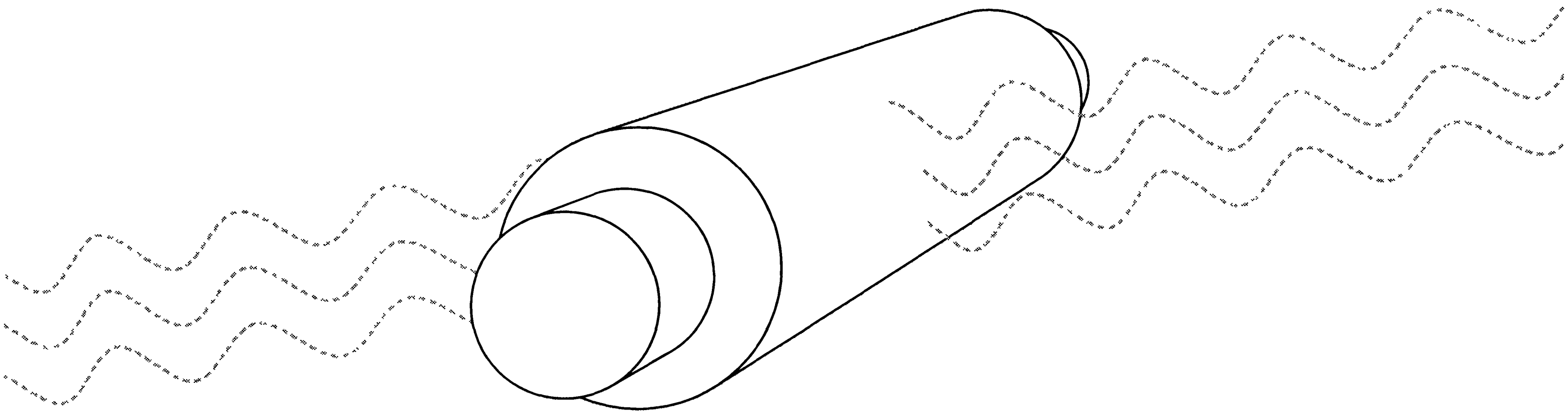
FINAL REPORT

# ENHANCED ULTRASONIC INSPECTION OF STEEL BRIDGE PIN COMPONENTS

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(The opinions, findings, and conclusions expressed in this report are those of the authors and not necessarily those of the sponsoring agencies.)

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## ABSTRACT

This report describes the development of a technique for obtaining a reliable assessment of the condition of steel bridge pins already determined by ultrasound to contain imperfections. The details of a technique for performing high-definition ultrasonic scans of pins in the field are described. Results demonstrating this technique with specially fabricated calibration pins with actual cracks and actual bridge pins in the field are presented. A mathematical model for tracing the propagation of ultrasonic sound rays is also described. This model can be used as a tool to help interpret scanned images of imperfect pins. The researchers recommend that future research be carried out to develop further the instrumentation, equipment, and models needed for accurate field assessment of steel bridge pins.

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## INTRODUCTION

Steel pin details are fracture-critical bridge members that are impossible to inspect visually.[1] Because they are present in at least 12 bridge structures in Virginia (Appendix A), this problem is of particular concern to the Virginia Department of Transportation (VDOT). Perhaps the most infamous instance of the need for inspection occurred on June 8, 1983, when portions of I-95 collapsed in Greenwich, Connecticut, killing three persons.

The inspection of steel pins is complicated because of limited access to the areas of the pin where critical cracks typically occur. Added to this complication is the fact that wear by surface abrasion will often cause grooves to develop in these same locations. Although undesirable, the grooves do not pose the same level of concern as fatigue cracks. To ensure safe use of the bridge structure, inspectors must be able to detect pin deterioration and differentiate between wear grooves and cracks. In addition, once the presence of a crack has been established, the rate of crack growth must be monitored so that when the crack becomes serious, the pin may be immediately replaced. Several attempts have been made to use ultrasonic inspection to detect and distinguish cracks in steel pins, yet no standard approach has been developed for solving this important problem.

## PURPOSE AND SCOPE

The objective of this project was to assess the various ultrasonic nondestructive evaluation methods that have been proposed in the literature and incorporate innovative detection and analysis approaches to achieve an optimal field inspection and monitoring capability.

# METHODS AND MATERIALS

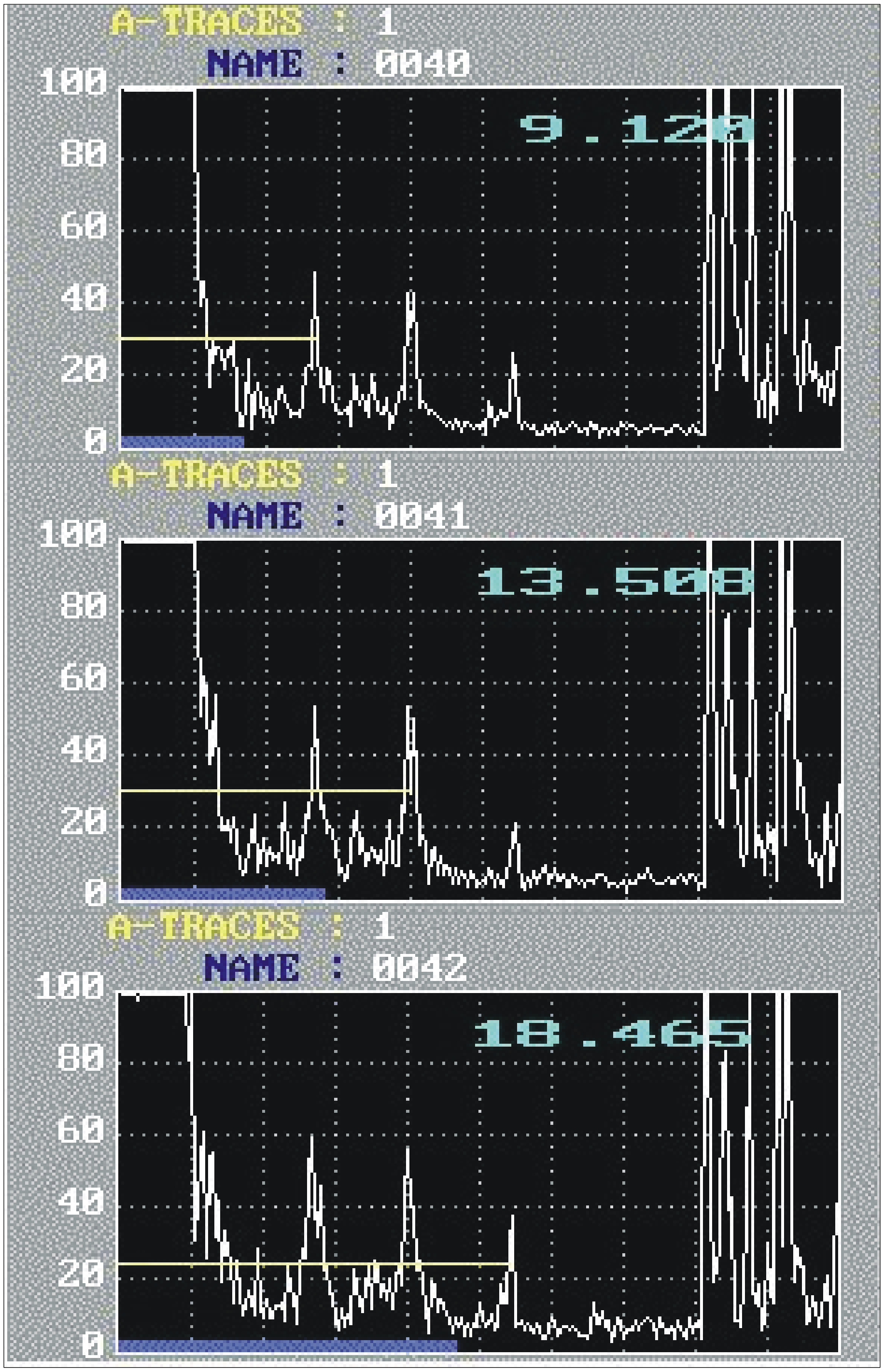
## Literature Survey

A comprehensive assessment of the technical literature was performed.[1-11] Many researchers have discussed the use of ultrasound for inspection of steel pins. The consensus approach is to exploit the beam spread of longitudinal straight beam transducers, supplementing this procedure with the use of angle beam probes. This approach, however, primarily addresses detecting cracks and wear grooves in high-shear areas in pins "frozen" because of corrosion. Such procedures do not provide sufficient data to allow for reliable determination of whether a detected imperfection is a crack. Because of the complicated nature of ultrasound interaction with fracture surfaces, questions may be raised as to whether these procedures are reliable for detecting the presence of cracks. Some investigators have successfully used special transducers inserted into central holes in pins. They have suggested that acoustic coupling which allows sound to enter hangers or girders prior to reflection back to the transducer may introduce unexpected geometric indications.[5,6] Recently, Komsky and Achenbach discussed using a scanning approach for obtaining more information about ultrasonically detected imperfections.[10] Results presented were preliminary and focused on scans performed in a laboratory under ideal conditions. Only one case involved actual crack imperfections.

Calibration specimens fabricated to be used as part of a bridge pin inspection procedure typically have simulated cracks using saw cuts, or electrodischarge machining (EDM) notches. Little work has been presented that actually explores the nature of the ultrasonic reflection and scattering from geometric or material discontinuities (cracks, wear grooves, inclusions). Gessel and Walther concluded that more research is needed for accurate interpretation of ultrasonic scattering from cracks, wear grooves, and geometric reflectors.[11]

Essentially all field examination of bridge pins is done by means of ultrasonic A-scan, where the bridge inspection technician carefully follows a procedure such as that used by VDOT (Appendix B). The technician moves transducers over the end of the pin surface after having selected the appropriate time/distance and signal amplitude setting for the length pin being examined. An amplitude versus time signal such as that shown in Figure 1 is observed. The signal contains an echo from the far end of the pin (and, if present, an echo for the shoulder), along with any other indication from imperfections in the pin. The technician searches for the different indications and records their location, the signal intensity, and most likely the actual A-scan in his or her portable ultrasonic pulser/receiver unit. Since recording all of the signals and locations is not possible, generally only the largest amplitude signal associated with a particular indication is recorded. Consequently, the report of the ultrasonic inspection is distilled to the point of that shown in Appendix C.[12] Ultrasonic C-scanning is a procedure that endeavors to image many hundreds of signals at locations that are impractical for recording through hand-held inspection procedures. The initial inspection procedure is a critical part of the process, since it provides the baseline location for consideration. Some very capable ultrasonic scanning systems allow for full waveform data recording while scanning over a two-dimensional area.

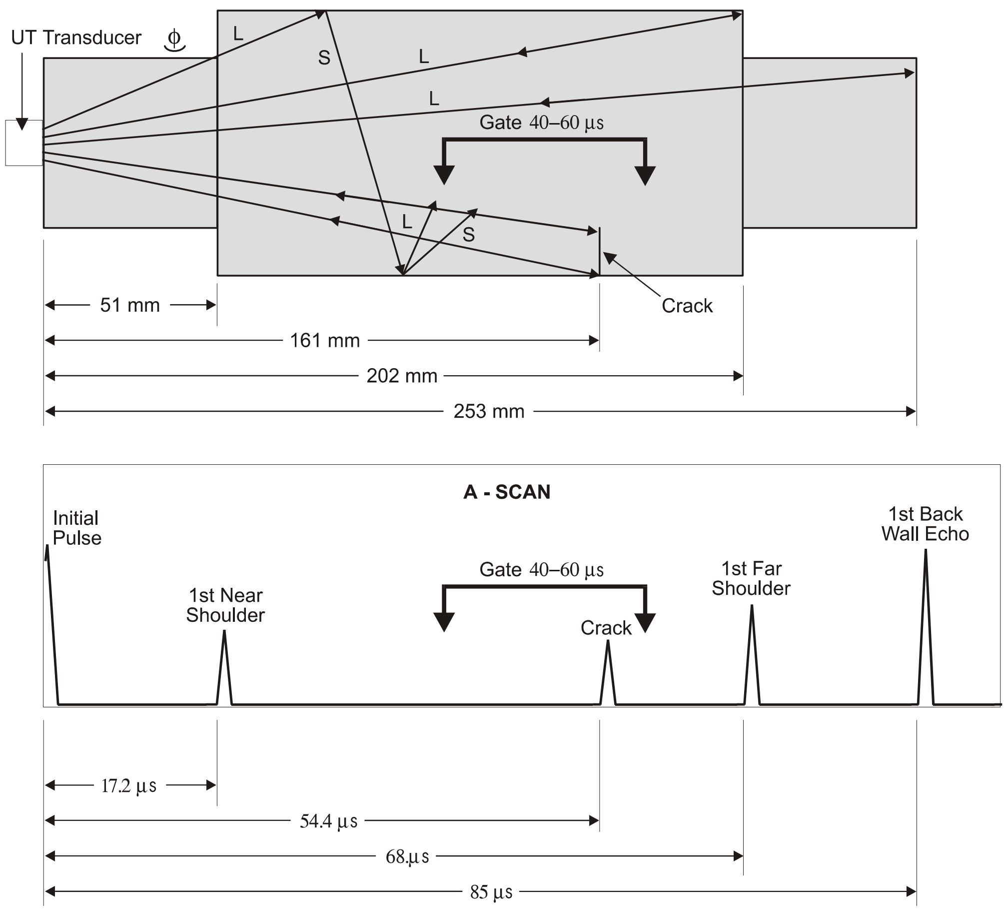
**Figure 1. Ultrasonic scan, typical amplitude vs. time signal**




## Fabrication of Calibration Pins

Ultrasonic inspection of steel bridge pins is complicated by the interaction of ultrasound and actual fracture surfaces (cracks) that may be faceted and oriented at various angles within the pin. In addition, the structure of the pin may be varied because of threaded ends, cotter pin holes, and changes in pin diameter. Previously, VDOT's Richmond Bridge Office fabricated a calibration pin (see Figure 2 for pin dimensions) to qualify inspectors for ultrasonic inspection of steel bridge pins. This pin, with reduced cross-section threaded ends, contained a surface-breaking crack near one end of the pin. The crack was produced by mechanical fatigue after special tensioning brackets were welded to the pin. Once the crack had formed and propagated to the desired length, the brackets were removed and the surface was ground smooth, consistent with the dimensions of the rest of the pin (Figure 2). This pin is similar to pins in service in bridges in Virginia, in particular in Structure 1042 in Tazwell in the Bristol Bridge District.

**Figure 2. Tazwell (small) reference pin**




A second reference pin, representative of pins found in the Radford Memorial Bridge (Structure 1903, Salem Bridge District), was also fabricated for calibration. This pin is 787.7 mm (31 in) in length with a central shaft 228.6 mm (9 in) in diameter and turned-down ends 152.4 mm (6 in) in diameter (Figure 3). Two imperfections were imbedded in the pin during fabrication (Figure 4). One was composed of a piece of slag approximately 12.7 mm (0.50 in) long, 3.2 mm (0.125 in) in diameter, with a 3.2-mm (0.125-in) crack growing from the slag. This flaw was imbedded approximately 1.5 mm (0.06 in) below the surface, approximately 330.2 mm

**Figure 3. Radford Memorial Bridge reference (large) pin**

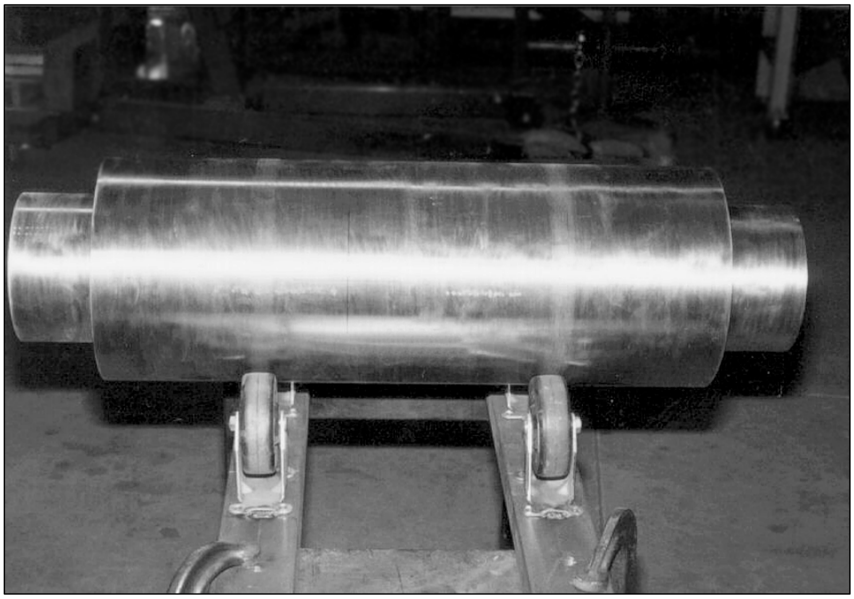
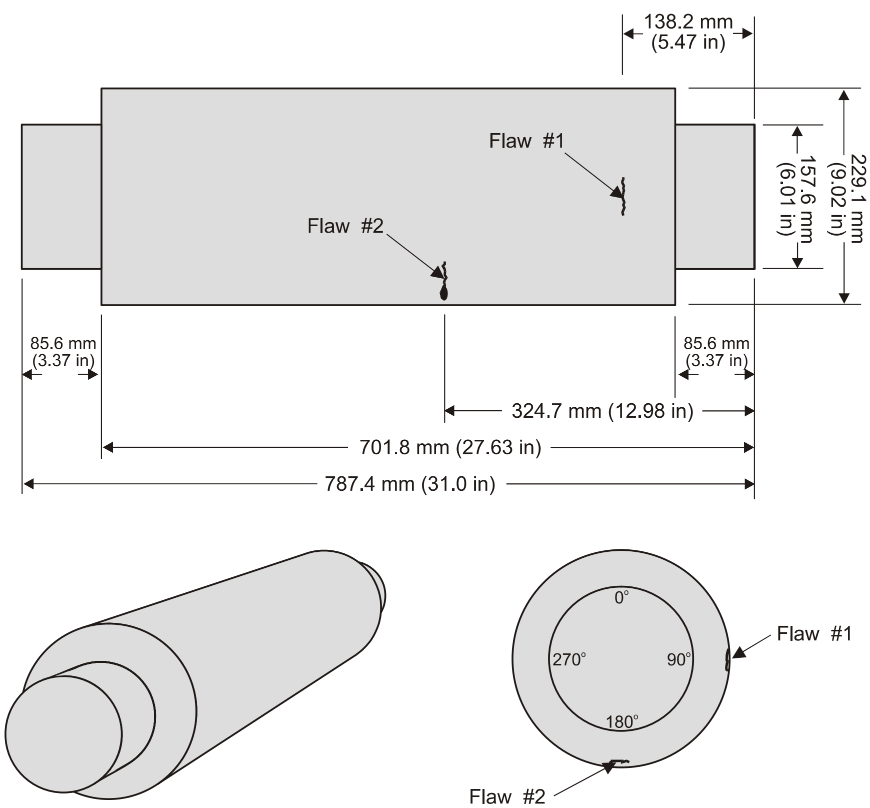


**Figure 4. Dimensions of and embedded imperfections in Radford Memorial Bridge (large) reference pin**



(13 in) from one end. A second surface-break mechanically induced fatigue crack was created, 19 mm (0.75 in) long (at surface) and 5.1 mm (0.20 in) high (deep), in a location expected to be in a region of high shear, approximately 139.7 mm (5.5 in) from the end of the pin.

## Mathematical Model for Tracing Ultrasonic Rays

The pin geometry (with threads, reductions in cross-section, cotter pin holes, central holes, keyways, etc.) and the ultrasonic beam spread geometry combine to produce non-trivial reflection patterns, especially when the transducer is off of the central axis of the pin, even in the absence of any imperfections. Consequently, it is difficult to interpret reflected scanned image patterns where imperfections of known size and location are present in calibration pins, let alone those resulting from unknown features in pins in service. The researchers developed a mathematical model to address this issue.

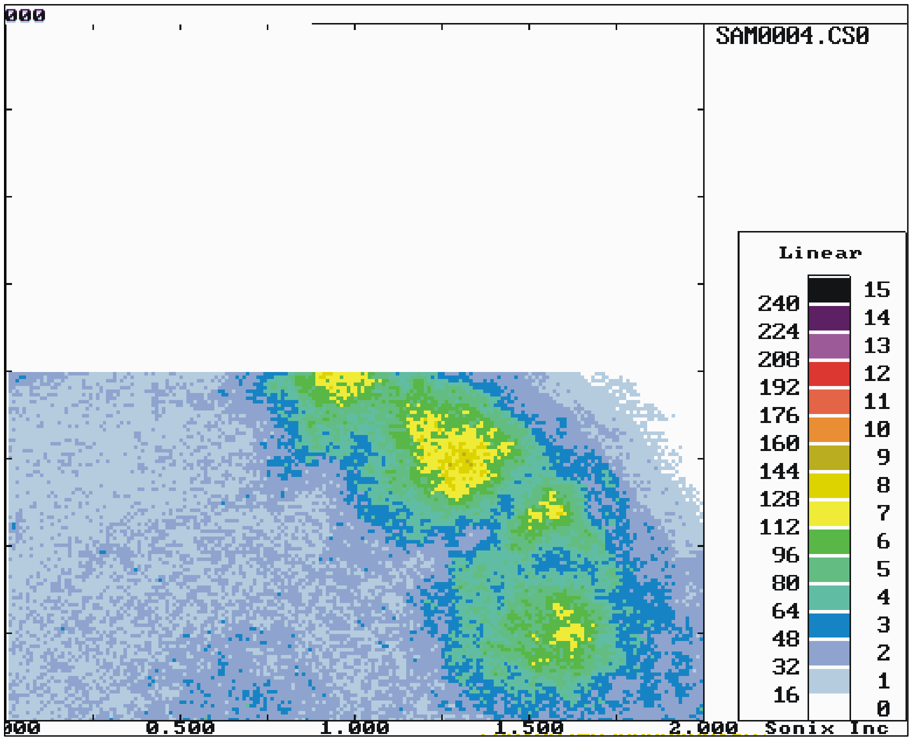
The model requires as input the geometry of the pin and the location, size, and orientation of any suspected imperfection. The model then simulates the transducer performance by generating rays at several prescribed angles; the rays are allowed to "propagate" until they encounter a boundary of either the pin or imperfection. The encounter is used as the basis for determining a reflection, and possible created ray-through-mode conversion, in accordance with mechanical analysis of a boundary value problem for a stress-free boundary (this would be inappropriate for modeling a boundary that was experiencing compressive stress). The model follows this process of propagation, reflection, and mode conversion for as long as desired, generally until a ray encounters the surface where the receiving transducer is located. It is possible for the model to consider this process for every point on the end surface of the pin. By appropriately adding the results for various points (what mathematically would be termed *linear superposition*), it is possible to predict what a transducer of finite diameter would detect at a specific location. If such an addition process is repeated appropriately, it is further possible to predict the image that would result from a C-scan with a "time gate" set to isolate a particular region of the pin. The data generated from the model allow for arbitrary location of this gate or the use of multiple gates.

## Ultrasonic Scans in the Laboratory

Both pins were examined using a laboratory ultrasonic scanner to obtain high-resolution images. Figure 5 depicts the small reference pin and shows the portion of the image where the imperfection is indicated. The larger calibration pin was examined before the flaws were implanted to document the presence of any as fabricated flaws and to be certain that any flaw present was not in a location where it was likely to be confused with the implanted flaws. No significant indications were detected, so these images were omitted.

These scans were performed under reasonably ideal conditions, with the pins oriented vertically and carefully leveled. Ultrasonic liquid coupling dams were employed. Despite the researchers' best efforts, some modest variation in transducer orientations occurred for the contact scanning procedure used. It was also necessary to attach a plate to the end of the pins to provide an extended flat region for the transducer to glide over as it moved in a raster pattern

**Figure 5. Ultrasonic scan of small pin imperfection**




over the circular pin end area. As the transducer direction changed during scanning, a slight tilt would at times occur, depending on the couplant layer thickness, the smoothness of the pin end, the speed of the scan, and the relative orientation of the pin end plane and the transducer scan plane. Further, for high-resolution scanning, the transducer effectively "scrubs" over much of the same area, which can actually remove the couplant. Care was taken to avoid this problem in the laboratory; it could pose a greater issue in the field.

The researchers conducted laboratory testing of the ultrasonic scanning system to be used in the field. They refined the field testing procedure and fixture and determined the parameters to be used in performing the field scans. The scanning system was composed of a translation bridge scanner attached to a linear crawler with magnetic, serrated wheels and a computer-controlled interface. A transducer fixture was attached to the translation bridge. A computer controlled pulser receiver card was used to drive the transducer and collect the return echoes in pulse-echo mode. The output from the pulser-receiver card was directed to an analog-to-digital (A/D) board, via software. The card was capable of gating the signal in two gated regions and recording the amplitude of the signal within the gates. The integrated system software allowed the researchers to select gate regions for the purposes of B-, or C-scan data collection. This automated system was originally developed in another project at the Virginia Transportation Research Council.[13,14]

## Ultrasonic Scans in the Field

To conduct C-scans of bridge pins in the field, it was necessary to situate the automated scanning system on a set of parallel magnetic (steel) tracks properly oriented to provide for coverage of the pin end. For the Tazwell Bridge, access was available from beneath the bridge by extension ladder; for the Radford Memorial Bridge, a Bridgemaster lift truck was required. In each case, an appropriate fixture was prepared and installed to allow the automated system to scan over the end of the pin. During field scanning, coupling fluid was applied manually using a squirt can. The orientation of the scanning system was vertical, since the pins in the field are typically oriented in the horizontal plane. Such an orientation adds to scanner movement and couplant problems because of the effect of gravity. Fine adjustments to the orientation of the scanner plane relative to the pin end face also could be more arduous in the field, because the pin face may not be flat or free of corrosion or paint. Consequently, although image quality in the field can be expected to be reasonably high, it is not likely to duplicate laboratory results.

# RESULTS

Figure 6 is an image obtained from a laboratory scan of the small reference pin with the automated system. The laboratory scan of the large reference pin with the automated system, Figure 7, shows images of (a) the slag inclusion, and (b) the surface breaking crack. Figure 8 displays the image obtained using the automated system to scan a pin in the Tazwell bridge. Figure 9 displays the images obtained using the automated system for a pin in the Radford Memorial Bridge. The three images correspond to three indications observed in the A-scan at times that correspond to distances, presumed to be depth locations of imperfections within the pin, 228, 330, and 457 mm, respectively (9, 13, and 18 in).

**Figure 6. Laboratory scan of small reference pin, automated system**

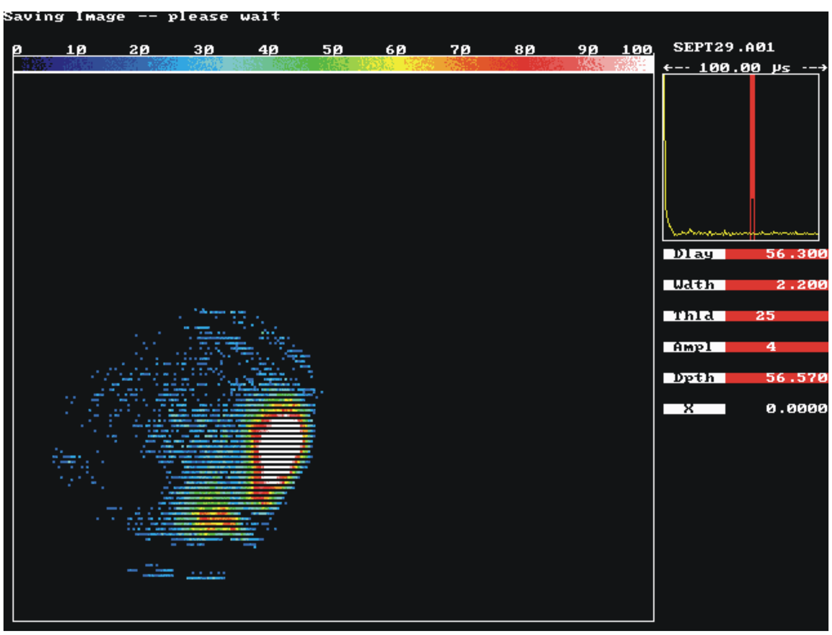


**Figure 7a. Laboratory scan of large reference pin with automated system, slag inclusion**

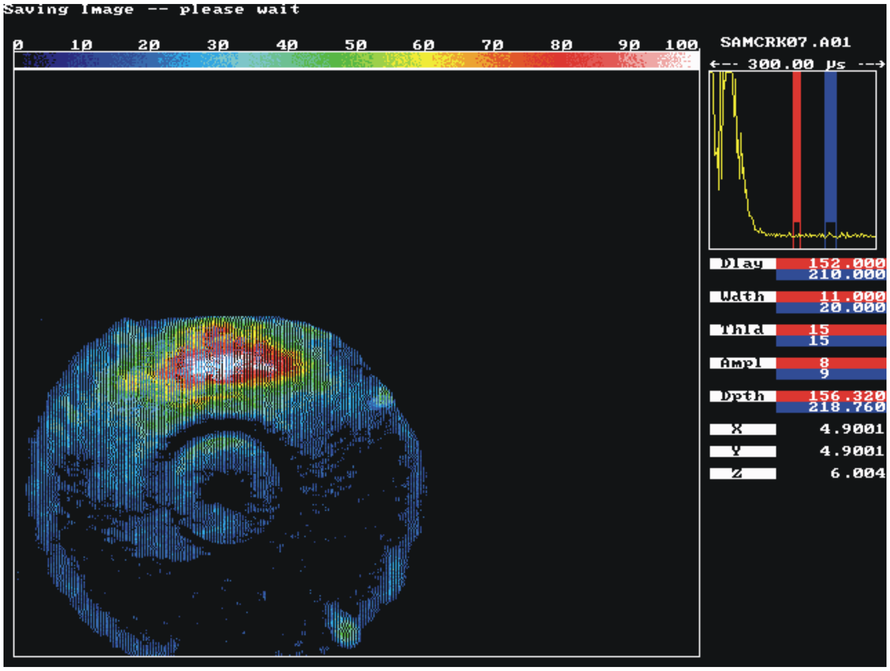



**Figure 7b. Laboratory scan of large reference pin with automated system, surface-breaking crack**

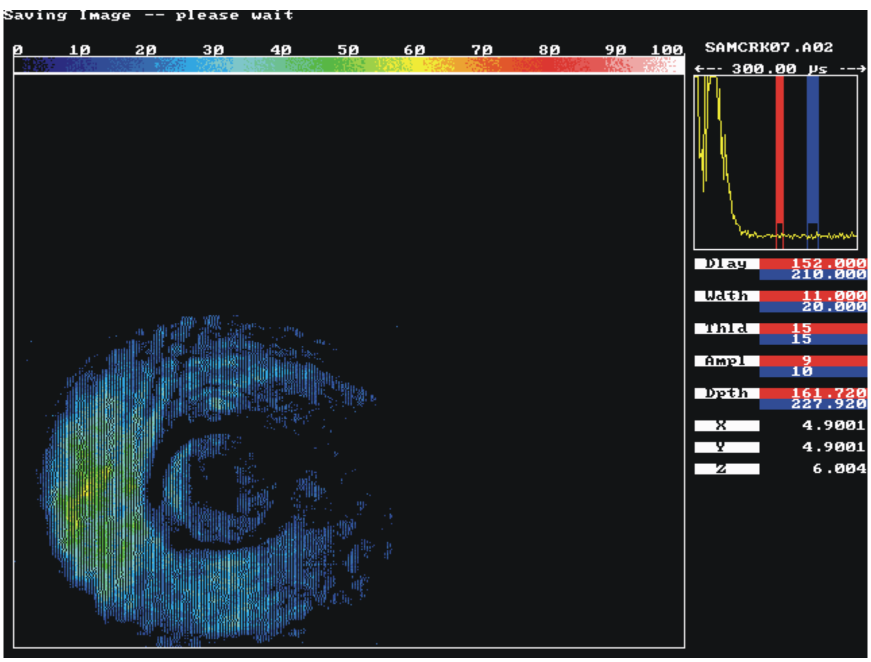


**Figure 8. Field scan of pin, Tazwell bridge, structure 1042, automated scan system**

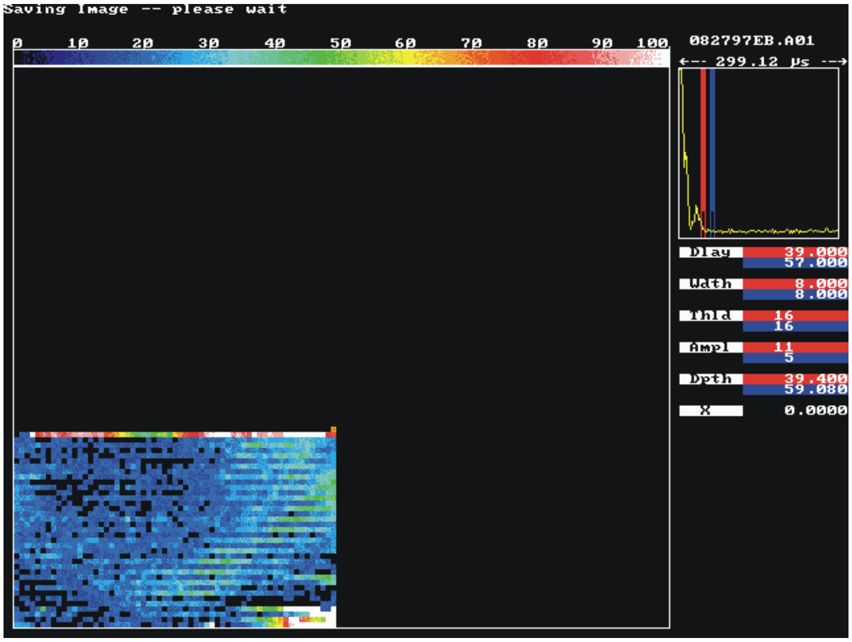



**Figure 9a. Pin in Radford Memorial Bridge, structure 1903, indication of imperfection at 228 mm**

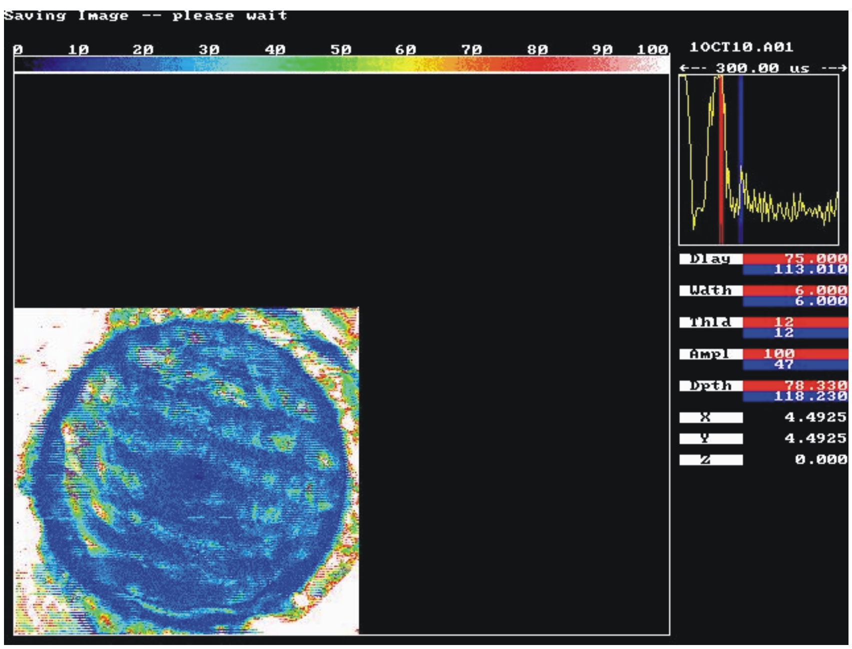


**Figure 9b. Pin in Radford Memorial Bridge, structure 1903, indication of imperfection at 330 mm**

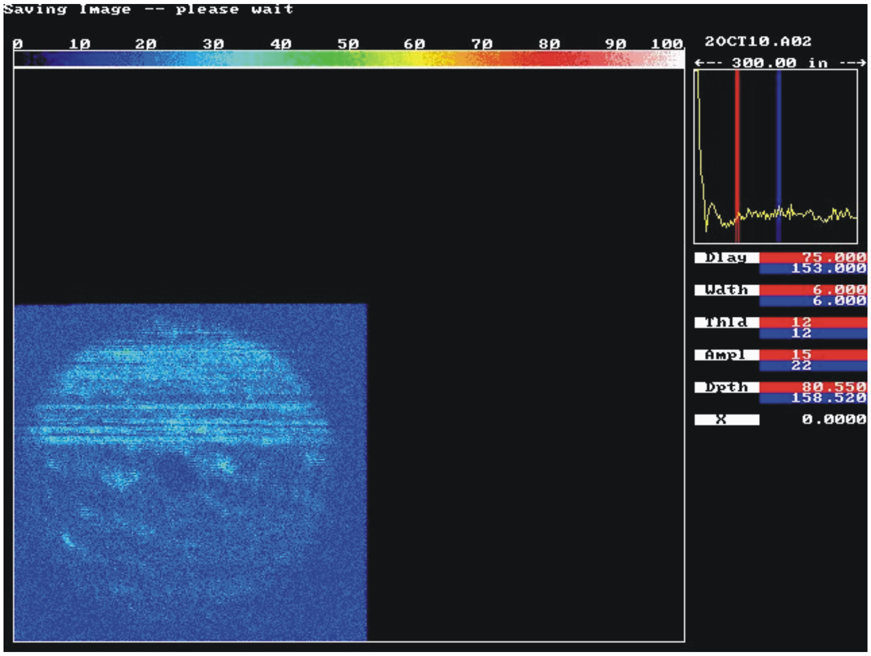
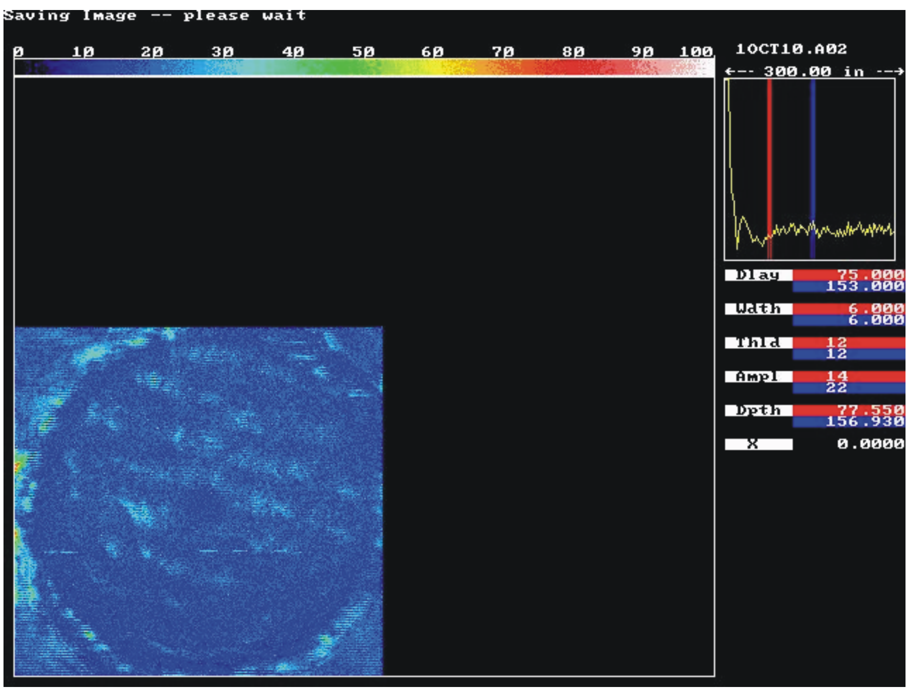



**Figure 9c. Pin in Radford Memorial Bridge, structure 1903, indication of imperfection at 457 mm**



## Raytrace Prediction for the Large Calibration Pin

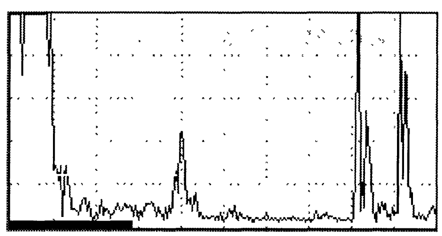
Using the raytrace mathematical model, the researchers were able to predict the A-scan that a transducer would detect for a given position on the end face. The transducer element size and the frequency must be specified to determine and limit the angles of rays considered to those predicted by the classical beam spread formula:

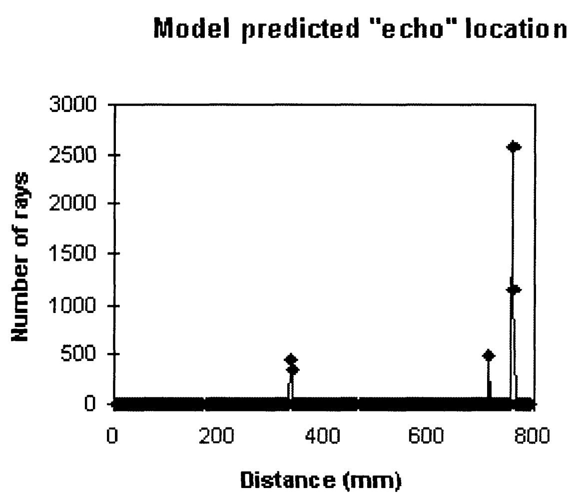
$$\varphi = 2\sin^{-1}\left[\frac{(1.2x10^{-3})(5900m/s)}{(transducer - frequency(MHz))(diameter(mm))}\right] \quad (1)$$

The parameters are also needed to establish the region over which rays must be added to represent the region of detection of the transducer in the receiving mode. Since the model determines the precise arrival time of each ray independently, for each location, a boxcar averaging procedure is used to simulate the temporal averaging that might be expected in a real detection system.

Figure 10 (top) is the actual A-scan for the large reference pin with simulated slag inclusion present, and a 4-MHz transducer, 9.5 mm (0.375 in) diameter, located 25.4 mm (1 in) off center in a radial direction toward the flaw. Figure 10 (bottom) is the A-scan predicted for the same situation, using the raytrace model.

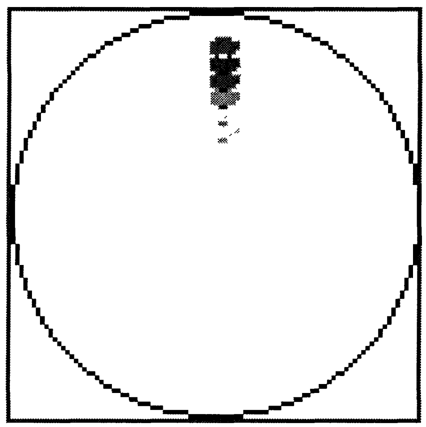
**Figure 10.** ***Top,*** **A-scan of large reference pin actual slag imperfection, portable ultrasound unit.** ***Bottom,*** **Raytrace model predicted A-scan for slag inclusion, large reference pin**





By adding the many different A-scan predictions limited by a time gate, and consistent with the transducer position associated with a specified resolution C-scan pattern, the C-scan image may be predicted. Figure 11 is the predicted C-scan image for the large reference pin with simulated slag inclusion present, and a 4 MHz transducer, 9.5 mm (0.375 in) diameter, scanned with a pixel resolution of 12 x 12 mm (0.46 x 0.46 in). The scan resolution of the corresponding image, Figure 7(a), is approximately 2.5 x 2.5 mm (0.1 x 0.1 in).

**Figure 11. Predicted C-scan image of large reference pin with simulated slag inclusion present, and a 4-MHz transducer, 9.5 mm (0.375 in) in diameter, scanned with a pixel resolution of 12 x 12 mm (0.46 x 0.46 in).**



## DISCUSSION

The laboratory scans of the reference pins provide images (Figures 6 and 7) for imperfections of known size and location within the respective pins. Examination of these images shows that the beam spread of the transducer allows the imperfection to be detected from many different transducer positions on the end face of the pin. However, the energy reflected back to the transducer depends not only on the transducer position and the transducer beam spread, but also on the nature of the imperfection and its location within the pin. By comparing the images with the actual flaws, it is clear that in some instances the size of the region of highest reflected ultrasonic amplitude does not correspond exactly with the size of the flaw. The fact that the ultrasonic indication typically is larger in area than that of the flaw is reassuring in that it suggests that even quite small flaws are detectable with this technique. However, sizing based on the ultrasonic C-scan image is not straightforward. In general, the larger the indication, the larger the flaw, as long as the depth within the pin is similar. If the same size indications were obtained for imperfections at different depths within the pin, it is likely that the imperfection causing the indication would be larger for smaller depths.

The depth of a flaw within the pin can be determined using an A-scan display (see Appendix C). The depth determination is accomplished by relating the time that a reflection echo occurs to the time required for the ultrasonic beam to propagate a corresponding distance. It is not possible to determine from the A-scan the exact path of propagation. Consequently, to be assured that an imperfection is indeed located at a specific depth within the pin, the pin must be examined from the opposite end as well. Ideally an indication is detected that corresponds to the depth measured from the other end of the pin. Unfortunately, the pin geometry may make such confirmation impossible. The time required for the ultrasonic beam to propagate to the opposite end of the pin and back (a known distance, twice the length of the pin) typically is used to calibrate the distance-time conversion.

Multiple reflections, shadows cast by geometric features such as cotter pin holes, surface irregularities of the imperfection, and the angle(s) of orientation, all complicate ultrasound image interpretation. In addition, various microstructural features in engineering materials such as porosity, inclusions and non-uniform grain size also interact with the ultrasound beam. The model, briefly described, was developed to assist with image interpretation.

The partial image obtained from C-scanning the Tazwell pin, Figure 8, shows that the imperfection is detectable over a reasonably large area of the pin end as compared with the image of the small surface crack in the small reference pin. However, the relatively uniform and low reflection amplitude is different than the strong reflection from the crack imperfection in the reference pin.

Images associated with ultrasonic indications, apparently at three different depths in the Radford Memorial Bridge pin, Figure 9, show that over an extended area of the pin end each of these indications are detectable. The intensity of the reflections from the imperfection, believed to be 228.6 mm (9 in) from the pin end, are significantly higher than those detected from either of the other two indications. The widespread and disconnected nature of the region of detection is quite different from that observed for the corresponding large reference pin with imbedded imperfections, Figure 7. It is also significant to note that the location of some regions of the indications believed to be at different depths, seem to coincide. The automated system allows for images of indications at two different depths to be formed simultaneously, which makes it possible to consider such coincidental indications, since the two images are in registration. Images (a) and (b) Figure 9 were formed at the same time, whereas image (c) was formed from another C-scan, where the associated second image was for the 228.6-mm (9-in) indication. The streaking apparent in image (c) (and in the companion image) resulted from a temporary depletion of the coupling fluid.

To guide interpretation of pin images, the mathematical raytrace model can be used to simulate the images that would result from a particular size flaw located at a specific depth within a pin. Since it is necessary to provide the model with some description of the imperfection, ingenuity is required to provide a possible imperfection description that will actually cause a C-scan image similar to that obtained from the C-scan of an unknown flaw.

To provide a comparison of the model simulation results with actual results from pins, the large reference pin was used along with a description of the actual slag imperfection. Figure 10 (top) displays the A-scan obtained using a portable ultrasonic unit, Figure 10 (bottom) displays the A-scan predicted for the slag inclusion in the large reference pin by the raytrace model.

Figure 11 displays the C-scan image predicted by the raytrace model for the slag imperfection, whereas Fig. 7a is the corresponding actual ultrasonic C-scan image. These results are encouraging for this simple raytrace model and are expected to improve significantly with additional refinements. The overlapping circular regions in Figure 11 result in part from the coarse grid that is used to reduce computer processing time.

## CONCLUSIONS

- The procedure for high-definition ultrasonic scanning of steel bridge pins in the field developed and demonstrated in this study can be used to detect even quite small flaws. However, sizing of the flaws using ultrasound scanning is not straightforward.

- The mathematical model for tracing the path of ultrasonic rays developed to guide interpreting scanned images shows considerable promise.

## RECOMMENDATIONS

- Develop a more compact transducer manipulation fixture exclusively for pin inspection.

- Develop more compact and reliable instrumentation for the automated field assessment of bridge pins.
- Use the ultrasonic raytrace model to explore procedures for more thorough field inspection and follow-up assessment of bridge pins.

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## APPENDIX A
## VIRGINIA STEEL BRIDGE PIN DETAILS

| District | Structure No. | Material | Total Length | Main Diameter | Ends Length | Ends Diameter | Comments |
|---|---|---|---|---|---|---|---|
| Bristol | 1032 | AISI 4140 | 9(3/4)" | 3" | 2(1/8)" | 2" | Rte 19 over Clinch River Tazwell County |
| Bristol | 1042 | A36 | 8(1/4)" | 3" | 1(1/4)" | 2(1/2)" | Rte 19 over Clinch River Tazwell County |
| Richmond | 1048 | A36 | 13(9/16)" | 3" | No ends | 4(1/2)" Butt | Rte 49 over Goodells Creek in Mecklenburg County |
| Richmond | 1942 | A36 | 11(1/8)" | 6" | 1(3/4)" | 4(1/2)" | Rte 147 over James River in Richmond/Henrico County |
| Salem | 1903 | A7 | 31" | 9" | 3(1/2)" | 6" | Radford Memorial Bridge, City of Radford |
| Salem | 1903 | A7 | 29" | 10" | 3(1/2)" | 6" | Radford Memorial Bridge, City of Radford |
| Suffolk | 2816 | A588 | 8(5/16)" | 4" | 1(5/8)" | 3" | Ramp C over Rte 64, City of Hampton |
| Suffolk | 2830 | A588 | 8(1/16)" | 4" | 1(5/8)" | 3" | Ramp B over Ramp C New Market Creek & Rte 64, Hampton |
| Suffolk | 2833 | A588 | 7(9/16)" | 4" | 1(3/8)" | 3" | Ramps A & B over New Market Creek Swamp, Hampton |
| Suffolk | 6097 | A7 | 16(1/4)" | 3" | 1(1/8)" | 2(1/2)" | Rte 684 over Nottoway River, South Hampton County |

## APPENDIX B
## VDOT PROCEDURE FOR ULTRASONIC TESTING OF BRIDGE PINS

### 1.0 Scope

This test method outlines the procedure for ultrasonically determining discontinuities in bridge pins by the pulse echo method, using straight beam longitudinal waves induced by direct contact of the search unit with the material being tested.

### 2.0 Reference

2.1 ASTM E114-85 Ultrasonic Pulse Echo Straight Beam Testing by the Contact Method.

### 3.0 Personnel

3.1 Personnel shall be qualified in accordance with SNT-TC-1A Level II and certified by VDOT Materials Division.

### 4.0 Equipment

4.1 Instrumentation: Krautkramer-Branson Ultrasonic Pulse Echo unit, model USK-7 or equivalent.

4.2 Transducer: 0.50 inch diameter, 2.25 MHz. (Angle-beam wedge, if applicable)

4.3 Couplant: Glycerin / cellulose gum with water added for desired consistency.

4.4 Reference Standard: Reference standard material and test pin material should be acoustically similar.

"NOTE: Equipment shall be qualified in accordance with AWS D1.5 Section 6, Part C.

### 5.0 Calibration

5.1 The ultrasonic unit shall be calibrated for distance on a standard of sufficient length and diameter to simulate the bridge pins being inspected. Sensitivity should be adjusted to a gain setting of at least 20 dB greater than that required for an 80% back-reflection from the end of the test pin.

5.2 Where the surface finish of the reference standard and the inspection item do not match, or where there is an acoustic difference between the standard and the inspection item, an attenuation correction shall be made.
5.3 Unless otherwise specified, the initial pulse and at least one back reflection shall appear on the screen of the CRT while testing for discontinuities in materials having parallel surfaces.

5.4 As a minimum, the calibration shall be checked each time there is a change of operators, when new batteries are installed, when search units are changed, when operating from one power source is changed to another power source, or when improper operation is suspected.

**6.0 Testing Surface**

6.1 Surfaces shall be uniform and free of loose scale and paint, discontinuities such as pits, gouges, dirt, or other foreign material that affect test results.

**7.0 Scanning**

7.1 Scanning may be either continuous or intermittent.

7.2 Apply a layer of couplant, hold the search unit in hand and move slowly over the surface of the pin.

7.3 Scan pin from each end to insure full coverage whenever possible.

**8.0 Test Data Records**

8.1 District, Structure, County and Route.

8.2 Total pins, pin length and diameter.

8.3 Instrument description - make and model.

8.4 Search unit description - type, size, frequency, special shoe.

8.5 Pin location and indication information.

8.6 Pertinent instrument settings necessary to duplicate test.

8.7 Reference standards and degree of attenuation correction, if applicable.

8.8 Operator.

## 9.0 Evaluation

9.1 The procedure is limited in that the signals do not indicate the depth of the defect. It is also difficult to distinguish between sharp wear grooves and small initial cracks. Artificial reflectors, such as slots, may be added to the reference standard for signal comparisons when the results are inconclusive. Angle-beam testing may also be used to enhance the reflection of small outside diameter cracking.

9.2 The frequency of inspection will be as directed by the Structure and Bridge Division.

# APPENDIX C: MANUAL ULTRASONIC INSPECTION RESULTS FOR RADFORD MEMORIAL BRIDGE PIN AND BRIDGE REFERENCE PIN

## *Virginia Department of Transportation*

**Ultrasonic Test Report**

Bridge Pin

**District:** Salem **Structure:** 1903 **Inspection Date:** 5/5/97

**County:** Montgomery

**Route:** 11

**Total Pins:** 16 **Pin Length:** T-31"(8) B-29.5"(8)

**Instrument:** K/B USN-50 **Transducer:** 0.50" 2.25 mhz

**Test Pin Back-Reflect.(80%):** 60 dB **Scan Level:** 80 dB

**Ref. Pin Back-Reflect.(80%):** N/A dB **Attenuation Corr:** N/A dB

| Pin Location | | | Indication | | | |
|---|---|---|---|---|---|---|
| Span | Girder | Top/Bott | Face | Depth | Position | Gain(40%) |
| 6 | U8-Lt | Top | Downstream | 13.8" | 1:00 | 70dB |
| 6 | U8-Lt | Top | Downstream | 13.6" | 7:00 | 73dB |
| 6 | U8-Lt | Top | Upstream | 9.1" | 10:00 | 72dB |
| 6 | U8-Lt | Top | Upstream | 13.7" | 10:00 | 74dB |
| 6 | U8-Lt | Top | Upstream | 18.7" | 10:00 | 79dB |
| 6 | U8-Lt | Top | Upstream | 13.5" | 4:00 | 75dB |
| 6 | L2-Lt | Bottom | Downstream | 13.2" | 1:00 | 73dB |
| 6 | L2-Rt | Bottom | Downstream | 25.4" | 5:00 | 70dB |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

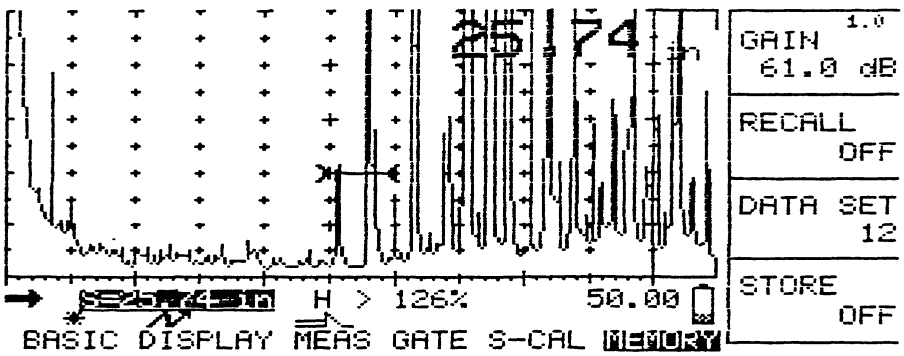
**Remarks:**

**Technician:** *S.R.Thomas*

**Rpt. Date:** 5/6/97

Bridge Reference Pin

USN 50




| | | | | | |
|---|---|---|---|---|---|
| GAIN: | 61.0 dB | | | | |
| RANGE: | 50.00 in | MTL VEL: | .2347/us | DELAY: | -0.805us |
| PULSER: | HIGH | MEASURE: | 0 TO 1st | a-THRESH: | 40 % |
| REJECT: | 0 % | TOF: | FLANK | a-START: | 24.63 in |
| DISPLAY: | FULL | ASCAN: | HOLLOW | a-WIDTH: | 5.000 in |
| b-THRESH: | 30 % | ZERO us: | 0.737 | RECALL: | OFF |
| b-START: | 10 % | | | DATA SET: | 12 |
| | | | | STORE: | OFF |

AMPLITUDE: % SCREEN HT
FREEZE MODE: FREEZE ALL
VELOCITY #1: .2330/us
VELOCITY #2: .1320/us
GATE LOGIC: MEASURE

OPERATOR: ____________ USN50 SN: 00600466

CODE: ____________ PROBE SN: ____________

LOCATION: ____________ CAL BLOCK SN: ____________

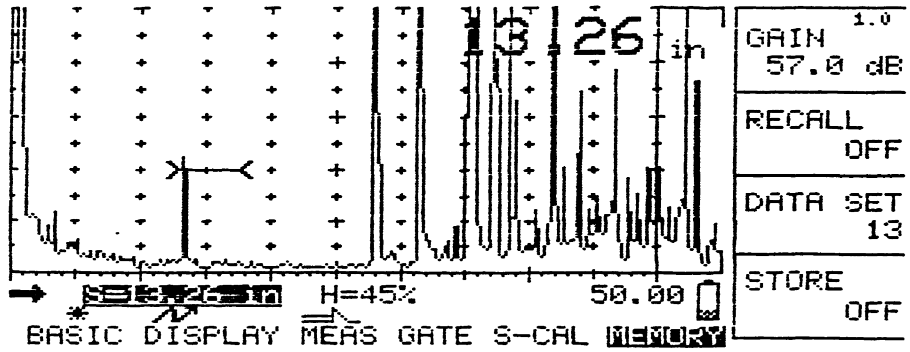
JOB NAME: ____________

TEST COMMENTS: Flaw # 1 from F.E.

SIGNATURE: ____________ DATE: ____________

Bridge Reference Pin

USN 50




| | | | | | |
|---|---|---|---|---|---|
| GAIN: | 57.0 dB | | | | |
| RANGE: | 50.00 in | MTL VEL: | .2347/us | DELAY: | -0.805us |
| PULSER: | HIGH | MEASURE: | 0 TO 1st | a-THRESH: | 40 % |
| REJECT: | 0 % | TOF: | FLANK | a-START: | 12.64 in |
| DISPLAY: | FULL | ASCAN: | HOLLOW | a-WIDTH: | 5.000 in |
| b-THRESH: | 30 % | ZERO us: | 0.737 | RECALL: | OFF |
| b-START: | 10 % | | | DATA SET: | 13 |
| | | | | STORE: | OFF |

| | |
|---|---|
| AMPLITUDE: | % SCREEN HT |
| FREEZE MODE: | FREEZE ALL |
| VELOCITY #1: | .2330/us |
| VELOCITY #2: | .1320/us |
| GATE LOGIC: | MEASURE |

OPERATOR: ____________ USN50 SN: 00600466

CODE: ____________ PROBE SN: ____________

LOCATION: ____________ CAL BLOCK SN: ____________

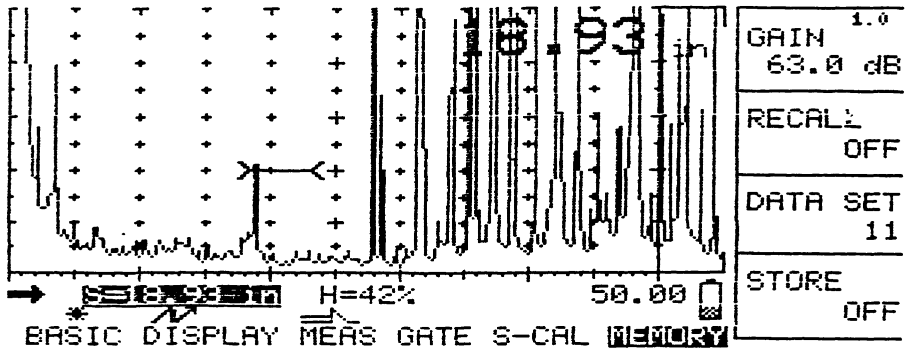
JOB NAME: ____________

TEST COMMENTS: Flaw # 2 from N.E.

SIGNATURE: ____________ DATE: ____________

Bridge Reference Pin

USN 50




| | | | | | |
|---|---|---|---|---|---|
| GAIN: | 63.0 dB | | | | |
| RANGE: | 50.00 in | MTL VEL: | .2347/us | DELAY: | -0.805us |
| PULSER: | HIGH | MEASURE: | 0 TO 1st | a-THRESH: | 40 % |
| REJECT: | 0 % | TOF: | FLANK | a-START: | 18.35 in |
| DISPLAY: | FULL | ASCAN: | HOLLOW | a-WIDTH: | 5.000 in |
| b-THRESH: | 30 % | ZERO us: | 0.737 | RECALL: | OFF |
| b-START: | 10 % | | | DATA SET: | 11 |
| | | | | STORE: | OFF |

AMPLITUDE: % SCREEN HT
FREEZE MODE: FREEZE ALL
VELOCITY #1: .2330/us
VELOCITY #2: .1320/us
GATE LOGIC: MEASURE

OPERATOR: ____________ USN50 SN: 00600466

CODE: ____________ PROBE SN: ____________

LOCATION: ____________ CAL BLOCK SN: ____________

JOB NAME: ____________

TEST COMMENTS: Flaw #2 from F.E.

SIGNATURE: ____________ DATE: ____________