Glass-Chek *ELITE*

Glass Thickness Meter and Low-E Detector with Laminates

Operating Manual

The Glass-Chek ELITE enables you to measure glass and air space thickness of single, double, triple, and quad pane windows from a single side. The GC3200 allows you to determine the presence, location and type of invisible low-E coatings, as well as identify and measure laminated glass (including the inner-layer thickness). There are numerous other applications described within this operating manual.

This manual will outline how to use the meter, including choosing language and measurement settings, explanations of "results" screens, proper use, and maintenance of the meter. Additionally, it will outline appropriate applications, technical details and warranty information. This Operating Manual is available in English, German, Spanish and French.

ENGLISH: To download the user manual in ENGLISH, please go to our website at:
DEUTSCH: Die Bedienungsanleitung in deutscher Sprache erhalten Sie auf unserer Webseite unter:
ESPANOL: Para descargar el manual del usuario en español, por favor, vaya a nuestro sitio web:
FRANCAIS: Afin de télécharger le manuel en français, rendez-vous sur notre site internet à l'adresse:

http://www.edtm.com/index.php/support/user-manuals

Table of Contents

Results display: DATA
- Digital measurement results of the glass, air space, laminate and overall IG thickness
- Also displays the type of Low E coating in the window, and the surface location

The ARROW keys are used to:
- Scroll between measurement result screens (forward and backwards)
- Press & Hold to enter the MENU system
- Move the cursor up and down in the MENU
- Toggle between options in the MENU

Results display: DIAGRAM
- A profile drawing of the window is shown at the bottom of the graphical display
- Each piece of glass is assigned a number
- Each glass surface is assigned a number for better understanding of the measurement results.
- Glass and Surface numbers match the DATA results shown at the top of the display
- Glass surface number will **BLINK** on the diagram if it is a Low E Coated surface
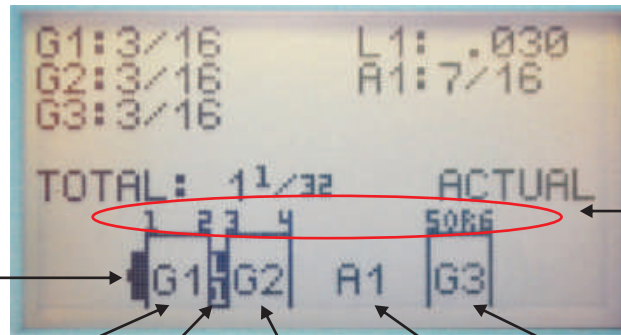
The POWER button is used to:
- Turn the power ON (Momentary press)
- Turn the power OFF (Press & Hold)
- Take a measurement (Momentary press)
- Make a selection in the MENU

Explanation of the Results Screen

Glass thickness typically shown in the left column

Air Space and Laminate Inner Layer thickness typically shown in the right column

Graphic display shows the position of the meter on the window.

Any identified Low E Surfaces will BLINK on the graphic display to show the location.

GLASS #1   LAMINATE#1   GLASS #2   AIR SPACE #1   GLASS #3

MENU OPTIONS

There are various OPERATING MODES and user-selectable options that will make your experience with the Glass-Chek ELITE more convenient. All of these options are available in the MENU system. To access the MENU system, turn the meter on by pressing and releasing the POWER BUTTON and wait for the WELCOME screen to complete its display. The WELCOME screen will show you the version of software that is in your meter, as well as confirm the current OPERATING MODE that the meter is operating in. Be sure you have selected the proper operating mode for your application. Choosing the wrong mode can result in incorrect measurement results, or no results at all. Remember if you change the operating mode, it will stay in that mode for all future measurements, until you change it again by entering the MENU system. Powering the meter OFF will NOT reset the operating mode.

WELCOME SCREEN

MEASUREMENT REMINDER SCREEN
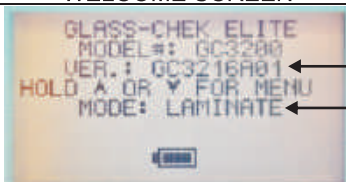
software version #

current operating mode

After the WELCOME SCREEN, the meter will go to its measurement reminder screen, reminding you to **place the GC3200 meter at the bottom center of the window for ALL MEASUREMENTS!!** This is the preferred measurement location that should be used for ALL MEASUREMENTS. Testing in this location will eliminate effects from glass that is flexing inward, resulting in a concave glass surface. The most accurate measurements of a window will be obtained in this location when using the GC32000 meter.

After the measurement reminder screen appears, PRESS and HOLD one of the ARROW buttons for several seconds until the ENTERING MENU screen appears. Release the ARROW button once that screen appears. You can enter the MENU system any time the meter is powered on by pressing and holding one of the ARROW buttons. Please note that you may need to hold the ARROW button down for several seconds before entering the MENU system.

Navigating Through the Menu

A small arrow will appear next to the top option. In the illustration below, the arrow is next to the "MODE" option.
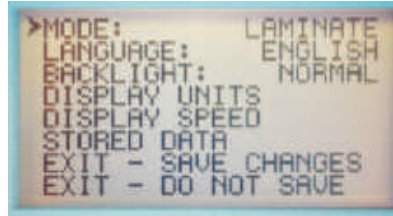

To move the cursor from line to line, press the UP or DOWN arrow buttons to navigate through the MENU. To select an option, press the POWER button one time. Once a category is selected, your options will be displayed. Use the ARROW buttons to scroll through the available options for that selection. Once you have the desired option on the display, press the POWER button one time to select that option. You will then move back one level in the MENU system. If you make a selection by mistake, press the POWER button again to select that option a second time and make your correct selection. Once you are finished making changes, use the ARROW buttons to move to the EXIT options: "EXIT - SAVE CHANGES"   OR   "EXIT - DO NOT SAVE".

Selecting Unit of Measure:

The GC3200 can display thickness measurements in various units. You also have the option of rounding measurements to the nearest "Glass Thickness Standard" (Refer to GC3200 Glass Standards chart on page 16). To choose the display units appropriate for your application, follow these steps:

In the MENU, select the "DISPLAY UNITS" option. The sub-menu to the right will be displayed:
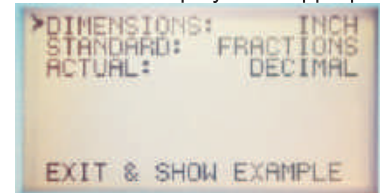
First, select the "DIMENSIONS" option by pressing the POWER button. Choose if you want your unit of measure to be **millimeters or inches**. Use the ARROW keys to toggle between units and press the POWER button to make your selection.

Next, determine whether you want the meter to: 1.) round measurements to the nearest Glass STANDARD, 2.) display the ACTUAL glass thickness dimensions or 3.) display both STANDARD and ACTUAL. To turn STANDARD rounding on or off, select the "STANDARD" option. If your dimensions are set to inches, you will have the options: FRACTION, DECIMAL or OFF. If your dimensions are set to millimeters, you will have the options: ON or OFF. Use the ARROW button to find your desired setting and press the POWER button to select it. PLEASE NOTE, if the STANDARD option is selected in inches, the glass thickness designations will always be shown in fractions. If decimal inches are chosen, only the air space thickness and overall IG unit thickness will be shown in decimal inches. The glass thickness will always be shown in fractions of an inch when STANDARD is turned on.

Next, choose your ACTUAL setting. If this setting is activated, your meter will display actual glass thickness dimensions without rounding. If your dimensions are set to inches, you will have the options: FRACTION, DECIMAL or OFF. If your dimensions are set to millimeters, you will have the options: ON or OFF.   Use the ARROW buttons to find your desired setting and press the POWER button to select it.

NOTE: STANDARD and ACTUAL cannot both be set to OFF. If they are both activated, the measurements will alternate on the screen after a measurement has been taken. For an illustration of this feature, see the "Measurement Examples" section.

When you exit the Display Units menu, the meter will show an example of what the measurement results screen will look like according to your selections. This will help you determine whether you chose the correct options. Press the POWER button to exit the example display.

Results Screen Display Speed:

Measurement results are displayed across multiple screens. These screens can be controlled two different ways. If you take no action, the screens will automatically advance from one to the next. If you do not want to wait for the screen to advance, you can use the ARROW keys to advance or go back to a previous screen. If you let the meter advance the screens for you, the speed at which these screens advance can be set in the MENU system.   Select DISPLAY SPEED in the MENU. You can independently select the number of seconds you want the THICKNESS measurement screens to display as well as the LOW-E results screen. Use the ARROW keys to change the time, and then press the POWER button to confirm the selection. Exit when complete to go back to the main MENU. PLEASE NOTE: If you would prefer that the meter only advances to the next result screen when you push the ARROW key, then change the Result Screen times to the maximum value of 60 seconds for both the THICKNESS and LOW E screens. This will maximize the time each screen is displayed, allowing you to advance the screens via the ARROW buttons when ready (as long as you do so before 60 seconds).
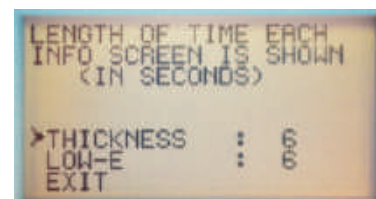
Operating Modes

Depending on your application, you may need to choose a different operating MODE. In the MENU, select MODE by pressing the POWER button. Then use the ARROW buttons to scroll through all of the available MODE options. Here is a list of the MODES you can choose from, as well as an explanation of the applications you would select for each MODE.

| MODE	APPLICATIONS
1. LAMINATE	1. This is the default MODE the meter is shipped in. This MODE allows the meter to search for and measure laminated inner layers in the window you are testing. This MODE will test for laminate inner layers in single pane applications, as well as if the laminated glass is included in an insulating glass unit (IG). The meter can also identify more than one laminated pane of glass in double and triple pane applications. While this MODE is called LAMINATE, the meter will still test regular glass and windows in single, double, and triple pane applications that do not include a laminate inner layer. Note that searching for laminate inner layers will extend the amount of time it takes to complete a measurement. Typically thinner glass will test the fastest, while thicker glass such as 1/4" (6mm) will take a little longer. If you know the windows you are testing do not include laminated glass, switching to NORMAL GLASS (NO LAMI) MODE will result in faster measurements. DO NOT use LAMINATE MODE to test glass that has multiple laminate inner layers in the same piece of glass, such as bullet resistant or fire rated glass. Choose MULTI-LAMINATE MODE for those applications.
2. NORMAL GLASS (NO LAMI)	2. If you know your applications will NOT include laminated glass, and you want the fastest measurements possible, choose NORMAL GLASS MODE. This mode will test single, double and triple pane (IG) windows without taking the time to search for laminate inner layers. If you use this mode to test laminated glass, the meter will display the overall thickness of the laminated glass, but not identify it as laminated glass nor provide details about the inner-layer thickness.
3. MULTI-LAMINATE	3. If the piece of glass you are testing contains more than one (1) laminate inner layer, choose this MODE. Common applications for this MODE include bullet resistant, blast resistant, or fire rated glass that contains numerous glass and laminate inner-layers. PLEASE NOTE, in this MODE you can only test monolithic assemblies. You can not test multi-laminate glass that is inserted into an IG. If you attempt to test an IG with multi-laminate layers, it will cause a mistake in the GC3200 measurement results. If you need to know the air space of the IG, change the MODE to NORMAL GLASS (NO LAMI), and the GC3200 will measure the IG as a regular double pane window, including the air space. See the application examples on Page 10 and 11 in this manual for further explanation.
4. LAMI + LOW E	4. Select this MODE if you are testing a laminated piece of glass that has a Low E coating placed against the laminate inner layer (Surface 2 or 3). This MODE will estimate the thickness of both pieces of glass in the assembly, and also identify if the Low E coating is on Surface 2 versus Surface 3. **PLEASE NOTE: ONLY USE THIS MODE WHEN THE LOW E COATING IS PLACED AGAINST THE LAMINATE INNER LAYER. USING THIS MODE ON ANY OTHER GLASS COULD CAUSE ERRORS IN YOUR MEASUREMENT RESULTS.**
5. REFLECTIVE SINGLE PANE (1G)	5. If you are testing commercial glazing that is very reflective (mirrored surface) this MODE will allow you to get measurements on monolithic glass. The NORMAL and LAMINATE MODES typically can not measure mirrored/reflective glass, or will give inaccurate results.
6. REFLECTIVE DOUBLE PANE (2G)	6. If you are testing an IG in a commercial application that includes the reflective (mirrored) glass, then select this MODE to measure the glass and air space thickness of the window. In this MODE, the meter will not identify the type of low e coating that is used in the window.
7. DARK GLASS SINGLE PANE (1G)	7. For applications with dark glass, the NORMAL or LAMINATE MODE may not be able to measure the glass thickness. If you have a single monolithic piece of glass that has a low Light Transmission value, try using this MODE. Do NOT attempt to test Insulating units in this MODE, as an ERROR will occur.
8. DARK GLASS DOUBLE PANE (2G)	8. For applications with dark glass, the NORMAL or LAMINATE MODE may not be able to measure the glass and air space thickness. If you have a known dual glazed IG that has a low Light Transmission value, try using this MODE. Do not attempt to test monolithic or triple pane insulating units in this MODE.
9. DARK GLASS TRIPLE PANE (3G)	9. For applications with dark glass, the NORMAL or LAMINATE MODE may not be able to measure the glass and air space thickness. If you have a known triple glazed IG that has a low Light Transmission value, try using this MODE. Do NOT attempt to test monolithic or double pane insulating units in this MODE, as an error could occur.
10. DARK GLASS LAMI SINGLE PANE (1G)	10. If you have a single piece of laminated that is dark, select this MODE. This MODE will only test monolithic pieces of laminated glass, and is designed for testing glass with low Light Transmission levels. For the best results, test the side of the laminate that contains the clear piece of glass.
11. SUSPENDED FILM	11. If you encounter a window that has film (polyester) suspended between the panes of glass, use this MODE to measure the glass and multiple air spaces that occur in the window. In this MODE, the meter will only test the nearest pane of glass for low e coatings. This MODE will only test for 1 piece of suspended film in the air space of the window. Testing regular windows in this MODE will cause an error.
12. QUAD PANE (4G)	12. Select this MODE to test windows that have four (4) panes of glass.

Choose Your Language

In the MENU, select the "LANGUAGE" option. Use the ARROW buttons to select LANGUAGE, then press the POWER button. Use the ARROW buttons to scroll through the available languages. Press the POWER button when your desired language appears. Save your changes and exit.

WARNING: Once the meter's language is changed, the menu will immediately change to the language selected. If you choose the wrong language and can't get back to your desired language, stop navigating the menu and allow the meter to automatically power down. The meter will automatically shut off after 1 to 2 minutes of inactivity. When the meter powers back up, it will display the previously selected language.

The following languages are available in the GC3200:   English, German, Spanish, French, Italian, Dutch, Danish and Swedish.
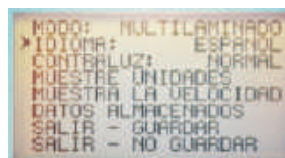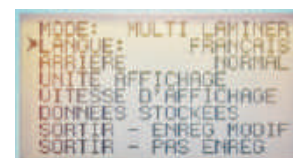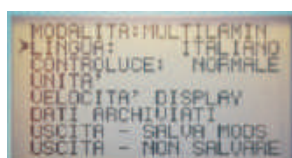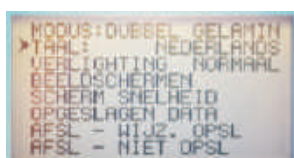
ENGLISH	GERMAN	SPANISH	FRENCH
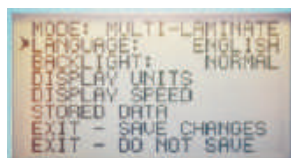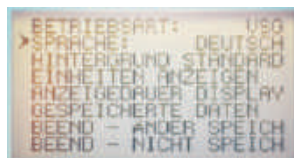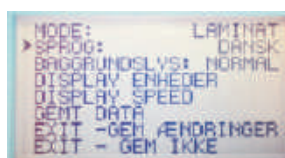
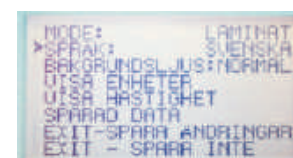| ITALIAN	DUTCH	DANISH	SWEDISH

Backlight Setting

If you want to conserve the life of the battery you can choose to turn the back-lighting of the display off. If you choose NORMAL, the back-light will stay on during measurements and also while the measurement results are displayed on the screen. The back-light will stay on through one rotation of the measurement results.   When the results begin repeating, the back-light will turn off, unless you press the ARROW buttons to move the results screens forward or backward. Any ARROW button press will cause the back-light to turn back on.   Please note that during the actual measurement, we turn off the back-light until the measurement results are obtained.   This helps to extend the life of the battery.
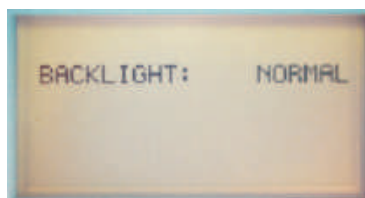
Stored Data

The GC3200 will automatically save the most recent 30 measurements. The stored data will continually update after every measurement. When you turn off the meter, the data is still stored in its nonvolatile memory. Note that you can not permanently store the measurements in the meter. Each time you take a measurement, the oldest data point will be deleted. To retrieve a recent measurement, enter the MENU system and select STORED DATA. Your most recent measurement will be at the top of the list under the heading "MOST RECENT DATA". As you move down the list, the measurements move from most recent to least recent. Therefore the oldest measurement in your list will be in entry #1. Select the measurement you would like to retrieve. Once you select the data point, the measurement results will appear, just as they did when you completed the measurement.   The screens will automatically advance from one result screen to the next, just as they did when you completed the measurement.   The ARROW keys will also allow you to advance or return as they do in normal measurements.   After you are finished reviewing the information, press the POWER button to return back to the STORED DATA MENU. You can select another measurement or RETURN TO MAIN MENU. The RETURN TO MAIN MENU selection is at the bottom of the list. You can get to the RETURN TO MAIN MENU entry by traveling down the measurement tree, or by moving to the top of the list and rolling over to the bottom of the list. Also at the bottom of the list are options to DELETE INDIVIDUAL data point, or DELETE ALL data points.

STORED DATA SCREENS
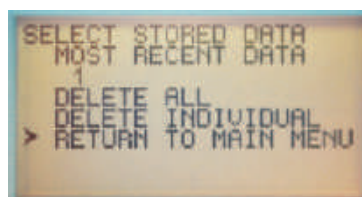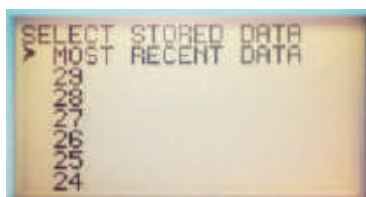
Place the meter at the bottom center of the window to be tested. Press _**and release**_ the POWER button to take a measurement. Do not hold the POWER button down, as this will cause the meter to shut off. The "TAKING READING" message will be displayed while your measurement is being completed. The "TAKING READING" screen also indicates the remaining battery life, as well as confirms the operating MODE the meter is in.


```
TAKING  READING
HOLD ▲ OR ▼ FOR MENU
    MODE: LAMINATE
```
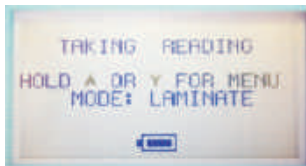
Turning The Meter Off
Hold the button down for several seconds to turn off the meter. A message will display on the screen notifying you that the meter is about to power down. Continue holding the button down until the screen goes blank. If the meter is left unused for a period of time, the unit will automatically shut off. To conserve battery life, it is recommended to turn the meter off manually when you are finished using it.

Guidelines For Most Accurate Results:
• Hold the meter steady and flat against the test surface during measurement
• Do not touch the glass with your hand while taking the reading
• Take readings at the **BOTTOM CENTER** of the window for best _thickness_
  accuracy (see explanation below)
• Take multiple measurements to verify results
• Make sure the window being measured is clean
• Make sure the two lenses on the back of the GC3200 are clean. See Image
  to the right. -------->
  _Use only clean compressed air to clean the lenses. Only use a lint
  free cloth if absolutely necessary to clean smudges, fingerprints, etc._
• Make sure nothing is touching the far side surface of the window during the
  measurement
• It is best to test windows in free air, not resting on a tabletop surface, or
  stacked on other pieces of glass.

Above: Back of GC3200 meter with the two lenses circled. Use clean compressed air to clean the lenses.

4 OPTIMAL TEST LOCATIONS

FOR MOST ACCURATE RESULTS

At Left: Recommended placement of meter:
• Hold the meter steady AND FLAT against the glass during measurement.
• The meter should be centered on one of the four edges of the window with the bottom edge of the meter placed parallel to the edge of the window (see image to the left). BOTTOM CENTER IS THE PREFERRED LOCATION. This will minimize the effect of a concave (or collapsed) window. As you move away from the edge of a window, many windows will bow inward (concave). Because the sensor runs parallel to the bottom edge of the meter, it is important to place the bottom edge of the meter along the edge of the window as shown. You can place the meter approximately 1 to 2 inches from the edge of the window.
• DO NOT touch the glass with your hand or thumb while taking measurements. Note the hand placement used in the picture at left. The user's thumb is resting on the GC3200 without touching the glass being measured. Also, be sure there are no other metallic objects touching the glass.
• DO NOT continue to hold down the button while taking a measurement.
• Place your index finger next to the button as shown at left.


At Right: Incorrect hand placement.
• DO NOT hold the POWER button while taking a measurement. This will cause the meter to turn off. Rest your index finger next to the button as shown above.
• DO NOT touch the glass with your hand while taking readings. The picture at right shows the user's thumb resting on the window while taking a measurement. This could cause incorrect results for the low-E measurement.

Application Examples

The Glass-Chek ELITE offers various display formats. The following illustrations are examples of measurement displays with explanations of the application being tested and how the display format was configured.
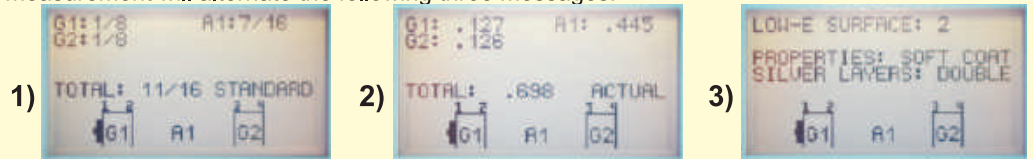

— Measurement Example One — Double Pane IG with Low E on Surface 2

Display Format
- Dimensions: Inch
- Standard: Fraction
- Actual: Decimal
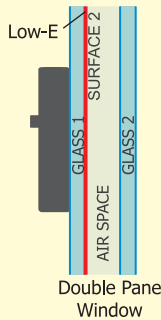
Resulting Measurement Displays: Due to the application and display format, the measurement will alternate the following three messages:

1)
```
G1: 1/8        A1: 7/16
G2: 1/8
TOTAL:  11/16  STANDARD
   G1      A1     G2
```

2)
```
G1: .127       A1: .445
G2: .126
TOTAL:   .698  ACTUAL
   G1      A1     G2
```

3)
```
LOW-E SURFACE: 2
PROPERTIES: SOFT COAT
SILVER LAYERS: DOUBLE
   G1      A1     G2
```

Display 1 shows fractional inches rounded to the nearest standard. Display 2 shows the actual measurements in decimal inches. Notice how the actual measurements in 2 are slightly different than the measurements in 1 because Display 1 shows the readings rounded to the nearest standard. Display 3 shows that the low-E coating is on surface 2, and it indicates that the coating properties are soft coat and have the performance of double-silver Low-E.
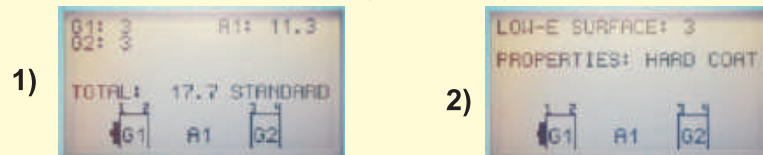

— Measurement Example Two — Double Pane IG with Low E on Surface 3

Display Format
- Dimensions: MM
- Standard: ON
- Actual: OFF
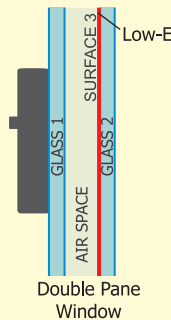
Resulting Measurement Displays: Due to the application and display format, the measurement will alternate the following two messages:

1)
```
G1: 3          A1: 11.3
G2: 3
TOTAL:  17.7  STANDARD
   G1      A1     G2
```

2)
```
LOW-E SURFACE: 3
PROPERTIES: HARD COAT
   G1      A1     G2
```
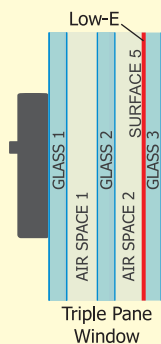
Display 1 shows millimeters rounded to the nearest standard. Since the "Actual" setting is set to OFF, there is no display showing the actual dimensions of the glass - only the dimensions rounded to the nearest standard. Display 2 shows that the low-E coating is on surface 3. Please note there are times where the meter will not specifically designate surface 3, and may show the result as Surface 3 or 4. This means that the meter is only indicating the coating is on the second pane of glass. In that instance, the user must test the window from the opposite side to confirm the exact low e surface.
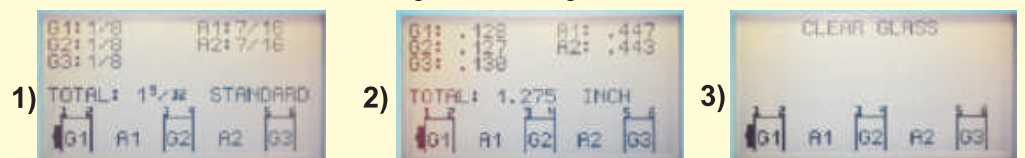

— Measurement Example Three — Triple Pane IG with Low E on Surface 5

Display Format
- Dimensions: Inch
- Standard: Fraction
- Actual: Decimal

Resulting Measurement Displays: Due to the application and display format, the measurement will alternate the following three messages:

1)
```
G1: 1/8        A1: 7/16
G2: 1/8        A2: 7/16
G3: 1/8
TOTAL: 1 5/16  STANDARD
  G1    A1   G2   A2   G3
```

2)
```
G1: .128       A1: .447
G2: .127       A2: .443
G3: .130
TOTAL:  1.275  INCH
  G1    A1   G2   A2   G3
```

3)
```
CLEAR GLASS
  G1    A1   G2   A2   G3
```

Display 1 shows fractional inches rounded to the nearest standard. Display 2 shows the actual measurements in decimal inches. Display 3 shows that the meter did not detect a low-E coating on G1 or G2. Since the GC3200 only detects coatings on the first 2 panes, you may be required to test both sides of a triple pane window to verify the presence of a low-E coating on the glass on the opposite side of the window.
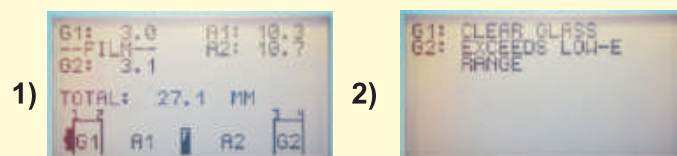

— Measurement Example Four — Double Pane IG with Suspended Film

Display Format
- Dimensions: MM
- Standard: OFF
- Actual: ON
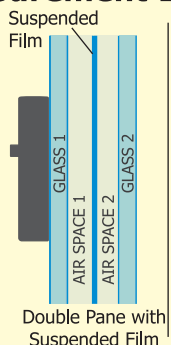
Resulting Measurement Displays: Due to the application and display format, the measurement will alternate the following 2 messages:

1)
```
G1:  3.0       A2: 10.2
--FILM--       A2: 10.7
G2:  3.1
TOTAL:  27.1  MM
  G1   A1       A2   G2
```

2)
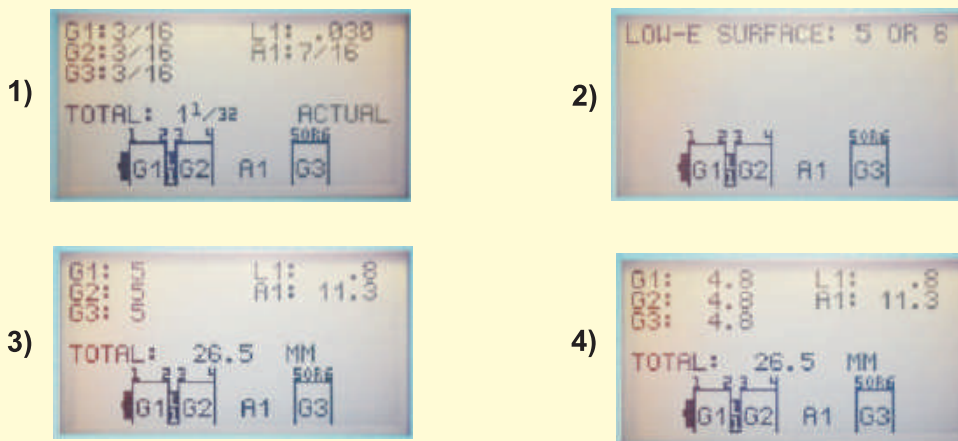```
G1: CLEAR GLASS
G2: EXCEEDS LOW-E
     RANGE
```

Display 1 shows the actual thickness of the window in MM. Since the "Standard" setting is set to OFF, STANDARD dimensions are not displayed. The word "FILM" indicates suspended film between the two panes of glass. Display 2 indicates that G1 does not have any low e coatings ("CLEAR" of any low-E coating). In Suspended Film Mode, the GC3200 will NOT test G2 for Low E Coatings.
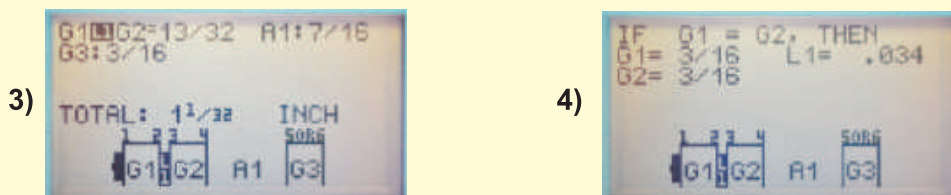
# Application Examples – Continued

Application Examples – Continued

Application Examples

## — Measurement Example Six — LAMI + LOW E (Low E Coating against LAMI inner layer)

When working with laminated glass that has a low e coating placed against the laminate inner-layer, the Glass-Chek ELITE helps identify which surface has the low-E coating (2 vs 3). To perform this function, the meter must be switched into "LAMI + LOW E" mode (see page 3&4). Please note for the example below, that STANDARD Mode has been set to FRACTIONS of an Inch, and the ACTUAL Mode has been set to DECIMAL Inches.
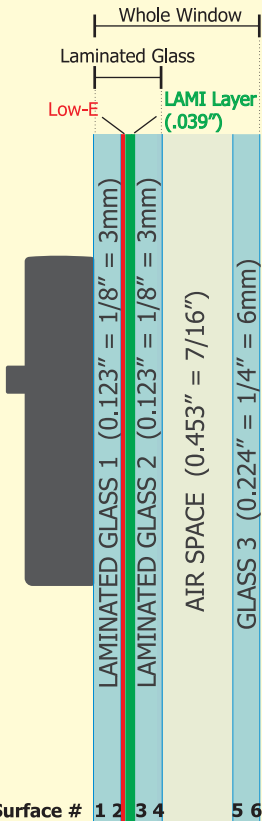
The LAMI + LOW E Mode of the GC3200 meter will allow you to test laminated Low E pieces of glass monolithically, and also with the laminated Low E glass assembled into a double pane (IG) window. For IG's, the GC3200 meter must be placed on the side of the window that contains the laminated low-E glass. The first screen that appears will show the thickness of the overall laminated piece of glass, the air space, the second pane of glass thickness, and also the overall thickness of the IG. The laminated piece of glass will be denoted as G1/L1/G2 on the display screens. Screen 1 and 3 below show this example. Screen 1 is displaying the information in fractions of an inch (STANDARD), while screen 3 shows the data in decimal inches (ACTUAL).

The next screens will show the make-up of the laminated Low E piece of glass by itself. The meter has been designed to add the thickness of the LAMI layer to the thickness of the glass that contains NO low-E coating. For the Low E piece of glass, the meter will display the actual thickness of the glass itself. **Therefore the piece of glass that is displayed as a "normal" standard thickness (0.123" or 1/8" for example) is the pane that has the low-E coating on it. This means that the piece of glass that has an abnormal (larger) glass thickness (caused by adding the LAMI thickness to the glass thickness) will be the glass pane that is *clear* of any Low E coating. In this example the clear glass + lami = .162" or 5/32".**

On screens 2 and 4, you will see that these two thickness values are denoted by the letter "D" (D1 & D2). Because the meter does not know which thickness value is the glass, and which one contains the glass + lami, an arbitrary value of D is assigned to the thickness values.

Screen 5 takes the evaluation one step further and makes the assumption that both pieces of glass comprising the laminated piece are the same thickness (G1 + G2). This is called the ASSUMPTION SCREEN. If G1 = G2 for your application, then Screen 5 will show the glass thickness, the laminate inner-layer thickness, and it will also confirm that the low e coating is on Surface 2 versus Surface 3. You will also notice on Screen 5, the meter actually identifies SURFACE 2 as the Low E surface in this example, and blinks the #2 in the drawing at the bottom of Screen 5. The rest of the screens blink both surface 2 & 3 since they are not the ASSUMPTION Screen.

The final Screen 6 in the sequence confirms the presence of the Low E Coating against the laminate inner-layer, and also indicates the type of Low E coating.

Whole Window

Laminated Glass

Low-E   LAMI Layer (.039")

LAMINATED GLASS 1 (0.123" = 1/8" = 3mm)
LAMINATED GLASS 2 (0.123" = 1/8" = 3mm)
AIR SPACE (0.453" = 7/16")
GLASS 3 (0.224" = 1/4" = 6mm)

**Glass Surface #**  1 2  3 4      5 6

**G1:** G1 (0.123" OR 1/8") nearest piece of glass (Screen 2 & 4-Line 1)

**L1 + G2:** LAMI L1 (0.039") + G2 (0.123"or 1/8") = 0.162" or 5/32" (Screen 2 & 4-Line 2)

**G1 + L1 + G2:** G1 (0.123" or 1/8") + LAMI Layer (0.039") + G2 (0.123" or 1/8") = 0.285" or 9/32" total laminated glass thickness (Screen 1 & 3-Line 1, Screen 2&4-Line 3, & Screen 5-Line 4)

**A1:** Air Space Thickness (.453" or 7/16") (Screen 1 & 3, Line 1)

**G3:** G3 (.123" or 1/8") (Screen 1 & 3, Line 2)

**TOTAL:** Total Window Thickness (.962" or 31/32") (Screen 1 & 3, Line 3)

STANDARD IN FRACTIONS (Inches)
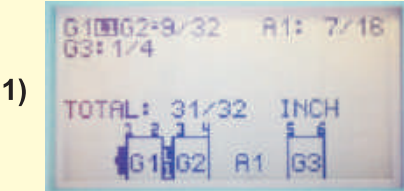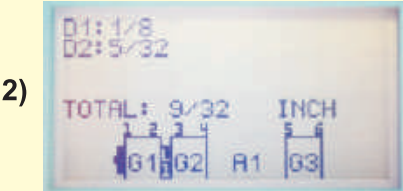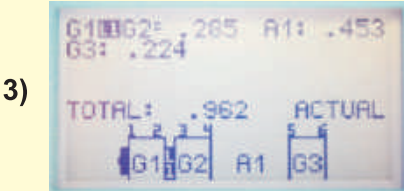
1)
```
G1■G2=9/32   A1: 7/16
G3: 1/4

TOTAL: 31/32   INCH
 1 2 3 4   5 6
 G1■G2   A1   G3
```

STANDARD IN FRACTIONS (Inches)

2)
```
D1: 1/8
D2: 5/32

TOTAL: 9/32   INCH
 1 2 3 4   5 6
 G1■G2   A1   G3
```

ACTUAL IN DECIMAL (Inches)

3)
```
G1■G2= .285   A1: .453
G3: .224

TOTAL: .962   ACTUAL
 1 2 3 4   5 6
 G1■G2   A1   G3
```

ACTUAL IN DECIMAL (Inches)

4)
```
D1: .123
D2: .162

TOTAL: .285   INCH
 1 2 3 4   5 6
 G1■G2   A1   G3
```

ASSUMPTION SCREEN (Inches)

5)
```
IF G1 = G2, THEN
G1= 1/8   L1= .039
G2= 1/8
TOTAL: 9/32
LOW-E SURFACE: 2
 1 2 3 4   5 6
 G1■G2   A1   G3
```

LOW E RESULTS SCREEN

6)
```
LOW-E SURFACE: 2 OR 3

PROPERTIES: SOFT COAT
SILVER LAYERS: DOUBLE
 1 2 3 4   5 6
 G1■G2   A1   G3
```
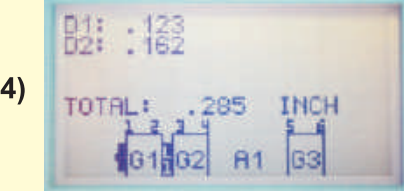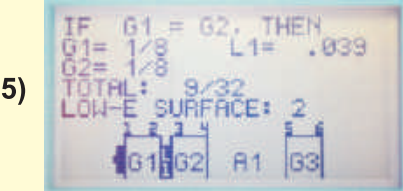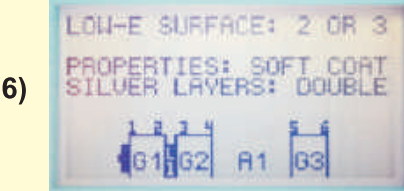
## — Measurement Example Seven —  Multi-Laminate Glass

If you are testing a piece of glass that contains more than one laminate inner-layer in a monolithic piece of glass, then you need to select the MULTI-LAMINATE Mode  (see page 3&4).  This would include applications such as bullet resistant glass and fire rated glass.  It is very important that the laminated glass you are testing is clean.  Because the laminate inner layers are so thin, any dirt or smudges on the glass can negatively impact the accuracy of the results, or the ability of the meter to detect the laminate inner layer.  Please clean the glass before you take a measurement.

The first result screen that appears will show the thickness of all the components comprising the window.  This will include each piece of glass and laminate inner layer.  For the laminated glass illustration to the right, the following result screens would occur.  Screen 1 shows the results in Fractions of an inch rounded to the nearest glass thickness standard.  Screen 2 shows the actual thickness of the layers in Fractions of an inch. Screen 3 shows the Low E results screen.  Please note, in Multi-laminate Mode the Low E measurement will typically only allow for a Low E coating to occur on the 1st surface or the last surface of the multi-laminate glass assembly.  In this application, there is no low e coating on Surface 1, and the last surface is too far away to be measured by the meter, thus the message that appears.

1)
```
G1: 1/8   L1: .049
G2:3/16   L2: .020
G3:3/16   L3: .047
G4: 1/8
TOTAL: 23/32 STANDARD
    1 2 3 4 5 6 7 8
  |G1| G2| G3||G4|
```

2)
```
G1: .128   L1: .049
G2: .155   L2: .020
G3: .172   L3: .047
G4: .131
TOTAL: .719 INCH
    1 2 3 4 5 6 7 8
  |G1| G2| G3||G4|
```

3)
```
GLASS EXCEEDS LOW-E
RANGE: GLASS IS
      TOO THICK
```

.

When testing laminated glass, there are applications where the GC3200 meter will not be able to completely identify the thickness of the laminate inner layer.   When this occurs, the meter may still display the overall thickness of a laminated section that might include a combination of G1 + L1 + G2.  When this occurs, the meter was not able to cleanly identify the laminate inner layer surfaces.  Screen 4 below shows an example of how this will appear.  When this condition occurs, the meter will add one additional screen to the rotation of results screen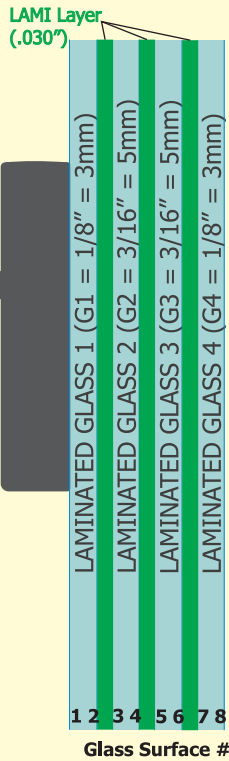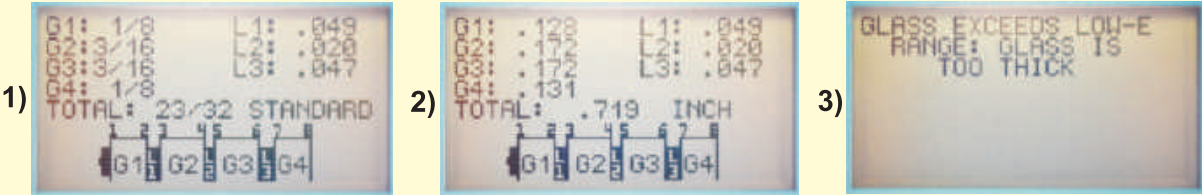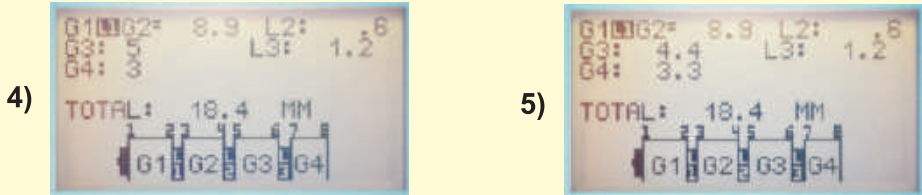s.  The additional screen is called the ASSUMPTION SCREEN.  If the user knows that both pieces of glass in the laminated piece (that are referenced in the ASSUMPTION SCREEN) are the same thickness, then the meter will show an assumption screen that presumes G1 = G2.  If the user knows that G1 = G2, then the meter will confirm the glass thickness, as well as provide an estimate of the laminate inner layer thickness.  If the user does not know for sure that G1 = G2, then the user should disregard the assumption screen.  In the example to the right, G1 does NOT equal G2, so this assumption screen would not apply to this application.  In this instance the user will only know the actual thickness of the first 2 pieces of glass and laminate inner-layer.  NOTE:  If the G1/L1/G2 combination continually appears through multiple measurements on the same glass, the user should attempt a measurement from the other side of the window if possible.    Screen 4 shows a measurement of the same glass example to the right, only the results are shown in MM and the meter was not able to identify the first laminate inner-layer thickness as described above.   Screen 4 shows the results rounded to the nearest STANDARD glass thickness while Screen 5 shows the results in ACTUAL.

4)
```
G1 G2= 8.9 L2:   .6
G3: 5   L3: 1.2
G4: 3
TOTAL: 18.4 MM
    1 2 3 4 5 6 7 8
  |G1| G2| G3||G4|
```

5)
```
G1 G2= 8.9 L2:   .6
G3: 4.4   L3: 1.2
G4: 3.3
TOTAL: 18.4 MM
    1 2 3 4 5 6 7 8
  |G1| G2| G3||G4|
```

LAMI Layer (.030")

LAMINATED GLASS 1 (G1 = 1/8" = 3mm)
LAMINATED GLASS 2 (G2 = 3/16" = 5mm)
LAMINATED GLASS 3 (G3 = 3/16" = 5mm)
LAMINATED GLASS 4 (G4 = 1/8" = 3mm)

1 2  3 4  5 6  7 8

**Glass Surface #**

## — Measurement Example Eight —  Multi-Laminate Glass and Multiple Data Screens

Here is another example of a MULTI-LAMINATE application.  As the number of laminate layers increases, the likelihood of achieving a complete measurement, with all of the laminate layers defined and measured, decreases.  Also, as t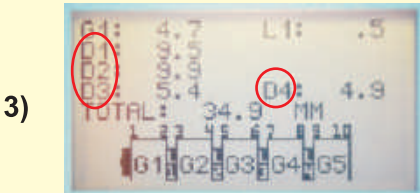he overall thickness of the glass increases, the likelihood of a complete measurement will also decline.  The example to the right is a 6 glass layer, and 5 laminate inner-layer assembly.  The display screen of the GC3200 can only hold a limited number of values simultaneously on one display.  In this example there are too many values for one screen.  On Screen 1 you see the first sets of data.  At the end of the data you will notice the word "MORE".   This lets the user know that additional measurement data is available on the next screen.  Screen 2 shows that additional data.  You will notice that the drawing at the bottom of the display is able to include all of the glass and laminate layers on the screen.  Only the data is separated onto two separate screens.

1)

2)

**LAMI Layers**

LAMINATED GLASS 1 (G1 = 1/4" = 6.0mm)
LAMINATED GLASS 2 (G2 = 3/32" = 2.5mm)
LAMINATED GLASS 3 (G3 = 3/32" = 2.5mm)
LAMINATED GLASS 4 (G4 = 3/32" = 2.5mm)
LAMINATED GLASS 5 (G5 = 3/32" = 2.5mm)
LAMINATED GLASS 6 (G6 = 3/32" = 2.5mm)

1 2  3 4  5 6  7 8  9  10 11 12
**Glass Surface #**
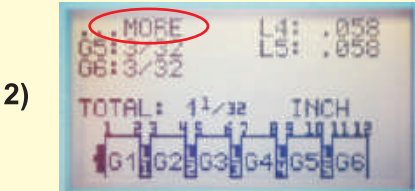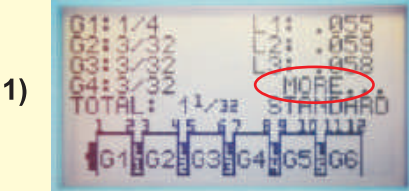
## — Measurement Example Nine —  Multi-Laminate Glass and "D" Values

As explained previously, as the multi-laminate glass gets more complex, it becomes more difficult for the GC3200 to provide a complete set of data.  The example to the right shows an example such as this.  Even if the meter is NOT able to identify all of the laminate layers, it typically is able to still provide supporting data that might be helpful to the user.  Rather than place an ERROR message on the display, the GC3200 will attempt to communicate as much data as possible to help you with your application.  In this example, the meter is not able to fully confirm the presence of a laminate inner-layer, so it will NOT default to the G1 + L1 + G2 algorithm that was explained in previous examples.  When the meter is not able to confirm a laminate inner-layer, the meter will default to showing a "D" dimension that groups at least one component into the dimension.  The "D" dimension could include a variety of component thickness values in its result.  For instance, the "D" dimension could include a single piece of glass (G), or it could be 1 piece of glass G + a laminate L (G + L).   At other times it could include a G + L + G + L combination.   Every application is unique, so the value and meaning of the "D" dimension will also be unique from application to application.  When the meter knows for sure there is a glass or laminate thickness, it will still show those values as before in the Results.  However when the meter encounters an unknown situation, it will default to the "D" value.  Again, the GC3200 will provide as much valid data as it can with each measurement.

For the example to the right, the following measurement result could occur (Screen 3).  The GC3200 measured the G1 and L1 values accurately.  However when it tested G2 it ran into an error condition, so it defaulted to the D1 value of 9.5mm.  If the user has some knowledge of the construction of the multi-laminate assembly, they may know that the 9.5 mm represents a 10mm piece of glass. The D2 value likely includes a 10mm piece of glass + L2 or L3 thickness.  D3 appears to be representing a piece of glass around 5mm, as well as the D4 value.  So while the user may not know the exact values, it may be possible to piece together the data that the GC3200 provides.

3)

**LAMI Layers**

LAMINATED GLASS 1 (G1 = 3/16" = 5mm)
LAMINATED GLASS 2 (G2 = 3/8" = 10mm)
LAMINATED GLASS 3 (G3 = 3/8" = 10mm)
LAMINATED GLASS 4 (G4 = 3/16" = 5mm)
LAMINATED GLASS 5 (G5 = 3/16" = 5mm)

1 2  3 4  5 6  7 8  9 10
**Glass Surface #**

# Low-E Detection Capabilities

The electronics that detect the presence of the Low-E coatings are impacted by the surroundings of the meter. This has been explained elsewhere in the manual by showing proper hand placement on the meter and positioning of the glass when testing. The Low-E detection circuitry is affected by conductive materials that are detected by the meter. Conductive materials could include the metal spacer in the window or muntin bars (grid) inside the window itself, just to name a few. Keeping the meter at least 2 inches away from any metal/conductive material when taking measurements will result in the most accurate Low-E measurements.

One additional note regarding Low E detection. If your application contains more than one low e coating in the window, the Glass-Chek ELITE will only identify the first (nearest) Low E coating that it encounters. Testing from the opposite side of the window would allow you to identify the other Low E coating in the window. The GC3200 detects the presence and location of low-E coatings on the following applications:
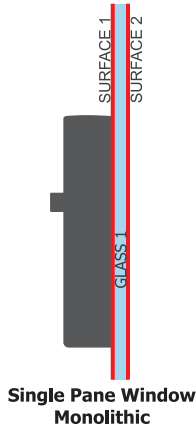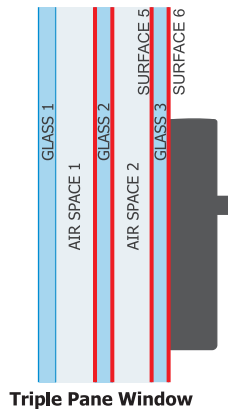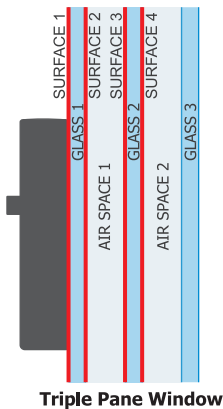
## Single Pane Windows

The GC3200 will specify if the coating is located on Surface 1 or Surface 2 of a single piece of glass.
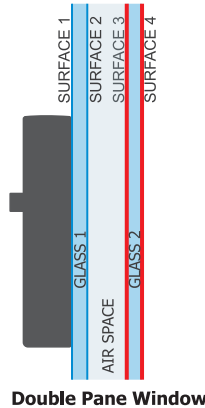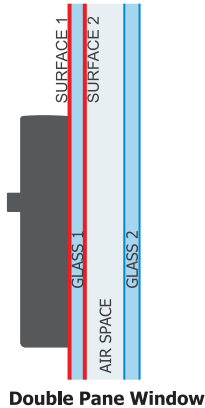
**Single Pane Window
Monolithic**

## Double Pane Windows

The GC3200 will specify if the coating is located on Surface 1, Surface 2, Surface 3, OR Surface 3 or 4. If the meter does not specifically identify Surface 3, you can move to the other side of the window to confirm the low e surface.

**Double Pane Window**          **Double Pane Window**

## Triple Pane Windows

The GC3200 will specify if the coating is located on Surface 1, Surface 2, Surface 3, or Surface 3or4. By moving to the other side of the window, the meter can specify Surface 5 and Surface 6. The GC3200 detects the presence of low-E coatings on the middle pane of a triple pane unit. It will either show results of Surface 3, or Surface 3or4. If there are multiple low-E coatings, the GC3200 will only identify the nearest coating.

**Triple Pane Window**          **Triple Pane Window**

## Identifying the Type of Low-E:

In addition to identifying the location of low-E coatings, the GC3200 determines the type of low-E on your window. The meter will specify it as "hard coat"(aka pyrolytic or on-line coating) or "soft coat" (aka sputtered or off-line coating). If the Low E is soft coat, the meter will also specify the number of silver-layers as single, double, or triple, based on the coating's energy performance. If you happen to know the manufacturer of the glass, in many cases you can identify the exact type of low-E coating used to make the window. A convenient reference chart is included with the GC3200 meter, that lists many of the common Low E coatings used in the USA. Here are some examples:

| SOFT COAT (sputtered) | | | HARD COAT (pyrolytic) |
|---|---|---|---|
| **Triple Silver** | **Double Silver** | **Single Silver** | |
| -Cardinal 366 | -Cardinal 270 & 272 | -Cardinal 180 | -Pilkington Energy Advantage |
| -PPG SolarBan 70 | -PPG SolarBan 60 | -PPG Sungate 100 & 400 | -PPG Sungate 500 |
| -Guardian CG 62/27 | -AFG TIPS, TIR, & TIAC | -Guardian ClimaGuard 75/68 | -AFG Comfort E2 |
| | -Guardian ClimaGuard 71/38 | | |

# Helpful Operating Tips & Explanations

1. Thin glass will measure the fastest, while thicker glass such as 1/4" will take longer to measure.

2. The darker the glass, the longer it will take to complete a measurement

3. To speed up measurements, switch the OPERATING MODE to NORMAL GLASS (NO LAMI) if you know there is no laminated glass.

4. If testing dark glass in a window or laminated piece, try to test from the side of the window that contains the clear piece of glass.

5. For a reminder of any Low E Coatings, check the drawing at the bottom of the display as the Low E coated surface #'s will be blinking.

6. Always conduct your measurements in the **BOTTOM CENTER** of the window.

7. Take multiple measurements to confirm your test results, but always test near the bottom center of the window (either side).

8. If you do not receive a complete set of results when testing laminated glass or multi-laminate, move to the other side and test again.

9. If the window has more than one low e coating, the GC3200 will only identify the first (nearest) coating it encounters.

# Explanation of Error Messages

**Error Messages:**      **Explanations:**

| ERROR: 1 CLEAN & PLACE METER BOTTOM CENTER. PRESS POWER BUTTON TO TAKE NEW READING. |
|---|

This error indicates a problem with the measurement. Be sure you are following the guidelines for the most accurate results outlined on Page 6, and attempt to take the reading again. Make sure the meter is flat against the glass during the measurement, and do not move the meter during the course of a measurement.

If the window area under test is excessively dirty or contaminated, the Glass-Chek ELITE may give improper thickness or low-E results or issue an error message. The window area under test must be CLEAN as well as the lenses on the back of the meter. Clean the lenses on the back of the GC3200 with compressed air. Use a lint-free cloth if absolutely necessary to clean smudges, fingerprints, etc., as shown on Page 6.

| EXCESS LIGHT: MOVE TO OPPOSITE SIDE |
|---|

The Glass-Chek ELITE uses a laser to measure the thickness of the glass and air space. The unit may be affected by **extremely** bright lights or facing the sun directly. The screen will display this error message if this condition occurs. Simply move to a different location, go to the other side of the window, or shade the laser aperture. If the window is operable you may be able open the window and reach through the opening to block the incident light from the back side of the meter.
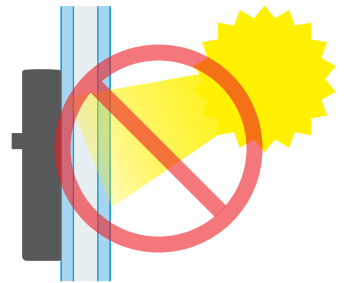
| GLASS EXCEEDS LOW-E RANGE: GLASS IS TOO THICK |
|---|

This error message indicates that your application is most likely out of the maximum thickness range for low-E measurement. See the "Specifications" section on Page 15 of this manual for more details on the GC3200's maximum thickness ranges.

| LOW BATTERY REPLACE SOON |
|---|

**Battery and replacement:** The GC3200 meter is powered by a 9-volt alkaline battery. When the battery is starting to get low, an error message will appear that recommends replacing the battery soon. This gives the user plenty of warning that a battery replacement is needed soon, but the meter will still function for a period after this initial warning. Once the battery voltage gets below a dangerous level that could impact the performance of the instrument, an error message appears that tells you to replace the battery immediately. The instrument will NOT take measurements once it reaches this level.

| REPLACE BATTERY NOW GC3200 WILL POWER DOWN IN: |
|---|

Please remember to ALWAYS replace the battery with a **9-volt ALKALINE** battery.

If you are having difficulty obtaining an accurate measurement, please follow these steps:

**1)** Be sure you are following the guidelines for most accurate results outlined on Page 5 of this manual.  Make sure you are testing the BOTTOM CENTER of the window.

**2)** Ensure that the Glass-Chek ELITE is placed flat against the glass surface and that you are testing at one of the four optimal locations detailed on Page 5.  The meter must be used with the surface opposite the Power button against the window.  Using the small end surface of the unit or tilting the unit away from the surface will give improper results.

**3)** Clean the glass surface or move to a cleaner area of the glass.

**4)** Remove dust particles from the two lenses on the back of the Glass-Chek ELITE.
**To clean the lenses:** WE STRONGLY RECOMMEND USING CLEAN COMPRESSED AIR ONLY TO CLEAN THE LENSES.  However, if there are fingerprints or other smudge marks on the lenses that can not be removed in any other way, a lint free cloth can be used to wipe off the smudges.

**5)** If only a partial reading occurs, move to another location on the glass or take a reading from the other side of the window.

**6)** Be sure nothing is touching the glass while taking measurements.  Placing your hand or any metallic object against the lite of glass you are testing may cause the Glass-Chek ELITE to yield improper Low E results.  Remove your hand or object.  Do not touch any part of the glass with your hand while taking readings.

**7)** Verify the operating temperature range

**8) If measurements seem to take a long time:**
The amount of time it takes the GC3200 to complete a measurement will vary by application.  This does not mean your meter is defective, it simply takes varying amounts of time depending on the application.  Be sure to hold the meter steady against the window until the results are displayed.  Measurements that will take longer include: Laminated Glass, Thick Glass, Dark Glass, and Multi-Laminate Glass.

**9) For operating in cold temperatures:**
**a)** Keep the unit in a warmer environment until you are ready to take the readings.  The meter will record accurate readings until the point the electronics reach the temperature below the operating range.  Depending on the degree of coldness, this will allow for several readings to be taken.

**b)** Carry the meter close to your body or in some other manner that will keep the unit near a warmer temperature.

**c)** When temperature is only slightly below the temperature range, operate the unit several times repeatedly in attempt to warm up the laser.

**9) For operating in hot temperatures:**
Keep the unit in a cooler environment until you are ready to take the readings.  The meter will record accurate readings until the point the electronics reach the temperature above the operating range.  Depending on the degree of heat, this will allow for several readings to be taken.

**10)  DO NOT STORE THE METER IN YOUR VEHICLE.**  TEMPERATURES INSIDE VEHICLES COMMONLY EXCEED THE MAXIMUM ALLOWED TEMPERATURE IN SUMMER MONTHS, AND ALSO DROP BELOW MINIMUM ALLOWED TEMPERATURES IN WINTER MONTHS.  CARRY YOUR METER INDOORS EVERY DAY.

**Important Safety Consideration:**
The GLASS-CHEK family of glass thickness and air space meters use a Class 2M laser to take its measurements.  Do NOT push the power button and point the instrument laser at a persons' eyes.  Always check the other side of the window being tested to ensure that no one will be looking directly into the laser.

# Specifications
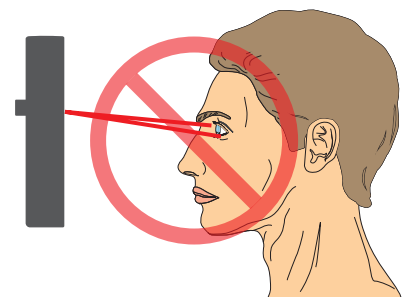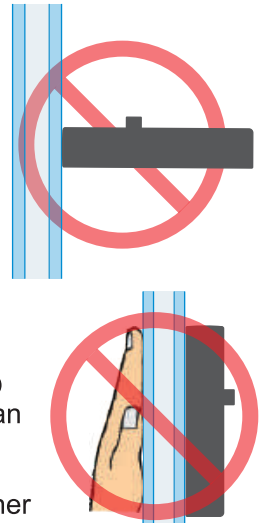
- Power Source: ................................................. 9 volt alkaline battery (NEDA 1604A) only
- Physical Dimensions: ..................................... 3.5" x 5.5" x 1.7 inch   (89 x 140 x 43mm)
- Weight: ........................................................... 0.75 pounds
- Maximum Laser Output: ................................ <1mW (2M laser product)
- Laser Wavelength: .......................................... 650 - 680 nm
- Storage Temperature: ..................................... +14 to 140 degrees F  (-10 to +60 degrees Celsius)
- Operating Temperature: ................................. +32 to 104 degrees F  (0 to +40 degrees Celsius)
- Display: ........................................................... Graphic
- Accuracy: ........................................................ Glass:        0.008 inch (0.2mm)
  Air Space:   0.012 inch (0.3mm)

This product complies with IEC 60825-1 and FDA regulation 21 CFR 1040.10.  The thickness tolerance is calibrated to NIST traceable standard No. 821/268634-03.
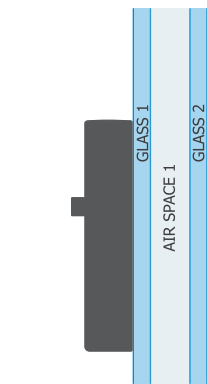
## Glass Thickness Range

- Minimum Glass Thickness Allowed:  **0.080 inch** or **2.0mm**
- Minimum Air Space Allowed:  **0.187 inch or 4.7mm**
- Glass Thickness Allowed for Low-E readings:  **up to 0.5 inch** or **12.7mm**
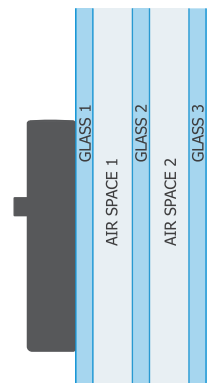
### Triple Pane Windows

The GC3200 will display the thickness of each pane of glass, the thickness of each air space, and the total IG thickness.  Depending on the thickness of the glass, the maximum allowable range for the total IG thickness changes according to the data below:

| Glass Thickness | Maximum Overall Thickness Range |
|---|---|
| 3/32" or **2.5mm** | 1.9" or **48mm** |
| 5/32" or **4mm** | 2.0" or **50mm** |
| 1/4" or **6mm** | 2.1" or **53mm** |
| 1/2" or **12mm** | 2.5" or **63mm** |

### Double Pane Windows

The GC3200 will display the thickness of each pane of glass, the thickness of each air space, and the total IG thickness.  Depending on the thickness of the glass, the maximum thickness range for the total IG thickness changes according to the data below.  **Note** these same dimensions apply when measuring a double pane window with suspended film.

| Glass Thickness | Maximum Overall Thickness Range |
|---|---|
| 3/32" or **2.5mm** | 1.9" or **48mm** |
| 1/4" or **6mm** | 2.0" or **50mm** |
| 1/2" or **12mm** | 2.2" or **55mm** |
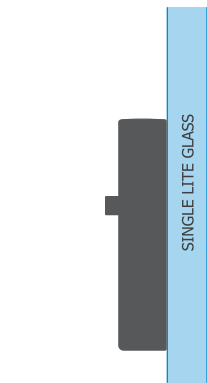
### Single Pane Monolithic Glass

The GC3200 will display the thickness of single pane monolithic glass up to **2.75 inches** or **70mm** thick.

## Glass Standards Table

When operating the GC3200 in "STANDARD" mode, the glass measurements will be rounded to the nearest standard thickness according to the table below:

### GC3200 Standards - Tolerance Specifications for Flat Glass
Based on the American Society for Testing and Materials (ASTM) Standards

| Traditional Designation | Designation mm | Designation inches | Glass Tolerance mm min | mm max | inches min | inches max |
|---|---|---|---|---|---|---|
| 3/32 in. (single) | 2.5 | 0.09 | 2.16 | 2.57 | 0.085 | 0.101 |
| 1/8 in. (double) | 3 | 0.12 | 2.92 | 3.40 | 0.115 | 0.134 |
| 5/32 in. | 4 | 0.16 | 3.78 | 4.19 | 0.149 | 0.165 |
| 3/16 in. | 5 | 0.19 | 4.57 | 5.05 | 0.180 | 0.199 |
| 1/4 in. | 6 | 0.23 | 5.56 | 6.20 | 0.219 | 0.244 |
| 5/16 in. | 8 | 0.32 | 7.42 | 8.43 | 0.292 | 0.332 |
| 3/8 in. | 10 | 0.39 | 9.02 | 10.31 | 0.355 | 0.406 |
| 1/2 in. | 12 | 0.50 | 11.91 | 13.49 | 0.469 | 0.531 |

### FRACTIONS TABLE

| Fraction |
|---|
| 1/32 |
| 1/16 |
| 3/32 |
| 1/8 |
| 5/32 |
| 3/16 |
| 7/32 |
| 1/4 |
| 9/32 |
| 5/16 |
| 11/32 |
| 3/8 |
| 13/32 |
| 7/16 |
| 15/32 |
| 1/2 |
| 17/32 |
| 9/16 |
| 19/32 |
| 5/8 |
| 21/32 |
| 11/16 |
| 23/32 |
| 3/4 |
| 25/32 |
| 13/16 |
| 27/32 |
| 7/8 |
| 29/32 |
| 15/16 |
| 31/32 |
| 1 |

### Low-E Coatings Table

**Triple Silver Soft Coat**
- Guardian ClimaGuard 62/27
- Cardinal LoE - 366
- PPG SolarBan 70XL

**Double Silver Soft Coat**
- Cardinal LoE - 240
- Guardian ClimaGuard 55/27
- PPG SolarBan 67
- Guardian ClimaGuard 63/31
- Guardian ClimaGuard 70/36
- Cardinal LoE - 270
- Guardian ClimaGuard 71/38
- AGC Comfort TIAC
- PPG SolarBan 60
- Cardinal LoE - 272
- AGC Comfort TIR

**Single Silver Soft Coat**
- AGC Comfort TIPS
- PPG Sungate 100
- Guardian ClimaGuard 75/68
- PPG Sungate 400
- Cardinal LoE - 180
- Guardian ClimaGuard 80/70

**Hard Coat Pyrolytic**
- Pilkington Solar E
- AGC Comfort E2
- PPG Sungate 500
- Pilkington Energy Advantage

## GC3200 Warranty

The manufacturer warrants all models of the GC3200 to be free from defects in material and workmanship under normal use and service as specified within the operator's manual. The manufacturer shall repair or replace the unit within twelve (12) months from the original date of shipment after the unit is returned to the manufacturers factory, prepaid by the user, and the unit is disclosed to the manufacturers satisfaction, to be thus defective. This warranty shall not apply to any unit that has been repaired or altered other than by the manufacturer. The aforementioned provisions do not extend the original warranty period of the unit which has been repaired or replaced by the manufacturer. Batteries are not covered by warranty.

The manufacturer assumes no liability for the consequential damages of any kind through the use or misuse of the GC3200 product by the purchaser or others. No other obligations or liabilities are expressed or implied. All damage or liability claims will be limited to an amount equal to the sale price of the GC3200, as established by the manufacturer.