The Hidden Variable: The True Cost of Air In Hydronic Systems

Stephen Clinton, PE, LEED AP
Director of Business Development
Spirotherm, Inc.

Straight to the Point

In most systems,

$$Q_{Water^{(in\ BTUH)}} \neq 500 \times GPM \times \Delta T$$

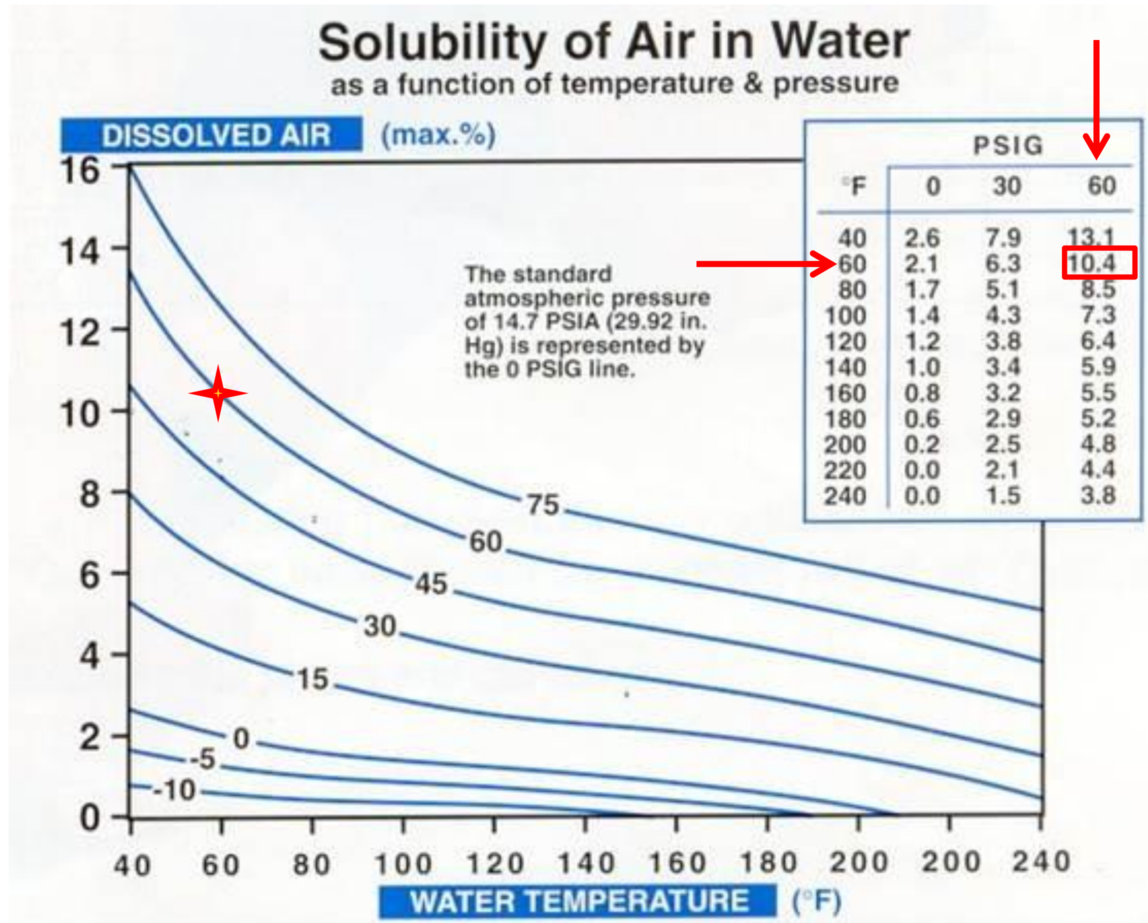
A fluid-air mixture cannot transfer heat as effectively as a fluid by itself.

Air: Entrained, Free and Dissolved

<u>Henry's Law:</u>

"At a given temperature, the amount of gas absorbed by a liquid is proportional to its pressure."

<u>Note:</u> Entering domestic water may contain 10%-15+% air by volume.



°F	PSIG 0	PSIG 30	PSIG 60
40	2.6	7.9	13.1
60	2.1	6.3	10.4
80	1.7	5.1	8.5
100	1.4	4.3	7.3
120	1.2	3.8	6.4
140	1.0	3.4	5.9
160	0.8	3.2	5.5
180	0.6	2.9	5.2
200	0.2	2.5	4.8
220	0.0	2.1	4.4
240	0.0	1.5	3.8

* Dissolved air by volume.

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Negative Effects of Air

- Reduced Heat Transfer Capability
- Increased Pump Energy
- Increased Supply Fan Energy
- Reduced System Energy Efficiency
- System Corrosion as Air is ~20% Oxygen
- Increased Chemical Treatment Costs
- Increased Maintenance Costs and Life Cycle Costs For Equipment and the Overall System

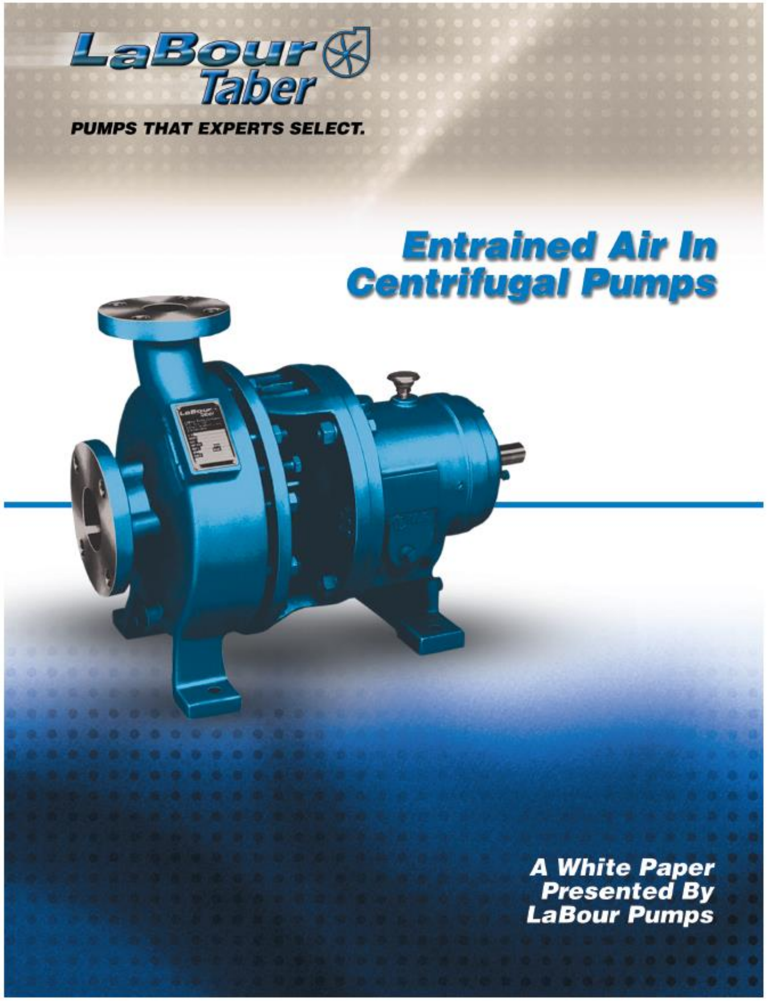
Reduced Thermal Performance (RTP)

Air present in a hydronic heating or cooling system negatively impacts the system’s ability to transfer heat.

Entrained Air Impact on Pumps

- Not Traditionally Addressed in the HVAC Industry
- *Gould's Pump Manual:*

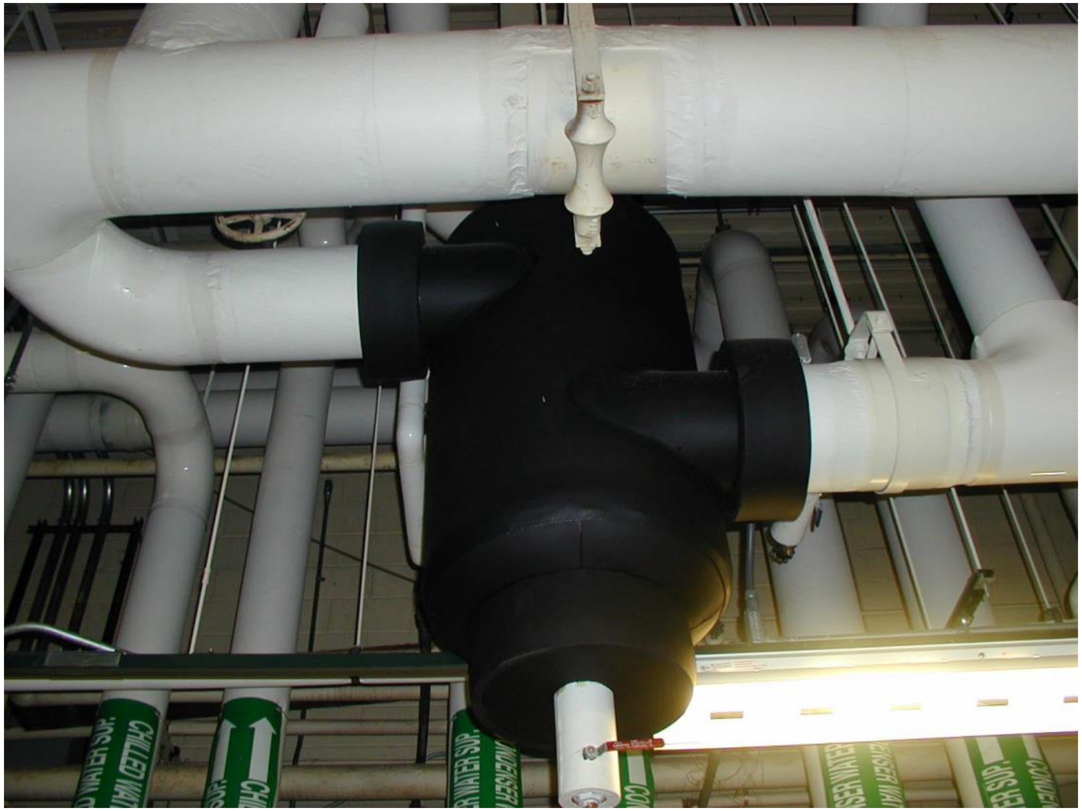
  "A mixture of only 2% gas by volume will cause a 10% reduction in capacity and 4% will cause a reduction in over 43%."



Reduced Pump Performance (RPP)

Entrained air affects the ability of pumps to perform as designed and results in increased energy usage.

Traditional Air Separation*



* Removes Certain Amounts of Entrained Air in Closed Hydronic Systems

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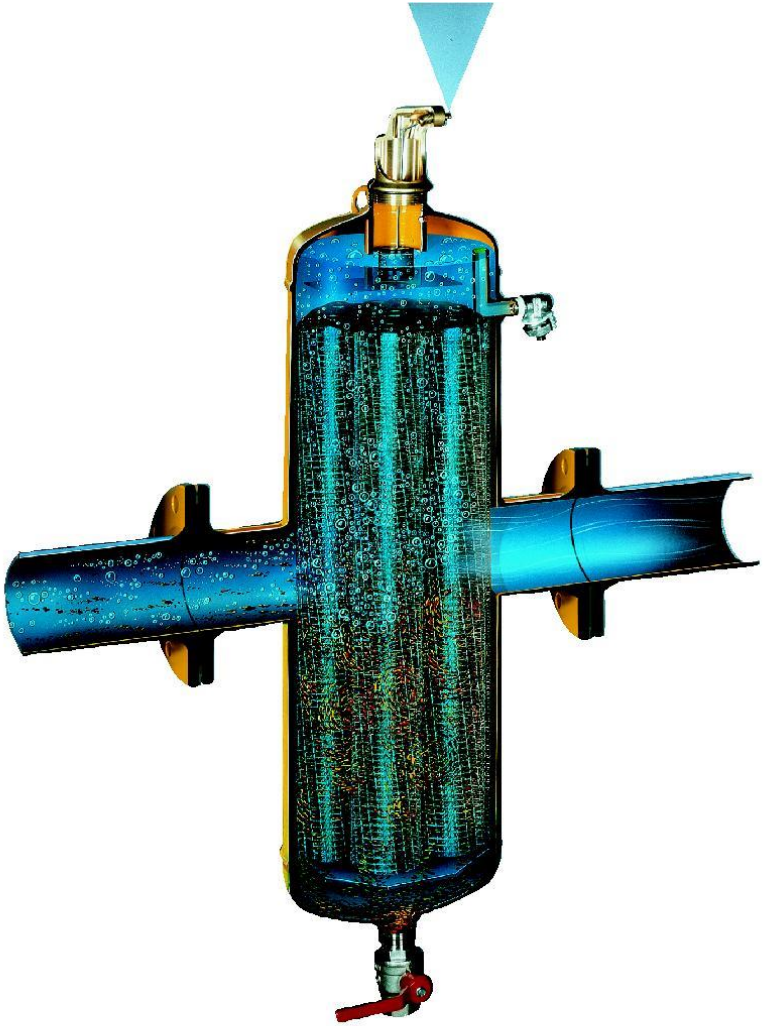
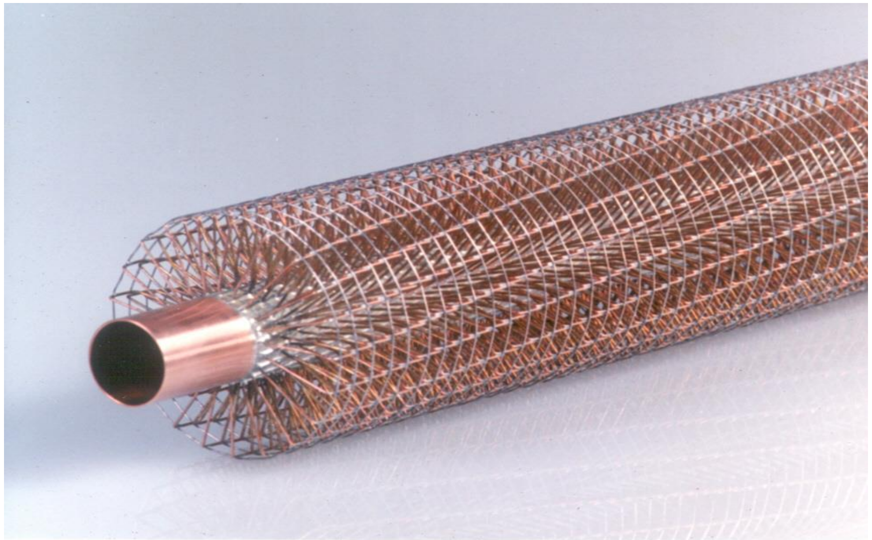
Coalescing Air and Dirt Separators**





** Spirovents Remove 100% of Entrained Air, 100% of Free Air, Up To 99.6% of Dissolved Air and Particles Down to 5 Microns in Size in Closed Hydronic Systems.

Case Study Results

- Increased chiller plant output (tonnage) by **15.9%**
- Decreased chilled water (CHW) pump speed by **22%** and pump motor HP by **50%+**
- Increased CHW system ΔT's by **1.5°F**
- Reduced cooling coil discharge air temperatures by **7°- 10°F**
- Reduced CHW system DP sensor set point by **10 psig**
- Flattened rate of decay charts for corrosion coupons and reduced corrosion prevention chemicals by **85%**
- Removed **20,000 gallons** of free, entrained, and dissolved **air** from a 250,000 gallon CHW system (**8% air**)
- Decreased heating hot water (HW) plant natural gas usage by **8%**
- Reduced start-up air purging time from **1-2 days** to **1 hour**
- Eliminated **water flow noise** problems
- Eliminated "no heat" calls in HW systems
- Improved **sustainability** by reducing water and energy usage

For case studies or more information, contact your local Spirotherm, Inc. sales representative: http://www.Spirotherm.com/sales-service/ or call (630) 307-2662.

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Focus on Energy Usage & Energy Cost

- Energy Modeling and Simple Payback Analysis
- Evaluate the Impact to RTP and RPP for Single Variable Change
- Building Type / Occupancy: Hospital
- Building Area: 402,500 sq. ft.
- Building Locations: 5 - U.S. Cities
- Cooling System: Chilled Water (CHW) – CV Prim. VV Sec.
- Heating System: Heating Hot Water (HW) VV Primary

Energy Model Input Criteria

Location	Climate Zone	Roof	Walls	Floor	Windows	Economizer High Limit	Elect. Rate $/kWh	Gas Rate $/therm
Tampa, FL	2A	U-0.048	U-0.124	F-0.73	U-0.70 SHGC-0.25	65 F	$0.0965	$1.138
Phoenix, AZ	2B	U-0.048	U-0.124	F-0.73	U-0.70 SHGC-0.25	75 F	$0.1047	$1.034
San Francisco, CA	3C	U-0.048	U-0.084	F-0.73	U-0.60 SHGC-0.25	75 F	$0.1579	$0.905
Nashville, TN	4A	U-0.048	U-0.064	F-0.73	U-0.50 SHGC-0.40	65 F	$0.1024	$0.846
Boston, MA	5A	U-0.048	U-0.064	F-0.73	U-0.45 SHGC-0.40	70 F	$0.1570	$1.248

Per *ASHRAE 90.1 – 2010* Standards

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Energy Modeling Analysis

	CHILLED WATER SYSTEM[1]						HEATING HOT WATER SYSTEM[2]					
Location, Weather Data and Utility Rates	**5% RTP and 10% RPP**		**10% RTP and 20% RPP**		**15% RTP and 30% RPP**		**2% RTP and 10% RPP**		**5% RTP and 20% RPP**		**8% RTP and 30% RPP**	
	Annual > Energy Cost ($)	Simple Payback (Years)	Annual > Energy Cost ($)	Simple Payback (Years)	Annual > Energy Cost ($)	Simple Payback (Years)	Annual > Energy Cost ($)	Simple Payback (Years)	Annual > Energy Cost ($)	Simple Payback (Years)	Annual > Energy Cost ($)	Simple Payback (Years)
Nashville, TN	$18,400	***0.95***	$37,136	***0.47***	$55,199	***0.32***	$6,790	***1.4***	$17,612	***0.54***	$29,341	***0.32***

2 – 1,220 Ton Chillers
2 – 11,675 MBH HW Boilers
Electric Rate: $0.1024 / kWh
Natural Gas Rate: $0.846 / therm
Annual Energy Cost: $718,468 (Assuming No Air)

System Changes (Basis of Design Thru 3 Levels of RTP / RPP)
Chilled Water System kW / ton: 0.759, 0.787, 0.815, 0.843
CHW & HW System Annual Cost $ / s.f.: 1.79, 1.83, 1.87, 1.91

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Energy Modeling Analysis

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Boston, MA	$15,549	***1.13***	$31,340	***0.56***	$46,645	***0.38***	$13,244	***0.72***	$34,351	***0.28***	$57,227	***0.17***

2 – 1,250 Ton Chillers
2 – 12,715 MBH HW Boilers
Electric Rate: $0.1570 / kWh
Natural Gas Rate: $1.248 / therm
Annual Energy Cost: $935,570 (Assuming No Air)

System Changes (Basis of Design Thru 3 Levels of RTP / RPP)
Chilled Water System kW / ton: 0.762, 0.790, 0.817, 0.845
CHW & HW System Annual Cost $ / s.f.: 2.32, 2.36, 2.39, 2.43

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Energy Modeling Analysis

Location, Weather Data and Utility Rates	CHILLED WATER SYSTEM[1]						HEATING HOT WATER SYSTEM[2]					
	5% RTP and 10% RPP		10% RTP and 20% RPP		15% RTP and 30% RPP		2% RTP and 10% RPP		5% RTP and 20% RPP		8% RTP and 30% RPP	
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Tampa, FL	$31,139	***0.50***	$62,819	***0.25***	$93,422	***0.17***	$658	***21.28***	$1,789	***7.83***	$2,964	***4.72***

2 – 1,430 Ton Chillers
2 – 8,665 MBH HW Boilers
Electric Rate: $0.0965 / kWh
Natural Gas Rate: $0.1138 / therm
Annual Energy Cost: $780,487 (Assuming No Air)

System Changes (Basis of Design Thru 3 Levels of RTP / RPP)
Chilled Water System kW / ton: 0.767, 0.800, 0.829, 0.857
CHW & HW System Annual Cost $ / s.f.: 1.94, 2.01, 2.08, 2.15

Energy Modeling Analysis

Location, Weather Data and Utility Rates	CHILLED WATER SYSTEM[1]						HEATING HOT WATER SYSTEM[2]					
	5% RTP and 10% RPP		10% RTP and 20% RPP		15% RTP and 30% RPP		2% RTP and 10% RPP		5% RTP and 20% RPP		8% RTP and 30% RPP	
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Phoenix, AZ	$22,971	***0.76***	$46,325	***0.38***	$68,908	***0.25***	$4,990	***2.81***	$12,949	***1.08***	$21,576	***0.65***

2 – 1,310Ton Chillers
2 – 8,050 MBH HW Boilers
Electric Rate: $0.1047 / kWh
Natural Gas Rate: $1.034 / therm
Annual Energy Cost: $766,155 (Assuming No Air)

System Changes (Basis of Design Thru 3 Levels of RTP / RPP)
Chilled Water System kW / ton: 0.763, 0.791, 0.819, 0.847
CHW & HW System Annual Cost $ / s.f.: 1.90, 1.95, 2.00, 2.06

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Energy Modeling Analysis

	CHILLED WATER SYSTEM[1]						HEATING HOT WATER SYSTEM[2]					
Location, Weather Data and Utility Rates	**5% RTP and 10% RPP**		**10% RTP and 20% RPP**		**15% RTP and 30% RPP**		**2% RTP and 10% RPP**		**5% RTP and 20% RPP**		**8% RTP and 30% RPP**	
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San Francisco, CA	$9,822	***1.43***	$19,785	***0.71***	$29,464	***0.48***	$6,201	***2.26***	$16,065	***0.87***	$26,755	***0.52***

2 – 1,370Ton Chillers
2 – 8,150 MBH HW Boilers
Electric Rate: $0.1579 / kWh
Natural Gas Rate: $0.905 / therm
Annual Energy Cost: $477,011 (Assuming No Air)

System Changes (Basis of Design Thru 3 Levels of RTP / RPP)
Chilled Water System kW / ton: 0.777, 0.804, 0.832, 0.860
CHW & HW System Annual Cost $ / s.f.: 1.19, 1.21, 1.23, 1.25

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Energy Modeling Analysis

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[1,2] The energy model was prepared by Clark Denson, PE, CEM, BEMP, LEED AP BD+C (cdenson@ssr-inc.com) in conjunction with Stephen Clinton, PE, LEED AP (swc1@spirotherm.com) using Trane Trace700 software and analyzed a 402,500 sq. ft. hospital facility located in five different U.S. cities. Each model included weather and utility rate data for the respective project location. The building and system data were based on *ASHRAE 90.1-2010*-minimum compliant criteria. A single variable was changed for each model iteration to isolate the impact of each variable change. Each CHW system was modeled as a constant primary-variable secondary system with two, electric, water-cooled chillers each sized for 57% of total load and a 12 degrees F ΔT. Each HW system was modeled as a variable primary system with two, natural gas-fired boilers each sized for 62.5% of total load and a 30 degrees F ΔT.

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Thank You

Questions?