

NON CONTACT MAGNETIC TOMOGRAPHY



PIPELINE SURVEY

Work from the ground surface

Detects and measures levels of stress

Defines features causing stress

Detects all metal defects in all orientations in a single pass

Detects defective insulation

Correlates the magnitude of stress raisers with operating pressure and defines the degree of danger

Principle features of MTM Magnetic Tomography Surveys

- **No interruption to the pipeline operation**
- **No minimum or maximum operating pressure required**
- **No need for special pipeline equipment or preparation**
- **No contact with or change to mode of the pipeline**



- **No limit to length of pipeline inspected**
- **Identifies all metal defects irrespective of orientation**
- **Identifies defective insulation coatings**
- **Suitable for all ferromagnetic pipelines including tight turns and small diameters**
- **Lower cost and more accurate than traditional survey methods**

Improve Efficiency with MTM

Magnetic tomography charts the attributes and characteristics of pipe sections by registering and analysing changes in the magnetic field of the pipeline. These changes are related to stress which in turn are related to defects in the metal and insulation.

Magnetic data is collected from the ground surface and anomalies detected are a function of stress, mechanical loading and structural changes in the metal. Magnetic tomography does not measure the dimensions of geometric defects alone but instead it measures the stress caused by these defects and identifies their character, location and orientation in accordance with the location and orientation of the area of stress. Linear and angular coordinates of flaws in the metal and coating are defined within a tolerance of $\pm 0,25m$



Measure Stress Not Geometry.

MTM determines the comparative degree of danger of defects by a direct quantitative assessment of the stress-deformed condition of the metal. Conventional surveys only measure the geometrical parameters of a defect. Their subsequent calculations to assess the impact of the defect on the safe operation of the pipe do not take into consideration the stress caused by the defect. Therefore conventional surveys may fail to detect dangerously stressed areas of the pipe or, conversely, classify a defect as one which requires urgent attention when, in reality, the stress level may be

low and the defect presents no immediate threat to the operation of the pipe. Since MTM directly measures the stress caused by defects it is an inherently more accurate guide to the safe operation of the pipeline than conventional survey methods.

Monitor Defect Growth

Because MTM allows any section of any length of a pipeline to be surveyed while the pipe remains in operation it can be used to monitor the evolution of defects and the increase in stress caused by such growth. These measurements may be taken at any interval of time and can be compiled into a database. Excavation and repair with its subsequent disruption to service is therefore more easily controlled and maintenance can be planned with confidence at convenient times.

Reduce Unnecessary Excavations

MTM is inherently more accurate than in line pig surveys both in its ability to determine the nature of a defect and in defining its position. Consequently the number of unnecessary excavations caused by spurious data and inaccurate positioning of detected defects are considerably reduced compared with in line PIG surveys.



Reduce Reporting Timescale

Preliminary reports identifying the position and degree of danger of defects located in the pipe is usually presented within three days of the magnetic data survey. Immediate remedial attention can therefore be applied to pipe sections if necessary.

Predict Deterioration

The final report includes a corrosion forecast and an assessment of the stress-deformed condition level.

Reduce Costs with MTM

Operational costs of MTM are considerably lower than in line inspection costs. Therefore not only are MTM surveys more accurate but they also cost significantly less than in line surveys. With MTM there is

- No need to equip the pipeline with a pig launch or trap,
- No need for a pipeline cleanout
- No need for inner surface preparation,
- No need to open a section of pipeline to recover a trapped Pig

and therefore

NO LOST PRODUCTION.

Improve Accuracy

Considerable savings are made from the greater accuracy of MTM defect definition and location. For example consider the following data which has been taken from a recent case study where a total of 6.6km of pipelines varying in diameter from 219 – 720mm were surveyed by both MTM and in line methods

| | Stage of works | PIG \$USk | MTM \$USk |
|---|--|-----------|-----------|
| 1 | Excavation (15 pits, 3m long and 2m deep) | 75.85 | 10.1 |
| 2 | Insulation coating repair following additional NDT | 61.94 | 8.25 |
| 3 | Highway repairs following excavation | 26.49 | 3.53 |
| 4 | Total direct expenses | 164.28 | 21.88 |

This table shows the costs of unnecessary excavations, repairs to insulation damaged during confirmatory NDT and making good to damaged road surfaces - all incurred because of false indications reported by the in line survey. The costs of MTM were incurred by verification works which subsequently confirmed that the MTM report was correct. In this example, then, the use of MTM would have saved US\$142.4k in unnecessary works. The cost of such works vary in different locations but the proportionate increase in costs incurred by the lower accuracy of in line surveys serves as a useful guide to the savings that can be made by using MTM. And this does not include the lower cost of the survey itself.



Detect Pipeline Defects with MTM

Geometrical (corrugations, dents, ovality)

Corrosive structural and mechanical changes

Metal loss (defines internal and external corrosion)

Discontinuities (delamination, non-metallic inclusions)

Crack-like defects (linear defects in all orientations)

Stress corrosion cracks

Weld defects

Stress deformation caused by sag, flexure, landslip

Defective insulation

Technical Data

| | |
|-------------------------------|--|
| Magnetometer dimensions | 200mm x 200mm x 750mm |
| Connection to an IBM PC | via RS232 interface |
| Casing protection category | IP-66 |
| Weight | 4.5kg |
| Power supply | PS1212 storage batteries or similar. 9 - 24 V DC external source |
| Continuous operating duration | > 8 hrs |

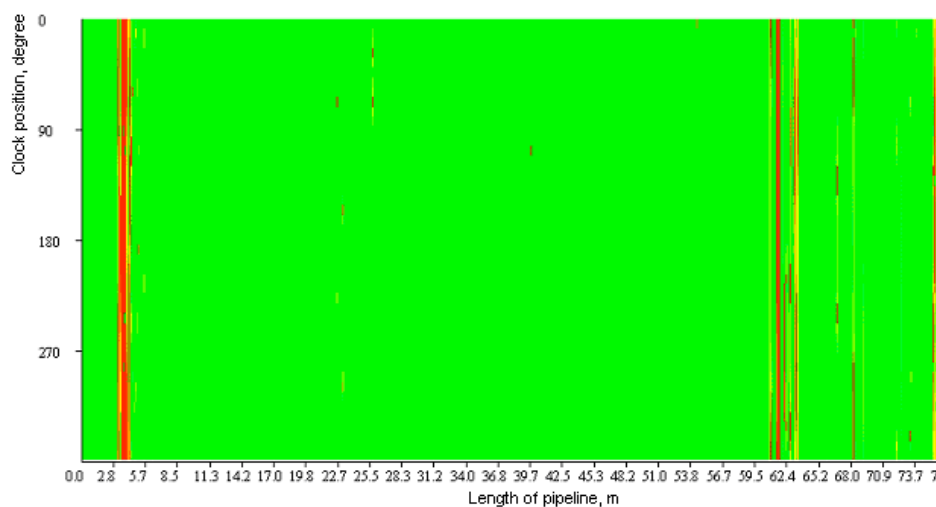
| | |
|------------------------------------|---|
| Detectable metal flaws | <p>Crack-like defects in any orientation (laps, scabs, scratches, cracking and exfoliation)</p> <p>Stress corrosion</p> <p>Weld defects (laps, pores, cracks, lack of fusion, lack of penetration, displacement, metal flakes, residual thermal stress within the heat affected zone)</p> <p>Compression marks, corrugations, scores, out of roundness and changes in wall thickness caused by corrosion pits and filiform corrosion</p> <p>Loss of metal – including internal and external corrosion defects of any nature</p> <p>Delamination</p> <p>Sections with deviations of a level of stress deformed conditions caused by, sagging, landslip, washouts or transitions under roads.</p> <p>Local corrosion under scaled insulating coating</p> <p>Indents and buckles</p> <p>Deviation from the specified laying axis</p> |
| Minimum length of detectable flaws | > 10mm |
| Opening of detectable flaws | 300 microns |
| Depth of detectable flaws | > 5% of the pipe wall thickness |
| Measurement tolerance | <p>< 20% of crack length</p> <p>< 30% of surface crack depth</p> <p>< 25% of wall thickness loss</p> |
| Features of surface examined | Flaw detection and cross-section metal loss for any ferro-magnetic underground or subaqueous pipe with any type of insulation provided it has operated under pressure |

| | |
|-----------------------------|--|
| Detection rate | Up to 2m/sec |
| Distance from pipe | 15 pipe diameters maximum depending upon operating pressure |
| Data logging | Initial data is fed to the display and recorded in memory at 0,25m intervals. Instrument memory span is sufficient to continuously record data over a 30km stretch of pipeline |
| Initial data processing | On line |
| Operating temperature range | -25 - +45 deg C |
| Pipe diameter range | 56mm - 1420mm |
| Pipe wall thickness range | 2.8mm - 22mm |

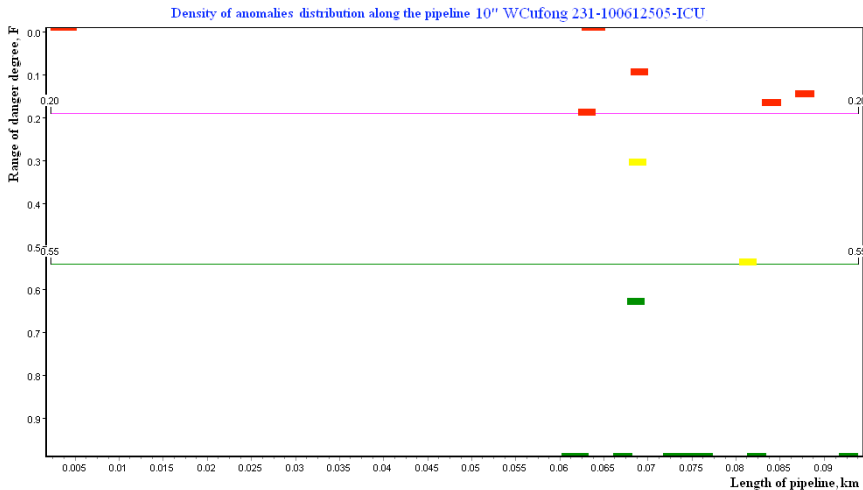
DIAGRAM OF MAGNETIC TOMOGRAPHY RESULTS
(Stress concentration distribution along the pipeline)

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Magnetic field strength data is collected by the magnetometer and fed into a patented tomographic reconstruction software algorithm. The chart shows the distribution of stress concentration and degree of danger along a section of pipeline taken from detected anomalies in its magnetic field.



The second shows how this information can be represented to show the density of anomalies (and therefore defects) in the axial plane and a more quantified representation of the degree of danger (ref y axis). Note that F (y axis) is an integral index of the degree



of hazard that takes into account the extent of magnetic anomalies, their amplitude and the shape of the distribution of magnetic intensity vectors over background values.

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