Compressed Air/Gases—Basic Concepts

Moisture is always present in compressed air, and oil can be present at some points in a compressed air system. For the efficient operation and long life of gaskets, hoses and air tools, this excess moisture and the oil must be removed from the system.

The removal of moisture and oil from a system involves more than just traps. To maintain high efficiency and avoid costly problems, a compressed air system also requires:

1. Aftercoolers to bring the compressed air down to ambient or room temperature.
2. Separators to knock down suspended droplets of water or fog. Separators are installed downstream from aftercoolers or in air lines near point of use, or both.
3. Drain traps to discharge the liquid from the system with a minimum loss of air.

Table LD-1. Weight of Water Per Cubic Foot of Air at Various Temperatures

Temp. °F	Percentage of Saturation									
	10	20	30	40	50	60	70	80	90	100
	Grains	Grains	Grains	Grains	Grains	Grains	Grains	Grains	Grains	Grains
-10	.028	.057	.086	.114	.142	.171	.200	.228	.256	.285
0	**.048**	**.096**	**.144**	**.192**	**.240**	**.289**	**.337**	**.385**	**.433**	**.481**
10	.078	.155	.233	.310	.388	.466	.543	.621	.698	.776
20	.124	.247	.370	.494	.618	.741	.864	.988	1.112	1.235
30	**.194**	**.387**	**.580**	**.774**	**.968**	**1.161**	**1.354**	**1.548**	**1.742**	**1.935**
32	.211	.422	.634	.845	1.056	1.268	1.479	1.690	1.902	2.113
35	.237	.473	.710	.946	1.183	1.420	1.656	1.893	2.129	2.366
40	**.285**	**.570**	**.855**	**1.140**	**1.424**	**1.709**	**1.994**	**2.279**	**2.564**	**2.849**
45	.341	.683	1.024	1.366	1.707	2.048	2.390	2.731	3.073	3.414
50	.408	.815	1.223	1.630	2.038	2.446	2.853	3.261	3.668	4.076
55	**.485**	**.970**	**1.455**	**1.940**	**2.424**	**2.909**	**3.394**	**3.879**	**4.364**	**4.849**
60	.574	1.149	1.724	2.298	2.872	3.447	4.022	4.596	5.170	5.745
62	.614	1.228	1.843	2.457	3.071	3.685	4.299	4.914	5.528	6.142
64	**.656**	**1.313**	**1.969**	**2.625**	**3.282**	**3.938**	**4.594**	**5.250**	**5.907**	**6.563**
66	.701	1.402	2.103	2.804	3.504	4.205	4.906	5.607	6.308	7.009
68	.748	1.496	2.244	2.992	3.740	4.488	5.236	5.984	6.732	7.480
70	**.798**	**1.596**	**2.394**	**3.192**	**3.990**	**4.788**	**5.586**	**6.384**	**7.182**	**7.980**
72	.851	1.702	2.552	3.403	4.254	5.105	5.956	6.806	7.657	8.508
74	.907	1.813	2.720	3.626	4.533	5.440	6.346	7.253	8.159	9.066
76	**.966**	**1.931**	**2.896**	**3.862**	**4.828**	**5.793**	**6.758**	**7.724**	**8.690**	**9.655**
78	1.028	2.055	3.083	4.111	5.138	6.166	7.194	8.222	9.249	10.277
80	1.093	2.187	3.280	4.374	5.467	6.560	7.654	8.747	9.841	10.934
82	**1.163**	**2.325**	**3.488**	**4.650**	**5.813**	**6.976**	**8.138**	**9.301**	**10.463**	**11.625**
84	1.236	2.471	3.707	4.942	6.178	7.414	8.649	9.885	11.120	12.326
86	1.313	2.625	3.938	5.251	6.564	7.877	9.189	10.502	11.814	13.137
88	**1.394**	**2.787**	**4.181**	**5.575**	**6.968**	**8.362**	**9.756**	**11.150**	**12.543**	**13.997**
90	1.479	2.958	4.437	5.916	7.395	8.874	10.353	11.832	13.311	14.780
92	1.569	3.138	4.707	6.276	7.844	9.413	10.982	12.551	14.120	15.639
94	**1.663**	**3.327**	**4.990**	**6.654**	**8.317**	**9.980**	**11.644**	**13.307**	**14.971**	**16.624**
96	1.763	3.525	5.288	7.050	8.813	10.576	12.338	14.101	15.863	17.676
98	1.867	3.734	5.601	7.468	9.336	11.203	13.070	14.937	16.804	18.661
100	**1.977**	**3.953**	**5.930**	**7.906**	**9.883**	**11.860**	**13.836**	**15.813**	**17.789**	**19.766**

Based on atmospheric pressure of 14.7 psia.

Water carried with air into tools or machines where air is being used will wash away lubricating oil. This causes excess wear to motors and bearings and results in high maintenance expense. Without adequate lubrication, the tools and machines run sluggishly and their efficiency is lowered. This effect is particularly pronounced in the case of pneumatic hammers, drills, hoists and sand rammers, where the wearing surfaces are limited in size and the excessive wear creates air leakage.

Where air is used for paint spraying, enameling, food agitation and similar processes, the presence of water and/or oil cannot be tolerated, nor can particles of grit or scale.

In instrument air systems, water will tend to cling to small orifices and collect dirt, causing erratic operation or failure of sensitive devices.

Pipeline Troubles

When water accumulates at low points in the pipeline, the air-carrying capacity of the line is reduced. Eventually, airflow over the pool of water will begin to carry the water along at high velocity. This produces "water hammer" along the line, and may even carry over a slug of water into a tool. In cold weather, accumulations of water may freeze and burst pipelines.

Air's Capacity to Hold Moisture

At atmospheric pressure (14.7 psia), 8 cu ft of air with an RH of 50% and a temperature of 70°F will contain 32 grains of moisture vapor.

When the pressure is doubled (without increasing the temperature) the volume is cut in half (4 cu ft), but there are still 32 grains of moisture. This means the relative humidity is now 100%—all the moisture in vapor form that it can handle.

Increasing the pressure to 100 psig (114.7 psia), the volume of air is further reduced to approximately 1 cu ft. This 1 cu ft of compressed air still at 70°F can hold a maximum eight grains of moisture.

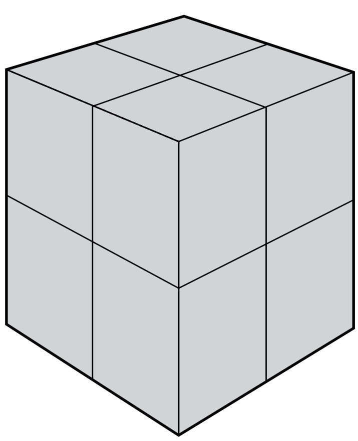


Figure LD-1.
Pressure: 0 psig (14.7 psia)
Temp: 70°F
Air = 8 CF
Moisture = 32 Grains
Max Possible = 64 Grains

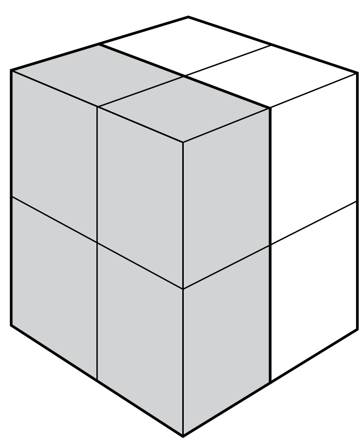


Figure LD-2.
Pressure: 15 psig (29.7 psia)
Temp: 70°F
Air = 4 CF
Moisture = 32 Grains
Max Possible = 32 Grains

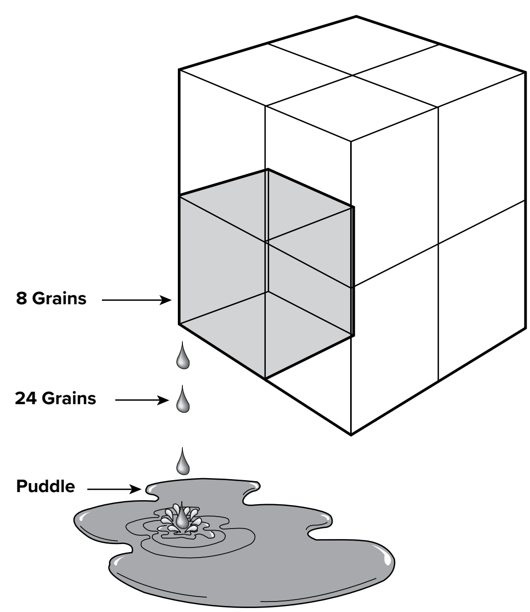


Figure LD-3.
Pressure: 100 psig (114.7 psia)
Temp: 70°F
Air = 1 CF
Moisture = 32 Grains
Max Possible = 8 Grains
24 Grains of Liquid

Drainage Problems and How to Avoid Them

Oil. A critical drainage problem exists at points where oil may be present in the compressed air (principally at intercoolers, aftercoolers and receivers).

Two facts create this problem:
1. Oil is lighter than water and will float on top of water.
2. Compressor oil when cooled tends to become thick and viscous.

The beaker simulates any drain trap that has its discharge valve at the bottom, Fig. LD-4. Like the beaker, the trap will fill with heavy oil that may be thick and viscous.

Compare with Fig. LD-5, which shows an identical beaker except that the discharge valve is at the same level as the oil. Oil will escape until the oil level is so thin that for every 19 drops of water and one of oil that enter the beaker, exactly 19 drops of water and one drop of oil will leave. The beaker always will be filled with water.

The conclusion is obvious. When there is an oil-water mixture to be drained from an air separator or receiver, use a trap with the discharge valve at the top.

Dirt and Grit. While scale and sediment is seldom a problem between the compressor and receiver, it is encountered in the air distribution system, particularly when the piping is old. In this situation, scale will be carried to a drain trap along with the water. If the drain trap is not designed to handle dirt and grit, the trap may fail to drain water and oil, or the trap valve may not close.

Air Loss. Often in compressed air systems, the solution to one problem may also cause another problem. For example, a common method of draining unwanted moisture is to crack open a valve; however, this also creates a leak. The immediate problem is solved, but the “solution” has an obvious, and usually underestimated, cost of continual air loss.

How much air is lost depends on orifice size and line pressure (see Table LD-2). The overall result is a decrease in line pressure, the loss of up to a third of the system’s compressed air, and the cost of compressing it.

Leak control involves:
- Looking for leaks during shut-down with an ultrasonic leak detector
- Determining total leakage by observing how fast pressure drops with the compressor off, both before and after a leak survey
- Fixing leaks at joints, valves and similar points
- Replacing cracked-open valves with drain traps
- Checking the system regularly

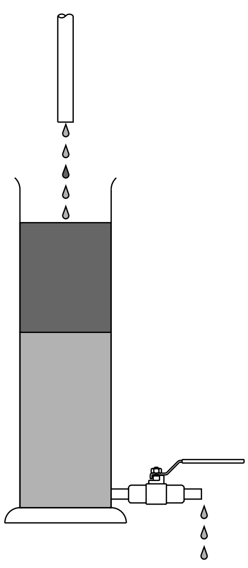


Figure LD-4.
If a beaker collecting oil and water is drained from the bottom at the same rate that oil and water enter, it will eventually fill entirely with oil because oil floats on water.

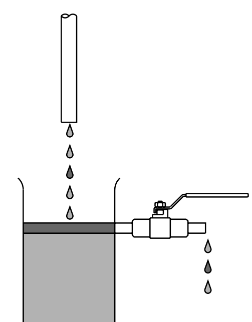
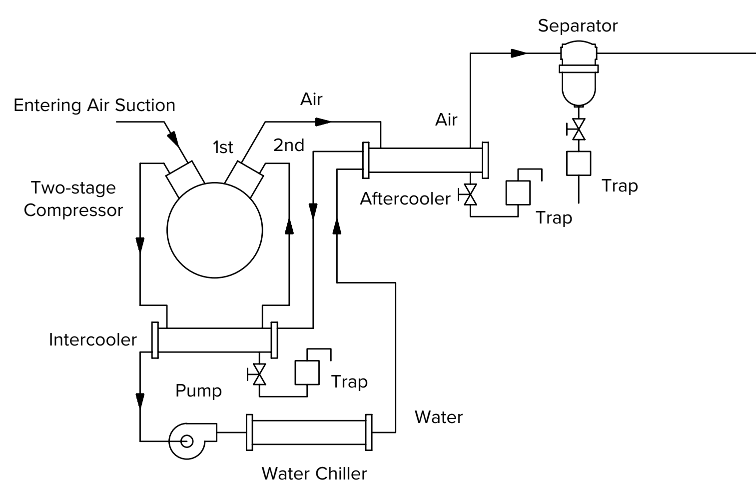


Figure LD-5.
If a beaker collecting oil and water is drained from the top at the same rate that oil and water enter, it soon will be entirely filled with water because the oil floats on the water.

Figure LD-6. Drain Trap Locations in a Compressed Air System
The use of drain traps is an effective way to remove water that collects in many places in a compressed air system. Each trap location must be considered individually.



Drainage Methods

Manual. Liquid may be discharged continuously through cracked-open valves, or periodically by opening manually operated drain valves.

Open drains are a continuous waste of air or gas—and the energy to produce it. A valve manually opened will be left open until air blows freely. Frequently, however, the operator will delay or forget to close the valve, and precious air or gas is lost.

Automatic. Automatic drainage equipment that is adequate for the system is seldom included in the original system. However, subsequent installation of automatic drain traps will significantly reduce energy and maintenance costs.

Drain Traps. Water collected in separators and drip legs must be removed continuously without wasting costly air or gas. In instances where drain traps are not part of the system design, manual drain valves are usually opened periodically or left cracked open to drain constantly. In either case, the valves are opened far enough that some air and gas are lost along with the liquid. To eliminate this problem, a drain trap should be installed at appropriate points to remove liquid continuously and automatically without wasting air or gas.

The job of the drain trap is to get liquid and oil out of the compressed air/gas system. In addition, for overall efficiency and economy, the trap must provide:

- Operation that is relatively trouble-free with minimal need for adjustment or maintenance
- Reliable operation even though dirt, grit and oil are present in the line
- Long operating life
- Minimal air loss
- Ease of repair

Table LD-2. Cost of Various Size Air Leaks at 90 psig

Orifice Diameter (in)	Leakage Rate (scfm)	Total Cost Per Month	Cost Total Per Year
3/8	138.00	$1 207.50	$14 490
1/4	61.00	533.75	6 405
1/8	**15.40**	**134.75**	**1 617**
7/64	11.80	103.25	1 239
5/64	6.00	52.50	630
1/16	**3.84**	**33.60**	**403**