ILRT PRESSURIZATION OPTIMIZATION SYSTEM

This System is Designed to:

1. Verify the Expected Capacity of the Pressurization System Both Prior to and During Pressurization

2. Minimize Pressurization Time

3. Minimize the ILRT Stabilization Interval Following Pressurization

4. Real-Time Monitor the Air Being Pumped into Containment for the Presence of Toxic Gasses, Oil Vapor/Droplets and Particulates

Jim Glover
jglover@FluxionTek.com
www.FluxionTek.com

FLUXION TECHNOLOGIES

Containment Pressurization

The First Phase of the ILRT is to Pressurize Containment with Clean Dry Air

A System of Diesel Driven Compressors, Electric After-Coolers and Desiccant Dryers are Typically Utilized For This Task

A Huge Amount of Air is Pumped Into Containment

Typical Values	M1-BWR	M2-BWR	M3-BWR	Small PWR	Large PWR
Free air Volume, ft^3	270,000	400,000	1,800,000	2,000,000	3,400,000
Peak Accident Pressure, psig	44.0	40.0	9.0	42.0	42.0
# of Compressors	2	3	4	8	16
Air Mass Addition, Lb_m	60,750	81,820	83,000	430,000	730,200
Best Pressurization Time, hrs	4.2	3.8	2.9	7.5	6.5

1. Verify Capacity of Pressurization System

Each air compressor is typically rated to deliver 1,600 cfm.

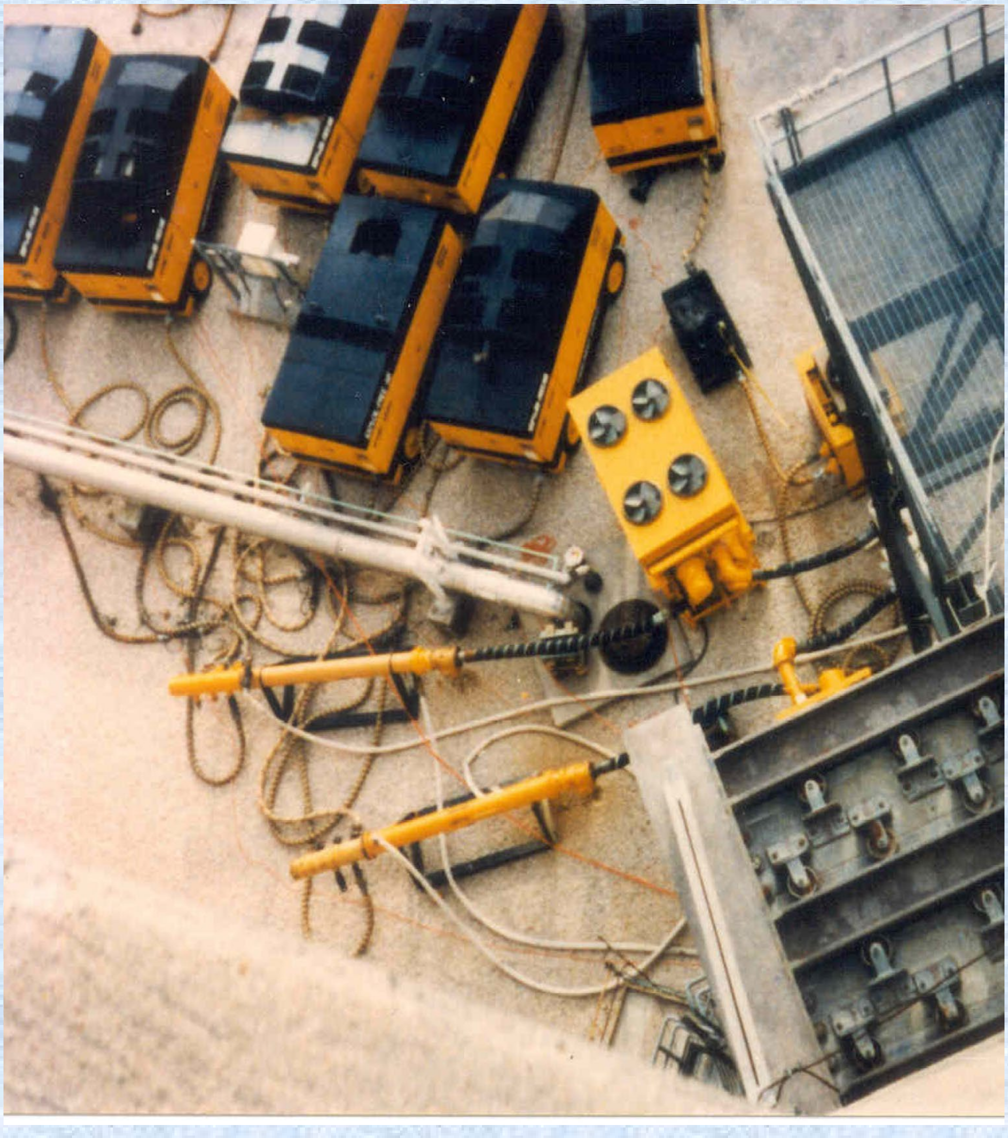
When many compressors are tied together with hoses, after-coolers and driers the expected rated total capacity may not actually be achieved.

While a functional test is usually performed after the full system is assembled prior to pressurization, this testing does not quantify the actual flow rate to be delivered to the containment.

The Pressurization Optimization System allows for flow rate measurement during the functional test prior to the ILRT. This allows for any issues to be identified and resolved prior to the ILRT.

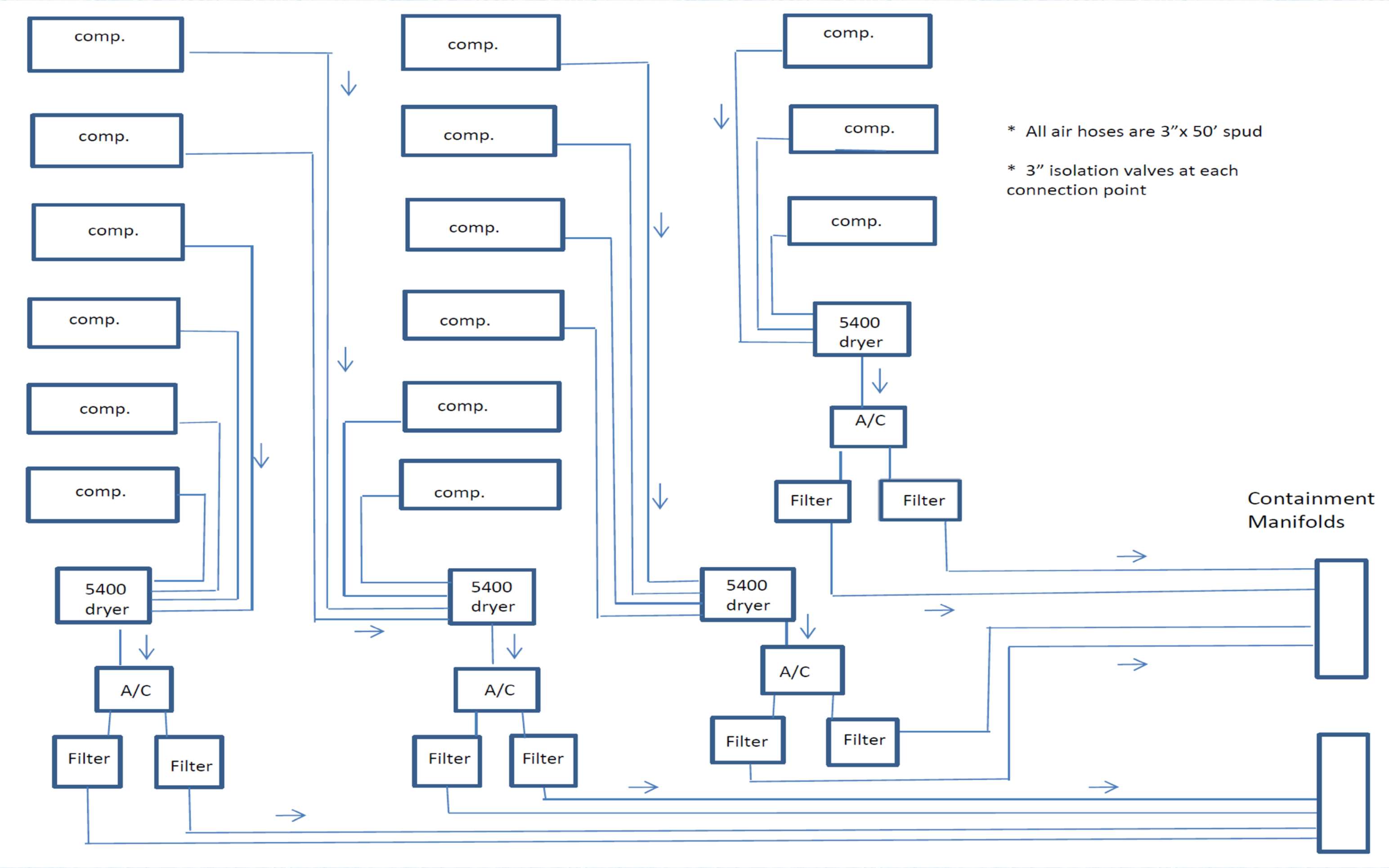
This avoids any unplanned increases in containment pressurization time.

Also, access to real-time pressurization flow rates towards the end of the pressurizations allows the test director to maintain high flow rates into containment longer without the danger of over-pressurization.



1. Verify Capacity of Pressurization System

Pressurization Systems Can Be Complex With Many Connections



If Any Connecting Hoses or Fittings are Kinked or of a Smaller Inner Diameter For a Given Flow Rate Than Listed in the Table Then That Flow Path May be Choked and Can Limit the Pressurization Rate.

Compressors Should be Verified to Meet Capacity With Expected Back-Pressure

The Pressurization Optimization System Allows For Full System Functional Verification and For Any Required Changes to be Made Before Testing Time is Lost.

Hose Table

D, (inches)	# Compressors	CFM
2.09	1	1,600
2.95	2	3,200
3.61	3	4,800
4.17	4	6,400
4.66	5	8,000
5.11	6	9,600
5.52	7	11,200
5.90	8	12,800
6.26	9	14,400
6.59	10	16,000
6.92	11	17,600
7.22	12	19,200
7.52	13	20,800
7.80	14	22,400
8.08	15	24,000
8.34	16	25,600

1. Verify Capacity of Pressurization System

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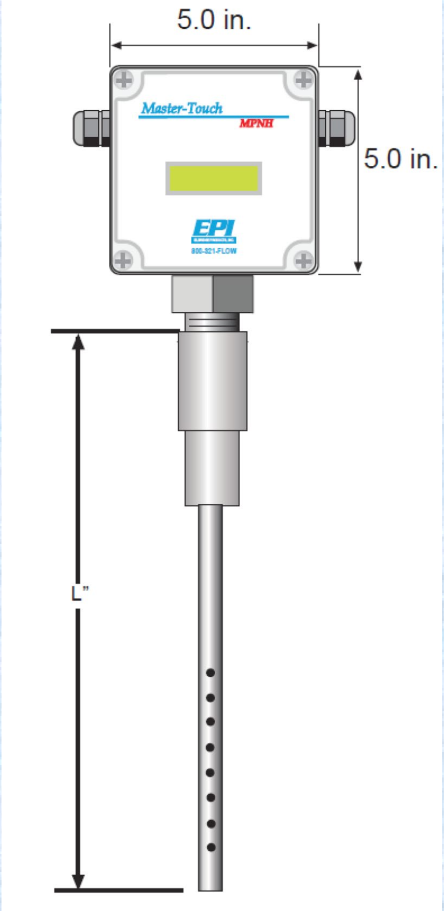
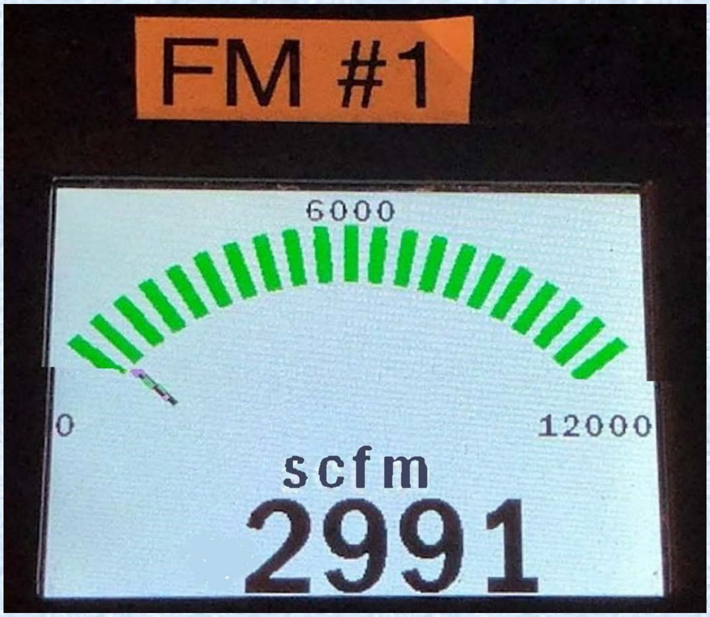
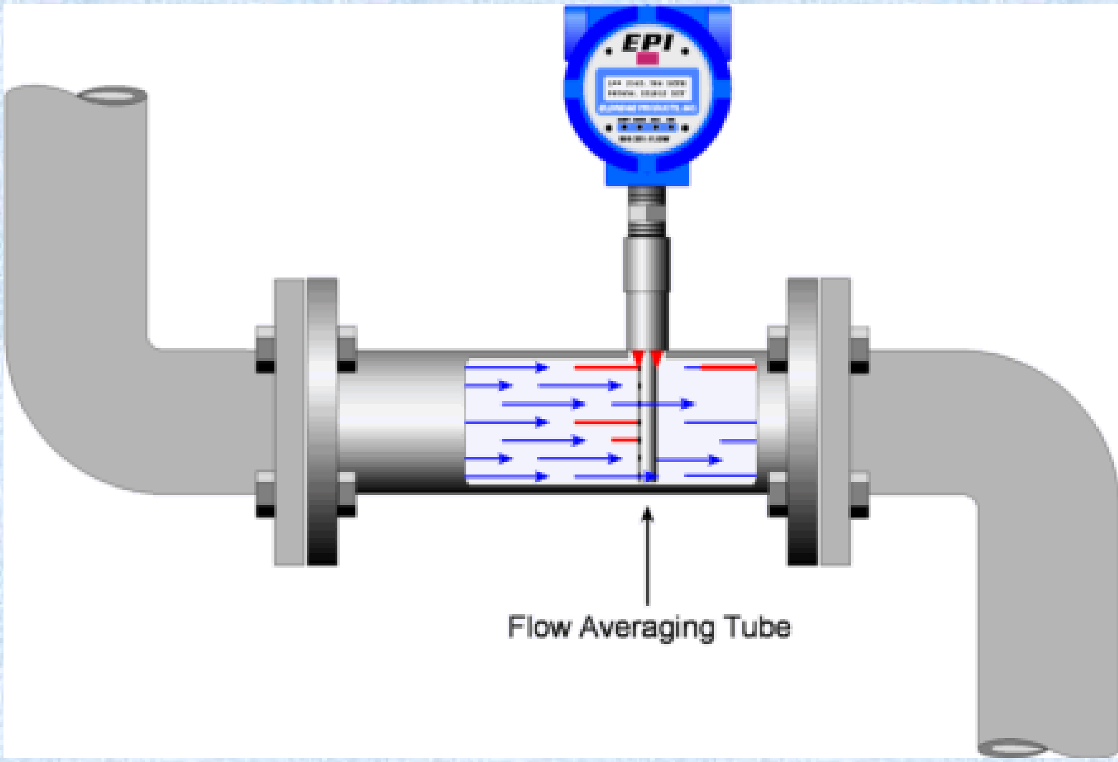


The System Uses a Thermal Mass Flow Meter With a Specially Designed Multi-Hole Flow Averaging Tube.

There is Both a Local Flow Rate Display as Well As a Meter on the Control Module



This Allows For the Flow Meter to be Installed in Short Strait Pipe Lengths Near Bends and/or Valves Without Any Loss in Accuracy



2. Minimize Pressurization Time

(continued)

Desiccant Driers Can Bleed Up to 20% of the Air Supplied From Compressors

These Driers Can Output Air With Dew Points as Low As -80 ^{o}F

This Dew Point is Much Lower Then Desired for the ILRT

The Pressurization Optimization System Measures Dew Point, Temperature and Pressure of the Incoming Air

A Proprietary Software Algorithm Allows for Selective By-Pass of Dryers to Both Optimize Incoming Humidity and Maximize Flow Rate by up to 20%

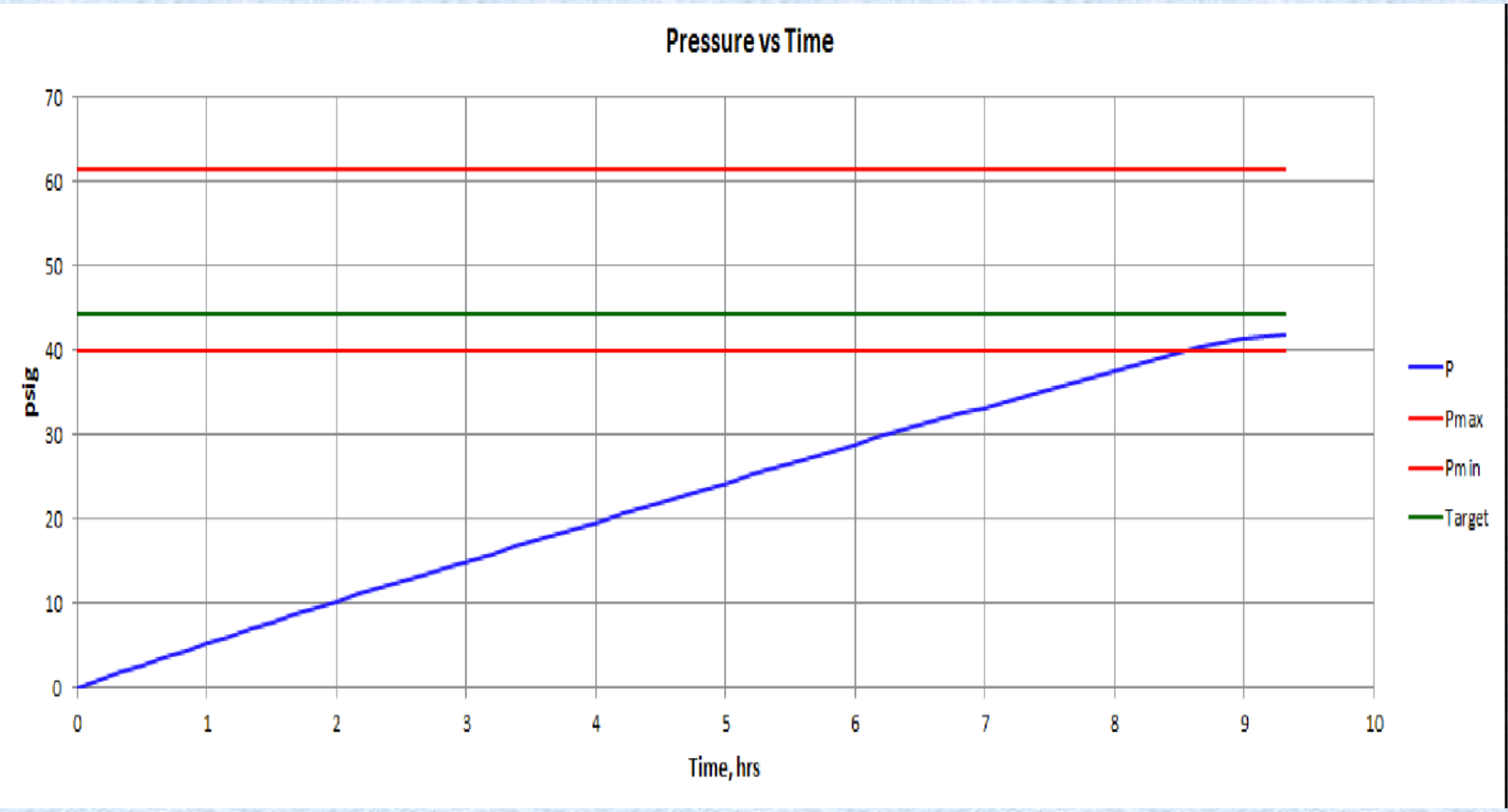
2. Minimize Pressurization Time

(continued)

Minimize Ramp-Down Towards End of Pressurization

It is common practice to slow the pressurization rate towards the end of pressurization by deactivating some of the compressors

The purpose of this is to ensure containment is not inadvertently over-pressurized



Flow meter(s) in the Pressurization Optimization System allow precise extrapolation of containment pressure

This allows for all compressors to be run longer minimizing the pressurization time

3. Minimize ILRT Stabilization Interval

The System Measures Incoming Air Pressure, Dew Point and Temperature

A Level II ILRT Technician Is Stationed at the Compressor Pad During the Pressurization Phase

The Level II is in Direct Communication with the Level III ILRT Engineer

Proprietary Algorithms Running on PC on ILRT Table Calculates the Proper Settings and Run Times for the Desiccant Driers and the After-Coolers in Order to Minimize The Stabilization Interval That Follows Pressurization

The Goal is to Adjust the Incoming Air Temperature and Humidity to Values That Will Results in Dry Air Mass Measurements to Stabilize as Quickly as Possible After the Containment Reaches Test Pressure

3. Minimize ILRT Stabilization Interval
(continued)

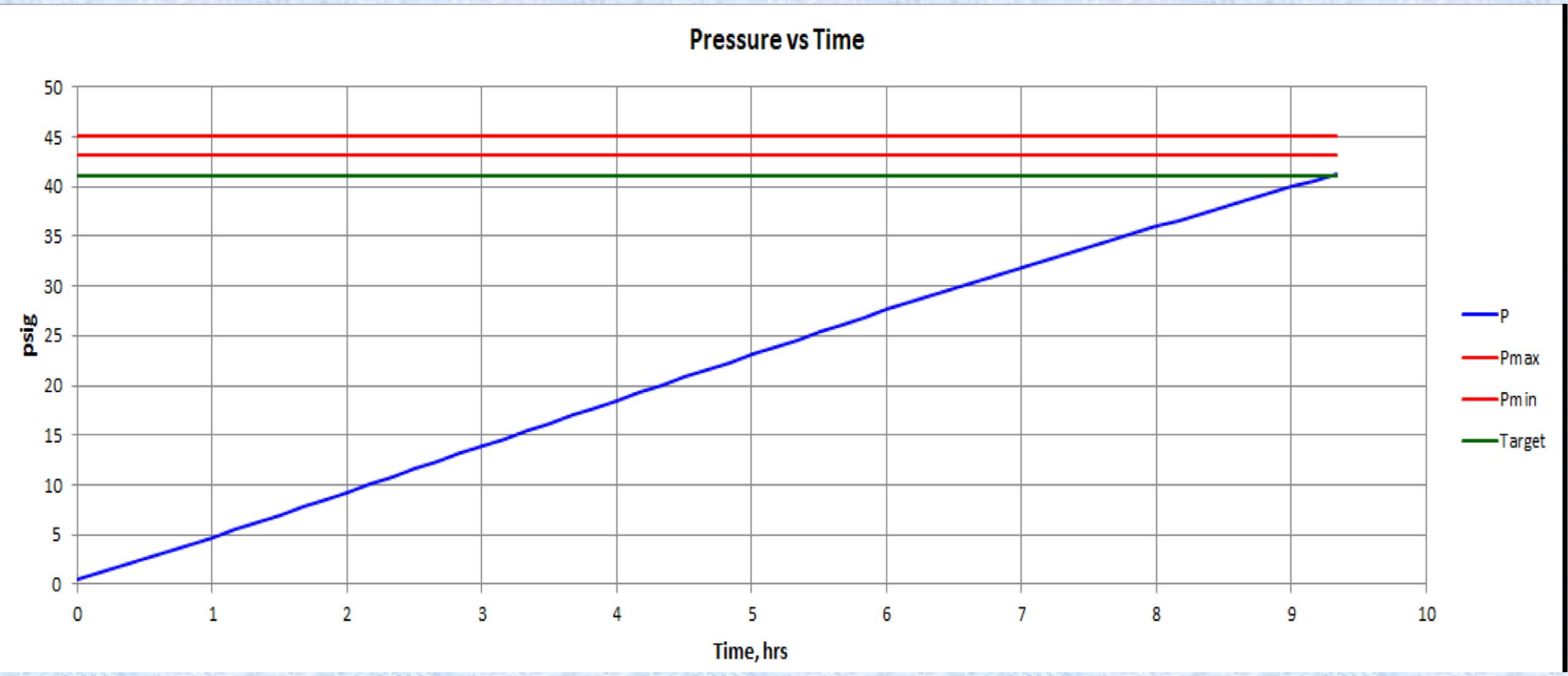
CASE STUDY #1

PWR Containment

Free Air Volume: 2,000,000 ft^3, Test Pressure: 43 psig

Tested April 2021

Compressors run near full capacity until test pressure was reached.



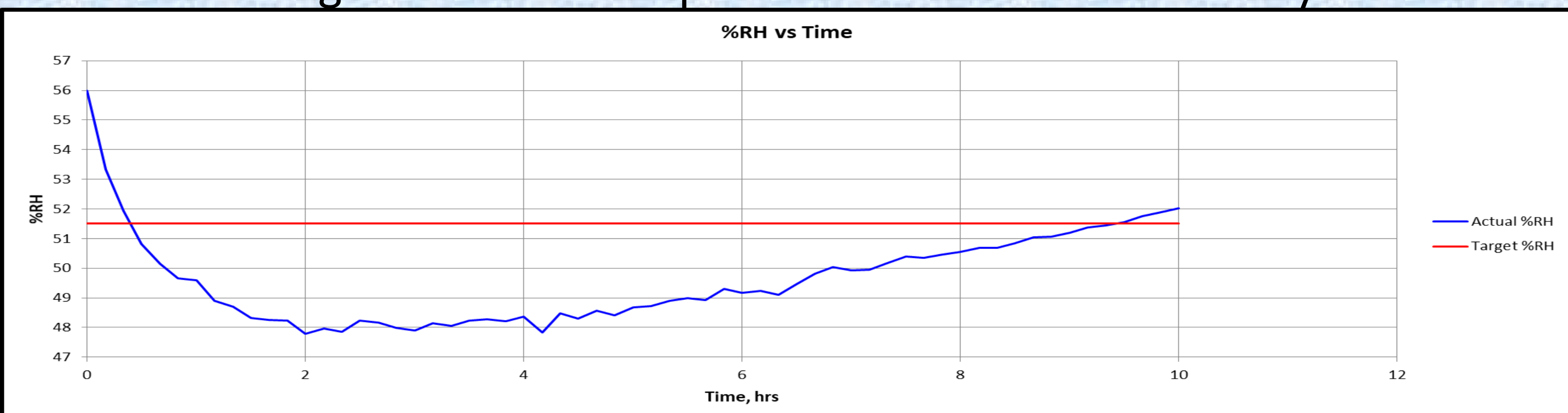
3. Minimize ILRT Stabilization Interval
(continued)

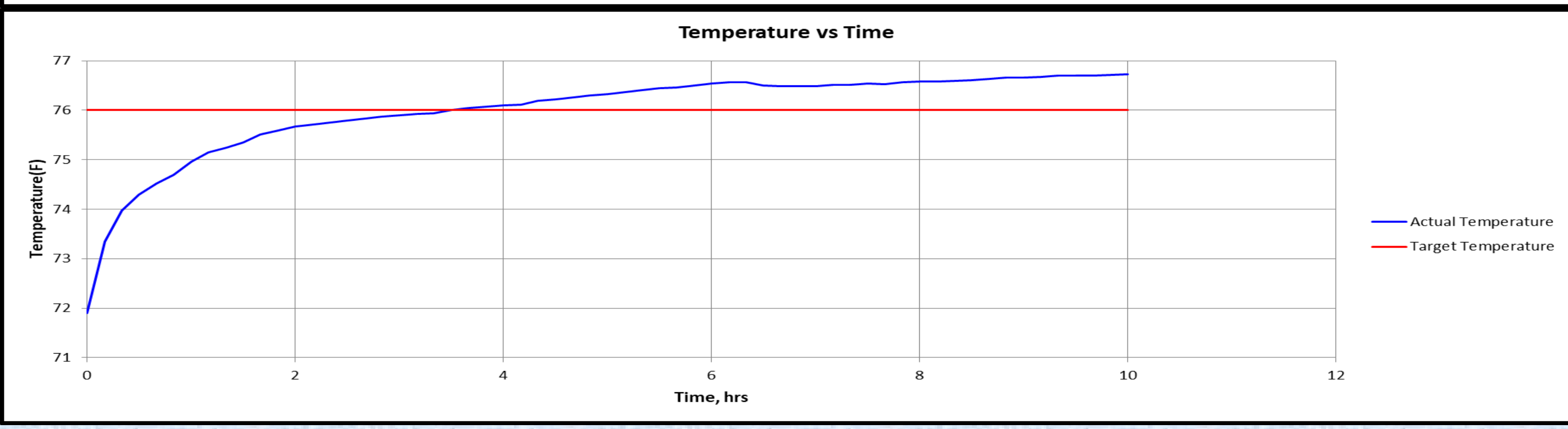
CASE STUDY #1,

Proprietary algorithms are used to calculated target values of incoming air temperature and humidity

<table>
<tr><td colspan="2">DSN</td><td>18</td><td>78</td><td colspan="2">Ambient Pressure, psia</td><td>14.6958</td></tr>
<tr><td colspan="2">45.00
Max Allowed
Pressure, psig</td><td>10.00
Max Allowed Containment Pressuration Rate, psi/hr</td><td>0.0614
Pressure Difference to Target Pressure, psi</td><td>76.00
Target Average Containment Temperature, °F</td><td>51.50
Target Average Containment Humidity, %RH</td><td>12,800
Rated Capacity of Pessurization System, scfm</td></tr>
<tr><td>43.8386
Actual Pressure at Last DSN, psig</td><td>43.90
Target Pressure, psig</td><td>4.34
Pressurization Rate, Average From Start, psi/hr</td><td>0.016
Time to Target Pressure, hours</td><td>76.73
Containment Average Temperature, At Last DSN, °F</td><td>52.03
Containment Ave Humidity, At Last DSN, %RH</td><td>8,621
Air Flowrate, Last Hour Average, scfm</td></tr>
<tr><td colspan="2">43.10
Min Allowed
Pressure, psig</td><td>3.87
Pressurization Rate, Last Hour Average, psi/hr</td><td>14:18
Projected Time When Target Pressure Reached</td><td>73.69
Target Inlet Temperature, °F</td><td>40.00
Target Inlet Relative Humidity, @ Amb P&T, %RH</td><td>67
Compressor Output, % Rated Capacity</td></tr>
</table>

This information is used real-time to control the after-cooler and dryers To match target values of temperature and relative humidity

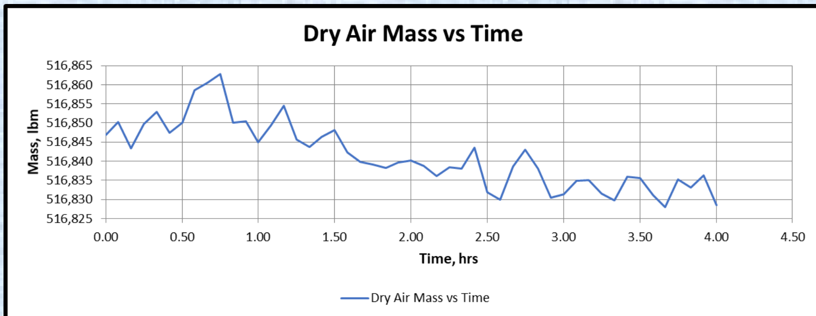


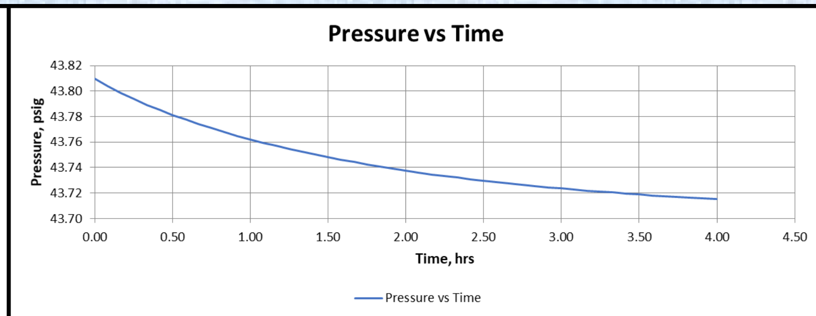


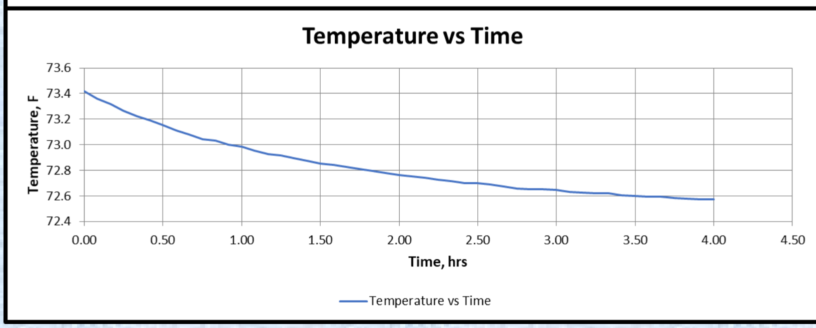
3. Minimize ILRT Stabilization Interval
(continued)

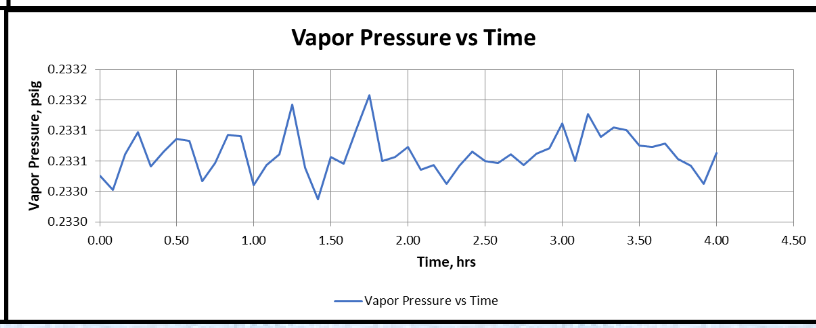
CASE STUDY #1

Mass, Temperature, Humidity and Pressure Were Monitored During Stabilization

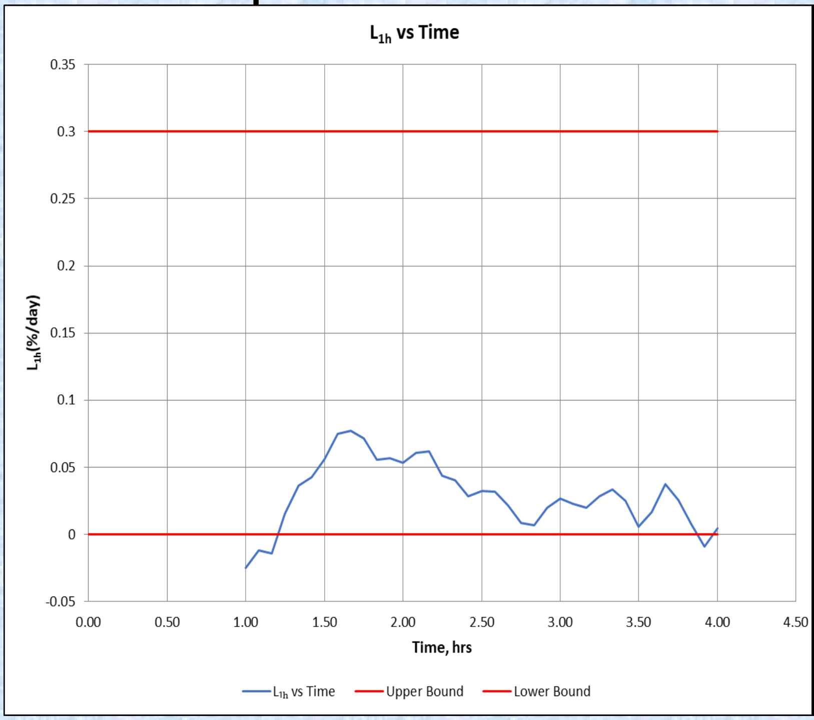


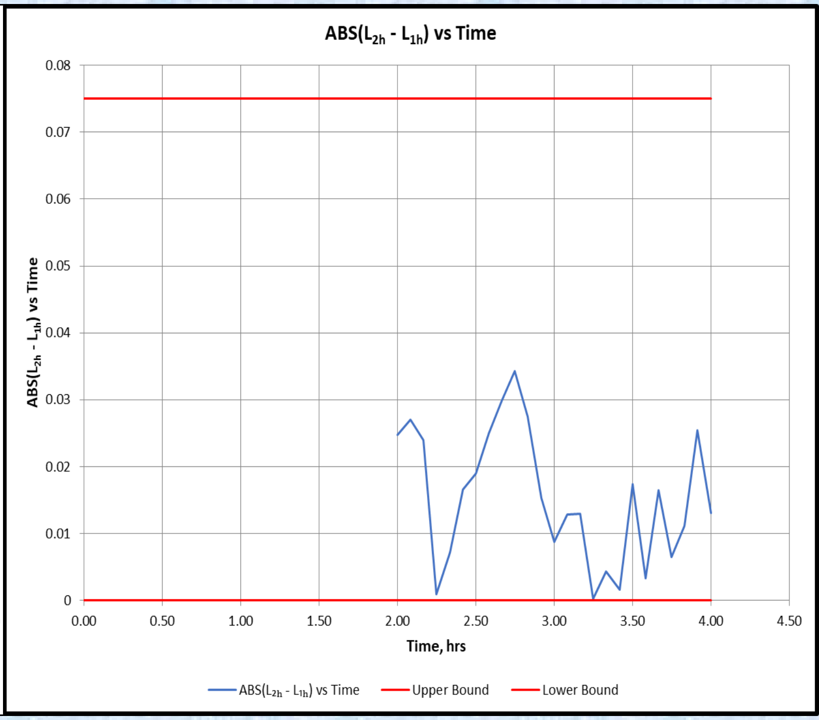






All required stabilization criterion were met in 4 hours





This plant required 12.5 hours to stabilize in a 2006 ILRT and 16 hours in a 2008 ILRT

3. Minimize ILRT Stabilization Interval

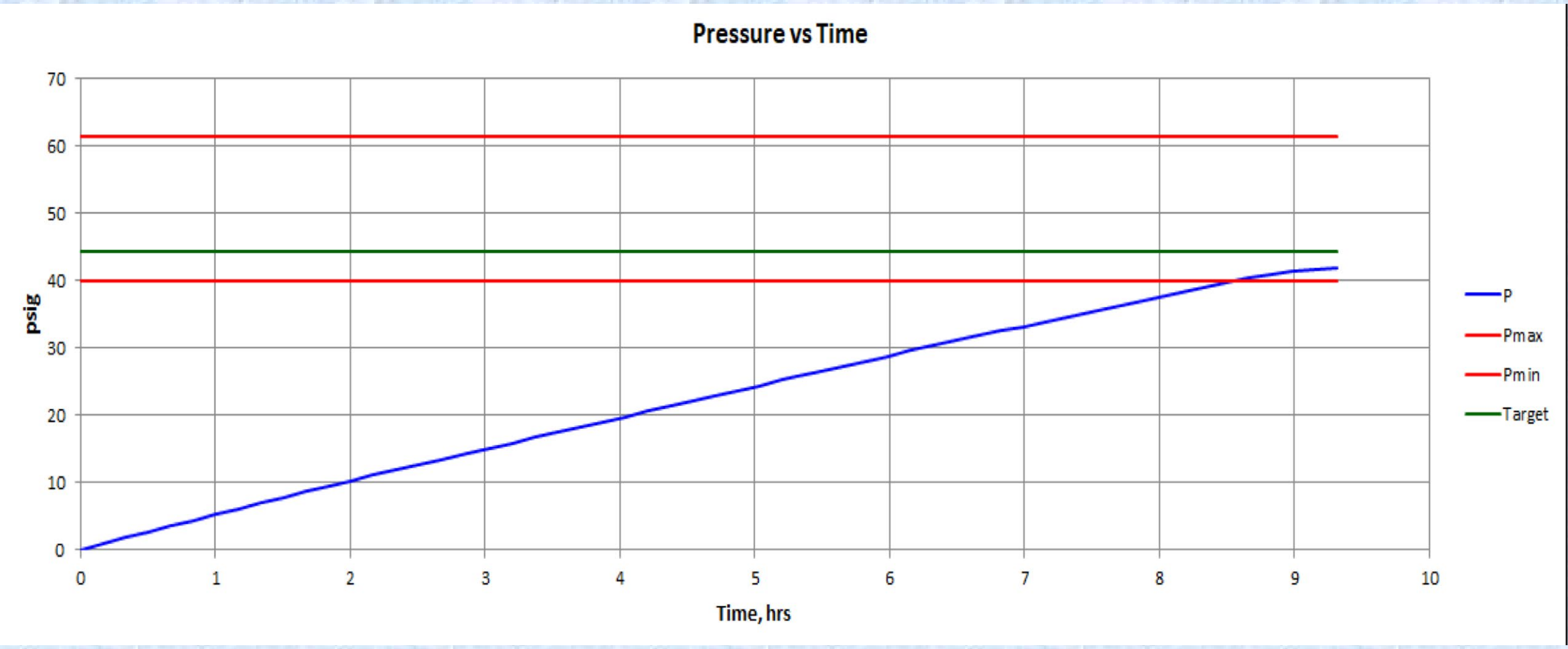
CASE STUDY #2

Very Large PWR Containment

Free Air Volume: 3,400,000 ft^{3}, Test Pressure: 42 psig

Tested March 2021

Compressors run near full capacity until test pressure was reached.



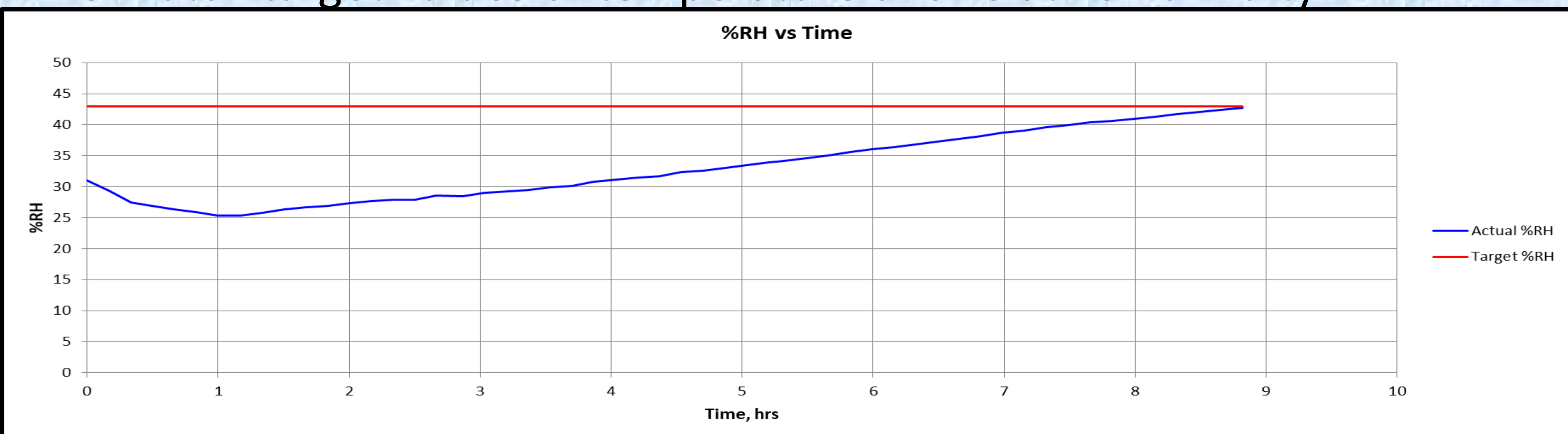
3. Minimize ILRT Stabilization Interval

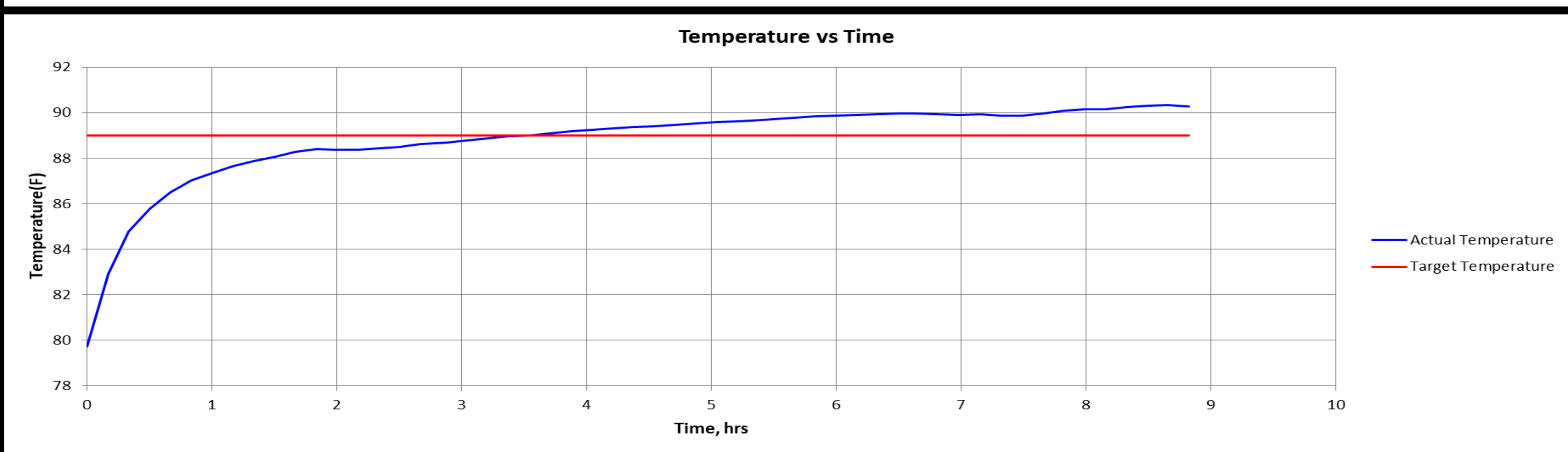
CASE STUDY #2, (continued)

Proprietary algorithms are used to calculated target values of incoming air temperature and humidity

DSN		22	78	Ambient Pressure, psia		14.6958
61.30 Max Allowed Pressure, psig		**10.00** Max Allowed Containment Pressuration Rate, psi/hr	**2.3913** Pressure Difference to Target Pressure, psi	**89.00** Target Average Containment Temperature, °F	**43.00** Target Average Containment Humidity, %RH	**12,000** Rated Capacity of Pessurization System, scfm
41.9087 Actual Pressure at Last DSN, psig	**44.30** Target Pressure, psig	**4.49** Pressurization Rate, Average From Start, psi/hr	**0.813** Time to Target Pressure, hours	**88.92** Containment Average Temperature, At Last DSN, °F	**44.72** Containment Ave Humidity, At Last DSN, %RH	**11,329** Air Flowrate, Last Hour Average, scfm
40.00 Min Allowed Pressure, psig		**2.94** Pressurization Rate, Last Hour Average, psi/hr	**16:10** Projected Time When Target Pressure Reached	**88.00** Target Inlet Temperature, °F	**40.00** Target Inlet Relative Humidity, @ Amb P&T, %RH	**94** Compressor Output, % Rated Capacity

This information is used real-time to control the after-cooler and dryers
To match target values of temperature and relative humidity

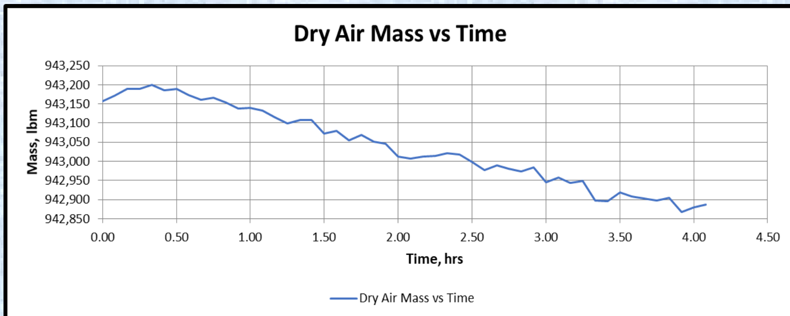


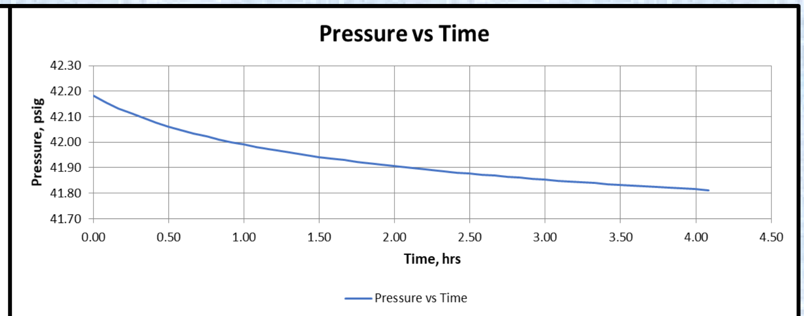


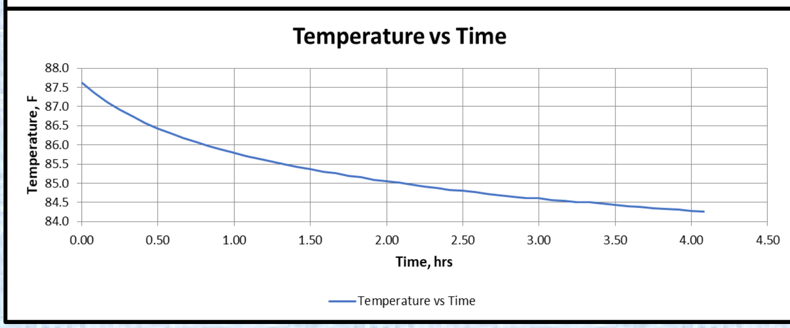
3. Minimize ILRT Stabilization Interval

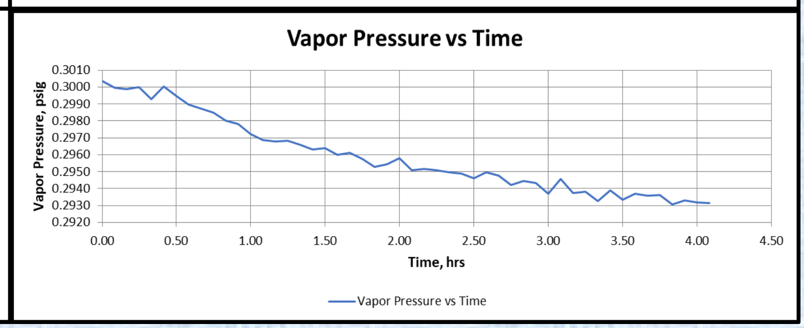
CASE STUDY #2, (continued)

Mass, Temperature, Humidity and Pressure Were Monitored In Stabilization

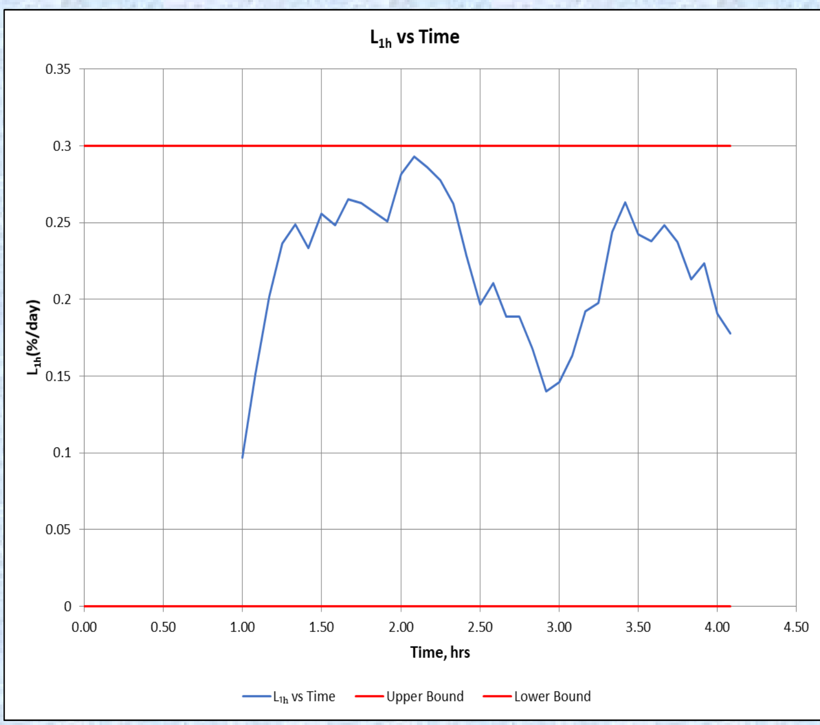


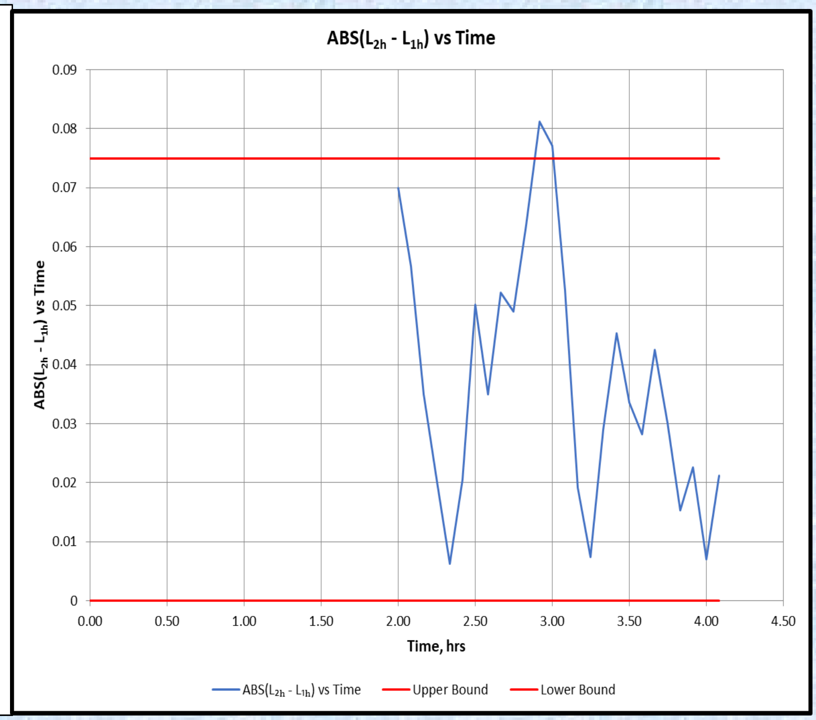






All stabilization criterion were met in 4 hours

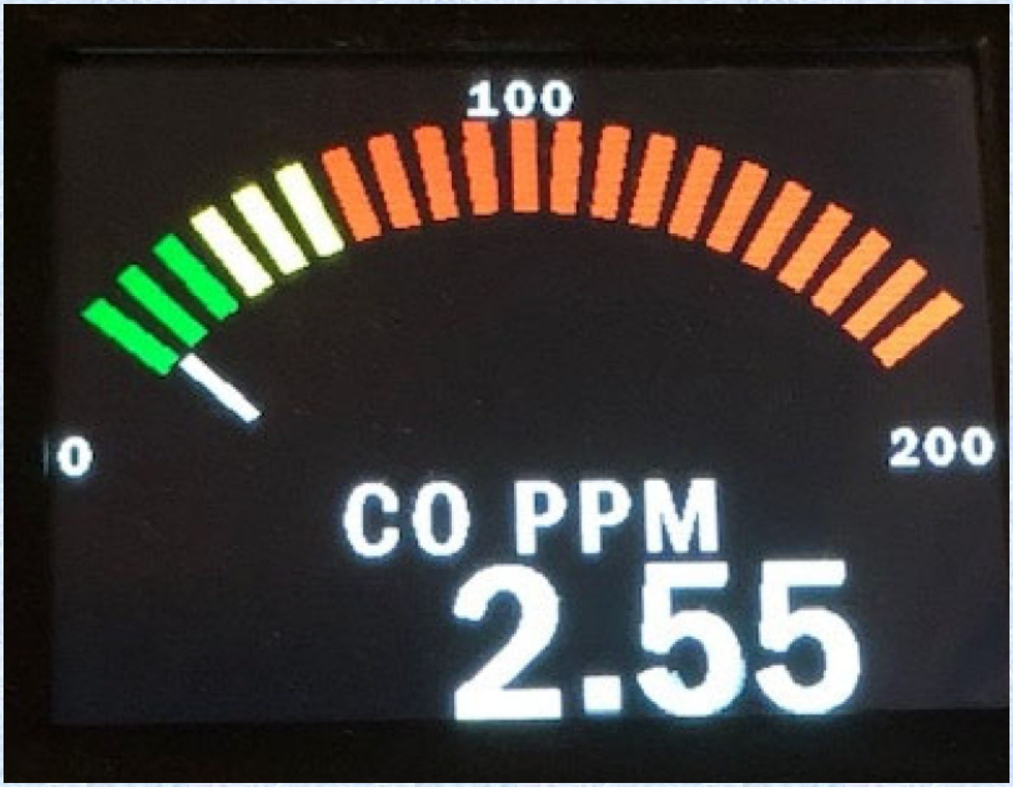




This plant required: 5.5 hours to stabilize in a 2007 ILRT and 6 hours in a 2008 ILRT

4. Real-Time Air Quality Monitoring

Real-Time Monitor the Air Being Pumped into Containment for the Presence of CO and NO^2



4. Real-Time Air Quality Monitoring

Case Study #4 (Continued)

Real-Time Monitor the Air Being Pumped into Containment for the Presence of Oil Vapor/Droplets

A small amount of air is bleed off passing through a coalescing filter

Any oil droplets in the airstream can be seen collecting in the clear bowl

This is still the most accurate method of monitoring for oil droplets

4. Real-Time Air Quality Monitoring

Case Study #4 (Continued

The System Monitors the Incoming Air Stream Real Time For Particulates

A laser-based particle sensor uses light scattering method to detect and count particles and calculate PM1.0, PM2.5 and PM10 concentration.

PM 1.0 Counts all particles less than 1.0 µm in diameter

PM 2.5 Counts all particles less than 2.5 µm in diameter

PM 10 Counts all particles less than 10 µm in diameter

Concentration range (PM2.5): 0-999 ug/m^3
Effective range (PM2.5): 0-500 ug/m^3
Accuracy: ±10ug/m^3(0-100 ug/m^3)
±10% (100-500 ug/m^3)
Minimum distinguishable Particle diameter: 0.3um