TRANSKOR 川斯科

NON CONTACT MAGNETIC TOMOGRAPHY

无接触式磁力层析X射线摄影技术

PIPELINE SURVEY

管道探测

Work from the ground surface	地面工作
Detects and measures levels of stress	探测并测量应力水平
Defines features causing stress	确定应力源
Detects all metal defects in all orientations in a single pass	一次性全方位探测所有金属缺陷
Detects defective insulation	探测保护层缺陷

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

寻找应力起源幅度与工作压力的相互关系并确定危险程度

Principle features of MTM Magnetic Tomography Surveys
磁力层析X射线摄影技术的关键特性

- **No interruption to the pipeline operation**

  不影响管道工作

- **No minimum or maximum operating pressure required**

  不要求最低或最高工作压力

- **No need for special pipeline equipment or preparation**

  不需要专用管道设备或准备工作

- **No contact with or change to mode of the pipeline**

  无须接触或改变为管道状态

- **No limit to length of pipeline inspected**

  对待检管道没有长度要求

- **Identifies all metal defects irrespective of orientation**

  可确定任何方向的所有金属缺陷

- **Identifies defective insulation coatings**

  可确定保护层故障

- **Suitable for all ferromagnetic pipelines including tight turns and small diameters**

  适用于铁磁性管道，包括弯管和小直径管道

- **Lower cost and more accurate than traditional survey methods**

  比传统探测法的成本更低， 精度更高

Improve Efficiency with MTM
使用磁力层析X射线摄影法提高效率

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.

磁力层析X射线摄影法通过记录并分析管道磁场的变化绘制出管道截面的特性和特征图表。这些变化是随金属和保护层故障产生的应力而变化。

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 +/-0,25m

从地面和探测的异常信息中收集的数据是金属结构变化、机械载荷、应力之间的一个函数。磁力层析X射线摄影法不是测量缺陷的几何尺寸， 而是依据应力面积的位置和方向测量这些缺陷造成的应力的大小、确定其特性、位置、方向。可在+/-0.25M的公差范围内确定金属及其保护层上的裂纹的线形及角度坐标。

Measure Stress Not Geometry. 测量应力而不是几何形状

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.

磁力层析X射线摄影法可以通过对金属产生的应力变形状态进行直接定量评定以确定缺陷造成的相应的危险程度。常规的探测法只测量缺陷的几何参数。而且随后进行的计算， 用于评定缺陷对管道安全操作的影响， 并没有考虑缺陷造成的应力。 所以，常规探测法有可能测不出管道的危险应力区，反而，可能会把近期不会对管道造成危险的缺陷确定为需要立即处理的缺陷。由于磁力层析X射线摄影法是直接测量缺陷应力， 所以对管道的安全使用来说， 比常规的探测法能提供更为精确的指导信息。

Monitor Defect Growth 监控缺陷的发展

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.

磁力层析X射线摄影法不受被测管道长度和截面的影响，而且可在管道正常工作状态下进行探测。所以， 此方法可以用来监控缺陷的发展以及由于发展而产生的应力增加。对缺陷进行间断测量， 并将结果录入数据库。便于以后对要进行的挖掘和修理以及因此而要求的服务中断进行有力的控制。有把握的将维护工作排列在最方便的时间段。

Reduce Unnecessary Excavations

减少不必要的挖掘

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.

无论是确定缺陷性质还是测定缺陷位置，磁力层析X射线摄影法要比常规（in line pig ）探测法精确很多。而且能大大减少因错误数据和不精确的缺陷位置导致的不必要的挖掘次数。

Reduce Reporting Timescale 减少报告时间段

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.

一般在磁力数据探测后三天内便可出具标明管道缺陷位置和危险程度的初始报告， 所以，可以当即关注需要修补的管道截面。

Predict Deterioration 预测衰变

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

最终报告还包括一个腐蚀预测和应力变形状态。

Reduce Costs with MTM 降低成本

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
使用磁力层析X射线摄影法的成本大大低于常规检验成本。所以说，和常规探测法比较使用磁力层析X射线摄法具有精度高、成本低的优势。
使用磁力层析X射线摄影法

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.

无须为管道配备铸铁发送器或收集器
无须清理管道
无须对管道内表面进行准备工作
无须打开管道截面回收铸铁块

因而也不影响生产

Improve Accuracy 提高精度

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

磁力层析X射线摄影法对缺陷的精密测定和精确定位， 可以大大节省开支。 例如，最近通过用磁力层析X射线摄影法和管内探测法同时对长度为6.6公里， 直径从219mm-720mm的管道进行探测，得出下列数据：

	Stage of works 阶段工作	PIG $USk 管内探测	MTM $USk
1	Excavation (15 pits, 3m long and 2m deep) 挖掘（15个坑，3米长， 2米深	75.85	10.1
2	Insulation coating repair following additional NDT 附加的无损探伤之后进行保护层修复	61.94	8.25
3	Highway repairs following excavation 挖掘后的道路修复	26.49	3.53
4	Total direct expenses 直接费用总计	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.

上述表格表明， 由于管内探测的误报信息，导致了不必要的挖掘、修复因进行无损探伤而破坏的保护层及被破坏的路面。这些工作都产生了不必要的费用。而使用磁力层析X射线摄影法所产生的费用是校准， 验证工作的费用，而且随后证明磁力层析X射线摄影法报告是准确的。在上述事例中， 仅使用磁力层析X射线摄影法一项就节省了$142,400美圆。这种工作成本因位置不同而变化。 尽管如此，由于管内探测精度低而导致成本增长的比例，便可以说明使用磁力层析X射线摄影法能够节省的成本。还不包括磁力层析X射线摄影法本身就是低成本这一优势。

Detect Pipeline Defects with MTM

使用磁力层析X射线摄影法能够测出的管道缺陷

Geometrical (corrugations, dents, ovality) 几何形状（波纹，压坑，椭圆形）

Corrosive structural and mechanical changes 腐蚀结构与机械变化

Metal loss (defines internal and external corrosion) 金属损失（确定内部和外部腐蚀）

Discontinuities (delamination, non-metallic inclusions) 断续性（脱层，非金属夹杂）

Crack-like defects (linear defects in all orientations 裂纹式缺陷（任何方向的线性缺陷）

Stress corrosion cracks 应力腐蚀裂纹

Weld defects 焊接缺陷

Stress deformation caused by sag, flexure, landslip 由于下沉、翘曲、滑坡造成的应力变形

Defective insulation 保护层故障

Technical Data

技术数据

Magnetometer dimensions 磁力计规格	200 x 200 x 750
Connection to an IBM PC 连接到IBM计算机上	via RS232 interface 用RS232接口
Casing protection category 壳体种类	IP-66
Weight 重量	4.5kg 4.5 公斤
Power supply 电源	PS1212 storage batteries or similar. 9 - 24 V DC external source PS1212或同等蓄电池。9-24V　直流电源

Continuous operating duration 连续工作时间	> 8 hrs ＞8小时
Detectable metal flaws 可检测的金属裂纹	Crack-like defects in any orientation (laps, scabs, scratches, cracking and exfoliation) 任何方向的裂纹缺陷（叠层、疤痕、划伤、裂纹及剥落） Stress corrosion 应力腐蚀 Weld defects (laps, pores, cracks, lack of fusion, lack of penetration, displacement, metal flakes, residual thermal stress within the heat affected zone) 焊接缺陷（叠层、孔隙、未熔透、未焊透、错位、金属脱层、热影响区的残余热应力） Compression marks, corrugations, scores, out of roundness and changes in wall thickness caused by corrosion pits and filiform corrosion 压缩印痕、波纹、划伤、因腐蚀坑和纤维状腐蚀引起的壁厚变化和不圆度。 Loss of metal – including internal and external corrosion defects of any nature 金属损失包括任何性质的内、外部腐蚀缺陷 Delamination 脱层 Sections with deviations of a level of stress deformed conditions caused by, sagging, landslip, washouts or transitions under roads. 由于下沉、滑坡、道路的变迁和冲溃导致管道截面因应力变形而产生的偏移。 Local corrosion under scaled insulating coating 保护层下的局部腐蚀 Indents and buckles 刻痕与翘区

	Deviation from the specified laying axis 偏离规定的轴线
Minimum length of detectable flaws 可探测的最小缺陷长度	> 10mm
Opening of detectable flaws 可测缺陷开口	300 microns 300微米
Depth of detectable flaws 可测缺陷深度	> 5% of the pipe wall thickness ＞5%管壁厚度
Measurement tolerance 测量公差	< 20% of crack length ＜20%裂纹长度 < 30% of surface crack depth ＜30%表面裂纹深度度 < 25% of wall thickness loss ＜25%壁厚损失
Features of surface examined 所检表面特性	Flaw detection and cross-section metal loss for any ferro-magnetic underground or subaqueous pipe with any type of insu lation provided it has operated under pressure 在压力下工作、带有任何保护形式的地下或水下铁磁管道的裂纹探测和横截面金属损失
Detection rate 探测速率	Up to 2m/sec 2米/秒以上
Distance from pipe 距管道距离	15 pipe diameters maximum depending upon operating pressure 因工作压力而异，一般最大为管道直径的15倍
Data logging 数据记录	Initial data is fed to the display and re corded in memory at 0,25m intervals. In strument memory span is sufficient to con tinuously record data over a 30km stretch of pipeline 原始数据输入显示器，以0.25米的间隔录入到存储器。仪器存储器的容量足以纪录30公里管道的数据。
Initial data processing 原始数据的处理	On line 在线处理

Operating temperature range 工作温度范围	-25 - +45 deg C −25−− +45摄氏度
Pipe diameter range 管道直径范围	56mm - 1420mm 56毫米—1420毫米
Pipe wall thickness range 管道壁厚范围	2.8mm - 22mm 2.8毫米—22米

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

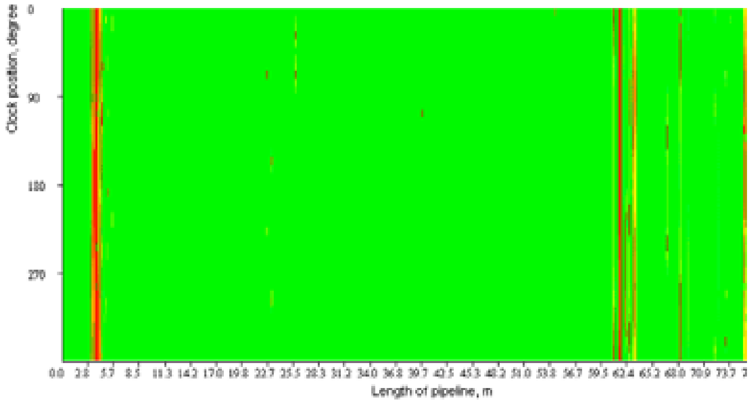

DIAGRAM OF MAGNETIC TOMOGRAPHY RESULTS
(Stress concentration distribution along the pipeline)

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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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