

No.1

The Latest MHI Inspection Technology for PWR Nuclear Power Plants in Japan

**Nuclear Service Quality Control Section
Quality Assurance Department
KOBE Shipyard & Machinery Works
MITSUBISHI HEAVY INDUSTRIES, LTD
JAPAN**



No.2

MHI Inspection Technology [Topics]

- **RV Inspection Technology**
- **Piping Inspection Technology**
- **Inconel Alloy Inspection Technology**
- **SG Tubing Inspection Technology**



RV Inspection Technology

[Contents]

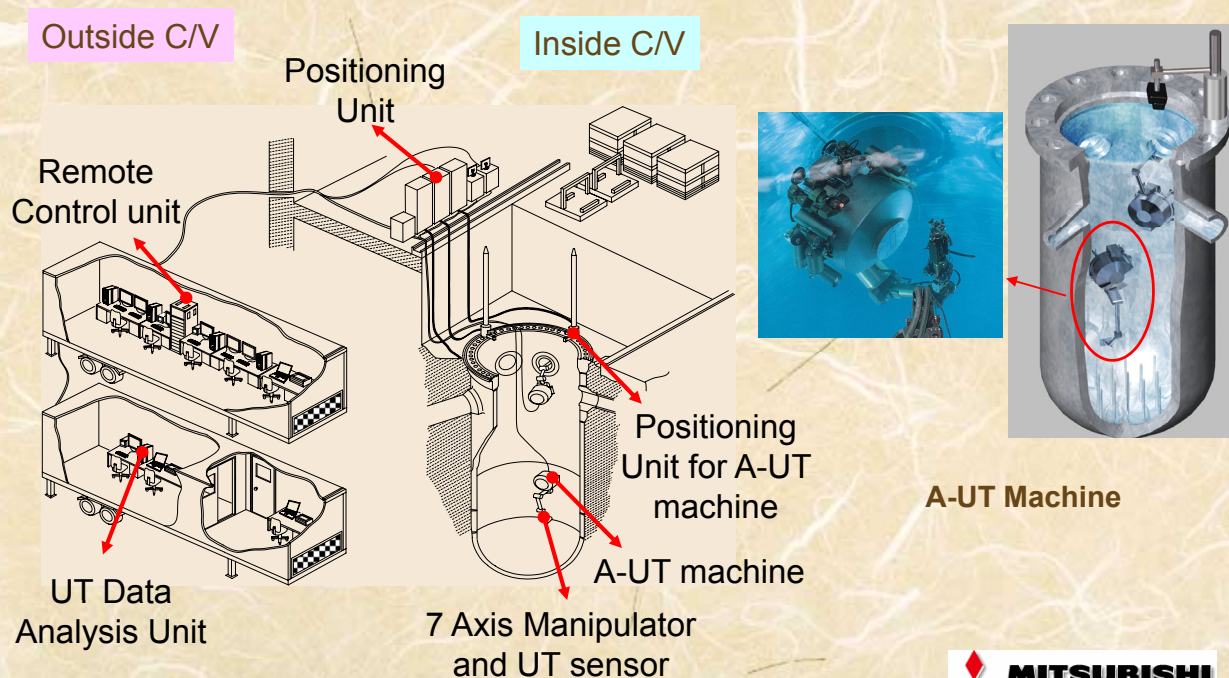
- **Advanced UT II System Overview**
- **Function of A-UT II System**
- **Advantage of A-UT II System**
- **Example of UT data**
- **Field Experience**



RV Inspection Technology

[Advanced UT II System Overview]

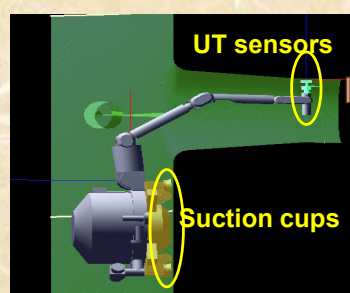
Remote Control Inspection System



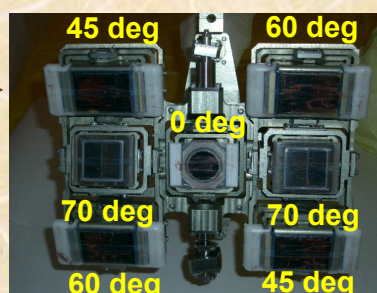
RV Inspection Technology

[Function of A-UT II System]

1. A-UT machine can move to inspection area by driving force with the **thruster**.
2. A-UT machine can be fixed on a wall of RV by the **suction cups**.
3. **UT sensors** (Conventional and Phased array sensor) can be installed in A-UT machine and data from each UT sensors can be acquired at the same time.



Adsorption mechanism



UT sensors



RV Inspection Technology

[Advantage of A-UT II System]



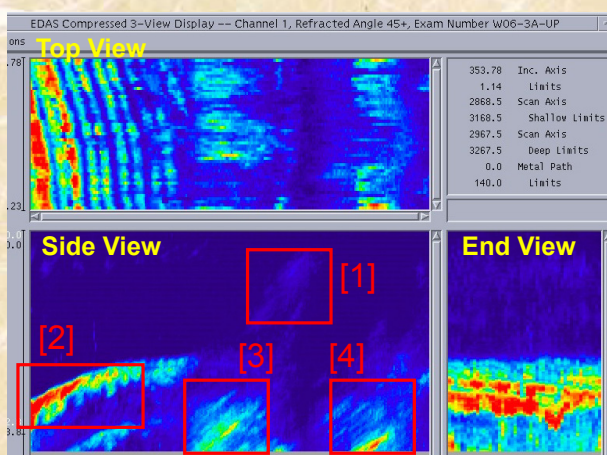
1. Possible to shorten the required time for inspection by using two(2) machines simultaneously
2. Two(2) machines are compatible with each other in performing inspection for all welding sections
3. Small and light-weight design
4. Easy and space-saving to assemble, disassemble, and clean up the machine.
5. Polar crane is not needed during inspection
6. Originally developed smooth scanning with seven(7) axis manipulators



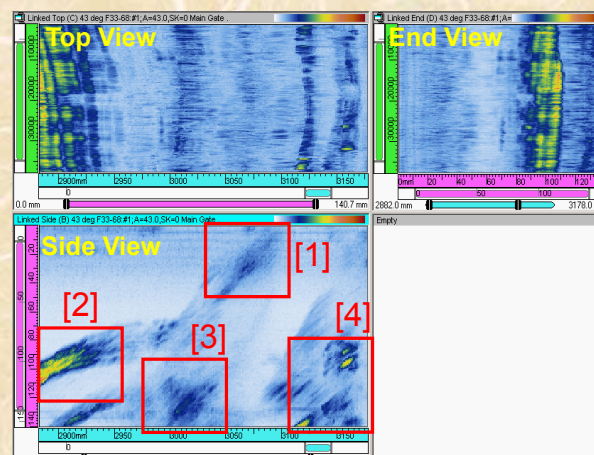
RV Inspection Technology

[Example of UT data]

Top View, Side View and End View



Conventional sensor



Phased array sensor
(Under Development)

Remarks: [1],[3] Weld Noise [2],[4] Geometry change Noise



RV Inspection Technology

[Field Experience of A-UT System]

As of June, 2009

A-UT system / one machine applied

[Conventional system]

Applied to 22 plants

A-UT II system / two machines applied

[The latest system]

Applied to 9 plants

2 loop plant : 3 plants

3 loop plant : 3 plants

4 loop plant : 3 plants



Piping Inspection Technology

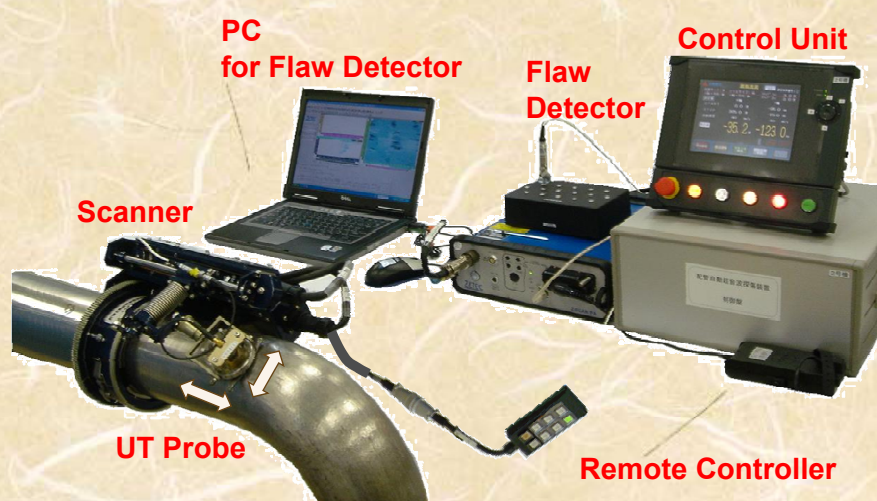
[Contents]

- Automatic UT Data Acquisition System
- UT Data Analysis System
- Field Experience
- MHI Point Focus Phased Array UT



Piping Inspection Technology

[Automatic UT Data Acquisition System]



Automatic UT Acquisition system makes it possible to record all digital UT data and locations automatically.



Piping Inspection Technology

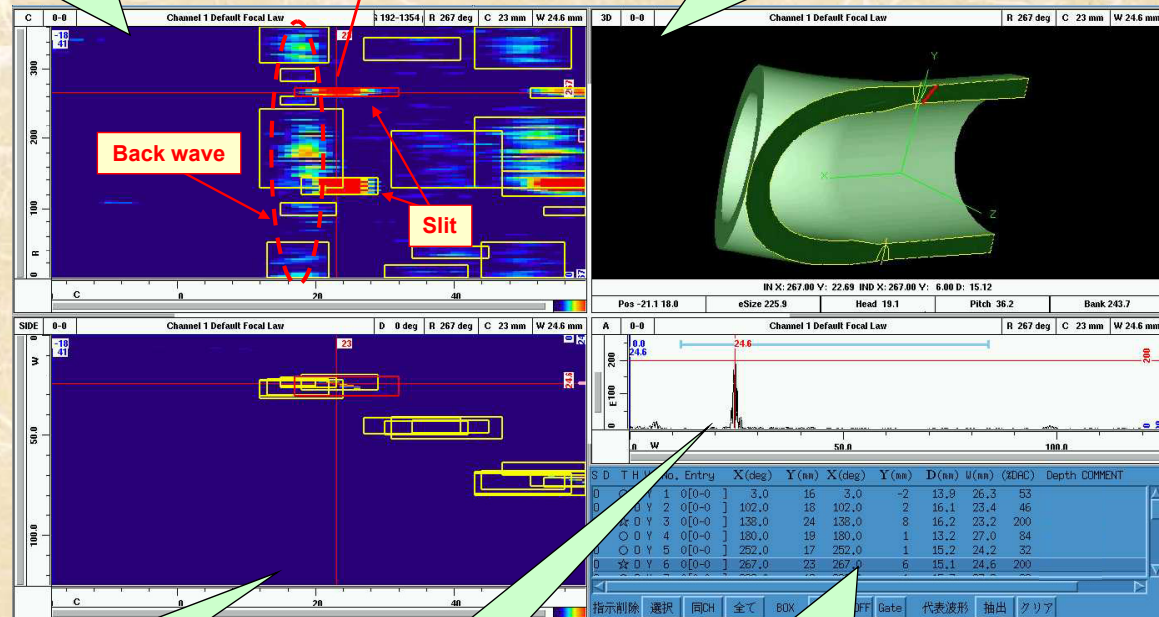
[UT Data Analysis System]

No.11

Top View (C-Scope)
Display of UT indication from the top surface

Indication BOX
Echoes over the threshold are picked up automatically

3D-Model Diagram
Analysis diagram of reflected position



Side View (B-Scope)
Display of UT indication from the side surface

UT Signal (A-Scope)
All UT signal data can be recorded

Indication Data List
Echoes exceeded record level are extracted automatically



Piping Inspection Technology

[UT Data Analysis System]

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Function and Advantage

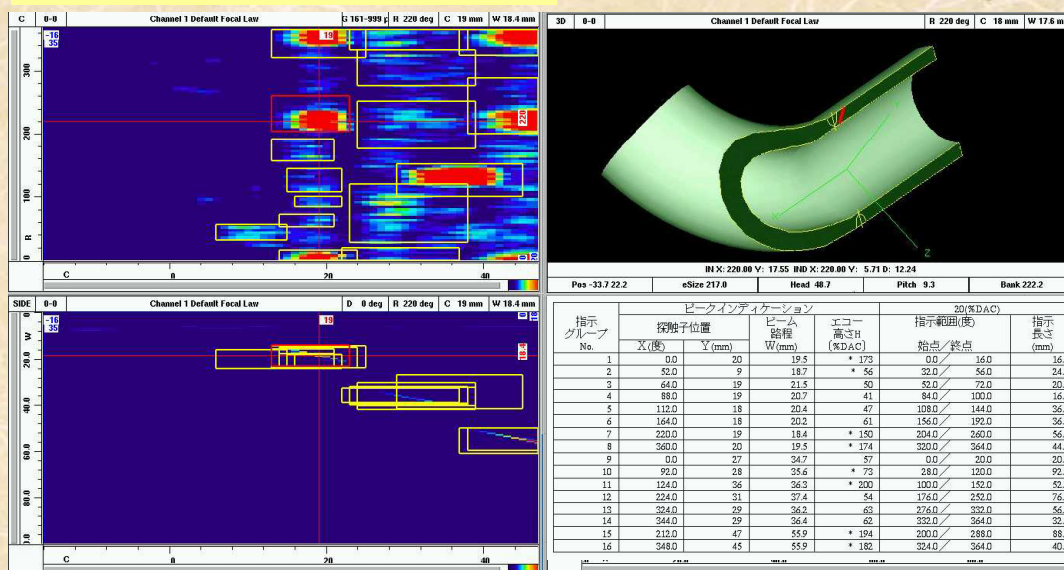
1. Automatic Extraction Function
2. 3-Dimensional Display Function
3. Advanced Filtering Function



Piping Inspection Technology

[UT Data Analysis System]

Automatic Extraction Function



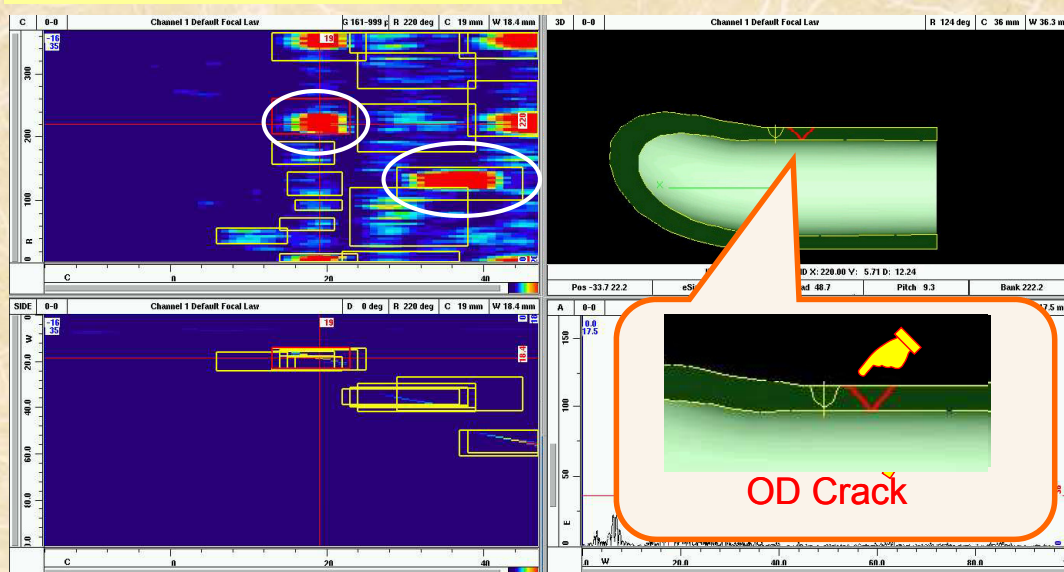
Automatic Extraction Function makes it possible to extract and record signals (location, level and length) greater than the threshold automatically.



Piping Inspection Technology

[UT Data Analysis System]

3-Dimensional Display Function



3-Dimensional Display Function makes it possible to locate the position of the reflection source easily and precisely.

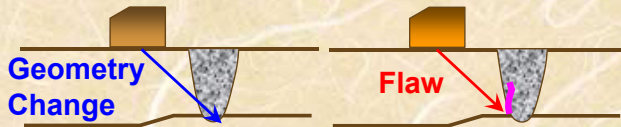


Piping Inspection Technology [UT Data Analysis System]

No.15

Advanced Filtering Function [under development]

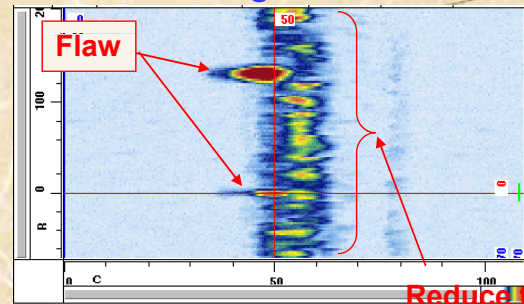
Flaw or Geometry Change ?



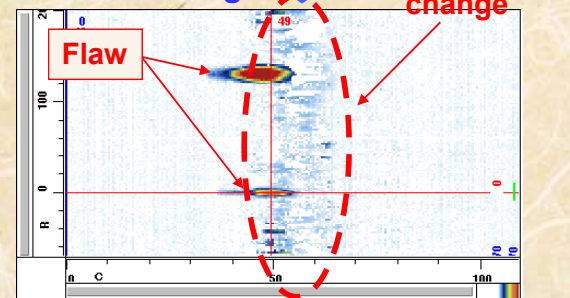
Solution !

Advanced Filtering Function
makes it possible to reduce
signal from geometry change
automatically.

Before Filtering

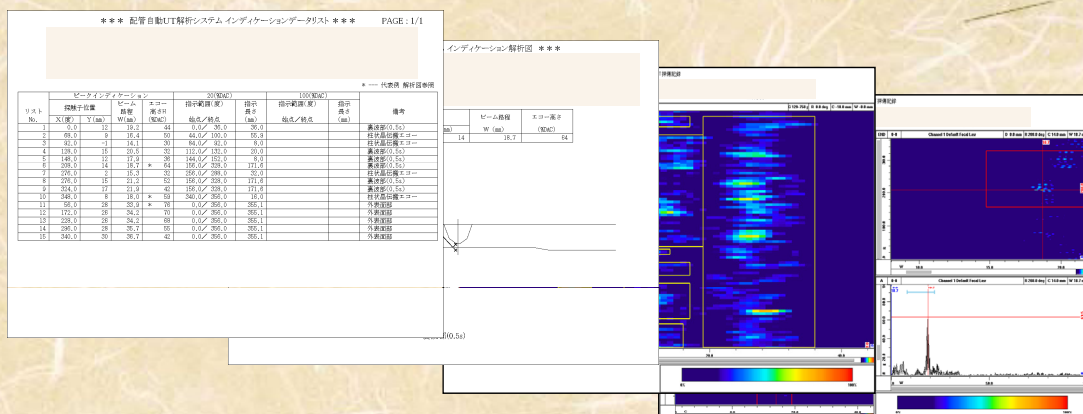


After Filtering



Piping Inspection Technology [Field Experience]

No.16

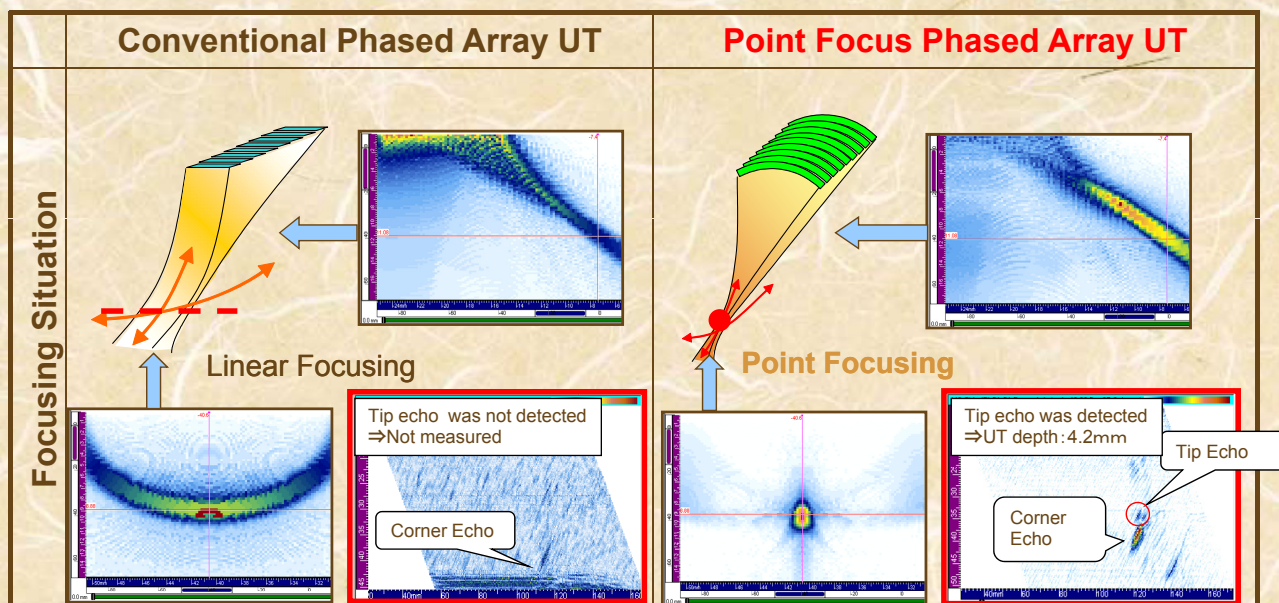


- MHI has already applied this technology to **over 200 piping welds** in domestic nuclear power plants.



Piping Inspection Technology

[MHI Point Focus Phased Array UT]



- The elements with three dimensional curvature makes it possible to perform point focusing.
- The signal from the tip of small crack can be detected.

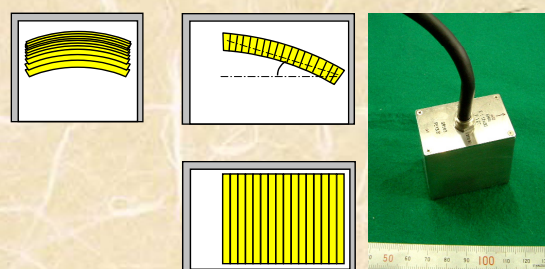
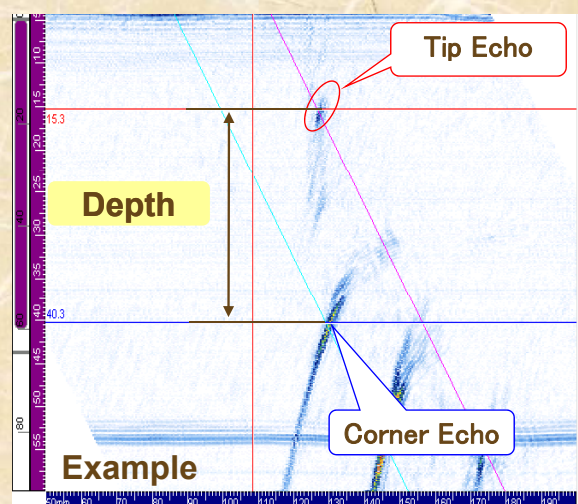


Piping Inspection Technology

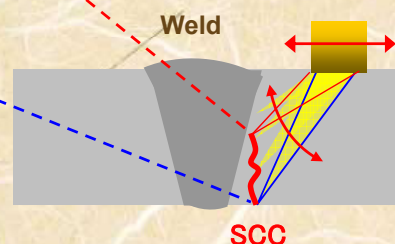
[MHI Point Focus Phased Array UT]

How to perform depth sizing ?

Depth Sizing Tip Echo method



UT Sensor

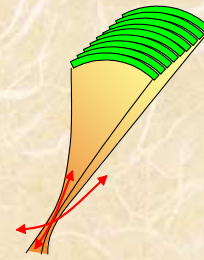
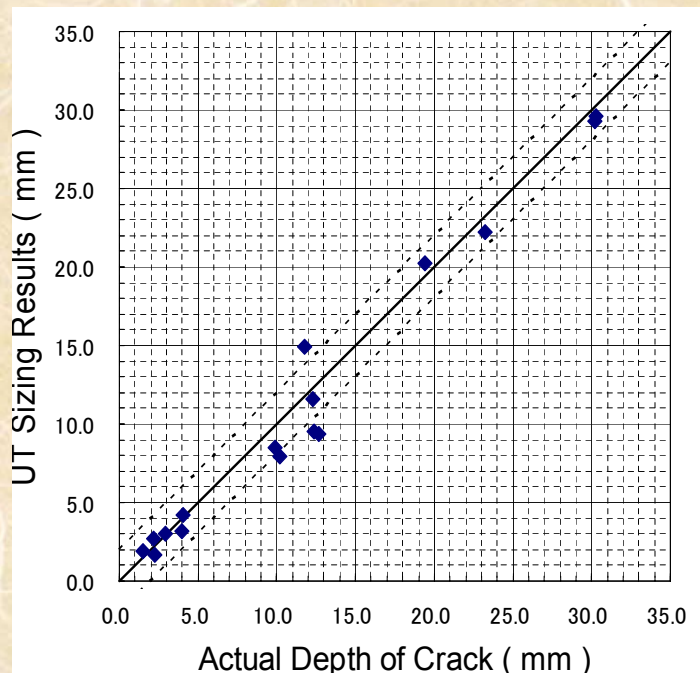


- ✓ Depth can be calculated based on the difference between Corner echo and Tip echo.



Piping Inspection Technology

[MHI Point Focus Phased Array UT]



**Good correlation
between UT Sizing
Results and
Actual Depth of
Crack**

**Correlation of UT sizing results
and actual depth of crack**



Alloy600 Inspection Technology

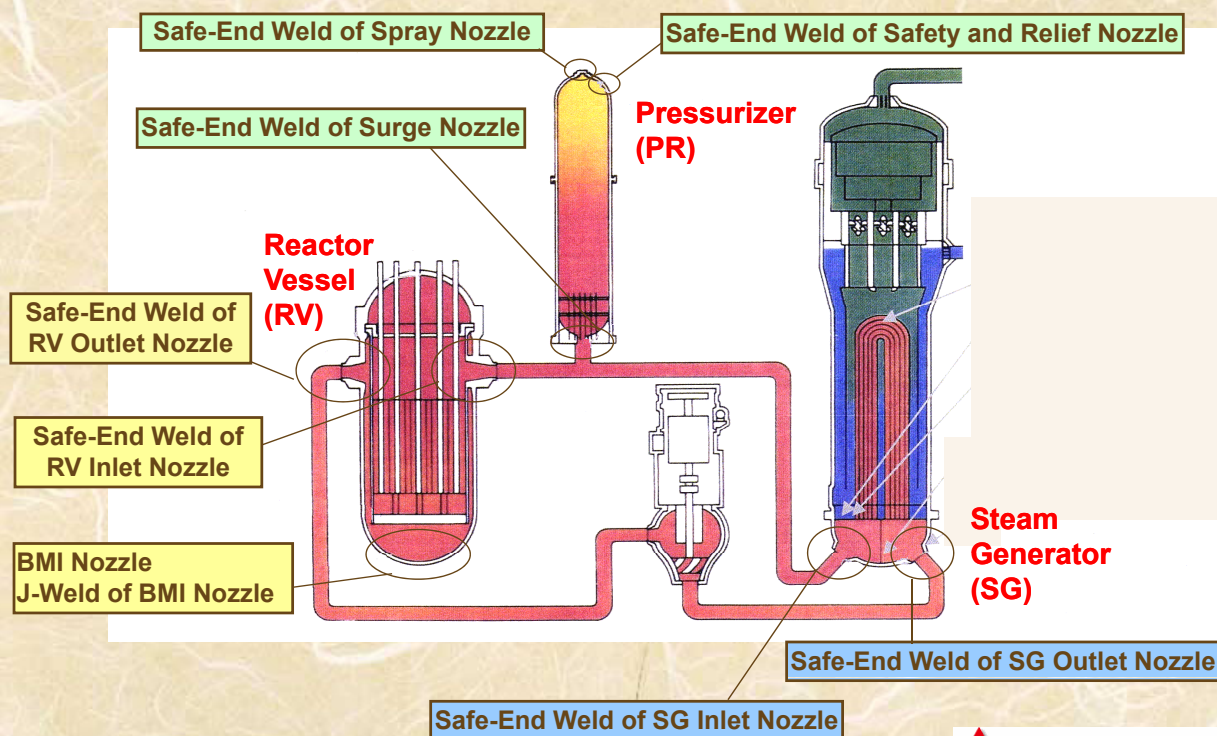
[Contents]

- Alloy600 components in Japanese PWRs
- NDE Techniques applied to Alloy600 components
- ECT Technique for Nozzle Weld
- UT Sizing Technique for Nozzle Weld
- Field Experience for Nozzle Weld



Alloy600 Inspection Technology

[Alloy600 components in Japanese PWRs]



Alloy600 Inspection Technology

[NDE Techniques applied to Alloy600 components]

Part		NDE Method	
		Detection	Depth Sizing
RV	BMI Nozzle	ECT	(UT)
	J-Weld of BMI Nozzle	VT	(UT)
		(ECT)	
	Safe-End Weld of Inlet and Outlet Nozzle	VT	UT
		ECT	
SG	Safe-End Weld of Inlet and Outlet Nozzle	ECT	UT
PR	Safe-End Weld of Safety, Relief, Surge and Spray Nozzle	UT	UT

Applied in Actual Plant
 Under Development

Alloy600 Inspection Technology

[ECT Technique for Nozzle Weld]

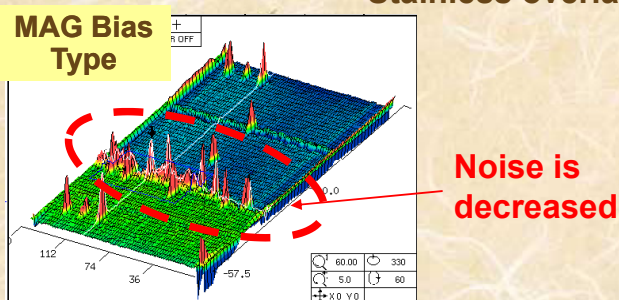
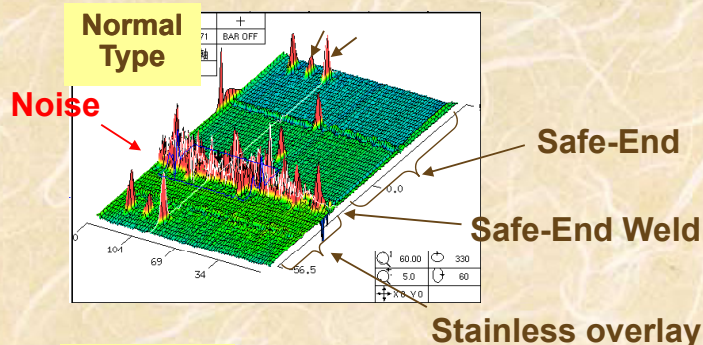
C-scan of Mock-Up with EDM-notch(0.5,1,2mm)

⑬ ⑮ ⑰	SUS	EDM depth
⑪		No.1-13 1mm
⑩		No.14,15 0.5mm
		No.16,17 2.0mm
⑨ ⑧ ⑦ ⑥ ⑤ ④ ③ ② ①	Alloy 600	Buttering
⑫ ⑭ ⑯	Overlay	

The drawing of Mock up

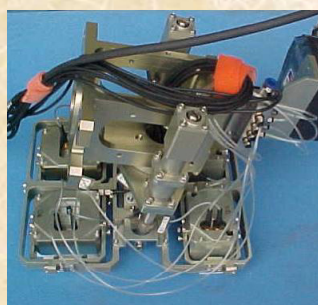
Purpose of MAG Bias Type

Reduction of noise signals in the boundary between Alloy600 weld and stainless overlay

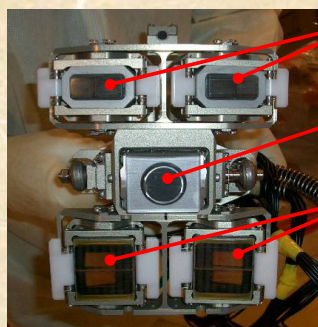


Alloy600 Inspection Technology

[UT Sizing Technique for Nozzle Weld]



Typical UT Probe
(Longitudinal 70°Probe)



Typical UT Probe
Attachment

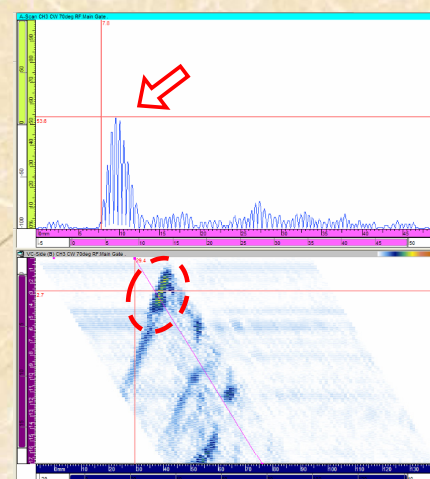
Longitudinal 70°probe
(for inside surface)

0°probe
(for volume)

Longitudinal
45°probe
(for volume)

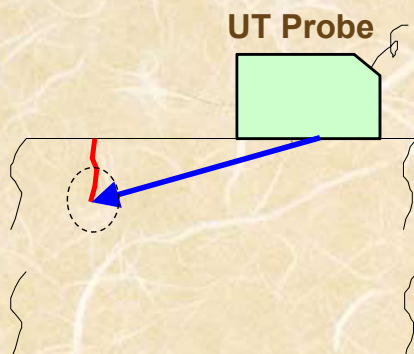
Five(5) UT probes can be installed in UT probe attachment and each data of UT probes can be acquired at the same time.

Example of UT Data
(10%t / 7.7mm deep EDM)

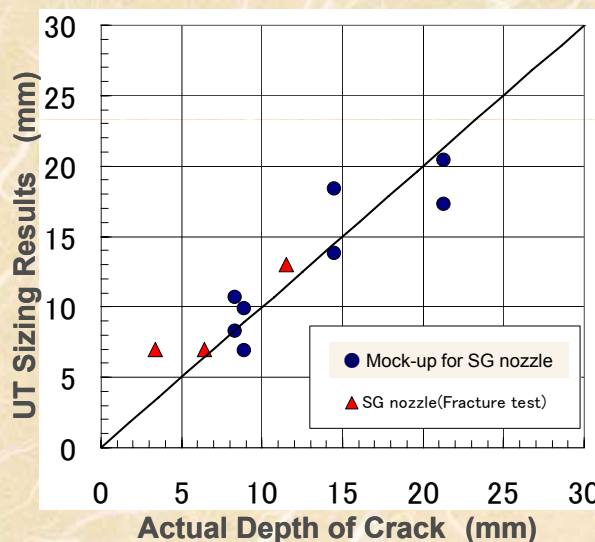


Alloy600 Inspection Technology

[UT Sizing Technique for Nozzle Weld]



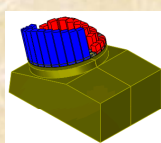
**Good correlation
between UT sizing
results and actual
depth of crack**



Alloy600 Inspection Technology

[UT Sizing Technique for Nozzle Weld]

Advanced Matrix PA-UT Probe



Dual Type



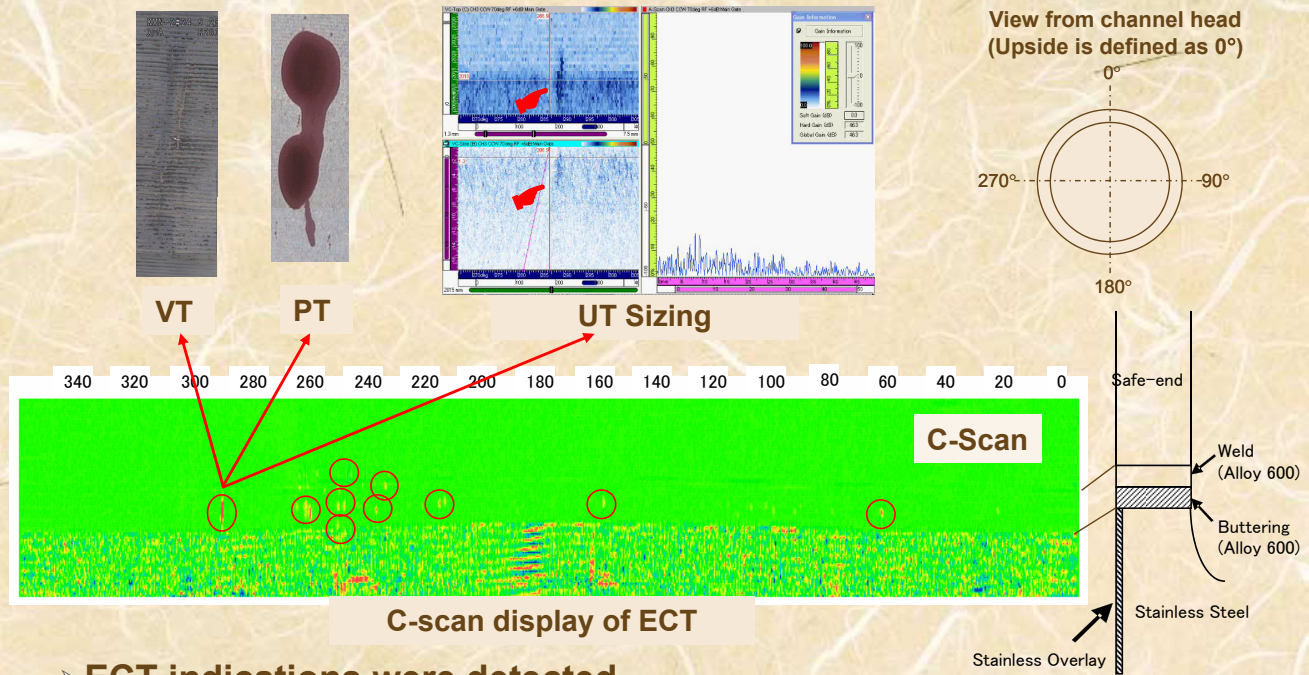
Advanced Matrix Phased Array UT is superior to Conventional UT for depth sizing.

	Conventional UT	Advanced Matrix PA-UT [Under Development]
SCC 20.8mm depth	Noise ? Evaluation depth: 16.1mm	Tip echo Evaluation depth: 20.9mm



Alloy600 Inspection Technology [Field Experience for Nozzle Weld]

No.27



- ECT indications were detected.
- UT Sizing results were in good agreement with actual depth.



SG Tubing Inspection Technology [Contents]

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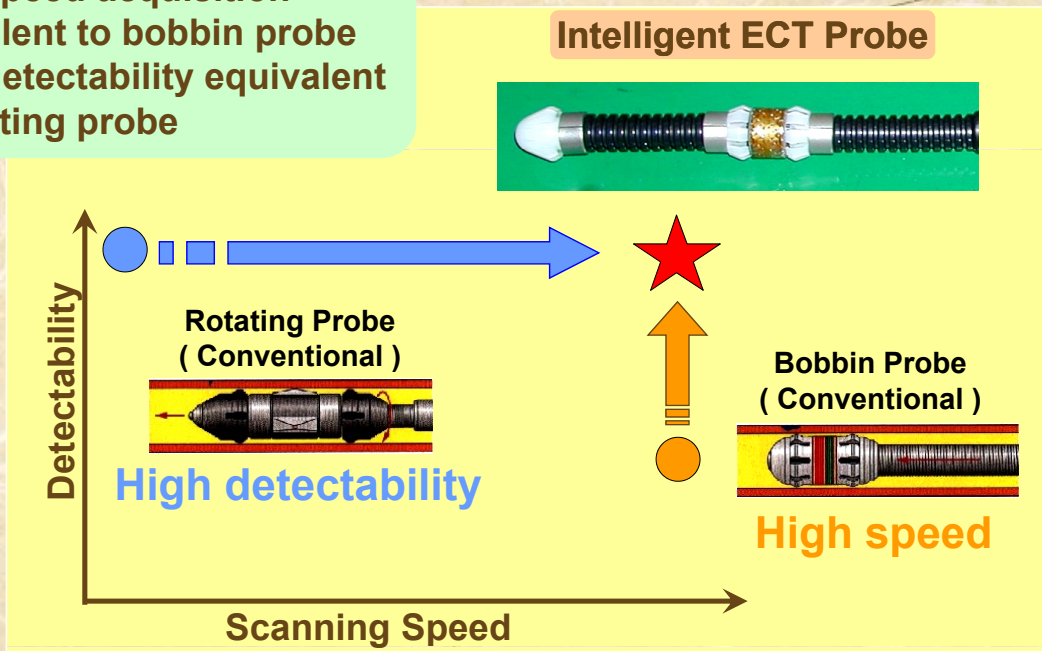
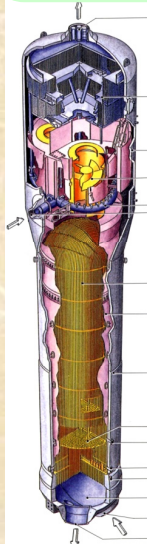
- MHI Intelligent ECT Probe Concept
- Feature of MHI Intelligent ECT Probe
- Advantage of MHI Intelligent ECT Probe
- Example of MHI Intelligent ECT Probe Data
- Field Experience in Japan and US



SG Tubing Inspection Technology [MHI Intelligent ECT Probe Concept]

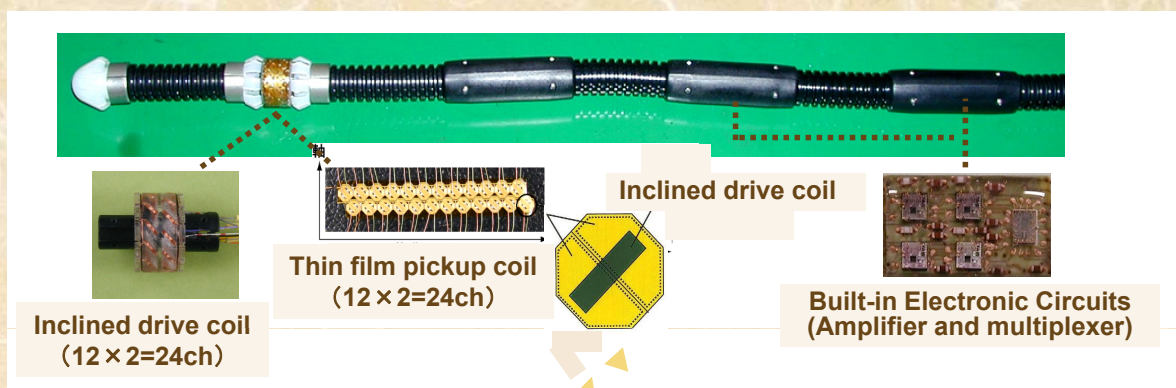
No.29

- High speed acquisition equivalent to bobbin probe
- High detectability equivalent to rotating probe



SG Tubing Inspection Technology [Feature of MHI Intelligent ECT Probe]

No.30



- 24ch driver pick-up type multi-array coil
- Thin-film pick-up coil enhances flaw detectability
- Built-in electronic circuits realize high S/N ratio
- Non-surface riding coil increases the probe life and durability of the probe



SG Tubing Inspection Technology

[Advantage of MHI Intelligent ECT Probe]

Advantage

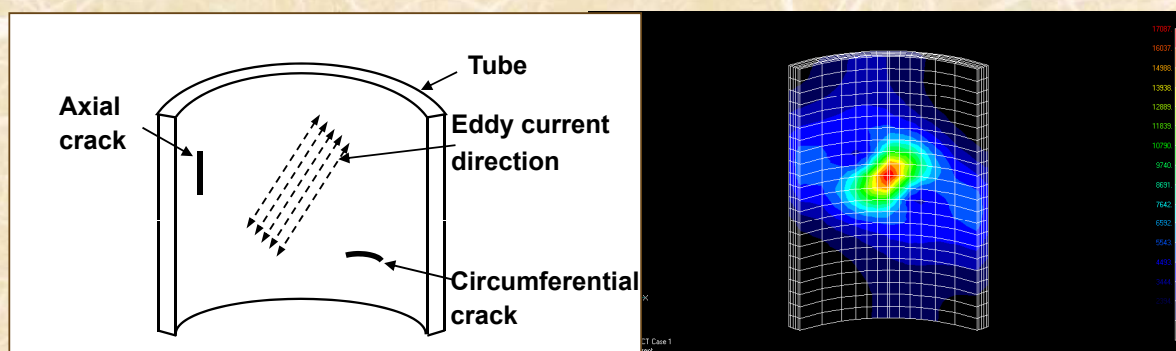
1. High Speed and High Detectability
2. Inclined drive coil is effective in both circumferential and axial flaw detection.
3. Flaw direction (circ./axial) can be determined easily by Lissajous figure.



SG Tubing Inspection Technology

[Advantage of MHI Intelligent ECT Probe]

Eddy current by inclined drive coil



(a) Eddy current direction

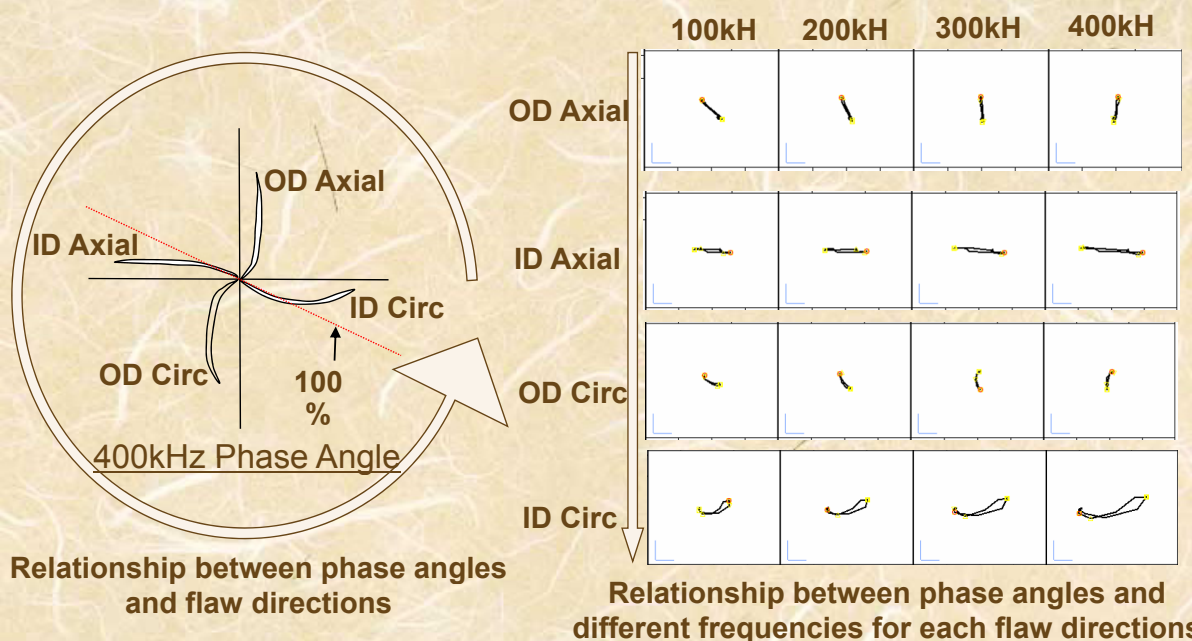
(b) Eddy current distribution by 3D numerical analysis

Inclined drive coil is effective in both circumferential and axial flaw detection



SG Tubing Inspection Technology

[Advantage of MHI Intelligent ECT Probe]

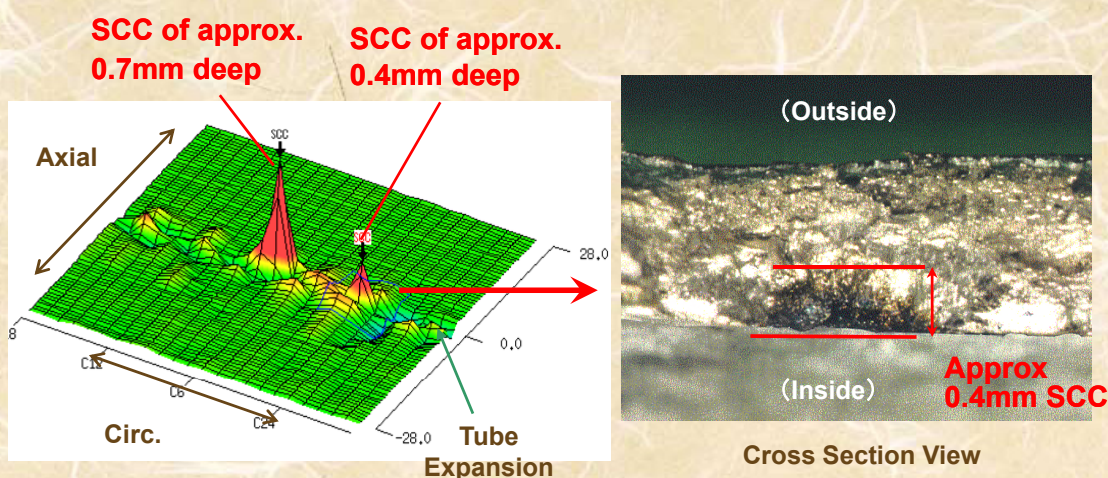


Flaw direction (circ./axial) can be determined easily by Lissajous figure.



SG Tubing Inspection Technology

[Example of MHI Intelligent ECT Probe Data]



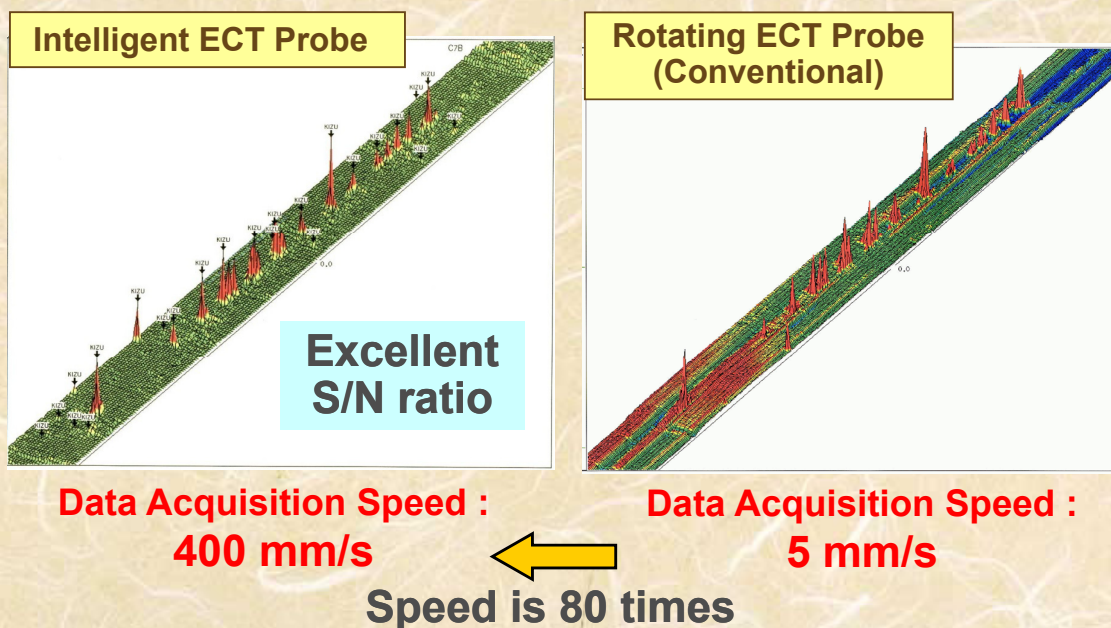
Example of Axial IDSCC signal at Tube Expansion



SG Tubing Inspection Technology

[Example of MHI Intelligent ECT Probe Data]

Comparison with Intelligent ECT Probe and Conventional Rotating ECT Probe

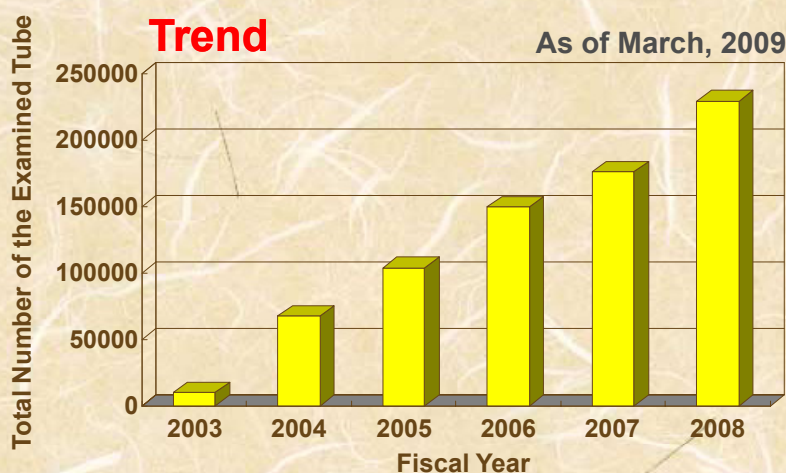


Example of Multiple circ. IDSCC signal at Row5 U-bend



SG Tubing Inspection Technology

[Field Experience in Japan]



- MHI Intelligent ECT has been applied to Inconel Alloy600 tubes in Japan since 2003.
- As of March, 2009, there have been over 225,000 tubes examined.



SG Tubing Inspection Technology

[Field Experience in US]

As of March, 2009

Category	Date	Plant	SG Model	Number of tubes	Tube Dia.
Field Trial	Feb. 2002	Prairie Island Unit-2	WH 51	124 tubes	7/8 in.
	Apr. 2002	Palo Verde Unit-2	CE System 80	41 tubes	3/4 in.
	Apr. 2002	Sequoyah Unit-2	WH 51	60 tubes	7/8 in.
	Jun. 2002	San Onofre Unit-2	CE 3410	104 tubes	3/4 in.
	Oct. 2002	Palo Verde Unit-1	CE System80	42 tubes	3/4 in.
	Oct. 2002	Arkansas Unit-1	B&W OTSG	211 tubes	5/8 in.
	Jan. 2003	Comanche Peak Unit-1	WH D4-2	21 tubes	3/4 in.
	Feb. 2003	Diablo Canyon Unit-2	WH 51	41 tubes	7/8 in.
	Nov. 2008	Oconee Unit-2	ROTSG	132 tubes	5/8 in.
	Mar. 2009	Catawba Unit-2	WH D5	7 tubes	3/4 in.
Inspection (ISI)	Sep. 2003	Watts Bar Unit-1	WH D3	3000 tubes	3/4 in.
	Oct. 2003	Sequoyah Unit-2	WH 51	3000 tubes	7/8 in.
	Apr. 2004	Callaway	WH F	1786 tubes	7/8 in.
Inspection (PSI)	Nov. 2005	OPPD Fort Calhoun RSG	MHI-49TT1	10400 tubes	3/4 in.

✓ As of March, 2009, Intelligent ECT Probe was applied for 14 plants in US.



MHI Inspection Technology

[Conclusion]

Our mission is to contribute to safe operation and life extension of the nuclear power plant at world wide by applying our inspection technology.



Our Technologies, Your Tomorrow