laminar airflow, the change in resistance for a given flow rate can be described as follows:

$$\Delta R = (8nl)/(\pi r^4)$$

where R = resistance, n = viscosity of air, l = length of tube and r = radius of opening.

From the above it can be seen that the most critical variable in determining changes in resistance for a given air-flow is the radius of the opening.

The relationship between force and pressure

The pressure exerted by a compression spring is equal to its force divided by the area over which the force is acting. With regard to the current application, the force of a compression spring is given in Newtons (N), whilst the rate is expressed in $\mathrm{N\,mm^{-1}}$. The area upon which the spring acts is given in $\mathrm{mm^2}$; thus, pressure can be expressed in $\mathrm{N\,mm^{-2}}$, such that:

$$\text{Pressure }(\mathrm{N\,mm^{-2}}) = \frac{\text{Force (N)}}{\text{Area }(\mathrm{mm^{-2}})}$$

Conventionally, respiratory muscle forces are given in cm H_2O; thus, a series of conversions are necessary to convert $\mathrm{N\,mm^{-2}}$ to cm H_2O, as follows:

$$\mathrm{N\,mm^{-2}} \times 1\,000\,000 = \mathrm{N\,m^{-2}}$$

$$1\text{ ft } H_2O = 2989\ \mathrm{N\,m^{-2}}$$

$$1\text{ inch } H_2O = \frac{2989}{12}\ \mathrm{N\,m^{-2}}$$

$$\therefore 1\text{ inch } H_2O = 249.1\ \mathrm{N\,m^{-2}}$$

$$1\text{ cm } H_2O = \frac{249.1}{2.54}\ \mathrm{N\,m^{-2}}$$

$$\therefore 1\text{ cm } H_2O = 98.07\ \mathrm{N\,m^{-2}}$$

The relationship between spring rate and working length is as follows:

$$\frac{\text{Working range (mm)}}{\text{Spring rate }(\mathrm{N\,mm^{-1}})} = \text{Maximum spring force (N)}$$

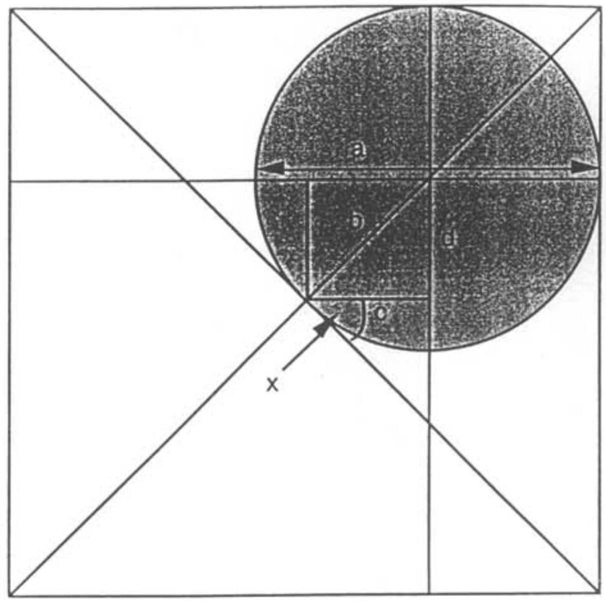

Figure 1 A cross-sectional view through one side of an o-ring, depicting the dimensions required to compute the area under an o-ring seal.

Maximum pressure load is determined by the maximum spring force divided by the area over which it acts; the area of a circle being equal to πr^2, where r equals the radius of the circle. In the case of an o-ring seal, r is dependant upon the internal diameter of the o-ring, the cross sectional area of the o-ring and the angle of the valve seat (see Fig. 1).

Figure 1 depicts a cross-sectional view through one side of an o-ring, radius b. The angle of the valve seat is shown as x. The diameter of the circle under the o-ring (valve sealing area) is equal to the internal diameter of the o-ring (not depicted here) plus the radius of the cross-section b plus dimension c as shown below. Given the relationship between these dimensions $c = b \sin x$. Thus, the valve sealing area = (internal radius of the o-ring + b + c)$^2 \times \pi$.

Designing an IMT device – putting theory into practice

A number of upper and lower limits were determined for inspiratory pressure and inspiratory flow. This enabled a desirable working range for the