

Working with Copper Tubing

by George Kekenos

Repurposing an A/C compressor as a vacuum pump is an inexpensive way to do small vacuum bagging projects. Adapting the compressor lines to a fitting you can use for whatever purpose you need the pump for can be a problem if you don't have experience in copper tubing. This article explains how to adapt copper tubing to pipe threads. To get started I have outlined the different types of copper tubing you'll encounter.

Common wall-thicknesses of copper tubing for the purpose of modifying compressor connections are "Type K", "Type L", "Type M" and "ACR". The different types are color coded, usually with a stripe, and will have markings every 18". Copper tubing is made in both "hard" and "soft" formulations, the soft can be bent in a wide radius with benders and in some cases by hand. The hard type must use fittings.

Type	Color	Formulations
Type K	Green	Hard in straight lengths and soft in coils
Type L	Blue	Hard in straight lengths and soft in coils
Type M	Red	Hard in straight lengths
ACR	Blue	Hard in straight lengths and soft in coils

Here are some charts that come in very handy when adapting copper tubing, they give the inside and out diameter of the different types of tubing.

Tube Type	Color Code	Standard	Application ¹	Commercially Available Lengths ²		
				Nominal or Standard Sizes	Drawn	Annealed
TYPE K	Green	ASTM B88 ³	Domestic Water Service and Distribution, Fire Protection, Solar, Fuel/Fuel Oil, HVAC, Snow Melting, Compressed Air, Natural Gas, Liquefied Petroleum (LP) Gas, Vacuum	STRAIGHT LENGTHS:		
				1/4-inch to 8-inch	20 ft	20 ft
				10-inch	18 ft	18 ft
				12-inch	12 ft	12 ft
				COILS:		
				1/4-inch to 1-inch	—	60 ft
					—	100 ft
				1 1/4 inch and 1 1/2-inch	—	60 ft
TYPE L	Blue	ASTM B88	Domestic Water Service and Distribution, Fire Protection, Solar, Fuel/Fuel Oil, Natural Gas, Liquefied Petroleum (LP) Gas, HVAC, Snow Melting, Compressed Air, Vacuum	STRAIGHT LENGTHS:		
				1/4-inch to 10-inch	20 ft	20 ft
				12-inch	18 ft	18 ft
				COILS:		
				1/4-inch to 1-inch	—	60 ft
					—	100 ft
				1 1/4 inch and 1 1/2-inch	—	60 ft
				2-inch	—	40 ft
TYPE M	Red	ASTM B88	Domestic Water Service and Distribution, Fire Protection, Solar, Fuel/Fuel Oil, HVAC, Snow Melting, Vacuum	STRAIGHT LENGTHS:		
				1/4-inch to 12-inch	20 ft	N/A
DWV	Yellow	ASTM B306	Drain, Waste, Vent, HVAC, Solar	STRAIGHT LENGTHS:		
				1 1/4-inch to 8-inch	20 ft	N/A
ACR	Blue	ASTM B280	Air Conditioning, Refrigeration, Natural Gas, Liquefied Petroleum (LP) Gas, Compressed Air	STRAIGHT LENGTHS:		
				3/4-inch to 4 1/4-inch	20 ft	4
				COILS:		
OXY, MED, OXY/MED, OXY/ACR, ACR/MED	(K)Green (L)Blue	ASTM B819	Medical Gas Compressed Medical Air, Vacuum	1/4-inch to 1 1/2-inch	—	50 ft
				STRAIGHT LENGTHS:		
				1/4-inch to 8-inch	20 ft	N/A

TABLE 2a. Dimensions and Physical Characteristics of Copper Tube: TYPE K

Nominal or Standard Size, inches	Nominal Dimensions, inches			Calculated Values (based on nominal dimensions)				
	Outside Diameter	Inside Diameter	Wall Thickness	Cross Sectional Area of Bore, sq inches	Weight of Tube Only, pounds per linear ft	Weight of Tube & Water, pounds per linear ft	Contents of Tube per linear ft	
							Cu ft	Gal
1/4	.375	.305	.035	.073	.145	.177	.00051	.00379
3/8	.500	.402	.049	.127	.269	.324	.00088	.00660
1/2	.625	.527	.049	.218	.344	.438	.00151	.0113
5/8	.750	.652	.049	.334	.418	.562	.00232	.0174
3/4	.875	.745	.065	.436	.641	.829	.00303	.0227
1	1.125	.995	.065	.778	.839	1.18	.00540	.0404
1 1/4	1.375	1.245	.065	1.22	1.04	1.57	.00847	.0634
1 1/2	1.625	1.481	.072	1.72	1.36	2.10	.0119	.0894
2	2.125	1.959	.083	3.01	2.06	3.36	.0209	.156
2 1/2	2.625	2.435	.095	4.66	2.93	4.94	.0324	.242
3	3.125	2.907	.109	6.64	4.00	6.87	.0461	.345
3 1/2	3.625	3.385	.120	9.00	5.12	9.01	.0625	.468
4	4.125	3.857	.134	11.7	6.51	11.6	.0813	.608
5	5.125	4.805	.160	18.1	9.67	17.5	.126	.940
6	6.125	5.741	.192	25.9	13.9	25.1	.180	1.35
8	8.125	7.583	.271	45.2	25.9	45.4	.314	2.35
10	10.125	9.449	.338	70.1	40.3	70.6	.487	3.64
12	12.125	11.315	.405	100.55	57.8	101	.701	5.25

TABLE 2b. Dimensions and Physical Characteristics of Copper Tube: TYPE L

Nominal or Standard Size, inches	Nominal Dimensions, inches			Calculated Values (based on nominal dimensions)				
	Outside Diameter	Inside Diameter	Wall Thickness	Cross Sectional Area of Bore, sq inches	Weight of Tube Only, pounds per linear ft	Weight of Tube & Water, pounds per linear ft	Contents of Tube per linear ft	
							Cu ft	Gal
1/4	.375	.315	.030	.078	.126	.160	.00054	.00405
3/8	.500	.430	.035	.145	.198	.261	.00101	.00753
1/2	.625	.545	.040	.233	.285	.386	.00162	.0121
5/8	.750	.666	.042	.348	.362	.506	.00232	.0174
3/4	.875	.785	.045	.484	.455	.664	.00336	.0251
1	1.125	1.025	.050	.825	.655	1.01	.00573	.0429
1 1/4	1.375	1.265	.055	1.26	.884	1.43	.00875	.0655
1 1/2	1.625	1.505	.060	1.78	1.14	1.91	.0124	.0925
2	2.125	1.985	.070	3.09	1.75	3.09	.0215	.161
2 1/2	2.625	2.465	.080	4.77	2.48	4.54	.0331	.248
3	3.125	2.945	.090	6.81	3.33	6.27	.0473	.354
3 1/2	3.625	3.425	.100	9.21	4.29	8.27	.0640	.478
4	4.125	3.905	.110	12.0	5.38	10.1	.0764	.571
5	5.125	4.875	.125	18.7	7.61	15.7	.130	.971
6	6.125	5.845	.140	26.8	10.2	21.8	.186	1.39
8	8.125	7.725	.200	46.9	19.3	39.6	.326	2.44
10	10.125	9.625	.250	72.8	30.1	61.6	.506	3.78
12	12.125	11.565	.280	105	40.4	85.8	.729	5.45

TABLE 2c. Dimensions and Physical Characteristics of Copper Tube: TYPE M

Nominal or Standard Size, inches	Nominal Dimensions, inches			Calculated Values (based on nominal dimensions)				
	Outside Diameter	Inside Diameter	Wall Thickness	Cross Sectional Area of Bore, sq inches	Weight of Tube Only, pounds per linear ft	Weight of Tube & Water, pounds per linear ft	Contents of Tube per linear ft	
							Cu ft	Gal
1/8	.500	.450	.025	.159	.145	.214	.00110	.00826
1/4	.625	.569	.028	.254	.204	.314	.00176	.0132
3/8	.875	.811	.032	.517	.328	.551	.00359	.0269
1	1.125	1.055	.035	.874	.465	.843	.00607	.0454
1 1/4	1.375	1.291	.042	1.31	.682	1.25	.00910	.0681
1 1/2	1.625	1.527	.049	1.83	.940	1.73	.0127	.0951
2	2.125	2.009	.058	3.17	1.46	2.83	.0220	.165
2 1/2	2.625	2.495	.065	4.89	2.03	4.14	.0340	.254
3	3.125	2.981	.072	6.98	2.68	5.70	.0485	.363
3 1/2	3.625	3.459	.083	9.40	3.58	7.64	.0653	.488
4	4.125	3.935	.095	12.2	4.66	9.83	.0847	.634
5	5.125	4.907	.109	18.9	6.66	14.8	.131	.982
6	6.125	5.881	.122	27.2	8.92	20.7	.189	1.41
8	8.125	7.785	.170	47.6	16.5	37.1	.331	2.47
10	10.125	9.701	.212	73.9	25.6	57.5	.513	3.84
12	12.125	11.617	.254	106	36.7	82.5	.736	5.51

TABLE 2e. Dimensions and Physical Characteristics of Copper Tube: ACR (Air-Conditioning and Refrigeration Field Service) (A= Annealed Temper, D=Drawn Temper)

Nominal or Standard Size, inches		Nominal Dimensions, inches			Calculated Values (based on nominal dimensions)				
		Outside Diameter	Inside Diameter	Wall Thickness	Cross Sectional Area of Bore, sq inches	External Surface, sq ft per linear ft	Internal Surface, sq ft per linear ft	Weight of Tube Only, pounds per linear ft	Contents of Tube, cu ft per linear ft
1/8	A	.125	.065	.030	.00332	.0327	.0170	.0347	.00002
1/8	D	.187	.128	.030	.0129	.0492	.0335	.0575	.00009
1/4	A	.250	.190	.030	.0284	.0655	.0497	.0804	.00020
1/4	D	.312	.248	.032	.0483	.0817	.0649	.109	.00034
3/8	A	.375	.311	.032	.076	.0982	.0814	.134	.00053
3/8	D	.375	.315	.030	.078	.0982	.0821	.126	.00054
1/2	A	.500	.436	.032	.149	.131	.114	.182	.00103
1/2	D	.500	.430	.035	.145	.131	.113	.198	.00101
5/8	A	.625	.555	.035	.242	.164	.145	.251	.00168
5/8	D	.625	.545	.040	.233	.164	.143	.285	.00162
3/4	A	.750	.680	.035	.363	.196	.178	.305	.00252
3/4	D	.750	.666	.042	.348	.196	.174	.362	.00242
3/4	A	.750	.666	.042	.348	.196	.174	.362	.00242
7/8	A	.875	.785	.045	.484	.229	.206	.455	.00336
7/8	D	.875	.785	.045	.484	.229	.206	.455	.00336
1 1/8	A	1.125	1.025	.050	.825	.294	.268	.655	.00573
1 1/8	D	1.125	1.025	.050	.825	.294	.268	.655	.00573
1 1/4	A	1.375	1.265	.055	1.26	.360	.331	.884	.00875
1 1/4	D	1.375	1.265	.055	1.26	.360	.331	.884	.00875
1 1/2	A	1.625	1.505	.060	1.78	.425	.394	1.14	.0124
1 1/2	D	1.625	1.505	.060	1.78	.425	.394	1.14	.0124
2 1/4	D	2.125	1.985	.070	3.09	.556	.520	1.75	.0215
2 1/2	D	2.625	2.465	.080	4.77	.687	.645	2.48	.0331
3 1/4	D	3.125	2.945	.090	6.81	.818	.771	3.33	.0473
3 1/2	D	3.625	3.425	.100	9.21	.949	.897	4.29	.0640
4 1/4	D	4.125	3.905	.110	12.0	1.08	1.02	5.38	.0833

Making Connections

The connections to adapt on the A/C compressor you are converting to vacuum pump will be ACR. You will need NPT (pipe thread) to connect to vacuum bagging/press components. There are several ways to make the conversions, but first let's look at the common ways copper tubing is connected.

- Solder or brazed joints which are strong permanent joints that require a torch and a filler metal. Solder/brazed joints provide the most choices in size, angle, length, placement, and type of tubing. These joints are permanent and require an acetylene, oxy acetylene or map gas torch along with the proper solder or filler metal for the type of tubing and pressure requirements needed. They are also inexpensive to make, once you have the torch and solder/filler you can make joints for pennies a piece depending on size and complexity.
- Flare fittings are strong and can be easily disconnected if needed. Flare fitting joints are more labor intensive in so much as each side of the tubing in the joint needs to be placed in a flaring tool and formed to the proper shape to attach to the fitting end with a lock nut. They are very strong and also able to be disconnected and reconnected easily. The fittings will cost from 5 to 7 dollars for small, simple ones. They are reusable and are readily available in many configurations.
- Socket or groove fittings incorporate a gasket to seal the connection. These joints are the least labor intensive and require no special tools to use. They are also weaker than the other types, not as readily available, and can be significantly more expensive to buy.

To demonstrate I went around my shop and took 4 pieces of copper tubing scraps I found and joined them together and converted to NPT.

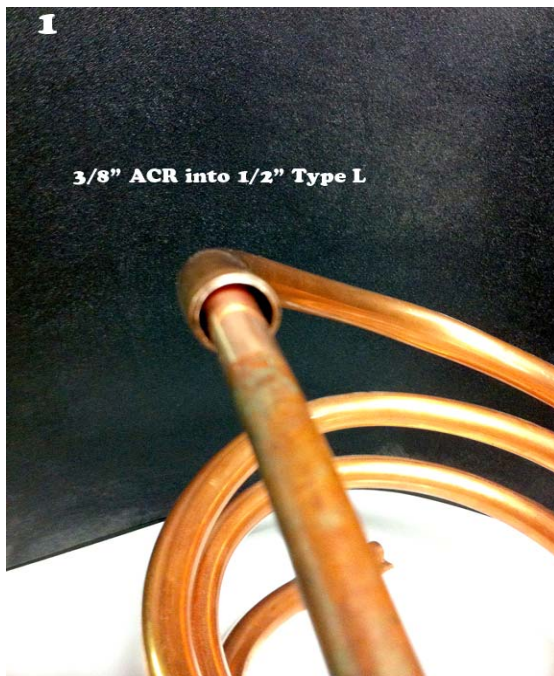


Image 1
3/8 Type-ACR easily slides into 1/2 Type-L copper.



Image 2
The pinched edge of the larger tube fits around the smaller tube.



Image 3

The joints are silver soldered with a propane torch.



Images 4 & 5

Use a flaring tool to flare both ends.

Always put your flare nut on the tubing first or you'll be cutting off the end and re-flaring.



Image 6
A proper flare

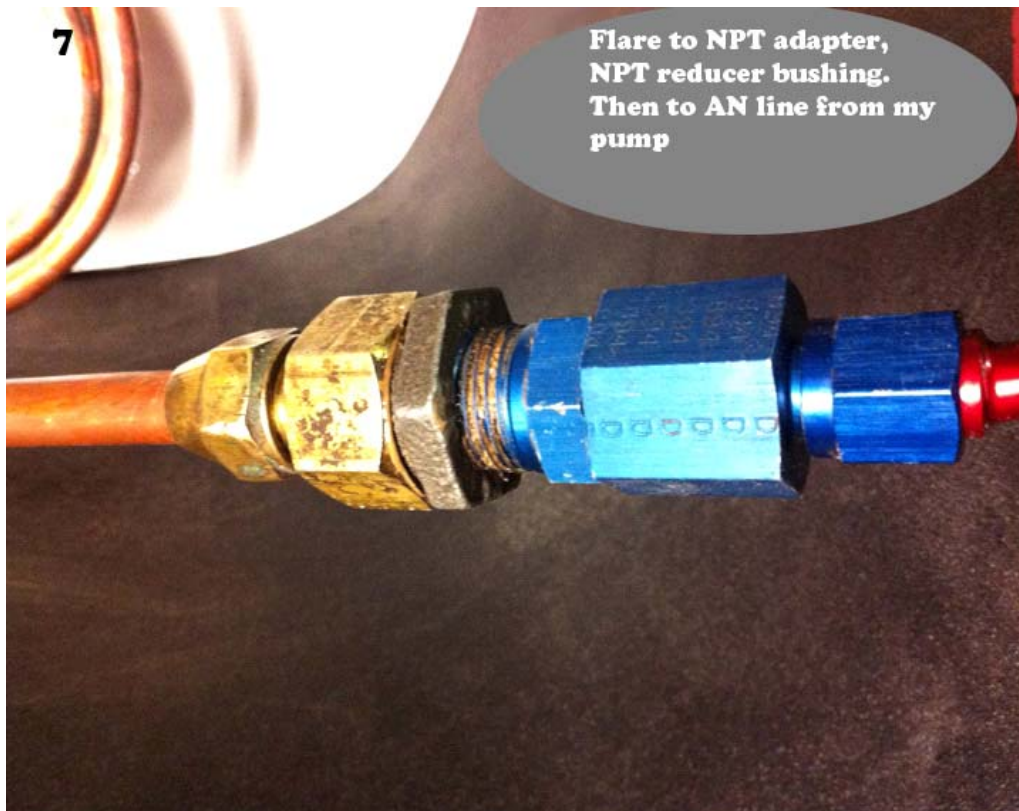


Image 7
Shows a flare adapter, NPT bushing, to get to 1/2 NPT then changed over to 6AN which is the fitting I use on my pump.



Image 8
The other side of the tubing, plugged for testing.



Image 9
A Millipore pump that I got at auction for \$7.

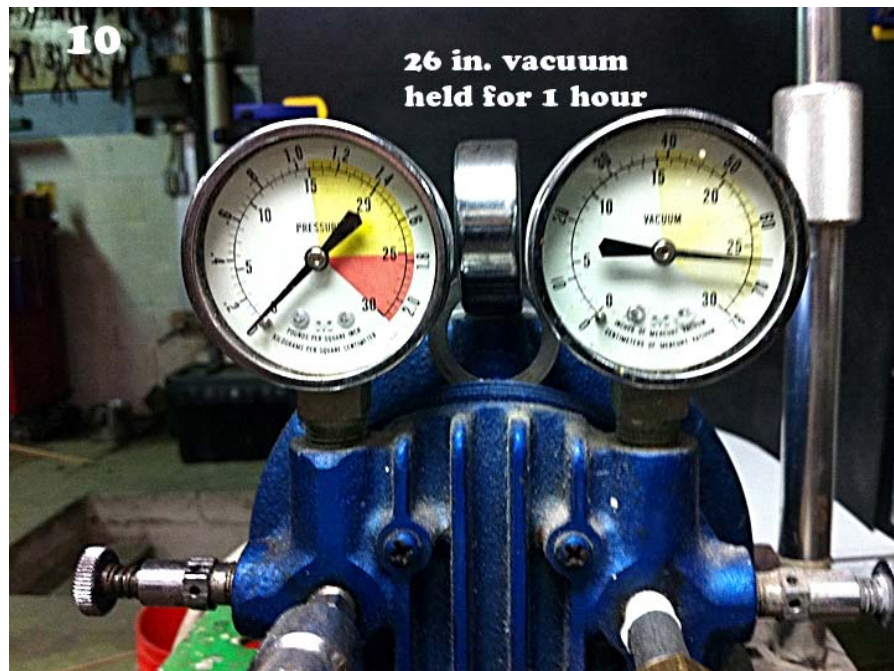


Image 10
Pulled down to 26" Hg to check for leaks.

You can see that there are several inexpensive and basic ways to adapt almost any type of copper tubing to any other fitting, thread, line, or hose you may need.

If you are just planning to adapt lines from an A/C compressor to make a vacuum pump, a flaring tool and adapter fittings are your best bet.

If you plan to do more adapting, your own plumbing and A/C repair or run into stuck bolts from time to time, a small torch is very handy to have around. Always use the proper safety equipment when working with torches.

I strongly suggest you do not find an old A/C unit and remove the compressor from it since releasing refrigerant gas is illegal, carries a hefty fine, and is not good for the environment. Also when heating up existing compressor joints without proper evacuation there's always a risk of burning a pocket of Freon in one of the copper tubing loops and creating a deadly poisonous gas. Scrap yards, junk yards, refrigeration companies, supply houses are all good sources for compressors.

