NDT & Plant Monitoring

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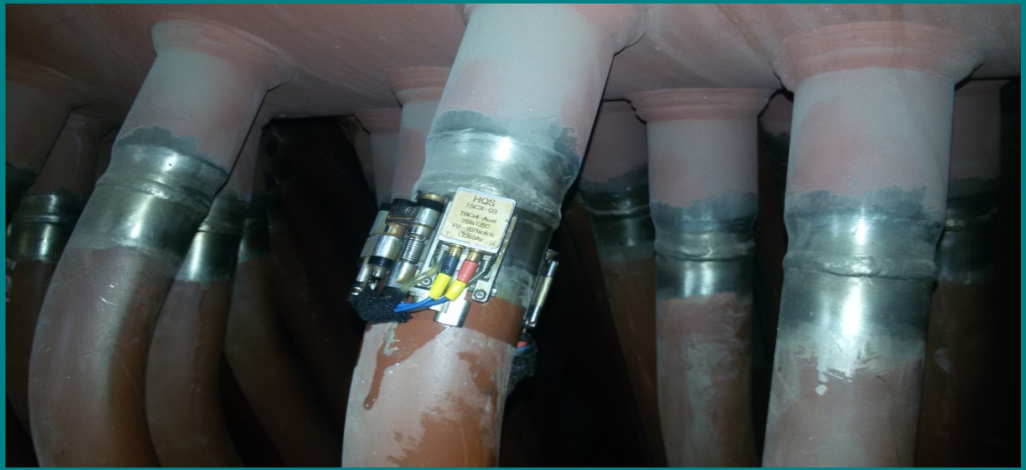
Non Destructive Testing

A course on NDT and Plant Monitoring:

- Common NDT techniques explained
- Examples of specific developments and applications of the techniques



Ultrasonic boiler tube weld

Non Destructive Testing

Why perform NDT at all? (1/ 2)

1. Safeguarding the reliability of products, components, installations
2. Preventing accidents & loss of human life
3. User benefits:
    - Good reputation
    - Improving products
    - Production process surveillance and reducing production cost
    - Constant level of quality

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Non Destructive Testing

Why perform NDT at all? (2/2)

4. Timely planning of maintenance: acquisition of parts and services, saving future planned and unplanned down time

5. Planning of revisions based on the <u>assessed</u> condition of an installation /component

NDT can help preventing....

Result of collapsing boiler component; Algeria 2004, 100 casualties.

- Low pressure steam turbine failure

NDT can help preventing…..

Steam pipe collapse in a coal fired plant in The NL, 2013; miraculously no casualties

Non Destructive Testing

- **At new build plants**

  1. Testing per each component
  2. Integral installation tests

- **During In-service period of a plant (once its operation started)**

  1. Installation in shutdown
     A. Intrusively: (much) dismounting work
     B. Non-intrusively: no or limited dismounting only
  2. Installation in operation (‘on stream’)
     C. On line, *continuous* -measurements (“Condition Monitoring”)
     D. On stream *repeating* measurements, e.g. 1 x per month or 1 x year

Non Destructive Testing

NEW BUILD INSTALLATION → **COMMISSIONING** → **IN-SERVICE PERIOD**

3 years | 1 years | 40 years

Typical timeline for a large electric power generation plant

Applicable NDT and indeed other type of testing programmes can differ greatly during these stages!

Non Destructive Testing

- NDT at new build installations

Features:

1. Not just *component* quality, but moreover: the quality of the *manufacturing* process (e.g. welding) is checked
2. Abundancy of international standards and guidelines
3. Often: routine application / heavily protocolled testing

Non Destructive Testing

- NDT in the in-service period of an installation; Features:

1. Aimed at damage and degradation that develop during plant operation;aimed at suspect and critical parts and areas of components :Risk Based Inspection (RBI) approach
2. Little , often *inadequate* standardisation for NDT
3. Follow-up by Fracture Mechanical Analyses after detection of flaw indications and observed material degradation : "Fitness for Purpose" analysis to make 'Run/Repair / Replace' decisions.
4. NDT data to feed into Remaining Life Time Analysis (LTA), answering: how much life time remains and which precautions should be taken into account and at what price ?

Common NDT Methods & Techniques

- Most common industrial ND testing methods* :
    - VT: Visual Testing**
    - UT: Ultrasonic Testing***
    - ET: Eddy current Testing)
    - MT: Magnetic Testing
    - PT: (Dye) Penetrant Testing
    - RT: Radiographic Testing**
    - LT: Leak Testing
    - IT: Infrared Thermography
    - AT: Acoustic Emission Testing

*) Within the limits of a testing *method*, several testing *techniques* are used, e.g.: UT-PA and UT-TOFD are two different *techniques*, that belong to the "realm" of the ultrasonic testing *method*

**) There is a distinction between *inspection* and *visual testing*, which is usually: the former is performed with *the naked eye* and the latter with *equipment* (e.g. camera, endoscope) ; in practice it these words are being mixed up!

***) '*Volumetrical*' testing methods : looking (deep) into the volume, opposite to *surface* testing methods

NDT Method: Visual Testing (VT)-1

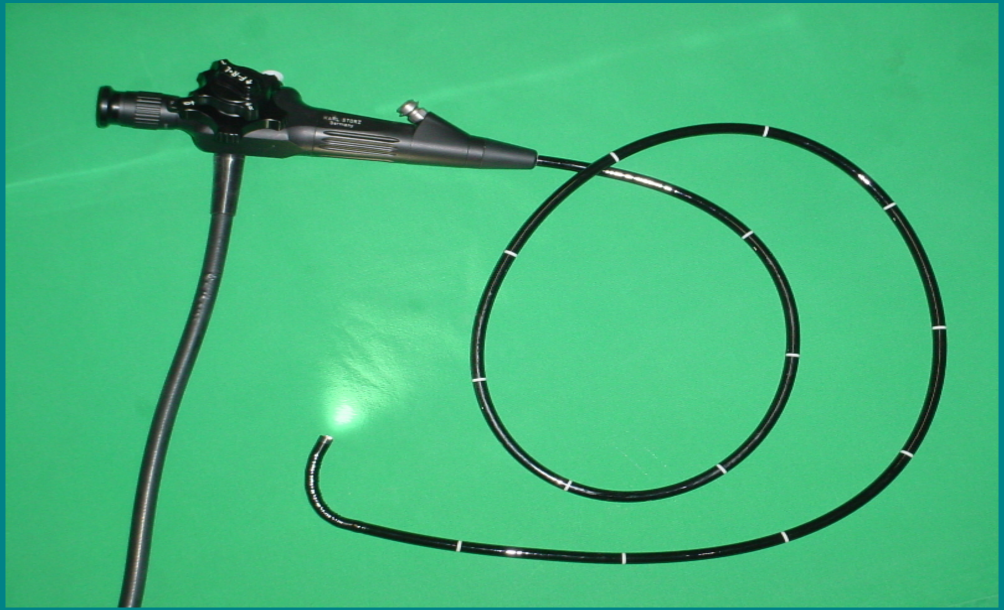
- VT: Visual Testing

  Important aspect for all NDT but more specifically for VT and RT: <u>Vision tests</u>

  - Naked eye (= Visual Inspection)
  - Magnifying glass
  - Endoscope (fiberscope, borescope);
    - video-endoscope
  - TV camera testing

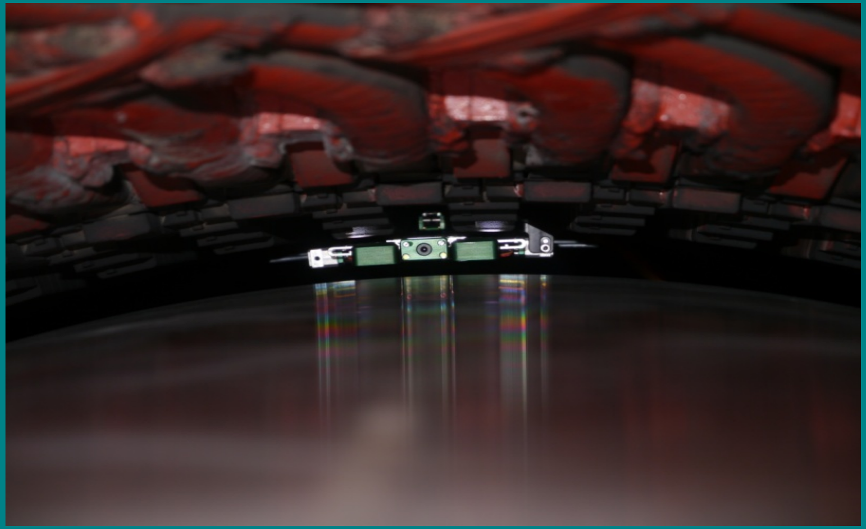
NDT Method: Visual Testing (VT)-2

- Endoscope inspection: widely used and the start of further testing. Industrial use (L) and home applications within reach nowadays (R)



NDT Method: Visual Testing (VT)-3

- Camera inspection: recent miniaturisation without loss of resolution sparked applications in small size inspection robots and drones (unmanned aerial vehicles, UAV)

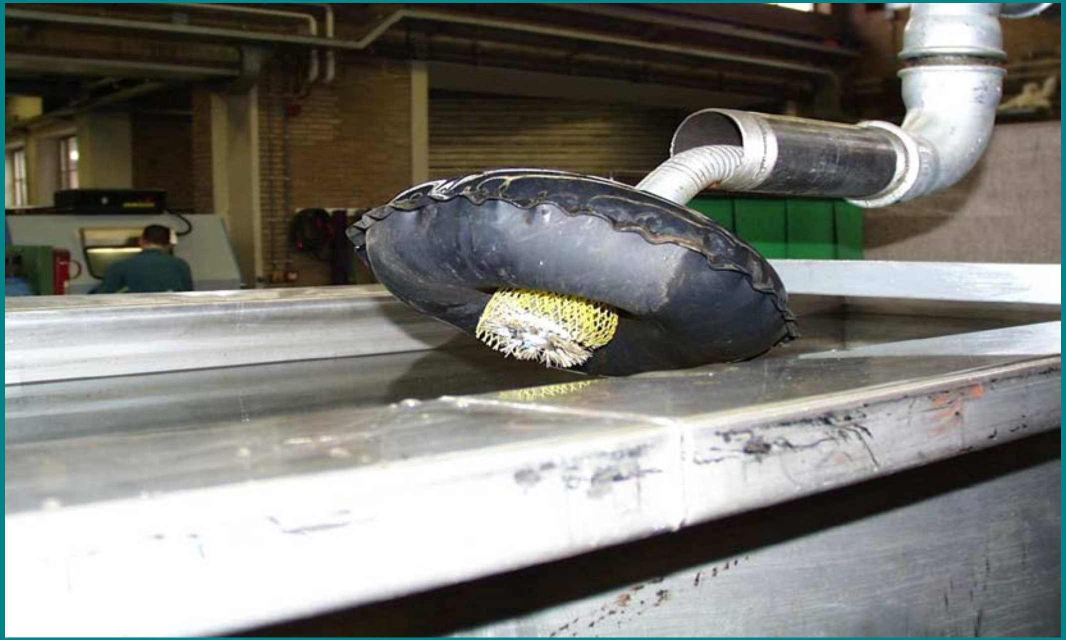


Generator testing robot with 4 miniature cameras

Drone for use in enclosed spaces

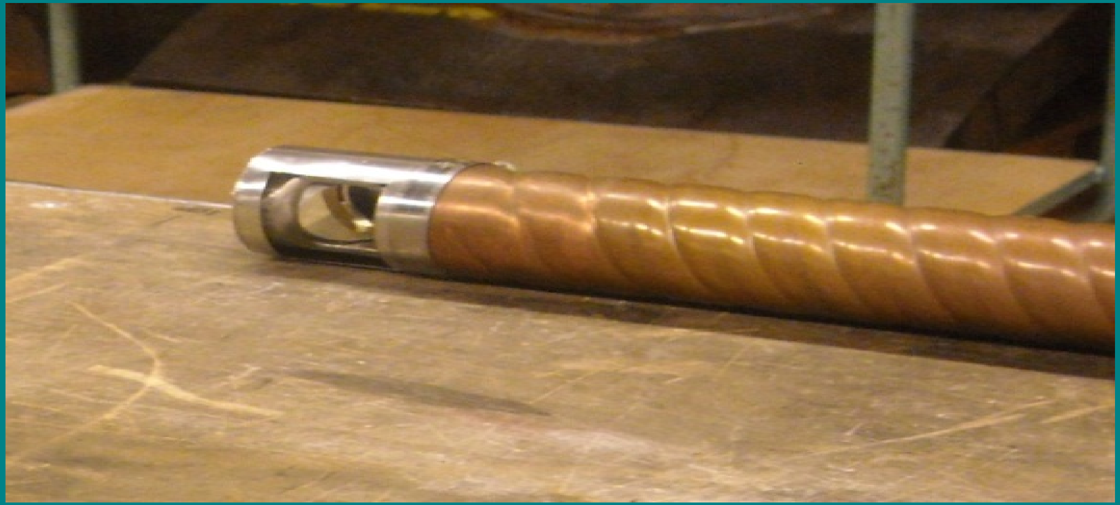
NDT Method: Visual Testing (VT)-4

- Special VT applications : inspection of a tunnel boring machine‘s cutterhead; one -off prototype shown on mock up, negociating 4 elbow pieces in 4 m entrance tube (2“) crossing the boring chamber (2 m length floating) . Entrance against 7 bar hydrostatic pressure in the boring chamber



NDT Method: Visual Testing (VT)-5

- Specific VT applications: water cooled camera head to insert in boilers in operation, „KEMCHRIS“ system



Extra information can be obtained during operation sometimes:

boiler wall deformations during operation that are not visible at standstill , etc

NDT Method: UT-1

- UT: Ultrasonic Testing
  - Manual vs automated testing: AUT
  - Pulse echo: PE (single angle)
  - Time of Flight Diffraction: TOFD
  - Phased Array: PA

NDT method:Ultrasonic Testing-2

Manual testing at a central tie rod of a large (gas)turbine

NDT Method: Ultrasonic Testing-3

Testing on difficult to reach Places:

test piece with spark eroded slots, for calibration..

Mock up for testing handling of the manipulator

- Online-off manipulator to test a specific HP steam turbine from inside its inlet nozzle;
- UT probe with special shoe.

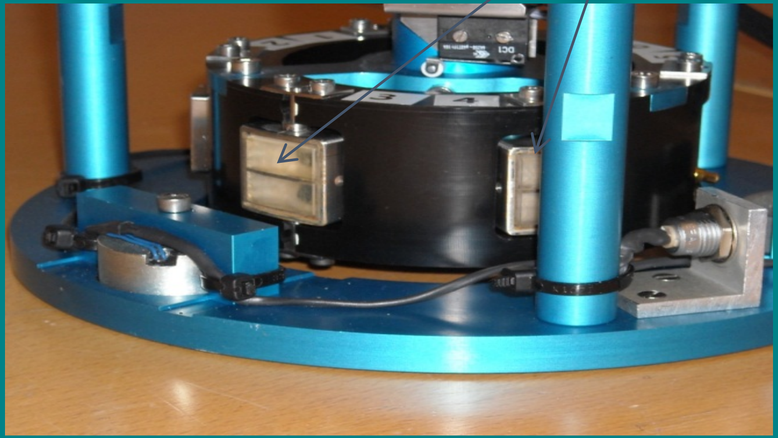
NDT Method: Ultrasonic Testing-4

- Manipulator for automated UT (AUT)

"Cuebis" manipulator for testing of GT disks from the bore 's surface; additional ET testing applied to test the surface

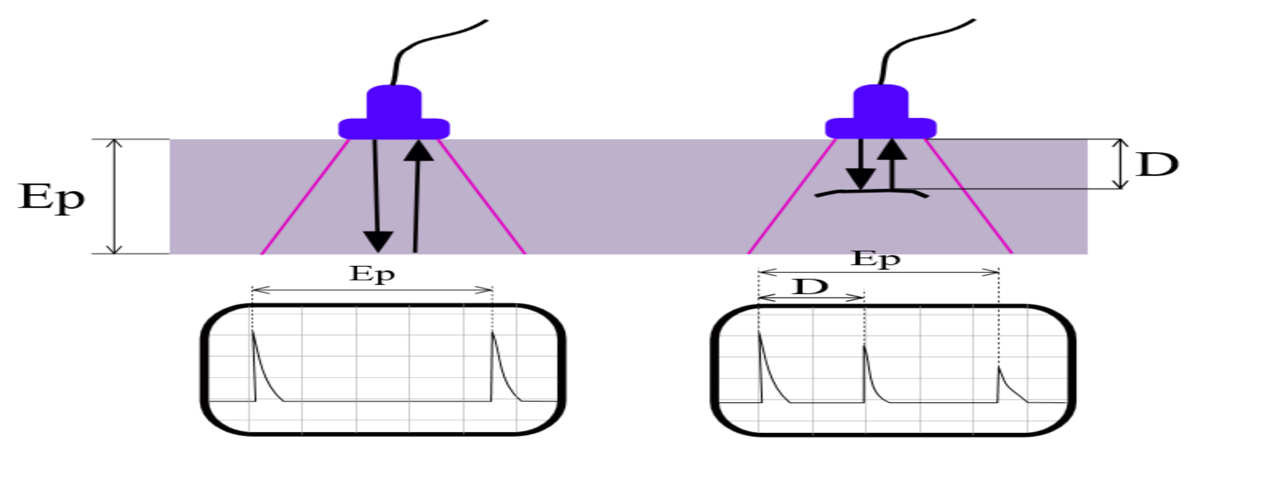
close up

UT probes



UT language (1)

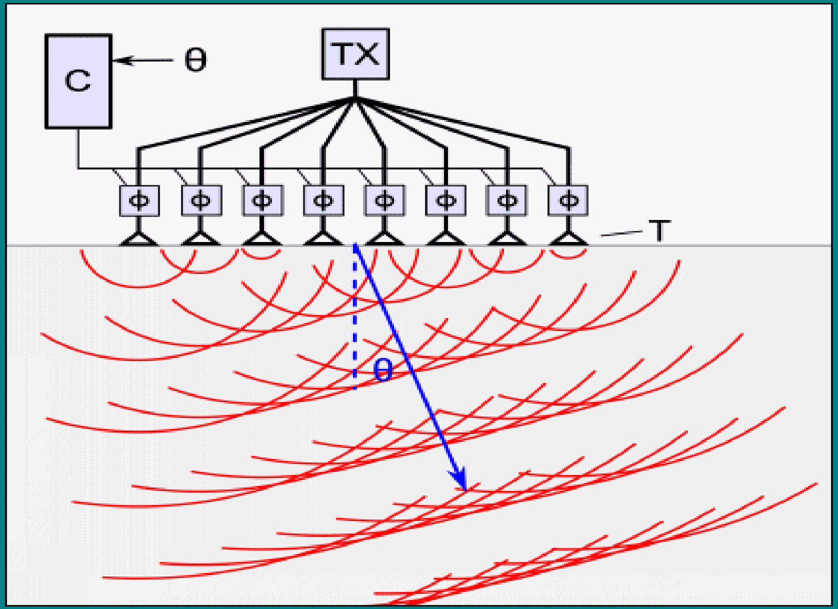
- PE = Pulse echo, meaning: broadband pulses (in the *time* domain: *short* pulses) are being sent into the test piece and the reflections measured, received , processed and displayed, in an “A-image”. The opposite is to send in continuously, a method virtually not used in NDT. Typical frequency range in industrial UT: 1 to10MHz.



Show is a 0° probe, its waves entering and returning perpendicular to the surface plane

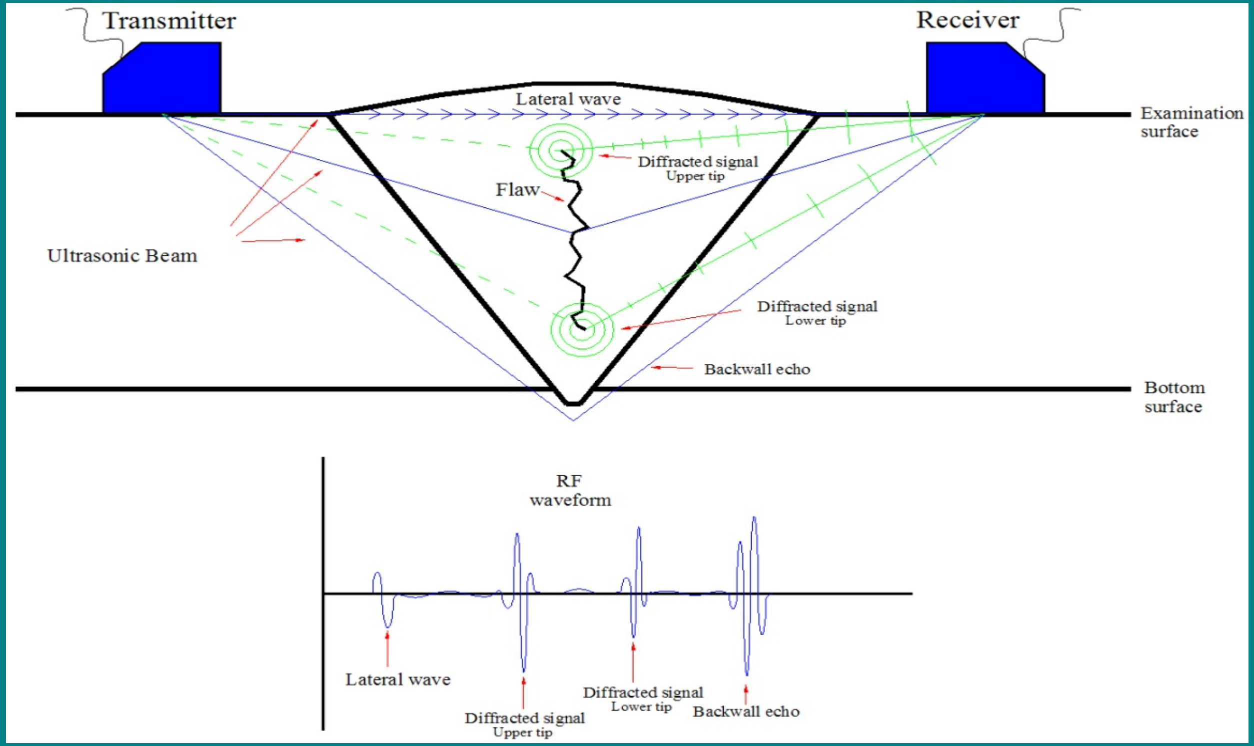
UT languague (2)

- PA = Phased Array; still *pulse echo,* but working at a range of angles, fixed or scanning in one direction (2D) or in two directions (3D); by manipulating the excitation delay of the piezo crystals the wavefront is sweeped: in the picture left crystal is striken first and then, at fixed intervals (0.1 µs-range), the neighbouring ones, one after the other.

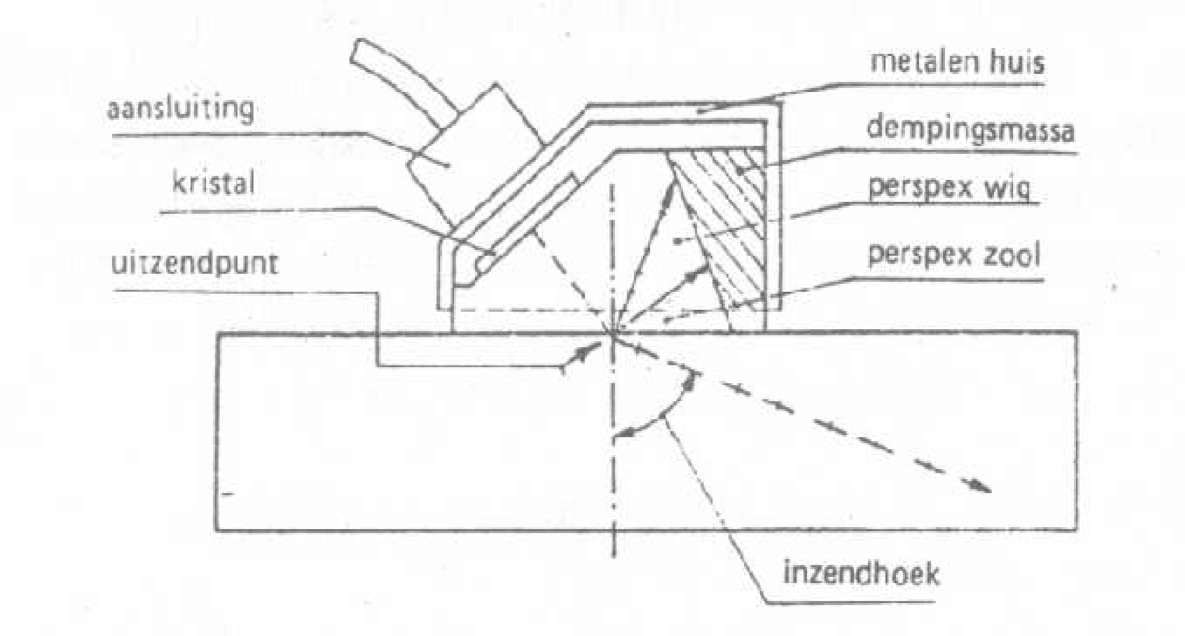


UT languages (3)

- TOFD : It is still pulses that are sent by the transmitter at a wide angle and reflections received at the receiver probe (‘pitch catch configuration ‘), but diffraction signals come in addition here: green lines: flaw tips act as secondary transmitters.

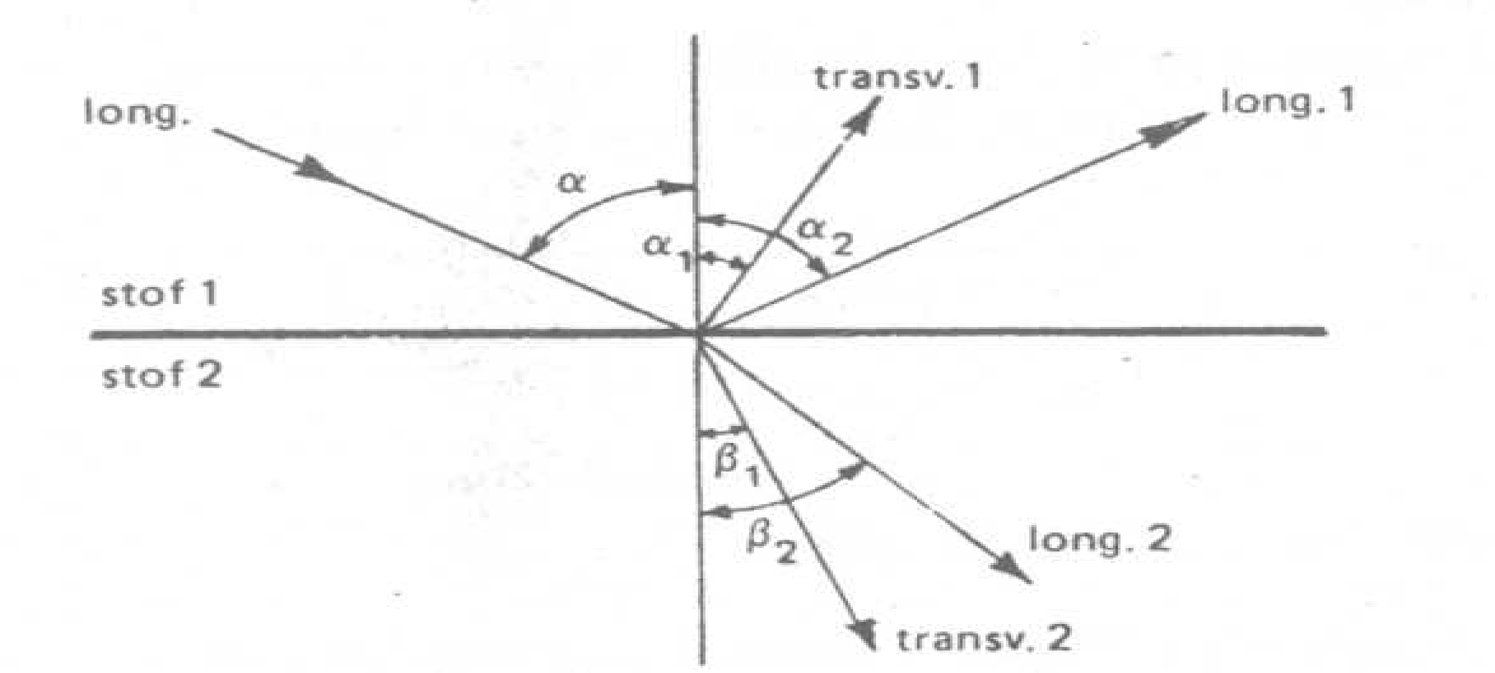


UT-PE Single angle probe



A typical PE probe: piezo crystal generates a compression wave upon excitation by an electrical pulse that at the entry point ("emission point") transmits a refracted wave; the crystal translates all reflecting waves back into electrical signals; swift damping of the reflected energy in the perspex wedge is important to avoid interference with the incoming reflections.

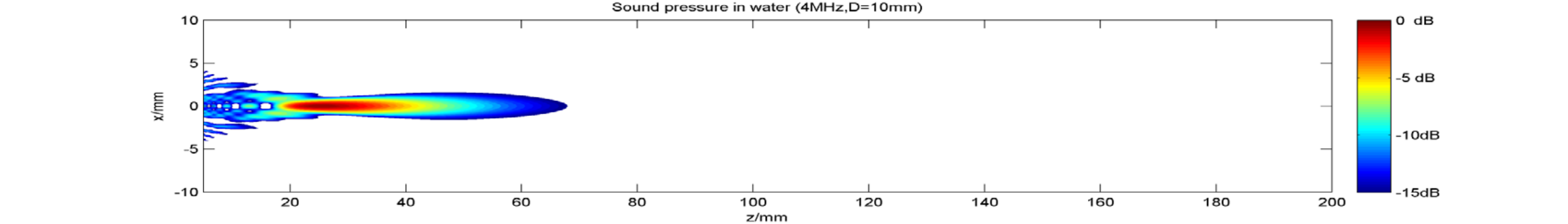
Transmission & reflection of ultrasonic waves



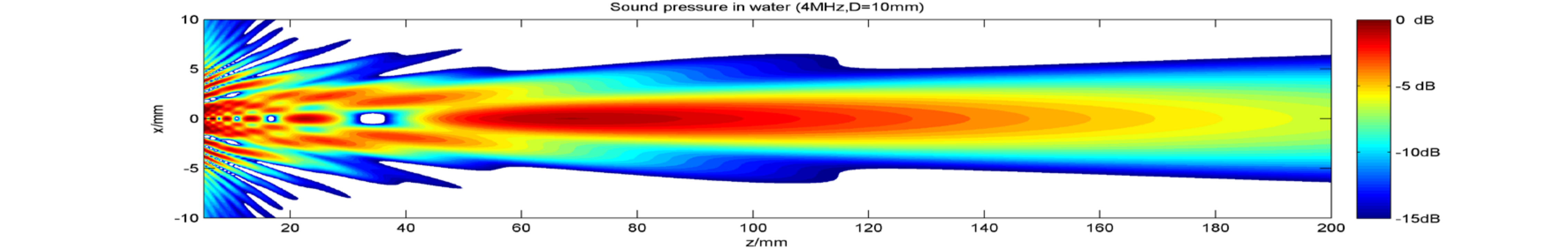
The incoming compression (longitudinal) wave at a boundary of two materials generates a reflected and a transmitted compression wave as well as shear waves (transversal waves): mode conversion.

Transmission & reflection of ultrasonic waves: beam focus on site of damage

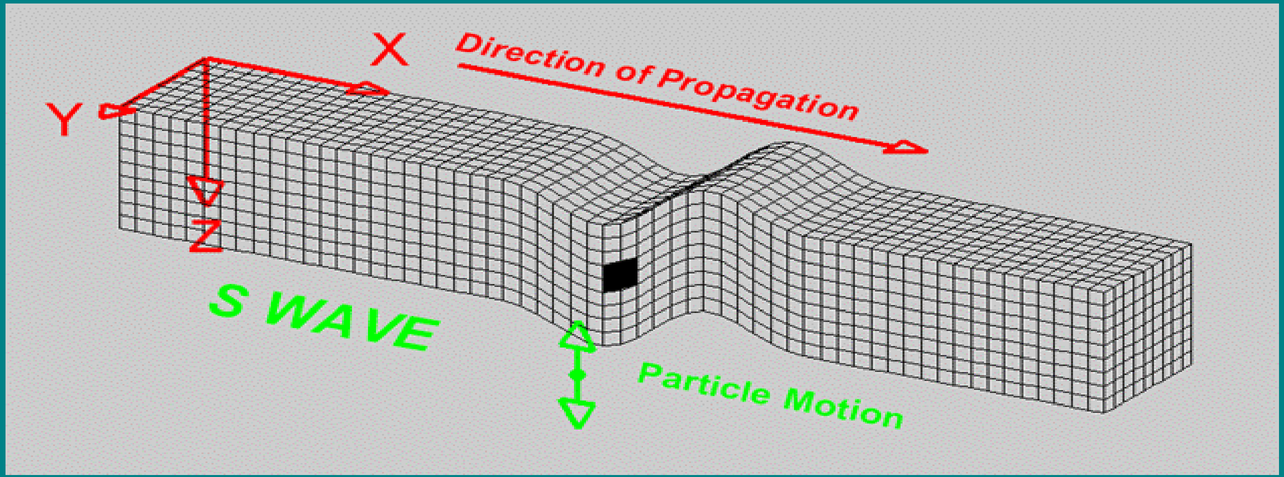
Ultrasonic beam in water; focused beam on site of defect.

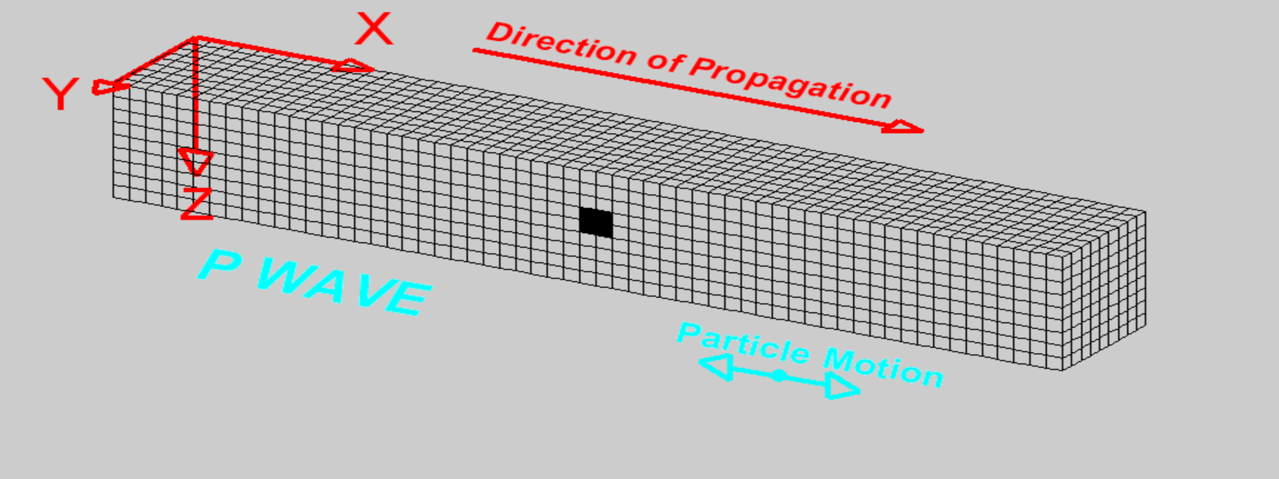


unfocused beam (never used).



Transmission & reflection of ultrasonic waves

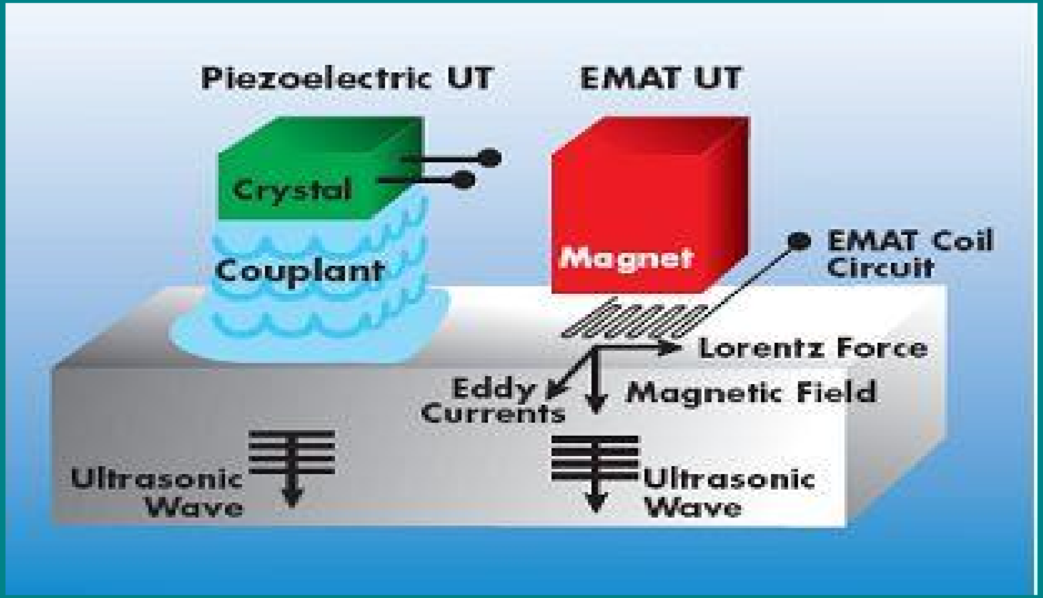




Shear waves : Particles move perpendicular to the propagation direction

Compression waves: particles move along the propagation direction

Transmission and reflection of ultrasonic waves



EMAT probe

A standard UT probe is based on piezo electrical crystal, but EMAT-s (Electromagnetic Acoustic Transducer) are helping in specific situations as no physical (fluid) coupling is necessary,

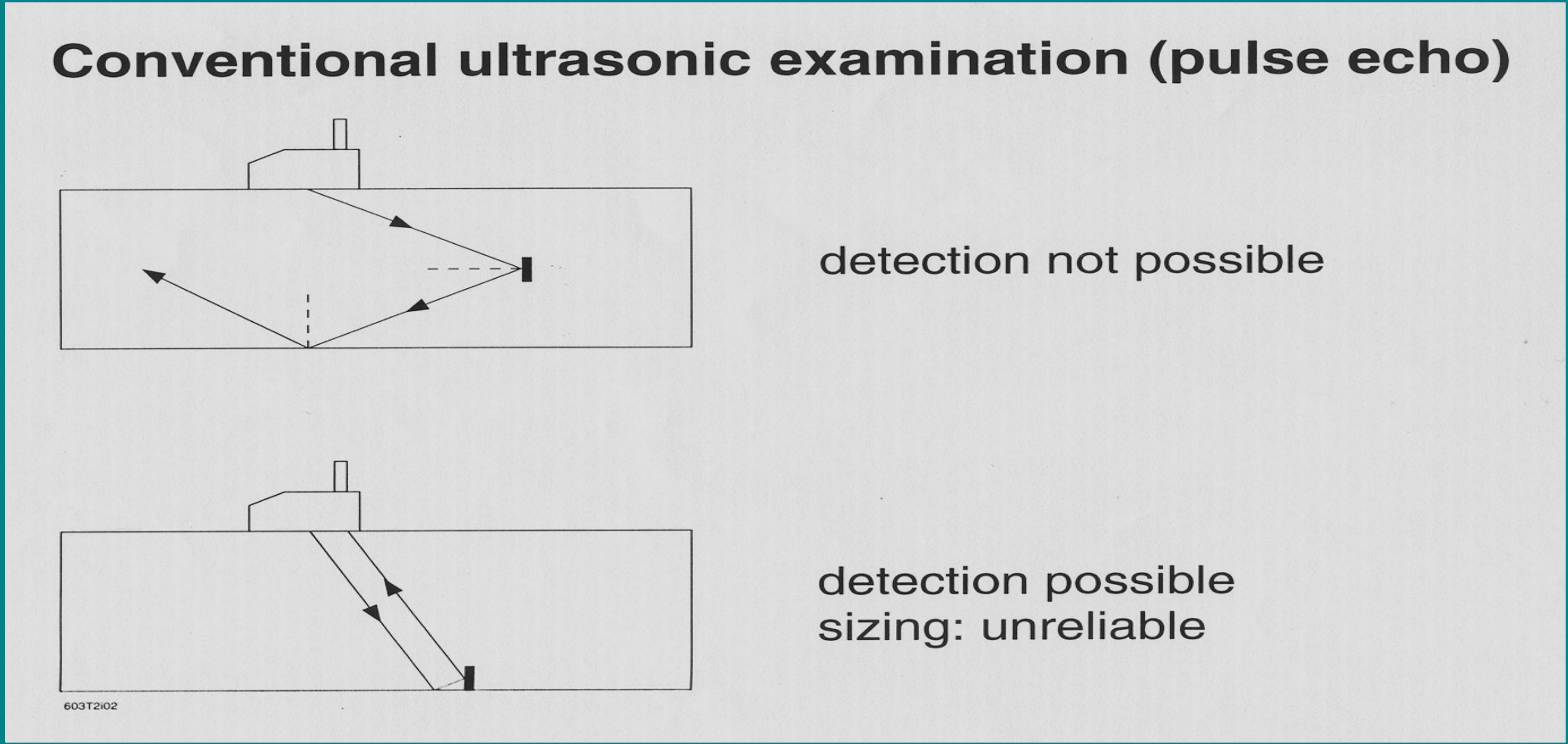
Advantages:

- High Temp applications
- Scaling / coating on surfaces present
- Surface roughness less important

Drawbacks:

- Low sensitivity
- Larger probe size
- Not easily applied at other angles than 0°
- SH (shear wave) only

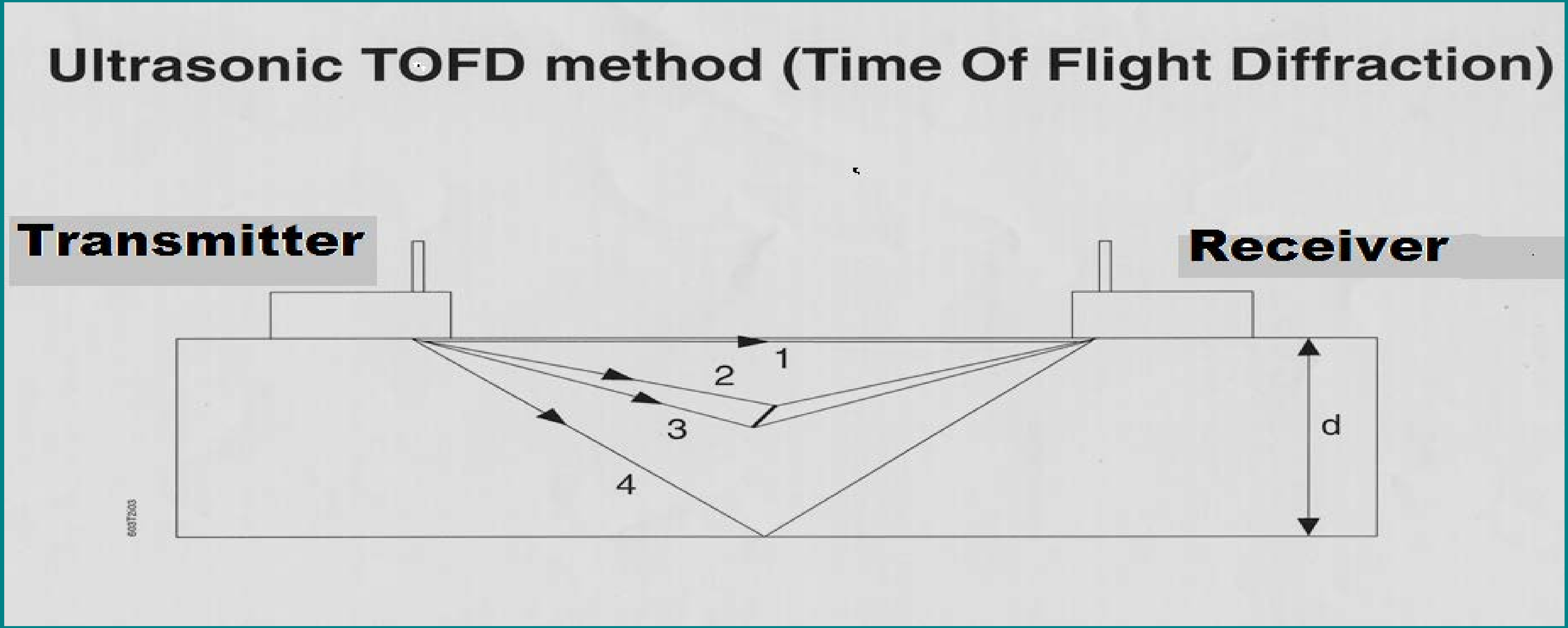
NDT Ultrasonic pulse echo(PE) testing



UT PE is like playing pool : “the ball returns from the corner, but doesn’t care about the length of the cushion “

Ultrasonic TOFD (time of flight diffraction) testing:

for welds; tips of cracks in the weld will diffract the signal back to receiver



TOFD schematic at static position of the probes : sizing and flaw position information

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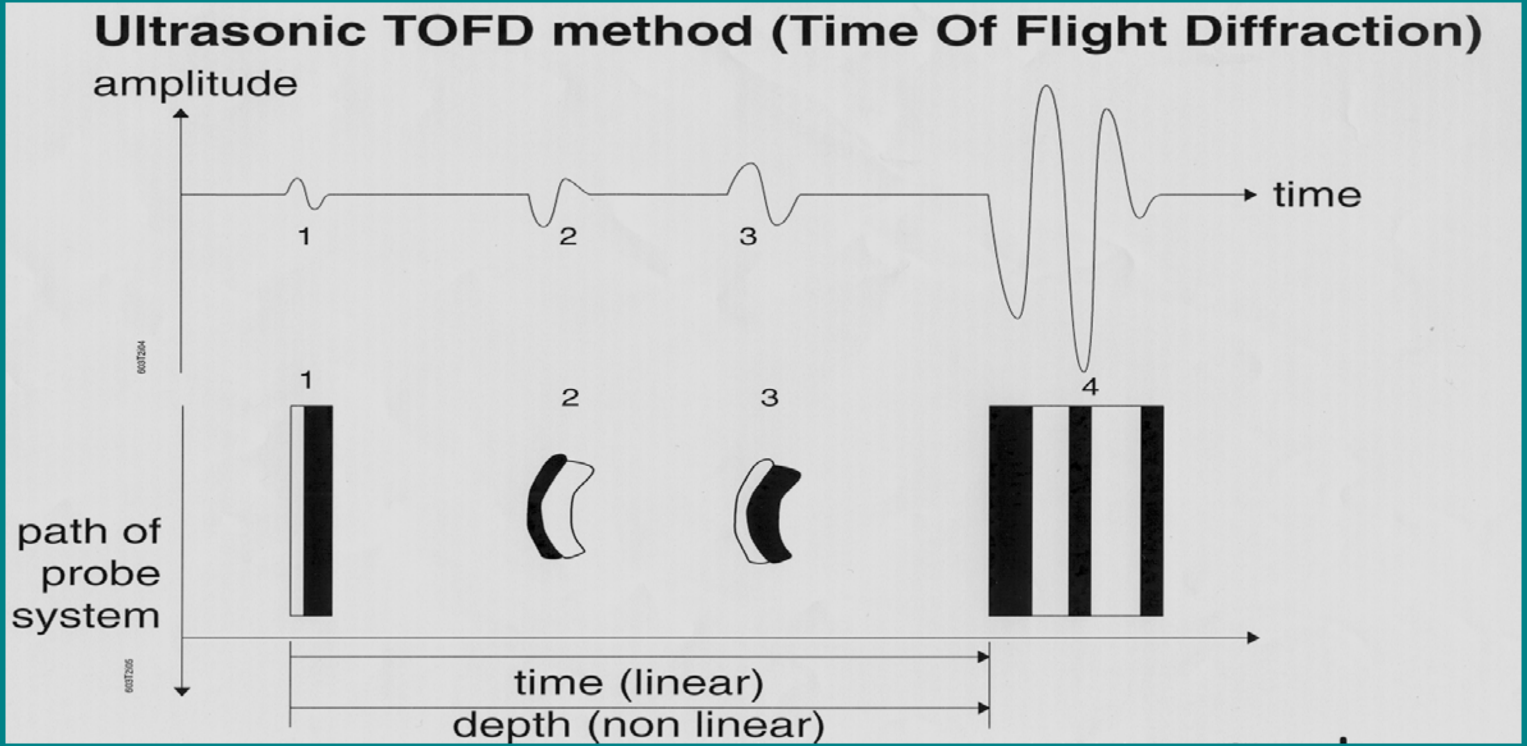
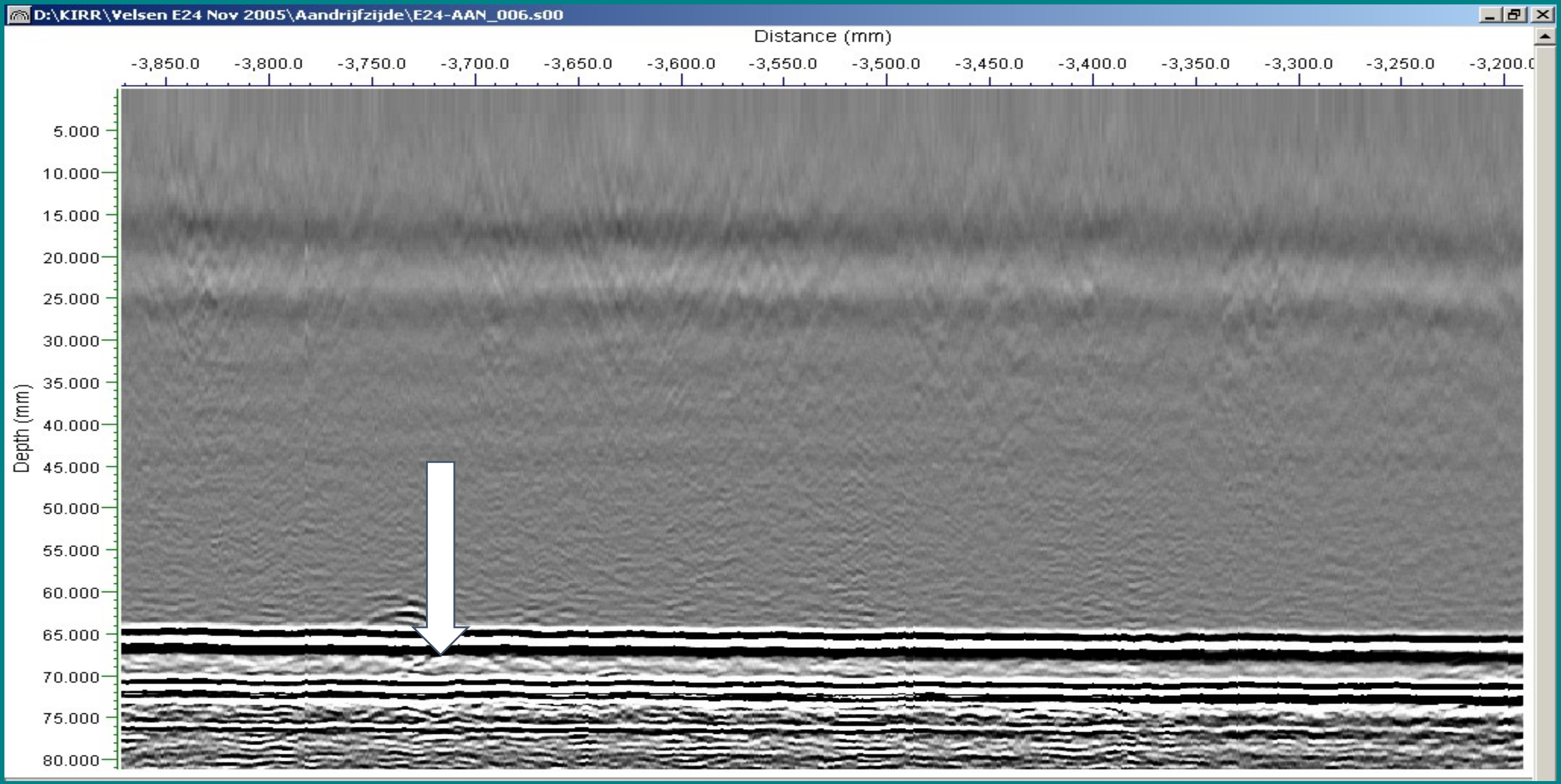
Ultrasonic TOFD testing

lenght of way (=time of flight) determines where the fault is located



TOFD, schematic : at scanning position of the probes moving:
accumulated A-scans translated in gray scales and displayed (trace below)

In situ inspection of generator retaining rings



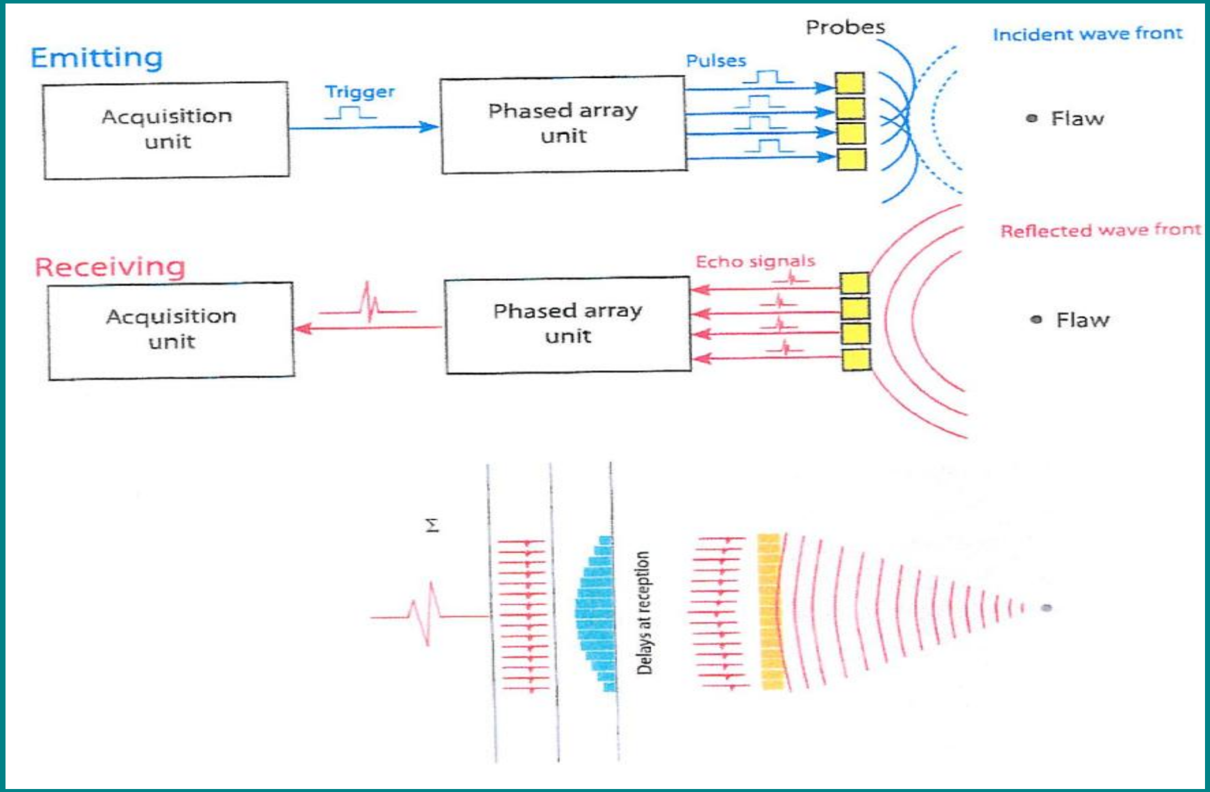
Wall thickness

UT-TOFD image with a crack indication at RR's inner surface.

Vertically: UT time-of-flight > wall thickness by back wall echo

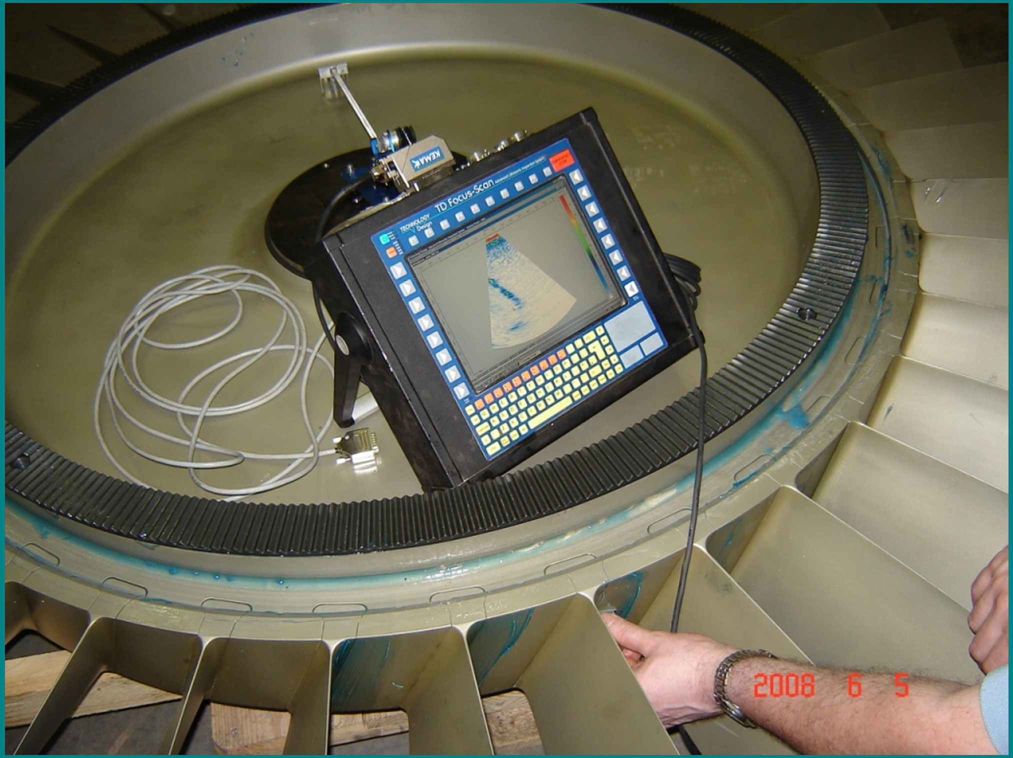
Horizontally: circumferential position

Principles of UT phased array technology



UT beam steered by manipulating delay times at which the array of piezo crystals are triggered: to *sweep* and to *focus*

Principles of UT phased array technology



UT beam steered: less probe movement involved in difficult to access areas, p.e between turbine blades

Automated UT with a crawler (robot) to test ORC boiler wall thickness

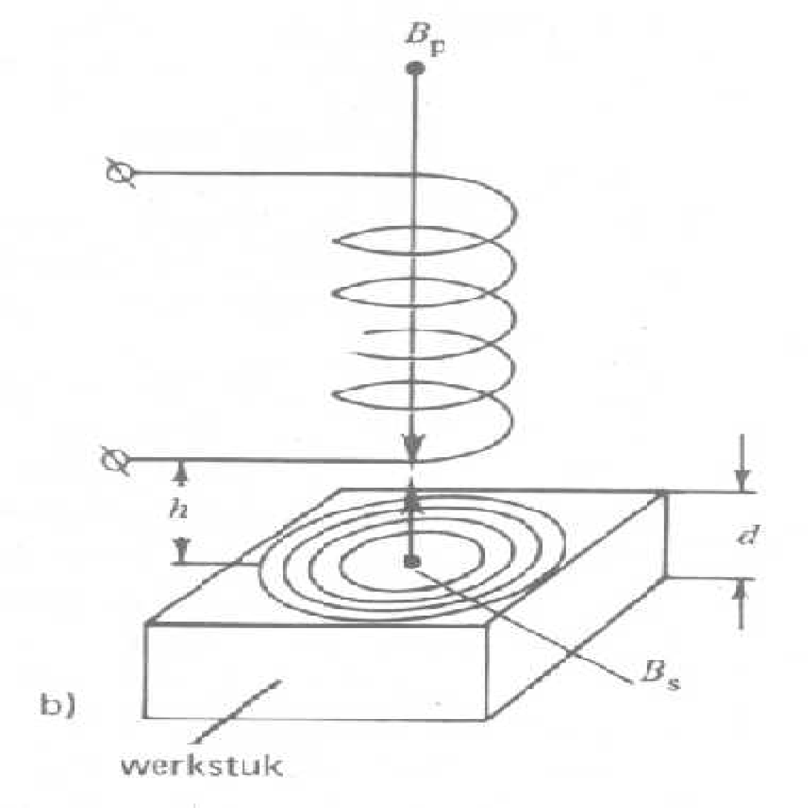
NDT Method: Eddy Current (ET)

- ET: Eddy Current Testing
  - Surface Testing (any metallic material)
  - Tube Testing (mostly: Heat exchangers)

Specific ET techniques:

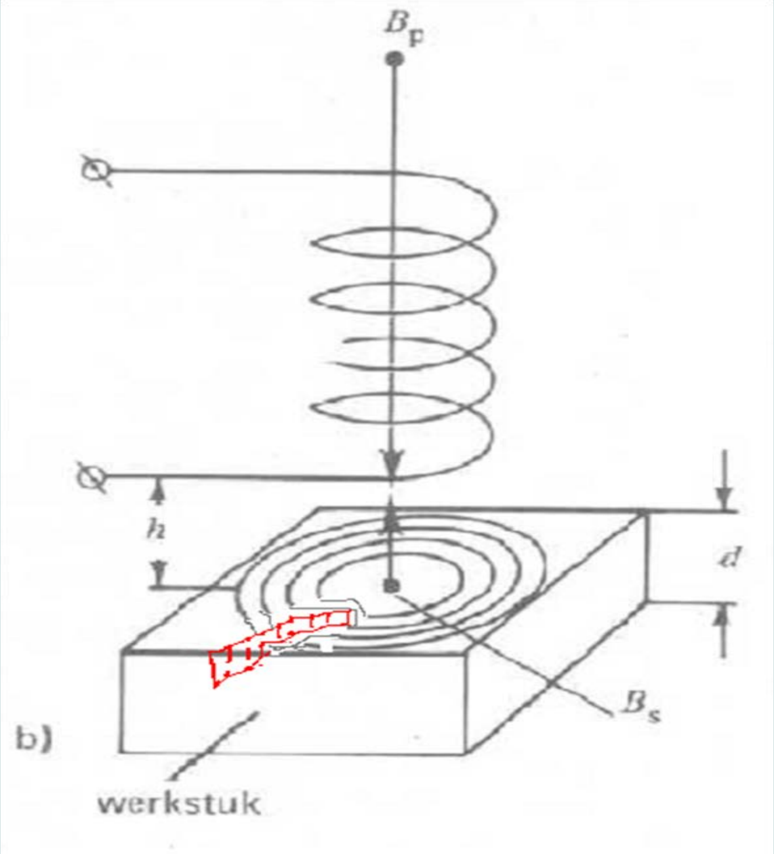
- Remote field ET (RFEC =RFT)
- Partial Premagnetisation technique (PSEC)
- Pulsed ET (PEC)
- Cross wound probes for weld testing

Electromagnetic induction of eddy currents



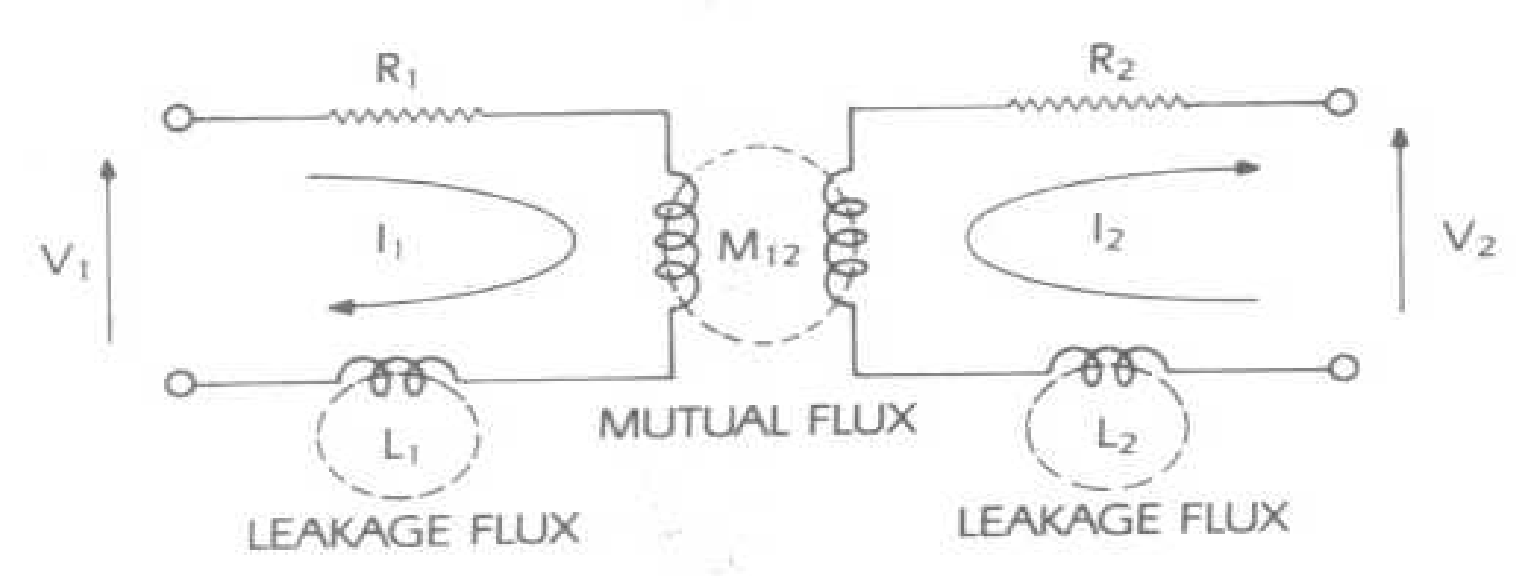
An alternating magnetic field (generated by a current carrying coil) induces eddy currents in a electrical conducting material (a metal); these currents counteract their source

Electromagnetic induction of eddy currents



This counteracting effect changes at flaws that occur at the surface or just below it (subsurface defects)

ET: Transformer analogon

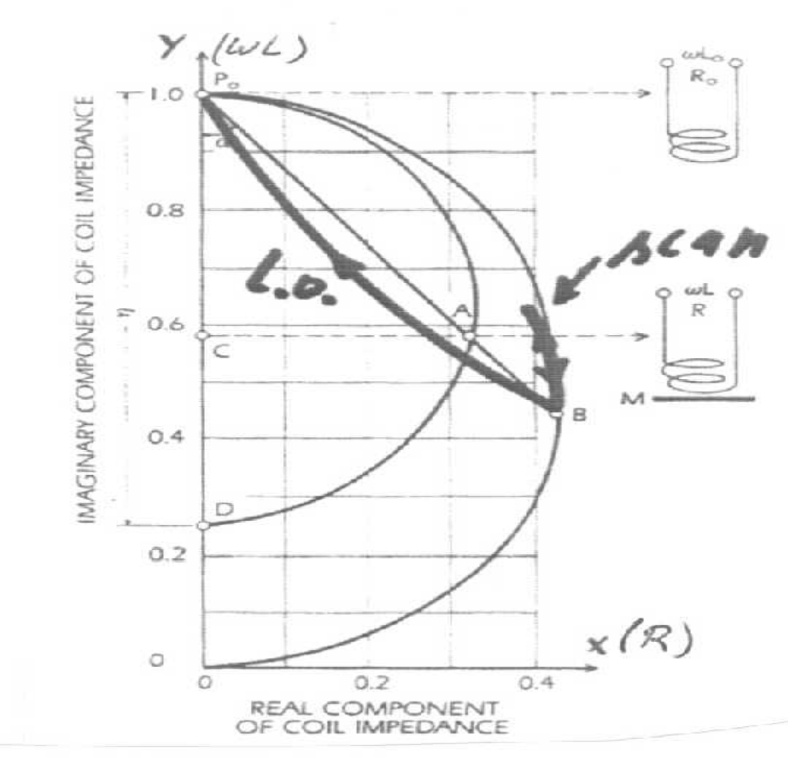


Primary circuit:
ET probe and equipment

Secondary circuit:
the test piece

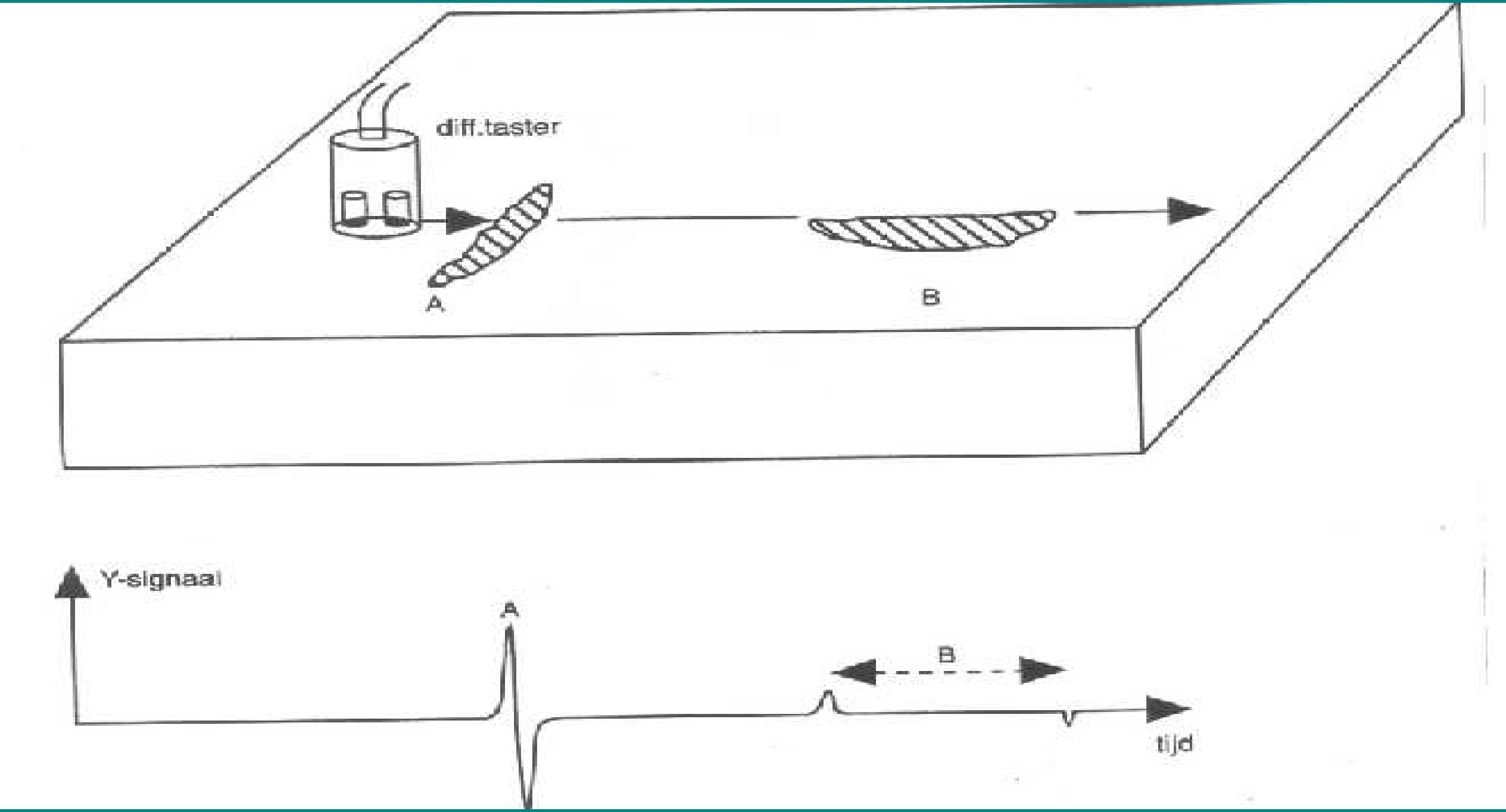
Electrical analogon : a transformer that gets loaded at the secondary circuit in a changing way: the impedance measured at the primary clamps changes with it

ET: Impedance plane



The lift off ("l.o.") is the effect in the impedance plane (XY-plane) when a probe is in air vs. on the metal surface. "Scan" occurs on a surface crack ; the vectors in the plane are distinguished and processed electronically.

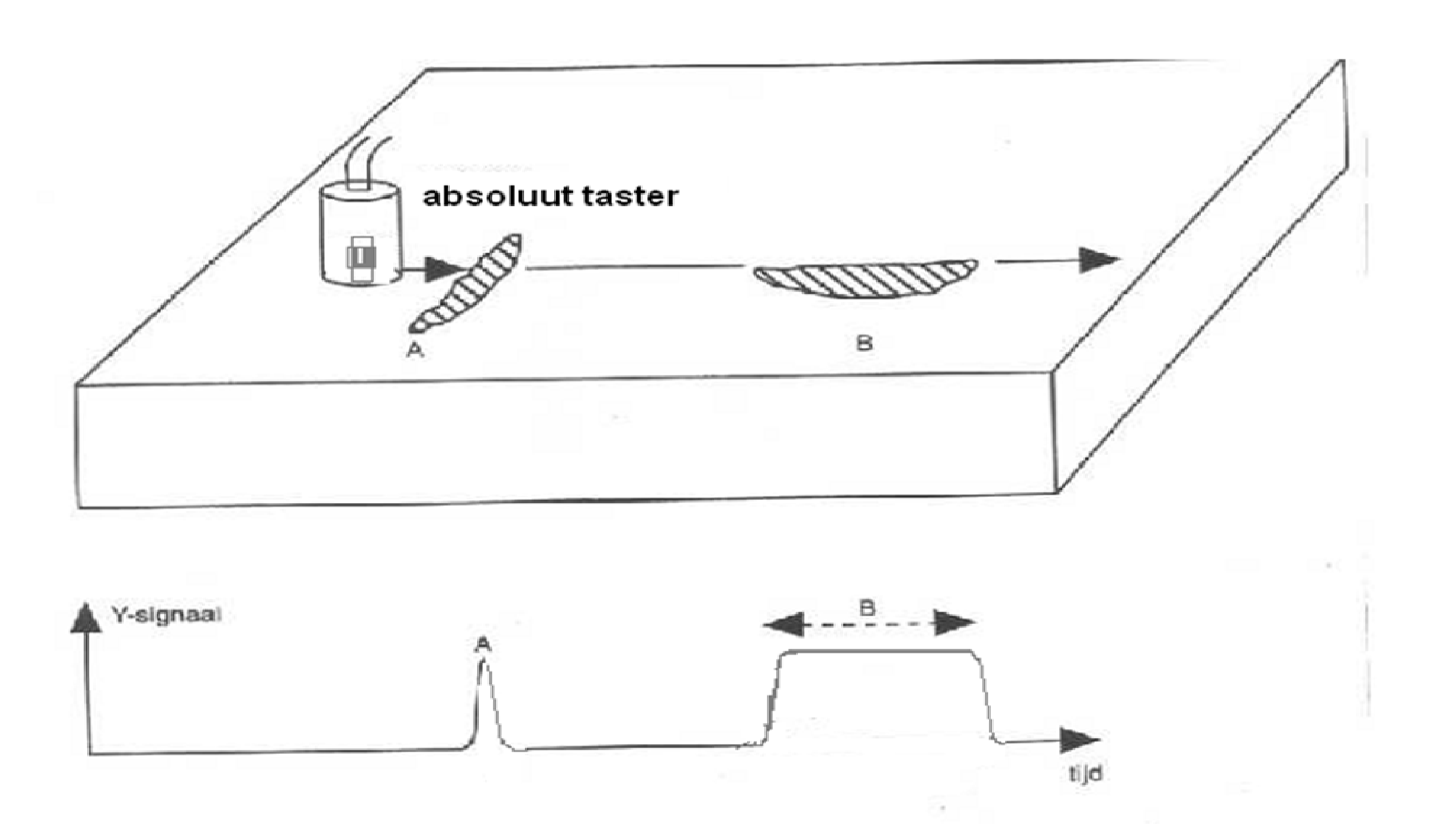
<u>Differential</u> probe: improved „signal to noise“ (S/N) ratio



Improved “signal to noise ratio” but *directional* differences

A: good visible   B:small signal

Absolute probe: lower S/N



Probe directionality is far less problematic

Tube testing of heat exchangers

- Flexibele ET (RFT) taster

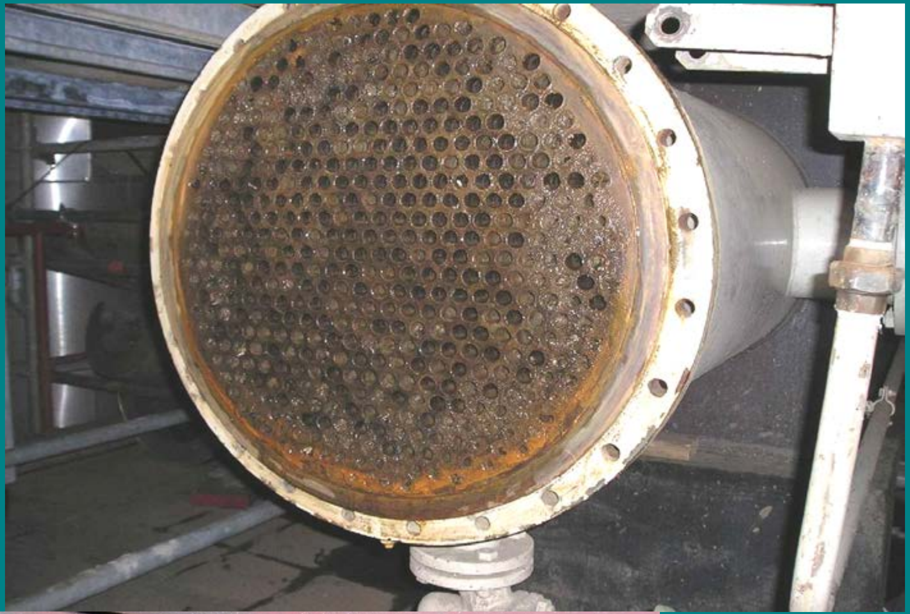
Example of an RFT probe that can negociate curved tubes

ET Heat exchanger testing :

Manual probe insertion for small numbers ;
Mechanical or pneumatical probe pusher-pullers are used for larger numbers (in all pipes)

ET Heat exchanger testing & inspection

- *'Standard'* ET for *non ferro* tube testing;
  RFT, PEC & PSEC for C-steel tubes
- Endoscopic testing to closer analyse damaged tubes
- Visual inspection of the waterboxes and connections:
  corrosion patterns/ lining &
  coating condition



ET Surface Testing example

ET testing of turbine compressor blades & vanes

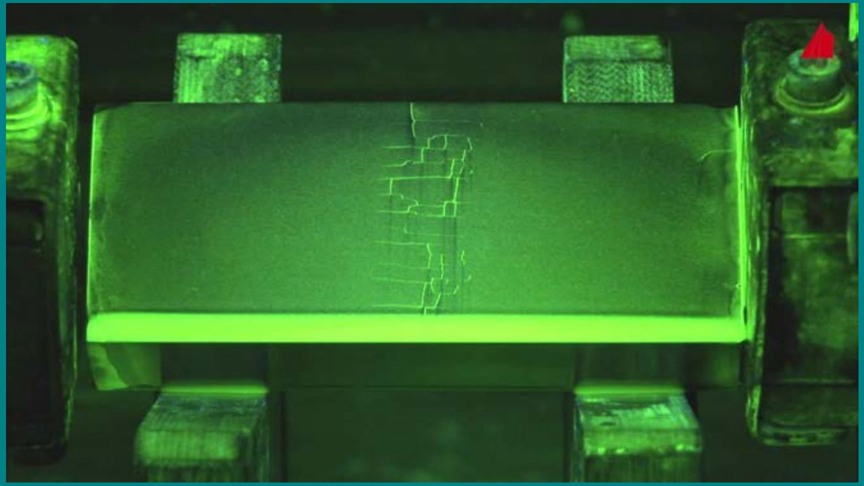
ET: example of its use

ET testing at a steam line in a power plant during operation (max 550°C) : pressured air cooled probe

ET testing example

ET prototype probe (PEC, segmented) for application in home connection gas pipes

NDT method: Magnetic Testing (MT)



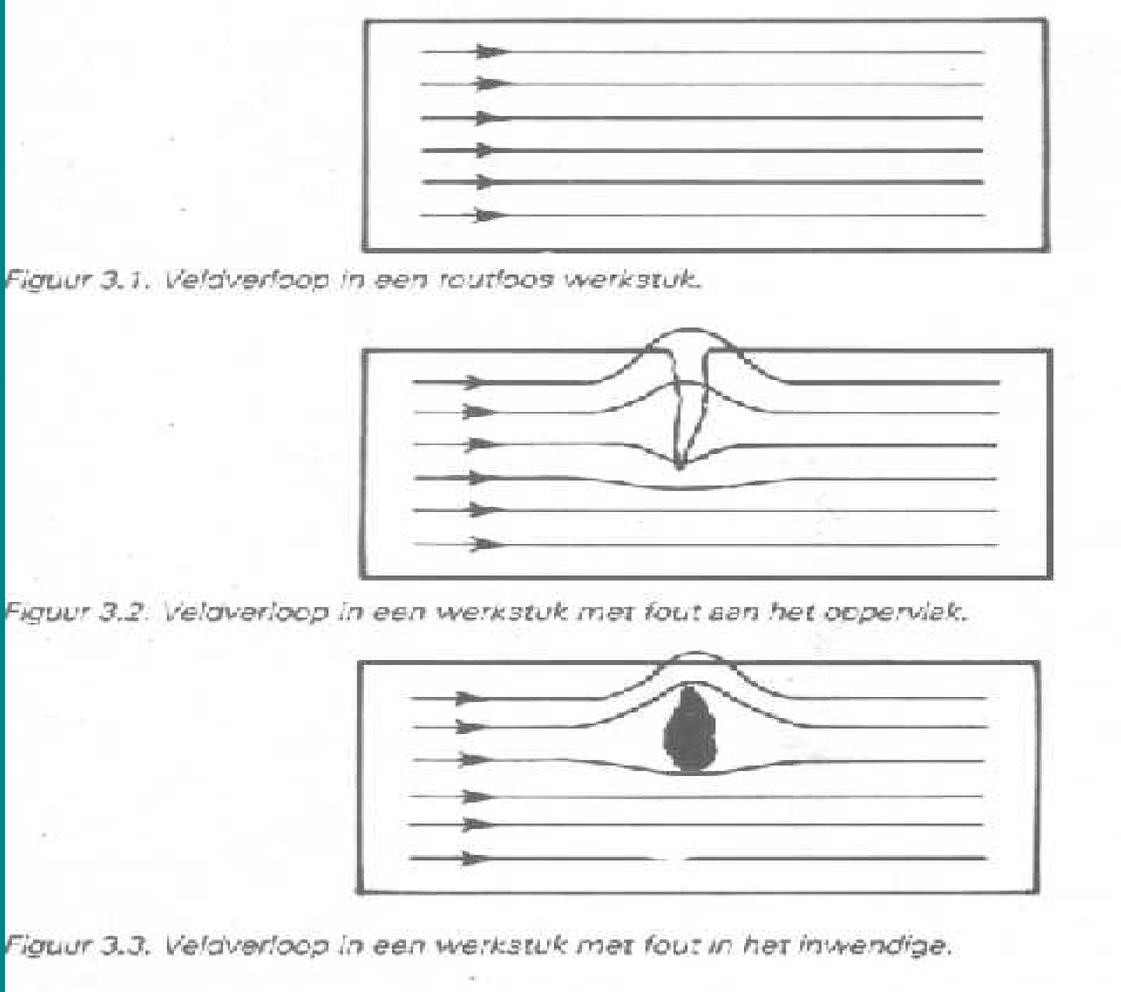
- Magnetic test rigs for production and large numbers
- Application of magnetic yokes
- Coil technique
- Applying a large current in the test object itself
- MFL : <u>m</u>agnetic <u>f</u>lux <u>l</u>eakage test Hall sensors
- Black & white and UV technique

MT-UV test:
surface cracks
visible Fe-powder

Magnetic testing (MT)

Applying yoke - UV technique : what essential item is missing?

Magnetic testing



Principles of the MT method

Clean surface

Crack or other flaw type: magnetic field lines extend out of the test piece attracting magnetic particles in the applied fluid

Some ‘subsurface’ capability: visible at surface

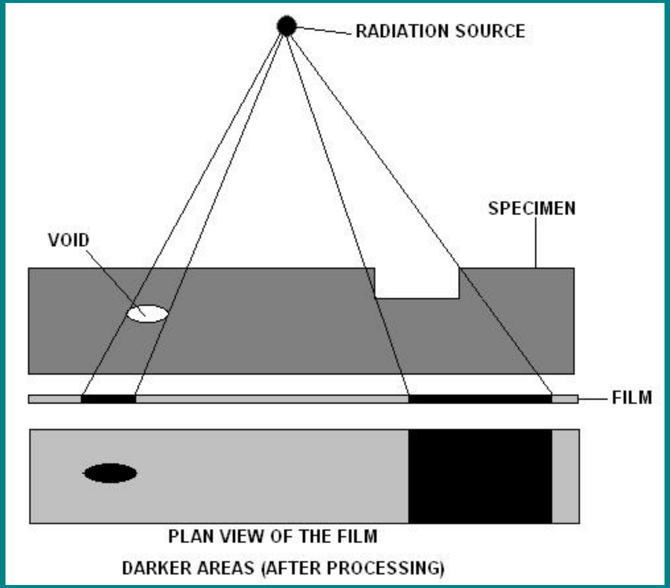
NDT method: dye Penetrant Testing (PT)

- Red /white method
- UV technique
- HT capability: powder applied

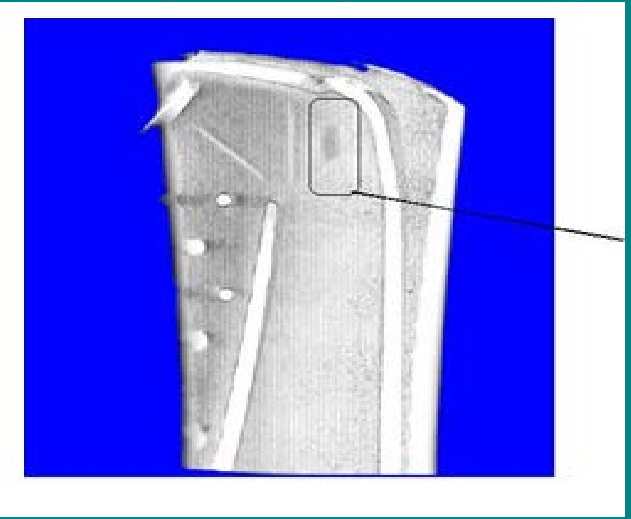
Aspects: imflammability and health concerns of the applied solvents

Radiographic Testing (RT)

- Industrial X-Ray
- Industrial Gamma ray: radioactive isotopes
- Aspects:
  - RT film technique being replaced gradually by digital RT technique
  - Radiation hazard, no simultaneous work can take place
  - Newer tomographic RT : far greater capability
  - Transport and storage becoming more and more strictly regulated



RT principle



3D tomography of a GT blade

NDT Method: Leak Testing (LT)

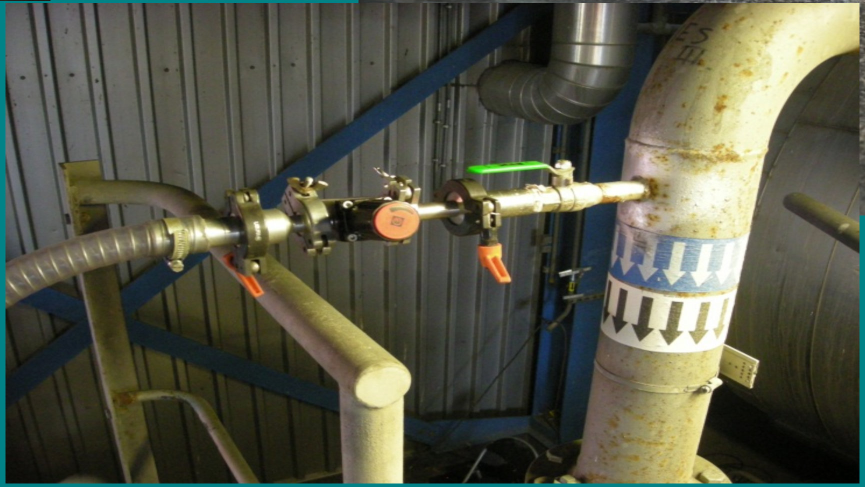
- Many techniques:
  - Pressure drop technique
  - Vacuum decay technique
  - Soap bubble test
  - Tracer gas, (NH_3, SF_6,H_2, He)
  - …….

Leak Testing (LT) method

Helium Leak Testing of new build titanium condensers

This is the most sensitive of all LT techniques; at the steam side the volume is filled with a 5-10% He/air mix and the tubes inside are evacuated at both ends with plates (one shown here); the helium that enters the group of evacuated tubes is detected with a mass spectrometer that is in the loop of the pump connected to the plate with a vacuum hose

Leak Testing method



On stream leak test at a plant: crack detected in a pipeline

Infrared Thermography method (IT)

- Using surface temperature differences
- Passively: “just watching”
- Actively: by inducing a heat pulse/ applying a temperature transient in the test piece

A large current is inducing a magnetic field in the stator core which in turn induces eddy currents to flow in the core laminations ; an IR camera establishes hot spots

AT (or: AE) Method

- AT: Acoustic Emission: “listening to things happening” at a larger range than UT can penetrate; lower frequencies used (100 -300 kHz)
  - promise: on stream integral monitoring of installations
  - problem: validation

AE probe attached to steam pipe

Acoustic Emission Testing Method

Piezo crystal sensor mounted at a wave guide to stick out of the insulation, thereby avoiding coupling problems as a result of temperature transients. Cables are led to a control box; one sensor every 2 or 3 meter

NDT & Plant Monitoring

Second part: Examples of specific developments and applications of the techniques

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NDT & Plant Diagnostics

Measurement techniques to assess *plant component condition* and support remaining life assessments

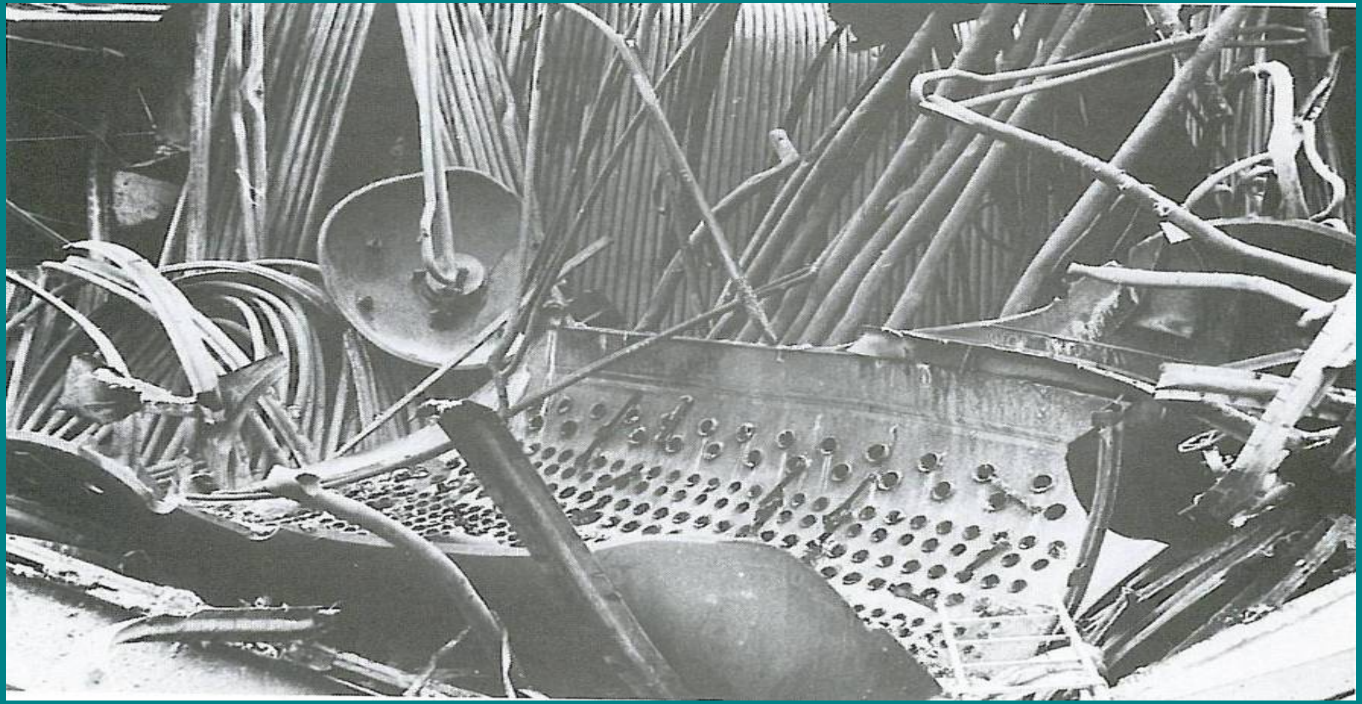
Main Drivers:

- safety : e.g. pressure vessels
- savings on *(unscheduled)* outages and (*unplanned*) maintenance
- savings on plant down time; tailored maintenance planning, less improvisation & optimized spare part availability
- feedback on operational changes (e.g from base load into load shifting operation)
- life assessment / life extension analyses

Besides *plant components*: transfer pipe lines (process water, steam, district heating), concrete & steel civil structures, GRP piping

NDT & Plant Diagnostics

Safety is a major driver to perform NDT: reliable testing technology is required to always detect critical flaws!



Failed steam drum in The NL, ~1965

NDT & Plant Diagnostics

Just in time….: dismounted old generator rotor retaining ring with inside cracking

Lower crack (100% through) occurred at a turbine trip (snow storm hitting the grid); the upper ones were coincidentally found after RR dismounting

NDT & Plant Diagnostics

Too late: generator failure in USA, 2013

NDT & Plant Diagnostics, range of activities

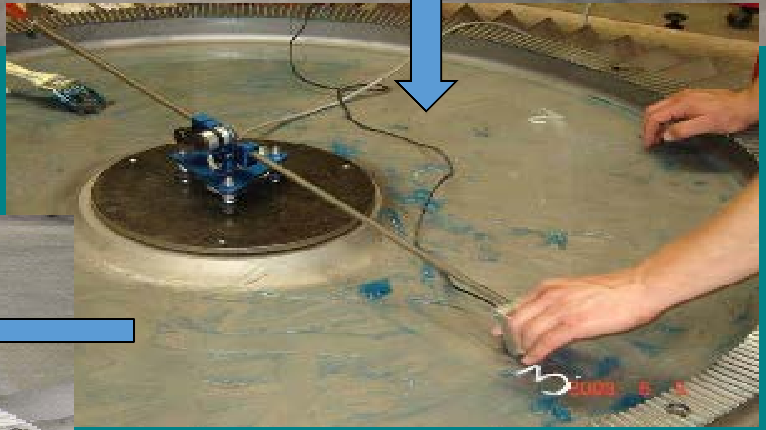
- Generator parts: rotor ret. rings, wedges, shaft, bearings, stator teeth, windings, core
- Pressure vessels: turbine housings
- Steam piping, valves, tubes
- Turbines: rotor bodies, blades & vanes
- Steam turbines: blades, disks, shafts, housing
- Heat exchangers: condensers, preheaters, etc.

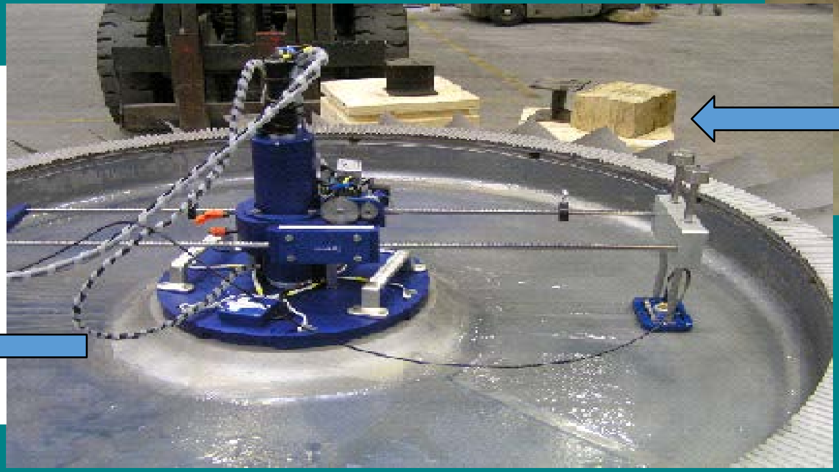
NDT & Plant Diagnostics, range of activities

- Process temperature profiling
- Tracing of process flow , on line leak testing (He)
- Civil structures: concrete & steel
- Transport piping: welding, corrosion
- Plastics, GRP
- Special tests, “R&D”

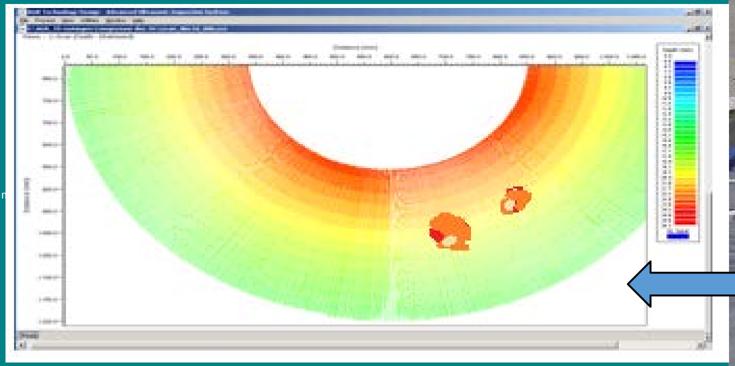
Tools for asset condition assessment & life time management

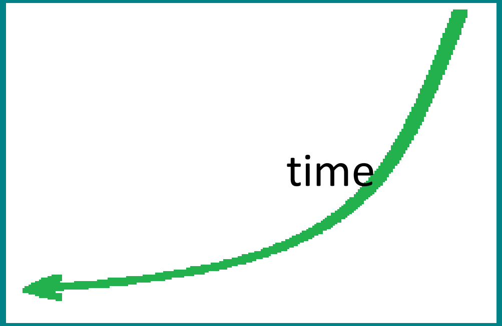
- Non Destructive Testing during shutdowns
- On stream monitoring
- Fitness for Purpose analysis following detection and sizing of flaw indications
- Mechanization when possible: decreasing testing time and enhancing testing Quality: from manual to semi-mechanized to fully mechanized testing





Stages : fron





NDT-method capabilities

Main techniques for Mechanized NDT:

- UT: Ultrasonic testing
- ET: Eddy current testing

Supporting / Additional techniques:

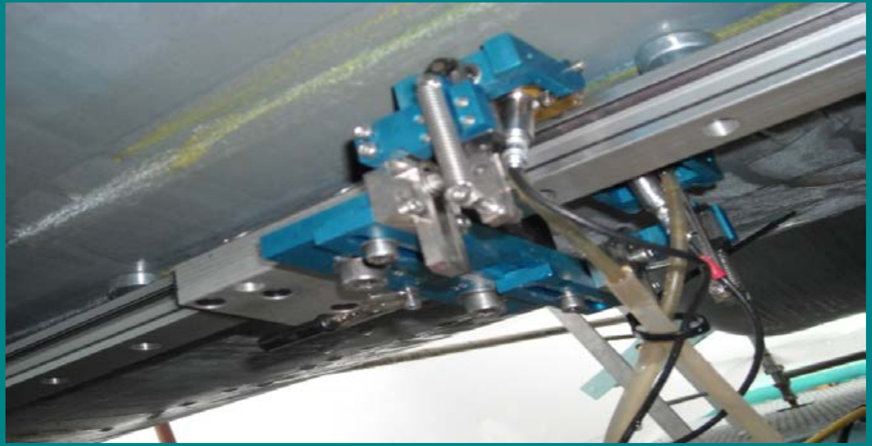
- MT: Magnetic testing
- PT: Dye Penetrant testing
- VT: Visual testing, endoscopy, TV camera, HTemp.
- LT: Leak testing, e.g. Helium LT
- AT: Acoustic techniques: Ac. Emission, Ac. Ranging
- IT : Infrared testing
- RT: Radiography, 3-D tomography

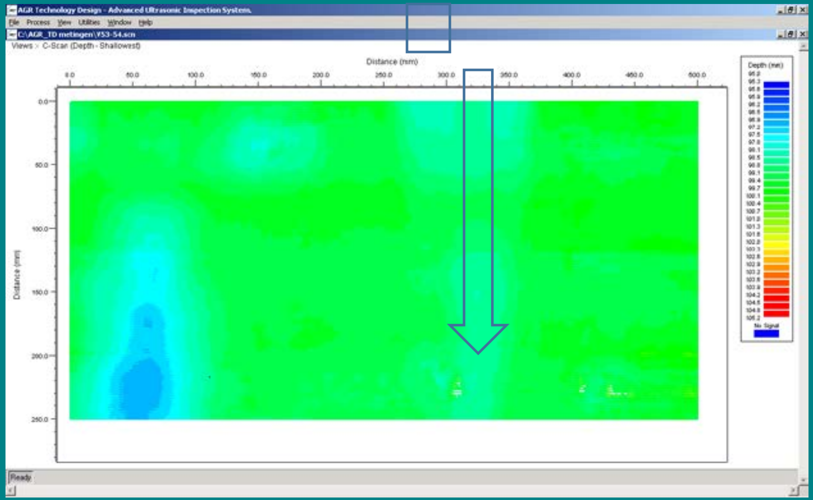
Special testing & diagnostic techniques

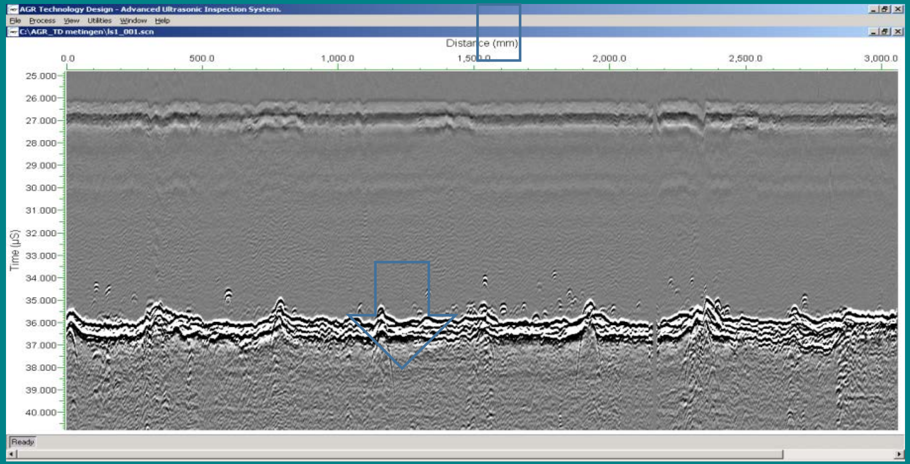
DEKRA NDT & PD Services focus on:

- Automated scanning: improved reliability, operator independent
- Recorded data and visualisation for trending
- Non-intrusive inspection: less wrenching time & cost
- Remote testing: avoiding scaffolding → no entering of dangerous areas
- On stream testing and monitoring
- Non-standard solutions; new technology
- Combination with other disciplines for integral advice:
    - (1) Fitness-for-Purpose analysis
    - (2) Chemical / corrosion analysis
    - (3) Materials /welding

Automated Pressure Vessel (Steam drum) Inspection



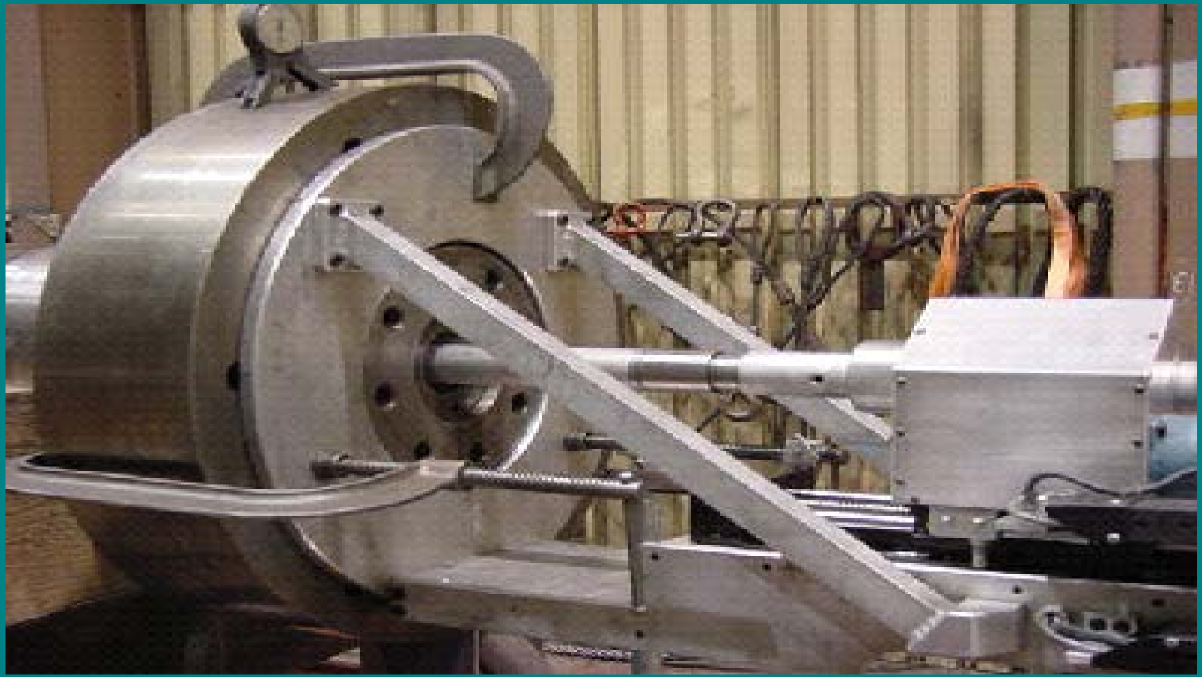


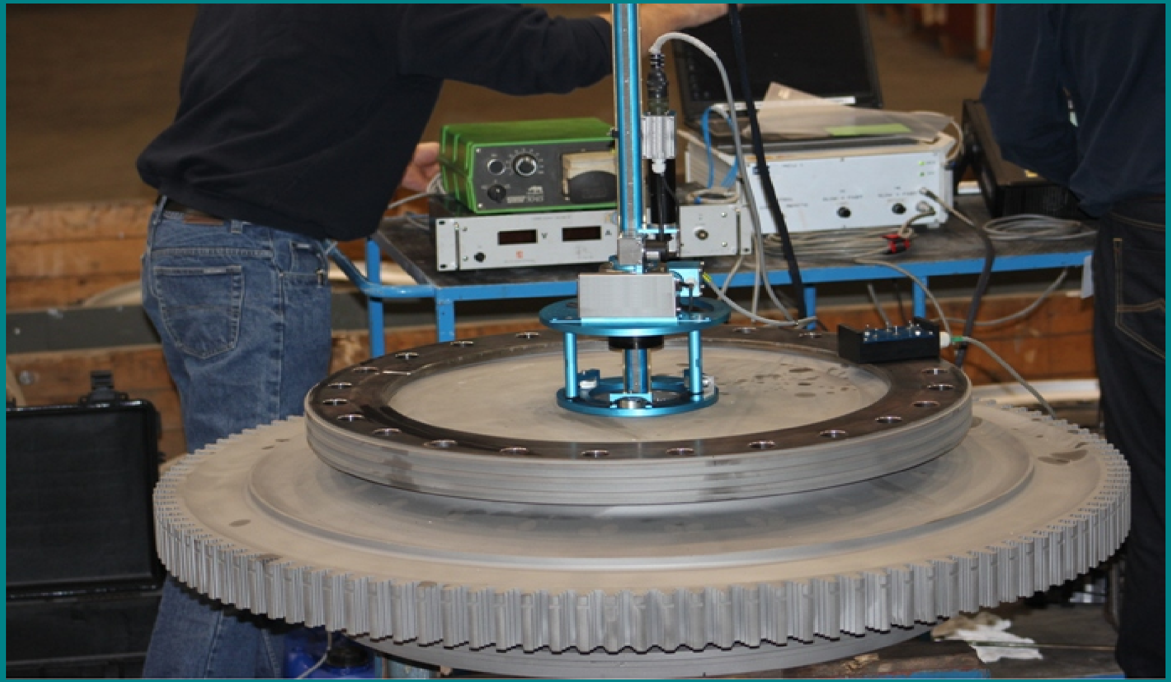


C-Scan-Corrosion-Mapping (XY-mechanized) TOFD-Testing of longitudinal stripwelds

Automated Boresonic inspection

Automated scanning of turbine and generator rotors : UT, MT or ET



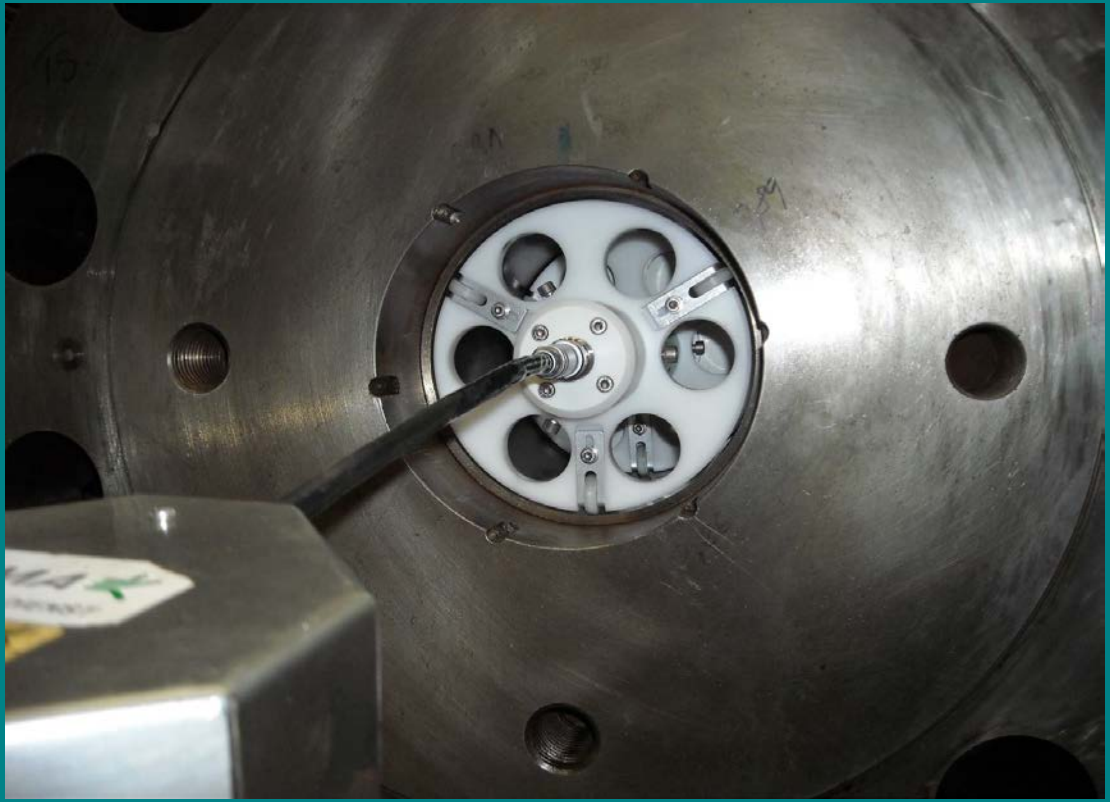


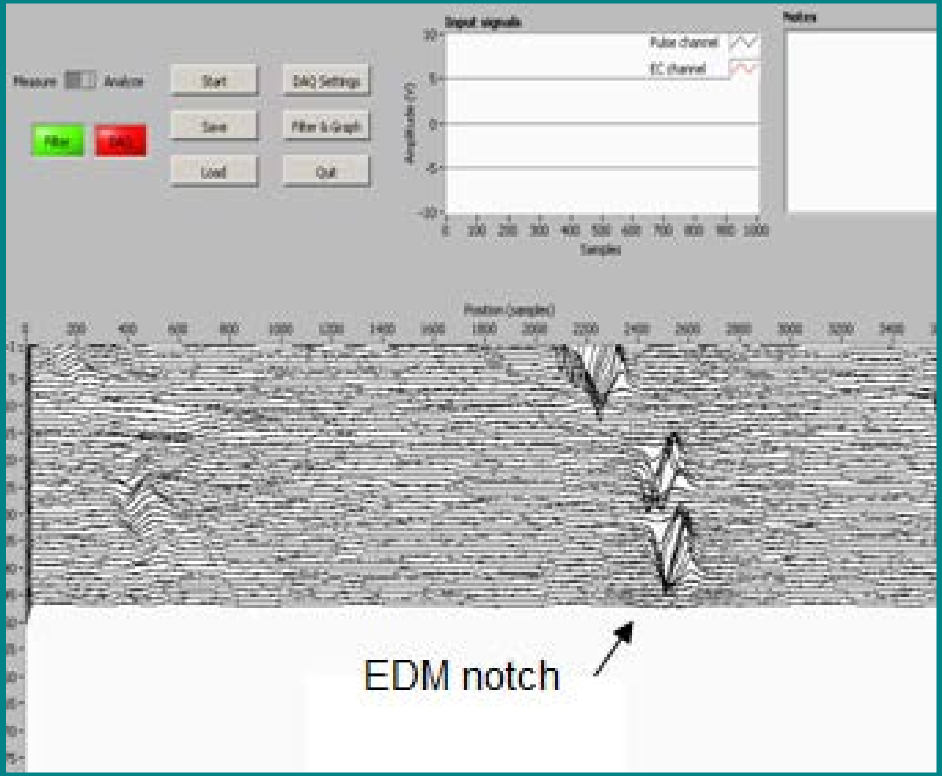
Boresonic equipment for long bores (upto 15m)

Boresonics for short bores (<1m)

Automated Boresonic inspection

Automated scanning of turbine and generator rotors : ET GROTEC spiral scanning system





Recording and Visualisation of test data: example

Semi-mechanised ultrasonic tube-to-nozzle weld testing. The UT transducer is guided along the tube circumference and UT images are projected to circumferential position

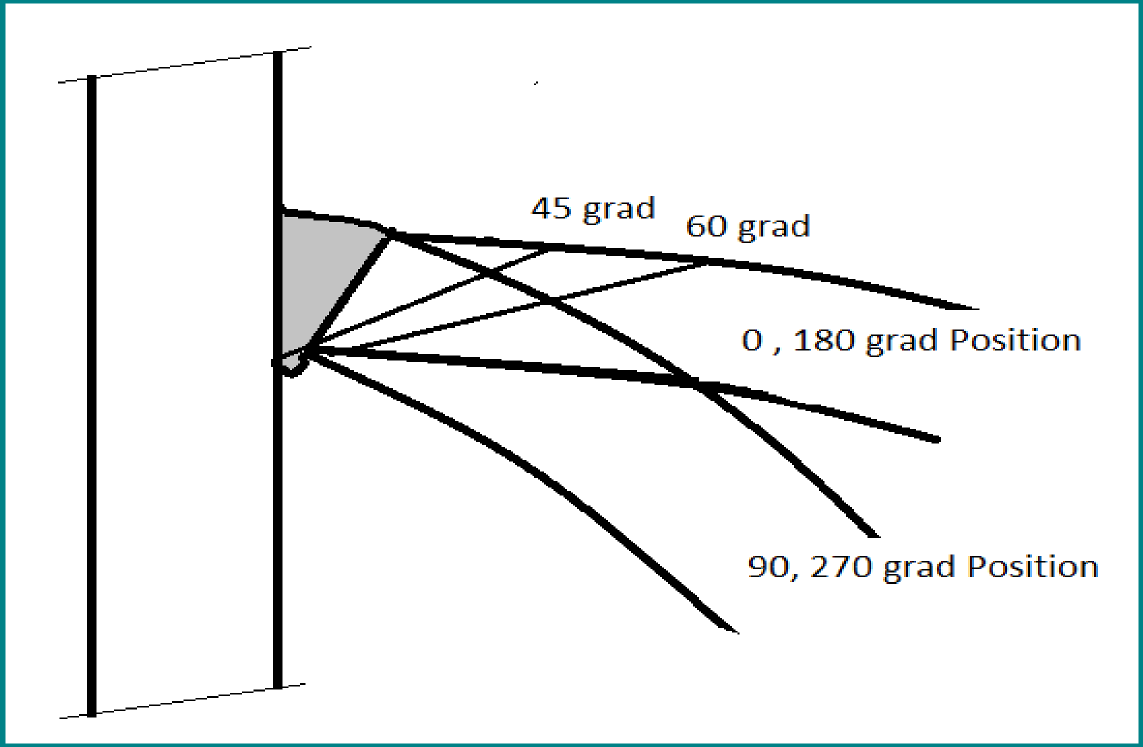
NDT & Plant Diagnostics: nozzle to vessel weld testing in a gas compression station

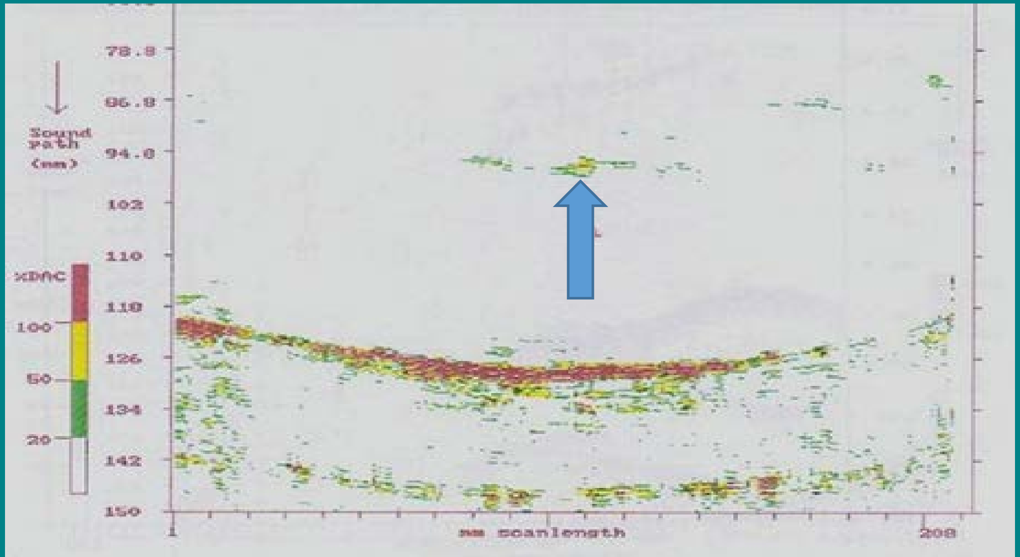
To be able to interpret UT-data from the ‘saddle’ weld

semi-mechanized scanning is performed with a prototype scanner

NDT & Plant Diagnostics: nozzle to vessel weld testing in a gas compression station

NDT & Plant Diagnostics: nozzle to vessel weld testing in a gas compression station



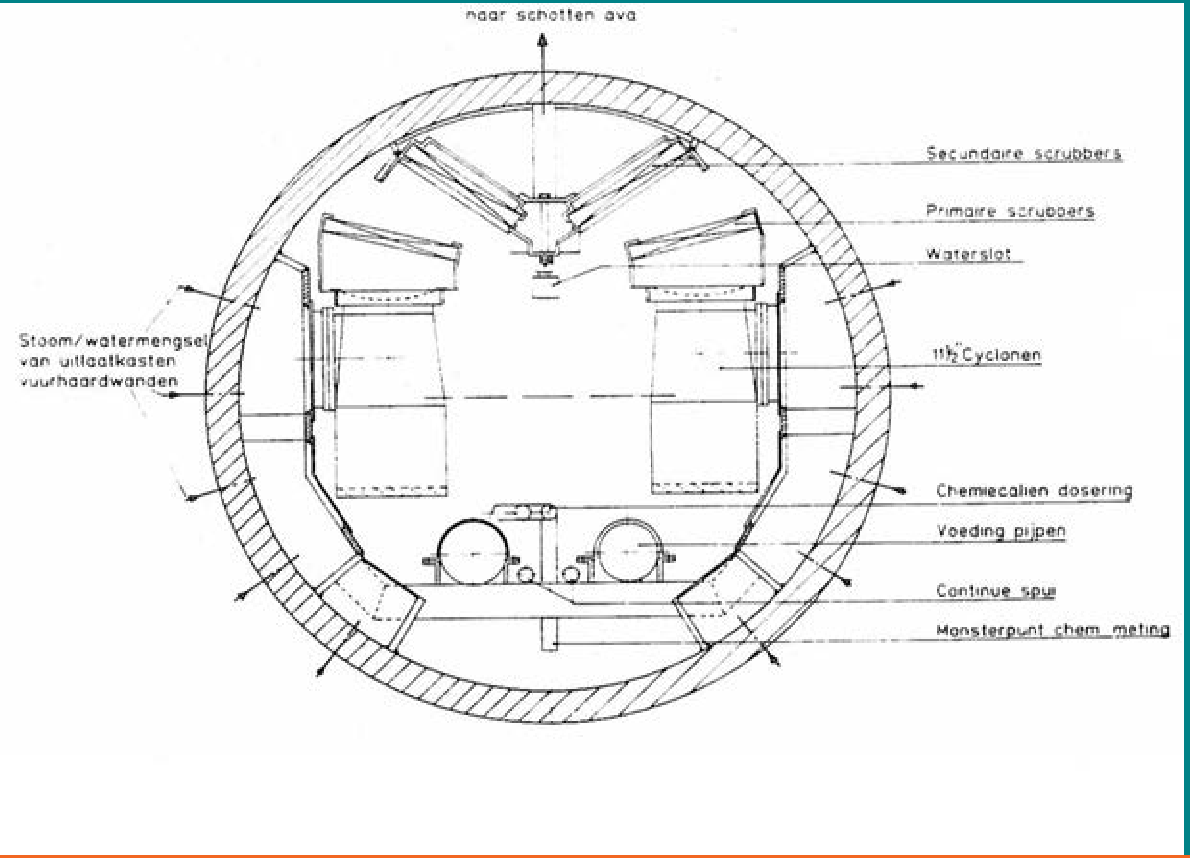


Semi-automated scanning producing UT “stacked A-scan” image: distinguishing geometrical reflections and a flaw indication (arrow)

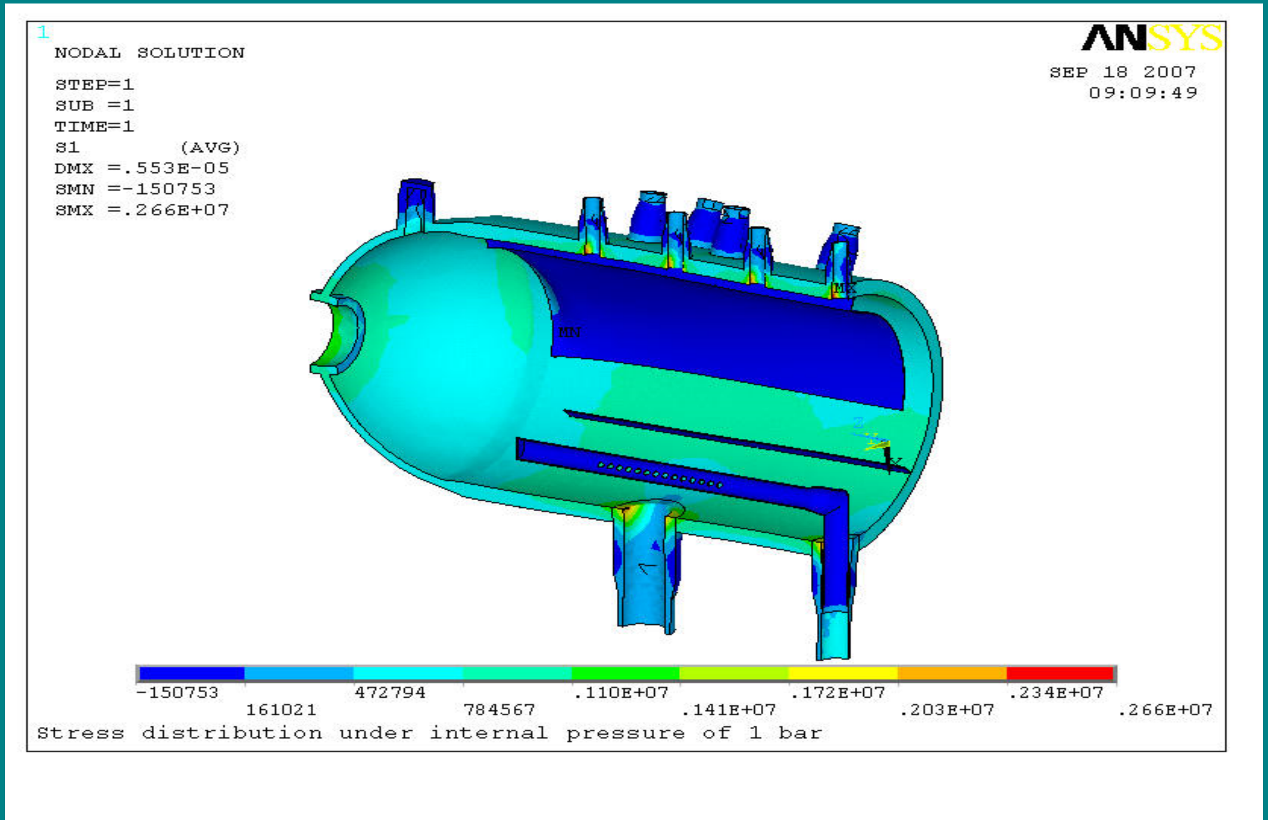
NDT & Plant Diagnostics:

Non- intrusive inspection of steam drums from the outside

A program of automated UT scanning replaces time-consuming dismounting of internals



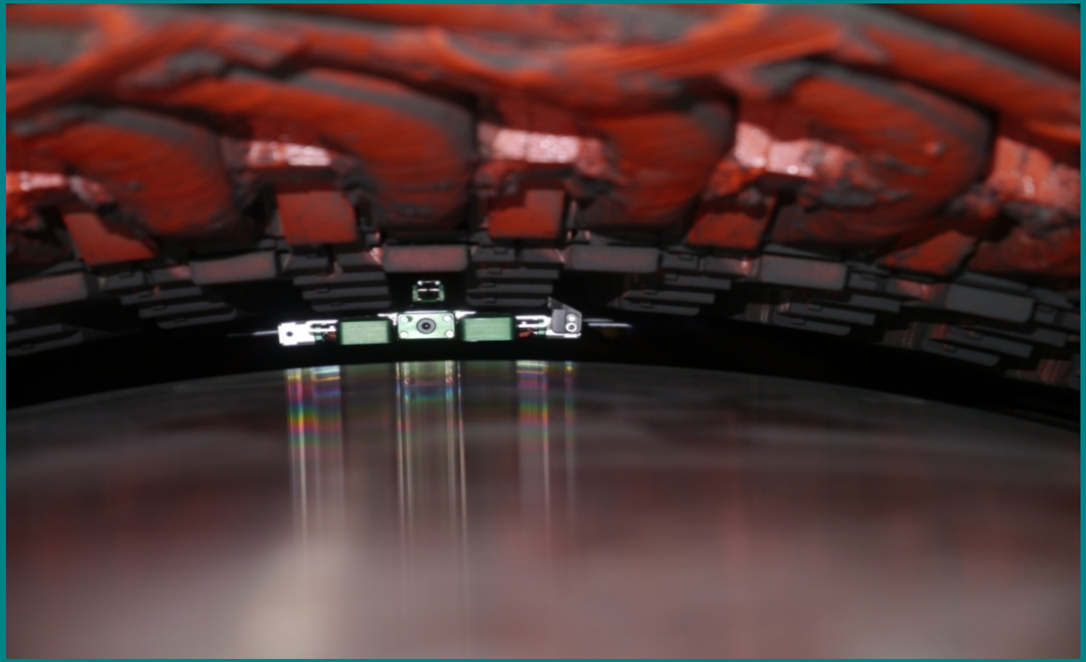
NDT & Plant Diagnostics: Fitness for Purpose Analysis to assess acceptance of detected and sized flaws



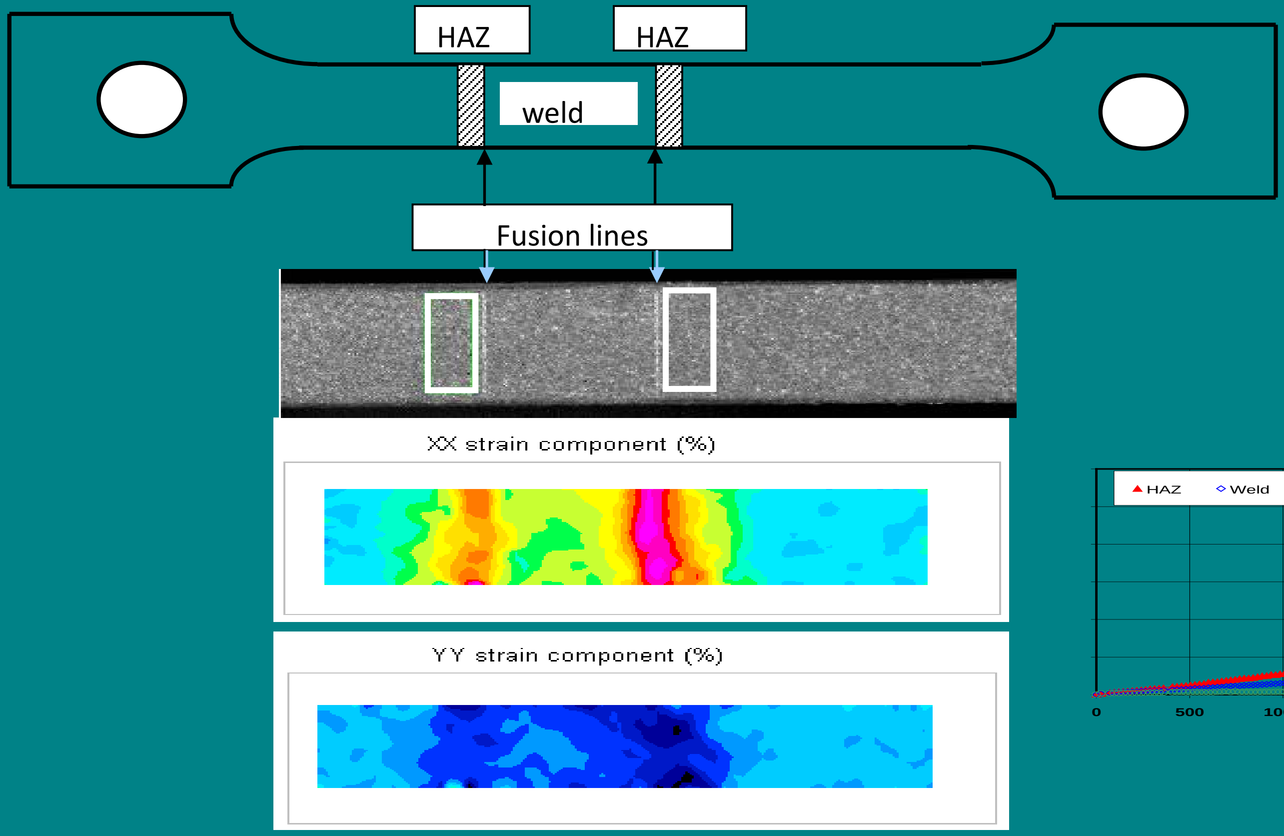
FfP modeling of steam drums: strain concentration at down comer nozzle connection during thermal transitions

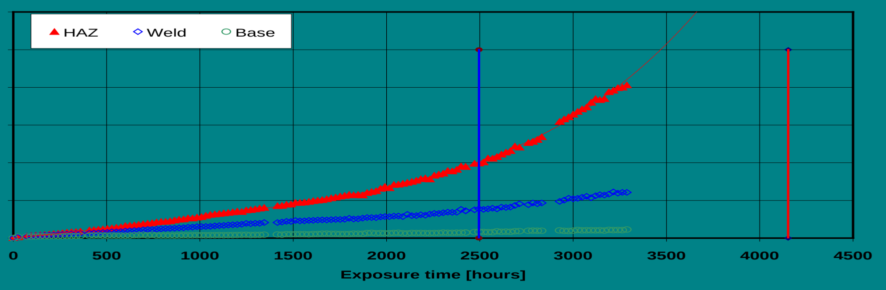
NDT & Plant Diagnostics, examples of innovations in the past & recently

- SPICA
- **KEMWAT**
- KEMBAT
- **KIRR**
- **KEMBUS**
- VINSPEC
- HT technology (UT,ET)
- Special CCTV (camera) inspections



SPICA recording system: strain image details



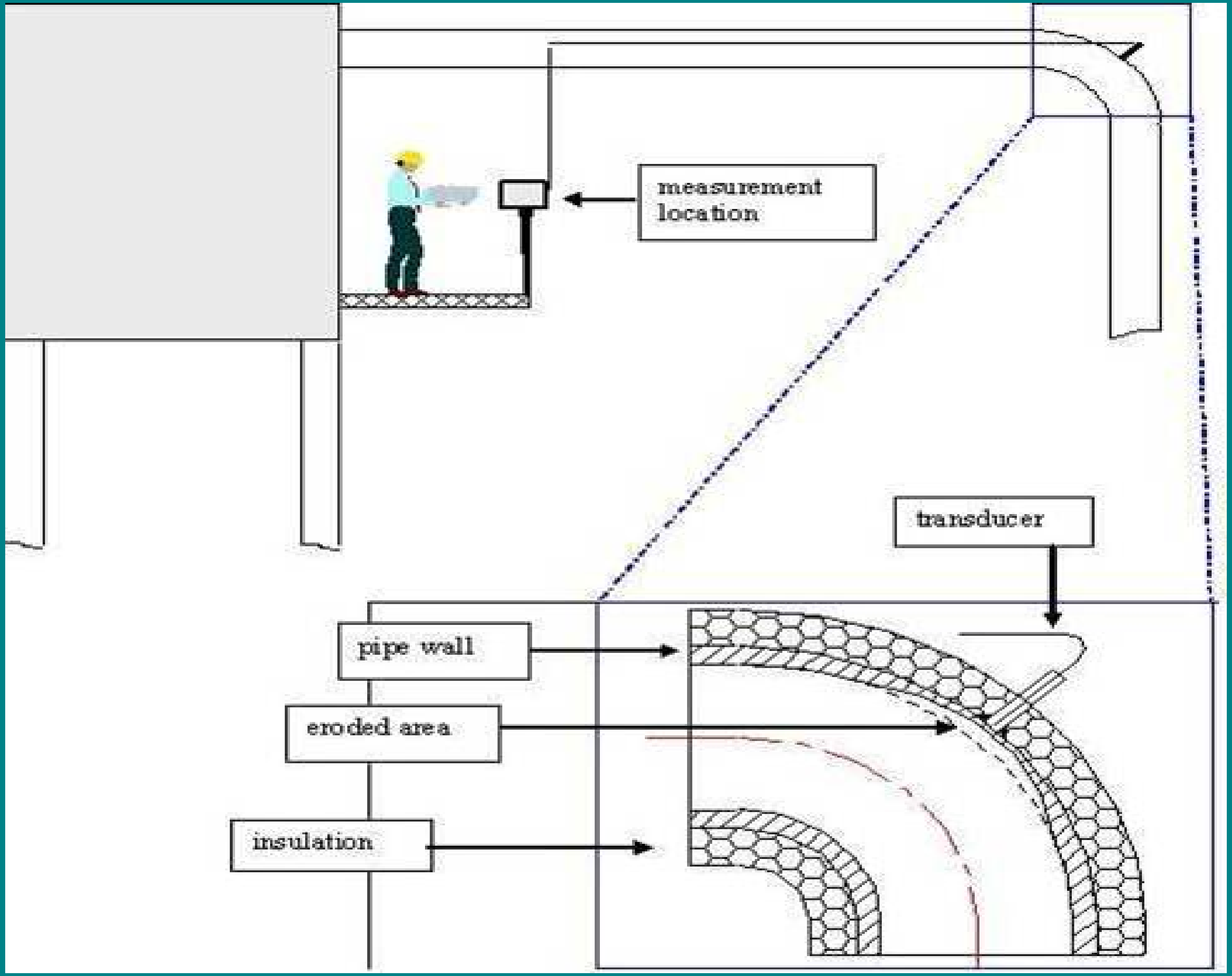


Local strain in the HAZ strongly exceeds the integral strain value

film

KEMWAT: ultrasonic on stream Wall Thickness monitoring at locations with limited access

KEMWAT: no scaffolding necessary to apply wall thickness measurement

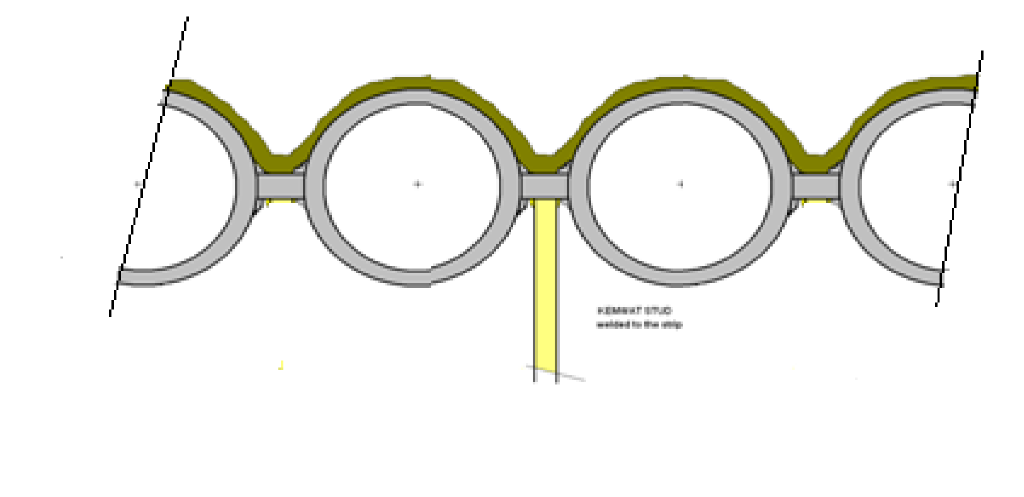


KEMWAT: on stream wall thickness monitoring

KEMWAT sensor in position after being applied during a plant shutdown; all further measurements at selected time intervals can be performed remotely and during plant operation

KEMWAT Application at Waste Incinerator Boilers

- Evaporator wall tubes of a Waste Incineration plant
- Walls have been clad (1 or 2 layers) at the inside
- Clad surface is very irregular: wall thickness varies heavily within millimeters of probe displacement (ax + circ!)
- Studs applied at the strips between the tubes



KEMWAT: Application at a Waste Incinerator Boiler

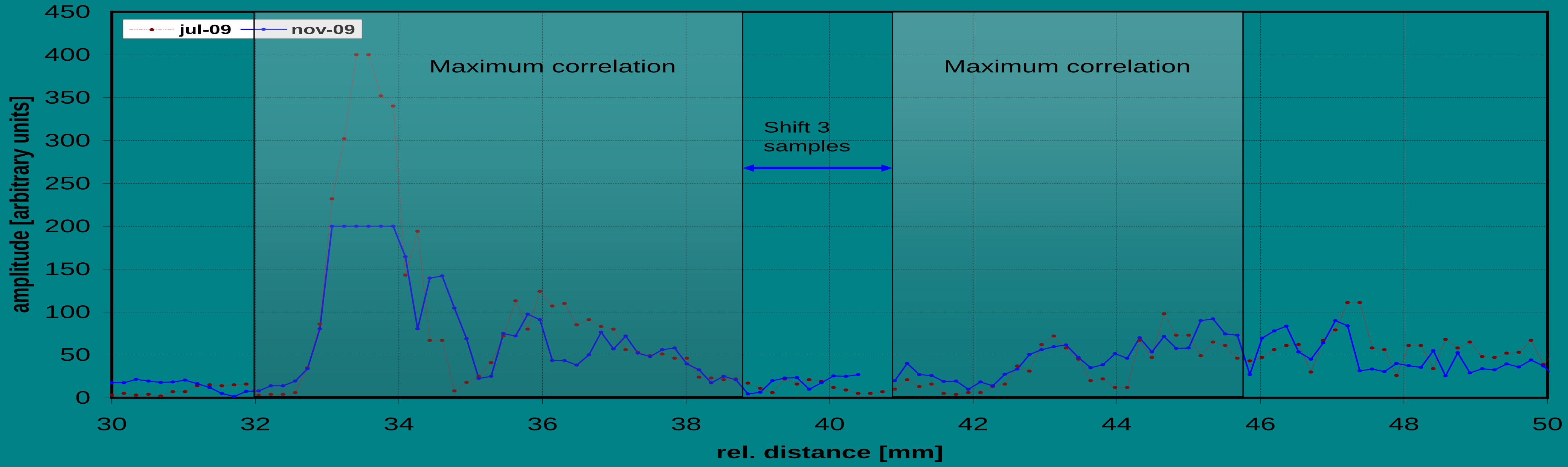
- Positions selected
- Stud welding acceptable
- Studs protruding from the insulation layer
- Probes mounted in space between insulation layer and boiler housing

KEMWAT: two types

- Measurement with hand held transducer “at a stick”
  or: with fixed sensors at each KEMWAT stud
- Recording of A-images

KEMWAT: Measurement results

- Measurement with a hand held transducer “at a stick”
  or: with fixed sensors
- Recording of A-images
- Evaluation through correlation processing



KEMWAT: Wall thickness changes WI boiler (4 month interval)

Floor level	Left wall	Front wall						Right wall
45m		FW18 0,1	FW40 0,3	FW62 0,15	FW87 0,25	FW110 0,1	FW135 0,25	
42m	LW68 0,17		FW2 0,5					
40m								
38 m						FW98 0,2		
35 m				FW72 0,1				
34 m		FW8 0						
29.4 m	LW26 0,5							RW37 0,34
28 m		FW18 0,5	FW40 0,68	FW62 0,5	FW87	FW110 0,5	FW133 0,7	
25 m		FW18 0,5	FW40 0,34	FW62 0,5	FW87 0,34	FW110 0,34	FW133 0,5	RW19 0,5
24 m		FW18 0,5	FW40 0,34	FW62 0,2	FW87 0,34	FW110 0,3	FW133 0,5	

Figures show *mm* ‘s of loss ; highest value 0.7 mm at the 28 m level in the front wall

KEMWAT: Wall thickness changes WI boiler (2 year interval)

Vloer	LW	Voorwand						RW
45m (Dak)		FW18 0,2	FW40 0,2	FW62 0,5	FW87 0,5	FW110 0,4	FW133 0,5	
42m	LW68 0,1	FW2 0,5						
40m	LW8 0,3							RW62 0,2
38 m						FW98 0,3		
35 m				FW72 0,5				
34 m		FW8 0,3						
29.4 m	LW26 0,3							RW37 0,5
28 m		FW18 0,6	FW40 1,2	FW62 0,7	FW87 0,7	FW110 1,2	FW133 1,0	
25 m		FW18 0,9	FW40 0,9	FW62 1,8	FW87 1,9	FW110 1,9	FW135 1,5	RW19 0,3
24 m		FW18 1,8	FW40 1,2	FW62 1,7	FW87 2	FW110 3,5	FW135 3,1	
Legenda		≤ 0,50	0,51-1,0	1,01-1,50	1,51-2,0	>2	mm	

Figures show mm ‘s of loss; highest value : 3.5 mm at the 24 m level in the front wall , left side

KEMWAT options

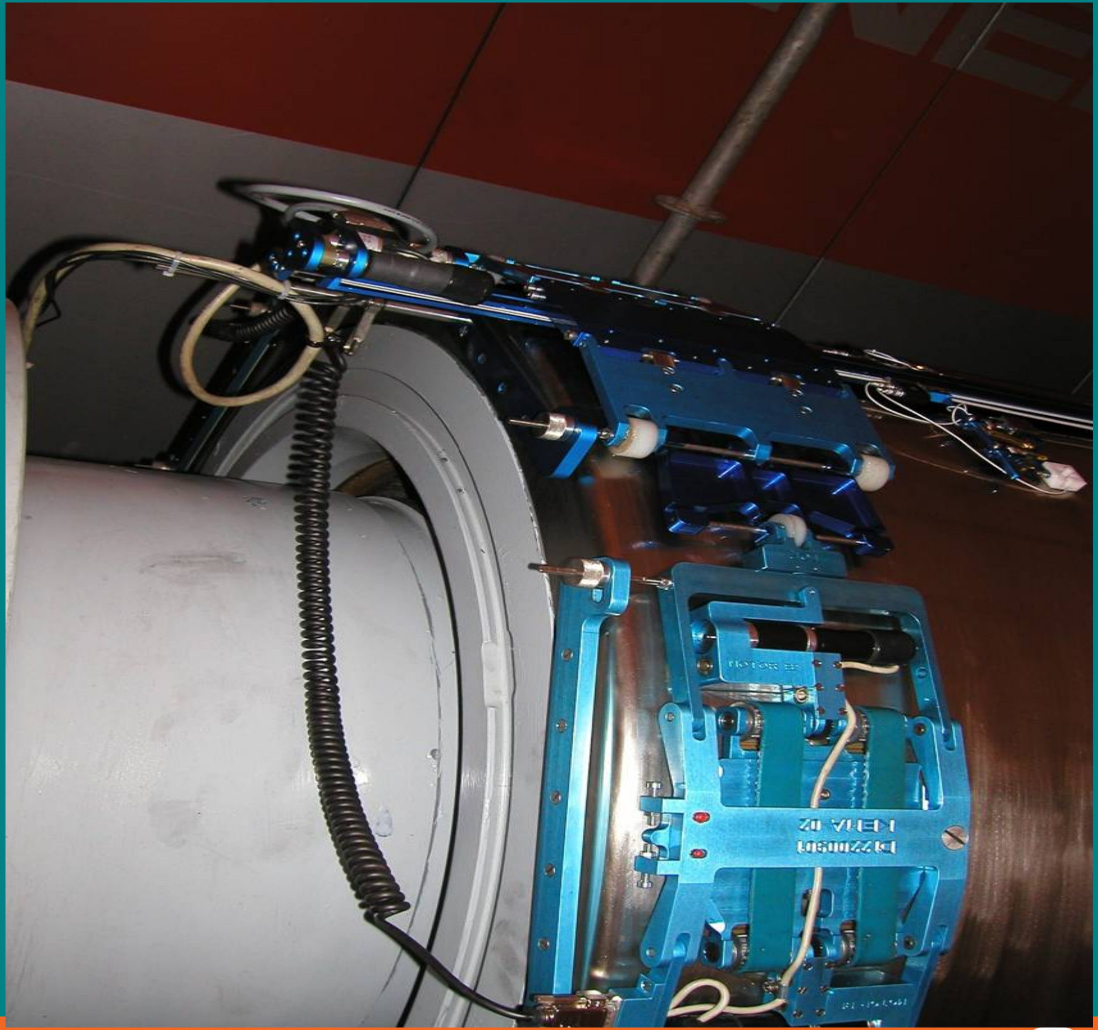
- Studs without fixed UT sensor
- With UT sensor applied and fixed cable to a terminal box
- Central read out in control room, Ethernet connection
- Developments: wireless , through GSM/GPRS link

KEMWAT studs with fixed UT sensor

KEMWAT Status 2016

- Stud material thus far: Inconel 601, 617 of 625
- Welding method accepted by PV authorities
- Measurement both at ambient temperatures and up to 550 ºC
- Pilot projects have been successful

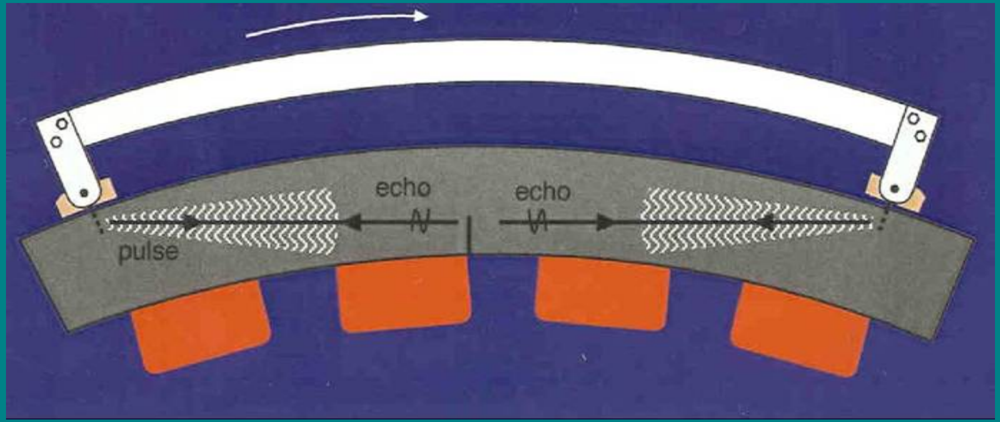
In situ Generator Retaining Ring Inspection & Life Assessment



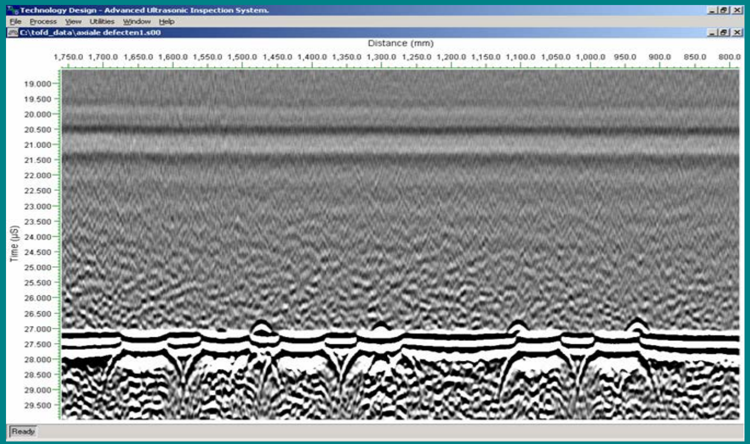
KIRR-MK3 manipulator for in situ inspections:

- RR to stator clearance as low as 8 mm
- Once mounted on the RR, 100% is measured; no remounting required
- Manipulator is normally mounted on RR , see picture, but can be mounted on applied extension rings

In situ Generator Retaining Ring Inspection & Life Assessment



- Ultrasonic Pulse Echo 'cross' technique: to distinguish reflections from teeth edges



- Ultrasonic TOFD technique at ref. model: rotor teeth visible and EDM notches

- Eddy Current technique

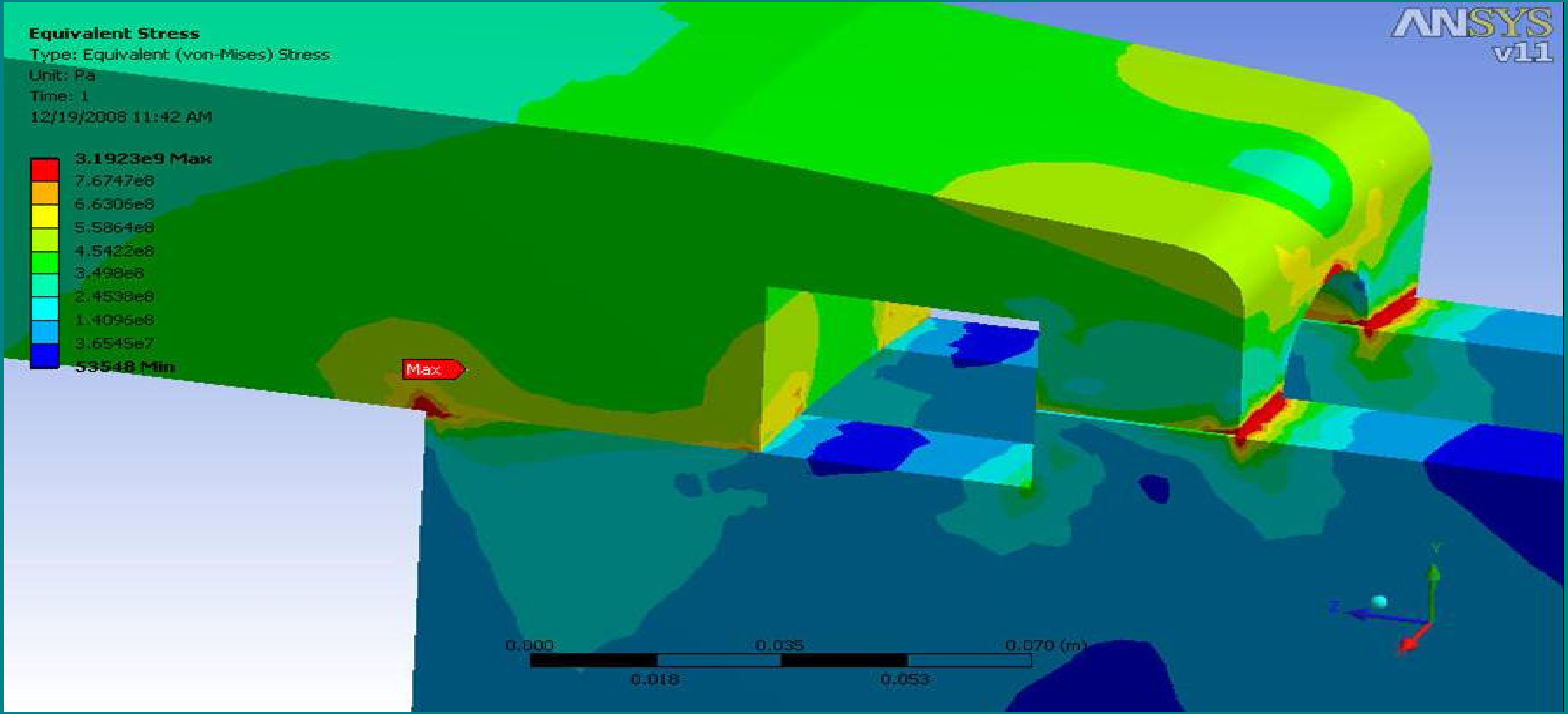
DEKRA

In situ Generator Retaining Ring Inspection & Life Assessment

Severely cracked RR rings, 2011; “new“ material (2005)

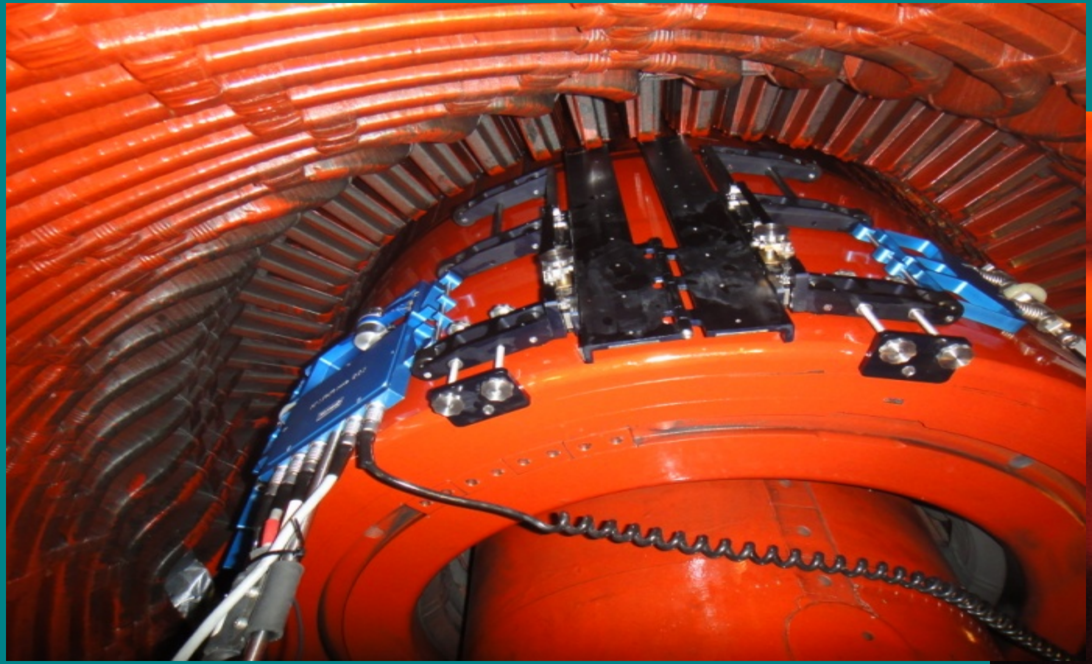
KIRR film

In situ Generator Retaining Ring Inspection & Life Assessment



Computer modeling and FfP-calculation

In situ inspection and life time assessment of generator stator cores and stator wedges



ARGIS / ROGIS robot in action at a generator with its rotor in situ

- animation
- ARGIS film

DEKRA

KEMBUS: ultrasonic testing of evaporator wall thickness without the need to enter the boiler

Do we need to do this always?

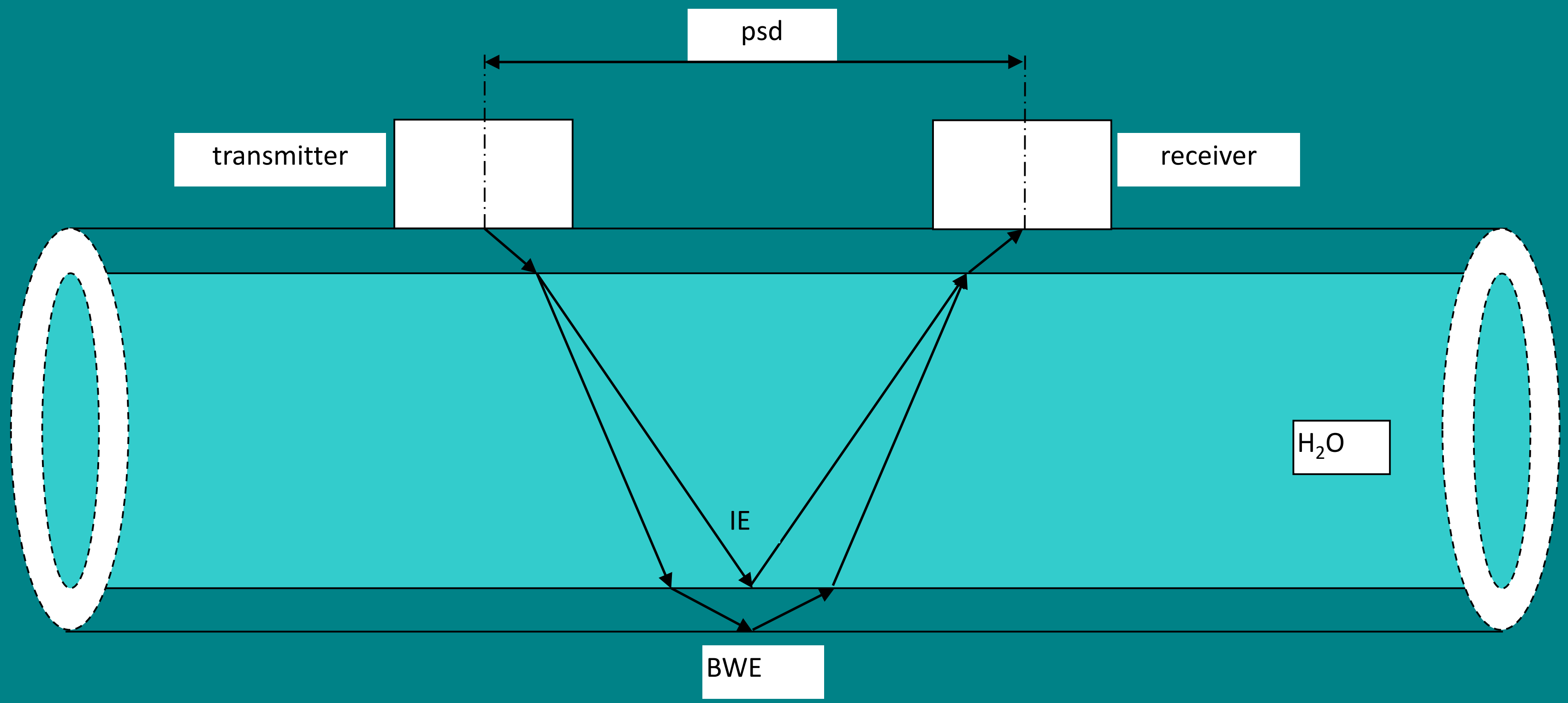
DEKRA

KEMBUS manipulator at a test panel

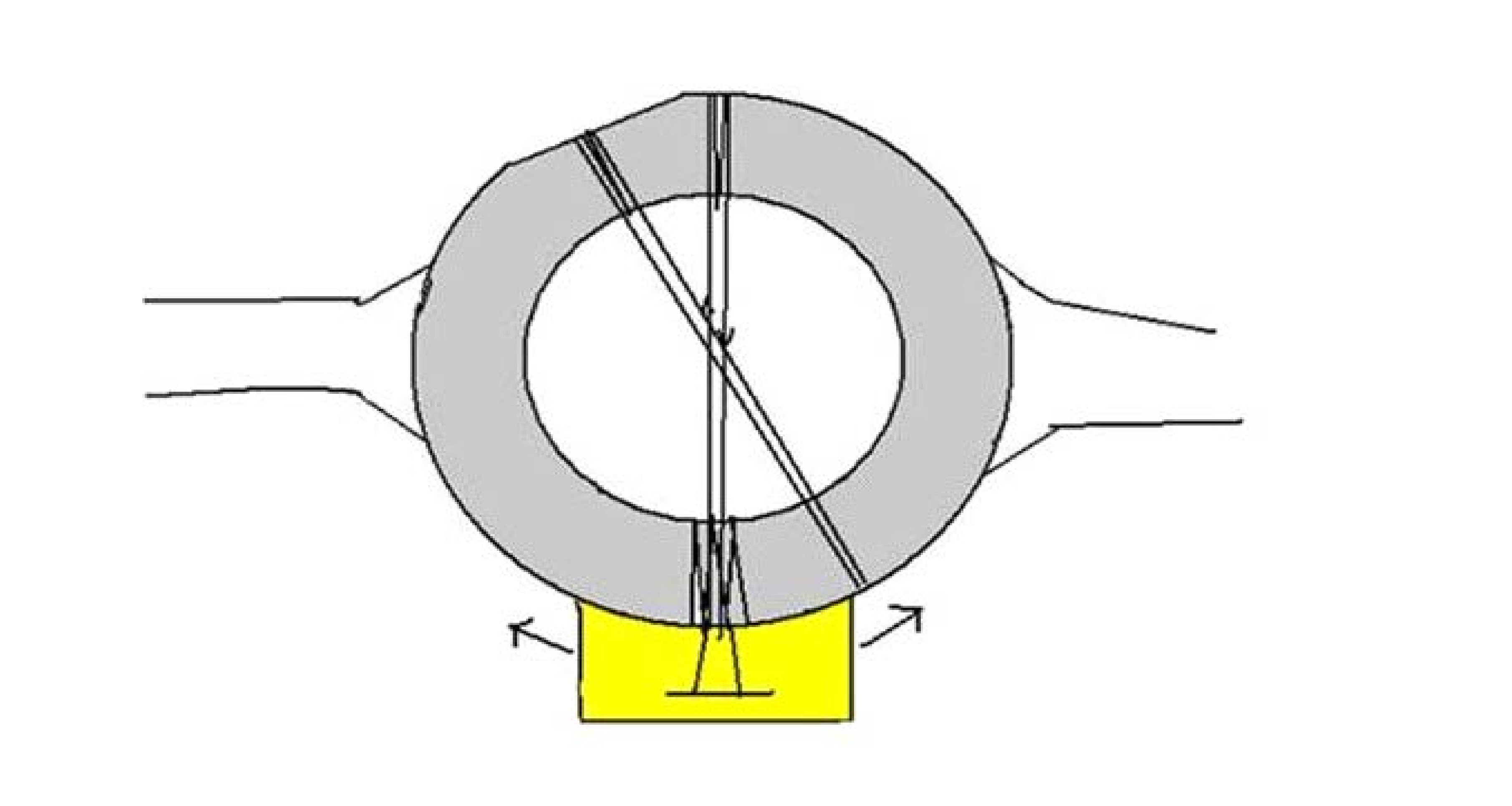
The hand held KEMBUS manipulator is moved along the tube surface in axial direction; the encoder signal represents the axial distance. Stacked A-scan images are recorded for future trending of wall thickness changes

KEMBUS: access from the outside

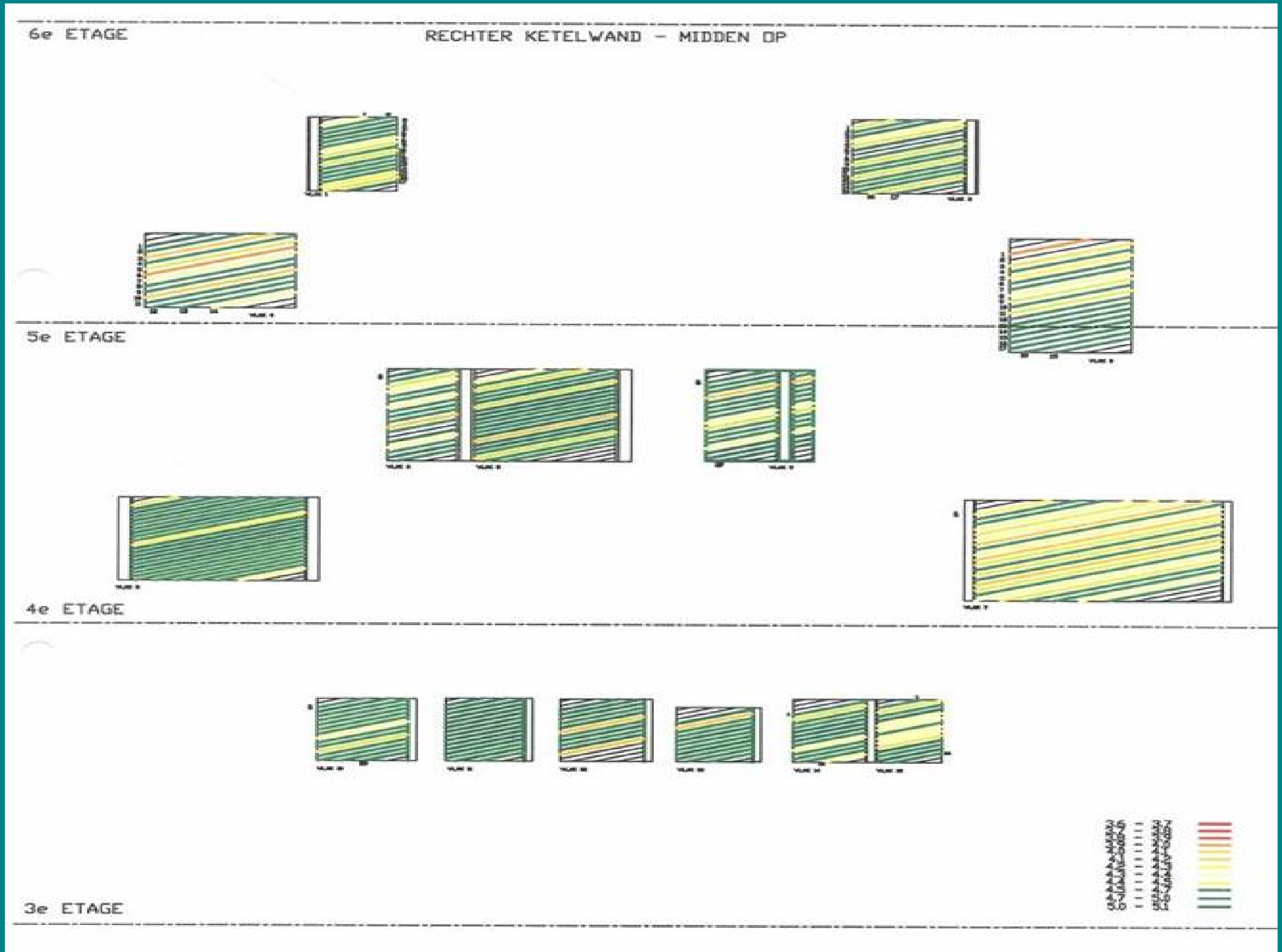
The KEMBUS principle



KEMBUS: *crossing* the pipe; water fill necessary



Boiler wall with “inspection windows”



The windows for applying KEMBUS are defined by customers , minimal wall thickness at a tube measured is presented in color codes

Conclusions(1)

- SPICA: saving inspection work scope during revisions; **life time extension** supporting; fits in long term strategy, prevents unplanned outages
- **KEMWAT**: **pre-inspection**, predictive for maintenance actions at revision: boiler overlay welding, vessel repair/ replacement; early warning system during operational changes
- **KIRR**: prevention of retaining ring failure; no rotor removal --> **less intrusive**
- **KEMBUS**: testing **non-intrusively, pre-inspection**
- VINSPEC: **non-intrusive pre-inspection**, preventing unplanned outages
- KEMRAS: quick testing of a boiler, **saving shutdown time**

Conclusions(2)

- General: *mechanized* (semi, or full) inspection: reliable predictive results, important especially during operational regime changes: maintenance planning
- DEKRA ´s Advanced NDT & Plant Diagnostics will save you money with:

  1. Automated testing: data trending →improved reliability
  2. Non-*intrusive* Inspection
  3. Pre-inspection and on stream monitoring
  4. Combination with Fitness-for-Purpose-Analysis

The strength of DEKRA NDT & Plant Diagnostics

- Special solutions / integral solutions
- Closely linked with other disciplines: FM, inspection, FA, corrosion, electric diagnosis and analysis, etc.
- Operating internationally since many years: Middle East & Africa, Asia and Australia

Some challenges in NDT work can be tough: KEMBAT (UT) for tile bond strength testing