The Increasing Importance of Earthquake Monitoring, Recording and Emergency Shutdown Systems in Industrial Environments.

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"Over the past several decades, significant advances in earthquake engineering and research related to structural hazard mitigation have been made and recently, industry has applied associated technologies to mitigate non-structural hazards, including the threat to human life, safety and financial loss."

Introduction.

By definition, non-structural damage relates to a facility's communications, mechanical systems, utilities lifelines, machinery, process lines, hazardous materials etc.

Considerable post-earthquake damage may be caused by flooding, fire, explosion, hazardous material release, gas leaks and other non-structural failures. Very often, non-structural failures can result in serious bodily injuries and death.

In some industries, potentially irreversible environmental damage can occur at sites where toxic chemicals or gases are present. Examples include the petrochemical, semiconductor, water storage / treatment and chemical industries, where elements used in production or storage can be widely destructive.

Significant losses can also arise as a consequence of lost revenue, diminished customer loyalty and lost competitive advantage as a result of downtime for site inspection and repairs. In some communities, legal liability may also exist in terms of workers' and nearby residents' compensation claims.

Inspired by recent destructive earthquakes in a number of industrialized countries, many industries are seeking to reduce exposure to such loss by the installation of cost effective, off- the-shelf, monitoring and control equipment.

Industrial Seismic Safety Systems

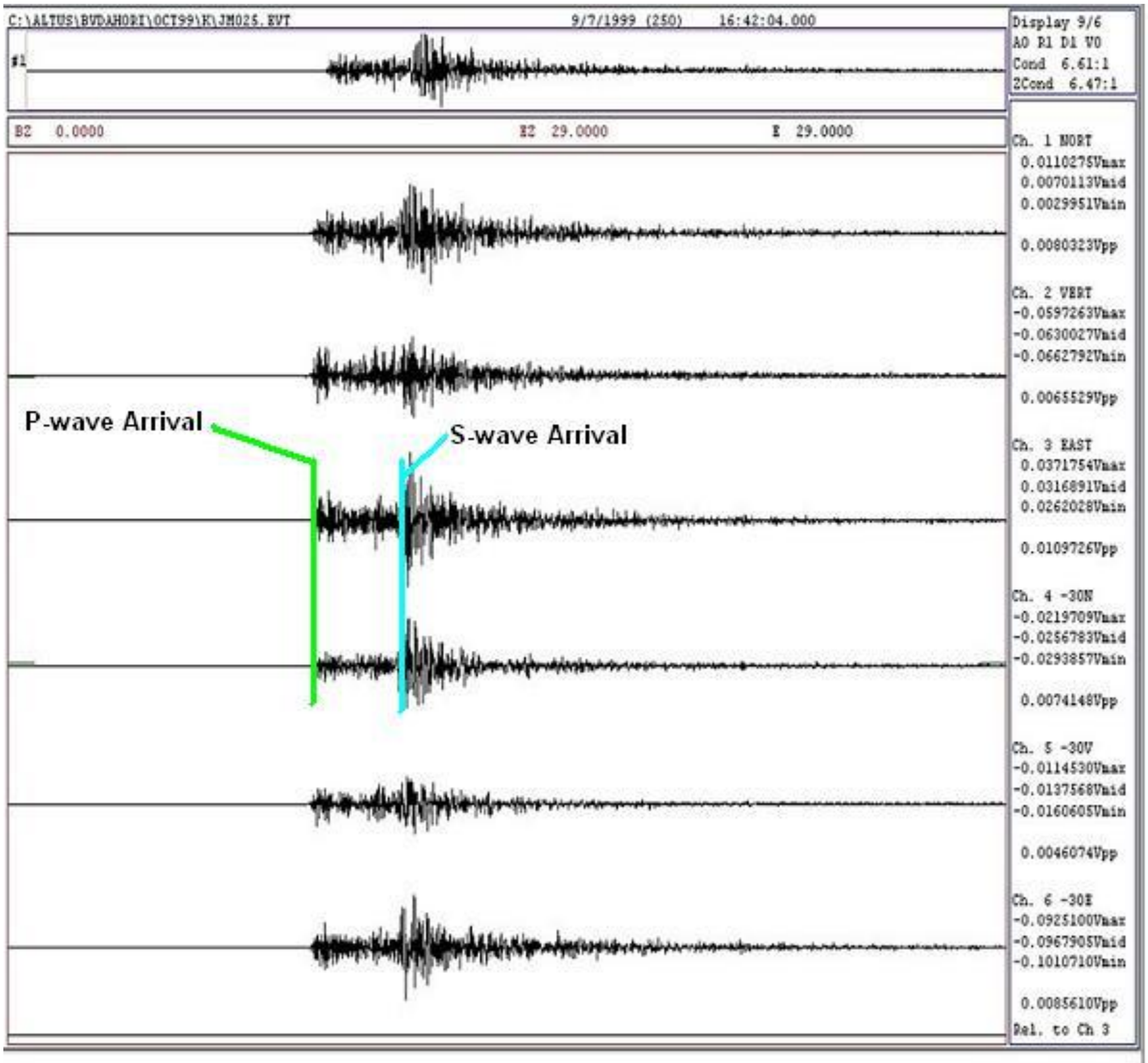
The nature of the earthquake threat demands that such critical industrial safety systems be:

- Site-specific with application specific acceleration set-point criteria.
- Industrial quality and autonomous.
- Completely automatic, providing real-time actuation upon exceedance of threshold criteria.
- Highly reliable and multi-tasking.
- Expandable and compatible with existing mechanical and signal systems.

Earthquake dynamics are extremely complex and unpredictable, the resulting destruction can often appear quite random. However, the phenomenon has been studied extensively by the international scientific community for many decades and certain characteristics are well known.

"P" & "S" Waves.

Earthquakes emit a variety of seismic energy waves, the two generally considered most important to man-made structures are the **"P"** and **"S"** waves. The **"P"** wave (compressional, normally non-destructive), travels in a predominantly vertical motion and has a velocity approximately twice that of the horizontal **"S"** (shear) wave, which normally has a larger displacement potential and is the motion most often associated with structural damage. While the precise speed of these waves from the earthquake focal area is dependent on geologic and other factors, their relative speed differential remains somewhat constant. Thus reliable detection of the **"P"** wave arrival provides an important opportunity for an automatic and instantaneous warning of the impending arrival of the more damaging **"S"** wave. This capability has resulted in extremely reliable off-the-shelf **Earthquake Early Warning** and **Shutdown Systems**, currently in common use for schools and industry in the United States and elsewhere.



[Reliable Seismic Measurement : The Key to Non- Structural Hazard Mitigation]()

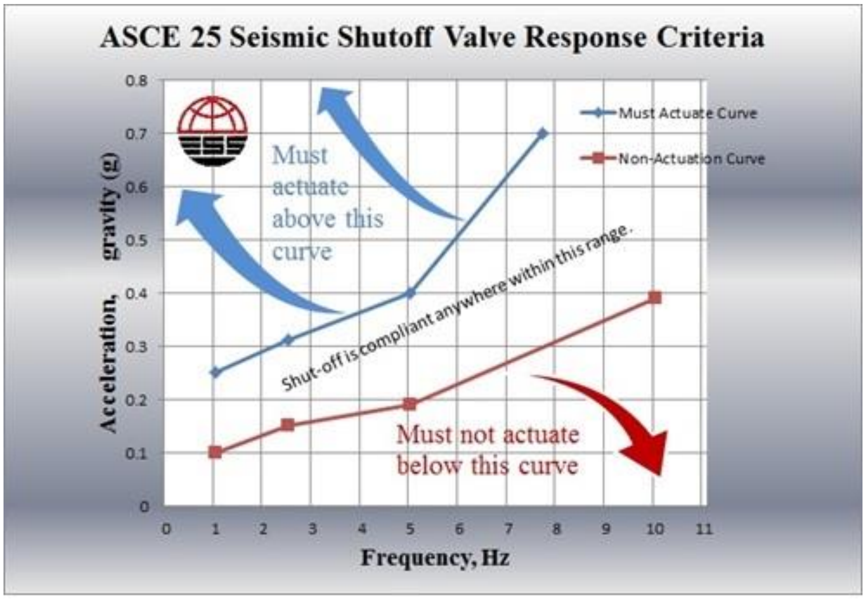
Due to the critical nature of these applications, the ability to ***accurately monitor and measure*** genuine seismic activity is the key to any credible mitigation effort. Careful selection of proven seismic sensor technologies is critical. In general, these sensors must operate linearly over a wide temperature range, be tri-axial in configuration (X,Y & Z axes), have field – adjustable actuation of setpoints, be immune to vibrations caused by industrial sources, and be able to withstand the demands of a rugged industrial environment.

In addition, the sensor must be ***integrated*** into an industrial quality enclosure with appropriate signal processing logic, autonomous power supply, human voice recording capability (where required) and directly support an array of auxilliary functions such as remote system monitoring and control via a client specified telemetry path (dial-up, hard wire cable, fiber optic or wireless).

How to Measure Earthquake Impact at a Given Location?

The commonly used *Richter Scale (RM magnitude)*, is an expression of the amount of energy released at the focal point (focus) of the earthquake. It is not an engineering scale and is often confusing to lay persons when comparing the effects of an earthquake at various distances from the epicenter.

Because the effects of an earthquake felt at specific distances from the epicenter vary widely, due to geology, local soil conditions, fault rupture mechanism, fault orientation, fault geometry and other factors, the major consideration when contemplating potential damage **is not** the Richter Scale, but the degree of shaking experienced at the facility (or location) in question (site specific).



In the absence of a risk-informed performance-based analysis, engineers often defer to the ANSI/ASCE/SEI 25 national standard which provides automatic valve actuation criteria based, in part, on a comparison of damage vs. the 1994 M_w6.7 Northridge Earthquake strong motion data. The actuation criteria are expressed as “Must Actuate” and “Must Not Actuate” response curves over the frequency range of 1 to 10 Hertz (Hz). Otherwise, ESS also offers a more traditional nominally ‘flat’ response between 1 and 15 Hz.

Amplitude / Intensity: Measurement in "g" Force.

The ground movement (creep, weak motion and strong motion) is generally measured in terms of displacement, velocity or acceleration. Accelerometers are the type of sensor used to transduce strong ground motion. The ASCE 25 standard (and other earlier standards) express earthquake actuated shutoff criteria as a percentage of earth's gravitational acceleration (9.8 m/s^2)- or "g" force in layman's terms. So, the scientific magnitude scales, such as Richter Magnitude or Moment (M_{w}), Magnitude, roughly quantify the amount of overall energy released by an earthquake, while ESS seismic sensors measure intensity in "g" levels and continuously compare those readings against the engineer's **"site – specific"** acceleration shutoff criteria.

It is precisely because the shaking intensity can vary dramatically from location to location that **"site – specific"** protection systems are necessary in order to avoid unnecessary plant shutdowns that might occur from a 'broadcast' based alarm. ESS systems initiate warnings, shut down or interrupt production, only if the impact is sufficiently severe at that ***specific*** location, thereby reducing lost production costs to a minimum.