

Frequency vs. Duration

The amount of time required for an impact to happen is described in two ways; frequency and duration. Frequency describes the time as compared to cycles per second and the unit of measure is called Hertz (Hz). Duration describes the time as compared to seconds and the usual unit of measure is milliseconds (msecs). The mathematical expressions related to these two terms are:

$$1 \text{ msec} = .001 \text{ seconds}$$

$$1 \text{ Hz} = \text{one cycle per second}$$

$$\text{Duration} = (1 / \text{Frequency}) / 2$$

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To convert duration to frequency, the calculation is as follows:

$$\text{Duration} = (1 / \text{Frequency}) / 2$$

Example: Convert 500 Hz to duration

$$\text{Duration} = (1 / 500) / 2$$

$$\text{Duration} = .001 \text{ seconds}$$

$$\text{Duration} = 1 \text{ msecs}$$

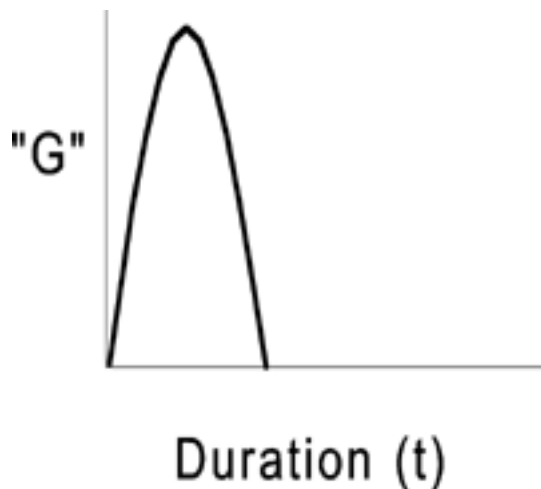
To convert frequency to duration, the calculation is as follows:

$$\text{Frequency} = (1 / \text{Duration}) / 2$$

Example: Convert 10 msecs to frequency

$$10 \text{ msecs} = .010 \text{ seconds}$$

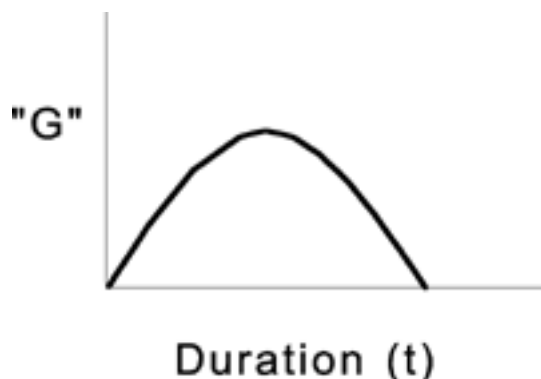
$$\text{Frequency} = (1 / \text{Duration}) / 2$$



Shock Pulse #2

$$\text{Frequency} = (1 / .010) / 2$$

$$\text{Frequency} = 50 \text{ Hz}$$



Shock Pulse #1

Shockwatch Activation Curves

By now you should be fully aware of the curves that have been developed that show Shockwatch activation acceleration vs. time duration. But do you know exactly what these curves mean? You should.

Here's what they mean:

The left side of the page shows a linear scale and is titled "G" or "G-level". This is the acceleration scale. A "G" is a multiple of the acceleration due to gravity (32.2 ft/s², or 9.8 m/s²). Five (5) G's equal five (5) times the acceleration due to gravity.

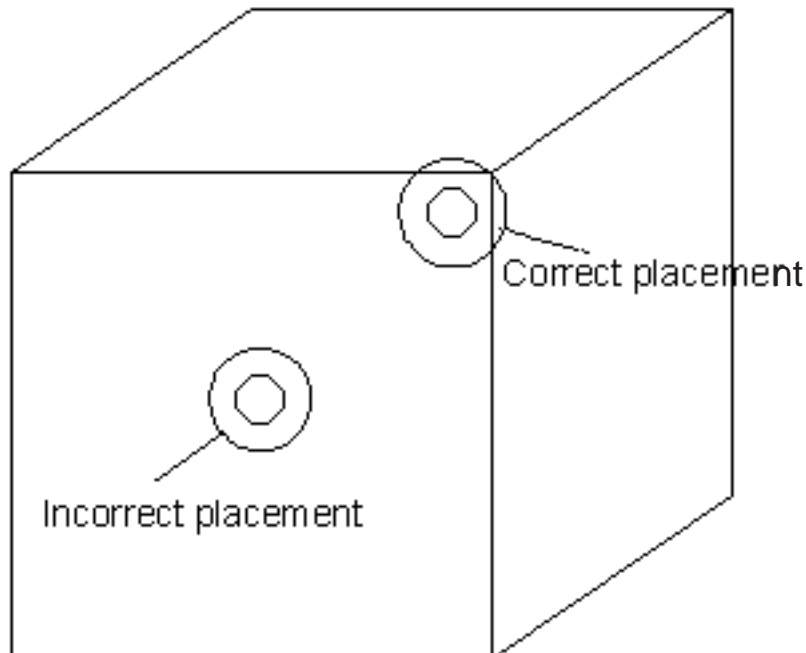
The bottom side of the page shows a linear scale that is titled "t". This is the duration scale and its unit is milliseconds. One millisecond is 1/1000 of a second.

The most critical thing to observe from the curves is that as duration decreases activation acceleration increases. The reason behind this is that our shock curves are based on a half-sine shock pulse. The area under the shock pulse is known as Delta V, or rather, the change in velocity. The Delta V is actually the phenomenon that activates a Shockwatch or causes damage to a good. As you can see, if you shorten the duration (make the shock pulse skinnier) you must make it taller (higher G) to keep approximately the same area under the curve (Delta V). If you will note on the following page the two shock pulses; the first one is wide and short, and the second one is tall and skinny. But they both could be used to describe the same Shockwatch because they have approximately the same area under the curve (Delta V). The second shock pulse makes up for its shorter duration with a high "G".

There is also one other parameter to be aware of. Each Shockwatch has a "minimum G" threshold that must be exceeded before a Shockwatch will activate. You can determine this "minimum" G for each Shockwatch by looking at the shock curves. It is the left most "G-level" value on the curve. It is the "G-value" where the shock curve intercepts, or runs into, the left acceleration scale. If this "minimum G" is not exceeded, regardless of the duration or the Delta V, the Shockwatch will not activate.

Shockwatch Placement

The correct placement of a Shockwatch is paramount to achieve proper Shockwatch operation. A Shockwatch placed in the wrong position on a package can alter that Shockwatch's response characteristics and cause erratic results.



Whenever possible, the Shockwatch should be placed on as rigid an area as possible. The reason for this is that if the surface to which the Shockwatch is attached is flexible, or can flex, it will dissipate an indeterminate amount of shock. The selection guide for Shockwatch is based on the assumption that the Shockwatch is placed on a package at a position that has minimal flex. If a Shockwatch is placed in a non-rigid position, its activation response will not correlate with the selection guide.

Typically, the most rigid area of a container (box) is at or near a corner. The most flexible area of a container is in the center of a side. To prove this to yourself, press against the center of one side of a corrugated container. You will see that it easily gives way and flexes. Now, press against that same side but at a point near the junction of that side with one of the other sides (corner). You will see that there is considerably less flex.

In conclusion, if a Shockwatch customer reports erratic results with Shockwatch, the first and foremost item to check is if the customer is placing the Shockwatch correctly.

Packaging

As you well know, the packaging of an item plays a very important role in ensuring that the product will reach its destination without damage. But do you know specifically how packaging protects the contents? The assumption is that packaging simply absorbs or dissipates shock. That is not exactly true. Actually, packaging uses physics to alter shock or impact so that it doesn't render damage to the contents. Here is how:

Please refer to Figure 1.

Figure 1 shows a damage boundary curve (dbc). A dbc can be developed for every product made. A dbc shows what shock is required to damage a product. Any impact whose characteristics fall within the damage area of the dbc will damage that product. For instance, on the dbc shown, an impact of 50G at 5 msec. would damage the product because that impact is within the damage area. For the same dbc, an impact of 10G at 5 msec. would not damage the product because it is outside the damage area. Two interesting characteristics of a dbc is that it clearly shows that for all products there is a minimum acceleration and a minimum time duration that must be exceeded in order to render damage to a product.

Please refer to Figure 2.

Figure 2 shows two shock pulses. The top pulse represents what a product is exposed to when it is dropped from a specific height with no packaging. The bottom pulse represents what a product is exposed to when it is dropped from the same height but is protected by packaging. You will note that each pulse occupies approximately the same area, as represented by the numbered squares. This area is called Delta V, or rather, the change in velocity experienced by the product when it was dropped. Delta V is purely a function of the drop height and since drops from the same height generated these shock pulses, they have the same Delta V. So how can two shock pulses have the same Delta V but be shaped so differently? When the product was dropped with packaging, the first thing to hit the ground was the box. When the box touched the ground it came to a stop very quickly. The amount of time required for an object (box) to stop once it has impacted another object (ground) is what we call the time duration of an impact. Although the box had stopped, the contents continued to move by compressing the packaging foam. Thus the contents had a longer time duration. So if the box and contents were experiencing the same Delta V but the contents experience a longer time duration, the peak acceleration seen by the contents had to be lower!

So what does all this mean?

Refer back to the dbc on figure 1. You will see two points. One is marked "A1, T1" and the other is marked "A2, T2". "A1, T1" represents the shock pulse without packaging shown on figure 2. As you can see "A1, T1" is within the damage area of the dbc and thus would damage the product. "A2, T2" represents the shock pulse with packaging shown on figure 2. "A2, T2" is outside of the damage area as thus would not damage the product. So in effect what the packaging did was to increase the time duration, lower the peak acceleration, and get the impact out of the damage area of the dbc.

So packaging really just changes the characteristics of shock to not damage the contents.

Damage Boundary Curve

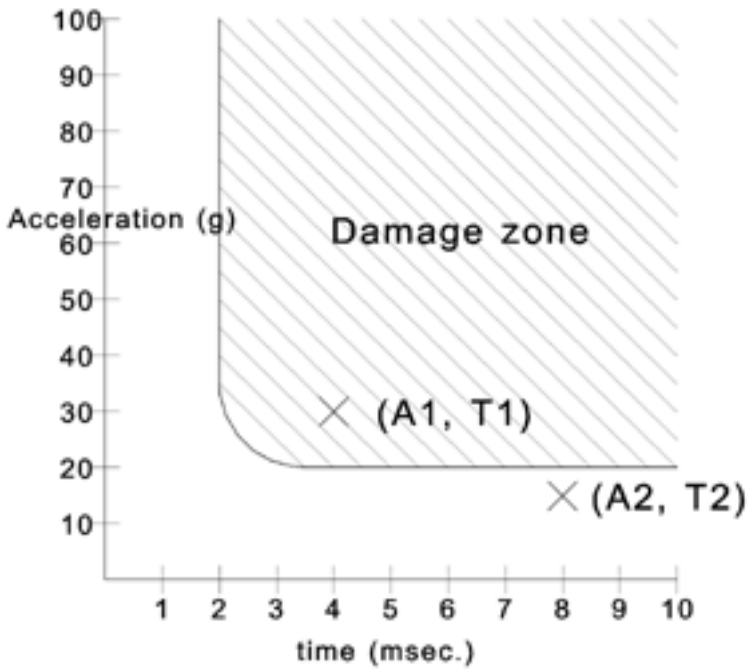


Figure 1

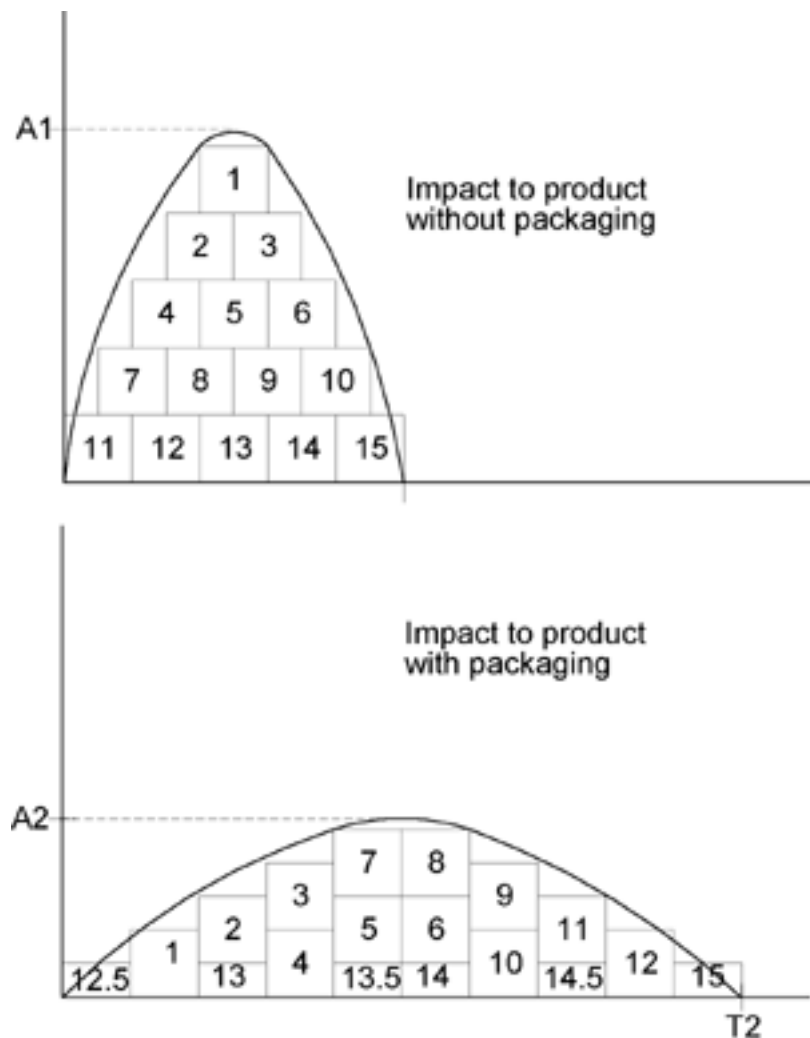


Figure 2

Shockwatch Activation Angles

All of the Shockwatch activation curves that we publish are based on the Shockwatch receiving an impact at a 45° angle. Shockwatch is most sensitive to impacts at this angle. There does exist, however, a slight deviation in the response of a Shockwatch to an impact at an angle of 90°. In most applications this deviation is not relevant. However, there are some applications where precise impact values at specific angles are required.

The deviation in a Shockwatch's response due to the change in angle generally follows this equation:

$$90^\circ \text{ acceleration (G) value} = 45^\circ \text{ acceleration (G) value} / .7071$$

Example:

$$45^\circ \text{ acceleration value for a C-65 at 10 msec} = 46\text{G}$$

$$90^\circ \text{ acceleration value} = 65\text{G}$$

Knowing this characteristic of Shockwatch can be a benefit. For instance, you may have a customer who has a specific engineering application where he wants an indicator that will react at a value that does not coincide specifically with one of our standard Shockwatches. It is sometimes possible to simply change the orientation of the Shockwatch so as to achieve the sensitivity required at a specific angle.

Shockwatch Activation Equations 45° Acceleration

	PRODUCT ANGLE EQUATION
$G = 367.2 / t + 102.5$	C-30, 45°
$G = 299.8 / t + 81.5$	C-35, 45°
$G = 233.1 / t + 52.7$	C-47, 45°
$G = 215.0 / t + 40$	C-55, 45°
$G = 201.1 / t + 25.1$	C-65, 45°
$G = 193.0 / t + 17.2$	C-75, 45°
$G = 187.8 / t + 10.6$	C-85, 45°

To calculate the 90° value use the following equation:

$$90^\circ \text{ acceleration (G) value} = 45^\circ \text{ acceleration (G) value} / .7071$$

Example:

45° acceleration value for a C-85 at 10 msec = 46G

90° acceleration value = 45G / .7071

90° acceleration value = 65G

Manufacturing Quality Specification

The quality specification used in the manufacturing process of the Shockwatch is as follows:

U.S. Military Specification (MIL SPEC)

MIL SPEC 105D

2.5% Cumulative AQL

This specification is a recognized means of statistically sampling manufactured goods and is acceptable to ISO 9001 concerned Shockwatch uses.