Magnetic Flux Leakage Nondestructive Testing System and Services
Contents

- Theory of Magnetic Flux Leakage Testing
- MFL Testing System Products Introduction
- Industry Applications and Services Provided
Magnetic Flux Leakage Nondestructive Testing Technology

- Magnetic Flux Leakage Testing (MFLT)

The basic principle is that a powerful magnet is used to magnetize the steel. At areas where there is corrosion or missing metal, the magnetic field "leaks" from the steel. In an MFL tool, a magnetic detector is placed between the poles of the magnet to detect the leakage field. Analysts interpret the chart recording of the leakage field to identify damaged areas and hopefully to estimate the depth of metal loss.
Magnetic Flux Leakage Nondestructive Testing System:

Powerful magnetic flux leakage tools saturate a ferromagnetic pipe wall with magnetic flux longitudinally and transversely. In the areas where defects are on inner and outer surfaces or inside of the wall, the magnetic flux “leaks” from these places. Applying the magnetizing filed in both directions (orthogonal to each other) can form the leakage flux of the defects at both axial and circumferential directions. The leakage flux is powerful enough to be measured by magnetism sensitive sensors accurately, these defects will be detected.
Magnetic Flux Leakage Intensity of Different Shape Defects Collation Map:

<table>
<thead>
<tr>
<th>Defect Shape</th>
<th>Axial Magnetic Field</th>
<th>MFL Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>strongest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>stronger</td>
</tr>
<tr>
<td></td>
<td></td>
<td>strong</td>
</tr>
<tr>
<td></td>
<td></td>
<td>weak</td>
</tr>
<tr>
<td></td>
<td></td>
<td>none</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Defect Shape</th>
<th>Circumferential Magnetic Field</th>
<th>MFL Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>none</td>
</tr>
<tr>
<td></td>
<td></td>
<td>weak</td>
</tr>
<tr>
<td></td>
<td></td>
<td>strong</td>
</tr>
<tr>
<td></td>
<td></td>
<td>stronger</td>
</tr>
<tr>
<td></td>
<td></td>
<td>strongest</td>
</tr>
</tbody>
</table>

Conclusion: All kinds of defects can be reliably detected when applying the magnetizing field in both directions (orthogonal to each other).
Important Characteristics of High Speed Magnetic Flux Leakage Testing System

Characteristic 1
- Defects conversion
- Magnetic leakage field
- High speed testing

Characteristic 2
- Material inside and outside
- Various defects
- Can be detected

Characteristic 3
- Ferromagnetic pipeline
- All directions
- Full coverage detection
5 Conventional NDT Technologies:

Ultrasonic Testing（UT）;
Radiographic Testing（RT）;
Magnetic Particle Testing（MT）;
Penetrant Testing（PT）;
Eddy Current Testing（ET）;
Disadvantages of Conventional NDT Methods on Steel Pipe Testing

Challenges of Conventional NDT methods:

- **Ultrasonic Method**: Influenced by surface, Need sound coupling liquid
- **Eddy Current Method**: Invalid to wall inner surface defect, Invalid to large diameter tube
- **Magnetic Particle Method**: Low speed, Slow distinguish
- **RT Method**: Low speed, Strict Protection
Comparison Between Magnetic Flux Leakage Testing and Conventional NDT Methods

Comparison with conventional NDT methods:

<table>
<thead>
<tr>
<th>Testing method</th>
<th>Testing diameter</th>
<th>Defect type</th>
<th>Testing speed</th>
<th>Testing Precision</th>
<th>Testing condition</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydrostatic testing</td>
<td>&lt;220mm</td>
<td>Penetrate defects</td>
<td>0.5 m/min</td>
<td>bad</td>
<td>Fixed, sealing</td>
<td>Serious Omission</td>
</tr>
<tr>
<td>ultrasonic testing</td>
<td>&lt;220mm</td>
<td>Longitudinal defects</td>
<td>8 m/min</td>
<td>d1.6</td>
<td>Clean, smooth</td>
<td>Omission</td>
</tr>
<tr>
<td>eddy current testing</td>
<td>&lt;180mm</td>
<td>Surface defects</td>
<td>20 m/min</td>
<td>d1.6</td>
<td>Clean</td>
<td>Omission</td>
</tr>
<tr>
<td>radiographic testing</td>
<td>Work piece short</td>
<td>Broad defects</td>
<td>0.1 m/min</td>
<td>d3.2</td>
<td>High protection</td>
<td>Omission</td>
</tr>
<tr>
<td>MFL testing</td>
<td>60–508mm</td>
<td>All kinds of defects</td>
<td>100 m/min</td>
<td>d1.6</td>
<td>No requirement</td>
<td>Most reliable</td>
</tr>
</tbody>
</table>

The MFL testing system has high speed, wide range, stable, reliable and other important characteristics.
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- Theory of Magnetic Flux Leakage Testing
- MFL Testing System Products Introduction
- Industry Applications and Services Provided
High Speed Steel Pipe MFL NDT and Thickness Measurement System
High Speed MFL Nondestructive Testing System

High Speed Steel Pipe MFL Testing System
Testing Results and File Query
Test Methods of Performance Characteristics of Automatic Magnetic Flux Leakage Testing Systems

1. Normative reference
2. Terms and definitions
3. Test conditions
4. Other Test conditions
5. Comparison samples
6. Specification of comparison samples
7. Treatment of comparison samples
8. SNR (Signal to Noise Ratio) of comparison samples
9. Manual defects of comparison samples
10. Test contents and methods
11. Tangential sensitivity uniformity test
12. SNR test
13. Inner and outer surface defects detection sensitivity deviation test
14. False and missing alarm rate test
15. System stability test
16. Maximum remnant magnetic field test
Significant Features of
High Speed Steel Pipe MFL Testing System

- **Modular design**
  System uses modular design. Easy for installation, operation, calibration and maintenance.

- **Rotary circumferential magnetizing and testing technology**
  In the process of a steel tube go through rotary circumferential magnetizing area, is drove by several clip and positioning servo unit and magnetized section by section. Two groups probe at the orthogonal position of the magnetic pole are rotating around steel tube together with the magnetic yoke. If there is a defect in the tube, leakage magnetic field will be formed in the outer surface of tube, detected by rotating probe, forming defects signals with low noise and high sensitivity.

- **No sparkle high current ring transmission technology**
  Contact parts adopt carbon fiber compound materials. Reliable operation, almost never wear.
# Magnetic Flux Leakage Testing Steel Pipe Specification table (samples)

<table>
<thead>
<tr>
<th>Number</th>
<th>Steel Pipe Type</th>
<th>Steel Pipe Specifications</th>
<th>Steel Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Diameter (mm)</td>
<td>Thickness (mm)</td>
</tr>
<tr>
<td>1</td>
<td>Oil casing pipe</td>
<td>60～508</td>
<td>6.2～22.22</td>
</tr>
<tr>
<td>2</td>
<td>Casing collar</td>
<td>60～508</td>
<td>15～30</td>
</tr>
<tr>
<td>3</td>
<td>Pipeline pipe body</td>
<td>60～508</td>
<td>6.6～31.8</td>
</tr>
<tr>
<td>4</td>
<td>Seamless steel tube for high pressure boiler</td>
<td>140～508</td>
<td>6～34</td>
</tr>
<tr>
<td>5</td>
<td>Seamless steel tube for low &amp; medium pressure boiler</td>
<td>140～508</td>
<td>6～30</td>
</tr>
</tbody>
</table>
Performance of High Speed Magnetic Flux Leakage Testing System

- The best test speed of testing system is 50-60 m/min.
- Steel pipe diameter range $40 \leq d \leq 610$ mm
- Average testing pipe number/hour. 100-120 pcs

Status of steel pipe before testing

1. Maximum curvature: pipe head $\leq 1.5$mm/1000mm;
   pipe body $\leq 2$mm/1000mm; full pipe body $\leq 80$mm
2. Maximum weight of single steel pipe: 2520kg;
3. Steel pipe temperature: $\leq 100^\circ$C
Technical Indicators of High Speed Magnetic Flux Leakage Testing System

- **Overall:** Meet with the national standard GB/T12606-1999 and GB/T25757-2010

1) **Pipe Diameter:** 40～610mm;

2) **Thickness:** 4.0～30.0mm;

3) **Length:** 6.0～18.0m;

4) **Max Sensitivity:** d1.6 hole and N5 notch, 50×（0.25～1）×5%;

5) **Speed:** （50～60）m/min ;

6) **Defect Types:** Inner and outer surface and inside wall

7) **Defect Sample Detection Rate:** 100%;

8) **Sample Detection Missing Rate:** 0.0%;
Technical Indicators of Magnetic Flux Leakage High-Speed Testing System

9) Sample False Alarm rate: \( \leq 0.5\% \);
10) Testing Display Modes: Computer graphics display testing process;
11) Defect marking Accuracy: \( \pm 20\text{mm} \);
12) Sorting: Correctly sort qualified and unqualified steel pipe;
13) Stability: 3dB /2h;
14) Tangential Sensitivity Uniformity: Steel pipe go along the circumference direction defects testing \(<3\text{dB};\)
15) Defects Spray Labeling Device: Set up defects spray labeling device in longitudinal and lateral direction respectively;
16) Testing Result Filing Mode: save graphics files for test result;
Acceptance Standard and Basis of MFL Testing System

- A. National standard GB/T12606-1999 magnetic flux leakage detection method of steel pipe;

- B. National standard GB/T25757-2010 test methods of performance characteristics of automatic magnetic flux leakage testing systems for steel tubes; (our company chaired the formulation)

- C. International standard:
  ISO 9598: Pressure seamless steel pipe testing horizontal flaw detection magnetic flux leakage testing method.
  ISO 9402: Pressure seamless steel pipe testing longitudinal flaw detection magnetic flux leakage testing method.
High Speed Steel Pipe MFL Testing System
High Speed Steel Pipe MFL Testing System
High Speed Steel Pipe MFL Testing System
Portable Drill Pipes MFL Testing System
System Software UI
Portable Drill Pipe MFL Testing System

- Magnetized power generator
- Axial magnetic device
- Flaw sniffer
- Signal preprocessor and DSP host processor
- Computer system
Technical Specifications of Portable Drill Pipes MFL Testing System

- **Meets the API-5D Standard**

1. **Max testing speed**: 10-20m/min;
2. **Drill pipe thickness**: 4～25mm;
3. **Drill pipe length**: 3～12m;
4. **Drill pipe diameter**: 40 ～ 168mm;
5. **Sensitivity**: N5 artificial notch
   (length 50mm; width1mm; depth 5% of drill pipe thickness);
6. **Defects Detected**: Cracks, corrosion, cavity, tear injury, folding on the surface or inside of the pipes;
Technical Specifications of Portable Drill Pipes MFL Testing System

7. **Reliability:** False alarm rate < 0.5%, defect missing rate = 0;

8. **Stability:** 4 circumferential defective signal error < 2dB, 4 defective signal error in hourly running < 3dB;

9. **Signal processing:** DSP digital signal processing;

10. **Detection process display:** graphical;

11. **Detecting scanning mode:** flaw detector moving along the drill pipe and scanning;

12. **Energy consumption:** approximately 2KVA.
Flexible Pipe and Tank MFL Testing Equipment
Equipment Software UI
Flexible Pipe and Tank  MFL Testing Equipment

- Magnetic field incentive defects technology and device
- Magnetic path design and convergence technology
- The moving scanning technology
- Signal acquisition with multiple array probes
- Data compression and transmission
- Customized testing software with visual UI
Technical Specs of Flexible Pipe and Tank MFL Testing Equipment

1. Max diameter: 60mm-plane (Change gear according to specific diameter);

2. Speed: 1-2m/min;

3. Sensitivity: L3 (Artificial defects can be reliably detected when it is more than pipe wall thickness 10%);

4. Length: > 1m;

5. SNR: >6dB;

6. Stability: < 3dB/h;

7. Archives saving: graphical testing results.
Basis Standards Equipment Follows

- **ASME SA210** -- American Standard of Boiler and Pressure Vessels
- **ASME SA213** -- American Standard of Boiler and Pressure Vessels
- **ISO9402**: Seamless and welded (except submerged arc-welded) steel tubes for pressure purposes -- Full peripheral magnetic transducer/flux leakage testing of ferromagnetic steel tubes for the detection of longitudinal imperfections
- **ISO9598**: Seamless steel tubes for pressure purposes -- Full peripheral magnetic transducer/flux leakage testing of ferromagnetic steel tubes for the detection of transverse imperfections
- **API-5GT, 5D, 5L** – Related standards of API (the American Petroleum Institute)
Actual Application of the Equipment
ZDK-200 defects sample maker is an automatic digital control defect samples making equipment, it uses electric pulses to make the defects notch. It can make the defects on steel plate, stick and pipe, the defect samples are used in the NDT system sensitivity, reliability, repeatability, SNR and other parameters performance characteristics testing.
Characteristics of the Equipment:

1. Precise defects sample, better than API standard;
2. Easy to make rectangular notch defects on the steel pipe inner and outside surface;
3. Defect samples in a consistent depth;
4. Low voltage, safe operation.;
5. Digital control, easy to operate, fully automatic;
6. Various type of equipment to meet all kinds of working places;
7. Stable and reliable;
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Industrial Applications of Magnetic Flux Leakage Testing System

MFL testing systems are widely used in iron and steel, oil and petrochemical, electric power, shipbuilding and other industries.

Iron and Steel Industry

China has become the world’s biggest steel tube manufacturing and exporting country. There are thousands of ferromagnetic steel pipe production lines including dozens of large steel pipe manufacturing enterprises such as Panzhihua steel pipe company, Anshan Steel, Baosteel and thousands of private steel tube enterprises. Our stable performance, accurate and reliable detection result, cost-effective high speed steel pipe MFL testing system has become the important tools for these steel enterprises to ensure the quality of pipe products and improve product competitiveness.
Oil Industry

In recent years oil pipeline leakage accidents happened ceaselessly in the world, damaged the ecological environment seriously, caused major disasters, it is important to carry out the ferromagnetic pipeline reliability testing to ensure economic security and production safety. When an oilfield reaches the late phase of stable production, oilfield enterprises, such as Daqing, Dagang, Liaohe, North China, Zhongyuan, Shengli and Jianghan need to reuse the old pipes. For production safety, it is important to carry out strict quality inspection before using old pipes. The pollution on old oil pipe outer and inner wall is serious and defects are complex. Currently oilfields mostly use hydrostatical process method, it can only test a few defects such as the drill pipe thread defect and through hole, cannot detect other defects. The pipe testing mainly relays on manual visual inspection. These testing methods cannot meet the drill pipe testing requirements. Therefore, adopting the corresponding MFL testing system is a great significant help to ensure
Petrochemical Industry

In the Petrochemical industry the pipelines also always have wall acid caused corrosion, crack and so on common defects after long time use, regular pipe on-line inspection can improve production safety. MFL testing system is the most suitable pipe on-line inspection tool, can conduct the comprehensive inspection at normal production working condition and provide dynamic and accurate pipeline health status data as a scientific basis for company to develop the system to plan the pipeline overhaul time, save huge cost.
Power Industry

In power industry, inside the boiler evaporation system, water is heated, evaporated and generate saturated steam heating surface which is consist of the steel pipe in rows arrangement, the pipe is called a boiling tube. Steam boiler water wall tube's erosion caused by smoke, ash, fire and water in the pipe of impurities through boiler's long running process, prone to corrosion, wear and damage, under high pressure, high temperature water and steam effects, eventually produce pipe burst leakage at the erosion site and cause serious accidents.

Pipeline MFL testing technology is more mature industrial applications and used widely. This technology can detect the internal and external corrosion of pipeline, more accurate qualitative and location. MFL testing has the advantages of simple process, coupling free, with very broad detection capability to boiler tube outer surface cracks, corrosion, pit defect, suitable for boiler pipelines NDT, and is easy to carry out pipeline testing automation.
Shipbuilding Industry

Special environment, strong external forces, complicated internal structure, the hull plate is very easy to grow different kinds of defects, these defects threaten the daily operation safety of ships. Plate defects will seriously affect the ship’s stability and reliability. In order to ensure the safety and replace defective components in time, the ship plate must be tested periodically. Steel plate defects mainly are fatigue crack, tanker plate corrosion, cargo pitting corrosion, welding defects and steel low temperature brittleness crack.

Magnetic flux leakage testing mainly use sensors to get signals, processed by the computer, so it is easy to realize automatic judgment. Accurate testing results and high efficiency make it applicable for defect testing of marine steel plate.
MFL Testing Product Technology and Service Features

High-speed steel pipe testing system has following important characteristics:

- Precision positioning and servo technology in steel tube testing;
- Photolithography chip based high sensitivity sensor manufacturing technology;
- Multi-channel noise suppression techniques;
- Exclusive spinning probe testing technology in China;
- High speed on-line testing defects, inner and outer surface or inside of the wall;
- Composite degaussing technology;
- Testing process visualization, monitoring steel pipe quality in the graphical way;
- High reliability, stable operation;
- Timely after-sale service and thoughtful.
Services Provided

- Steel pipe, plate and tank online MFL Testing services in steel, oil, chemical, power, railway and shipbuilding industries
- Drill pipe and steel pipe onsite MFL testing services in oilfield drilling industry
- Develop new MFL testing system for customer special application
- Upgrade imported MFL testing systems
- MFL testing system probes and accessories
- Professional training on MFL testing system operation
- MFL testing system long term and short term on loan
Achievements

- National level high-tech company, specialized in MFL Testing technologies, with strong technical force and rich experiences.

- Chaired the formulation of the National Standard GB/T 25757-2010 “Non-destructive testing-Test methods of performance characteristics of automatic magnetic flux leakage testing systems for steel tubes”.


- With core technology and independent IP rights, been granted with several MFL Testing invention patents and other pipeline testing patents.

- 80s High Speed Steel Pipe MFL Testing systems have been installed, largest install base in China. System specifications meet API-5CT, 5D and GB.
Obvious Advantages of MFL Testing Systems

- Shengli Oilfield adopted a large number of MFL Testing systems and almost put an end to oil well accidents which happened dozens of times every year before due to drill pipe and steel tube broken.

- Various kind of high speed steel pipe MFL testing systems have already installed and used in national enterprises TPCO, Baosteel, AnShan Iron & Steel and other 50s companies, made great achievements and fostered economic and social benefits.

- Zhejiang JianLi Group adopted 5 sets of high speed steel pipe MFL testing system in production quality assurance, so far all export steel pipes are quality problem free.
Patent and Accreditation Certificates

MFL Testing Invention Patent

The National Accreditation of Steel Pipe MFL Testing System
Chaired The Formulation of the National Standard on MFL Testing System

中华人民共和国国家标准

GB/T 25757—2010

无损检测 钢管自动漏磁检测系统综合性能测试方法

Non-destructive testing—Test methods of performance characteristics of automatic magnetic flux leakage testing systems for steel tubes

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Sun Create Electronics / Zhongda Testing
“Technology and System of High Speed Steel Pipe MFL Testing”
We care about

Magnetic flux leakage testing is the best method to ensure ferromagnetism pipe quality and use safety.

We care about production safety, we care about people safety, we care about society security.
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