RESONANT FREQUENCY OF A BOURDON TUBE

Using an oscillation generator the resonant frequency of different Bourdon Tube pressure ranges was determined, see Fig. 9 (note these tests were without the movement attached to the tube end). For example, the resonant frequency for a 4 bar Bourdon Tube is about 100Hz and for a 25 bar tube just under 200Hz.

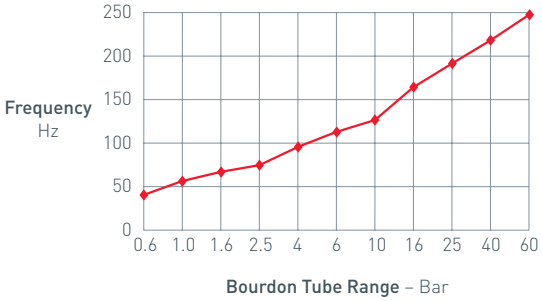

Fig. 9 The red diamonds show the resonant frequency of different Bourdon Tubes.

The red diamonds in figure 10 show the deflection at the end of the tube caused by the resonant frequency oscillating the tube. The blue triangles show the normal design deflection permitted for the tube. Clearly even at quite low accelerations of only 2.5g the tube will quickly fail.

For higher pressure the greater tube strength and more rounded geometry, reduces the deflection at the end of the tube. As can be seen from the graph at 16 bar and 2.5g acceleration (red diamond) the deflection falls within the design limits of the tube. The green squares show that by increasing the acceleration to 5g the deflection of the tube once again moves outside its design limits.

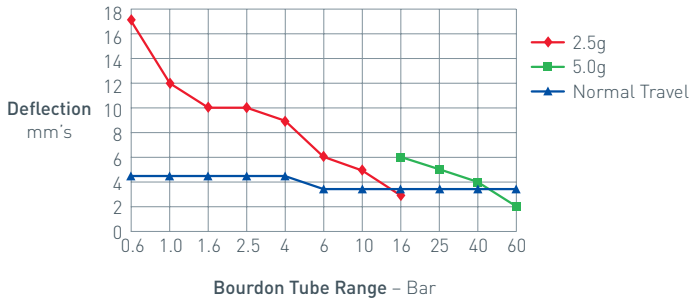

Fig. 10 The red diamonds and green squares show the deflection at the end of the Bourdon Tube at their resonant frequencies. The blue triangles are design deflections for the Bourdon Tube.

RESONANT FREQUENCY OF A BOURDON TUBE (CONTINUED)

Design Variant	Bourdon Tube Assembly	Acceleration	Number of Resonant Cycles Before Rupture
Design 1	Traditional flat tube H/W = 0.30	2.5g	30,000
Design 2	Traditional flat tube inserted 7mm into shank H/W = 0.30	2.5g	30,000
Design 3	New WIKA tube design H/W = 0.52	2.5g	100,000
Design 4	New WIKA tube design, glycerine filled case – 86.5% concentration	2.5g	10 million – no rupture
Design 4	New WIKA tube design, glycerine filled case – 86.5% concentration	10g	10 million – no rupture

Fig.11 The number of cycles before rupture of the different Bourdon Tube assemblies subjected to their resonant frequency. The WIKA tube design is 3 times better than a flat tube, but liquid filling gives considerable protection against rupture.

Instrument Type	Zero Error After 50 Hrs	200 Hrs	Instrument Condition after 200 Hrs
Damped movement – single pinion viscous pot	2.3%	66%	Inoperable, toothing & bearing necks severely damaged, quadrant broke loose, tube free to resonate
Damped movement – double pinion & quadrant arbour viscous pots. PTFE toothing	3.9%	34%	Inoperable, severely worn connection linkage
New WIKA Bourdon Tube – no damping	2.3%	3.0%	Still operable, but out of calibration.
Glycerine filled case – New WIKA Bourdon Tube undamped movement. 86.5% glycerine 13.5% water	0.6%	0.8%	Fully operational, still within calibration limits. No wear to the movement

Fig. 12 Four complete gauges subjected to vibration tests. Damping pots put excessive load onto the movement, leading to early failure. Liquid filling is the best solution.