Fact-Finder

NUMBER 5
Issue 2 05/04

BRA INTERPRETATION of KEY ISSUES in EN378:2000 for COMMERCIAL REFRIGERATION

British Standard BS 4434:1995 introduced terminology with which BRA members, sections of the commercial refrigeration industry and users may not be familiar. It also identified other aspects of refrigeration safety which BRA and the Institute of Refrigeration consider may be more demanding when using HFC refrigerants and transitional refrigerant blends.

The Institute of Refrigeration has addressed many issues relating to EN 378 in their paper 'Designing for new Refrigerants Using BS EN 378 : 2000". The terminology used in BS 4434:1995 is now used in EN378:2000.

EN378-2:2000 tables 1 and 2 pages 6 and 7 respectively illustrate the following:-

Table 1	Specified design temperatures.
Table 2	Relationship between various pressures and the maximum allowable pressure (ps).
Table 2	Describes the relationship between the various pressures when designing the system very much in the same way as BS4434:1995, except the strength test pressure and relating to this issue it states "in accordance with existing standards". Therefore the strength test pressure will be between 1.0 – 1.3 x the maximum allowable pressure as described in BS 4434:1995 (table 7).

IMPORTANT DEFINITIONS

The maximum allowable pressure ps (previously maximum working pressure) is the pressure which shall not be exceeded either in operation or at rest, except within the operating range of a pressure relief valve.

It may be differently specified for the low and high pressure sides of the system. The minimum permitted value of the allowable pressures for selected HFC refrigerants is shown in the table over the page.

The maximum allowable pressure p, may be equal to, but no greater than, the design pressure.

The selection of the maximum allowable system pressure may need to be increased above that established from minimum design temperatures, due to considering any influence from factors such as non-condensable gases, defrosting, application, solar radiation, condenser fouling and the setting of the pressure relief valve.

The designer must therefore be particularly alert at operating pressures of the refrigerant selected for new systems, or to be charged into an existing system in a retrofit situation.

Where the maximum allowable pressure needs to be increased in an existing system, the pressure vessel (generally the HP liquid receiver) should be carefully checked by a competent person as defined by the Pressure Systems Safety Regulations:2000 to ensure that it is suitable for the increased pressure. This will be a common occurrence where a change of refrigerant, with resultant increased pressures, necessitates an increase in the relief valve setting.

Similarly the standstill pressure of a new refrigerant will demand a check of the low pressure side equipment to ensure that the tube material and components remain suitable. This particularly relates to large diameter copper tube which should be checked as to its wall thickness and allowable maximum test pressure using data from BS 1306:1975 (1980).

SELECTING OF APPROPRIATE COPPER TUBE

The following example may assist in establishing the required copper tube wall thickness.

BS 1306 provides the following formula to calculate the minimum wall thickness of straight copper tube. The value of "f" is based on an appropriate value* (annealed) to reflect the heating during fabrication.

$$t = [ps \times d] / [ps + (20 \times f)]$$

where: t = minimum thickness mm
ps = maximum allowable pressure p bar gauge
d = outside diameter of straight tube mm (taken here as the maximum od)
f = design stress N/mm^2 (taken as annealed tube)

Note: For copper tube joined by brazing and operating at temperatures up to 50°C, f = 41 N/mm^2. For example, 3 1/8" od tubing operating with an maximum allowable pressure (ps) of 14 bar gauge e.g. R404A at 32°C bubble point pressure.

$$t = [14 \times 79.56]/[14 + (20 \times 41)]$$

Tube wall thickness = 1.336 mm [minimum wall thickness]

Select: 16 SWG tube, since typical wholesale supplies have a minimum wall thickness of 1.470 mm.
Note: Bending allowable would not normally be required for correctly formed bends, e.g. with a radius of 3 x od of tube when applied to "half hard tube" remote from section annealed by local heating.

To ascertain the acceptable maximum allowable pressure ps for a given tube, a re-arrangement of the formula above gives:

Allowable pressure p for a given tube size.

$$P = [20 \times f \times t]/[d - t] \text{ bar gauge}$$

(Using the maximum valve for d and the minimum for t)

2, Milley Lane, Hare Hatch, Reading, Berkshire. RG10 9TH
Tel: 0118 940 3416 Fax: 0118 940 6258

EXAMINATION OF MINIMUM VALUE FOR MAXIMUM ALLOWABLE PRESSURES

Minimum design temperatures with approximate corresponding bubble point pressure for selected HFC refrigerants.

Minimum value for maximum allowable pressure Bar (g)				
	Ambient ≤ 32°C		Ambient ≤ 43°C	
Refrigerant	Low Pressure Side Bar G at 32°C	High Pressure Side Bar G at 55°C	Low Pressure Side Bar G at 43°C	High Pressure Side Bar G at 63°C
R134a	7.1	13.8	9.4	16.0
R404A	14.0	24.8	18.6	29.7
R407A	13.9	24.7	18.6	29.6
R407B	14.7	26.0	19.6	29.5
R407C	13.1	23.5	17.6	28.1
R410A	18.8	33.3	25.0	39.8
R410B	18.7	33.0	24.8	39.5
R507	14.4	25.3	19.1	31.2

The following comments apply:-

- For ambient temperatures below 32°C the low side minimum design temperature, is also 32°C. Therefore the allowable pressure must not be less than the equivalent bubble point pressure at this temperature.

- Similarly, between ambient temperatures of 32°C and 43°C the low side design temperature becomes 43°C. Therefore the allowable pressure must not be less than the equivalent bubble point pressure at this higher temperature.

Where the maximum allowable pressure ps is to be increased in an existing system the following must be carefully checked:-

- Systems safe operating limits as applied in accordance with the Pressure Systems Safety Regulations 2000 (PSS regs).
- Test pressures for installed vessels and components, in particular where the low pressure side maximum allowable pressure differs from that of the high pressure side, e.g. copper tube.

- Pressure relief device settings.

- Pressure limiting device settings.

- Provision of relevant information to the user for the purpose of reviewing the scheme of examination (PSS regs) if appropriate.

STRENGTH PRESSURE TEST ADVICE

The strength test shall be carried out at pressure between 1 and 1.3 times the maximum allowable pressure ps of the system or relevant part of the system.

Note: The strength test pressure shall not exceed strength test pressure applied to components by the manufacturer; this may require the testing of the LP side of the system separately from the HP side.

Protection against excess pressure during operating and in the event of a fire.

Primary protection against excess pressure is the requirement for an appropriately set pressure relief valve.

Note: Where the low side allowable pressure is lower than the high side allowable pressure, the LP side must be designed using the HP side pressure, unless a suitable pressure relief device is fitted e.g. a bursting disc and pressure relief valve, selected for the low side allowable pressure, is fitted to the LP side. (This applies even if there are no pressure vessels on the low pressure side). This being the case, BRA recommends that when deemed necessary, members install a suitable pressure relief device on a convenient suction pipe or header, in or adjacent to the main refrigeration plant.

PRESSURE RELIEF DEVICES

The Institute of Refrigeration Safety Code and Manufacturers' recommended life for pressure safety relief valves is a maximum of five years. Whereas high side bursting discs shall be replaced at least every two years. A pressure relief valve that has discharged should be replaced immediately. Most refrigeration systems require examination at regular intervals in accordance with the PS Regs, the opportunity should be taken to check the life of all relief valves (and bursting discs) fitted to many existing systems.

EN378-2:2000 states an indicating device shall be provided to check whether the relief valve has discharged to atmosphere. This can be achieved by placing a pressure sensor between the bursting disc and pressure relief valve.

The selection of the correct replacement pressure relief valves, taking into account the refrigerant, the system allowable pressure, the liquid receiver rating, the pressure setting and the vent line diameter is essential, and manufacturers' selection data should be carefully followed. Also see EN 378-2:2000 pages 17 and 18, 7.4.3.1 pressure relief

devices, 7.4.3.2 minimum discharge capacity and BS EN 13136:2001 refrigerating systems and heat pumps, pressure relief devices and their associated piping method of calculation.

The Code of Practice for the Minimisation of Refrigerant Emissions from Refrigeration Systems published by the Institute of Refrigeration also calls for high pressure relief devices to discharge to the low pressure side of the system, where practicable. It is recommended that where applicable a bursting disc is installed up stream of any high pressure relief valve as a precaution against leakage past the pressure relief valve seat.

2, Milley Lane, Hare Hatch, Reading, Berkshire. RG10 9TH
Tel: 0118 940 3416 Fax: 0118 940 6258