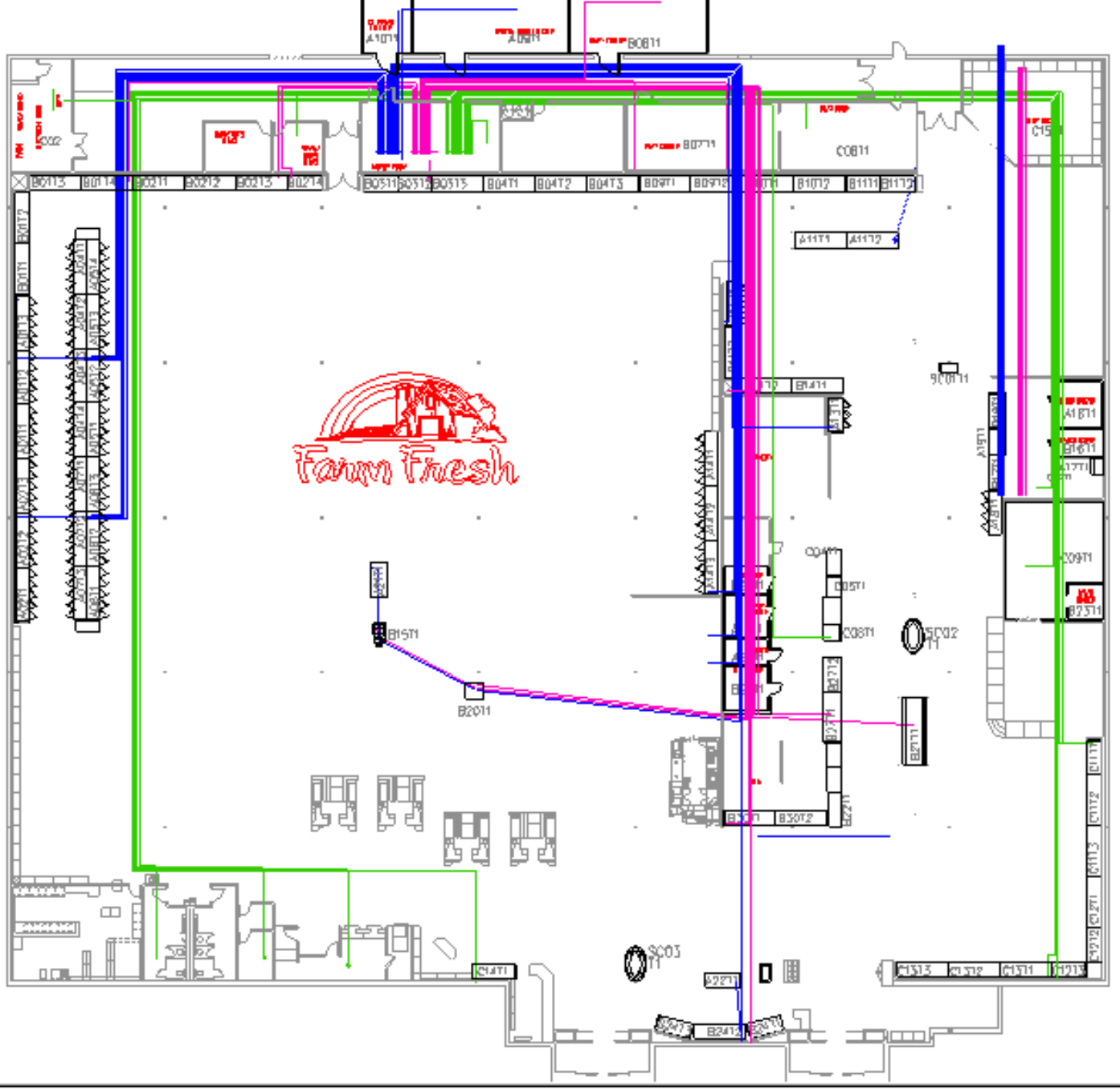
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Manifolded Piping

Pipe size	Feet	Cost/ft	Total	Outside Surface sq ft/ft	Outside Surface sq ft	Weight of tube lb/ft	Weight of tube lb
158	1780	$6.66	$11,855	0.425	756.5	1.140	2029.2
138	4500	$5.20	$23,400	0.360	1620.0	0.882	3969.0
118	3980	$3.88	$15,442	0.295	1174.1	0.653	2598.9
78	3700	$2.68	$9,916	0.229	847.3	0.454	1679.8
58	2560	$1.71	$4,378	0.164	419.8	0.284	727.0
12	8180	$1.41	$11,534	0.131	1071.6	0.198	1619.6
	24700		$76,525		5889.3		12623.6

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Central system loop piping

Loop system				Outside	Outside	Weight	Weight
Pipe size	Feet	Cost/ft	Total	Surface sq ft/ft	Surface sq ft	of tube lb/ft	of tube lb
358	80	$27.48	$2,198	0.949	75.9	4.290	343.2
318	500	$21.02	$10,510	0.818	409.0	3.330	1665.0
258	760	$15.63	$11,879	0.687	522.1	2.480	1884.8
218	580	$10.49	$6,084	0.556	322.5	1.750	1015.0
158	960	$6.66	$6,394	0.425	408.0	1.140	1094.4
138	1020	$5.20	$5,304	0.360	367.2	0.882	899.6
118	1040	$3.88	$4,035	0.295	306.8	0.653	679.1
78	1380	$2.68	$3,698	0.229	316.0	0.454	626.5
58	1200	$1.71	$2,052	0.164	196.8	0.284	340.8
12	1460	$1.41	$2,059	0.131	191.3	0.198	289.1
	8980		$54,213		3115.6		8837.6

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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*

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Less Components

- *Only 6 compressors with, 6 dual pressure switches*
- *No oil separator*
- *Only 1 receiver*
- *Only 2 oil regulators (floats)*
- *Drastically reduced EPRs (8)*
- *No three way heat reclaim valves*
- *No hold back valves*
- *No desuperheating/No water-cooled heads*

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Reduced Oil Waste

- *The compressor motors are external to the system*
- *Open Drive Compressor burnouts cannot contaminate system / Less environmental damage*
- *Often systems have high levels of acid and are not cleaned up leading to early compressor failure*

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Hydrogen Leak Detection

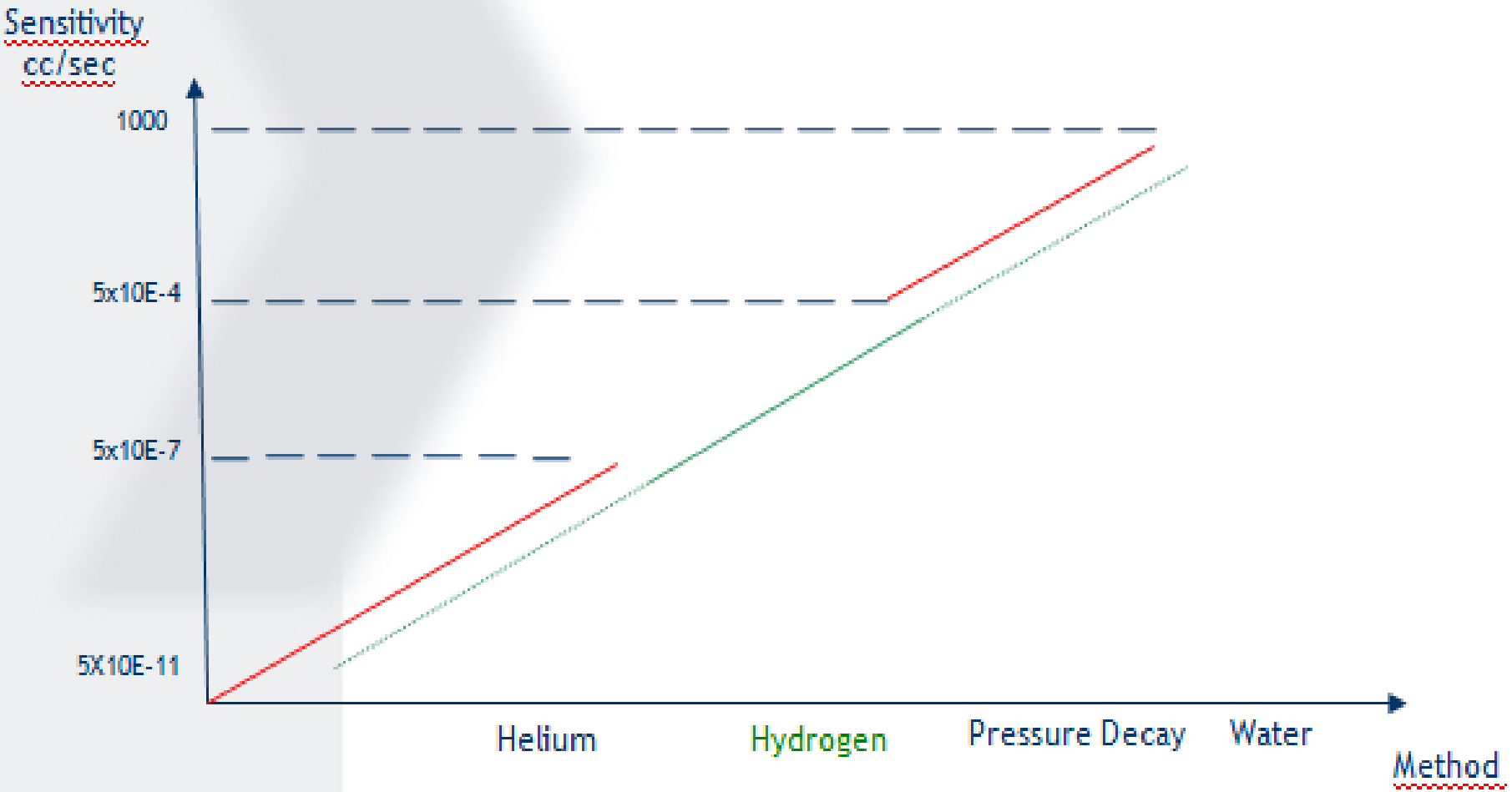
Hydrogen Leak Detection is similar to electronic refrigerant leak detection only the gas used as a tracer gas has a component of pure hydrogen

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 14,0001 and ISO 10156 (meaning it is Green and Safe)***

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	1.3 seconds
10^{-2}	3 Months	$7.6x10^{-3}$	100 seconds	13.3 seconds
10^{-3}	2.7 Years	$7.6x10^{-4}$	16.67 minutes	14.5 minutes
10^{-4}	27 Years	$7.6x10^{-5}$	2.78 hours	24 minutes
10^{-5}	270 Years	$7.6x10^{-6}$	27.8 hours	4 hours
10^{-6}	2,700 Years	$7.6x10^{-7}$	11.57 days	
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?

- *Traditional installations do not remain leak tight over time, costing refrigerant*
- *New construction of non-traditional systems are significantly higher cost ($100,000 - $200,000 per site)*
- *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*

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

How well does it work?

- ***Our first tested store was put to 300 psi of Hydrostar for 60 hours and did not loose 1 psi of pressure.***
- ***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 analysis mode, which is lower than factory settings***

Large Leaks Start Out Small

How well does it work?

- ***We installed a deli case in a lineup.***
- ***I had the tech leak check the lineup the day before with a handheld leak detector***
- ***We leak checked the case with hydrostar before installing it***
- ***Upon installation of the new case there were pinhole leaks in the case to the right of the new case that he did not pick up with electronic leak detection. They showed immediately with hydrogen leak testing***

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 vacuums below 125 microns.*

Trying to improve the system

- ***I wanted to see what was feasible for pressurizing and pulling vacuums.***
- ***So, I wanted to create a super tight typical system and find out how long I need to pressurize a system and how long it should take to pull vacuum***
- ***I wanted to dispel myths about vacuums or prove them true***
  - ***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

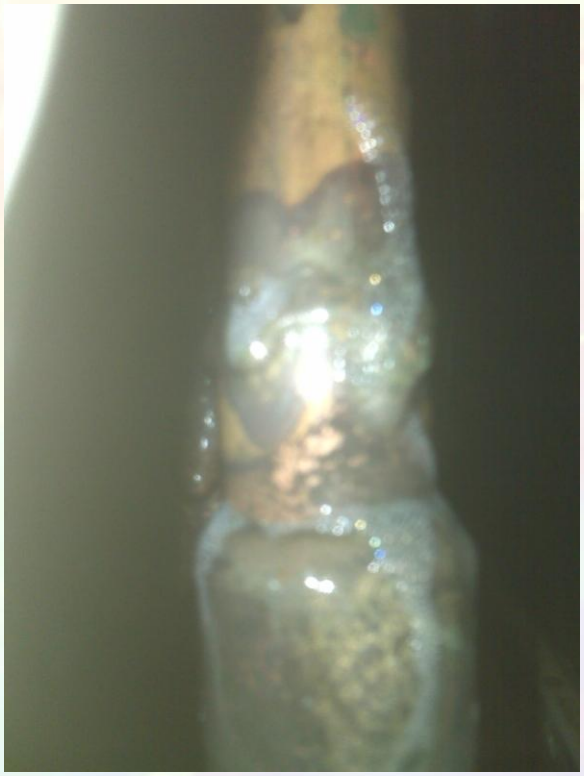
- ***200 feet of suction 1-3/8”, 10 feet 7/8” risers and ½” liquid line piping with 2 Dairy Cooler evaporator coils (Bohn Model:ADT208)***

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***

The Suction Riser of the Leaking Evaporator Pressurized to 300 psi

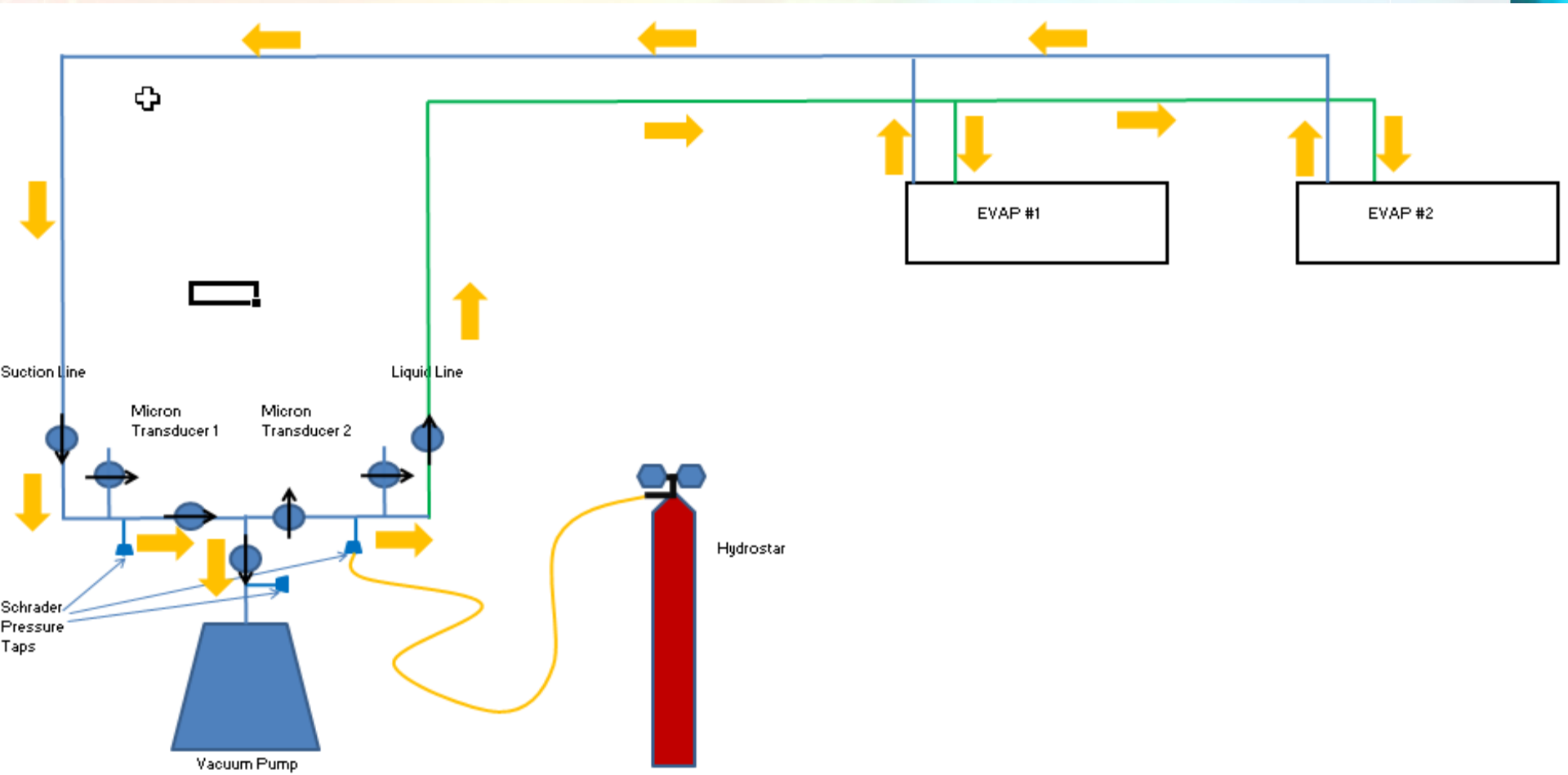
Hydrostar ***vs*** ***R22***



New Vacuum Procedure

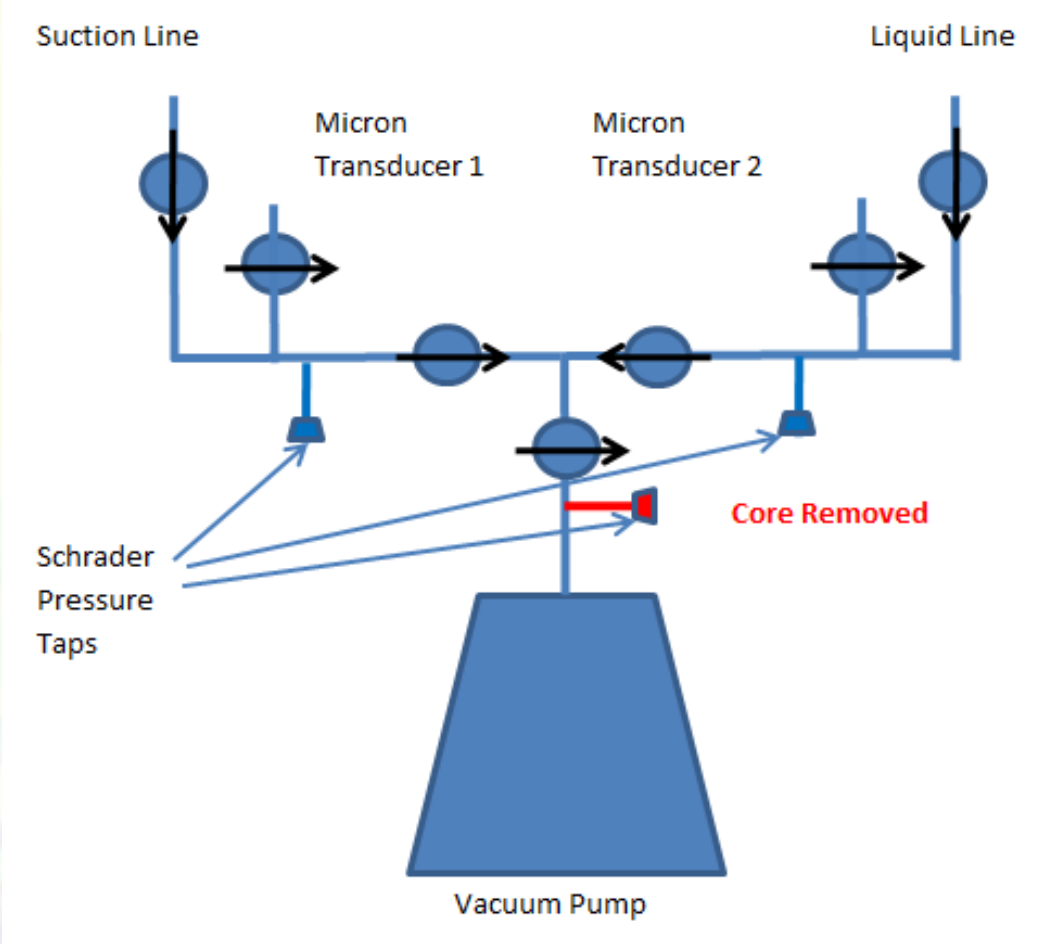
- ***First pressure test the entire system to a pressure of 50-100 psi Hydrostar, including vacuum pump. (Make sure to remove core of last schrader cap at pump to not blow up pump)***
- ***If no huge leaks are found go to max pressure. (We are typically going to 300 psi.)***
- ***Length of time depends on the job. We do 1 hour minimum and long enough to leak check entire system***
- ***Once the test has held at least 1 hour and no leaks were found release gas***

New Vacuum Procedure



New Vacuum Setup

- ***We no longer break vacuums in the traditional method. We now pull a vacuum and break what we term "dynamic flow"***



New Vacuum Procedure

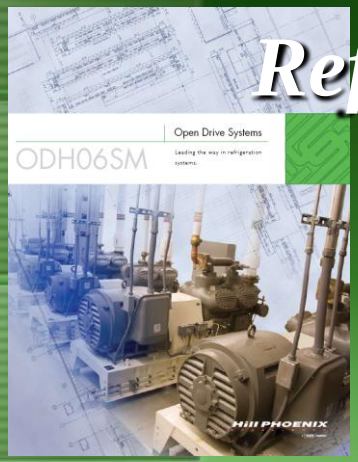
- ***Reinstall the core to the schrader at the pump***
- ***Valve off the manifold from the system and test the vacuum pump and oils integrity. (It should pull 50 microns in a matter of minutes)***
- ***Connect the hydrostar through a regulator, and guage manifold to the liquid side of the vacuum manifold. Back the regulator down to a low, low pressure. Less than 2 psi.***
- ***Now open the pump to the suction side of the system. Having all valves on the system wide open and the valve closed so the pump does not pull through the liquid line.***

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***
- ***Open and close the manifold gauge quickly***
- ***Watch the micron guages. The liquid one 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***
- ***Disconnect the hydrostar with it flowing so no atmosphere enters the system***

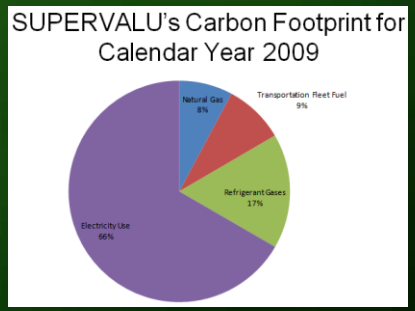
New Vacuum Procedure

- ***Let the system pull either until you have the desired micron reading and valve off and let it stablize.***
- ***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***

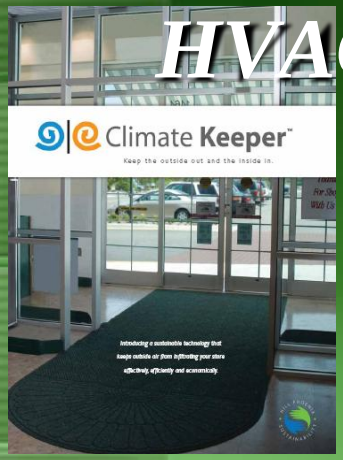


Refrigeration Energy Efficiency

- Premium efficiency Toshiba motors approximately 10% more efficient and low rpms
- Two stage compression 7% savings
- Open Drive Direct Connected Carlyle compressors are still the most efficient compressor 50 years later
- Access to entire store THR for heat reclaim
- Loop piping reduces heat gain by reducing surface area by 50% on suction and liquid lines



HVAC Efficiency - Climate Keeper



- Reduces Infiltration
  - Prevents humidity from reaching display cases in summer
  - Reduces cold drafts in winter
  - Improves customer comfort
- Keeps the building neutral
  - Reduces the need for pressurization
  - Roughly removes 20 tons of cooling on this store
- Flying insect control

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Reliability (Sustainability)

- *Carlyle Open Drive Compressors installed correctly have 25 + years average life*
- *Superior oil management*
  - *Compressors have oil overflow*
  - *Compressor oil pumps move the oil*
- *Reduce materials*
  - *Less copper, solder, nitrogen, insulation, unistrut, saddles, glue , acetylene, etc*
  - *Less refrigerant*
  - *Fabric Duct*

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Where are we headed?

- *We are studying 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)*
- *Constant Technician Training*
- *Improved installation techniques*
  - *Higher pressure testing for longer periods*
  - *Lower vacuums for longer periods*
  - *Hydrogen leak testing*

Thank you

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Also, I would like to thank specifically….

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- *Ed Estberg of*
- *Laurie Gethin of*
- *Tom Backman*
- *Scott Martin and John Galleher*

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