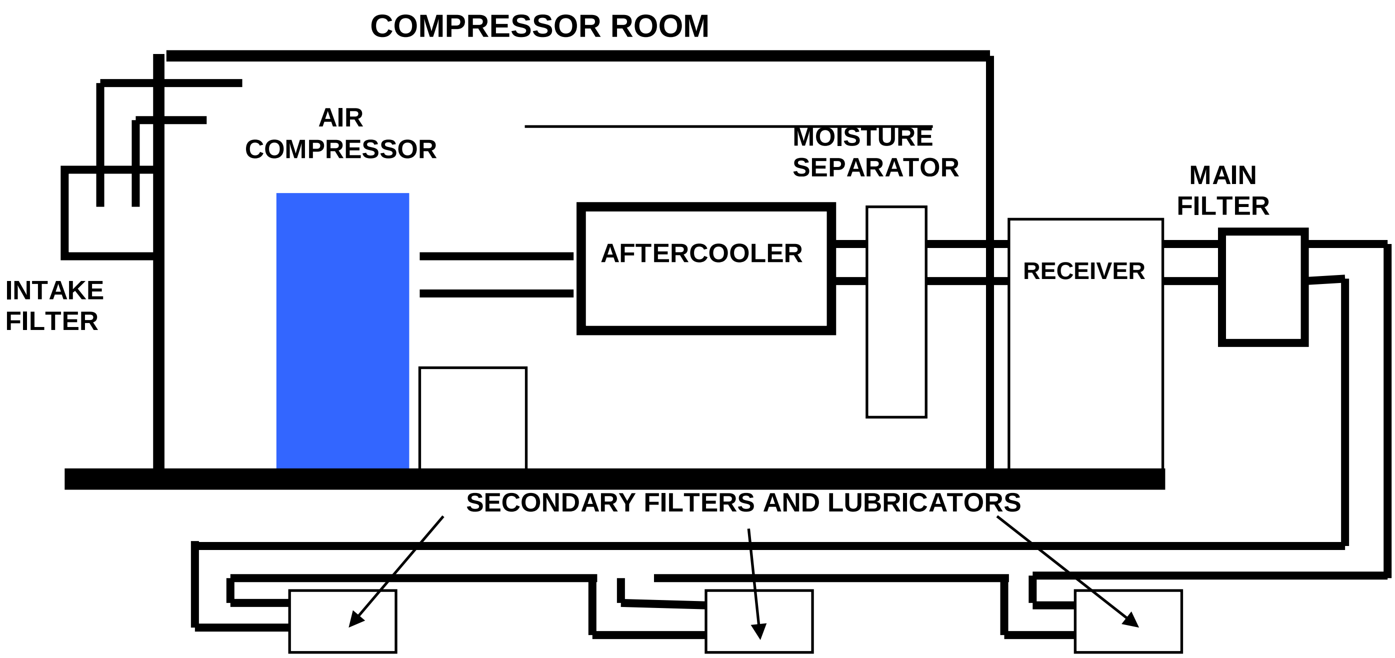
COMPRESSED AIR
ULTRASONIC LEAK DETECTION GUIDE



UE Systems Compressed Air Leak Detection Guide

Compressed air is one of the most costly utilities in a facility today. A simple program of leak inspection and repair can go a long way towards reducing excessive energy costs.

In addition to your leak survey, take the time to review your compressed air system. Look for areas of misuse, check for inefficiencies. Review your compressors: are they too large or too small for the load? If you're not sure about how well your system is designed or working, invite your local compressor dealer over or you might hire the services of a consultant who specializes in compressed air systems. If you would like to use a leak detection company to perform your survey look up our on-line directory of service providers:
UE Service Partners at: http://www.uesystems.com/service/srvcprtnr.html

Our guide is full of useful information to help you get your leak detection and repair program started. You'll find a step by step guide for leak detection and data that can help you report your leak savings. In addition, we've included two "Guesstimator" charts to help determine the cfm loss through specific leaks. One is for the analog instruments: Ultraprobe 550 and Ultraprobe 2000 and the other is for the digital Ultraprobe 9000. If you should have any questions, or comments, please feel free to contact us at:

914-592-1220, Fax: 914-347-2181 or mail: info@uesystems.com

Setting up a Compressed Air Leak Detection Survey

1. Walk through your plant. While you walk, pay attention to obvious problems such as loud leaks that you can spot and tag without the aid of an ultrasonic detector. Observe misuse of air such as valves left wide open, rags placed over pipes to reduce the noise level of large leaks, unattended machines left on with air blowing all over the place. Check and repair all drain traps, do not leave them "cracked" open. Check defective tools, quick connection points, etc.

   As you walk, try to determine the best route for inspection. If possible, take a print of the compressed air piping system, or make a simple sketch. These graphics will help you identify the leaks and make it easier to find them for repair.

2. Use an Ultraprobe to scan for leaks. Always wear your headphones. If you have difficulty determining direction, reduce your sensitivity. Follow the sound to the loudest point.

3. For consistency, start at the compressor/supply side and work your way to the use side.

4. When you begin your inspection, create a series of inspection "zones". This will help organize your approach and prevent the possibility of overlooking a section and missing some leaks. Move from one "zone" to the next in a planned organized manner.

5. Tag all leaks. The tag will make it easy to spot the leaks for repair.

6. Test all leaks after they have been repaired. Sometimes leaks can be fixed and new ones created inadvertently.

7. Calculate your savings using cfm charts and formulas accompanying this guide.

8. Report your results. Let management know what a great job you're doing.

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In the field of leak detection there are many confusing elements that appear when two or more people try to convey the type or size of loss that they need to detect. One way to resolve this is to convert all forms of leak loss descriptions into one common format.

Below is a formula that converts a divergence of leak descriptions into the term: "CFM or cubic feet per minute.

The formula is:

$$\frac{\left(\dfrac{\text{Pressure Loss}}{\text{1 Atmosphere}}\right) \times \text{Volume in ft3}}{\text{Time in minutes}} = \text{CFM}$$

The formula is universal, in that one can use any form of leak measurement. To use the formula factors, refer to the chart that explains what one atmosphere is for a particular measurement unit. This measurement unit can be PSI, Inches of Mercury, Feet of Water or Bars.

Conversion Chart

1 Cubic Foot	= 1728 cubic inches
1 Atmosphere	= 14.7 PSI
	= 29.9 inches of HG (Mercury)
	= 33.9 Ft. of H2O
	= 1.00 Bars

EXAMPLE:
A leak in a system of 300 cubic feet is losing 10 psi in 2 minutes. The system pressure is 100 PSI.

NOTE: the system pressure will almost always be given. It is not to be used in this formula. The only reason it is given in this example is to alert you to the fact that it is not necessary even when provided.

FORMULA

$$\text{CFM} = \frac{\frac{10}{14.7} \times 300}{2} = \frac{.680 \times 300}{2} = 102 \text{ CFM}$$

DISCHARGE OF AIR THROUGH AN ORIFICE

In cubic feet of free air per minute at standard atmospheric pressure of 14.7 lb. Per sq. in. absolute and 70°F

Gauge Pressure before Orifice in Pounds per sq. in.	DIAMETER OF ORIFICE										
	1/64”	1/32”	1/16”	1/8”	¼”	3/8”	½”	5/8””	¾”	7/8”	1”
	Discharge in cubic feet of free air per minute										
1	.028	.112	.450	1.80	7.18	16.2	28.7	45.0	64.7	88.1	115
2	.040	.158	.633	2.53	10.1	22.8	40.5	63.3	91.2	124	162
3	.048	.194	.775	3.10	12.4	27.8	49.5	77.5	111	152	198
4	.056	.223	.892	3.56	14.3	32.1	57.0	89.2	128	175	228
5	.062	.248	.993	3.97	15.9	35.7	63.5	99.3	143	195	254
6	.068	.272	1.09	4.34	17.4	39.1	69.5	109	156	213	278
7	.073	.293	1.17	4.68	18.7	42.2	75.0	117	168	230	300
9	.083	.331	1.32	5.30	21.2	47.7	84.7	132	191	260	339
12	.095	.379	1.52	6.07	24.3	54.6	97.0	152	218	297	388
15	.105	.420	1.68	6.72	26.9	60.5	108	168	242	329	430
20	.123	.491	1.96	7.86	31.4	70.7	126	196	283	385	503
25	.140	.562	2.25	8.98	35.9	80.9	144	225	323	440	575
30	.158	.633	2.53	10.1	40.5	91.1	162	253	365	496	648
35	.176	.703	2.81	11.3	45.0	101	180	281	405	551	720
40	.194	.774	3.10	12.4	49.6	112	198	310	446	607	793
45	.211	.845	3.38	13.5	54.1	122	216	338	487	662	865
50	.229	.916	3.66	14.7	58.6	132	235	366	528	718	938
60	.264	1.06	4.23	16.9	67.6	152	271	423	609	828	1082
70	.300	1.20	4.79	19.2	76.7	173	307	479	690	939	1227
80	.335	1.34	5.36	21.4	85.7	193	343	536	771	1050	1371
90	.370	1.48	5.92	23.7	94.8	213	379	592	853	1161	1516
100	.406	1.62	6.49	26.0	104	234	415	649	934	1272	1661
110	.441	1.76	7.05	28.2	113	254	452	705	1016	1383	1806
120	.476	1.91	7.62	30.5	122	274	488	762	1097	1494	1951
125	.494	1.98	7.90	31.6	126	284	506	790	1138	1549	2023
150	.582	2.37	9.45	37.5	150	338	600	910	1315	1789	2338
200	.761	3.10	12.35	49.0	196	441	784	1225	1764	2401	3136
250	.935	3.80	15.18	60.3	241	542	964	1508	2169	2952	3856
300	.995	4.88	18.08	71.8	287	646	1148	1795	2583	3515	4592
400	1.220	5.98	23.81	94.5	378	851	1512	2360	3402	4630	6048
500	1.519	7.41	29.55	117.3	469	1055	1876	2930	4221	5745	7504
750	2.240	10.98	43.85	174.0	696	1566	2784	4350	6264	8525	11136
1000	2.985	14.60	58.21	231.0	924	2079	3696	5790	8316	11318	14784

Table is based on 100% coefficient of flow. For a well rounded entrance, multiply values by 0.97. For sharp edged orifices a multiplier of 0.61 may be used for approximate results. Values for pressures from 1 to 15 lbs. gauge calculated by standard adiabatic formula. Values for pressures above 15 lb. gauge calculated by approximate formula proposed by S.A. Moss Where:

$$W = 0.5303 \frac{ACp_1}{\sqrt{T_1}}$$

Where: W = discharge in lbs. per sec.
A = Area of orifice in sq. in.
C = Coefficient of flow
p_1 = Upstream total pressure in lbs. per sq. in. absolute
T_1 = Upstream temperature in °F.

Values used in calculating above table were: C = 1.0, p_1=gauge pressure + 14.7 lbs./ sq. in., T_1 = 530°F. abs. Weights (W) were converted to volumes using density factor of 0.07494 lbs./cu. ft. This is correct for dry air at 14.7lbs. per sq. in. absolute pressure and 70°F. Formula cannot be used where P_1 is less that two times the downstream pressure.

Inches x 25.4 = mm; psi x 6.895 = kPa; chn x 0.02832 = rn^3/rnin; 70°F = 21.1°C

UE SYSTEMS inc.

Air Leak Cost

Diameter Of Leak	Cubic Feet/Minute	Cubic Feet/Day	Loss/Day Dollars	Loss/Month Dollars	Loss/Year Dollars
1/64"	.45	576	$0.13	$4.00	$48.00
I/32"	1.60	2,304	$0.51	$15.50	$186.00
3/64"	3.66	5,270	$1.16	$35.30	$424.00
1/16"	6.45	9,288	$2.04	$62.00	$744.00
3/32"	14.50	20,880	$4.59	$139.50	$1,674.00
1/8"	25.80	37,152	$8.17	$248.40	$2,981.00
3/16"	58.30	83,952	$18.47	$561.50	$6,738.00
1/4"	103.00	148,320	$32.63	$992.00	$11,904.00
5/16"	162.00	233,280	$51.32	$1,560.00	$18,721.00
3/8"	234.00	336,960	$74.13	$2,253.60	$27,036.00

Based on 100 PSIG, $ 0.22/MCF, 8,760 Hours/Year

Air Leak Cost

Diameter of Leak	Cubic Feet/Minute	Cubic Feet/Day	Loss/Day Dollars	Loss/Month Dollars	Loss/Year Dollars
1/64"	.45	576	$0.18	$5.50	$66.00
1/32"	1.60	2,304	$0.71	$21.60	$259.00
3/64"	3.66	5,270	$1.63	$49.60	$595.00
1/16"	6.45	9,288	$2.886	$87.60	$1,051.00
3/32"	14.50	20,880	$6.47	$196.70	$2,360.00
1/8"	25.80	37,152	$11.52	$350.20	$4,202.00
3/16"	58.30	83,952	$26.03	$791.30	$9,496.00
1/4"	103.00	148,320	$45.98	$1,397.80	$16,744.00

Based on 100 PSIG, $0.31/MCF, 8,760 Hours/Year

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GUESS-TIMATOR CHART FOR UP9000/10,000

dB vs CFM

DIGITAL READING	100 PSIG	75 PSIG	50 PSIG	25 PSIG	10 PSIG
10 dB	0.35	0.26	0.15	0.08	0.05
20 dB	0.93	0.73	0.48	0.31	0.20
30 dB	1.64	1.34	0.96	0.68	0.47
40 dB	2.45	2.06	1.56	1.18	0.85
50 dB	3.35	2.87	2.27	1.82	1.35
60 dB	4.33	3.78	3.09	2.58	1.97
70 dB	5.37	4.76	4.01	3.47	2.71
80 dB	6.47	5.81	5.02	4.48	3.58
90 dB	7.64	6.93	6.13	5.61	4.57
100 dB	8.85	8.12	7.32	6.87	5.69

NOTES:
ALL READINGS ARE COMPENSATED FOR ATMOSPHERIC PRESSSURE.
All readings were taken at 40 kHz.

PROCEEDURE:

Use the Scanning Module to conduct the broad scanning to pinpoint the air leaks. The Scanning Module with the Rubber Focusing Probe RFP) is used to determine air losses. The tip of the RFP on the UP9000 should be fifteen (15) inches away from the leak location for determination of the leak rate.

Notice: The values presented in this table are not stated as factual CFM measurement. This table is provided solely for convenience and should only be used as a general guideline.

Factors such as turbulence, leak orifice configuration, pressure, moisture and instrument sensitivity can significantly effect your results.

COMPRESSED AIR LOSS GUESS-TIMATOR V 3.0

Procedure for using the UE SYSTEMS INC. ULTRAPROBE® 2000 to locate and roughly measure air leakage in compressed air systems.

Use the scanning module to conduct the broad scanning to pinpoint the air leaks. The scanning module with rubber focusing probe is used to determine the air losses. The tip of the rubber focusing probe on the Ultraprobe 2000 should be held 12 - 15" from the point of leakage. The sensitivity dial is used to increase or decrease sensitivity until the meter is at 50% of scale.

FLOW RATE CHART = CFM

Notice: The values presented in this table are not stated as factual CFM measurement. This table is provided solely for convenience and should only be used as a general guideline.

Factors such as turbulence, leak orifice configuration, pressure, moisture and instrument sensitivity can significantly effect your results.

For information on measurement of total compressed air system loss contact your local compressed air vendor or contact UE Service Partners to have a compressed air specialist provide this service for you.

Sensitivity Dial	100 PSIG	75 PSIG	50 PSIG	25 PSIG
8.5	.50	.30	.15	.10
8.0	1.0	0.5	.30	.20
7.5	1.1	0.8	0.7	0.7
7.0	1.6	1.0	1.0	0.9
6.5	2.0	1.3	1.3	1.4
6.0	2.3	1.7	1.7	1.8
5.5	3.3	2.2	2.2	2.2
5.0	3.9	2.8	2.6	2.7
4.5	5.5	3.6	3.2	3.7
4.0	6.2	3.9	3.7	4.0
3.5	6.9	4.9	4.6	4.6
3.0	7.5	5.7	5.2	5.1
2.5	8.0	6.2	5.8	6.0
2.0	8.5	7.2	6.3	6.9
1.5	8.8	8.4	7.6	7.3
1.0	10.1	10.0	7.8	8.0

CALCULATING THE COST OF AIR PER THOUSAND CUBIC FEET (MCF)

To get the cost of air per thousand cubic feet (MCF), use the following formula:

$$\frac{\left(\frac{\text{BHP X 0.746}}{0.90}\right)\left(\text{\$/KWH}\right)}{\left(\frac{\text{CFM X 60}}{1000}\right)}$$

0.746 KW/BHP (Kilowatts per Break Horse Power)
Average efficiency = 0.90
4.2 CFM/BHP (an average of CFM per Break Horse Power suggested from Compressor Manufacturers)

The breakdown:

KWH (To run the Compressor) = $\frac{\text{BHP of Compressor x 0.746}}{0.90}$

KWH X $ / KWH = Cost of running Compressor for one hour

$\frac{\text{CFM of Compressor X 60}}{1000}$ = MCF / Hour

$\frac{\text{Cost of running Compressor for one hour}}{\text{MCF/Hour}}$ = $/MCF

HOW TO CALCULATE YOUR CFM LOSS AS DOLLAR LOSS PER YEAR

The basic calculation of a leak cost in terms of CFM can be determined using the following formula.

$$\frac{(CFM \times 60)(8760)}{1000} \times MCF = \text{Leak Cost per year}$$

1. Convert your CFM into Cubic Feet per hour

CFM x 60

Example: 3.6 cfm x 60 = 216 cubic feet per hour

2. Calculate Cubic feet per year. Multiply the number of hours the system is in use by the hourly figure.

Example: 216 x 8760 (hours per year) = 1892160 cubic feet per year

3. To determine the cost per year, determine the cost of compressed air. This is usually represented in MCF(Thousand Cubic Feet). First divide the hourly figure by 1000 and then multiply by the MCF cost figure.

Example: MCF cost is $0.22
1892160 ÷ 1000 = 1892.16
1892.16 x $.22 = $416.28 cost per year

Quantifying Compressed Air Loss and Savings From a Survey

The going estimate in the field is that about 25% of all compressed air is wasted through leaks.

Here's a simple formula that can be used to estimate the loss/savings of your compressed air survey.

$$S=(L/4.2)(0.746)(T)(C) \div 0.90$$

S = Annual Savings, $
L= Air loss, cfm
4.2 = average number of cfm/bhp. This is based on manufacturers' equipment data*
0.746 = average power requirement in kW/bhp to generate one bhp
T = hours of operation
C = Cost per kWh
0.90 = motor efficiency factor

Example: 100-hp air compressor produces 450 cfm of air
Electrical cost of $0.08/kWh
Air leaks amount to 25%.

25%(leaks) of 450 cfm = 112.5 cfm (this is *L*)

112.5/4.2 cfm/bhp = 26.8 bhp

26.8bhp x 0.746kW/bhp = 19.9928 (kW)

19.9928kW x 8760 hrs (24 hrs/day, 365days/year) = 175136.9 kWh

175136.9 x $0.08/kWh = $14010.95

$14010.95 ÷ .90 = $15,567.72

*This number varies with equipment type. For specific information, consult a compressed air handbook or a manufacturer's data sheet.