Cautionary Tale XXXXI Speed of testing

A very common question asked of IST is “how fast should these springs be tested?” The answer given depends upon a number of factors. For constant pitch, parallel sided, non-buckling compression springs, the maximum speed of testing is limited by the natural frequency of the springs. The natural frequency is the speed at which a loaded spring will move or vibrate if it is suddenly released. If a spring is tested at half its natural frequency it will resonate. Resonance will occur at lower frequencies as well leading to uncontrolled additional dynamic stresses, which will usually lead to premature fatigue failure.

IST advise that the maximum test speed should not exceed 1/13 of the natural frequency of the spring. If you use the formulae in Wahl you would find that at $1/13^{th}$ of the natural frequency the additional stresses due to dynamic effects are slightly less than 1%. This approach is accurate enough and practical, except when the calculated test speed exceeds 20 Hz. That is to say, if the calculated natural frequency is 39,000 rpm, a typical value for an index 7, six coil spring made from 0.12” wire, the spring could be tested at 3000rpm or 50Hz in order to meet the $1/13^{th}$ rule. IST also advise that the test speed should mimic the speed used in service, but there are practical limits about how slow fatigue testing can be accomplished, and testing at speeds significantly greater than those in service should not usually give rise to misleading results – but this advice is slightly qualified by the results shown below.

If springs are to be life tested to verify their fitness for purpose, the customers of the spring industry like to have their results in a very short timescale. Similarly, laboratories or spring manufacturers that offer fatigue or life testing like to complete the test quickly so as to free up the test machine for the next order. The purpose of this article is to describe recent research results that shed light on just how fast it is reasonable to test compression springs. The research was carried out by a consortium of European companies lead by IST under the title “TECHSPRING”, and the work was part funded by the European Commission.

Recent results have shown that the life to first failure and the average life can be higher than expected when the test speed exceeds 20Hz. Results from the Techspring project are presented in table I and figure 1.

	Lives			
50Hz	304,660	1,583,770	740,160	1,638,980
	605,470	1,481,780	764,830	1,009,240
	901,000	2,036,930	989,400	2,397,750

20Hz	190,000	220,000	220,000	350,000
	380,000	380,000	480,000	500,000
	510,000	540,000	800,000	820,000
10Hz	245,860	754,470	1,020,610	575,260
	433,380	445,220	455,730	513,020
	268,090	603,750	340,710	316,090

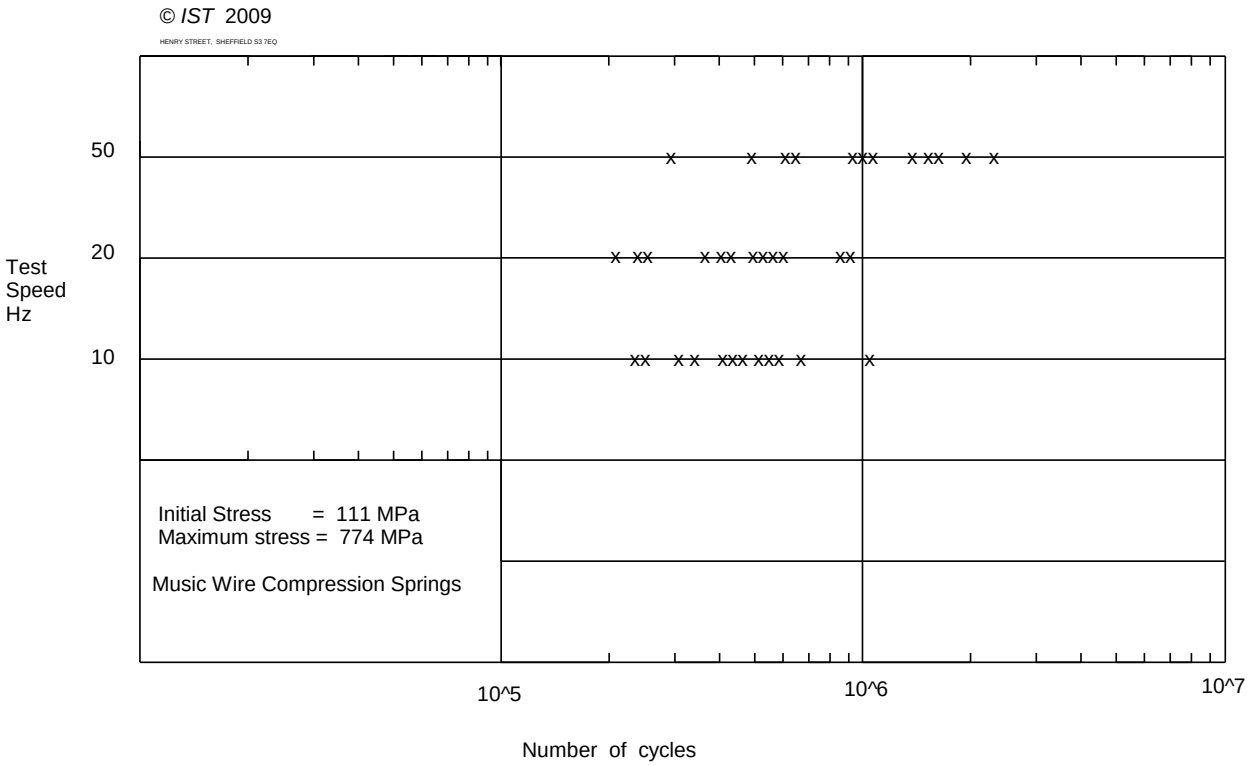

Figure 1 Graph showing that the life to first failure and the mean life is longer for the springs tested at 50Hz

The point of this cautionary tale is that testing at speeds greater than 20Hz may give you a somewhat optimistic view of the life of the springs. If the objective of the above test was to check whether the springs were capable of withstanding 100,000 cycles, then the springs pass whatever the test speed used. Similarly, if the requirement was for a Weibull B10 life of 500,000 cycles, then they fail whatever the test speed. If the design life requirement was 250,000 then testing at 50Hz gives a rose tinted view! It is presumed that the longer life at high test speeds is due to the inability of fatigue cracks to propagate on every cycle when the test speed is high, whereas at slower speeds the fatigue crack has time to advance on every cycle whilst the applied stress reaches its maximum.

Another related topic is the measurement of natural frequency and magnitude of the additional dynamic stresses when springs are tested at speeds greater than 1/13th natural frequency. Methods to measure these parameters have also been established during the Techspring project and these will be the subject of the next tale in this series.

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