

OLYMPUS

Your Vision, Our Future

Automated Ultrasonic Inspection for Pipeline Girth Welds

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Bob Peck – EMEA – NDT Business Development Mgr.



Pipeline Girth Weld Inspection:

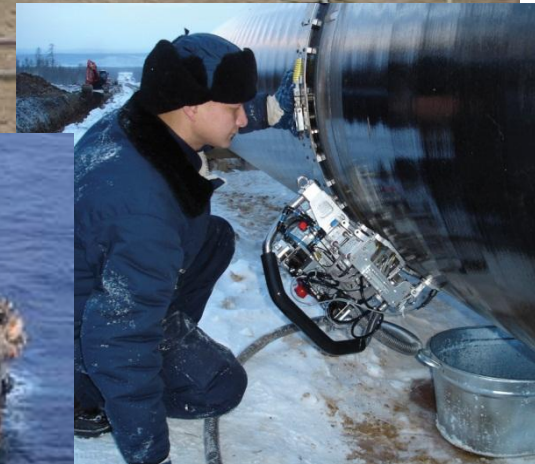
In the last several years Automated Ultrasonic Inspection (AUT) , has begun to really replace traditional X-Ray crawler radiography.

AUT phased-array vs. radiography

Radiography has significant limitations compared to AUT:

- Poor detection of Planar Defects in some circumstances.
- Accuracy of vertical defect sizing.
- Safety Issues.
- Environmental Concerns.

Girth Weld Inspections: Onshore / Offshore




Codes governing pipeline AUT inspection

ASTM E 1961

API 1104

DNV-OS-F101



Designation: E 1961 – 98 (Reapproved 2003)¹

Standard Practice for Mechanized Ultrasonic Examination of Girth Welds Using Zonal Discrimination with Focused Search Units¹

This standard is issued under the fixed designation E 1961; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

¹ Note—Footnote was added to paragraph 6.4.1 in June 2003.

1. Scope

1.1 This practice covers the requirements for mechanized ultrasonic examination of girth welds. Evaluation is based upon the results of mechanized ultrasonic examination. Acceptance criteria are based upon flaw limits defined by an Engineering Critical Assessment (ECA) or other acceptance criteria defined by the Contracting Agency.

1.2 This practice shall be applicable to the development of an examination procedure agreed upon between the users of this practice.

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound units given in brackets are for information only.

1.4 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 The following documents form a part of this practice to the extent specified herein:

2.2 *ASTM Standards:*
 E 164 Practice for Ultrasonic Contact Examination of Weldments²
 E 317 Practice for Evaluating Performance Characteristics of Pulse-Echo Examination Systems Without the Use of Electronic Measurement Instruments³
 E 1316 Terminology for Nondestructive Examinations²
 2.3 *ASNT Standards:*⁴
 ASNT Practice SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing

¹ This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.06 on Ultrasonic Methods.

² Current edition approved June 10, 2003. Published August 2003. Originally approved in 1996. Last previous edition approved in 1998 as E 1961 – 98.

³ Annual Book of ASTM Standards, Vol 03.03.

⁴ Available from The American Society for Nondestructive Testing (ASNT), PO. Box 25118, 1711 Arlington Ave., Columbus, OH 43228-0118.

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Welding of Pipelines and Related Facilities

Pipeline Segment

ANSI/ASNT-CP-189 Standard for Qualification and Certification of Nondestructive Testing Personnel
 2.4 *Military Standard:*
 MIL-Std-410 Nondestructive Testing Personnel Qualification and Certification⁴
 2.5 *API Standard:*
 API STD-1104 Welding of Pipeline and Related Facilities⁵
 2.6 *CSA Standard:*
 CSA Z-662 Oil and Gas Pipelines Systems⁶

3. Terminology

3.1 *Definitions:*

3.1.1 *Definitions* relating to ultrasonic examination, that appear in Terminology E 1316 shall apply to the terms used in this practice.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *acceptance criteria*—definition of acceptable/rejectable flaws as defined by an Engineering Critical Assessment (ECA), such as defined in CSA-2662 or API 1104, or workmanship criteria as defined by the contracting agency.


3.2.2 *contract documents*—any document specified in the contract between the contracting agency and contractor, including the purchase order, specification, drawings or other written material.

3.2.3 *contracting agency*—a government agency, prime contractor or subcontractor procuring ultrasonic examination services.

3.2.4 *contractor*—the nondestructive examination contractor engaged by the contracting agency in work covered by this practice.


3.2.5 *mapping type presentations*—an ultrasonic image presentation whereby the digitized A-scan signal is represented as colors or grayscale for amplitude variation along one axis

API STANDARD 1104
 NINETEENTH EDITION, SEPTEMBER 1999



American Petroleum Institute

Helping You Get The Job Done Right.™



OFFSHORE STANDARD
 DNV-OS-F101

SUBMARINE PIPELINE SYSTEMS

OCTOBER 2007

DET NORSKE VERITAS

Code Compliance:

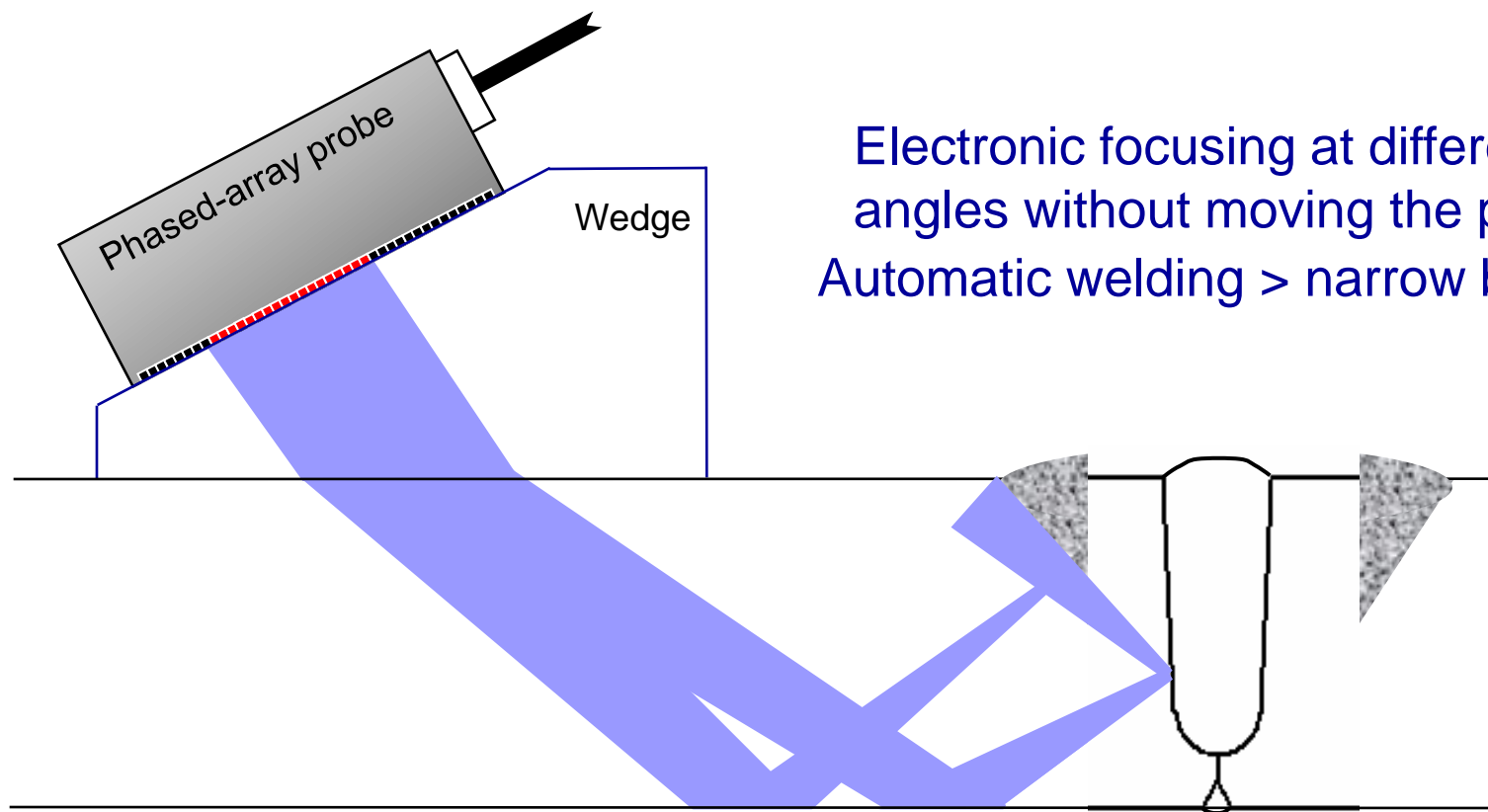
In 1998, the ASTM published the E-1961-98 code (reapproved in 2003), which covers key elements of AUT of girth welds - **zone discrimination, rapid data interpretation, specialized calibration blocks**, and configuration procedures.

The E-1961 code is designed for ECA. Similarly, in 1999, the American Petroleum Institute (API) published the 19th edition of Standard 1104, which covers mechanized ultrasonic testing and radiography of girth welds.

PipeWIZARD allows inspections to comply with the ASTM E-1961 code, and by inference, with the API 1104 standard. It also allows compliance with the DNV-OS-F101 standard, the offshore AUT code.

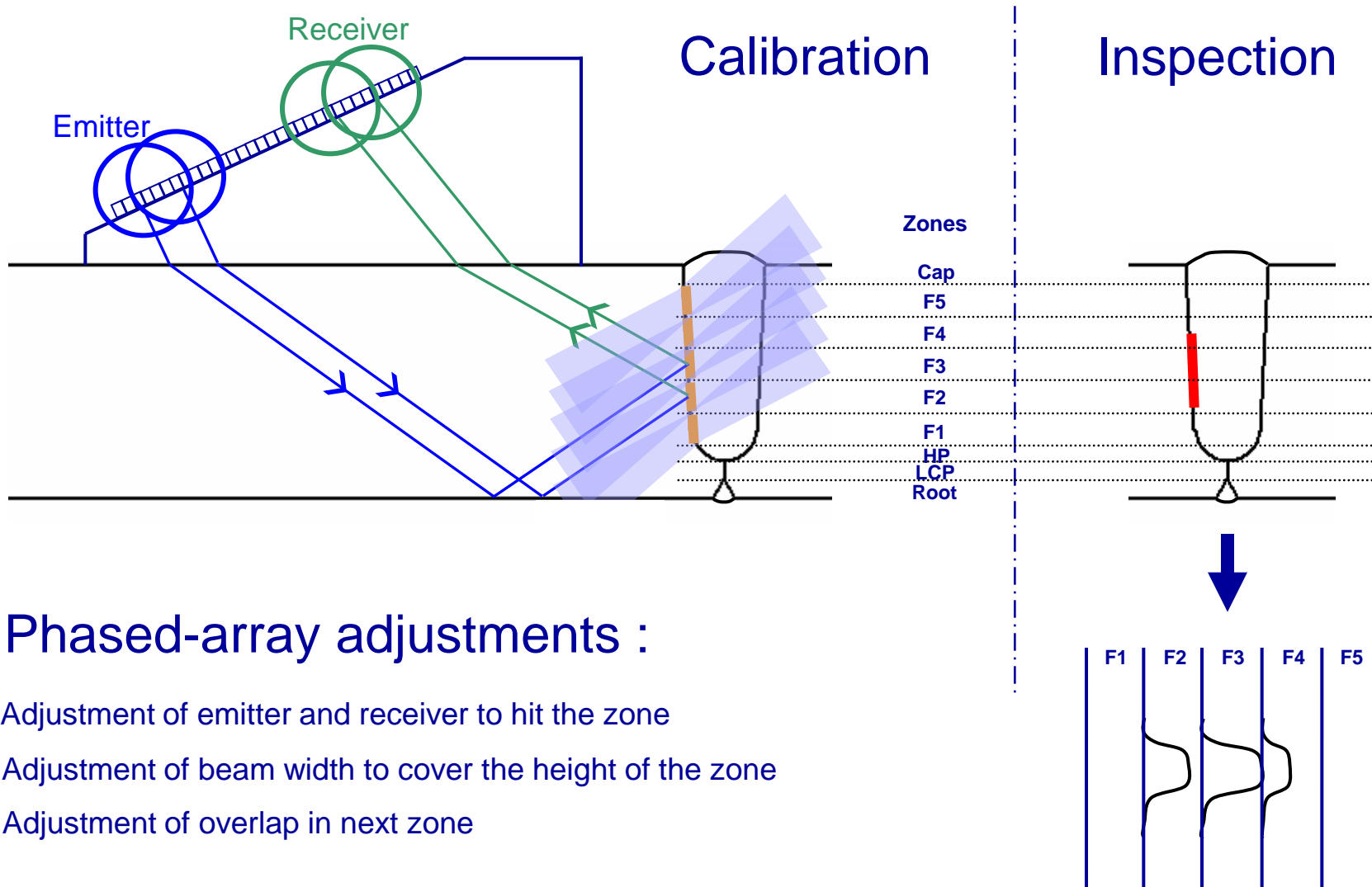
Company specifications may exceed the codes, typically by asking for improved sizing or better resolution.

AUT - Basic Ultrasonic Phased-array principles



Electronic focusing at different angles without moving the probe
Automatic welding > narrow bevel

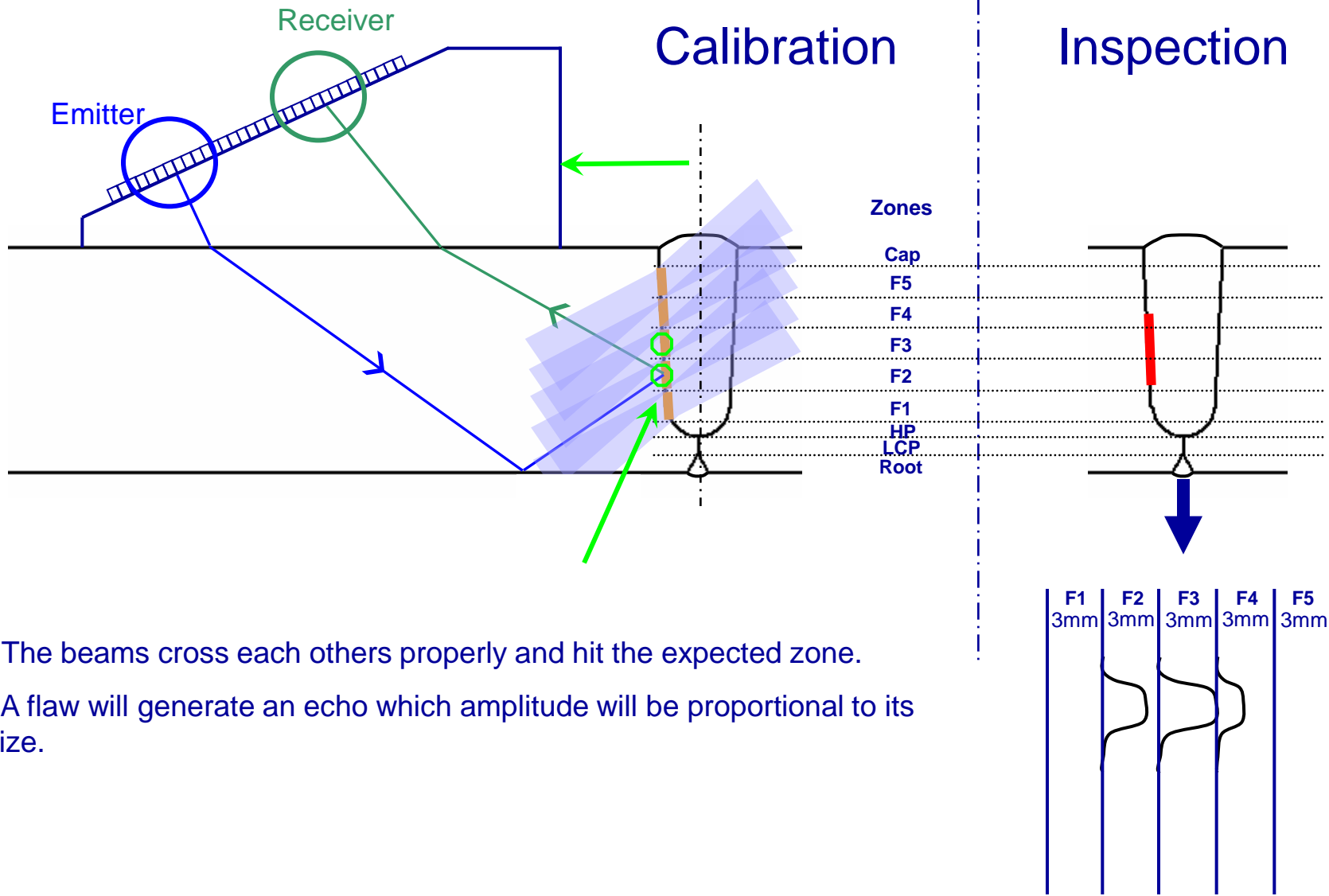
AUT - Zone discrimination technique



Phased-array adjustments :

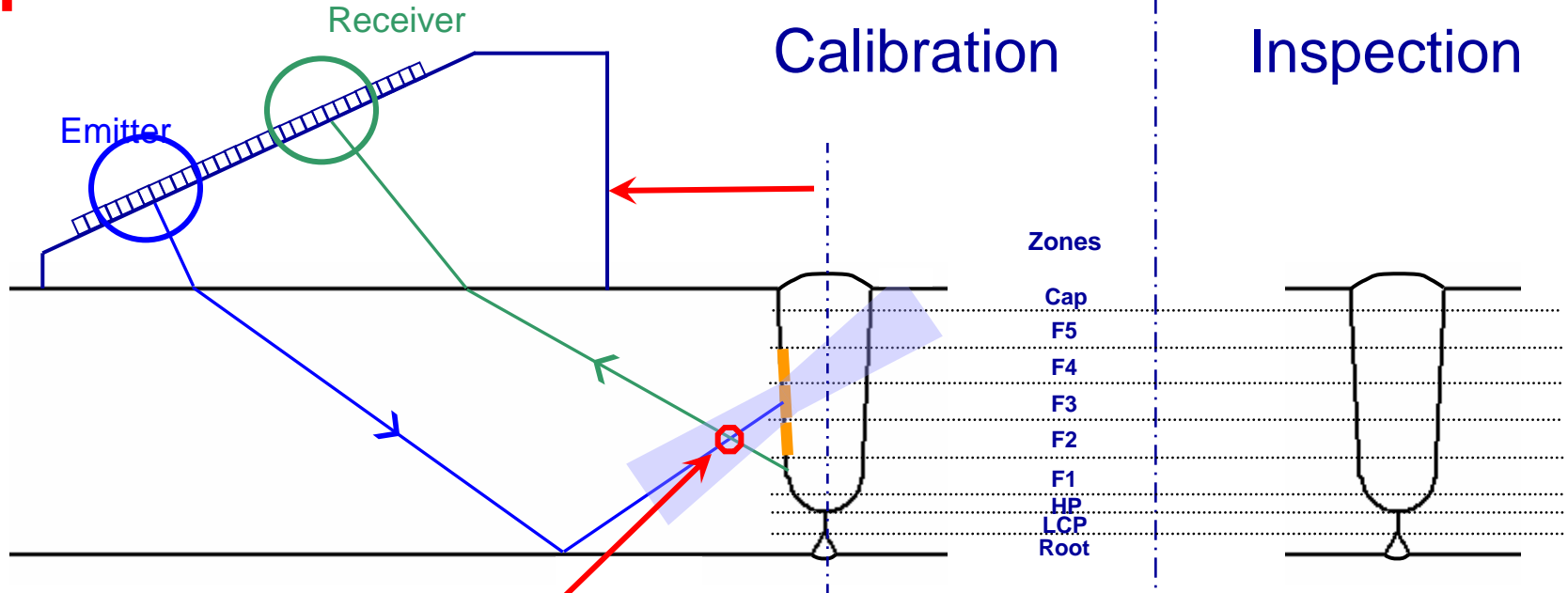
- Adjustment of emitter and receiver to hit the zone
- Adjustment of beam width to cover the height of the zone
- Adjustment of overlap in next zone

Zone discrimination technique: **GOOD** position to the centre line of the weld



- The beams cross each others properly and hit the expected zone.
- A flaw will generate an echo which amplitude will be proportional to its size.

Zone discrimination technique : **BAD** position to the centre line of the weld

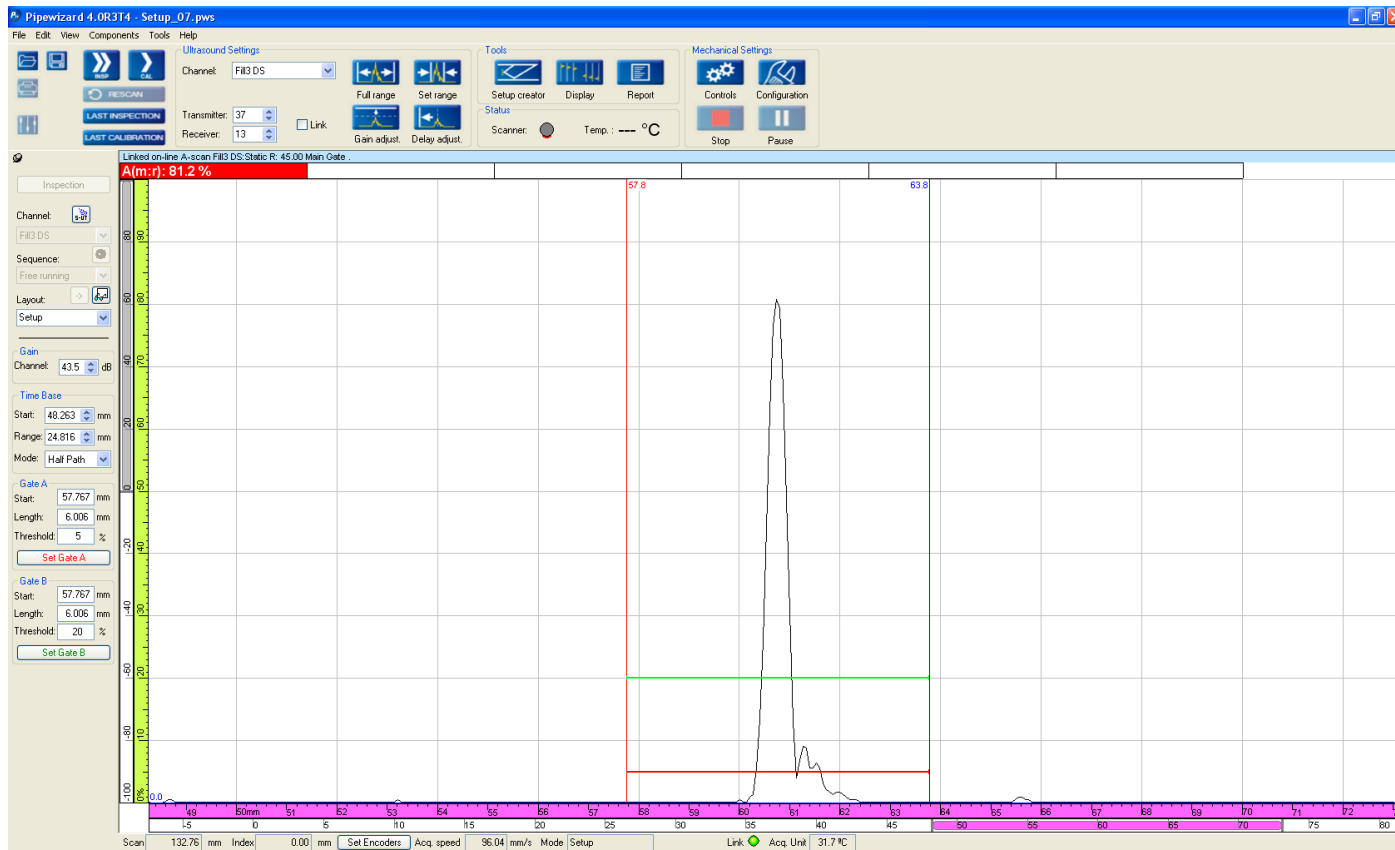


- Position of the crossing points of the UT beams are not anymore on the fusion face.
- Any indication located on the fusion face will be missed
- Or the amplitude will drop significantly underestimating the flaw size and giving a wrong depth

PipeWIZARD V4 - Software

User-friendly advanced software

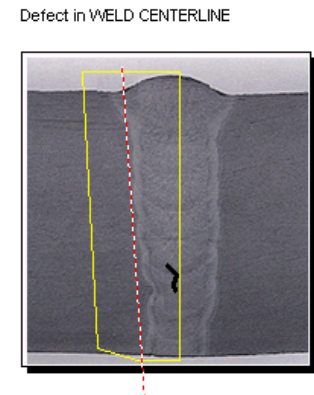
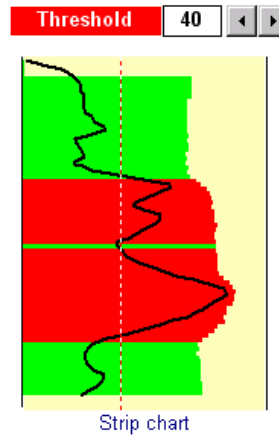
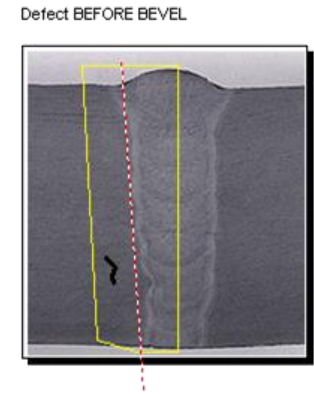
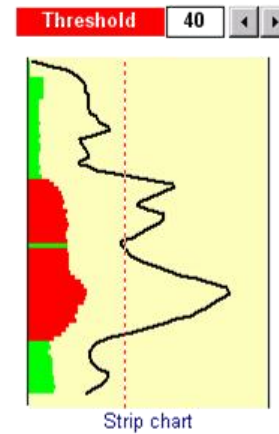
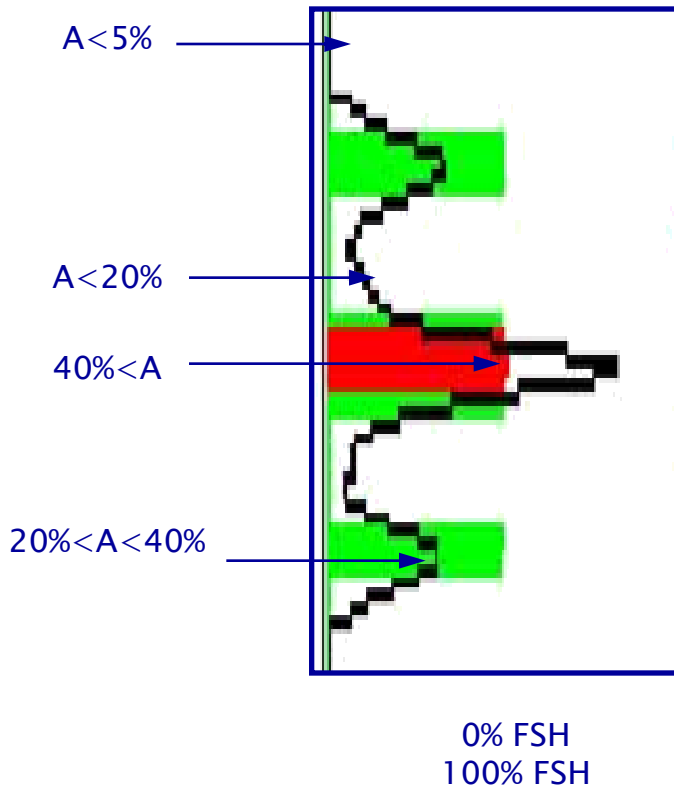
- Twin-gate strip chart : amplitude and position



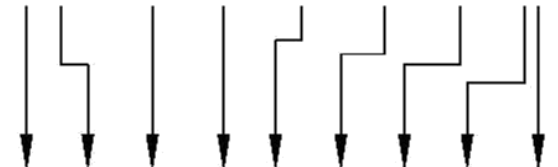
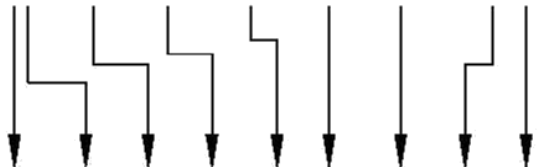
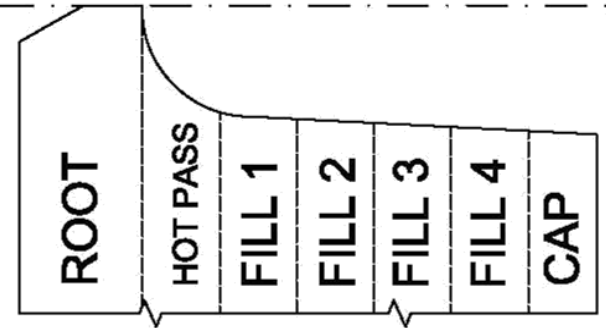
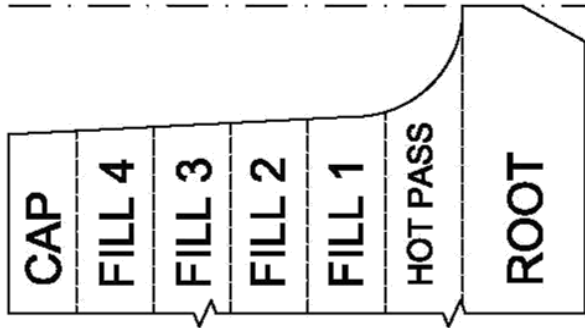
PipeWIZARD V4 - Software

User-friendly advanced software

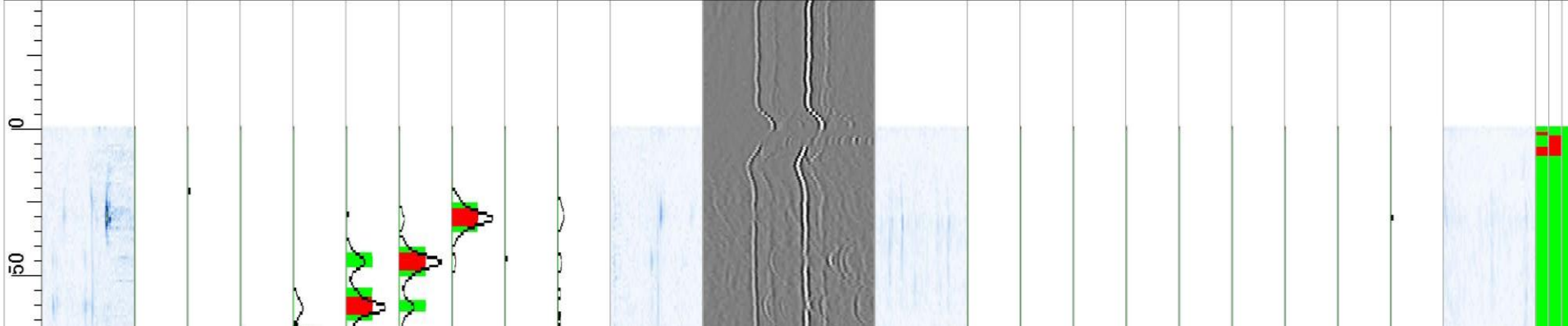
- Twin-gate strip chart : amplitude and position



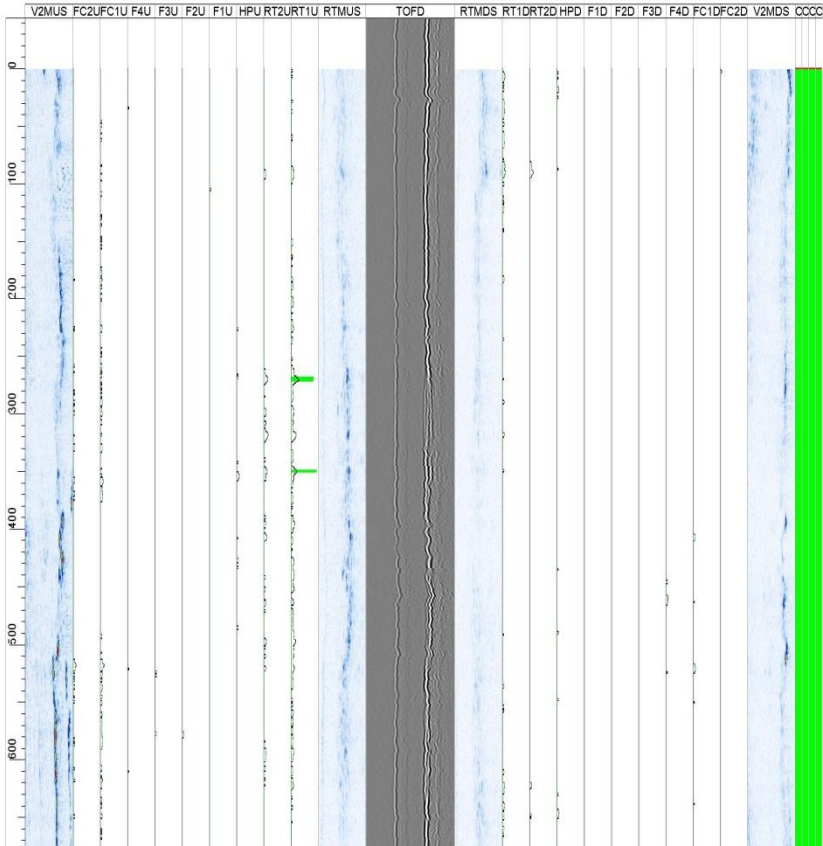
Strip-chart layout



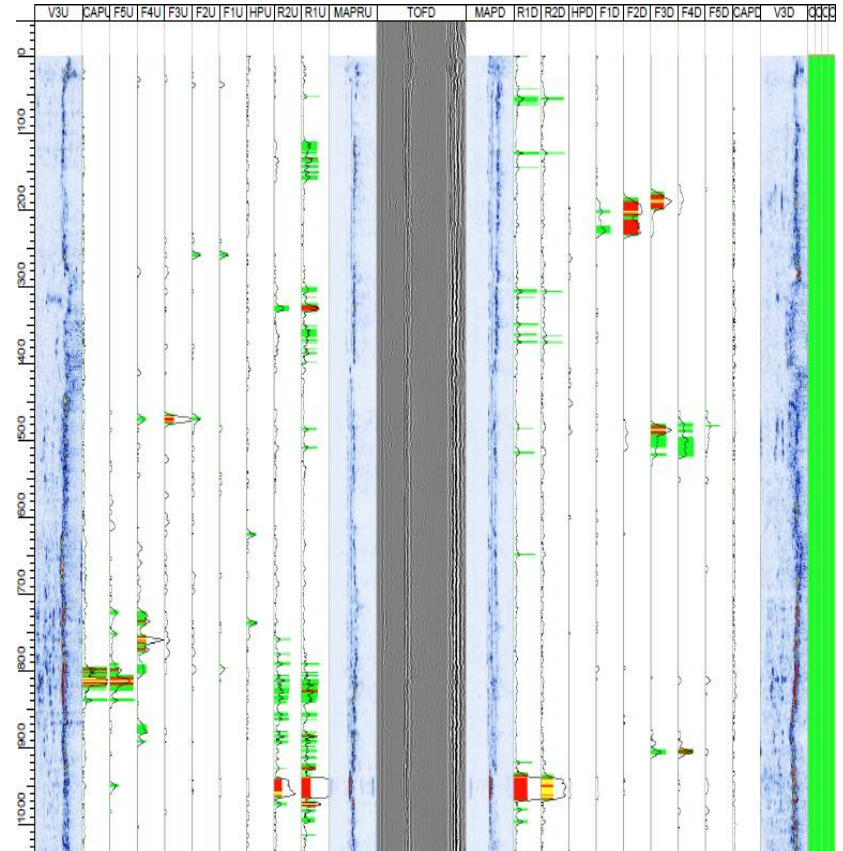
V2MUS FC2UFC1U F4U F3U F2U F1U HPU RT2URT1U RTMUS TOFD RTMDS RT1DRT2D HPD F1D F2D F3D F4D FC1DFC2D V2MDS CC



Scan output of a weld without indication



Scan output of a weld with indications

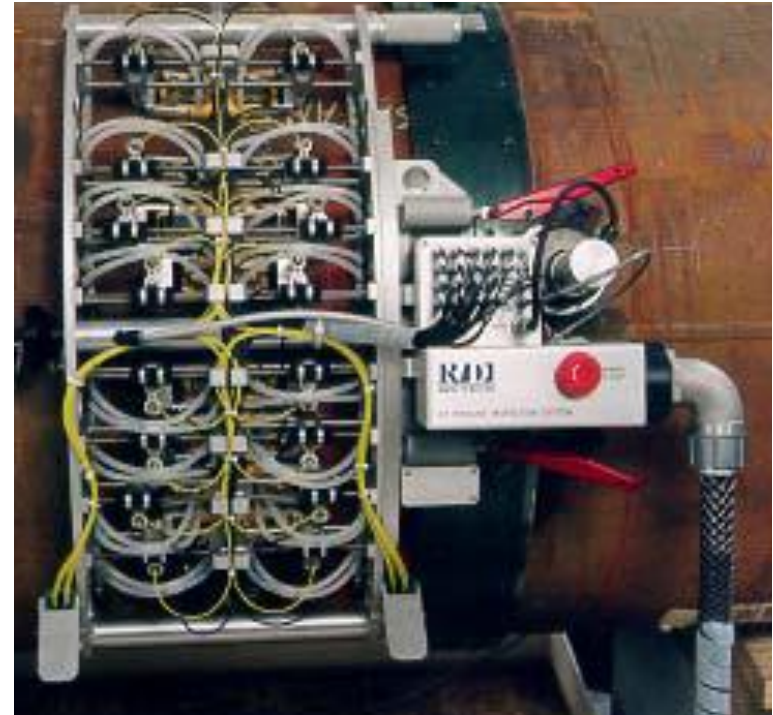


The weld is accepted or rejected according to the acceptance criteria

AUT phased-array vs. AUT multiprobe

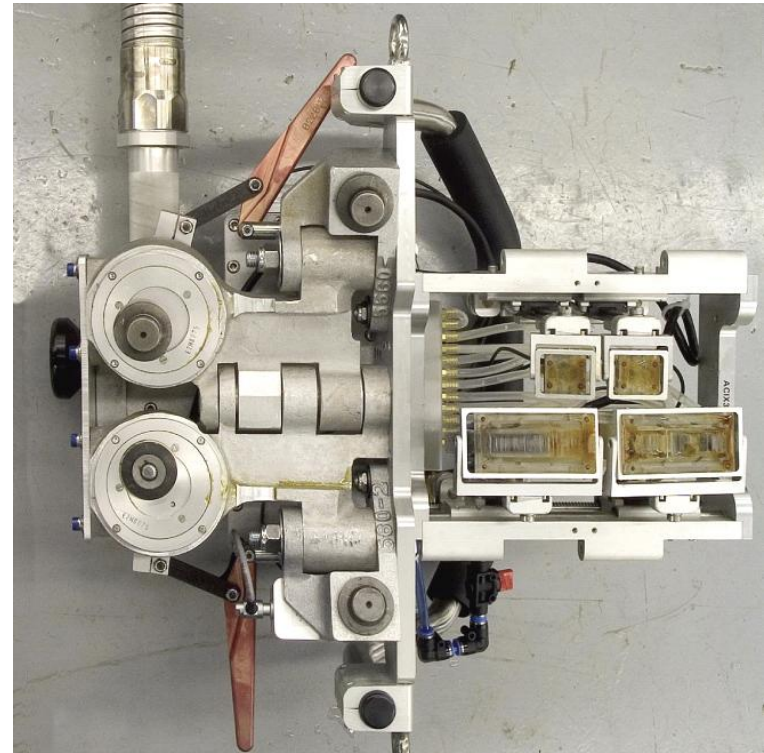
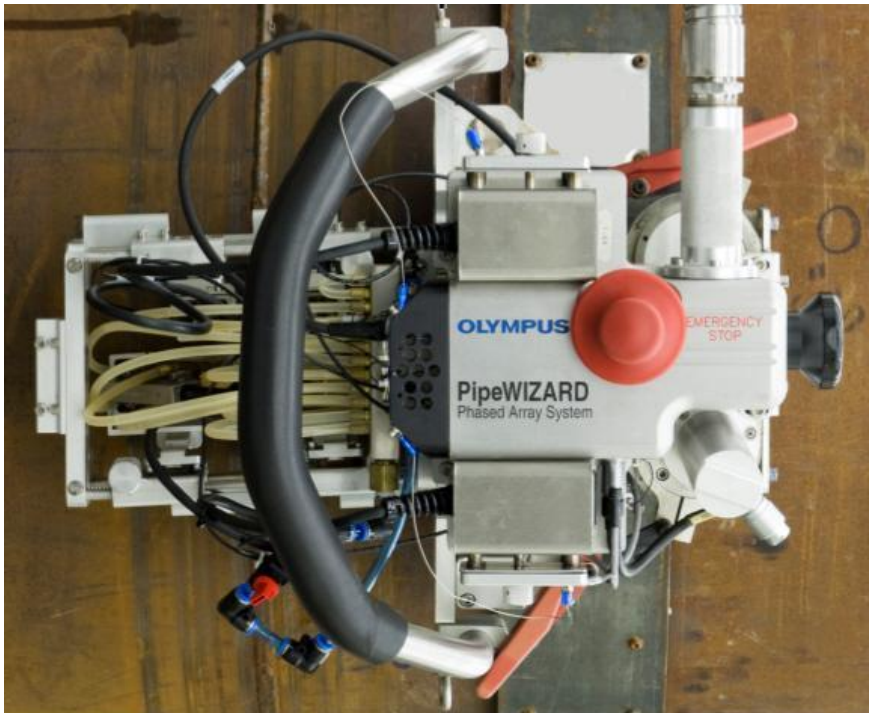


Phased-array scanner



Old multiprobe scanner

PipeWIZARD scanner



PipeWIZARD V4

Built upon the proven PipeWIZARD[®], the PipeWIZARD V4 system offers a highly reliable solution for onshore and offshore inspections in harsh environments.



PWZ-V2

PWZ-V4

PipeWIZARD V4

Reliability

- **FocusLT 64:128** rackmount housing (IP64)
- **Strong field experience :**
 - > more than 200 units in the field
 - > more than 3 million welds inspected
 - > hundreds operators trained on PipeWIZARD
- Designed for **harsh environments** :
Middle-East deserts, Brazil forests, Siberian colds, salty-air offshore laybarges, etc.
(IP 66 Scanner Head)
- **Umbilical cable** has been redesigned and field tested for more than 3 years.

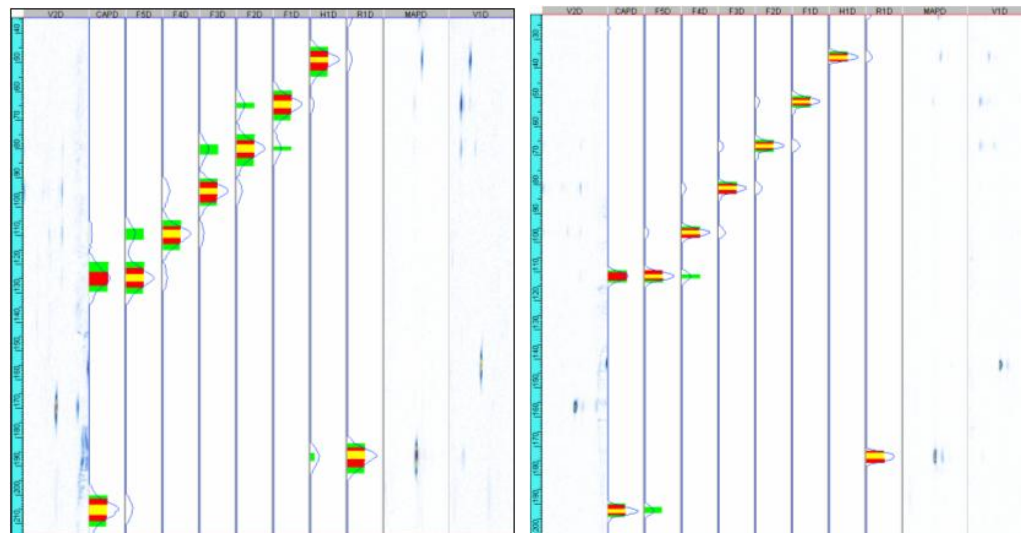


PipeWIZARD instrumentation

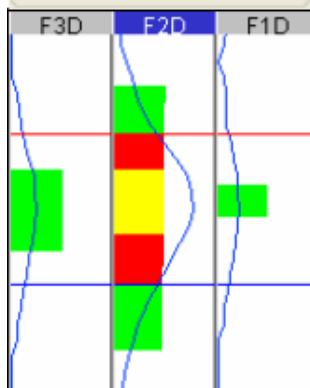


Improved defect length sizing

Laterally focused arrays

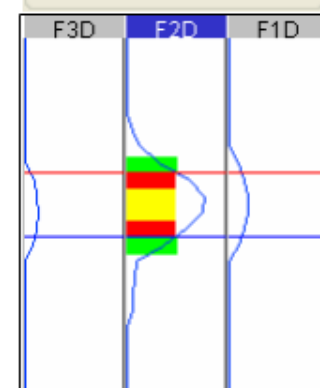


Cumulative: 6 mm
Cum. Thresh.: 40 %



Non focused probe

Cumulative: 3 mm
Cum. Thresh.: 40 %



Focused probe

Reflector size used for this example is of 3mm

Note : optional probes, std probes are non-focused.

PipeWIZARD V4

User-friendly advanced software

Easy setup creation:
software designed with automatic features
for fast and accurate setup creation

Bevel Definition 1.0R1

Name: CRC

Bevel Type: CRC Type J Type

Bevel Offset: 0

Fill Sections: 1 2

Section	Height (mm)	Angle (°)	Emission Angle (°)	Division	Target (mm)
Cap			55	<input type="radio"/> PE <input type="radio"/> PC	1
Fill	5		55	<input type="radio"/> PE <input type="radio"/> PC	2

Section	Height (mm)	Angle (°)	Emission Angle (°)	Division	Target (mm)
HP	3.3	45	45		
LCP	1.27		65		
Root	1.27	37	53		
Map		45			
Volumetric		45			
Coupling					

Specimen Definition

Specimen Velocity

Transversal: (m/s) 3230

Longitudinal: (m/s) 6920

Weld

Thickness: (mm)

Gate Settings

Gate Information

"Before" and "after" values relative to target

"Before" relative to target and "after" relative to weld centerline

Gate before: (mm) -3.00

Gate after: (mm) 3.00

Threshold (%): 5

Probe Definition

Name: PA Upstream

Type: Linear Phased Array

Model: 7.5L60-PWZ1

Frequency: 7.50 MHz

Element quantity: 60

Primary axis pitch: 1.00 mm

First element connected on pulser: 1

Connected on device: Device 1

Wedge

Model: ABW122A

Default nominal refracted angle: deg

Position

Orientation: Upstream

Skew: 90

Scan axis offset: 0.0 mm

Index axis offset: -10.0 mm

Setup Creator 4.092142

Zone	Tx/Rx	Name	Type	Config	Wave	Angle Start (°)	Focus (mm)	Et. Start	Active	Index (mm)	Velocity (m/s)	Probe
1	Tx/Rx	Root US	Root	Pulse-Echo	Shear	53.0	40.57	34	16	32.88	3300	Upstream
2	Tx/Rx	Root DS	Root	Pulse-Echo	Shear	53.0	40.57	34	16	32.88	3300	Downstream
3	Tx	LCP US	LCP	Pitch and Catch	Shear	70.0	78.54	2	9	-73.81	3300	Upstream
3	Rx	LCP DS	LCP	Pitch and Catch	Shear	70.0	67.27	6	17	-63.21	3300	Upstream
4	Tx	F81 US	Fill	Pitch and Catch	Shear	70.0	78.54	2	9	-73.81	3300	Downstream
4	Rx	F81 DS	Fill	Pitch and Catch	Shear	70.0	67.27	6	17	-63.21	3300	Downstream
5	Tx/Rx	HP1 US	HP	Pulse-Echo	Shear	45.0	39.59	39	17	-29.72	3300	Upstream
6	Tx/Rx	HP1 DS	HP	Pulse-Echo	Shear	45.0	39.59	39	17	-29.72	3300	Downstream
7	Tx	F81 US	Fill	Pitch and Catch	Shear	55.0	56.90	20	16	-49.25	3300	Upstream
7	Rx	F81 DS	Fill	Pitch and Catch	Shear	61.0	35.43	31	16	-33.83	3300	Upstream
8	Tx	F81 US	Fill	Pitch and Catch	Shear	55.0	56.90	20	16	-49.25	3300	Downstream
8	Rx	F81 DS	Fill	Pitch and Catch	Shear	61.0	35.43	31	16	-33.83	3300	Downstream
9	Tx	F82 US	Fill	Pitch and Catch	Shear	55.0	61.95	16	17	-53.54	3300	Upstream
9	Rx	F82 DS	Fill	Pitch and Catch	Shear	61.0	23.46	35	16	-28.56	3300	Upstream
10	Tx	F82 US	Fill	Pitch and Catch	Shear	55.0	61.95	16	17	-53.54	3300	Downstream
10	Rx	F82 DS	Fill	Pitch and Catch	Shear	61.0	23.46	35	16	-28.56	3300	Downstream
11	Tx	F83 US	Fill	Pitch and Catch	Shear	55.0	67.00	13	16	-57.83	3300	Upstream
11	Rx	F83 DS	Fill	Pitch and Catch	Shear	61.0	23.49	39	16	-23.49	3300	Upstream
12	Tx	F83 US	Fill	Pitch and Catch	Shear	55.0	67.00	13	16	-57.83	3300	Downstream
12	Rx	F83 DS	Fill	Pitch and Catch	Shear	61.0	23.49	39	16	-23.49	3300	Downstream
13	Tx	F84 US	Fill	Pitch and Catch	Shear	55.0	72.05	9	17	-62.12	3300	Upstream
13	Rx	F84 DS	Fill	Pitch and Catch	Shear	61.0	17.52	43	16	-18.42	3300	Upstream
14	Tx	F84 US	Fill	Pitch and Catch	Shear	55.0	72.05	9	17	-62.12	3300	Downstream
14	Rx	F84 DS	Fill	Pitch and Catch	Shear	61.0	17.52	43	16	-18.42	3300	Downstream
15	Tx	F85 US	Fill	Pitch and Catch	Shear	59.0	86.00	1	8	-76.96	3300	Upstream
15	Rx	F85 DS	Fill	Pitch and Catch	Shear	65.0	13.49	44	16	-15.47	3300	Upstream

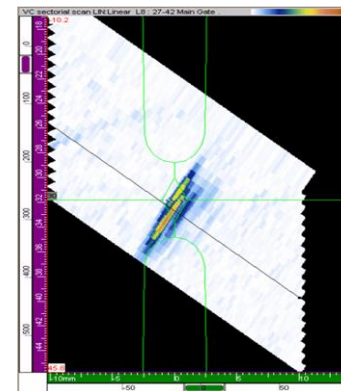
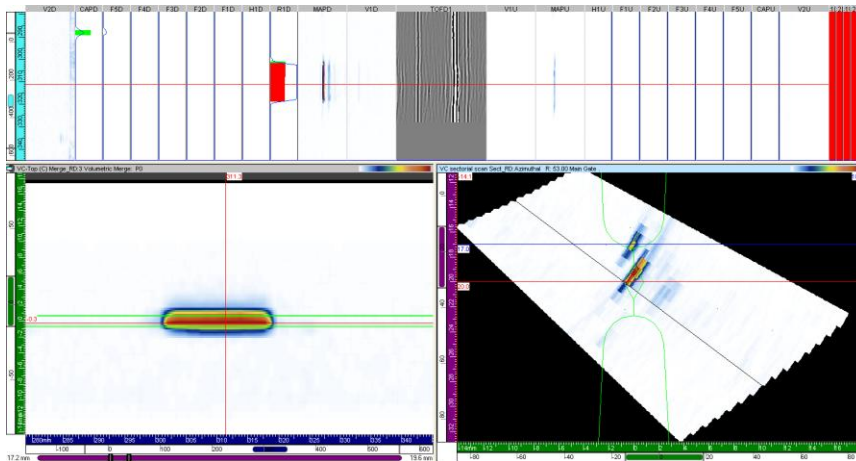
Zone: F83 DS
Probe: Downstream
Index: 57.83 mm
Focus: 67.00 mm
Y: 2.95 mm
Z: 11.48 mm
Gate Before: -3.00 mm
Gate After: 3.00 mm

PipeWIZARD V4

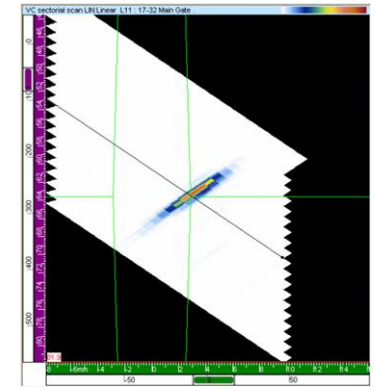
User-friendly advanced software

- Sectorial and linear scan capabilities
- More data information for better interpretation
- Weld overlay display
- Tip-diffraction technique
- Data merged to get a top view and side view of the weld

Zone	Tx/Rx	Name	Type	Scanning	Config	Wave	Angle Start (°)	Angle Stop (°)	Focus (mm)	Et Start	Et Stop	Active	Index (mm)	Velocity (m/s)	Probe
16	Tx	F85 DS	Fill	Static	Pitch and Catch	Shear	59.0	59.0	86.00	1	8	8	76.96	3300	Downstream
16	Rx	F85 DS	Fill	Static	Pitch and Catch	Shear	65.0	65.0	13.49	44	59	16	15.47	3300	Downstream
17	Tx	F85 US	Fill	Static	Pitch and Catch	Shear	49.0	49.0	71.68	14	30	17	-57.49	3300	Upstream
17	Rx	F85 US	Fill	Static	Pitch and Catch	Shear	55.0	55.0	91.88	2	5	4	-78.86	3300	Upstream
18	Tx	F86 DS	Fill	Static	Pitch and Catch	Shear	49.0	49.0	71.68	14	30	17	57.49	3300	Downstream
18	Rx	F86 DS	Fill	Static	Pitch and Catch	Shear	55.0	55.0	91.88	2	5	4	78.86	3300	Downstream
19	Tx/Rx	Cap US	Cap	Static	Pulse-Echo	Shear	55.0	55.0	87.21	3	10	8	-74.99	3300	Upstream
20	Tx/Rx	Cap DS	Cap	Static	Pulse-Echo	Shear	55.0	55.0	87.21	3	10	8	74.99	3300	Downstream
21	Tx/Rx	MAP US	Map root	Static	Pulse-Echo	Shear	45.0	45.0	34.70	44	59	16	-24.53	3300	Upstream
22	Tx/Rx	MAP DS	Map root	Static	Pulse-Echo	Shear	45.0	45.0	34.70	44	59	16	24.53	3300	Downstream
23	Tx/Rx	VOL1 US	Volumetric	Static	Pulse-Echo	Shear	45.0	45.0	42.94	39	54	16	-30.29	3300	Upstream
24	Tx/Rx	VOL1 DS	Volumetric	Static	Pulse-Echo	Shear	45.0	45.0	42.94	39	54	16	30.29	3300	Downstream
25	Tx/Rx	VOL2 US	Volumetric	Static	Pulse-Echo	Shear	45.0	45.0	54.24	32	47	16	-38.35	3300	Upstream
26	Tx/Rx	VOL2 DS	Volumetric	Static	Pulse-Echo	Shear	45.0	45.0	54.24	32	47	16	38.35	3300	Downstream
27	Tx/Rx	VOL3 US	Volumetric	Static	Pulse-Echo	Shear	45.0	45.0	64.83	25	41	17	-45.84	3300	Upstream
28	Tx/Rx	VOL3 DS	Volumetric	Static	Pulse-Echo	Shear	45.0	45.0	64.83	25	41	17	45.84	3300	Downstream
29	Tx	TOFD1	TOFD	Static	TOFD	Longitudinal	80.0	80.0	500.00	1	1	1	28.87	5920	TOFD US
29	Rx	TOFD1	TOFD	Static	TOFD	Longitudinal	80.0	80.0	500.00	1	1	1	28.87	5920	TOFD DS
30	Tx/Rx	C1 US	Coupling	Static	Pulse-Echo	Longitudinal	0.0	0.0	25.00	15	24	10	-71.51	5920	Upstream
31	Tx/Rx	C1 DS	Coupling	Static	Pulse-Echo	Longitudinal	0.0	0.0	25.00	15	24	10	71.51	5920	Downstream
32	Tx/Rx	C2 US	Coupling	Static	Pulse-Echo	Longitudinal	0.0	0.0	25.00	35	44	10	-54.87	5920	Upstream
33	Tx/Rx	C2 DS	Coupling	Static	Pulse-Echo	Longitudinal	0.0	0.0	25.00	35	44	10	54.87	5920	Downstream
34	Tx/Rx	Linear	E-Scan	Linear	Pulse-Echo	Shear	60.0	60.0	53.12	83	43	12	-63.97	5920	Upstream
35	Tx/Rx	Sectorial	E-Scan	Azimuthal	Pulse-Echo	Shear	40.0	50.0	78.26	25	36	12	-50.30	3300	Upstream



Root reflector

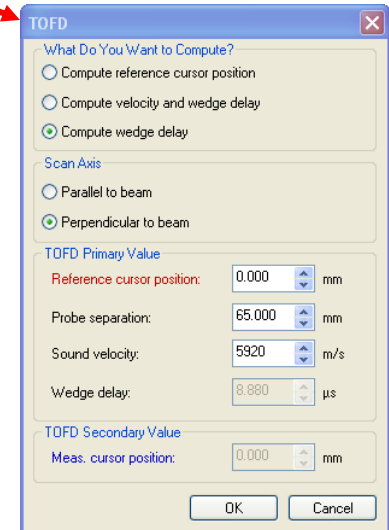
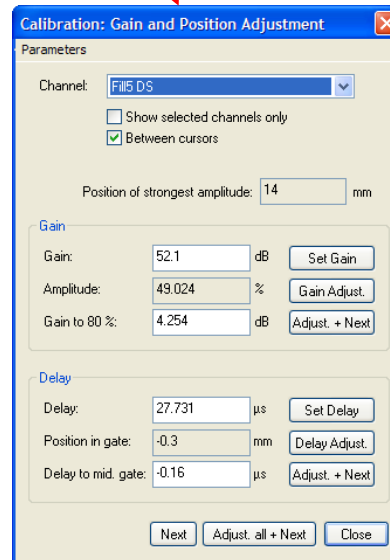
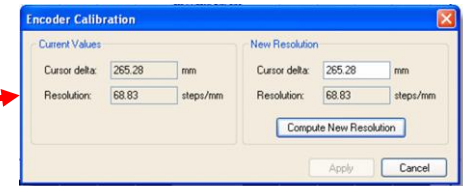
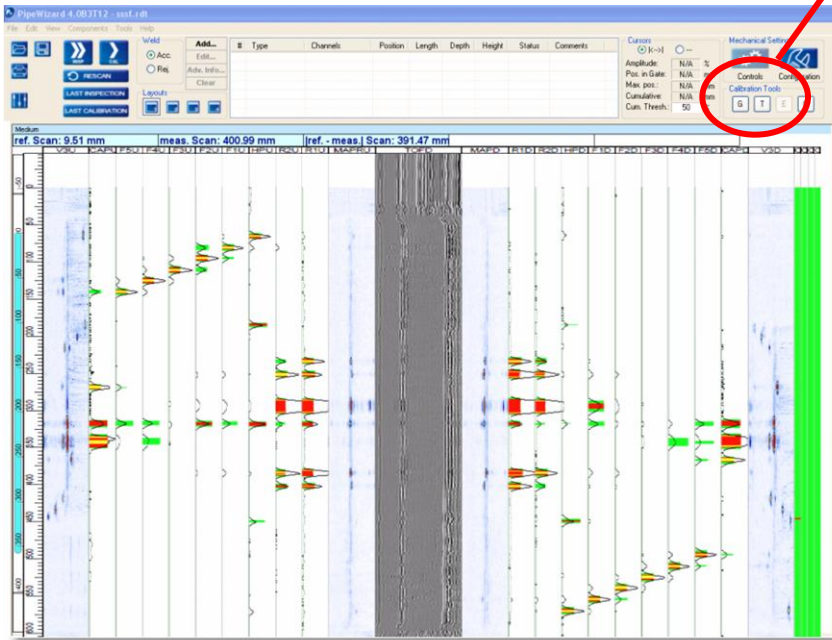


Cap reflector

PipeWIZARD V4

User-friendly advanced software

Fast calibration verification and adjustments for each channel (gain, signal position in gate), TOFD channel and encoder resolution.



PipeWIZARD V4

User-friendly advanced software

Easy interpretation:

Many tools available for fast and accurate analysis

Cursors

|<--> | ...

Amplitude:	27	%
Pos. in Gate:	3.0	mm
Max. pos.:	91	mm
Cumulative:	0	mm
Cum. Thresh.:	50	%

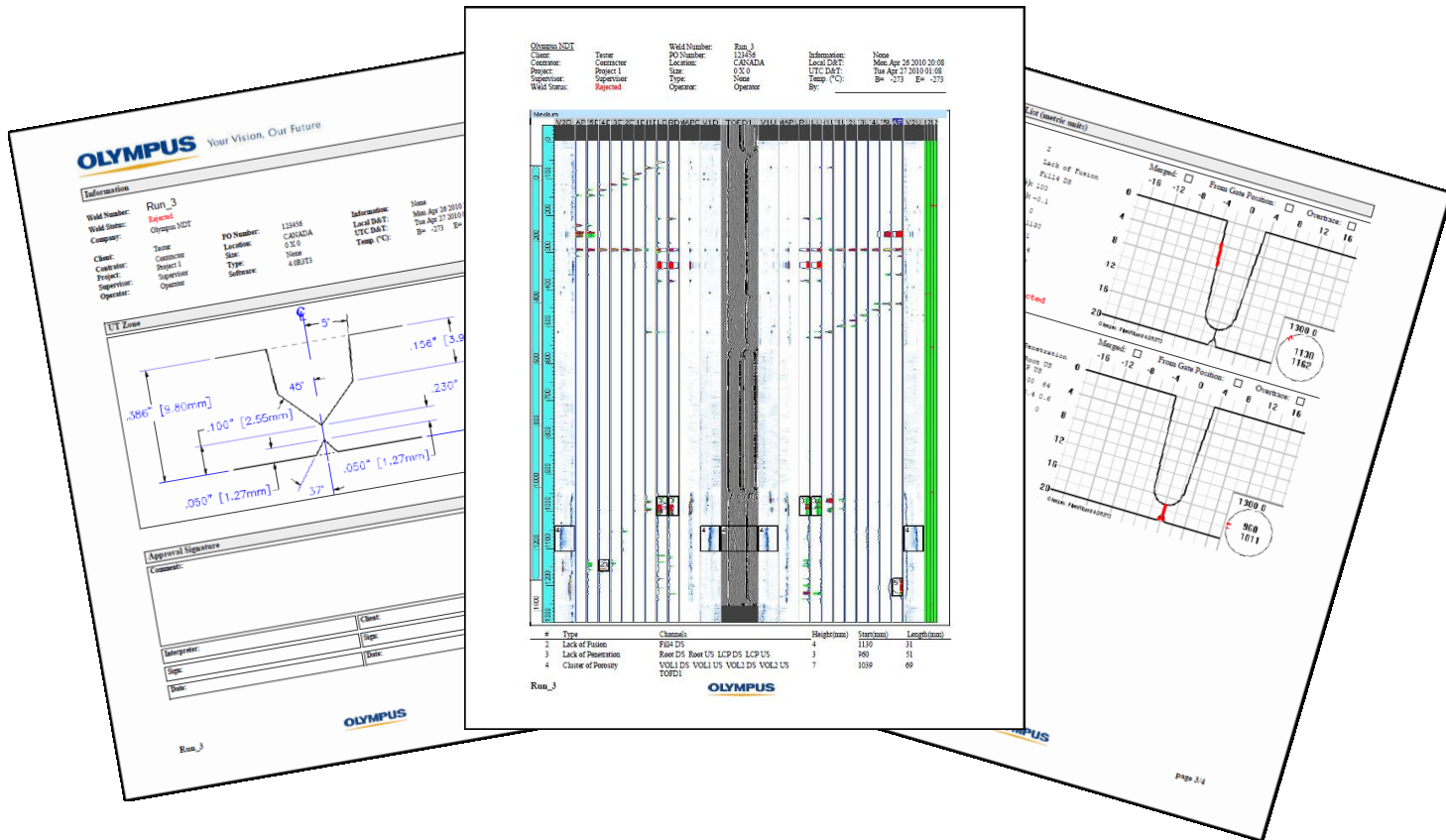
The main interface displays a table of scan data with columns for Channels, Position, Length, Depth, Height, Status, and Comments. A red circle highlights the 'Cursors' settings panel in the top right corner of the interface. Below the table, a 'Defect information' window is open, showing a graph of a defect profile and its parameters: Start (mm) 191.2, Stop (mm) 202.8, Depth (mm) 19.5, and Height (mm) 2. The window also includes options for 'Type' (L.O.F., Acceptable, Rejectable) and '3DView Display' (Merged Defects, Defects From Gate Position, Overtrace Defects).

The 'Defect information' window provides a detailed view of a defect. It features a graph with a horizontal axis from -20 to 20 and a vertical axis from 0 to 30. A defect profile is shown as a U-shaped curve. A red dot on the profile is labeled with '600, 0' and '191, 203'. Below the graph, the 'Type' is set to 'L.O.F.' and 'Rejectable'. The data fields are: Start (mm) 191.2, Stop (mm) 202.8, Depth (mm) 19.5, and Height (mm) 2. The window also includes a 'Comments' field and '2DView Display' and 'ScrollingView' options.

PipeWIZARD V4

User-friendly advanced software

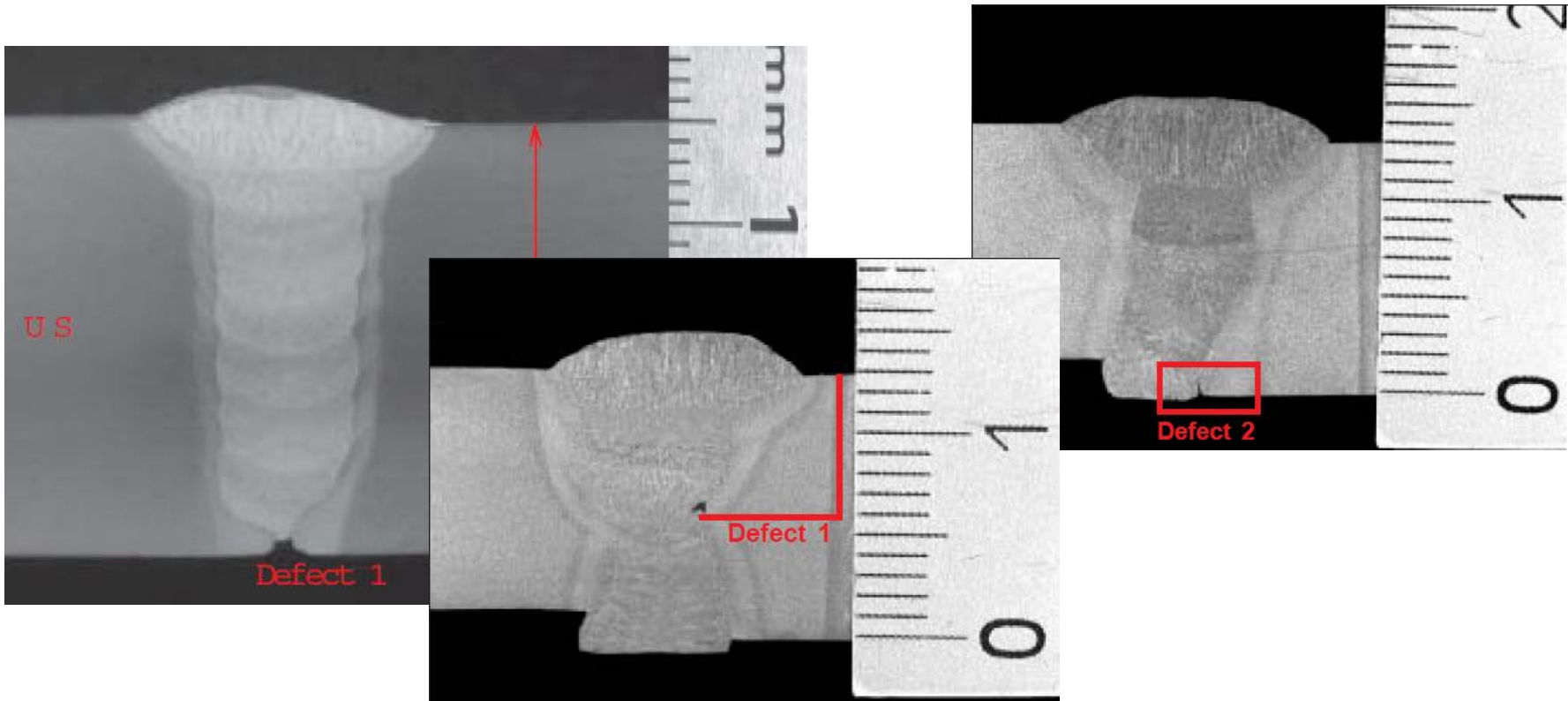
Easy reporting: detailed and clear automatic reports



PipeWIZARD V4

High accuracy in defect sizing

All inspection projects with phased-array PipeWIZARD systems have demonstrated an accuracy between 0.5mm (20 mil) and 1mm (40 mil) when sizing the height of defects



PipeWIZARD V4

Short AUT inspection cycle time for high production rates

Typical operation (depends on operators, type of weld, location, environment, etc):

- Water quenching of the weld (if necessary – offshore) → 20s to 60s
- Position inspection band on pipe → 50s
- Position scanner on band → 20s
- Positioning scanner for inspection start → 5s
- Scanning the weld (depending on pipe diameter) → 20s to 120s
- Analysis and defect marking → done during scanning and 30s after
- Removing the scanner and place it on calibration block → 20s
- Removing inspection band → 10s
- Calibration every weld (offshore) or every 10 welds (typical onshore): during band removing and/or water quenching of next weld.

Total : from 2min to 5min

PipeWIZARD key points

- Highly reliable, compact and modular.
- **Over 200 systems in use, and over 3 Million Welds inspected to date.**
- Sectorial and linear scan available in addition to standard strip-charts and TOFD
- High accuracy in defect height sizing: between 0.5mm (20 mil) and 1.0mm (40 mil)
- Advanced capabilities for special configurations (special pipe material, very thick pipe, pipe with wall-thickness variations)

- **The PipeWIZARD phased-array system has been qualified for many of the major pipeline projects around the world in the last 10 years, and is already pre-qualified by many companies**

Olympus Worldwide Support

> Fast spare parts supply and equipment calibration

- ◆ India (Blue Star)
- ◆ China
- ◆ Middle-East (Abu Dhabi)
- ◆ Australia
- ◆ Singapore
- ◆ Korea
- ◆ Japan
- ◆ Europe (UK, France, Italy & Germany)
- ◆ Canada
- ◆ USA
- ◆ Brazil
- ◆ Mexico

PipeWIZARD V4 advanced AUT inspections



Questions ?