Measurement of Impacts

Impact measurements in many industries have traditionally been measured and reported in units of g's (gravitational units). This is a measurement of acceleration and the following relationships apply:

$$1g = 9.81 m/s^2 = 32.2\ ft/s^2$$

One common example of the use of g's to report acceleration and thus determine the severity of an impact is crash testing in the automotive industry. Here, the vehicle under test is launched at a fixed velocity (40 km/hr, for example) toward an obstacle. Accelerometers are strategically placed within the vehicle, often on a 'crash dummy', in order to measure the magnitude of the acceleration felt upon impact. The severity of the impact for each vehicle under test is determined based upon the output of these accelerometers; higher measured acceleration (higher g's) results in greater injury. From the collected acceleration data, testers determine the performance of that particular vehicle in protecting those within.

In some industries, it was difficult to utilize this technology due to the small size of the product under test. Until recently, with the miniaturization of electronics and advances in data collection technology, it was almost impossible to measure acceleration directly in smaller items in real-world situations. For this reason, velocity measurements were used as an indicator of potential damage to the product under test.

With recent advances in technology it is now possible to insert multiple accelerometers, associated data collection and storage electronics, and a radio module into a small package. This enables the collection and display of acceleration data wirelessly, and in real-time. This information then is used in determining the impacts undergone by a package or vessel. Agent QC uses this method to collect impact information in units of g's and immediately relay the results to the user.

FAQ

Q: What is velocity?

A: Velocity is the speed of an object in a particular direction. Technically, it is the rate of change of displacement (distance). Thus, the SI units for velocity are m/s, but inches per second (IPS), centimetres per second (cm/s), and miles per hour (mi/hr) are often used, depending on the application.

Q: What is acceleration?

A: Acceleration is the rate of change of velocity. For example, if a motorist 'accelerates' from a standstill (0 mi/hr) to 60 mi/hr in 10 seconds, then his or her average acceleration is 6 mi/hr/s or 0.00167 mi/s^2 or 2.682 m/s^2. The SI units for acceleration are m/s^2, but for some purposes units of g's are used. Note that, technically speaking, 'deceleration' is simply 'negative acceleration' and therefore we will use only the term acceleration to refer to both acceleration (positive magnitude) and deceleration (negative magnitude).

Q: What is a g or G or g-force?

A: A g (or G) is an acceleration equal to the acceleration of gravity, 980.665 centimetres per second-squared, approximately 32.2 feet per second per second at sea level; used as a unit of stress measurement for bodies undergoing acceleration. The common term "g-force" is a measure of acceleration and is not a measure of force. Everything is said to feel normal at 1 g, twice as heavy at 2 g, and weightless at 0 g.

Q: What is the relationship between velocity and acceleration?

A: Since acceleration is the time rate of change of velocity, then it can be described mathematically with the following relationship:

$$a = dv/dt$$

Alternatively:

$$v = \int_{t_0}^{t_n} a\,dt$$

The above equations clearly illustrate that except in special cases, there is no linear relationship between acceleration and velocity. Instead, velocity is dependent upon the acceleration, its time duration and the shape of the acceleration curve, which may not be linear.

Q: Why use acceleration not velocity in impact measurement?

A: As illustrated in the previous explanation, high-magnitude impacts for short durations may have the same velocity as low-magnitude impacts for longer durations. Historical data has shown that high-magnitude, short-duration impacts cause the majority of damage. Thus, in order to provide a single, meaningful value which will determine potential damage from impacts, Agent QC measures g's.

Q: What are accelerometers?

A: Accelerometers are electromechanical devices used to measure the acceleration of an object in a particular direction. This may be achieved in various ways, but one common method is to use the piezoelectric effect – piezoelectric crystals within the accelerometer output a charge when they are compressed (subjected to a force). Electronics convert this charge output of the crystal to a voltage which is proportional to the acceleration of the unit. This data can be used to determine the probability of injury or damage. Acceleration is the rate at which velocity (speed) changes and an abrupt change in velocity (high acceleration) tends to cause injury.

Q: What does the scale on Agent QC indicate? What are the units?

A: The short answer – on the PDA, the scale indicates the magnitude of the total impact, measured as acceleration, felt by the bottle at a particular instance in time. The unit of measure is g's (gravitational units). To convert to other units, one may use the following relationship:

$$1g = 9.81 m/s^2 = 32.2\ ft/s^2$$

The longer answer – the Agent QC product uses five accelerometers to measure impacts on the bottle in three directions and at two positions. These accelerometers measure acceleration in the x direction at both heel and shoulder, in the y direction at both heel and shoulder, and in the z direction (for vertical impacts). In the PDA, vector addition is used to determine the magnitude of the overall impact and this single value is reported to the user in units of 'g'. Once the data file is downloaded, the PC application provides a more detailed description of the data. On the PC, the user can view the magnitude of the heel impact (combination of x and y directions), the shoulder impact (combination of the x and y directions), and the vertical impact, as well as the overall impact reported by the PDA. On the PC, as in the PDA, all measured impacts are reported in g's.