

Extending the Life of Your ParaFlow Unit

Introduction

Trending data is vital to the longevity of a ParaFlow™ absorption unit. Trending gives the operator an early warning sign that problems are about to develop. Two items that must be monitored closely are the quantity of non-condensable production and the solution chemistry in the machine.

Both of these items, if not monitored properly, will most certainly lead to poor system performance and decreased unit life due to internal corrosion.

The key to extending the life of ParaFlow™ machines is to maintain the solution chemistry within the Factory specified ranges at all times and find and repair leaks (no matter how small) as quickly as possible.

This section will focus on non-condensable monitoring and trending.

Non-Condensable Monitoring

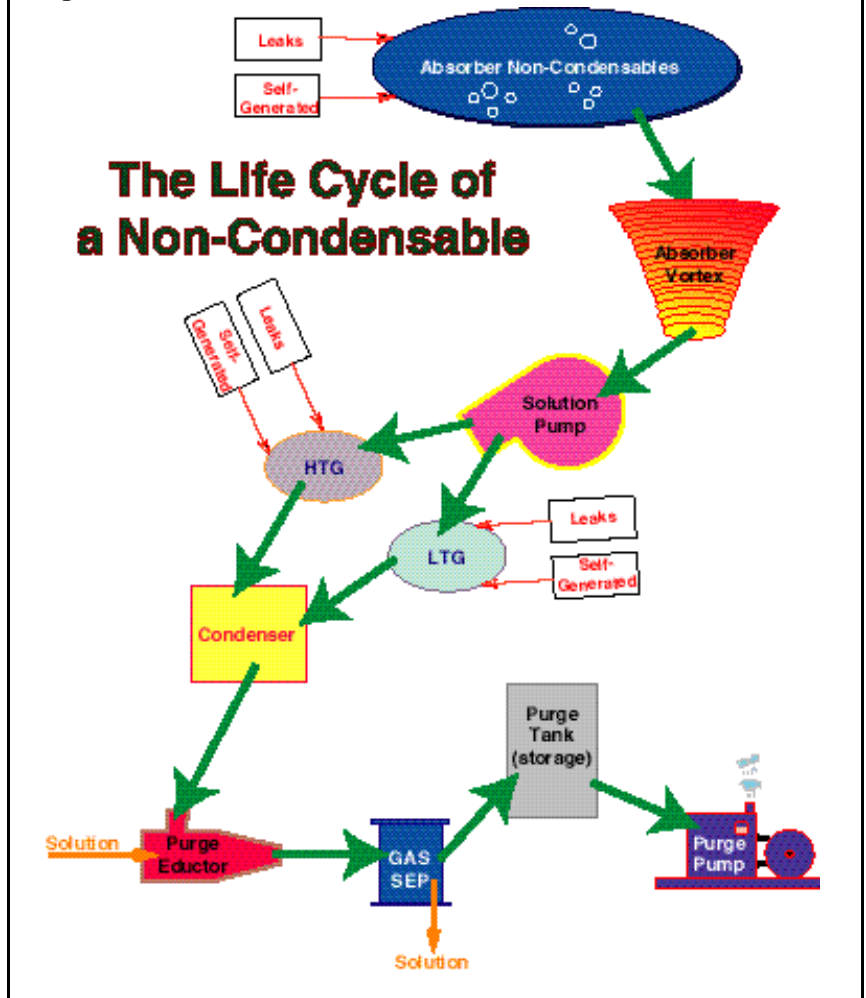
Monitoring non-condensable production in the purge tank is the easiest way to determine the present health of a ParaFlow™ unit. It is also an essential diagnostic tool to determine if a solution chemistry imbalance has occurred and/or an air leak is present.

The previous philosophy was to purge the machine daily for a fixed time period whether or not it needed it. Purging daily without monitoring purge tank pressure simply keeps the machine on line. An invaluable troubleshooting tool is being wasted. Also, operators have a tendency to walk away from the unit once the purge pump is on. If a power failure occurs or solution begins to flow out of the machine, no one is there to catch it.

What is a non-condensable?

A non-condensable is defined as a gaseous substance that cannot be liquefied or condensed at the pressure and temperature surrounding it.

Figure 1



Non-condensables may be generated internally or they may be drawn in from outside due to the low system pressures.

Internally generated non-condensables include such things as, hydrogen (H^+), Ammonia (NH_3), NO_x gases, and Nitrogen (N).

Hydrogen - a byproduct of corrosion. Hydrogen in the purge gas indicates corrosion in the machine. Hydrogen in molybdate inhibited machines (even with normal molybdate levels) indicates that the protective magnetite (Fe_3O_4) layer has broken down. Nitrate must be added in these instances to help reform the layer and control hydrogen gas generation (Refer to solution chemistry section for details).

Ammonia (NH_3)- Both nitrogen and hydrogen must be present for ammonia generation to occur. The nitrogen

molecule comes from the depletion of the Lithium Nitrate (LiNO_3) inhibitor in the machine. Ammonia is typically present in nitrate inhibited units only. Although rare, copper tube stress cracking has been linked to the presence of ammonia in absorption units.

NO_x Gases - NO_x gases are formed due to a rapid depletion of the Lithium Nitrate inhibitor (LiNO_3). Typically NO_x gases will be noticed when air leaks are present. High operating generator temperatures, typically caused by over firing of a machine has also been linked to NO_x production (Refer to the solution chemistry section for details).

External gases will enter the machine through a leak. The constituents of air are the most common gases, however any gas that is present around a leak can be sucked into the unit.

Non-condensables will make their way through the unit and eventually end up in the purge tank. Refer to **Figure 1** (Life Cycle of a Non-Condensable) for a graphical representation of how non-condensables flow through a ParaFlow™ chiller.

The purge tank is isolated from the system through the use of a liquid (solution) trap. This trap is capable of holding about 100mmHg before its seal is broken and non-condensables flow back into the absorber. Because all the non-condensables eventually end up in this iso-

lated purge tank, it is possible to monitor this tank's pressure over time to determine the magnitude of the non-condensable production. Trending this information can lead to a quick diagnosis of a problem before it becomes a major issue (i.e. increased corrosion rates, reduced performance, etc.). Refer to **Figure 2** for a schematic view of the purge system piping.

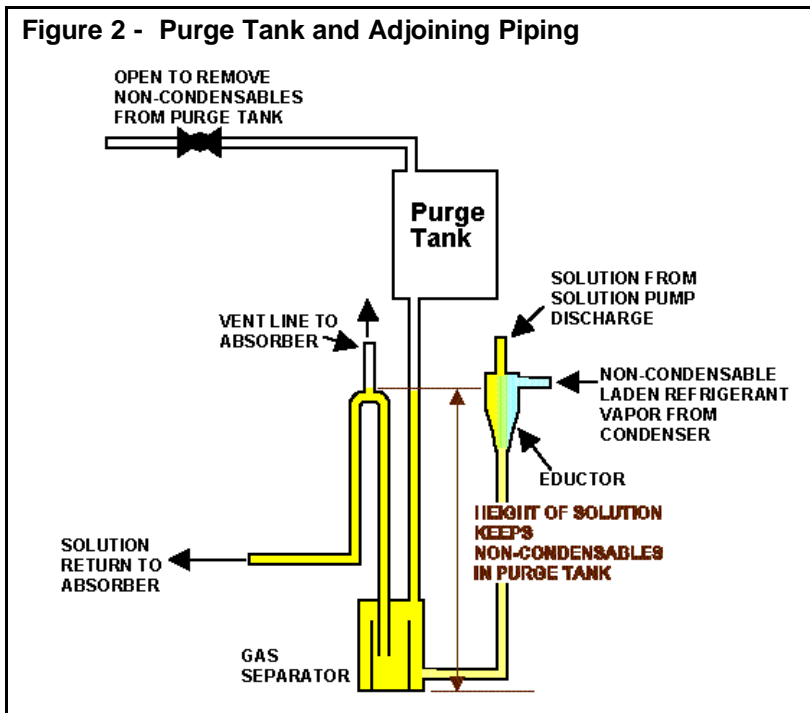
Logging the Data

In the past, the volume of gas was collected in a graduated cylinder from both the absorber and purge tank and a leak rate in cc/min. was calculated. This test is difficult to conduct and does not always give a true indication of the condition of the machine (test is dependent on how well the vacuum pump is working). A much simpler test is to monitor the pressure in the purge tank over time. The **Purge Log Form** illustrated in **Figure 3** should be used to monitor such non-condensable production. A blank form is located at the end of this bulletin.

The following information must be recorded daily on the ParaFlow™ Purge Log Form:

Job Name, Model Number and Serial Number - Used to identify the chiller.

Date - The two weeks ending date on the form should always end on a Saturday.



Purge Tank Pressure (mmHg) - The purge tank pressure can be read using the systems absolute pressure gauge. This is usually in the form of a mercury manometer. With VP2 open and all other purge valves closed, read the pressure at the manometer. The pressure is read as the total height of the mercury column.

Pressure Difference (mmHg) - The pressure difference is defined as the amount of pressure build-up in the purge tank over a 24 hour interval. It is determined by simply taking today's pressure reading and subtracting from it, yesterday's reading.

Was purging performed? - Purging is to be performed only when the purge tank pressure exceeds 60 mmHg. When purging is required, purge the tank down to 30 mmHg.

Figure 3 - Sample Purge Log Form

YORK INTERNATIONAL CORPORATION
ParaFlow™ Purge Log Form
 (TO BE FILLED OUT BY OPERATOR DAILY)

Job Name: _____

Unit Model Number: _____ Unit Serial Number: _____

Two Weeks Ending (Insert Date): _____ Average Load (%): _____ Average Ambient Temp: _____

Day	Purge Tank Press. (mmHg)	Pressure Difference (mmHg)*	Purging Performed?	If so, purged down to (mmHg)	Operators Initials
Sunday					
Monday					
Tuesday					
Wednesday					
Thursday					
Friday					
Saturday					
Sunday					
Monday					
Tuesday					
Wednesday					
Thursday					
Friday					
Saturday					

The purge tank pressure (through VP2) must be monitored on a daily basis. Take the readings at the same time each day. Purging is required only when the tank pressure exceeds 60 mmHg. If purging is required, purge tank down to 30 mmHg.

Note: * The pressure difference column is the difference between today's pressure reading and yesterday's reading. It is this value that should be plotted in the graph below. If purging is required, log the final purge tank pressure in the column (if so, purged down to) above. It is this value that must be used to determine the following day's pressure difference.

Plotting The Pressure Difference Trend

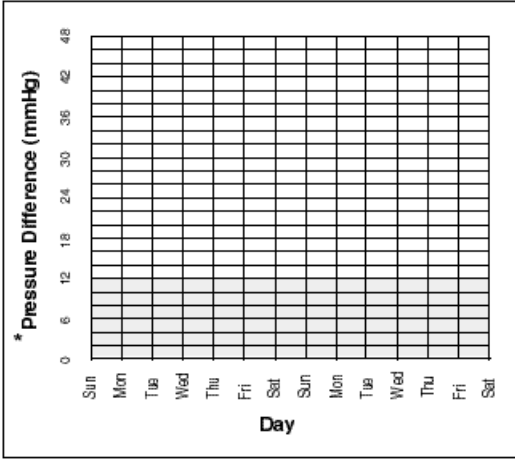
1. Plot the pressure difference for each day above on the chart to the right.

2. Monitor the trend over time.

The trend should remain flat and in the gray area at full load operation. Flat trends above the gray area indicate small air leaks. Leak test using recommended Factory procedures.

If the trend increases gradually over time, the unit has developed a solution chemistry imbalance or small air leak. Take a solution chemistry sample and send to lab for analysis. Make correction as necessary. If trend falls into the shaded area after the chemicals have been added and stays there, the problem was simply related to solution chemistry. Otherwise, an air leak is present. Leak test the unit and repair immediately. If no chemical additions were necessary, an air leak is present. Leak test the unit and repair immediately.

If the trend increases very quickly, as in a few days, the unit has most likely developed an air leak. Leak test the unit and repair immediately.



(after purging) must be recorded, so an accurate pressure difference can be determined the following day.

Initials - Operators should write their initials in the spaces provided.

Remember these simple rules:

1. The readings should be taken at the same time each day (24 hr. intervals).
2. Purge only when the purge tank pressure reaches 60 mmHg.
3. Purge down to 30 mmHg.

Note: The purge system must be functioning properly for these log readings to have meaning. Non-condensables only accumulate in the purge tank while the machine is in good working condition. A simple way of determining if the purge system is operating efficiently is to check for a temperature rise across the purge eductor. Purge eductors for both S and G series machines are illustrated in **Figure 4**. The temperature of the solution leaving the eductor will be between 3-10 degrees higher than the temperature entering. The solution is heated because it is being diluted by the induced refrigerant vapor coming from the condenser.

The purge tank pressure should never be allowed to exceed 100 mmHg. If the pressure in the tank exceeds this value, the non-condensables will be forced back into the absorber section. Crystallization will most likely occur.

If purging was performed, to what pressure was the tank reduced to? - The purge tank should not be purged below 30 mmHg. Solution can be sucked out of the purge piping and into the vacuum pump if the absorber pressure is elevated. Obviously, it is not always possible to purge to exactly 30 mmHg. The actual purge tank pressure

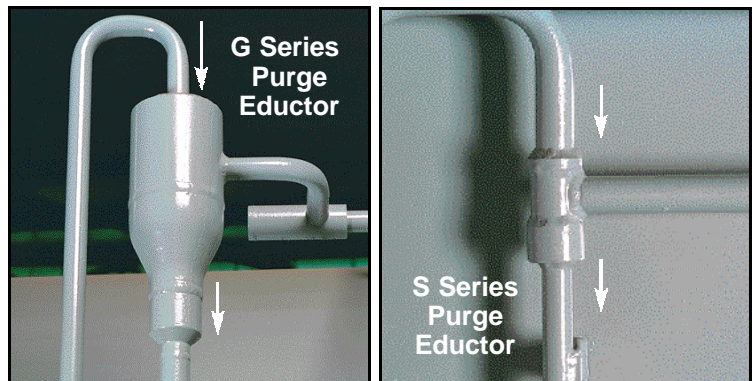


Figure 4 - Purge Eductor G and S Series Units

Trending Pressure Differences

Figure 5 shows a completed form over a two week period. The information at the top of the form was filled in to identify the unit.

The purge tank pressures were logged in the first column and pressure differences were calculated and logged in the second column. When the purge tank reached 60 mmHg, the tank was purged to 30 mmHg.

Note: If the tank is pulled down below this pressure, it is this pressure that should be written in the fourth column (If so, purged down to (mmHg)).

The operator's initialed the form in the appropriate boxes.

For each day, the pressure difference was plotted on the graph at the bottom of the log form.

Points are connected with straight lines to form a curve.


This graph gives a visual trend over time and eliminates the need to have to re-examine the data in the future.

Deciphering the Data

Examining the data in Figure 5, the following conclusions can be made.

1. The machine is generating a constant rate of non-condensables as shown by the flat line on the graph.
2. The plotted curve is contained within the shaded area of the graph indicating that the machine is most likely producing an acceptable amount of non-condensables.
3. The solution chemistry of the machine is within Factory specifications indicative by the flat curve. (Refer to the solution chemistry section for further details).
4. No noticeable air leaks are present in the machine.

Figure 5 - Completed Purge Log Form



ParaFlow™ Purge Log Form

(TO BE FILLED OUT BY OPERATOR DAILY)

Job Name: York International Corporation

Unit Model Number: YPC-FN-13SC Unit Serial Number: HFBM100000

Two Weeks Ending (Insert Date): 7/12/97 Average Load (%): 95% Average Ambient Temp: 85°F

Day	Purge Tank Press. (mmHg)	Pressure Difference (mmHg)*	Purging Performed?	If so, purged down to (mmHg)	Operators Initials
Sunday	30	--			RWN
Monday	35	5			RWN
Tuesday	41	6			BH
Wednesday	46	5			RWN
Thursday	50	4			BH
Friday	55	5			RWN
Saturday	61	6	Yes	30	RWN
Sunday	35	5			JAB
Monday	39	4			BH
Tuesday	45	6			RWN
Wednesday	51	6			RWN
Thursday	57	6			BH
Friday	62	5	Yes	30	BH
Saturday	35	5			BH

The purge tank pressure (through VP2) must be monitored on a daily basis. Take the readings at the same time each day. Purging is required only when the tank pressure exceeds 60 mmHg. If purging is required, purge tank down to 30 mmHg.

Note: * The pressure difference column is the difference between today's pressure reading and yesterday's reading. It is this value that should be plotted in the graph below. If purging is required, log the final purge tank pressure in the column (If so, purged down to) above. It is this value that must be used to determine the following day's pressure difference.

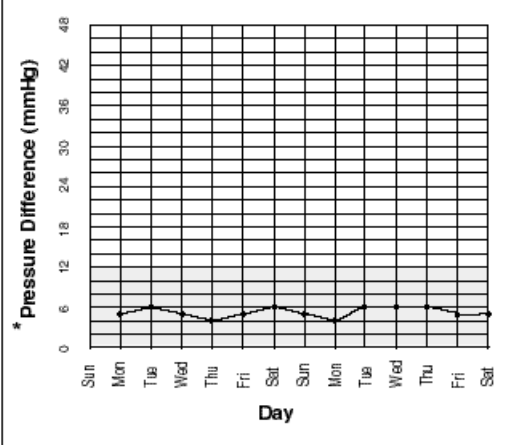
Plotting The Pressure Difference Trend

1. Plot the pressure difference for each day above on the chart to the right.
2. Monitor the trend over time.

The trend should remain flat and in the gray area at full load operation. Flat trends above the gray area indicate small air leaks. Leak test using recommended Factory procedures.

If the trend increases gradually over time, the unit has developed a solution chemistry imbalance or small air leak. Take a solution chemistry sample and send to lab for analysis. Make correction as necessary. If trend falls into the shaded area after the chemicals have been added and stays there, the problem was simply related to solution chemistry. Otherwise, an air leak is present. Leak test the unit and repair immediately. If no chemical additions were necessary, an air leak is present. Leak test the unit and repair immediately.

If the trend increases very quickly, as in a few days, the unit has most likely developed an air leak. Leak test the unit and repair immediately.



* Pressure Difference (mmHg)

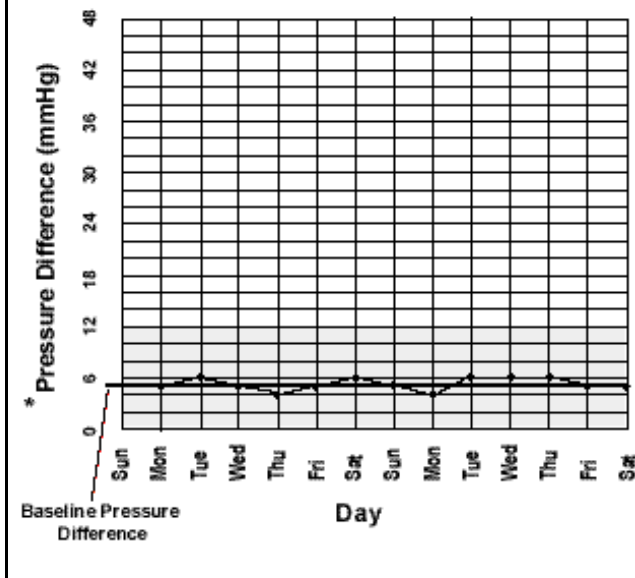
Day

This is the trend that would be expected on a "healthy" unit.

Using the shaded area of the chart as a guide is the first step in the war against corrosion. If the curve goes above this line, immediate attention is necessary. (Refer to troubleshooting section for details).

Note: There may be rare instances, on old poorly maintained machines, that the normal operating pressure differences may fall above the shaded area. If the non-condensable production cannot be brought into the shaded area, contact York Factory Service for advice.

Figure 6 - Pressure Difference Trend w/ Base Line



The Baseline Pressure Difference

Greater accuracy can be achieved by determining a baseline pressure difference for the machine. It is this baseline that will be used throughout the life of the unit. **How to develop a base line pressure difference for a known "tight" machine.**

Each machine will have its own base line pressure difference. It can be determined by monitoring the non-condensable pressure difference over time with a known tight machine and proper system chemistry. The machine should also be operating at full load. A baseline can and should be determined for new and old units. Typical base line pressure differences for machines will vary from 1 to 15 mmHg depending on the following factors.

- A. Size of machine.** Larger machines generate more non-condensables than smaller ones due to the increased internal surface area.
- B. Overall leak tightness of unit.** All machines leak to some extent. Some leak more than others.
- C. Type of Inhibitor.** Nitrate machines will typically generate more non-condensables than molybdate inhibited ones.
- D. Run time of machine.** The longer the unit operates, the more non-condensables will be produced in the

same sample period.

E. Average loading of machine. Units that operate at higher load conditions will generate more non-condensables. This is caused by increased temperatures and concentrations in the units which increase corrosion rates.

An example of a unit that will have a low base line pressure difference would be a new small unit using molybdate inhibitor, while an example of a unit with a high baseline pressure difference would be an old large machine using nitrate inhibitor.

The baseline pressure difference when determined, should be recorded and used throughout the life of the unit.

Baseline Determination

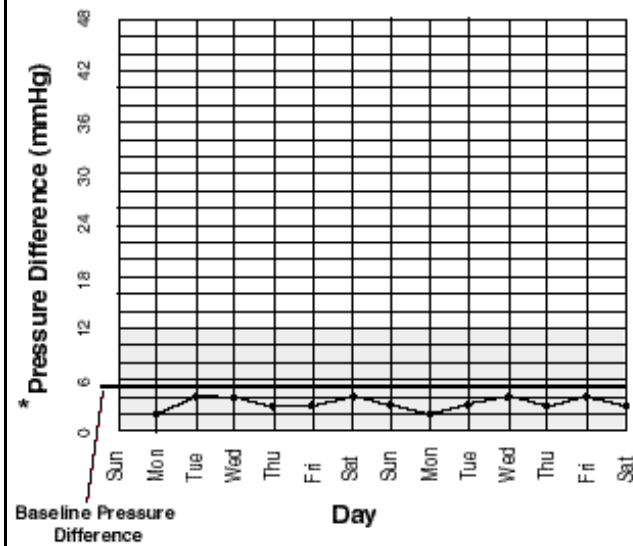
1. Take a solution sample and send to lab for analysis. Adjust the inhibitor levels as necessary (Refer to solution chemistry section for details).
2. The machine will have to operate at or near full load for at least a three to four day period.
3. Use the Purge Log Form and trend the pressure difference over this period. Trending for longer period of times will lead to more accurate results.
4. Take the average of the pressure difference column and this will be the unit's baseline pressure difference.

An example is listed below.

Job Name : York International Corp.
Unit Model # : YPC-FN-13SC
Unit Serial # : HFBM100000

1. A solution sample was taken for this machine and all parameters were within their specified ranges.
2. The machine operated for a two week period with an average load of approximately 95%.
3. The purge tank pressure was monitored during this two week period. The pressure differences were calculated. Purging was performed only when necessary. **Refer to Figure 5.**
4. The average of all the pressure differences was calculated and is equal to approximately 5.2 mmHg.

Figure 7 - Flat Trend Below Baseline



It is this value that is the baseline for this particular unit.

Once the baseline is determined, it can be used as a guide to determine if problems are occurring. Instead of using the shaded area as the guide, the baseline can be used as a maximum. Trends going above the baseline, will require immediate attention.

Figure 6 shows the chart from the log sheet in **Figure 5** with the baseline pressure difference added.

Troubleshooting

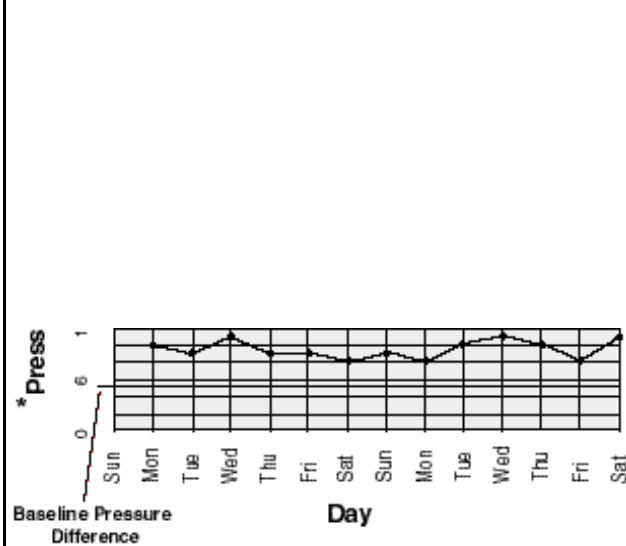
The following trends are typical of machines with impending or existing problems. Spikes in the trend curves may not be indicative of a problem.

For example: the unit may have been shut off for a few days and when it is turned back on, the non-condensable production would be high during the first day or so of operation. This would be expected. Another scenario may be a service technician accidentally getting air in the unit during a service procedure. Once the air is purged, the machine will again settle out.

The same YPC-FN-12SC unit will be used through this section. The baseline has already been determined and is equal to 5.2 mmHg.

Case 1 : Non-condensable rates constant but lower than baseline pressure difference (**Figure 7, Log Form**

Figure 8 - Flat Trend Above Baseline



1 Appendix B)

This trend may mean one of two things.

- a. The unit is operating at conditions lower than full load.
- b. If the machine is operating at full load, the baseline that was determined should be lowered to this new value. It's possible that when the baseline was originally determined, the non-condensable production had not yet reached a minimum.

Referring to the Log Form #1 in Appendix A, it can be seen that this machine operated at an average load of 40% during this time period. These lower load conditions would explain the lower pressure differences.

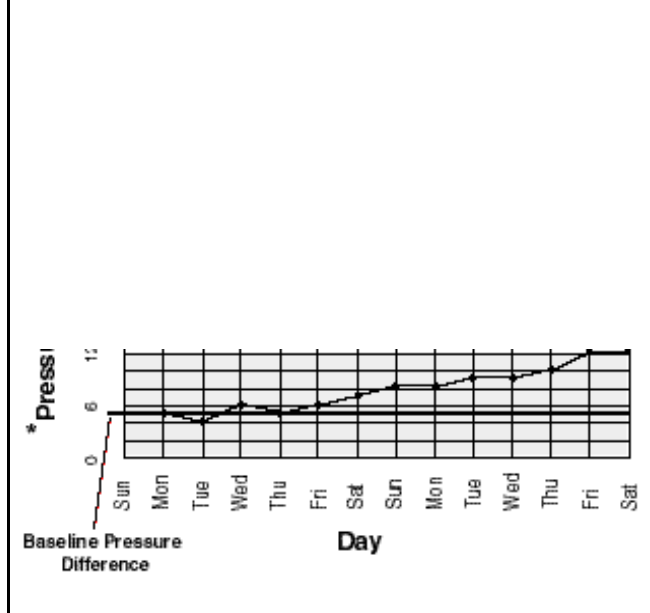
Corrective Action: Change baseline to new value.

Case 2 : Non-condensable rates constant but higher than baseline pressure difference (**Figure 8, Log Form 2 Appendix B**).

This trend indicates the following.

- a. The solution chemistry in the machine is within Factory Specifications - indicative by the flat curve.
- b. The unit has developed some small air leaks, essentially raising the baseline for the machine.

Figure 9 - Gradually Increasing Trend



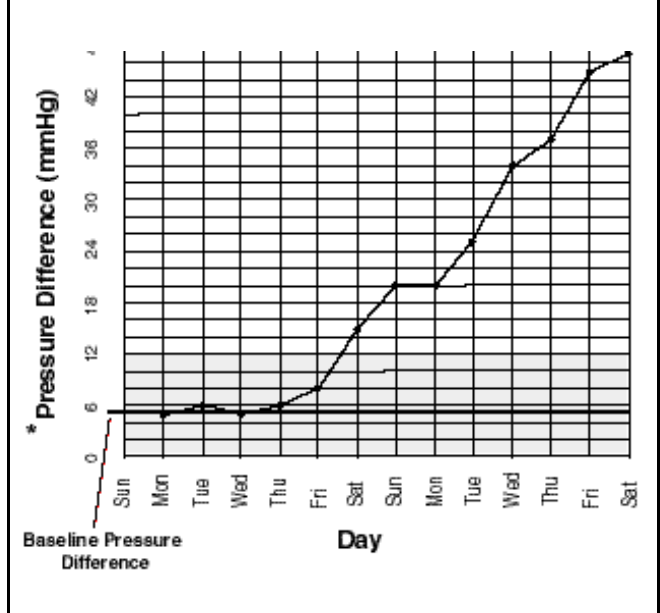
Although no immediate action needs to be taken, the non-condensable production should be closely monitored to make sure the condition doesn't worsen. If the condition remains stable, small leaks probably exist, raising the baseline pressure difference. Because the leaks are very small, a helium leak test should be performed on the unit to bring the baseline pressure back down to its original level. This work can be scheduled at a convenient time. Remember that additional air leaks raising the pressure difference above the base line will cause increased corrosion rates and inhibitor depletion. For the long term benefit of the machine, a helium leak test should be performed to find these small leaks.

Corrective Action:

1. Take a solution sample and send to the lab for analysis. Make adjustments to solution chemistry as needed.
2. Again trend the purge tank pressure differences over time. If the pressure difference doesn't return to the baseline, proceed to Step 3.
3. Leak test the machine, using recommended Factory procedures, to bring the baseline back to its original value. This should be done as soon as possible to minimize corrosion damage to the machine.

Note: Solution analysis should be done on a more frequent basis as the inhibitors in the unit will deplete faster due to the greater leak rate.

Figure 10 - Rapidly Increasing Trend



This type of trend if left for too long, will cause corrosion problems. The life of the machine will be reduced if not corrected in a timely fashion.

Case 3 : Gradually increasing pressure difference trend. (Figure 9, Log Form 3 Appendix B).

Figure 9 illustrates a trend that remained at the baseline for the first three to four days and then started to slowly increase over time.

This type of trend could be caused but not limited to one of the following.

- a. Inhibitors have depleted below their specified ranges and corrosion rates have started to increase.
- b. Air leaks may have developed in system which are accelerating this inhibitor depletion.

This increase over time is indicative of a problem in the machine which requires **immediate** attention. A problem is just beginning to rear its ugly head. Catch it before it becomes a major one.

Corrective Action :

1. Take a solution sample and send to the lab for analysis. Make adjustments to solution chemistry as needed.
2. Again trend the purge tank pressure differences over time. If the pressure difference doesn't return to the

baseline, proceed to Step 3. If it does, the problem was simply related to solution chemistry.

3. Leak test the machine, using recommended Factory procedures, to bring the baseline back to its original value. This should be done as soon as possible to minimize corrosion damage to the machine.

During the leak testing and trending procedures, a solution chemistry sample should be sent to the lab on a regular basis to make sure that the inhibitor levels stay within the Factory specified values at all times. This will minimize corrosion damage to the unit.

Continue leak testing, repairing leaks and adjusting solution chemistry, until the pressure difference trend drops to the baseline and remains there.

A more detailed description is given in the troubleshooting section.

Case 4 : Pressure Difference Trend Increases Very Quickly Over Time (**Figure 10, Log Form 4 Appendix B**).

This type of trend illustrates a slightly different scenario than the previous. As before, the pressure differences started around the baseline (5.2 mm Hg). Instead of the pressure increasing slowly over time, an immediate increase was observed. This big jump is almost always an indication that an air leak has developed.

Corrective Action:

Leak test the unit **immediately** Using factory recommended leak test procedures. Waiting for any length of time will cause major internal damage to the machine.

During the leak testing and trending procedures, a solution chemistry sample should be sent to the lab on a regular basis to make sure that the inhibitor levels stay within the Factory specified values at all times. This will minimize corrosion damage to the unit.

Refer to the Troubleshooting section for additional details.

Case 5 : Large amounts of non-condensables in system (well above the baseline). Vacuum pump running continuously, just to keep the machine on line.

The worst case scenario would be a machine that has its vacuum pump running continuously to keep up with the

non-condensable production. This practice should be avoided as irreparable damage is being done to the machine during this time period. Additional leaks will develop and catastrophic failure will eventually occur. The machine has a leak and must be repaired immediately.

Corrective Action:

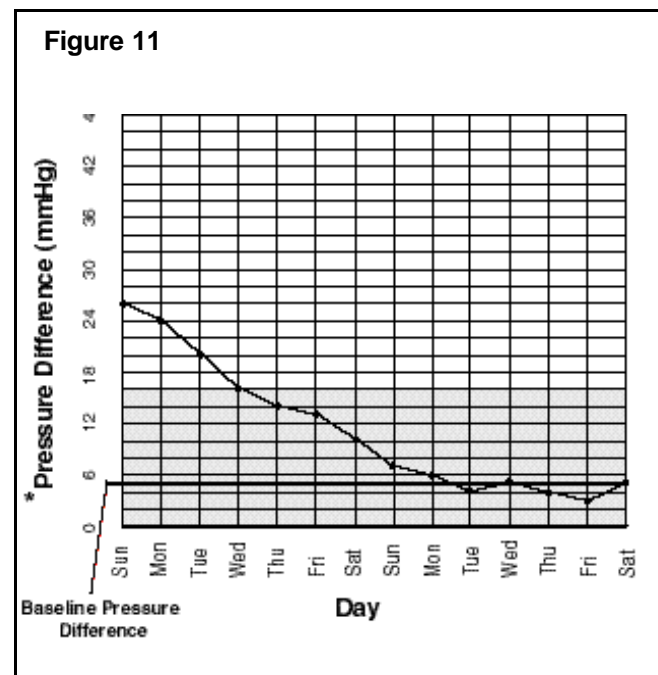
Leak test the unit **immediately** using factory recommended leak test procedures. Waiting for any length of time will cause major internal damage to the machine.

During the leak testing and trending procedures, a solution chemistry sample should be sent to the lab on a regular basis to make sure that the inhibitor levels stay within the Factory specified values at all times. This will minimize corrosion damage to the unit.

Troubleshooting : Solution Chemistry Problem or Air Leak ?

The following procedure should be used to determine if the unit has a solution chemistry problem, an air leak, or both. This procedure is only necessary if the non-condensable production has increased (Refer to previous trends).

1. Take a solution sample and send to lab for analysis. Sample kits may be ordered from Rocky Research (702) 293-0851 ATTN: Mara Saunders. Sample instructions,



bottles, filter paper and log forms are contained in these kits.

2. An analysis report will be sent listing the chemical additions necessary to bring the solution chemistry back to Factory specifications.
3. Make corrections as necessary. If no corrections are required, an air leak has developed. Leak test the machine.
4. Monitor non-condensable production.
 - a. If the non-condensable production drops off to the baseline or into the shaded region and remains there as illustrated in **Figure 11**, the problem was related to solution chemistry only.

- b. If the non-condensable production drops to a low point (usually higher than the baseline) and then begins to increase again as illustrated in **Figure 12**, an air leak is present. Leak test the machine.

During the leak testing and trending procedures, a solution chemistry sample should be sent to the lab on a regular basis to make sure that the inhibitor levels stay within the Factory specified values at all times. This will minimize corrosion damage to the unit.

Continue leak testing, repairing leaks, monitoring purge tank pressure difference trends, performing solution analysis and adjusting inhibitor levels, until the purge tank pressure difference trend drop to the baseline and remain there (Figure 11).

