AEGIS

Quantitative Acoustic Emission (QAE)

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ELECTRIC GENERATION
ISSUES, TRENDS, and PRACTICAL SOLUTIONS

AEGIS

Objectives

- Why inspect High Energy Pipe (HEP)?
- What is QAE Technology?
  - A Non-Destructive Inspection (NDI) screening & monitoring tool
- How does QAE work?
  - The phenomenon of acoustic emission

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Objectives

- What is the QAE process?
  - Equipment / Installation / Testing / Analysis
- Applicability
  - P22 and P91
- Case studies
  - Effectiveness, advantages, and cost savings
- Summary

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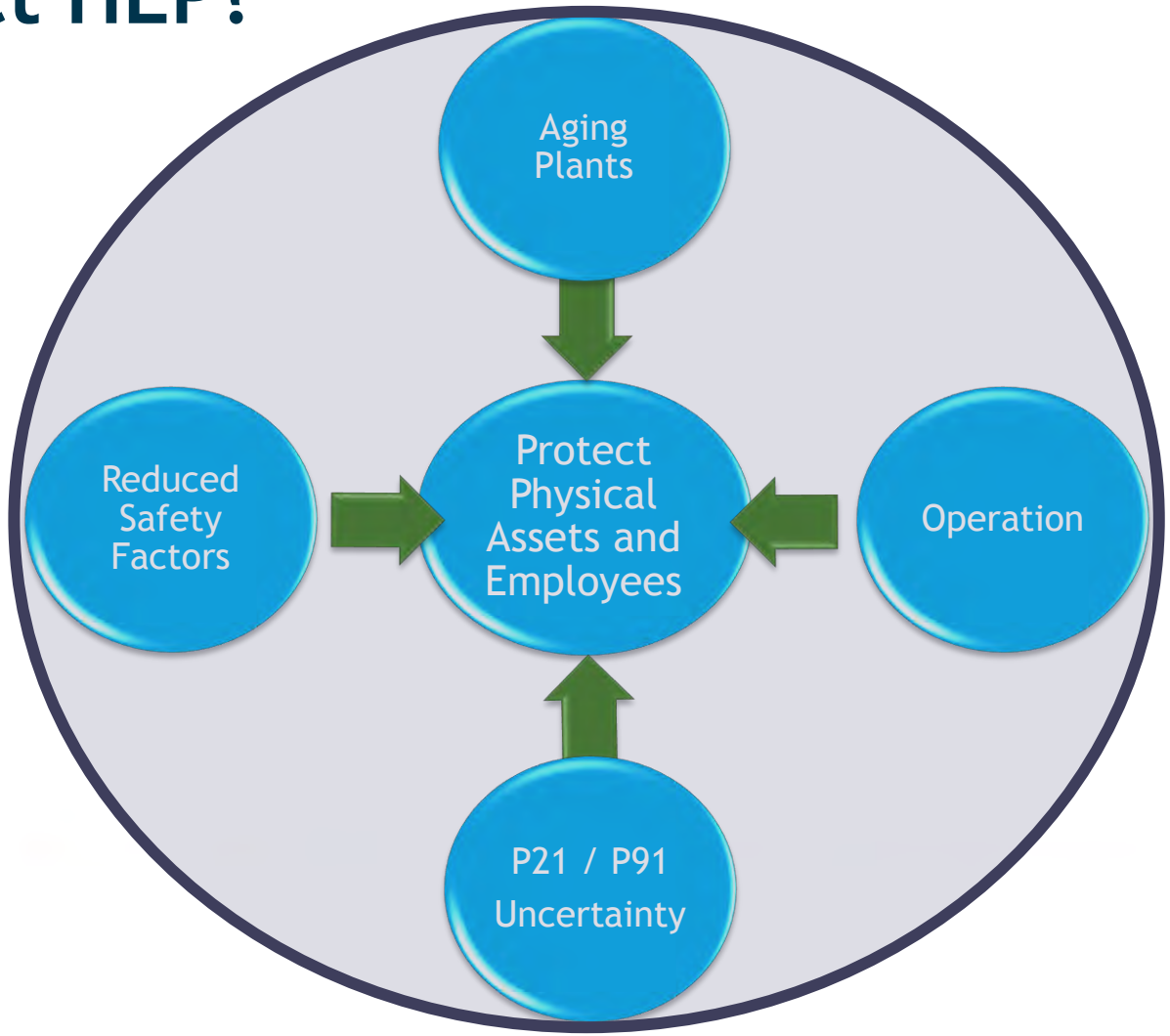
Why Inspect HEP?

Comprehensive Inspection Program



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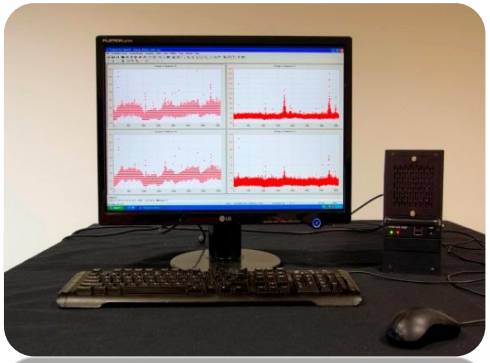
What Is QAE

- A passive system
  - Converts released flaw development energy into acoustic signature
  - Does not induce seismic or sonic energy into the HEP
- On-line system
  - Sensing devices are installed while on-line
  - Data is collected while on line



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What Is QAE

- A Predictive Maintenance (PdM) tool for your Reliability Centered Maintenance (RCM) tool kit
  - Flexible coverage
    - 100% or can be limited to high risk zones

- Can move traditional NDE from time based to conditioned based inspections

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What Is QAE

- A monitoring process
  - Continuous real time or period based
  - Entails trending data
  - Provides early alert to developing issues

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What Is QAE

- A strategic – screening tool
  - Optimizes knowledge of HEP integrity over time
    - Provides visual map
  - Assists in prioritizing NDE inspection efforts
    - UT, MT, LPA, replication
  - Reduces uncertainty
    - Provides sense of urgency
  - Facilitates outage planning

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What Is QAE

- A strategic – screening tool
  - Helps improves budget process
  - Enables cost reductions
  - Helps defer or avoid unnecessary NDE
  - Reduces need for
    - Scaffolding
    - Insulation removal

QAE Limitations

- Indication must be active
  - Emit or resonate when placed under stress
- Does not “precisely” locate indication along linear length
  - +/- 10% (or approximately 1 foot)
- Does not differentiate between surface and subsurface location
- Does not provide size of indication

QAE Limitations

- Sensitive to background noise fluctuation and magnitude
- Can be overly sensitive
  - Small but very active indications
- Multiple flaws near same location cannot be differentiated

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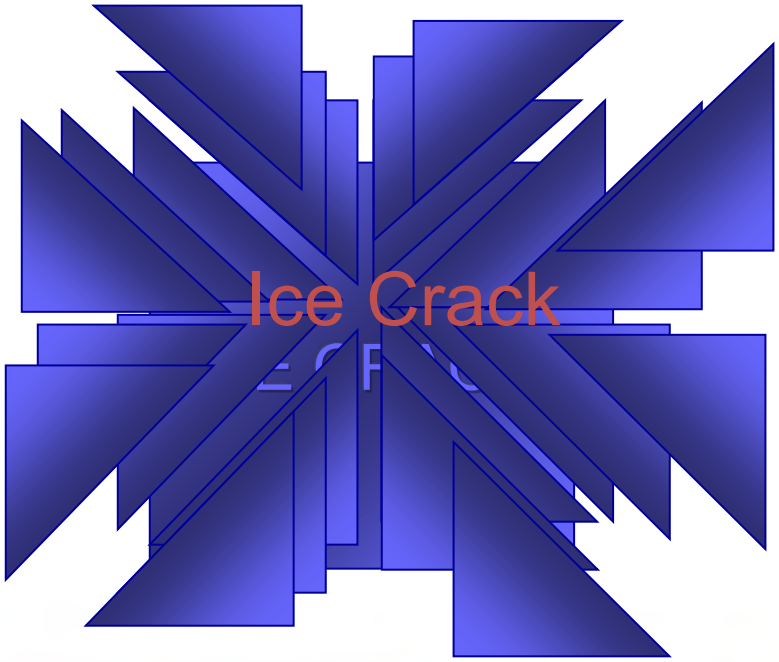
How Does QAE Work?

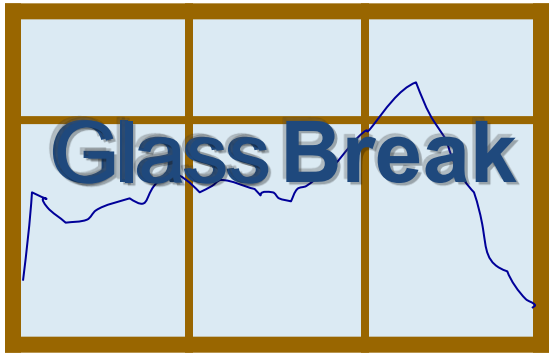
Fracture or deformation processes in differing materials have different signatures.

AEGIS

How Does QAE Work?

Fracture or deformation processes in differing materials have different signatures.





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How Does QAE Work?

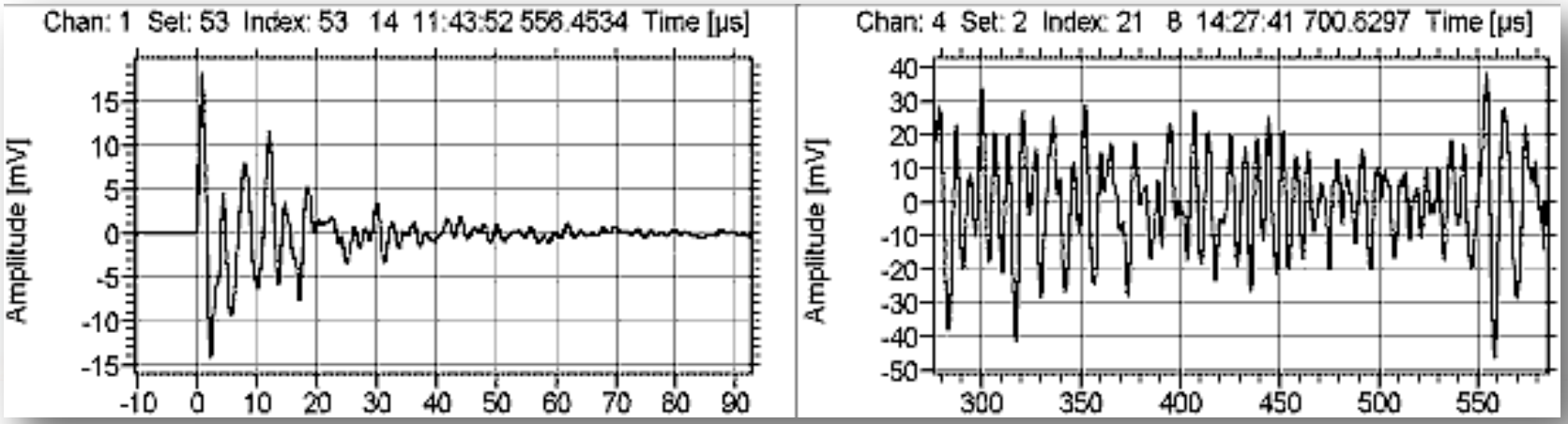
QAE System Collects and Converts

Acoustic Emission is a phenomenon of sound and ultrasound wave radiation in materials that undergo deformation and fracture processes.

How Does QAE Work?

Burst AE is a qualitative description of the discrete signal's related to individual emission events occurring within the material

Continuous AE is a qualitative description of the sustained signal produced by time-overlapping signals



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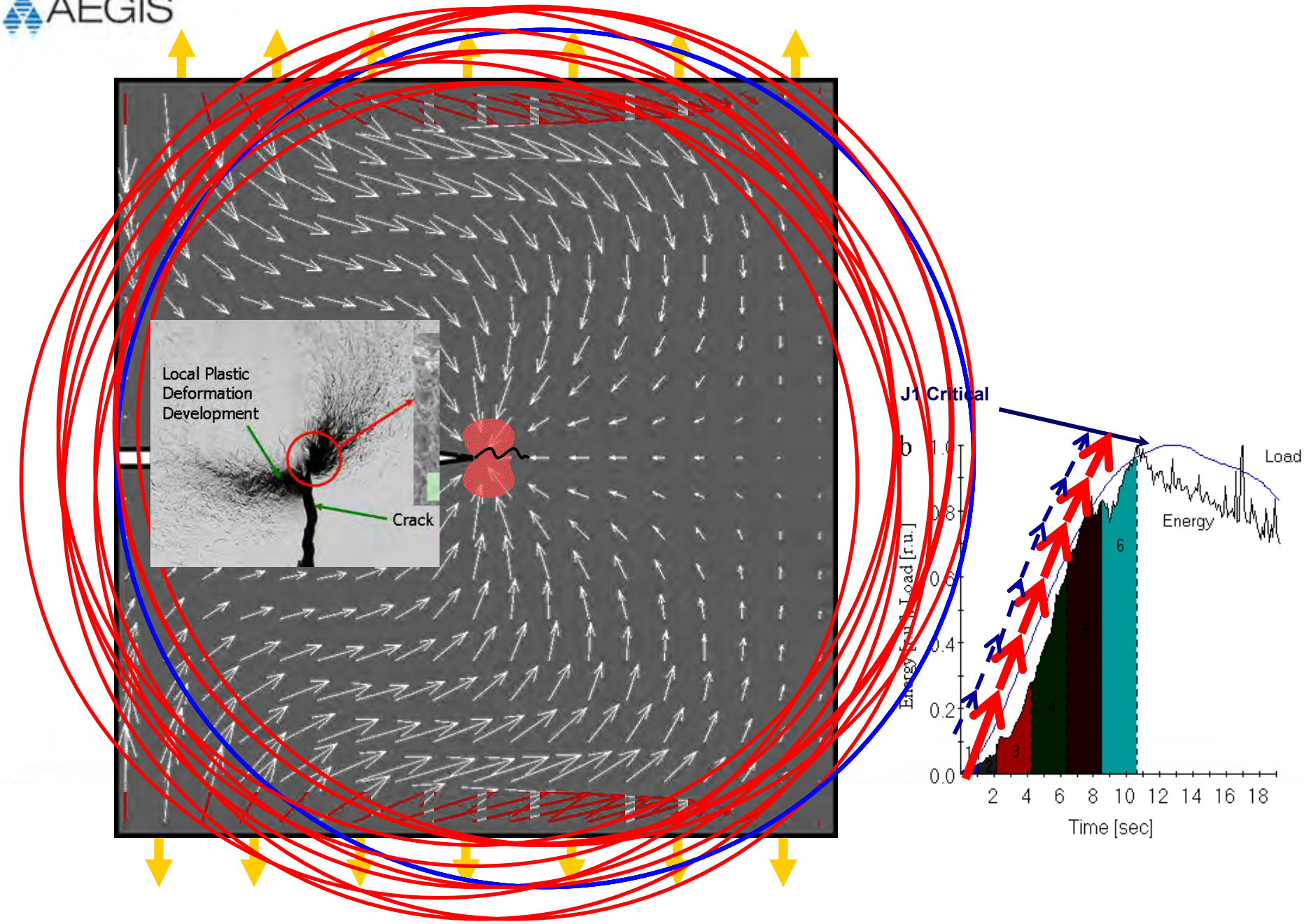
Local Plastic
Deformation
Development
Crack
J1 Critical
b
Load
Energy
Energy [r.u.] Load [r.u.]
0.0
0.2
0.4
0.6
0.8
1.0
2
4
6
8
10
12
14
16
18
Time [sec]
1
2
3
4
5
6

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What Can QAE Detect?

Flaw accumulation and development

- Micro / macro-cracking
- Fracturing and de-bonding of hard inclusions
- Creep development

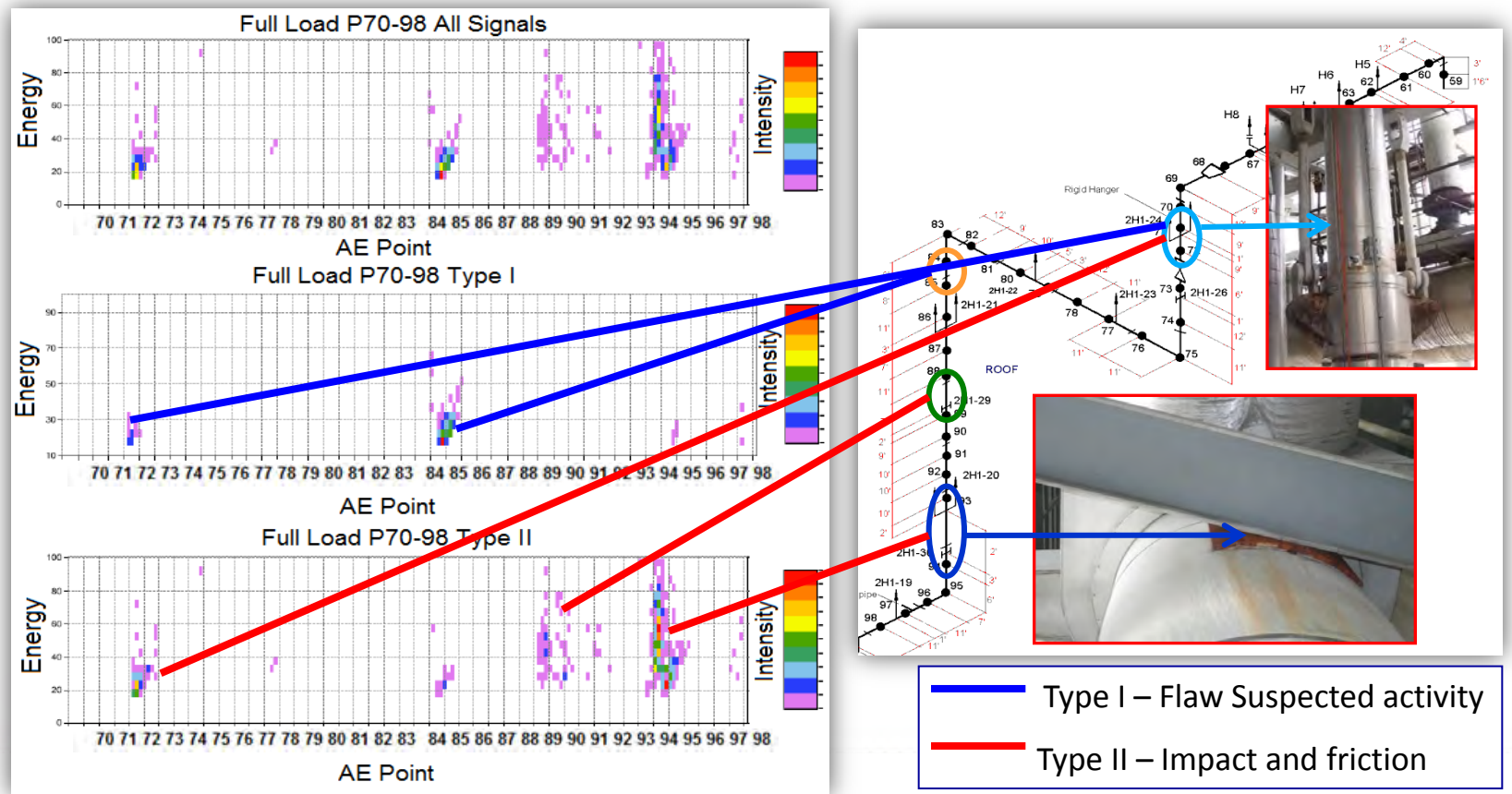
Mechanical impacts and friction

- Hanger impacts and knocks
- Friction at side supports
- Dynamic overstressing
- Shock waves due to steam pulsation

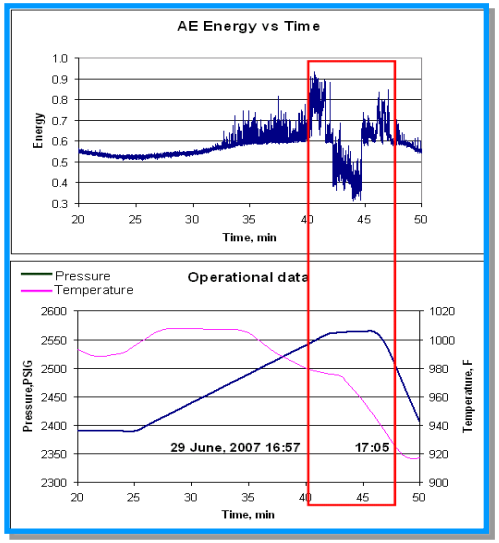
Leaks, malfunctioning valves, and steam fluctuations

- Leaks
- Malfunctioning valves
- Steam fluctuations due to control problems

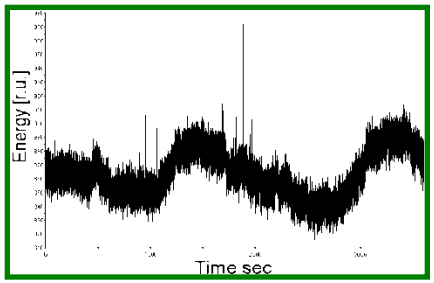
Examples of AE Sources

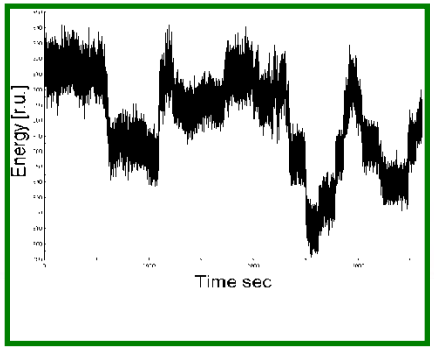


Examples of AE Sources



Valve Leaks





Malfunctioning Valves

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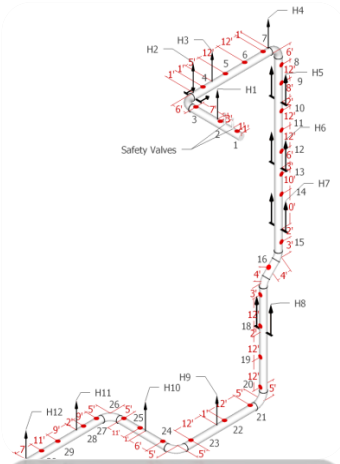
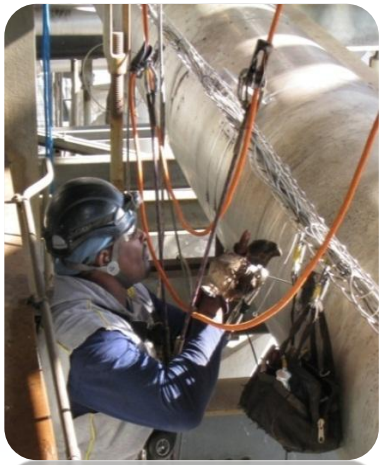
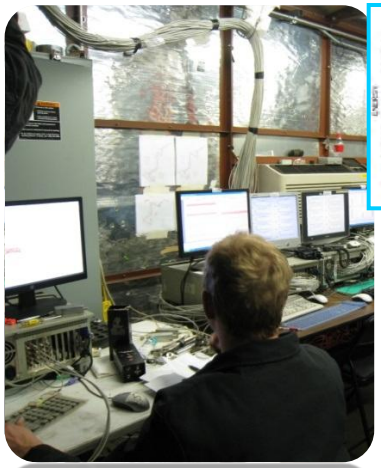
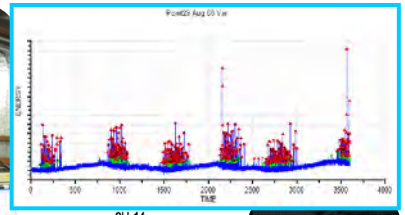
What Is Margan's QAE Process?

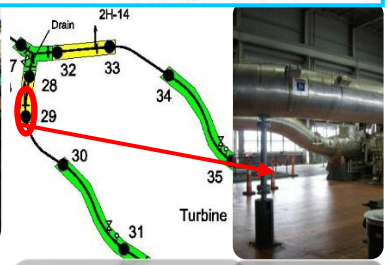
Equipment → System Design & Installation → Data Acquisition → Data Analysis → Report

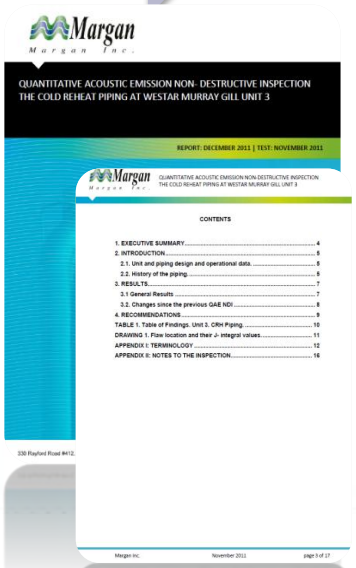






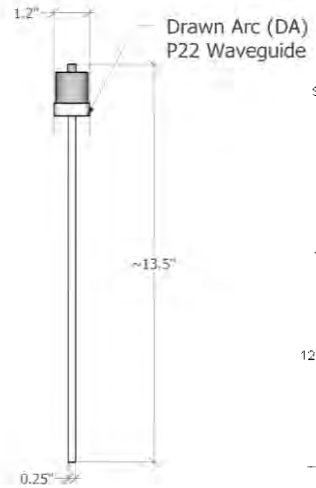






Equipment

- P22 Waveguide
  - Provides signal pass & dissipates heat before sensor
  - ¼” Stainless steel with an aluminum flux ball
  - Ceramic sensor converts pulse to electrical signal



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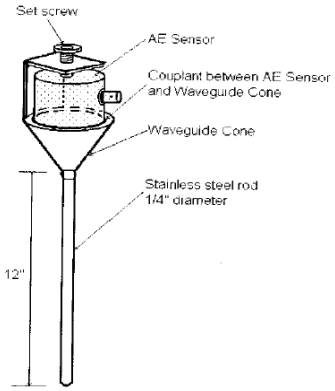
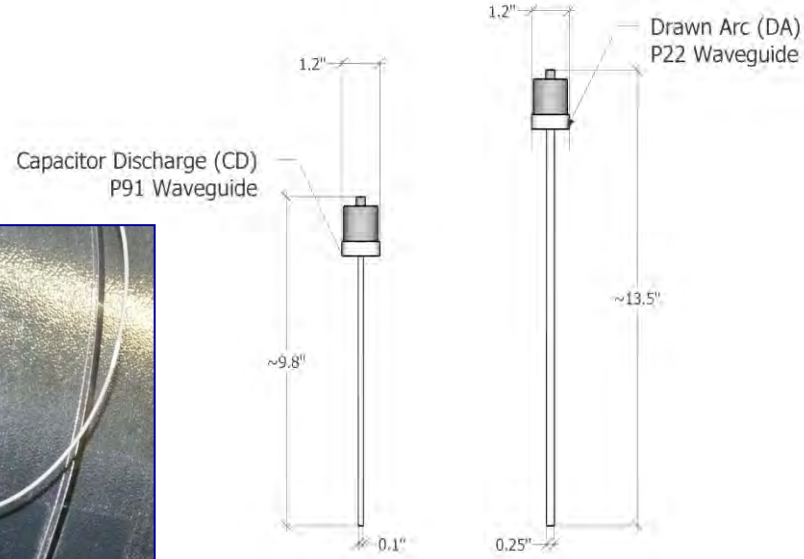


EPRI

Equipment

- P91 Waveguide
  - P91 material welding attachment standards require
    - Capacitor welding method
      - A specific waveguide



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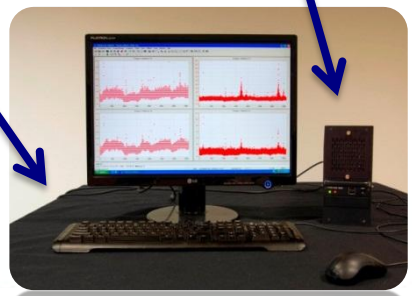
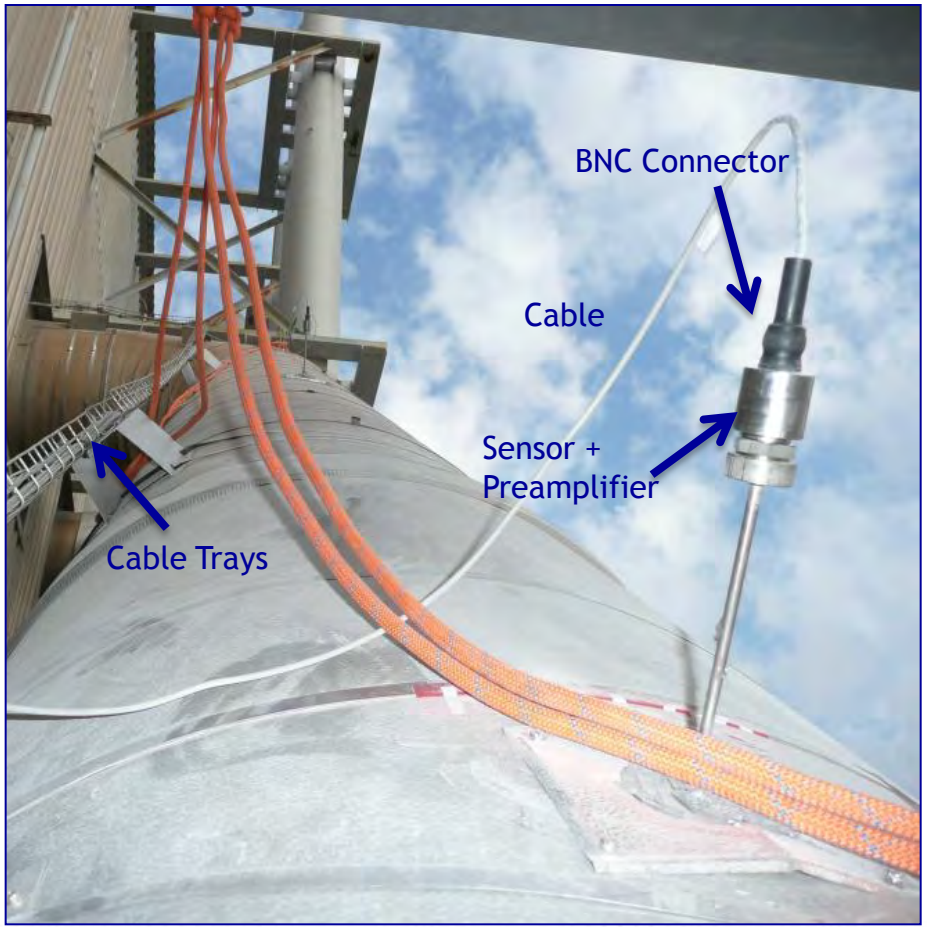
Equipment

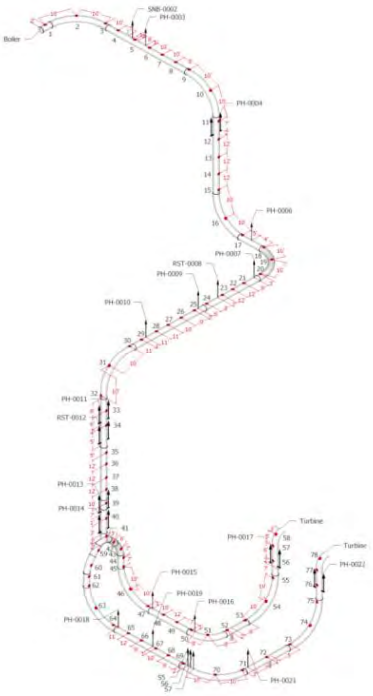
- Other
  - Cable
  - Preamplifier
  - BNC Cable Connectors
  - Resonance Sensor
  - Integrated Pre-amplifier
  - AE PCI 4 Cards
  - Software





Design

- Sensors strategically spaced
  - Sensor spacing is function of sensor sensitivity, background noise, piping accessories, attentuation, etc.
    - EPRI guidelines
      - 15 to 18 feet in low background noise
      - 10 to 13 feet in high background noise
    - Margan procedure
      - 12 feet maximum
        - Increased sensitivity and reliability
      - <3 feet from piping accessories
        - Wye blocks, attempterators, hangers, etc.
      - Install on same circumferential side of pipe



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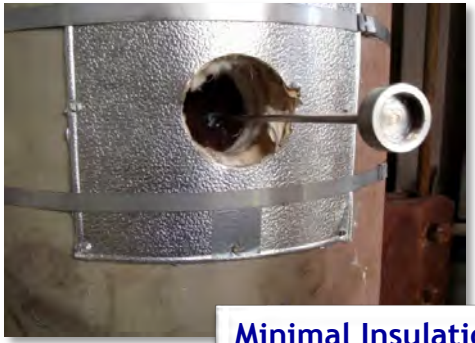
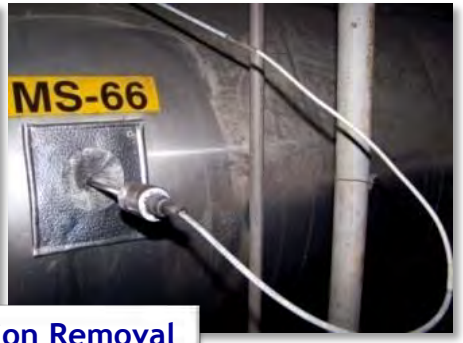
No Scaffolds - Rope Access





Minimal Insulation Removal

Welding Waveguide

Terminal Point

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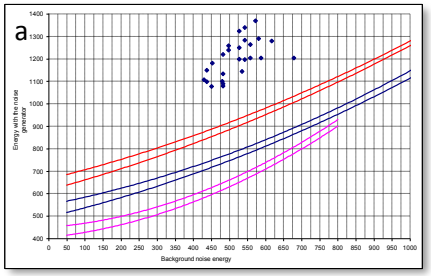
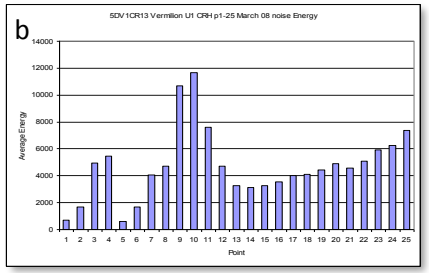
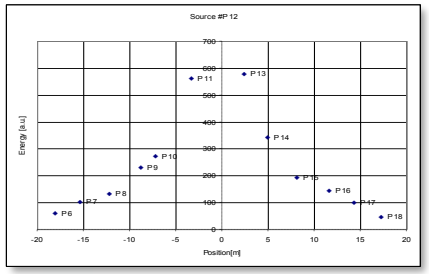
Data Acquisition

- Margan uses 3 calibration protocols
  1) Sensor response to a preset noise level
  2) Acoustic emission energy distribution
  3) Sensor attentuation v distance to sensor
- Calibration is critical stage for accuracy







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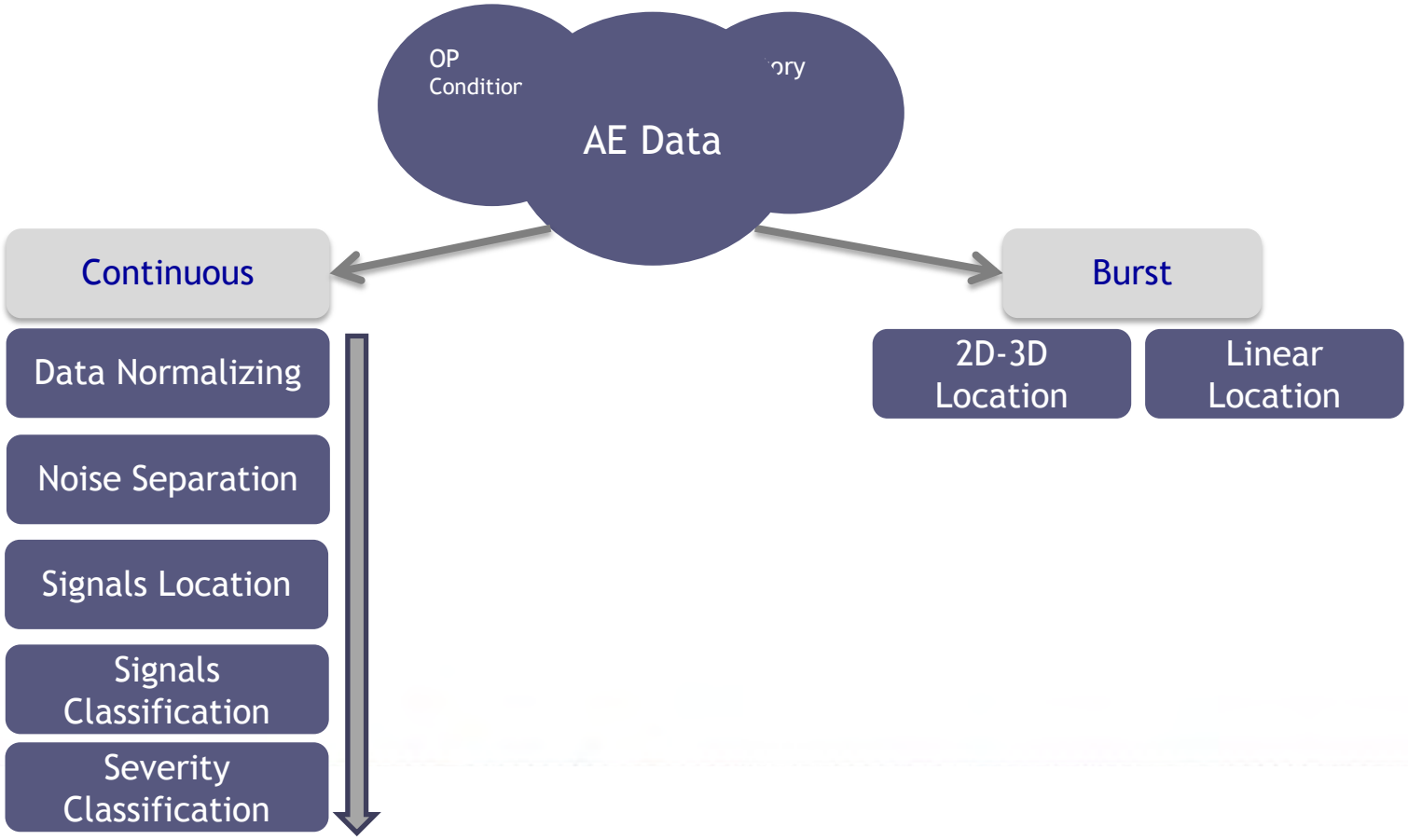
Data Acquisition

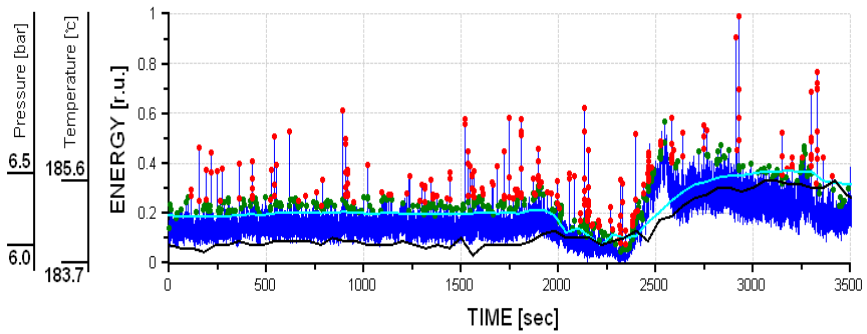
Margan Procedures	EPRI Guidelines
Most of the inspection is performed under stable load conditions of plant operation. During baseline, it is recommended to perform low and variable load measurements (see below)	Stress method should not excessively stress the piping. Piping should be monitored under normal stable conditions.
Variable load measurement- the load swings between 90% to 100% of full load back and forth. This is done to monitor dormant flaws, which emit under changes in stress.	The load swing should include a pressure change of at least 25% of the piping operating pressure range.
Low load measurement- the load is lowered to 70% of full load. This is done especially to monitor piping with high noise background, which will assist in filtering it.	

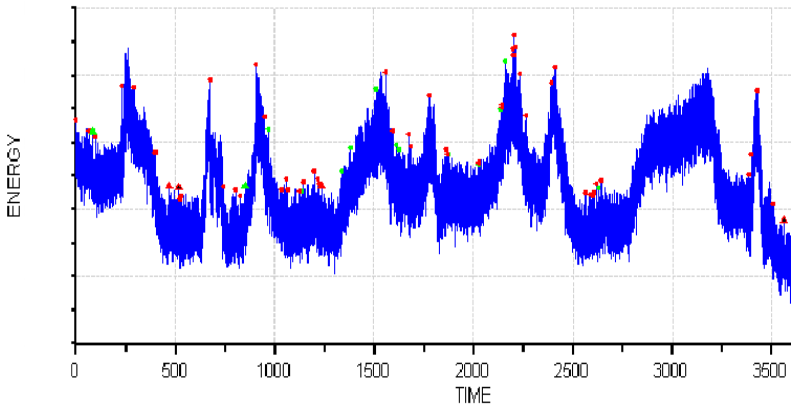
Data Analysis



Data Analysis

a





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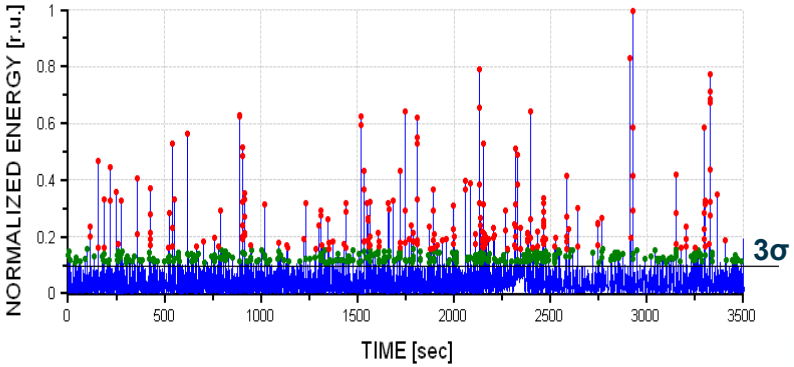
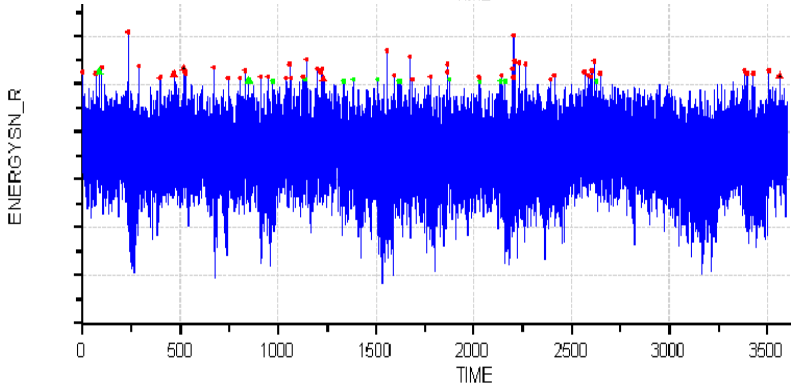
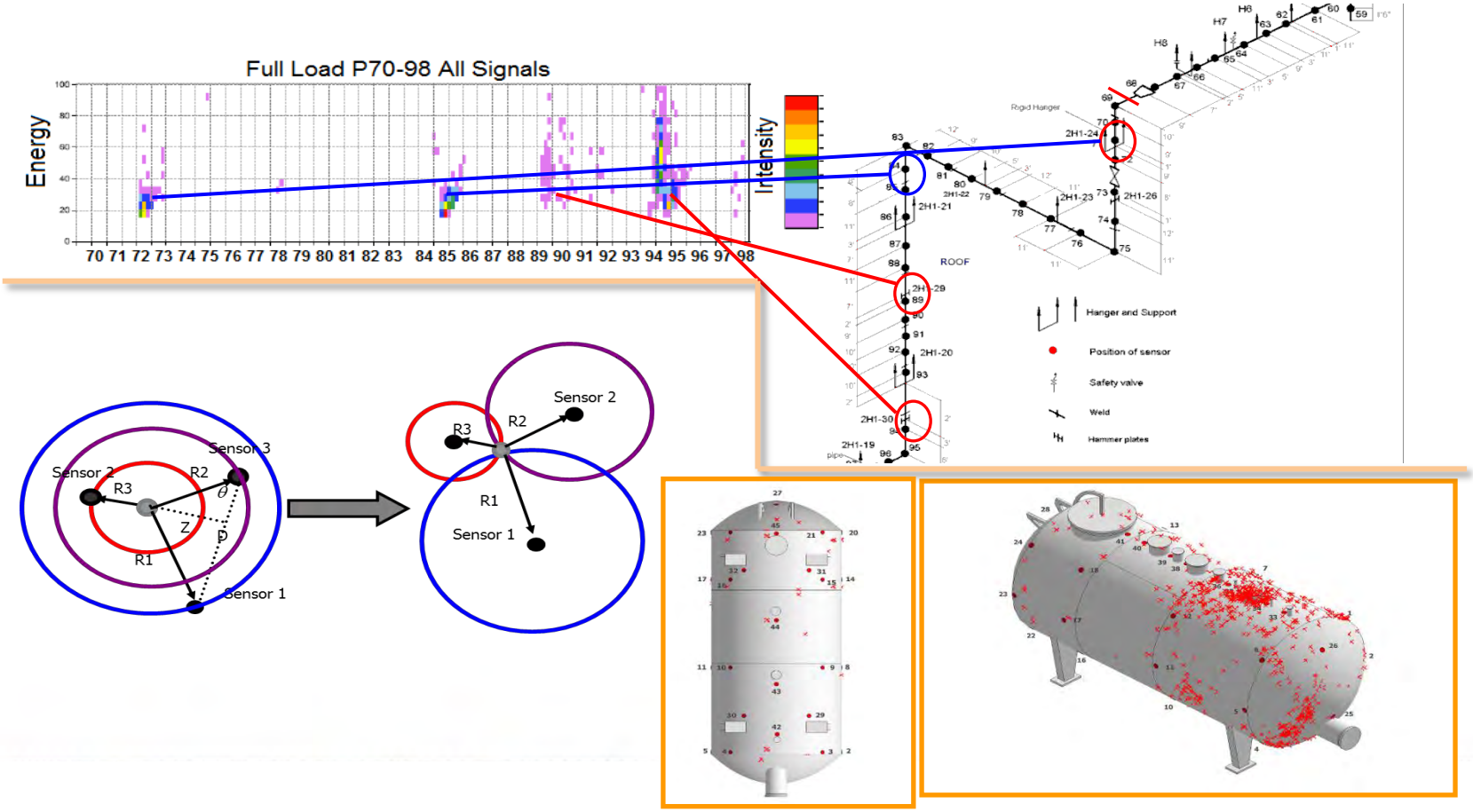




Data Analysis



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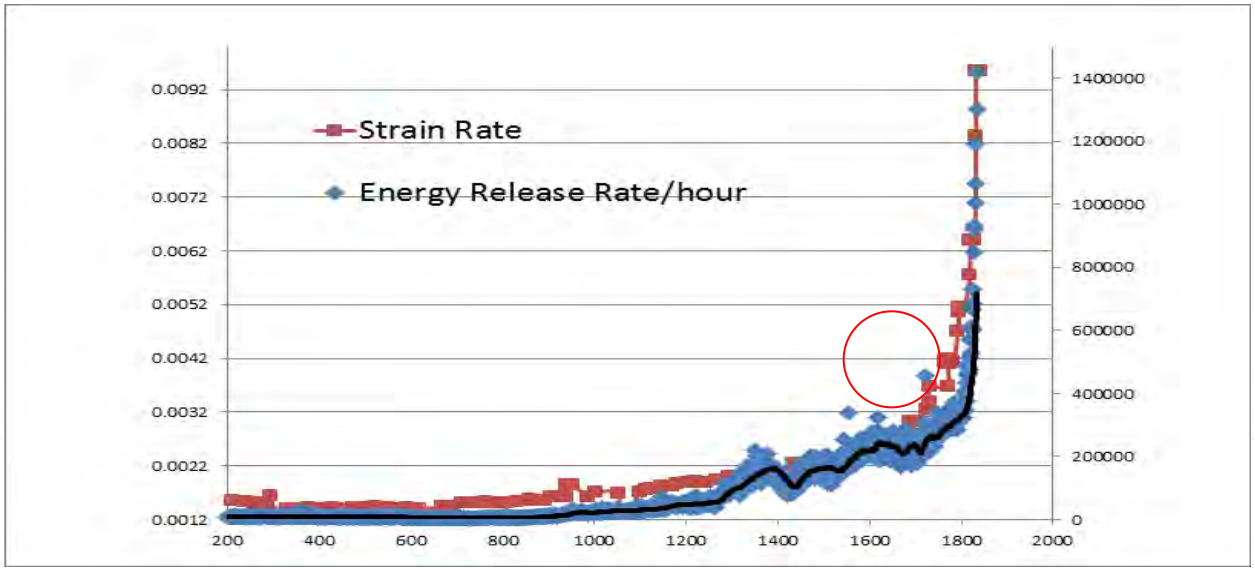
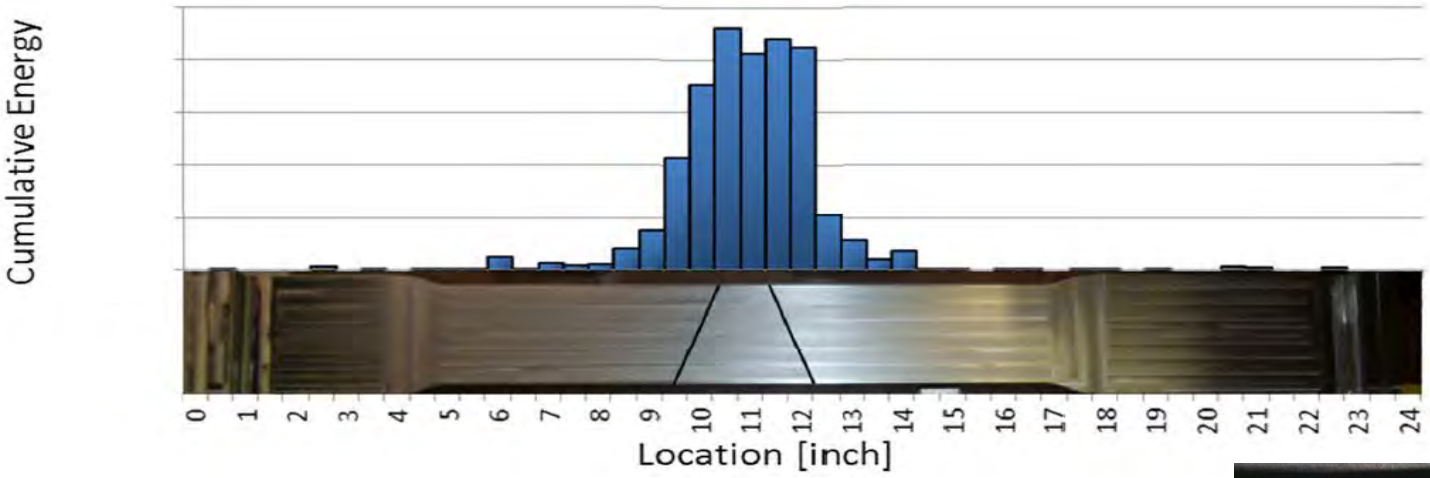
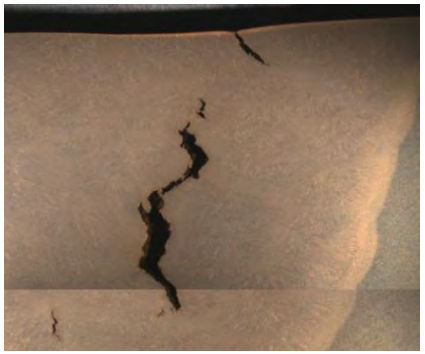
Applicability To P22

- Bench test P22 correlation strain v AE v time
  - Transition point occurs at ½ life
  - Transition correlates to 1st QAE increase
  - Strong correlation



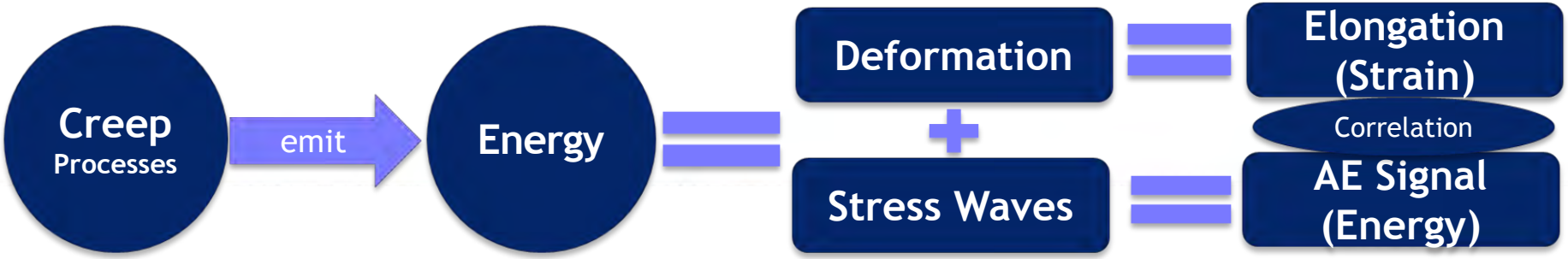
Applicability To P22





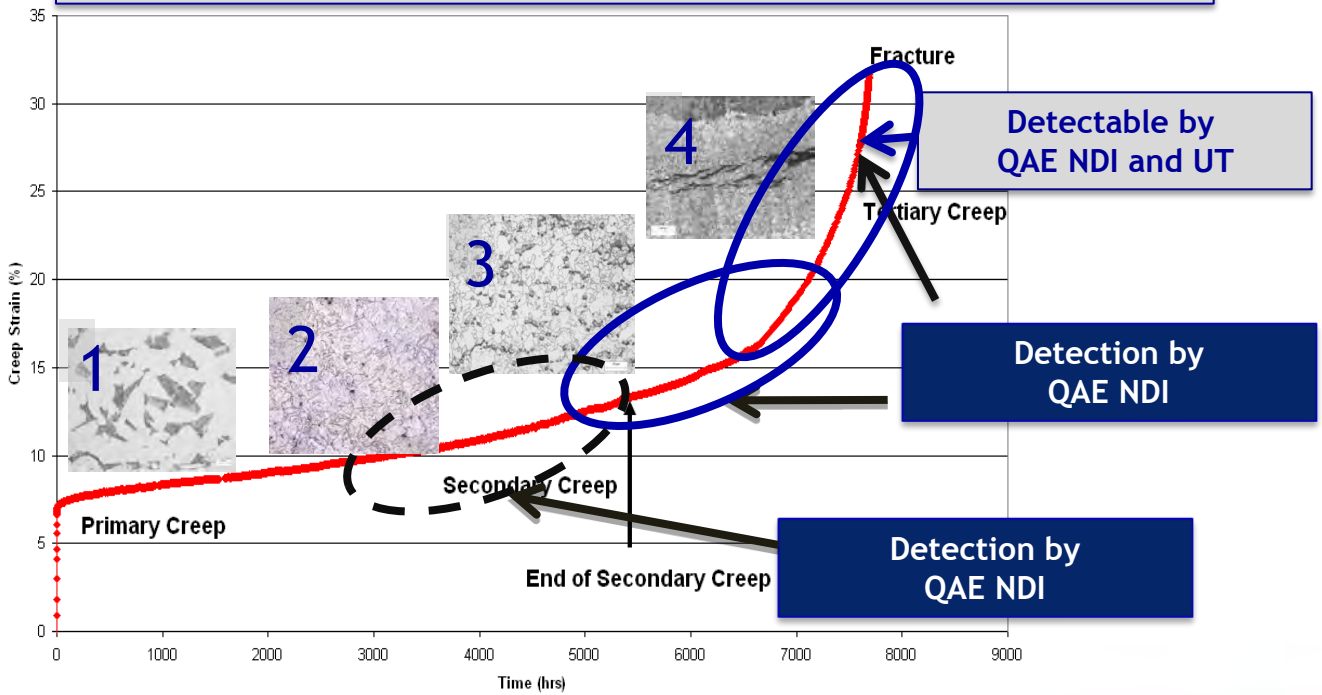
Applicability

- For both P91 and P22
  - QAE can detect and accumulate energy trend
    - Anticipate failure and location of failure
    - Highlights use as a PdM tool to reduce risk
- P91 reacts differently to strain than P22
  - More sudden failure
    - Supports even a greater need for use on P91



Applicability

Creep Damage Accumulation Diagram



* Under normal background noise conditions

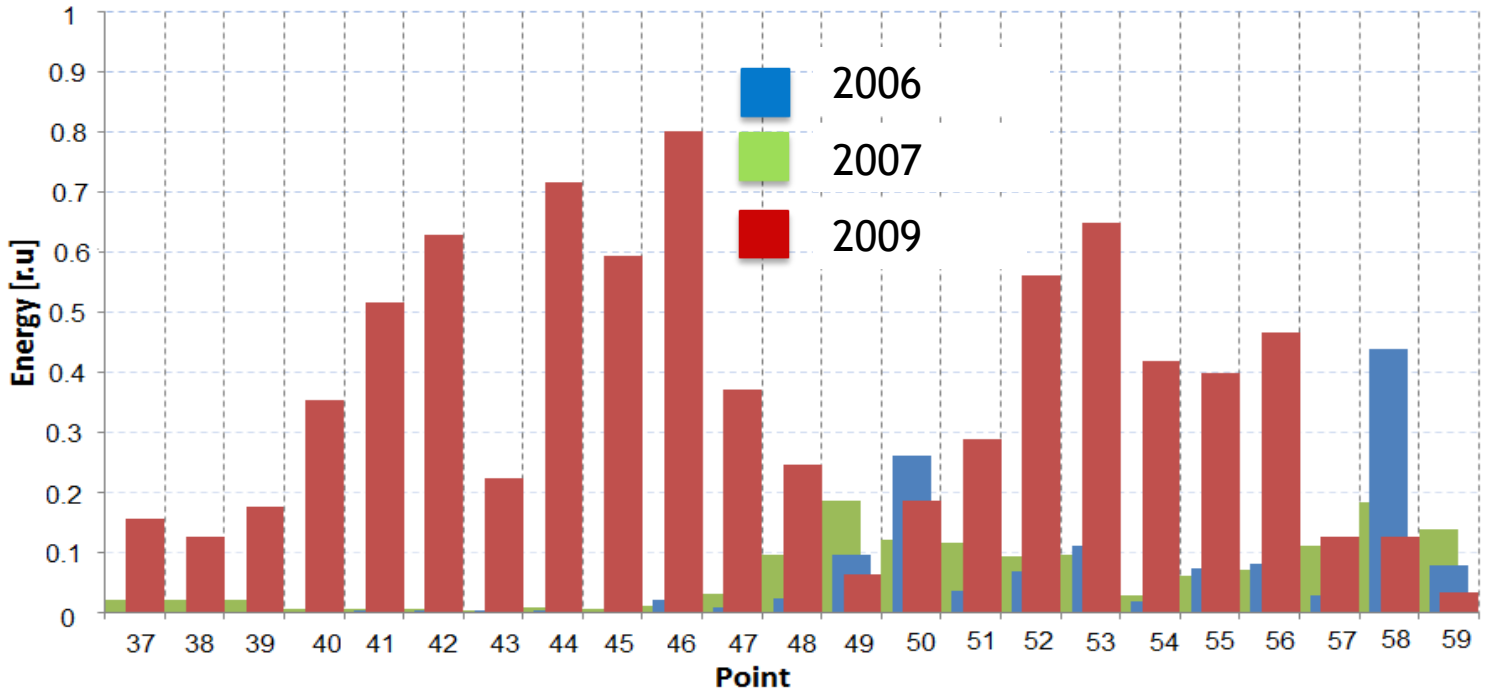
AE Is Emitted As Creep Accumulates

Case Studies

- Case study 1 MS line
  - System installed on MS line IN 2004
  - No special events reported until 2009
    - Inspection reported abnormal activity in section leading to turbine leads
  - During 2011 outage, client performed NDE
    - Cracks and creep were found

Case Studies

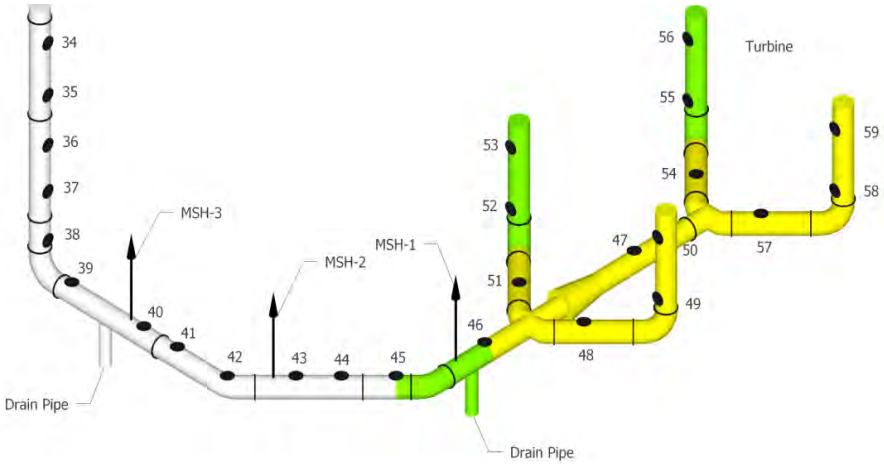
Case study 1 MS line



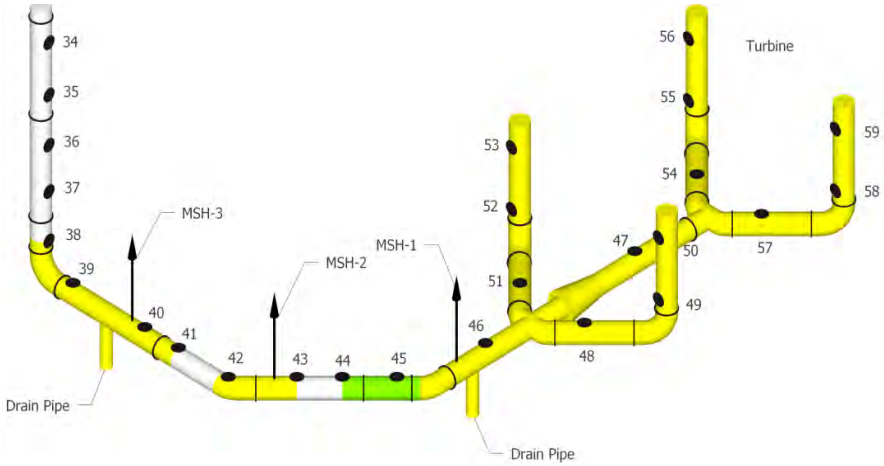
Case Studies

Case study 1 MS line

February 2006 and 2007



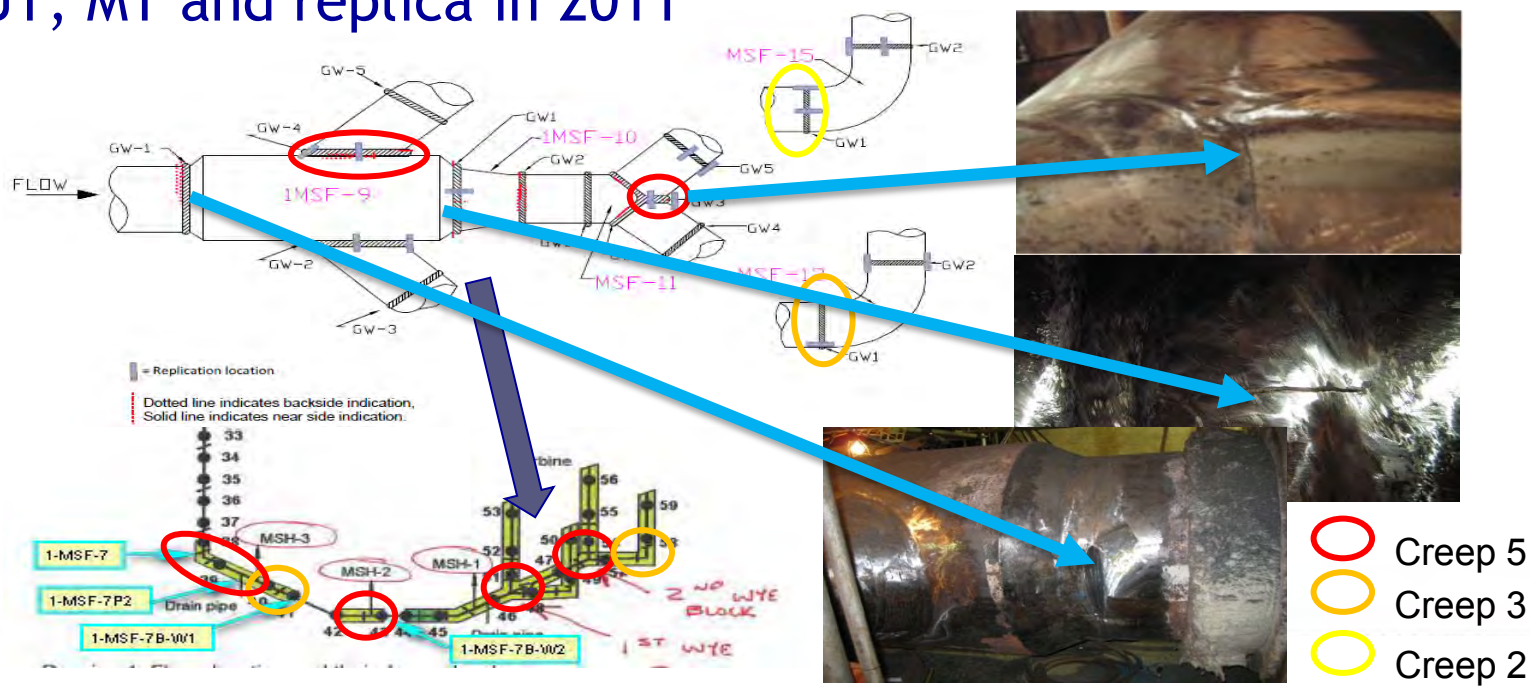
January 2009



Case Studies

Case study 1 MS line

UT, MT and replica in 2011

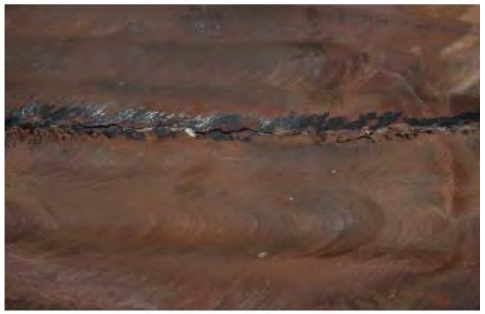


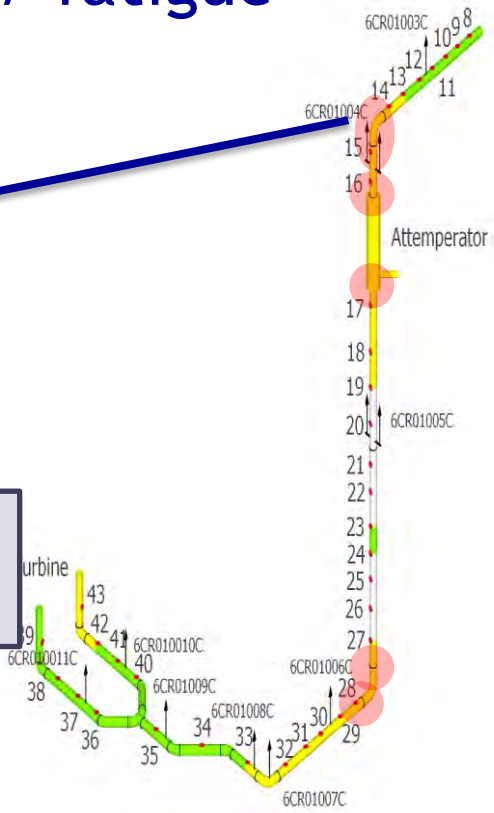
Case Studies

Case study 2 CRH line: thermal shock / fatigue

TMI- Trend monitoring Inspection
MC- Micro-Cracking
MT- Magnetic Particles Inspection
LPA- Linear Phased Array
NRI- No Reportable Indications

Fatigue Crack



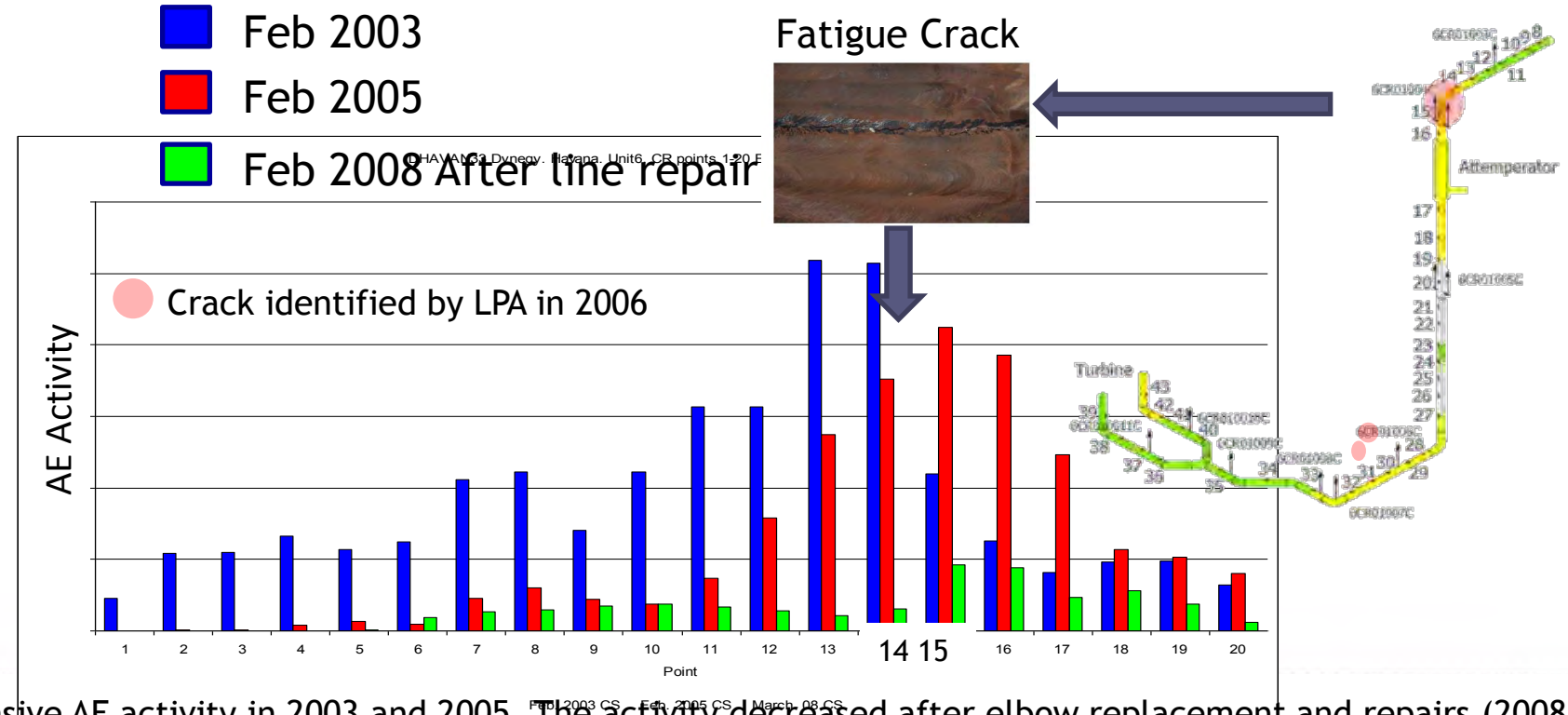


Baseline QAE **MC**	1st TMI QAE **Increased Activity** MT LPA **NRI**	2nd TMI QAE **Increased Activity**	**Leak In weld 14**	2x40'' Thermal Fatigue cracks
Feb 2003	Oct 2003	Feb 2005	July 2006	2 days later

Crack identified by LPA in 2006

Case Studies

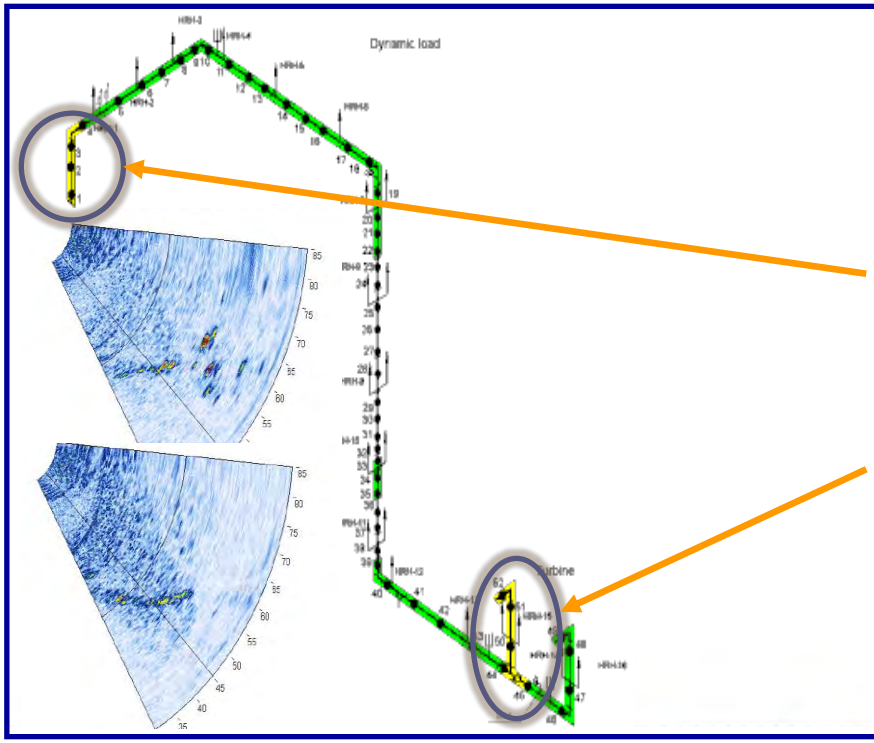
Case study 2 CRH line: thermal shock / fatigue



Intensive AE activity in 2003 and 2005. The activity decreased after elbow replacement and repairs (2008)

Case Studies

Case study 3A HRH line



2004 - Two areas were recommended by QAE NDI to be inspected by localized NDE methods due to indications of micro-cracking and creep development.

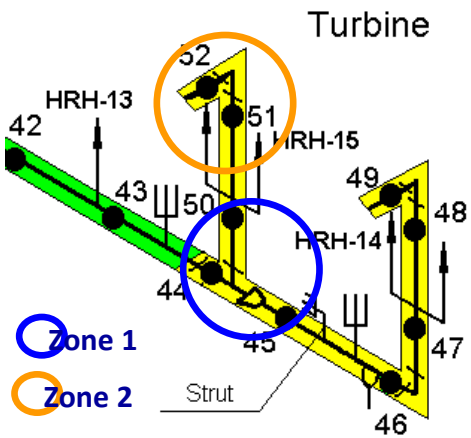
2005 - Top area: creep class 3 was revealed by replica several indications were revealed by UT. Surface cracks were revealed by MT and grind out.

Bottom area: creep class 4 was verified by replica investigation.

Linear Phased Array Ultrasonic Examination revealed accumulation of multiple processing indications.

Case Studies

Case studies 3A and 3B HRH line

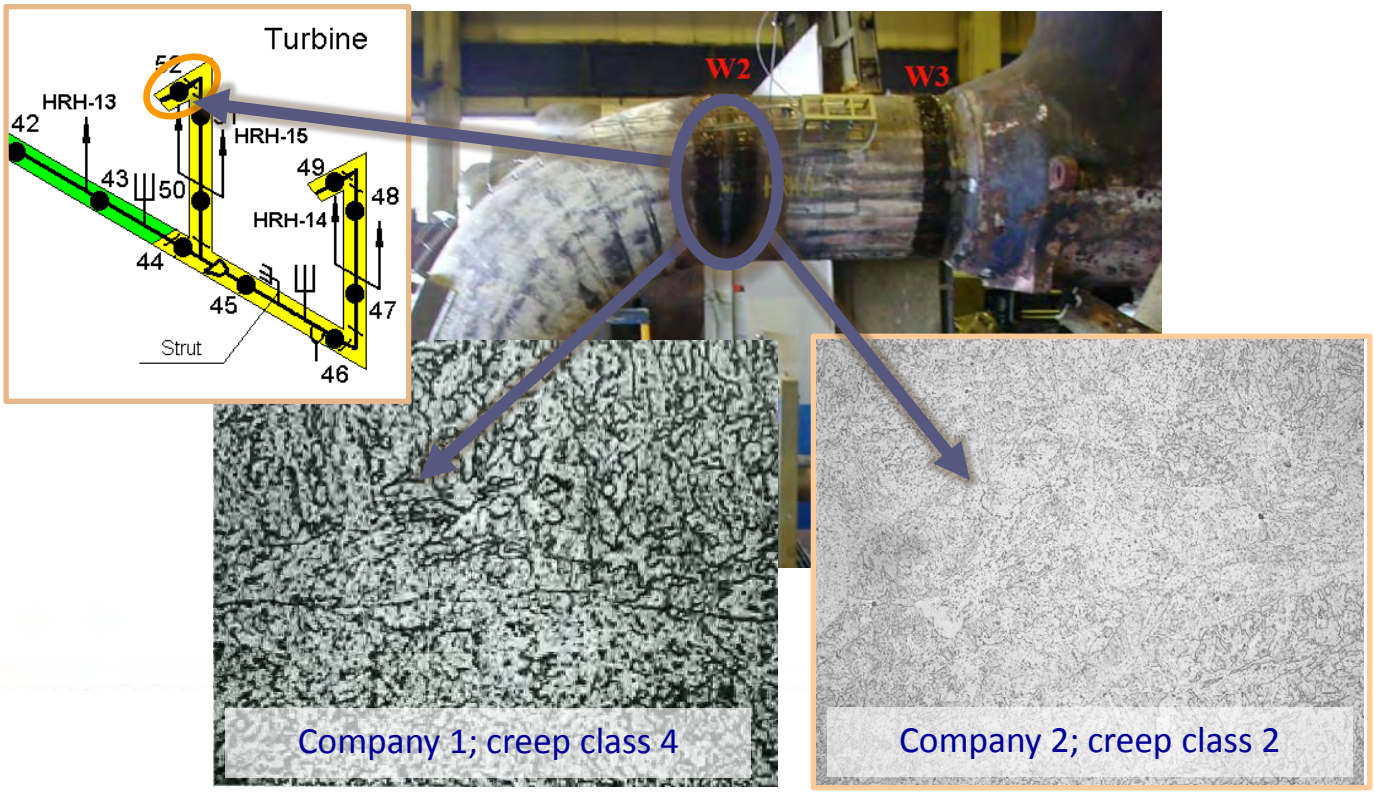


Replica investigation at girth welds located at zones between AE points 44-45-50 and 51-52.

	Company 1	Company 2
Zone 1	Class 3 creep 2/2*	Class 1 creep 7/12, Class 2 creep 5/12
Zone 2	Class 4 creep 2/2	Class 1 creep 3/12, Class 2 creep 9/12
Recommend	Repair in six months to one year time period.	Re-inspect in 8-10 years.

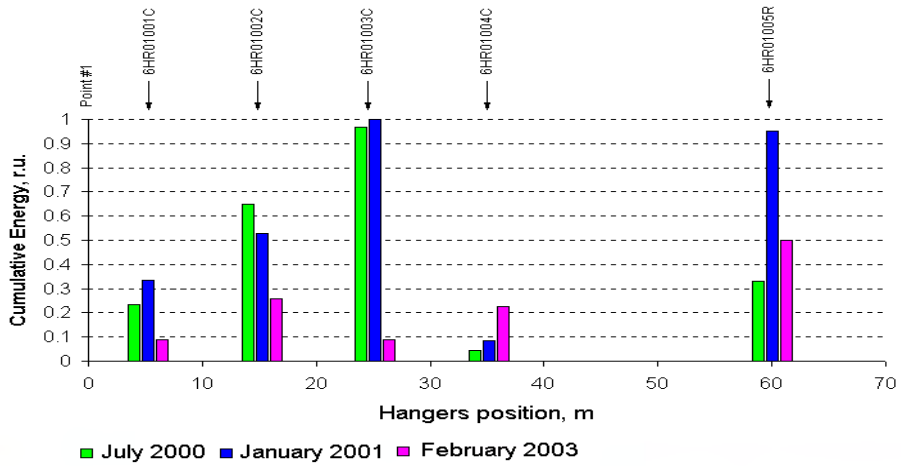
Case Studies

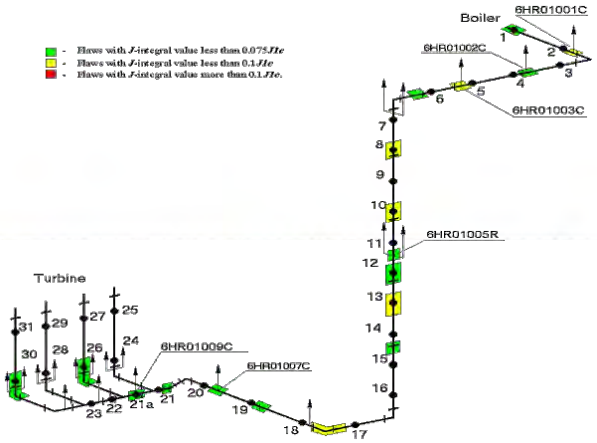
Case studies 3A and 3B HRH line



Case Studies

- Case study 4 hanger assessment
  - In 2000 Unusual AE Activity Noted
  - Activity Increased 6-Months Later
  - Visual Inspection
    - Rigid Hangers
    - Hanger Repaired

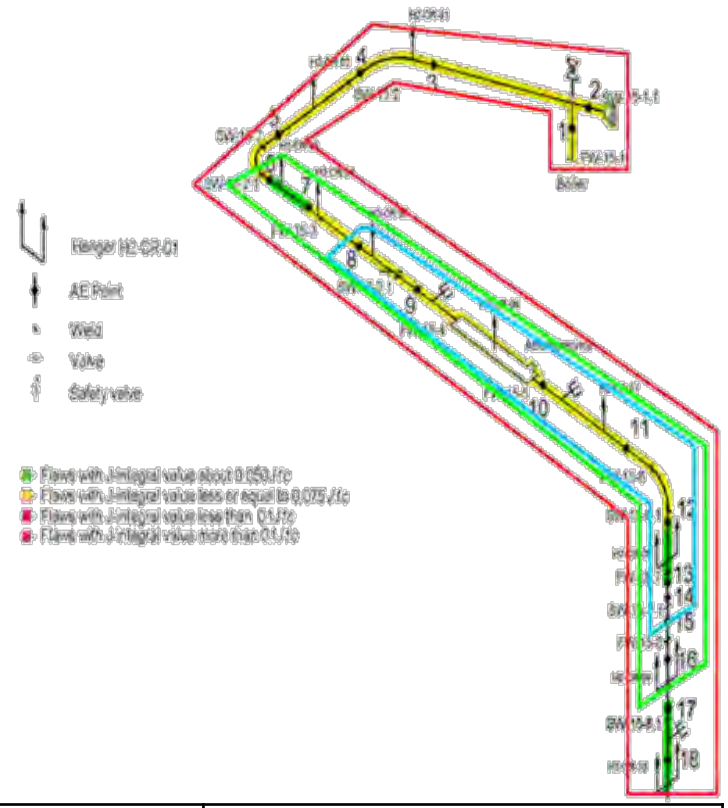


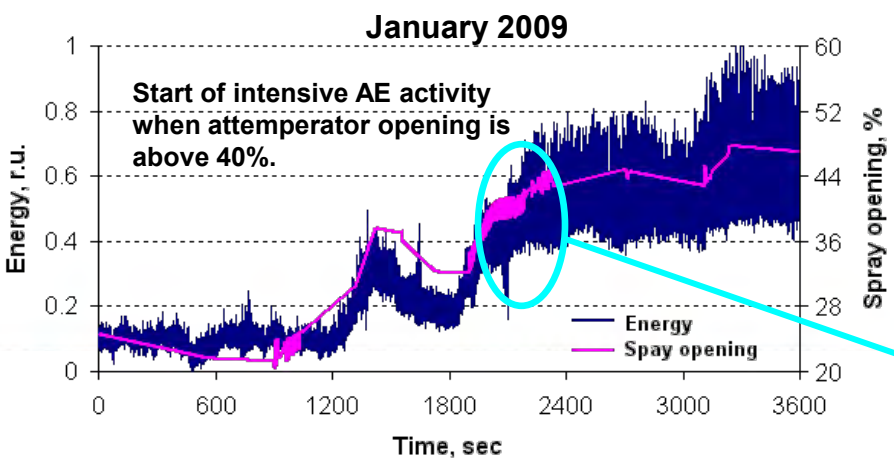


Margan Provides Hanger Assessment With Each Report

Case Studies

- Case study 5 thermal shock
  - Thermal shock zone is increasing
  - With time and as more
  - Attemperation is applied

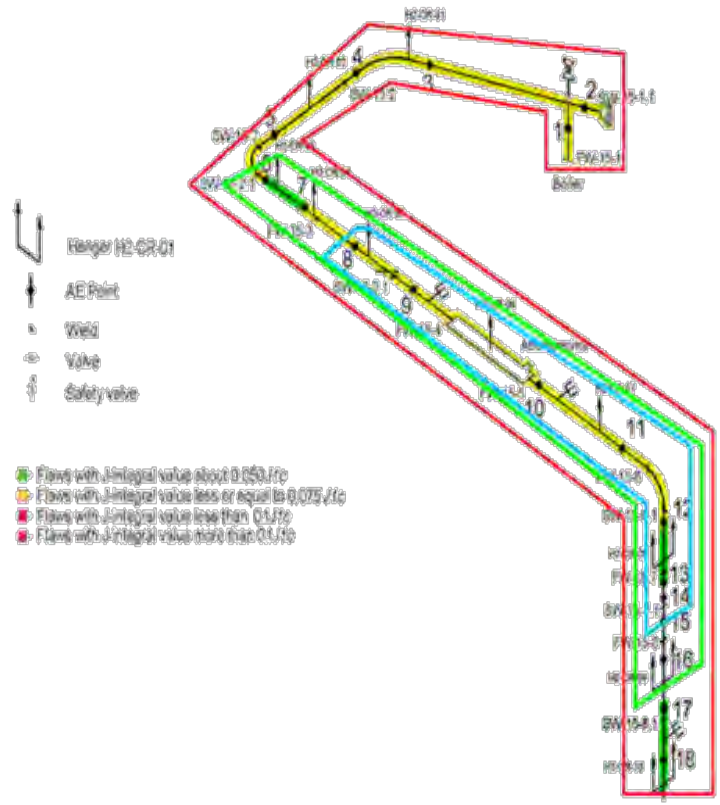


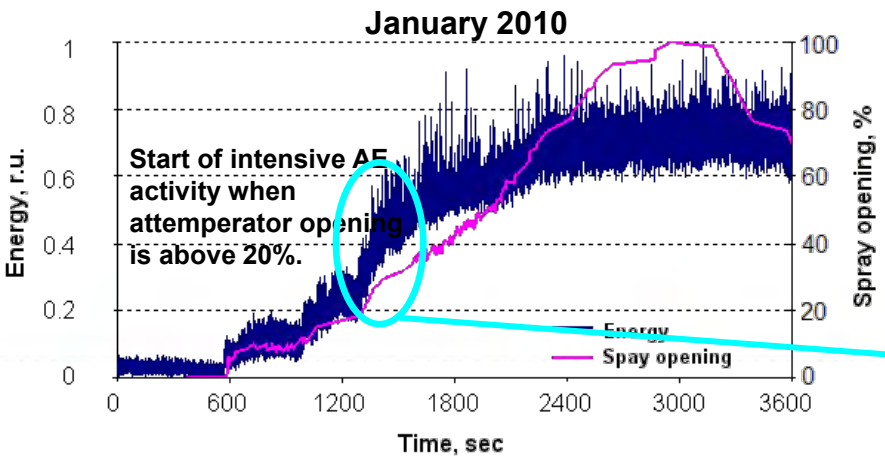


Attemperator valve opening [%]	Piping area subjected to thermal shock/overstresses between
0-30%	AE points 8-14
30-40	AE points 6-16
>40	AE points 1-19

Case Studies

- Case study 5 thermal shock
  - Thermal shock zone is increasing
  - With time and as more
  - Attemperation is applied



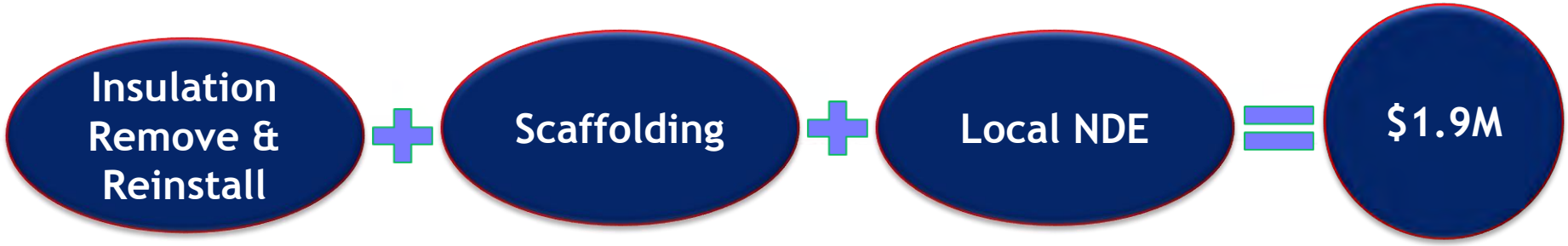


Attemperator valve opening [%]	Piping area subjected to thermal shock/overstresses between
0-20	**AE points 8-13**
>20	**AE points 1-19**

AEGIS

Case Studies

- Case study 6 new install economics
  - Probability of failure <1%, but consequences very high
  - After 10 years only about 21% of the HEP inspected
    - QAE would provide 100% coverage more frequently
  - Cost from traditional NDE on 100% of MS, CHR, and hrhline equaled ~$1.9 million / unit (excluding any asbestos)



AEGIS

Case Studies

- Case study 6 new install economics
  - Unit had to be off line to complete traditional NDE
    - Replacement power could add to $1.9 million cost
  - QAE capital had <3 year payback
    - Would provide 100% coverage every 2 to 3 years
    - Would help prioritize NDE on higher risk areas
    - Required less scaffolding and insulation removal

AEGIS

Summary

- QAE NDI is:
  - A PdM monitoring and trending program and
  - A RCM diagnostic and screening tool
- QAE is a part of a comprehensive HEP inspection program
- QAE can differentiate between various acoustic signatures

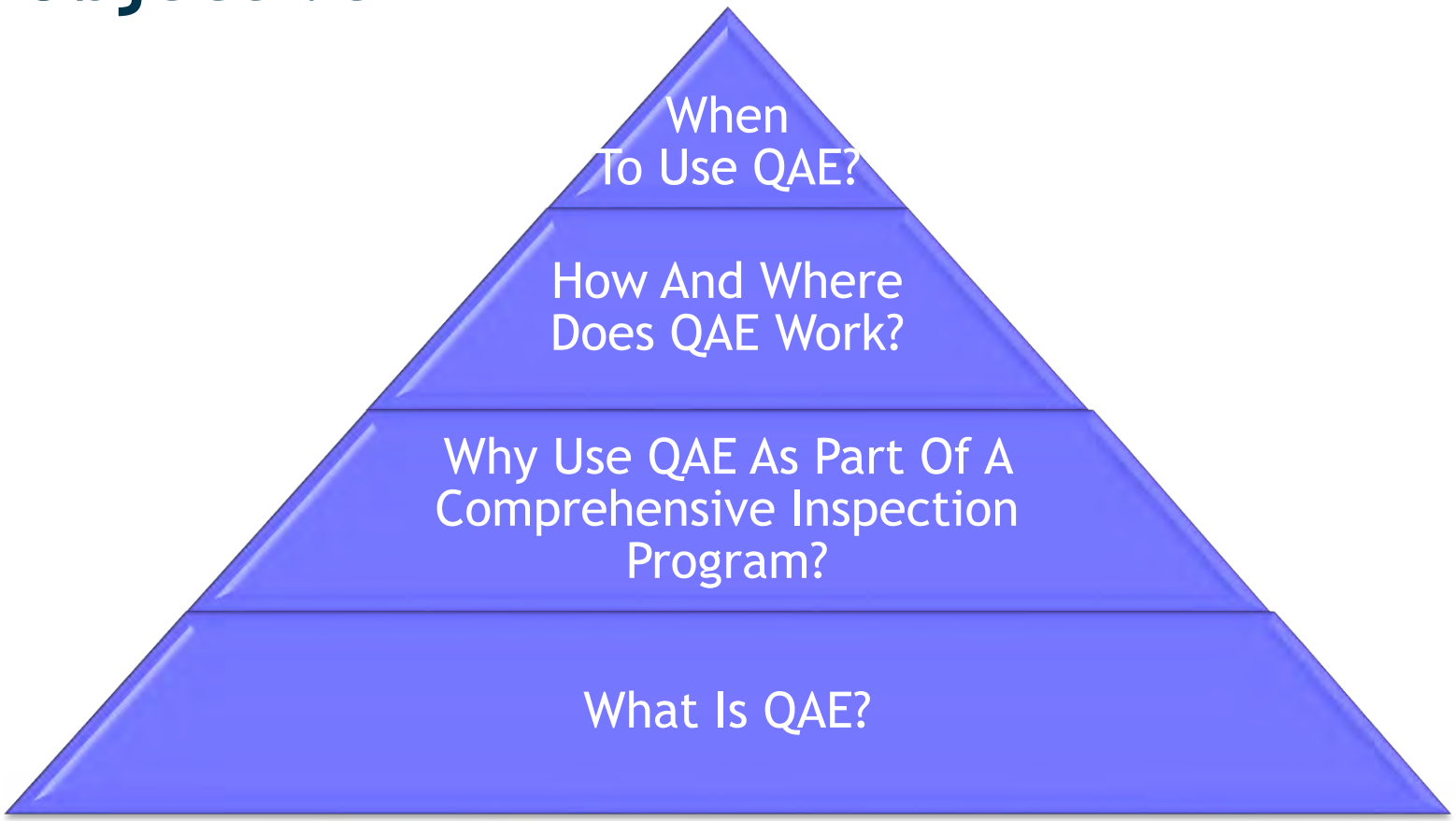
AEGIS

Summary

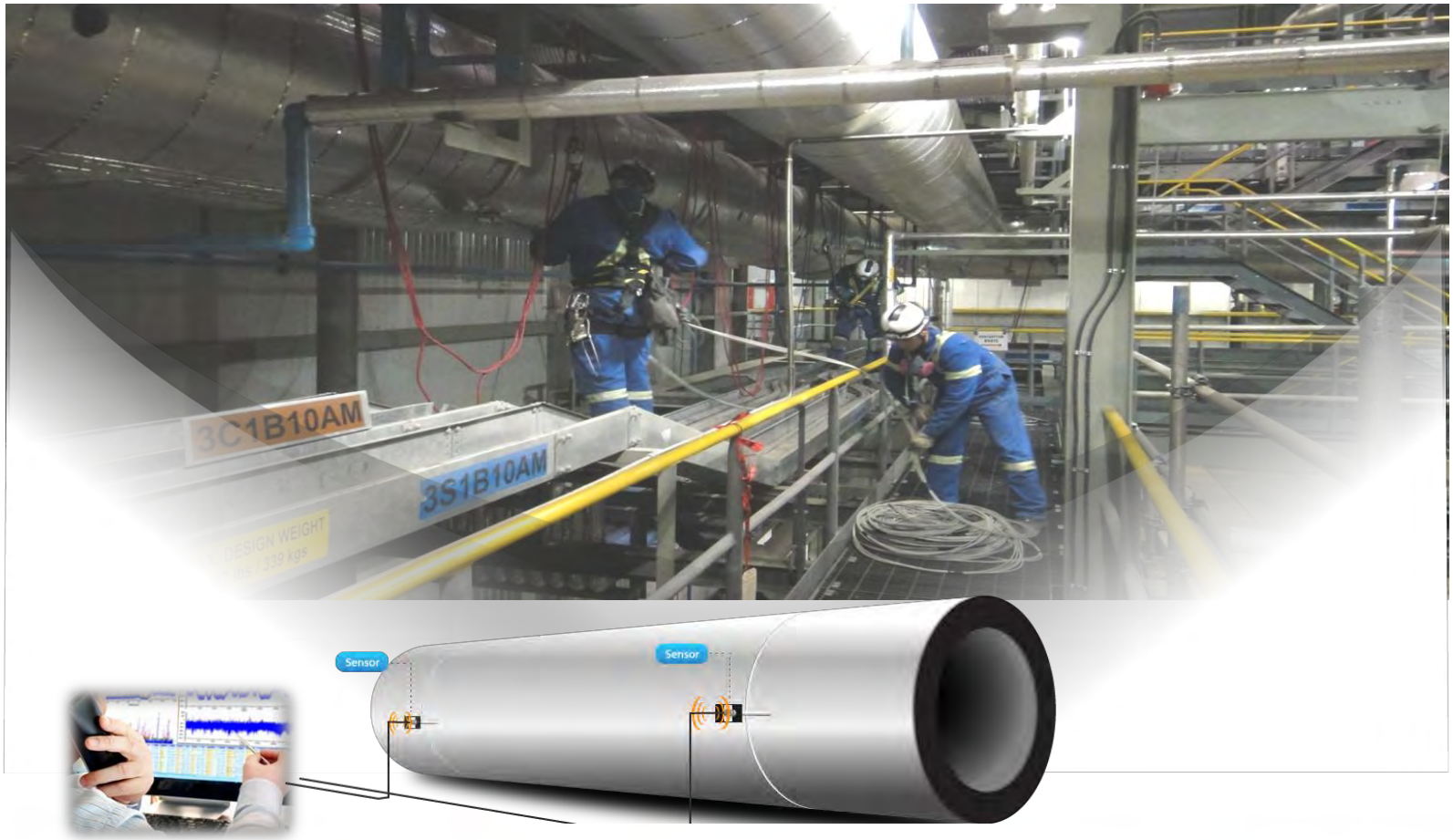
- QAE works on both P22 and P91
- QAE reduces overall risk
- QAE helps to target and prioritize higher risk areas
- QAE supplements traditional NDE
- QAE is cost effective
  - QAE facilitates outage planning and budget process

AEGIS

Objective



AEGIS



Margan
We hear it first.