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1.0. INTRODUCTION

NDT Systems thanks you for your purchase of the **NOVA TG900** Hand Held Ultrasonic Thickness Gage, a precision instrument that provides exceptional value and unmatched features. The TG900 provides ultra-high resolution (0.0001 inch/0.001 mm) in a light-weight, Bench Top thickness gage found only in larger, bulkier portables and bench-tops. A significant advantage offered by the Nova 900 is the bright LED thickness display. This display is very quick and easily viewable at a distance. The many additional features contribute to the exceptional ease of operation and flexibility in applications. The TG900's rugged design assures dependable performance for a wide variety of field and lab inspection requirements.

1.1 Principle of Operation

The NOVA TG900 enables measurement of thickness variations and other conditions that can impair the safety and function of countless structures, systems, and materials. Measurements are made with access to only one accessible surface of the test object. High frequency single-element contact and delay-line transducers can be used interchangeably to satisfy a multitude of applications.

1.2 Basics of Ultrasonic Thickness Gaging

The NOVA operates on a principle similar to Sonar, but at much higher frequencies (Megahertz range) and electronic speeds. An ultrasonic frequency sound-beam is generated which emanates from the transducer and is coupled into the test object.

High-frequency ultrasonic waves travel through monolithic materials at essentially constant velocities, depending upon the type of material supporting the ultrasonic wave. This fact provides the basis for accurately measuring the thickness of metals and some non-metals, with access to only one side of the test object.

The NOVA accurately senses the time interval between the initiation of a short pulse of ultrasonic energy into the test object and the time taken to travel through it. This time interval is short; for example, the velocity of ultrasound in steel is approximately one-quarter inch (6.3 mm) in one millionth of a second (one microsecond). Thus, in order for the NOVA to accurately measure steel thicknesses from as small as 0.0050 inch to 20.00 inches (0.25 to 25 cm), it must have highly stable and accurate timing circuitry. Think of it as a highly sophisticated, super-accurate stop-watch.

Attached to the NOVA is a cable connected to an ultrasonic transducer, or probe. The transducer has a thin wafer of a piezoelectric material at its surface. Piezoelectric materials convert short pulses of electrical energy into tiny mechanical displacements, and, conversely, from mechanical displacements into electrical impulses. The probe acts both as transmitter and receiver

When coupled to the surface of the test object – call it the *entry surface* – the probe receives a short-duration electrical pulse from the pulser in the NOVA. Fundamentally, the "clock" starts with this pulse. The ultrasonic sound-beam begins its transit within the test object, induced by the electrical-to-mechanical impulse generated by the transducer. The ultrasonic impulse travels through the test object at a velocity characteristic of the material. When it reaches a boundary – for example, the side of the test object opposite the entry surface – the *back surface* – it reflects (*echoes*) back toward the entry surface. As it impinges on the entry surface, the transducer senses the tiny mechanical echo displacement and converts it into a small electrical signal. In the receiver section of the NOVA, the "clock" is signaled to stop. The time interval between the start and stop is converted into a thickness measurement. The characteristic velocity of the test material – distance divided by time (e.g., inches or millimeters per microsecond) – divided by the round-trip transit time (microseconds) yields total distance traveled. Since the total transit path is twice the actual thickness, it is automatically divided by one-half and displayed as a decimal thickness. On test objects with smooth, parallel surfaces, the displayed thickness is true within the resolution of the last decimal place displayed.

This round-trip time of the echo is linearly correlated to the test material's thickness – the thicker the material, the longer the round-trip time. The NOVA's sophisticated circuitry precisely measures the round trip-time and compensates for the characteristic ultrasonic velocity of the material being gaged. The measured thickness is displayed, virtually instantaneously, on the digital display and in the units selected, either inches or millimeters.

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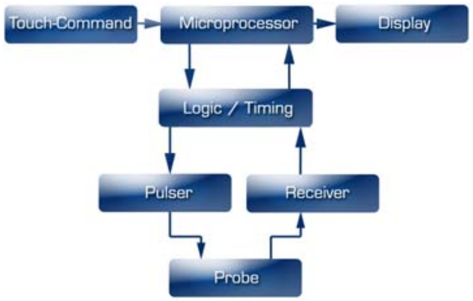

Functional Diagram

1.3 General Applications

The NOVA TG900 gages a wide range of thicknesses on metals, plastics, ceramics, glass or virtually any other material which satisfactorily conducts ultrasound, and has relatively parallel (or concentric) surfaces. Its high-resolution capabilities make the TG900 uniquely applicable to gaging very thin materials – for metals, as thin as 0.005 inch (0.13 mm) – with resolution of 0.0001 inch (0.001 mm). However, it can also be effectively used to gage thickness up to 20 inches (500 mm). Small, local thickness variations, such as those caused by corrosion, erosion, and certain types of internal flaws may also be detected.

The durable custom-extruded "Easy Grip" case design allows the unit to withstand the rigors of heavier industrial environments, while its accuracy makes it suitable for use in less rugged conditions.

General applications include:

- Aircraft Structural and Engine Components
- Aircraft Windows
- Rocket and Spacecraft Components
- Machined, EDM, Mechanically Formed Parts
- Ceramics
- Certain Composite Materials
- Glass Plate and Tubing
- Plastic Shapes and Piping
- Boiler and Pressure Vessel Components
- Heat Exchangers
- Pipes and Tubing
- Petroleum, Gas, Water, Waste Storage Tanks
- Railcar Axles and Wheels, Railroad Rails

- Building and Bridge Components:
- Primary Metal Forms: Plates, Slabs, Billets, Bars, Blooms, Forgings, Castings, Extrusions
- Ship Hulls, Decking, and Propulsion Components

1.4 Major Features

- Membrane-sealed TOUCH-COMMAND controls simplify setup and use.
- 128 x 64 pixel, high contrast, graphic Liquid Crystal Display (LCD) provides simple, plain text menus and easy readability of thickness data.
- Backlight – automatic, or on/off selectable.
- Ultra-portability – a pocket-sized, handheld instrument incorporating NDT Systems' "Easy Grip" custom extruded aluminum case.
- State-of-the-art microprocessor-based design offers unparalleled, high accuracy performance for numerous thickness gaging applications..
- Adjustable velocity setting.

The NOVA TG900 incorporates the latest technology available in microprocessor design. Through sophisticated on-chip programming, the microprocessor computes, linearizes, and directs processing operations at high speeds. It also offers intuitive, simplified setup, calibration, and operation via the TOUCH-COMMAND pushbuttons and simple Menus.

The high-powered transmitter (pulser), high-sensitivity receiver, and informative digital display function together with the microprocessor to produce exceptional performance from a compact, light-weight, precision measurement instrument.

2. GETTING STARTED

2.1 Lay Out Shipment Contents

Separate and lay out the NOVA TG900, probe(s), cable(s), couplant, and any other accessories ordered. The NOVA comes with two AA-size alkaline batteries installed in its battery chamber.

2.2 Connect Probe and Cable

All probes, with the exception of "Mini-Probes", use a detachable cable for connecting to the TG900. Connect the cable to the probe. Connect the other end of the cable to the corresponding receptacle located on top of the gage.

Various probes are available to optimize performance for the broad spectrum of gaging applications that may be encountered. The General Purpose Delay-Line Transducer (D11) can be used for most applications encompassing a thickness range in steel from approximately 0.0050 to 0.700 inch (0.130 to 1.780 mm), and for surface temperatures up to about 250ºF (120ºC). The General Purpose Contact Transducer (C11) has a range of approximately 0.062 inch to 20.000 inches (1.57 to 500 mm). It is recommended to use the C11 Contact Transducer for the familiarization and operation procedures that follow.

For the extensive listing of probes for higher temperature and specialized applications, see Section 9 of this manual.

2.3 Reference Standards

To calibrate the TG900, it is necessary to have one or more known thicknesses of the same material as that of the test object. Initial calibration procedures require reference samples representative of the material to be gaged.

Machined stepped-wedges having thicknesses across the range of interest are convenient and commonly used reference standards. For the purposes of familiarization with the TG900, it is recommended to use steel stepped-wedges having several steps with thicknesses ranging from 0.100 to 2.000 inches (2.50 to 50.00 millimeters). Other stepped wedges encompassing that general range of thicknesses can also be used. Such standards are readily available or can be custom-produced. Contact NDT Systems for further information.

For high-accuracy calibration and subsequent high-resolution measurements, Users of high-resolution instruments, such as those in the NOVA 900 Series, may be required to use thickness-certified precision gage blocks and shims.

NOTE: Selection and use of reference standards is of primary importance in order to calibrate and assure the accuracy of any ultrasonic thickness gage. For more detailed discussion on the selection and use of reference standards, see Section 6, Gaging Tips and Techniques, and Section 7, Gaging Precautions.

2.4 Using Couplants

A couplant film is needed to transfer the high frequency ultrasonic energy from the probe into the test material. Adequate probe coupling is essential to qualify the integrity of a thickness reading. Typically, couplant is applied to the test material surface, although it can be applied to the tip of the probe (as during some high temperature applications).

The type of couplant used is very important for optimum performance. Smooth material surfaces require a lower viscosity couplant, such as water, glycerin, oil, or similar fluid. Rougher surfaces may require use of grease or specially formulated gels. The couplant used must be compatible with the test material. While it is usually removed following inspection, remnant

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couplant residue can produce surface corrosion or discoloration of the test object. Special high temperature couplants should be used on surfaces above 175ºF (90ºC). NDT Systems offers numerous ultrasonic couplants which cover virtually all application areas for the TG900. These specially formulated couplants are recommended. Contact NDT Systems for further information.

3. OPERATION STEPS

3.1 Power On - Battery Check - Auto-Off

Momentarily depress the ON/OFF Touch Command. NDT Systems' Logo and contact information are displayed. After the system boots, the Measurement Display automatically switches on. If a probe is not connected when the gage is powered ON, a highlight in the Measurement Display reads, **NO PROBE**, and highlighted, **Attach NOVA Transducer**. Attach the appropriate cable and Probe. With a Contact-type transducer attached (C11, for example), the Measurement Display reads, **Contact**, has an irrelevant thickness measurement with **IN** (Inches) and, below that, **Velocity: 0.2330** (inch per microsecond). If metric units had been previously selected, the units will be displayed as **mm** (millimeters) and the Velocity will be 5.918 (millimeters per microsecond). Instructions for selecting measurement units are in Section 3.3.

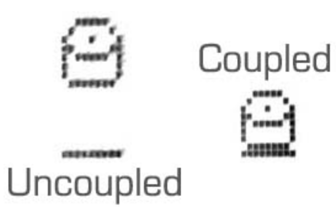
The Battery Level Indicator icon appears on the left side of the LCD display indicating the current battery charge state. The NOVA TG900 comes with two AA-size alkaline batteries installed in its battery chamber. If the Battery Level Indicator fails to register more than approximately 20% full-scale, it is recommended that the batteries be replaced. When power becomes marginal, the Power-Guard Cutoff feature automatically turns the power off until the batteries are replaced. If the TG900 fails to respond to the initial ON/OFF Command, the batteries should be replaced.

To turn the gage off at any time during operation, momentarily press and briefly hold the ON/OFF button. All previous settings are retained in memory and will be restored the next time it is powered up.

3.2 Probe Coupling

First, apply a small amount of couplant to a surface of the Reference Standard selected. If necessary, refer back to ***Section 2.4, Using Couplants****.* Before placing the probe on the Reference Standard, note the Coupling Icon on the right side of the display.

With the probe uncoupled, the Probe Coupling Icon appears as shown on the left, with a space between the probe symbol and the horizontal bar that represents the surface of the test object. When the probe is properly coupled, the Icon changes to that shown on the right. In this state, the Coupling Icon indicates satisfactory coupling, adequate



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material penetration, and proper probe/beam normalization (perpendicularity to surface). Thickness readings should not be considered reliable if the Coupling Indicator intermittently blinks, or flickers.

3.3 Basic Menu Selections and Controls

<u>**Function Key** – (**FUNC**):</u>

Backlight: With power ON, and the C11 Probe connected, press the FUNC key. At the bottom of the Measurement display, Velocity: will toggle to **Backlite:** . Pressing FUNC and either of the Arrow keys will toggle sequentially through **Auto**, **Off**, **On**. In the **Auto** mode the backlight will turn on automatically when the transducer has valid coupling with the test object, and will turn off automatically after approximately 5 seconds (after the displayed measurement has stabilized) and until the next measurement is made. In **Off**, the backlight will stay off indefinitely. In **On**, the backlight will remain on continuously whenever the gage is powered on. If the gage is being used in an area with high ambient light, there is no need to use the backlight. With the backlight turned **Off**, battery life will be extended.

Contrast : Overall contrast of the display can be adjusted if needed to accommodate unusual ambient viewing conditions. To select Contrast, press the Function key to display **Contrast:**. The UP Arrow key will increase contrast to a maximum of 30. The DOWN Arrow key reduce Contrast to 0. The effect will be seen as the contrast is changed. Setting the Contrast in the range between 25 and 30 will produce appropriate contrast for most ordinary conditions.

Units : To select the desired measurement units, inches or millimeters, press the Function key to display Units:. Either of the ARROW keys will toggle between **in** (for inches) and **mm** (for millimeters).

After making any Function adjustments, use the FUNC key to return to the Measurement Display with **Velocity:** displayed.

3.4 Calibration Procedures

Thickness Calibration: Couple the probe to an accurately known thickness on an appropriate reference standard within the expected thickness range. If necessary, refer back to ***Section 2.3***, ***Reference Standards***. Scroll with the Up or Down ARROW keys until the display precisely reads the reference thickness.

Velocity Calibration: Though infrequently used, if the ultrasonic velocity of the test material has been previously established or recorded, and reference standards are unavailable, velocity calibration will produce accurate measurements. To set velocity, while in the Measurement Display, the currently stored velocity value is displayed immediately below the thickness readout. The Up or Down ARROW keys can then be used to toggle or scroll velocity until the display precisely reads the known velocity value.

Since many factors can affect ultrasonic velocity, the Velocity Measurement procedure should produce significantly more accurate results than using published velocity data. If approximate gaging accuracy is acceptable, the use of published data, such as shown in the following Longitudinal Ultrasonic Velocity Table, can be considered.

This approach is reasonable for some of the simpler, more-rugged applications; for example, the gaging of mild steel or plain carbon steel alloys. Published velocity data will be found to differ somewhat in different publications. This is due to chemical or physical variations within the material that are within the range of acceptable compositions for a particular alloy.

Velocity Measurement: To accurately measure the Longitudinal Ultrasonic Velocity characteristic of any particular material, it is necessary to have a sample of the material having known composition, and, if a metal, the heat treatment condition. Case-hardened, coated, or plated samples are not acceptable. Both front and back surfaces should have a fine finish, such as that produced by finish surface grinding. The surfaces should be flat and parallel. The ideal nominal thickness of the sample should be approximately 0.3 to 1.0 inch (7.5 to 25.4 mm). The precise thickness should be determined to at least 0.001 inch (0.01 mm) accuracy using an appropriate measurement tool.

Couple the probe to the surface of the reference sample, and, using the Up/Down ARROW keys, scroll or toggle to the known thickness. As the displayed thickness is adjusted to the known thickness, note that the velocity value, displayed immediately below the thickness readout, If the gage has been set to English units (inches), the velocity value will be displayed as a number having four decimal places. If millimeters were set, the velocity will have three decimal places. The units of velocity are inches per microsecond (in/µs), or millimeters per microsecond (mm/µs).

Longitudinal Ultrasonic Velocity Table
(At Room Temperature)

Material	Velocity - in/µs	Velocity - mm/µs
Acrylic Resin	0.105	2.67
Aluminum	0.249	6.32
Naval Brass	0.174	4.43
Phosphor Bronze	0.139	3.53
Cast Iron	0.181	4.60
Copper	0.183	4.66
Window Glass	0.267	6.79
Inconel	0.225	5.72
Wrought Iron	0.232	5.90
Magnesium	0.248	6.31
Monel	0.237	6.02
Nickel	0.222	5.63
Mild Steel	0.232	5.90
4340 Steel	0.230	5.85
CRES 303	0.233	5.66
Titanium	0.239	6.07
Zirconium	0.183	4.65

4. GAGING TIPS AND TECHNIQUES

4.1 Reference Standards

The more closely the reference standard matches the actual test material, the better the gaging accuracy. For metals, to compensate for variations such as composition, microstructure, heat-treat condition, grain direction, thickness range, surface roughness and geometry, the ideal reference material would be samples produced from pieces of the actual material to be tested. This type of reference standard is used for critical applications requiring maximum gaging accuracy.

For many applications, satisfactory gaging accuracy can be obtained by using a single reference sample. This sample should have the same composition and geometry as the actual test object. Reference standard thicknesses should be measured using a micrometer or similar device to accurately establish known thicknesses. If a thickness range is anticipated, use a reference sample that represents the thicker end of the range.

Machined stepped-wedges having thickness steps across the range of interest can frequently be used provided they are of the same general composition as the test material. Experimentation with known thicknesses of the test objects is recommended.

When gaging thin materials that approach the lower performance limits of the gage/probe combination, experiment with reference samples to determine the actual lower limit. Do not attempt to gage materials thinner than this limit. See **Very Thin Sections** in **Section 5, Gaging Precautions**.

For exceptionally large thickness ranges, particularly in alloys where microstructure variations can occur, use separate samples and calibration setups at selected intervals across the range.

Many wrought and cast metal microstructures exhibit directionality, depending upon the beam direction, that causes a slight variation in ultrasonic velocity. For improved accuracy, reference samples should have the same directionality/sound beam orientation as that of the material to be gaged.

4.2 Test Surface and Geometry Considerations

Surface Condition: Prior to gaging, remove performance-hindering foreign substances from the material surface; e.g.: dirt, loose scale, corrosion, soil, flaking paint.

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Excessive surface roughness can cause erratic, extremely low, or no thickness readout. In such cases, consider scraping, sanding, grinding or filing the surface smooth enough to obtain a proper response (provided such a procedure and the amount of material removal are acceptable). Best results can be achieved by using the Contact Mode. First, try using a high-viscosity couplant. Adjusting the receiver gain may also remedy the problem. Use the GAIN control located in the MODIFY Sub-Menu. The Contact Hi-Power Probe (C17) may also significantly improve the response.

Surface Geometry - Cylindrical Shapes: For gaging on cylindrical shapes such as pipe, tubing, small diameter tanks, etc., it is vital to establish probe normality (perpendicularity to surface). To determine normality, rock the coupled probe back and forth in the direction of curvature and observe the accompanying decrease/increase the thickness readout. Use the minimum thickness reading, as this represents probe normality.

Surface Geometry - Compound Contours: For gaging on convex surfaces such as piping elbows and spherical shapes, rock the probe for a minimum reading in both the circumferential and longitudinal directions, and use the smaller of the two minimum readings. Successful gaging on concave surfaces depends upon the degree of curvature. If reliable coupling cannot be achieved, the use of special probes may be required. Various Mini-Probes are available that may suffice, but it is not feasible to absolutely specify the minimum radii to which they will successfully apply.

Non-Parallel Surfaces: The surfaces on both sides of a section must be relatively parallel or concentric in order to obtain a satisfactory ultrasonic echo for a thickness reading. Non-parallel or tapered surfaces will produce less accuracy or no reading at all.

4.3 Material Temperature Effects

Both the dimensions and, especially, the ultrasonic velocity, of a material change with temperature, which, in turn affects calibration and gaging accuracy. This undesirable effect holds true for the material being gaged as well as for the probe. Although it is always good practice to re-calibrate for significant changes in ambient temperature, the effect can normally be ignored for modest changes.

The situation becomes more complex when the material temperature is considerably different from ambient. One solution is to calibrate on a reference sample at the same temperature as the material. Another solution is to calibrate on a reference sample at ambient temperature and then add an experimentally derived correction factor for the temperature of the material.

4.4 Additional Test Material Factors

Excessively Attenuative Materials: Some materials (fibrous, porous, large-grained, etc.) may absorb or scatter so much ultrasound that either a reading cannot be obtained or some abnormal reading (usually abnormally thin) occurs. In such cases, use the Contact Mode, and, if necessary, the C17 Hi-Power Probe.

Grain Directionality Effects: In both wrought and cast metals, the microstructural properties frequently are directional. The ultrasonic velocity (thus, gage calibration) may differ within the material, depending upon the ultrasonic beam direction with respect to the grain direction. For optimum measurement accuracy, calibrate, and subsequently gage, in the same material grain direction.

5. GAGING PRECAUTIONS

5.1 Very Thin Sections

As with any ultrasonic thickness gage, when the sectional thickness falls below the minimum operating thickness for the specific probe in use, erroneous readings will result. It is virtually impossible to precisely specify the minimum thickness which can be gaged with a given probe/TG900/material combination. The minimum thickness limit can be closely approximated by experimentation on the test object or reference standards of the same material, and using different probes.

One erroneous effect, called "thickness doubling", sometimes occurs when gaging thicknesses fall below the minimum limit. Another effect "pulse-envelope cycle-jumping" produces a reading somewhat larger than the actual thickness. If the thickness measurement is either significantly greater or less than expected, try switching transducers from Contact to Delay-Line or vice-versa.

5.2 Pitting Corrosion

Pitted areas on the test object's back surface can cause unexpected erratic changes in thickness readout, or, in extreme cases, no thickness readout. Very small, or sharply pointed pits may go undetected, especially small, isolated single pits. When pitting is either detected or suspected, the area should be very carefully scanned. To more fully evaluate suspected

corrosion, use an instrument having an A-Trace.

5.3 Material Misidentification

Always verify the type and anticipated thickness of material to be gaged. Erroneous thickness readouts can result if an instrument is calibrated on a material and/or thickness other than that of the test material.

5.4 Worn or Malfunctioning Probes

Immediately replace any probe that is malfunctioning, or showing excessive or uneven wear.

5.5 Material Stacks

It is not possible to gage the stack thickness of uncoupled material sheets piled upon one another. Ultrasound reflects totally from the back surface of the outer sheet. Likewise, it is not recommended to attempt to gage bonded laminates – layers of similar or dissimilar materials adhesively bonded. Depending upon the adhesive properties, it may be possible for the instrument to receive an adequate back-echo to be able to read the thickness of the outer layer. However, for reliable ultrasonic testing of laminates, it is recommended to use an instrument having an A-trace.

5.6 Plated or Painted Materials

If a surface has plating of known and uniform thickness, it can be possible to obtain accurate and reliable thickness measurement of the substrate material. However, appropriate reference standards are necessary. If, for any reason, the plating is separated from the basis material, the readout, if any, will be erratic or unstable.

Painted surfaces may, or may not, create gaging problems. It is essential to experiment with reference samples having the same condition as the test material.

5.7 Abnormal or Unusual Thickness Readings

The operator should always qualify abnormal or questionable thickness indications. While such indications may be legitimate, they should be carefully evaluated. If an unexpected indication is seemingly random, or cannot be reproduced, it was possibly caused by a couplant break or a small foreign particle on the surface. If it can be reproduced, even if erratic, it should be further evaluated. *Something* caused the strange or erratic, but location-reproducible, indication.

6. ACCESSORIES

6.1 Standard Accessories:

The standard NOVA TG900 Kit contains the gage (batteries installed), Standard Probe, Probe Cable, Couplant Container, and User's Operating Manual.

6.2 Optional Accessories:

Transducers and Probe Cables are required accessories. They are not included due to the broad based nature of the applications the TG900 can address. Other accessories include the EZDoc Instrument Docking Station, Spring-Loaded V-Groove Probe Housings, and a Slip-On Protective Leather Case for the gage. Contact NDT Systems for a complete list of available options.

7. PROBES AVAILABLE

The following Probes are in-stock at NDT Systems. For high resolution applications, the D11 General Purpose Delay-Line suffices for the majority of applications. However, within limits, some Contact transducers can also be used to produce high resolution. The C11 General Purpose Contact probe complements the D11 Delay-Line applications. Often, when gaging problems are encountered, many can be readily overcome by using an alternative or special-purpose probe. Contact NDT Systems' Application Analysis Department for specific guidance.

MODEL	TYPE/DIGITAL RESOLUTION (INCH)	NOMINAL THICKNESS RANGE-IN.[2]	DESCRIPTION/APPLICATIONS [1]	NOM. FREQ. MHz	ELE. DIA. (INCH)	HOUSING SIZE (INCHES)[5]	
						DIAM.	HGT.
D11	Delay Line 0.0001	0.0050-0.700	General Purpose For Thin Relatively Smooth Materials. Permanent Delay Line.	15	0.250	0.45	0.81
D11TC	Delay Line 0.0001	0.0050-0.7000	D11 With Top-Mounted Connector	15	0.250	0.45	0.90
D11R	Delay Line 0.0001	0.0050-0.7000	D11 With Replaceable Delay Line. Body Dia..0.45; Tip Dia. 0.29.	15	0.250	0.50	0.90
D11RTC	Delay Line 0.0001	0.0050-0.7000	D11R With Top-Mounted Connector.	15	0.250	0.50	1.12
D11L[3]	Delay Line 0.0001	0.0050-0.7000	D11 With LED Alarm Light.	15	0.250	0.45	1.19
D12	Delay Line 0.0001	0.0050-0.3000	Same As D11 With Smaller Size Element & Housing; Top-Mounted Connector. Tip Diameter 0.25.	15	0.188	0.32	1.16
D13R	Delay Line 0.0001	0.0400-1.0000	Lower Frequency, Replaceable Delay Line For Attenuative Materials With Relatively Smooth Surfaces. Useful On Plastics. Body Diam. 0.69; Tip Diam. 0.55.	10	0.500	0.89	1.25
D15	Delay Line 0.0001	0.0050 -0.2500	Similar To D11 But Specifically Used For Plastic-Backed Metals (As In Chem-Mill Applications Or Bonded Face Sheets In Laminates).	15	0.250	0.45	0.70
D15L[3]	Delay Line 0.0001	0.0050-0.2500	D15 With LED Alarm Light.	15	0.250	0.45	1.20

MODEL	TYPE/DIGITAL RESOLUTION (INCH)	NOMINAL THICKNESS RANGE-IN.[2]	DESCRIPTION/APPLICATIONS[1]	NOM. FREQ. MHz	ELE. DIA. (INCH)	HOUSING SIZE (INCHES)[5]	
						DIA.	HGT.
D16R	Delay Line 0.0001	0.0260-1.1000	Similar To D11R With Extended Delay Tip. Extends 0.0001 Resolution To More Than 1.00 Thickness (Steel). Body Diameter 0.45; Tip Diameter 0.29.	15	0.250	0.45	1.00
D17	Delay Line 0.0001	0.0220-0.7000	Similar To D15. Produces Greater Penetration; Useful On Plastics, Other More Attenuative Materials.	15	0.250	0.45	0.81
D20R[6]	Delay Line 0.0001	0.0050-0.7000	D11 With Replaceable Delay Line. Body Dia. 0.45; Tip Dia. 0.125.	15	0.125	0.50	0.90
C11	Contact 0.001	0.062-19.999	General Purpose; For All But The Most Attenuative Materials.	5	0.375	0.63	0.56
C11L[3]	Contact 0.001	0.062 - 19.999	C11 With LED Alarm Light.	5	0.375	0.63	0.96
C11E	Contact 0.001	0.062-1.000	For Thickness Measurement Of Cylinder Walls From Cylinder ID, Convex Cylindrical Face, Approximately 2" Radius.	5	0.125x0.375 Rectangular	0.63	0.56
C13	Contact 0.001	0.062-19.999	General Purpose, Similar To C11 But Smaller Size.	5	0.250	0.45	0.55
C14	Contact 0.001	0.062-2.000	General Purpose, Sub-Miniature; Similar To C11 And C13 But Smaller. Has Top-Mounted Connector. Tip Dia. 0.25.	5	0.125	0.32	1.16
C16	Contact 0.001	0.200-19.999	For Relatively Thick, More Highly Attenuative Materials (Castings, Plastics).	2.25	0.500	0.75	0.61
C16L[3]	Contact 0.001	0.200-19.999	C16 With LED Alarm Light.	2.25	0.500	0.75	1.05
C17	Contact 0.010	2.00-99.9	Very High Power For Thick, Attenuative Materials or Long Rods.	2.25	0.500	0.75	0.61

MODEL	TYPE/DIGITAL RESOLUTION (INCH)	NOMINAL THICKNESS RANGE-IN.[2]	DESCRIPTION/APPLICATIONS[1]	NOM. FREQ. MHz	ELE. DIA. (INCH)	HOUSING SIZE (INCHES)[5] DIA.	HGT.
DM-123 [4]	Delay Line 0.0001	0.0050 - 0.4000	Swivel-mounted on a 4.00" long handle for stacked turbine blades & other difficult to reach surfaces. Recommended for use only with oscilloscope monitoring Nova output. Body size 0.30" x 0.50"; Tip size 0.13" x 0.35".	15	0.125 x 0.313 Rectangular	--	0.35
IBU-25* [4]	Immersion 0.0001	0.0100 - 0.2000	High resolution, sharp focus immersion transducer with plastic cone bubbler. Recommended for use only with oscilloscope monitoring NOVA output.	20	0.250	0.88	2.10
AEX-01C [6]	Delay Line 0.0001	0.0230 - 0.1250 [7]	Focused delay line transducer, delay tip tapers to .060" diam. contact surface. special purpose for thin, smooth flat or curved surfaces. Useful for accessing small diam. recesses, etc. Replaceable delay tips.	15	0.188	0.350	4.00
AEX-03C [6]	Delay Line 0.0001	0.0230 - 0.1250 [7]	Focused delay line right angle transducer, delay tip tapers to .060" diam. contact surface. Special purpose for thin, smooth flat or curved surfaces. Useful for accessing small diam. recesses, etc. Permanent delay tip.	15	0.188	0.350	4.00
AEX-02C [6]	Delay Line 0.0001	0.0230 - 0.1250 [7]	Focused delay line transducer, delay tip tapers to .060" diam. contact surface. Special purpose for thin, smooth flat or curved surfaces. Useful for accessing small diam. recesses, etc. Permanent delay tip.	15	0.188	0.350	4.00

8. MAINTENANCE:

Normal maintenance consists of little more than keeping the gage surfaces and probes clean. The probes and cables should be inspected periodically, and replaced, if excessively worn.

Battery life depends upon the type, freshness, and quality of the batteries used, and, to a lesser extent, upon some of the features used. If the backlight is used extensively, battery life will be reduced. See Section 4.1, Power On - Battery Check - Auto-Off.

To change batteries, loosen the large cap-screw on the bottom of the gage with a coin or screwdriver. Remove the discharged batteries and replace them with two new disposable AA-size alkaline batteries. Install them with the positive (+) polarity inward. Replace and tighten the battery chamber cap-screw. If the batteries are completely discharged, removed, or replaced, re-establish calibration settings. Other previous settings will be retained.

WARRANTY

NDT Systems, Inc. (hereinafter, NDT Systems) warrants that reasonable care was used in the choice of materials and the manufacture of this instrument, and that the instrument conforms to the published ratings and characteristics applicable to the instrument at the time the instrument is shipped to the Buyer. This warranty shall extend for a period of one year from the date of shipment of the instrument (FOB Seller's plant) and shall in no event extend beyond such term. The Buyer shall notify NDT Systems by registered or certified mail, return receipt requested, of any claim of discovery of such defect. Failure to notify NDT Systems within the time and in the manner specified herein shall constitute a waiver of any such claim of defect or breach of warranty. The final determination of the existence of a defect or breach of this warranty shall be made by NDT Systems. This warranty shall extend to the Buyer only, and shall not be assignable or transferable to any other person.

DISCLAIMER OF WARRANTIES
There are no warranties, expressed or implied, including any implied warranty of merchantability or fitness for a particular purpose other than those warranties set forth in the paragraph above. The above warranty shall not apply to digital panel meters and items with a limited life, such as batteries, probes or cables, nor to any instruments which have been subjected to misuse, improper installation, or repair, alteration, or use beyond the published maximum ratings of the instrument.

BUYER'S REMEDIES
The Buyer's sole and exclusive remedy for breach of the above warranty shall be the repair or replacement (at the discretion of NDT Systems) of the instrument by NDT Systems, free of charge. The Buyer shall return the instrument to NDT Systems, transportation prepaid. NDT Systems shall promptly repair or replace the instrument and return same to Buyer, FOB Seller's Plant, collect.

If, for any reason, NDT Systems is unable or unwilling to repair or replace the instrument, or because of circumstances, the exclusive remedy provided herein fails of its essential purpose, or operates to deprive either party of the substantial value of its bargain, then the Purchaser's exclusive remedy will be the return of the purchase price for the instrument. The liability of NDT Systems shall, in no event, be greater than the full amount of the purchase price for the instrument.

Any attempt by NDT Systems to repair or replace any instrument sold hereunder shall not constitute an admission that the instrument, or any part thereof, is defective within the meaning of the above warranty, nor that NDT Systems has any legal responsibility to make such repair, or effect such replacement.

Any such attempts, if unsuccessful, shall not create any liability on the part of NDT Systems, and the purchaser is limited to the remedy set forth herein.

LIMITATIONS ON LIABILITY
NDT Systems shall not, under any circumstances, be liable for direct, incidental, or consequential damages for any breach of contract, breach of warranty or misrepresentations, including the negligence of NDT Systems, and including, but not limited to damages resulting directly or indirectly from the use, or loss of use of the instrument sold hereunder, or the business of the Buyer or third persons wherein the instrument is utilized.

The above warranty and the obligations of NDT Systems hereunder, are expressly in lieu of, and the Buyer expressly waives, any other liability of NDT Systems based upon warranty, expressed or implied, contract, or the negligence of NDT Systems, including but not limited to negligence in the design of the instrument, or in the choice of the materials therefor, or negligence in the repair or replacement of the instrument, whether such repair or replacement is required by the terms hereof, or is voluntary, upon the part of NDT Systems.

Except as provided herein, no person is authorized to assume, on behalf of NDT Systems, any other, or additional liability or responsibility in connection with the instrument. These terms and warranty are applicable to, and complete acceptance of, such a binding legal agreement.

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