BRA FACT FINDER Number 7

(Fully revised March 2014)

A Guide to Selecting Copper Tube and Fittings for Refrigeration & Air Conditioning Systems with Air Cooled Condensers

This note provides guidance on selecting copper tube and fittings for Refrigeration and Air Conditioning Systems with Air Cooled Condensers to Comply with EN378-2:2008 and updates BRA Facfinder 7 "A Guide to Selecting Copper Tube and Fittings for New Refrigeration & Air Conditioning Systems with Air Cooled Condensers to comply with BS4434 : 1995" and the IOR Guidance Note 8 "Designing for new refrigerants".

The Original BRA Factfinder No.7 and IOR Guidance notes based on BS1306 covering copper pipe wall sizing calculations were updated in 2005 following the introduction of EN378:2000 and BS EN 12735:1. EN 378 has been updated and the current standard is EN378:2:2008. BS1306 has not been withdrawn however a new standard EN14276:2007 has been introduced with a revised calculation for wall thickness. Unfortunately the design stress values for copper tube were not included in EN14276 which is the reason for previously not updating the Factfinder/Guidance notes. Recently an amendment has been proposed to include the stress values in a future revision of EN14276 and following discussions with the Institute of Refrigeration it has been agreed that this information can now be used in the UK. The effect of this will be to increase the maximum allowable pressure (PS) for equivalent thicknesses of copper tube and bring the UK into line with European Practice.

Effects of changes to Safety Standard BS EN378

The strength pressure test to copper pipe systems was unclear in the original version. The latest version has now been clarified and allows, subject to certain criteria being met, for the strength pressure test to be carried out at 1.1xPS.

Effect of changes from BS1306 to EN14276

Although there is a slight difference in the formulae for calculating the wall thickness, the major change is the reduction in the safety factor allowing increased pressures for the same wall thickness. The original notes recognised that BS1306 was an extremely conservative standard and did in fact suggest that the stress values at 100°C should be used for discharge lines. Now that a more realistic standard has been introduced it is recommended that the stress value at 150°C is used as the discharge gas temperature can be in excess of 100°C when it leaves the compressor.

Effect of Bending Copper Tube

The previous note was based on the assumption that the weakest point of the tube was at the fully annealed section immediately adjacent to the brazed joint. There have been some suggestions that the pipe is weaker when it has been bent however it should be noted that the tube is normally in the half hard as supplied condition when it is bent. The tensile strength is 250N/mm^2 in the as supplied condition compared to 200N/mm^2 (material condition R200) in the fully annealed condition.
Using the formulae from EN 14276-2:2008 paragraph 6.9.2.1 for straight tube and paragraph 6.9.2.2 for bent tube, the following values are obtained for a tube OD of 1.1/8":

Straight tube at temperature of 50°C (fully annealed) - PS 42.59 bar
Straight tube at temperature of 150°C (fully annealed) - PS 37.27 bar
Bent Tube with a radius of 3D (half hard @ 50°C) - PS 49.14 bar
Bent Tube with a radius of 3D (half hard @150°C) - PS 44.23 bar

This difference will be constant for all sizes of tube since:
- PS is directly proportional to the tensile strength

- The factor allowing for the tube being bent is constant for all diameters of tube.

This demonstrates that the weakest point on the tube is in the fully annealed condition immediately adjacent to the brazed joint.

Copper Fittings

The fittings commonly used are manufactured to the dimensions of ASME B16.22. Maximum allowable pressure information has been produced as a result of tests carried out by the UK distributors of these fittings and it is therefore necessary to obtain this information from the appropriate supplier.

Selection of Correct Tube

The selection information has been presented in two tables:

Table 1 – Maximum Allowable Pressure (PS) of copper tube for the commonly available diameters and wall thickness at temperatures of 50°C, 100°C and 150°C.

			Maximum Operating Pressure (Ps)		
Outside Diameter	Wall Thickness	Wall Thickness	Tube Temperatures		
(in)	(swg)	(mm)	Up to 50°C	Up to 100°C	Up to 150°C
1/4	22	0.71	124.45	124.45	108.90
3/8	21	0.81	93.10	93.10	81.46
1/2	21	0.81	68.78	68.78	60.18
1/2	20	0.91	77.84	77.84	68.12
5/8	20	0.91	61.54	61.54	53.85
5/8	19	1.22	83.25	83.25	72.85
3/4	19	1.02	56.89	56.89	49.78
3/4	18	1.22	64.82	64.82	56.72
3/4	16	1.63	93.25	93.25	81.60
7/8	19	1.02	48.51	48.51	42.44
7/8	18	1.22	55.22	55.22	48.32
7/8	16	1.63	74.59	74.59	65.27
1.1/8	18	1.22	42.59	42.59	37.27
1.1/8	16	1.63	57.36	57.36	50.19
1.1/8	14	1.83	64.85	64.85	56.75
1.3/8	18	1.22	34.67	34.67	30.34
1.3/8	16	1.63	46.61	46.61	40.78
1.3/8	14	2.03	58.74	58.74	51.40
1.3/8	12	2.64	77.32	77.32	67.65
1.5/8	18	1.22	29.24	29.24	25.58
1.5/8	16	1.63	39.25	39.25	34.35
1.5/8	14	2.03	49.40	49.40	43.23
1.5/8	12	2.64	64.90	64.90	56.79
2.1/8	18	1.22	22.25	22.25	19.47
2.1/8	16	1.63	29.83	29.83	26.10
2.1/8	14	2.03	37.48	37.48	32.80
2.5/8	18	1.22	17.97	17.97	15.72
2.5/8	16	1.63	24.06	24.06	21.05
2.5/8	14	2.03	30.20	30.20	26.42
2.5/8	12	2.64	39.51	39.51	34.57
3.1/8	16	1.63	20.16	20.16	17.64
3.1/8	14	2.03	25.29	25.29	22.13
3.1/8	12	2.64	33.05	33.05	28.92
3.5/8	16	1.63	17.34	17.34	15.18
3.5/8	14	2.03	21.75	21.75	19.03

3.5/8	12	2.64	28.40	28.40	24.85
4.1/8	16	1.63	15.22	15.22	13.32
4.1/8	14	2.03	19.08	19.08	16.69
4.1/8	12	2.64	24.90	24.90	21.79

Notes : Tolerances:
- outside diameter to EN12735-1:2010 Table 3
- wall thickness to EN12735-1:2010 Table 4

Maximum Stress Values for material condition R200 (fully annealed)
- at 50°C from EN12449 200N/mm^2 with a safety factor of 3.5
- at 100°C from proposed revision of EN14276 200N/mm^2 with a safety factor of 3.5
- at 150°C from proposed revision of EN14276 175N/mm^2 with a safety factor of 3.5

Table 2 – This contains the minimum value for the Maximum Allowable Pressure (PS) as derived from BS EN 378-2:2008 clause 6.2.2.1 method 2 for commonly used refrigerants for the high and low side at an ambient temperature of 32°C. This is the specified design temperature defined in EN378-2:2008 Table 2 for systems with an air-cooled condenser.

Minimum Design Pressures for commonly used Refrigerants

Refrigerant	Low pressure side Corresponding to 32°C	High Pressure Side Corresponding to 55°C
	bar g	bar g
R134a[1]	7.16	13.93
R404A[1]	14.03	24.8
R407A[2]	14.05	25.15
R407C[1]	13.12	23.47
R407F[3]	12.9	23.9
R410A[1]	18.83	33.27

Notes: Refrigerant Data obtained from:
[1] DuPont Refrigerants (UK)
[2] Mexichem Fluor
[3] Honeywell

Where the low side is subjected to the same pressure as the high side as is the case in a reverse cycle Air Conditioning system, the high side pressure should also be used for the low side.

Carbon Dioxide (CO_2) has not been included as PS will be dependent on the design characteristics of the system being used.

Appendix

The formulae from Paragraph 6.9.2.1 of EN 14276-2:2006 has been rearranged as follows to calculate the Maximum Allowable Pressure:

PS = 2 x f x z x t / (De - 0.8 x t)

PS = Maximum Allowable Pressure
f = minimum tensile strength of copper at operating temperature / safety factor
z = joint factor (1 for seamless copper tube)
t = minimum wall thickness
De = Maximum outside diameter

References and sources of further information

- Safety Standards are available for purchase from BSI http://shop.bsigroup.com/

Prepared in conjunction with the Institute of Refrigeration (IOR). This content also exists as IOR Guidance Note 8.