BY JOHNSON CONTROLS	ISOLATOR EFFICIENCY	
TECHNICAL DATA	Supersedes: 160.00-E1 (1108)	Form 160.00-E1 (511)

Johnson Controls' YORK large tonnage chillers, the YK, YK-EP, YMC², YD, YS, YR, CYK, and YST come with standard neoprene isolation pads for vibration absorption, shown in Figure 1. The isolator pads are used to reduce the amount of vibration that is translated into the building from the unit. This vibration isolation becomes important when chillers are not mounted at ground level. The vibration of a chiller on a higher floor level can be transmitted throughout the building.

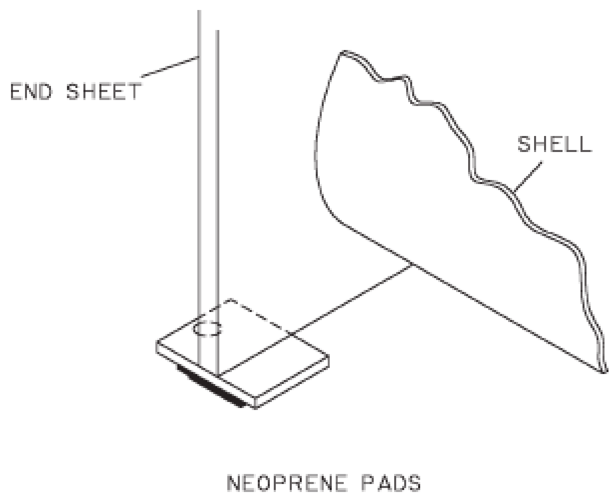

FIGURE 1 – STANDARD NEOPRENE ISOLATION PADS

Due to the nature of the magnetic bearing technology employed in YMC², there is very little vibration energy transmitted from the rotating components of the drive line to the remaining structure of the chiller. The use of patented OptiSound technology on centrifugal chillers virtually eliminates the chances for these machines to operate in a stalled condition. For these reasons and since any resulting vibrations are in the very high frequency range, JCI typically recommends the use of neoprene pads for vibration isolation of centrifugal chillers in slabs-on-grade installations. Furthermore, JCI recommends the use of neoprene pads for seismic applications due to the propensity for springs to severely amplify the earthquake input motion which can impart very high loads to the equipment and its interconnection to the building.

Also available, as a vibration absorber option, is a spring isolator system shown in Figure 2.

Note: This does not apply to YST Steam Turbine Driven Chillers

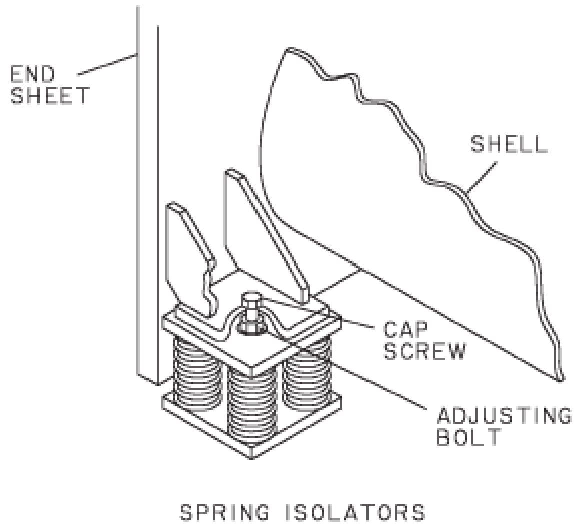

FIGURE 2 – SPRING ISOLATOR OPTION.

The following data will show that the isolation pads reduce 98.1% of vibration in 60Hz models and 97.3% in 50 Hz models. The spring isolator system will eliminate 99.7% of the vibration in 60 Hz models and 99.6% 50 Hz models.

The first step in finding the isolator efficiency is to find the natural frequency of the isolator. The natural frequency, F_m, shown in Equation 1, is the frequency that the vibration isolator will naturally oscillate at a given load

$$F_m = 188\left(\frac{1}{D}\right)^{\frac{1}{2}} \qquad (1)$$

with D being the static deflection, in inches, of the isolator and F_m in cycles per minute.

The next step is to determine the disturbing frequency, F_d, which is the lowest frequency of the forced vibration. The disturbing frequency should be the lower of either the RPM of the equipment or the motor. Once the disturbing frequency is found, the percent transmissibility must be calculated. The percent transmissibility, T, shown in Equation 2, is the percent of the total force that is transmitted to the supporting structure through the isolators for a given disturbing frequency against a given natural frequency for the isolator.

$$T = 100\left[\frac{1}{\left(\frac{F_d}{F_m}\right)^2 - 1}\right] \qquad (2)$$

The final step is to determine the isolator efficiency, E. The efficiency is given as:

$$E = 100\% - T$$

CALCULATIONS:

Isolation Pads:

Natural Frequency – F_m

$$F_m = 188\left(\frac{1}{D}\right)^{\frac{1}{2}}$$

F_m in CPM (cycles per minute)
D = static deflection (inches)

STD Neoprene Isolation Pads
Static Deflection at Rated Load, 0.15”, D=0.15”

$$F_m = 188\left(\frac{1}{0.15}\right)^{\frac{1}{2}} = 485.41$$

Disturbing Frequency – F_d

Motor Drive: 60 Hz, 3540 RPM (2 Pole)
F_d = 3540

Percent Transmissibility – T

Theoretical,

$$T = 100\left[\frac{1}{\left(\frac{F_d}{F_m}\right)^2 - 1}\right]$$

$$\frac{F_d}{F_m} = \frac{3540}{485.41} = 7.2928$$

$$\left(\frac{F_d}{F_m}\right)^2 = 53.185$$

$$\left(\frac{F_d}{F_m}\right)^2 - 1 = 52.185$$

$$T = 100\left[\frac{1}{52.185}\right] = 100 * 0.0196 = 1.916\%$$

Isolation Efficiency – E

E=100% - T
E=100% - 1.916% = 98.08% (60 Hz)

Isolation Pads (continued):

Natural Frequency – F_m

$$F_m = 188\left(\frac{1}{D}\right)^{\frac{1}{2}}$$

F_m in CPM (cycles per minute)
D=static deflection (inches)

STD Neoprene Isolation Pads,
Static Deflection at Rated Load, 0.15”, D=0.15”

$$F_m = 188\left(\frac{1}{0.15}\right)^{\frac{1}{2}} = 485.41$$

Disturbing Frequency – F_d

Motor Drive: 50 Hz, 2970 RPM (2 Pole)
F_d = 2970

Percent Transmissibility – T

Theoretical,

$$T = 100\left[\frac{1}{\left(\frac{F_d}{F_m}\right)^2 - 1}\right]$$

$$\frac{F_d}{F_m} = \frac{2970}{485.41} = 6.1185$$

$$\left(\frac{F_d}{F_m}\right)^2 = 37.437$$

$$\left(\frac{F_d}{F_m}\right)^2 - 1 = 36.437$$

$$T = 100\left[\frac{1}{36.437}\right] = 100 * 0.0274 = 2.744\%$$

Isolation Efficiency – E

E=100% - T
E=100% - 2.744% = 97.26% (50 Hz)

Spring Isolators:

Natural Frequency – F_m

$$F_m = 188\left(\frac{1}{D}\right)^{\frac{1}{2}}$$

F_m in CPM (cycles per minute)
D = static deflection (inches)

Spring Isolators
Static Deflection at Rated Load, 1.00”, D=1.00”

$$F_m = 188\left(\frac{1}{1}\right)^{\frac{1}{2}} = 188$$

Disturbing Frequency – F_d

Motor Drive: 60 Hz, 3540 RPM (2 Pole)
F_d = 3540

Percent Transmissibility – T

Theoretical,

$$T = 100\left[\frac{1}{\left(\frac{F_d}{F_m}\right)^2 - 1}\right]$$

$$\frac{F_d}{F_m} = \frac{3540}{188} = 18.83$$

$$\left(\frac{F_d}{F_m}\right)^2 = 354$$

$$\left(\frac{F_d}{F_m}\right)^2 - 1 = 353$$

$$T = 100\left[\frac{1}{353}\right] = 100 * 0.00283 = 0.283\%$$

Isolation Efficiency – E

E=100% - T
E=100% - 0.283% = 99.717% (60 Hz)

Spring Isolators (continued):
Natural Frequency – F_m

$$F_m = 188\left(\frac{1}{D}\right)^{\frac{1}{2}}$$

F_m in CPM (cycles per minute)
D=static deflection (inches)

STD Neoprene Isolation Pads,
Static Deflection at Rated Load, 1.00", D=1.00"

$$F_m = 188\left(\frac{1}{1}\right)^{\frac{1}{2}} = 188$$

Disturbing Frequency – F_d

Motor Drive: 50 Hz, 2970 RPM (2 Pole)
F_d = 2970

Percent Transmissibility – T

Theoretical,

$$T = 100\left[\frac{1}{\left(\frac{F_d}{F_m}\right)^2 - 1}\right]$$

$$\frac{F_d}{F_m} = \frac{2970}{188} = 15.80$$

$$\left(\frac{F_d}{F_m}\right)^2 = 250$$

$$\left(\frac{F_d}{F_m}\right)^2 - 1 = 249$$

$$T = 100\left[\frac{1}{249}\right] = 100 * 0.00402 = 0.402\%$$

Isolation Efficiency – E

E=100% - T
E=100% - 0.402% = 99.598% (50 Hz)

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Form 160.00-E1 (511) Supersedes: 160.00-E1 (1108)

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