Reinforced concrete is ubiquitous for the construction of buildings, bridges and highways across the world. The material consists of concrete, a combination of cement, aggregate and water that reacts to form a solid material with high compressive strength, and steel reinforcing bars (rebar) embedded within the concrete (Fig. 1). The rebar is used to carry tensile forces in the concrete and control cracking and plays an important role in the strength and durability of reinforced concrete structures. This article provides an introduction to the typical characteristics and role of rebar, common deterioration mechanisms and nondestructive testing technologies that can be used to detect and locate rebar in concrete.

Concrete has relatively high compressive strength, typically in the range of 27579 to 55158 kPa (4000 to 8000 lb/in.²). However, the tensile strength of concrete is very low, typically only 10 to 15 percent of its compressive strength. As a result, concrete is generally unable to resist tensile forces. The steel rebar is intended to carry tensile forces to prevent concrete cracking and provide structural capacity. As such, reinforced concrete is a type of composite material, with concrete typically carrying compressive forces, and steel carrying tensile forces.

Dimensions
Reinforcing bar diameters are typically described by a number (Table 1). For #8 bars and smaller, the number represents the number of millimeters in the rebar diameter. For example, #3 bar has a diameter of 3 mm.

Figure 1. Steel reinforcing bars embedded in concrete control cracking and carry tensile forces.

*University of Missouri, Department of Civil and Environmental Engineering; E 2509 Lafferre Hall; Columbia, MO 65211; (573) 884-0320; washerg@missouri.edu.
Mechanisms for Deterioration

Corrosion of the rebar is a typical damage mode that leads to the cracking and spalling of concrete. Fresh concrete provides a high–alkalinity environment that creates a passive corrosion layer on the surface of the steel, which prevents the advancement of corrosion. The pH levels in fresh concrete are typically 12-13; the onset of corrosion begins when the alkalinity drops to approximately 9 or below, either due to carbonation of the concrete or chloride intrusion (or a combination of these two factors). Carbonation occurs when atmospheric carbon dioxide (CO₂) diffuses into the concrete and reacts with pore water to reduce pH levels in the concrete. Chlorides are introduced into the concrete from deicing chemicals and the environment surrounding the concrete, or may be present in the materials combined to form the concrete mix. Chlorides from the environment and deicing chemicals find ingress into the concrete through diffusion into the porous concrete microstructure, and through cracks in the concrete. When chloride levels at the rebar surface exceed a certain threshold value, corrosion of the rebar initiates and progresses. The negatively-charged chlorides play a critical role in the electrolytic process of corrosion, and generally increased chloride levels at the rebar correspond to increased rates of corrosion.

The concrete layer between the rebar and the surrounding environment provides a buffer to the intrusion of chlorides and carbonation. This concrete layer is called the concrete cover, and is typically on the order of 25 to 76 mm (1 to 3 in.) in thickness, depending on the exposure of the concrete to the weather. For example, design requirements for reinforced concrete structures require a minimum of 51 mm (2 in.) of cover for concrete exposed to earth or weather, while minimum cover requirements for concrete not exposed to weather can be as little as 13 mm (0.5 in.). Ensuring that adequate concrete cover is provided during construction is an important element in the durability of a structure, as structures with low cover may quickly suffer corrosion damage.

The corrosion of rebar results in the expansion of the bars, because the corrosion products (iron oxides) are larger in volume than the original steel in the bar. The increase in volume of the rebar can be two to six times the original volume of the steel, depending on the composition of the concrete and the iron oxides produced through the corrosion reaction. Because concrete has low resistance to tensile stresses, this volumetric expansion results in cracking. Figure 2 is a photograph of the rebar and surrounding concrete cracking that was obtained by removing a core of material from a concrete deck section undergoing accelerated corrosion tests.

Cracking from multiple rebars, typically spaced 0.15-0.3 m (6–12 in.) apart in the concrete, tend to join together between adjacent rebars, resulting in a horizontal subsurface crack known as a delamination. These delaminations can develop into large areas of subsurface damage that are not apparent through visual inspection. Eventually, cracks propagate to the surface, resulting in spalling of the concrete.

Structural Assessment with NDT

A challenge with structural analysis of aging concrete structures is that the rebar is located beneath the surface of the concrete, hidden from view. When original construction plans are unavailable, the size and spacing of the rebar may be unknown. Because the rebar carries primary tensile forces, it plays a critical role in the structural capacity of a concrete structure. The rebar size and distribution pattern (spacing between bars) needs to be determined to perform adequate structural analysis. Additionally, during the service life of a concrete structure, it may become necessary to core through a concrete member to install utilities, make attachments or structural modifications, or to place anchors in the concrete to connect attachments.

Because the rebar is embedded in the concrete, there is a need for nondestructive technologies that can determine the concrete cover protecting the rebar, and the location, spacing and size of the rebar for the following applications:

1. assessing concrete cover above the rebar, as a quality control tool for new construction,
2. assessing corrosion resistance and durability provided by the concrete cover for an existing structure,
3. locating steel bars so that coring and drilling processes can avoid cutting the bars, particularly where bars carry primary forces and

---

FOCUS continued from page 1.

of 1/8 in. diameters in the bar. For example, a number 4 bar has a diameter of 4/8 in. and a number 6 bar has a 6/8 in. diameter. Larger bars are sized to match the cross-sectional area of square bars, which was the original geometry of reinforcing steel. The diameter of the #9 bar is set so that the area is 1.0 in.², similar to a 1.0 in.² square bar used historically. The remaining bars, #10, #11, #14, and #18, correspond to 1.0, 1.25, 1.5 and 2.0 in. square bars, respectively. Table 1 indicates typical bar sizes for reinforcing steel, bar diameters and cross-sectional area of the bar. The bars typically have deformations in the surface to provide mechanical load transfer between the concrete and the rebar, to ensure the bars do not slip.

<table>
<thead>
<tr>
<th>Bar Size</th>
<th>Diameter mm (in.)</th>
<th>Cross sectional area mm² (in.²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#3</td>
<td>9.5 (0.375)</td>
<td>71 (0.11)</td>
</tr>
<tr>
<td>#4</td>
<td>12.7 (0.500)</td>
<td>129 (0.20)</td>
</tr>
<tr>
<td>#5</td>
<td>15.9 (0.625)</td>
<td>199 (0.31)</td>
</tr>
<tr>
<td>#6</td>
<td>19.1 (0.750)</td>
<td>284 (0.44)</td>
</tr>
<tr>
<td>#7</td>
<td>22.2 (0.875)</td>
<td>387 (0.60)</td>
</tr>
<tr>
<td>#8</td>
<td>25.4 (1.000)</td>
<td>510 (0.79)</td>
</tr>
<tr>
<td>#9</td>
<td>28.7 (1.128)</td>
<td>645 (1.00)</td>
</tr>
<tr>
<td>#10</td>
<td>32.3 (1.270)</td>
<td>819 (1.27)</td>
</tr>
<tr>
<td>#11</td>
<td>35.8 (1.410)</td>
<td>1006 (1.56)</td>
</tr>
<tr>
<td>#14</td>
<td>43.0 (1.693)</td>
<td>1452 (2.25)</td>
</tr>
<tr>
<td>#18</td>
<td>57.3 (2.257)</td>
<td>2581 (4.00)</td>
</tr>
</tbody>
</table>

4. Evaluation of rebar spacing and estimating rebar size for structural analysis, when plans are missing. Under these circumstances, it is necessary to identify the location and depth of the reinforcing bars nondestructively. The most common method of determining the location, depth and size of reinforcing bars is a cover meter, which locates reinforcing steel through magnetic induction and estimates the amount of concrete cover. Other common technologies include ground penetrating radar (GPR) and radiography (RT). The following sections briefly describe these technologies.

**Cover Meters**

A typical method of locating reinforcing bars in concrete is the use of a cover meter, sometimes called a pachometer. Cover meters work on the principle of magnetic induction. They can generally be classified as those based on the principle of magnetic reluctance and those based on eddy currents.

**Magnetic Reluctance Meters.** Magnetic reluctance meters consist of a current-carrying coil surrounding a ferromagnetic, U-shaped core or yoke, similar to the design of yoke used for magnetic particle testing (MT). When the coil is energized with an alternating current, a magnetic field is created between the poles of the yoke (Fig. 3). When the probe is placed on the surface of the concrete, the reluctance in the magnetic circuit is high. However, if a ferromagnetic material such as rebar is located between the poles, the reluctance of the magnetic circuit is reduced. A second coil monitors the magnetic flux in the yoke, which is increased when the reluctance of the circuit is decreased. Thus, the presence of a steel bar within the aperture of the yoke is indicated by monitoring the output of the sensing coil, and is dependent on the distance between the steel rebar and the yoke. The location and concrete cover are thereby assessed based on the output signal. The area of steel present also affects the output signal, such that there is a different relationship between the change in sensor output and the depth in the concrete, for each bar size.²

**Eddy Current Meters.** Eddy-current based cover meters are essentially metal detectors, and work on the same principles as eddy current testing (ET). When a coil of wire carries a time-varying current, a time varying magnetic field is produced surrounding the coil. Conversely, when a time-varying magnetic field interacts with a conductive material, currents are produced in the material. These eddy currents also generate a time-varying magnetic field, in opposition to the primary field, and a secondary current in the coil in opposition to the primary current is produced. As a result, the presence of the conductive material can be assessed based on the apparent increase in impedance of the primary coil. The location of the rebar and its depth (concrete cover) can be estimated based on this output.²

Figure 4 shows a concrete cover meter in use on a wall. The sensor head is placed on the surface of the concrete, and scanned over the surface to locate the rebar. The depth of the rebar is then calculated based on the output signal of the sensor, and is typically displayed on the instrument. Cover meters can also estimate the rebar size based on the output signal; these estimates are typically ± 1 rebar size. A limitation of the technology is that closely spaced bars can result in errors; additional steel area within the aperture of the sensor head can increase magnitude of signals and reduce the effectiveness of the device.

**Ground Penetrating Radar.** Ground penetrating radar is based on the propagation of electromagnetic waves in dielectric or nonconductive mediums such as concrete. When the waves encounter a boundary between materials that have different dielectric constants – for example, the boundary between concrete and air – a portion of the wave energy is reflected at the boundary. When the wave encounters a conductor, such as rebar in concrete, the wave is entirely reflected. For new concrete, the depth of concrete cover can be measured if the velocity of wave propagation is known, much the same way that an ultrasonic thickness gage can measure the thickness of a steel plate. Signals reflected by the rebar can also be used to locate the rebar and determine the spacing between rebar. Operating frequencies for GPR antennas used for concrete inspections typically range from 900 MHz to 2.5 GHz.

---

**Figure 2.** Concrete core shows cracking resulting from expansion of corroded reinforcing steel. BAM Federal Institute for Materials Research and Testing © 2012. Berlin, Germany. Reprinted with permission.

**Figure 3.** Cover meters: (a) reluctance-based and (b) eddy current-based.

---

TNT · April 2013 · 3
GPR systems are generally configured as either ground-coupled or air-coupled devices. Ground-coupled devices utilize the antenna held against the surface of the concrete, and are typically equipped with wear plates to protect the antennae and to allow the units to be dragged along the surface of the concrete. These devices may be hand-held (Fig. 5a). Air-coupled devices utilize antennae not in contact with the surface of the material, and antennae may be vehicle mounted. The advantage of air-coupled systems is that the testing can be conducted at driving speeds, allowing large areas to be inspected quickly. Ground-coupled units allow more energy to be imparted into the material under test, and typically have reduced air-surface signals. Because the surface of the antenna is in contact with the material under test, the velocity at which the antenna can be moved is limited. Figure 5a shows a hand-held GPR device with an integrated display. As the device is scanned along the surface of the concrete, parabolic patterns in the signal are created as the antennae passes over the rebar, due to the almost total reflection of the electromagnetic wave from the rebar (Fig. 5b). If the velocity of the wave in concrete is known, the depth to the rebar can be calculated from the resulting signals.

**Radiography**

Radiography can also be used to locate rebar in concrete. Industrial radiography is generally implemented using either X-ray or gamma ray sources. X-ray sources are typically X-ray tubes or linear accelerators, which generate radiation through an electronic process of excited electrons colliding with a suitable target, which emits X-rays. In contrast, gamma rays are generated by decomposing isotopes, such as Iridium or Cobalt. Radiography is based on the principle that as radiation is transmitted through a material, intensity of the transmitted radiation is lost due to absorption and scattering. Voids or areas of lower density within the material allow more radiation to pass through than does the surrounding material; areas of higher density, such as rebar in concrete, allow less radiation to pass. This difference in the intensity of the radiation is then recorded on a film or detector.

![Figure 4. Sensor head of concrete cover meter scanning surface of concrete to locate rebar. Collins Engineers, Inc. © 2012. Chicago, IL. Reprinted with permission.](image-url)
The density of concrete is such that the penetration of radiation is approximately 4 times the penetration in steel. Gamma ray sources such as IR-192 can penetrate concrete sections up to 0.25 m (10 in.) thick, and Co-60 sources can penetrate up to thicknesses of about 0.5 m (20 in.). For thicker sections of concrete, high-energy X-ray sources can be used to penetrate thicknesses of 1.27 m (50 in.) or more, depending on the energy level of the device. A significant disadvantage of the radiography approach is that access to both sides of the concrete is required, so that the radiographic film can be placed on the side opposite the source. Figure 6 illustrates a radiograph of reinforcing steel inside a concrete anchorage. In this image, spiral reinforcement that surrounds the anchorage of a high-strength tendon comprised of wire strands is shown.

Conclusion

This article has described several typical methods of locating rebar embedded in concrete and evaluating the concrete cover provided above the rebar. These methods have applications for the quality control of new concrete construction, for determining the rebar characteristics in structures where plans are missing or for locating rebar during cutting and coring operations. Ground penetrating radar is also widely used to assess the condition of aging bridge decks, as the wave responses from rebar reflections can be interpreted to identify areas of corrosion damage in the deck. Radiography also has applications for identifying embedded defects in concrete, such as subsurface voids in concretes and grouts, or significant areas of section loss or fracture for embedded steel rebar and high-strength strands. For both ground penetrating radar and magnetic induction technologies like cover meters, scanning devices and reconstruction software are available for generating two-dimensional and three-dimensional images of steel embedded in concrete. These scanner-based technologies are used in applications like locating subsurface utility ducts and evaluating the placement and spacing of critical rebar patterns, among other applications.

References


Figure 5. Hand-held ground penetrating radar system with integrated display for inspection of concrete: (a) device in use; (b) resulting display. Geophysical Survey Systems, Inc. © 2012. Salem, NH. Reprinted with permission.

Figure 6. Radiograph of reinforcing steel inside concrete shows spiral reinforcement surrounding high-strength tendon comprised of wire strands. Federal Highway Administration, NDE Center, McLean, VA.
Continued high failure rates in industry performance demonstration tests show that training for NDT technicians in the ultrasonic examination of welds lacks a fundamental process for the effective detection and sizing of discontinuities. These demonstration tests include the American Petroleum Institute (API) Qualification of Ultrasonic Examiners Certification Program (QUTE) tests and those required by leading oil and gas companies. This article is the first in a series of three that will provide a practical process consisting of simple steps for the detection, evaluation, and reporting of discontinuities in welds. The series is not applicable to structural welds controlled by AWS D1.1 nor does it apply to the aerospace industry.

This article describes the equipment and parameters of ultrasonic weld examination accompanied by clear examples. It also includes tips for effective technician training. Article two will describe how to determine the type of discontinuity and how to clearly characterize it. Actual ultrasonic discontinuity detector images will be provided. Article three will describe various welding processes, reference standards and types of discontinuities common to various processes. Piping welds, pressure vessel welds and tank welds of various thickness and size will be discussed. Conclusions from the first two articles will be integrated.

Equipment

Several issues developed as analog ultrasonic discontinuity detectors evolved into the current digital instruments now prevalent in the industry. Screen displays on earlier digital instruments lacked the resolution of current digital instruments. Additionally, the incorporation of trigonometric functions related to ultrasonic angle beam inspection created a tendency for technicians to become too reliant on the numbers on the screen. Failure to understand how trigonometric functions were derived introduced potential for erroneous conclusions.

Discontinuity signal characteristics are an invaluable aid in identifying the type of discontinuity. The closer a digital discontinuity detector can approximate an analog signal, the easier it is for discontinuity characteristics to be seen. Analog signals displayed on a cathode ray tube were the norm for ultrasonic discontinuity detectors for many years. In modern instruments, the analog signal must be reproduced digitally. This is done by the digitizer, which samples the analog signal and turns it into a series of coordinates. The signal is then converted from analog to digital by an analog-to-digital converter and displayed on the liquid crystal display (LCD) panel. Instruments today use full video graphic array (VGA) screens and modern processors and chips. As a result, discontinuity signals on modern instruments can rival analog signals (Fig. 1a and b).

Technicians using analog discontinuity detectors had to determine sound path distance by observing where the signal was on the screen. The sound path distance then had to be plotted with a pencil, paper, protractor and ruler to determine the depth and surface distance to a reflector. Modern digital

Figure 1. Display screens for discontinuity detectors: (a) analog and (b) digital.
instruments incorporate trigonometric functions and display all these values on the screen. All indications must be correlated by plotting.

Training

The skill of the trainer is key to imparting proper information and practices to students. The trainer should have significant personal field experience in the application of the practical aspects of angle beam weld examination. In-depth knowledge of the applied theory and physics of the processes and an ability to communicate the information to students.

Students must first be exposed to the relevant theory. Depth of comprehension should then be explored. Finally, the relevance of the theoretical knowledge should be demonstrated. Students should be made aware that relevant theory will always be required to understand and explain unusual conditions during field operations.

The next stage of training is to apply the knowledge acquired to practical applications. This begins with calibration of the angle beam set-up for beam exit point, verification of the refracted angle and adjustment of the baseline to correspond with the sound path of the ultrasonic beam. All of the calibration steps are based on the ability of the operator to establish the maximized signal amplitude and require a combination of comprehension and manual dexterity. Failure to properly calibrate the instrument will integrate any error into the detection, location and characterization of discontinuity indications.

Learning the proper application of the weld examination procedure consists of the selection of appropriate probes and the mastery of scanning technique, plotting, signal characteristics discrimination and indication sizing techniques.

This training falls within the skills described for an ultrasonic Level II in SNT-TC-1A.

It is essential for training to be conducted on specimens with real discontinuities. Each discontinuity type produces different signal characteristics and it is very difficult to learn these with artificial reflectors. These test pieces are readily available commercially.

Prior to conducting the critical scans discussed below, the crown of the weld must be reproduced using a profile gage. Thickness measurements must be taken on each side of the weld and through the crown in order to produce an accurate scale cross section drawing of the weld.

When scanning welds, students can be easily overwhelmed trying to decipher which signals are coming from geometry and which are from real discontinuities. For training purposes and to reduce confusion, it is helpful to break the scans down into three separate critical scans. These are implemented after a lamination scan of the test plate.

Root Scan. The first critical scan is the root scan in which students are taught to set up a line scan to interrogate the root area of the weld (Fig. 2a and b). Magnetic strips are used as guides for the probes. The distance from the centerline of the weld to the probe exit point is set so that the sound intersects the centerline of the weld at the inside diameter (ID). As the probe is moved along the magnetic strip and into an area with a root indication, the signal from the root geometry (if present) will shift to the left. This technique makes it simple to separate actual discontinuities from root geometry.

Toe Scan. Students setting up the magnetic strips for a toe scan (Fig. 3a and b) are instructed to place them so that the

FYI continued on page 9

Figure 2. Diagrams for (a) cross section of root scan and (b) plan view of line scan setup for root area of weld.

Figure 3. Diagrams for (a) cross section of toe scan and (b) plan view of line scan setup for toe area of weld.
exit point of the probe is at a distance from the toe of the weld sufficient to allow the sound beam to intersect the outside diameter (OD) surface at the toe of the weld. The probe is then moved along the strip. When a toe crack is present, a signal will appear in the appropriate location along the time base on the discontinuity detector screen.

**Body Scan.** The body scan is a raster scan conducted with the angle that is closest to perpendicular to the weld bevel angle; typically 60°. The aim of this scan is to interrogate the volume of the weld. Indications seen in the root area during this scan should be ignored because the previously completed root scan should have detected any root indications that were present. Any signals seen in the root area other than the discontinuities found during the root scan will be due to geometry. The weld should also be scanned for transverse discontinuities during the body scan. Students often forget this step during training.

Although technicians working in the field will not be using the critical scan method and putting magnetic strips on welds, the technique has proven very effective for training purposes. Many students have difficulty grasping the overall procedure of a weld inspection without it. It is a step-by-step method that eliminates a great deal of confusion. Again, it is important to point out that the technique should not be used in the field because of varying weld geometries. Commercially available test samples all have consistent geometry.

**Inspection Steps**

Inspection steps should be as follows:

1. Information gathering
2. Visual inspection
3. Lamination scan
4. Detection scan
5. Indication evaluation
6. Reporting

**Information Gathering.** Before beginning any weld inspection, technicians must know the purpose of the examination being conducted and the code that applies. Is it new construction or in-service? If in-service, what is the most likely damage mechanism?

The technician must next determine the details of the equipment to be inspected. Knowledge of the part material, thickness and weld joint configuration are critical in addition to knowledge of the welding process used. If the equipment is in-service, what is the operating temperature? Is there a history of damage?

**Visual Inspection.** As with any inspection technique, the first step in the actual inspection should be a visual examination of the weld. This gives a good idea of what is to be expected in the inspection. For example, shop welds are likely to be much cleaner than field welds. Note the condition of the weld cap. Are there areas of undercut or underfill? Look for areas of obvious mismatch or misalignment.

**Lamination Scan.** The first ultrasonic technique is a compression wave 0° lamination scan. This will detect anything that may interfere with the angle beam examination, such as laminations. For vessels in wet H₂S service, it will reveal any blistering that may be present. During this scan, the average thickness on each side of the weld should be recorded.

**Detection Scan.** The detection scan is conducted in accordance with a written procedure. The procedure should state what equipment and calibration blocks are to be used, what and how many angles to use and the scanning sensitivity level. ASME type inspections typically require the use of at least two different angles. While most procedures require that you scan at two times the reference level, or + 6 dB, it is highly recommended that you scan at + 12 dB. It is well known that ultrasonic testing is very good at detecting planar discontinuities, but less successful at detecting volumetric discontinuities. It is very easy to miss porosity when scanning at only two times reference. Indications that are not obviously due to weld geometry are noted in this step.

**Indication Evaluation.** After completion of the detection scan, it is time to evaluate the indications that were found and determine if they are due to geometry or are actual discontinuities. Any discontinuities should be characterized through plotting and the observation of signal characteristics. Discontinuity information such as sound path, surface distance, and amplitude should be recorded along with the length and datum position of the discontinuity. The discontinuity is then accepted or rejected based upon the acceptance criteria described in the procedure.

**Reporting.** A report should describe what was inspected, how it was inspected, the equipment it was inspected with and what was found. The report should be clearly written with correct grammar and no misspelled words. The report should also answer any questions the client might possibly have. It should never be necessary for the client to call for clarification or to ask about something that was not addressed in the report. In the end, the report is a legal document and failure to fully complete a form requiring specific items to be reported can be damaging in a law suit.

**Conclusion**

Improving results on industry performance demonstration tests starts with a proper training program. Without an extensive library of weld test specimens containing real discontinuities, a clear procedure and proper instruction, it is difficult for technicians to gain the necessary skills and experience.
Maintenance & Inspection Services, Inc.
Service Disabled Veteran Owned Small Business

www.misnc.com

- Nuclear Power Industry
- Petro Chemical Industry
- Commercial Shipyards
- US Coast Guard
- US Navy
- US Army
- Magnetic Particle Testing
- AC Field Measurement
- Eddy Current Testing
- Ultrasonic Testing
- Penetrant Testing
- Visual Testing

Full Range of NDT Solutions

"Your NDT Technical Specialist"
828-754-3054

- National Defense Industry Association
- American Society of Naval Engineers
- Tube Plugging
- Turn Key Services
- Supplemental Work Force
- Tube Cleaning and Repair

ASNT Corporate Partner
**Jesse Cayabyab**

Jesse Cayabyab is an inspector working in quality control on the largest public works job in the history of California — the San Francisco-Oakland Bay Bridge. His employer describes his inspection work as extremely accurate. "It’s almost a waste of time to double-check Jesse because he’s just that good and that diligent."

**Q: How did you first become involved in nondestructive testing?**

A: I was a welder and I wanted to know what the inspectors were really looking at when they inspected my work with UT and MT. I wanted to understand why an indication was rejected or irrelevant. I decided to take the AWS test to become a Certified Welding Inspector and I passed it. The company I was working for asked me if I would do some UT inspections but I was still just a rookie and I didn't feel qualified. So, I worked with the Level II UT inspector and I watched and I learned. Then I took a class at Contra Costa College to get my 40 hours for UT Levels I and II. The company I was working for did not want to buy any more UT equipment at that point so — I bought my own scope. That was about 12 years ago. It was an analog instrument and I paid about 700 dollars for it. I still have it. I continued to work along with the Level II and used that scope to help with the work process. It was an opportunity for me to practice so that was good for me. I logged my hours so that I could complete all my hours according to the recommendations in SNT-TC-1A. If I didn't understand what I was doing, I would go to ASNT and order a book. So, I kept reading and it helped me to know what I was looking at — whether it was an irrelevant indication or not. Then, since I'm a welder, I decided to make my own flaw plate. I put a side-drilled hole there on the one-inch plate, and I think probably a penny — so I could practice with UT to find all the flaws in the fit-up of the plate, kind of making it like offset of the plate — you know, just practicing.

**Q: Where did you go from there?**

A: I went to work for my current employer. When they asked if I was interested in working for them, I said yes. They gave me additional training and certification in MT, PT and VT.

**Q: Will you describe a typical day working as an inspector on the San Francisco-Oakland Bay Bridge?**

A: It's hard work and long days and it can be stressful. We have a crew of about ten inspectors here to document that every step is done per procedure. Right now we are inspecting the structural steel at the base of the bridge tower and the tower skirt. This is the tower that holds all of the cabling for the bridge. The tower steel is from 80 to 100 mm thick. I check all the fit-up of the steel visually before it’s welded — and then, everything has to be preheated per procedure. After the steel is welded, post heat treatment has to be done on it — that takes about three hours, depending on the thickness of the steel. The steel is heated with thermal induction. It’s wrapped in an insulating blanket and then heated with ceramic heaters. The indications we look for are things like cracks, porosity and slag inclusions.

**Q: You have a reputation for being extremely accurate. How do you ensure that your inspections are always correct?**

A: I read the scope carefully. I check at every angle per procedure using scanning patterns A, B, C, D or E as applicable for the specific weld. We are following the AWS D1.5 Bridge Welding Code, using Table 6.3 Tensile
Stress and Table 6.4 Compression Stress as applicable per project specifications. I measure carefully for depth and length to determine if it is rejectable or not. I always measure carefully and I check every angle.

**Q:** You are particularly successful at communicating with both welders and state inspectors. Any pointers on how you accomplish that?

**A:** Well, communicating with the welders can sometimes be hard. I don’t want to teach them how to weld but, if they have a problem, I try to help them out. The best way to correct a problem is to talk to the welders and explain to them what happened to the weld. Some of the guys here know me as a welder and that helps. Working with the quality assurance inspectors from the California Department of Transportation isn’t a problem because I call it what it is. If there’s an indication in a particular weld, I always lay it out as accurately as possible. I mark it where I see it and I put the indication rating. The QA inspectors back check me all day, every day. Sometimes there are even two of them and they are either Level II or Level III inspectors.

**Q:** What would you say is the most difficult part of your work?

**A:** The work can be physically difficult. Communicating with people can be difficult; sometimes we have stubborn people. And some situations can be political.

**Q:** What do you like most about your work?

**A:** I’ve traveled quite a bit in this job — to Japan and China and many places here in the US. I enjoy that a lot, especially traveling out of the country. And, I like a challenge — the challenge of the work itself and the challenge of working with people.

**Q:** Do you have plans for additional training or certification?

**A:** Actually, I’ll be in Ohio this month for the Level III Basic Refresher Course and the Level III Basic Exam. I’d also like to get additional training in phased array and TOFD UT. And, I’d like to take a class in RT.

**Q:** How would you advise someone considering an NDT career?

**A:** Keep studying until you’re good at it. If you’re not sure about something, find help from someone that knows. Contact Jesse Cayabyab at jessec@smithemery.com.cn.
Q: I have a use question pertaining to penetrameters. If I am X-raying plate material or bare material without weld and see an inclusion/indication on the radiograph, can I use a pen to determine depth of the indication? D.S.

A: No, pens are designed to indicate sensitivity and contrast; they cannot be used to determine flaw depth. There is a technique for determining depth by using two offset exposures and performing the trig calculations, but it would be simpler to use ultrasonic testing.

Q: My ASNT NDT Level III and ACCP Level III certifications are both coming due early this year. I renewed both by submitting points last time, but I have heard that I will be required to take a written examination to renew my ACCP Level III certificates this time. Is that correct?

A: Yes, your ASNT NDT Level III certifications can be renewed by points (or by taking the full length Method examinations), but the ACCP requires that all certificate holders take an abbreviated examination at the 10-year interval (10 years after your initial certification or your last recertification by examination). At that time ACCP Level III certificate holders are required to take an abbreviated multiple-choice written examination consisting of 10 questions on Recommended Practice No SNT-TC-1A (the "Basic" component), and 20 questions on each of the Methods (the "Method" components) in which you wish to recertify. If you hold ACCP Level III in three Methods, your examination would be 70 questions in size and would be a single 2-hour exam; for four methods it would be a 90-question, 2.5-hour exam, and so on. If you should fail a Method component (they are graded separately even though they’re on the same test form and answer sheet), you would only have to retake the failed component. If you retake and pass a failed component before your current expiration date, you would be recertified in that Method also. If you fail the Basic component and fail to pass it before your expiration date, you would lose all certifications, so you should examine early (you can do so up to 6 months prior to expiration) so that you have time to retake a failed component if necessary. Because the ASNT NDT Level III and the ACCP are separate programs, failing an ACCP component will not affect your ASNT NDT Level III renewals or vice-versa.

Respectfully,
James W. Houf,
Senior Manager, ASNT Technical Services Dept.

E-mail, fax or phone questions for the "Inbox" to the Editor:
humphries@asnt.org, fax (614) 274-6899, phone (800) 222-2768 X206.