



Eliminating Unit Interruptions by enhancement of predictive condition monitoring of stationary and rotary equipment in refinery

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INTERRUPTION & CONDITION MONITORING AN OVERVIEW

Impact of Unit Interruption

- Production Loss
- Higher Maintenance Cost
- SHE-Challenges
- Equipment Deterioration

INTERRUPTION & CONDITION MONITORING AN OVERVIEW

Condition monitoring

- Alleviation of equipment deterioration
- Evaluation of equipment condition
- Prediction of future trend

Types

- Continuous (online)
- Periodic

Advantages

- Repair & replacement can be planned.
• Frequency can be established.

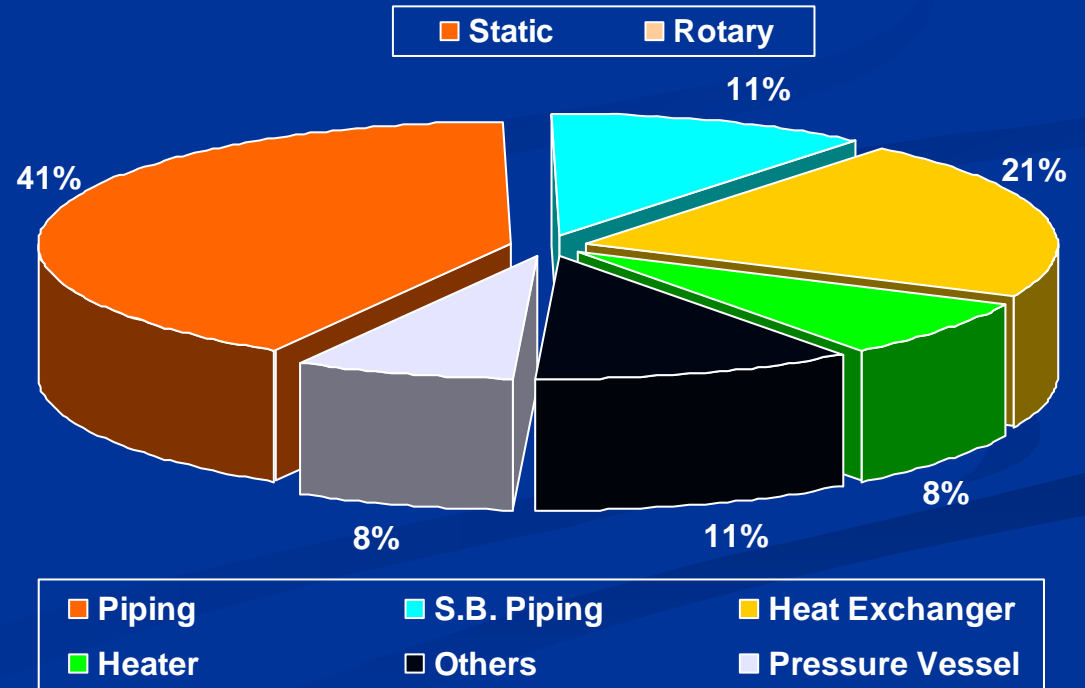
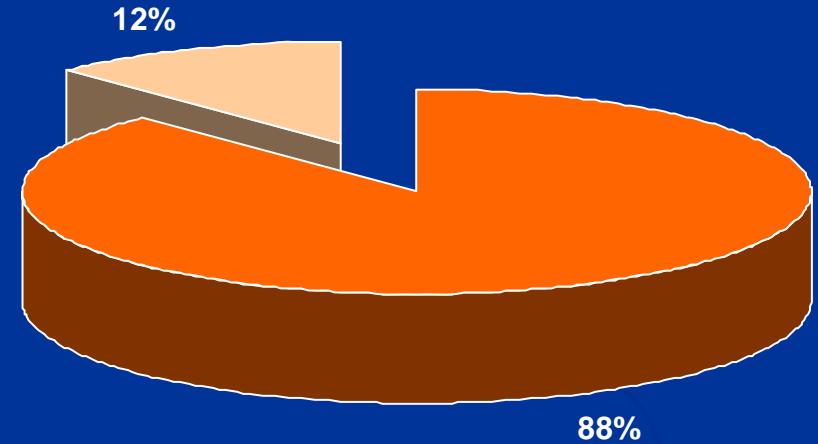
EQUIPMENT CLASSIFICATION & FAILURE PATTERN

Static equipment:

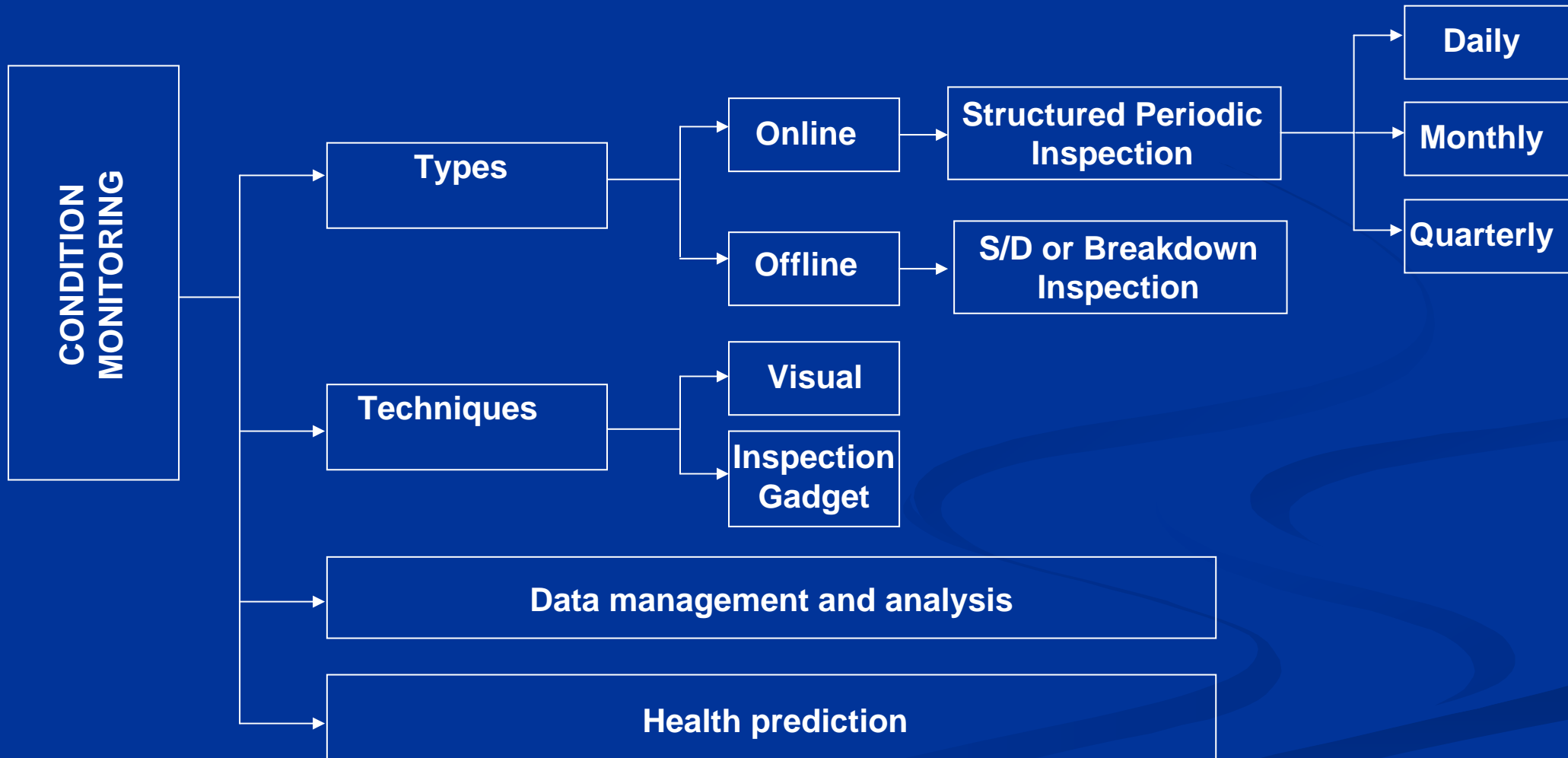
- Heaters
- PV (Columns, Reactors & Vessels)
- Heat Exchangers
- Piping
- Others (Valves, Blinds, Gaskets & Bellows)
- Tanks

Rotary equipment:

- Pumps
- Compressors
- Turbines



PREDICTIVE CONDITION MONITORING STRATEGIES



MONITORING TECHNIQUES : STATIC EQUIPMENT

ONLINE

- Corrosion Control through dosing Treatment
- Corrosion Monitors:
 - ✓ ER and LPR based probes
 - ✓ Corrosion Skid
 - ✓ Field Signature Method-IT
- Infrared Thermography
- Long Range Ultrasonic Testing (LRUT)
- Acoustic Emission Testing (AET)
- Pearson Survey / CAT

OFFLINE

- Ultrasonic Techniques.
- Internal Rotary Inspection System (IRIS)
 - Time of Flight Diffraction Technique (TOFD)
 - Phased Array (PA)
 - “H” Scan Technique
 - Low Frequency Electromagnetic Test (LFET)
 - Remote Field Electromagnetic testing (RFET)
 - Insitu Replication Metallography

CORROSION CONTROL THROUGH DOSING TREATMENT

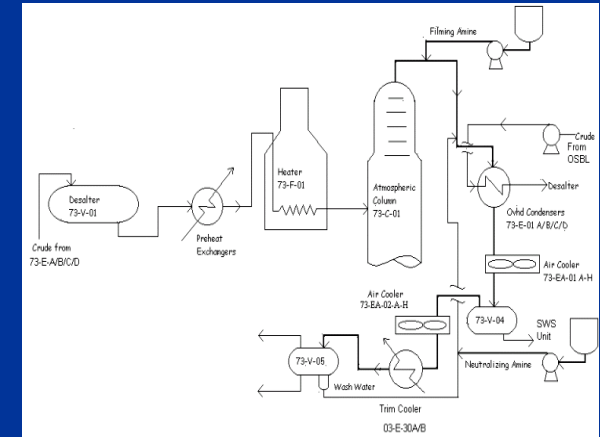
Crude Distillation Units:

Overhead corrosion due to condensation of HCl gas

- $\text{MgCl}_2 + 2\text{H}_2\text{O} \rightleftharpoons 2\text{HCl} + \text{Mg}(\text{OH})_2$
- $\text{Fe} + 2\text{HCl} \rightleftharpoons \text{FeCl}_2 + \text{H}_2$
- $\text{FeCl}_2 + \text{H}_2\text{S} \rightleftharpoons 2\text{HCl} + \text{FeS}$
- Deposition causes fouling & under deposit corrosion

Monitoring

- Monitoring of neutralizing amine to maintain pH 6.0 - 6.5.
- Caustic injection to reduce HCl formation.
- Monitoring of wash water injection.



CORROSION CONTROL THROUGH DOSING TREATMENT

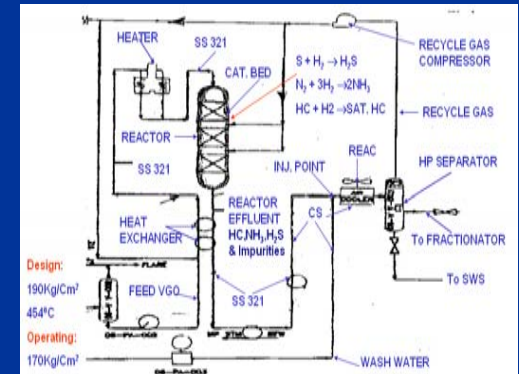
Hydro-processors

ABS Corrosion in REAC

- NH_3 (g) and H_2S (g) combine to form NH_4SH (s) (ABS).

Monitoring

- ABS con. < 6 Wt.% in the separator water.
- velocity within 3 to 6 M/Sec.
- wash water injection rate > 5 % of feed.



CORROSION CONTROL THROUGH DOSING TREATMENT

Light Ends Recovery Units (GCU, LPG Wash & SWU):

Wet H_2S Damage:

- Hydrogen Blistering
- HIC & SOHIC
- SCC

Monitoring

- Injection of filmy amine & polysulfide
- wash water to dilute poison
- Monitoring pH within 5.5 to 7.5.



ONLINE CORROSION MONITORS

Corrosion monitors are to be installed at strategic locations:

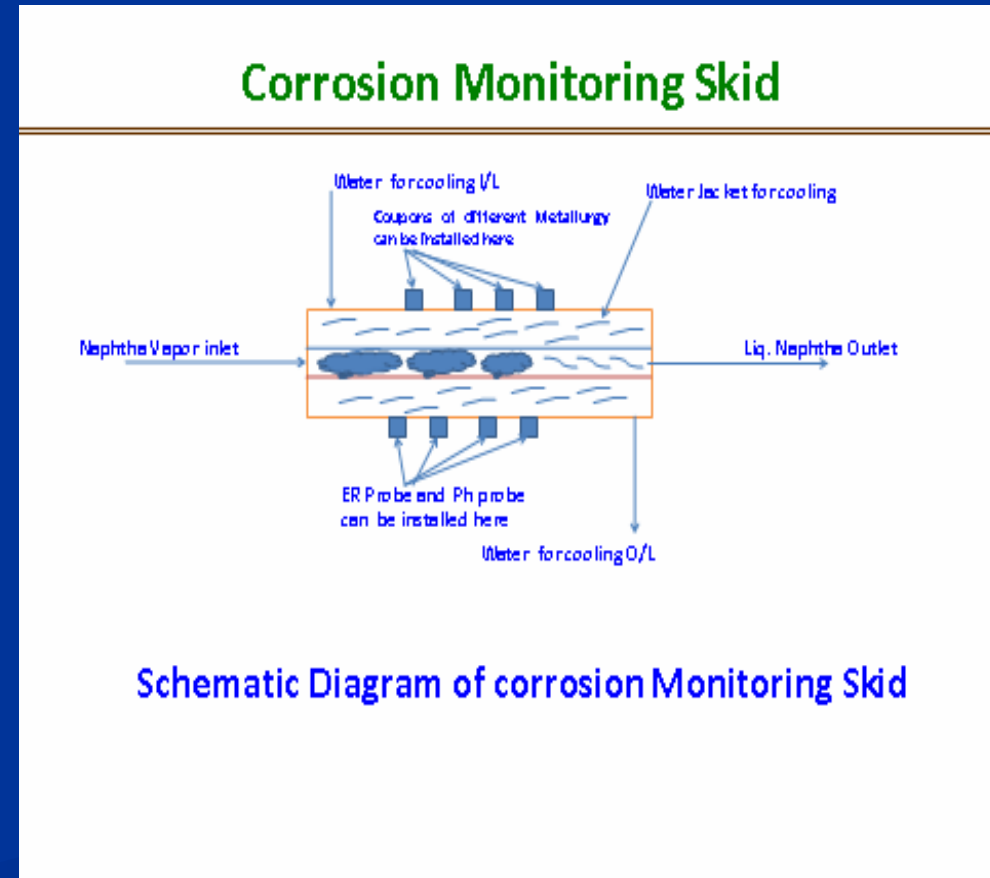
- Liner Polarization Resistance (LPR): Used to provide real time information on corrosion rates to monitor treatment programme, normally in CW service.
- Electrical Resistance (ER) based probes: normally used in HC service.



ONLINE CORROSION MONITORS

Corrosion Monitoring Skid

- Provides general and pitting corrosion rate – real time display with DCS connectivity
- Corrosion rate change can be monitored with change in operating parameters
- Efficacy of inhibitors can be assessed;



ONLINE CORROSION MONITORS

Field Signature Methods-IT

- An FSM-IT system comprise of sensing pin matrixes that are installed onto hardware.
- Low temperature upto 120°C.
- High temperature upto 500°C.



INFRARED THERMOGRAPHY

Principle

- The intensity of infrared radiation emitted from an object is a function of its surface temperature.

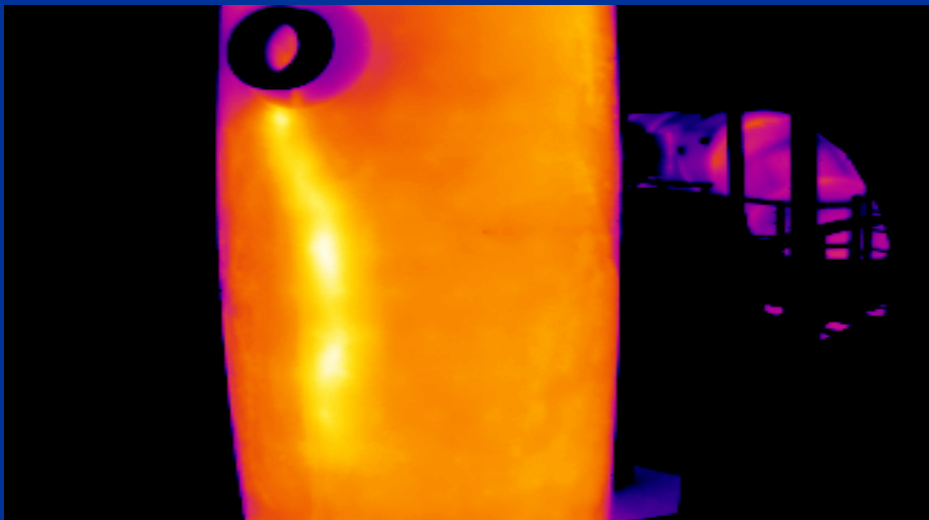
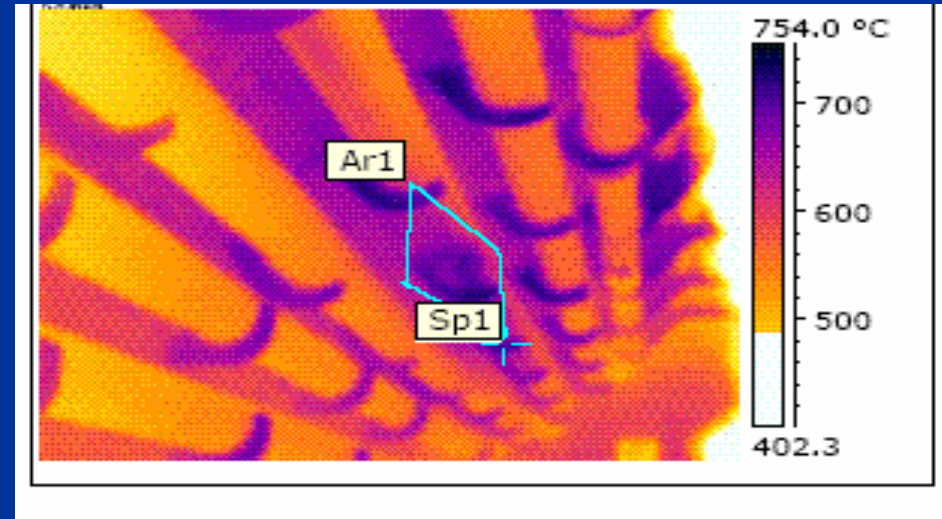
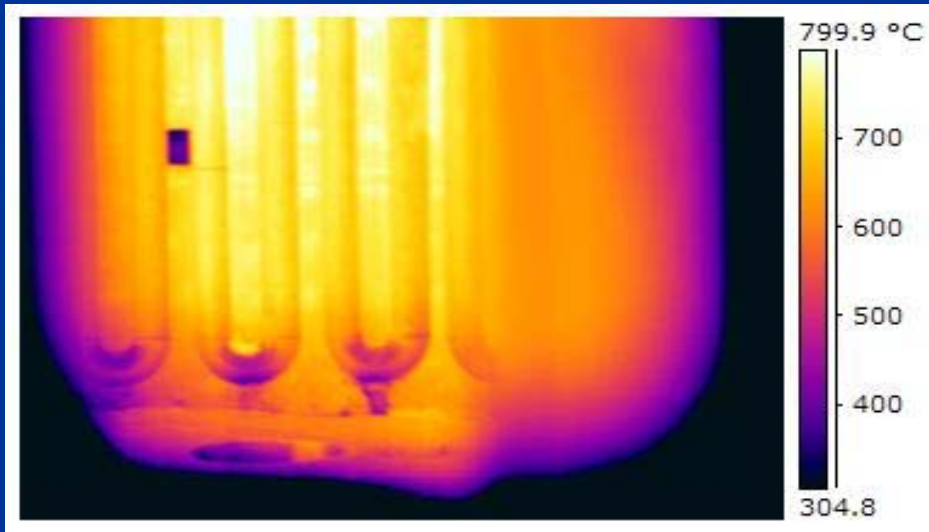
Types of Camera

- Long Wave - 8-14 micron (for outdoor Thermography)
- Short / Mid Wave - 3.9 micron (for furnace applications)

Applications

- Skin Temp monitoring of process heater tubes
- Refractory health assessment of cold walled equipments
- Corrosion under insulation assessment.
- Insulation Deterioration
- Rotary application – Bearing temperature & alignment.

THERMAL IMAGES OF HEATER TUBES & REFRACTORY LINED REACTOR



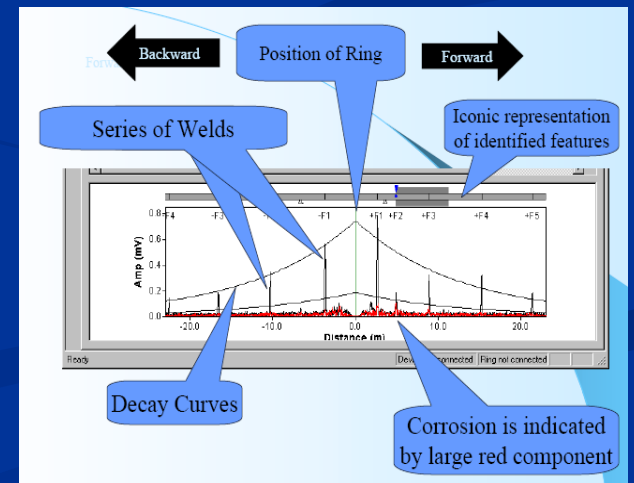
LONG RANGE ULTRASONIC TESTING (LRUT)

Principle

- Low frequency ultrasound is transmitted and received from a single location.
- A ring of transducers is placed around the pipe

Application

- Used for condition monitoring of buried pipes & Insulated pipes
- It is a screening tool & covers 100% inspection



ACOUSTIC EMISSION TECHNIQUE (AET)

Principle

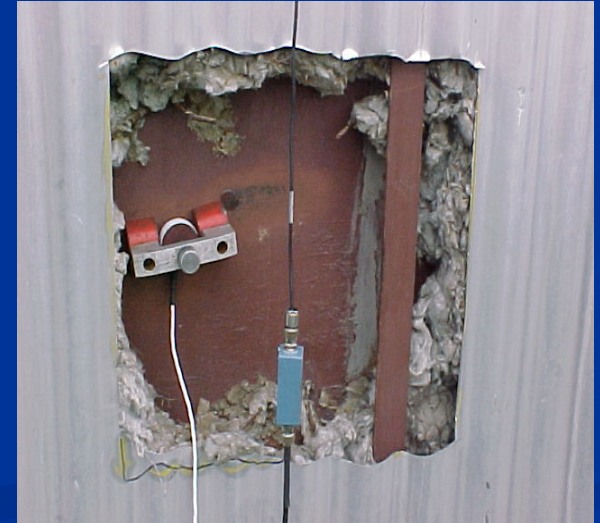
- Acoustic Emission Testing (AET) utilizes highly sensitive acoustic sensors, which are attached to the equipment.

Application

- Tanks & Vessel
- Only relevant active sites are detected.

Advantages

- Tank bottom testing without removal of product.
- A real Time monitoring.
- It is a screening technique.



PEARSON SURVEY

Principle

- The technique make the use of an AC signal introduced to pipeline and compares the potential difference between the underground coated pipe & ground surface

Application

- Condition monitoring of buried piping

Advantages

- To detect holidays in the coating of buried pipeline without excavation.
- Locating the rout of U/G piping.



INTERNAL ROTARY INSPECTION SYSTEM (IRIS)

Principle – Ultrasonic

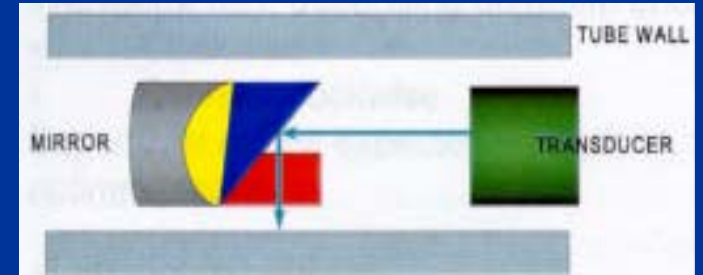
- The Internal Rotary Inspection System (IRIS) is an ultrasonic inspection system consist of a high frequency, high resolution transducer and a 45 deg mirror probe mounted on water driven turbine.

Application

- It is used for assessment of thickness loss in smaller diameter tubes of Air fin coolers, exchangers or boilers.

Advantages

- A 360⁰ scan of the entire tube length from ID side.
- Thickness loss & local corrosion can be detected.
- A high examination speed reduces the shut down time.



TIME OF FLIGHT DIFFRACTION (TOFD)

Principle – Ultrasonic

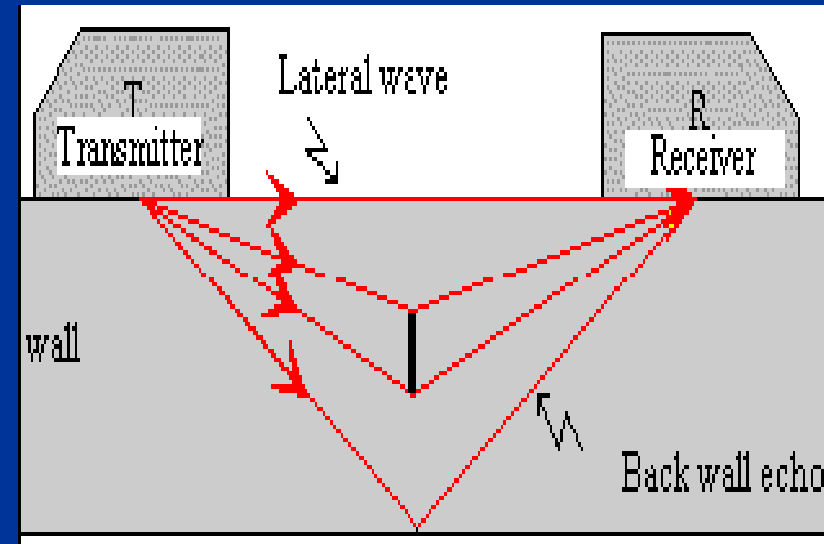
- It captures ultrasonic signals diffracted by the imperfection and provide an exact size and position.

Application

- This technique is used for condition monitoring of thick wall vessel for high temperature H attack

Advantages

- Provide an exact size and position.
- It is also used as a substitute to radiography during fabrication



PHASED ARRAY TECHNIQUE

Principle

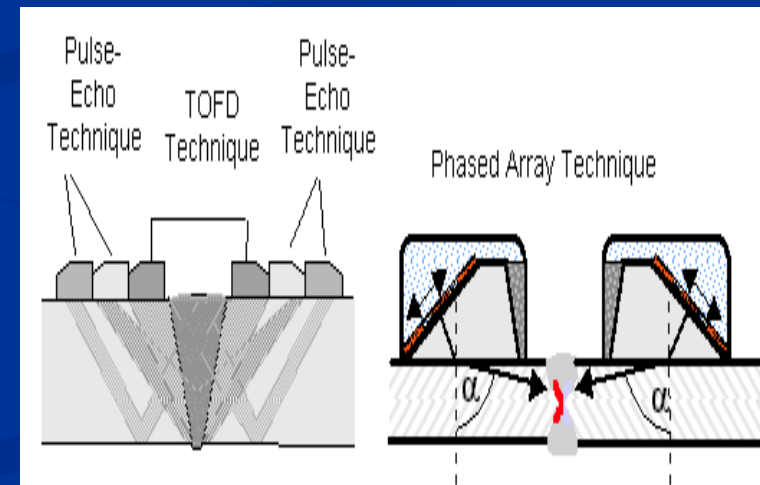
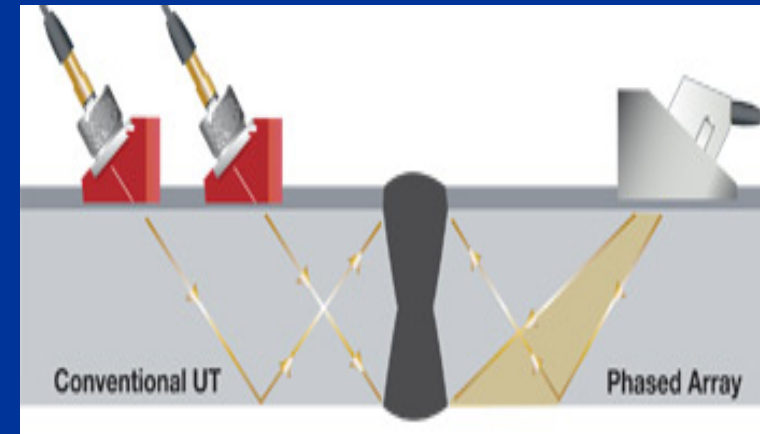
- "Phased Array" implies handling the many signals from multi-element transducers. It consists of ultrasonic beams of various angles and focal lengths using a single array of transducers.

Application

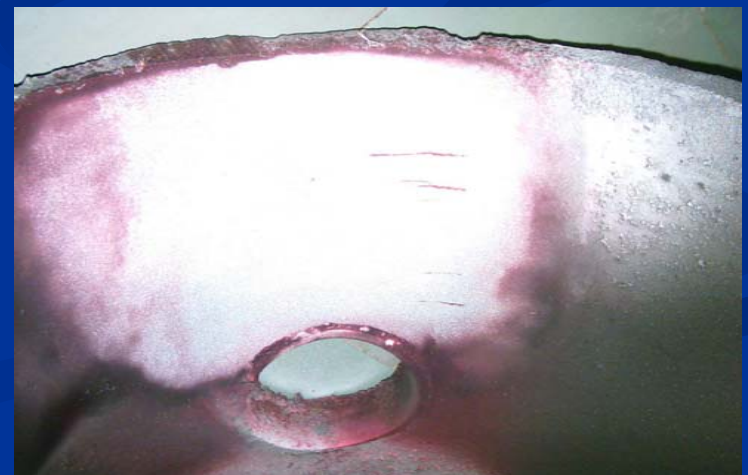
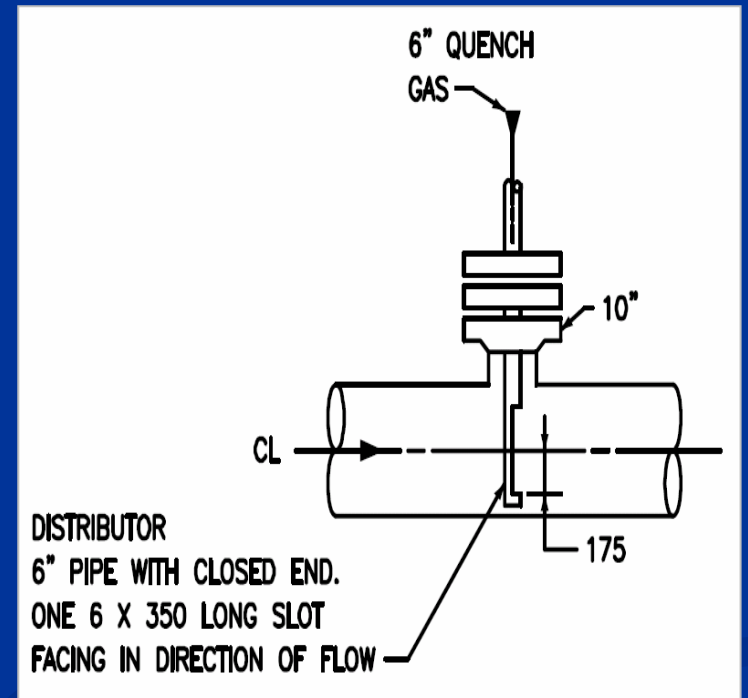
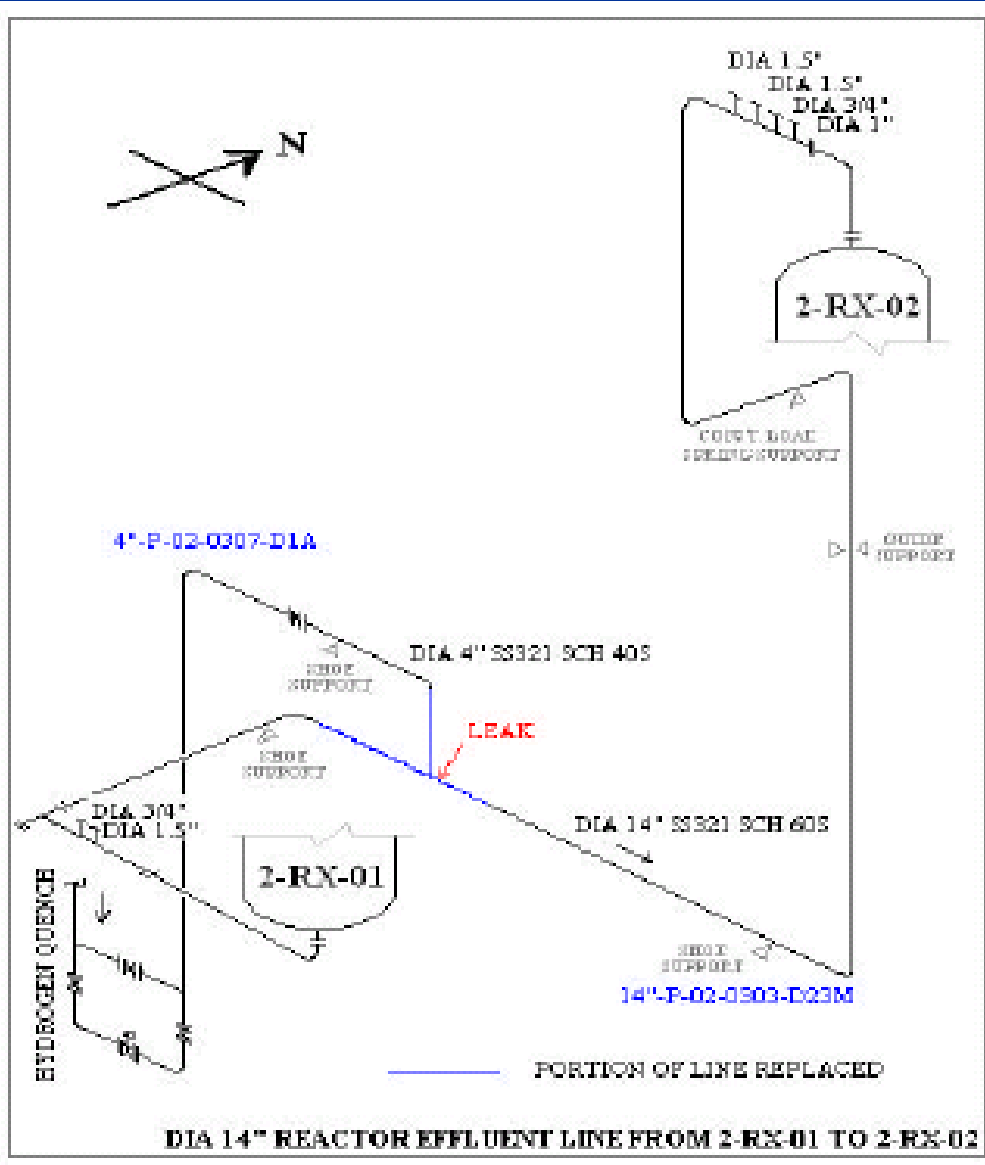
- Mixing tee locations.
- Substitute of radiography

Advantages:

- 100 % coverage
- Exact size & location determination
- Substitute for radiography



PHASE ARRAY TECHNIQUE



H-SCAN TECHNIQUE

Principle – Combination of ultrasonic & electromagnetic

- In service damages such as voids & fissures (AUS)
- OD growth & Thickness loss
- confirmation of flaw (Eddy current).
- Test results & past history is evaluated by software to predict health.
- Tube are categorized as per damages

Application

- Hydrogen reformer tube inspection

Advantages

- Very fast inspection
- No Scaffolding required
- No removal of catalyst



LOW FREQUENCY ELECTROMAGNETIC TECHNIQUE (LFET)

Principle

- LFET uses Low Frequency Electromagnetic Field, which penetrates through the plate thickness and detects any abnormal variation.

Application

- Corrosion mapping of tank bottom plate

Advantages

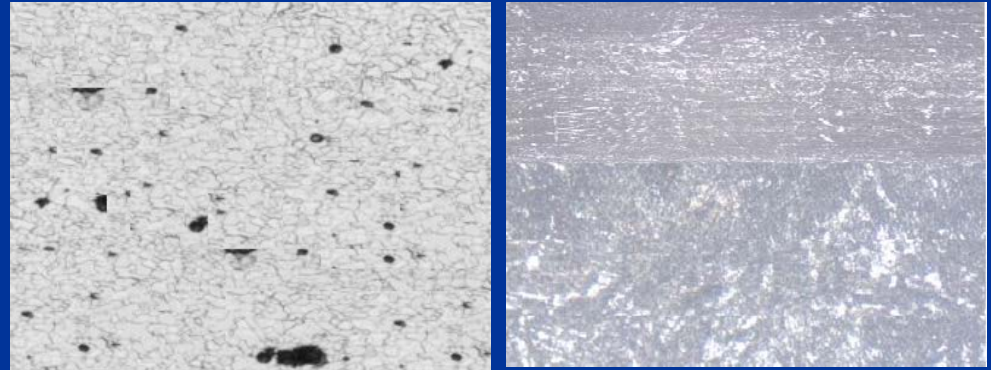
- Rapid Inspection
- No, special Surface preparation & couplant
- Real Time Data Display & storage



INSITU REPLICATION METALLOGRAPHY

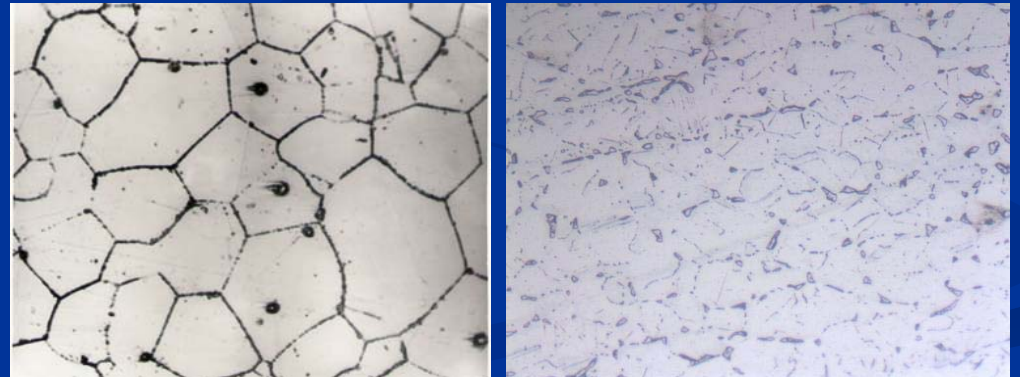
Carbon Steel

- Graphitization
- Carburisation



Stainless Steel

- Sensitization
- Sigma phase



Alloy steel

- Temper embrittlement

CONDITION MONITORING OF PUMP AND MOTORS

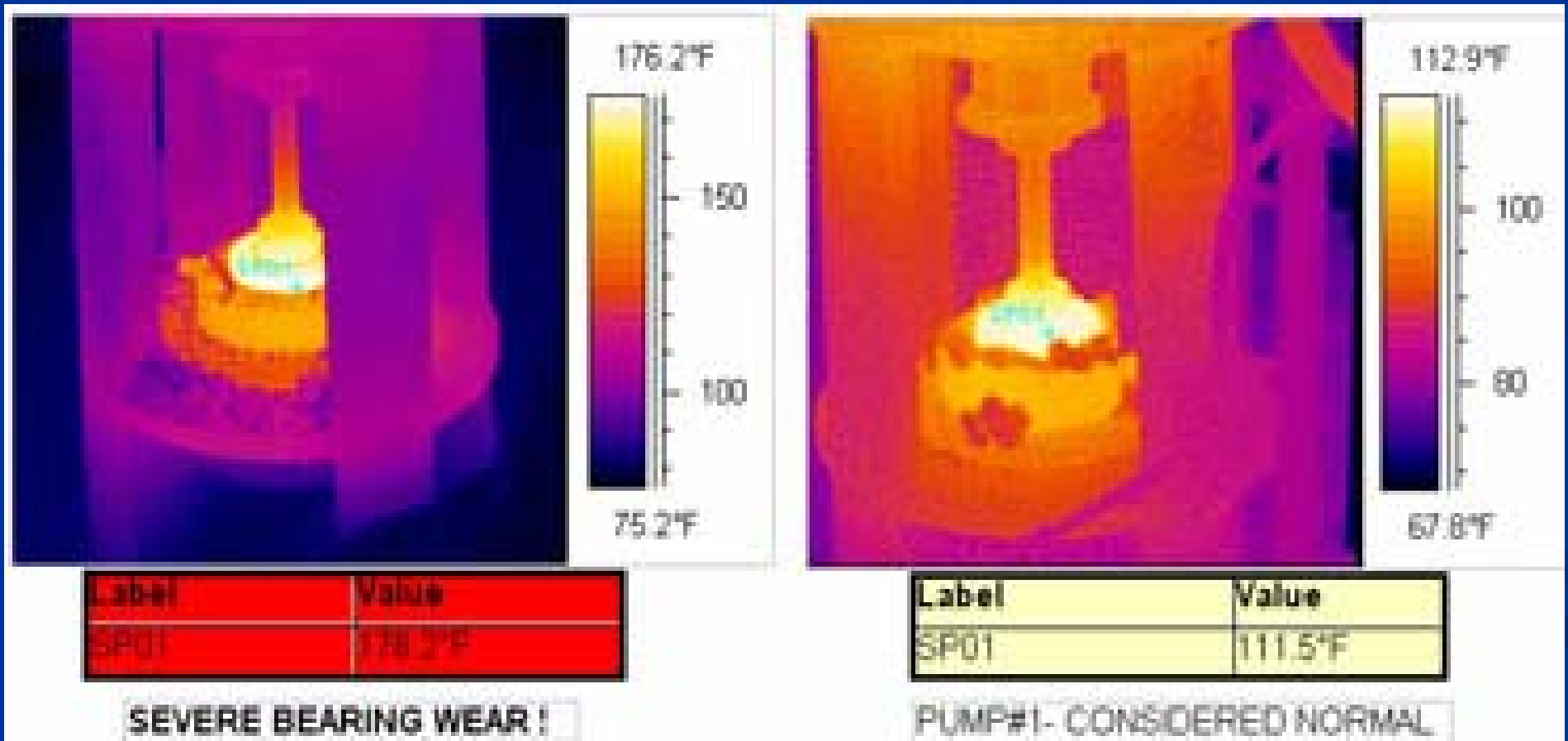
- Vibration analysis.
- Infrared thermography
- Current signature analysis for critical motors.

Technology	Application
Periodic Vibration	All rotating equipment
On-line Vibration	Critical rotating equipment
Oil & Wear Particle Analysis	Critical and low speed equipment
Thermography	Electrical components, roofs, insulation, refractory, mechanical equipment, process
Motor stator analysis, Electrical Surge, MCE	Motor stator and insulation breakdown, electrical balance
Motor current	Motor rotor bars, eccentricity signature analysis
Air Borne Ultrasonic	Steam trap, compressed gases, vacuum leaks, corona

CONDITION MONITORING OF PUMP AND MOTORS

Infrared Thermography

- A failing bearing (left) and a normal bearing in a vertical pump.



Thanks