

TNT NDT TECHNICIAN

A Quarterly Publication for the NDT Practitioner



TNT Focus: Testing the Liberty Bell

The Liberty Bell is owned by the City of Philadelphia, but the responsibility for day-to-day care belongs to the National Park Service. As curator for the Liberty Bell, the National Park



Full-size radiograph of Liberty Bell on single sheet of film. Copyright © 1975. Kodak Corporation. Reprinted with permission.

Service has employed various nondestructive testing techniques to assess its overall condition and stability. The bell was first inspected with radiography in 1975 in preparation for a move from Independence Hall to a new pavilion built for the American bicentennial. It was inspected

again in 2001 to assess damage caused when a vandal struck the bell.

Birth of the Bell

Long before it became recognized as an American icon, the Liberty Bell played a utilitarian role in the daily life of Philadelphians. It was originally hung as the State House bell on June 11, 1753, almost a quarter of a century before it would ring to call the people of Philadelphia to hear the first public reading of the Declaration of Independence on July 8th, 1776. The bell we know today is the third in a

series of three castings. The Pennsylvania Assembly ordered the first casting from an English firm, Whitechapel Foundry, to embellish their new — and very grand — State House. It broke "...cracked by a stroke of the clapper without any other violence as it was hung up to try the sound." (Isaac Norris, Assembly Speaker and Chairman of the State House Superintendents - March 10, 1753). The second and third castings were made by two American entrepreneurs eager for the opportunity to recast the new State House bell right in its own backyard.

Physical Description

The bell weighed 2,080 pounds when it was cast for the third time. It's somewhat less than that now. A section of the bell was removed (drilled) in an attempt to keep the famous Liberty Bell crack from propagating and, unbelievably, over the years, bits and pieces of the bell were collected as souvenirs. It's three feet tall and twelve feet in circumference at the widest point. Thickness will vary at a consistent height around the bell but generally, it's about an inch and a quarter thick at the crown and about three inches thick at the lip or sound bow. It is bronze with a copper to tin ratio that varies point to point around the bell. It also contains lead, zinc and nickel as is typical in a bronze alloy

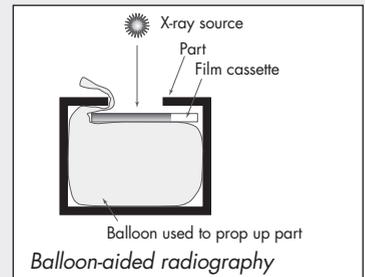
continued on page 2

TNT Tips: Balloon-Aided Radiography

Parts with a closed cavity sometimes require the opening to be radiographed using single wall techniques. The problem associated with this is keeping the film in contact with the part, since the back of the film cannot be accessed easily.

A simple fix is to use a balloon beneath the film. Allow the end to protrude from behind the film cassette. Note film cassette must be bent to get it into the cavity. Inflate to raise the cassette into position. Remove the cassette by breaking the balloon. (I saw this in *NASA Tech Briefs* a few years ago.)

Stuart Kleven
Bensenville, Illinois



Gamma Radiography – No Longer a Pain in the Back

During a workplace study on back injury prevention, we were surprised to learn how much lifting, twisting and bending were involved with gamma radiography. Field work presents unique problems but we were able to implement changes in our exposure bunker that made repetitive radiography of pipe joints easier and safer. Some of these are:

- use pipe vises to hold work at a convenient height,
- place a small table nearby to hold accessories,
- make a tripod stand to support crank handle at waist height,
- adapt a hand cart to transport camera, cables, and other equipment, and
- use a portable hydraulic engine block lifter to lift heavy spools into position.

John Woollven
St. John, New Brunswick,
Canada

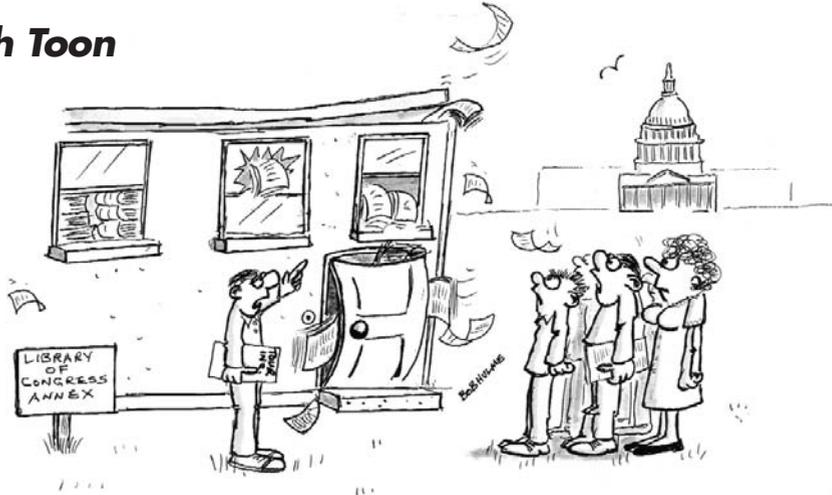
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Volume 1, Number 3

July 2002

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Tech Toon



"And this building is for NDT codes and specifications."

Readers are invited to submit ideas. Send your humorous NDT experiences to Tech Toon.

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with small traces of iron, silver, antimony, arsenic and gold.

Foundry Technology in the Colonies

American foundrymen John Pass and John Stow (those are their names blazoned across the bell below the inscription) broke up the cracked English bell, added an ounce and a half of copper for every pound of the old bell

to adjust for what they construed as its brittle condition and recast it — no small feat. It meant heating 2,000 pounds of metal to a molten state. Foundry technology of the day couldn't accommodate a single pour of that magnitude. Multiple small crucibles were used in an ongoing series of pours over a period of about forty-eight hours.

Upon completion, the Pass and Stow bell was hoisted to the State House belfry.

However, "Upon trial, it seems that they have added too much copper. They were so teased with the witticisms of the town that they will very soon make a second essay." (Isaac Norris - March 29, 1753). The bell tone was not bright and clear. It was closer to a thud. Pass and Stow carted the bell back to the foundry for another try. The third casting was in place on June 11, 1753. There was still controversy about the tone of the bell and the Philadelphia Assembly ordered another Whitechapel bell but when the two were compared, it was decided that the English bell sounded no better than the Pass and Stow bell. The Whitechapel bell was made part of the clock mechanism and rang the hours. The Pass and Stow bell kept its place in the tower as the State House bell. Thus began the life of the Liberty Bell.

Bells in the Colonial Community

Bells were utilitarian in colonial America. They afforded the quickest and most efficient way to communicate with the townspeople. They rang to announce the hours, church service, community events, convening of the legislature, public assembly, and to signify public mourning (tolling slowly with the clapper muffled in

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FROM THE EDITOR:

At its fiftieth anniversary, the American Revolution was still tangible. Some participants in the seminal events of 1776 were still living. In those fifty years, the dust had settled, the country had grown and prospered, and the significance of all that had transpired was apparent. The Liberty Bell was among the objects and events that Americans had come to revere. This year, on America's birthday and in light of September 2001, we have an imperative to consider again the freedom we hold dear. The Liberty Bell is now an international symbol — a physical manifestation of a basic right to freedom regardless of national origin. It's gratifying to NDTERS to understand the role NDT has played and will continue to play in the bell's safety and well-being. It's but a simple step to realize it's a role that NDT plays in the world community.

TNT wants feedback from our readers and ASNT is offering an incentive. Check out *The NDT Technician* survey at

www.asnt.org/publications/tnt/tnt.htm.

The *NDT Contract Employee Listing Service (NDT CELS)* Internet recruiting database is up and running. Return the *NDT CELS* application available at www.asnt.org/Publications/The NDT Technician or contact the TNT editor.

Hollis Humphries

TNT Editor

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heavy cloth) as in the death of citizens of note or even at the abuse of colonial liberties.

As the State House bell, the Liberty Bell rang for many of the events that eventually lead to the American Revolution. In September of 1777, the one ton Liberty Bell was removed from its steeple in Philadelphia for a nine-month stint tucked under the floorboards of Zion Reformed Church in Allentown, Pennsylvania. As the British approached, the citizens of Philadelphia had spirited away any metal that could be recast as ordnance. All bells, including the bell from the State House, were brought down and hidden.

During its long tenure in the State House belfry, cracks were noted in the bell and repairs in the manner of the day were made. But in February of 1846, the Liberty Bell was cracked for good. It rang its last in honor of Washington's birthday. It was removed from the steeple belfry and placed in Declaration Chamber of Independence Hall.

American Icon

The Liberty Bell played an anonymous role pretty much up until the fiftieth anniversary of the American Revolution. On that anniversary, many things, such as the old State House bell and Independence Hall itself, began to grow in importance for the American people. In the

1840s, the bell's association with the struggle for American freedom, in addition to its biblical inscription "Proclaim Liberty thro' all the Land to all the Inhabitants thereof" made its image a natural choice for abolitionists. It appeared in the frontispiece of the 1837 edition of *Liberty* and thereafter became a focus for antislavery groups. Finally, reeling in the aftermath of the Civil War, all factions of the country sought to celebrate a mutual history, that is to say, the American Revolutionary War. To that end, the Liberty Bell was toured in many regions of the country throughout the 1880s and 90s.

Fragile Structure

The Liberty Bell is a fragile structure principally because of a long crack. It's probable the propensity for cracking is a result of casting technology, or lack of it, in the mid 1700s. Multiple crucibles make a consistent alloy difficult and inherent in the process of adjoining pours are variations in crystal structure that produce resident stresses. Also, adjustments made by Pass and Stow, first for brittleness then for tone, may have left the strength of the alloy compromised. The long fine crack extends well beyond the drilled and pinned portion of the Liberty Bell crack we are so familiar with (Fig. 1a and b). It travels up through the word

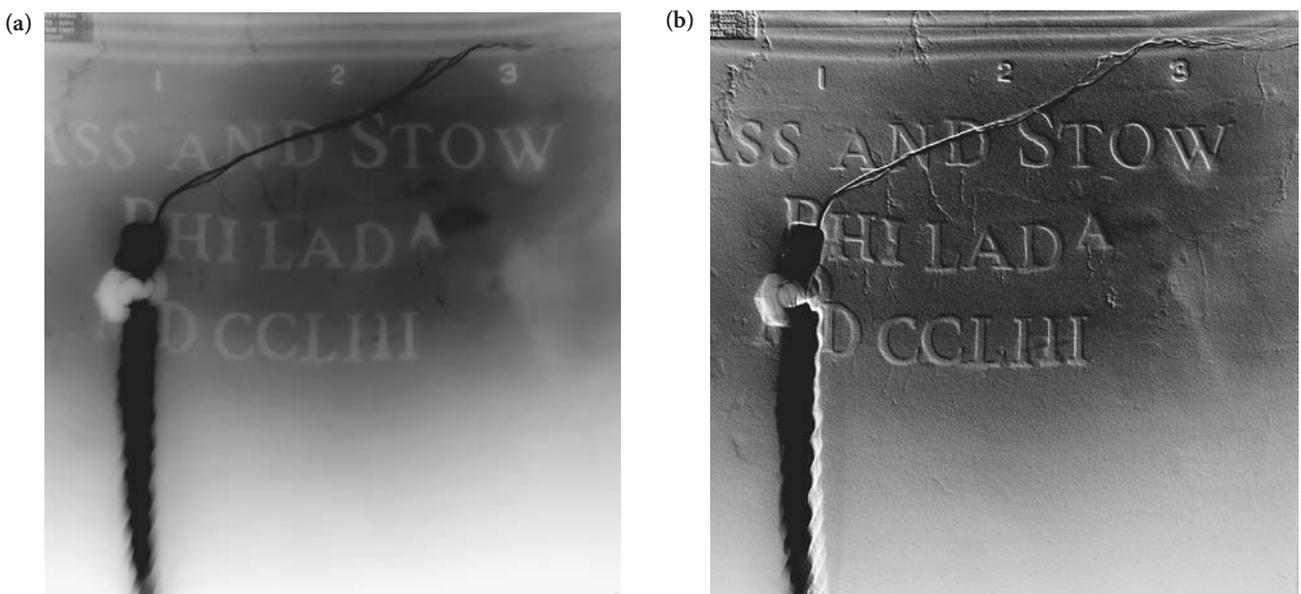
"Liberty" in the inscription and then upward and to the right well into the crown where it finally terminates under the yoke.

Nondestructive Testing of the Liberty Bell

Bicentennial Inspection. In 1975, X-ray fluorescence to determine metallic content at the bell's surface was performed at ten different points around the rim. Again in 1975, radiography was done in preparation for a bicentennial move to a new site. Universal Technical Testing Laboratories, Inc. of Philadelphia, Pennsylvania was asked to make the radiographic examination. Forty single-section radiographs covering the entire bell were made using iridium-192 in 52 and 100 Ci source strengths in a gamma ray projector. Some previously unknown shrinkage separations and cracks around the shoulder of the bell were detected. New cracks and those known to exist were definitively charted for the first time as a result of these radiographs.

At the same time, a single double-wall radiograph (at the time, the world's largest) was suggested by Ralph E. Turner, a former ASNT president. The large radiographic exam, performed by Technical Operations, Inc. of Boston, Massachusetts, was technically challenging and required special licensing from

Figure 1. Radiography showing propagation of large crack in Liberty Bell: (a) initial radiograph and (b) radiograph following digital enhancement.



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the Nuclear Regulatory Commission for the 670 Ci cobalt-60 source. Much of the setup for the test required custom fabrication. Fourteen sheets of film measuring 52 by 84 in. were stacked in a frame constructed specifically to accommodate film of such large dimensions. The source was shielded in a lead ball twenty-four inches in diameter and weighing two thousand pounds. A collimator confined the radiation to a five-foot beam spread and was aimed precisely with a rifle scope. Reinforcement and special rigging were required to move the source, shielding and containing structure (weight concentration over two tons) into place inside Independence Hall's 18th century structure. Six tons of high-density concrete block were hauled into place behind Independence Hall to provide shielding. The exposure took seven and a half hours and determined a crack in the bell's clapper and cracks and corrosion in tie rods in the bell's yoke.

Damage Assessment. Plans were already in place in April of 2001 to examine the bell's condition again as preparation for a move in 2003 to the new Liberty Bell Center now under construction. The exam schedule was expedited when the bell was hit repeatedly by a vandal with a hand sledge.

Conam Inspection, Inc. of Sharon Hill, Pennsylvania was asked to evaluate the damage with radiographic testing. Conam assembled a team of twelve that would invest over 300 hours in the preparation and execution of an eight hour inspection. Vince Roding, of the 1975 inspection team, also participated in the project. A total of six radiographs in 14 x 17 in. and 10 x 12 in. formats reproduced the film size and some of the positioning of the 1975 radiographs along with added perspectives.

These radiographs were scanned, converting them to digital format. The images were then processed to enhance readability. Interestingly, the images from 1975 were also scanned and digitally enhanced. Allowing for improvements in film technology and some film degradation in the 1975 radiographs, the images were quite good and provided an excellent platform for comparison. Digitally acquiring the radiographs placed them in a permanent format that will not degrade over time.

The National Park Service, most interested in pinpointing the active crack tip and determining substantial differences in the area around it, decided to investigate further with other NDT methods. The Boeing Company was asked to submit a proposal for evaluation of the bell. Boeing originally planned to

develop an eddy current test to pinpoint the tip and to make an overlay plotting it. The overlay could then be used for future comparison purposes

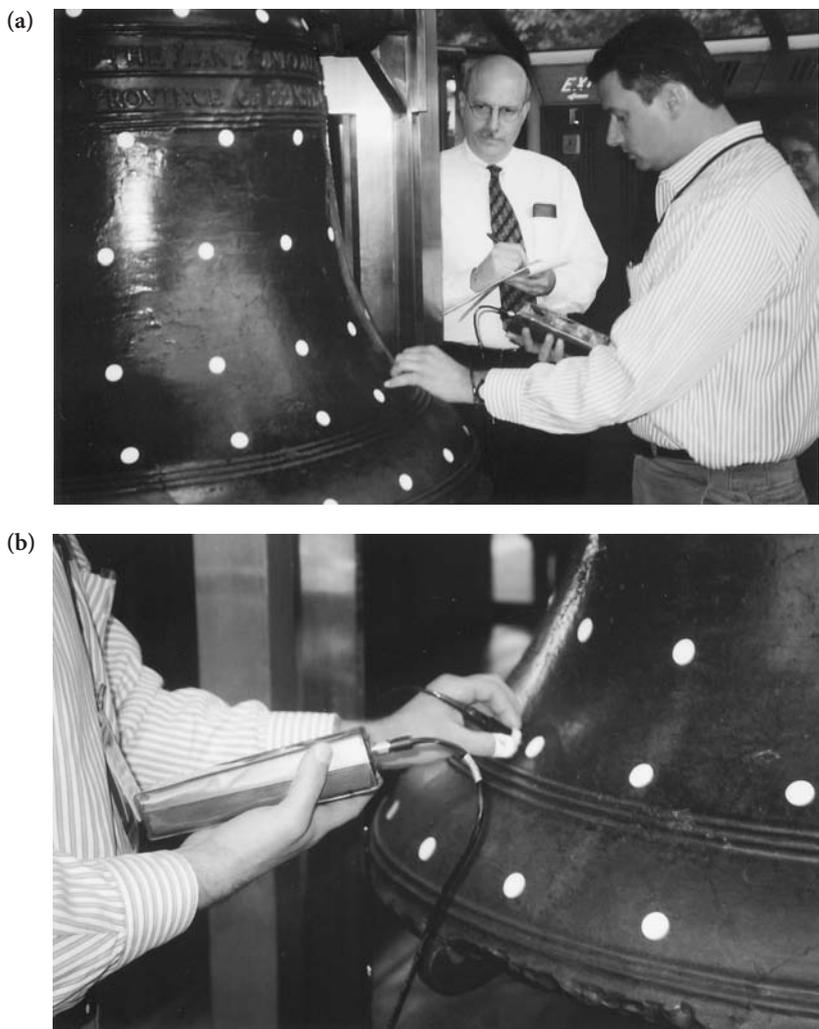
In May 2001, Boeing began by mapping the bell with electrical conductivity to determine brittle areas (Figure 2a and b). Ultrasonic testing was then used to determine laminar flaws. Laminar flaws are parallel to the surface but inside the structure and therefore not apparent in a surface inspection. Unfortunately, the bell surface was greatly attenuative. That is, much of the energy of the ultrasound wave was absorbed instead of

reflected. Because of this, the sensitivity of the ultrasound inspection was diminished and only gross laminar flaws could be detected.

Boeing also used liquid penetrant testing in areas around the blows from the sledgehammer attack. Extra care had to be taken in surface cleaning but it was "Probably the most revealing [test] in a direct and straightforward way ... It showed more clearly the crack damage around the sites of impact." (Andrew S. Lins, Chief Conservator of the Philadelphia Museum of Art and consultant to the National Park Service in the care of the Liberty Bell - April 10, 2002).

continued on page 5

Figure 2. Metal content in large castings of the mid 1700s varied considerably from point to point. Boeing employees, Ira Sherman and Lou Truckley make a series of measurements using electrical conductivity to determine homogeneity of the bell's bronze: (a) white dots are visual reference points for measurements made with (b) portable electrical conductivity equipment.



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Eddy current induces an electromagnetic field in the surface of the part. A variation in the field indicates a discontinuity. However, the Liberty Bell exterior is noisy, with many small fractures and inclusions, probably as a result of casting. Eddy current tests conducted by Boeing on the exterior of the bell could not conclusively locate the crack tip. The bell's interior is relatively clean and therefore free of noise. Eddy current tests of the interior surface pinpointed the crack termination precisely.

The National Park Service is still pursuing issues of material stability. Nondestructive testing methods of the types used in 1975 and 2001 will assuredly play a role in the ongoing care of the bell. NDT test results are now a permanent record of the condition of the Liberty Bell at the time of testing and will be used as points of comparison for future tests. Additional NDT methods are also under consideration. The NPS is investigating the use of strain gages permanently affixed across the active crack tip with the potential that they can be remotely monitored to immediately indicate any changes in the bell structure.

Conclusion

Today the voice of the bell is poignantly quieter. It is tapped annually on Martin Luther King Day. "It is only tapped — not rung or pealed. The bell's literal, physical fragility quite neatly parallels what many people think of as the conceptual fragility of human liberty in the face of war, holocaust, dictatorial regimes, discrimination, and etc. The bell tapping ceremony held annually on Martin Luther King Day is intended to be a reminder of the great sacrifices made throughout our history in the fight for human freedom." (Karie Diethorn, Chief Curator for Independence Park and the Liberty Bell - April 5, 2002) ■

TNT wishes to express its gratitude to Karie Diethorn, Chief Curator, and Phil Sheridan, Public Affairs Officer, of Independence National Historical Park and Andrew S. Lins, Chief Conservator of the Philadelphia Museum of Art, for their generous contributions of information and time. TNT would also like to thank Vince Roding of Vincent F. Roding NDT Training and Consulting, Ira Sherman, Senior Manager of Quality Systems and Processes, and Lou

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TNT Practitioner Profile: Vince Roding



When Vince Roding is not busy running his NDT training and consulting firm, he volunteers as a trainer for his ASNT Section, serves as the Section awards chair, teaches NDT in the local college and serves on the Radiation

Protection Advisory Committee (RPAC) for the Pennsylvania Department of Environmental Protection. He earned the ASNT Fellow Award in 1983 and was the first recipient of the Greater Philadelphia Section's Meritorious Service Award in 1996. Vince was a member of the team that radiographed the Liberty Bell in 1975 in preparation for and after its move to its bicentennial setting. The opportunity to examine one of the most readily recognized symbols of American liberty presented itself again in April of 2001 when the bell was vandalized.

When did you first become involved in nondestructive testing and how did you become a member of ASNT?

I first began working in NDT in 1951 and I was invited to attend an ASNT meeting by a coworker who belonged to the local Section.

Tell us about the radiography of the Liberty Bell that was done in 1975. You were involved in all stages of both the single wall exposures and the large double wall radiograph, is that correct?

Yes, the initial work for the bell, the single wall exposures, shooting of the bell, the initial radiography looking for discontinuities prior to moving the bell — I established the techniques for that. I checked the bell from top to bottom to see if there were any cracks or defects that would propagate during the move.

What was the biggest challenge in making the large double wall exposure?

Actually, for the large exposure, I can say the big challenge was determining the proper exposure time. The bell was fifty feet from the source and we were making one exposure. How do you determine a proper exposure time for that setup in just a single shot?

How was the time finally determined?

We did it twice. We made a test exposure on the first night, fine-tuned it and did it again on the next night. We were also checking the radiation in the area. It was too high when we first started. We corrected that by stacking solid concrete blocks inside a truck to make a barrier and then pulled the truck right in front of the doorway. The big single exposure could never have been done without the concrete barrier.

Can you describe the source and how it was arranged in relation to the bell?

The shielded container for the source was like a big round ball. The collimator was a telescopic sight. In other words the source remained inside the [shielding] unit. A window or port opened up to allow the radiation to come out. You only get a direct beam not 360 degrees. We used a telescopic sight because we were so far away from the bell that we had to line the shot up perfectly. If we were a little bit left or right or up or down, we would have projected off the film.

Can you compare/contrast the materials and equipment used in 1975 and 2001. What differences were there between the old and the new.

I thought the film back then was not that different from the film used today. It was

excellent quality. I think that what has changed is that now the radiographs are digitized. When you digitize the film, you can enhance the image, make it easier to see.

Have radiography and radiation testing changed significantly during your career?

Oh yes, the equipment, the training, the certification needed to do the work. When we started in the business, we didn't have the SNT-TC-1A training, the guidelines and books. I actually worked on a medical machine when I started. Personnel are better trained now — far superior, and techniques are much improved.

Do you find that radiography has wider application now?

Vastly so. Industry has become aware of what NDT can do. The potential was always there. The tests could have been done but nobody knew about NDT.

What can industry do to encourage careers in NDT?

It's important for industry to recognize the value of nondestructive testing and to provide recognition for the NDT technicians doing that work.

What can ASNT and TNT do to encourage careers in NDT?

Well, I think it's important to provide instructors with the newest training materials on what's out there and how to do it.

What is the smartest route to a career in NDT today?

Get into a training program and then get on-the-job training. First get training, then learn the theory and finally put hands-on to make it understandable. ■

TNT Inbox:

Q: How often must I recertify?

A: Many specifications require 3 year intervals for Level I and II personnel but this will be determined by your company's written practice.

Q: I want to calibrate to perform a shear wave inspection but get no signal from my transducer. What should I do?

A: One suggestion is to remove the acrylic wedge and check for couplant.

Q: I only need to produce one or two radiographs today. Should I really perform a full equipment warmup procedure?

A: A complete warmup procedure should always be performed to avoid damage and extend the life of your X-ray equipment.

Q: I'm confused about the documents SNT-TC-1A and CP-189. Is there a major difference between the two?

A: One major difference is that SNT-TC-1A is a guideline or recommended practice and CP-189 is an ANSI standard.

Q: When should I clean the blacklight lens?

A: Remove and clean the lens before you turn it on and while it is cold. Frequency should be determined by your Level III.

Q: I took a centrifuge sample from the magnetic particle test unit and the reading is below the specification requirement. What should I do?

A: Using the solution application hose and a brush, brush and wash the boards on the bed of the unit. Remove the boards to brush and wash the interior surfaces of the tank. Use the brush along the bottom middle of the tank to stir any settled particles. Replace all boards and take another sample. If the reading is still low, new particles must be added according to the proper procedure. Consult your Level III.

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