



### Focus

## Nondestructive Testing of Concrete

by Glenn A. Washer

Concrete is a composite material consisting of cement, fine aggregates (sand) and coarse aggregates (stone). When combined with water and cured, the components form a heterogeneous matrix with high compressive strength and very limited tensile strength. Deformed steel bars (rebar) embedded within the concrete carry tensile loads and control cracking. This combination can be cast to form a wide variety of structural and architectural elements. As a result, concrete is one of the most widely used construction materials in structures and facilities.

#### Inservice Deterioration

Concrete can suffer from several forms of *inservice deterioration*. The most common deterioration mode is *corrosion induced delaminations* and *spalling*. The corrosion process is driven by moisture and oxygen that can permeate the concrete. Application of deicing materials, such as salt (sodium chloride), to the surface of the concrete can significantly increase the corrosion rate. Embedded rebar expands significantly as it corrodes due to the creation of corrosion products along the surface of the rebar. This expansion causes tensile stresses that lead to horizontal cracking. As adjacent rebars corrode, horizontal cracks join to form an area in which there is a delamination in the concrete at the level of the rebar. Untreated, a delamination may increase in size and propagate to the surface, resulting in the chipping or spalling of the concrete.

*Freeze-thaw* damage can also deteriorate inservice concrete. Freeze-thaw damage is a progressive deterioration of the concrete material caused by the entrance of water (into the concrete pores) which subsequently expands when it freezes, introducing tensile stresses that can cause concrete to crack. As

freeze-thaw cycles continue, the crack gets larger, more water enters, which in turn causes more expansion upon freezing with increased stresses, and so on. Freeze-thaw cycles can play a role in propagating delaminations when water can penetrate to the level of the reinforcing steel. Freeze-thaw damage leads to a generalized deterioration of the concrete strength properties, widespread cracking, spalling and eventually loss of section (Fig. 1).

Other forms of deterioration also afflict inservice concrete. Carbon dioxide penetrating to the rebar level can react with calcium phases causing carbonation that results in increased potential for corrosion. Reactivity between cement paste and certain aggregates can cause an alkaline-silica reaction producing expansive reaction products with widespread concrete cracking.

#### Discontinuities Introduced During Construction

In addition to inservice deterioration, construction related factors can undermine concrete durability. These include *low cover*, *honeycombing* and *voids*. Low cover occurs when insufficient material is placed between the embedded rebar and the atmosphere. This causes rapid entrance of water to the level of the rebar and a rate of corrosion more rapid than if sufficient cover had existed.

Honeycombing and internal voids usually result from: (1) improperly vibrated concrete, (2) a lack of workability (plasticity) of wet concrete, (3) a rebar layout that does not allow for the concrete to completely fill the forms, or (4) a



Figure 1. Exposed steel reinforcement is result of freeze-thaw damage to concrete bridge.

### CONTENTS

Volume 3, Number 2

April 2004

|                                                                  |    |
|------------------------------------------------------------------|----|
| Focus: Nondestructive Testing of Concrete . . . . .              | 1  |
| From The Editor . . . . .                                        | 2  |
| Tech Toon . . . . .                                              | 2  |
| FYI: Practical Contact Ultrasonics — Angle Beam Inspection . . . | 5  |
| Resume Writing and Interview Skills . . . . .                    | 9  |
| Job Safety: Confined Space Entry . . . . .                       | 10 |
| Practitioner Profile: Kevin O'Steen . . . . .                    | 11 |



Looking for ways to energize your NDT career? Need more training or a way to network with others in NDT? Get in touch with your local ASNT Section representatives. Click the *Local Section* link on the ASNT Web site <[www.asnt.org](http://www.asnt.org)>. You'll find meeting times and locations along with links for Section contacts for US Sections as well as International and Student Sections. If you're a Section officer, consider attending the Section Leaders Conference (SLC) coming up June 11 and 12 in Columbus, Ohio. SLC is designed to provide the expertise that every Section needs to develop programs and training to benefit the careers and interests of its Section members.



In case you hadn't noticed, *TNT* is growing. More of the same great content from the industry experts presented in the new full color format we're so proud of. The Technicians Advisory Committee works very hard to bring you the topics you've told us you want to see. Let us hear your comments.

Hollis Humphries  
TNT Editor  
PO Box 28518, Columbus, Ohio 43228  
(800) 222-2768 X206; fax (614) 274-6899  
<[tnt@asnt.org](mailto:tnt@asnt.org)>

combination of these factors. Discontinuities introduced during construction can lead to poor durability, reduced load carrying capacity and poor aesthetic quality of the finished concrete.

## Acoustic Testing Methods

### Hammer Sounding and Chain Drag Techniques.

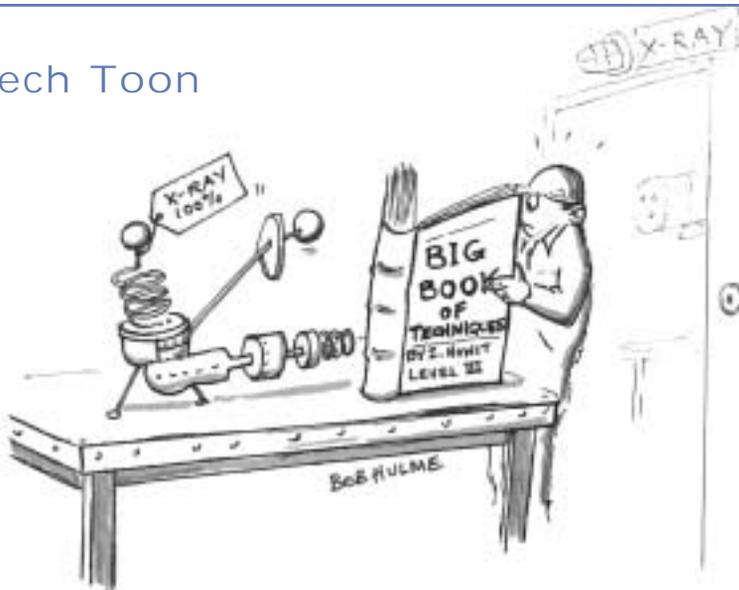
*Hammer sounding* is a rudimentary approach for the nondestructive testing of concrete structures. A common hammer is used to strike the surface of the structure. Hollow or dull tones that can be heard and recognized by the inspector indicate the existence of relatively shallow delaminations in the structure. Because soft concrete results in a dampened tone that can be recognized by an inspector, hammer sounding can also be useful for locating areas of severe damage to the cement matrix that correspond to reduced strength. This technique is applicable to most accessible concrete surfaces.

The *chain drag* technique is more commonly applied to concrete decks. As in hammer sounding, chain drag relies on the inspector's ability to recognize tone changes that occur as the chain is dragged over the surface of the concrete above a delamination. This method, effective for delaminations several inches beneath the surface of the concrete, is a subjective technique dependent on the experience and ability of the operator. Delaminations within two inches of the concrete surface are generally recognized without difficulty. The advantage of chain drag over hammer sounding is that the method can be implemented from a standing position (Fig. 2). Thus, larger areas can be covered more quickly with less inspector fatigue. Many different sizes, shapes and configurations of chain are found in the practice of this technique. A variation of chain drag incorporates a rotary impact device that produces tones as it is rolled across the concrete surface. Still another incorporates electronic recording and mechanical impact devices housed in a cart that is rolled along the surface as data is recorded.<sup>1</sup>



**Figure 2.** Chain drag technique, effective in locating delaminations within several inches of concrete surface, relies on inspector's ability to recognize tone changes.

## Tech Toon



**Impact Echo.** Related to the sounding technique is the *impact echo* method.<sup>2</sup> Impact echo consists of striking the concrete surface with a small, spherical hardened steel ball 4 to 20 mm (0.16 to 0.8 in.) in diameter (Fig 3). Stress waves generated by the impact propagate in the concrete and are detected by either a piezoelectric displacement transducer or an accelerometer located adjacent to the impact location. Data is collected over sufficient time to allow for several reflections of a primary (longitudinal) wave (*p-wave*) through the thickness of the concrete.



Figure 3. Impact echo is useful in determining slab thickness, voids and subsurface discontinuities. Concrete surface is impacted with hardened-steel ball to generate stress waves.

This method is effective for determining the thickness of concrete slabs and can also be applied to the detection of subsurface defects including delaminations and voiding.

However, for defect detection the situation can be more complicated due to the resonance of flexural waves and varying concrete properties. As a result, impact echo data is sometimes difficult to interpret. The method has also been applied to the detection of grout voids in post tensioning ducts with some success in research efforts that are on-going.<sup>3</sup>

**Ultrasonic Pulse Velocity.** Ultrasonic pulse velocity provides a tool for the qualitative assessment of concrete material properties.<sup>4</sup> This method uses the travel time of a longitudinal wave over a known distance to determine the pulse velocity. The quality of the concrete is inferred from the pulse velocity, with lower velocity corresponding to poorer quality of concrete. The method is commonly applied as a through transmission technique, though indirect measurements such as shown in Fig. 4 are also used. The method can be effective for determining the extent of damage resulting from fire or freeze-thaw cycles, detecting poor quality concrete, and is commonly applied to detect internal honeycombing or voids.

Because concrete is a heterogeneous material incorporating a variety of mix designs and

aggregates, the anticipated velocity for a particular specimen can rarely be known. For this purpose, test cylinders or cores removed from the specimen can be tested and used for calibration. This process can also be used to determine the strength of inservice concrete by comparing the cores to samples of known strength and performing a *regression analysis*. Research has indicated that velocity varies to the fourth power as a function of concrete compressive strength.<sup>5</sup>



Figure 4. Ultrasonic pulse velocity is applied as through transmission technique.

## Electromagnetic Testing Methods

**Ground Penetrating Radar.** Used in a variety of concrete inspection tasks, *ground penetrating radar* (GPR) systems transmit microwave pulses into concrete and detect the reflected energy with a receiving antenna. Reflections are generated at the interface between materials of different dielectric properties. For example, a wave launched from air into concrete will have a portion of its energy reflected at the air-concrete interface. Subsequent reflections may be generated from subsurface features in the concrete such as defects or embedded rebar. The bottom of the deck will provide another reflection from the concrete-air interface. As a result, the method can be applied to measuring deck thickness, estimating the concrete cover over rebar and locating internal defects.<sup>6</sup> Ground penetrating radar has a significant advantage in that it has the ability to penetrate asphalt overlays to evaluate the condition of concrete decks beneath the overlay. Ground penetrating radar systems launch waves at frequencies ranging from 500 MHz to 3 GHz. Most common systems operate in the range of 1 to 1.5 GHz. Systems can be *air-coupled* or *ground-coupled*. In air-coupled systems, the antenna is not in contact with the surface of the deck. In ground-coupled systems, the antenna is placed in contact with the deck and pulled along by the inspector (Fig. 5). The advantage of air-coupled systems is their ability to be vehicle-mounted and therefore traverse a

large area quickly. Ground-coupled systems are more difficult to mount on vehicles, but generally deliver more power than a similarly designed air-coupled system.



Figure 5. Ground penetrating radar transmits microwave pulses that are reflected from interfaces of materials with different dielectric properties.

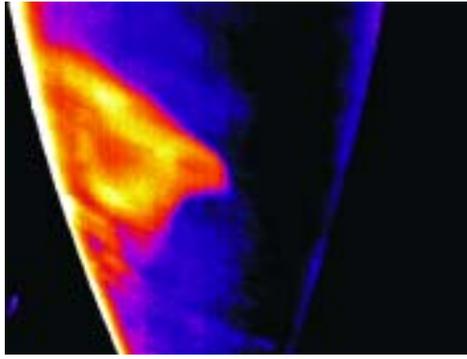
**Infrared Thermography.** Thermographic cameras can be used to detect subsurface defects in concrete structures.<sup>7</sup> Delaminations can disturb the thermal transfer properties of the concrete structure and result in temperature variations at the surface of the concrete. Under proper conditions, these temperature variations can be detected using commonly available infrared cameras. Figure 6a illustrates the detection of a delamination in the soffit of a box girder. Daily ambient temperature variations provide a temperature gradient in the concrete necessary to provide temperature contrast between the delaminated area and the intact concrete (Fig. 6b).

In practice, the method is complicated by many factors that contribute to the temperature contrast apparent in images. These include variations in material properties, variations in moisture content of the concrete, debris typically found on bridge decks, and variable environmental conditions.

**Covermeters.** Magnetic concrete *covermeters* are widely used to determine the thickness of concrete (cover) over embedded rebars. The meters produce a time varying magnetic field that interacts with the ferromagnetic rebars and is monitored with a search coil. The method works best when the meter head is located over a single rebar. The technique is sensitive to the distance from the search coil to the ferromagnetic material, and the concrete has little influence on results provided that it does not contain aggregates with ferromagnetic properties. Modern instruments also estimate the rebar size, although the technique is generally less sensitive to rebar size than it is to depth.



(a)



(b)

Figure 6. Examination of concrete box girder with (a) infrared camera and (b) resulting image.

### Conclusion

The methods described in this article are a brief description of just a few of the nondestructive testing technologies available for inspection of concrete structures. Many others exist with widespread use, including *half-cell potential* measurements, *rebound hammers* and many variations on the acoustic methods described here. Information on these techniques and others can be found in other sources.<sup>8,9</sup> TNT

Glenn Washer is Director of the FHWA NDE Center. He received his Ph.D in Materials Science and Engineering from Johns Hopkins University in 2001 and a Masters degree in Structural Engineering from the University of Maryland in 1996. Dr. Washer has been with the FHWA for more than 13 years during which time he has been involved with the development and testing of NDE technologies for highway bridges. He is currently chairman of the Transportation Research Board's Subcommittee on Nondestructive Evaluation of Bridges. He is a member of ASNT's Handbook Development Committee and the Research Council Program Committee. (202) 493-3082, <glenn.washer@fhwa.dot.gov>

### References

1. ASTM D 4580-03, *Standard Practice for Measuring Delaminations in Concrete Bridge Decks by Sounding*. West Conshohocken, PA: ASTM International (2003).
2. ASTM D 4580-03, C1383-98a *Standard Test Method for Measuring the P-Wave Speed and the Thickness of Concrete Plates Using the Impact-Echo Method*. West Conshohocken, PA: ASTM International (2003).
3. Maierhofer, C., Wigggenhauser, H., Krause, M., Streicher, D., *Advances in Nondestructive Testing of Tendons Ducts*. Transportation Research Board, Washington, DC (2004).
4. ASTM C597-02, *Standard Test Method for Pulse Velocity Through Concrete*. West Conshohocken, PA: ASTM International (2003).
5. Olson, L.D., *Stress Wave NDE Methods for Condition Assessment of the Superstructure and Substructure of Concrete Bridges*. Transportation Research Board, Workshop on NDE Technologies for Highway Bridges, (January 2004).
6. ASTM D6087-03, *Standard Test Method for Evaluating Asphalt-Covered Concrete Bridge Decks Using Ground Penetrating Radar*. West Conshohocken, PA: ASTM International (2003).
7. ASTM D 4788-03, *Standard Test Method for Detecting Delaminations in Bridge Decks Using Infrared Thermography*. West Conshohocken, PA: ASTM International (2003).
8. ACI 228.1R-03, "In-Place Methods to Estimate Concrete Strength." *American Concrete Institute Manual of Concrete Practice*, Part 2. Farmington Hills, MI.
9. Malhotra, V.M. Carino, N. J., *Handbook on Nondestructive Testing of Concrete*. CRC Press, Boca Raton, FL (2003).

# Revolutionary New Blacklight for NDT

- Cordless
- Instant-ON
- 2200  $\mu\text{w}/\text{cm}^2$  Output
- Low Cost Replacement Bulbs



SPECIAL INTRODUCTORY OFFER

## \$695<sup>00</sup>



**Test Equipment Distributors, LLC**  
 1370 Piedmont, Troy, MI 48083  
 (800) 962-1788  
 Fax (770) 978-0115  
 www.tedndt.com

U.S. Patent # 5,999,306

## ECT CAL. STANDARDS & PROBES

### Calibration Standards

- 300 Individual ASME Cal Standards
- Full Quality Documentation
- Protective Cover provides Access to the Tube I.D.



### MOST ORDERS SHIPPED SAME DAY AT NO EXTRA CHARGE

### Probes

- Kink Proof Cable
- Replaceable Probe Heads
- 50' (15m) Probes / O.D. 0.25" (6.35mm) - 1.5" (38mm)
- Certified Stock Tubing Including Titanium



Telephone 412-798-8990

Website [www.testex-ndt.com](http://www.testex-ndt.com)

Fax 412-798-8995

Email [testex@adelphia.net](mailto:testex@adelphia.net)



# FYI

## Practical Contact Ultrasonics - Angle Beam Inspection

by Jim Houf\*

Angle beam inspection uses shear (transverse) waves to interrogate a part as opposed to the longitudinal waves used in straight beam testing. Properly used, highly effective and accurate angle beam evaluations can determine the soundness of the part being inspected.

In the simplest terms, angle beam inspection combines the basic operating principle of a fish finder with a bank shot in a game of pool or billiards. The sound beam is sent through the part at a known angle that is created by attaching a piezoelectric transducer to an acoustically transparent wedge at a predetermined angle. The sound beam reflects from the back surface of the part and returns to the inspection surface some distance away from the transducer. The direction the sound takes is called the *sound path* (Fig. 1). For purposes of illustration, only the centerline of the sound beam is shown. The sound beam between the transducer and the back surface of the material is called the *first leg or node*. Sound that reflects back up from the back surface is called the *second leg*. The total distance down the sound path from the entry point to the point where the beam again hits the top surface, the sum of the legs, is called the *skip distance*. As the transducer is moved back and forth over the surface of the part, the sound beam travels through the part ahead of the transducer. If the sound beam does not hit a reflector (discontinuity) while traveling through the part, it will simply reflect back down into the part, traveling outward until the sound attenuates or dissipates.

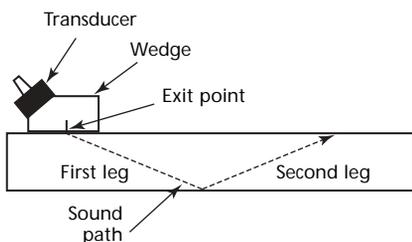


Figure 1. Sound beam emitted by transducer is reflected from back surface of part and returns to the inspection surface.

This is typical behavior of the angle beam sound path in a piece of flat material. The next step is to determine precisely *where* the sound is going. To do this, it is necessary to know the angle of the sound beam in the part in relation to a line drawn vertically through the material thickness. This is called the *refracted angle* and is determined by the angle at which the transducer is mounted on the wedge in the transducer assembly or probe. The most commonly used search angles in contact UT work are 45, 60 and 70 degrees as referenced to steel. The refracted angle in other materials will not be the angle marked on the probe. Figure 2 illustrates a 45 degree probe.

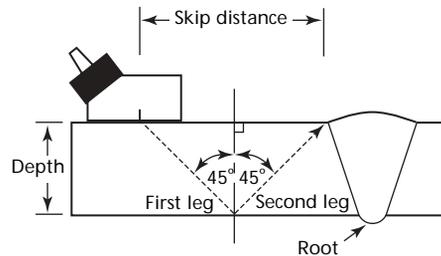


Figure 2. A 45 degree wedge and resulting sound path.

On the side of most commercial wedges is a mark called the *exit point* that denotes the point at which the center of the sound beam leaves the base of the transducer. When using a 45 degree probe, the distance from the exit point to the point directly above an internal reflector is the same as the depth to that reflector. Another use of the exit point is to determine the location of the probe with respect to a fixed point on the part such as a weld centerline. This distance should be recorded on the inspection report form as the *surface distance* and as long as the reference point is also recorded, the inspection can be accurately repeated should the need arise.

### Probe Selection

In many cases, the governing code or specification will specify the angle to be used

for a given inspection. However, operators may find that for some inspections no wedge angle, probe size or frequency is specified and the operator will be required to determine what combination of equipment will be needed to perform a valid inspection. In this situation, the factors to be considered are material thickness, length of the transducer's near field, type and possible orientation of discontinuities and geometry of the part.

Material thickness will define the inspection angle required to adequately cover the full volume of the area to be inspected. For example, on thinner materials, if a wedge with a steep angle such as 45 degrees is used, the second leg of the sound beam may come back up under the front edge of the wedge, making it impossible to measure the surface distance. If a shallower angle is used such as 70 degrees, the distance the probe must be backed away from the area of interest may be excessive and can exceed the part size or geometry. Generally, to ensure a complete inspection, the operator must be able to back the transducer away from the nearest edge of the area of interest by at least the full skip distance for the angle being used plus the length of the transducer. This will permit the sound beam to interrogate the part using both legs of the sound beam (Fig. 3). The scanning surface must be free of weld spatter, dirt, loose scale and other foreign matter to allow proper coupling of probe and base metal. Part size may limit choice of search angle if there is limited scanning space next to the area of interest.

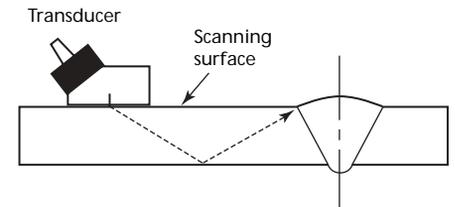


Figure 3. Demonstration of minimum backoff distance.

The *near field* length of a transducer varies depending on the diameter and frequency of the crystal. As discussed in the first article of this series, inspections performed using the near field are not reliable. If uncertain of the length of the near field for a given transducer, the operator should either calculate it or have the Level III do so to confirm the proper frequency/diameter combination. Some near field will always exist, but if made short enough to be kept within the wedge material, an accurate inspection can be performed.

Probe size is often dictated by the near field effect, but geometry of the part should also be considered when selecting a probe. In some conditions, the physical size of the probe can

affect the inspection. For example, when inspecting a girth weld on small diameter pipe, a large transducer may not sit flat on the scanning surface. It may have a tendency to rock from side-to-side while scanning the part. When this occurs, the probe is not coupled properly to the part and some of the sound can be lost. The amount of sound entering the part is less than the amount of sound used to calibrate the system. This results in less sound striking the potential discontinuity and negates the value of the inspection. Changing to a smaller width probe reduces lateral rocking and more nearly matches the calibration conditions thereby providing better inspection results. In some situations, it may even be necessary to use a wedge contoured to fit the inspection surface.

The distance from the probe exit point to the front end or *nose* of the wedge is another consideration. If too small a search angle is used, the nose may hit the *toe* or edge of a weld crown before the sound beam reaches the *root* or bottom of the weld. In this instance, the root will not be interrogated in the first leg and the probability of missing a root indication is greatly increased. If too steep an angle is used on thinner materials, the sound path may remain totally under the wedge and no sound will enter the area of interest.

Orientation of discontinuities should also be considered when selecting a wedge angle. The greatest amount of sound will be reflected back from a discontinuity if the sound beam strikes it perpendicularly to the major surface of the discontinuity. As an illustration, visualize a blade held in a stream of water. If parallel to the flow, no water bounces off the blade but just flows past it. However, if held perpendicular to the flow, water hits the flat side of the blade and bounces back. The same effect occurs with sound and a discontinuity. The best results are obtained when the sound beam is perpendicular to the largest surface of the discontinuity.

It should be noted that if the backwall of the material being inspected is not parallel to the scanning surface, the angle of the second leg will change, and reflectors will display a screen signal at an improper location. This can occur at pipe-to-fitting welds where the fitting may have an internal bevel.

## Equipment Setup

Once material thickness is determined and the correct probe combination is selected, the next step is to set up the equipment. Selection of *screen width* greatly affects the ability of the operator to discriminate between vertical screen traces or signals that appear when sound is reflected back to the transducer. The term screen width refers to the distance that the baseline of the screen represents. Operators must inspect parts requiring sound paths of

various lengths. It is necessary to adjust the screen face to represent the distance that best displays the image of the sound reflecting back from the part.

To select optimum screen width, the length of the sound path for a full skip distance in the thickness of material to be tested must be determined. As thickness increases, the length of a full skip also increases, and at some point can require that a wider screen width be used. The screen width must be able to display the full skip. If not, indications generated at the far end of the second leg may not appear on the screen.

Commonly used screen widths for general weld inspections are 5 and 10 in. (13 and 25 cm). This means that the width of the screen is set to represent either a 5 or 10 in. sound path. If the screen is set to 5 in., each major graticule (numbered left to right) represents 0.5 in. (1.3 cm) of sound path with minor graticules equal to 0.1 in. (0.25 cm). For a 10.0 in. screen, major graticules represent 1 in. and minor graticules equal 0.2 in. (0.5 cm). Figure 4 shows the sound path and screen presentation for a sound beam striking a reflector at 1 in. and a back-wall at 5 in. Each major vertical graticule is shown, with each representing 0.5 in. of sound path. In an angle beam inspection, different reference blocks would be used. However, for demonstration purposes, Fig. 4 shows the relationship between the transducer, sound beam and screen presentation.

When using a 70 degree probe on 1.5 in. (3.8 cm) thick material, the sound beam reaches the back surface at a distance (sound path) of approximately 4.25 in. (11 cm) with a full skip distance of approximately 8.5 in. (22 cm). Therefore, if a 5 in. screen is used, 3.5 in. of the sound path is not shown on the screen and any discontinuities covered by that segment of the beam will be missed. For this example then, it would be necessary to use a 10.0 in. screen (Fig. 5). As can be seen, the point where the sound enters the part under the probe exit point, shows a strong signal at the extreme left of the screen, and the sound reflecting from the hole shows a screen signal at an 8 in. (20 cm) sound path. No signal is seen where sound reflects from the back wall at 4.25 in. because all sound is reflected away from the transducer.

The sound beam is not a single solid line like a laser beam as shown in most illustrations but is cone shaped and more like the beam of a flashlight that spreads as it travels farther from the source. This is called *beam spread*. As the transducer moves forward toward a reflector, the leading edge of the sound cone strikes the reflector first. The sound beam is less intense at this location and as a result, less sound is reflected back. This gives a low amplitude signal at a longer screen distance or sound path (Fig. 6a).

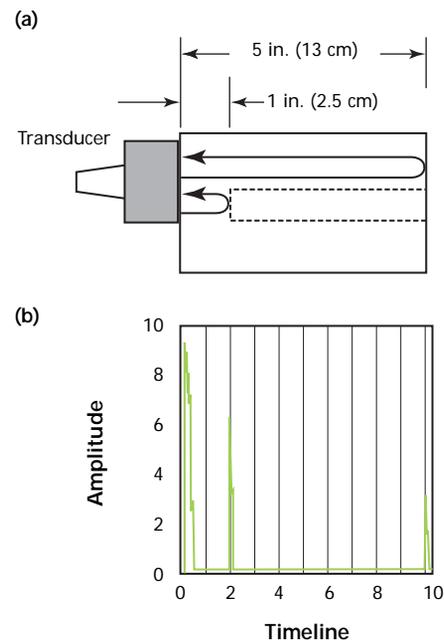


Figure 4. A reflector at 1 in. (2.5 cm) on a 5 in. (13 cm) screen.

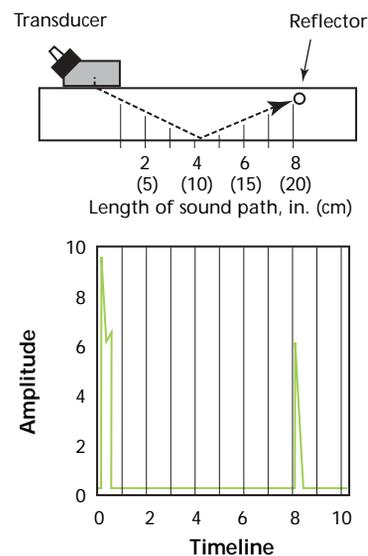


Figure 5. A 10 in. (25 cm) screen showing a signal at 8 in. (20 cm) of sound path.

As the transducer continues to move toward the reflector, the centerline of the sound beam strikes the base of the notch where maximum reflection will occur (Fig. 6b), resulting in a higher signal amplitude at a shorter sound path than was seen in Fig. 6a. As the back portion of the sound beam travels over the notch (Fig. 6c), the majority of the sound beam has already passed over the notch. Thus a low amplitude screen signal is seen at an even shorter sound path. The amplitude of this signal may be higher than that of Fig. 6a because the shorter

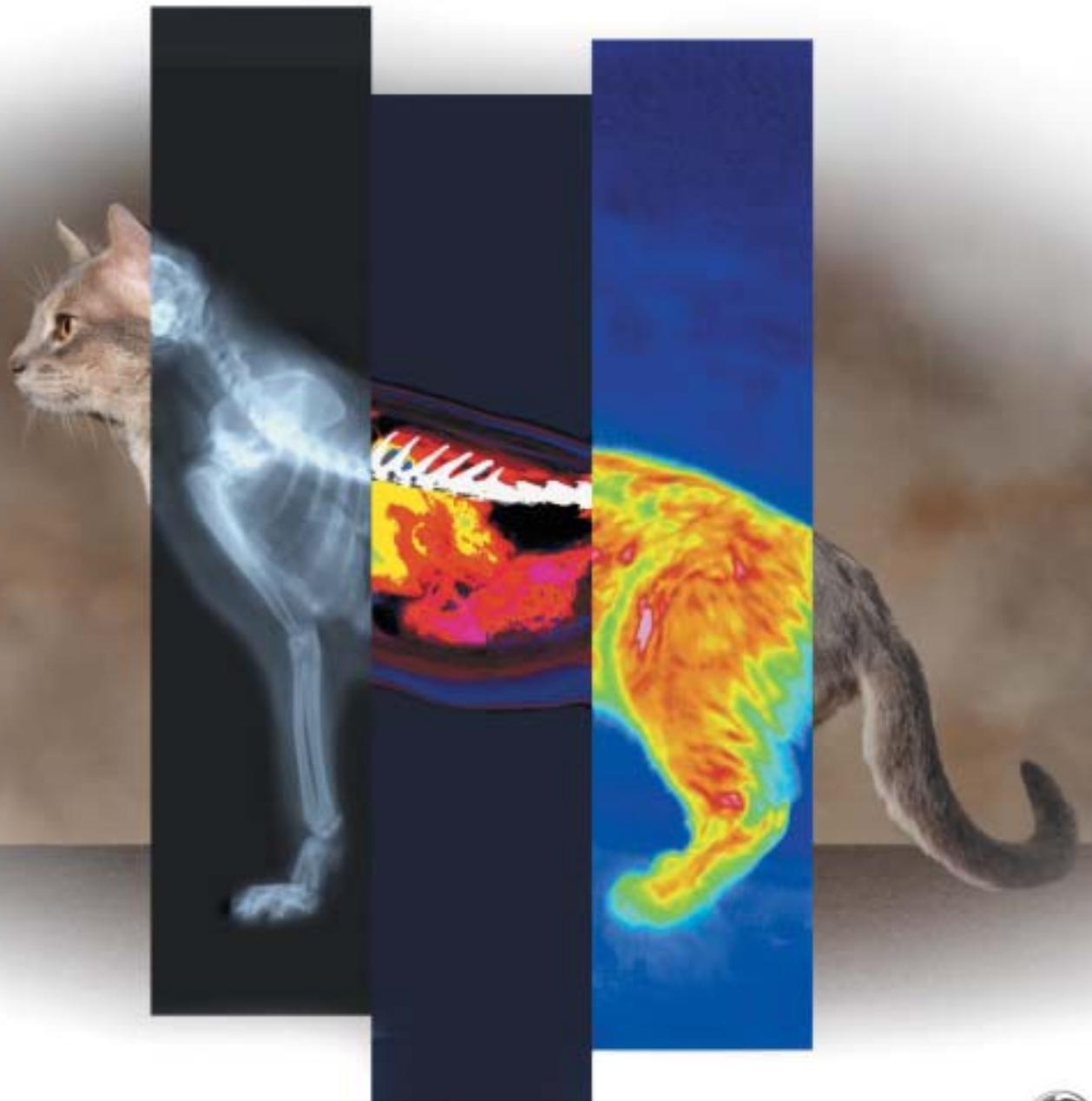
When you need the inside scoop on a product but can't tear it apart, trust GE Inspection Technologies. We offer the widest range of inspection and non-destructive testing

solutions anywhere, from analog and digital radiography to ultrasonic imaging and eddy current. And we have experts stationed near you in application centers around the

world. So no matter what kind of part you have, we can quickly suggest a solution or customize one from scratch. Learn more at [GEInspectionTechnologies.com](http://GEInspectionTechnologies.com).

**GE Inspection Technologies**

**There's more than one way to not skin a cat.**



imagination at work



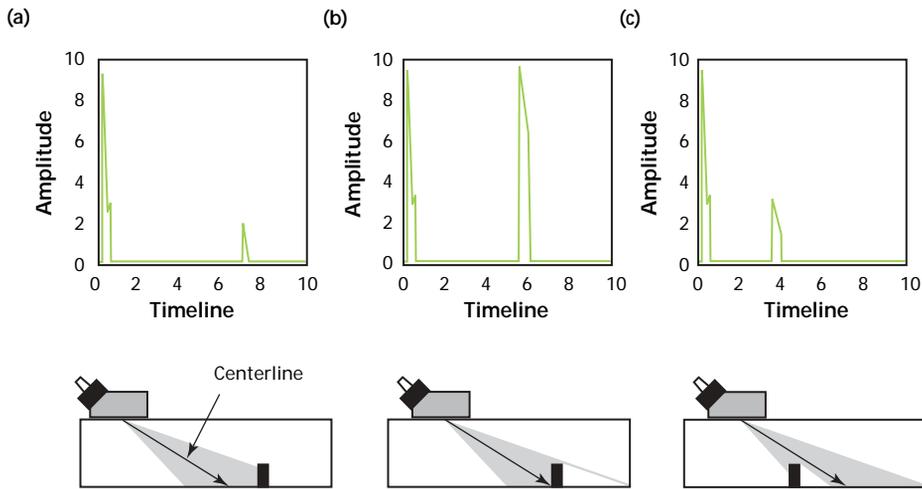


Figure 6. As the centerline of the sound beam moves in relation to the reflector, the resulting signal changes in amplitude: (a) leading edge of sound beam striking reflector, (b) centerline of sound beam as it strikes base of reflector (maximized signal) and (c) screen image as back edge of sound beam has passed over top of reflector.

sound path results in more sound being reflected back to the transducer.

### Scanning Patterns

In order to ensure that the full volume of the area of interest is inspected, several standard scanning patterns are often required by the governing code or specification. The more common patterns are described here and shown in Fig. 7. Proper transducer manipulation is required to ensure full coverage, and with practice and some dexterity the motions will become second nature to the operator.

The primary scan pattern requires that the operator move the transducer toward and away from the area of interest for at least a full skip distance back from that area (Fig. 7a). On each

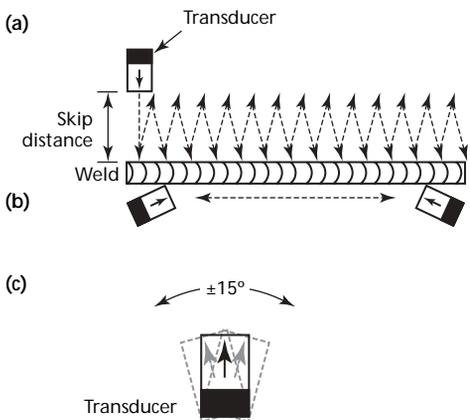


Figure 7. Standard scanning patterns ensure full inspection of the area of interest: (a) primary pattern moves transducer forward and back for a full skip distance, (b) transducer is moved laterally and (c) both patterns require transducer to be oscillated approximately  $\pm 15$  degrees.

successive scan, the transducer is moved slightly to the right, so that the path the transducer follows overlaps the previous scan. The percentage of overlap is usually spelled out in the governing documents. At the same time as the transducer is being moved forward and back, it also needs to be oscillated sideways over a range of approximately  $\pm 15$  degrees as in Fig. 7c. Again, the actual range of oscillation should be set by the code or specification. The weld (in this example) should be inspected from both sides to ensure no possible indications are missed.

The scan pattern shown in Fig. 7b is used to detect transverse discontinuities. The transducer is again oscillated as before but is guided along the side of the weld with the transducer point slightly in toward the weld centerline so that the full width of the weld is interrogated. As shown, the weld should be scanned from both ends and from both sides of the weld.

The need for scanning from both sides of the weld is demonstrated in the following example. Figure 8 shows a welded plate with a planar discontinuity oriented parallel to the original weld groove, which is typical of sidewall lack of fusion.

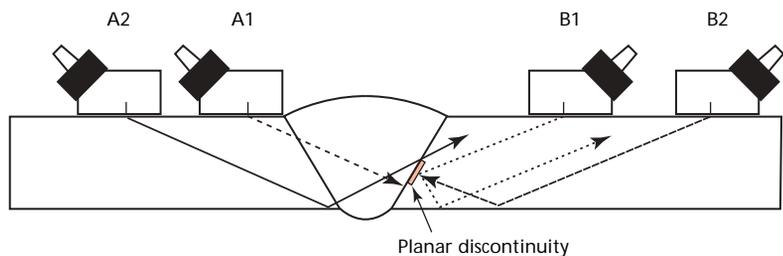


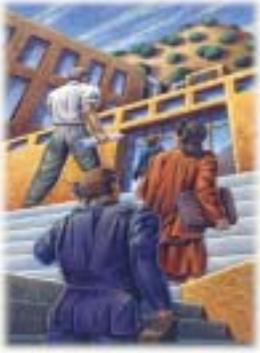
Figure 8. Scanning from both sides of the weld is necessary to locate a planar discontinuity oriented parallel to the original weld groove.

When scanning from the left side of the weld, as the transducer is moved toward the weld the nose of the transducer bumps into the weld crown at position A1. At that point the sound beam has not yet moved forward far enough to reflect off of the discontinuity. As the transducer is moved back away from the weld, the sound will reflect from the root reinforcement, and when it does start reflecting from the base metal back-wall, the second leg is above the discontinuity and it is missed again. Therefore, if the weld is only scanned from the left side, this discontinuity would not be found. Because of beam spread, it is likely that some signal would be seen on the screen caused by the sound at the edges of the sound beam hitting the discontinuity, but it is entirely possible that the reflected sound would not cause a signal amplitude high enough to be rejectable.

If the weld is scanned from the right side also, the operator must make sure that the transducer is moved back far enough to ensure full coverage of the weld volume. At position B1, the orientation of the discontinuity is such that the reflected sound would most likely reflect back and down to the back-wall, reflecting from there back up to a point behind the transducer, so the discontinuity would again be missed. Only when the transducer is moved back to position B2 would the main portion of the sound beam hit the discontinuity at a near-perpendicular angle, giving a solid signal.

This is not an unusual example, for this condition occurs much more frequently than expected. The condition can be further aggravated if the weld joint has poor initial fit up. Then, the weld crown can be excessively wide, making the odds of seeing a far-side planar discontinuity even more difficult. However, experienced UT operators should realize that if fit-up is poor, greater diligence is required when they see a weld crown that is too wide for the material thickness. **TNT**

\*Jim Houf is Senior Manager of ASNT's Technical Services Department and administers all ASNT certification programs. Involved in NDT since 1972, he has been an ASNT Level III since 1984 and currently holds ASNT NDT and ACCP Professional Level III certificates in four NDT methods. He's an AWS Senior Welding Inspector and an ASQ Certified Quality Auditor. (800) 222-2768 X212, (614) 274-6899 fax, <jhouf@asnt.org>.



# Feature

## Resume Writing and Interview Skills

by Raymond G. Morasse

Most of us put little thought into resume writing and job interview skills until it becomes necessary to look for a job. We spend much time preparing for the career but do little to prepare for the job search. However, as in all successful business endeavors, preparation is essential. Getting a job is a business opportunity — an opportunity to get what you want.

### The Resume

When writing a resume, what is the purpose? To get a job? To provide a prospective employer with information he needs to hire you? Not quite. The purpose of a resume is to obtain an interview. As a beginning, remember that most employers are conservative people. Likewise, the way your resume looks should be conservative. Keep the typeface simple and legible and print it on a white paper. Make certain information provided is accurate. Keep it brief, one page in length. The information you provide should be applicable to the job you are seeking. Only include information that enhances your chances of getting an interview. You want the potential employer to want to know more about you. If you provide all your information in a resume, there is no need for an interview. The employer can make a decision about you without it. Anyone in sales will tell you, the best way to make a sale is face-to-face. The value of shaking a person's hand and personally assuring them that you are the best person for the job is priceless. Lastly, check your spelling. One misspelled word can negate an otherwise perfect resume.

### The Interview

Every employer's purpose is to get the best employee for the best price. Your purpose should be to get a job offer. Only after you receive a job offer do you have the ability to decide if you want to work for this company or move on to something else. The interview, like any business meeting, needs to be valuable for both sides. The employer does not want to waste your time, so do not waste his. Knowledge is key when preparing for a job interview. Learn everything you can about the

company — its structure and product and, if possible, about the department you would be working in and the person you would be working for. The more you know, the better you will be prepared.

**First Impressions Count.** Be conscious of your appearance. In today's market, it's not expected that you wear a suit but better to be safe than sorry. If you are sitting when the interviewer enters the room, stand to greet him or her. Introduce yourself again. Have additional copies of your resume and training certificates with you that you may leave if asked. When you sit, use good posture and maintain good eye contact. It implies interest.

**Know Your Facts.** Memorize the specifics of your resume and review them before your meeting. The interviewer will want details and may have many questions. Preparation is the best way to overcome any nervousness.

**Interviewer's Questions.** During an interview, you may be asked to respond to very pointed questions that seem to have no right answer. The following are examples.

- 1. How do you like your current boss?**  
Keep this response positive.
- 2. How do you take direction?**  
This is actually two questions. "How do you take direction?" and "How do you take criticism?". Explain that you take direction well, that you know direction comes in the form of instruction as well as correction and you view both as positive.
- 3. Describe a situation in which you were criticized.**  
Avoid criticism of your work. Instead, try describing an idea you had that was criticized. From an employer's point of view, work costs money and ideas cost nothing.
- 4. What things have you and your supervisor disagreed upon?**  
Be wary of questions that ask about negative situations in your current employment. Try to put a positive spin on your response. Remember, it reflects positively on you.
- 5. How do you rate yourself?**  
Difficult but often asked. If you rate yourself too high, you may come across as boastful. Too low, you may leave a negative impression. Most people rate themselves as a seven. Try considering yourself a nine.

**Your Questions.** It's good to be prepared with questions of your own. Use appropriate timing in asking your questions. If your first question is "When do I get a vacation?" you probably aren't going to get the job.

Companies are often structured in a way that causes you to be caught up in their hiring policies. If possible, try to speak directly with the person that would hire you instead of the human resources department.

Remember, you're not looking for a job yet, just the job offer. Avoid talking about salary on the first interview, unless the interviewer brings it up. Let them express the desire to hire you first. It's also hard to impress and negotiate at the same time. Focus the first interview on how your technical skills and you as an individual would fit with the company and company objectives. The interviewer will be looking for some bonus that the company gets when they hire you. Be prepared to address collateral benefits to be gained by hiring you. These might include computer skills, writing skills or your ability to interact well with coworkers. Do not use inappropriate language or jokes during the interview. Avoid ethnic or discriminatory comments. It's not only discourteous, it's illegal.

### The Job Offer

The interview has gone well and you have a job offer. Before negotiating salary, do some research. A good place to start is the Internet. Check out the *Personnel for Quality & Nondestructive Testing Web site* at <http://www.pqndt.com/surveyresults2003.pdf>. The 2002-2003 NDT Salary Survey lists salary ranges and benefits for 1997, 1999 and 2002 and it's broken out by industry, region and certification level. It's important to be practical and it's vital to be totally prepared at this point. Be assured that the employer knows what his upper and lower limits are for this part of the interview process, and you need to be just as prepared. You never get what you deserve, but what you negotiate. You will never get what you do not ask for and the employer will never say yes if you do not ask.

**Follow up.** The interview will do its job if the interviewer likes what he sees and hears. When you leave, be courteous and respectful. If you are concluding the first interview, address the next step. Try to get a time for the next interview. Finally don't forget to follow up and continue to do so. It shows your interest and that often can make all the difference. **TNT**

Ray Morasse is Chair of the Section Operations Council Section Management Division, a member and past chair of the Student Interests Committee and a member of the Technicians Advisory Committee. He's been an NDT professional for 30 years. Much of that time has been spent in management positions responsible for the hiring and training of NDT personnel. (619) 421-1355, <[rmorasse@hyspan.com](mailto:rmorasse@hyspan.com)>.



# Feature

## Job Safety: Confined Space Entry

by William W. Briody

How many of you are familiar with the basic safety problems that can be encountered on field projects? How many of you are aware that safety is one of – if not the most – important concern of industry today. It's no longer acceptable to perform one's work in an efficient and capable manner; rather, the individual must have the proper safety training and all work must be performed in accordance with federal and/or individual state Department of Labor safety standards. Some areas of importance for NDT personnel include personal protective equipment, fall protection, use of ladders and scaffolding, confined space entry, lockout/tagout procedures, use of hand tools and working procedures around cranes or other heavy equipment. In most instances, your employer will provide initial and periodic training in appropriate topics, but this is often not enough to provide total insight into the opportunities for injury – or even sickness – you might encounter on field sites.

### Statistics

Thousands of workers are exposed to possible death or injury in what are referred to as *confined spaces*. The Occupational Health and Safety Administration (OSHA) estimates that some 238,800 establishments employing over 12.2 million workers have confined spaces on their property or work areas. Each year, over 12,000 injuries occur in confined spaces. Fatalities are not uncommon.

### What is a Confined Space?

By definition, a confined space is one that is large enough for an employee to enter, has restricted means of entry and exit and is not designed for continuous employee occupancy. A *permit-required* confined space presents or has the potential for hazards related to atmospheric conditions (flammable, toxic, asphyxiating), engulfment, configuration or any other recognized serious hazard. Regulations governing entry into confined spaces are specified by OSHA in 29 CFR 1910.146. Examples of confined spaces include ship compartments, fuel or storage tanks, vats, silos, sewers, tunnels and vaults. Although often dangerous, you may very well be called upon to conduct NDT operations inside one of these environments. If there are hazards in the space, you may enter

only if you are following the confined space permit program procedure for that particular facility. Spaces do not require permits if the only hazard is an atmosphere that can be made safe for entry through continuous ventilation.

### What Makes a Confined Space Hazardous?

Dangerous gases and vapors can accumulate in confined spaces. Fires, explosions and physical hazards can also cause injury or even be fatal for the unprotected worker. Physical hazards may result from mechanical equipment or moving parts such as agitators, blenders or stirrers. Dangers may also be present from gases, liquids or fluids entering the space from connecting pipes. Other physical hazards include heat (temperatures can build up quickly in the permit space and induce exhaustion or dizziness) and noise (sounds may reverberate and make it difficult to hear important directions or warnings). Oxygen deficiency is the primary hazard associated with confined spaces. Normal air contains 20.8 percent oxygen by volume, and OSHA has set the minimum safe level of oxygen at 19.5 percent with a maximum level of 23.5 percent. At 16 percent, you will feel disoriented; and from 8 to 12 percent you will be rendered unconscious. Oxygen is reduced in confined spaces by either displacement (usually by other gases) or consumption (possibly by chemical reactions or burning). Flammables and combustible gases or vapors may be present and can be ignited by faulty electrical equipment, static electricity or sparks from welding operations. Another major cause of sickness – and death – can occur from the undetectable presence of toxins from residual contaminants. It is, however, possible to work safely in confined spaces if you follow basic guidelines.

### Guidelines

1. Have a plan. Examine the physical nature of the space and determine potential hazards.
2. Control any hazardous energy using locks and tags. Before entering a permit space, all mechanical equipment must be locked out/tagged out. *Lockout*, or the placement of a lockout device on an energy-isolating device (dedicated locks, blocks, chains, etc.), should be done in accordance with an established procedure to ensure that the energy-isolating

device and the equipment being controlled cannot be operated until the lockout device is removed. *Tagout* is the placement of a tagout device or tag on an energy-isolating device, in accordance with an established procedure, to indicate that the energy-isolating device and the equipment being controlled may not be operated until the tagout device is removed. Tags and lockout devices must be strong enough to prevent removal and withstand the surrounding conditions. All lines containing hazardous materials such as steam, gases or coolant must also be shut off. Use only safe, grounded, explosion-proof equipment and fans in possible combustible atmospheres.

3. Test the air. Special instrumentation is required to test for levels of oxygen, combustibility and toxicity. Test at the entry and then at all locations. Continual follow up testing is necessary to insure worker safety. Purge and ventilate as necessary; but be prepared to use proper, well fitted respirators, eye and hearing protection and protective clothing.
4. Develop rescue procedures. Although the entrants must be trained to recognize hazardous situations and recognize when to exit a confined space before a rescue operation is necessary, at least one trained attendant with the necessary personal protective equipment must remain outside of the confined space. That attendant should also be trained in first aid and CPR and be able to maintain constant communication with those inside the space. If an emergency situation arises that actually requires emergency entry, the attendant should not enter until additional help is present. Experience has taught us that failed rescue operations usually result in serious injury or even death to all concerned.
5. Full body harnesses with attached lifelines are to be worn by all personnel entering the space to facilitate any rescue operations.

### Conclusion

Recognizing the nature of work areas and following rules carefully allows one to work safely even in permit-required confined spaces. Additional information for OSHA regulations can be viewed or downloaded from the OSHA Web site. [TNT](#)

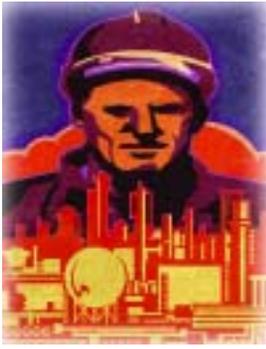
#### OSHA Confined Spaces Advisor

<<http://www.dol.gov/elaws/osha/confined/menu.asp>> includes examples of confined spaces, frequently asked questions, a glossary of terms, a summary of the rule, an entry checklist and permit form.

#### OSHA Lockout-Tagout Home page

<<http://www.osha.gov/dts/osta/lototraining/index.htm>> features a Lockout-Tagout Interactive Training Program with: (1) a tutorial, (2) hot topics and (3) interactive case studies.

Bill Briody is a Lifetime member of ASNT. He is currently Chair of the Section Operations Council Membership Division and a member of the TNT Technicians Advisory Committee. (804) 264-2701, <[bbriody@fandr.com](mailto:bbriody@fandr.com)>



# PRACTITIONER PROFILE

**Kevin O'Steen**

**K**evin O'Steen has been an active member in ASNT's San Diego Section and is currently the Section Chair. He has been employed by Ketema Aerospace since 1996 as an NDT Technician. He's married with two children. Kevin was selected as corecipient of the 2002 Lou DiValerio Technician of the Year Award.

*Q: How did you first become involved in NDT?*

A: I was an ordnance man in the Navy. I was trained to do penetrant inspection on weapons release systems on airplanes. I took the penetrant class in addition to that training and that was my introduction to NDT. When I got out, I found a job in a test lab and started from the bottom. Got training on X-ray and more training on penetrant. I went on from there.

*Q: What is your current certification?*

A: I'm a Level II in RT, PT and visual.

*Q: What kind of NDT do you do in your work now?*

A: Mainly X-ray and penetrant. I usually spend most of my time in X-ray, some in penetrant, inspecting aerospace components and aircraft engine components or space components in projects such as the Delta Four and Atlas rockets.

*Q: Can you give us an overview of your responsibilities?*

A: Well, I work in a lab — the parts are brought to me. Most of our work is aerospace — MIL STD 2219, what used to be MIL STD 453 and now, I believe, it's ASTM E 1417. The day starts with daily system checks, making sure all the equipment is running the same every day. My work is not supervisory but I do train other people. Our Level III writes the procedures. The first time we get a part in, we'll develop the technique for it (X-ray, for example) and then submit it to the Level III that either approves it or gives us changes to make to the technique. That's the initial test. After that, it's in the book. When the part comes back to us, we refer to the book as our guideline to shoot the part. Sometimes we shoot the same part over and over again, straight up — but at other times the part has different configurations and that's the challenge.

*Q: What particular industries or methods do you think have the greatest growth potential?*

A: Aerospace is slow right now. It's still a good field to go into — aerospace/aviation. The majority of the work that we do is commercial aircraft. Land-based turbines, power turbines are an

area that might have good potential. I would recommend UT and RT as the most valuable methods.

*Q: What is the most interesting NDT work you've done?*

A: I would have to say that field work — something different every day, traveling around — was most interesting.

*Q: What are your plans for further training and certification?*

A: I'd like to get Level III certification in X-ray and penetrant.

*Q: What is the most difficult part of NDT?*

A: Every customer is different. Each one requires dealing with different parameters. That's probably the most difficult part.

*Q: What's the best part of NDT?*

A: It's challenging. Keeps you thinking.

*Q: What recommendations can you make to individuals considering careers in NDT?*

A: Education is the most important thing, especially if you are considering becoming a Level III. Get your college education and your NDT training behind you.

*Q: How are you involved with your ASNT Section?*

A: I've held various offices in the San Diego Section and I'm the current chairman. We have about 110 members. We usually have a pretty good turnout for our technical sessions and we have a very good education program. We do training for RT and PT classes and last year we had a UT class. Our RT classes are a total of 80 hours — 40 hours for Level I and 40 hours for Level II. These are usually conducted on weekends and run 8 to 10 hours per day. Level IIIs typically volunteer to teach the classes and can earn recertification points for ASNT certification by doing so.

*Q: How can practitioners become involved in ASNT?*

A: Get in touch with your local Section representatives. They're glad to help. There's often a Section Web site they can go to or they can contact the ASNT Membership Department. ASNT Section membership has many benefits and it's a very good place to network. **TNT**





*"When only the best is good enough"*

Schedule of NDT Training Courses for 2004

MT LI /II – April 26 – 28, July 19 – 21, Sept. 13 - 15  
PT L I/II – April 29 – 30, July 22 – 23, Sept. 16 - 17  
UT L I – May 3 – 7, July 26 – 30, November 1 - 5  
UT L II – May 10 – 14, August 2 – 6, Nov. 8 - 12  
Radiation Safety (IRRSP Prep) – March 29 – April 2, June 7 - 11  
RT L I – April 5 – 9, June 14 – 18, June 14 - 18  
RT L II – April 12 – 16, June 21 - 25  
RT Film Interpretation – Dates TBD  
ET L I – May 17 – 21, Dec. 8 - 10  
ET L II – May 24 – 28, Dec. 13 - 17  
Special Courses – Please call for details  
Aircraft Composite & Bonding Inspection, ACFM, TOFD  
NDT Level III Refresher Courses  
Basic – September 27 – Oct. 1      Eddy Current – Oct. 20 - 22  
Radiography – Oct. 11 – 13      Penetrant – Oct. 14 - 15  
Ultrasonic – Oct. 4 – 8      Magnetic Particle – Oct. 18 - 19

**New NAS 410 MT & PT training requirements**

PT Top Up (16 hrs), MT Top Up (16 hrs) Please call for next dates

All courses will run if payment is received two weeks in advance

Level III Consulting Services and Qualification Examinations  
Prepared and administered by Richard Harrison,  
ASNT NDT Level III in UT, RT, ET, MT, PT and VT (Cert # 73537)  
Contact: Richard Harrison, 193 Viking Ave. Brea, CA 92821  
Ph (714) 255-1500 Fax (714) 255-1580 Website: [www.testndt.com](http://www.testndt.com)

# Reveals Even the Smallest Surface Defects!

## Introducing the Maxima™ ML-3500 — the world's most powerful UV-A lamp!

Latest micro discharge light (MDL) technology enables the Spectroline® Maxima™ ML-3500 UV lamp to deliver a steady-state UV-A intensity of 50,000  $\mu\text{W}/\text{cm}^2$  at 15 inches!

*Features:*

- **Instant on/off/restrike switch** — No lamp warm-up required
- **Safe** — Virtually no emission of hazardous UV-B light
- **Super rugged** — Lamp head and handle constructed of special engineering polymer
- **Prefocused bulb** — Ensures optimum performance
- **Ergonomic design** — Not affected by excessive shock and vibration, provides fatigue-free handling
- **Mounting accessories** — Ideal for custom assembly



For more information, call 1-800-274-8888

Battery-operated and flood versions also available.

**SPECTRONICS CORPORATION**  
Westbury, New York U.S.A.  
[www.spectroline.com](http://www.spectroline.com)

## The NDT Technician

A Quarterly Publication for the NDT Practitioner

Volume 3, Number 2

April 2004

**Publisher:** Wayne Holliday  
**Publications Manager:** Paul McIntire

**Editor:** Hollis Humphries  
**Technical Editor:** Ricky L. Morgan

**Review Board:** William W. Briody, Bruce G. Crouse, Ed E. Edgerton, Anthony J. Gatti Sr., Jesse M. Granillo, Edward E. Hall, Richard A. Harrison, James W. Houf, Eddy Messmer, Raymond G. Morasse, Ronald T. Nisbet

*The NDT Technician: A Quarterly Publication for the NDT Practitioner* (ISSN 1537-5919) is published quarterly by the American Society for Nondestructive Testing, Inc. The *TNT* mission is to provide information valuable to NDT practitioners and a platform for discussion of issues relevant to their profession.



ASNT exists to create a safer world by promoting the profession and technologies of nondestructive testing.

Copyright © 2004 by the American Society for Nondestructive Testing, Inc. ASNT is not responsible for the authenticity or accuracy of information herein. Published opinions and statements do not necessarily reflect the opinion of ASNT. Products or services that are advertised or mentioned do not carry the endorsement or recommendation of ASNT.

IRRSP, Level III Study Guide, *Materials Evaluation*, *NDT Handbook*, *Nondestructive Testing Handbook*, *The NDT Technician* and [www.asnt.org](http://www.asnt.org) are trademarks of The American Society for Nondestructive Testing, Inc. ACCP, ASNT, *Research in Nondestructive Evaluation* and *RNDE* are registered trademarks of the American Society for Nondestructive Testing, Inc.

### The NDT Technician

PO Box 28518  
Columbus, Ohio 43228

NONPROFIT  
US POSTAGE  
PAID  
ST JOSEPH, MI  
PERMIT NO. 84