Best Practices for Commercial Refrigeration Systems

This document was created in summer 2021 by Minnesota Technical Assistance Program (MnTAP) intern Julian Kern Steffen in association with South-Town Refrigeration and Mechanical.

South-Town Refrigeration and Mechanical engineers, installs, and services commercial and industrial refrigeration, operating throughout Minnesota since 1954.In addition to refrigeration, South-Town designs heating, cooling, building automation, custom ductwork and energy saving solutions for their clients.

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Introduction

In operating a grocery store, one undertakes many responsibilities including product, employees, equipment, and customer experience. One of these responsibilities is a complex network of refrigerant piping, heavy mechanical equipment and storefront cases that comprise the refrigeration system. It falls on the store owner/operator to keep their product cold and that means installing a custom refrigeration system to fit their needs and maintaining this system.

This document serves as a tool to give the end user information to run their refrigeration system responsibly, efficiently, safely, and environmentally consciously. The complexity of a refrigeration system results in a myriad of pitfalls. An irresponsible storeowner would give no thought to their refrigeration system until it fails catastrophically and requires emergency service to prevent goods from spoiling. Now the information is in your hands and by executing

these practices you have an opportunity to save on your energy bill, extend the life of your equipment and prevent costly equipment failure.

Catastrophic Failure

A catastrophic failure can occur at any component in the system and cause total loss of cooling. If this occurs, massive financial loss is unavoidable. Between emergency services, loss of product, potential loss of business, significant extra work for managers and other store employees to mitigate the situation. Preventing just one of these futures by catching the issue before failure occurs, saves a significant amount of money across all these categories, and avoids an urgent and stressful emergency. The emergency service alone can cost $800-$1000, without considering store losses or energy savings. Implementing these practices by completing the checklist in Appendix I costs approximately $15 a month in employee time. This means if the program prevents just one emergency service call over the course of four years it has paid for itself.

Preventative Maintenance

Commercial refrigeration systems are comprised of many components that require upkeep and maintenance to run efficiently. Once a system has failed and requires emergency service it is too late and irreversible financial damage has already been done. The only way to mitigate this scenario is through preventative maintenance. A preventative maintenance checkup should occur two to four times per year. Develop a concrete schedule for maintenance with your service provider to ensure you do not miss maintenance checks. Service anything flagged during a maintenance check.

During a maintenance call or servicing of any type ensure that necessary areas are accessible to technicians (ideally) before or as soon as they arrive. Time spent waiting for doors to be unlocked is a waste of billable technician hours.

Compressor Room

Clean Room

Keeping equipment clean and the floor clear of obstacles makes the compressor room more accessible to technicians. A cramped and difficult to navigate compressor room can result in more technician hours for the same service. Keeping a compressor room tidy makes leaks and problems easier to spot and allows issues to be discovered earlier.

Oil Seepage

On a monthly basis inspect compressor racks and piping in the compressor room. Pay close attention to valves, mechanical and brazed connections, and any other components. The compressor room is the most likely location for a leak due to the high concentration of components, connections, and vibrational strain. Any oil seeping means there is a refrigerant leak and needs to be serviced as soon as possible. See oil seepage under Piping, Leak Detection for more details. Figure One is an example of what oil residue leaking from a line looks like.

Figure One: Oil Residue

Doors

Walk-In freezers must be equipped with strip curtains; otherwise, any opening of the door causes far too much heat entering the space. Inspect these curtains for ice as a door with compromised insulation will form ice towards the top of the doorway. If any ice is discovered and the source of insulation loss cannot be identified, servicing should occur promptly. The example in Figure Two represents not only a severe and ongoing inefficiency but also a safety hazard.

Figure Two: Severe Ice Buildup on a Low Temperature Walk-In

Door Alarm

Walk-ins should be outfitted with a door alarm that detects if the door has been open for to long and sounds an alarm. Other varieties flash a light while the door is open as well. Without this system, a door left open overnight this will cause high temperature product while also stressing refrigeration system causing large financial losses.

Fan Switch

Another control system that should be installed on any walk-in are evaporator fan switches. When the door is opened, the fans should switch off and not blow cold air out the door. Listen carefully to your fans when you open the door to ensure this function is operational.

Opening/Closing

The number of times the door is opened and closed should be kept to a minimum. Below are some steps to minimize the additional cooling draw that door openings creates.

- A coatrack nearby the door means employees can make longer & less trips inside without getting cold.
- Signage on the door. For example, “Only open if you know what you need from the walk-in!”
- Stationing a cart nearby or inside the walk-in to consolidate multiple trips.

Latch

Inspect the latch, it must provide pressure to the door to prevent heat seeping through. Check that the door does not move when the latch is engaged. See Store Floor > Door Cases > Gaskets for information on inspecting the gasket lining the walk-in door.

Airflow

There must be good air circulation within the case for the evaporator to perform effectively. Blocking the intake or exhaust of the evaporator will cause it to ice over and lose cooling power. Inspect the loading of the walk-in regularly to ensure nothing is stacked close to the evaporator. Consider implementing a mesh net to block the area near the evaporator from being loaded with product.

While it is tempting to push shelving all the way to the wall to maximize space within the unit, this compromises airflow around the product. Leave at least an inch between the shelves and the walls to allow air to flow behind the shelves.

Panels

Inspect the paneling within the walk-in. The panels should be continuous. If any are warped and have wood visible between panel edges the insulation has been compromised and requires fixing.

Leak Detector

Walk-ins are not ventilated like the rest of the store and while closed they keep the cold air contained within the refrigerated space. If a leak develops within a walk-in, the refrigerant will collect in the air. This presents a safety hazard as someone inside the walk-in could inhale harmful levels of refrigerant. For this reason, most walk-ins are equipped with a leak detector mounted inside the refrigerated space. Know if your walk-in has one and ensure it is operating correctly. Figure Three shows what one looks like.

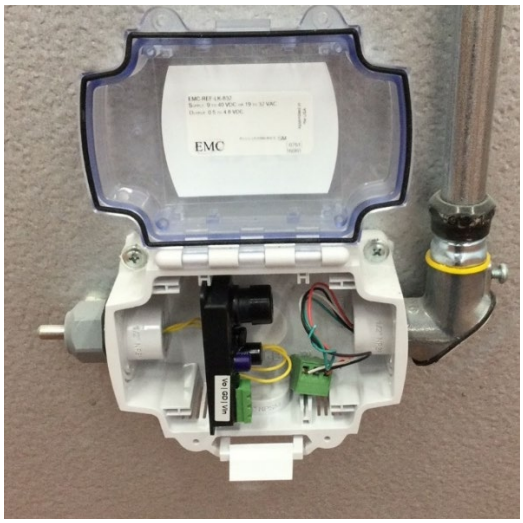

Figure Three: Walk-In Leak Detector

Store Floor

Evaporators

Evaporator coils are in more of a controlled environment when compared to the rooftop condenser. As a result, they have less dust buildup that needs to be removed. However, the fans, intake and coils should all be inspected regularly and cleaned if dusty or dirty. The main concern for evaporator performance is frost and ice buildup on the coil. Check coils and compressor return line regularly for frost or ice. Defrost if necessary. Ice buildup blocks airflow and insulates the piping both of which severely diminish performance. Rack systems typically have an automatic defrost system however it is important to know which defrost system is used. Some common defrost methods are:

- Electric Defrost, built in electric heaters for defrost.
- Spray/wiping down with hot water.
- Off-Time Defrost, simply turning the system off and stopping refrigerant flow.
- Hot Gas Defrost, Running hot refrigerant vapor through the coils.

If frost buildup occurs and cannot be easily removed by hot water or the systems automatic defrost control, then there is likely a deeper issue such as loss of an evaporator fan. Figures Four and Five show a system with one evaporator fan stopped and the icing it caused.

Figure Four: Iced Over Compressor Return Line

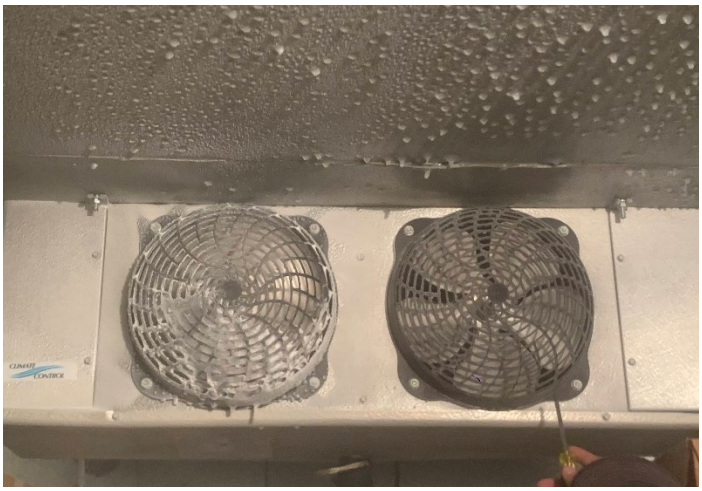

Figure Five: Right Evaporator Fan is Out Causing Icing

Drain Pan

Locate the condensate drainage system on your evaporator and ensure you know how to access it. While inspecting evaporator coils, check the drain pan for blockages. A blocked drain pan will result in icing and ultimately compromise the performance of the evaporator.

Door Cases

Gaskets

Cases with doors and walk-ins will have rubber lining that insulates the edges of the door called a gasket. During the monthly walkthrough, inspect all gaskets for tears, discoloration, frost, or other wear. This inspection should cover the all cases and all walk-ins. If mold is present on the gasket, this is an indicator that it has been exposed to moisture and heat and has likely cracked or failed. Additionally, gaskets that do not allow the door to shut fully should be repaired. A worn-out gasket will cause heat to leak into the case and the unit to draw a higher cooling load and operate inefficiently. Figure Six shows a severely damaged gasket. If a gasket is so damaged that it causes a high temperature alarm, then it may have been overlooked and wasting electricity for a long time.

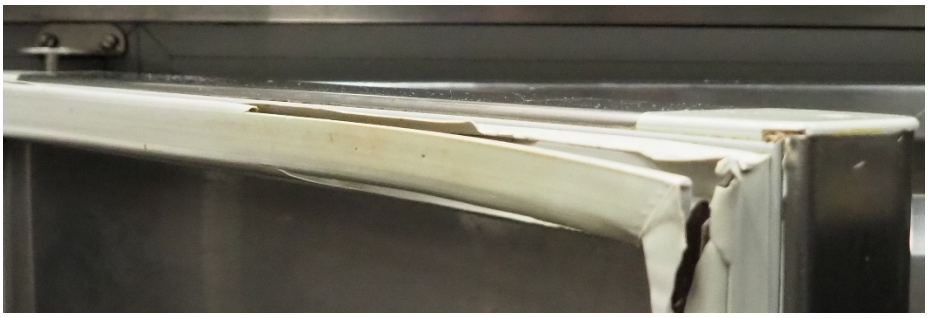

Figure Six: Torn Gasket

Open Cases

Cases with no doors to insulate the product most, (grocery store operators' typical choice for displaying produce) are insulated by a curtain of air moving down in front of the product. Blocking this airflow compromises the refrigeration process and can raise the temperature in the case, as stagnant air will not insulate as well as flowing air. This phenomenon is easy to observe by feeling near the intake. Cold air should be noticeably flowing in the pattern shown in Figure Seven. Many cases come with a guideline usually labeled "Load Line" to inform loading of the case.

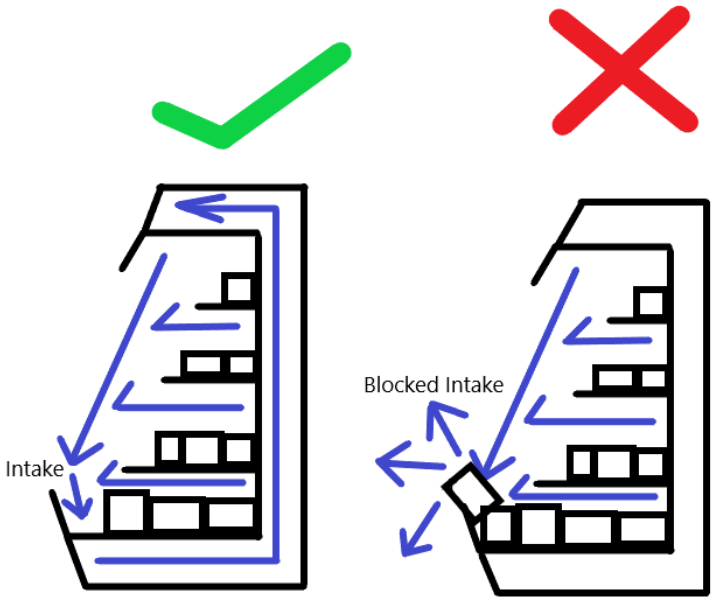

Figure Seven: Case Loading Graphic

within cases happens on a faster scale than the development of other refrigeration issues, and this means that they should be inspected weekly rather than monthly.

Rooftop Air Cooled Condenser (ACC)

Airflow

To maintain proper airflow there must be certain clearances around the condenser. This means there cannot be any blockages above or immediately to the sides of a condenser. This must be avoided in the installation phase but must be kept in mind if the roof is ever used for storage.

Underside and Underneath the Unit (Intake)

Large ACCs take in air from the underside and the fans push it out the top. If the underside of the condenser becomes dirty, then the airflow becomes compromised. As little as 0.01 inches of buildup can reduce capacity by 5%, further buildup can lose up to one fifth of the efficiency. Table One projects the cost savings of cleaning a condenser based on loss of efficiency, find the cooling power of your condenser and reference Table One to see how much cleaning the condenser will save.

Nominal Cooling [Tons]	3	5	7.5	10	15	20	25	30	40	50	60
KWH per 1000 hours (Dirty)	5,700	8,100	11,200	16,800	24,400	32,400	40,800	48,900	66,400	82,300	98,600
KWH per 1000 hours (Clean)	4,100	5,500	7,400	12,300	16,000	20,800	27,000	30,800	41,500	52,100	63,000
Cost Savings per 1000 hours	$141	$230	$228	$336	$743	$1,025	$1,220	$1,600	$2,201	$2,670	$3,147

Table One: Condenser Cleaning Savings

These projected savings are based only on electricity saved at a rate of $0.0884 per KWh. Additional savings occur during peak electricity demand hours and result from extended compressor life. These figures are based off expert estimates from South-Town Refrigeration. Figure Eight shows an ACC with dust buildup.

Figure Eight: Condenser coil comprimised by buildup

It is recommended that someone examine the underside of the unit on a weekly basis. Because air flows through the bottom, it is very easy for dust and blockages like seeds, cottonwood, and garbage to accumulate. If the unit is in an area where cottonwood is present be especially vigilant for buildup during cottonwood season. For the same reason it is recommended that leaves should be raked out from underneath the unit on a regular basis.

Routine maintenance should include a thorough cleaning of the compressor intake and fan. However, if accumulation is present, it should be cleaned before the next servicing. Use compressed air or wipe off dust and be sure not to damage the coils. One way to determine whether the airflow is compromised is to

During inspection, take note of any oil dripping from the condenser coils. If oil is present a leak has occurred. Turn the condenser off and inspect the coils visually or using soap bubble method (Piping > Leak Detection > Soap Bubble Method). Once the leak has been identified and/or pinpointed, service immediately.

Fan blades

Look also for wear and structural damage on the fans and the hub where the fan blades connect to the center. Listen to the fans as well and, if any fan is particularly noisy it is not operating correctly and risks breaking. As a part of the monthly inspection, locate the switch to deactivate the condenser fans (Figure Nine) and flip it to inspect the fans. **Do not leave the condenser off for more than a couple minutes.** The inspection should be brief, and its goal is to identify fatigue cracks like the one in Figure Ten. If there is significant dust buildup on the fans they should be cleaned as well. This should be done in stages, so the condenser does not stay off for longer than a minute. Excess dust will cause higher load on the fan.

Figure Nine: Condensor Kill Switch

Figure Ten: Condenser Fan Blade Crack

If a fan blade breaks while spinning, the consequences may be severe. The blade may fall into the coils and damage the condenser potentially even causing a significant leak. Coil breakage in this manner can result in charge loss and even compressor failure. Observing a fatigue crack or other signs of strain on the fan and replacing it before the failure occurs could save refrigerant and product by preventing a catastrophic failure. Figure Eleven is an example of a fan blade failure, and in this case the failure spun the motor, broke the mounting, and damaged the condenser fins. This fan had fatigue cracks on 2 of the remaining three fins, meaning there was multiple signs that would have alerted a store owner that this fan was going to fail beforehand.

Figure Eleven: Failed Condenser Fan

Winter

During winter, the lower ambient temperature results in a larger temperature difference to drive condensation. This means that condenser fans do not need to work nearly as hard as they do in the summer and measures can be taken to ensure that the fans are not operating

excessively and wasting electricity. Split condenser models will typically run to parallel compressor systems. During cooler times, these models will only run one side of the condenser. Ensure that servicing occurs to pump down the other half before winter to take advantage of this feature and prevent refrigerant freezing and blocking the return. This is typically achieved with a pump down solenoid and orifice already build into the system.

Condensing Unit

Rather than a separate compressor rack and rooftop condenser, some grocery stores employ a condensing unit which contains the whole system except for the evaporator. The condenser contained within the condensing unit will have vertical coils and fans instead of horizontal ones. This means air flows horizontally across the unit instead of upwards from the bottom. The condensing unit needs more clearance on the sides and, there should be no significant obstructions within four feet of the unit and at least five feet between units.

As with regular condensers, examine the fan blades, intake, and coils (if accessible) for dirt and dust buildup which reduce airflow. The condenser intake is likely on the side instead of the bottom. Inspect accessible piping and components for leaks.

Piping

Insulation

The condensate drain line and all suction lines should be completely insulated and insulation on the roof should be UV protected to prevent it from breaking down. Insulation that appears at all sun damaged is likely providing no insulation effects, once insulation starts to break down it is already too late. Check that there are no gaps in insulation and inspect critical areas where gaps are likely to occur, like the following:

- P-Traps (small dips before a riser to trap oil)
- Places where pipe penetrates walls, ceilings or walk in walls. The insulation should be continuous through the wall. (Not doing so compromises not just pipe insulation but insulation of the walk-in unit the pipe penetrates)
- Pipe hangers and other supports or clamps

Any gaps in insulation should be serviced or fixed with appropriate insulating cover and/or contact cement.

Insulation gaps allow heat into the suction line and warm the refrigerant, which reduces the efficiency of the system. Figure Twelve shows a gap in insulation compared to an infrared image of the gap. The surface of the pipe is low temperature and this difference drives heat transfer into the refrigerant.

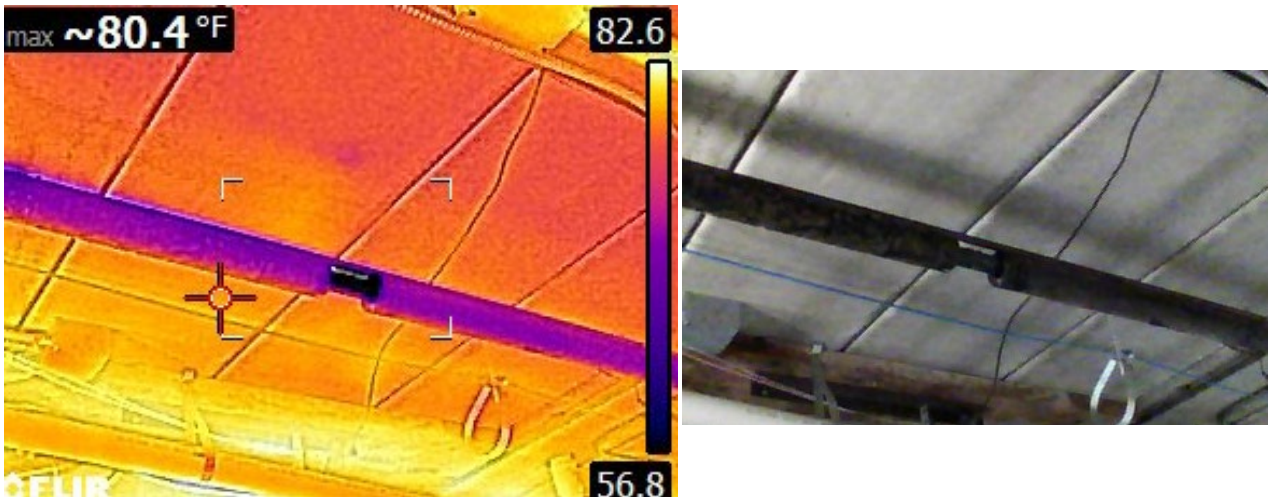

Figure Twelve: Insulation Gap Infrared image

Sight Glasses with Moisture Indicators

While the liquid receiver may have sight glasses to check the level of refrigerant in the tank, there are likely sight glasses along the line that measure moisture content in the refrigerant. Locate any sight glasses on the system and check them during store walk through. One is shown in Figure Thirteen. There should be a color indicator that chemically reacts to the moisture level and can be compared to the ring around the glass to determine the moisture level. If the color corresponds to “Caution” contact your service provider and determine the issue.

Figure Thirteen: Sight Glass with Moisture Indicator

This type of sight glass can also be used to estimate refrigerant charge level. A large quantity of bubbles flowing through the window is an indication that the refrigerant level is low. A condensing unit will likely have a sight glass of this type located after the filter drier.

Leak Prevention

Wear

When inspecting the piping system in accordance with the checklist in Appendix I, ensure that there is never anything hanging from or set on top of a pipe. Nothing should contact piping except for insulation and piping support. Ensure all employees know this.

Vibrational Strain

Due to compressor mechanics, pipes attached to the compressor will undergo vibration. If this is not properly accounted for in the pipe routing and mounting, then the pipes will undergo fatigue loading which will develop a fatigue crack and cause a leak if ignored. Ideally, the piping may have a section of braided line to dampen the vibrations; otherwise, attention must be paid to mountings near the compressor. Figure Fourteen shows an example of overly rigid mounting that would strain the pipe and compares it to a correct mounting of the same situation.

Pipes not exposed to vibrational strain may still be supported incorrectly. During a store walkthrough check for any sections of overhead or otherwise suspended pipe that sag between supports, paying special attention to corners.

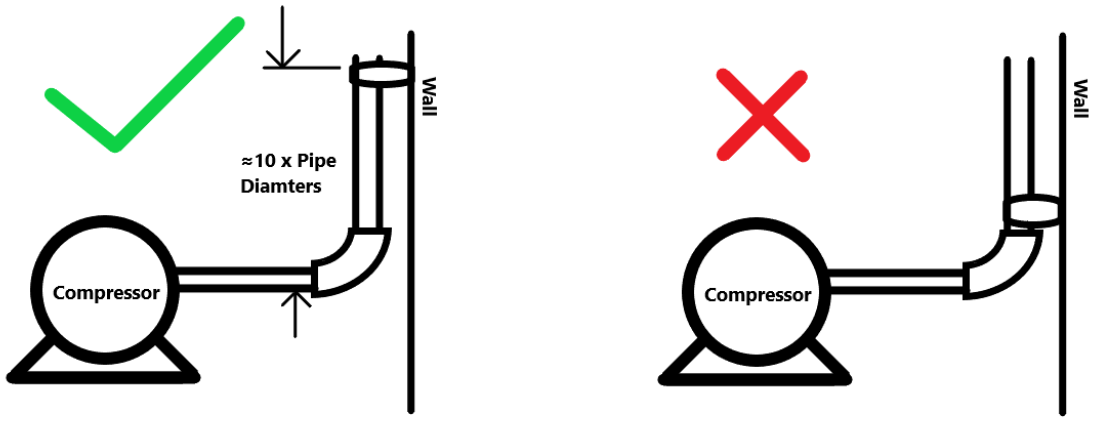

Figure Fourteen: Proper Pipe Mounting to Account for Compressor Vibration.

Correctly accounting for this should happen during the installation phase. If, upon inspection, the pipes have been installed incorrectly, service to fix the issue must occur.

Similarly, metal pipes should not touch each other, or other obstructions or surfaces because small vibrations will cause rubbing stress, and this will develop into leaks.

Corrosion

Corrosion of copper piping, if unattended, will result in pinhole leaks and loss of refrigerant. Sources of corrosion to prevent are:

- Dripping condensation onto rack components or piping
- Improper cleaning materials, check that cleaning products are safe for use on metal.
- Contact with food acids, such as vinegar.

Leak Detection

Identifying leaks as soon as possible is important and every day that a leak persists wastes valuable refrigerant which will pollute the atmosphere, reduce the efficiency of the system, and possibly not allow the system to meet desired temperature. Storeowners should be aware of the global warming potential (GWP) value of the refrigerant in use. Most common refrigerants contribute to global climate change at several thousand times the potency of carbon dioxide. A similar metric exists to measure ozone depletion of refrigerants (ODP). Table Two shows common refrigerants and their GWP, ODP, and price per pound.

Refrigerant	HFC-134a	HCFC-22	R-404A	R-507A	R-448A	R-449A	R-407A	R-410A	CO2
GWP	1,430	1,810	3,922	3,985	1,273	1,397	2,107	2,088	1
ODP	0	0.055	0	0	0	0	0	0	0
Cost Per Pound*	$6.17	$13.33	$9.29	$8.18	$13.96	$15.80	$8.06	$8.43	$4.90

Table Two: GWP of Common Refrigerants

*Refrigerants are a commodity with variable pricing and cost per pound is subject to change based on the market. These estimates are based on July 2021.

The financial toll of ignoring a leak is significantly higher than the cost of the raw refrigerant required to refill the system. A service call to refill a system with refrigerant ranges from $400-$700. If a leak is ignored, eventually the refrigerant will deplete, and recharge service will be required. Ignoring a leak will drastically increase the frequency of these service calls and cause financial loss much larger than the cost of repairing the leak.

Charge Monitoring

The easiest way to determine if a system is leaking is by keeping a record of every refrigerant recharge. Ensure that the date and weight of refrigerant added is archived. Appendix II is an empty table with headings to guide recording. This sheet should be printed along with Appendix I and kept safely. From this record it should be easy to determine the rate at which refrigerant is leaking. Included in this record should be the total charge of the system. This information allows you to calculate the leakage as a percent of total charge.

Receiver Level

Excess liquid refrigerant is stored in the liquid receiver, located in the compressor room. This tank should have sight glasses and/or liquid level indicator/gage. mounted to observe the amount of refrigerant in the reservoir. It is recommended to record this amount monthly. Keep a log and watch for dips, which may indicate a leak.

Condensing units will likely have no sight glasses mounted on the receiver and instead will have an inline sight glass (see Piping > Sight Glasses with Moisture Indicator). The receiver level can be estimated from such a sight glass visually. If there are heavy bubbles flowing through the glass the refrigerant level to low.

Leak Servicing Policy

It is recommended to observe a **zero-tolerance policy** on leaks. Any leak that is detected should be serviced as soon as possible. Even if the drop in system charge is not deemed high, any leak that is detected is causing significant financial and environmental damage and must be fixed. Below are several methods for detecting leaks.

If the leak is significant enough to cause an alarm, emergency service is warranted. Otherwise, standard service should be arranged as soon as possible.

Oil Seepage

The most obvious sign of a leak is oil seeping from the leak site as oil runs through the liquid line and will not vaporize once leaked. Follow the piping circuits throughout the store looking for oil monthly. Critical points to be especially aware of are:

- Compressor Inlets and Outlets
- Bolted connections
- Bends
- Valves
- Sight Glasses
- High Contact Areas
- Any other component inlets and outlets

Leak Detector

The most effective way to catch leaks is to invest in a leak detector. These handheld devices detect traces of refrigerant in the air. Regular maintenance checkups should include a walkthrough of the store with a leak detector. Ensure your maintenance person has this equipment and checks every room with refrigerant piping.

When searching for a leak in an enclosed room, it may be advantageous to turn off ventilation to the room. This technique is especially prudent in the compressor room where there are many critical potential leak sites.

Soap Bubble Method

Pinpointing the location of a detected leak can be accomplished by applying soapy water. Mix soap and water and spray or drizzle at a suspected leak site. Soap bubbles will form at the leak site and the size/speed of the bubbles will give an idea of the severity of the leak. If oil is found in an area but the leak cannot be found this is a good option. Once the leak has been pinpointed, it should be tagged and serviced.

Relief Valve

Your refrigeration system likely has intermittent valves to discharge and release pressure in an emergency. A relief valve will have a pin, tag and/or balloon mechanism to discharge them. These components make them easy to identify (See Figure Fifteen). Locate all such valves and inspect them monthly. If any have discharged, service immediately as leaking from this location is likely seeping refrigerant.

Figure Fifteen: Example of a Relief Valve

Appendix I: Checklist

This checklist serves as a condensed list of tasks that a grocery store operator performs or delegate on a consistent monthly basis to ensure their refrigeration system will perform efficiently and environmentally consciously. For questions about individual items refer to the original best practices document where many of these tasks are outlined in more detail.

Weekly Items

1.____ **Examine Case Loading:** Check every open-air refrigeration unit. Feel for the proper air flow across the front of all doorless cases and look for the load-line on marked cases. Restock any overloaded cases to an appropriate level. This inspection should be done weekly rather than monthly as restocking happens constantly. (Page 9)

Monthly Items

2.___ **Condenser (or unit) Airflow:** Check the roof condenser or condensing unit for leaves collecting underneath the unit or blockages on or above condenser. Examine the underside and fans of the condenser for dust accumulation. Wipe off dust accumulation with a rag. Look also for oil seepage. (Page 11)

3.___ **Condenser (or unit) Fan Blades:** Switch the condenser off so the fans stop and can be seen. Look for developing cracks or other wear and listen for loud fans. Replace cracked fans asap. Inspection should be brief; do not leave the condenser switched off for longer than a minute. (Page 13)

4.____ **Receiver Tank Level:** Using sight-glass (tank mounted or in-line) or electronic monitoring check the level or refrigerant in the receiver tank and record in an ongoing log. Conduct an extensive leak check in response to a significant drop. (Page 18)

5.___ **Inspect Case Door Gaskets:** Inspect the rubber lining on the edge of every case door and check for wear. Check doors for condensation or frost. Service any torn or degraded gaskets. (Page 10)

6.____ **Check for Discharged Relief Valves:** Check each relief valve for discharge. Ensure you know the location of all valves and service immediately if any have discharged. (Page 19)

7.____ **Follow Refrigerant Piping Through Store:** Follow every pipe circuit. Look for oil leaking from or nearby the pipe (this is the most important thing to catch), gaps in insulation or improper mounting that stresses the piping. Check any moisture indicating sight glasses. Ensure any piping on the roof with insulation has UV protection. (Page 14)

8.___ **Inspect Walk-Ins:** Ensure no product is blocking the evaporators intake or exhaust, nothing should be stacked near the evaporator. Check the top of the strip curtain for ice and the gaskets for wear. When closing the door make sure the latch engages firmly. (Page 6)

9.___ **Check Maintenance Schedule:** Regular maintenance should occur at least semiannually. Ensure that you are up to date on service checkups and schedule upcoming checks as needed. (Page 5)

10.___ **Inspect Evaporator:** Look at all accessible coils and compressor return line checking for frost and ice buildup. Also check drain pan for blockages, ensure condensate can drain away. Clean any dirty/dusty parts of the unit including fan blades, intake, and drain pan. (Page 8)

Appendix II: Refrigerant Charge Logging Sheet

Date of service	Company	Pounds of Refrigerant Added	Time Since Last Refill	Leak Rate (Pounds of Refrigerant Added/Time Since Last Refill)	Notes (Refrigerant type or circuit number)

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