

Purpose

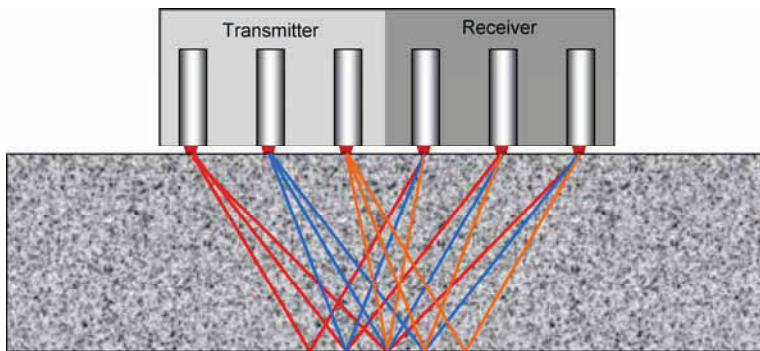
EyeCon is a portable hand-held instrument for flaw detection and thickness measurement. It is based on the ultrasonic pitch-catch method and uses an antenna composed of an array of dry point contact (DPC) transducers, which emit shear waves into the concrete. Test results can be displayed as individual **A-Scans** (reflection amplitude versus time or depth) or as **B-scans** showing the cross section of the test object along a scan line. **EyeCon** can be used for the following applications:

- Thickness measurement
- Detection of voids in grouted tendon ducts
- Detection of poor quality bond in overlays and repairs
- Detection of delaminations
- Detection of voids and honeycombing in concrete members



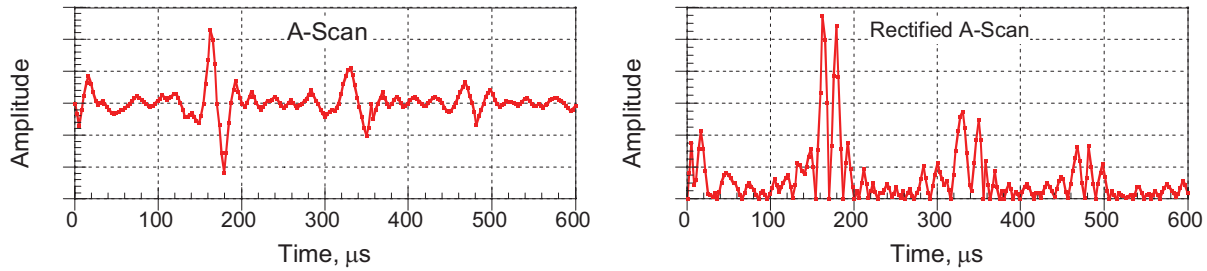
Principle

EyeCon is based on the ultrasonic pulse-echo method using transmitting and receiving transducers in a "pitch-catch" configuration as illustrated on page 87. **EyeCon** uses an antenna composed of 24 transducers arranged in a 4 by 6 array as shown to the right. Each transducer is independently spring loaded to conform to surface irregularities. As is shown below, the first three rows of transducers act as transmitters and the other three rows act as receivers. By using the multiple transmitters and receivers, the signal-noise ratio is improved because random reflections from aggregate particles will tend to cancel, while reflections from large concrete-air interfaces will be superimposed.



The averaged signal recorded by the receiving transducers is stored in the hand-held unit as a time-domain waveform. An example of such a waveform is shown at the top of the next page. In this case, the test was done on a solid concrete slab with a thickness of about 200 mm. The figure on the left side of the next page shows signal amplitude as a function of time (**A-Scan**). The three peaks are due to multiple reflections

of the pulse by the back wall (bottom) of the slab. The figure on the right is the **rectified** version of the signal in which the negative portion of the original signal is plotted as a positive signal. **EyeCon** allows the user to display the signal as recorded originally (left side) or as a rectified signal. The latter is preferred because it allows more detail in the display. These time-domain signals of the received pulse are used to measure the solid thickness or detect the presence of voids or cracks within the test object.



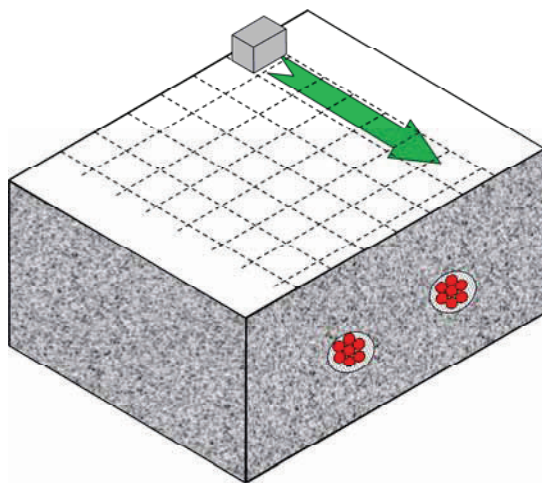
The key features **EyeCon** include the following:

- The use of a 4 by 6 array of point transducers to introduce into the concrete pulses of **shear waves** with a nominal center frequency of 50 kHz. The use of the array increases the signal-noise ratio at the test point.
- The transducers are spring loaded to conform to an irregular surface, and they do not require a coupling medium, that is, testing is done in the dry.
- The signals captured by the antenna are stored as a time-domain waveforms (**A-Scans**).
- Signals captured in a 2-dimensional scan can be displayed on the hand-held unit as a black and white cross section of the test object (**B-Scan**) along each scan line.
- Data can be transferred to a computer for subsequent analysis and construction of a 3-dimensional view of reflecting interfaces with color to represent different signal amplitudes.

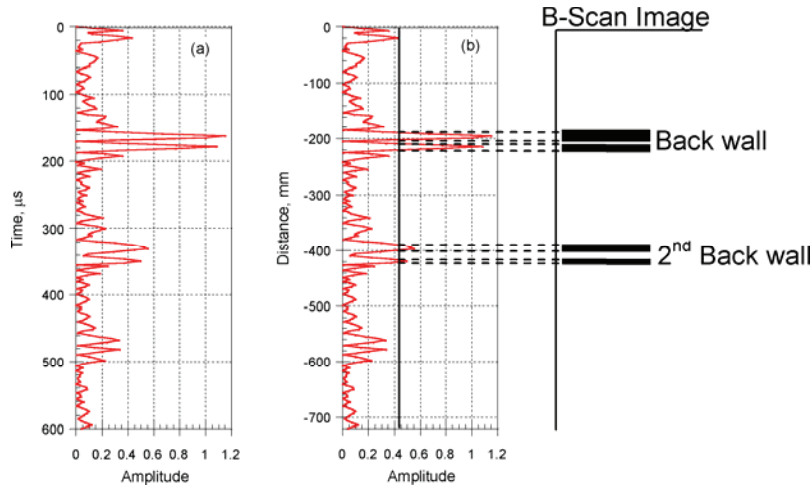
Method of operation

The handheld unit includes a 320 by 240 pixel LCD with backlighting. Setup parameters for recording and displaying signals are entered using a menu system. These parameters can be stored in memory for reuse. A series of icons is used to select the active display mode for the instrument. There are two basic display modes for the **EyeCon**:

- **A-Scan**—This display mode is used to show the results of individual measurements. The amplitude of the received signal can be displayed as a function of time or as a function of distance (depth) if the shear-wave speed is known. The signal can be displayed in its actual form or in rectified form (preferred). There are two A-Scan display modes: REVIEW and ZOOM. These are described later.
- **B-Scan**—This display mode uses the stored A-Scan records to create cross-sectional views along scan lines. There are two modes available: BAND for displaying the cross section along a single scan line and MAP for displaying cross sections along a series of parallel scan lines. These are also described later.

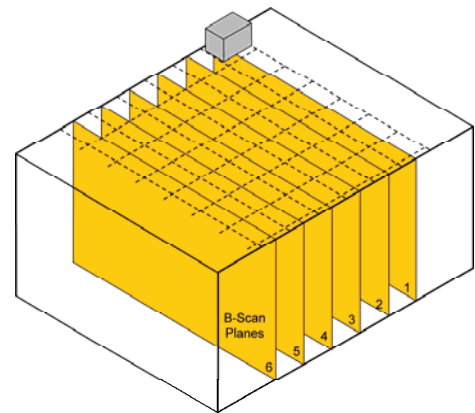


To carry out an inspection of a concrete member, the user first lays out a 2-dimensional grid on the testing surface. The grid lines should have the same spacing (step) in both directions. The step spacing depends on the size of defects to be detected, with a smaller spacing for smaller defects. The long axis of the antenna is oriented perpendicular to the scan direction and data are recorded at each step along each scan line. The grid layout (step distance, number of steps per line, and the number of lines) is entered into the hand-held unit and that information is used in referencing the displayed test results to the testing position on the test object.



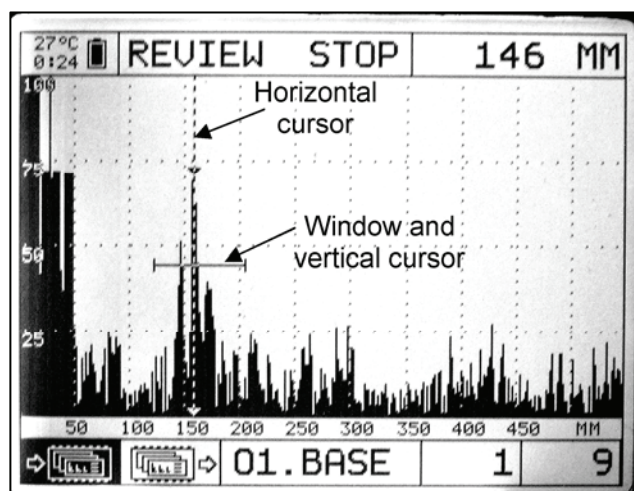
After the scanning is completed, the results can be displayed in two ways. The individual A-Scans can be analyzed or cross sections (B-Scans) along each scan line can be viewed. The following explains the approach used to construct a cross-sectional view of the test object and show the depth of reflecting interfaces. The signal at each test point is plotted with time in the vertical direction as shown in left hand figure (a). If the shear-wave speed in the concrete is known, the time axis

can be converted to distance from the surface by multiplying by one-half of the wave speed (because the travel time is for a round trip equal to twice the depth). If the shear wave speed is assumed to be 2400 m/s, the distance axis is as shown in figure (b). To construct a cross-sectional view, a threshold level of signal amplitude is chosen and a black dash is drawn at the depth where the signal exceeds the threshold amplitude. In this example, a low threshold is used and the second echo from the back wall is plotted. If a higher threshold were used, only the first back wall echo would be shown. This process is repeated for each signal along the scan line, and the end result is a 2-dimensional representation (or a B-Scan) of the locations of reflecting interfaces along each scan line. As shown on the right, each scan line has an associated B-Scan plane that can be viewed as shown below.



Examples of Display Modes

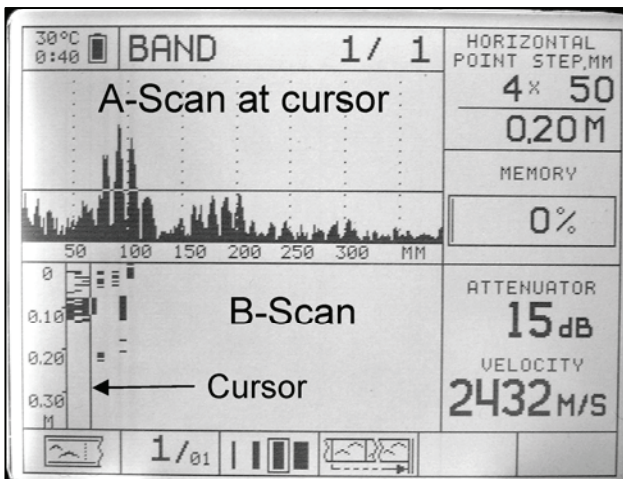
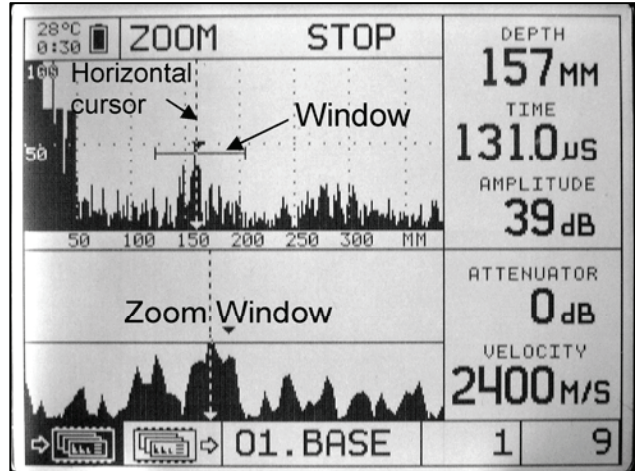
The following are examples of the various displays that are available in **EyeCon**.



REVIEW—This display mode shows the recorded signal at a single antenna position. The signal can be from one set of pulses or an average of several sets of pulses, depending on the set up of the instrument. Different display formats are available. In this case, the signal has been rectified and filled in. The horizontal axis is in units of time (microseconds), but it could also be displayed in units of distance if the wave speed is entered when the instrument is set up. Various measurements can be made such time to first peak or peak-to-peak interval. A portion of the signal can be selected for a more detail view by using an adjustable window and switching to the ZOOM mode.

EyeCon

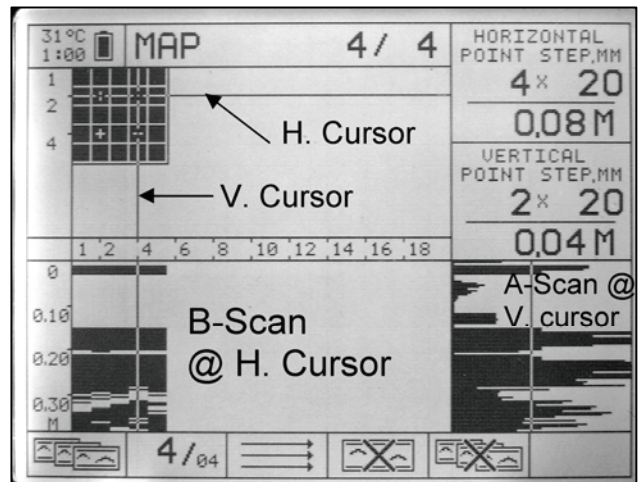
ZOOM—This display mode shows the full signal in the top half of the display. The bottom half of the display is an expanded view of the portion of the signal within the selected window. The user defines the location and length of the window. The right side of the display shows the shear-wave speed entered during instrument setup. The depth and time corresponding to the position of the horizontal cursor is shown in the upper right corner.



BAND—This is one of the B-Scan modes that can be used after testing along a scan line is completed and the individual A-Scans have been stored. The scan line is defined by the number of steps and the step distance. There are five boxes in the display. The lower left shows the B-Scan for the scan line. The cursor can be used to select a test point along the scan line. The upper left box shows the A-Scan for the selected test point. The upper right box shows which point along the scan is selected (4), the step distance (50 mm), and the location of the selected point along the scan line (0.2 m). The middle box on the right is the amount of memory used. The lower right box shows the

wave speed entered during instrument set up.

MAP—This mode is used to review results acquired when a 2-dimensional testing grid is used. The upper left box shows the grid layout (5 lines, 5 steps/line). The horizontal cursor is used to select the scan line for which the B-Scan cross section is to be shown. The vertical cursor selects the step along a scan line for viewing the individual A-Scan. The lower left box is the B-Scan along the selected scan line. The lower right box shows the A-Scan for the test point defined by the two cursors. The positions of the horizontal and vertical cursors in terms of steps in each direction (and corresponding distance) are shown in the two remaining boxes on the right side of the display.



EyeCon Specifications

- Dry point contact shear-wave transducers with ceramic wearing tip
- 50 kHz center frequency
- Transducers are spring loaded to conform to rough surfaces
- Antenna array: 4 by 6
- Maximum testing depth: 600 mm
- Error in depth measurement: less than 10 %
- Rechargeable batteries
- Time for one measurement and saving to memory: 10 s
- Saves up to 200 non-rectified A-Scans
- 320 × 240 pixel black and white LCD
- Backlight illumination
- A-Scan and B-Scan display
- Operating temperature -20 °C to 45 °C
- Connection for data transfer to computer
- Software for 3-D visualization on PC

EyeCon Ordering Numbers

Item	Order #
Hand-held unit with rechargeable battery and soft carrying case	EYE-1001
Antenna array (4 by 6)	EYE-1002
Cables	EYE -1003
Battery charger	EYE -1004
AC adapter	EYE -1005
Software on CD-ROM	EYE -1006
User manual	EYE -1007
Hard shell carrying case	EYE -1008



Approximate dimensions of case and total mass of equipment

405 mm x 315 mm x 165 mm, 5.5 kg

16 in. x 12 in. x 6.5 in, 12 lb

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