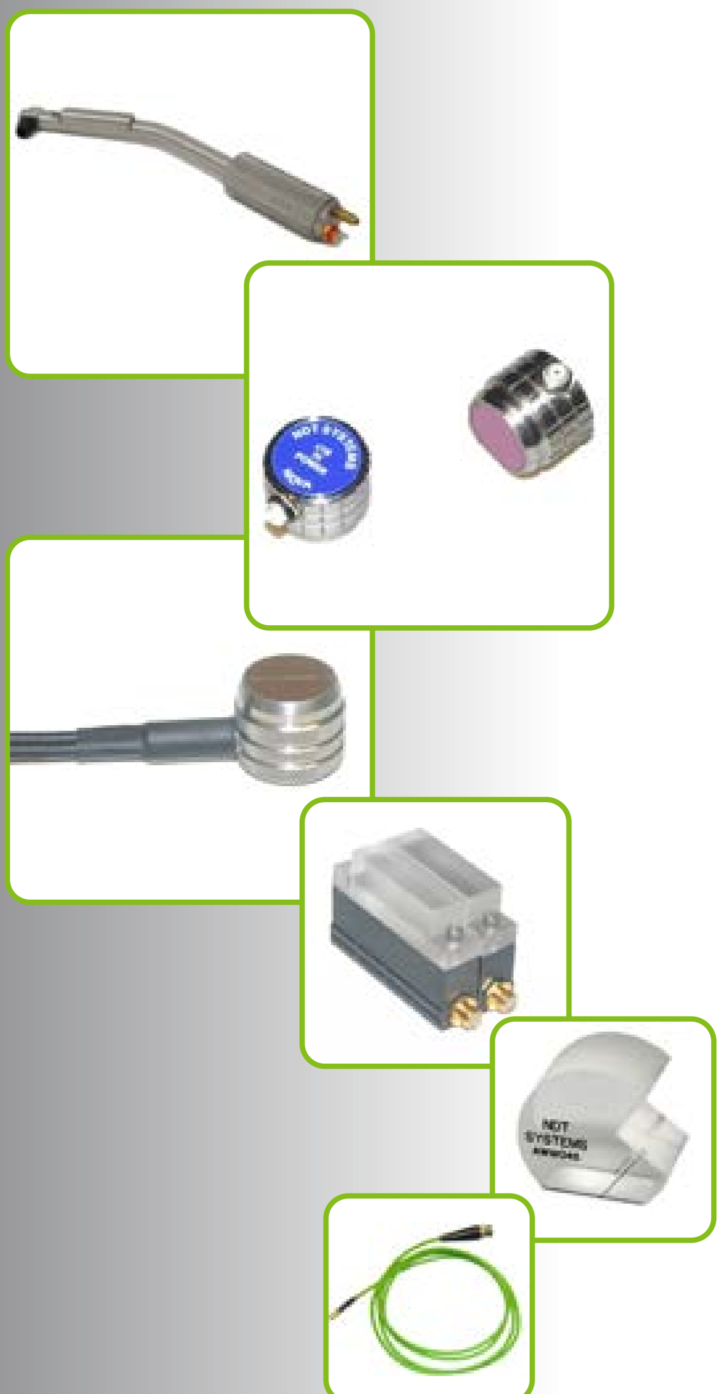
AdvancedNDT

NDT Systems
Worldwide Excellence in Ultrasonics



Transducer Catalog

Version 2

www.ndtsystems.com

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AdvancedNDT

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Company Introduction

For more than 48 years, NDT Systems Inc. has been a leader in designing, manufacturing, and selling high quality, advanced ultrasonic testing and bond testing equipment to the non-destructive testing marketplace.

Our wide variety of non-destructive testing equipment includes:

- Thickness Gauges
- Bond Testers and Probes
- Portable Ultrasonic Flaw Detectors
- Precision Ultrasonic Transducers
- Manual and Automated Scanners

NDT Systems manufactures customized solutions, including fully automated inspection systems and specialized transducers. These transducers are available in all frequency domains and upon request.

Based in Huntington Beach, California, NDT Systems offers a wide portfolio of products to support the inspection of almost all materials types from metals, ceramics, and plastics to advanced composite materials and laminated structures.

NDT Systems products are used in nearly all industries such as Aerospace and Composite Inspection/ Manufacturing, Oil and Gas (pipeline inspection), Power Generation, Military and Transportation, and Metal Forming. Our high-quality equipment offers full functionality at a very competitive price.

Made in USA

All products are 100% made in the USA

Ultrasonic Transducers

NDT Systems takes pride in its vast transducer offerings. We manufacture and inventory a wide range of transducers, in addition to accessories that support the range. All transducers are certified prior to shipment.
A recertification service is also available, based upon applicable standards.

Our complete range of transducers and accessories includes:

- Contact / Delay Line
- Dual Element
- Angle Beam
- Immersion
- Bond Testing
- Gauge Specific
- Scanner Specific
- Cables
- Test Blocks

Custom Design Transducers

NDT Systems has the ability to engineer custom design transducers, upon request, to meet your specific needs. If we do not already have exactly what you require then our design team can discuss your requirements further to find a solution for your specific application.

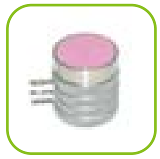
Modern Open-Cell manufacturing space

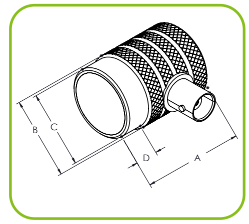
Contents

1 Contact Transducers

Standard Rugged Housing - Properties

- Easy grip knurled housing
- Tough aluminum oxide face material for long life
- Superior SN ratio
- BNC connector





Rugged Contact Series	
Narrow bandwidth = High Gain	X
Wide bandwidth = High Resolution	
Medium bandwidth = General Purpose	X

Element Diameter	Rugged Dimensions (in)			
	A	B	C	D
0.5	1.31	0.79	0.74	0.32
0.75	1.31	0.98	0.93	0.32
1.0	1.31	1.25	1.19	0.32

1.1 Standard Rugged Case - General Purpose with BNC Connector

Frequency	Element Dia. (in.)	Part Number	Connector Type
0.5	0.5	CHRF0.54	BNC
0.5	0.75	CHRF0.56	BNC
0.5	1	CHRF0.58	BNC
0.5	1.125	CHRF0.59	BNC
1.0	0.5	CHRF014	BNC
1.0	0.75	CHRF016	BNC
1.0	1	CHRF018	BNC
1.0	1.125	CHRF019	BNC
2.25	0.5	CHRF024	BNC
2.25	0.75	CHRF026	BNC
2.25	1	CHRF028	BNC
2.25	1.125	CHRF029	BNC
3.5	0.5	CHRF034	BNC
3.5	0.75	CHRF026	BNC
3.5	1	CHRF028	BNC
3.5	1.125	CHRF029	BNC
5.0	0.5	CHRF054	BNC
5.0	0.75	CHRF056	BNC
5.0	1	CHRF058	BNC

1.2 Standard Rugged Case - High Gain with BNC Connector

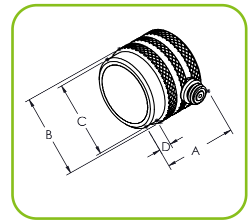
Frequency	Element Dia. (in.)	Part Number	Connector Type
0.5	0.5	CMRF0.54	BNC
0.5	0.75	CMRF0.56	BNC
0.5	1	CMRF0.58	BNC
0.5	1.125	CMRF0.59	BNC
1.0	0.5	CMRF014	BNC
1.0	0.75	CMRF016	BNC
1.0	1	CMRF018	BNC
1.0	1.125	CMRF019	BNC
2.25	0.5	CMRF024	BNC
2.25	0.75	CMRF026	BNC
2.25	1	CMRF028	BNC
2.25	1.125	CMRF029	BNC
3.5	0.5	CMRF034	BNC
3.5	0.75	CMRF036	BNC
3.5	1	CMRF038	BNC
3.5	1.125	CMRF039	BNC
5.0	0.5	CMRF054	BNC
5.0	0.75	CMRF056	BNC
5.0	1	CMRF058	BNC

1 Contact Transducers

Fingertip Housing - Properties

- Easy grip knurled housing
- Tough aluminum oxide face material for long life
- Superior SN Ratio
- Microdot connector

Fingertip Contact Series	
Narrow bandwidth - High Gain	
Wide bandwidth - High Resolution	X
Medium bandwidth - General Purpose	X



Element Diameter	Fingertip Dimensions (in)			
	A	B	C	D
0.25	0.55	0.45	0.36	0.15
0.375	0.56	0.625	0.50	0.16
0.50	0.61	0.75	0.62	0.16
0.75	0.65	1.0	0.87	0.16

1.3 Finger Tip Case - General Purpose with Microdot Connector

Frequency	Element Dia. (in.)	Part Number	Connector Type
1.0	0.25	CHF012	Microdot
1.0	0.375	CHF013	Microdot
1.0	0.5	CHF014	Microdot
1.0	0.75	CHF016	Microdot
2.25	0.25	CHF022	Microdot
2.25	0.375	CHF023	Microdot
2.25	0.5	CHF024	Microdot
2.25	0.75	CHF026	Microdot
3.5	0.25	CHF032	Microdot
3.5	0.375	CHF033	Microdot
3.5	0.5	CHF034	Microdot
3.5	0.75	CHF036	Microdot
5.0	0.25	CHF052	Microdot
5.0	0.375	CHF053	Microdot
5.0	0.5	CHF054	Microdot
5.0	0.75	CHF056	Microdot
7.5	0.25	CHF072	Microdot
7.5	0.375	CHF073	Microdot
7.5	0.5	CHF074	Microdot
10.0	0.25	CHF102	Microdot
10.0	0.375	CHF103	Microdot
10.0	0.5	CHF104	Microdot

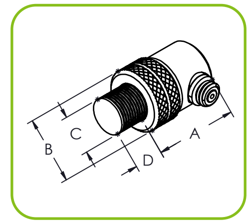
1.4 Finger Tip Case - High Gain with Microdot Connector

Frequency	Element Dia. (in.)	Part Number	Connector Type
1.0	0.5	CHG014	Microdot
1.0	0.75	CHG016	Microdot
2.25	0.25	CHG022	Microdot
2.25	0.375	CHG023	Microdot
2.25	0.5	CHG024	Microdot
2.25	0.75	CHG026	Microdot
3.5	0.25	CHG032	Microdot
3.5	0.375	CHG033	Microdot
3.5	0.5	CHG034	Microdot
3.5	0.75	CHG036	Microdot
5.0	0.25	CHG052	Microdot
5.0	0.375	CHG053	Microdot
5.0	0.5	CHG054	Microdot
5.0	0.75	CHG056	Microdot
7.5	0.25	CHG072	Microdot
7.5	0.375	CHG073	Microdot
7.5	0.5	CHG074	Microdot
10.0	0.25	CHG102	Microdot
10.0	0.375	CHG103	Microdot
10.0	0.5	CHG104	Microdot

2 Delay Line Transducers

Replaceable Delay Line (RD) - Properties

- Replaceable delay lines extend transducers useful life
- Superior near surface resolution especially on thin materials
- Microdot connector
- **Option:** High temperature delay line options provide intermittent operation to 1000°F



Replaceable Delay Line Series	
Narrow bandwidth = High Gain	
Wide bandwidth = High Resolution	X
Medium bandwidth = General Purpose	

Element Diameter	Delay Line Dimensions (in)			
	A	B	C	D
0.25 Replaceable Delay	0.64	0.50	0.30	0.27
0.50 Replaceable Delay	0.87	0.87	0.55	0.38

2.1 Replaceable Delay Line with Microdot Connector

Frequency (MHz)	Element Dia. (in.)	Part Number	Connector Type
1	0.25	RDG012	Microdot
1	0.5	RDG014	Microdot
2.25	0.25	RDG022	Microdot
2.25	0.5	RDG024	Microdot
5	0.25	RDG052	Microdot
5	0.5	RDG054	Microdot
10	0.25	RDG102	Microdot
10	0.5	RDG104	Microdot
15	0.25	RDG152	Microdot
20	0.25	RDG202	Microdot
25	0.25	RDG252	Microdot

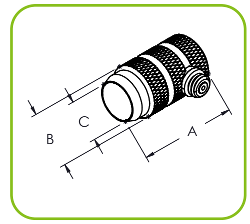
Replacement Delays:
RDL - 2
RDL - 4

2 Delay Line Transducers

Permanent Delay Line (PD) - Properties

- Superior near surface resolution especially on thin materials
- No couplant required between delay line and transducer face
- Microdot connector

Permanent Delay Line Series	
Narrow bandwidth = High Gain	
Wide bandwidth = High Resolution	X
Medium bandwidth = General Purpose	



Element Diameter	Delay Line Dimensions (in)			
	A	B	C	D
0.25 Permanent Delay	0.80	0.45	0.36	---
0.50 Permanent Delay	0.80	0.75	0.62	---

2.2 Permanent Delay Line with Microdot Connector

Frequency (MHz)	Element Dia. (in.)	Part Number	Connector Type
2.25	0.5	PDG024	Microdot
5	0.25	PDG052	Microdot
5	0.5	PDG054	Microdot
10	0.25	PDG102	Microdot
10	0.5	PDG104	Microdot
15	0.25	PDG152	Microdot
20	0.25	PDG202	Microdot
25	0.25	PDG252	Microdot

2 Delay Line Transducers

Protected Element: General Purpose - Properties

Membrane face (default configuration)

- Flexible polymeric membrane assists coupling to rough or uneven surfaces
- Allows dry-coupling to certain materials
- BNC connector

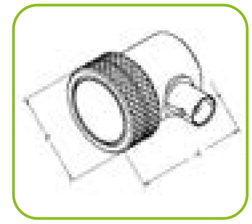
Option: Wear Cap

- Removeable wear cap protects transducer face
- Used on rough and abrasive surface

Option: High temperature delay line

- One inch long heat resistant delay line
- Provides protection to the transducer in high surafce temperature applications (intermittent use up to 1000°F)

Permanent Delay Line Series	
Narrow bandwidth = High Gain	X
Wide bandwidth = High Resolution	
Medium bandwidth = General Purpose	X



Element Diameter	Protected Dimensions (in)		
	A	B	C
0.50	0.95	0.70	1.28
0.75	1.18	0.95	1.28
1.00	1.37	1.20	1.28
1.125	1.50	1.33	1.33

Face Type	Element Diameter (in)			
	0.50	0.75	1.00	1.13
Standard Wear Cap	WC4	WC6	WC8	WC9
Elastomeric Membrane	RM4	RM6	RM8	RM9
1 Inch Delay Hi Temp	RD4-1	RD6-1	RD8-1	RD9-1

2.3 Protected Element - General Purpose with BNC Connector

Frequency (MHz)	Element Dia. (in.)	Part Number	Connector Type
0.5	0.75	RHF0.56	BNC
0.5	1	RHF0.58	BNC
0.5	1.125	RHF0.59	BNC
1	0.5	RHF014	BNC
1	0.75	RHF016	BNC
1	1	RHF018	BNC
1	1.125	RHF019	BNC
2.25	0.5	RHF024	BNC
2.25	0.75	RHF026	BNC
2.25	1	RHF028	BNC
2.25	1.125	RHF029	BNC
3.5	0.5	RHF034	BNC
3.5	0.75	RHF036	BNC
3.5	1	RHF038	BNC
5	0.5	RHF054	BNC
5	0.75	RHF056	BNC

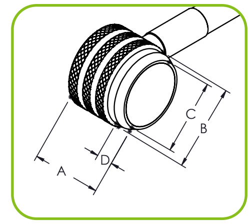
2.4 Protected Element - High Gain with BNC Connector

Frequency (MHz)	Element Dia. (in.)	Part Number	Connector Type
0.5	0.75	RMF0.56	BNC
0.5	1	RMF0.58	BNC
0.5	1.125	RMF0.59	BNC
1	0.5	RMF014	BNC
1	0.75	RMF016	BNC
1	1	RMF018	BNC
1	1.125	RMF019	BNC
2.25	0.5	RMF024	BNC
2.25	0.75	RMF026	BNC
2.25	1	RMF028	BNC
2.25	1.125	RMF029	BNC
3.5	0.5	RMF034	BNC
3.5	0.75	RMF036	BNC
3.5	1	RMF038	BNC
5	0.5	RMF054	BNC
5	0.75	RMF056	BNC

3 Dual Element Transducers

Potted Fingertip - Properties

- Ideal for corrosion detection
- Intermittent operation on hot surfaces up to 400°F with a 15% duty cycle
- Permanently side-mounted cable with BNC connectors



Dual Element Series	
Narrow bandwidth = High Power	
Wide bandwidth = High Resolution	
Medium bandwidth = General Purpose	X

Element Size	Element Dimensions (in)			
	A	B	C	D
.250 Dia	0.55	0.45	0.36	0.15
.375 Dia	0.56	0.625	0.50	0.16
.500 Dia	0.61	0.75	0.62	0.16

3.1 Potted Fingertip with Dual BNC connector

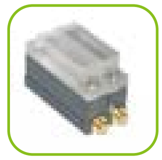
Frequency MHz	Element Dia. (in.)	Part Number	Connector Type
1	0.5	DVF014	Dual BNC
2.25	0.25	DVF022	Dual BNC
2.25	0.375	DVF023	Dual BNC
2.25	0.5	DVF024	Dual BNC
3.5	0.25	DVF032	Dual BNC
3.5	0.375	DVF033	Dual BNC
3.5	0.5	DVF034	Dual BNC
5	0.25	DVF052	Dual BNC
5	0.375	DVF053	Dual BNC
5	0.5	DVF054	Dual BNC
7.5	0.25	DVF072	Dual BNC
7.5	0.375	DVF073	Dual BNC
7.5	0.5	DVF074	Dual BNC
10	0.25	DVF102	Dual BNC
10	0.375	DVF103	Dual BNC

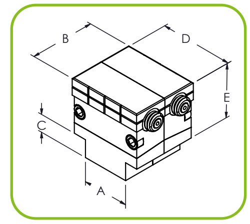
DVF style transducers are available with Lemo 00 connectors

3 Dual Element Transducers

Rectangular Dual Element - Properties

- Recommended for more rugged applications
- Applications requiring greater coverage
- Delay lines and cross-talk barriers are replaceable
- High temperature delay lines available
- Microdot connectors





Permanent Delay Line Series	
Narrow bandwidth = High Power	
Wide bandwidth = High Resolution	
Medium bandwidth = General Purpose	X

Element Size	Dual Element Dimensions (in)				
	A	B	C	D	E
.50 x .50	0.52	0.70	0.20	0.80	0.83
.50 x 1.00	1.05	0.70	0.25	1.50	1.04

3.2 Rectangular Dual Element with Dual Microdot Connector

Frequency (MHz)	Element Dia. (in.)	Part Number	Connector Type
1	.5 x .5	DXR0144	Dual Microdot
1	.5 x 1.0	DXR0148	Dual Microdot
2.25	.5 x .5	DXR0244	Dual Microdot
2.25	.5 x 1.0	DXR0248	Dual Microdot
3.5	.5 x .5	DXR0344	Dual Microdot
3.5	.5 x 1.0	DXR0348	Dual Microdot
5	.5 x .5	DXR0544	Dual Microdot
5	.5 x 1.0	DXR0548	Dual Microdot

3.3 Replacement Delay Lines

Type	Element Dia. (in.)	Part Number
Acrylic	.5 x .5	DX44
Acrylic	.5 x 1.0	DX48
Hi-temp	.5 x .5	DXH44
Hi-temp	.5 x 1.0	DXH48

* Cork Barrier included with replacement delay lines

NDT Systems
Worldwide Excellence in Ultrasonics

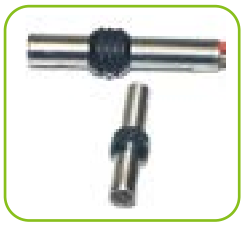
4 TG-110 Specific Transducers

Dual Element - Properties

- Specifically designed for corrosion inspection
- Self-identification to TG-110 instrument
- Rugged easy-grip housings
- Sizes, shapes and frequencies for every application

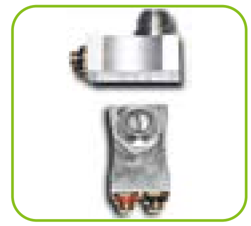
TG-110 Specific Dual Element Series	
Narrow bandwidth = High Gain	
Wide bandwidth = High Resolution	
Medium bandwidth = General Purpose	X


TG-506 & TG-560P


TQ-506


TG-790 & TG-790HP


TG-502 & TG-702


TG-101HR

TG-110DL Transducer Series Properties

Transducer	TG-506	TG-560P	TQ-506	TG-790	TG-790HP	TG-502	TG702	TG101HR
Freq (MHz)	5	5	5	5	5	5	7.5	10
Dia (in)	0.375”	0.375”	0.375”	0.325”	0.325”	0.20”	0.20”	0.20”
Details	Standard	Through-paint	Very high temp	High temp	High temp High power	Small tip, cable attached	High frequency, cable attached	Very high frequency

4.1 TG-110DL Dual Element

Frequency (MHz)	Element Dia. (in.)	Tip Dia. (in.)	Part Number	Range (in.)	Cable Type	Max. Temp. (°F)	Probe Holder
2	0.375	0.56	TG-208	0.200-9.999	LMD1	450	BH-2
2	0.6	0.9	TQ-506	0.200-9.999	LMD1	1000	BH-3
5	0.375	0.56	TG-506	0.040-9.999	LMD1	450	BH-1
5	0.375	0.56	TG-556	0.040-9.999	LMD1	600	BH-1
5	0.375	0.9	TG-560P	0.040-9.999	LMD1	450	BH-1
5	0.28	0.43	TG-790	0.040-9.999	LMD1	900	TG-790-EXT
5	0.28	0.43	TG-790HP	0.040-9.999	LMD1	900	TG-790-EXT
5	0.375	0.6	TG-505	0.040-9.999	Potted	450	
5	0.375	0.56	TG-505TM	0.040-2.000	Potted	450	
5	0.28	0.38	TG-502	0.060-1.000	Potted	450	
50	0.28	0.38	TG-502TM	0.060-1.000	Potted	450	
10	0.25	0.25-0.5	TG-101HR	0.022-1.875		250	

4 TG-110 Specific Transducers

TG-208

TG-505

TG-100D Transducer Series Properties		
Transducer	**TG-208**	**TG-505**
Freq (MHz)	2.25	5
Dia (in)	0.75”	0.30”
Details	Low Frequency	Medium tip, cable attached

4.2 TG-100D Dual Element

Frequency (MHz)	Element Dia. (in.)	Tip Dia. (in.)	Part Number	Range (in.)	Cable Type	Max. Temp. (°F)	Probe Holder
2	0.375	0.56	TG-208	0.200-9.999	LMD1	450	BH-2
5	0.375	0.6	TG-505	0.040-9.999	Potted	450	

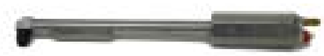
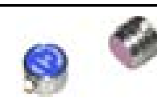
5 900 and Novascope 6000 Specific Transducers

Precision Transducer - Properties

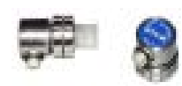
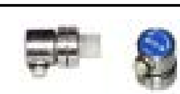
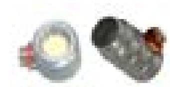
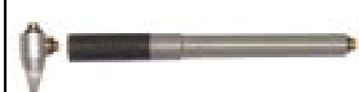
- Specifically designed for precision thickness gauging
- Contact, delay line and bubbler models for the most exacting applications

900 & Novascope Specific Transducer Series	
Narrow bandwidth = High Gain	X
Wide bandwidth = High Resolution	X
Medium bandwidth = General Purpose	

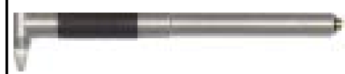
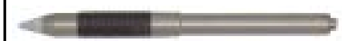
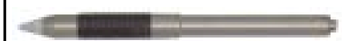
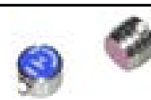
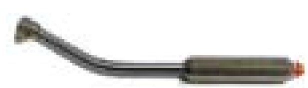
5.1 900 and Novascope Specific Transducers

Frequency (MHz)	Element Dia. (in.)	Part Number	Range	Type	Description	Product Image
30	0.25	E11877	0.009-0.200	Bubbler	Water feed delay line Includes IBUC	
25	0.25	HBX2-30	0.012-0.500	Pencil / Bubbler	30° Shaft bend Shaft: 0.311” Tip: 0.433”	
25	0.25	HBX2	0.012-0.500	Pencil / Bubbler	Straight shaft Shaft: 0.311” Tip: 0.433”	
25	0.125	C98	0.040-0.250	Contact	High frequency	
25	0.25	IBU25-A	0.012-0.500	Immersion Bubbler	Water feed delay line Includes IBUC-H, RTS	
25	0.25	IBU25	0.012-0.500	Immersion Bubbler	Water feed delay line Includes IBUC	
15	0.1	VTX1-B	0.050-0.400	Pencil Mini Vane	Fixed Delay 90° Swivel Head H: 0.180” Tip: 0.090”	
15	0.1	VTX1	0.050-0.400	Pencil Mini Vane	Fixed Delay 90° Swivel Head H: 0.150” Tip: 0.060”	
15	0.1	PTX6S	0.050-0.400	Mini Pencil	Removeable Delay 90° Swivel Head H: 0.175”	
15	0.1	PTX6	0.050-0.400	Mini Pencil	Removeable Delay 90° Head H: 0.175”	
15	0.1	PTX5	0.050-0.400	Pencil	Removeable Delay 90° Head H: 0.350”	
15	0.125 x 0.300	DM123	0.050-0.400	Pencil	Fixed Delay 90° Swivel Head H: 0.350”	

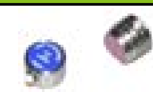
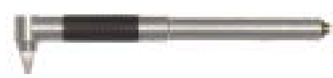
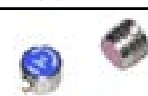
5.1 900 and Novascope Specific Transducers (Continued)

15	0.125	D20R	0.050-0.700	Delay Line	Replaceable Delay Line	
15	0.25	D16R	0.025-1.1	Delay Line	Replaceable Delay Line	
15	0.25	D15	0.050-0.250	Delay Line	Permanent Delay Line	
15	0.25	D11TC	0.050-0.700	Delay Line	Perm Delay Line Top mount connector	
15	0.25	D11RTC	0.050-0.700	Delay Line	Replaceable Top mount connector	
15	0.25	D11R	0.050-0.700	Delay Line	Replaceable Delay Line	
15	0.25	D11	0.050-0.700	Delay Line	Permanent Delay Line	
15	0.157	AE11605	0.040-0.300	MINI IBU Bubbler	Water feed delay line	
15	0.25	IBU15	0.015-0.600	Bubbler	Water feed delay line Includes IBUC	
12	0.188 Straight	BEX05C	0.040-0.300	Pencil	Removeable delay 90° or straight head	

5.1 900 and Novascope Specific Transducers (Continued)

Frequency (MHz)	Element Dia. (in.)	Part Number	Range	Type	Description	Product Image
12	0.188	BEX03C	0.040-0.300	Pencil	Removeable Delay 90°	
12	0.188	BEX02C	0.040-0.300	Pencil	Fixed Delay Straight head	
12	0.188	BEX01C	0.040-0.300	Pencil	Removeable Delay Straight head	
10	0.5	D13R	0.040-1	Delay Line	Replaceable Delay Line	
10	0.125	C95-SM	0.040-0.300	Contact	Side mount connector	
10	0.125	C95	0.040-0.300	Contact	Contact transducer	
10	0.25	C92-SM	0.040-0.500	Contact	Side mount connector	
10	0.25	C92	0.040-0.500	Contact	Contact transducer	
10	0.1	VTX2	0.050-0.400	Pencil	Fixed Delay 90° Swivel Head H: 0.350”	
10	0.188	AE12205-G	0.040-0.300	Pencil	Removeable Delay 90° Head H: 0.350”	
10	0.188	AE12205-A	0.040-0.300	Pencil	Removeable Delay 90° Head H: 0.350” Angled	
10	0.188	AE12205	0.040-0.300	Pencil	Removeable Delay 90° Head H: 0.350”	
10	0.25	IBU10	0.030-0.700	Bubbler	Water feed delay line Includes IBUC	
5	0.125	C14	.062-2	Contact	Contact transducer	

5.1 900 and Novascope Specific Transducers (Continued)

Frequency (MHz)	Element Dia. (in.)	Part Number	Range	Type	Description	Product Image
5	0.25	C13TC	.062-20	Contact	Top mount connector	
5	0.25	C13	.062-20	Contact	Contact transducer	
5	0.375	C11TC	.062-20	Contact	Top mount connector	
5	0.375	C11E	.062-20	Contact	With Contoured face for cylinder walls	
5	0.375	C11	.062-20	Contact	Contact transducer	
5	0.1	VTX3	0.050-0.700	Pencil	Mini Vane Probe, Fixed Delay Line, 90° Swivel Head, 0.150" Clearance	
5	0.187	AEX07C-90	.062-20	Pencil	Removeable Delay 90º Head	
5	0.09	AEX07C	.062-20	Pencil	Removeable Delay Straight Head	
5	0.25	IBU05	0.050-0.700	Bubbler	Water feed delay line Includes IBUCS	
2.25	0.5	C17	2-200	Contact	Contact transducer	
2.25	0.5	C16	.200-20	Contact	Contact transducer	

5.2 900 and Novascope Specific Transducer Accessories

Part Number	Description	Quantity Per Pack	Accessory for Part No.(s)
BEX-T	BEX Replacement Tip | Small ø	1	BEX01C, BEX03C, BEX05C (Standard)
BEX-TL	BEX Replacement Tip | Large ø	1	BEX01C, BEX03C, BEX05C (Standard)
AEX-T	AEX Replacement Tips | Tip ø0.070" | Grooves	1	AEX01C, AEX03C, AEX05C (Standard)
AEX-T09	AEX Replacement Tips | Tip ø0.090" | Grooves	1	AEX07C, AEX07C-90 (Standard)
AEX-TS-NG	AEX Replacement Tips | Tip ø0.070" | No Grooves	1	AE12205, AE12205-A (Standard)
AEX-TS	AEX Replacement Tips | Tip ø0.070" | Grooves	1	AE12205-G (Standard), AE12205, AE12205-A (Option)
PTX5-T	PTX5 Replacement Tips	1	
PTX6-T	PTX6 Replacement Tips	1	
IBUC	Cone | IBU Replacement | Standard | Includes IBUT	1	IBU10, IBU15, IBU25, E11877
IBUC-H	Cone | IBU Replacement | Standard | Includes IBUT-H	1	IBU10, IBU15, IBU25, IBU25-A, E11877
IBUCS	Cone | IBU Replacement Short | Standard | Includes IBUT	1	IBU05
AE11605-C	Cone | AE11605 Replacement | Short Stainless Steel	5	AE11605
IBUT	Tip | IBU Replacement | Standard Stainless Steel | Flat	5	IBU05, IBU10, IBU15, IBU25, E11877
IBU-TP	Tip | IBU Replacement | Standard Stainless Steel | Flat	5	IBU05, IBU10, IBU15, IBU25, E11877
IBUT-H	Tip | IBU Replacement | Hardened Stainless | Flat	5	IBU05, IBU10, IBU15, IBU25, IBU25-A, E11877
IBUT-V	Tip | IBU Replacement | Standard Stainless | V-Groove	5	IBU05, IBU10, IBU15, IBU25, IBU25-A, E11877

5.2 900 and Novascope Specific Transducer Accessories (continued)

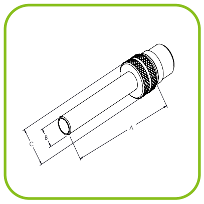
Part Number	Description	Quantity Per Pack	Accessory for Part No.(s)
IBUT-NF	IBU Tip | Nylon Flat	1	IBU05, IBU10, IBU15, IBU25, IBU25-A, E11877
AE11605-T	Tip | AE11605 Replacement | Short Stainless Steel	5	AE11605
T300	Bubbler Tank | Water Recirculation System Applications Include: • Stationery inspection sytem for any IBU transducer Package Includes: • T300 Bubbler tank • Power adapter • T300A, adaptor to fit any IBU transducer • (Does not include transducer nor cable) Features include: • Continuours and fully adjustable water flow • Brushless motor • 110/240V compatible	1	For Immersion Bubbler Probes 
T300A	Bubbler Tank Adaptor	1	Fits all IBU Transducers

6 Immersion Transducers

Housing Styles

A-Housing - "Pencil Case"

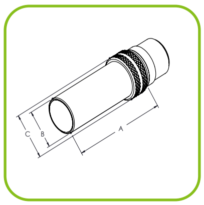
- Applications with limited access
- Small and high frequency transducers
- UHF connector



Permanent Delay Line Series	
Narrow bandwidth = High Gain	X
Wide bandwidth = High Resolution	X
Medium bandwidth = General Purpose	X

B-Housing - "Slim Case"

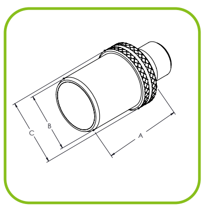
- Large variety of models available
- Most used immersion transducer style
- UHF connector



Housing	Rugged Dimensions (in)		
	A	B	C
A	2.500	0.375	0.75
B	1.750	0.625	0.75
C	1.375	1.00	1.125
D	1.375	1.25	1.375
E	0.750	0.62	0.620

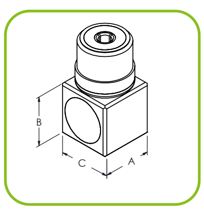
C-Housing - "High Power Case"

- High beam energy and low frequencies
- Used on mill finish surfaces
- Large diameter elements permit greater scan indexes for faster coverage test objects
- UHF connector



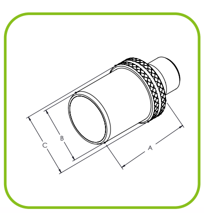
E-Housing - "Right Angle Case"

- Direct right-angle beam applications
- Ideal for inside diameters, bore holes and other limited access conditions
- UHF connector



D-Housing - "Boomer Case"

- Large elements and low frequencies combined for best rough surface or attenuative material test objects
- Perfect for 'noisy' materials
- UHF connector



Immersion Transducer Options

Spherical or Cylindrical Focus

A spherical focus allows to actively define the focal length of the transducer, and let the focus be as close to the shape of a point as possible.

A cylindrical focus shapes the focus a transducer to the shape of a line at a specified distance from the transducer face.

Both focus variations increase sensitivity of the detection of small discontinuities and enhance near-surface resolution and flaw depth discrimination.

Slip-on Angle Reflectors

For a select number of transducers, NDT Systems offers slip-on right-angle reflectors to direct the sound beam over a 90 degree turn before being emitted into the immersion tank.

6 Immersion Transducers

6.1 Immersion Transducers - General Purpose with UHF Connector

Frequency (MHz)	Element Diameter (in.)	Characteristics	Type	Minimum Focal Length (in)*	Maximum Focal Length (in)*	Part Number
0.5	0.5	General Purpose	C - Style	N/P	N/P	ICHF0.54
0.5	0.75	General Purpose	C - Style	N/P	1	ICHF0.56
0.5	1	General Purpose	D - Style	1	1.5	IDHF0.58
0.5	1.125	General Purpose	D - Style	1.5	2	IDHF0.59
1	0.25	General Purpose	A - Style	N/P	N/P	IAHF012
1	0.25	General Purpose	B - Style	N/P	N/P	IBHF012
1	0.25	General Purpose	E - Style	N/P	N/P	IEHF012
1	0.375	General Purpose	B - Style	N/P	0.5	IBHF013
1	0.375	General Purpose	E - Style	N/P	0.5	IEHF013
1	0.5	General Purpose	B - Style	N/P	0.75	IBHF014
1	0.5	General Purpose	C - Style	N/P	0.75	ICHF014
1	0.5	General Purpose	E - Style	N/P	0.75	IEHF014
1	0.75	General Purpose	C - Style	100	1.75	ICHF016
1	1	General Purpose	D - Style	1.5	3	IDHF018
1	1.125	General Purpose	D - Style	1.5	4	IDHF019
2.25	0.25	General Purpose	A - Style	N/P	0.5	IAHF022
2.25	0.25	General Purpose	B - Style	N/P	0.5	IBHF022
2.25	0.25	General Purpose	E - Style	N/P	0.5	IEHF022
2.25	0.375	General Purpose	B - Style	N/P	1	IBHF023
2.25	0.375	General Purpose	E - Style	N/P	1	IEHF023
2.25	0.5	General Purpose	B - Style	1	1.75	IBHF024
2.25	0.5	General Purpose	C - Style	1	1.75	ICHF024
2.25	0.5	General Purpose	E - Style	1	1.75	IEHF024
2.25	0.75	General Purpose	C - Style	1.5	4	ICHF026

* N/P = Not possible

6.1 Immersion Transducers - General Purpose with UHF Connector /Continued

Frequency (MHz)	Element Diameter (in.)	Characteristics	Type	Minimum Focal Length (in.)*	Maximum Focal Length (in.)*	Part Number
2.25	1	General Purpose	D - Style	2	7	IDHF028
2.25	1.125	General Purpose	D - Style	2	9	IDHF029
3.5	0.125	General Purpose	A - Style	N/P	N/P	IAHF031
3.5	0.25	General Purpose	A - Style	N/P	0.75	IAHF032
3.5	0.25	General Purpose	B - Style	N/P	0.75	IBHF032
3.5	0.25	General Purpose	E - Style	N/P	0.75	IEHF032
3.5	0.375	General Purpose	B - Style	0.75	1.5	IBHF033
3.5	0.375	General Purpose	E - Style	0.75	1.5	IEHF033
3.5	0.5	General Purpose	B - Style	1	3	IBHF034
3.5	0.5	General Purpose	C - Style	1	3	ICHF034
3.5	0.5	General Purpose	E - Style	1	3	IEHF034
3.5	0.75	General Purpose	C - Style	1.5	4	ICHF036
3.5	1	General Purpose	D - Style	2	11	IDHF038
5	0.125	General Purpose	A - Style	N/P	N/P	IAHF051
5	0.25	General Purpose	A - Style	0.5	1	IAHF052
5	0.25	General Purpose	B - Style	0.5	1	IBHF052
5	0.25	General Purpose	E - Style	0.5	1	IEHF052
5	0.375	General Purpose	B - Style	0.75	2	IBHF053
5	0.375	General Purpose	E - Style	0.75	2	IEHF053
5	0.5	General Purpose	B - Style	1	4	IBHF054
5	0.5	General Purpose	C - Style	1	4	ICHF054
5	0.5	General Purpose	E - Style	1	4	IEHF054
5	0.75	General Purpose	C - Style	1.5	9	ICHF056
5	1	General Purpose	D - Style	4	16	IDHF058
7.5	0.125	General Purpose	A - Style	N/P	N/P	IAHF071
7.5	0.25	General Purpose	A - Style	0.5	1.5	IAHF072
7.5	0.25	General Purpose	B - Style	0.5	1.5	IBHF072
7.5	0.25	General Purpose	E - Style	0.5	1.5	IEHF072
7.5	0.375	General Purpose	B - Style	0 75	3.5	IBHF073
7.5	0.375	General Purpose	E - Style	0.75	3.5	IEHF073

* N/P = Not possible

6.1 Immersion Transducers - General Purpose with UHF Connector /Continued

Frequency (MHz)	Element Diameter (in.)	Characteristics	Type	Minimum Focal Length (in.)*	Maximum Focal Length (in.)*	Part Number
7.5	0.5	General Purpose	B - Style	1.5	6	IBHF074
7.5	0.5	General Purpose	C - Style	1.5	6	ICHF074
7.5	0.5	General Purpose	E - Style	1.5	6	IEHF074
7.5	0.75	General Purpose	C - Style	3.5	13	ICHF076
10	0.125	General Purpose	A - Style	N/P	0.5	IAHF101
10	0.25	General Purpose	A - Style	0.5	2	IAHF102
10	0.25	General Purpose	B - Style	0.5	2	IBHF102
10	0.25	General Purpose	E - Style	0.5	2	IEHF102
10	0.375	General Purpose	B - Style	0.75	4.5	IBHF103
10	0.375	General Purpose	E - Style	0.75	3.5	IEHF103
10	0.5	General Purpose	B - Style	1	8	IBHF104
10	0.5	General Purpose	C - Style	1	8	ICHF104
10	0.5	General Purpose	E - Style	1	8	IEHF104
15	0.125	General Purpose	A - Style	0.5	0.75	IAHF151
15	0.25	General Purpose	A - Style	0.5	3	IAHF152
15	0.25	General Purpose	B - Style	0.5	3	IBHF152
15	0.25	General Purpose	E - Style	0.5	3	IEHF152
15	0.375	General Purpose	B - Style	0.75	7	IBHF153
15	0.375	General Purpose	E - Style	0.75	7	IEHF153
15	0.5	General Purpose	B - Style	1	12	IBHF154
20	0.125	General Purpose	A - Style	0.5	1	IAHF201
20	0.25	General Purpose	A - Style	0.75	4	IAHF202
20	0.25	General Purpose	B - Style	0.75	4	IBHF202
20	0.25	General Purpose	E - Style	0.75	4	IEHF202
25	0.125	General Purpose	A - Style	0.5	1.25	IAHF251
25	0.25	General Purpose	A - Style	0.5	5	IAHF252
25	0.25	General Purpose	B - Style	0.5	5	IBHF252
25	0.25	General Purpose	E - Style	0.5	5	IEHF252

* N/P = Not possible

6.2 Immersion Transducers - High Resolution with UHF Connector

Frequency (MHz)	Element Diameter (in.)	Characteristics	Type	Minimum Focal Length (in)*	Maximum Focal Length (in)*	Part Number
1	0.125	High Resolution	A - Style	N/P	N/P	IAHG011
1	0.25	High Resolution	A - Style	N/P	N/P	IAHG012
1	0.25	High Resolution	B - Style	N/P	N/P	IBHG012
1	0.25	High Resolution	E - Style	N/P	N/P	IEHG012
1	0.375	High Resolution	B - Style	N/P	0.5	IBHG013
1	0.375	High Resolution	E - Style	N/P	0.5	IEHG013
1	0.5	High Resolution	B - Style	N/P	0.75	IBHG014
1	0.5	High Resolution	C - Style	N/P	0.75	ICHG014
1	0.5	High Resolution	E - Style	N/P	0.75	IEHG014
1	0.75	High Resolution	C - Style	100	1.75	ICHG016
1	1	High Resolution	D - Style	1.5	3	IDHG018
1	1.125	High Resolution	D - Style	1.5	4	IDHG019
2.25	0.125	High Resolution	A - Style	N/P	N/P	IAHG021
2.25	0.25	High Resolution	A - Style	N/P	0.5	IAHG022
2.25	0.25	High Resolution	B - Style	N/P	0.5	IBHG022
2.25	0.25	High Resolution	E - Style	N/P	0.5	IEHG022
2.25	0.375	High Resolution	B - Style	N/P	1	IBHG023
2.25	0.375	High Resolution	E - Style	N/P	1	IEHG023
2.25	0.5	High Resolution	B - Style	1	1.75	IBHG024
2.25	0.5	High Resolution	C - Style	1	1.75	ICHG024
2.25	0.5	High Resolution	E - Style	1	1.75	IEHG024
2.25	0.75	High Resolution	C - Style	1.5	4	ICHG026
2.25	1	High Resolution	D - Style	2	7	IDHG028
2.25	1.125	High Resolution	D - Style	2	9	IDHG029
3.5	0.125	High Resolution	A - Style	N/P	N/P	IAHG031
3.5	0.25	High Resolution	A - Style	N/P	0.75	IAHG032
3.5	0.25	High Resolution	B - Style	N/P	0.75	IBHG032
3.5	0.25	High Resolution	E - Style	N/P	0.75	IEHG032
3.5	0.375	High Resolution	B - Style	0.75	1.5	IBHG033

* N/P = Not possible

6.2 Immersion Transducers - High Resolution with UHF Connector /Continued

Frequency (MHz)	Element Diameter (in.)	Characteristics	Type	Minimum Focal Length (in.)*	Maximum Focal Length (in.)*	Part Number
3.5	0.375	High Resolution	E - Style	0.75	1.5	IEHG033
3.5	0.5	High Resolution	B - Style	1	3	IBHG034
3.5	0.5	High Resolution	E - Style	1	3	IEHG034
3.5	1	High Resolution	D - Style	2	11	IDHG038
5	0.125	High Resolution	A - Style	N/P	N/P	IAHG051
5	0.25	High Resolution	A - Style	0.5	1	IAHG052
5	0.25	High Resolution	B - Style	0.5	1	IBHG052
5	0.25	High Resolution	E - Style	0.5	1	IEHG052
5	0.375	High Resolution	B - Style	0.75	2	IBHG053
5	0.375	High Resolution	E - Style	0.75	2	IEHG053
5	0.5	High Resolution	B - Style	1	4	IBHG054
5	0.5	High Resolution	C - Style	1	4	ICHG054
5	0.5	High Resolution	E - Style	1	4	IEHG054
5	0.75	High Resolution	C - Style	0.75	2	ICHG056
5	1	High Resolution	D - Style	4	16	IDHG058
7.5	0.125	High Resolution	A - Style	N/P	N/P	IAHG071
7.5	0.25	High Resolution	A - Style	0.5	1.5	IAHG072
7.5	0.25	High Resolution	B - Style	0.5	1.5	IBHG072
7.5	0.25	High Resolution	E - Style	0.5	1.5	IEHG072
7.5	0.375	High Resolution	B - Style	0.75	3.5	IBHG073
7.5	0.375	High Resolution	E - Style	0.75	3.5	IEHG073
7.5	0.5	High Resolution	B - Style	1.5	6	IBHG074
7.5	0.5	High Resolution	C - Style	1.5	6	ICHG074
7.5	0.5	High Resolution	E - Style	1.5	6	IEHG074
7.5	0.75	High Resolution	C - Style	3.5	13	ICHG076
10	0.125	High Resolution	A - Style	N/P	0.5	IAHG101
10	0.25	High Resolution	A - Style	0.5	2	IAHG102
10	0.25	High Resolution	B - Style	0.5	2	IBHG102

* N/P = Not possible

6.2 Immersion Transducers - High Resolution with UHF Connector /Continued

Frequency (MHz)	Element Diameter (in.)	Characteristics	Type	Minimum Focal Length (in.)	Maximum Focal Length (in.)	Part Number
10	0.25	High Resolution	E - Style	0.5	2	IEHG102
10	0.375	High Resolution	B - Style	0.75	3.5	IBHG103
10	0.375	High Resolution	E - Style	0.75	3.75	IEHG103
10	0.5	High Resolution	B - Style	1	8	IBHG104
10	0.5	High Resolution	C - Style	1	8	ICHG104
10	0.5	High Resolution	E - Style	1	8	IEHG104
15	0.125	High Resolution	A - Style	0.5	0.75	IAHG151
15	0.25	High Resolution	A - Style	0.5	3	IAHG152
15	0.25	High Resolution	B - Style	0.5	3	IBHG152
15	0.25	High Resolution	E - Style	0.5	3	IEHG152
15	0.375	High Resolution	B - Style	0.75	7	IBHG153
15	0.375	High Resolution	E - Style	0.75	7	IEHG153
20	0.125	High Resolution	A - Style	0.5	1	IAHG201
20	0.25	High Resolution	A - Style	0.75	4	IAHG202
20	0.25	High Resolution	B - Style	0.75	4	IBHG202
20	0.25	High Resolution	E - Style	0.75	4	IEHG202
20	0.375	High Resolution	B - Style	1	9	IBHG203
25	0.125	High Resolution	A - Style	0.5	1.25	IAHG251
25	0.25	High Resolution	A - Style	0.5	5	IAHG252
25	0.25	High Resolution	B - Style	0.5	5	IBHG252
25	0.25	High Resolution	E - Style	0.5	5	IEHG252

6.3 Immersion Transducers - High Gain with UHF Connector

Frequency (MHz)	Element Diameter (in.)	Characteristics	Type	Minimum Focal Length (in.)*	Maximum Focal Length (in.)*	Part Number
0.5	0.375	High Gain	B - Style	N/P	N/P	IBMF0.53
0.5	0.375	High Gain	E - Style	N/P	N/P	IEMF0.53
0.5	0.5	High Gain	B - Style	N/P	N/P	IBMF0.54
0.5	0.5	High Gain	C - Style	N/P	N/P	ICMF0.54
0.5	0.5	High Gain	E - Style	N/P	N/P	IEMF0.54
0.5	0.75	High Gain	C - Style	N/P	1	ICMF0.56
0.5	1	High Gain	D - Style	1	1.5	IDMF0.58
0.5	1.125	High Gain	D - Style	1.5	2	IDMF0.59
1	0.125	High Gain	A - Style	N/P	N/P	IAMF011
1	0.25	High Gain	A - Style	N/P	N/P	IAMF012
1	0.25	High Gain	B - Style	N/P	N/P	IBMF012
1	0.25	High Gain	E - Style	N/P	N/P	IEMF012
1	0.375	High Gain	B - Style	N/P	0.5	IBMF013
1	0.375	High Gain	E - Style	N/P	0.5	IEMF013
1	0.5	High Gain	B - Style	N/P	0.75	IBMF014
1	0.5	High Gain	C - Style	N/P	0.75	ICMF014
1	0.5	High Gain	E - Style	N/P	0.75	IEMF014
1	0.75	High Gain	C - Style	100	1.75	ICMF016
1	1	High Gain	D - Style	1.5	3	IDMF018
1	1.125	High Gain	D - Style	1.5	4	IDMF019
2.25	0.125	High Gain	A - Style	N/P	N/P	IAMF021
2.25	0.25	High Gain	A - Style	N/P	0.5	IAMF022
2.25	0.25	High Gain	B - Style	N/P	0.5	IBMF022
2.25	0.25	High Gain	E - Style	N/P	0.5	IEMF022
2.25	0.375	High Gain	B - Style	N/P	1	IBMF023
2.25	0.375	High Gain	E - Style	N/P	1	IEMF023
2.25	0.5	High Gain	B - Style	1	1.75	IBMF024
2.25	0.5	High Gain	C - Style	1	1.75	ICMF024

* N/P = Not possible

6.3 Immersion Transducers - High Gain with UHF Connector /Continued

Frequency (MHz)	Element Diameter (in.)	Characteristics	Type	Minimum Focal Length (in)*	Maximum Focal Length (in)*	Part Number
2.25	0.5	High Gain	E - Style	1	1.75	IEMF024
2.25	0.75	High Gain	C - Style	1.5	4	ICMF026
2.25	1	High Gain	D - Style	2	7	IDMF028
2.25	1.125	High Gain	D - Style	2	9	IDMF029
3.5	0.125	High Gain	A - Style	N/P	N/P	IAMF031
3.5	0.25	High Gain	A - Style	N/P	0.75	IAMF032
3.5	0.25	High Gain	B - Style	N/P	0.75	IBMF032
3.5	0.375	High Gain	B - Style	0.75	1.5	IBMF033
3.5	0.5	High Gain	B - Style	1	3	IBMF034
3.5	0.5	High Gain	C - Style	1	3	ICMF034
3.5	0.5	High Gain	E - Style	1	3	IFMF034
3.5	0.75	High Gain	C - Style	1.5	4	ICMF036
3.5	0.75	High Gain	E - Style	1.5	4	IFMF036
3.5	1	High Gain	D - Style	2	11	IDMF038
3.5	1.125	High Gain	D - Style	4	14	IDMF039
5	0.125	High Gain	A - Style	N/P	N/P	IAMF051
5	0.25	High Gain	A - Style	0.5	1	IAMF052
5	0.25	High Gain	B - Style	0.5	1	IBMF052
5	0.25	High Gain	E - Style	0.5	1	IEMF052
5	0.375	High Gain	B - Style	0.75	2	IBMF053
5	0.375	High Gain	E - Style	0.75	2	IEMF053
5	0.5	High Gain	B - Style	1	4	IBMF054
5	0.5	High Gain	C - Style	1	4	ICMF054
5	0.5	High Gain	E - Style	1	4	IEMF054
5	0.75	High Gain	C - Style	0.75	2	ICMF056
5	1	High Gain	D - Style	4	16	IDMF058
7.5	0.125	High Gain	A - Style	N/P	N/P	IAMF071

* N/P = Not possible

6.3 Immersion Transducers - High Gain with UHF Connector /Continued

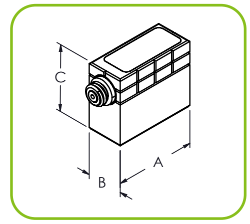
Frequency (MHz)	Element Diameter (in.)	Characteristics	Type	Minimum Focal Length (in)*	Maximum Focal Length (in)*	Part Number
7.5	0.25	High Gain	A - Style	0.5	1.5	IAMF072
7.5	0.25	High Gain	B - Style	0.5	1.5	IBMF072
7.5	0.25	High Gain	E - Style	0.5	1.5	IEMF072
7.5	0.375	High Gain	B - Style	0.75	3.5	IBMF073
7.5	0.375	High Gain	E - Style	0.75	3.5	IEMF073
7.5	0.5	High Gain	B - Style	1.5	6	IBMF074
7.5	0.5	High Gain	C - Style	1.5	6	ICMF074
7.5	0.5	High Gain	E - Style	1.5	6	IEMF074
7.5	0.75	High Gain	C - Style	3.5	13	ICMF076
10	0.125	High Gain	A - Style	N/P	0.5	IAMF101
10	0.25	High Gain	A - Style	0.5	2	IAMF102
10	0.25	High Gain	B - Style	0.5	2	IBMF102
10	0.25	High Gain	E - Style	0.5	2	IEMF102
10	0.375	High Gain	B - Style	0.75	3.5	IBMF103
10	0.375	High Gain	E - Style	0.75	3.5	IEMF103
15	0.25	High Gain	B - Style	0.5	3	IBMF152
15	0.25	High Gain	E - Style	0.5	3	IEMF152

* N/P = Not possible

7 Mini Potted Angle Beam Transducers

Properties

- Element and wedge combined into compact housing
- Internal serrations and unique bi-material element dampening eliminates internal noise
- Permits testing in highly confined areas
- Inspection of small parts and limited access
- Inspection of highly contoured surfaces
- Very precise flaw location from narrow sound beam
- Microdot connector



Element Size (in.)	Dimensions (in.)		
	A	B	C
0.19 x 0.19	0.75	0.34	0.62
0.25 x 0.25	0.75	0.34	0.62
0.38 x 0.38	0.95	0.50	0.82
0.50 x 0.50	1.25	0.62	0.92

Fingertip Contact Series	
Narrow bandwidth - High Gain	X
Wide bandwidth - High Resolution	
Medium bandwidth - General Purpose	

Frequency (MHz)	Refracted Angle	Element Dimension	Part Number*
2.25	45	.19 x .19	MPA0214x
2.25	45	.25 x .25	MPA0224x
2.25	45	.38 x .38	MPA0234x
2.25	45	.50 x 50	MPA0244x
2.25	60	.19 x .19	MPA0216x
2.25	60	.25 x .25	MPA0226x
2.25	60	.38 x .38	MPA0236x
2.25	60	.50 x .50	MPA0246x
2.25	70	.19 x .19	MPA0217x
2.25	70	.25 x .25	MPA0227x
2.25	70	.38 x .38	MPA0237x
2.25	70	.50 x .50	MPA0247x
5.0	45	.19 x .19	MPA0514x
5.0	45	.25 x .25	MPA0524x
5.0	45	.38 x .38	MPA0534x
5.0	45	.50 x 50	MPA0544x

Frequency (MHz)	Refracted Angle	Element Dimension	Part Number*
5.0	60	.19 x .19	MPA0516x
5.0	60	.25 x .25	MPA0526x
5.0	60	.38 x .38	MPA0536x
5.0	60	.50 x .50	MPA0546x
5.0	70	.19 x .19	MPA0517x
5.0	70	.25 x .25	MPA0527x
5.0	70	.38 x .38	MPA0537x
5.0	70	.50 x .50	MPA0547x
10.0	45	.19 x .19	MPA1014x
10.0	45	.25 x .25	MPA1024x
10.0	45	.38 x .38	MPA1034x
10.0	45	.50 x 50	MPA1044x
10.0	60	.19 x .19	MPA1016x
10.0	60	.25 x .25	MPA1026x
10.0	60	.38 x .38	MPA1036x
10.0	60	.50 x .50	MPA1046x
10.0	70	.19 x .19	MPA1017x
10.0	70	.25 x .25	MPA1027x
10.0	70	.38 x .38	MPA1037x
10.0	70	.50 x .50	MPA1049x

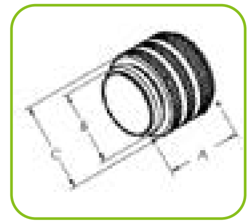
* MPAxxxxA = Aluminium, MPAxxxxS = Steel
** Special metal designs available at additional cost

8 Angle Beam Transducers & Wedges

Quick Change Properties

- Threaded housing allows ‘quick changes’ to wedges of different angles
- Smaller physical dimensions allows for inspections in tighter spaces
- Available in both regular and composite piezoelectric element designs

Quick Change Shear Wave Series	
Narrow bandwidth - High Gain	
Wide bandwidth - High Resolution	
Medium bandwidth - General Purpose	X



Element Diameter (in)	Quick Change Dimensions (in)		
	A	B	C
0.25	0.45	0.38	0.45
0.375	0.58	0.38	0.575
0.50	0.70	0.42	0.70

8.1 Quick Change Shear Wave - Piezo

Frequency (MHz)	Element Dia. (in.)	Part Number	Connector Type
1	0.5	TAB014	Microdot
2.25	0.25	TAB022	Microdot
2.25	0.375	TAB023	Microdot
2.25	0.5	TAB024	Microdot
3.5	0.5	TAB034	Microdot
5	0.25	TAB052	Microdot
5	0.375	TAB053	Microdot
5	0.5	TAB054	Microdot
7.5	0.25	TAB072	Microdot
7.5	0.375	TAB073	Microdot
7.5	0.5	TAB074	Microdot
10	0.25	TAB102	Microdot
10	0.375	TAB103	Microdot
10	0.5	TAB104	Microdot

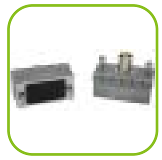
8.2 Quick Change Shear Wave - Composite Piezo

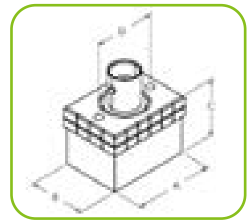
Frequency MHz	Element Dia. (in.)	Part Number	Connector Type
2.25	0.25	TAC022	Microdot
2.25	0.375	TAC023	Microdot
2.25	0.5	TAC024	Microdot
5	0.25	TAC052	Microdot
5	0.375	TAC053	Microdot
5	0.5	TAC054	Microdot

8 Angle Beam Transducers & Wedges

Standard Properties

- Classic rectangular design
- Multiple element and housing sizes available
- Fit both snail and standard style wedges





Element Diameter (in)	Standard Shear Wave Dimensions (in)			
	A	B	C	D
0.5 x 0.5	1.05	0.75	0.75	0.81
0.5 x 1.0	1.58	0.75	0.75	1.31
0.75 x 1.0	1.58	1.00	0.75	1.31
1.0 x 1.0	1.75	1.25	0.75	1.38

Standard Shear Wave Series	
Narrow bandwidth - High Gain	
Wide bandwidth - High Resolution	
Medium bandwidth - General Purpose	X

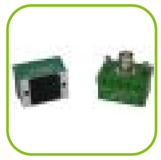
8.3 Standard Shear Wave - Rectangular

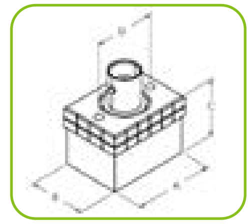
Frequency (MHz)	Element Dia. (in.)	Part Number	Connector Type
1	.5 x .5	LSA0144	BNC
1	.5 x 1.0	LSA0148	BNC
1	.75 x .5	LSA0168	BNC
1	1.0 x 1.0	LSA0188	BNC
2.25	.5 x .5	LSA0244	BNC
2.25	.5 x 1.0	LSA0248	BNC
2.25	.75 x .5	LSA0268	BNC
2.25	1.0 x 1.0	LSA0288	BNC
3.5	.5 x .5	LSA0344	BNC
3.5	.5 x 1.0	LSA0348	BNC
3.5	.75 x .5	LSA0368	BNC
3.5	1.0 x 1.0	LSA0388	BNC
5	.5 x .5	LSA0544	BNC
5	.5 x 1.0	LSA0548	BNC
5	.75 x .5	LSA0568	BNC
5	1.0 x 1.0	LSA0588	BNC

8 Angle Beam Transducers & Wedges

AWS Code Compliant Properties

- AWS D1.1 and D1.5 code compliant
- 2.25MHz only design



AWS Shear Wave Series	
Narrow bandwidth - High Gain	
Wide bandwidth - High Resolution	
Medium bandwidth - General Purpose	X

Element Diameter	Standard Shear Wave Dimensions (in)			
	A	B	C	D
0.625 x 0.625	1.25	0.85	0.75	1.00
0.625 x 0.75				
0.75 x 0.75				

8.4 AWS Code Compliant Shear Wave

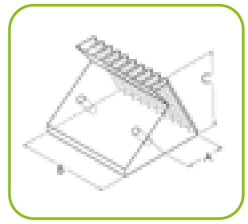
Frequency (MHz)	Element Dia. (in.)	Part Number	Connector Type
1	.5 x .5	LSA0144	BNC
1	.5 x 1.0	LSA0148	BNC
1	.75 x .5	LSA0168	BNC
1	1.0 x 1.0	LSA0188	BNC
2.25	.5 x .5	LSA0244	BNC
2.25	.5 x 1.0	LSA0248	BNC
2.25	.75 x .5	LSA0268	BNC
2.25	1.0 x 1.0	LSA0288	BNC
3.5	.5 x .5	LSA0344	BNC
3.5	.5 x 1.0	LSA0348	BNC
3.5	.75 x .5	LSA0368	BNC
3.5	1.0 x 1.0	LSA0388	BNC
5	.5 x .5	LSA0544	BNC
5	.5 x 1.0	LSA0548	BNC
5	.75 x .5	LSA0568	BNC
5	1.0 x 1.0	LSA0588	BNC

8 Angle Beam Transducer Wedges & Wedges

8.5 Standard Angle Beam Wedges

Properties

- Machined grooves scatter internal sound waves
- LSWxxxx = Steel, LAWxxxx = Aluminium
- Standard wedges are designed and manufactured based on inspections of mild carbon steel (S) or aluminum (A)**
- Specific contouring options available (AOD, AID, COD or CID)***



	Dimensions (in)		
	A	B	C
0.50 x 0.50	1.05	0.75	0.75
0.50 x 1.00	1.58	0.75	0.75
0.75 x 1.00	1.58	1.00	0.75
1.00 x 1.00	1.75	1.25	0.75

Refracted Angle	Standard Series Wedges (To fit Element Dimension)			
	0 .50 x 0.50	0.50 x 1.00	0.75 x 1.00	1.00 x 1.00
30*	LSW4430	LSW4830	LSW6830	LSW8830
45	LSW4445	LSW4845	LSW6845	LSW8845
60	LSW4460	LSW4860	LSW6860	LSW8860
70	LSW4470	LSW4870	LSW6870	LSW8870
90*	LSW4490	LSW4890	LSW6890	LSW8890

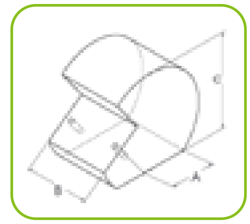
* Advanced wedge angles incur additional cost
** Special metal designs available at additional cost
*** Wedge contouring incurs additional cost

8.6 AWS Code Compliant Angle Beam Wedges

Properties

- Acrylic “Snail” wedge design
- Rounded backwall to dissipate and trap unwanted sound waves to provide a superior signal-to-noise ratio
- Available only for AWS transducers





Refracted Angle	AWS Wedges
45	AWW045
60	AWW060
70	AWW070

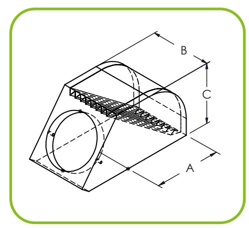
Dimensions (in)		
A	B	C
0.75"	1.265"	1.95"

8.7 Quick Change Angle Beam Wedges

Properties

- Design combines of acoustically transmissive material and attenuating material in the direct path of internal undesired noise
- Excellent signal-to-noise ratio
- Limited contouring options available





Refracted Angle	Element Diameter		
	0.250”	0.375”	0.500”
30	TAW230S	TAW330S	TAW430S
45	TAW245S	TAW345S	TAW445S
60	TAW260S	TAW360S	TAW460S
70	TAW270S	TAW370S	TAW470S
90	TAW290S	TAW390S	TAW490S

Suffix key:
TAWxxxS = Carbon Steel TAWxxxA = Aluminum
*Advanced wedge angles incur additional cost below table

Element Diameter	Angle°	Dimensions (in)		
		A	B	C
0.25	45°	0.36	0.45	0.39
	60°	0.44	0.45	0.39
	70°	0.44	0.45	0.45
0.375	45°	0.38	0.55	0.48
	60°	0.55	0.55	0.54
	70°	0.55	0.55	0.57
0.50	45°	0.50	0.70	0.55
	60°	0.57	0.70	0.64
	70°	0.68	0.70	0.69

9 Transducer Cables

Properties

- All connectors are male
- Standard cable length is 6 foot
- Other cable lengths available on request



End #1	End #2	Cable Type	Part Number
BNC	BNC	RG-174	BB01
BNC	BNC	RG-58A/U	BB02
BNC	BNC	RG-174, Heavy Duty, Green	BBG01
BNC	BNC	RG-174, Heavy Duty, Red	BBR01
BNC	BNC	RG-174 Heavy Duty	BBR01
BNC	Dual Selectro	RG-174	DBS-01
BNC	LEMO-00	RG-174	BL01
BNC	LEMO-00	RG-174, Heavy Duty, Green	BLG01
BNC	LEMO-00	RG-174, Heavy Duty, Red	BLG02
BNC	Lemo-00 Right Angle	RG-174	BRL-01
BNC	LEMO-01	RG-174	BL02
BNC	MICRODOT Right Angle	RG-174	BMR01
BNC	SELECTRO	RG-174	BS01
BNC	UHF	RG174	BU01
BNC	UHF	RG-58A/U Waterproof	BU02
DUAL BNC	DUAL BNC	RG-174	DBB01
DUAL BNC	Dual Lemo-00	RG-174	DBL01
DUAL MICRODOT	DUAL BNC	RG-174	DMB01
DUAL MICRODOT	Dual Lemo-00	RG-174	DML01
DUAL MICRODOT	Dual Lemo-00	RG-174	LMD1
DUAL MICRODOT	Dual Lemo-00	RG-174, Shielded	LMD1-S
DUAL MICRODOT	Dual Lemo-01	Dual Coax for Olympus D790 Style Transducers	LMD-79X
DUAL MICRODOT	Dual Lemo-02	Dual Coax for Olympus D790 Style Transducers, Shielded	LMD-79XS
DUAL MICRODOT	Dual Selectro	RG-174	DML02

9 Transducer Cables - Continued

End #1	End #2	Cable Type	Part Number
Lemo-00	Lemo-00	RG-174	LL01
Lemo-00	Lemo-01	RG-174	LL03
Lemo-01	Lemo-01	RG-174	LL02
Microdot	BNC	RG-174	MB01
Microdot	BNC	RG-174, Heavy Duty, Green	MBG01
Microdot	BNC	RG-174, Heavy Duty, Red	MBR01
Microdot	BNC	RG-174, Heavy Duty	MBR01
Microdot	LEMO-00	RG-174	ML01
Microdot	LEMO-00	RG-174, Heavy Duty, Green	MLG01
Microdot	Lemo-00 Right Angle	RG-174	MRL01
Microdot	LEMO-01	RG-174	ML02
Microdot	UHF	RG-174	MU01
UHF	LEMO-01	RG-58A/U	UL-01
UHF	UHF	RG-174	UU01

10 Calibration Blocks

Properties

- All blocks are available in other metal types, contact us for further details
- All Industry standard block configurations are available, contact us for further details



10.1 Carbon Steel (1018 Metal Type) Calibration Blocks

Description	Part Number	Case Number
DC- Shearwave Distance Calibration	TBS101	TBC101
DC- Shearwave Distance Calibration, Metric	TBS101M	TBC101
SC- Shearwave Sensitivity Calibration	TBS102	TBC102
SC- Shearwave Sensitivity Calibration, Metric	TBS102M	TBC102
DSC- Shearwave Distance/ Sensitivity	TBS103	TBC103
DSC- Shearwave Distance/ Sensitivity, Metric	TBS103M	TBC103
Miniature Angle Beam - IIW Type	TBS104	TBC104
Miniature Angle Beam - IIW Type, Metric	TBS104M	TBC104
IIW Type 1	TBS109	TBC109
IIW Type 1, Metric	TBS109M	TBC109
IIW Type 2	TBS110	TBC109
IIW Type 2, Metric	TBS110M	TBC109
NAVSHIPS	TBS111	TBC111
NAVSHIPS, Metric	TBS111M	TBC111
4 Step Block (0.25” 0.5” 0.75” 1”)	TBS113	TBC113
4 Step Block (6.35 12.7 19.05 25.4mm)	TBS113M	TBC113
5 Step Block (0.1” 0.2” 0.3” 0.4” 0.5”)	TBS114	TBC114
5 Step Block (2.54 5.08 7.62 10.16 12.7mm)	TBS114M	TBC114

10.2 Stainless Steel (304 Metal Type) Calibration Blocks

Description	Part Number	Case Number
DC- Shearwave Distance Calibration	TBSS101	TBC101
DC- Shearwave Distance Calibration, Metric	TBSS101M	TBC101
SC- Shearwave Sensitivity Calibration	TBSS102	TBC102
SC- Shearwave Sensitivity Calibration, Metric	TBSS102M	TBC102
DSC- Shearwave Distance/ Sensitivity	TBSS103	TBC103
DSC- Shearwave Distance/ Sensitivity, Metric	TBSS103M	TBC103
Miniature Angle Beam - IIW Type	TBSS104	TBC104
Miniature Angle Beam - IIW Type, Metric	TBSS104M	TBC104
IIW Type 1	TBSS109	TBC109
IIW Type 1, Metric	TBSS109M	TBC109
IIW Type 2	TBSS110	TBC109
IIW Type 2, Metric	TBSS110M	TBC109
NAVSHIPS	TBSS111	TBC111
NAVSHIPS, Metric	TBSS111M	TBC111
4 Step Block (0.25” 0.5” 0.75” 1”)	TBSS113	TBC113
4 Step Block (6.35 12.7 19.05 25.4mm)	TBSS113M	TBC113
5 Step Block (0.1” 0.2” 0.3” 0.4” 0.5”)	TBSS114	TBC114
5 Step Block (2.54 5.08 7.62 10.16 12.7mm)	TBSS114M	TBC114

10.3 Aluminum (7075-T6 Metal Type) Calibration Blocks

Description	Part Number	Case Number
DC- Shearwave Distance Calibration	TBA101	TBC101
DC- Shearwave Distance Calibration, Metric	TBA101M	TBC101
SC- Shearwave Sensitivity Calibration	TBA102	TBC102
SC- Shearwave Sensitivity Calibration, Metric	TBA102M	TBC102
DSC- Shearwave Distance/ Sensitivity	TBA103	TBC103
DSC- Shearwave Distance/ Sensitivity, Metric	TBA103M	TBC103
Miniature Angle Beam - IIW Type	TBA104	TBC104
Miniature Angle Beam - IIW Type, Metric	TBA104M	TBC104
IIW Type 1	TBA109	TBC109
IIW Type 1, Metric	TBA109M	TBC109
IIW Type 2	TBA110	TBC109
IIW Type 2, Metric	TBA110M	TBC109
NAVSHIPS	TBA111	TBC111
NAVSHIPS, Metric	TBA111M	TBC111
4 Step Block (0.25” 0.5” 0.75” 1”)	TBA113	TBC113
4 Step Block (6.35 12.7 19.05 25.4mm)	TBA113M	TBC113
5 Step Block (0.1” 0.2” 0.3” 0.4” 0.5”)	TBA114	TBC114
5 Step Block (2.54 5.08 7.62 10.16 12.7mm)	TBA114M	TBC114

11 Adapters and Accessories

11.1 Adapters

End #1	M/F	End #2	M/F	Part Number
BNC	M	UHF	F	ABU01
BNC	M	UHF	M	ABU02
LEMO	F	BNC	M	ALB01
LEMO	M	BNC	F	ALB02
BNC	F	BNC	F	ABB01
UHF	F	UHF	F	AUU01
UHF	M	Flanged		AFU01
UHF-90deg	M	UHF	F	AUR01
UHF-45deg	M	UHF	F	AUR02
BNC	M	BNC	F	ABT01



11.2 Search Tubes

Length	Connection	Part Number
1”	Male-Female UHF	SW01
2”	Male-Female UHF	SW02
4”	Male-Female UHF	SW04
6”	Male-Female UHF	SW06
12”	Male-Female UHF	SW12
12”	Male-Female Microdot	AE09501-12
18”	Male-Female UHF	SW18
24”	Male-Female UHF	SW24
38”	Male-Female UHF	SW36


11.3 Angle Reflectors

Transducer Style	Part Number
Immersion Pencil Style	LAR3
Immersion Slim Style	LAR5

12 Ultrasound Introduction - A snap shot

Ultra (Lat. for "beyond") -sound is essentially sound of frequencies above audible sound. Industrial ultrasonic non-destructive testing employs frequencies mostly between 0.5MHz and 30MHz.

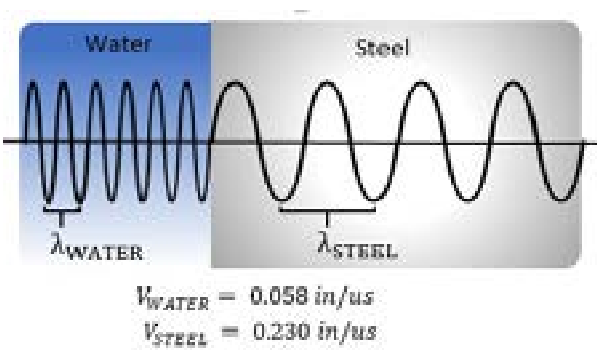
1. ***The frequency (F)*** with which the piezo-electric element vibrates inside the transducer determines the wavelength of the ultrasound it emits.

2. ***The sound velocity (V)*** of a certain medium is a function of its density and elastic modulus ("stiffness"), and further depends on its temperature and pressure. As a result, material sound velocities are constant under standardized environmental conditions for a given material. This matter of fact allows ultrasonic measurements to be extremely precise.

3. ***The wavelength (λ)*** depends on the frequency and the sound velocity of the medium that a soundwave travels through. Generally speaking, the lower the sound velocity in a certain medium, the shorter the wavelength

$$\lambda = \frac{V}{F}$$

λ: Wavelength   V: Material sound velocity   F: Frequency



4. ***The acoustic impedance*** is the opposition which a material presents to a physical elastic deformation caused by a sound beam or pressure. It is equal to the product of the material sound velocity and material density.

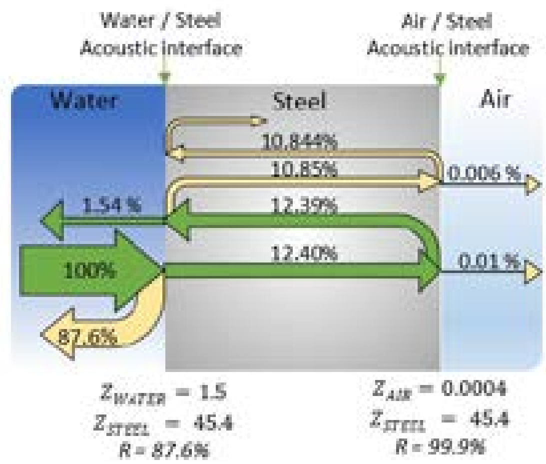
$$Z = V\rho$$

Z: Acoustic impedance
V: Material sound velocity
P: Material density

4. (cont) For ultrasonic testing, the acoustic impedance is primarily important to define reflection and transmission ratios when a sound beam passes from one material into another material – happening at the so-called acoustic interface. The larger the difference of acoustic impedances of both materials, the greater the reflection.

$$R = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2, \qquad T = 1 - R$$

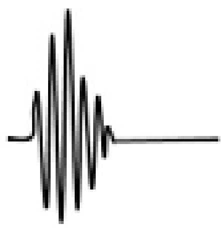
Z: Acoustic impedance   R: Reflection   T: Transmission



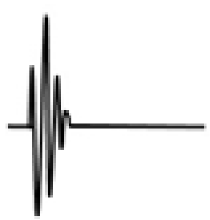
Note that the diagram above displays a typical thickness measurement setup on a steel plate immersed in water where only 1.54% of the originally transmitted energy is available.

5. ***The sensitivity*** of an ultrasonic transducer is its ability to detect small reflectors. Since for a given material, the emitted sound beam wavelength is inversely proportional to its frequency, the frequency ultimately dictates the level of sensitivity achievable by a transducer in a certain material. For flaw detection, this means that the higher the frequency, the shorter the wavelength, and thus the higher the probability that a portion of the incident sound beam will reflect from a small internal discontinuity.
   The trade-off for high sensitivity is a low penetration ability. In coarse-grained metals, a small wavelength sound beam causes reflections, noise and sound beam dissipation at grain boundaries and impurities which results in extensive scattering and absorption – summarized as sound attenuation.

Practice has shown that defects the size of at least half the wavelength can be detected. Smaller defects do not represent a significant enough reflector for such wavelengths and thus such sound beams pass through such defect.

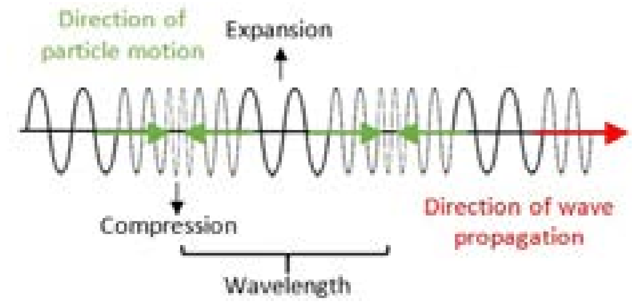


6. ***The resolution*** is the ability to distinguish between two reflectors which are spatially located close to another. In order to accomplish that, the sound beam duration or total length needs to be short, otherwise two echoes from closely located reflectors cannot be clearly distinguished from another. As per the previously mentioned formula, a higher frequency results in a shorter wavelength, increased sensitivity and resolution.

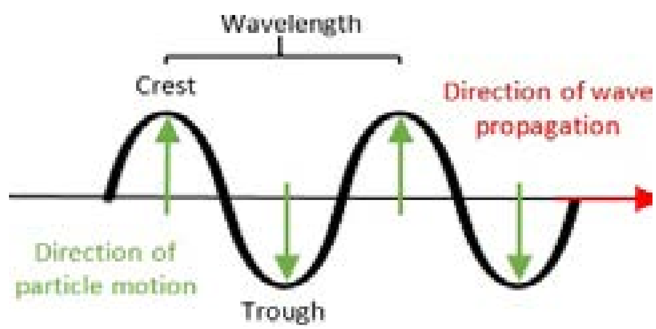


7. ***The wave propagation modes:*** For ultrasonic NDT, longitudinal waves (or compression waves) and transverse waves (or shear waves) are most commonly used. While longitudinal waves can exist in gaseous, liquid and solid media and create increases and decreases in pressure, shear waves displace at right angle to the direction of propagation and can only occur in a solid. Their velocity of propagation is roughly half of the velocity of a longitudinal wave in the same material. While both material specific velocities can be calculated using a number of material properties, they are usually found in tables for specific materials.

Longitudinal / Compression wave propagation



Transverse / Shear wave propagation



A special case relates to surface (Rayleigh) waves. These types of waves include both longitudinal and transverse motions and typically travel at one wavelength underneath the material surface, presenting a unique advantage for near-surface material integrity inspections.

8. ***Snell's Law*** is important in order to understand angles of refraction of sound beams which travel from one acoustic impedance to another one, and how they relate to both varying incident angles as well as various material sound velocities.

$$\frac{\sin \alpha_1}{V_1} = \frac{\sin \alpha_2}{V_2}$$

α_1: *Incident angle within material 1*

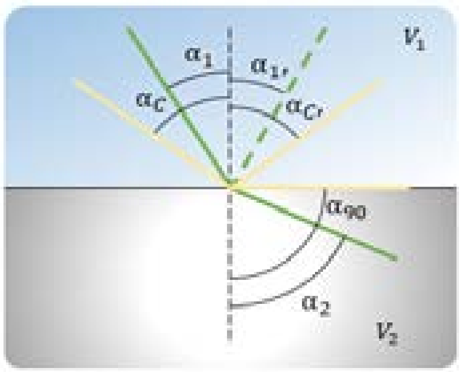
α_2: *Refracted angle within material 2*

V_1: *Sound velocity of material 1*

V_2: *Sound velocity of material 2*

Is it important to understand that both V_1 and V_2 values can actually be the longitudinal or the transverse sound velocity of material 1 or 2. The different values will result in the respective angles of refraction.

For the purpose of explaining specifically the scenario of a longitudinal sound beam being refracted into a transverse sound beam, the example below is illustrated.



V_1:	*Longitudinal sound velocity of material 1*
V_2:	*Transverse sound velocity of material 2*
α_1, α_C:	*Incident longitudinal wave angle*
α_1':	*Reflected longitudinal wave angle*
α_2:	*Refracted shear wave angle*
α_{90}:	*Right angle*
α_2':	*Reflected angle*

If $(\alpha_1 = 0)$ *then* $\alpha_2 = 0$
(The sound beam enters into the other material straight as it does in any regular flat contact transducer application)

If $(\alpha_1 < \alpha_C)$ *then* $\alpha_2 = Arcsin(sin(\alpha_1) \frac{V_2}{V_1})$
(Snell's Law applies)

If $sin(\alpha_1)$ *V_2/V_1* $= sin(\alpha_2) = 1$ then $\alpha_2 = 90°$ *and* $\alpha_C =$ $(sin(\alpha_1) \frac{V_1}{V_2})$

(α_1 reaches a limit to where α_2 reaches its maximum of 90°.
For higher values of α_1, α_2 remains at 90°.)

Transducer introduction

The notions of the ultrasonic basics which have been reviewed will now be applied to an ultrasonic transducer. The following definitions are specific to UT NDT applications.

9. Thickness gaging is performed by measuring the time elapse between sound transmission and sound beam reception. Knowing the material sound velocity in question, the thickness is a result of:

$$T = \frac{V * t}{2}$$

T: Material thickness
V: Material sound velocity
t: time of flight

10. Flaw detection is performed by tracking the amplitude of any possible echo appearing within a specified range of depth within the material in percent of Full Screen Height (FSH). A challenge in sizing and thus quantifying physical flaws which were discovered by such echoes is due to the fact that the sound beam is attenuated exponentially over the distance travelled. In other words, a flaw of a certain size creates a much stronger echo signal if located close to the surface in comparison to the same sized flaw located deeper within the material. In order to overcome this non-linearity and maintain amplitude consistency within the range of depth under investigation, various techniques have been developed in the signal amplification of ultrasonic instruments.

11. The near-field: Within a zone beginning immediately at the surface of a transducer, the sound field is highly irregular, having both high and low signal amplitude regions. The length N of the near-field is defined as the distance from the face of the transducer to the last signal amplitude maximum within the near-field. (For unfocused immersion transducers, the near-field length can be considered as f: focal length). Although it is not recommended, sometimes thickness measurements are performed with echoes resulting from the near-field. Since their amplitudes can vary randomly, flaw detection inspections cannot be conducted since they rely on signal amplitude to quantify a defect.

12. The far-field: In the subsequent far-field, the sound beam tends to radiate outwardly with a uniform wave front of a somewhat radial cross-sectional shape. In addition, the sound beam diverges and the sound wave pressure diminishes with the inverse square of distance – not including any additional attenuation losses. In reality, most measurements are performed in the far-field, ideally immediately following the end of the near field as this is the area of highest soundwave energy. When selecting a transducer, one should be aware of the extent of the near-field and its ramifications in that this region may not necessarily be able to return a proper echo.

13. Sound beam diffraction: The frequency and the element size establishes the length of the near-field. Beyond the near-field, the soundbeam tends to radiate outwardly with a uniformed wavefront. In this far-field, the soundbeam diverges and the soundbeam pressure diminishes with the square of the distance – and that is neglecting any additional attenuation losses.

14. Sound beam attenuation is an inevitable "friction" which a sound beam is experiencing when traveling through any kind of medium. Sound attenuation is dependent on various parameters such as material, propagation direction, material manufacturing process, etc. which is why it is very difficult to capture its equation mathematically. Yet, generally speaking the attenuation is proportional to the square root of the sound frequency.

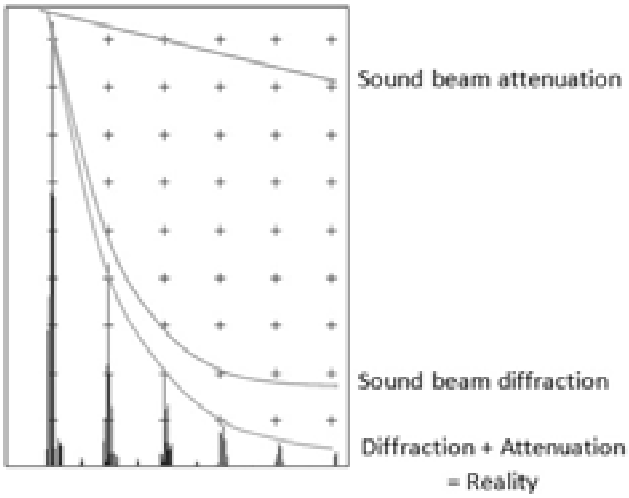
Attenuation = Absorption + Scattering

Absorption: Since any medium in which sound can travel is elastic, that medium absorbs some of the sound pressure or energy when hit by a sound beam.
Scattering: Material impurities as well as grain structures partially reflect sound into random directions – resulting in sound scattering.

The shown signal amplitude can be plotted and characterized by the following formula:

$$A = A_0 * e^{-\alpha t}$$

A_0: Initial amplitude at time equal zero
α: attenuation coefficient
A: Amplitude curve at any given time t
t: Time



Generally speaking, the selection of the right transducer for an application is dependent on the following 3 factors:

Material factors

Metals: The metallurgical structure such as grain type, size and distribution influence the ultrasonic sound beam propagation. Large or directionally oriented grains tend to scatter and absorb ultrasonic sound beams to a greater extent than fine, randomly oriented grains. For instance, cast iron is far more attenuative than aluminum.

Plastics: Polymers and elastomers are often highly sound absorbing or attenuative. Reinforced plastics and other types of multi-phase and composite materials are generally attenuative and produce scattering of the sound field. Most ceramics are likewise attenuative.

Accessibility factors

In many cases, the surface geometry, condition and location are set additional requirements to the design of the ultrasonic transducer.

Inspection factors

Last but not least, the thickness of the material, the expected depth of the flaw to be detected and the estimated flaw size define the useable range of ultrasonic sound frequencies. In other words, an appropriate trade-off between penetration and sensitivity needs to be identified when selecting a transducer.

The following UT variables relationship helps in understanding the advantages of higher or lower frequencies.

↑	↓	↑	↓	↑	↓	↑	↓	↑
F	P	A	D	S	C	R	λ	N
↓	↑	↓	↑	↓	↑	↓	↑	↓

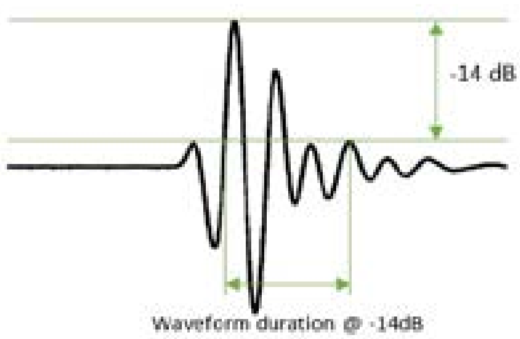
F: Frequency
P: Penetration
A: Attenuation
D: Divergence (beam spread)
S: Sensitivity
C: Crystal thickness
R: Resolution
: Wavelength
N: Near-field length

Transducer series

Despite the fact that transducers are primarily categorized by their nominal frequency, no real transducer emits ultrasound of just one single frequency. Therefore, when it comes to selecting an appropriate transducer regardless of its type, another consideration aside from its nominal frequency is significant – its frequency bandwidth. NDT Systems provides transducers in three different bandwidth categories.

The frequency bandwidth

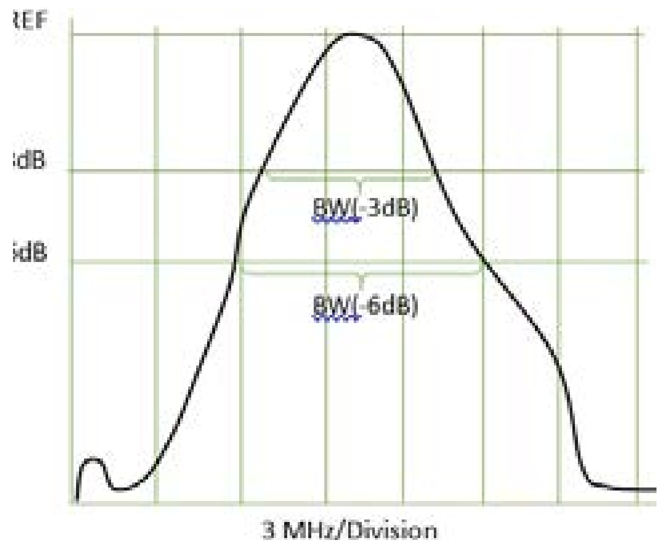
The frequency bandwidth is the variation between the higher and the lower frequency components of one continuous set of frequencies found in an ultrasonic sound burst. While in theory a piezoelectric element would vibrate purely at its natural resonance frequency, reality prohibits that from happening. The simple fact that the element needs to be electrically wired and mechanically kept in place alters the frequency response. Furthermore, as explained in greater detail in the following sections, an optional backing material serves the purpose of additional damping by coupling the element to an inert mass to the desired effect of a decreased element ringing. It shortens the spatial waveform duration and thus improves axial resolution.



A Fast-Fourier Transform (FFT) analysis of an echo signal yields the frequency composition of the signal shown above (for illustration purposes only). The resulting frequency spectrum can be used to identify the peak frequency as well as the frequency bandwidth at different levels of the spectrum.

$$BW\ [MHz] = F_{High} - F_{Low}$$

$$BW\ [\%] = \frac{F_{High} - F_{Low}}{F_{Center}} * 100$$



Peak frequency:	*10.2 MHz*
Center frequency @ -3dB:	*10.0 MHz*
Bandwidth @ -3dB:	*6 MHz ≡ 60%*
Center frequency @ -6dB:	*10.5 MHz*
Bandwidth @ -6dB:	*9 MHz ≡ 85.7%*

Narrow bandwidth - High Power - "M"

Piezoelectric elements with minor damping will vibrate close to their natural, resonant frequency. As a result, they vibrate over a relatively narrow range of frequencies and are called narrow-banded. As a result of being only lightly dampened, they also vibrate with greater amplitude or power and they ring out longer.

The corresponding strong and relatively long ultrasonic waveform signal is put to use best in applications which require a lot of power – such as highly attenuative, rough surfaced or relatively thick materials. In turn, the length of the waveform signal sacrifices near-surface resolution.

Such transducers include the letter “M” (minor damping) in their part number.

Wide bandwidth - High Resolution - "G"

In contrast, heavily damped elements are inhibited from ringing at their natural resonance frequency and ring for a few cycles only, at most. As a result of the damping, their overall signal amplitude is weakened and their frequency expands over a wider range – thus they are called broad-banded.

This type of transducer is primarily used to yield maximum near-surface resolution - excellent results are frequently obtained for many flaw detection applications.

Even when used with tuned, narrow-banded receivers as found in many flaw detector instruments, these transducers have sufficient frequency components of the nominal frequency to give more than adequate sensitivity and resolution for many flaw detection applications. Finally, these transducers will produce superior results for thickness gaging regardless of the type of receiver/amplifier.

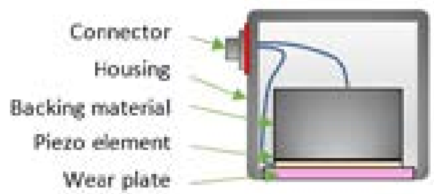
Such transducers include the letter "G" ((thickness) Gaging) in their part number.

Medium bandwidth - General Purpose - "F"

NDT Systems also offers a midway transducer for general purpose flaw detection, thus designated with the letter "F". These transducers offer the best combination of gain, sensitivity and resolution. It's signal amplitude and waveform duration represent a perfect compromise for the majority of flaw detection applications.

Transducer Types

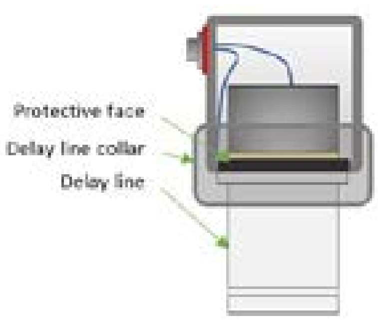
Generally speaking, the conventional ultrasonic non-destructive testing industry discerns between the following types of conventional ultrasonic transducers:



Contact transducers

Contact transducers represent the most basic as well as versatile ultrasonic transducer design. The piezo-electric element is essentially coupled to its backing material on the inner side of the transducer and to a durable wear plate on the lower side. The sound beam is transmitted into the material under test by coupling the wear plate to the material using couplant. This yields a strong signal from with a robust yet simple design.

Contact transducers are most frequently used on materials or structural forms which are relatively flat. Application examples would be thickness gaging on mill-finished wrought metals, forgings, extrusions and castings, lamination detection, material sound velocity measurements and through-transmission testing. These transducers are available in the following constellations:



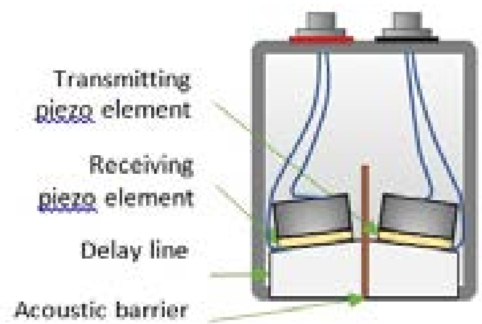
Delay line transducers

Delay line transducers feature a delay line – typically an acrylic cylinder – which is installed onto the face of the transducer. When a sound beam is emitted by the initial pulse of the piezo element, it travels through the delay line first prior to entering the material under test. The amount of time this takes allows the piezo element to stop ringing and thus be ready to receive a possible return echo by the time the sound beam enters the material under test.

This principle provides a considerable improvement precision thickness gaging and to the near-surface resolution. (For contact transducers, the initial pulse and the return echo would be located too close together and thus they would overlap and couldn't be discerned.)

Delay lines may also enhance physical access to hard-to-reach areas since their diameter is usually smaller than equivalent contact transducer housings. Further, the delay line tips can be made to very small diameters, allowing very precise flaw location as well as measurement of curved surfaces. Finally, delay lines made of special material allow high-temperature applications since the delay line separates and isolates a hot material under test from the piezo element.

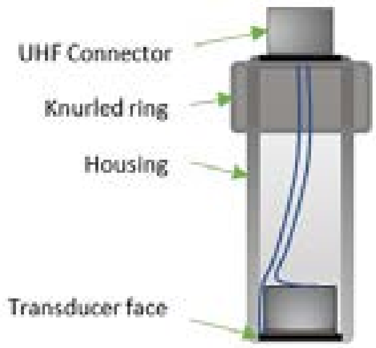
A disadvantage is that for one, the signal strength is weakened by the time it can be put to use, and second the delay line interface will generate undesired multiple return echoes which have to be identified as such within the echo return signal. The reasonable measurement range of delay line transducers is therefore limited by the length of its delay line - the echo from the tip of the delay line represents the end of the useful measurement range.



Dual element transducers

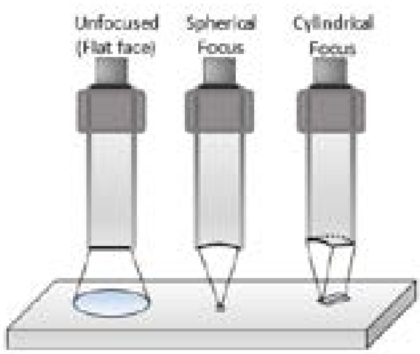
In a dual element transducer design, the elements typically have a semicircular shape, are separated by an acoustically isolating material and are each mounted on a short tip slightly angled towards another.

The purpose of dual element design in a transducer is twofold: A) Near-surface resolution is given because of the fact that one element emits a sound beam while the other one is at rest to receive an echo at any point in time. B) The fact that the sound path is not one-dimensional but travels along a V-path greatly improves the sensitivity towards non-perpendicular interfaces as found with corrosion for instance. The drawback of this design is the range limitation – because of the angled elements, a very distant interface will generate an echo which drifts sideways and will miss the transducer by the time it traveled back towards the surface of the material.



Immersion transducers

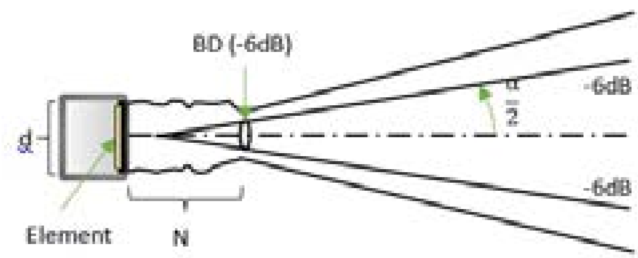
As their name implies, immersion transducers are used to conduct underwater inspections. The primary advantage is that the probe will essentially be surrounded by couplant, and thus it does not need to be in direct contact with the material under test. As a result, basically any geometry can be targeted, the material can be moved during an automated inspection and the uniform coupling under constant pressure provides uniform signal sensitivity.



For an unfocussed transducer, the distance to the test piece is not that critical while focused transducers provide increased sensitivity within a specific depth.

Unfocused immersion transducers

Unfocussed immersion transducers have fundamentally the same sound field characteristics as any other ultrasonic transducer.



$$N = \frac{d^2 \cdot F}{4 \cdot V}$$

$$BD\,(-6dB) = 1.028 * \frac{F * V}{N * d}$$

$$Sin\left(\frac{\alpha}{2}\right) = 0.514 * \frac{V}{F * d}$$

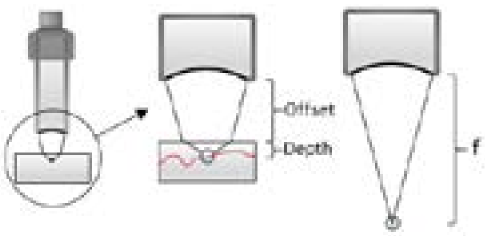
N:	*Near-field*
BD (-6dB):	*Beam diameter within -6dB boundaries*
α:	*Beam spread angle within -6dB boundaries*
d:	*Element Diameter*
F:	*Frequency*
V:	*Material Sound Velocity*

However, because of the fact that the sound velocity in water is much smaller than the sound velocity of most engineering materials (the longitudinal sound velocity in steel is about 4 times greater for instance), the length of the near-field is proportionally longer as per teh above equation. Further, beam divergence is also proportionally greater, causing significant energy dispersion between the transducer and the test object. Since the sound beam diverges in the far-field, unfocussed transducers are said to have their natural focus at the end of their near-field, N, since after that point both their energy/signal amplitude drops exponentially and their beam profile spreads proportionally.

Focused immersion transducers

In order to limit the energy losses occurring in the near-field of an unfocussed transducer and to actively control the length of the near-field altogether, immersion transducers are often used with a specific focus incorporated on the transducer face.

As mentioned earlier, the water sound velocity is considerably smaller than the velocity in most any materials under test. Therefore, as per Snell's Law, the sound will be further converged once it passes from water into the material. This effect needs to be well understood when determining the appropriate focal length prior to any application.



$$OFFSET = f - DEPTH \cdot \left(\frac{V_{Mat}}{V_{Water}}\right)$$

F:	*Focal length*
Offset:	*Distance from transducer face to material*
Depth:	*Distance from surface of material to flaw*
V_{Mat} :	*Material under test sound velocity*
V_{Water} :	*Water sound velocity*

As a result of this, the sensitivity of a focused sound beam and its ability to respond to very small discontinuities is much greater than the sensitivity of a divergent sound beam as found in an unfocused transducer. However, the volume of material being instantaneously illuminated by a focused beam is substantially smaller than that of a divergent beam.

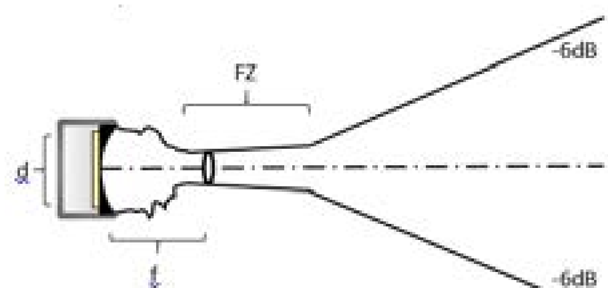
In water, a spherical lens focuses the sound beam towards a point and a cylindrical lens towards a line. The distance between the lens surface and the local point depends upon the spherical or cylindrical radius of the lens, as well as the size and frequency of the element.

The possible focal lengths for a certain transducer are dependent on its frequency and its piezo-element size. Because of the fact that no transducer rings at one single frequency, the realistic near-field length is shorter than the theoretical natural focal length Y_0^+. In fact, the more broad-banded the transducer, the shorter its relative focal length.

- The practical maximum listed in the table is limited to about ¾ of the theoretical natural focal length Y_0^+ of an equivalent unfocused transducer.

- There is also a practical minimum focal length that is effective, mostly driven by the smallest applicable lens. Both maximum and minimum practical limits of focal lengths are presented in the table below.

In practice, in neither case can the sound beam be focused precisely to a point or line. At or near the theoretical focus, the sound beam maintains its shape within a short zone called the "focal zone" before it diverges and disperses. The beginning and the end of the focal zone are defined by a 50% amplitude drop (or -6dB drop) from the peak amplitude found at the focal point.



$$N = \frac{d^2 \cdot F}{4 \cdot V}$$

$$BD\,(-6dB) = 1.028 \cdot \frac{F \cdot V}{f \cdot d}$$

$$FZ\,(-6dB) = N \cdot \left(\frac{f}{N}\right)^2 \cdot \left[\frac{2}{1 + 0.5 \cdot \frac{f}{N}}\right]$$

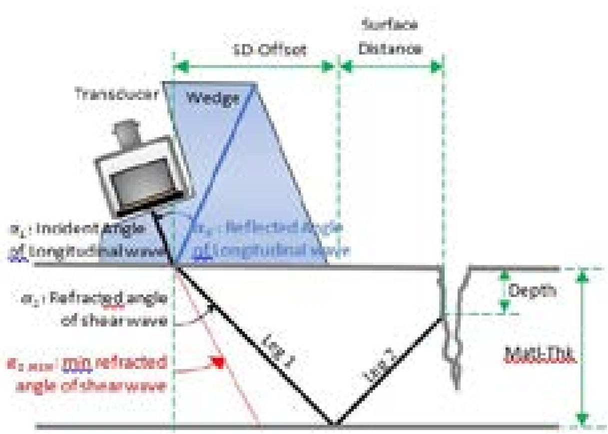
BD (-6dB): Beam diameter within -6dB boundaries
FZ (-6dB): Focal zone within -6dB boundaries

N:	*Near-field length (unfocused)*
f:	*Focal length*
F:	*Frequency*
V:	*Material Sound Velocity*

Shear wave transducers

Contact Angle Beam tests are a variation of contact testing whereby the sound beam is introduced into the test material at an angle. Plastic wedges of controlled geometry are attached to the transducer in order to establish the desired angle. NDT Systems' wedges are precision-machined to produce a refracted shear wave within the test object at specific angles, as indicated on the wedge or transducer housing. In some cases, the geometry of the material to be inspected will dictate the selection of the beam angle.

The beginning of this section explained the fundamental physics behind Snell's Law and how it affects refracted sound beams. In addition, it showed that once the incident angle reached a critical value for which the refracted shear wave angle is 90°, the law does not apply anymore. For incident angles beyond this value, the refracted angle remains 90°.
In practice, one ought to consider another limitation: For very small incident angles, the sound beam does not split well into a refracted shear wave as most of its energy remains in an undesired refracted longitudinal wave. With respect to these constraints, the industry-established refracted angles for any materials to be inspected are 30°, 45°, 60°, 70°. Again, surface waves represent a special case at 90°.



- Every time a sound beam passes from one material with V_1 to another material with V_2, there will also be an acoustic impedance change, and so there will be partial reflection. By definition, reflection means that the reflected sound beam keeps traveling in the same medium. In that case, $V_1=V_2$ and so $\alpha_1 = \alpha_2$,
- If ($\alpha_2 < \alpha_{2\ MIN}$), then basically the refraction does not produce a good shear.
- If ($\alpha_{2\ MIN} < \alpha_2 < 90°$), then the only wave produced is a shear wave.
- If ($\alpha_2 = 90°$), then the only wave produced is a close-surface (Rayleigh) wave.

In order to limit sound attenuation, the transducer frequency should be sufficiently low for shear wave applications. Typically, the frequency does not exceed 10MHz. The American Welding Society or (AWS) requires a 2.25MHz exclusively for angle beam applications.

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