TVC

Corrosion Testing in Steel Lighting Columns

ColcheK2™

Basic Principles: Reproducibility and Applicability

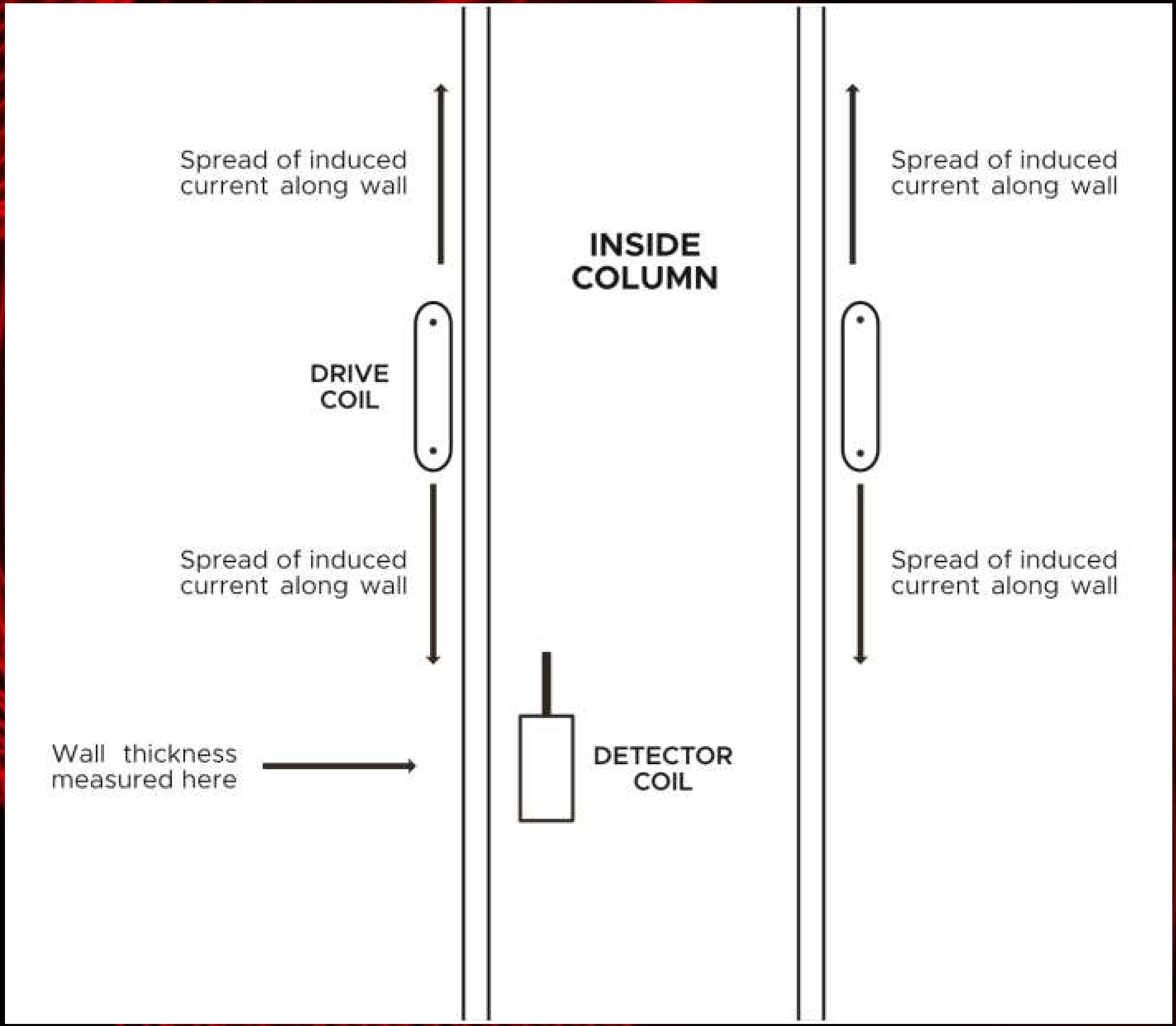
Basic principles

The ColcheK2™ :

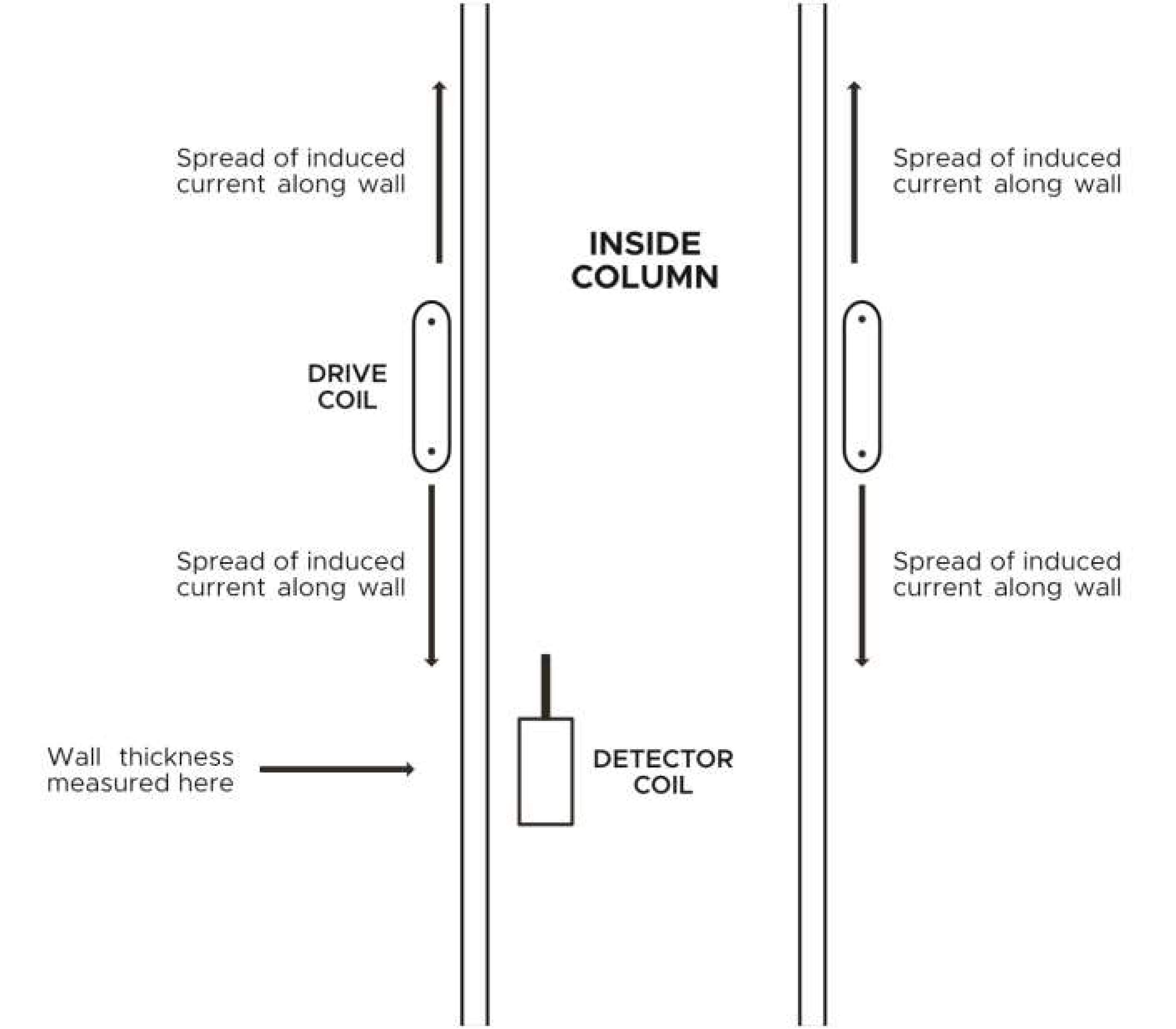
- is a specialist form of eddy current non-destructive inspection equipment;
- uses ‘through transmission’ from an external drive coil to an internal detector coil;
- has an external drive coil inducing eddy currents into the column steel.

Whilst these currents are strongest immediately under the drive coil, they also spread much further along the length of the column.

In a carbon steel tube, these induced currents can be detected at least 1 metre away from the drive coil.

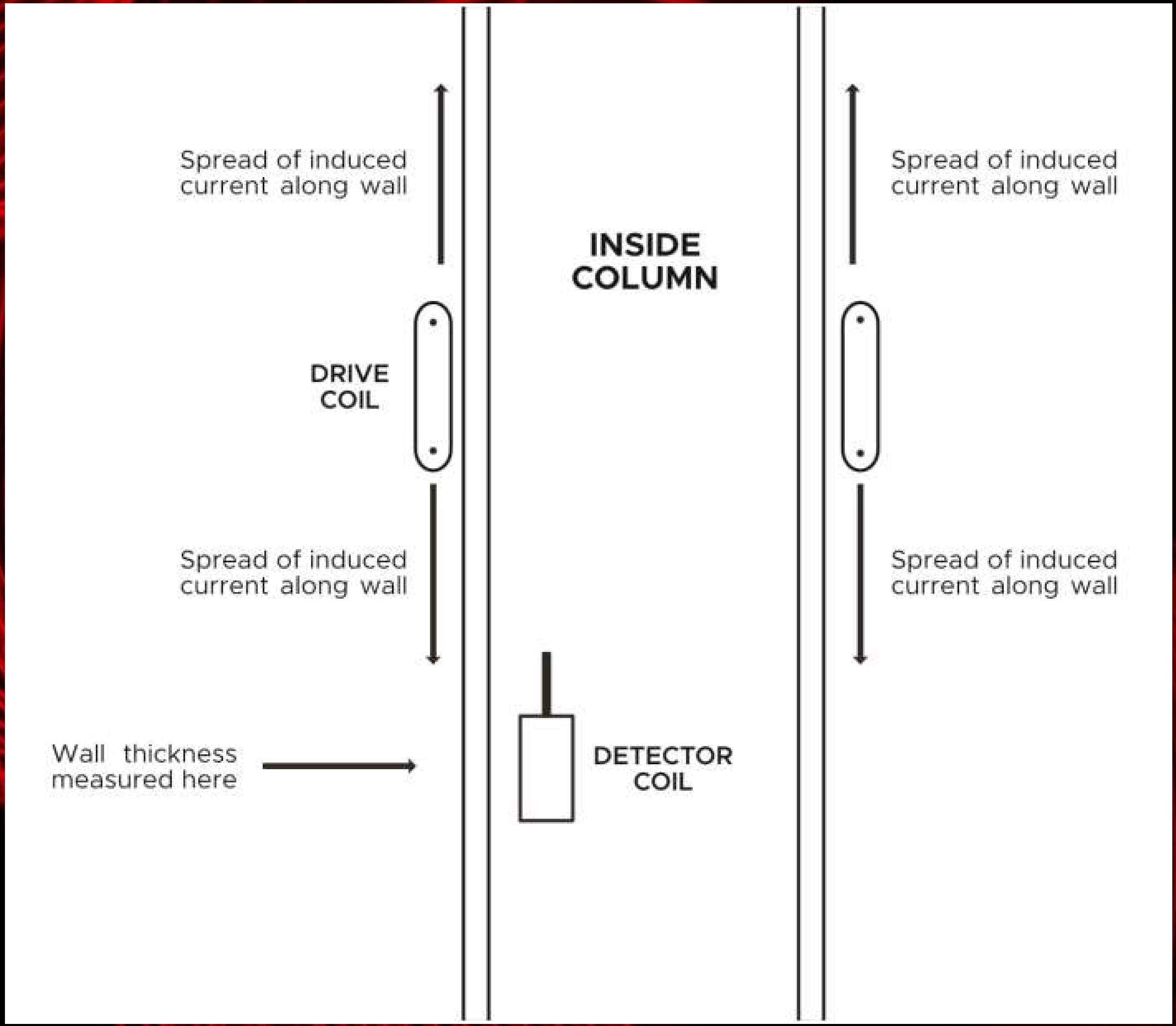


- induced currents are not confined to the outer layer of the column but penetrate through the wall thickness;
- the deeper you go into the steel, the current density falls and the phase of the current changes, relative to that at the outer surface;
- the thicker the column wall, the greater the reduction in current density and the greater the change in phase.



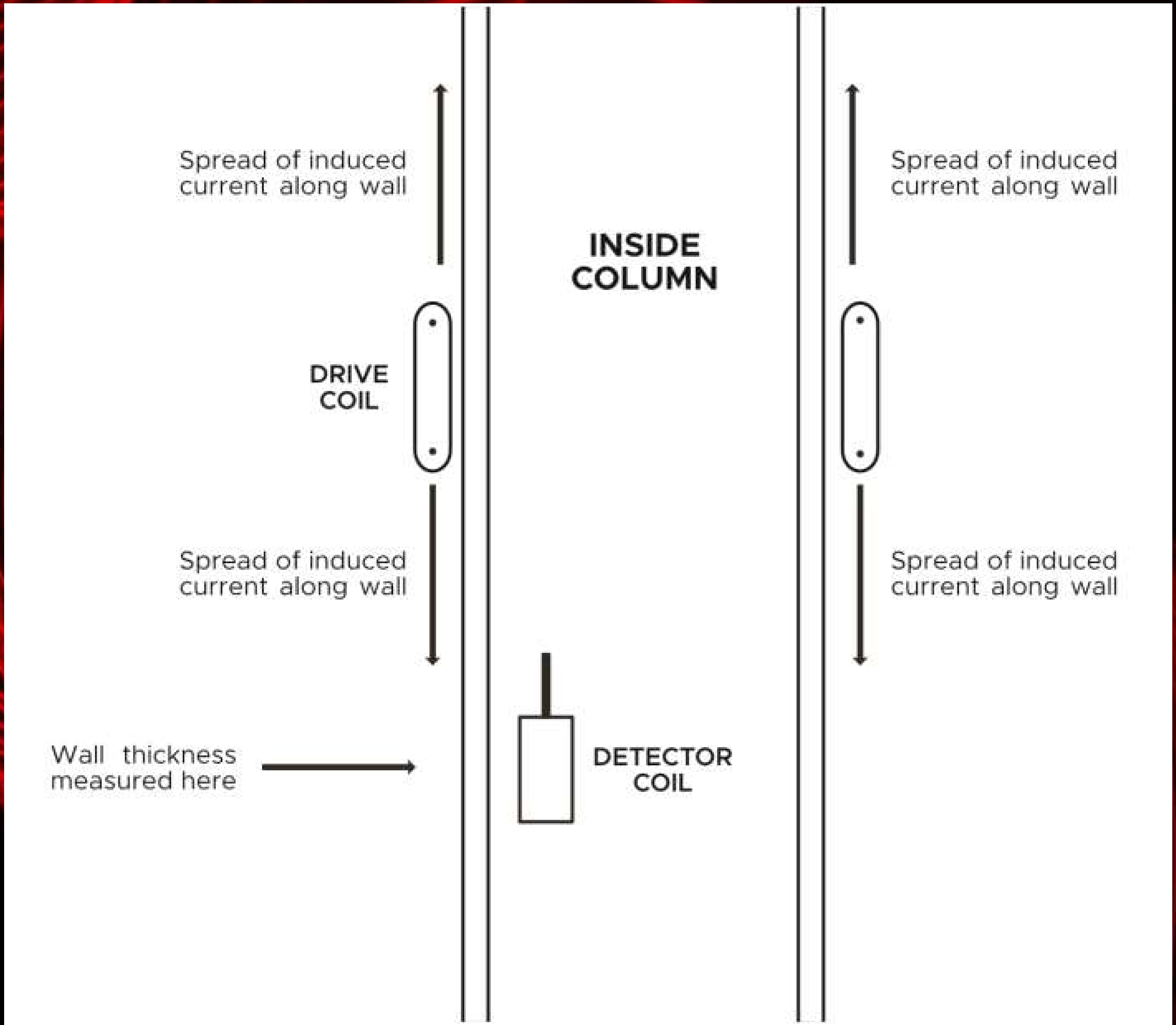
Consequently, the amplitude and phase of the current flowing on the inside surface of the column depends on the thickness of the column wall.

Due to the spread of the currents along the column, the internal, induced currents exist at points far removed from the site of the external drive coil.



The detector coil inside the column responds to the induced currents within the column steel and indicates the loss of thickness of the column wall adjacent to the detector coil.

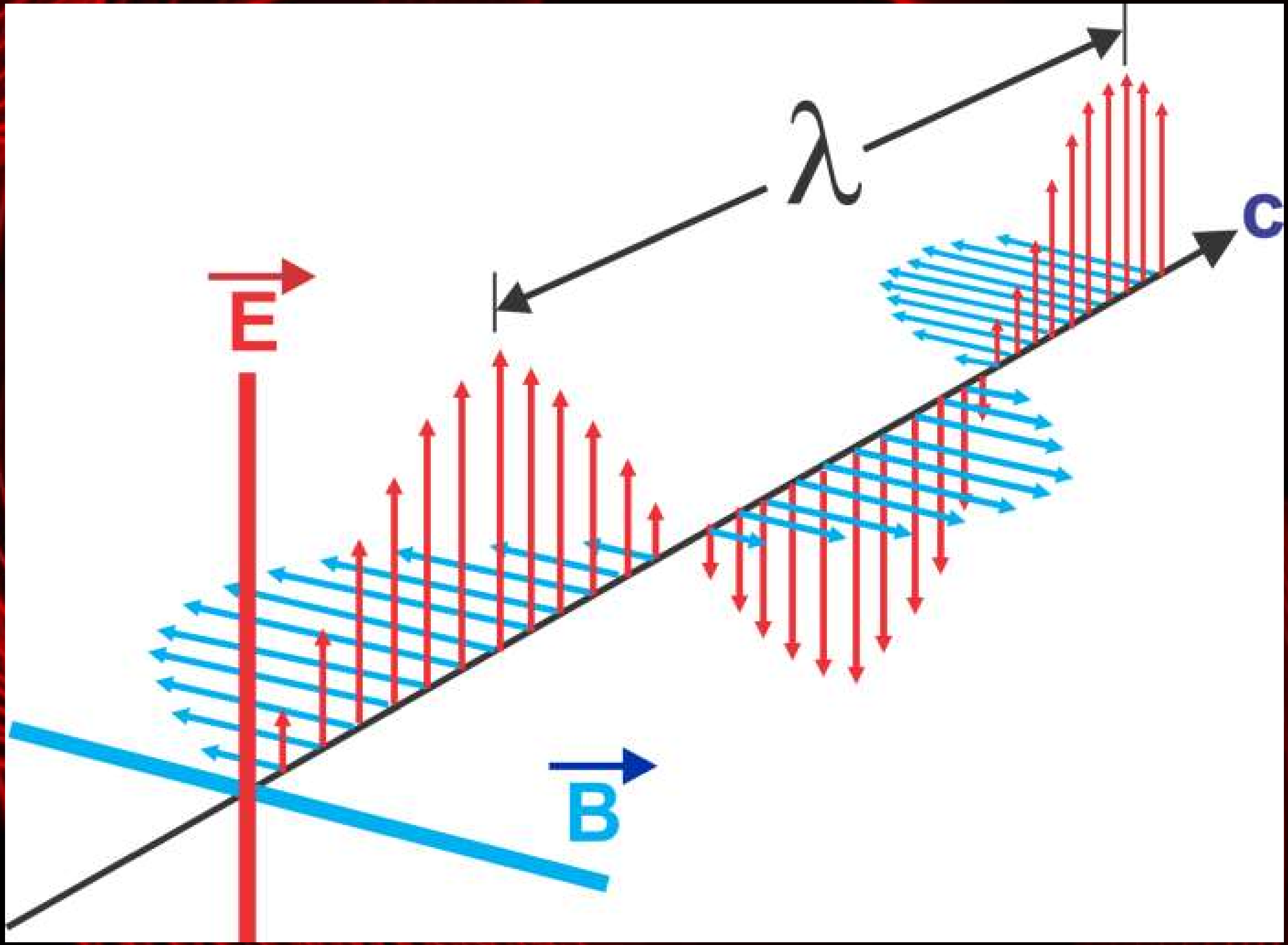
Electronic processing converts the signal caused by disturbances in the induced eddy currents into a linear measure of the relative loss of thickness of the column wall.



Problems Related to Carbon Steel

While carbon steels can be of a high metallurgical standard, the material used for lighting columns only has to satisfy some basic mechanical criteria; the electrical and magnetic properties are not important.

However, the electrical and magnetic properties can be important to the correct working of any eddy current system, as these factors could influence the system performance.



Experience has shown that consistency of these electrical and magnetic properties cannot be relied upon from column to column, even among columns that are from the same manufacturing batch.

Fortunately, we can isolate these differences in material properties by comparing a known, sound section of steel and the below ground unknown section.

Image of defects located using ColcheK™ technology

Lighting columns historically corrode mostly at, and immediately below, ground level.

Only rarely is the column seriously corroded at the above ground level, and in any case this area is easy to inspect visually.

The good state of the column at about 100mm up, can be visually checked externally and then internally once the access door is open.

Image of defects located using ColcheK™ technology

At worst, the operator can tell if the column is acceptable or not at this point.

The ColcheK2™ compares the wall thickness of the column further down with the wall thickness at this 100mm level.

This ensures that the readings are accurate for the column being inspected and do not depend on any assumptions as to the grade, or the state of quality or material of the column.

Image of defects located using ColcheK™ technology

The equipment is zeroed with the detector coil at the 100mm level, opposite the top part of the drive coil system.

Once set for the column being inspected, the detector coil gives direct readings of percentage of wall loss, if any, at any location further down the column to 750mm below ground level without the need for excavation.

Image of defects located using ColcheK™ technology

Performance trials

This section lists some of the trials made of the ColcheK2™ system to establish its reliability and reproducibility in the measurement of wall loss.

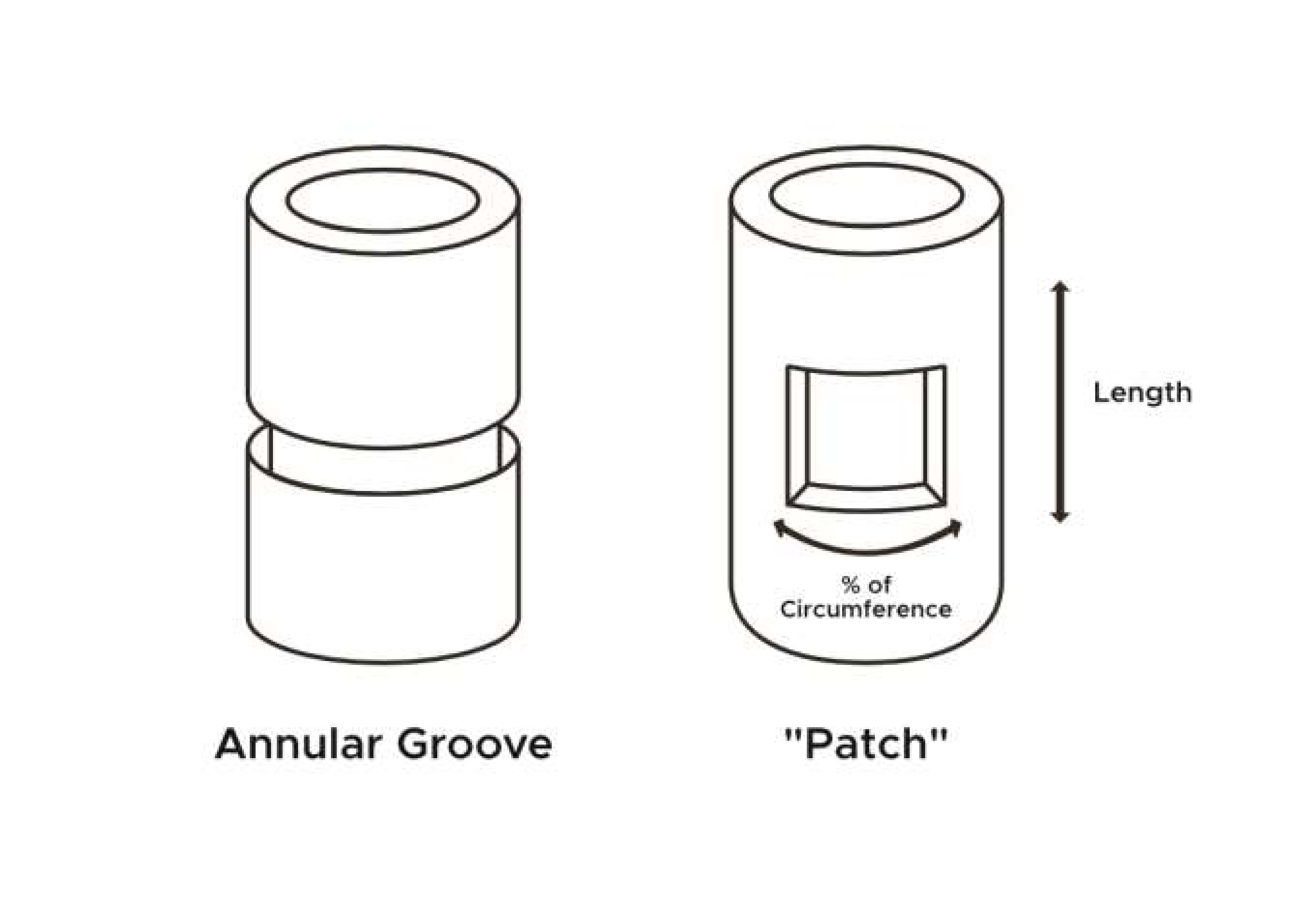
Naturally corroded samples are notoriously difficult to assess for wall loss because the corrosion is never of uniform depth. It is usually in the form of large, overlapping pits, each of different depth.

For this reason, the tests detailed here have been made on machined samples of carbon steel pipe.

Various diameters and thicknesses have been used and various machining techniques.

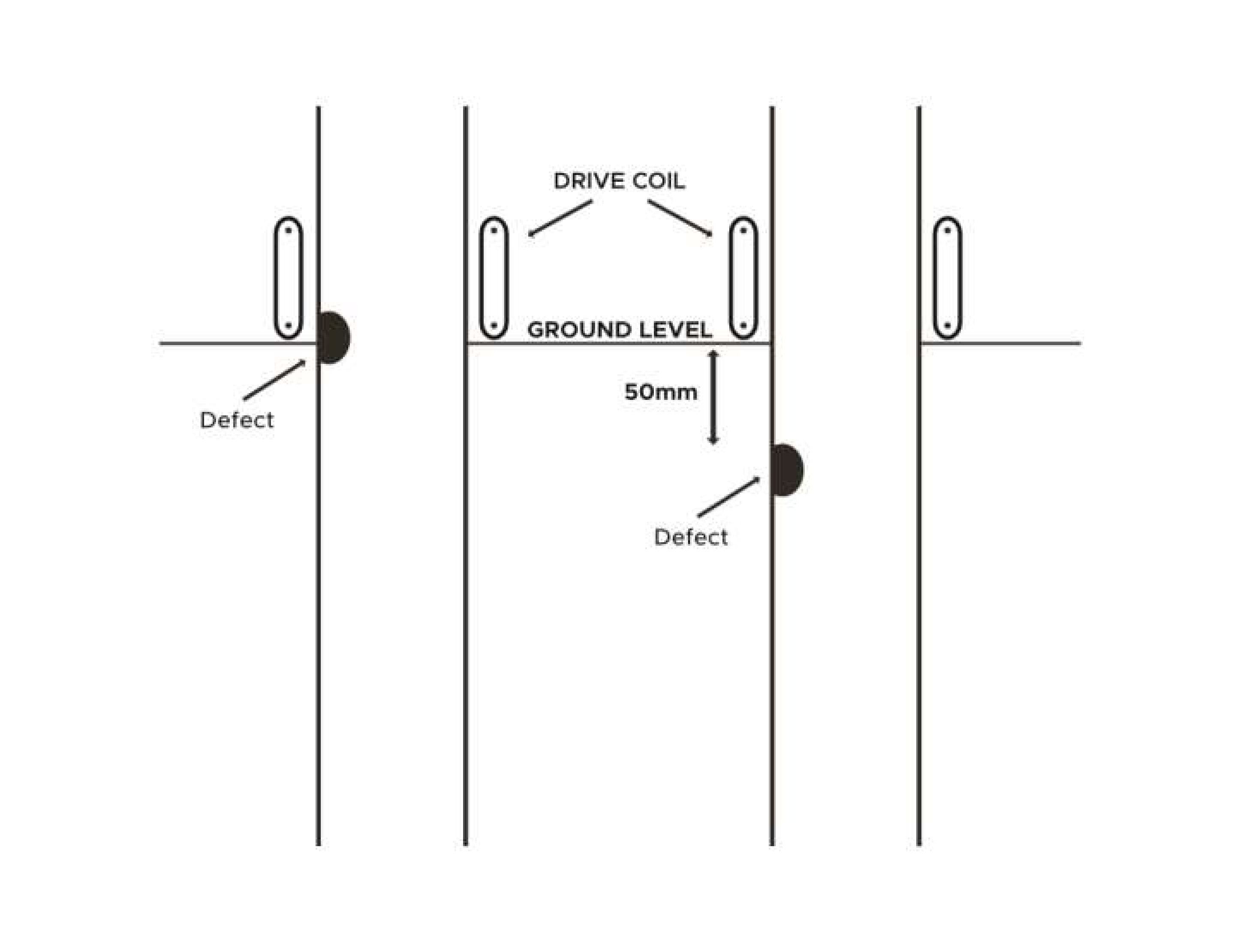
The initial wall thickness and the wall loss have been measured mechanically with Vernier callipers and micrometer depth gauges.

They have also been measured by an ultrasonic thickness gauge and with the ColcheK2™.



This allows us to compare simple mechanical measurement, a conventional ultrasonic measurement and the ColcheK2™.

Two situations have been investigated, one with the ‘defect’ centred at ground level, the other with the top of the ‘defect’ 50mm below ground level.



There are three widely differing diameters of pipe in the results **Table 1** opposite.

All were measured with the same ColcheK2™ unit, no changes in drive or detector coils were made and no adjustments (other than the usual set zero adjustment at the start of each measurement sequence.)

PIPE DIAMETER (mm)	WALL THICKNESS (mm)		DEFECT			% WALL LOSS		
	Mech	U.T.	Type Annular or Patch	Length along pipe (mm)	Width % of Circum.	Mechanical Measure	Ultrasonic Measure	ColcheK
195	6.1	5.85	A	75	100	13	12	16
195	6.1	5.85	A	75	100	37	34	40
195	6.1	5.85	A	75	100	51	48	50
195	6.1	5.85	A	75	100	56	57	60
195	6.1	5.85	A	75	100	75	71	85
195	6.1	5.85	A	25	100	51	51	57
195	6.1	5.85	A	125	100	48	44	57
195	6.1	5.9	A	200	100	50	49	55
195	6.1	5.85	P	75	25	56	57	52
195	6.1	5.8	P	75	50	52	53	55
195	6.1	5.9	P	75	75	53	56	58
170	4.6	4.4	P	70	15	50	40	50
60.5	5.6	5.6	A	30	100	56	53	60
60.5	5.5	5.7	A	30	100	27	25	25
60.5	5.7	5.8	P	30	25	85	64	95

Table 1

Comparing the wall loss readings in the three right-hand columns, the general tendency is for the ColcheK2™ readings to be slightly higher than the mechanical measurement and for the ultrasonic thickness gauge reading to be slightly lower than the mechanical measurement.

Note also that the ultrasonic measure of the full wall thickness in the 195mm pipes is 4% lower than the mechanical measurement.

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195	6.1	5.85	P	75	25	56	57	52
195	6.1	5.8	P	75	50	52	53	55
195	6.1	5.9	P	75	75	53	56	58
170	4.6	4.4	P	70	15	50	40	50
60.5	5.6	5.6	A	30	100	56	53	60
60.5	5.5	5.7	A	30	100	27	25	25
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Table 1

The only major discrepancies occur when the wall loss is very large; 75% mechanical in the 195mm pipe and 85% mechanical in the 60.5mm pipe.

ColcheK2™ reads high by a greater margin than when the wall loss is less.

The significant under reading by the ultrasonic gauge in the 60.5mm pipe is probably caused by the very poor surface condition of the sample; a common occurrence in real life inspections of steel lighting columns.

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Table 1

In all the measurements the defect was half above and half below ground level.

With the 75% and 85% defects, their presence appeared to adversely affect the eddy current pattern induced by the drive coil.

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Table 1

The defect was entirely, but only just, below ground level.

As soon as the drive coil was raised so that the large defect was outside the drive coil, the ColcheK2™ readings dropped to much nearer the mechanical measurements; 80% for the 195mm pipe and 90% for the 60.5mm pipe.

The mechanical and ultrasonic wall loss readings for **Table 2** are the same as in **Table 1** and the previously discussed comments apply.

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195	6.1	5.9	P	75	25	56	57	52
195	6.1	5.85	P	75	50	52	53	52
195	6.1	5.9	P	75	75	53	56	54
170	4.6	4.4	P	70	15	50	40	47

Table 2

The ColcheK2™ readings are more consistent with the mechanical measurements and slightly lower when the defect is at ground level.

This observation is consistent with the presence of the defect within the drive coil having some influence on the eddy current pattern; an effect most markedly experienced with the 75% and 85% defects at ground level and commented on previously.

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170	4.6	4.4	P	70	15	50	40	47

Table 2

Reproducibility of readings

The mechanical measurement of wall loss was made using Vernier callipers for diameter and full wall thickness, and a micrometer depth gauge for the amount of metal removed.

The full wall thickness measurements had to be made at the ends of the pipe, some 600mm from the machined area. As it was ERW pipe made from rolled sheet material, the readings should have been representative of the full wall thickness before machining.

When several readings of the full wall thickness and metal removed were taken on the same pipe, reproducibility was ±0.1mm.

The implication is that the mechanical measurement of wall loss is to about ±3%, dependant somewhat on the depth of the defect.

Ultrasonic thickness gauge measurements were made with a standard gauge with current calibration certificate.

The unit had not been specifically calibrated for the grade of carbon steel in the pipes.

This would not be important as the wall loss was deduced from a ratio of recorded remaining wall thickness at the defect to the recorded full wall thickness nearby; both readings were taken from the same gauge.

Reproducibility of readings appeared to be about ±0.1mm, similar to the mechanical readings with the wall loss to about ±3%.

The ColcheK2™ has to be set to zero at the start of each set of measurements in a given pipe.

The reproducibility depends on the alignment and location of the detector coil relative to the top of the drive coil.

With reasonable care this can easily be to ±2% of deflection.

The principal causes of error are:

- detector coil not opposite top drive coil
- detector coil well away from pipe wall instead of close or in contact
- detector coil tilted relative to the axis of the pipe (i.e. wand not straight in the pipe)

In all cases, the set zero is not especially sensitive to errors in position.

The same type of location and alignment errors can also occur at the site of the defect but, as the defect is “searched for” by moving the detector coil until the defect is “found”, the potential errors are probably less than in the set zero.

Overall, ColcheK2™ will read the loss to better than ±4% on the scale reading.

Surface condition and shape

The following comments are based on the physical principles behind the operation of ColcheK2™ and also practical experience gained during the four years of development trials in the UK.

The operating system of the ColcheK2™ does not require any form of contact with the surface of the column, either inside or outside.

Protective paint coatings, dirt or rust which would affect or prevent contact with the metal are of no consequence and do not have to be removed.

Unlike some eddy current systems, lift-off from the surface of the metal, unless it becomes excessive (50mm), does not affect the readings so the thickness of any protective coating is unimportant.

If the column is galvanised, the thin layer of zinc has no effect on the readings due to its electrical and magnetic properties being significantly different from those of steel and it is relatively much thinner than the steel.

Most columns are circular, occasionally hexagonal or octagonal.

ColcheK2™ has been used on non-circular columns.

It detected corrosion equally well in all shapes and the calibration appeared to be sufficiently similar to make special calibration unnecessary.

Most columns are fabricated from longitudinally welded pipe.

If the weld is cracked or there is complete lack of fusion over more than 10mm, ColcheK2™ will respond to the defect and indicate loss of metal.

The size of the indication will depend on the length of the weld defect.

If ColcheK2™ indicates corrosion loss in a column that appears not to be corroded, check the state of the welding.

Conclusion

- To date, there is no clear knowledge of the degree of damage that will make a lighting column unsafe.
- There appears to be a general acceptance that defects over 50% wall loss and extending some distance round the column are unacceptable.
- Except for the problems noted previously with very severe defects (75% and more) at ground level, the ColcheK2™ readings are consistent with the other techniques to at least the accuracy required to assess the condition of lighting columns.
- With very severe defects, ColcheK2™ would appear to somewhat overestimate the wall loss; meaning there is no danger that an unsafe column will be passed as safe because a defect has been underestimated.