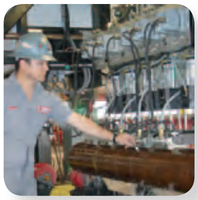
Phased Array Probes and Wedges

Your Vision, Our Future



- **Matched to Rexolite Probes**
- **Matched to Water Probes**
- **Integrated Wedge**
- **Curved Array Probes**
- **Wedges**

Table of Contents

Introduction to Phased Array Technology

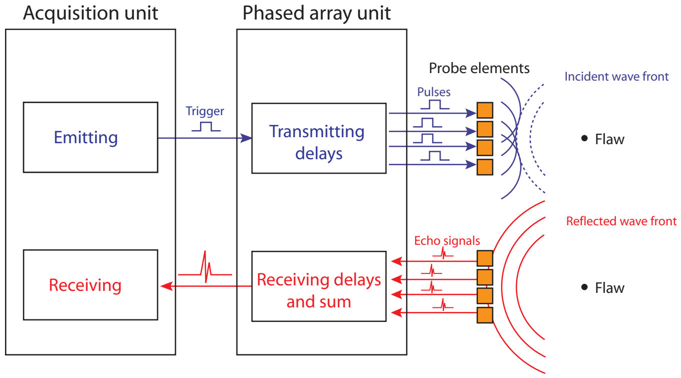
The distinguishing feature of phased array ultrasonic testing is the computer-controlled excitation (amplitude and delay) of individual elements in a multielement probe. The excitation of multiple piezocomposite elements generates a focused ultrasonic beam allowing the dynamic modification of beam parameters such as angle, focal distance, and focal spot size through software. To generate a beam in phase by means of constructive interference, the various active transducer elements are pulsed at slightly different times. Similarly, the echo from the desired focal point hits the various transducer elements with a computable time shift. The echoes received by each element are time-shifted before being summed together.
The resulting sum is an A-scan that emphasizes the response from the desired focal point and attenuates echoes from the other points in the test piece.

All Olympus phased array systems offer the following capabilities:

Software Control of Beam Angle, Focal Distance, and Focal Spot Size

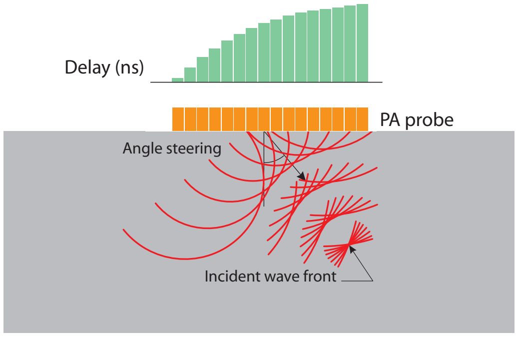
To generate a beam, the various probe elements are pulsed at slightly different times. By precisely controlling the delays between the probe elements, beams of various angles, focal distances, and focal spot sizes can be produced. The echo from the desired focal point hits the various probe elements with a computable time shift.

The signals received at each probe element are time-shifted before being summed together. The resulting sum is an A-scan emphasizing the response from the desired focal point and attenuating various other echoes from other points in the material.



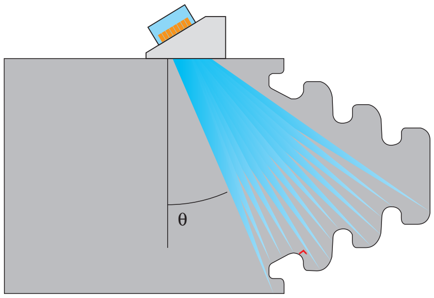
Multiple-Angle Inspection with a Single, Small, Electronically Controlled, Multielement Probe

A conventional UT inspection requires a number of different transducers. A single phased array probe can be made to sequentially produce the various angles and focal points required by the application.



Inspection of Complex Shapes

The capacity to produce at will, and under computer control, various beam angles and focal lengths is used to inspect parts with complex shapes such as turbine discs, turbine blade roots, reactor nozzles, and other complex shapes.



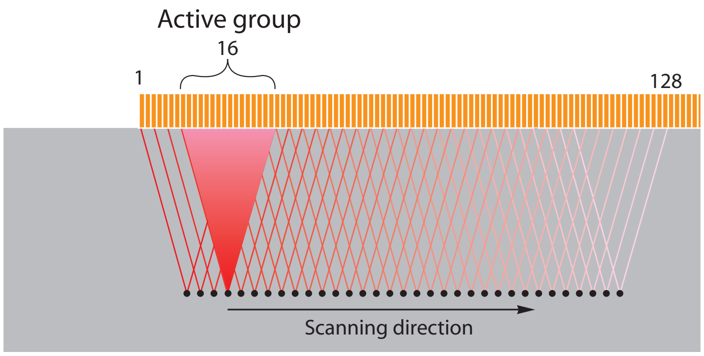
High-Speed Scans with No Moving Parts

While phased arrays imply handling the many signals from multielement probes, it is important to note that the resulting signal is a standard RF signal (or A-scan) comparable to that of any conventional system with a fixed-angle transducer.

This signal can be evaluated, processed, filtered, and imaged just as any A-scan from a conventional UT system. B-scans, C-scans, and D-scans built from the A-scan are also identical to that of a conventional system. The difference is that a multiple-angle inspection can be handled with a single transducer.

Multiplexing also allows motionless scanning: a focused beam is created using a few of the many elements of a long phased-array probe. The beam is then shifted (or multiplexed) to the other elements to perform a high-speed scan of the part with no probe movement along that axis. More than one scan may be performed with various inspection angles.

The principle can be applied to flat parts using a linear phased array probe or to tubes and rods using a circular phased array probe.



High-speed linear scan: Olympus phased array systems can also be used to inspect flat surfaces such as steel plates. Compared to a wide, single-element transducer—often referred to as a "paint brush"—phased array technology offers a much higher sensitivity due to the use of a small focused beam.

Defect Positioning

For manual inspections, real-time readings are essential to quickly position the reflected signal source with respect to the part's geometry and/or probe location.

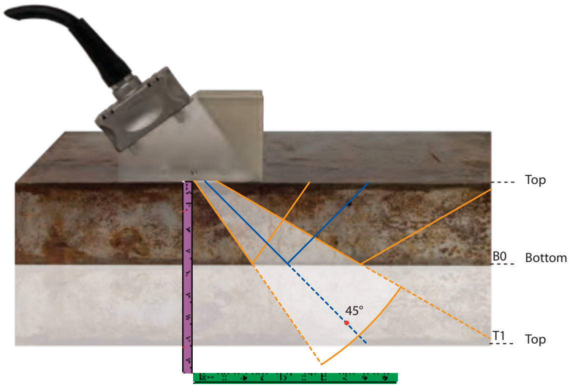
RA, PA, DA, and SA readings allow the user to accurately position the defect in real time during an inspection.

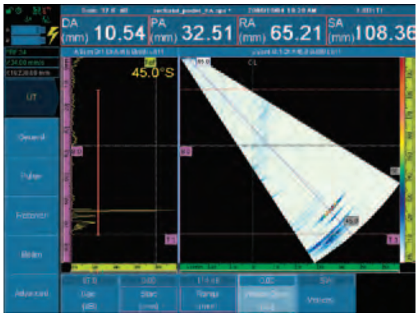
RA: Reference point to the indication in gate A

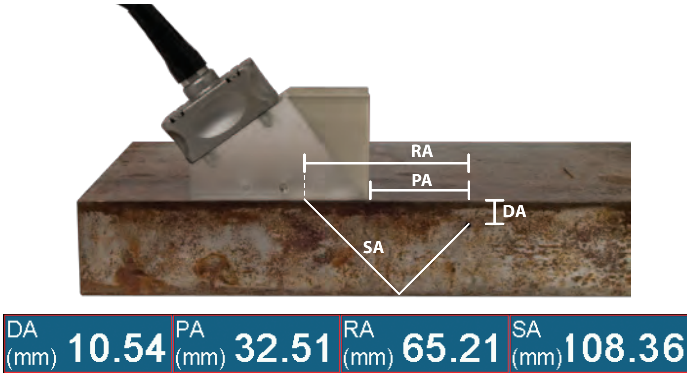
PA: Probe front face to the indication in gate A

DA: Depth of the indication in gate A

SA: Sound path length to the indication in gate A



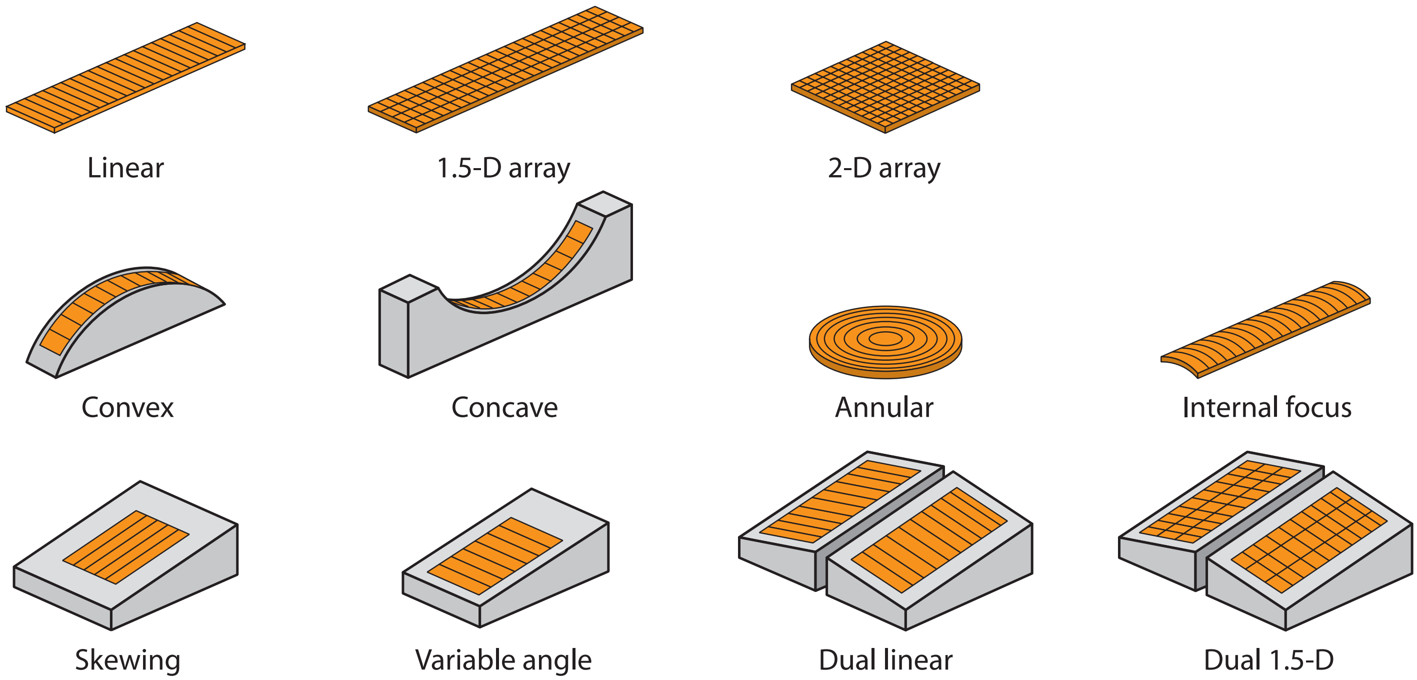




Phased Array Probes

Phased array probes are made in a variety of shapes and sizes for different applications. A few types are illustrated here.

Typical array probes have a frequency ranging from 1 MHz to 17 MHz and have between 10 and 128 elements. Olympus offers a wide variety of probes using piezocomposite technology for all types of inspections. This catalog shows Olympus standard phased array probes, which are divided into three types: angle beam probes, integrated wedge probes, and immersion probes.



Other types of probes can be designed to suit the needs of your application.

Linear arrays are the most commonly used phased array probes for industrial applications. One of the important features that defines phased array probes is the active probe aperture.

The *active aperture* (*A*) is the total active probe length. Aperture length is calculated by the following formula:

$$A = n \bullet p$$

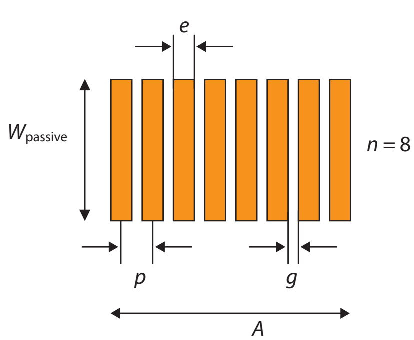
where n = number of elements in the PA probe

p = elementary pitch—distance between the centers of two adjacent elements

A more precise way of finding the active aperture is calculated by this formula:

$$A = (n - 1) \bullet p + e$$

where e = element width—width of a single piezocomposite element (a practical value is $e < \lambda/2$)



The *near-field (N)* value gives the maximum depth of usable focus for a given array. This value is given by the following formula:

$$N = \frac{D^2 f}{4c}$$

where D = element diameter

f = frequency

c = material velocity

- To calculate the near-field value in the active (primary) axis of a phased array probe: $D = n' \bullet p$, where n' is number of elements per group in the focal law.
- To calculate the near-field value in the passive (secondary) axis of a phased array probe: $D = W_{passive}$, which is often called elevation.

Custom Probes

Olympus can manufacture custom phased array probes to suit specific applications and geometries. To develop your custom probe, we will need to know:

- Application
- Comparable UT single element transducer
- Frequency
- Number of elements, pitch, and elevation
- Array shape (flat, curve)
  - Curved in active dimension
  - Curved in passive dimension (focused)
- Probe type (angle beam, immersions, integrated wedge, matrix)
- Cable jacket required
- Cable length
- Connector style
- Housing restrictions and/or size constraints

Ordering Information

Numbering System Used to Order Standard Phased Array Probes

5L16-9.6x10-A1-P-2.5-OM

Frequency
Array type
Number of elements
Active aperture
Elevation
Probe type
Casing type
Cable type
Cable length
Connector type

Glossary Used to Order Phased Array Probes (Typical options shown)

Frequency

- **1.5 =** 1.5 MHz
- **2.25 =** 2.25 MHz
- **3.5 =** 3.5 MHz
- **5 =** 5 MHz
- **7.5 =** 7.5 MHz
- **10 =** 10 MHz

Array type

- **L =** linear
- **A =** annular
- **M =** matrix probe (1.5D, 2D)
- **CV (ROC) =** convex in azimuth
- **CC (ROC) =** concave in azimuth
- **CCEV (ROC) =** elevation focused

Number of elements

Example:

- **16 =** 16 elements

Active Aperture

Active aperture in mm.
Refer to page 6 for details.

Elevation

Elevation in mm
Example:

- **10 =** 10 mm

Probe type

- **A =** angle beam with external wedge
- **NW =** near-wall
- **PWZ =** weld inspection angle beam
- **W =** angle beam with integrated wedge
- **I =** immersion
- **DGS =** DGS inspection/Atlas (AVG probe)
- **AWS =** AWS inspection

Casing type

Casing type for a given probe type

Cable type

- **P =** PVC outer
- **M =** metal armor outer

Cable length

Cable length in m

- **2.5 =** 2.5 m
- **5 =** 5 m
- **10 =** 10 m

Connector type

- **OM =** OmniScan® connector
- **HY =** Hypertronics connector
- **OL =** OmniScan Connector with conventional UT channel on element 1 (LEMO 00 connector)

ROC: radius of curvature (mm)

Phased Array Probes Application Matrix

Probe Model	Composite	Corrosion	Weld	Immersion	Small Footprint	Deep Penetration	General Purpose	Typical Application Use		Scan Type	Additional information
								Manual	Automated		
A00					✓			✓		Sectorial	Developed for scribe mark applications
A0			✓		✓		✓	✓		Sectorial	Small access, reduced footprint
A1			✓		✓		✓	✓	✓	Sectorial	A10 recommended for weld applications
A2			✓				✓	✓	✓	Sectorial and Linear	A12 recommended for weld applications
A3			✓			✓			✓	Sectorial	
A4			✓			✓			✓	Sectorial	
A5			✓			✓			✓	Sectorial	
A10			✓		✓		✓		✓	Sectorial	
A11			✓				✓		✓	Sectorial	Developed for OmniScan 32:128 shear wave and L-wave manual S-scan crack sizing applications
A12			✓				✓		✓	Sectorial and Linear	Primary probe for carbon steel weld inspection for thickness up to 50 mm (16:128) and 70 mm (32:128)
A14			✓				✓		✓	Sectorial and Linear	
AWS			✓					✓		Sectorial	AWS weld inspection
NW1	✓								✓	Linear	Designed for near-wall and close access applications
NW2	✓								✓	Linear	
NW3	✓								✓	Linear	
PWZ1			✓						✓	Sectorial and Linear	Primary probe for carbon steel weld inspection for thickness over 50 mm (16:128)
PWZ3			✓						✓	Sectorial	
DGS1			✓				✓	✓		Sectorial	DGS applications
I1				✓					✓	Sectorial and Linear	
I2				✓					✓	Sectorial and Linear	
I3				✓					✓	Sectorial and Linear	
I4		✓									HydroFORM corrosion mapping solution

This table is only a general application guideline. Please consult your Olympus sales representative prior to ordering.

A10, A11, A12, and A14 Universal Probes

10L32-A10

5L64-A12

5L60-A14

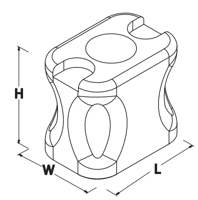
Advantages

- Probes are designed to have a low-profile probe/wedge combination for easier access in restricted areas.
- Wave layers with acoustic adaptation to Rexolite
- Captive anchoring screws are provided with the probe.
- A wide selection of wedges is available to suit any angle beam application.

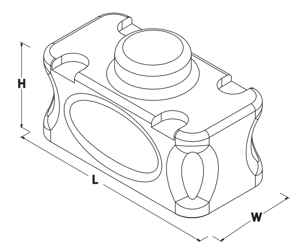
Typical Applications

A10, A11, and A12 Probes

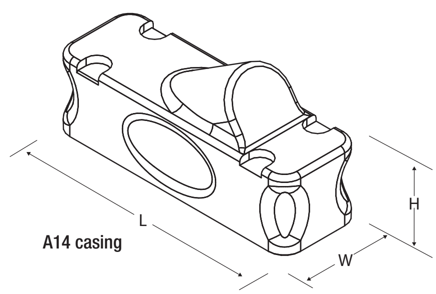
- Manual or automated inspection of 6.35 mm to 38 mm (0.25 in. to 1.5 in.) thick welds
- Detection of flaws and sizing
- Inspections of castings, forgings, pipes, tubes, and machined and structural components for cracks and welding defects



A10, A11 casing



A12 casing



A14 casing

Probe Specifications and Dimensions

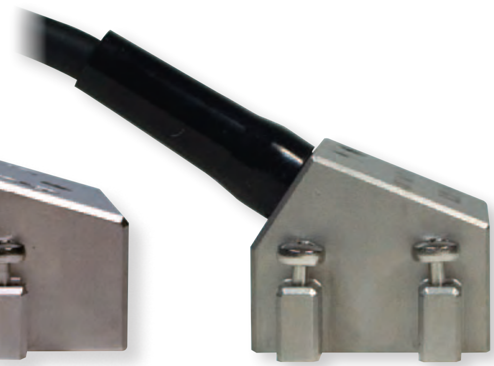
Part Number	Item Number	Frequency (MHz)	Number of Elements	Pitch (mm)	Active Aperture (mm)	Elevation (mm)	External Dimensions mm (in.)		
							L	W	H
5L16-A10	U8330595	5.0	16	0.60	9.6	10.0	23 (0.91)	16 (0.63)	20 (0.79)
10L32-A10	U8330251	10.0	32	0.31	9.9	7.0	23 (0.91)	16 (0.63)	20 (0.79)
5L32-A11	U8330274	5.0	32	0.60	19.2	10.0	25 (0.98)	23 (0.91)	20 (0.79)
5L64-A12	U8330593	5.0	64	0.60	38.4	10.0	45 (1.77)	23 (0.91)	20 (0.79)
5L60-A14	U8330785	5.0	60	1.0	60.0	10.0	68 (2.68)	23 (0.91)	20 (0.79)
7.5L60-A14	U8330804	7.5	60	1.0	60.0	10.0	68 (2.68)	23 (0.91)	20 (0.79)

These probes come standard with an OmniScan® connector and a 2.5 m (8.2 ft) cable or can be specially fitted with other connectors and cable lengths.

A3, A4, and A5 Deep Penetration Probes

A3

A4



A5

Advantages

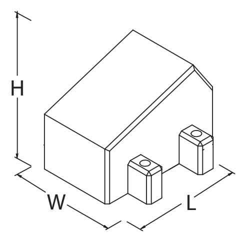
- Wave layers with acoustic adaptation to Rexolite
- Captive anchoring screws are provided with the probe.
- A wide selection of wedges is available to suit any angle beam application.

Typical Applications

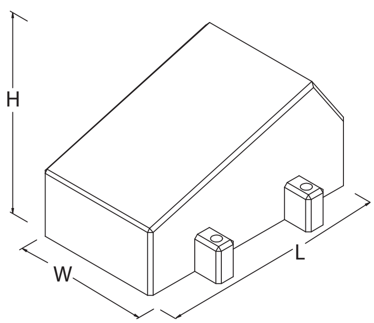
A3, A4, and A5 Probes

Deep penetration applications

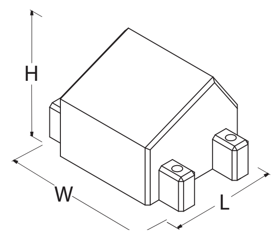
- Thick plates and welds
- Forging
- Noisy or granular material



A3 casing



A4 casing



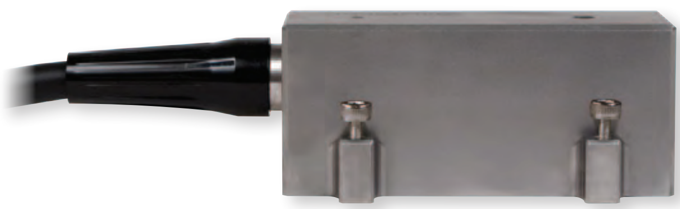
A5 casing

Probe Specifications and Dimensions

Part Number	Item Number	Frequency (MHz)	Number of Elements	Pitch (mm)	Active Aperture (mm)	Elevation (mm)	External dimensions mm (in.)		
							L	W	H
3.5L16-A3	U8330094	3.5	16	1.60	25.6	16.0	36 (1.42)	36 (1.42)	25 (0.98)
5L16-A3	U8330092	5.0	16	1.20	19.2	12.0	36 (1.42)	36 (1.42)	25 (0.98)
1.5L16-A4	U8330098	1.5	16	2.80	44.8	26.0	57 (2.24)	46 (1.81)	30 (1.18)
2.25L16-A4	U8330692	2.25	16	2.00	32.0	20.0	57 (2.24)	46 (1.81)	30 (1.18)
2.25L32-A5	U8330141	2.25	32	0.75	24.0	24.0	29 (1.14)	43 (1.69)	24 (0.94)
5L32-A5	U8330139	5.0	32	0.60	19.2	20.0	29 (1.14)	43 (1.69)	24 (0.94)

These probes come standard with an OmniScan® connector and a 2.5 m (8.2 ft) cable or can be specially fitted with other connectors and cable lengths.

PWZ1, PWZ2, PWZ3, and A16 Weld Inspection Probes



7.5L60-PWZ1

7.5LCCEV100-60-A16

NEW Laterally Focused Arrays (CCEV)

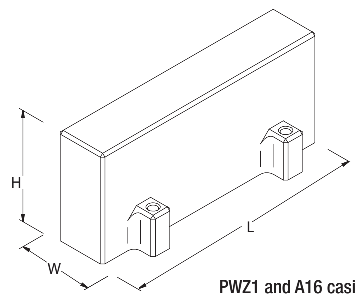
These new probes for girth weld inspection used with the PipeWIZARD system or COBRA scanner have curved elements in the passive plane, focusing the beam in the lateral direction. An integrated lens permits the use of standard wedges. These cylindrically focused probes significantly reduces oversizing and excessive repairs. Their capacity to discriminate small indications is a major advantage when sizing the length of an intermittent defect using interaction rules. In addition, beam energy is better maintained in small pipe/thin wall applications.

Advantages

- Low-profile housing
- Front-exit cable to avoid interference with the scanner probe holder
- Fits special PipeWIZARD® wedges designed for automated inspections of girth welds (sophisticated irrigation channels, locking carbide wear pins)
- Can be ordered with CE-certified Hypertronics connector
- Suitable for manual and automated inspections
- Available laterally focused probes improve defect length sizing (7.5CCEV100-60-A16)

Typical Applications

- Automated inspection of girth welds with PipeWIZARD systems
- Manual or automated inspection of thick welds
- Detection of flaws and sizing
- Inspection of castings, forgings, pipes, tubes, and machined and structural components for cracks and welding defects



PWZ1 and A16 casing

Probe Specifications and Dimensions

Part Number	Item Number	Frequency (MHz)	Number of Elements	Pitch (mm)	Active Aperture (mm)	Elevation (mm)	External Dimensions mm (in.)		
							L	W	H
5L60-PWZ1	U8330164	5.0	60	1.0	60.0	10.0	68 (2.68)	26 (1.02)	30 (1.18)
7.5L60-PWZ1	U8330144	7.5	60	1.0	60.0	10.0	68 (2.68)	26 (1.02)	30 (1.18)
7.5L60-PWZ1*	U8330086	7.5	60	1.0	60.0	10.0	68 (2.68)	26 (1.02)	30 (1.18)
5L48-PWZ2	U8330964	5.0	48	1.0	48.0	10.0	56 (2.20)	26 (1.02)	30 (1.18)
5L32-PWZ3	U8330770	5.0	32	1.0	32.0	10.0	40 (1.57)	26 (1.02)	30 (1.18)
7.5L32-PWZ3	U8330209	7.5	32	1.0	32.0	10.0	40 (1.57)	26 (1.02)	30 (1.18)
10L32-PWZ3	U8330221	10.0	32	1.0	32.0	10.0	40 (1.57)	26 (1.02)	30 (1.18)
7.5CCEV100-60-A16	U8330958	7.5	60	1.0	60.0	18.0	68 (2.68)	29 (1.14)	30 (1.18)
7.5CCEV100-60-A16**	U8330796	7.5	60	1.0	60.0	18.0	68 (2.68)	29 (1.14)	30 (1.18)

These probes come standard with an OmniScan® connector and a 2.5 m (8.2 ft) cable or can be specially fitted with other connectors and cable lengths.

* Designed for PipeWIZARD system, this probe comes with a CE Hypertronics connector and a 0.6 m (2 ft) cable.

** Designed for PipeWIZARD system, this probe comes with a CE Hypertronics connector and a 0.75 m (2.5 ft) cable.

A00, A0, and A15 Small-footprint Probes
NW1, NW2, and NW3 Near-wall Probes

7.5CCEV35-A15

10L16-A00

10L16-A00
with SA00-N60S wedge

5L10-A0-TOP

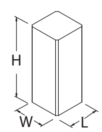
5L64-NW1

Advantages of Small-footprint Probes

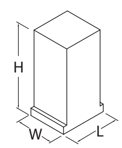
- Access to confined areas (A00 probe has an 8 × 8 mm footprint)
- Cable connector can come out from either the side or the top (A0 only).
- Special-design small-footprint wedge
- 10L16-A00 is used for aerospace scribe-mark applications.

Advantages of Near-wall Probes

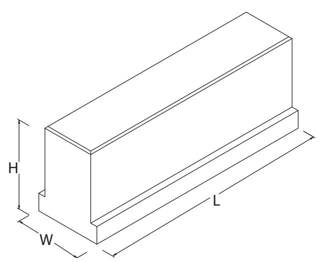
- Shortened dead zone at both ends (1.5 mm between center of first or last element and housing edge)
- Well suited for composite channel inspections
- Used for C-scan inspections of composites (delamination, disbonding, and porosity)



A00 casing
Dimensions are without the strain relief.



A0 casing



NW1 casing

Probe Specifications and Dimensions

Part Number	Item Number	Frequency (MHz)	Number of Elements	Pitch (mm)	Active Aperture (mm)	Elevation (mm)	External Dimensions mm (in.)		
							L	W	H
Small-Footprint Probes									
10L16-A00	U8330145	10.0	16	0.31	5.0	5.0	8 (0.31)	8 (0.31)	23 (0.91)
5L10-A0-SIDE	U8330080	5.0	10	0.60	6.0	6.0	13 (0.51)	10 (0.39)	23 (0.91)
5L10-A0-TOP	U8330075	5.0	10	0.60	6.0	6.0	13 (0.51)	10 (0.39)	23 (0.91)
10L10-A0-SIDE	U8330110	10.0	10	0.60	6.0	6.0	13 (0.51)	10 (0.39)	23 (0.91)
10L10-A0-TOP	U8330111	10.0	10	0.60	6.0	6.0	13 (0.51)	10 (0.39)	23 (0.91)
7.5CCEV35-A15	U8330826	7.5	16	0.50	8.0	10.0	26 (1.02)	22 (0.87)	9.7 (0.38)
Near-Wall Probes									
3.5L64-NW1	U8330148	3.5	64	1.0	64.0	7.0	66 (2.60)	19 (0.75)	25 (0.98)
5L64-NW1	U8330134	5.0	64	1.0	64.0	7.0	66 (2.60)	19 (0.75)	25 (0.98)
3.5L24-NW2	U8330965	3.5	24	1.0	24.0	7.0	26 (1.02)	19 (0.75)	30 (1.18)
5L24-NW2	U8330155	5.0	24	1.0	24.0	7.0	26 (1.02)	19 (0.75)	30 (1.18)
3.5L128-NW3	U8330695	3.5	128	1.0	128.0	7.0	130 (5.12)	21 (0.83)	35 (1.38)
5L128-NW3	U8330647	5.0	128	1.0	128.0	7.0	130 (5.12)	21 (0.83)	35 (1.38)

These probes come standard with an OmniScan® connector and a 2.5 m (8.2 ft) cable or can be specially fitted with other connectors and cable lengths.