Process Plant and Equipment UP-TIME

The essential engineering maintainers and operators need to keep plant reliability up and operating costs down.

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Contents

Volume 1 Edition 2 topics

Process Control Talk

ULTRASONIC LEVEL DETECTORS

Consider these Experiences when making a Selection

What you will learn from this article.

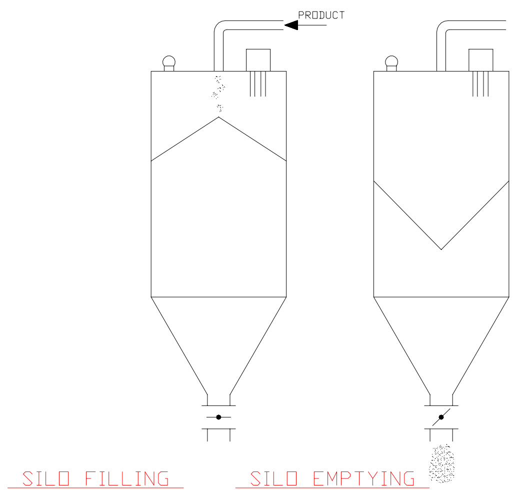
- How ultrasonic level detectors work.
- Issues to consider when reviewing their suitability for use.
- Issues to consider when selecting their location.
- The importance of process and chemical compatibility.

Ultrasonic level detectors (ULD's) work on the principle of measuring the time delay between emitted high frequency sound and its reflection from a surface. In many applications these devices have been used successfully as level detectors. However in the situations discussed below they did not give satisfactory long-term service.

POWDERED PRODUCT SILOS

One application that proved difficult for the model of ULD selected was in measuring the level of powdered product in vertical silos. It appeared that the dust created during filling caused interference with the reflections and resulted in false level readings. The dust also coated the surface of the detector, thereby causing intermittent spurious readings during the normal operating mode.

A further complication that occurred in the silo was the inversion of the product surface shape. This situation arose because the product experienced core flow as it was removed from the bottom of the silo.



Drawing No 1. Ultrasonic level detector in a silo.

Figure No. 1 highlights the change in surface geometry from conical pyramid to inverted cone as the product was removed from the bottom of the silo.

FLAT ROOF TANKS

Fictitious levels have been experienced when ULD's were installed in the roof of a flat roof, liquid storage tank. The same model sensor, when used in the roof of a conical roof liquid storage tank, produced reliable results. Figure No. 2 shows a method that proved successful in overcoming the spurious results. It was to mount the sensor at the apex of a fabricated cone sitting over the tank manway entrance.

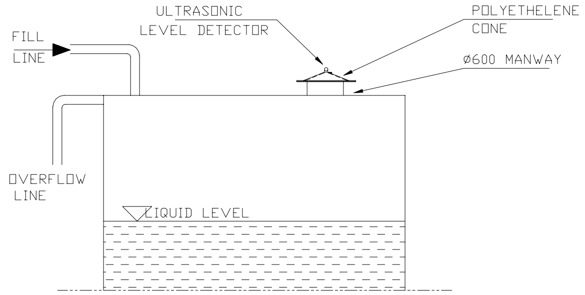


Figure No. 2. Ultrasonic level detector in a flat top roof

When the same cone mounted sensor idea was used on a flat top reactor vessel the results were mixed. The major difference between applications was that the liquid surface in the storage tank was still, while in the reactor the liquid surface was undulating and turbulent with a great deal of vapor generation. This environment did not appear suited to the use of ULD's. Putting the detector at the top of a dip pipe may have improved the situation by removing the turbulence and reducing some of the generated vapor.

MATERIAL OF CONSTRUCTION COMPATIBILITY

One consideration that affects the selection of instrumentation in direct contact with process chemicals is the compatibility of the materials of construction with the product being monitored.

The use of one manufacturer's ULD to measure the liquid level in storage tanks for 30% hydrochloric acid (HCL) eventually resulted in the detector's plastic housing dissolving from acid attack. The plastic used for the housing was not suited for long term application in HCL vapors.

PROCESS TEMPERATURES and CHEMICALS

The ULD in the flat top reactor previously mentioned had an operating temperature limitation of 70^{o} C. The process involved mixing chemicals with HCL during which the high temperature generated from the reaction was to be cooled to 50^{o} C through a heat exchanger. The manufacturer's specifications were apparently satisfied. However the local temperature at the surface of the liquid in the reactor was higher than the design temperature of the bulk liquid and it was to this temperature which the ULD was exposed. Not long into service the ULD was removed due to chemical attack from the vapors aggravated by the high temperature in the reactor.

A better selection would have been made had consideration been given to the local environment in which the equipment and its housing were located and not the expected average conditions.

VACUUM SERVICE

Since ULD's require sound to be transmitted and reflected they will only operate in environments which contain sound transmitting atmosphere. As such they will not be reliable in a process conducted under vacuum conditions.

INTERNAL STRUCTURES

The pulse emitted from a ULD will be reflected back by any object in its path. If there are internal structures within a tank below the ULD they will reflect the pulse and produce a false signal. Relocate the ULD to a place where there is clear space below it.

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CALIBRATIONS

It is necessary to check and calibrate the high and low levels and the span when the ULD is in its final position. With tanks this is done by filling them with water and physically dipping and measuring the levels and comparing results. In situations where water cannot be used it may be possible to use the product and dip it, or take the ULD to a 'dummy' test set-up on another item of equipment where water can be used and then replace it back in its required position.

Mike Sondalini - Maintenance Engineer

TRACKING LARGE ROTATING EQUIPMENT

What you will learn from this article.

- The importance of using datum's for aligning kilns.
- How to set-up the necessary datum.
- The effect of trunnion alignment on the behaviour of the kiln.
- How axial float is achieved by skewing the trunnions.

Rotary dryers, kilns, mills and reactors turn on tyres and trunnions. Each tyre is mounted to the rotating shell and revolves on two roller trunnions. The shell is rotated mechanically. Generally the tyres and trunnions are made of steel but in lightweight equipment with low rolling surface temperatures the trunnions can be lined with hard wearing plastic. In those situations where the product is continuously fed through the equipment the entire shell is inclined a few degrees. With each rotation the product is lifted and moved along a distance.

The rotating shell is aligned by correctly positioning of the tyres and trunnions. Guide rollers are fitted to the front and back of a tyre and trunnion set to limit axial movement. If the alignment between the tyre and trunnions is lost due to wear, poor repair, installation error or impact, the equipment will need to be tracked

AXIAL ALIGNMENT

Installation and maintenance personnel will flounder when tracking the tyres without proper references to align the equipment. Proper tracking of rotary equipment requires access to a datum from which the axial alignment of the tyres can be set. The datum is a series of points whose relative vertical and horizontal positions are accurately known. Figure No. 1 show how the datum is used to set the vertical and horizontal position of the tyres.

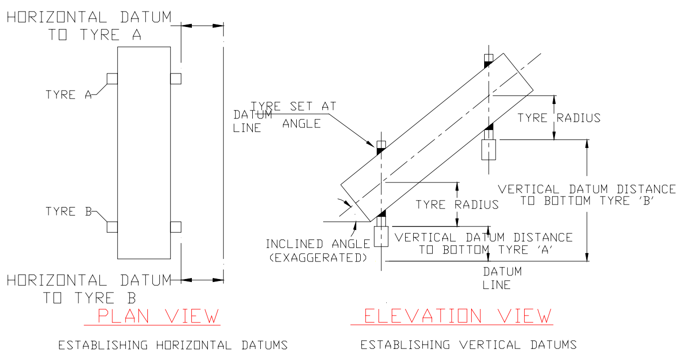
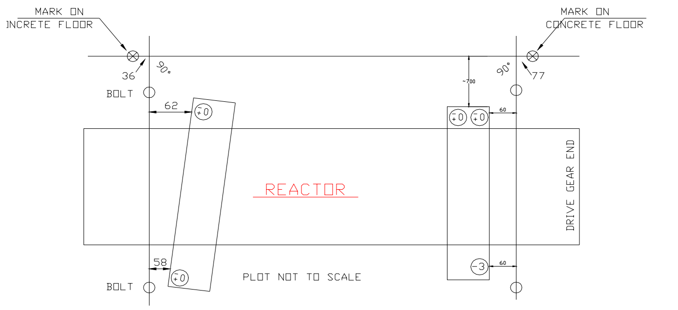


Figure No. 1 Vertical and horizontal datum.

Unless the equipment manufacturer or installer provided the datum's, you need to be creative in establishing the necessary reference points. One method that proved suitable on a rotary reactor was to use laser surveying to establish both the vertical heights of the trunnion pedestals under each tyre and to position a datum line offset from the tyre axis to provide horizontal reference points. This allowed accurate measurement of the horizontal and vertical position of each tyre axis to within 0.5 mm.

Drawing No. 2 shows how the hold down bolts were used as a horizontal reference on the assumption that the pedestals were cast identical and had been properly aligned when the equipment was originally installed. The numbers in the circles represent the vertical datum and show that all but one end of one pedestal were at the same level. The "marks on the concrete floor" distance represent the offset from the hold down bolts to give the horizontal alignment.

Provided the drive alignment can be adjusted it is simpler to line up the tyres and trunnions to the datum and then align the drive to the shell.

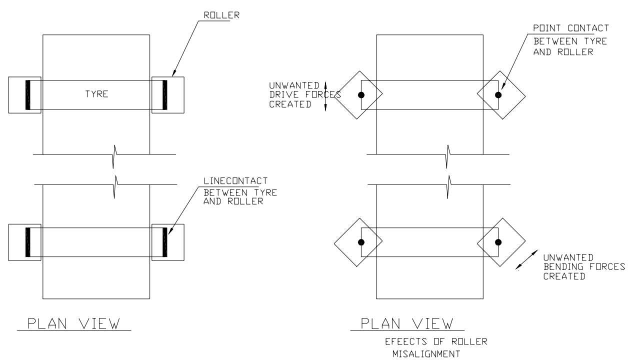


Drawing No. 2 Locating horizontal datum

ROLLING FACE ALIGNMENT (Training the kiln)

A further consideration in tracking large rotating equipment is the alignment of the trunnions to the tyre. The tyre and trunnion must always be aligned to each other. Where the shell is inclined the trunnions must also be inclined to the same angle.

If the rollers are set skew to the tyre axis forces are created which drive the shell along its axis. This can advantageous and necessary if the shell requires 'floating' between the axial guide rollers, but otherwise leads to unnecessary wear. Misalignment between tyre and rollers can cause excessive wear of the rolling faces because the previous line contact between the two surfaces becomes a highly stressed point contact. Offsetting one trunnion pair from the other will cause twisting of the shell. Drawing No. 3 highlights the problems caused by rolling face misalignment.



Drawing No. 3 Contact stress changes due to trunnion alignment.

Correct tracking of rotating dryers, kilns and reactors is achieved by first aligning the tyre and trunnion sets axis true to each other. It is easier if all trunnions are the same diameter otherwise compensating calculations have to be made for each different sized trunnion. The shell and tyres are lowered or raised by jacking the trunnions respectively out or in. Axial trusting is then removed by giving the trunnions a miniscule amount of offset relative to the tyre axis.

Axial 'float' adjustments are done by jacking alternate sides of each trunnion pair in or out depending on which direction the float is required. A 'rough-in' adjustment can be done while the shell is cold but the final setting must be done at operating temperature while under load.

Drawing No. 4 shows one of the two possible orientations of the trunnions to create axial movement of the shell. One way to understand what the trunnion offsets does is to think of the shell with an imaginary helical 'thread' on its outside. By skewing all four trunnions minutely they act like a nut running along the 'thread'. But

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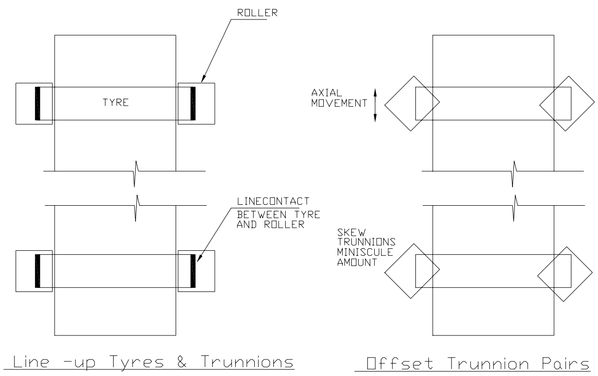
since the trunnions are stationary it is the shell that gets the thrusting action from the trunnions and moves along the 'thread'.

To select the trunnion bearing housing to be jacked stand behind the trunnion concerned, with the fingers of both hands pointing in the opposite direction to the rotation of the shell. The hand with the thumb pointing in the direction the shell has to be steered is the same hand as the bearing housing that needs to be jacked minutely inward to the shell.



Drawing No. 4 Offsetting trunnions to float the kiln

Set-up dial indicators at the shell end of each bearing housing to be jacked. Jack both bearing housings on each trunnion pair at the same time by equal amounts. Move the bearing housings 0.025-mm (0.001") at a time. Continue the equal adjustment till the tyre moves away from the axial thrust guide roller. As little as 0.1 mm (0.004") can suffice to steer the shell.

Mike Sondalini – Maintenance Engineer

CHEMICAL CORROSION CONTROL

What you will learn from this article.

- Corrosion control is necessary to get long service life.
- Materials are available for the safe containment of chemicals.
- When selecting materials consider the metallurgy of the material.
- Welding changes the chemical resistance properties of a metal.

Chemical corrosion can destroy the containment materials in contact with a process. Means exist to mitigate and even prevent chemical corrosion. This article focuses on several such methods.

ACCEPTABLE CORROSION

At times chemical corrosion is acceptable and one need only allow for it by using thicker materials. An example is the storage of sulphuric acid in mild steel tanks at ambient conditions and concentrations higher than 80%. Though the acid attacks the metal, the rate of corrosion is extremely slow. Using thick walled steel tanks with a corrosion allowance which takes decades to thin can be a cost-effective option. At 80% strength sulphuric acid will corrode a 12 mm thick wall tank to less than 6 mm in about 6 years.

Sulphuric acid absorbs moisture from the air. If the top layer in a mild steel tank is left undisturbed it will dilute and attack the steel. A 12 mm steel plate can corrode through in 12 months. Circulating the acid weekly, if it is stored in carbon steel tanks, will reduce this problem. For small bulk quantities of sulphuric acid a suitable plastic tank can solve the storage and corrosion problem cheaply.

SELECT CHEMICAL RESISTANT MATERIALS

Using more resistant materials will reduce the effect of chemical attack. Specialist metals and non-metals to contain aggressive environments are available. These can be expensive and their use is based on their cost effectiveness.

In particular, select low corrosion rate metals for flexible diaphragms used in process instrumentation. It is false economy to select a 316 stainless steel diaphragm for a pressure transmitter on a tank of 98% sulphuric acid. Though corrosion tables indicate 316 stainless has a low corrosion rate, experience shows that after two years of service the diaphragm can fail by pin holing. For an additional 20% cost a Hastalloy C diaphragm provides a corrosion life 10 times longer.

COMPATIBLE COATINGS AND LININGS

Prevent chemical attack by coating in a material unaffected by the chemical. Rubber lining of hydrochloric acid storage tanks and plastic lining of process piping are examples. Teflon coating can protect a stainless steel sparge feeding sulphuric acid into a mixing vessel. Polyurethane liners can be sprayed onto tank walls.

Rubber linings normally fail at joins. Check the correct procedure is used when they are mounted in place and test for holidays (pin holes) with spark testing.

BEWARE CHANGED MATERIAL PROPERTIES

Heat from welding processes alters the metal properties at the heat-affected zone (HAZ) of the weld. Stresses are introduced into the metal and grain microstructures are altered. Consideration of the welding method, weld procedure and use of stress relief can mitigate the effects.

The effect of welding is particularly evident when hot caustic solutions are contained in mild steel vessels. If carbon steel is used with hot caustic soda it is necessary to stress relieve the welds. Unless stress relieved, chemical attack can occur at the HAZ of the welds where stresses are high.

CONSIDER THE CHANGING PROCESS CONDITIONS

Using corrosion tables without considering all the process conditions can lead to poor materials selection. Most published data on compatibility do not take into affect agitated conditions. Some data only applies to ambient temperatures. Data is normally not available on the effect of aeration. Nor is data readily available on the effect of other contaminants, for example chlorides with stainless steels.

In uncertain or changeable situations will occur in a vessel consult the material manufacturer and ask for their advice. If they cannot help, then the only remaining option is to conduct your own laboratory tests or field trials.

The chemical compatibility table below was derived from numerous published data. The most conservative temperatures were selected. Where no temperatures are shown ambient conditions apply.

Chemical corrosion control and mitigation requires creative use of a few basic principles.

Process Chemicals Corrosion Compatibility Table

CHEMICALS >>	SULPHURIC ACID 98%	SULPHURIC ACID 80%	SULPHURIC ACID LESS THAN 80%	HYDROCHLORIC ACID 28%	CAUSTIC 50%	CAUSTIC 25%	GASOLINE PETROL	DIESEL FUEL	DEMIN WATER	SEA WATER	ETHYL ALCOHOL
METALS	Hastalloy C (95 C)	Hastalloy C (95 C)	Hastalloy B (100 C)	Hastalloy B (70 C)	316L Stainless steel (95 C)	316L Stainless steel (80 C)	316 L Stainless steel	316 L Stainless steel	316 L Stainless steel	316 L Stainless steel	Carbon steel
In order of corrosion resistance	316L Stainless steel	316L Stainless steel	Alloy 20 (60 C)	Hastalloy C (40 C)			Carbon steel	Bronze, Brass		Bronze	316 L Stainless steel
	Carbon steel	Carbon steel			Carbon steel (40 C)	Carbon steel (95 C)		Carbon steel			Bronze
PLASTICS	Teflon (95 C)	Teflon (95 C)	Teflon (95 C)	Teflon (150 C)	uPVC (60 C)	uPVC (60 C)	uPVC (60 C)	Teflon (180 C)	Teflon (200 C)	Polyethylene (80 C)	Polypropylene (80 C)
In order of temperature	Polypropylene (80 C)	Polypropylene (80 C)	Polypropylene (80 C)	uPVC (60 C)	ABS (60 C)	ABS (60 C)		Polyethylene (60 C)	uPVC (60 C)	uPVC (60 C)	uPVC (60 C)

temperature limits											
	uPVC (60 C)	uPVC (60 C)	uPVC (60 C)	Polyethylene (60 C)	Polyethylene (40 C)				Polyethylene (60 C)		
			Polyethylene (60 C)	ABS (60 C)							
ELASTOMER (Rubber)	Hypalon (50 C)	Viton (60 C)	Viton (120 C)	Viton (180 C)	Hypalon (140 C)	Hypalon (120 C)	Viton (50 C)	Nitrile Buna-N (80 C)	EPDM (95 C)	Hard Rubber (80 C)	Nitrile Buna-N (60 C)
In order of temperature limits	Viton (20 C)	Hypalon (50 C)	Neoprene (95 C)	Natural rubber (95 C)	Neoprene (95 C)	Neoprene (95 C)	Nitrile Buna-N (80 C)	Viton (80 C)	Hard Rubber (80 C)	Nitrile Buna-N (80 C)	EPDM (40 C)
			Hypalon (50 C)		Hard Rubber (80 C)	Hard Rubber (80 C)			Neoprene (80 C)	Viton (80 C)	
COATINGS			Fiberglass & vinyl ester (95 C)	Epoxy resins (95 C)	Epoxy resins (50 C)				Vinyll ester		
				Fiberglass & vinyl ester (80 C)	Fiberglass & vinyl ester	Fiberglass & vinyl ester					
				Asphalt resin (50 C)							

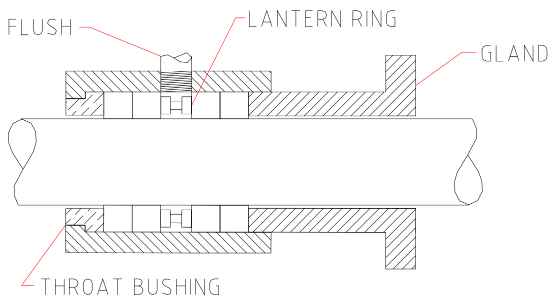
From the Mechanical Workshop

Shaft Sealing with a Packed Gland.

What you will learn from this article.

- How shaft packing works.
- What to consider when selecting and using shaft packing.
- Good installation practices.
- Proper commissioning of shaft packing.

Compressed, stacked packing is used to seal the hole created by a shaft passing through a piece of equipment. The sketch below shows a typical packed shaft configuration.



Because compressed, stacked packing requires leakage to cool and lubricate, one would normally use packing on harmless products. If used on environmentally unfriendly products or dangerous goods, the leakage must be collected and suitably treated to protect people and environment.

HOW COMPRESSED PACKING WORKS

As packing is squeezed into place it fills the cavity in which it sits. The packing will seal against the side and bottom of the stuffing box and on the shaft surface. When the shaft turns, it rubs against the packing and is wiped clean. Except for slurries, 70% of wear normally takes place in the first two packing rings nearest the gland throat.

The selection of suitable packing includes consideration of chemical compatibility of the components, the operating temperature of the process, the material of the shaft, whether additional lubrication imbedded in the packing, such as graphite, will be useful, whether a cooling and lubricating flush will be used.

CONSIDERATIONS WHEN USING PACKING

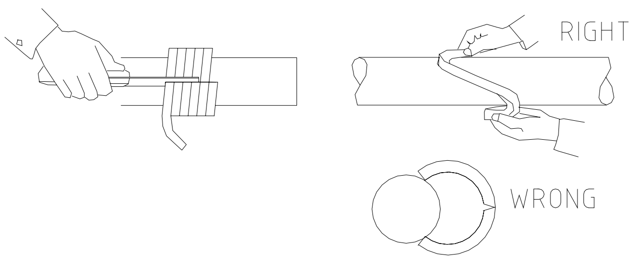
Because packing rubs on the shaft, friction is generated and wear occurs. The preferred methods of minimising shaft friction are to:

i. use a very smooth surface finish
ii. use a hardened rubbing surface (protect the shaft with a hardened, replaceable sleeve if practicable)
iii. use the slowest shaft speeds allowable
iv. insure stuffing boxes are cylindrical; shafts are machined round and run true to within 0.08 mm (0.003”), the gland throat clearance prevents packing extruding through it (maximum of 3% of packing width)
v. install a lantern ring to flush away contaminants
vi. install a lantern ring to feed a cooling and lubricating fluid to the rubbing surface
vii. select packing which helps heat to be removed
viii. select packing with friction minimising properties
ix. select a braid structure suited to the process fluid and pressures - close twined for gasses and high pressures.
x. for valves the packing cross section must be a snug fit in the stuffing box; for pumps packing cross section must have a slight (3%) clearance in the stuffing box.

GOOD INSTALLATION PRACTICES

In order to minimise the extent of leakage from a packed gland do the following:

i. cut each ring with a slanted end join as shown below
install the packing with each ring join staggered 90 degrees from the previous



ii. set each ring individually in place with a tamping tool, or split hollow cylinder, turning the shaft occasionally
iii. push each ring hard up against the previous ring with no gaps. This insures the force generated by tightening the gland follower is transmitted to all rings
iv. lantern rings must line up with the flush port
v. continue fitting rings until the gland follower projects 25% to 30% of the stuffing box depth
vi. a lantern ring flush must be a clean source and at a pressure 100 to 200 kPa above stuffing box pressure (about two thirds the discharge pressure)

COMMISSIONING SHAFT PACKING

Commissioning a packed gland is a slow process. Proper bedding-in of the packing on rotating applications will take two to three hours to achieve.

Start with a generous leak and tighten the gland follower hand tight. Continue tightening evenly with a tool until the leakage flow levels off (even though the follower is being tightened). From then on make a half turn every fifteen minutes till the required leakage rate is achieved. Monitor heat build-up in the wall of the stuffing box by hand so it rises no higher than warm to the touch.

Packed glands on pumps, when properly seated and adjusted ought leak from five to twenty drops of product or flush liquid a minute.

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Asset Management

Some Quality Paradigms are Expensive.

ABSTRACT
Some quality paradigms are expensive. Quality is a mindset! When a wise man is given the chance to buy quality items he does so because quality pays for itself. A quality item lasts longer, runs better and looks good when others fade. To change the way you think about quality takes a lot of experience with using poorer options. When you are sitting down with your head in your hands wondering what can be done to get costs down, to get production up and how you are going to hit the key performance indicators, remember the importance of quality equipment, quality systems, quality training and your quality mindset!
Keywords: quality control,

It is the way of people in many cultures to look at the purchase cost of a thing and not its life cycle cost. They have been taught short-term thinking at the expense of long-term benefits. It is an expensive paradigm by which to live your life.

When you go to buy a suit do you buy the least expensive suit that will fit you? That is what I used to do. In my ignorance I thought I was making a smart purchase. I did not understand why it was cheap.

It was cheap because it was not a thick, well woven fabric, it was not double stitched, the thread holding the buttons were not ended properly, the person sewing the suit would have been paid a meagre wage and it would have been made on piece work. Such a suit, by the nature of its manufacture, could not be a quality product. I needed to buy two such suits and leave one in the wardrobe awaiting the failure of the first. I took this philosophy with me into my engineering career. I did not know better at the time.

For 50% more I could have got a quality, world-class suit that would have lasted twice as long as the two cheaper suits. And for no extra cost it would have been altered for free to look good on me. Such a fine suit would have told the world that here is a person of quality with high standards and high expectations from life.

But I had been brought up with the wrong paradigm. Rather, … the effect of my choices had never been explained to me. So in my ignorance I thought buying cheap was buying smart.

It has taken me a long time to realise my great error. Even today, knowing full well the consequences of buying cheaply, the first thought that comes into my mind is how little do I have to spend to get the job done. I will have to fight against that way of thinking till the day I die. It is the wrong paradigm to use to make equipment purchase choices, terribly wrong!

If such an approach to doing business is ingrain in an organisation it will lead to loss of potential long-term profits. It must, because that which is cheap must be replaced often. Just like buying a cheap suit.

Suppose that instead the paradigm was turned around!

As an example, take an equipment design engineer or project design engineer given the task to make a thing do a job. But it must last 25 years without a single failure.

It now becomes critical to consider every possible failure cause and design adequate protection for 25 years fault-free service. That is a totally different perspective to what we are used to today.

Now cost is not the decision driver. Instead quality, creativity, craftsmanship, degrees of perfection and fault-free longevity of service become the decision drivers. That would be something wouldn't it! What great pride that would bring the persons that built with perfection as the aim and not the least cost to get through the warranty period. And what great benefits such a piece of equipment would bring its user. For a few dollars more they would get quality production , problem-free for 25 years.

If you think that such a requirement would cause the equipment to be too expensive to sell or buy? Well, …. let me tell you what I learnt long ago about buying suits…!

Mike Sondalini
Equipment Longevity Engineer.