MHG Business and Field Applications presented to NACE, Jubail Chapter December 2010

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Physical Acoustics

PHYSICAL ACOUSTICS LIMITED
A MISTRAS Holdings Company

Overview of Mistras' Businesses

MISTRAS Holdings Group

International Subsidiaries & Affiliates

PHYSICAL ACOUSTICS CORPORATION

Innovative Leadership in Acoustic Emission Since 1968

NDT Automation

Advanced Automated Ultrasonic Inspection Systems

Vibra•Metrics®

Vibration Sensors and Systems for Predictive Maintenance

QSL Plus Quality Services Laboratories, Inc.

CONAM PCMS

CONAM The First Choice for Quality Services

Complete Engineering & NDT Inspection Services And Software

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We Serve the Public Worldwide . . . by providing quality products and services needed to enhance the environmental safety for gas and oil pipelines, petrochemical pressure vessels and storage tanks, strategic components of nuclear and fossil fuel plants, metal and concrete bridges, advanced aerospace composites, and much more.

Our Group develops, manufactures and employs leading-edge technologies for nondestructive testing and predictive maintenance, such as advanced acoustic emission, ultrasonics, eddy current, radiography, vibration monitoring and resistivity systems. In addition, we provide on-line asset management by employing Internet-based data acquisition and real-time assessment of the world's industrial & public infrastructure.

Physical Acoustics MHG Group

- $275m specialist engineering and advanced NDT/inspection products/services company operating worldwide.
- $15m annual R+D contracts.
- >1500 people, ~100 at H.Q. in Princeton NJ, rest worldwide, ~700 certified inspectors, ~50 Phd/MSc in R&D.
- Specialist Technologies: Acoustic Emission, Advanced Automated Ultrasonics, Vibration, Resistivity.
- In-house software, electronic design, SMD and Hybrid electronics manufacture, sensor development and manufacture.

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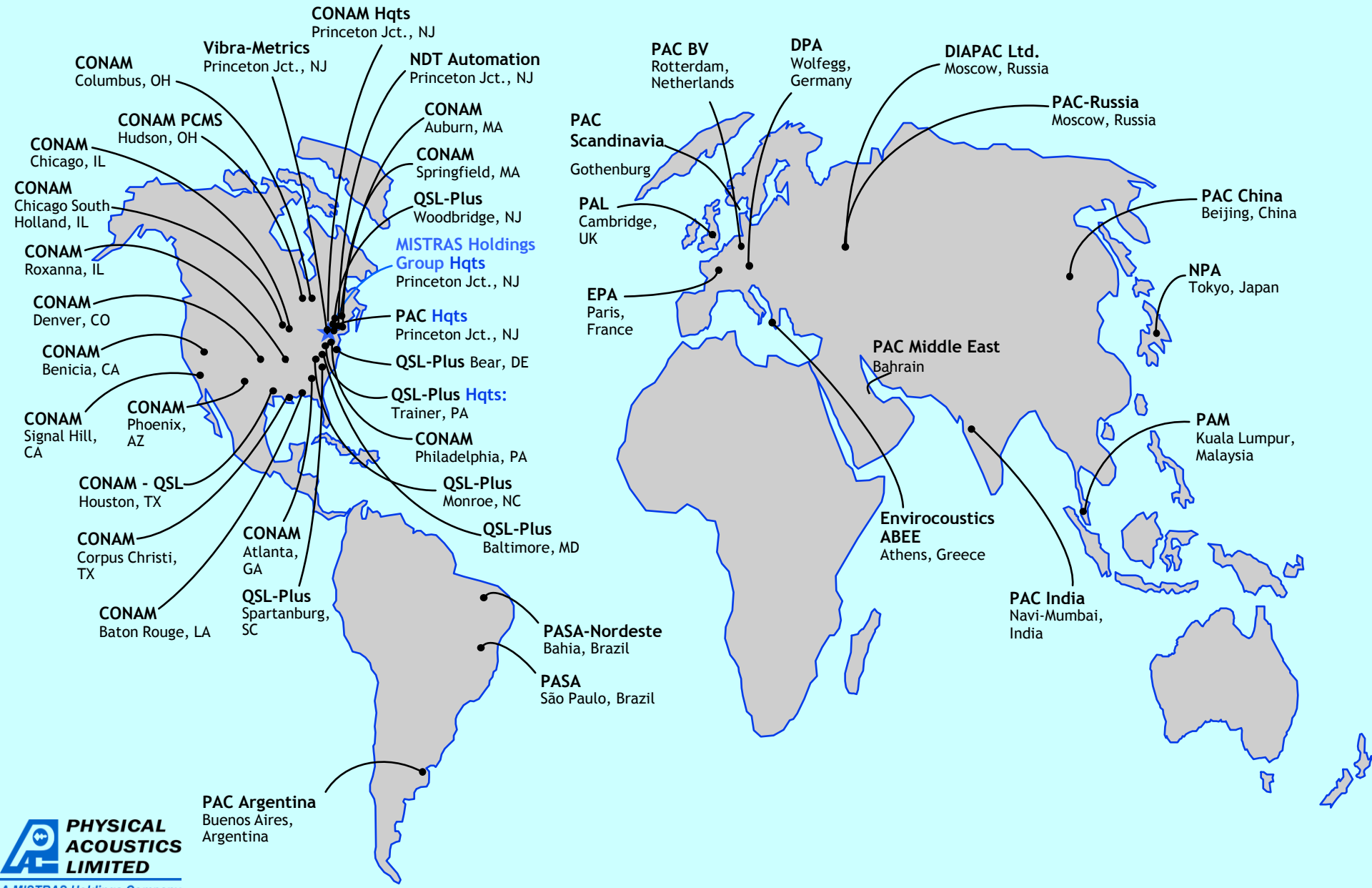
MISTRAS Group Locations



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Tank testing services

- Acoustic Emission Tank Floor Testing
- Ultrasonic testing of Annular Ring plates
- High-Speed Corrosion Mapping of tank walls and roofs

In-Service Tank Testing

Maintenance Planning for Tank Farms

SHELL: LSI (UT) Corrosion Mapping

NOTE: If All Tests Show Good condition the Period In-Service is Extended, delaying costly cleaning for internal inspection.

ANNULAR RING: TALRUT™

Long Range UT Mapping.

FLOOR: TANKPAC™ Test

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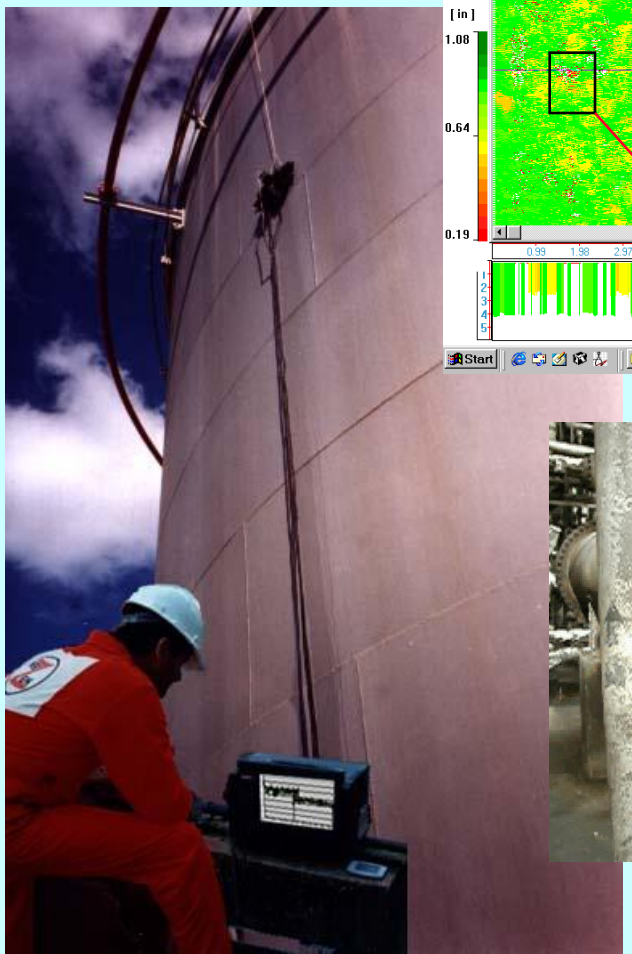
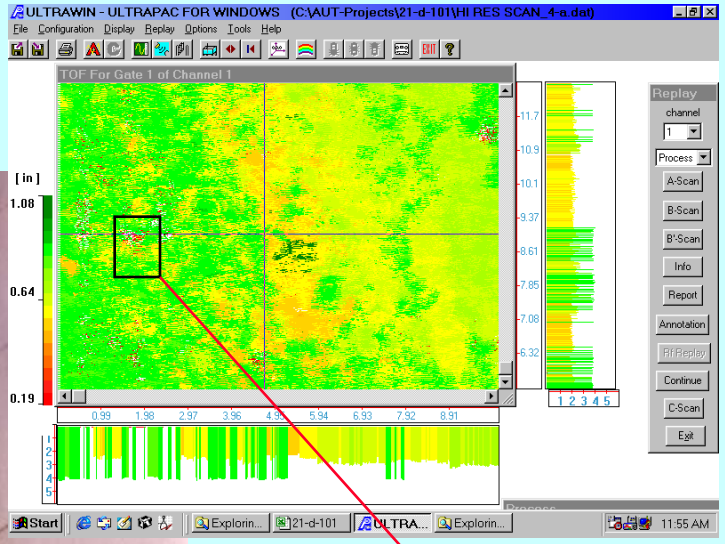
Shell LSI-UT Fast Corrosion Mapping

- LSI-UT Mapping:
  - Ground level access.
  - C-Scan at up to 5000 sq.cm per minute *(10,000 with LSI-2).*
  - Quantitative results.
  - Identifies HAZ corrosion.
  - Can run horisontal for weld HAZ inspection.
  - Export to Excel or UTIA for FFS calculations.
  - Operates on poor surfaces.





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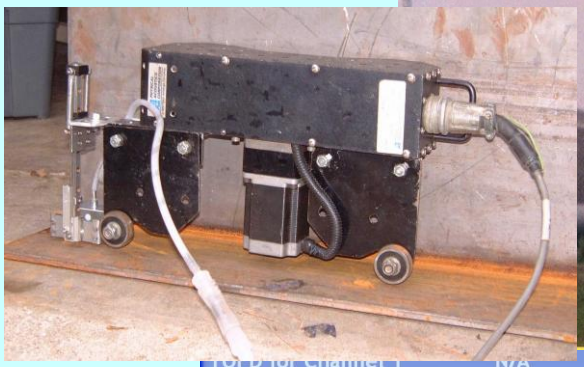
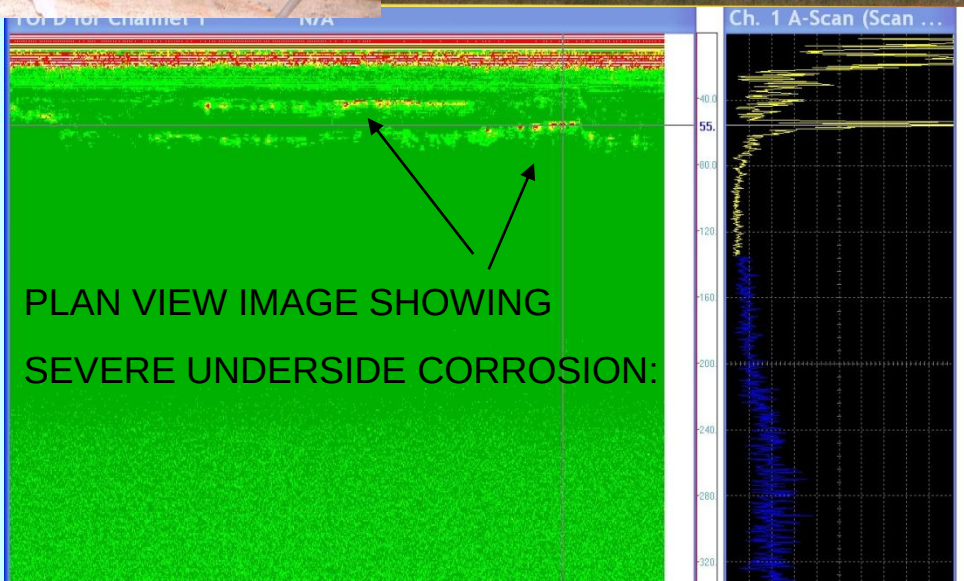
TALRUT Annular Ring Test

- TALRUT
  - Inspects critical area, ~30cm in.
  - Automated UT, Plan image.
  - 40 m/day.
  - Indicative, not quantitative.

Collapsed Gas-Oil Tank from annular corrosion:



SHELL:



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Tank Floors are the only structural part of a tank with no access for inspection during operation

Why TANKPAC™ ?

- TANKPAC™ is still the ***only*** procedure to have been ***independently verified*** by subsequent internal inspection of a large number of tested tanks.
  - The results published!!
    - ECNDT 1998 Shell, Dow Chemical, KPE etc
    - ECNDT 1998 Saudi Aramco
    - 2000 French Petroleum Institute Study

Strategy for Using TANKPAC™ The Three Scenarios:

- A ***Under-maintained*** and leaking tanks;
  - » Use TANKPAC™ to test all tanks and direct NDE to worst ones first.
  - » Site “X” leakage incidents reduced from ~3/year, to zero in past 3 years!!
- B ***Over-maintained*** tanks, many opened and no repairs carried out or could have lasted several more years.
  - » Opportunity for TANKPAC™ to defer internal and save $’s on unnecessary cleaning costs!! (Aramco savings >$25m p.a. ref. ECNDT paper)
- C ***Perfect*** tank maintenance practice, all tanks taken out and repaired before they leak, few tanks taken out that do not require repairs.
  - » How do you do this??? --TANKPAC™ !!!

Cost Saving Example -1

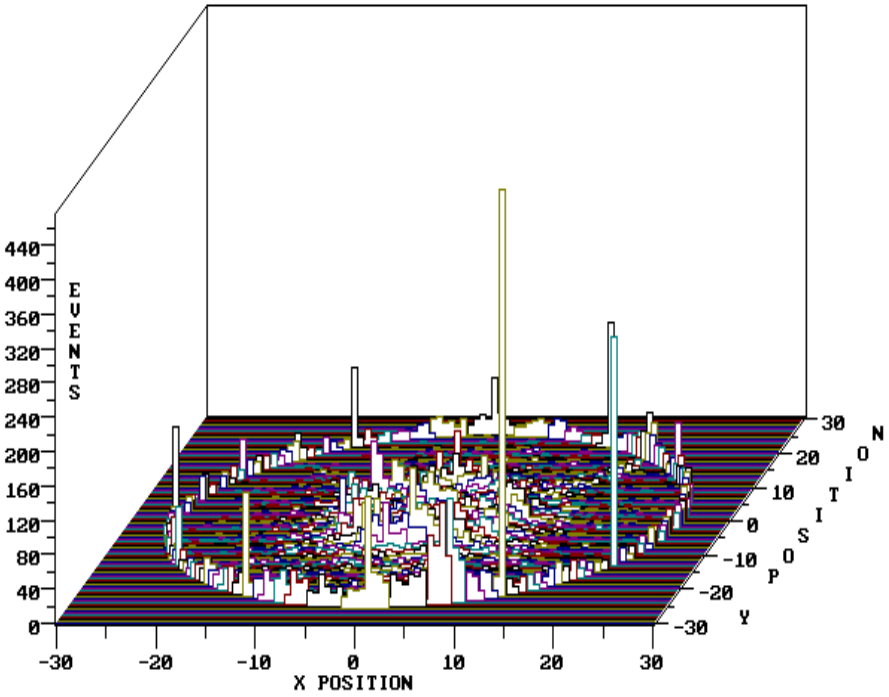
- **OLD method**: Company opens for inspection 100 very large tanks per year at a cost of $250,000/tank including cleaning: **cost: $25m**
- Historically 55% needed no repair
- **USING TANKPAC:** test 100 tanks at $20k per tank
- Open 45% needing repair and so clean and inspect 45 tanks at $250,000 per tank. **cost: $12.25m**
- **Overall saving $12.75m**

TANKPAC™ tests around the world

- Europe
  - UK, Netherlands, Germany, France, Italy, Spain, Ireland, Russia, Greece, Czech Republic, Belgium
- Middle East:
  - Saudi Arabia, Kuwait, Oman, UAE, Bahrain,
- Africa:
  - South Africa, Gabon, Ivory Coast,
- South America:
  - Brazil, Argentina
- Asia and Far East:
  - India, Japan, Malaysia, Singapore, Indonesia, Australia, New Zealand
- North America:
  - USA

Hot Fuel Oil Tank 50m

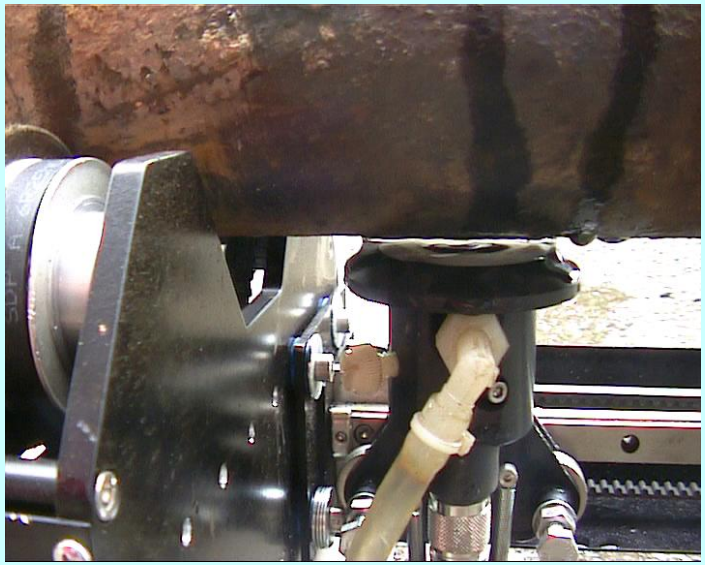
- “E” grade overall.
- Annular ring very active.
- Dug underneath annular ring in most active areas:
  - Up to 8mm loss of metal on 15mm annular plates
- Tank shut down immediately, avoiding failure (see next slide).

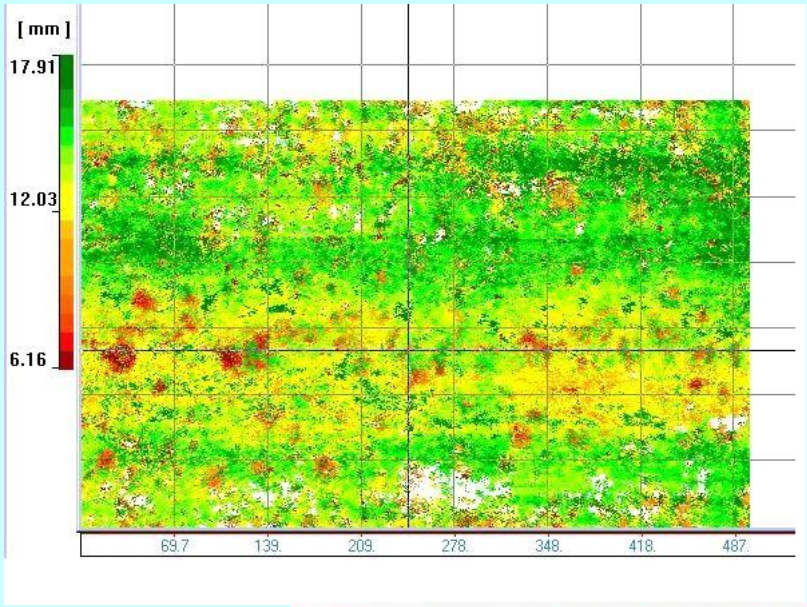


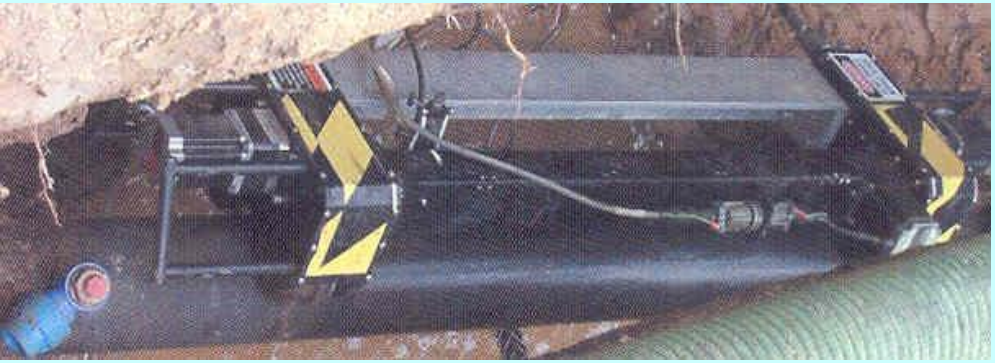
Other applications of the LSI system

- Corrosion Mapping of buried pipe-work
- Process pipe-work inspection
- Heat exchanger shell Corrosion Mapping
- Corrosion mapping of buried vessels
- Large Area Corrosion Mapping

LSI-UT Corrosion Mapping
Buried Corroded Cast Iron Pipe







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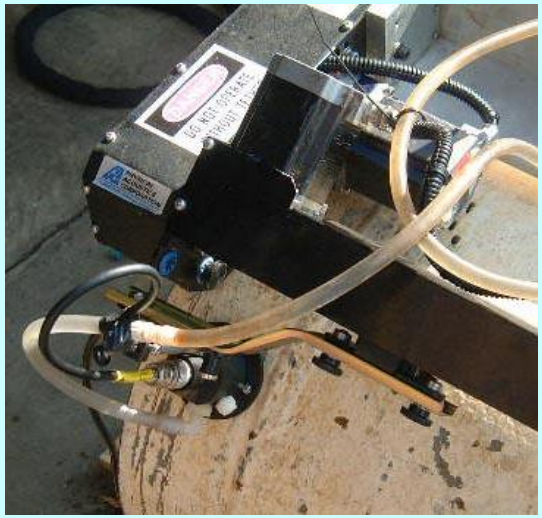
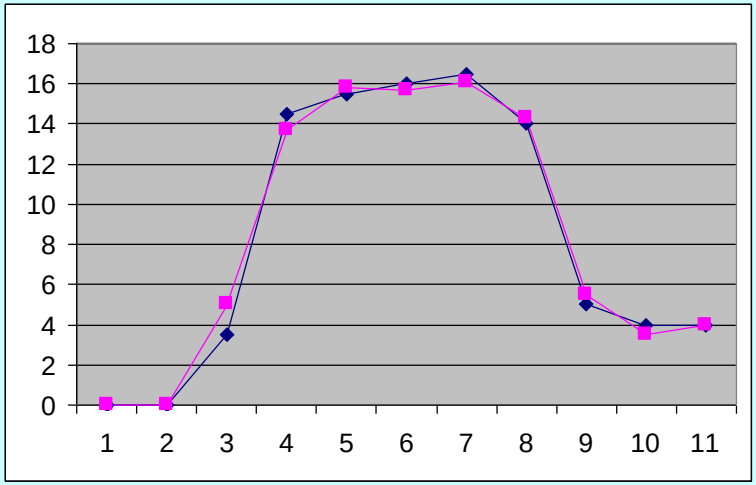
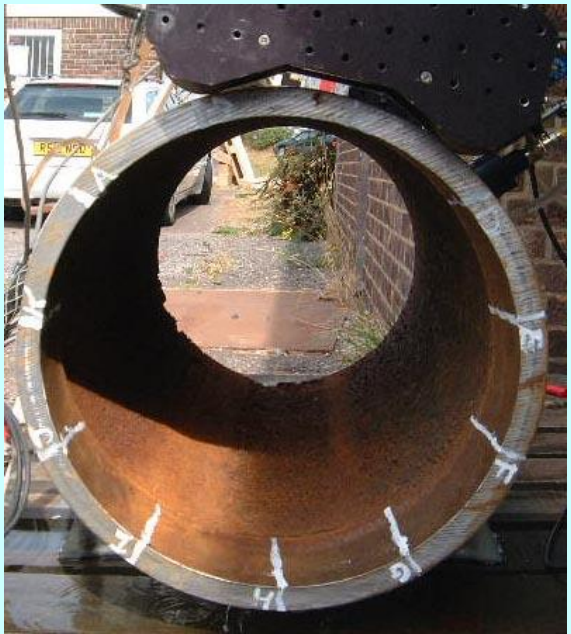
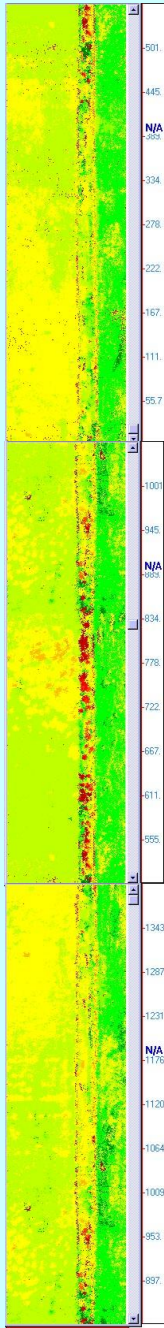
LSI-UT Corrosion Mapping

Process Pipe-work –Including Welds









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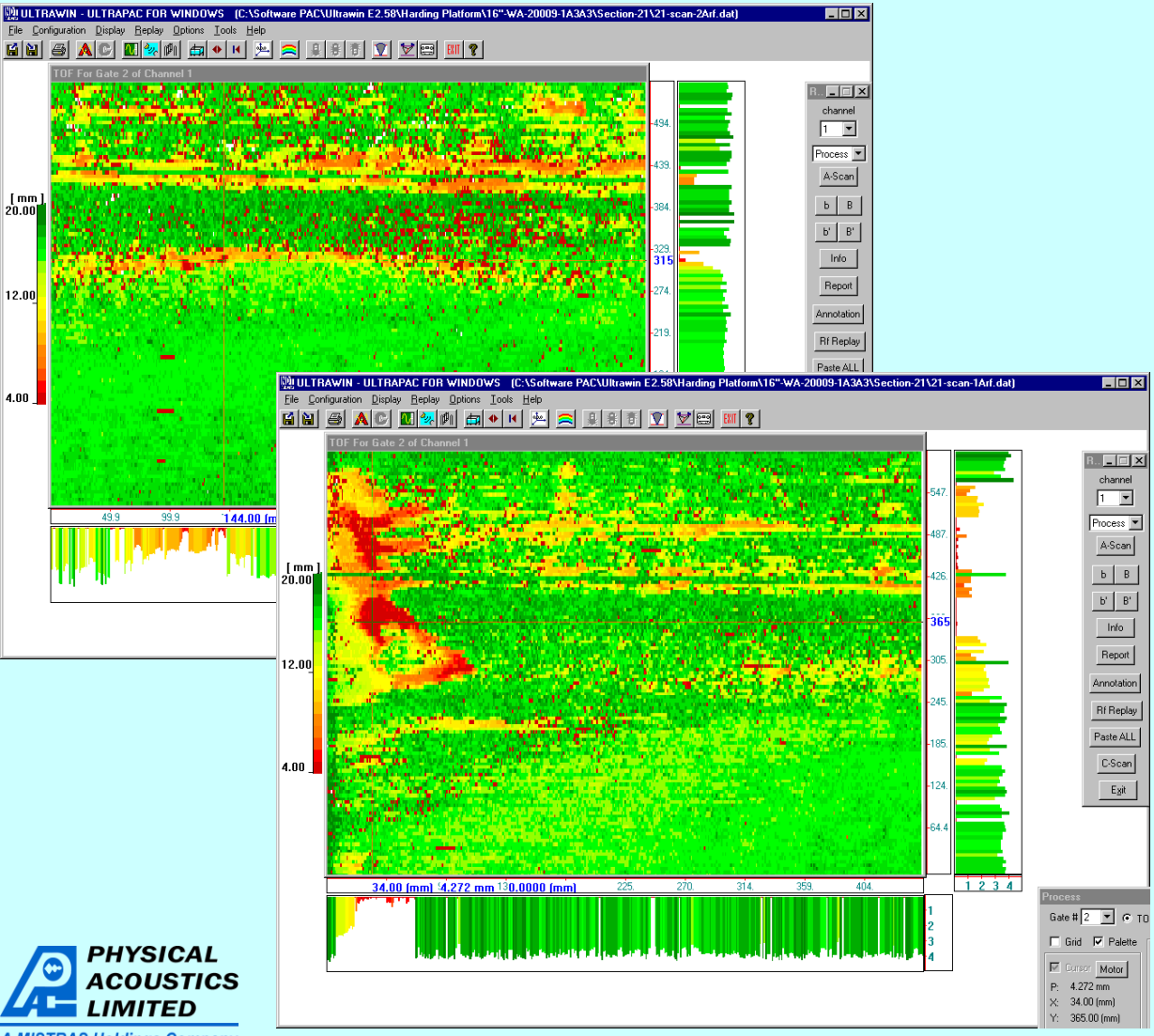
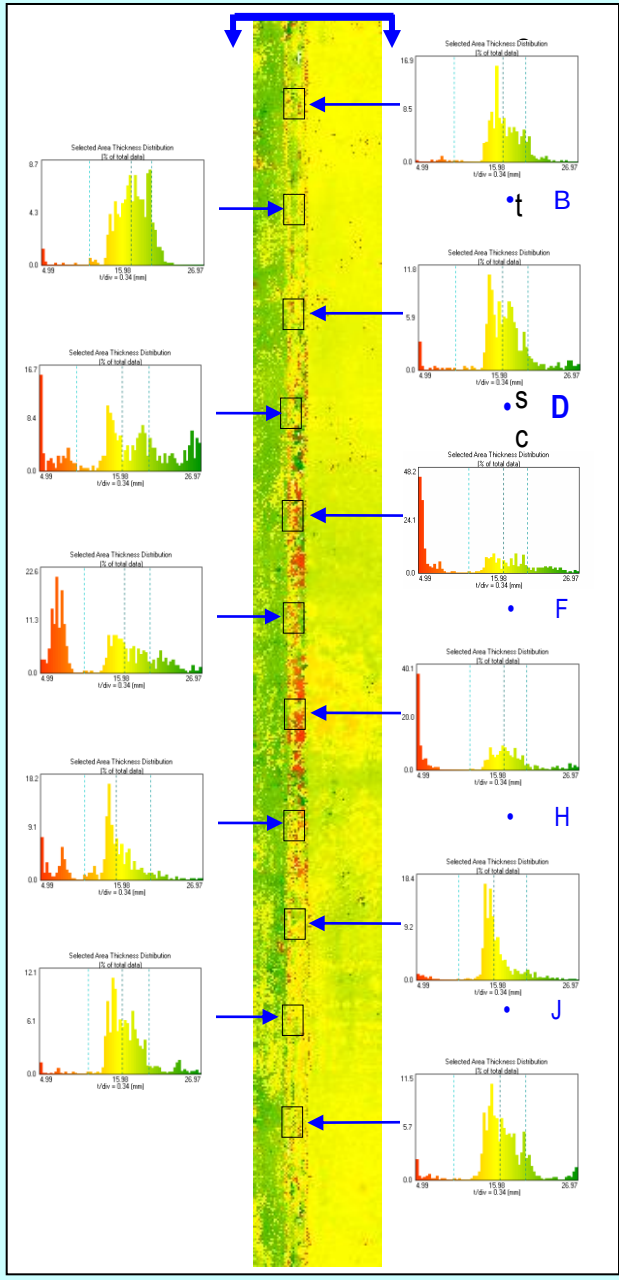
LSI-UT Corrosion Mapping on Pipe-Work
16” pipe 100% mapped 1 metre/10 minutes





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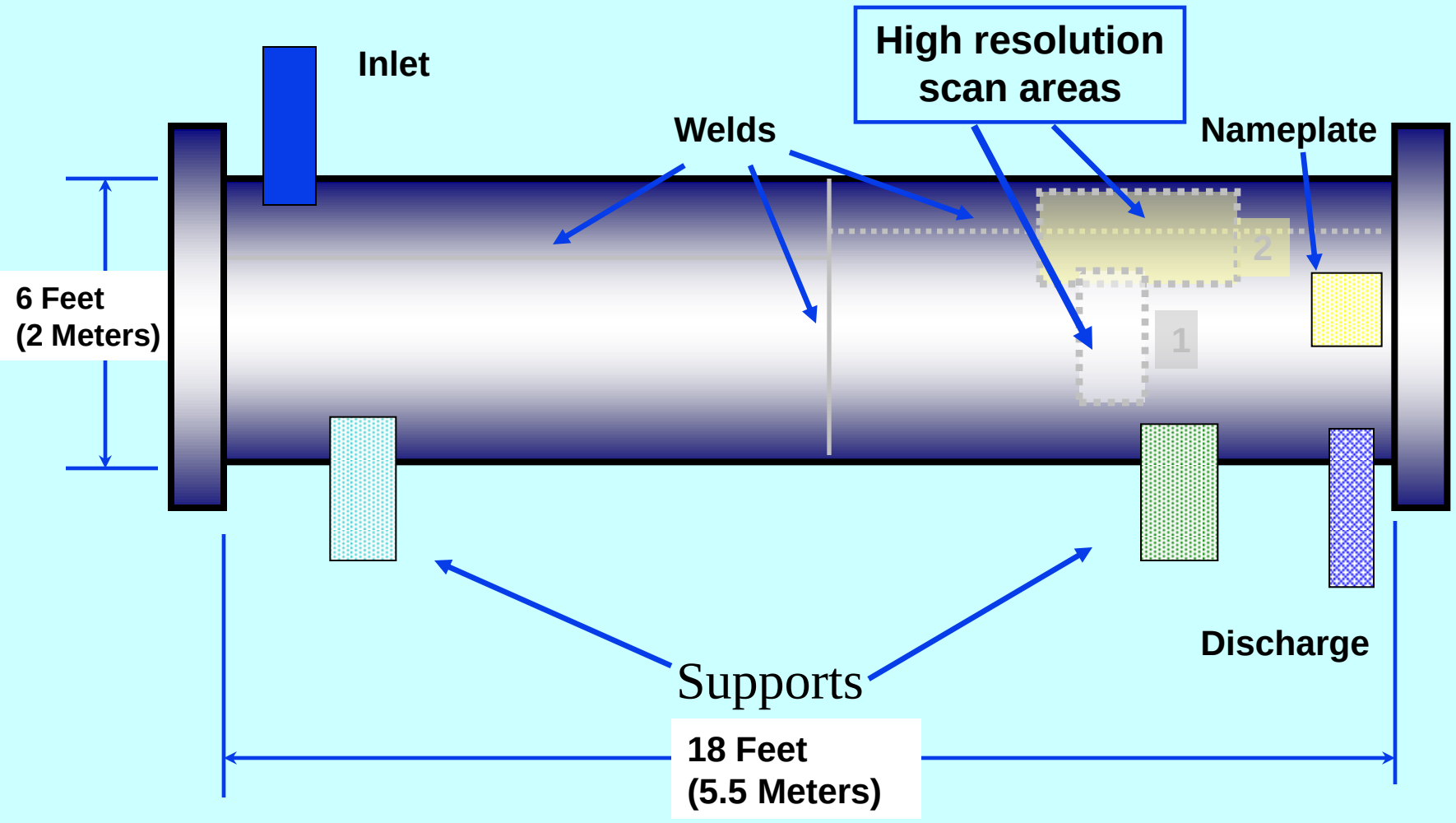
Example of Heat Exchanger Shell Inspection
100% Area C-Scan plus selected High Resolution scans



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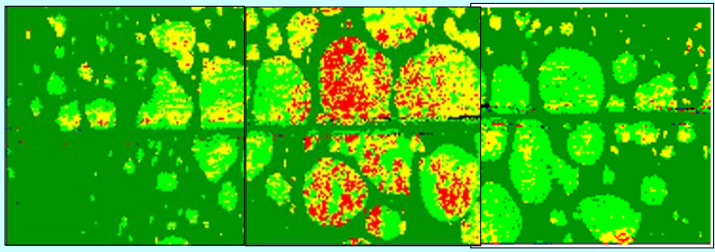
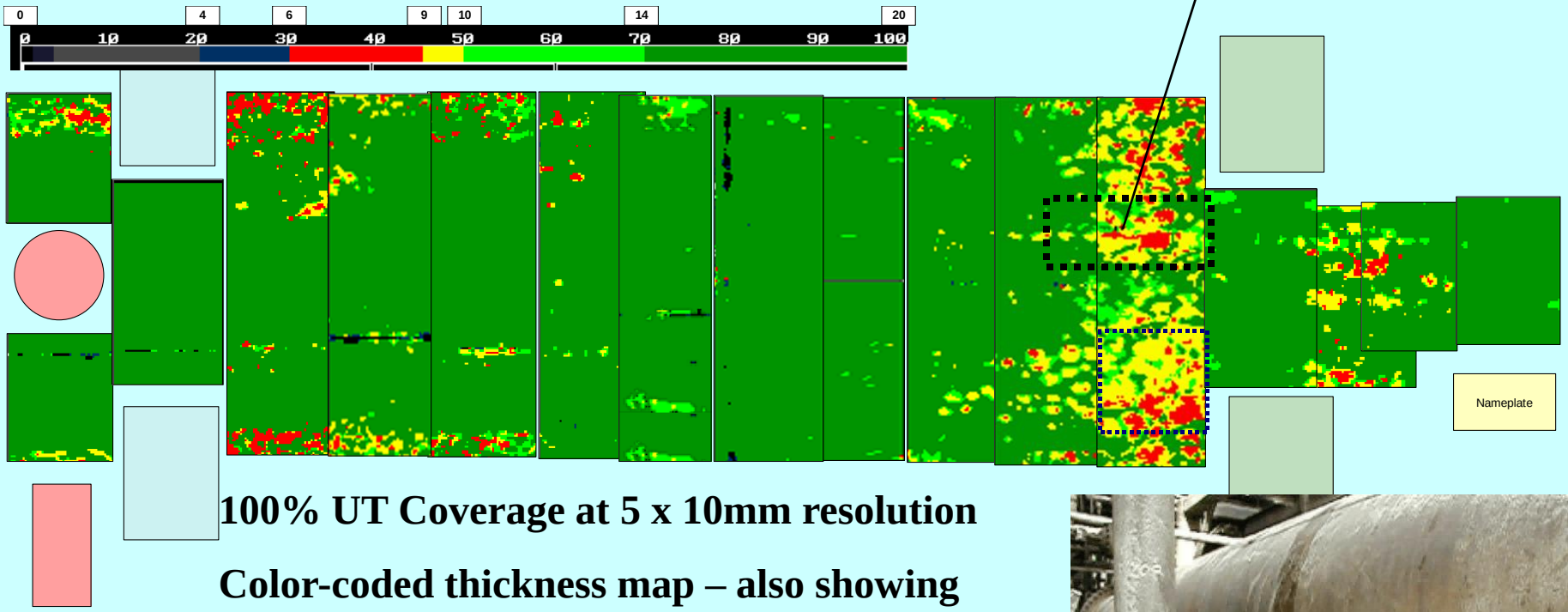
Example of Heat Exchanger Shell Inspection Imaging Results with LSI System 100% Surface Area C-Scan Scan Time: One shift



HR scan 1 x 1mm, 750 x 250 mm area



100% UT Coverage at 5 x 10mm resolution

Color-coded thickness map – also showing location of obstacles and supports – top of tank is at center of scan. Vertical axis is tank circumference.

1mm x 1mm high resolution follow-up scan.

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LSI APPLICATIONS - INTERNAL INSPECTION

USED FOLLOW UP AE TESTS ON THE 1500 BURIED PRESSURE VESSELS.....COMPLETE SOLUTION.....

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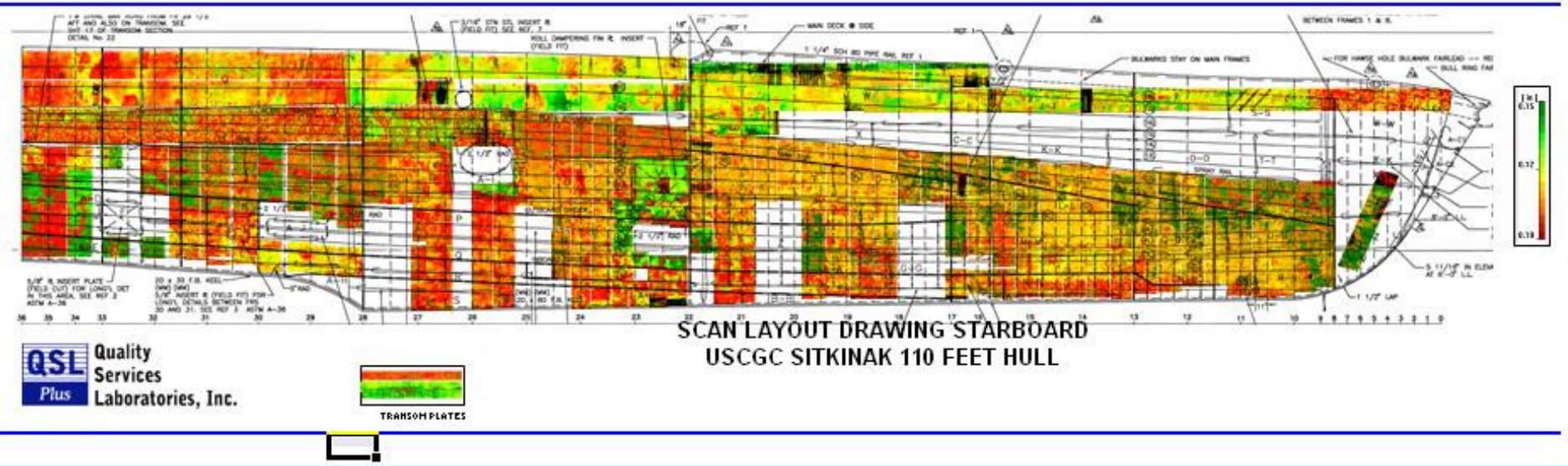
Buried Drum

- Buried 5m diameter, 35m T-T.
- Nominal 32mm with 3mm corrosion allowance.
- LSI scanned from inside.
- 840 scans 500mm x 1300mm (65,000 readings each, total 54,600,000 thickness measurements).
- Measurement resolution 0.1mm.
- Dual range gates, 3-33mm and 28-33mm.
- 10 days scanning time.
- Indications:
  - Grinding marks
  - Plate inclusions.

Corrosion Mapping On Ships and Vessels



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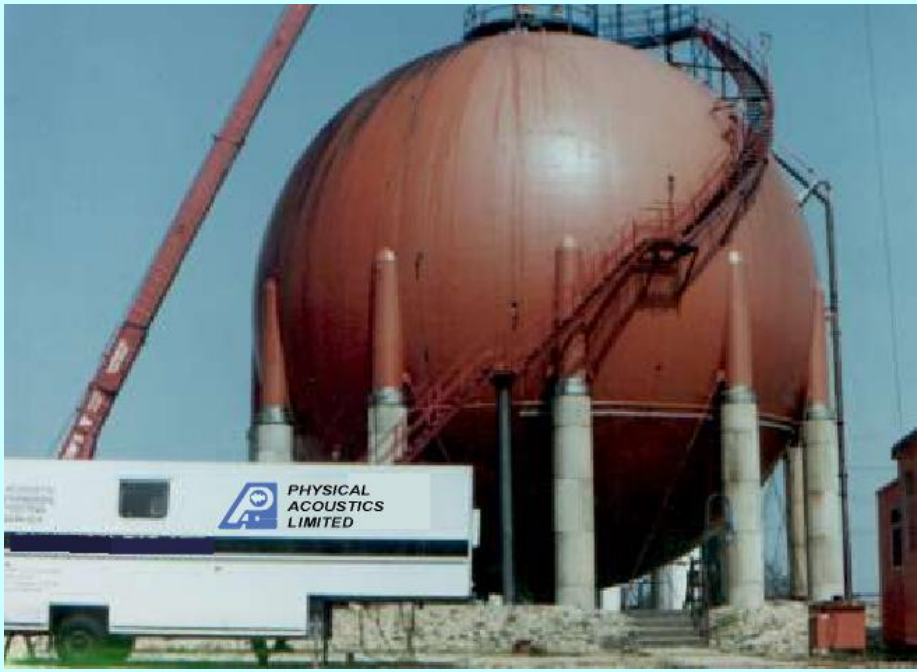
Acoustic Emission Testing of Pressure Systems and Vessels

- Spheres, Bullets, Columns
- High and low temperature process systems
- Pipe-work systems
- Cryogenic Storage vessels
- Insulated vessels
- Continuous Monitoring solutions

AE-Storage Spheres and Bullets

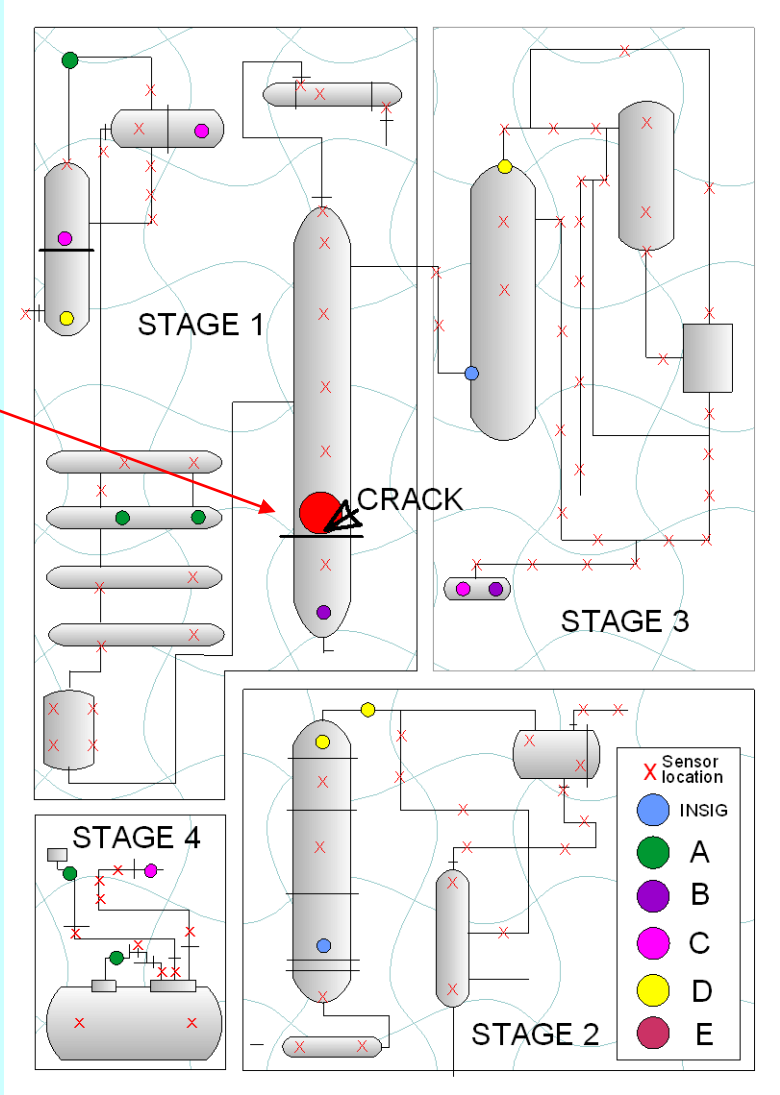
- Majority tested on-line using MONPAC™ procedure (Monsanto licence based on >1000 tests).
- Pressure raised by product or gas injection.
- Abseilers used for sensor placement.
- 95% “good” resulting in continued operation.
- >1000 tests in Europe.
- Procedure adopted by ASME for new vessels.



134A Process Plant Schematic showing MONPAC grades.

Hastelloy Process System.
Pneumatic test with MONPAC AE Monitoring.

CRACK Confirmed by local inspection at “E” grade location 12 months later when Column was separated at flange.



To Date test Carried out on entire process system on Four Occasions at start of Planned Shutdown.

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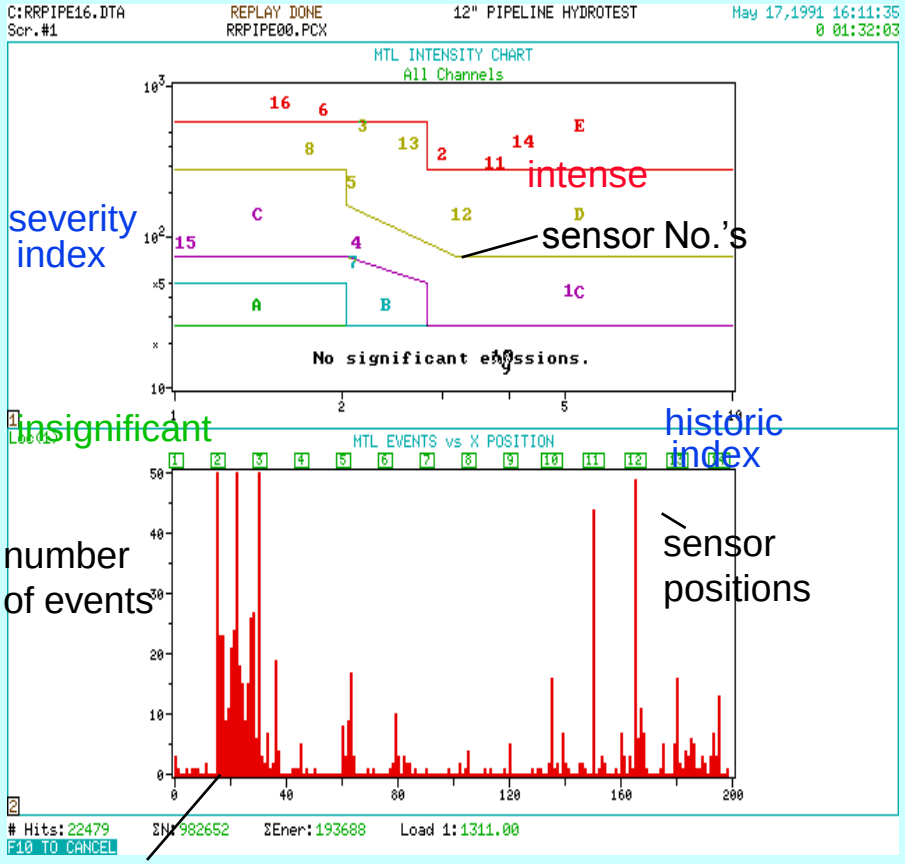
Acoustic Emission testing of Pipe-work

- Sensors spaced 10-50 metres apart.
- Procedure “A” requires pressurisation.
- Procedures “B” requires line to be “dead” and in a quiet area of plant.
- “A” gives direct integrity
- “B” highlights active corrosion.
- Leaks also detected if turbulent.

Intensity evaluation showing major damage



AE sources along 200 metres of line

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30,000 ton Cryogenic Tank

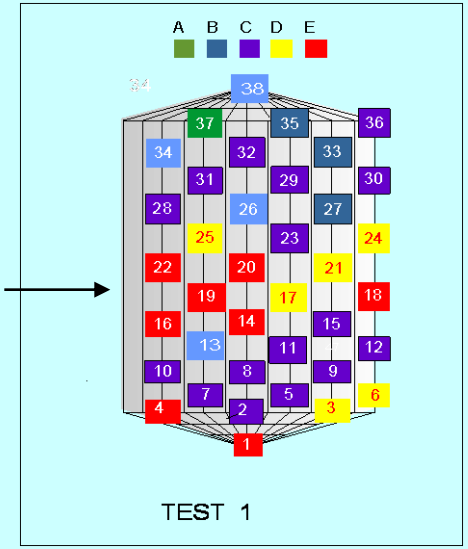
- 10 year Re-certification:
- Design review.
- In-service AE test:
  - MONPAC™ procedure.
- Other NDE:
  - ACFM for roof welds and hold-downs.
  - C-Scan for roof corrosion.
- Savings >>$1m.

Concrete Bund Wall, inner steel tank.

316 Stainless Acid Column (4m dia. x30m)

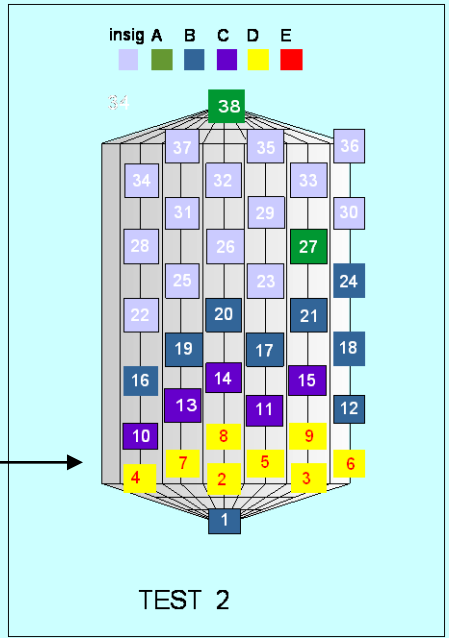
- 30m x 4m, concern about ext. Chloride SCC under insulation.
- MONPAC test using nitrogen:
- Follow-up NDT (DP) found through-cracks.
- Repaired by patching, cleaning and treating.

External SCC, (through-wall)



- 2 years later follow-up MONPAC test indicated further problems:
- Knifeline corrosion on internal weld HAZ.
- 16 shifts of welding to repair.
- Corrosion was caused by process running column “lean” to save $’s.
- Major incident avoided.

Knifeline corrosion of weld HAZ (internal to 40%)



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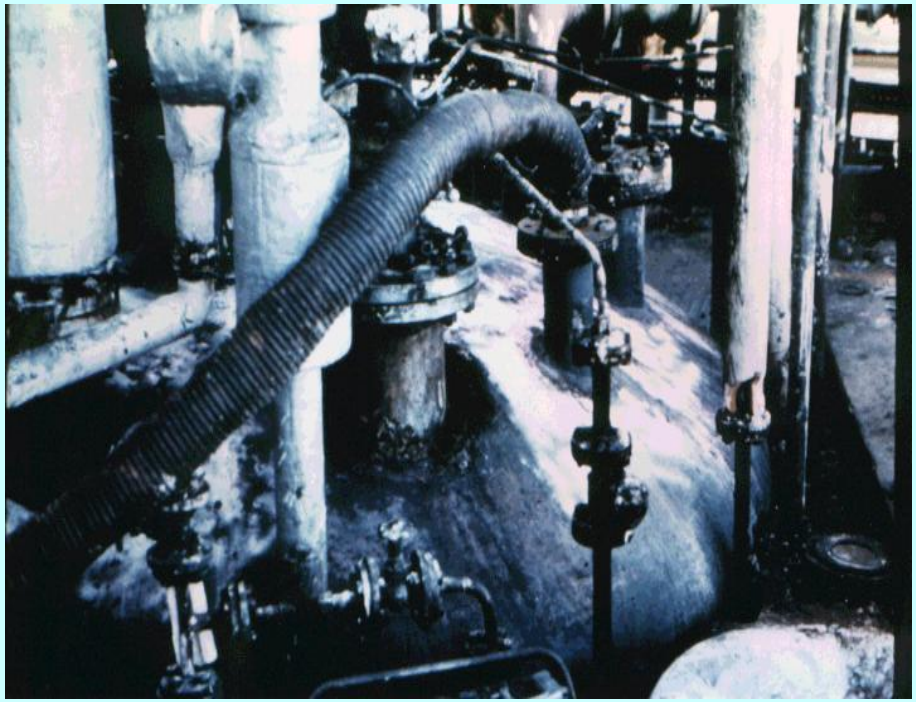
Stainless Reactors with SCC

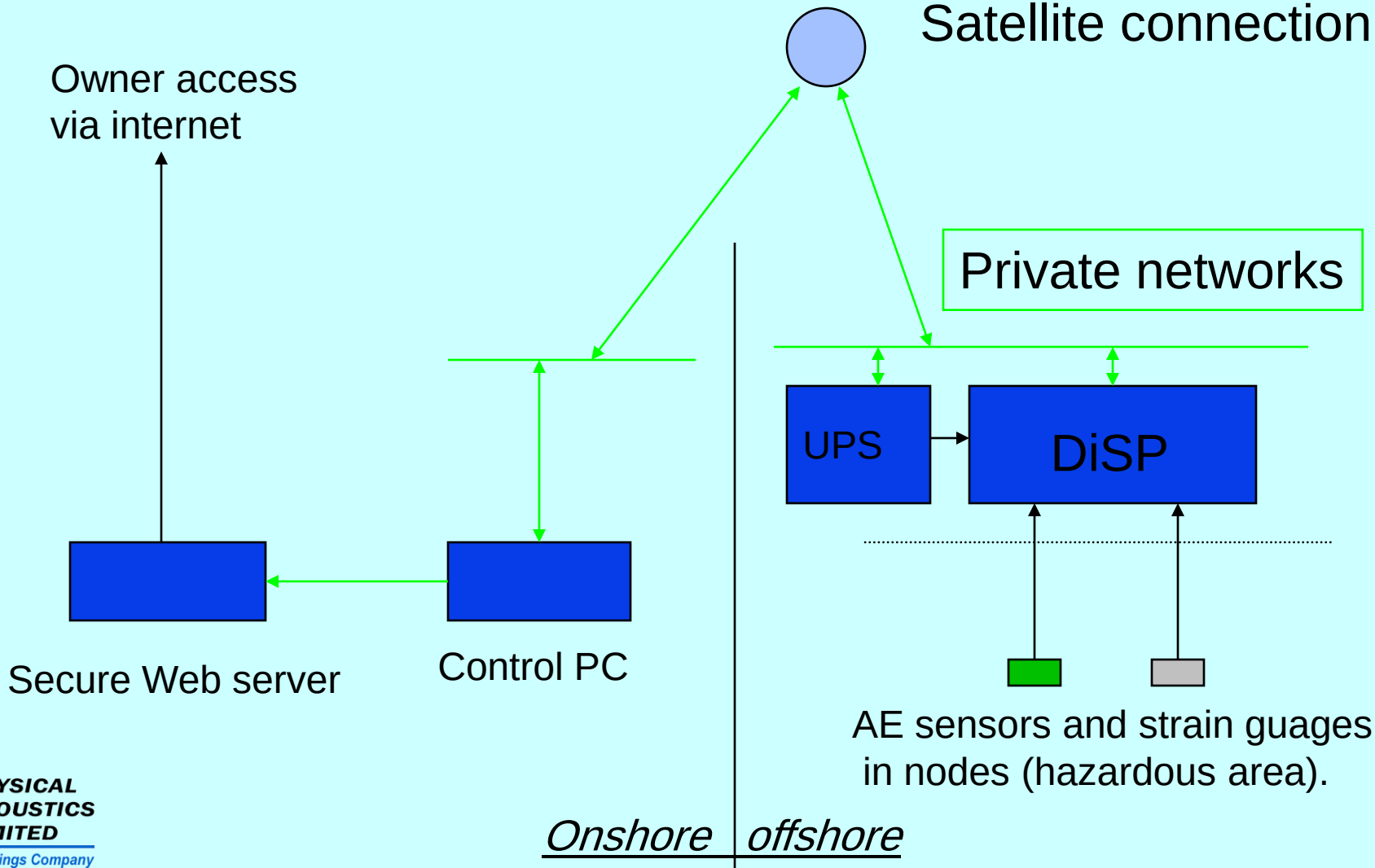
- Operating 0.5 bar:
  - AE test 0.55 bar.
  - design 6 bar.
  - Nitrogen injection during temporary process stop.
- MONPAC “E” grade on top heads of two reactors. (five tested at same time).
- At shutdown SCC from inside, 80% through wall, confirmed. Top heads were replaced.
- Advance warning saved >$2 million production.



Ammonia Converter

- Multi-layer construction not inspectable conventionally, layers transmit LF sound at higher pressures.
- Thermal stress during startup/cool-down is main concern.
- Waveguides used due to the temperature.
- “Signature” from AE source location is compared at each startup/shutdown.

Remote Monitoring- Typical System Schematic



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Hot Blast Stove Domes

- Concern about nitrate SCC.
- 32 AE sensors on each of four stoves.
- 32 channel AE system switches between stv.
- Manufacturing defects and fatigue cracks located (cycle 20 mins.)
- 24 hrs./quarter gives sufficient data.

Steel-Hot Blast Stove Dome-Example (or "don't ignore E- grades")

- Concern about nitrate Stress Corrosion Cracking.
  - » Stove Dome has blown off in several countries!!
- ~32 AE sensors on each of three stoves.
- In-service monitoring for 24 hours per stove.
- Serious problems identified by AE test, c/d/e grades.
- Results not acted upon.
- Stove dome blows off 10 months later!!!

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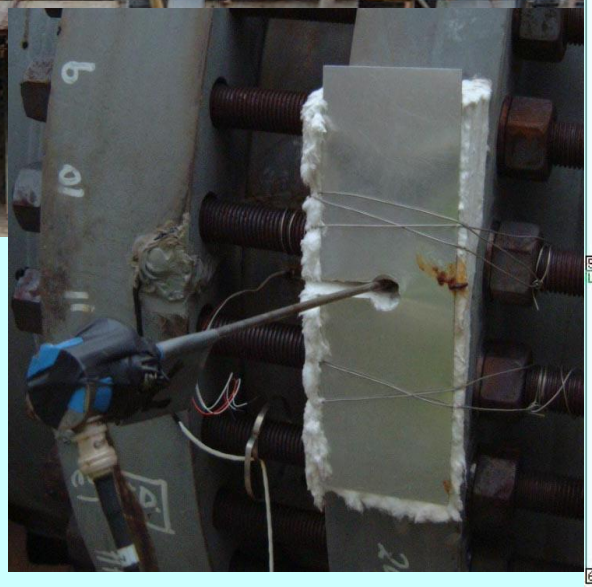
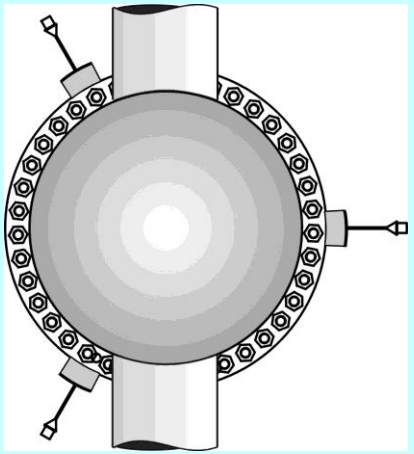
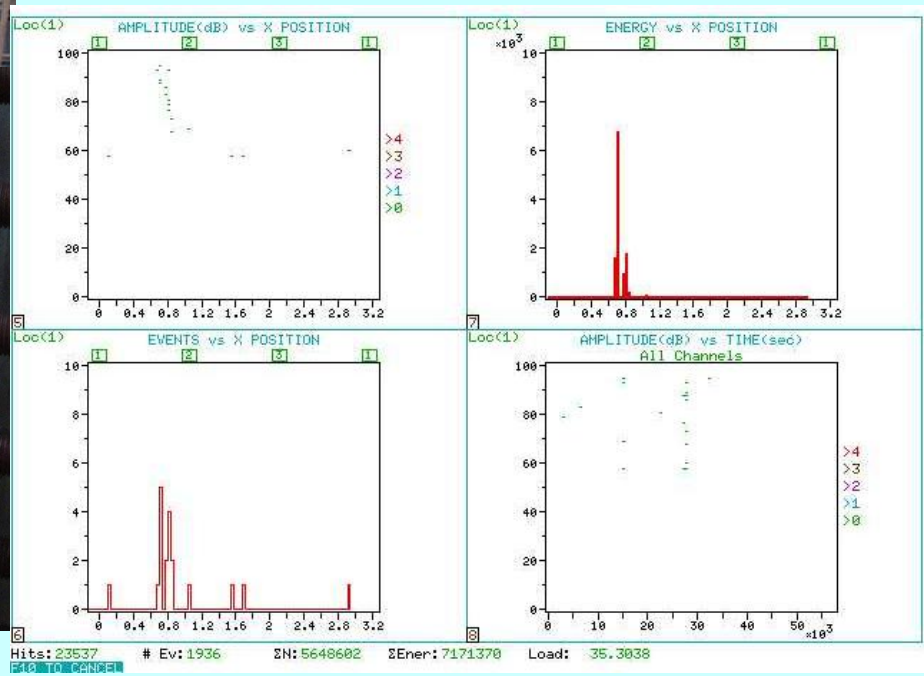
14 Heat Exchangers-Bolt Cracking Extended Permanent Monitoring







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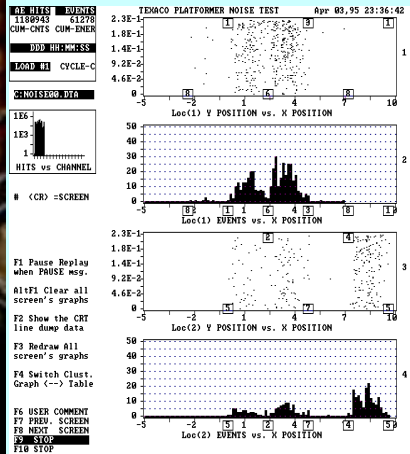
Platformer Reactor

- 48m high, 3m diameter
- 3 vessels “stacked” on top of each other.
- Continuous process with catalyst.
- Stainless internals and lining.
- 550 degrees C operation, 64 welded waveguides.
- High thermal stresses:- cracks during start/stop.
- AEM during shutdown.



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Methanol Secondary Reformer Continuous "Alarm" Monitoring

- Refractory lined vessel.
- Hydrogen and steam at 40 bar and 780>1300 deg.C.
- 100mm thick shell.
- "Blow-Out" at another unit is reason for alarm system.
- Refractory failure results in shell burn-through in less than 2 minutes.
- Thermal monitoring too slow to stop burner.

VPAC-Quantification of through-valve leakage

- BP Licence.
- Intrinsically safe.
- Simple/quick.
- Quantitative: litres/min.
- >500 systems in use.
- Savings:
  - BP Kwinana 14k tons/yr.
  - Mobil US $3m to $12m/site.
  - Shell UK 3-5 systems/site.

Microsoft Excel

File Edit Formula Format Data Options Macro Window Help

Normal

K4

PTCVG.XLS

	A	B	C	D	E	G	H	I	J	K
1		VPAC GAS LEAK CALCULATION--PHYSICAL ACOUSTICS								
2	N.B. The signal level to be entered is the reading on the LCD display of the 5							Data Entry Form VPAC-1		
3	Fluid density is used only in the calculation of tonnes/year l							Complete B-H+I for t/yr.		
4	Fax completed data sheet to PAL on +44 (0)1954 231102							Contact:		
5	COMPANY:	XXX Refining			LOCATION:		Unit 2b		Date:	09/02/95
6	Test	Valve	Signal	Pressure	Inlet	Gate	Ball	Fluid	Leak	Loss
7	Point	I.D.	Level	Difference	Size	Valve	Valve	Density	Rate	
8			(dB)	(barg)	(ins NB)	(y/n)	(y/n)	(kg/m^3)	(l/min)	(Tonnes/yr)
9	e.g									
10	1	PRC 401B	29	1	6.0	N	N	1.25	13.5	8.884
11	2	SV 411	16	25	4.0	N	N	1.25	0.9	0.624
12	3	SV 412B	15	21	4.0	N	N	1.25	0.9	0.591
13	4	SV 412A	16	21	4.0	N	N	1.25	1.0	0.656
14	5	D 207	14	21	2.0	N	N	1.25	0.4	0.278
15	6	SV 255	15	21	2.0	N	N	1.25	0.5	0.309
16	7	D 206	13	21	2.0	N	N	1.25	0.4	0.251
17	8	D 202	86	17	4.0	N	N	1.25	1571.9	1032.726
18	9	D 204	13	21	4.0	N	N	1.25	0.7	0.480

Ready

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Process Monitoring and Leak detection 1276-IS-ASL (Series of I.S. systems)

- ASL series has 4-20ma output to DCS or PIE.
- Intrinsically Safe, uses standard barriers.
- Custom configurations for:
  - Leakage through valves.
  - Leakage in pressure systems.
  - Airborne leakage in boilers.
  - Airborne leakage in offshore modules*.
  - Simple Particle Monitoring to control erosion.
  - Pig detection and monitoring.
  - Burners.
  - Mixing and blending operations of minerals and pharmaceuticals.
- 1276 I.S. pre-amplifier and sensors for AE monitoring.

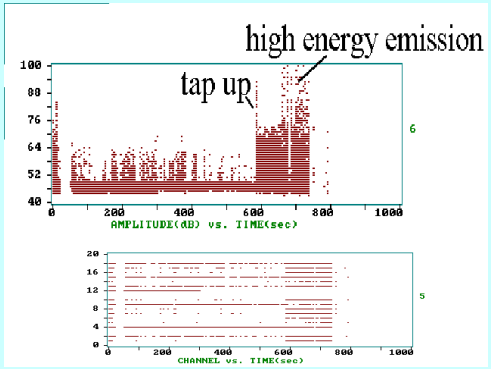
* 5mm diameter methane leak at 10 bar, detected at > 35 metres

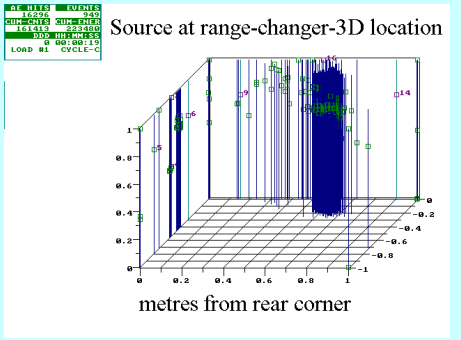
AE in Rotating applications

- The use of AE in rotating machinery applications:
  - Extends monitored frequency range
  - Can be used on very low-speed applications:
    - Crushing of debris, yielding, fracture
    - Lack of lubrication
    - Fatigue cracks
  - Provides detection of transient events:
    - Earlier damage detection
    - Improved diagnostics

Power Transformers

- R+D, procedure verification:
  - >500 tests since 1982
- Code: EPRI recommended practice.
- Acceptance: EPRI, all XF Manuf.,
- Usage:
  - GEC Alstrom
  - ABB
  - VA Tech
  - NP, NGC, other generators and distributors, I.C.I. (chlorine) etc
- Method:
  - AE during normal operation.
  - AE during test.
  - AE continuous monitoring.





AE due to winding fault, and source location from a range-changer fault.

Overview of Mistras' Businesses

MISTRAS Holdings Group

International Subsidiaries & Affiliates

PHYSICAL ACOUSTICS CORPORATION

Innovative Leadership in Acoustic Emission Since 1968

NDT Automation

Advanced Automated Ultrasonic Inspection Systems

Vibra•Metrics®

Vibration Sensors and Systems for Predictive Maintenance

QSL Plus Quality Services Laboratories, Inc.

CONAM PCMS

CONAM The First Choice for Quality Services

Complete Engineering & NDT Inspection Services And Software

PHYSICAL ACOUSTICS LIMITED
A MISTRAS Holdings Company

We Serve the Public Worldwide . . . by providing quality products and services needed to enhance the environmental safety for gas and oil pipelines, petrochemical pressure vessels and storage tanks, strategic components of nuclear and fossil fuel plants, metal and concrete bridges, advanced aerospace composites, and much more.

Our Group develops, manufactures and employs leading-edge technologies for nondestructive testing and predictive maintenance, such as advanced acoustic emission, ultrasonics, eddy current, radiography, vibration monitoring and resistivity systems. In addition, we provide on-line asset management by employing Internet-based data acquisition and real-time assessment of the world's industrial & public infrastructure.