Appendix B - Site and equipment

Contents

Introduction

Technical Safety BC investigated an incident that occurred on May 26, 2022, involving refrigeration equipment at an ice making facility in Kamloops. The site consisted of two ammonia refrigeration systems:

- P34 System: a single Vogt Ice P34 ice making machine (labeled as #4 by the owner)
- P24 System: two Vogt Ice P24 ice making machines (labeled as #2 and #3 by the owner)

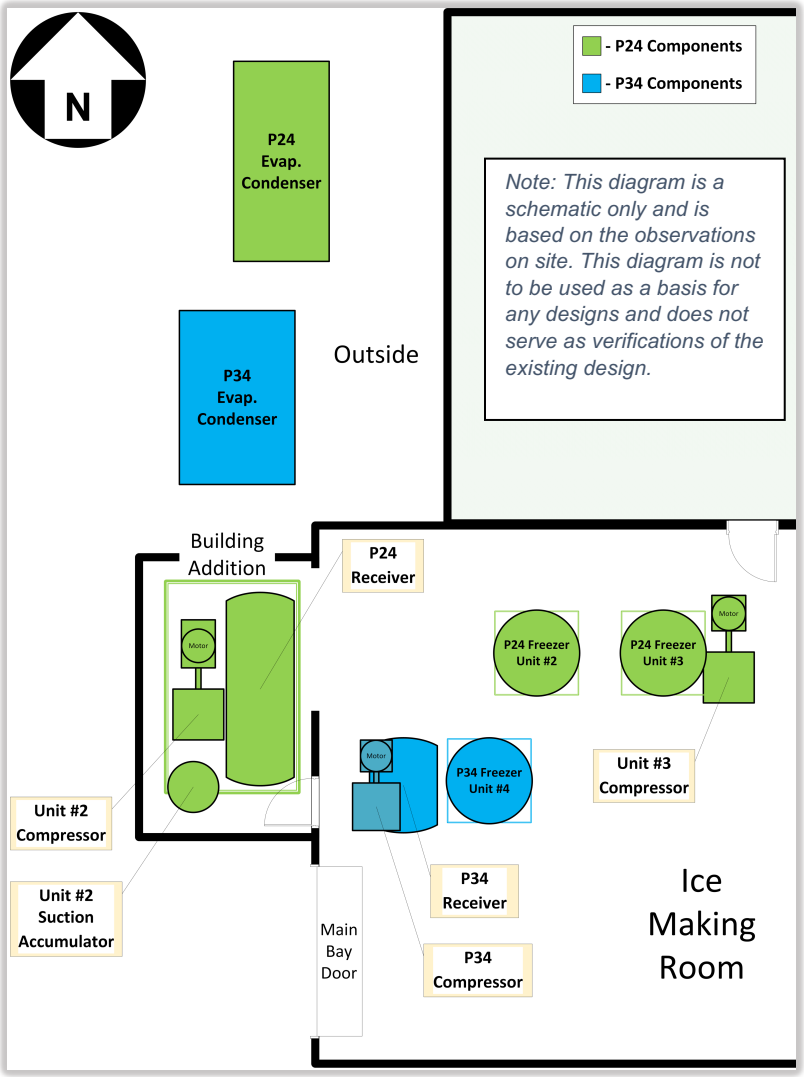
The two ammonia systems were in in the process of being disassembled when ammonia was released from the P34 system's high-pressure receiver. When the Technical Safety BC investigation team arrived on site, many of the systems' pipes were cut and pieces of the system had already been moved outside. Below describes the ammonia refrigeration systems as they were installed and how they were found on site after the incident.

System overview:

The P34 and P24 systems were both single stage refrigeration systems.

The systems were installed at the ice making facility, as shown in Figure 1.

- The main freezers (evaporators) were in the ice making room.
- Several components of System B were in a small building addition adjacent to the main ice making room.
- The evaporative condensers for both systems were located outside.



Ice making process

The two ammonia refrigeration systems were used to produce cube ice. Both systems consisted of the following five primary components:

1. High-pressure receiver
2. Hand expansion valve
3. Freezer/ ice maker
4. Reciprocating compressor
5. Evaporative condenser

These components were piped together in a loop (**Error! Reference source not found.**) to serve as the primary components for the refrigeration cycle. During typical operation, ammonia cycles through these components and acts as a refrigerant to generate ice inside of the freezers, which is then chopped into cubes of ice. This ice making process happens in two stages:

1. Refrigeration cycle
2. Harvest cycle

Refrigeration cycle

During the refrigeration cycle ammonia cycles through the refrigeration system (**Error! Reference source not found.**) and acts as a refrigerant to generate ice in the freezers.

Inside the P34 refrigeration system, ammonia begins in the receiver as a high-temperature, high-pressure liquid. Pressure differences in the system are created by the compressor and allow for ammonia to travel though the system. As ammonia travels through the hand expansion valve, from the receiver to the freezer, the pressure of the ammonia is reduced—resulting in a proportional decrease in temperature. The ammonia enters

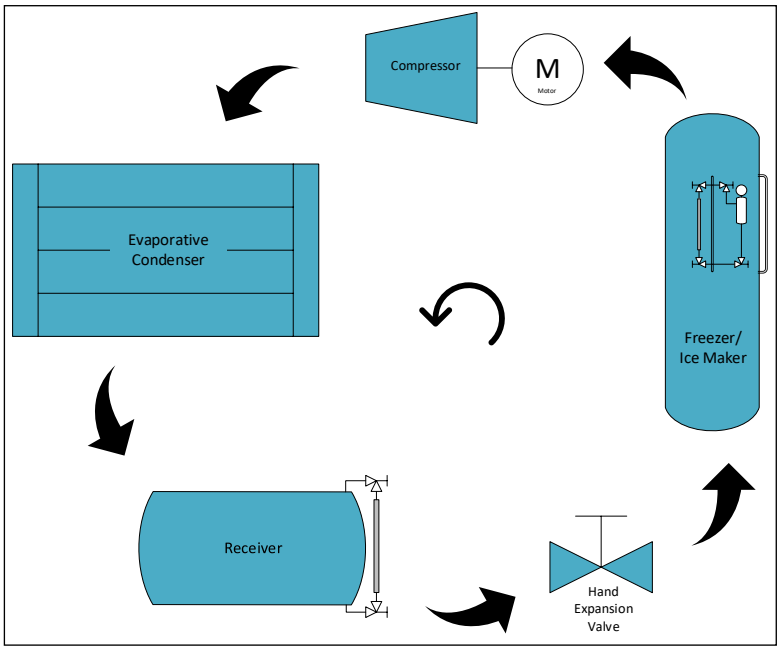


Figure 2: Basic flow diagram of P34 refrigeration cycle

Note: The flow diagrams in this appendix are schematics only and are based on the observations on site. These flow diagrams are not to be used as a basis for any designs and does not serve as verifications of the existing design.

the freezer as a low temperature low pressure liquid.

Inside the freezer heat is transferred from water to the ammonia, resulting in the water freezing and the ammonia evaporating to become a vapor. The ammonia vapor is then pulled into the compressor. Inside the compressor the ammonia is pressurized, resulting in a high-pressure high-temperature ammonia vapor. This ammonia vapor cycles through an internal heating loop within the receiver and then enters the condenser.

Inside the condenser, heat is removed from the ammonia and exhausted outside. During this process, the pressure is held constant, thus as the ammonia is cooled, it changes state from a gas to a liquid. The ammonia leaves the condenser as a high-pressure liquid and cycles back to the receiver where it will begin the refrigeration cycle again.

The P24 System functioned like the P34 System however, the P24 System was configured to have two independent freezers (unit #2 and #3). Each freezer had its own expansion valve and compressor but shared a common condenser and receiver (Figure 3).

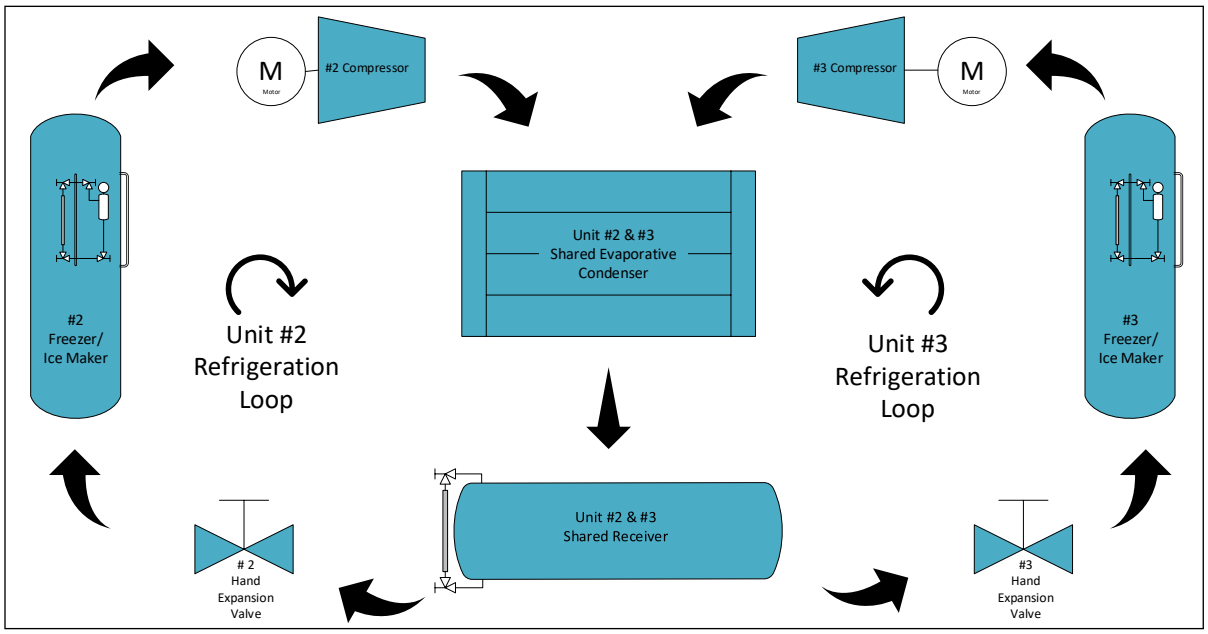


Figure 3: Basic flow diagram of P24 refrigeration cycle

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Harvest cycle

Once the ice has sufficiently formed inside the freezer a pressure switch will stop the refrigeration cycle by closing a valve between the freezer and the hand expansion valve. Ammonia vapor is pumped from the top of the receiver into the freezer via a separate gas line (thaw gas line) causing the ice to start to melt. As the ice begins to melt it slides out of the freezer to be chopped into cubes. After all the ice is removed from the freezer, the thaw gas line is closed, and the ammonia refrigeration cycle begins again to create more ice.

P34 refrigeration system

The P34 is an ice making machine originally manufactured as a packaged unit. This means that all the components of the system were assembled on a skid at the manufacturer's facility before shipping, with minimal installation required at site.

The P34 system was acquired second hand and was installed at the site in Kamloops. When the P34 was installed, the water-cooled condenser originally provided by the manufacturer was not included and an evaporative condenser was used in its place. This evaporative condenser was installed outside and connected to the system with piping.

The rest of the P34 was assembled on two separate skids. One skid containing the high-pressure receiver, compressor, and associated equipment. The other skid containing the freezer, hand expansion valve, and associated equipment. (Figure 4). Both skids were installed side by side in the NW corner of the ice making room near the main bay door.

See Appendix for P&ID of the entire P34 system and table of valves.

Figure 4: P34 Skids Pre-Incident; high-pressure receiver and compressor on left; freezer and hand expansion valve on right

P34 post incident

Upon arrival at the scene post-incident, the P34 ammonia refrigeration system was partially disassembled, several pipes were cut, components of the system had been moved, and some components had already been transported off site.

Figure 5 shows the location of the P34 ammonia refrigeration equipment as found on site after the incident. The P34 was split into three parts:

1. Receiver – inside
2. Freezer – outside
3. Evaporative condenser – removed from site

A refrigeration mechanic was brought in to verify valve positions and purge any remaining ammonia from the system. The following outlines the state of the systems by describing the locations of cut pipes and the state of the valves (open/closed).

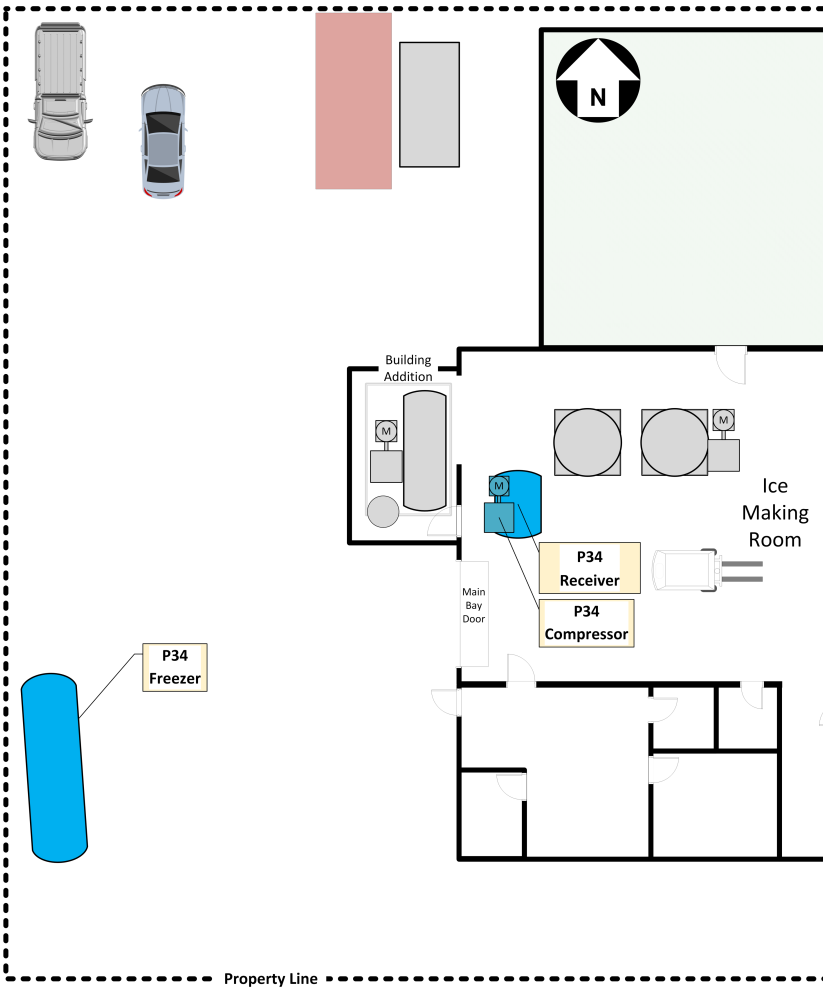

Figure 5: P34 System As-Found Post Incident

Note: This diagram is a schematic only and is based on the observations on site. Theis diagram not to be used as a basis for any designs and does not serve as verifications of the existing design.

P34 receiver

The portion of the P34 system containing the high-pressure receiver was in the state shown in Figure 6 below.

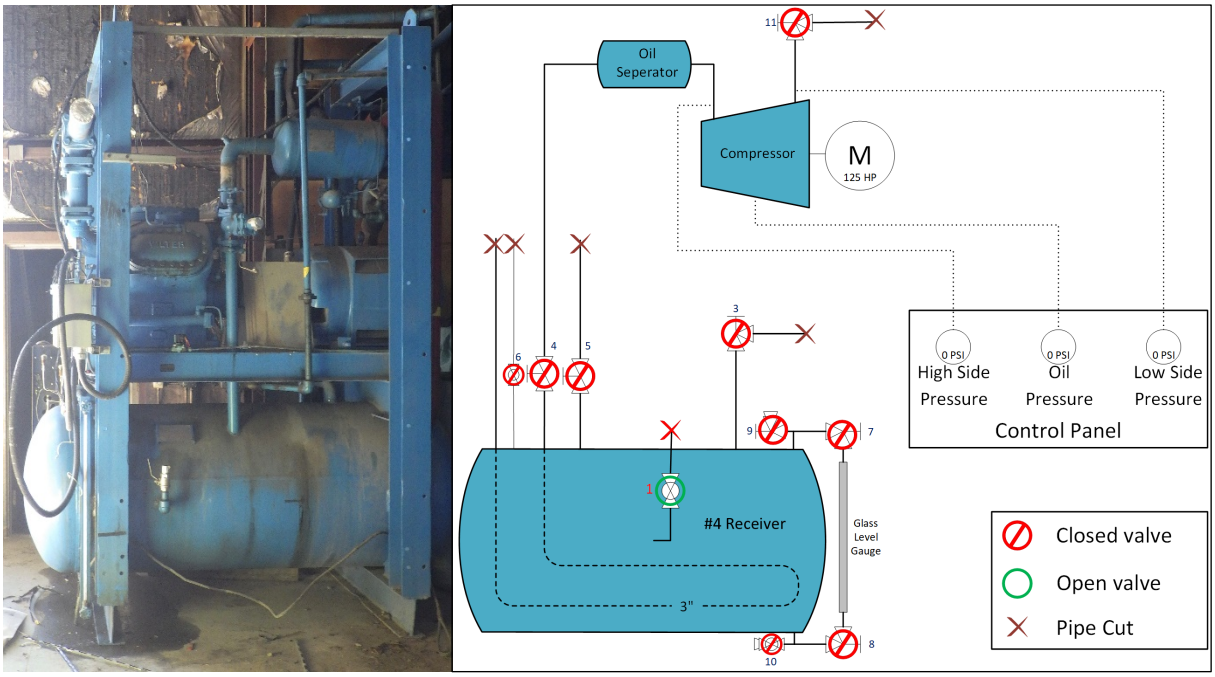

Figure 6: P34 Receiver as Found (Left) and Piping Configuration (Right) Post Incident (See Table 1: P34 Valve Index in Appendix B.1: Process flow diagrams and valve index for valve information)

Note: The flow diagrams in this appendix are schematics only and are based on the observations on site. These flow diagrams are not to be used as a basis for any designs and does not serve as verifications of the existing design.

The P34 receiver had a quarter turn ball valve on the liquid feed line (valve #1,Figure 6). This ball valve was found in the open position with the handle aligned parallel with the pipe as depicted in Figure 6. More detailed valve information is provided in Table 1 and Table 2 of Appendix B.1.

There was a glass level gauge on the side of the receiver with isolation valves on the top and bottom of the gauge. Both isolation valves were closed, and the level gauge was empty.

There was a control panel on the back side of the receiver that had three pressure gauges on it. These three gauges all read 0 PSI and were connected to the compressor inlet, the compressor oil pan, and the compressor outlet (Figure 6). None of the gauges were directly connected to the receiver to read the pressure within the vessel.

The high-pressure receiver had an internal cooling loop (3” Diameter Piping) as depicted by the dashed line in Figure 6. This 3” piping starts at the compressors oil separator, passes through the inside of the high-pressure-receiver, then exits again to feed the evaporative condenser. The 3” piping exiting the receiver had been cut leaving the internal cooling loop open to atmosphere. At first glance this gave the impression that the receiver was open to atmosphere, but as the piping was part of an internal loop it would be isolated from the contents of the receiver.

It was also noted that there was no pressure relief valve attached to the P34 Receiver or its ancillary piping.

P34 freezer

Every valve on the freezer skid was found to be closed and many pipes were cut as depicted in Figure 7. The freezer had a control panel with 2 pressure gauges. These gauges both read 0 PSI.

The two pressure gauges on a control panel were installed to measured pressure at the suction accumulator and at a strainer along the system thaw gas line. Neither of the gauges were installed provide information regarding the pressure within the P34 high-pressure receiver.

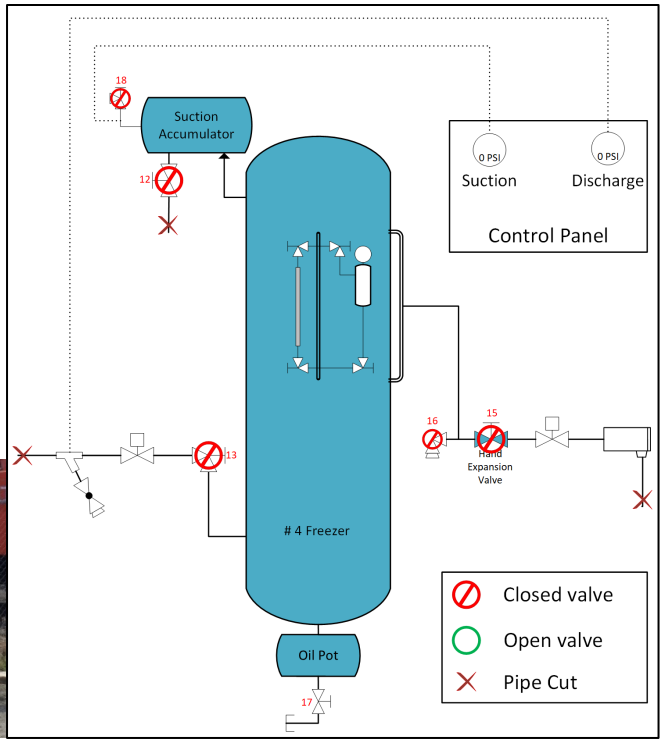

Figure 7: P34 Freezer as Found (Left) and Piping Configuration (Right) Post Incident

Note: The flow diagrams in this appendix are schematics only and are based on the observations on site. These flow diagrams are not to be used as a basis for any designs and does not serve as verifications of the existing design.

P34 Evaporative Condenser

The evaporative condenser was no longer on site, and according to witness statements had been removed in 2018.

P24 system

The P24 system is comprised of two P24 ice making machines (freezers) originally manufactured as individually packaged units. The two P24 freezers, unit #2 and #3, were acquired second hand and were installed at site in Kamloops in a combined loop as shown previously Figure 3. The two freezers shared a common high-pressure receiver and evaporative condenser.

The P24 refrigeration system had components installed in three separate locations on site that were all piped together to form a complete system (Figure 1).

1. The main ice making room contained the freezers
2. The building addition contained the high-pressure receiver
3. The evaporative condenser was outside

P24 freezers - unit #2 skid and unit #3 skid

Unit #2 and unit #3 are both ice making machines that were originally manufactured as package units and preassembled on steel superstructures or skids (Figure 8). The skids were acquired second hand and contained the following components when they were installed on site:

1. The unit #2 skid contained a freezer, hand expansion valve, and several secondary components.
2. The unit #3 skid contained a freezer, hand expansion valve, compressor, several secondary components, and a disconnected condenser/receiver.

Each freezer had a control panel with two pressure gauges labeled “Suction” and “Discharge”. For each freezer the pressure gauge labeled as “Suction” was connected to the unit’s suction accumulator and the gauge labeled “Discharge” was connected to a strainer on the thaw gas line. The gauge connection points are represented by the dotted lines in Figure 8.

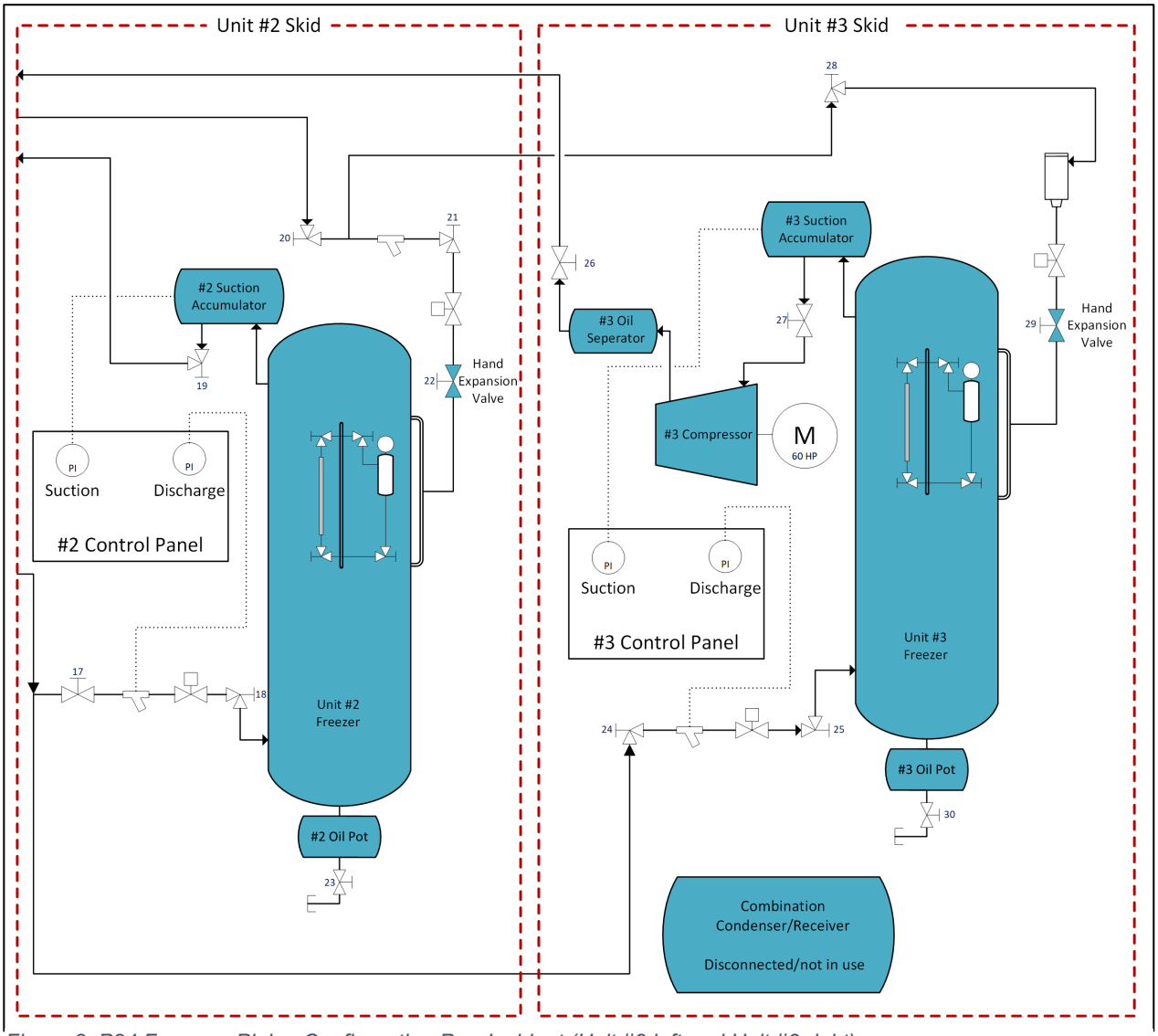

Figure 8: P24 Freezers Piping Configuration Pre- Incident (Unit #2 left and Unit #3 right)

Note: The flow diagrams in this appendix are schematics only and are based on the observations on site. These flow diagrams are not to be used as a basis for any designs and does not serve as verifications of the existing design.

P24 components in the building addition

There was a building addition at the NW corner of the main ice making room. This room housed several of the components of the P24 system, including a high-pressure receiver, the unit #2 compressor, and the unit #2 suction accumulator (Figure 9).

The P24 receiver had an internal cooling loop and glass level gauge like the P34 receiver. The level gauge has isolation valves above and below it so it could be isolated from the receiver.

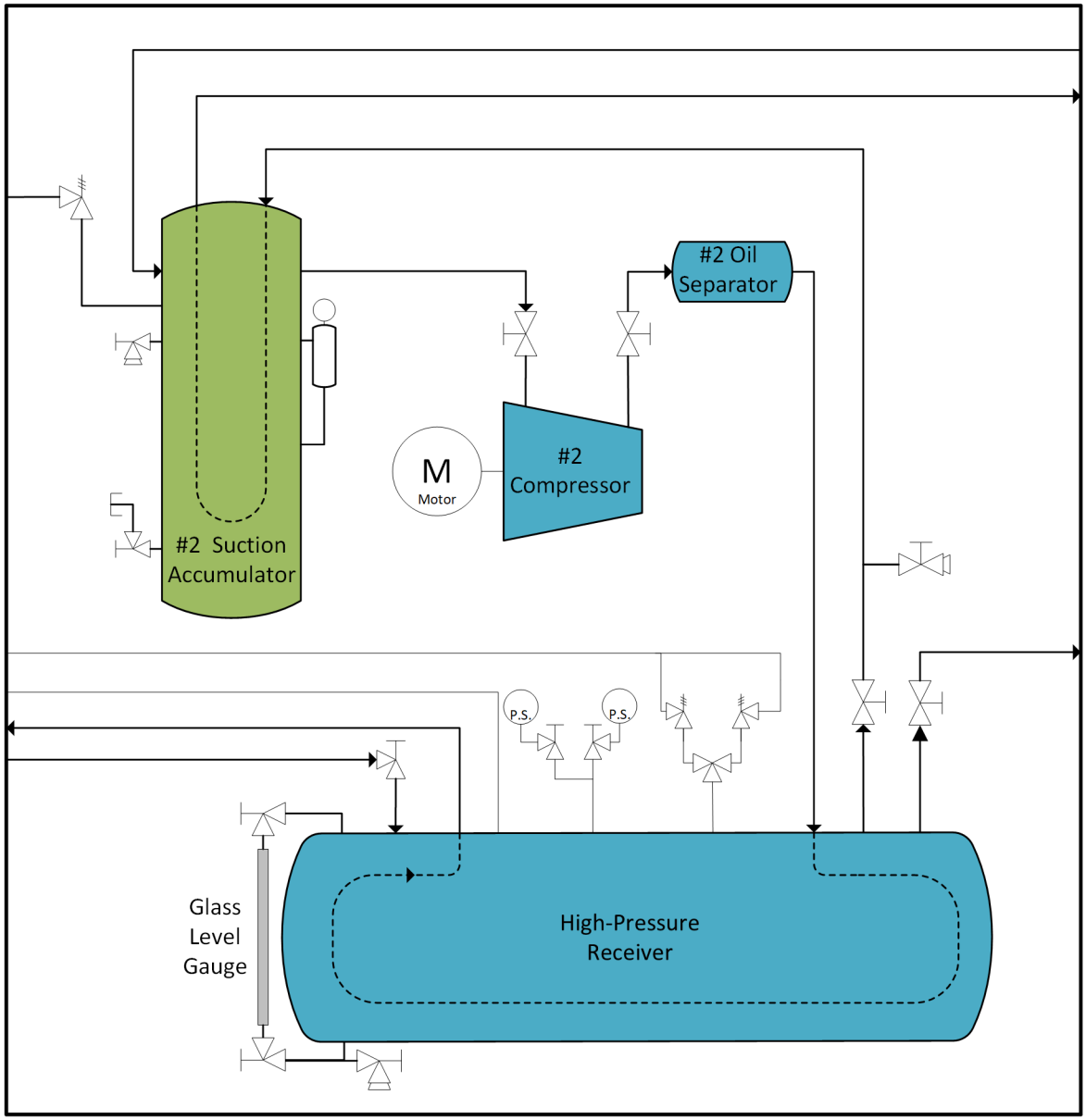

Figure 9: P24 Building Addition Piping Configuration Pre- Incident

Note: The flow diagrams in this appendix are schematics only and are based on the observations on site. These flow diagrams are not to be used as a basis for any designs and does not serve as verifications of the existing design.

P24 evaporative condenser

The P24 evaporative condenser was outside the building just north of the lean-to building. The piping configuration that connected the condenser to the rest of the system is unknown as the pipes had been previously removed from the system.

P24 post incident

Upon arrival at the scene post-incident, the P24 ammonia refrigeration system was partially disassembled. Several pipes were cut, and segments of piping had been removed. Figure 10 shows the location of the P24 ammonia refrigeration equipment as it was found on site after the incident.

The P24 had been cut into three main parts:

1. Unit #2 and #3 freezers
2. Components in the building addition
3. Evaporative condenser outside

A refrigeration mechanic was brought in to verify valve positions and purge any remaining ammonia from the system. The following outlines the state of the systems by describing the locations of cut pipes and the position of the valves (open/closed).

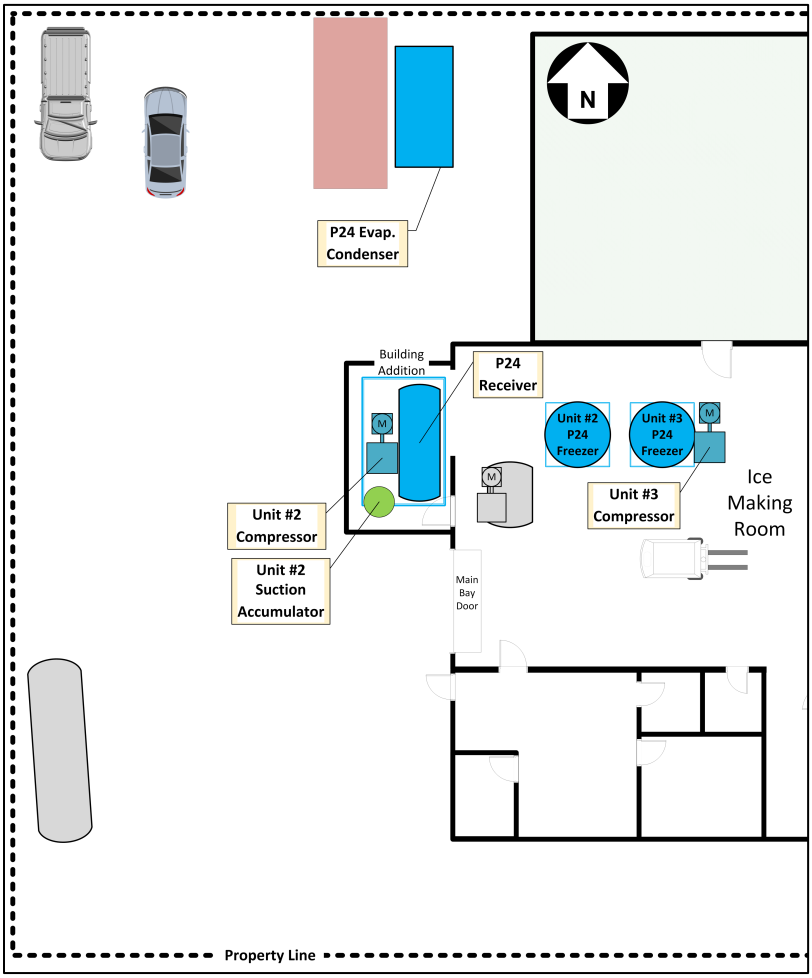

Figure 10: P24 System Components As-Found Post Incident

P24 freezers - unit #2 and #3

Both freezers (unit #2 and unit #3) were in the NW corner of the ice making room, with several

of the pipes cut and/or removed. Figure 11 depicts which pipes had been cut and whether the connected valves were found in the open or closed position.

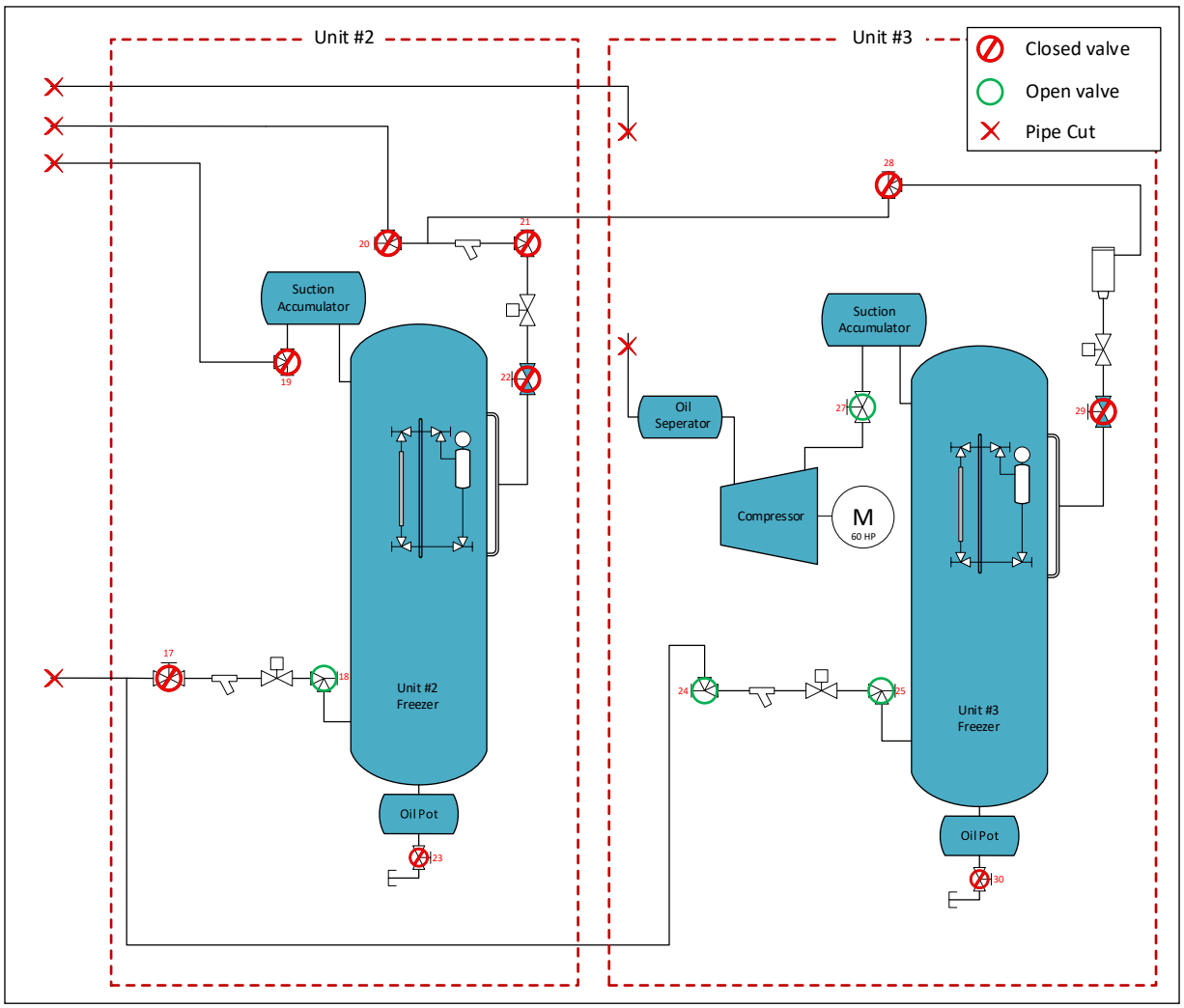

Figure 11: P24 Freezers Piping Configuration As-Found Post Incident (Unit #2 left and Unit #3 right)

Note: The flow diagrams in this appendix are schematics only and are based on the observations on site. These flow diagrams are not to be used as a basis for any designs and does not serve as verifications of the existing design.

P24 system components in the building addition

The unit #2 compressor package, unit #2 suction accumulator, and the system's high-pressure receiver were in the lean-to adjacent to the NW corner of the ice making room. There were several pipes that had been cut and/or removed. Figure 12 depicts which pipes had been cut and whether the connected valves were found in the open or closed position.

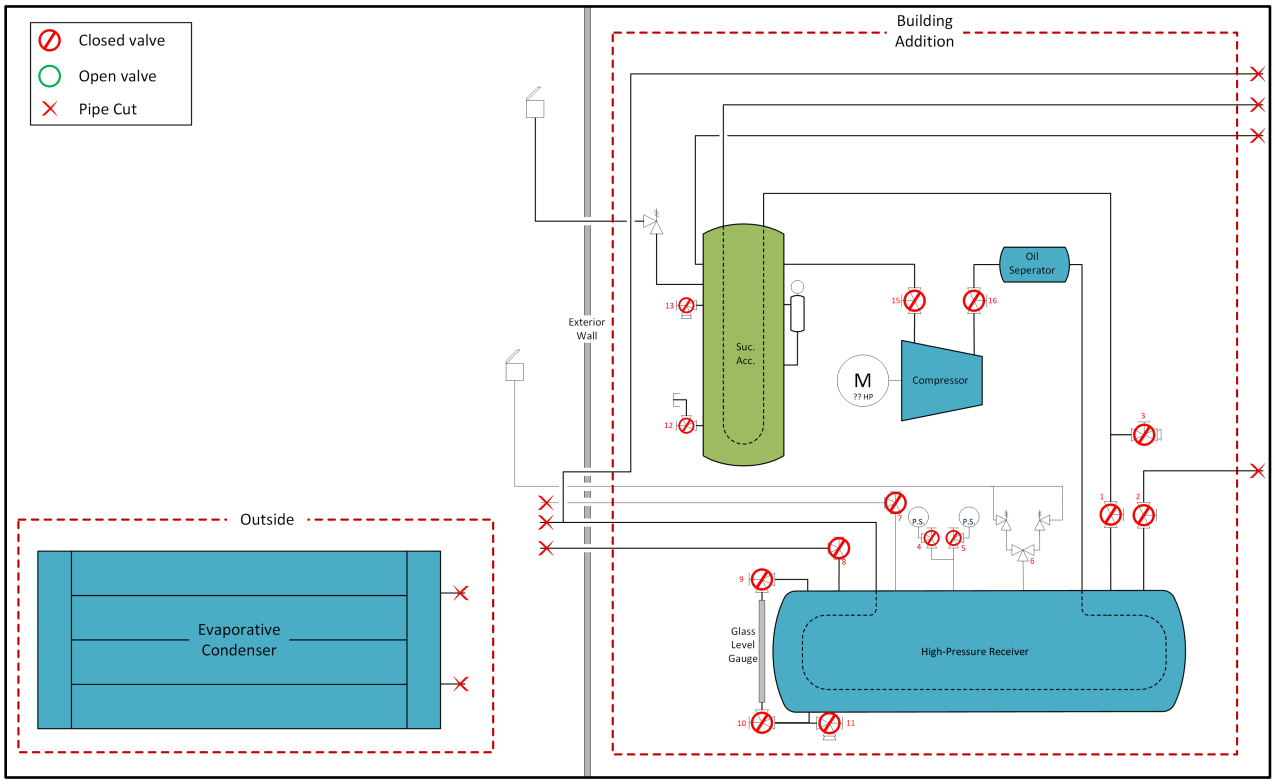

Figure 12: P24 Building Addition As-Found Piping Configuration and Outdoor Evaporative Condenser

Note: The flow diagrams in this appendix are schematics only and are based on the observations on site. These flow diagrams are not to be used as a basis for any designs and does not serve as verifications of the existing design.

There was a garden hose attached to the outlet of valve #3 on the P24 high-pressure receiver. This garden hose was piped outside and into a black garbage bin at the NW end of the building addition (Figure 13). There was another hose in the garbage bin that was connected to the building water supply.

Figure 13: Hose connected to the P24 high-pressure receiver (left) and piped into a garbage bin outside (right)

P24 evaporative condenser

The evaporative condenser had been disconnected from the system. All pipes that had connected the evaporative condenser to the components inside had been cut at the building wall and removed from site.

TECHNICAL SAFETY BC

Nov. 14/2022

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PERMIT TO PRACTICE
TECHNICAL SAFETY BC

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Appendix B.1: Process flow diagrams and valve index

The process flow diagrams were put together with information gathered at the site, through interviews, and from the manufacturer. Many of the components that had been cut and/or removed have been replicated as best as possible with the information obtained. The piping from the lean-to building to the outdoor evaporative condensers for both the P24 and P34 systems had been removed therefore, any valves that may have been on those lines are unknown and not shown. The flow diagrams in this appendix are schematics only and are based on the observations on site. These flow diagrams are not to be used as a basis for any designs and do not serve as verifications of the existing design.

Table 1: P34 Valve Index

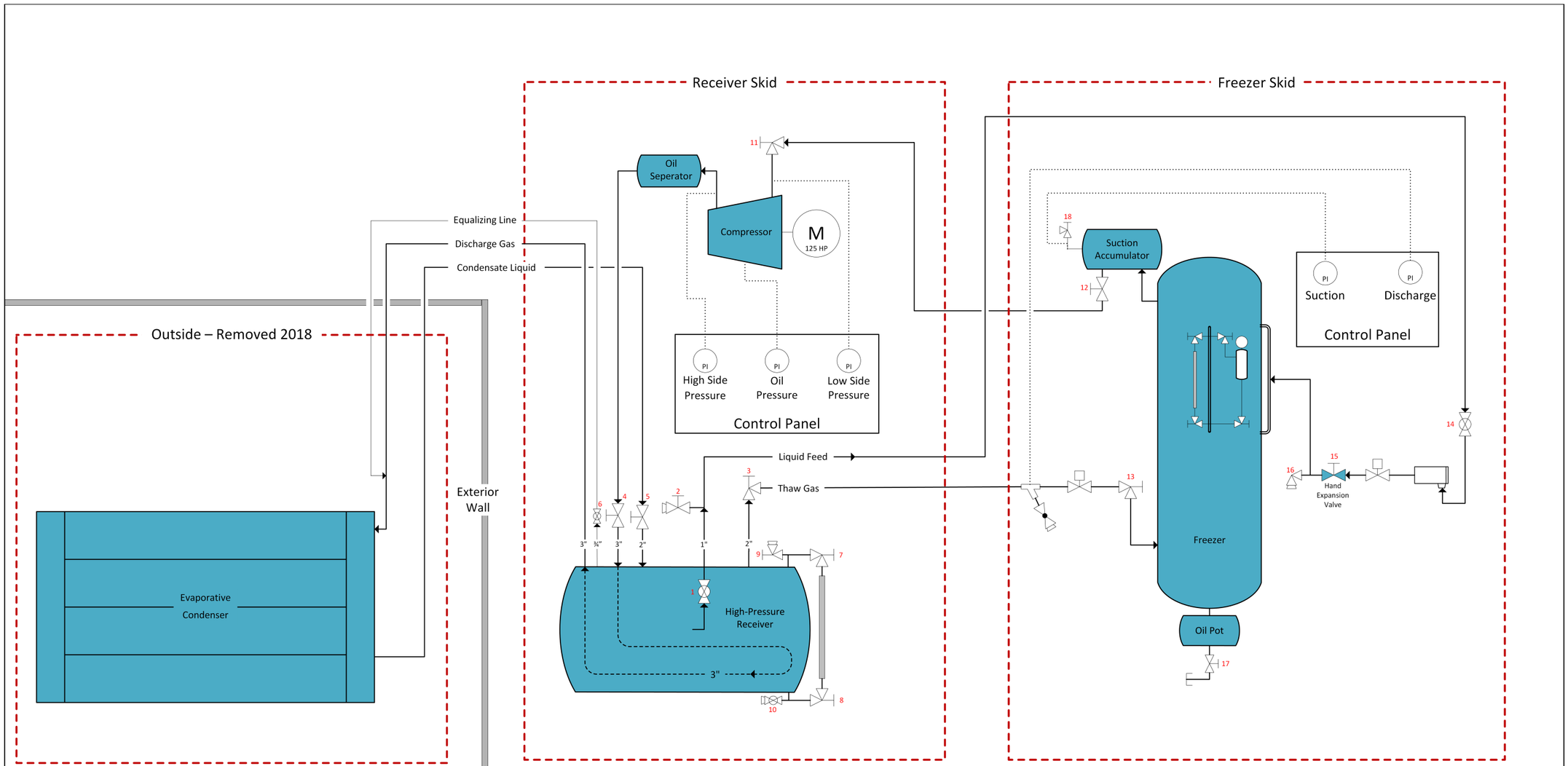
Valve Number	Description	Valve Type	As-Found Position
1	HPR Liquid Outlet Valve	1" Ball Valve	Open
2	HPR Liquid Charging Valve	1" Globe Valve - Hand Wheel	Closed
3	HPR Hot Gas (Thawing gas) outlet Valve	2" Angle Valve - Hand Wheel	Closed
4	HPR Discharge gas inlet (to internal coil)	3" Globe Valve - Hand Wheel	Closed
5	HPR Condensate Liquid inlet Valve	2" Globe Valve - Hand Wheel	Closed
6	HPR Equalizing (gas) line valve	3/4" Ball Valve	Closed
7	HPR Sight Glass Isolation valve	1/2" Globe Valve - Hand Wheel	Closed
8	HPR Sight Glass Isolation valve	1/2" Globe Valve - Hand Wheel	Closed
9	HPR Purge Valve	1/2" Angle Valve - Hand Wheel	Closed
10	HPR Drain Valve	1/2" Ball Valve	Closed
11	Compressor Suction inlet	3" Angle Valve - Hand Wheel	Closed
12	Suction Accumulator Suction gas valve	3" Globe Valve - Hand Wheel	Closed
13	Thawing Gas inlet isolation Valve (HX)	2" Globe Valve - Hand Wheel	Closed
14	Liquid feed isolation valve (HX End)	1" Ball Valve	Closed
15	1" Liquid Hand Expansion Valve	1" Hand Expansion Valve	Closed
16	Liquid Line Service Valve	1" Angle Valve - Hand Wheel	Closed

17	Oil Drain Valve	3/4" Globe Valve - Hand Wheel	Closed
18	Suction Accumulator Service/Drain Valve	1/2" Angle Valve - Hand Wheel	Closed

Table 2: P24 Valve Index

Valve Number	Description	Valve Type	As-Found Position
1	HPR Liquid Outlet Valve	1" Globe Valve - Hand Wheel	Closed
2	HPR Hot Gas (Thawing gas) outlet Valve	2" Angle Valve - Seal Capped	Closed
3	HPR Liquid Charging Valve	1" Globe Valve - Hand Wheel	Closed
4	HPR - Pressure Switch Isolation Valve	3/4" Globe Valve - Hand Wheel	Closed
5	HPR - Pressure Switch Isolation Valve	1/2" Angle Valve - Hand Wheel	Closed
6	HPR Relief Valve	-	-
7	HPR Equalizing (gas) line valve	3/4" Angle Valve - Hand Wheel	Closed
8	HPR Condensate Liquid inlet Valve	2" Angle Valve - Hand Wheel	Closed
9	HPR Sight Glass Isolation valve	1/2" Angle Valve - Hand Wheel	Closed
10	HPR Sight Glass Isolation valve	1/2" Angle Valve - Hand Wheel	Closed
11	HPR Drain Valve	1/2" Globe Valve - Hand Wheel	Closed
12	Suction Accumulator Drain valve	1/2" Angle Valve - Hand Wheel	Closed
13	Suction Accumulator Purge valve	1/2" Globe Valve - Hand Wheel	Closed
14	Suction Accumulator Relief Valve	-	-
15	Compressor Suction inlet	3" Globe Valve - Hand Wheel	Closed
16	Compressor Discharge Outlet	3" Globe Valve - Hand Wheel	Closed
17	Unit # 2 Thawing Gas Isolation Valve	2" Globe Valve - Hand Wheel	Closed
18	Unit # 2 Thawing Gas Isolation Valve	2" Angle Valve - Hand Wheel	Open
19	Unit # 2 Suction Accumulator Suction gas valve	3" Angle Valve - Hand Wheel	Closed
20	Unit # 2 Liquid feed isolation valve (HX End) Strainer isolation Valve	1" Angle Valve - Hand Wheel	Closed
21	Unit # 2 Liquid feed isolation valve (HX End) Strainer isolation Valve	1" Angle Valve - Hand Wheel	Closed
22	Unit # 2 1" Liquid Hand Expansion Valve	1" Hand Expansion Valve	Closed
23	Unit # 2 Oil Drain Valve	3/4" Angle Valve - Hand Wheel	Closed

24	Unit # 3 Thawing Gas Isolation Valve	2" Angle Valve - Hand Wheel	Open
25	Unit # 3 Thawing Gas Isolation Valve	2" Angle Valve - Hand Wheel	Open
26	Unit # 3 Compressor / Oil Separator Discharge Valve	3" Globe Valve - Hand Wheel	Open
27	Unit # 3 Compressor Suction Valve	3" Globe Valve - Hand Wheel	Open
28	Unit # 3 Liquid feed isolation valve (HX End) Strainer isolation Valve	1" Angle Valve - Hand Wheel	Closed
29	Unit # 3 Liquid feed Hand Expansion valve	1" Globe Valve - Hand Wheel	Closed
30	Unit # 3 Oil Drain Valve	1/2" Globe Valve - Hand Wheel	Closed



Notes:
1. This flow diagram is a schematic only and is based on the observations on site. This flow diagrams is not to be used as the basis for any designs and does not serve as verifications of the existing design.

TITLE: Unit #4 Process Flow Diagram As Found at Arctic Glacier, Kamloops		DRAWN BY: CHRIS NUMAN
		DATE: 7/12/2022
FILENAME: P34.VSDX	PAGE: 1 OF 1	REVISED: 11/4/2022

TECHNICAL SAFETY BC

Building Addition

Unit #2

Unit #3

#3 Discharge Gas

#2 & #3 Subcooled Liquid

#2 Suction Gas

#2 & #3 Liquid Feed

#3 Liquid Feed

Exterior Wall

#2 Suction Accumulator

#2 Oil Seperator

#2 Compressor

M ?? HP

#2 Suction Accumulator

#2 Hand Expansion Valve

PI Suction Discharge

#2 Control Panel

Unit #2 Freezer

#2 Oil Pot

#3 Suction Accumulator

#3 Oil Seperator

#3 Hand Expansion Valve

#3 Compressor

M 60 HP

PI Suction Discharge

#3 Control Panel

Unit #3 Freezer

#3 Oil Pot

Relief Vent

Equalizing Line

#2 Discharge Gas

Condensate Drain Liquid

Thaw Gas

P.S.

P.S.

Glass Level Gauge

High-Pressure Receiver

#3 Thaw Gas

Combination Condenser/Receiver

Disconnected/not in use

Outside

Evaporative Condenser

Notes:
1. This flow diagram is a schematic only and is based on the observations on site. This flow diagrams is not to be used as the basis for any designs and does not serve as verifications of the existing design.

TECHNICAL SAFETY BC

TITLE: Unit #2 and #3 Process Flow Diagram As Found at Arctic Glacier, Kamloops		DRAWN BY: CHRIS NUMAN
		DATE: 7/12/2022
FILENAME: P24.VSDX	PAGE: 1 OF 1	REVISED: 11/4/2022