KEY REFERENCES

Chemical Data Guide	p. 298
Code of Federal Regulations (CFR) Subchapter O	
Compressed Gases	46 CFR 151.50-30
Vinyl Chloride	151.50-34
Leaks	151-50-34(2)
Clearing Loading Lines	151.50-34(4)
Warning Signs	151.45-2(e)
	154.1830(A)-(F)
Regulated Areas	151.50-31(j)
Respiratory Equipment	151.50-30(d)
VC Transferring Operations	40.15-1
VC Inhibiting	154.1740
Cargoes of Particular Hazard	33 CFR 126.10
	126.15
	126.16
Respiratory Protection Requirements	29 CFR 1910.93-4(g)

LOW TEMPERATURE STORAGE PRESSURE CONTROL SYSTEM

START-UP, SHUTDOWN, AND BASIC TROUBLE-SHOOTING (WHERE APPLICABLE) WILL BE DISCUSSED FOR THE FOLLOWING SECTIONS

1. REFRIGERATION (G-2 AND G-3)
2. VCM CONDENSORS, E-3 AND E-4, CHANGE-OVERS
3. VCM CONDENSATE PUMPS, P-5 AND P-6
4. VENT COMPRESSORS, C-4 AND C-5

I. ~~H~~. Holding System Operating Procedures

Start-ups and shutdowns of the holding system are very infrequent since the holding system is on essentially 100% of the time. Anytime the holding system is down, the pressure in the storage tanks will increase. Short duration shutdowns are possible without exceeding the 4 psig set pressure on the storage tank relief valves, but it is anticipated that these shutdowns will not be often. Typical holding system start-ups and shutdowns would be the shutdown (or start-up) of system G-3 along with the start-up (or shutdown) of system G-2 for holding.

Holding system operation will be discussed as follows:

A. Start-up of holding system with G-3 refrigeration system.

B. Shutdown of holding system with G-3 refrigeration system (for short duration outages only).

C. Start-up of G-2 system along with shutdown of G-3 system. This would be only as necessary, G-2 system is normally not used for holding.

D. Start-up of G-3 system along with shutdown of G-2 system. This restores normal operation.

E. Troubleshooting on holding system.

Operation of other miscellaneous loads on the holding system is discussed in other sections.

A. Start-ups with G-3 Refrigeration System

1) Start-ups of this type are usually after relatively short shutdowns, short enough so that the pressure in the VCM storage tanks does not go over about 3-3.5 psig. The shutdowns could be caused by short or emergency maintenance outages, power failures, or incineration system shutdowns.

2) Establish with supervision which VCM condenser/ammonia evaporator, E-3 or E-4, is to be put in operation. Open up the manual liquid ammonia feed and ammonia vapor discharge valves and any other necessary valves on the ammonia side of the VCM condenser to be used.

3) Switch the ammonia evaporator pressure controller to the "normal" set point position, if in the "remote" position, by the manual air switch. Adjust the set point to about 15 psig (50% of scale) by using the hand wheel air valve. This corresponds to a temperature of about $0^{\circ}F$. The pressure and temperature in the evaporator (ammonia side) will be well above the 15 psig and $0^{\circ}F$ so the pressure controller will drive the pressure control valve all the way open. The temperature can be seen on the evaporator; the pressure can be seen on the compressor suction if the compressor suction valve is open.

4) Start-up the refrigeration system G-3 to pull the pressure down and cool the VCM condenser. The pressure will be pulled down very quickly. If the Capacity Control selector switch is in "automatic", shortly after the compressor starts up, the high suction pressure will cause it to load up. Then as the suction pressure is pulled down, the compressor will unload and hot gas bypass flow will be started. If the Capacity Control selector switch is in manual, the compressor will stay unloaded. The pressure and temperature pull down in the evaporator will be much slower, and it may be necessary to slightly (manually) load up the compressor. When the pressure has been pulled down, the capacity control switch can be put in "automatic".

5) When the system has stabilized, the VCM condensing load can be put to the system. This is done by opening three valves on the VCM condenser.

   a) Vapor line valve on line from storage tanks - at the top of the higher end of the condenser. This allows flow of vapor from the storage tanks into the condenser.

   b) Condensate line valve on line to T-3 - at the bottom of the lower end of the condenser. This allows flow of condensed VCM from the condenser to the VCM condensate tank, T-3.

   c) Vent line valve on line to vent compressors - at the top of the lower end of the condenser. This allows flow of non-condensed VCM and N_2 from the condenser to the vent condenser K.O. drum, T-4, and on to the vent compressors, C-4 or C-5.

If the condenser was lined up to the deriming surge tank, T-7, as it should be if it was down long enough to warm up, two valves first need to be closed before any valves are opened.

a) The 2" condensate drain valve to T-7.

b) The 6" vent line valve to the back pressure control line - This takes high pressure (45 psig) off the condenser and allows it to quickly bled down when the vapor line on vent line valves above are opened.

Note: It is very important to make sure that the correct valves have been opened. There are several valves each in the vapor inlet, vent, and liquid drain lines on each VCM condenser since each condenser can be used for several different purposes. Opening the wrong valve(s) can have very undesirable results. At the least, the condenser wouldn't operate properly. More serious results would be allowing liquid flow in the vent lines (during deriming or filling of T-7), allowing high pressure vents to flow into the low pressure system, allowing wet deriming liquid to get into the condenser and cause it to ice up, or allowing the compressed vapor flow from the emergency vent compressor, C-6, to flow back to the VCM storage tanks. There are also many other possible results. Every time that valves on the VCM condensers are operated, the flows should be checked and double checked before and after the valve changes have been made.

6) After the VCM load has been lined up to the right condenser, the pressure in the VCM header will start to drop (assuming that it was higher than normal). When the VCM header pressure drops to normal, the ammonia evaporator pressure controller can be switched to the "remote" set point. This will allow operation of the variable condensing temperature VCM header pressure control system.

7) When the VCM header pressure was high, before start-up of the holding system, the header pressure control system (or the high-high pressure switches) would have been calling for the operation of one of the vent compressors. Therefore, they both should have been in the "off" position. After the holding system has been started and the VCM load put on a VCM condenser, one of the vent compressors can be put on "auto". Then it will come on and go off as allowed by the timers and as required by the VCM header pressure control system. Detailed instruction for the operation of the vent compressors can be found in another section.

8) As condensate starts to accumulate in T-3 , one of the VCM condensate pumps, P-5 or P-6 can be lined up with T-3 and one of the VCM storage tanks. The pump should be put in "auto" for the automatic pumping out of T-3. Detailed operation of the VCM condensate pumps can be found in another section.

B. Shutdowns with G-3 Refrigeration System

1) This is a complete shutdown of the holding system and will most likely be of short duration. If at all possible, the pressure in the VCM storage tanks should be pulled down below 1 psig (to around .6-.8 psig) before shutting down. This is done by changing the set point on the VCM header pressure controller.

2) Close the VCM vapor valve, the vent line valve, and the condensate line valve on the VCM condenser in use. When the VCM condensing load is removed, the G-3 refrigeration system compressor should start to unload. If the condenser will be down long enough to warm up, it should be lined up to the deriming surge tank and the back pressure control line.

3) Shut down the G-3 refrigeration system.

4) Switch the vent compressor which is on "auto" to "off" so that it won't run as storage tank pressure (VCM header pressure) increases. Additional shutdown instructions can be found in another section of this manual.

5) The VCM condensate pump in service can be left on "auto" since it won't run unless the level in the VCM condensate tank, T-3, is high.

6) Purging and/or isolation of certain sections of the VCM holding system or ammonia refrigeration system may be required. This should be done as directed by supervision.

C. Transfer of Holding Load form G-3 System to G-2 System

1) Changeovers like this mainly involve operation of the refrigeration system ammonia flows and do not require operational changes in the VCM flows. The major reason for this type of changeover would be for scheduled or emergency maintenance on the G-3 refrigeration system.

2) Start-up refrigeration system G-2. The load control should be in the suction pressure mode and the Capacity Control switch should be on "automatic". The hot gas bypass flow will go through ammonia evaporator E-2. A liquid level will be maintained in E-2 for desuperheating the hot gas bypass. The hot gas bypass flow will need to be manually controlled by using the manual position of the E-2 ammonia evaporator VCM outlet temperature controller. Hot gas bypass should be used when the compressor is at a low load (that is the only time the hot gas bypass solenoid valve is open) and the suction pressure is getting down close to the low suction pressure alarm and shutdown setting of 5 psig.

On planned shutdowns G-2 system should be started up before G-3 is shutdown.

3) When VCM transfers-in are being made, G-2 system will already be on. This will have the following impact.

a) Switchover from G-3 to G-2 will be much faster and easier.

b) The transfers-in rate will be decreased (automatically) somewhat depending on the overall holding system load. Note: It may be possible to lessen the VCM transfer rate decrease by decreasing the intermediate temperature (discharge from first stage VCM chiller E-1) from 50°F down to about 45°F.

c) Load control of system G-2 should be changed from VCM outlet temperature to suction pressure. But hot gas bypass will still be automatically controlled in the unlikely event that it is needed.

d) It will be necessary to reduce the transfers-in temperature, as controlled by the temperature control valve, to about 6°F to maintain the capability of achieving the 5°F condensing temperature.

4) After G-2 has been started (or is already on) G-3 system can be shut down and the ammonia system valving changed. First, shut down system G-3.

5) Close the G-3 compressor, C-3, suction isolation valve. Isolate the high pressure liquid ammonia system by closing the valve on the line off the shell side of the liquid subcooler going to the ammonia evaporators. The ammonia evaporators have now been isolated from the rest of system G-3.

6) Slowly open the valve in the compressor suction line which ties the vapor lines from ammonia evaporators E-3 and E-4 into the suction of system G-2 compressor, C-2. Now the suction pressure will be pulled on E-3 and/or E-4 by compressor C-2. As the suction pressure increases, C-2 will load up to maintain the desired pressure.

7) Open the liquid valve off the G-2 system subcooler that allows flow of liquid into ammonia evaporators E-3 and/or E-4 from the G-2 system subcooler. Liquid ammonia can now go into E-3 and/or E-4 to maintain level.

8) Parts of the G-3 system shut down may need to be further isolated and blown down for maintenance. This should be done as directed by supervision.

9) This completes the transfer of the holding load from G-3 system to G-2. It should be possible to make this transfer without upsetting the VCM header pressure control system.

D. Transfer of Holding Load from G-2 System Back to G-3 System

1) Changeovers of this type do not involve changes in the VCM operation, but only in the operation of the refrigeration systems. This change restores the holding system to normal operation. Usually system G-2 will be shut down, but if transfers-in are in progress, G-2 will remain in operation.

2) Close valves between system G-2 and G-3 on the high pressure liquid line and the compressor suction line. If G-2 is on only for holding the compressor will unload when the VCM condensing load is removed.

3) Start-up system G-3. It may be necessary to open some additional valves depending on if and what maintenance work was done.

4) Shutdown G-2 system if it is not being used for transfers-in chilling. However, do not shut it down until system G-3 is on and operating satisfactorily. G-2 can be left on, unloaded, until it is found that G-3 can adequately handle the holding load. Normally this should be no problem, but after maintenance work, it is better to be prepared.

If G-2 is being used for transfers-in, the load control should be switched from suction pressure to VCM outlet temperature. The set point on the temperature (flow) control system should be raised back up to $10^{o}F$ from $6^{o}F$. The transfers-in rate should increase a little.

5) G-3 should be started up with the Capacity Control switch on "automatic". Shortly after start-up, the load on the compressor will automatically increase because the compressor suction pressure will be above the set point due to the short holding outage.

6) This changeover in holding refrigeration system should be possible with only a slight upset (increase) in VCM header pressure.

E. Troubleshooting of Holding System

The following conditions can cause operating problems with the VCM storage tank holding system:

1) Operating problems with the G-3 refrigeration system (and the back-up system G-2). This will be seen by storage tank pressures higher than desired, more frequent operation of the vent compressor in service, C-3 refrigeration compressor 100% loaded, VCM condenser temperature higher than normal, etc. The refrigeration system should be thoroughly checked out to locate and correct the problem.

2) The VCM condenser in service, E-3 or E-4, is iced up and needs to be derimed. This will probably be the most frequent source of holding system problems. It is anticipated that a condenser will need to be derimed approximately once per month. The need to derime will be indicated by higher than normal storage tank pressures, more frequent operation of the vent compressor in service, operation of C-3 more unloaded than usual, and the vent gas temperature may be slightly higher than usual. When deriming is necessary, the spare VCM condenser will need to be put on stream and the iced up condenser shut down. If the spare condenser happens to be in some other service, a decision will have to be made by supervision whether to shut down the other service or keep the iced up condenser in holding service. The procedures for switching condensers and deriming can be found in another section of this manual.

3) Control system problems. The following control systems, in addition to the refrigeration system controls, maintain the desired operation of the holding system:

a) VCM header pressure control loop - No. 6424. This control loop supplies the signals that operate the vent compressors and set the set point on the variable condensing temperature refrigeration control system.

b) Auto, off, manual control and shutdown interlocks on the vent compressors. Malfunction of these controls could prevent the compressors from operating.

c) Ammonia evaporator (VCM condenser) pressure control loops - No. 6470 on E-3 and No. 6472 on E-4. This system with set point from the VCM header pressure control loop, or a manual set point, maintains the desired ammonia pressure (and condensing temperature) in the VCM condensers.

Troubleshooting the control systems can be very difficult especially since the symptoms can be the same as for other problems. One way to rule out a control system problem is to put the controllers in manual and then check the operation of the rest of the system.

4) Miscellaneous undesirable conditions can also upset the holding operation. Partial or complete power failures, instrument air failures, improper valving, and mechanical equipment problems can all cause upsets in the holding system.

Note: The holding system is probably the most important function in the entire low temperature storage system. Improper operation or failures in the holding system will likely result in sizable VCM losses to the atmosphere. Therefore, considerable care and attention should be given to the holding system at all times.