# Level Measurement Techniques In A Modern Quarry

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## History

The application and use of Level Measurement in Quarries has come from very basic techniques. Factory Automation type devices were very common due to their availability, simplicity and acceptability. They mainly fell into the following categories

- Proximity Sensors
- Paddle Switches
- Photo Electric Beams
- Tilt Probes

Although very simple in their use and installation there were inherent problems. The devices main uses were designed around a cleaner less robust environment. The quarry product has the following changeable properties

- Density
- Product Size
- Abrasiveness
- Dust
- Vibration
- Product Hang-up

Manufacturers were constantly trying to improve the design both technically and mechanically to meet these demands. Some advancement was made with the introduction of

- Protective Shrouds
- Better IP Ratings on Units
- Better Body Materials

Manufacturers had to face the reality that the products in a lot of cases did not meet the needs of both the Applications and the Requirements of the Quarry Industry. A large investment in R&D was needed along with a better working relationship between the Manufacturers and the Industry.

## Why Is Level Measurement Required

The modern Quarry runs 24 Hours per Day and 7 Days a week and its primary function is to produce product for a vast amount of other Industry needs.
For this to be achieved a number of areas of operation need to be reliable, whether they are: -

- Electrical
- Mechanical
- Mobile Equipment
- Manpower

For reliability Plant needs to be run constantly and unnecessary starting and stopping of equipment can introduce unwanted and unplanned impact and breakdown of machinery.

The Quarry produces a saleable product and with this in mind equipment efficiency and productivity is a major factor. In some cases Urban sprawl of the population has encroached into the vicinity of plants and environmental concerns such as dust and noise are now a factor that has to be monitored.

## Which type of Level Device Do I require?

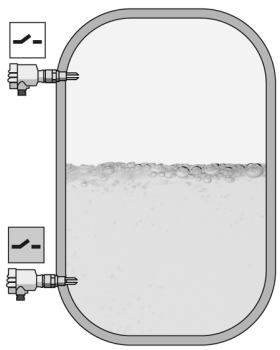
Before we can answer that question we need to look at the requirements of the application.

The use for Level Instruments can be broken down into 2 Categories

1. Level Detection
2. Level Transmitter

## Level Detection

The simplest form of level measurement giving you a single or multiple points switched or alarmed output once that predetermined action has been reached. These actions can occur in the field or fed back to a controller or PLC to activate other devices such as drives, Motors or Pumps.



## Types of Level Detection

These are broken down into the sections of Contact and Non-Contact

## Contact

## Capacitance Probes

The instrument is either of a solid rod construction or flexible steel cable. The principle of operation is that there are 2 plates and a dielectric measured material. One plate being the Rod or rope the other being the bin or chute wall. The dielectric material is the Product and once a contact is made between the two plates via the product then the output of the device will change state.

Typical Applications

- High / Low Level Detection
- Block Chute Detection

Pros

- Rugged in construction
- Tuneable to ignore build-up on the rod or rope probe
- Various Output Switching Options

Cons

- Difficult to set-up in lined bins or chutes
- Once tuned is activated by a consistent type product
- Lateral forces need to be taken into account

## Vibration Probes

The instrument is either of a solid rod construction or flexible steel cable with the measuring part either as a tuning fork arrangement or vibrating rod housed in a hollow tube. The principle of operation is vibration usually at around 150Hz. On the fork both blades vibrate and the contact with material will dampen the vibration and change the state of the out –put. The tube version works on the internal rod vibrating and the contact with material will dampen the vibration and change the state of the out-put.

Typical Applications

- High / Low Level Detection
- Stockpile Pile Height Limit Detection

Pros

- Simple method of operation
- Selectable for density minimums
- Self Cleaning action

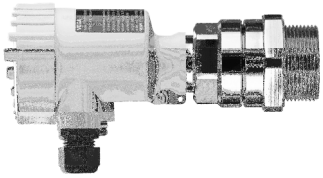
Cons

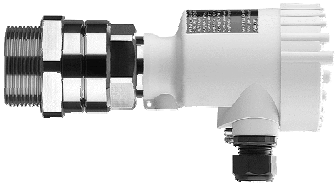
- Limited in use to powders or small pebble size material
- Can be easily damaged if installed incorrectly
- Lateral forces need to be taken into account

## Non-Contact

## Microwave Beam

This device consists of 2 parts, a Transmitter and a Receiver. The Transmitter emits a high frequency microwave signal (usually 10 – 30 GHz) and the receiver processes the received correct microwave frequency. The units are set-up to face each other and a blocking of the beam path will change a change of state in the output.





Typical Applications

- High / Low Level detection
- Block Chute Detection
- Vehicle Detection

Pros

- Selectable Detection density
- Ranges up to 100 metres
- Do not have to be perfectly aligned
- Imune to dust and other environmental impacts

Cons

- Transmitter and receiver both require power supply

## Level Transmitters

A more advanced form of Level Measurement giving you a continuous proportional output as well as the options of selectable programmable switch and/or alarm points. Once again these actions can occur directly in the field or fed back to Controllers, PLC's and DCS Systems to control devices such as VVVF Drives, Valves and Conveyer Feed Rates.

## Level Transmitter Devices

These are broken down into the sections of Contact and Non-Contact

## Non-Contact

## Ultrasonic Level Transmitters

This type of technology uses sound waves to measure distance. A system usually comprises a sensor which mounts at the top of the Bin with either an integral or remote transmitter.

The transducer of the ultrasonic sensor transmits short high frequency ultrasonic pulses towards the product to be measured. The speed of the sound pulses is about 340m/sec. These pulses are reflected by the product surface and received again by the transducer as echoes. The running time of the ultrasonic pulses from emission to reception is proportional to the distance

travelled and hence the level. The determined level is converted into an appropriate output signal and transmitted as a measured value.
As the speed of sound can vary depending on the temperature, a temperature sensor is installed in the transducer to compensate for the changes

Typical Applications

- Bin Level Indication
- Sump Level Indication
- Conveyer Height Monitoring

Pros

- Non Contact Operation
- Low cost solution
- Variable Voltage Supply to Instrument

Cons

- Not good in High Dust or Noise areas
- Has a Blocking Distance in front of Transducer
- Limited Temperature Operating Range

## Radar Level Transmitters

This type of technology uses microwaves to measure distance. A system usually comprises a sensor which mounts at the top of the Bin or end of the boom with an integral transmitter.

In the Radar sensor the antenna of the instrument emits short radar pulses with duration of approximately 1nS. The speed of the microwave pulses is about 300,000km/sec. Similar to an ultrasonic, these pulses are reflected by the product and received by the antenna as echoes. The running time of the microwave pulses from emission to reception is proportional to the distance travelled and hence the level. The determined level is converted into an appropriate output signal and transmitted as a measured value. The microwaves from pulse radar have an average power of only about 0.002mW, so quite suitable for use around people and machines. Note all Radar Level Transmitters are suitable for Solids Applications. For these types of applications the correct unit will be 26GHz and have a narrow beam angle and have high gain electronics.

Typical Applications

- Crusher Level Control
- Bin Level Indication
- Stockpile Heights

Pros

- Non Contact
- Fast Reacting
- Not Affected by Dust or other environmental influences
- Low Power Consumption

## Contact

## Capacitance Level Transmitters

Similar to the Capacitance Level Detection Probes except the unit transmits a proportional output of level. The most common form of probe is the flexible rope version. Either AC or DC Power sources can power the units. This type of transmitter is not common now and has been replaced in many applications by other forms of Transmitters

Typical Applications

- Fines Bin Level Indication

Pros

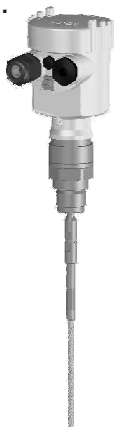
- Cable length can be shortened to suit application
- Can handle high temperature applications

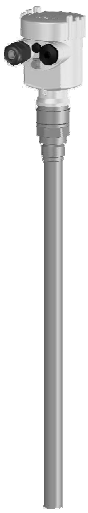
Cons

- Has to be set-up in a live calibration with product
- Abrasive products cause mechanical damage to probes
- Can only be used on fine materials
- Changing product types in bin causes inaccuracies

## Guided Microwave Transmitters

The newest form of technology to come to market. This transmitter works on the very similar principle to the Radar Transmitter except the emission of the microwave pulse is along a stainless Steel cable or rod and not from a horn. The principle is based on Time Domain Reflectrometry which basically means that a product in contact with the rod or rope that has a dielectric value will give a reflection of energy. The dielectric mass or volume of the product will determine the signal strength. The probe or rod is a permanent fixture in the vessel.





Typical Applications

- Dust Collector Level Indication
- Fines Bin Level Indication
- Diesel Tank Level Indication

Pros

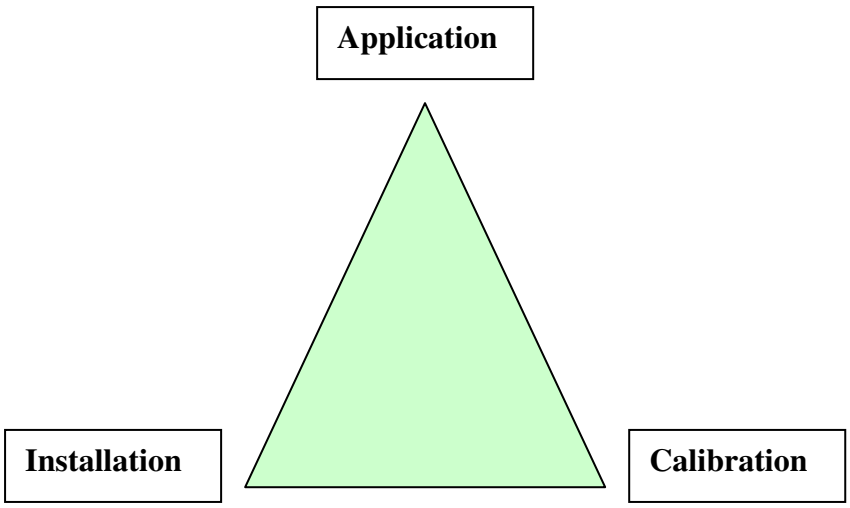
- Can be set-up prior to the installation
- Low power supply requirements
- Cables and rods can be shortened to suit the application

Cons

- Abrasive product does cause mechanical damage
- Limited to small product size
- Draw down forces on cable need to be taken into account

## Choice of Instrument Criteria

When making the choice of an instrument for level detection or for level measurement the following 3 key points form the basis for that decision




## Application

- You need to determine whether you need simple switching outputs for High and Low Levels or Indication of Blocked Chute. Will the product properties adversely affect the performance of your instrument as in Abrasion, Temperature , Density ?
- If a Transmitter is desired then can the principle of operation live up to the rigors of the material product characteristics ? Will the instrument

be subjected to product abrasion , Product down forces , Product Measurability .

- What functions do I require from my outputs ? Are you seeking alarm level only or do you need to know the continual level contents of the bin

## Installation

- Do I have existing Mounting points for the Unit ? If not what are the requirements to fit the instrument.
- Will the position of these mounting points give the best opportunity for the unit to work correctly ? Level Switches need to be placed in a position in which they can achieve their proposed objective. Level transmitters need to be located so that the full 0 – 100% range can be achieved without other influences such as product filling point and obstructions.
- Have I taken the Manufacturers recommendations into account ? The best person to indicate the requirements for product performance is the manufacturer or their representative. Continual performance can only be achieved if these are adhered to.

## Calibration

- Do I have the correct commissioning tools ? A lot of today's modern Level Transmitters are capable of interfacing with set up software. This software not only allows remote communication but also has the benefit of being able to save the settings electronically. Most faults in instruments are a direct result in incorrect calibration.
- Does the supplier have the capabilities to assist me if required. A good supplier will have a full working knowledge of their product and it's capabilities. With the reality that in most industry today the luxury of a large number of maintenance personnel being on site is long gone then the support externally can be extremely beneficial.
- Will I need training to conduct ongoing maintenance ? In most cases the simple solution is often the best. When selecting a Level Instrument the main criteria should always be that this unit will give me long term performance with little or no ongoing maintenance.

## Future Proofing Of Level Instruments

Technology is evolving at the fastest rate in history and Level Instruments are not immune to this. Consideration should always be given to the reality that the plant may need to go through major upgrades. These upgrades can and do include the communication of plant information, whether that be the status of machinery at present or the remote monitoring of stock inventory.

It is not uncommon today to utilise such technologies as :

- Wireless Communication
- Ethernet
- Web Based Monitoring
- Plant Networks
- Modem Based Reporting

In some cases existing plant may be capable of being upgraded to any of these but unfortunately it is not the case for all. Manufacturers now need to take this into account and be able to guarantee that their instruments do meet this future proofing requirement. More importantly is that the companies and individuals representing these manufacturers also have the knowledge and capability of being able to offer the After Sales and Support of existing product and future developments.

## Conclusion

The three important factors when obtaining a successful level solution in a Quarry are always; correct selection of the sensor for the application, ideal mounting position, and commissioning by trained persons. With these factors adhered to a successful level solution can be found for each application.

The purchase of any Level Instrument is an investment into the Plant Performance and therefore the long term capabilities and performance of that unit should be a major part of the decision.

All instruments have their limitations and exceeding these boundaries will expose the user to a drop in performance and possibly a costly outcome.