

Lithium Nitrate Inhibited Units

Solution Chemistry

When you receive a solution analysis report, the report will show the amounts of various substances found in the solution that you sent to the lab. These substances may be divided into the “Good Guys” and the “Bad Guys”. The following section describes what exactly these good guys and bad guys do.

Please remember...

Lithium Bromide solution has an uncanny ability to corrode steel in the presence of oxygen. The LiBr itself does not corrode steel. It is the reaction of the steel with the water in the solution that creates the corrosion, however the presence of the LiBr salt increases the conductivity of the water to such a great degree that the normal corrosion seen between steel and water proceeds at a very rapid pace. With the addition of inhibitors and by keeping the pH high, we endeavor to slow down the process of corrosion in the unit to an acceptable rate. This endeavor will fail if a unit is not kept leak free.

The Good Guys

Lithium Nitrate (LiNO₃): Lithium Nitrate is used in the solution as a corrosion inhibitor. It works by chemically slowing down the natural tendency of steel to oxidize or corrode. This results in a much smaller amount of hydrogen being produced since hydrogen is a by-product of corrosion.

Lithium Nitrate is slowly consumed over time. However, the presence of air will greatly accelerate the rate of consumption. Higher corrosion rates due to the presence of air also contribute to the Nitrate combining with Hydrogen to form Ammonia. Some research indicates that higher than normal temperatures (greater than 320°F) in the 1st stage generator can rapidly deplete the inhibitor.

YORK's control range for LiNO₃ concentration (based on 53% LiBr by weight) is 230-280 mg/l, only time will reduce the level as the normal depletion process occurs.

Lithium Hydroxide (LiOH): Lithium Hydroxide is a chemical that is commonly called a base (opposite of acid). Lithium Hydroxide is used to alter the pH or the Alkalinity of the solution. pH is a measurement scale with a range from 1 to 14 with 7 being a neutral. A high pH (higher than 7) means that the solution is more alkaline, and a low pH (lower than 7) means that the solution is more acid. We refer to the measure of pH or the degree of alkalinity in solution by the amount of LiOH content. *Note that the term “pH” is used here as a means of explaining alkalinity only. Measurement of a pH is not done in salt solutions. Do not attempt to use a pH meter to determine the degree of alkalinity of the solution.* The LiOH content in the solution is expressed by a unit of measure called Normality, abbreviated “N”. If you see “.12N” on an analysis report, it is said “point one two normal”. Normality is a standard chemical term used to express the amount of a substance dissolved in solution.

Steel corrosion slows appreciably when its pH is above 10. The effect of the high alkalinity in the solution passivates the steel surface it comes in contact with. Before cutting a unit open for repair, a Lithium Hydroxide wash should be performed to give temporary protection to the steel surfaces during the time when they will inevitably encounter oxygen.

YORK's control range for alkalinity is .12N to .14N (based on 53% LiBr by weight).

As inhibitor is consumed, the tendency over time will be for the alkalinity of the solution to increase slightly. Seldom is it necessary to have to correct solution for being too alkaline. Even though the high point of the control range is 0.14N, we generally accept values as high as 0.2N. In some units, factors such as repeated air

leaks may cause the alkalinity of the solution to decrease. If the LiOH drops below .12N, Lithium Hydroxide must be added.

The Bad Guys

Ammonia (NH₃): Air leaks cause increased steel corrosion. As a result of the increased corrosion rate, a chemical reaction involving the Nitrate (NO₃) ion, hydrogen, heat and water takes place, forming ammonia gas as well as other compounds of nitrogen.

Ammonia dissolves copper oxide (so does LiBr) which may contribute to copper plating. Ammonia is one of the two vital ingredients needed to cause stress corrosion cracking to the copper heat exchanger tubes. The other ingredient is stress. Some of the nitrate may be converted to other nitrogen compounds. On rare occasions, NO_x seems to appear after high temperature situations and when non-condensables have not been purged for awhile. NO_x resides in the unit as a non-condensable and affects capacity the same way any non-condensable would.

If ammonia is present, it can be detected in the refrigerant *or* the solution of a unit. Experience has shown that the solution will usually test higher for ammonia than the refrigerant. Although testing the solution for ammonia requires that a sample be sent to a lab, it is possible to test for ammonia in refrigerant in the field. Ammonia can be detected in refrigerant water using the *York ParaFlow™ Solution Test Kit*. The levels of ammonia found in the refrigerant can be used as a guide to determine the trend of the ammonia level present overall in the unit.

An acceptable Ammonia level within a unit is below 50 mg/l (adjusted for 53% LiBr). The alarm level is between 50 and 100 mg/l. Anything in excess of 100 mg/l is unacceptable.

Ammonia will purge out of the unit over time, but it is a very slow process.

There are two methods of removing ammonia from a unit:

1. The most commonly used method is to replace the refrigerant charge. Although this may sound easy initially, consider the fact that the entire amount of refrigerant in a unit is not only the weight of the refrigerant charged into the unit but also the water constituent of the solution as well. For example, if a unit was originally charged with 600 lb. of water and 10,000 lb. of solution at 53%, the total refrigerant charge that would have to be changed out would be [600 lb. + 47% of 10,000 lb.] or 5300 lb. Since the entire refrigerant charge cannot be changed out at one time, this method may take some time to complete.

2. A lesser known method that has been used successfully utilizes a purification unit to remove the ammonia from the refrigerant in the unit. Refrigerant is pumped through a water conditioning system for ammonia removal. This method is less labor intensive, but does require more investment in tools and equipment. Once purchased, though, the tools and equipment can be used on many jobs.

Dissolved Copper (Cu₂O; CuO): Dissolved copper is a result of the LiBr's ability to dissolve copper oxide on the tubes. All tubes will have some copper oxide on them, even as they come out of the box. Once the copper oxide is dissolved in the LiBr solution, providing there is no oxygen present to re-oxidize. The LiBr will in turn re-dissolve the copper oxide. This process will continue until the oxygen is depleted. The higher the concentration of the solution, the more dissolved copper it can hold. Levels in excess of 50 mg/l (based on 53% solution) are cause for concern.

Copper plating is a result of high copper concentrations in the solution. Although copper plating is still not fully understood, the results of copper plating are usually not good. Copper may plate out on internal steel surfaces causing galvanic cells which produce hydrogen. Copper

plating on the rotating parts of a pump may cause pump failures. Although pump repairs or replacements are expensive, an even more tragic result of copper plating on the inside surface of the nozzles. Solution contaminated refrigerant, even in relatively small concentrations may cause copper plating in the refrigerant side of the unit, hence the importance of regular refrigerant blow down (See page 17 for more details on refrigerant blow down).

Dissolved copper cannot be filtered out of the solution. Copper can be removed by taking the solution out of the unit, aerating and diluting it. The copper, once aerated, cannot remain dissolved in the diluted solution (<40% LiBr by weight) and will precipitate out as a solid. The solution must then be filtered as it is put back into the unit. This method, though time intensive, is effective. Care must be exercised not to create more copper by getting air into the unit during the process.

Dissolved Iron: Dissolved Iron is presently tested for but will soon be removed from the analysis procedure. It is virtually impossible for dissolved iron to exist in solution with high alkalinity levels.

Suspended Solids: Suspended solids are comprised, for the most part, of iron oxide or rust. Other substances that could be present are copper sludge and assembly dirt. Suspended solids are usually a result of corrosion, because of air leaks or exposure of the unit to air during a maintenance procedure. Suspended solids will settle out of the solution if allowed to sit for some time. Solution with suspended solids will be discolored. Any solution that is dark brown or black in color can be assumed to have too many suspended solids. The cure for suspended solids is filtration.

Suspended solids may clog absorber and evaporator spray nozzles and the abrasive action of the solids while circulating may cause pump bearing damage as well as tube erosion.

Although we currently specify a maximum of 600 mg/l of suspended solids, we will soon be removing this test from the analysis procedure. We believe that a visual observation of the solution sample is all that is necessary to determine if filtration is necessary. If the solution is dark brown or black, a clean-up filtration system should be installed on the unit.

For the most part, solution chemistry can be addressed solely on the basis of the above categories, however there are exceptions. Due to the complexity of the many interactions within a unit, there may be times when the chemistry does not seem to follow the rules. If this is the case, a more complex solution analysis may be necessary.

Nitrate Inhibited ParaFlow™ Units**Solution Parameters Based on 53% LiBr by Weight**

Item	New Solution	Control Range	Action Required	Type of Action ¹	Remarks
Lithium Nitrate (LiNO ₃)	380 mg/l	230-380 mg/l	< 230 mg/l	Add LiNO ₃	Corrosion of Steel
Lithium Hydroxide (LiOH)	.12 N	.12 -.14 N	< .12 N > .20 N	Add LiOH Call York Service	Corrosion of Steel
Ammonia (NH ₃)	< 0.3 mg/l	< 50 mg/l	> 100 mg/l	Replace or Condition Refrigerant	Stress corrosion of cracking copper tubes
Dissolved Copper (Cu ₂ O CuO)	< 0.1 mg/l	< 20 mg/l	> 50 mg/l	Condition Solution	Copper Plating
Dissolved Iron	< 0.1 mg/l	< 50 mg/l	> 200 mg/l		High Iron cannot exist in Alkaline Solution
Suspended Solids	0	< 50 mg/l	> 600 mg/l	Filter Solution	Plugging of Nozzles

Note that the above table states the various parameters based on milligrams per liter (mg/l) of 53% Lithium Bromide by weight. Since most of the time your sample will be exactly 53%, it will be necessary to put your sample results in terms that are relative to the parameters of 53% solution. The following formula is used to establish a **Conversion Factor**. Find the Concentration and Density (specific gravity) of your sample on the analysis report. Multiply any of the parameters on the analysis report by the Conversion Factor and then compare them to the above table.

$$\text{Conversion Factor} = \frac{53}{\text{sample concentration (\%)}} \times \frac{1.58}{\text{sample specific gravity}}$$

There may be some analysis results stated in parts per million (ppm). To convert ppm to mg/l or vice versa use the formulas:

$$\text{ppm} = \frac{\text{mg/l}}{\text{specific gravity (S.G.)}}$$

$$\text{mg/l} = \text{ppm} \times \text{specific gravity (S.G.)}$$

1. Type of Action in the above table requires a certain service procedure to be executed. These procedures should only be performed by qualified YORK personnel.

Lithium Nitrate Replacement Procedure

When the solution analysis results indicate that it is necessary to add LiNO_3 to the unit, use the following procedure to calculate the amount of LiNO_3 necessary.

Warning: Working with chemicals such as LiNO_3 requires that the user exercise extreme care. The use of face and eye protection, rubber gloves and apron is mandatory. Never work with chemicals without first reading the appropriate Material Safety Data Sheet.

Useful Information:

1 gal = 4 qts = 3.785 liter

1 kg = 2.2 lb

1 kg = 1000 gm = 1,000,000 mg

$$\text{ppm} = \frac{\text{mg/l}}{\text{specific gravity (S.G.)}}$$

$\text{mg/l} = \text{ppm} \times \text{specific gravity (S.G.)}$

S.G. of $\text{H}_2\text{O} = 1$ kilogram per liter (kg/l)
 = 8.33 lbs per gallon (lbs/gal)
 = 2.2 lbs per liter (lb/l)

S.G. of 53% LiBr = 1.583 kilograms per liter (kg/l)
 = 13.186 lbs per gallon (lbs/gal)
 = 3.483 lbs per liter (lbs/l)

LiNO_3 (1 lb bag bag) = YORK p/n
 = 011-00524-002

1. Determine the present amount of LiNO_3 in the solution based on 53%.

If it hasn't already been done, the present LiNO_3 content in the solution must be taken from the lab analysis and converted to mg/l of 53% LiBr by weight. If the lab result shows the LiNO_3 content in mg/l at some other concentration and specific gravity, use the formula above the chart on page 7 to calculate the present amount

of LiNO_3 in the solution corrected to 53% LiBr. If the corrected amount of LiNO_3 is less than 230 mg/l, then it is necessary to add inhibitor.

2. Determine the amount of LiNO_3 to add to the unit.

Using the LiNO_3 in mg/l corrected to 53% from Step 1, refer to the chart on the next page to find the amount of LiNO_3 to add per lb. of 53% solution in the unit.

The amount of solution in the unit can be obtained from the Factory Test Report (if the actual amount of the solution in the unit is different from the amount on the test report, use the actual amount). After finding the amount in pounds to add per pound of 53% solution in the unit, multiply that number times the total solution charge in pounds to arrive at the total amount of LiNO_3 in pounds to charge into the unit.

3. Charging inhibitor into the unit.

Note: Inhibitor charging should only be done during the cooling season.

The total amount of inhibitor should be mixed with ten (10) times its weight in refrigerant. To do this, calculate the amount of refrigerant necessary by multiplying the total weight of the LiNO_3 inhibitor by 10. If, for example, the required amount of LiNO_3 was .455 lbs, we would multiply .455 x 10 which results in 4.55 lbs of refrigerant or slightly more than 1/2 US gallon. For convenience, the refrigerant may be removed from the unit. Mix the inhibitor with the refrigerant in an open container (plastic bucket). Hook up a clear plastic hose to the solution sample valve on the Solution Pump (P1) and hold the other end of the hose under the mixture of refrigerant and inhibitor. Run the Solution Pump and open the sample valve for a few seconds to flush the hose into the container of inhibitor and refrigerant. This will flush the air from the hose. Keep the end of the hose under the refrigerant/inhibitor mixture back into the unit. **Be very careful to shut the sample valve before the**

hose end is uncovered so that air is not drawn into the unit.

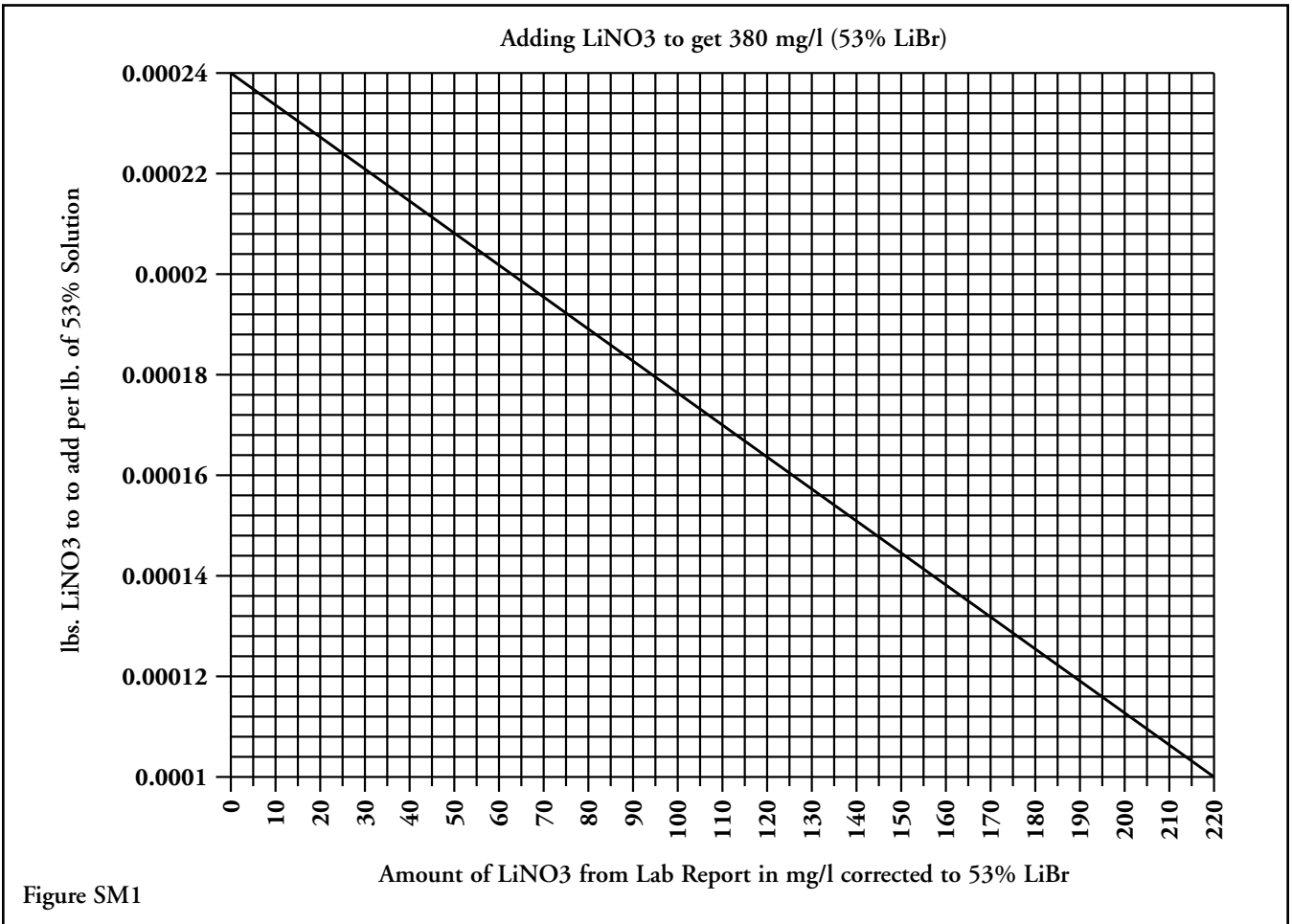
Repeat the procedure of running the solution pump and pumping some solution into the unit. This will serve to clear the line and valve of pure LiNO_3 .

The unit should now be operated in the cooling mode.

4. Purging frequency for first week after adding inhibitor.

Note: More frequent purging will be necessary for about 1 week after the addition of inhibitor. This is because addition of LiNO_3 will cause increased hydrogen generation in the unit for about a week. If the hydrogen is allowed to accumulate in the unit, it will tend to generate ammonia. It may be necessary to change the purge pump oil more frequently during this period, perhaps as much as once every 2 days.

$$\text{mg/l of LiNO}_3 \text{ from Lab Report} \times \frac{53}{\text{sample concentration (\%)}} \times \frac{1.58}{\text{sample specific gravity}} = \text{mg/l of LiNO}_3 \text{ corrected to 53\%}$$



Lithium Hydroxide Replenishment for Nitrate Inhibited Units

When the solution analysis results indicate that it is necessary to add LiOH to the unit, use the following procedure to calculate the amount of LiOH necessary.

Warning: Lithium Hydroxide Monohydrate is a very strong base. It will cause severe chemical burns if allowed to come in contact with skin or eyes. Wear a full face shield, rubber gloves, and protective apron when handling and mixing LiOH. Never work with chemicals without first reading the appropriate Material Safety Data Sheet.

Useful Information:

- 1 gal = 4 qts = 3.785 liter
- 1 kg = 2.2 lb
- 1 kg = 1000 gm = 1,000,000 mg

$$\text{ppm} = \frac{\text{mg/l}}{\text{specific gravity (S.G.)}}$$

$$\text{mg/l} = \text{ppm} \times \text{specific gravity (S.G.)}$$

- S.G. of H₂O = 1 kilogram per liter (kg/l) = 8.33 lbs per gallon (lbs/gal) = 2.2 lbs per liter (lbs/l)

- S.G. of 53% LiBr = 1.583 kilograms per liter (kg/l) = 13.186 lbs per gallon (lbs/gal) = 3.483 lbs per liter (lbs/l)

LiOH Monohydrate = YORK p/n = 044-02985-000 (5 lb bag)

1. Determine the present amount of LiOH in the solution based on 53%.

If it hasn't already been done, the present LiOH content in the solution must be taken from the lab analysis and corrected to equate to 53% LiBr by weight. If the lab analysis result shows the LiOH gravi-

$$\text{LiOH (N) from Lab Report} \times \frac{53}{\text{sample concentration (\%)}} \times \frac{1.58}{\text{sample specific gravity}} = \text{LiOH (N) corrected to 53\%}$$

Adding LiOH to get .14 N LiOH (53% LiBr)

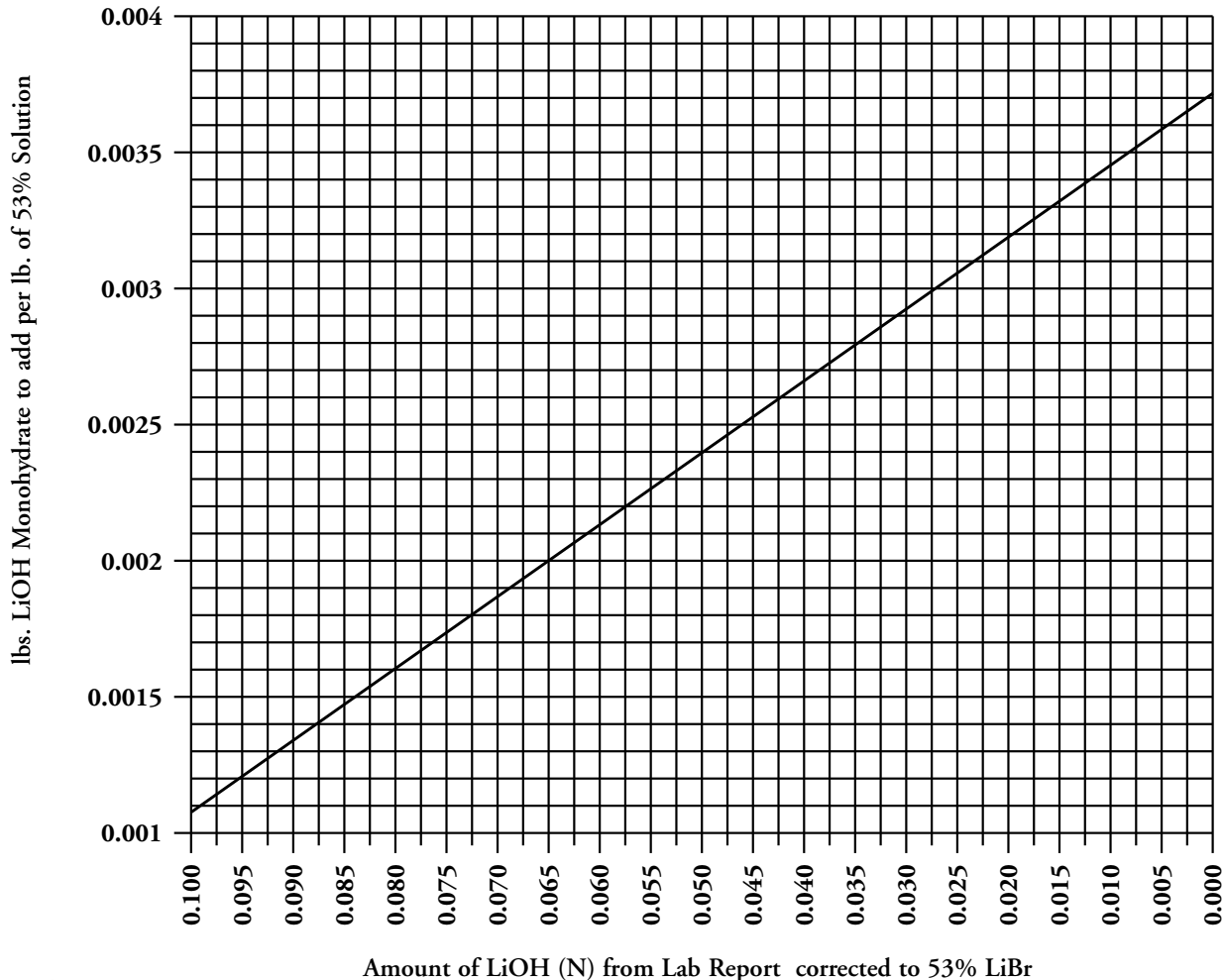


Figure SM2

ty, use the formula above the chart on this page to calculate the present amount of LiOH in the solution corrected to 53% LiBr. If the corrected amount of LiOH is less than .12N, then it is necessary to add Lithium Hydroxide.

2. Determine the amount of LiOH to add to the unit.

Using the corrected LiOH from Step 1, refer to the chart on page 10 to determine the amount of LiOH to add per pound of 53% solution in the unit.

The amount of solution in the unit can be obtained from the Factory Test Report (if the actual amount of solution in the unit is different from the amount on the test report, use the actual amount). After finding the amount in pounds to add per pound of 53% solution in the unit, multiply that number times the total solution charge in pounds to arrive at the total amount of LiOH in pounds to charge into the unit.

3. Charging Lithium Hydroxide into the unit.

Material Needed:

- 1 30 gallon plastic garbage can
- 1 wooden/plastic rod to stir
- 20 ft. length of plastic tubing (028-12514-000)
- 1 Spindle valve adapter (if applicable)
- LiOH Monohydrate (044-02985-000) (5lb) (actual amount used must be calculated)
- Assorted fittings and hose clamps
- Accurate scales
- Safety Apparel

1. Unit should be shut down during the charging operation. Charge LiOH during the cooling season on units with separate hot water heat exchanges.

2. Hook hose up to P1 Solution Pump Discharge Sampling Valve (v14) using a spindle valve adapter if necessary, so that the connection at the sampling valve is leak-free. Put other end of hose into plastic garbage can.

3. Operate P1 Solution Pump. After confirming the pump is running, open the P1 Solution Sampling Valve (v14) and allow the pump to discharge approximately 15 gallons of solution into the garbage can. Close P1 Solution Sampling Valve (v14). Allow P1 pump to continue to operate.

4. Dissolve no more than 2 lbs. of LiOH into the 15 gallons of solution. The solubility of LiOH in LiBr is not very high, so care should be used to prevent adding too much LiOH at one time. Using the non-metallic LiOH is completely dissolved, shut off the P1 Solution Pump. Allow the unit vacuum to suck the mixture back into the unit by opening the P1 Solution Sampling Valve (v14) (without the pump running). **Do not suck air into the unit.**

5. Repeat Step 4 as many times as necessary to charge the required quantity of

LiOH. After the final mixture is sucked into the unit, again run the solution pump and after running for a few minutes, open the P1 Solution Sampling Valve (v14) and pump 5 more gallons of solution into the can. Suck this solution back into the unit. This will clear the sampling valve and hose of any solution with a high concentration of LiOH.

6. Remove all hoses and fittings and re-install the spindle valve caps or pipe plug in the P1 Solution Sampling Valve (v14).

7. Run the unit in the cooling mode for at least 1 hour to completely distribute the Li OH throughout the unit.

Procedure for Removal of Dissolved Copper from LiBr Solution

Dissolved copper cannot be filtered out of the solution by normal mechanical filtration methods. The only practical method we presently have at our disposal to remove copper from solution is to take the solution out of the unit, aerate and dilute the solution with water, which will cause the copper to drop out on its own as sediment.

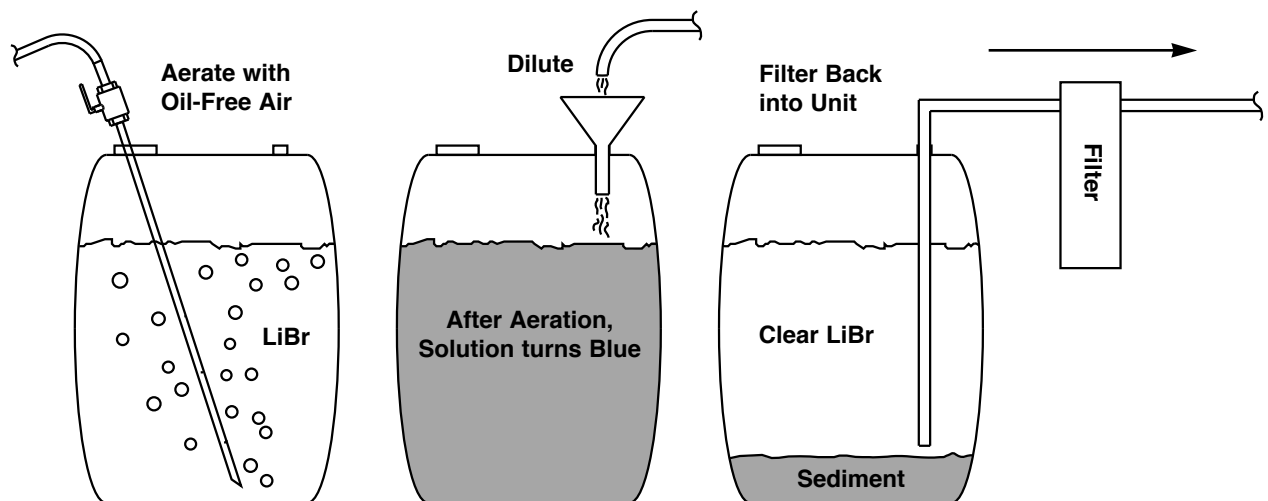
When copper oxide is dissolved by the LiBr solution with water, which will cause the copper to drop out on its own as sediment.

When copper oxide is dissolved by the LiBr solution, it is in the form of cuprous oxide (CuO). Inside the unit, without any oxygen present it will stay in this form while in the solution. Dissolved cuprous oxide is virtually colorless in the solution. In the presence of oxygen, the dissolved cuprous oxide combines with oxygen and becomes cupric oxide (CuO). As this occurs, the solution color changes to blue. Pure cupric oxide is a blue-black color. Once the solution has turned blue, some of the cupric oxide may precipitate out as sediment depending on how diluted the solution is. The solubility of dissolved copper in the LiBr solution becomes less as the solution gets weaker in concentration. To predictably and expediently cause the copper to precipitate out of the solution, it is normally necessary to further dilute the solution with refrigerant or de-ionized water to approximately 40% LiBr by weight. The Cupric oxide will drop out fairly quickly as a whitish blue sediment.

In order to remove the copper, the following four basic steps must be performed.

1. Remove solution from the unit into plastic drums. Prior to removing the solution, go through a complete dilution cycle of the unit. Blow down the refrigerant into the solution so it is as dilute as possible. The idea is to have the solution

Figure SM3 - Copper Removal



as weak as possible to avoid having to add a lot of water later. Leave some space in the drums for later addition of refrigerant water.

2. Aerate the solution in the drums with **oil-free** air which will change the dissolved cuprous oxide to cupric oxide. The object is to expose the solution to oxygen, so the finer and more numerous the bubbles of air, the better. As the cuprous is being converted to cupric, the solution will turn blue.

3. Dilute the solution using de-ionized water to the point (-40% LiBr by weight) where the cupric oxide precipitates out. Allow the precipitate to settle out in the bottom of the drums. Complete settling may take a few days. Once settled, it is best not to move the drums, so plan the placement of the drums carefully.

4. Draw the solution back into the unit using a clear plastic hose to suck just above the sediment layer in the drum. An in-line filter should be placed between the drum and the unit with a filter cartridge capable of catching any residual sediment that is still suspended in the solution (1 micron should work). The same filter that is used later to filter the solution in the unit can be used here (See the Filtration Procedure for more details). Use the refrigerant removal tank or some other clear tank as an intermediate vessel between the drum of solution and the unit. That way, if you would accidentally suck air or sediment into the hose, you will see it passing into the clear tank and will be able to prevent it from clogging the filter or getting into the unit in case of air.

The most effective method to determine how much dilution of the solution is necessary is to experiment with a small amount of the solution of known volume in a beaker. Aerate this solution until it turns blue. Add refrigerant to the beaker of solution in small increments (10-20 ml) until the copper oxide begins to fall out of solution and the solution color becomes clear. By knowing the original volume of the dilute solution, you will

know how much it was diluted by. Use the same ratio of dilution on the bulk of the solution in the drums from the unit.

Be aware that whatever extra refrigerant is added to promote the precipitation of the cupric oxide must be later removed from the unit during start up. A good practice is to keep a record of exactly how much extra refrigerant water was added in order to precipitate the cupric oxide.

The final word of caution here is that this procedure is lengthy and expensive from a labor point of view. Copper was in the solution due to the unit being exposed to air. **Do not allow air inside the unit during any of this process or you will be achieving nothing.** In fact, you will be creating more dissolved copper.

Ammonia Reduction Procedure

Removing Ammonia by Replacing the Refrigerant

Ammonia gas dissolved in the refrigerant water contained in the unit must be removed if the amount of NH_3 present in the solution sample (adjusted for 53%) exceeds 100 mg/l.

It must be understood that the ammonia resides in the water. Therefore, the refrigerant (which can be considered pure water in this example), and the water that is present in the solution must both be dealt with. See the piping diagram below to pipe up the removal equipment. Use stainless steel reinforced clear plastic tubing together with hose clamps for piping.

Material Needed:

- Electric Pump (Teel 1/2 hp)
- Mixed Bed De-Ionizer Tank
- Refrigerant Removal Tank
- 1/2" Diaphragm Valves
- Various Fittings
- Hydrometer Flask (150 ml)
- Clear Vacuum Hose
- Hydrometers
- Hose Clamps
- Vacuum Flask
- Pipe Sealant (Loctite 567)

- Water Flow Meters (2) 20 gpm
- Dow Silicone Vacuum Grease
- Ammonia Test Kit

Removing Ammonia By Purification of the Refrigerant

Ammonia gas dissolved in the refrigerant water may also be removed using a de-ionizing purification unit. Both an Anion and Cation resin bed in series must be used. These tanks are available from companies such as Culligan.

Care should be taken to replace fittings on the tanks that could leak in a deep vacuum. Refrigerant should be blown down several times before using this system since any LiBr in the refrigerant will quickly poison the resin. The tanks can be refilled at the place of purchase.

The *Teel* circulation pump is optional and offers the advantage of allowing better control of the unit capacity while removing the ammonia.

See the piping diagram below to pipe up the removal equipment. Use clear plastic tubing with stainless steel reinforcing together with hose clamps for piping.

Material Needed:

- Electric Pump (*Teel* 1/2 hp)
- Anion and Cation Resin Tanks
- 1/2" Diaphragm Valves
- Various Fittings
- Hydrometer Flask (150 ml)
- Clear Vacuum Hose
- Hydrometers
- Hose Clamp
- Vacuum Flask
- Pipe Sealant (Loctite 567)
- Dow Silicone Vacuum Grease
- Ammonia Test Kit

Figure SM4 - Ammonia Removal by Replacement of Refrigerant

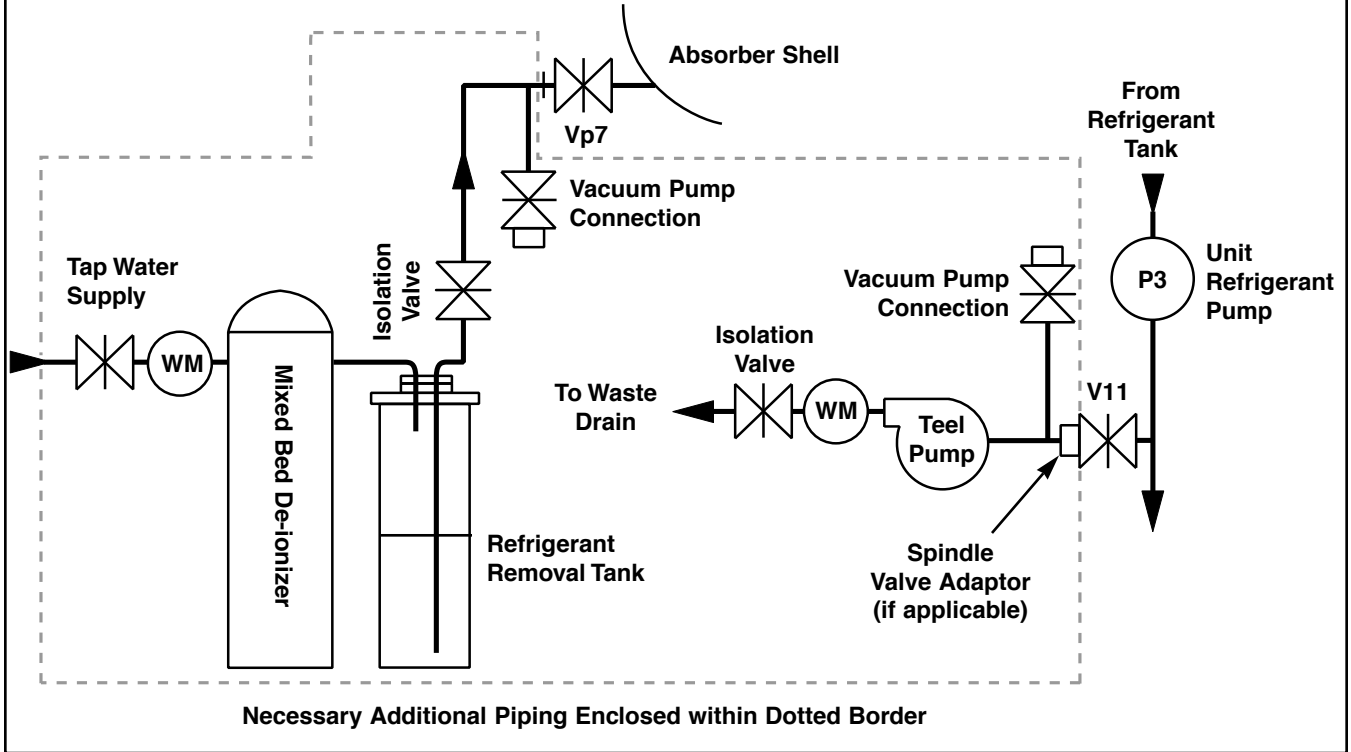
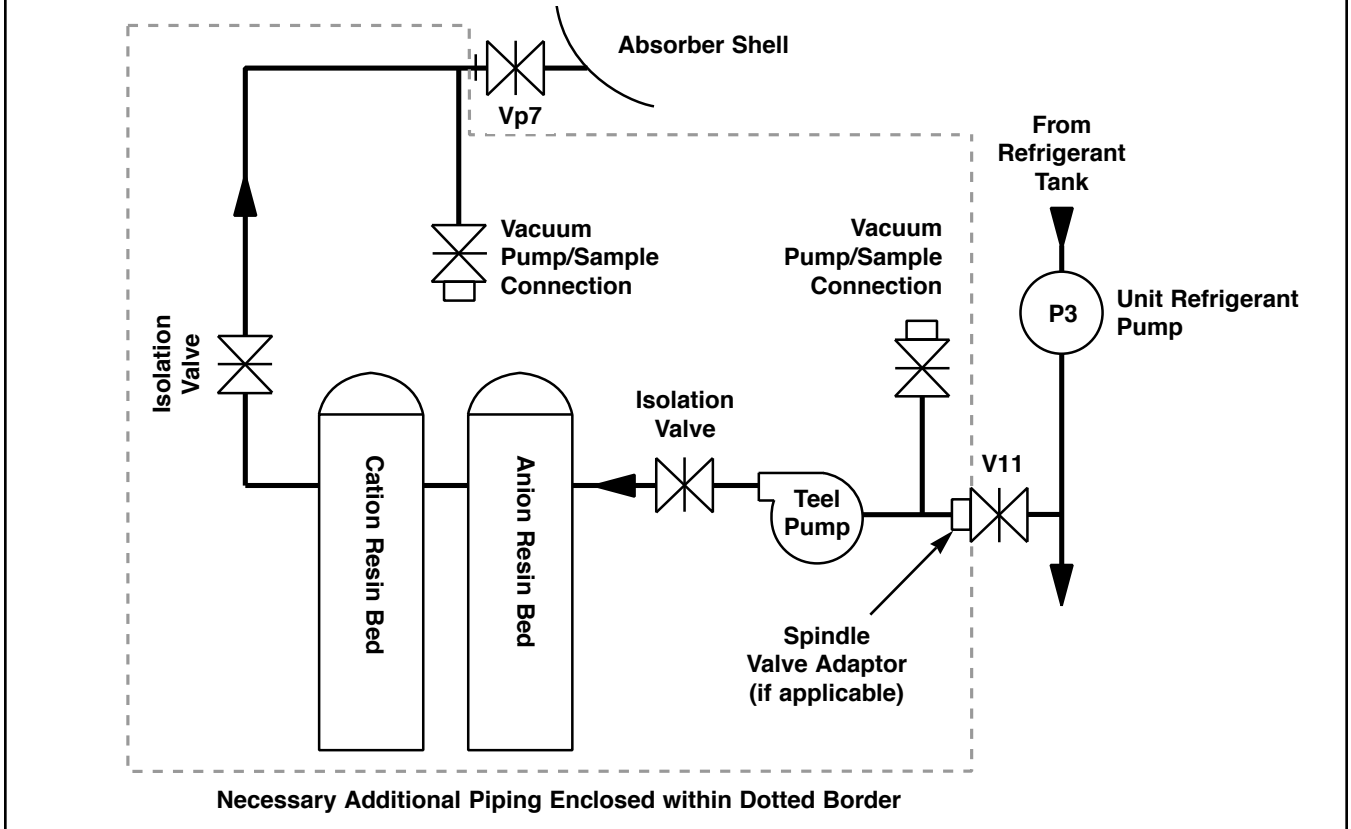


Figure SM5 - Ammonia Removal by Replacement Purification



Taking Samples

There are several reasons for taking samples. The two main ones are (1) to obtain solution or refrigerant concentration during unit troubleshooting and (2) sending a sample for laboratory analysis or in some cases, analyzing the sample at the job.

Taking Samples to obtain concentration during troubleshooting

Material Needed:

Spindle Valve Adapter
 Allen Wrench (Metric 10mm)
 Barbed Fitting (1/4" barb x 1/2" MPT)
 Clear Vacuum Hose (YORK p/n 028-12514-000)
 Hose Clamp
 Pipe Sealant (Loctite 567)
 Silicone Vacuum Grease (Dow Corning)
 Plastic Bucket (2-5 gal.)
 Hydrometer Flask (150 ml)
 Hydrometers (YORK p/n 026-32366-000)
 Vacuum Flask (Bel Art Products)
 Protective Face Shield and Gloves

In order to troubleshoot and absorption unit, it is essential to know the concentration of the solution and refrigerant in various sections of the unit. The table below shows the sample points of a *ParaFlow*[™] unit and what the samples mean.

Warning: When taking samples, wear a full face shield, protective gloves and apron to avoid the danger of hot solution splashing on the skin or eyes. Do not use glass sample flask. Use polypropylene or other vacuum suitable, laboratory grade plastic.

In order to take a sample from any point on the unit, it is necessary to connect the sample flask using the proper fittings and suitable vacuum tubing tread.

Be aware that if the unit is equipped with spindle-type valves for sampling, you must use a special spindle valve adapter fitting. The spindle valve has a straight thread. If you screw in a 1/2" pipe nipple, it may appear to work, however, there is a good possibility that it will leak. **Do not take the chance.**

If the sample point is in a positive pressure, it is relatively easy to take the sample. **Never assume that a sample point is in a positive pressure.** Units will vary. On "G" Model units, it is typical for the main solution pump (P1) discharge to be in a positive pressure. This is the case only when the pump is operating and turning in the correct direction. If you are not sure of a sample point pressure, assume it is in a vacuum or check the pressure with a pressure gauge.

If the sample point is in a negative pressure, it will be necessary to evacuate the sample flask to a pressure lower than the sample point so that the solution will flow into the sample flask and air will not enter the unit. To do this, you may use the unit purge pump or a separate vacuum pump if available. When using the unit purge pump, install a tee and an isolation valve between the manometer and the purge piping. The manometer will be used as the vacuum indicator when evacuating the sample flask. Since accidents do happen, it is a good idea to install a trap of some kind between the sample flask and the manometer. The refrigerant

Table SM2

Sample Point	Valve Number ¹	Pressure ²	Temperature ³	Concentration ⁴	Remarks
Solution Leaving Absorber	V14	Normally a positive pressure	100°F	58-59%	Used for solution sample analysis
Solution leaving 2nd Stage Generator	V17	Vacuum	170-190°F	62-63%	Used to check 2nd stage performance
Solution leaving 1st Stage Generator	V18	Vacuum	140-160°F	64-65%	Used to check heat input
Refrigerant Pump Discharge	V11	Vacuum	45°F	< 2%	Blowdown if > 2%
Strong Absorber Sprays (19GL-22GL only)	V25	Vacuum	120°F	62-63%	Seldom used for troubleshooting
Weak Absorber Sprays (19GL-22GL only)	V36	Sometimes positive-don't depend on it	105-115°F	60%	Seldom used for troubleshooting

1. Valve Numbers may not be uniform throughout product line. See valve location drawing and valve list on Factory Test Report.
2. Pressure is shown with all pumps running. Actual pressure may vary. Always assume that the sample point in a vacuum.
3. Temperatures are only a general guide. Actual temperatures may vary depending on unit operation and actual sample valve on heat exchanger.
4. Concentrations shown are with unit at full load. Use only as a guide. Actual concentrations may differ.

removal tank may be used for this purpose. When connecting hoses to fittings, the use of vacuum grease will ease installation and help prevent air leaks.

After completing the tubing connections to the sample flask, open the valve to the flask and any isolation valves between the flask and the vacuum source. Evacuate the flask to 1-3 Hg absolute. Slowly open the sample valve until solution or refrigerant begins to flow into the flask. Hold the sample flask so that the incoming solution does not exit the flask through the vacuum connection. As the sample flask fills up it is normally possible to close the valve on the vacuum connection to the flask and then close the unit sample valve. It is not important what order the valves are closed in, but it is very important to avoid introducing air into the unit or sucking solution into the vacuum pump. After ensuring that the sample valve is completely closed, remove the sample flask. To break the vacuum in the sample flask, hold the flask upright and slowly open the valve on the vacuum connection of the flask. Pour the contents into a hydrometer flask. Empty the contents of the hydrometer flask into a bucket. This liquid may later be returned to the system. Its purpose was to wash out the sample apparatus and the sample valve. Never use the first sample drawn. Re-install the sample flask and repeat the above procedure.

Using an accurate thermometer, measure the temperature of the second sample. Gently stir the thermometer in the solution until the temperature stabilizes. Record the temperature. Select a hydrometer that is in the correct range of the sample liquid. Carefully read the specific gravity of the liquid and record it. Using the solution or refrigerant tables, find the concentration equivalent to the specific gravity and temperature of the sample.

Taking a Sample for Laboratory Analysis

Material Needed:

Spindle Valve Adapter
Silicone Vacuum Grease (Dow Corning)
Allen Wrench (Metric 10mm)
Plastic Bucket (2-5 gal.)
Barbed Fitting (1/4" barb x 1/2" MPT)
Hydrometer Flask (150 ml)
Clear Vacuum Hose (YORK p/n 028-12514-000)
Hydrometers (YORK p/n 026-32366-000)
Hose Clamp
Vacuum Flask (Bel Art Products)
Pipe Sealant (Loctite 567)
Protective Face Shield and Gloves
ParaFlow[™] Solution Test Kit
Sample Bottles (150 ml and 50 ml)

Although the sampling procedure for lab analysis is essentially the same as taking a sample for troubleshooting purpose, the lab analysis sample, since it is taken from the absorber, will most likely be in a positive pressure. To take a solution sample for lab analysis, it is very important to get a representative sample from the unit. Incorrect sampling techniques could lead to a sample that is not a true indicator of the system chemistry.

For best results, adherence to the following rules when taking a sample for lab analysis is advisable.

1. The unit should have been running in the cooling mode for a week or more and 4 continuous hours prior to taking the sample.
2. New units or units where inhibitor has recently been added should be allowed to run until the purging of non-condensables has subsided (this may take a week or more) before taking a sample.
3. If a unit has recently been de-crystallized, do not sample it until it has run at least 48 hours without any signs of crystallization.

4. Always sample solution from the absorber (V14) when taking a sample for the lab.

5. Before taking the sample, put the unit into a dilution cycle and blow down the refrigerant so that the sample is as dilute as possible. Allow the dilute solution to circulate for a few minutes before taking the sample. Samples when taken with high concentrations have been found to be more prone to inaccuracies and they may crystallize in route to the lab. **Do not send in solution samples with concentrations in excess of 55%.**

6. Always wash out the sample apparatus with at least one sample before taking the actual sample for analysis.

7. Do not use copper or brass fittings when taking samples.

8. Use clean, plastic (polypropylene/nal-gene) sample bottles. Do not use glass.

Remove at least one pint of solution from the unit. Of this pint, fill one 150 ml sample bottle to the top. Install the cap and seal it with tape to prevent turning. Out of the remaining solution, using *non-acid* filter paper, filter 20 ml into a small sample bottle. Cap this bottle and tape it. The small sample bottle should be free of any particulate matter or sediment immediately after the filtration. The small bottle will be used for the dissolved copper test in the lab. Tape the two bottles together and label them. Fill out the appropriate lab analysis request form and send the samples to the lab. The *York ParaFlow*[™] *Solution Test Kit* contains the necessary items for filtering the sample.

Solution Filtration

Filtration Instructions

Material Needed:

Spindle Valve Adapter (1/2" straight to 1/2" FPT) (available from Houston Service)

Pressure Gauge (30 psi compound) (2) (YORK p/n 026-32300-000)

1/2" Diaphragm Valve (5) (YORK p/n 022-08869-021)

1/2" Black Steel Pipe

Various Steel Fittings (tees, elbow, pipe plugs)

Filterite Filter Canister (6FM01A-21P)

Filterite Poly-Fine ARD cartridges w/ EPDM gaskets

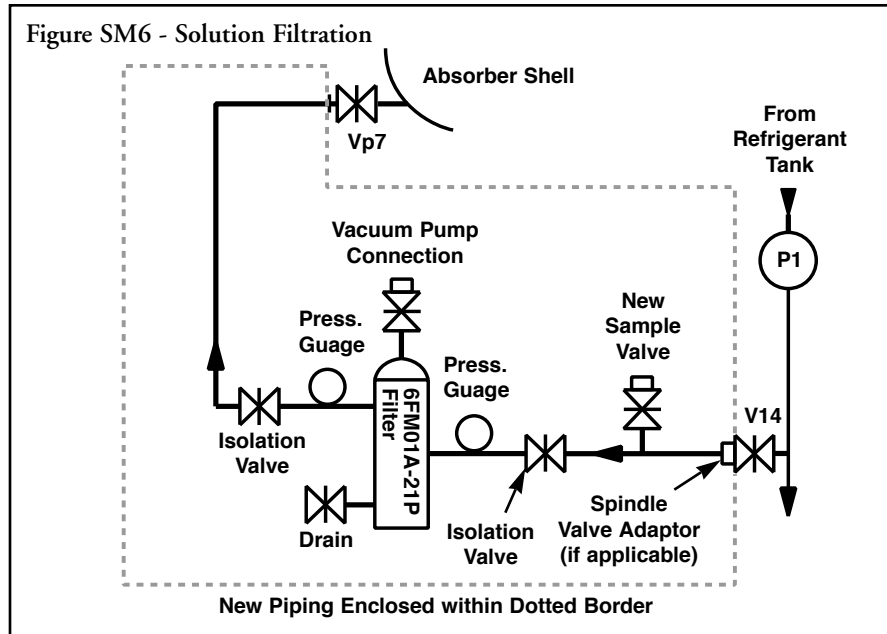
Loctite PST 567 (YORK p/n 013-02280-000)

Loctite Primer "N" (YORK p/n 013-01753-000)

If V14 is a spindle valve, a spindle valve adapter will be necessary to connect the steel piping. Connections may be threaded, provided they are kept to a minimum and the proper sealant is used. All valves with open ends must have a pipe plug installed when not being used. (New sample valve, bleed valve on top of filter and filter drain.)

During pump operation, in most cases, there will be a positive pressure at V14. By throttling Vp7 to control the flow through the filter, a positive pressure will be maintained on the piping which will help prevent air ingress if there were any small leaks. Unfortunately, when the pump shuts off, the piping will all be in a deep vacuum (absorber pressure). If this is of any concern, it is best to instruct the operator to valve off Vp7 and V14 during the dilution cycle on extended shutdowns.

It is important to remember that the filter system is meant to filter only a portion of the total flow of P1 during unit operation, otherwise the unit will suffer from lack of flow to the 1st stage, 2nd stage and Absorber sprays. If the unit has a P1 flow bypass valve (usually called



V20), this could be closed during filtration operation. If filtration is desired when the unit is not operation, of course more flow can be put through the filter (up to 60 GPM). If the unit is equipped with 3 solution pumps, P2 must run at the same time as P1 or solution will not return from the generators.

Actual filter pressure drop will vary depending on the flow through the filter. The setting of Vp7 and the pressure drop should be checked and recorded on new filter cartridges. When the pressure drop increases by 5 psig, check the cartridges. If they are dirty, change them.

Cartridges should be of the Poly-Fine ARD type (spiral wound Polypropylene). The cartridges are available in micron ratings of 1, 3, 5, 10, 20, and 40 um absolute. Typically you should start with 40 u and work down to 3 u, or if you have the time and want to do a super job of cleaning the solution, finish with a 1 u cartridge. Cartridges should have EPDM gaskets. The filter canister O-rings should also be made of EPDM.

Lithium Hydroxide Wash Procedure

A Lithium Hydroxide wash prior to opening a unit for major repairs may pro-

vide beneficial effects for the ferrous metal in the machine. I should be noted that this procedure does nothing to protect the copper and copper alloy tubes which are the main problem when a unit is opened and exposed to air. Care should be taken to follow the instructions so that the recommended amount of LiOH is not exceeded.

With present environmental considerations and discharge rules for sewer systems, the amount of LiOH recommended for the was is 200 ppm lithium hydroxide monohydrate. Use YORK p/n 044-02985-000 (Lithium Hydroxide Monohydrate-5 lb container). This amounts to a pure LiOH content of 114 ppm. This will keep the pH above 11 for the steel. At this level of alkalinity, there should not be any problems with discharging directly into the sewer and residual amounts left in the machine will not alter significantly the alkalinity of the LiBr charge after the wash and repair operation.

The rough procedure is as follows:

1. Drain LiBr solution into drums. If the solution contains dissolved copper, exposure to air will cause the dissolved copper (Cu_2O or cuprous oxide) in solution which is basically clear to change to

a blue solution (CuO or cupric oxide). Dilution of this solution will cause the cupric oxide to precipitate out as a white substance which can be filtered out later when the solution is returned to the machine (use 3 micron Polypropylene Filter). (See Copper Removal on page 9 and Solution Filtration on page 15 for more information)

2. Fill unit with water and circulate hot (approximately 180F) for about 30 minutes. Use a water meter to measure the amount of water necessary to fill the unit. Drain and fill again with water, circulate hot and drain. (City water may be used providing the pH is neutral and the mineral/solids content is within normal boiler feed water specifications.)

3. Fill unit with water containing approximately 9 grams (0.02 pounds) of lithium hydroxide monohydrate per 100 pounds of water. This equates to approximately 0.75 gram per U.S. gallon. Heat, circulate for 30 minutes, and drain. Remove pump assemblies for easy draining. Pumps will have to be disassembled and washed prior to being put back into service.

4. Open system for repairs. When opening inspection windows, final cut through steel should be made using a grinder or saw. **Do not use a cutting torch.** Every effort should be made to keep oxygen out of the unit. Cover all openings with plastic and keep covered unless actually working on the unit. Use a nitrogen or argon purge to help keep air out of the system whenever possible.

5. Install a clean-up filter kit on solution pump (P1) between pump discharge sample valve and the absorber (Vp7). Use a *Filterite* Stainless Steel Filter Housing #6FM01A-21P with *Filterite* 3 micron *Poly-Fine* Pleated Polypropylene Cartridges with EPDM gaskets.

If work related to absorber or evaporator spray header cleaning was done, a 20 mesh stainless steel Spiraz/Sarco Type 527 strainer may be added to the respective spray header supply line. The clean-

able strainer will help prevent future plugging of spray nozzles due to dirt.

All welds must have a **TIG root pass**. No backup rings. The object is to have **no** crevices for corrosion to form in the inside of the unit.

6. After repair work has been completed, the unit should be leak checked by pressurizing with 12 psig of N₂ (rupture disks not installed). After a successful leak check at 12 psig, relieve the pressure and install the rupture disk(s) and leak check to 5 psig.

7. Immediately prior to charging filtered LiBr solution back into the machine, fill the unit with water and drain. A thorough attempt to drain all residual water from the unit should be made. Remaining water must be removed by taking out excess refrigerant while running the unit. Evacuate the unit and charge with solution and refrigerant.

Non-condensables

It could be speculated that over ninety percent of all capacity related complaints on *ParaFlow*[™] units involve the presence of non-condensables.

The most common types of non-condensables found in the purge exhaust, in the order of their probability, are:

Nitrogen - No smell. There may be an air leak. **This non-condensable is the only one that is not self-generated by the unit.** Oxygen contained in the air that leaks into the unit is consumed as it oxidizes the copper tubes and any uncoated steel surfaces. The leak may be very difficult to find. Some leaks do not show up unless the unit is at operating temperature. Put baggies over sample valves, vacuum sealant elsewhere and check again.

Hydrogen Gas - No smell. Much lighter than air. Place a match by non-condensables collected in an upside down, open cylinder. In a popping sound occurs, hydrogen is present, which is a product of corrosion of metal inside the unit. The

presence of hydrogen is an indication that the inhibitor may be depleted. The flammability limits of hydrogen in the presence of air are approximately 4 percent and 75 percent. The point being, that it is difficult to determine whether non-condensables are solely hydrogen based on a "pop" test. Try inflating a small balloon. If it floats, chances are that a large portion of the gas is hydrogen.

NH₃ - Ammonia. Colorless, pungent gas which is extremely soluble in water. It is lighter than air. Most of the ammonia in a unit will remain dissolved in the refrigerant water or solution, however, depending on the amount of ammonia in a unit, some will find its way into the purge system.

NO_x - Several compounds of nitrogen may be produced by a *ParaFlow*[™] unit. Although not nearly as common as hydrogen, one or more of these compounds may be produced, usually after a unit has been exposed to high temperatures such as during crystallization or severe overfiring.

N₂O - Nitrous Oxide. Colorless, somewhat sweet smelling although the odor of the alcohol in the purge gas may overpower any odor it may have. 1.5 times as heavy as air. Supports combustion much like oxygen. Commonly referred to as laughing gas.

NO - Nitric Oxide. Colorless, slightly heavier than air, does not support combustion, and usually oxidizes to NO₂ when exposed to air.

NO₂ - Nitrogen Dioxide. Reddish brown gas, 1.6 times heavier than air, very soluble in water, unpleasant odor, and poisonous.

N₂O₄ - Nitrogen Tetroxide. Pale yellow gas formed as two molecules of NO₂ combine to form one molecule of N₂O₄.

Alcohol

C₈H₁₈O - 2-EthylHexyl Alcohol - This is an octyl alcohol sometimes referred to as 2-Ethyl-1-Hexanol. It is a colorless liquid having a molecular weight of 130.22. The specific gravity is 0.8344, so it is lighter than water. The boiling point is 184-185C, and the flash point is 81C. It dissolves about 2.5% its weight in water at 25C.

The alcohol is used to provide better heat transfer in the absorber. It promotes a type of convection called *Marangoni Convection* in the solution film that collects on the outside surface of the absorber tubes. The alcohol may account for slightly more than fifteen percent of the unit total capacity.

All *ParaFlow*TM units have alcohol traps. The purpose of the alcohol trap is to separate the alcohol that gets carried over to the condenser from the refrigerant. Alcohol is returned from the trap to the solution where it needs to be. The proper amount of alcohol is a definite visible layer on top of the solution as observed in the sight glasses of the absorber during part load conditions. The layer may be as small as 1/8 inch in thickness.

A sufficient amount of alcohol is added to the unit at the factory. Over time, some of the alcohol will exit the unit via the purge gas. This amount is generally very small. Seldom is it necessary to add alcohol. **Too much alcohol will have the opposite effect and reduce the capacity of the unit.**

Refrigerant Blowdown

Over a period of time the refrigerant water will become contaminated with solution. The rate at which this occurs is largely dependent on the manner in which the unit is operated. Many starts and stops, rapid load fluctuations and large tower water temperature changes are some of the things that may cause increased rates of contamination. Small amounts of solution in the refrigerant is normal, however, as the amount of solu-

tion in the refrigerant increases, a reduction in cooling capacity will occur.

On standard units, purification of the refrigerant is accomplished by manually opening the blowdown valve (normally V8) for a period of time. The opening of the valve allows a portion of the refrigerant being pumped by the refrigerant pump to flow into the solution in the absorber shell. This operation is continued until the level of the refrigerant in the refrigerant tank is just above the refrigerant pump suction connection. Usually this level can be observed in the lower sight glass of the refrigerant tank. The valve is then closed and the blowdown process is complete.

The refrigerant will gradually return to the refrigerant tank as it is boiled out of the solution, but it should return in a more pure state. In other words, the refrigerant purification or blowdown is basically a distillation process.

The best time to low down a unit is just after start-up, when the refrigerant level is fairly low in the tank. Occasionally it may be necessary to blow the refrigerant down more than once at low load. To do this, close the blowdown valve which will let the level rise back up again, then open the blowdown valve again until the level falls again. If you try to blow down the refrigerant at full load, the rate at which the refrigerant is being replenished by the condenser may be greater than the blowdown rate, consequently, the level will never fall in the tank. This is not to say purification will not occur, only that it is difficult to know when to stop the process.

There will be a noticeable reduction in unit cooling capacity while the blowdown valve is open.

The method used to measure the amount of solution contamination in the refrigerant requires special tools and procedures and is best left to the YORK Service Engineer. At the time of start-up, the YORK Service Engineer should train the operating personnel in the proper blow-

down procedure. He will also measure the actual amount of refrigerant contamination in the unit after start-up and he will check the contamination level at each subsequent inspection visit during the first year of the units operation. He should let the operating personnel know if the blowdown frequency is sufficient.

Refrigerant Quality

The refrigerant used in the *ParaFlow*TM unit consists of de-ionized water. Should it be necessary to charge refrigerant into a unit, a de-ionizing unit may be used to process ordinary tap water. A reverse osmosis system can also provide de-ionized quality water. Usually local water treatment companies will rent a *mix bed* de-ionizer tank with an indicator light that will tell you when the tank needs recharging. Each charge is normally good for over a thousand gallons of water.

The allowable impurities after conditioning can be found below.

Refrigerant Impurity Limits

ph	7
Hardness (Ca, Mg)	20 ppm
Oil	0 ppm
Cl	10 ppm
SO ₄	50 ppm
Na, K	50 ppm
NH ₃	0 ppm
Cu	5 ppm

ParaFlow™ Solution Sampling Procedures

Taking a Sample for Laboratory Analysis

Suggested Tools and Materials:

Spindle Valve Adapter
 Allen Wrench (Metric 10mm)
 Barbed Fitting (1/4" barb x 1/2" MPT)
 Hydrometers
 Clear Vacuum Hose (YORK p/n 028-12514-000)
 Hose Clamps
 Protective Face Shield and Gloves
 Solution Sample Kit-[Order from Analysts, Inc.-(800)222-0071]
 Silicone Vacuum Grease (Dow Corning)
 Plastic Bucket (2-5 gal)
 Hydrometer Flask (150 ml)
 Pipe Sealant (Loctite 567 and Primer N)
 Loctite Cleaner 7070
 Vacuum Flask
 Small Plastic Funnel (50 ml)

Caution: When taking samples, wear a full face shield, protective gloves and apron to avoid the danger of hot solution splashing on the skin or eyes. Do not use glass sample flasks. Use polypropylene or other vacuum suitable, laboratory grade plastic containers.

To take a solution sample for lab analysis, it is very important to get a representative sample from the unit. Incorrect sampling techniques could lead to a sample that is not a true indicator of the system chemistry.

Strict adherence to the following rules when taking a sample for lab analysis is strongly advisable.

1. The unit should be running in the **cooling** mode for at least 4 continuous hours prior to taking the sample.
2. New units or units where chemicals have recently been added should be allowed to run until the purging of non-condensables has subsided (this may take a week or more) before resampling.

3. If a unit has recently been de-crystallized, do not sample it until it has run at least 8 hours without any signs of crystallization.

4. Remove the sample from the main solution pump (P1) discharge sampling valve. This point should be in a positive pressure when the pump is running, although it is always best to prepare the sampling flask as though a vacuum is present. **Do not allow air to enter the unit!**

5. Before taking the sample, put the unit into a dilution cycle and blow down the refrigerant so that the sample is as dilute as possible. Allow the dilute solution to circulate for a few minutes before taking the sample. *Samples taken with high concentrations have been found to be more prone to inaccuracies, and they may crystallize en route to the lab.* Crystallized samples will not be accepted by the lab.

Do not submit solution samples with concentrations in excess of 55%.

6. Always wash out the sample apparatus with at least one sample before taking the actual sample for analysis.

7. Do not use copper or brass fittings when taking samples.

8. Use clean, plastic (polypropylene or nalgene) containers to draw and handle solution samples. Do not use glass.

9. Generally speaking, for preventive maintenance purposes, two samples should be taken on each unit per year. One at the beginning of the cooling season and one near the end. After chemical corrections are made to a unit, resampling should be done as necessary.

How to Take the Sample

In order to take a sample from any sample point on the unit, it is necessary to connect a sample flask using the proper fittings and suitable vacuum tubing.

Be aware that if the unit is equipped with

spindle-type valves for sampling (all USA built ParaFlow™ units have spindle-type sampling valves), you **must** use a special *spindle valve adapter fitting*. The spindle valve has a special internal straight tread. If you screw in a 1/2" pipe nipple, it may appear to work, however, it will leak and possibly damage the internal valve threads.

Never assume that a sample point is in a positive pressure. Units will vary. Although on most "G" Model units, it is normal for the main solution pump (P1) discharge to be in a positive pressure, however, this is only the case when the pump is operating and turning in the correct direction.

Evacuate the sample flask to a pressure lower than the sample point so that the solution will flow into the sample flask and air will not enter the unit. To do this, you may use the unit purge pump, install a tee and an isolation valve between the manometer and the purge piping. The manometer is used as the vacuum indicator when evacuating the sample flask. Since accidents do happen, it is a good idea to install a trap of some kind between the sample flask and the manometer. The refrigerant removal tank may be used for this purpose. When connecting hoses to fittings, the use of vacuum grease will ease installation and help prevent air leaks.

After completing the tubing connections to the sample flask, open the valve to the flask and any isolation valves between the flask and the vacuum source. Evacuate the flask to 1-3 mm Hg absolute. Slowly open the sample valve until solution or refrigerant begins to flow into the flask. Hold the sample flask so that the incoming solution does not exit the flask through the vacuum connection to the flask and then close the unit sample valve. It is not important what order the valves are closed in, but it is very important to avoid introducing air into the unit or sucking solution into the vacuum pump. After ensuring that the sample valve is completely closed, remove the sample flask. To break the vacuum in the sample

flask, hold the flask upright and slowly open the valve on the vacuum connection of the flask. Pour the contents into a hydrometer flask. Empty the contents of the hydrometer flask into a bucket. This solution may later be returned to the system. Its purpose was to wash out the sample apparatus and flush the sample valve. Never use the first sample drawn.

Re-install the sample flask and repeat the above procedure.

Using an accurate thermometer, measure the temperature of the second sample. Gently stir the thermometer in the solution until the temperature stabilizes. Record the temperature. Select a hydrometer that is in the correct density range of the sample liquid. Normally, this will be the 1.600-1.800 hydrometer. Carefully read the specific gravity of the liquid and record it. Using the solution tables, find the concentration equivalent to the specific gravity and temperature of the sample. It should be less than 55% for lab analysis purposes.

Remove the two sample bottles and one piece of the filter paper from the Solution Sample Kit. Fill the larger of the two bottles (4 oz.) with the solution from the hydrometer flask. Replace the cap tightly. Using one piece of the filter paper, fold it into quarters so that it fits into a small funnel. Place the funnel into the smaller sample bottle (2 oz.) from the kit. Pour solution from the hydrometer flask into the filter paper in the funnel and carefully allow the smaller bottle to fill with filtered solution. This may take some time. When the bottle is nearly full, replace the cap, insuring it is tight.

Be sure both bottles have a tracking number label on them and that the tracking number matches the label on the Sample Submittal Form.

Carefully fill the Sample Submittal Form completely, making sure that all data is printed in a legible fashion. **The unit serial number is the tracking identification for future trending of analysis data, so it is very important that the number**

is totally correct.

Keep the yellow and pink copies (the pink copy maybe given to the customer) of the Sample Submittal Form and **put the original white copy of the form with the tracking number label that matches the bottles** back in the Sample Kit Box along with the two samples. Be sure the laboratory address label is on the outside of the box. Seal the box and mail it immediately. Postage is *not* prepaid.

Lithium Molybdate Inhibited Solution

What is Lithium Molybdate?

Lithium Molybdate is a chemical compound that is added to the Lithium Bromide solution to act as a corrosion inhibitor much the same as the Lithium Nitrate is. It protects the steel surfaces within the unit by forming a dense boundary layer of magnetite magnetic iron oxide). Using the same comparisons as we made in the beginning of this manual, Lithium Molybdate can be considered one of the *good guys*.

Actually, when we refer to *York* Lithium Molybdate inhibited solution, we are referring to a specific inhibitor blend. We even have some lithium nitrate in the blend. The nitrate helps prevent annoyingly large accumulations of hydrogen within the unit while the magnetite layer is forming. As the unit ages, the nitrate is depleted. Since the magnetite layer should be completely formed by the time the nitrate is depleted. Since the magnetite layer should be completely formed by the time the nitrate is depleted, there will normally be no need to add additional nitrate throughout the life of a unit.

Alkalinity is maintained at a slightly higher level for molybdate inhibited solution. Be sure to use the correct chart for adding Lithium Hydroxide to Molybdate Inhibited solution when calculating amounts of LiOH to add.

Lithium Molybdate may not be added to

Lithium Nitrate inhibited solution. If for some reason it becomes necessary to replace the entire charge of a nitrate inhibited unit, the new charge may be Lithium Molybdate inhibited solution.

York Lithium Molybdate Inhibited Solution is shipped on a 55% weight basis. This differs from the 53% Lithium Nitrate Inhibited Solution. All control parameters for the molybdate inhibited solution are therefore based on 55%. Don't forget to correct laboratory results to 55% when checking if they are within the allowable range.

To summarize, the following are the points to remember about York Lithium Molybdate inhibited Lithium Bromide solution:

- Corrosion Inhibitor
- Blend of Ingredients
- Slightly Higher Alkalinity
- 55% LiBr Weight Basis
- Do Not Mix With LiNO₃

The above table is based on a solution

Lithium Molybdate (Li_2MoO_4) Inhibited Solution Parameters Based on 55% LiBr by weight

Item	New Solution	Control Range	Remarks
LiOH	.22-.28 wt.% .147-.187 N	.21-.28 wt.% .14-.187 N	Alkaline solution protects the steel
Li_2MoO_4	159-189 ppm 258-306 mg/l	140-200 ppm 225-325 mg/l	Higher than 200 ppm will not dissolve
LiNO_3	< 28-44 ppm < 46-72 mg/l	< 48 ppm < 76 mg/l	LiNO_3 is only necessary in brand new units. Do not replenish LiNO_3
Ammonia	< 2ppm	< 31 ppm < 50 mg/l	Ammonia should not be a problem on Molybdate units
Copper	< 1 ppm	< 31 ppm < 50 mg/l	High copper content is a result of air getting into the unit

concentration of 55% by weight. Unless your lab sample is at exactly 55% concentration, you will have to convert its results to 55% before being able to determine if the results are acceptable or not. To convert from concentrations other than 55% use the following formula to derive a *correction factor*:

$$\text{correction factor} = \left\{ \left(\frac{55}{\text{other concentration}} \right) \left(\frac{1.62}{\text{other specific gravity}} \right) \right\}$$

Multiply the parameter you wish to convert to the 55% basis by the correction factor.

For example, you receive a sample analysis from a unit you are working on with a solution concentration of 50%, a specific gravity of 1.53, and a lithium molybdate content of 200 mg/l. You are not to be able to determine if the amount of molybdate in the unit is sufficient or not since the sample value is based on 50% solution and the table above is based on 55% solution. You must correct the molybdate value to 55% before being able to determine if the amount of lithium molybdate in the unit is sufficient. Using the formula above, a correction factor can be obtained.

$$\left\{ \left(\frac{55}{50} \right) \left(\frac{1.62}{1.53} \right) \right\} = 1.165 \text{ (correction factor)}$$

The correction factor (1.165) can now be used to convert any of the values in the example sample analysis to a 55% basis.

For the molybdate value the following calculation is made which gives the converted value of 233 mg/l lithium molybdate at 55%.

$$200 \text{ mg/l (at 50\%)} \times 1.165 = 233 \text{ mg/l (at 55\%)}$$

From the table above, it can be seen that the corrected molybdate value is just inside the lower end of the molybdate control range.

The same correction factor is used to convert the other parameters (alkalinity, ammonia or copper) from a 50% to 55% basis.

Lithium Molybdate Replenishment Procedure

When the solution analysis results indicate that it is necessary to add Li_2MoO_4 to the unit, use the following procedure to calculate the amount of Li_2MoO_4 necessary.

Warning: Working with chemicals such as Li_2MoO_4 requires that the user exercise extreme care. The use of face and eye protection, rubber gloves and apron is mandatory. Never work with chemicals without first reading the appropriate Material Safety Data Sheet.

Useful Information:

1 gal = 4 qts = 3.785 liter
 1 kg = 2.2 lb
 1 kg = 1000 gm = 1,000,000 mg

$$\text{ppm} = \frac{\text{mg/l}}{\text{specific gravity (S.G.)}}$$

$$\text{mg/l} = \text{ppm} \times \text{specific gravity (S.G.)}$$

S.G. of water = 1 kilogram per liter (kg/l)
 = 8.33 lb per gallon (lb/gal)
 = 2.2 lb per liter (lb/l)

S.G. of 55% LiBr = 1.62 kilogram per liter (kg/l)
 = 13.49 lb per gallon (lb/gal)
 = 3.56 lb per liter (lb/l)

Li_2MoO_4 (1 lb bag) = YORK p/n 011-00557-000

1. Determine the present amount of Li_2MoO_4 in the solution based on 55%.

If it hasn't already been done the present Li_2MoO_4 content in the solution must be taken from the lab analysis and converted to mg/l of 55% LiBr by weight. If the lab analysis result shows the Li_2MoO_4 content in mg/l at some other concentration and specific gravity, use the formula at the top of page 19iv to calculate the present amount of Li_2MoO_4 in the solution corrected to 55% LiBr. If

the corrected amount of Li_2MoO_4 is less than 225 mg/l, then it is necessary to add inhibitor.

2. Determine the amount of Li_2MoO_4 to add to the unit.

Using the Li_2MoO_4 in mg/l corrected to 55% from Step 1, refer to the chart on page 19iv to find the amount of Li_2MoO_4 to add per pound of 55% solution in the unit.

The amount of solution in the unit can be obtained from the Factory Test Report (if the actual amount of solution in the unit is different from the amount on the test report, use the actual amount). After finding the amount in pounds to add per pound of 55% solution in the unit, multiply that number times the total solution charge in pounds to arrive at the total amount of Li_2MoO_4 in pounds to charge into the unit.

3. Charging inhibitor into the unit.

Inhibitor charging should only be done during the cooling season. The unit should be operating during this procedure.

The total amount of powder inhibitor necessary should be mixed with ten (10) times its weight in refrigerant removed from the unit.

Refrigerant from the unit will normally be alkaline in nature. If there are any doubts concerning this, check the refrigerant alkalinity prior to using it. Mixing powdered Lithium Molybdate in water or refrigerant where the pH is less than 7.0 (neutral) will cause the inhibitor to form undesirable compounds.

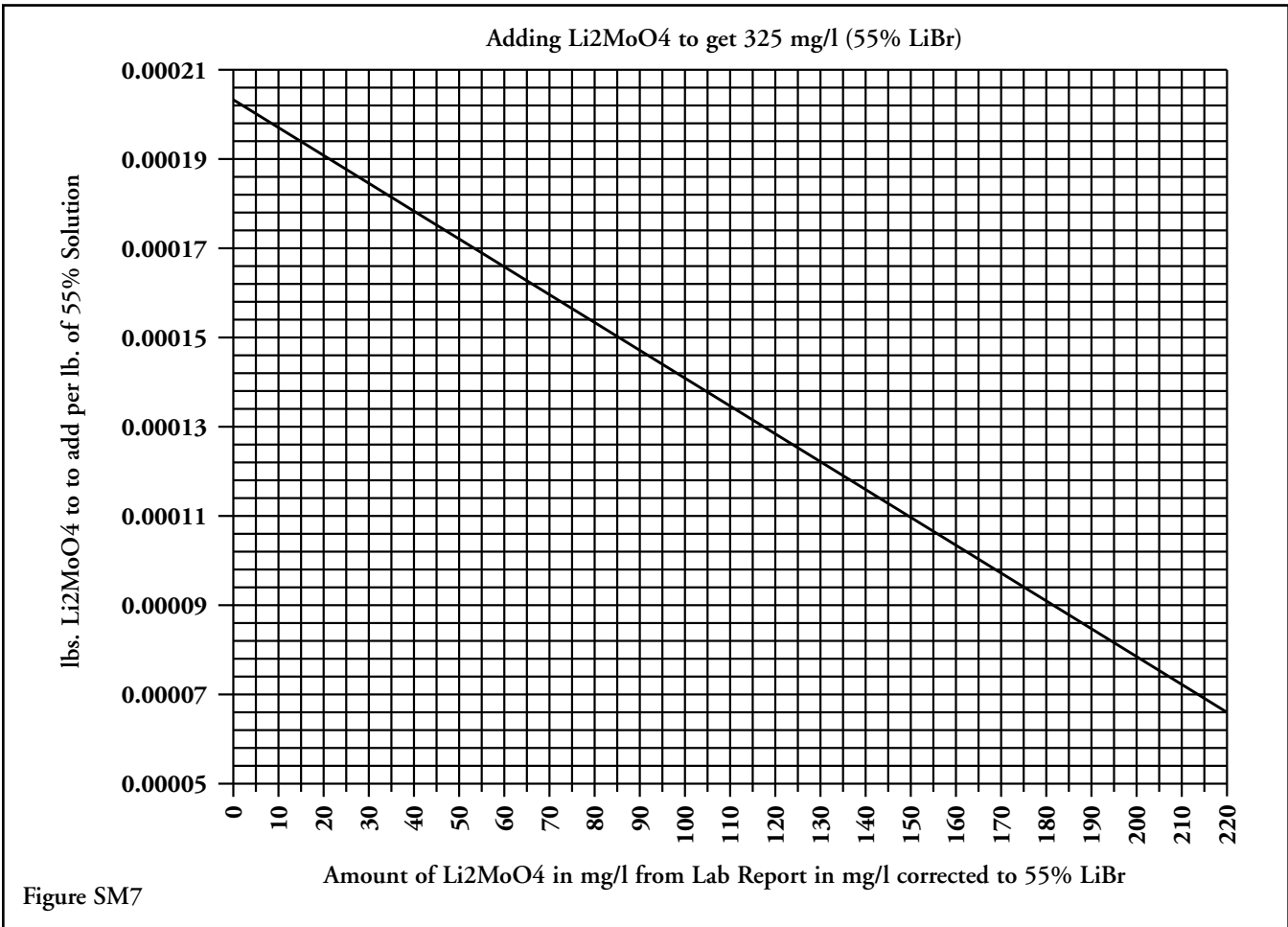
Calculate the amount of refrigerant necessary by multiplying the total weight of the Li_2MoO_4 inhibitor by 10. If, for example, the required amount of Li_2MoO_4 was .455 lb, we would multiply .455 x 10 which results in 4.55 lb of refrigerant or slightly more than 1/2 US gallon. The refrigerant should be removed from the unit using the refriger-

ant removal tank. Connect the purge pump to the connection on the refrigerant tank that has the shortest pipe and connect the other connection to the refrigerant sampling valve V11 at the discharge of the refrigerant pump (P3). Evacuate the refrigerant removal tank until the tank pressure has been lowered to 20 mm Hg absolute. After the tank has been evacuated, open the refrigerant sampling valve (V11) while the refrigerant pump is running and allow the refrigerant to flow into the tank. The tank holds approximately 2.5 US gallons, so judge the level accordingly. After the correct amount of refrigerant has been removed, close V11. Mix inhibitor with the refrigerant in the tank, taking care that all of the inhibitor has dissolved. Using the existing hose that is connected to V11, attach a piece of plastic pipe to the end of the hose stopper connection. Fill this hose up with the refrigerant/inhibitor mixture in order to displace any air in the hose. Immediately plunge the end of the hose with the pipe connected into the refrigerant/inhibitor mixture. Open the refrigerant sampling valve and allow the refrigerant/inhibitor mixture to be drawn into the unit.

Be very careful to shut the sample valve before the hose end is uncovered so that air is not drawn into the unit.

Run the unit in the cooling mode for a few minutes. While the unit is running, remove some additional refrigerant from the unit into the tank and then repeat the procedure to suck this refrigerant back into the unit, again taking care not to introduce air into the unit. This serves to flush the refrigerant tank and hoses of inhibitor mixture. Continue running the unit for thirty (30) additional minutes in the cooling mode. While the unit is still running, open valve V8 and blow the refrigerant into the absorber until the refrigerant level is visible in the lower sight glass of the refrigerant tank. If the unit is running at full load, it may not be possible to lower the level to the bottom sight glass. If this is the situation, blow down the refrigerant for 30 minutes and then close valve V8. Operate the unit in

$$\text{mg/l of Li}_2\text{MoO}_4 \text{ from Lab Report} \times \frac{55}{\text{sample concentration (\%)}} \times \frac{1.62}{\text{sample specific gravity}} = \text{mg/l of Li}_2\text{MoO}_4 \text{ corrected to 53\%}$$



the cooling mode for at least another 30 minutes before shutting the unit down.

4. Purging frequency for first week after adding inhibitor.

Note: More frequent purging will be necessary for about 1 week after the addition of inhibitor. This is because addition of Li₂MoO₄ will cause increased hydrogen generation in the unit for about a week. It may be necessary to change the purge pump oil more frequently during this period, perhaps as much as once every 2 days.

Lithium Hydroxide Content in Molybdate Inhibited Units

The alkalinity of the solution in molybdate inhibited units is kept slightly higher than the solution in the nitrate inhibited units.

Since the allowable range of alkalinity is based on 55% LiBr solution in Molybdate Inhibited Units, sample results also must be converted to a 55% basis.

Use the formula below to convert from another concentration basis. If the alkalinity of the converted result is less than .147 N, refer to the chart to find out how

many pounds of Lithium Hydroxide *Monohydrate* must be added *per pound* of 55% solution in the unit. Refer to the Factory Test Report for the amount of 55% solution contained in the unit. If solution was removed or added in appreciable amounts at the job site, use that adjusted amount of 55% solution to determine the amount of Lithium Hydroxide to add.

Refer to *Lithium Hydroxide Replenishment Procedure for Nitrate Inhibited Units* on page 7 for specific instructions on how to add the Lithium Hydroxide into the unit. Remember to use the amount derived from the chart below in the procedure, ignoring the references to 53% solution in the Nitrate Unit Procedure.

$$\text{LiOH (N) from Lab Report} \times \frac{55}{\text{sample concentration (\%)}} \times \frac{1.62}{\text{sample specific gravity}} = \text{LiOH (N) corrected to 55\%}$$

Adding LiOH in Molybdate Inhibited Solution (55%) to get .187 N

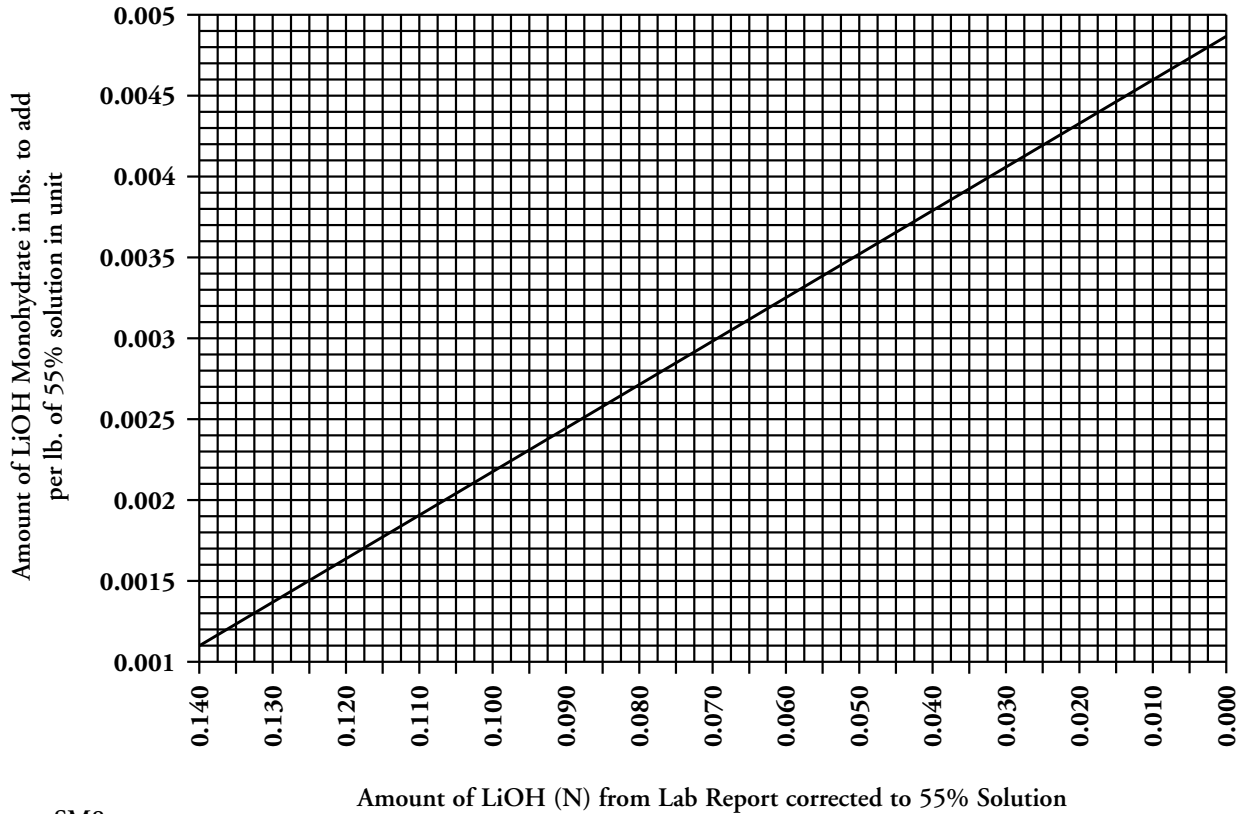


Figure SM8