GEK 103802A
Revised, April 2003
Last Reviewed, October 2003

GE Power Systems

Turbine Off-Frequency Operation

(for 50 Hz Modern Units)

Off-frequency operation guidelines were first initiated in the mid to late 1960s following the "Northeast Blackout" in the U.S. These guidelines were developed for the entire fleet of existing GE units, some of which had first gone into service during the 1940s and 1950s. Therefore, the instructions had to take into consideration older equipment with considerable variety in construction, design limits, design philosophies, etc.

A number of variations were introduced between the original introduction of off-frequency guidelines and the present time. These were aimed at providing flexibility for the operators to incorporate various electrical distribution strategies that would satisfy the specific needs of the distribution system. These variations had all been based on the same fundamental concept used to protect the equipment while giving the involved owners flexibility in operation.

The limiting steam turbine components which dictate off-frequency operation are the longer later stage buckets. These buckets typically have their lower modes of vibration separated from the lower harmonics of speed. The objective of this separation is to prevent the excitation of these modes at or near resonance by the harmonics of steam related forces. These forces may arise from flow non-uniformities caused by tolerances, obstructions, and other stationary steam flow variations considerations. When the frequencies of these steam related forces are sufficiently removed from the lower resonant frequencies of the involved bucket, the bucket response is of no concern. On the other hand, with coincidence or near coincidence of these frequencies, the response level can be of concern due to the involved resonant amplification factor which is related to the level of damping in the structure.

An example of the involved factors is shown in Figure 1.Figure 2 shows a Campbell Diagram which depicts the objective of separating the bucket resonant frequencies and steam harmonic frequencies. This diagram has been used for many years to demonstrate the separation objective. The resonant frequencies of a given long bucket are obtained first by analysis followed by factory verification tests. As the speed of the unit during operation departs from the design speed, this departure will encroach into the margin between nominal speed and the coincidence of the bucket resonant frequency with its adjacent steam stimulus (harmonic). If coincidence occurs, the response stress of the bucket will increase to the peak of the curve shown in Figure 3. If near coincidence occurs, the bucket response follows the prescribed curve in Figure 3.

GE has reviewed the modern designs currently offered and has concluded that these designs have optimum long bucket margins between the lower modes of vibration and their corresponding adjacent steam force (stimulus) harmonics. Accordingly, for these designs the off-frequency operation permitted are those shown in Table 1. This table also lists applicable last stage buckets.

For those units now in service, the off-frequency operation permitted is that which had been provided to the owners at the time of sale of the unit and located in the Operation Manual.

Table 1. GE Steam Turbine Off-Frequency Limits for all Modern 1500 and 3000 RPM Units

50 HZ Units		
Lifetime Limit	Frequency Range	
Unlimited	47.0 to 52.5 Hz	
90 minutes	46.5 to 47.0 Hz	52.5 to 53.0 Hz
12 minutes	46.0 to 46.5 Hz	53.0 to 53.5 Hz
1 minute	45.0 to 46.0 Hz	53.5 to 55.0 Hz

All Applicable Units with Following Modern Last Stage Buckets	
3000 RPM	**1500 RPM**
17.5"	41"
26"	52"
33.5"	
42"	
48” Steel	

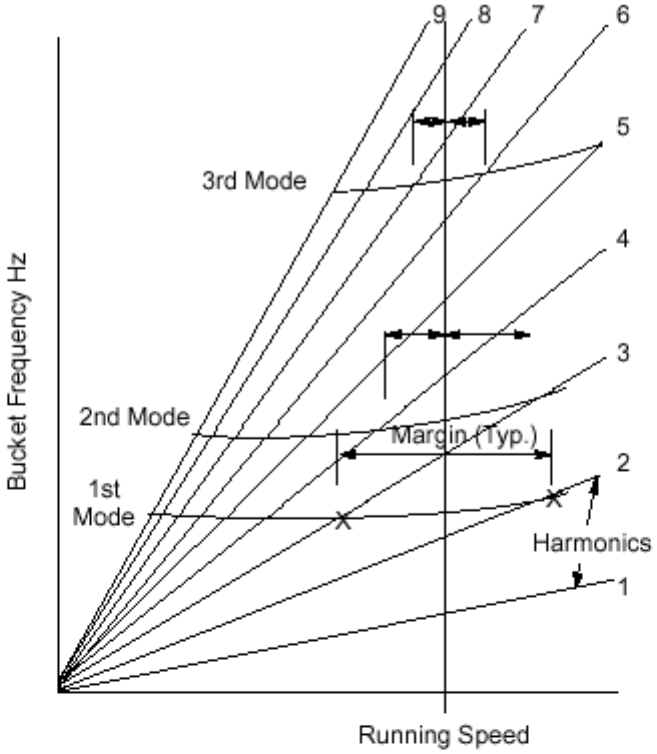

Figure 1A. Turbine Speed Hz Typical Campbell Diagram.

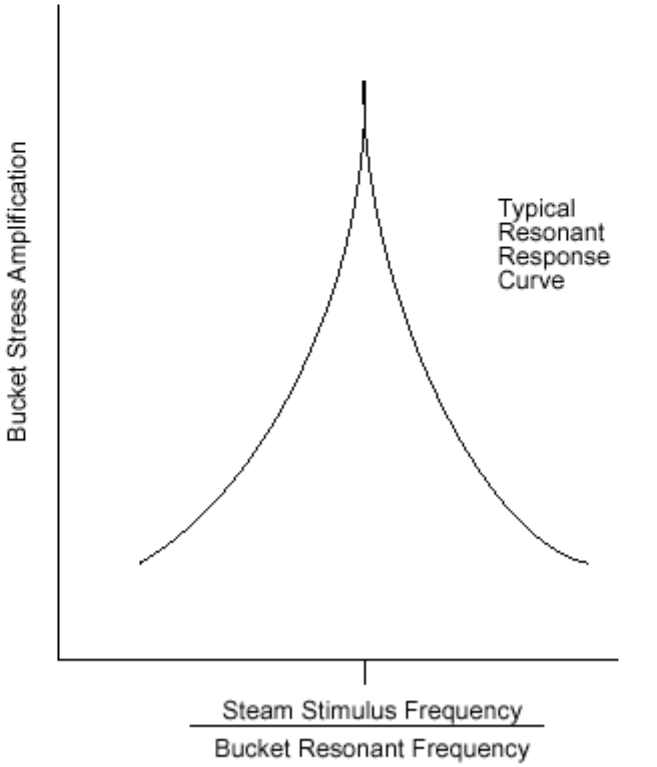

Figure 1B. Typical Stress Amplification Factor.

Figure 1.

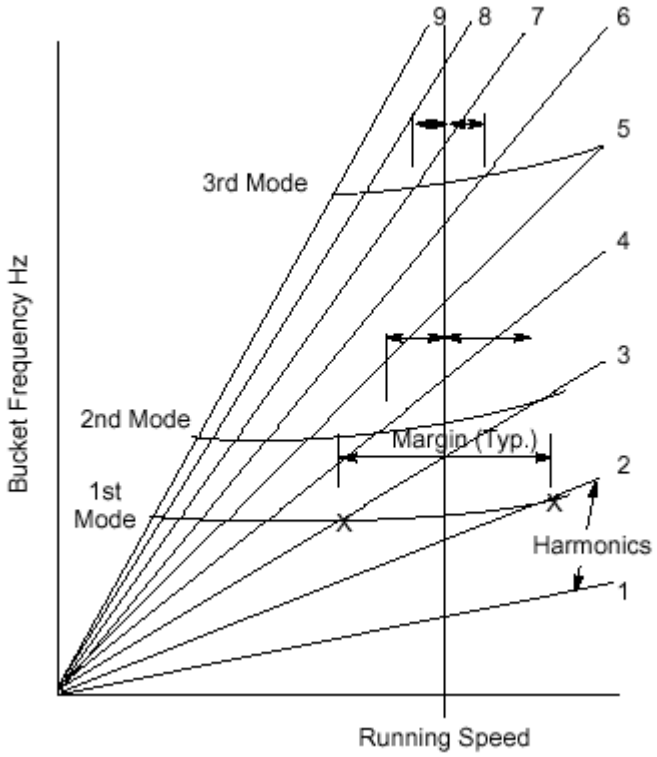

Figure 2. Turbine Speed Hz Typical Campbell Diagram.

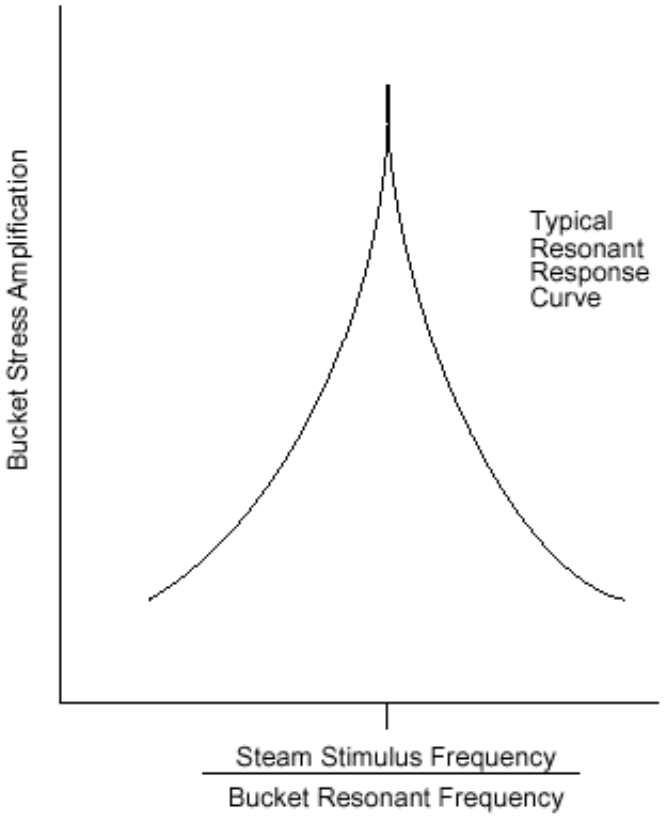

Figure 3. Typical Stress Amplification Factor.

GE Power Systems

General Electric Company
One River Road, Schenectady, NY 12345
518 • 385 • 2211 TX: 145354