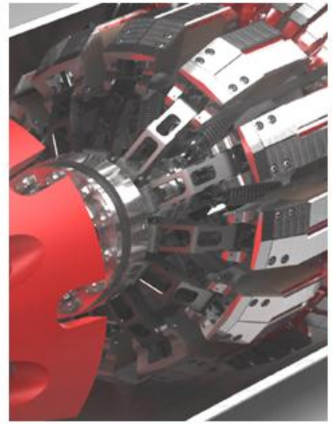
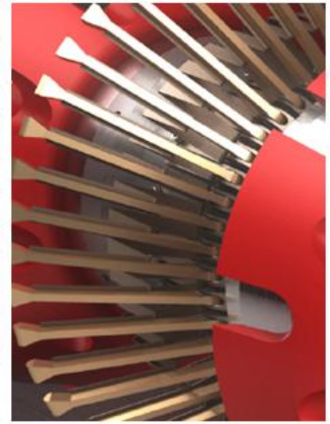
Pipeline Performance™



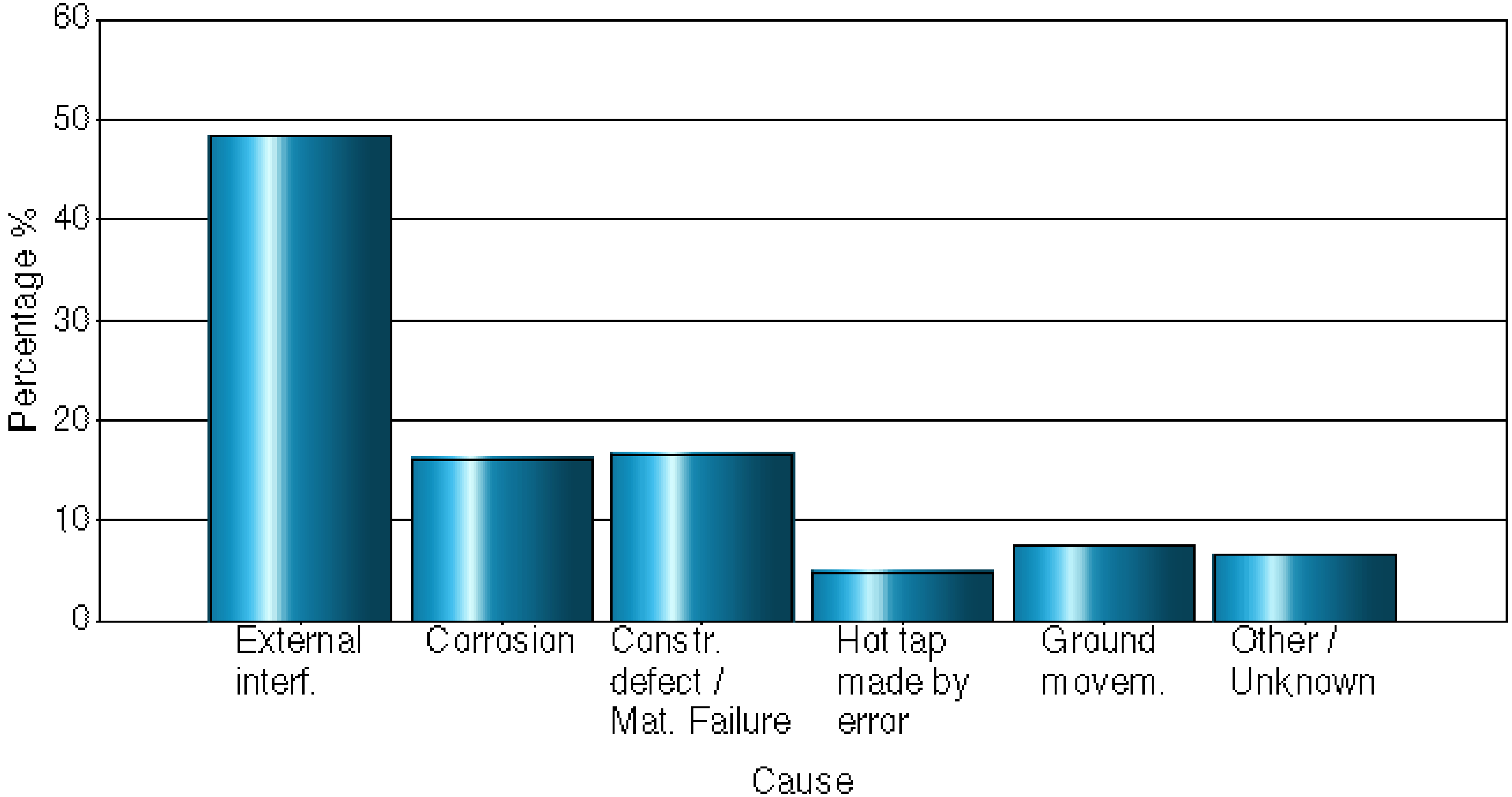
ASSESSING MECHANICAL DAMAGE USING MULTIPLE DATA SETS IN ILI

Abel Lopes
Market Development Manager EH
14th November 2012

www.tdwilliamson.com

TDW

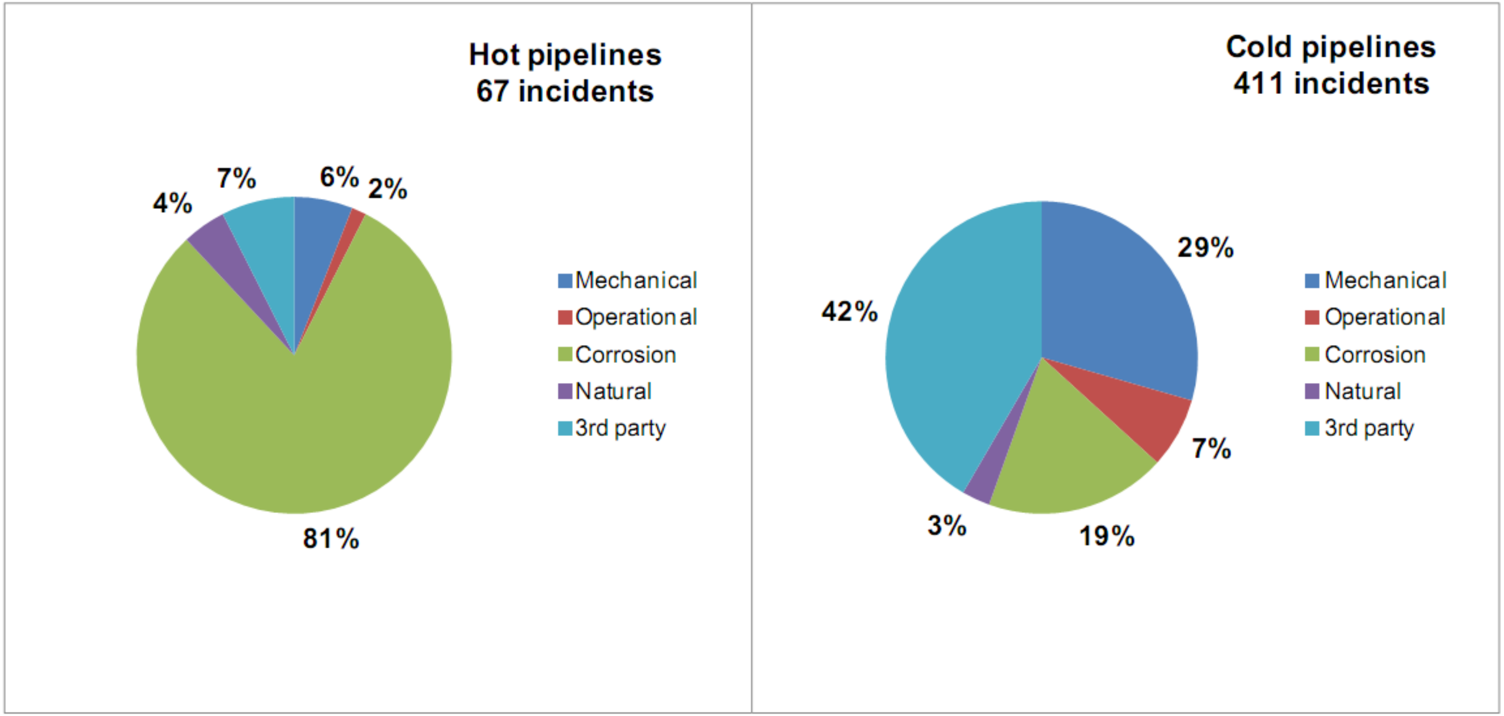
Failure Causes



Source: 8th Report of the *E*uropean *G*as Pipeline *I*ncident Data *G*roup

Failure Causes

Figure 18 Distribution of major spillage causes



Source: Performance of European cross-country oil pipelines
Statistical summary of reported spillages in 2010 and since 1971

Prepared by the CONCAWE Oil Pipelines Management Group's Special Task Force on oil pipeline spillages (OP/STF-1)

Technology Limitations

SP0102-2010

Table 1: Types of ILI Tools and Inspection Purposes(6)

Anomaly	Imperfection/ Defect/Feature	Metal Loss Tools			Crack Detection Tools		Deformation Tools
		Magnetic Flux Leakage (MFL)					
		Standard Resolution (SR)	High Resolution (HR)	Ultrasonic Compression Wave(M)	Ultrasonic Shear Wave(M)	Transverse MFL	
Metal Loss							
	External Corrosion	Detection,(A) Sizing(B)	Detection,(A) Sizing(B)	Detection,(A) Sizing(B)	Detection,(A) Sizing(B)	Detection,(A) Sizing(B)	No Detection
	Internal Corrosion						
	Gouging	No ID/outer diameter (OD) discrimination					
Crack-Like Anomalies							
	Narrow Axial External Corrosion	Detection(A)	Detection(A)	Detection,(A) Sizing(B)	Detection,(A) Sizing(B)	Detection,(A) Sizing(B)	No Detection
	Stress Corrosion Cracking	No Detection	No Detection	No Detection	Detection,(A) Sizing(B)	Limited Detection,(A)(C) Sizing(B)	No Detection
	Fatigue Cracks	No Detection	No Detection	No Detection	Detection,(A) Sizing(B)	Limited Detection,(A)(C) Sizing(B)	No Detection
	Long Seam Cracks, etc. (toe cracks, hook cracks, incomplete fusion, preferential seam corrosion)	No Detection	No Detection	No Detection	Detection,(A) Sizing(B)	Detection,(A)(C) Sizing(B)	No Detection
	Circumferential Cracks	No Detection	Detection,(C) Sizing(B)	No Detection	Detection,(A) Sizing(B)(D)	No Detection	No Detection
	Hydrogen-Induced Cracking (HIC)	No Detection	No Detection	Detection (A)	Limited Detection	No Detection	No Detection
Deformation							
	Sharp Dents	Detection(E)(G)	Detection(E)(L)	Detection(E)(G)	Detection(E)(G)	Detection(E)(G)	Detection,(F) Sizing

(6) For additional information, refer to API 1163.[3]

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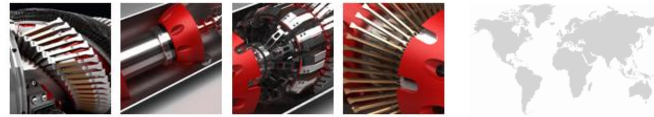
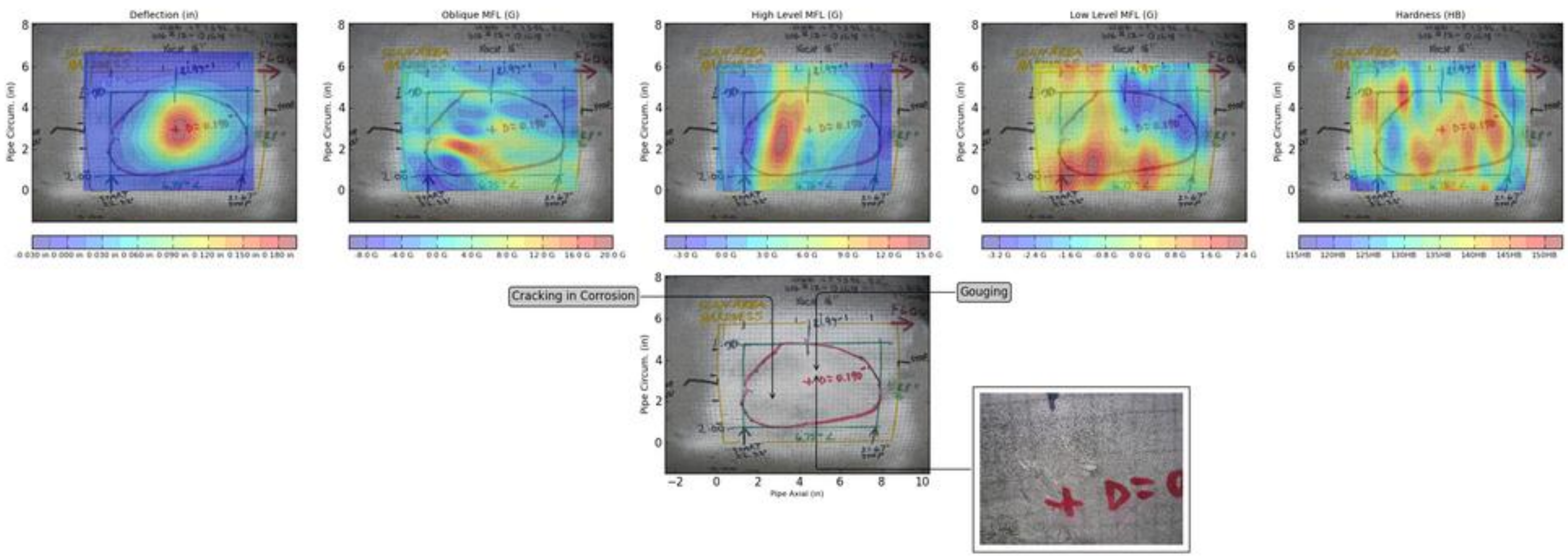


TDW Offer

SPIRALL/MDS

Dent with Gouging, Corrosion and Cracking at 12-0164



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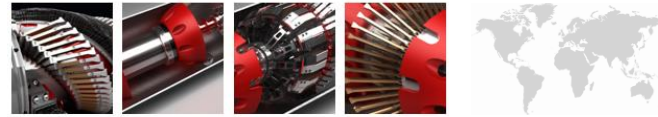
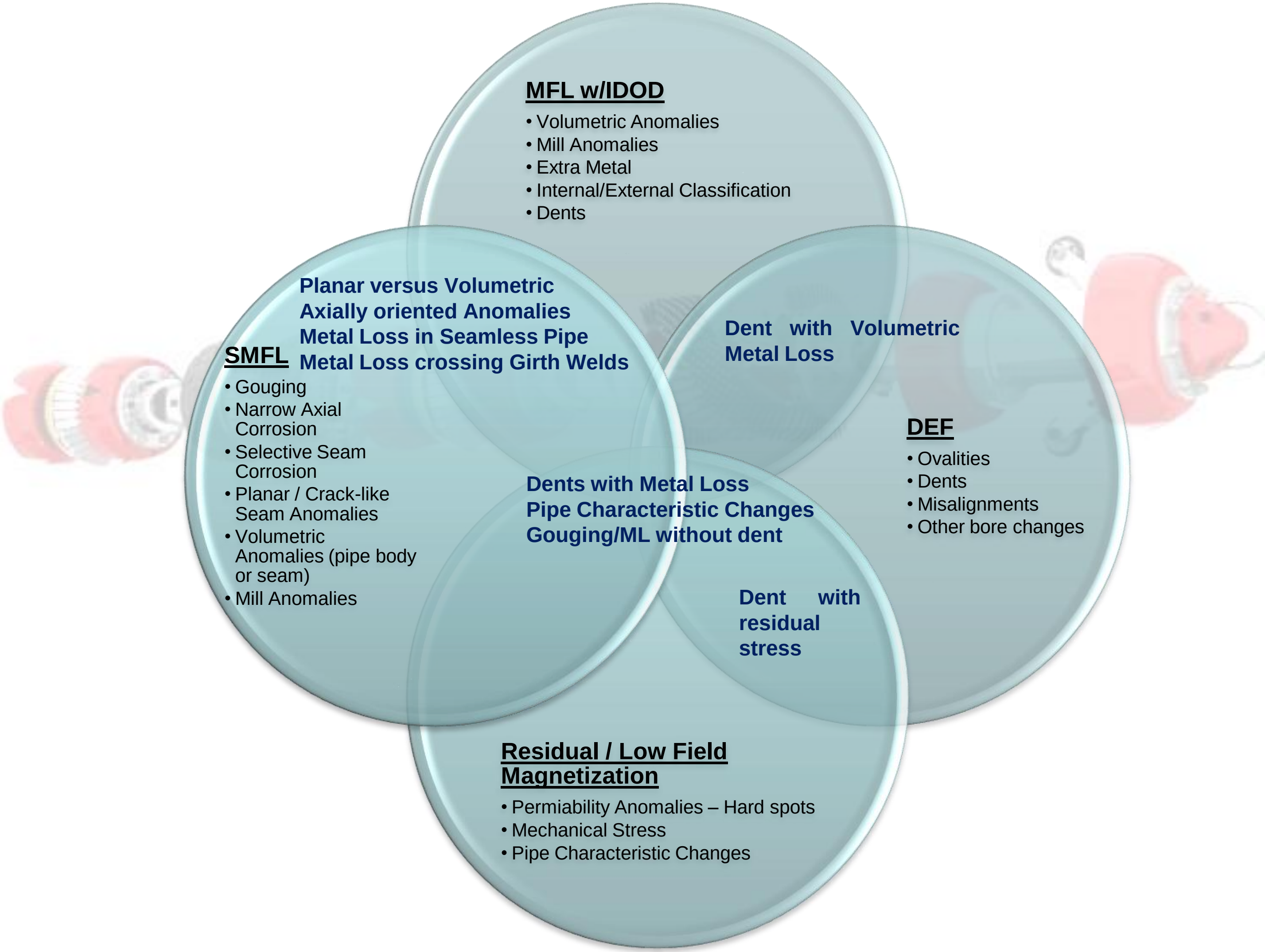
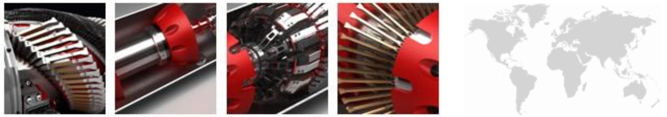
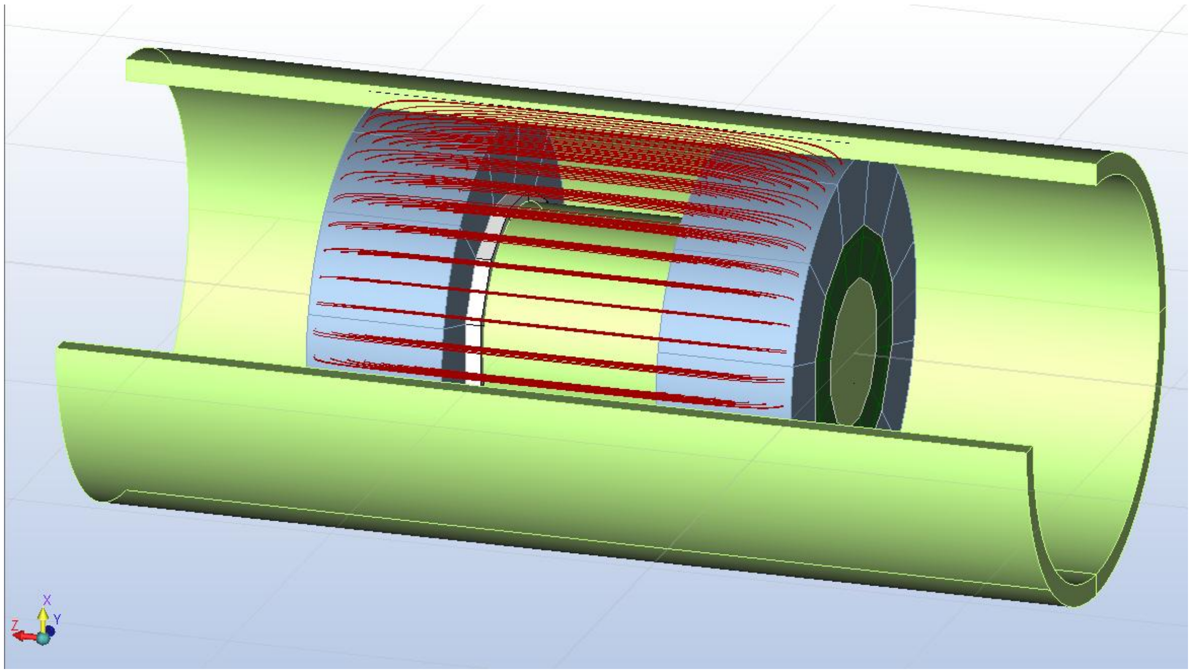
Value of Multiple Datasets



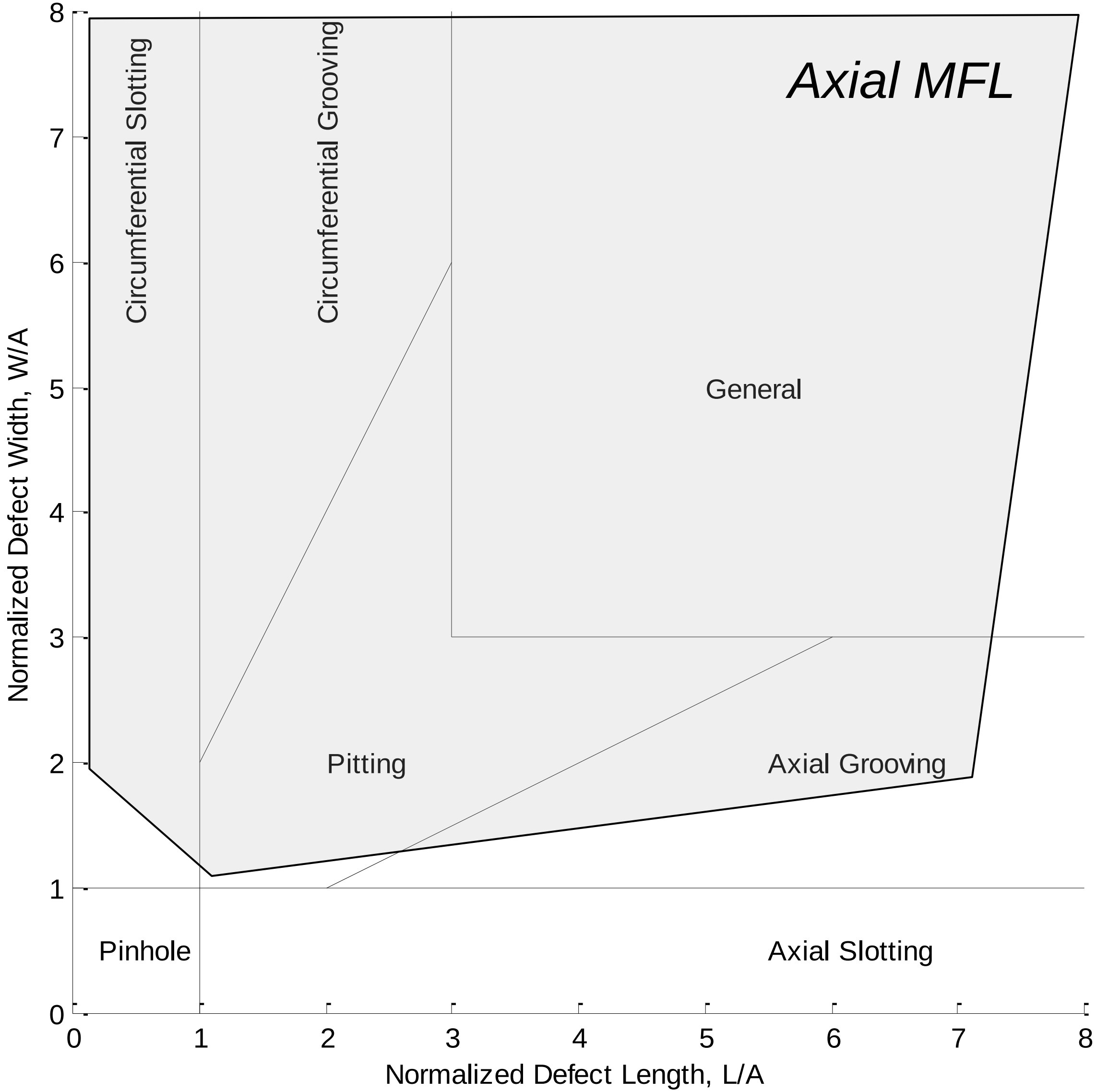




Axial MFL

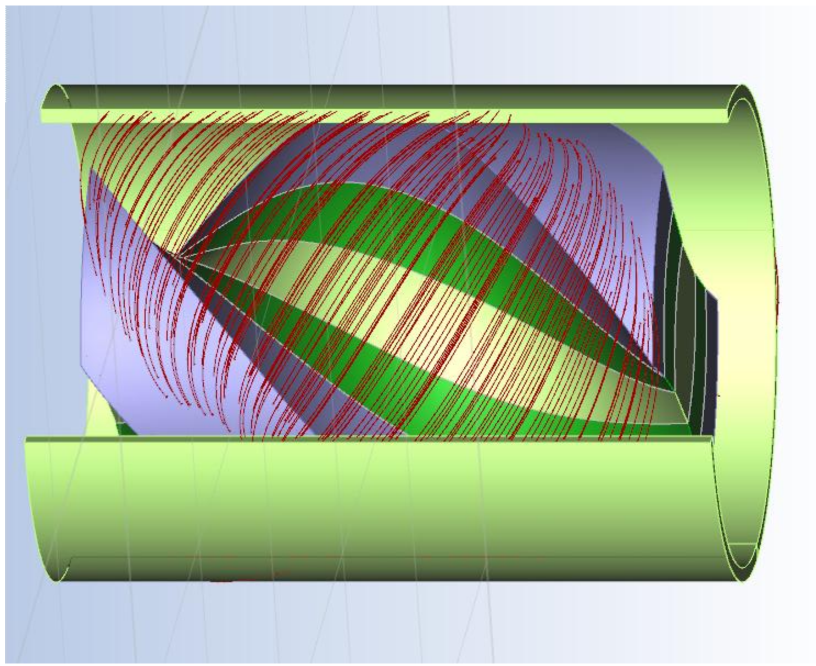


Axial MFL

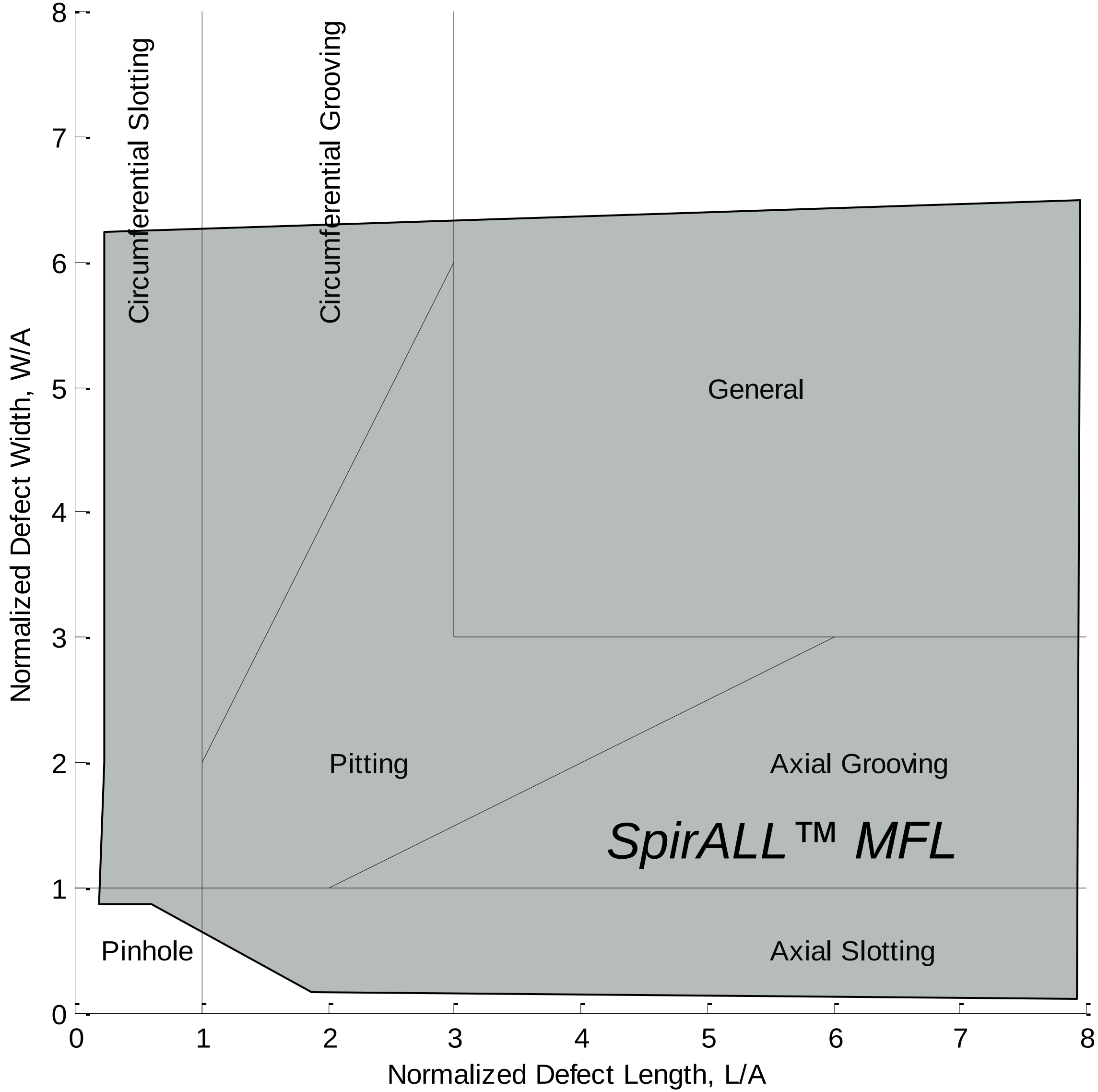


Pipeline Performance™

SpirALL™ MFL Technology



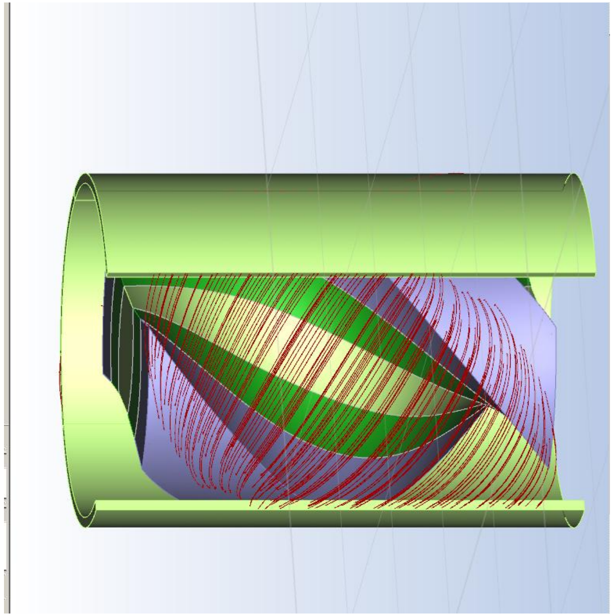
SpirALL™ MFL Technology

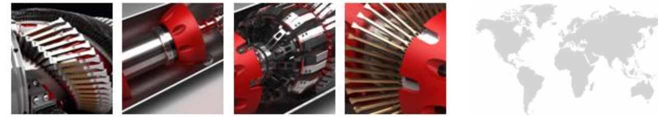


Pipeline Performance™

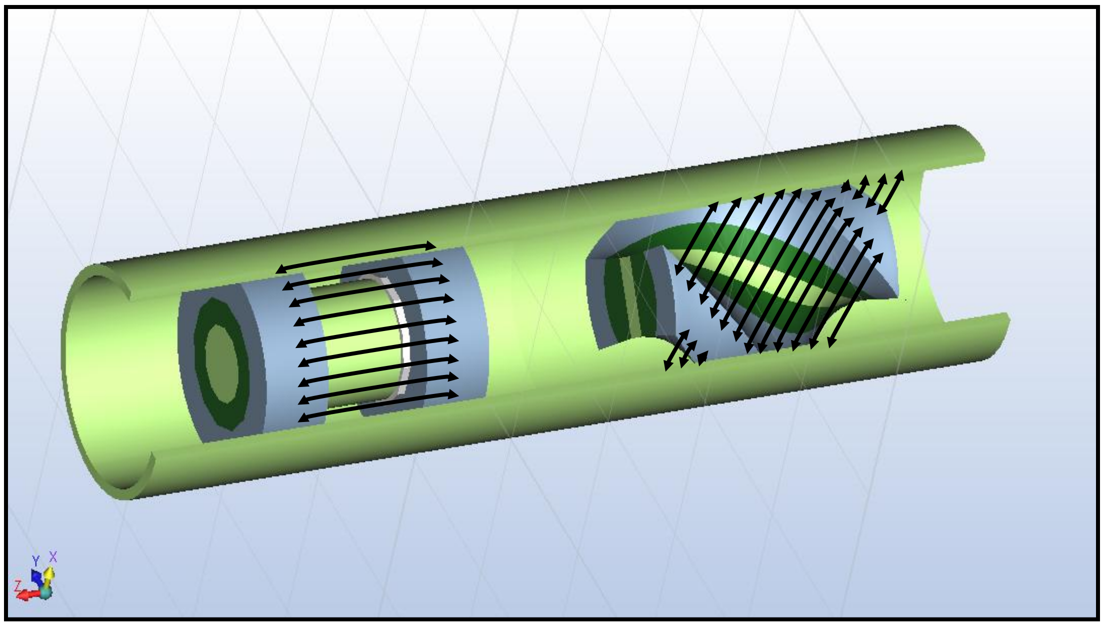
SpirALL™ MFL Technology

- **Magnetizer**
  - **SMFL concept enables Multiple DataSet platform**



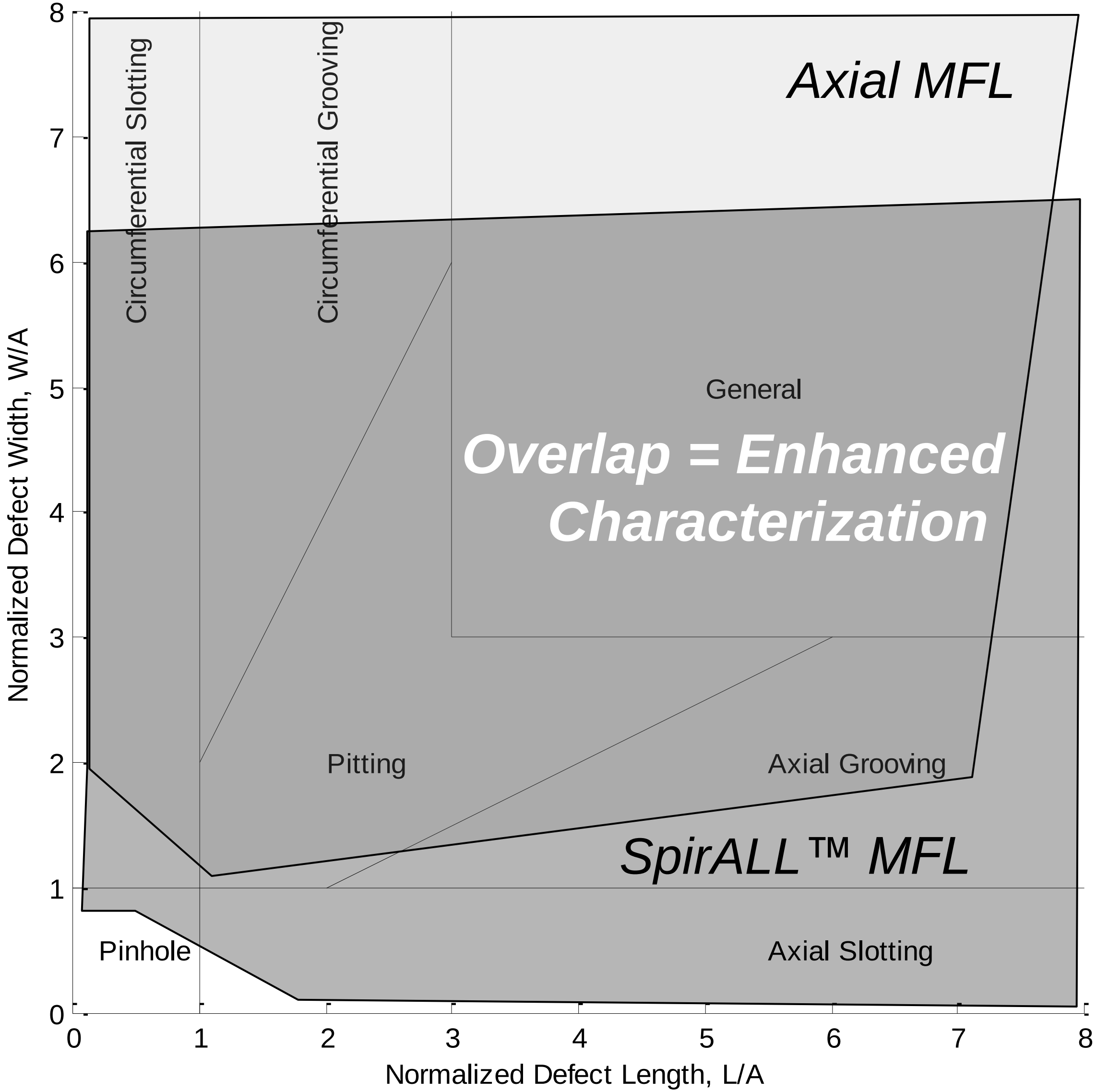


Axial MFL + SMFL



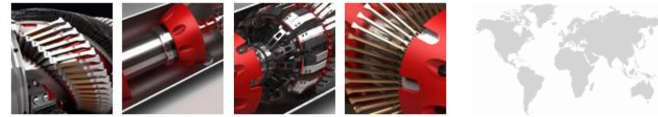
Pipeline Performance™

Axial MFL + SMFL

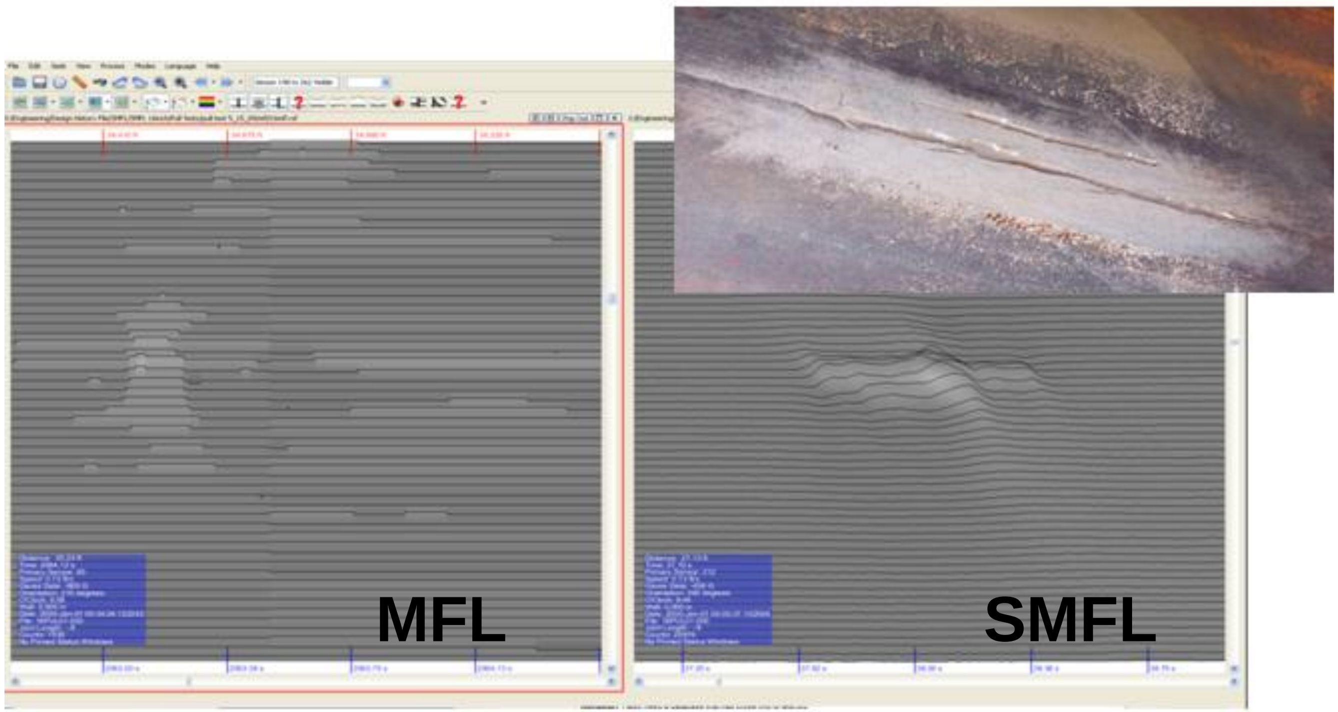


Pipeline Performance™

Axial MFL + SMFL



- 16-inch inspection tool runs indicated that SpirALL™ MFL technology successfully identifies narrow axial defects that normally would not be reported by axial MFL alone.



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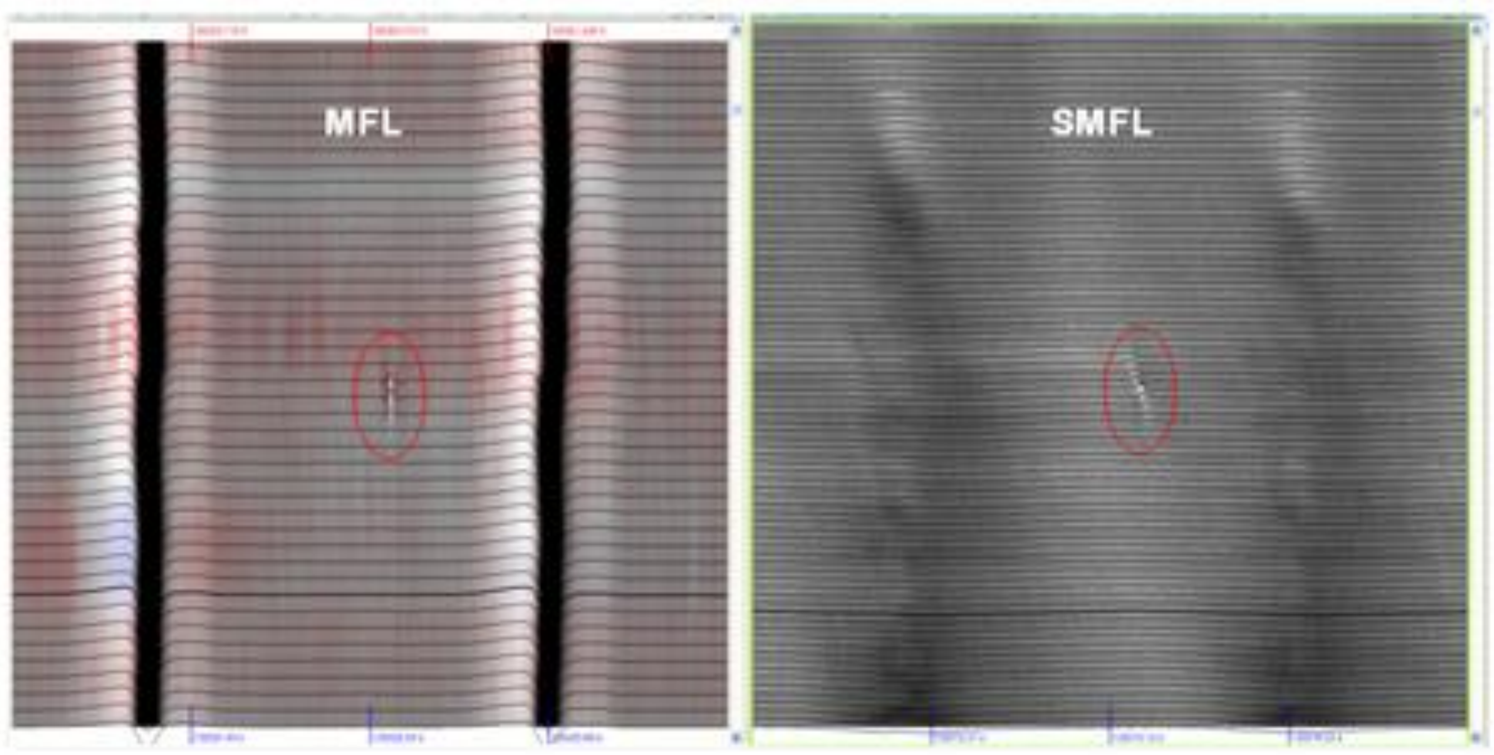
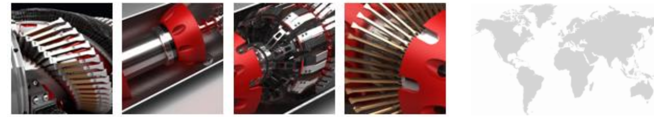
Axial MFL + SMFL

- By combining axial MFL with SpirALL™ MFL in the same run, it becomes possible to identify the anomaly as a metal loss feature that happens to be in the seam weld instead of a crack-like feature in the seam

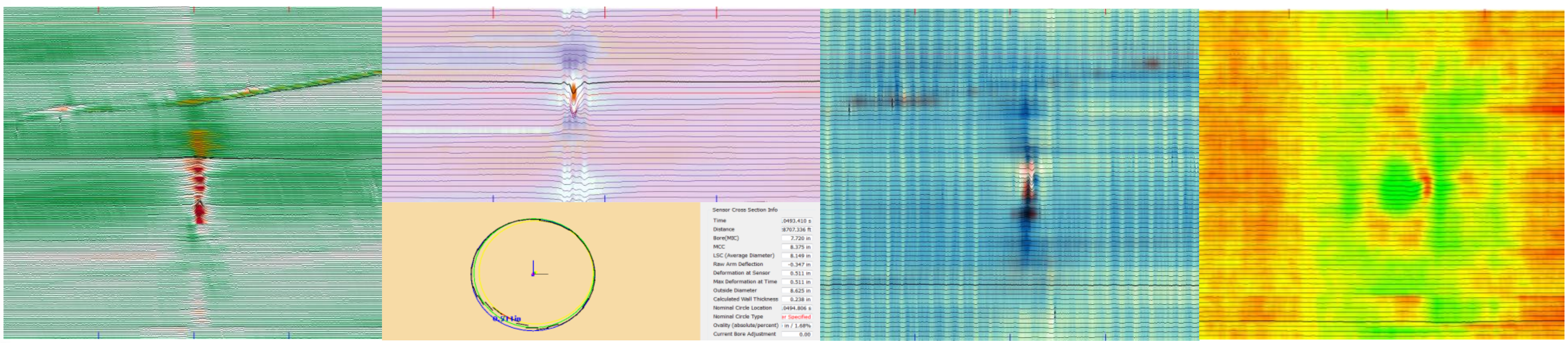


Pipeline Performance™

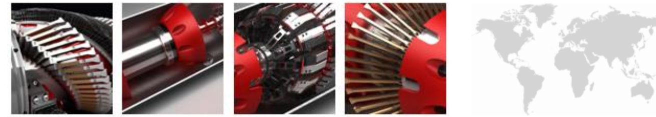


Pipeline Performance™

The Multiple DataSet Advantage



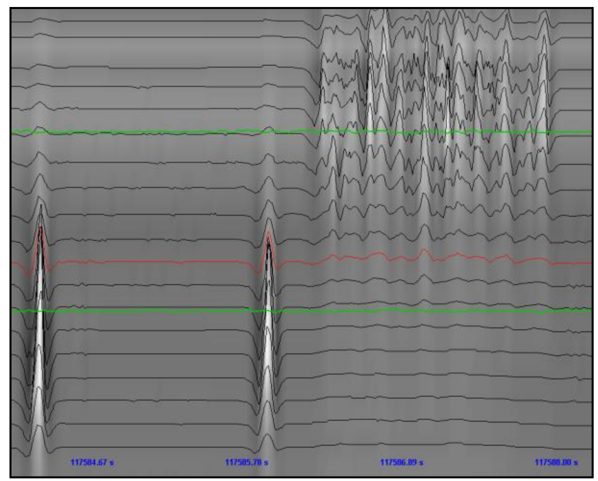
Single Dataset – MFL



Detection

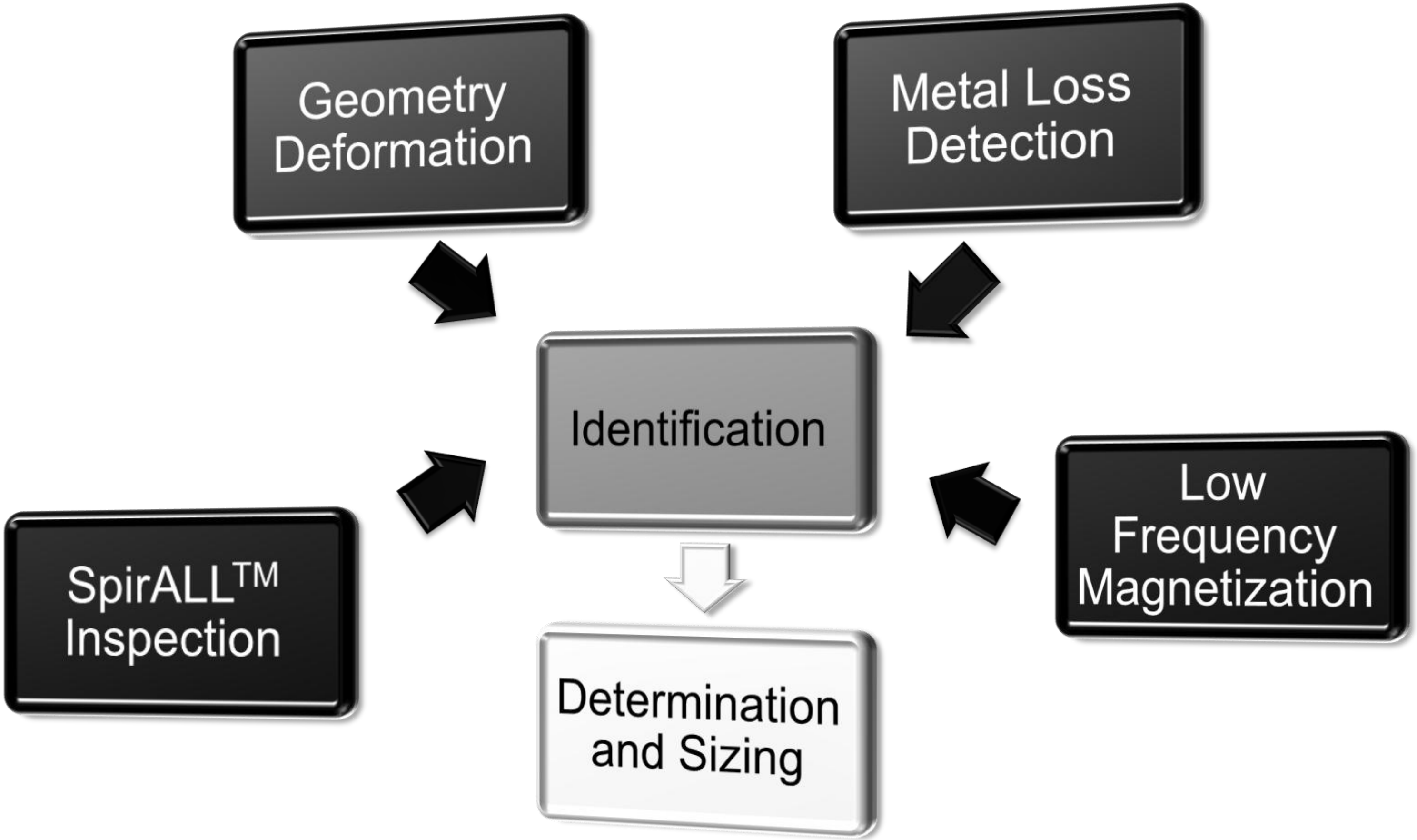
Identification

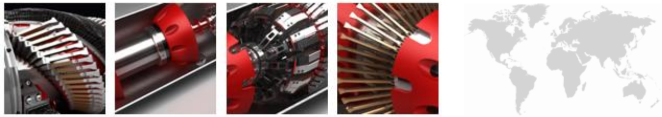
Determination and Sizing



Pipeline Performance™

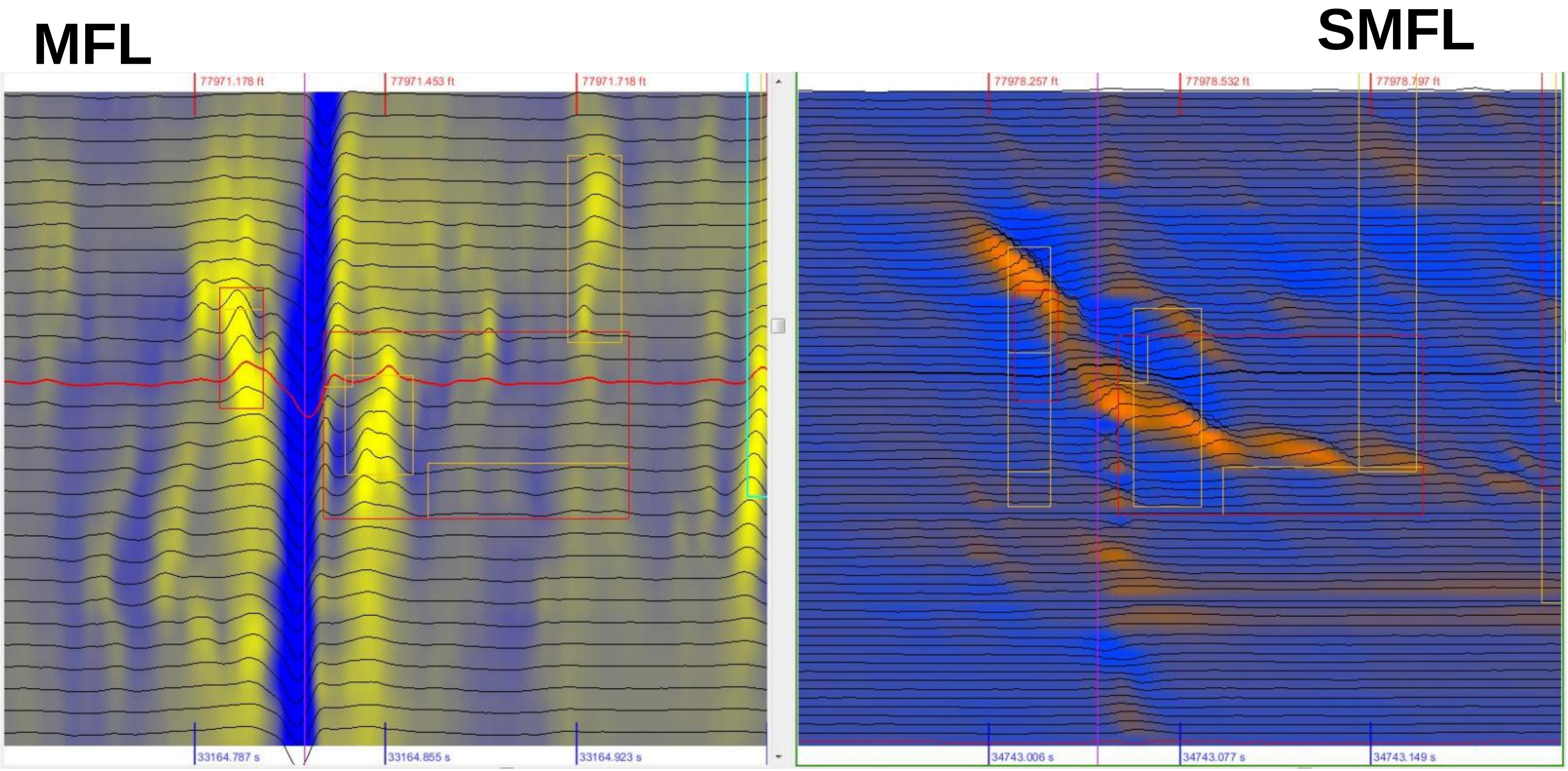
Multiple Datasets





Characterization

Metal Loss crossing and within a girth weld

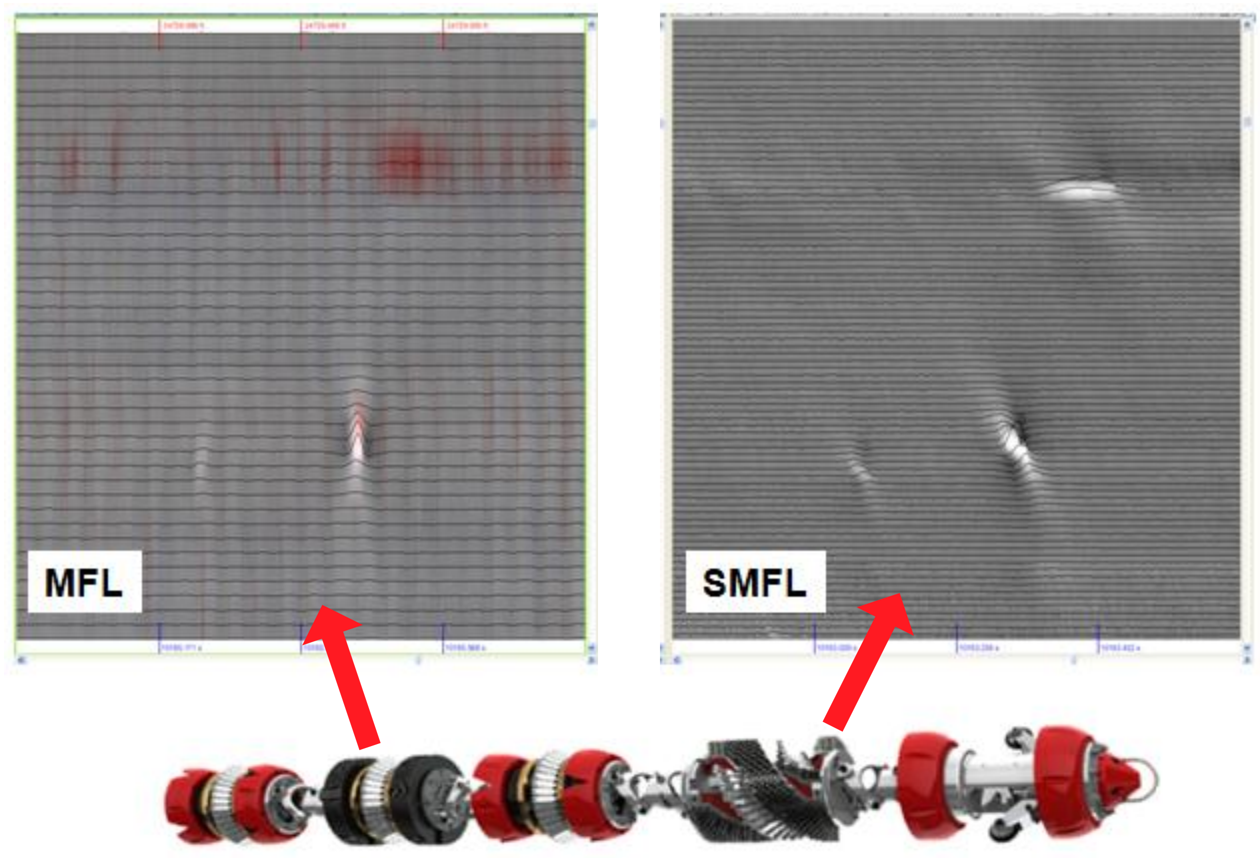


Characterization

- **Mechanical Damage**

Characterization

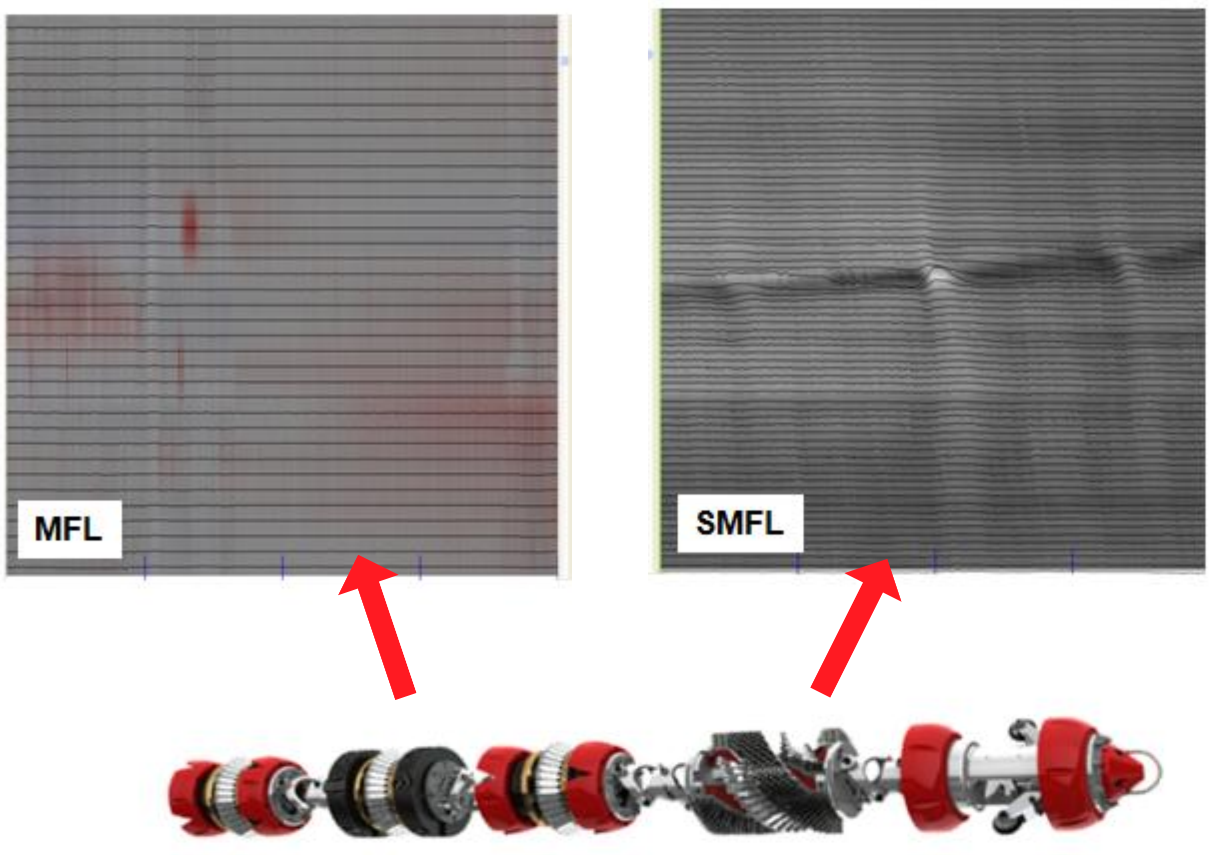
- **Axial (Planar) Defects**

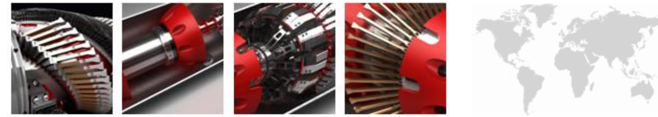


Pipeline Performance™

Characterization

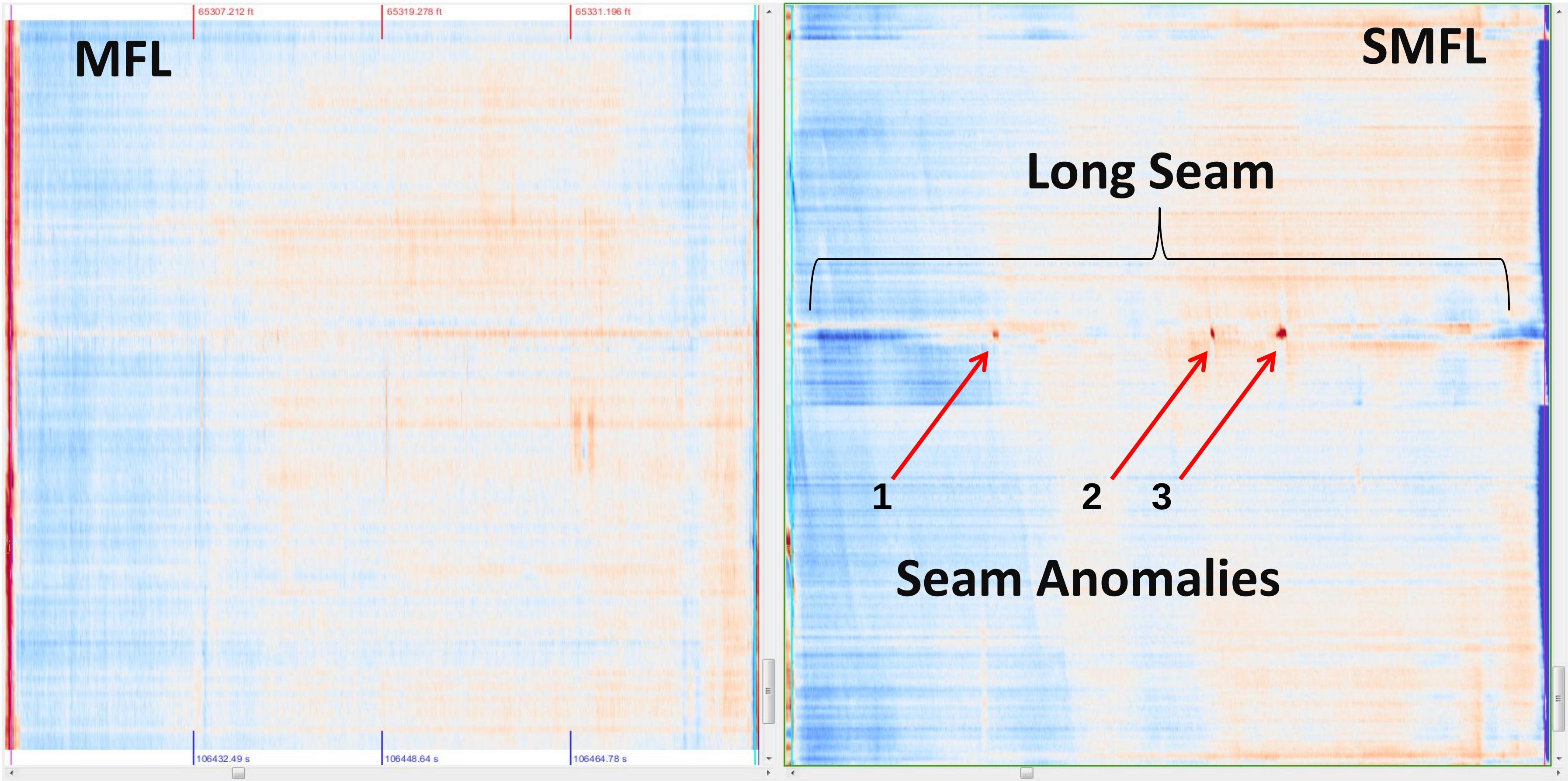
- **Seam Weld Defects**



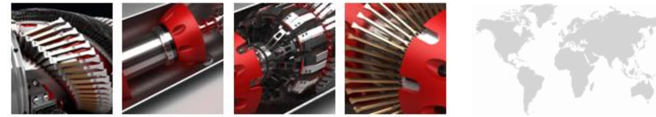


Characterization

Planar / Crack-like Anomalies

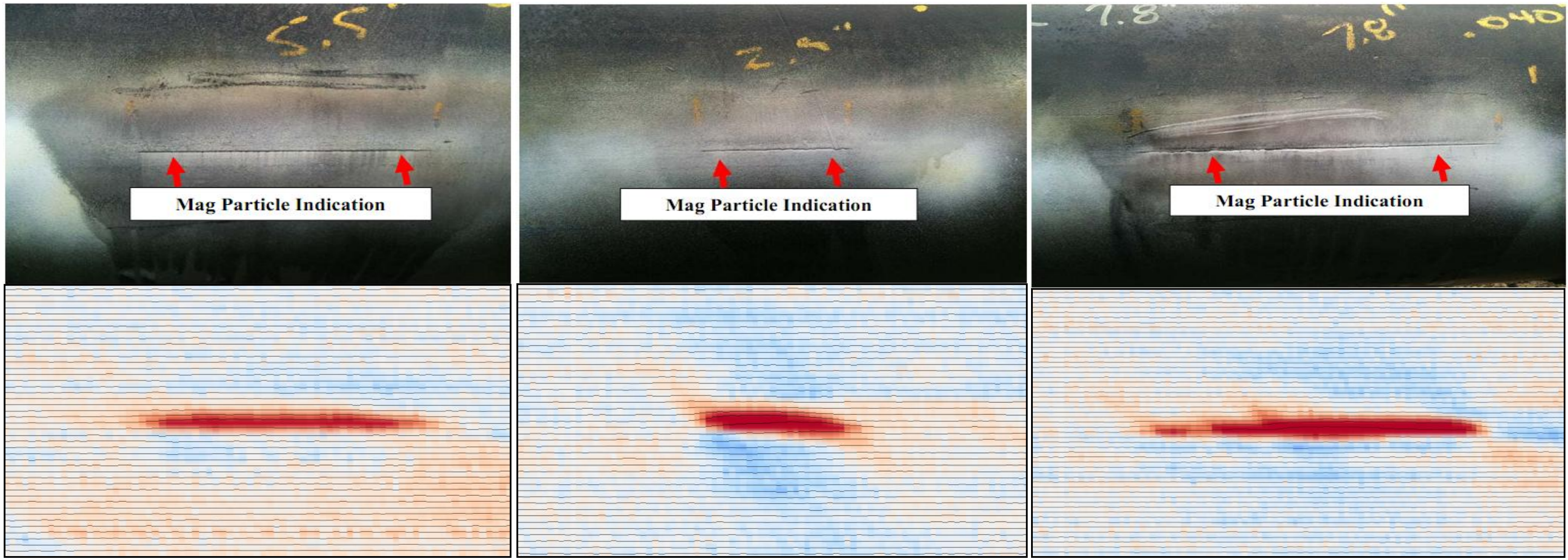


Characterization



Planar / Crack-like Anomalies

Anomaly 1, 2 and 3 (left to right): zoomed in SMFL screenshot with dig photo



#	Descr.	ILI %	Field %	ILI Length (mm)	Field Length (mm)	ILI Width (mm)	Field Width (mm)
1	Planar	19	16	109	140	1.3	Linear
2	Planar	29	14	61	73	1.8	Linear
3	Planar	15	16	188	198	2.0	Linear

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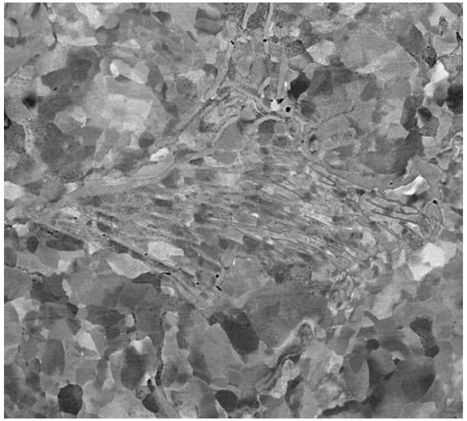
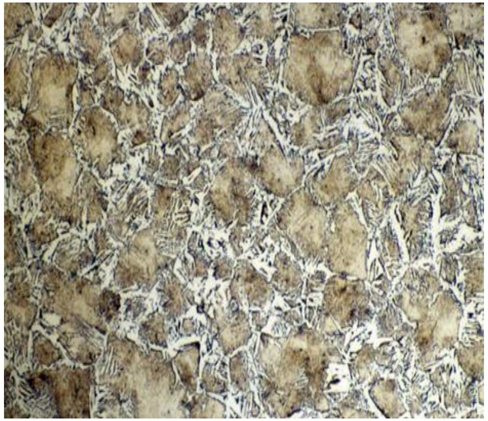
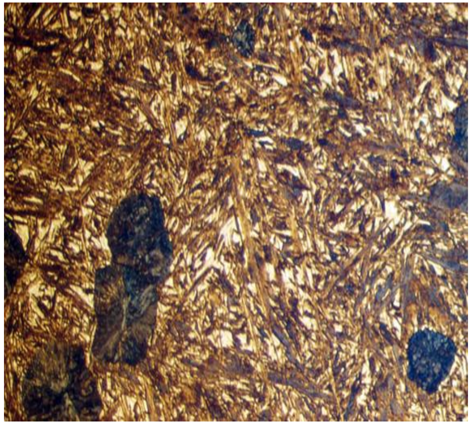
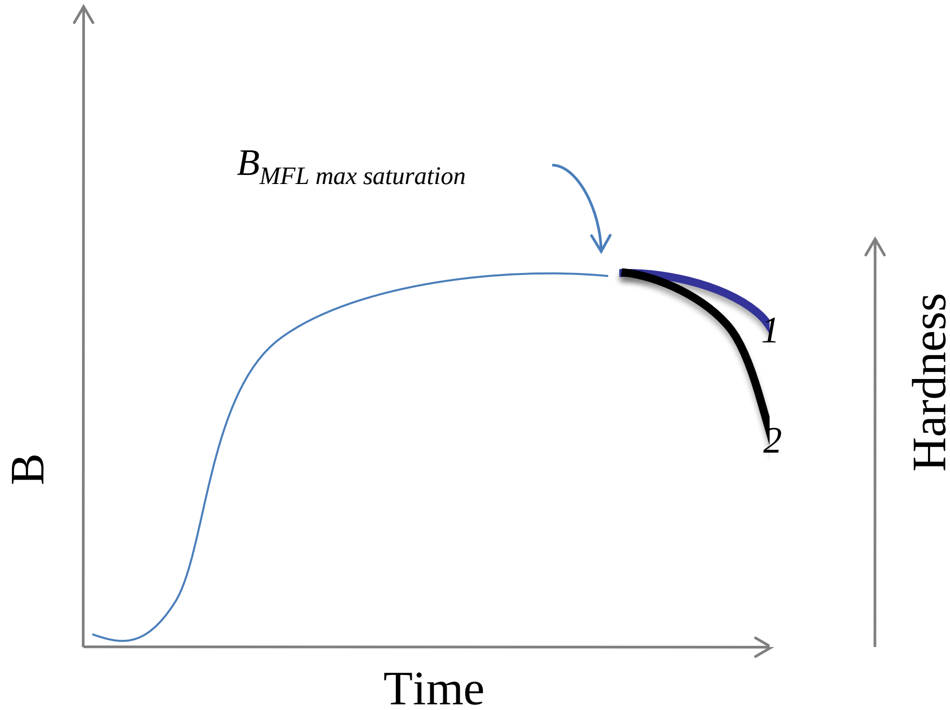
Residual and Low Field MFL

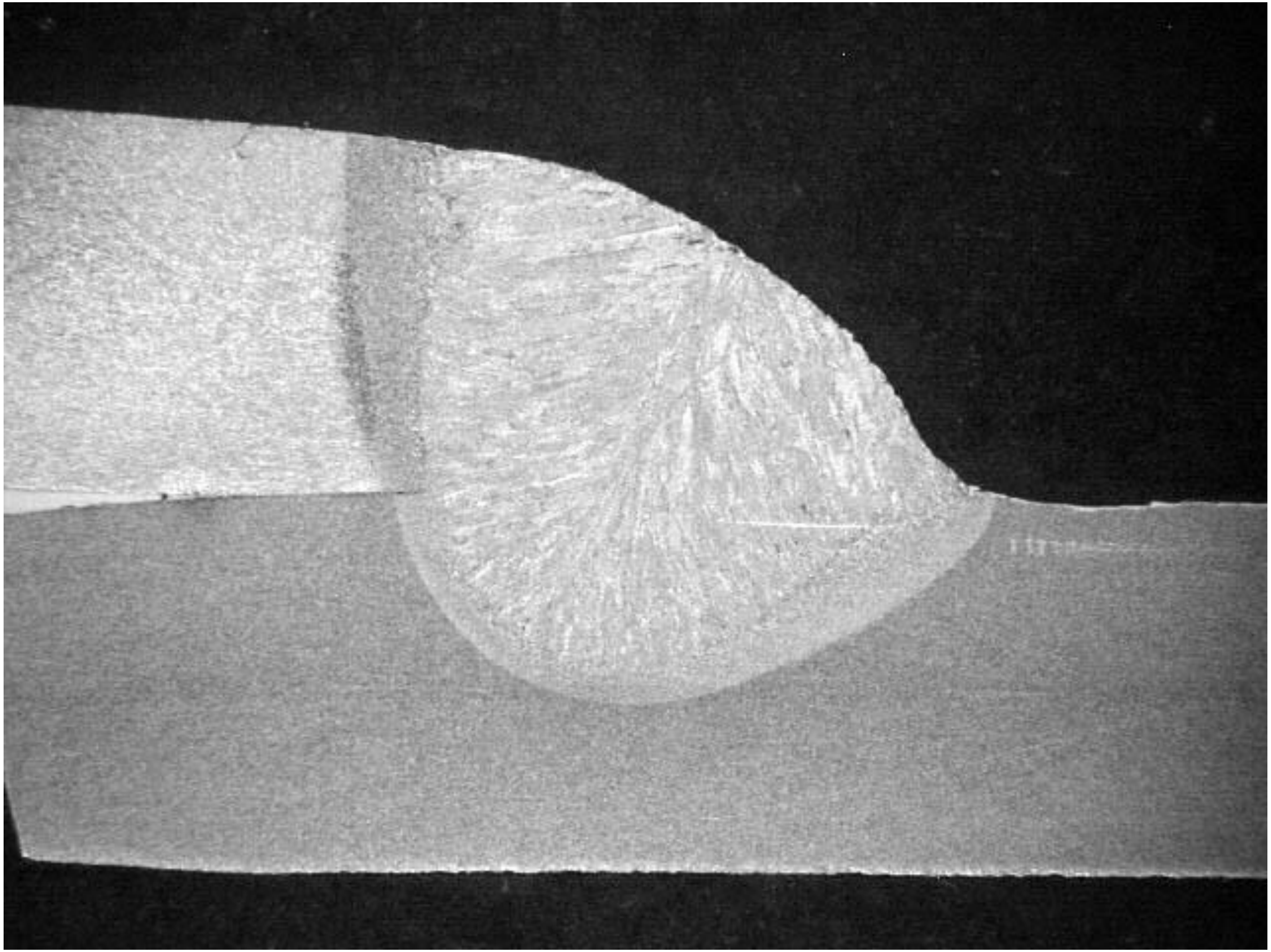




Residual and Low Field



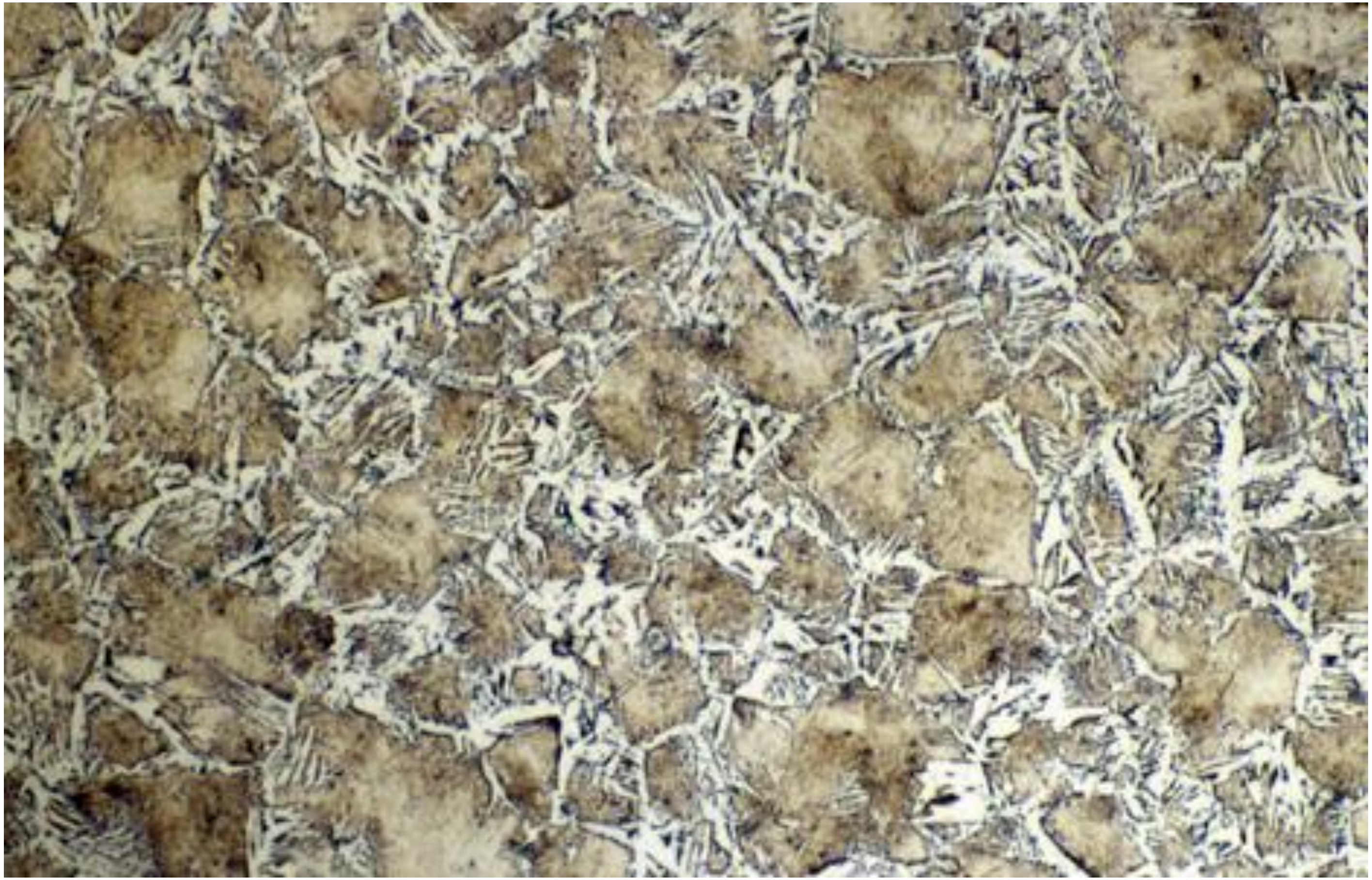
- ***Two different steel lattices will produce two different residual measurements (1,2)***
- ***This happens with hard spots, heat affected zones, and stress.***

Steel Microstructure



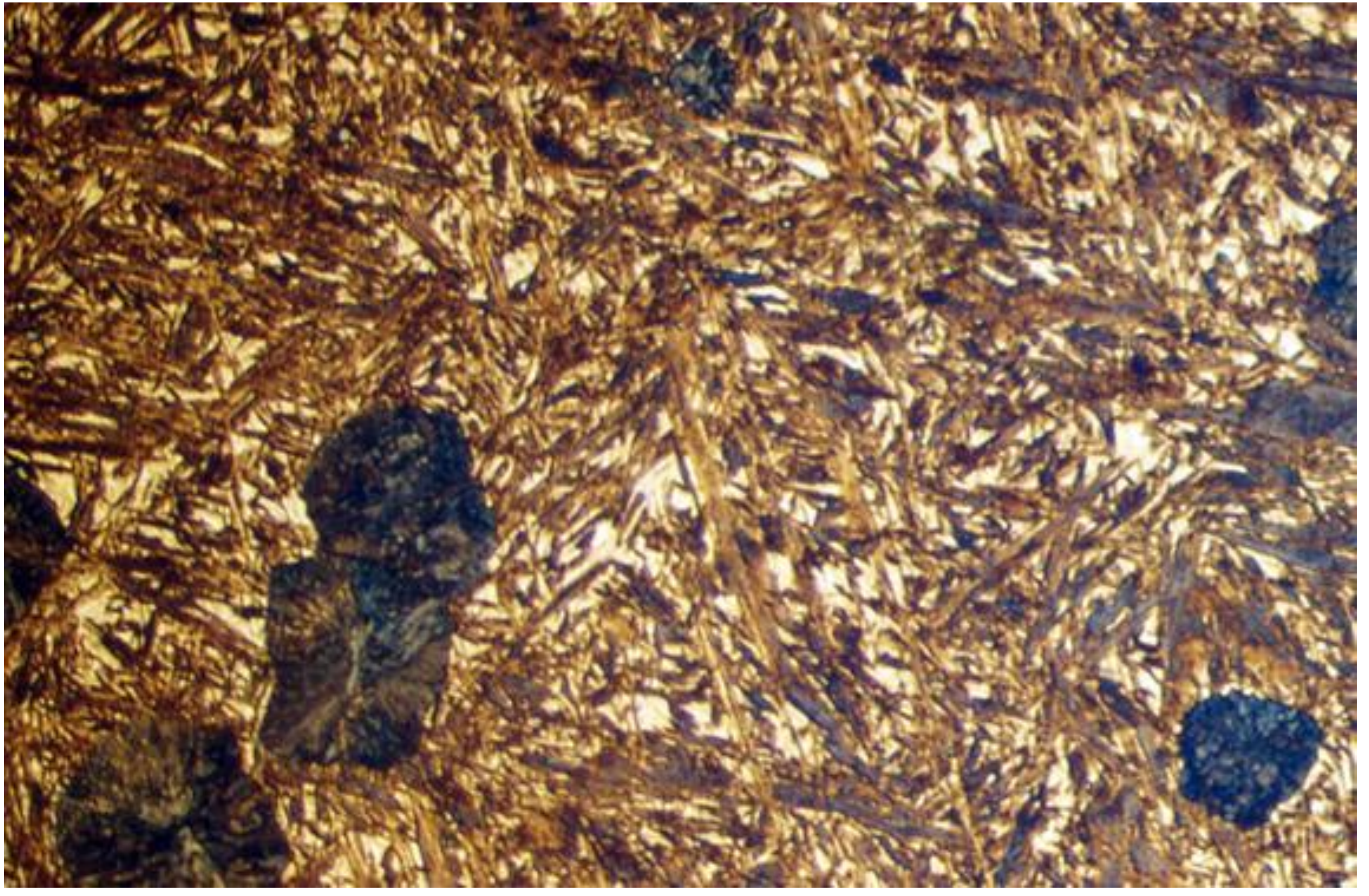
Steel Microstructure

- **Low Carbon**



Steel Microstructure (High-carbon)

- **High Carbon**



Hard Spot / Crack

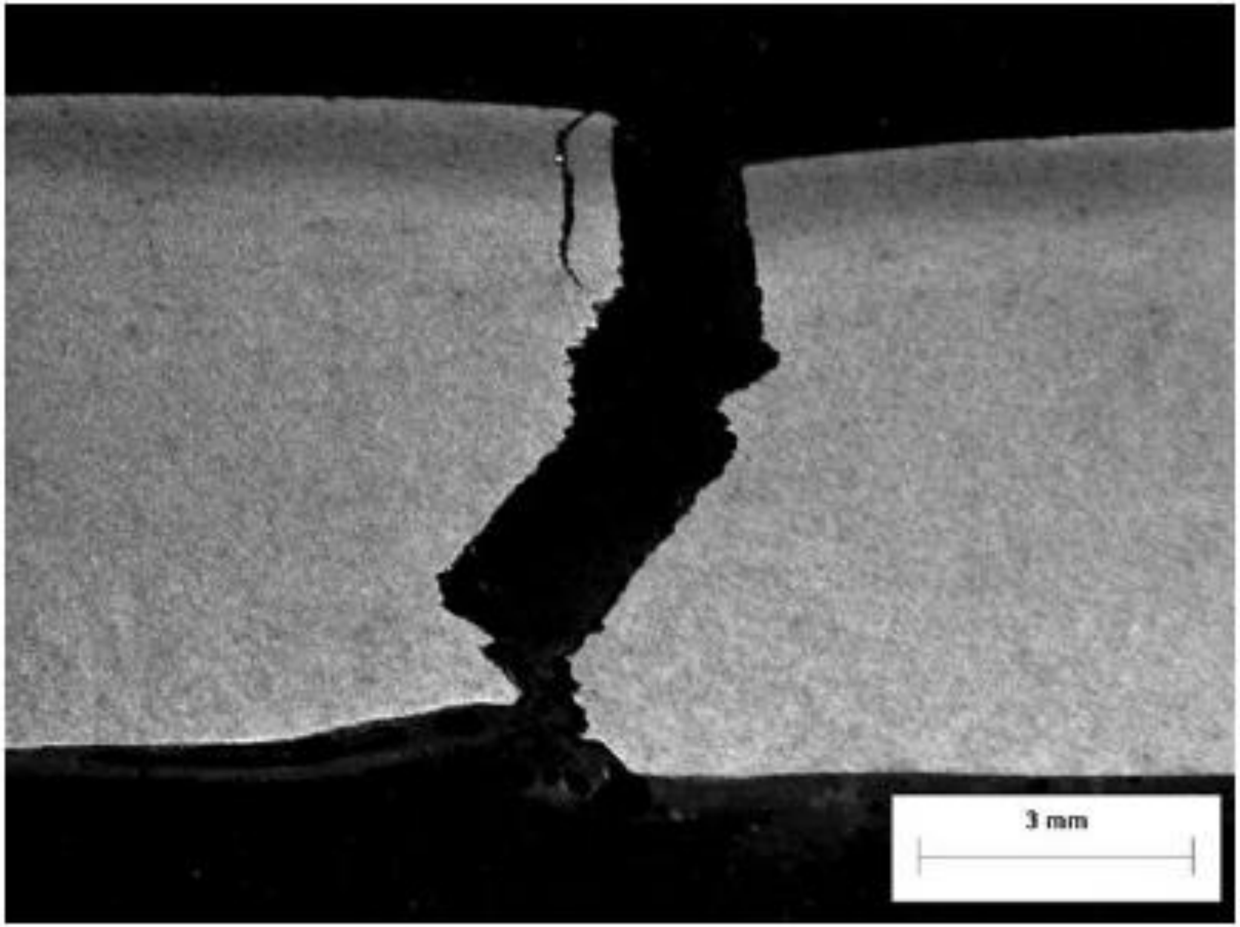
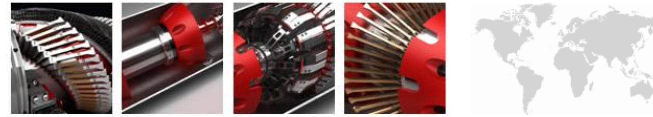


Figure 11. Photomicrograph of cracking initiating in a hard spot.

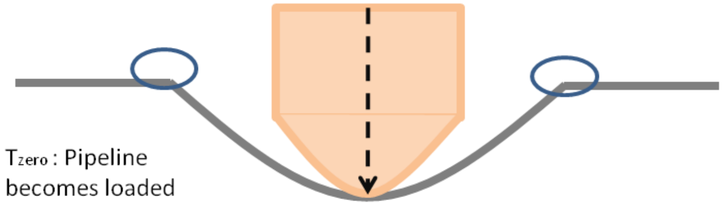
Analysis of High-Collapse Grade P110 Coupling Failures - A Case Study by Stork Materials

Pipeline Performance™

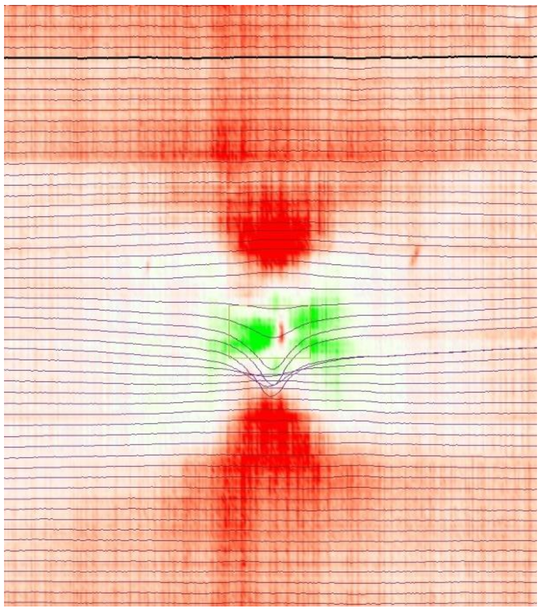
Mechanical Damage



Re-rounded versus Cycled Dents

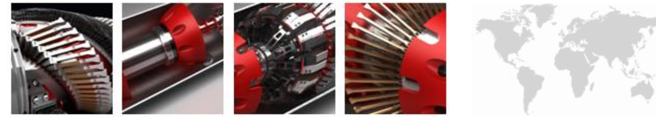


Re-rounded versus Cycled Dents

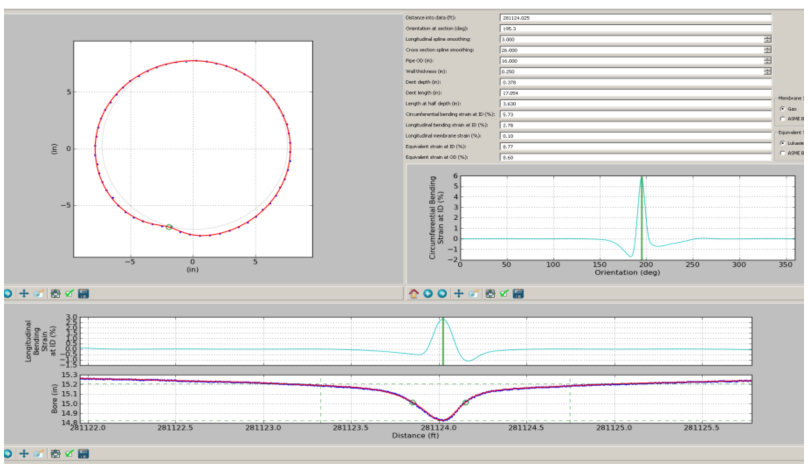


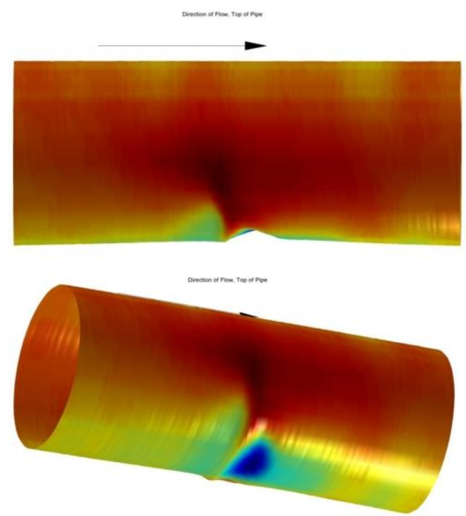
Re-rounded dent signature

Strain Calculations

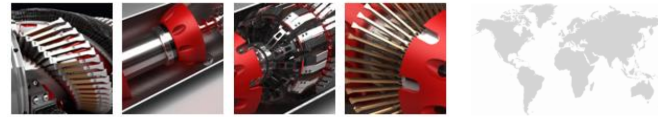


- ASME B31.8 provides non-mandatory Appendix R which outlines methods for estimating strains in a dent
  - Enhancements to the ASME formulas, suggested by recent industry research, have been incorporated
- Computations can be carried out using high resolution deformation data
- Local dent strain can be estimated by analyzing the deformed shape
- The Battelle prioritization model is then supplemented:
  - If a dent exhibits strain > 6% then considered higher priority

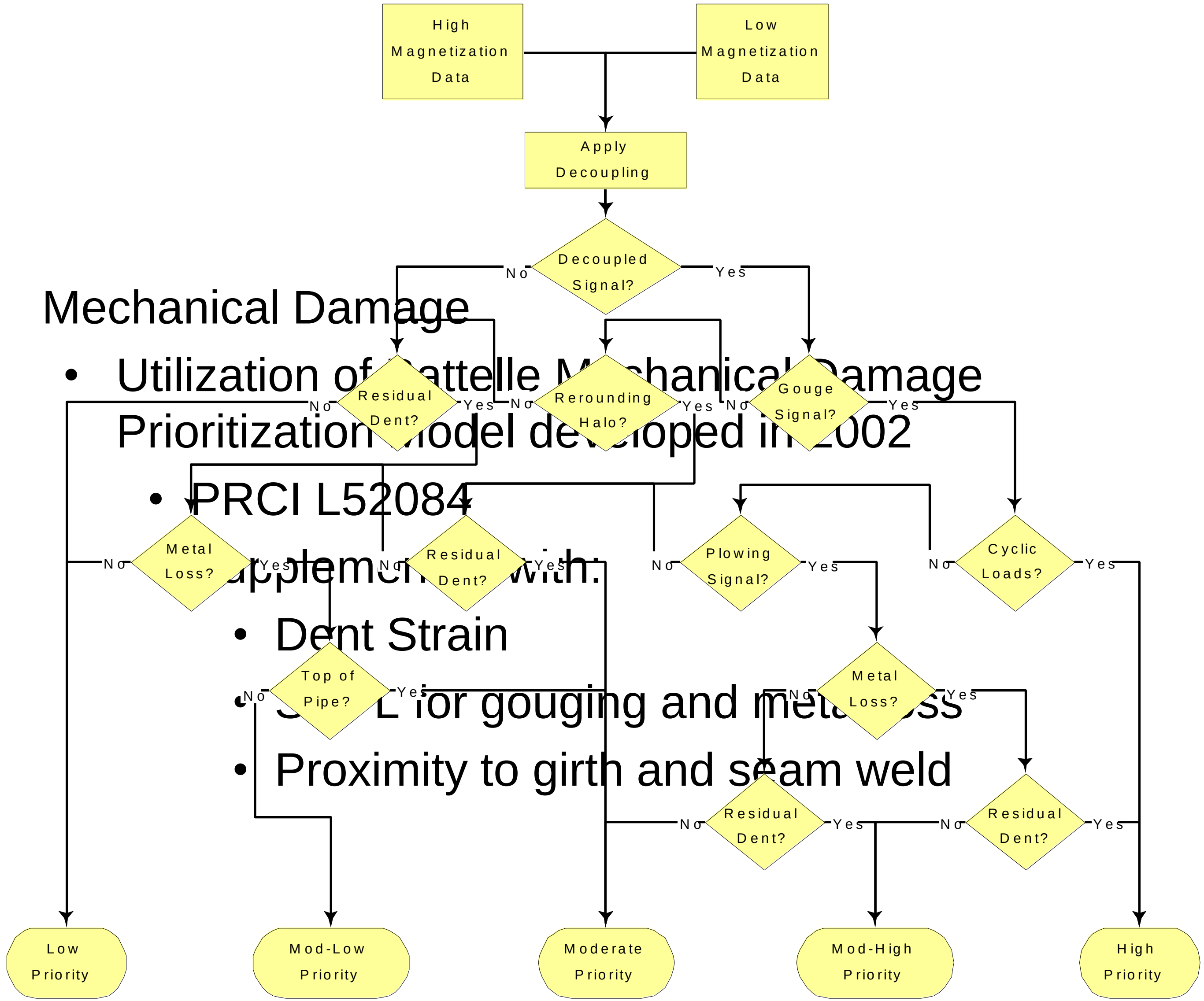




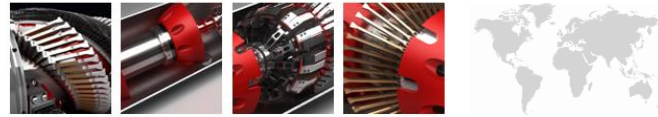
Prioritization



- Mechanical Damage
  - Utilization of Battelle Mechanical Damage Prioritization Model developed in 2002
    - PRCI L52084
    - Supplemented with:
      - Dent Strain
      - S[illegible]L for gouging and metal loss
      - Proximity to girth and seam weld



Prioritization



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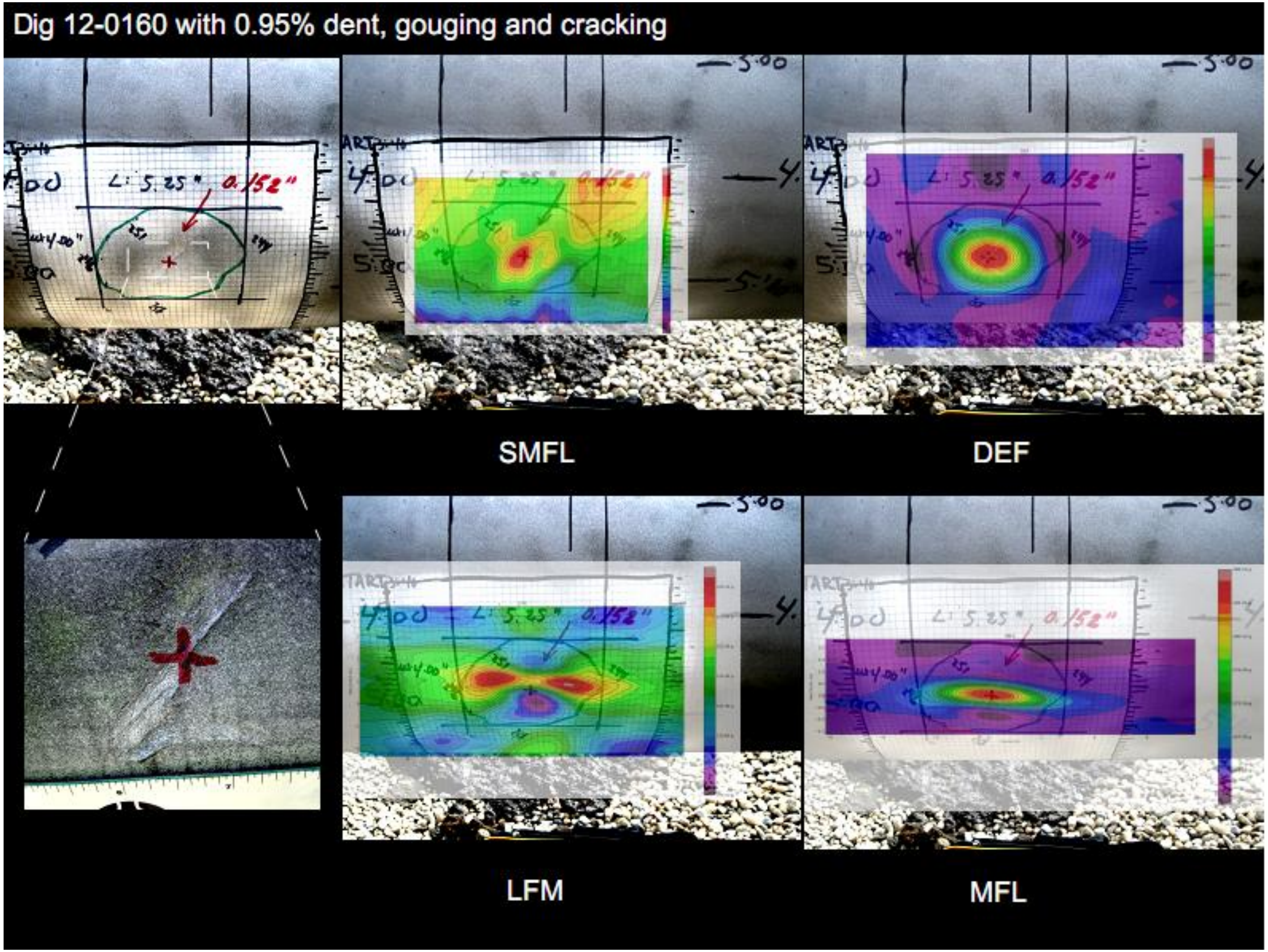
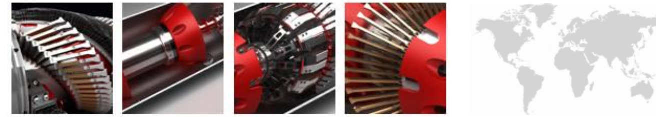
Dist Start	Dent Depth (in)	Orientation (Deg)	Description	Seam or not	Depth %	Dent Length (in)	Severity Number	Final Severity
563805.8569	0.32	146	Dent w/ Metal Loss - Re-rounded (3.61% Strain)		2.0%	4.24	1	High
659396.4219	0.19	6	Dent w/ Metal Loss (3.03% Strain)		1.2%	2.24	1	High
130172.3133	0.17	301	Dent w/ Metal Loss - Re-rounded (5.72% Strain)		1.1%	2.36	1	High
377391.8188	0.16	299	Dent w/ Metal Loss - Re-rounded, Found in SpirALL (4.75% Strain)		1.0%	4.24	1	High
565775.0268	0.16	334	Dent w/ Metal Loss - Re-rounded (2.27% Strain)		1.0%	3.18	1	High
366167.134	0.15	194	Dent w/ Metal Loss, Found in SpirALL (1.47% Strain) Cycled		0.9%	3.30	1	High
679479.7892	0.14	352	Dent w/ Metal Loss - Re-rounded, Found in SpirALL (1.67% Strain)		0.9%	11.43	1	High
286669.7504	0.14	65	Dent w/ Metal Loss - Re-rounded (2.67% Strain)		0.9%	1.53	1	High
274771.2529	0.12	103	Dent w/ Metal Loss - Re-rounded, Found in SpirALL		0.8%	3.06	1	High
281119.0863	0.47	173	Re-rounded (8.7% Strain)		2.9%	4.95	2	Moderate High
145897.5576	0.38	150	Re-rounded (8.56% Strain)		2.4%	5.42	2	Moderate High
82737.50682	0.24	352	Cycled		1.5%	4.71	2	Moderate High
604442.564	0.15	23	Re-rounded	Seam	0.9%	1.06	2	Moderate High
317119.5096	0.15	327	Re-rounded	Seam	0.9%	2.00	2	Moderate High
389412.3769	0.15	194	Dent w/ Metal Loss, Found in SpirALL (1.88% Strain)		0.9%	4.83	2	Moderate High
202455.0887	0.13	3	Re-rounded	Seam	0.8%	1.65	2	Moderate High
575501.0933	0.13	266	Cycled		0.8%	1.53	2	Moderate High
619295.5526	0.4	150	Re-rounded (4.58% Strain)		2.5%	5.42	3	Moderate
564414.8644	0.39	162	Re-rounded (5.37% Strain)		2.4%	4.71	3	Moderate
599695.4015	0.39	154	Re-rounded (4.7% Strain)		2.4%	6.95	3	Moderate
605422.7802	0.37	144	Re-rounded (3.03% Strain)		2.3%	4.95	3	Moderate
287642.8391	0.35	163	Re-rounded (4.5% Strain)		2.2%	3.65	3	Moderate
654564.5542	0.35	141	(2% Strain)		2.2%	4.48	3	Moderate
632760.8802	0.32	130	Cycled (3.3% Strain)		2.0%	3.65	3	Moderate
475118.7453	0.23	356	Re-rounded (5% Strain)		1.4%	2.12	3	Moderate
62031.35495	0.23	281	Re-rounded (2.65% Strain)		1.4%	3.30	3	Moderate
465704.099	0.21	321	Re-rounded		1.3%	1.41	3	Moderate
425597.8694	0.17	24	Re-rounded		1.1%	2.00	3	Moderate
121592.4458	0.16	316	Re-rounded		1.0%	2.71	3	Moderate
413966.4564	0.16	175	Re-rounded	Seam	1.0%	2.36	3	Moderate
325555.1375	0.15	33	Re-rounded		0.9%	4.59	3	Moderate
599471.0623	0.13	337	Re-rounded		0.8%	2.00	3	Moderate
434338.2514	0.13	45	Re-rounded		0.8%	2.12	3	Moderate
551561.8431	0.13	144	Cycled (2.38% Strain)		0.8%	4.01	3	Moderate
474250.7626	0.1	337	Re-rounded		0.6%	4.36	3	Moderate
363526.537	0.08	224	Cycled		0.5%	3.06	3	Moderate
142303.7616	0.01	284	Re-rounded		0.1%	0.82	3	Moderate
605031.3181	0.23	154	Re-rounded (3% Strain)		1.4%	2.59	4	Moderate Low
598349.445	0.23	169	Re-rounded		1.4%	2.71	4	Moderate Low
67242.64924	0.22	146	Re-rounded		1.4%	4.01	4	Moderate Low
432175.6281	0.21	159	Re-rounded		1.3%	6.83	4	Moderate Low
125388.8254	0.2	139	Re-rounded		1.3%	1.88	4	Moderate Low
442481.8584	0.19	146	Re-rounded		1.2%	6.60	4	Moderate Low
177801.1426	0.17	153	Re-rounded		1.1%	2.71	4	Moderate Low
223890.7645	0.16	127	Re-rounded		1.0%	3.42	4	Moderate Low
80958.45209	0.15	153	Re-rounded		0.9%	4.12	4	Moderate Low
195467.1257	0.15	138	Re-rounded		0.9%	5.18	4	Moderate Low
414568.2678	0.12	176	Re-rounded		0.8%	4.83	4	Moderate Low
61580.10436	0.09	200	Re-rounded		0.6%	2.12	4	Moderate Low
575503.2139	0.04	223	Re-rounded		0.3%	1.06	4	Moderate Low
575499.6501	0.04	196	Re-rounded		0.3%	0.71	4	Moderate Low
142072.992	0.02	231	Re-rounded		0.1%	0.35	4	Moderate Low

Case Study


Dig 12-0160 with 0.95% dent, gouging and cracking
SMFL
DEF
LFM
MFL

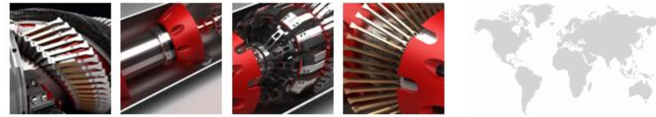
Conclusion



- Individual technologies have limitations when used independently as defined by NACE SP0102-2010

- Multiple Datasets (DEF+SMFL+MFL+RES):
  - Overcome limitations of individual technologies
  - Provide clarity of axial anomalies, and because of combination of Axial MFL with SpirALL,
  - More effectively detects and characterizes crack-like and metal loss anomalies whether seam or pipe body
  - Accurately detects and characterizes 3rd party damage for prioritization
  - Will ultimately translates into greater accuracy of results
  - Proven to eliminate unnecessary seam anomaly excavations

Thank You!



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