NDT TECHNICIAN

A Quarterly Publication for the NDT Practitioner



TNT Focus: Ultrasonic Thickness Testing in Refineries and Pulp Mills

by Ronald E. Nisbet¹ and Marc D. Busby²

Properties of high frequency ultrasound permit it to be generated by a transducer, travel at a constant velocity through elastic solids, reflect

from the opposite surface and return to the transducer to be detected. Accurate thickness measurements can be obtained from a surface if the velocity of the wave is known or if

equipment is calibrated on a known reference standard.

Corrosion or erosion reduces material wall thickness to a point where failure can occur with dramatic and disastrous results. Before the development of ultrasonic thickness measurement, physical measurement using a micrometer or caliper was the only method to determine wall thickness in piping or pressure vessels. This required access to the end of the pipe or vessel or drilling a hole.

Application in Refineries and Chemical Plants

After visual examination, ultrasonic thickness measurement is the single largest application of nondestructive testing in the petrochemical industry. The number and frequency of *thickness measurement locations* (TMLs) is designated by engineering and is based

upon service of the piping, tankage or pressure vessel.

Thickness measurement data is downloaded to computers that determine thickness diminution trends. These trends are used to schedule component replacement in advance of the projected minimum allowable wall thickness.

Evolution of Equipment. Early ultrasonic thickness measurements were obtained using analog flaw detector instruments. These instruments required visual interpretation of a screen grid. Analog instruments still have some advantages. They provide excellent penetration through thick materials, are less affected by high temperature attenuation and give excellent resolution on thin materials.

Much progress has been made in the development of digital thickness gages and flaw detectors. When first developed, digital thickness gages provided a digital measurement only and the operator was obliged to rely on the thickness readout with no assistance from a waveform display. Thickness gages that provide a digital measurement only have limited application and are best used for quickly determining the scheduling of new piping and spot measurements. This type of equipment cannot discern

continued on p 2

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Volume 2, Number 2	April 2003
TNT Focus: Ultrasonic Thickness Testing in Refineries and Pulp Mills	
TNT Tips: Solving problems in ultrasonic evaluations	1
Tech Toon	2
FYI: Ultrasonic Phased Array	
TNT Practitioner Profile: Brian Murray	8
TNT Inbox	8

TNT Tip: Applying Couplant in Restricted Areas

When taking ultrasonic thickness measurements in areas with restricted access and application of ultrasonic couplant to the exact location is a problem, this approach can be helpful. Load couplant into an inexpensive large syringe available from chemical supply catalogues or many plant chemical labs. Using a syringe allows couplant application to measurement locations before transducer placement. In addition to ensuring transducer coupling, if couplant of a contrasting color is used, e.g., light colored couplant gels on dark surfaces and dark couplants on light surfaces, predetermined thickness measurement locations are very distinct.

> Bill Perrin Fredericton, New Brunswick Canada

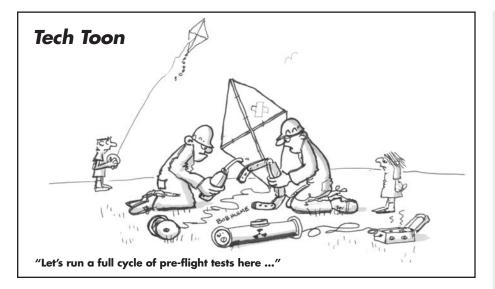
D-Meter Resolution with Analog Display

If you need to measure wall thickness to 0.1 mm on a thick-walled specimen and have only an analog ultrasonic set, you can still measure with that degree of accuracy using this set. Calibrate the timebase to 10 mm using a calibrated step wedge, then simply delay off the backwall echoes - not forgetting to count them as you wind them off. This way the timebase progresses 0-10 mm, 10-20 mm, 20-30 mm, etc. and each subdivision represents 0.2 mm. Now read the timebase as if it's 0-10 mm, e.g., 4.6 mm. Interpolation between gives 0.1 mm, making 4.7 mm, add on the thickness that you have delayed off, 20 mm. Now you are ready to give that measurement as 24.7 mm.

> John M. Armstrong Dorset, England

Couplant Degradation in Summer Heat

We use dry powder ultrasonic couplants and recently have experienced some problems during the summer heat. If all mixed couplant is continued next page



differences between thin materials and laminar indications and will often provide conflicting numbers on the screen requiring the operator to decide which number to choose. Many refineries will not permit the use of this equipment for critical thickness measurements. Instruments are now available with an oscilloscope or A-scan waveform display in addition to the digital thickness readout (see Fig. 1). Digital thickness gages with this display can provide accurate and consistent thickness measurements in the hands of a properly trained operator. To be competent, the operator should be aware of potential sources of error and be able to

interpret the waveform display to avoid those that reliance on a digital thickness reading alone might have allowed. Potential sources of error include:

- misalignment of the cross talk barrier of dual beam transducers on curved surfaces,
- · nonparallel surfaces,
- · coated surfaces
- · laminar indications
- rough surfaces (both contact and reflecting),
- attenuative materials (such as cast iron),
- · measurements doubling on thin materials,
- velocity change due to high temperature or difference in materials.

When encountered, a closer examination of continued on p 3

continued from page 1

not used, our inspectors save the leftover mixed couplant for use on the next job. In summer heat, mixed couplant sometimes loses consistency and reverts to a watery state. After investigation, it was discovered that simple emulsifier might aid in correcting this problem.

We mixed a fresh batch of dry powder couplant and placed equal amounts of couplant into identical bottles. To one of the bottles, we added a small amount of lipophilic emulsifier, just enough to change color of the couplant to a very light pink. The other bottle was left as plain couplant. Both were placed in the trunk of a car for about ten days. At the end of the trial period, the emulsified couplant was still gelatinous while the untreated couplant had reverted to a liquid state. The emulsifier worked. In addition, we have not experienced any sound transmission problems, nor any reaction with materials under test.

If you have experienced this problem, try adding a small amount of lipophilic emulsifier to your couplant. Certain codes or specifications may not allow this mixture of couplant and emulsifier, but for general testing applications it works for us.

Richard L. Tiefenauer St. Louis, Missouri

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FROM THE EDITOR:

The TNT Reader Survey conducted in July 2002 provided plenty of ideas for TNT content. Top of the request list was ultrasonic testing — developing technology, high temperature applications, use in refineries and pulp mills. Ultrasonic Thickness Testing in Refineries and Pulp Mills in this issue was built in direct response to reader requests. Our contributors share their considerable experience in both industries.

Be sure to read the FYI article on *Ultrasonic Phased Array*. Phased array technology has been around for about twenty years but was expensive to implement and use was restricted to labs and medical applications. Technical innovations in the intervening years have made ultrasonic phased array systems a real growth sector and, increasingly, a viable alternative to conventional UT. Technicians aware of the potential and that want to learn more are encouraged to search the Web. Many phased array manufacturers have informative Web sites with animated line drawings and simple tutorials.

From time to time, we get letters from readers whose opinions differ from our content. Visit the *TNT* Web page for reader correspondence and the replies in full.

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We're not done with ultrasonic testing. Watch for angle beam ultrasound in the July issue.

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

Figure 1. Ultrasonic thickness testing instrument with oscilloscope display and digital thickness readout.



these errors should be made with a flaw detector. A flaw detector provides better penetration, more efficient scanning, high temperature measurement capabilities, flexibility with a variety of transducers and better screen update capability.

Transducers, the workhorse of the UT thickness system, have also been improved over the last twenty years. Selecting the proper transducer enables a trained operator to obtain thickness measurements on pitted and coated materials at ambient or high temperature with an accuracy of \pm 0.005 in. (0.127 mm). The *dual beam* transducer is most often used for determination of thicknesses in the range of 0.05-1.5 in. (1.27-38.1 mm). It enables thickness determination in thin wall materials, detection of pitting, localized wall loss, laminar indications, wet hydrogen sulfide ($\rm H_2S$) damage and scanning to plot damaged areas.

Single beam transducers are used for thicker materials, thickness determination using a standoff delay and for coarse grain materials. Most transducers are in the range of 0.25-0.5 in. (6.35-12.7 mm) diameter with frequencies between 2.25 to 5.0 MHz. A field calibration is conducted on reference blocks of the same material as the test material. Blocks are usually stepped in increments of 0.1 in. (2.54 mm) and should provide the operator with thicknesses greater and less than the test material thickness. High temperature thickness measurements require transducers and couplant capable of withstanding the temperature of the test material and a method of compensating for the errors in thickness caused by the increase in temperature.

Certification and Training. The varied instrumentation used in ultrasonic digital thickness measurement places added emphasis on training and certification requirements for operator competency. Most petrochemical plants and contractors that provide thickness measurements, base their training, experience and certification on the ASNT document, *Recommended Practice No. SNT-TC-1A*. This document requires that a company develop a written practice to document personnel training and certification. This gives considerable latitude as to the number of hours of training and the amount of experience a company can require before certifying a technician to conduct thickness measurement. Unless the technician is thoroughly familiar with the physics of sound beam propagation and reflection, misinterpretation will lead to inaccurate measurements or even the inability to detect potentially disastrous conditions. Technicians should be able to distinguish echo characteristics that indicate:

- · pitting,
- · laminar indications,
- · loss of signal,

- · reduction in signal amplitude,
- · potential damage from wet hydrogen sulfide service,
- · high temperature hydrogen damage.

In addition, technicians should be able to obtain accurate measurements:

- at temperatures up to 900 °F (482 °C),
- · through paint coatings and on rough and corroded surfaces, and
- · when scanning surfaces to delineate corroded and pitted areas.

The suggested minimum requirement should be the equivalent of the recommended hours for UT Level I. This includes 40 hours of structured classroom training covering theory of compression, beam propagation and reflection, and specific laboratory drills that simulate conditions encountered during actual field testing. Good samples of pitted and coated materials, materials with laminations and inclusions, thin materials and materials with nonparallel surfaces are essential to an adequate thickness measurement class. Training programs in the form of interactive software, accompanied by samples of actual problems, can also be used by individuals or incorporated into a class.

Field Experience. *SNT-TC-1A* recommends three months of field experience prior to certification as a Level I. This experience can be gained working as an assistant to a competent technician and will allow the trainee to become familiar with equipment and field conditions prior to taking a class. However, even after becoming certified, technicians should undergo a period of strict oversight. Most major oil companies now require that technicians engaged in the process of obtaining pipe

continued on p 4

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and vessel wall thickness measurements demonstrate satisfactory skills on test pieces with known areas of corrosion or erosion, with and without coatings and at ambient and high temperature.

Employer based certification based upon SNT-TC-1A implies that employers will follow their written practice using good faith and integrity. Refineries using contract personnel should audit the contractor certification program for satisfactory practice.

Technicians should be given strong support from management and supervisors and should feel comfortable asking for spot checks from more experienced individuals. Structured protocol should be used for dealing with measurements inconsistent with specified original wall thickness, previous measurements in the same location or other measured thicknesses on the same test item. Protocol should require:

- · drawings be rechecked to determine design thickness,
- · replacement history of equipment be checked,
- calibration of equipment be rechecked,
- the number of measurement locations be increased,
- · comparison of local measurements with other locations on test item,
- · measurements be rechecked using a flaw detector,
- a spot check or second opinion from a qualified technician and
- information from these items be included with the test report.

With the use of computer software, measurements should never reach the point of input without conducting the above protocol.

Documentation. Most data obtained, such as thickness measurements from designated TMLs, are input into a computer program. Data is downloaded directly from the ultrasonic thickness instrument into the computer program. This technology is currently limited to digital thickness gages. Measurements taken in areas requiring a one hundred percent scan or in areas where the measurements are taken in a grid cannot be downloaded and should be reported in a manner similar to an ultrasonic flaw detection report. Reports should include the test location, equipment used, calibration periods and technician identification.

The process of obtaining accurate thickness measurements in refineries is not simple. Technicians conducting this type of inspection must be well trained and experienced. They must also feel empowered and valuable and operate as an "inspector" and not just a gatherer of data.

Digital Thickness Gaging in Pulp Mills

The paper industry uses many chemicals including chlorine dioxide, caustic soda, black liquor and a variety of acids in the processing of pulp, production of steam, bleaching and other activities required to provide paper as a product. Systems used to store and transport these chemicals are subject to internal erosion and corrosion, corrosion under insulation (CUI), galvanic corrosion and many other mechanisms detrimental to service life. A program of visual inspection and ultrasonic thickness surveys on these systems is invaluable in preventing catastrophic failure that could result in injuries, environmental hazards or even fatalities. These inspections are also an important tool in preventive maintenance. Timely and efficient replacement of components reaching the end of useful service life is economically critical to a successful operation.

Inspection Policy. The paper industry uses ultrasonic thickness inspections on equipment such as piping, tanks, pressure vessels, boilers, paper machine dryer cans (large diameter hollow cylinders heated from within), yankee dryers used in coating processes after the paper is made, batch and continuous digesters and bark and wood delivery systems. Most companies have an inspection policy for these systems that is written to comply with codes associated with the construction and maintenance of such components. These codes give the frequency and extent of inspections and can be of use in many areas of inspection. A typical example would include the selection of thickness measurement locations or TMLs for a piping system. Method specifications for ultrasonic testing procedures are required and, though there are many codes, the specifications are usually written to comply with codes such as



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Be the Big Dog

ASTM and the ASME Boiler and Pressure Vessel Code, Section V – Nondestructive Evaluation. In addition to these, most qualification requirements of governing codes, such as the ASME Boiler and Pressure Vessel Code, Section IX – Welding and Brazing Qualifications, refer to SNT-TC-1A for personnel certification.

Analog to Digital. Thickness testing has evolved from analog flaw detector type devices requiring interpretation of a CRT scope and a time versus amplitude A-scan display to modern digital presentation devices. Digital instruments have many advantages such as reduced size that increases portability, greater accuracy (to 5×10^{-3} in.), speed of inspection and the ability to capture or log data digitally.

In performing thickness testing, technician responsibilities are twofold. The technician collects data on component thickness and visually surveys the entire system as well. Without visual inspection, a technician may collect requested data and miss an obvious trouble area. All suspect areas should be investigated. These include bulges in insulation that could indicate corrosion under insulation, failed insulation or coatings, pipe hanger clamp abrasion and piping resting on concrete or other pads. Learning as much about the system as possible increases efficiency and improves accuracy. The following questions are examples of information that should be obtained in advance of testing.

- What is the original nominal thickness of components?
- Is the system in service during inspection?
- What is the temperature of the component during inspection?
- Is high temperature couplant needed?
- Is the system insulated?

Calibrating Test Equipment. Proper calibration of equipment is most important and should be rechecked periodically during the inspection process. Calibration blocks should be of like material or within the same P number as the component. P number refers to the material class. All metals within the same P number grouping are considered similar metallurgically. When testing piping with a diameter less than 20 in. (50.8 cm), a curved calibration block must be used. Refer to the written procedure or referenced code for the given inspection to determine actual sizes required. Temperature can also effect results. Readings can vary on the high side as much as one percent for every 100 F° (56 C°) difference between the test standard and the hot specimen. When testing a hot component, place the calibration standard on the test piece and allow the temperature to normalize before calibration. Temperature differences between block and specimen should not vary more than 25 F° (14 C°). Thickness Measurement Locations. Several factors should be considered when determining the number and placement of TMLs. Piping circuits that:

- · carry hazardous materials,
- · are more complex (with branch connections and dead legs) or
- · with a history of high corrosion

require a greater number of TMLs placed with greater frequency. It is also important to locate TMLs before and after dead legs and branch connections since turbulence and change of flow at these points increase the potential for erosion (see Fig. 2). Fewer TMLs spaced at longer intervals are needed for relatively straight runs of piping or on circuits that are less corrosive in nature. Readings should be taken in four quadrants at each TML. Areas of scale or rough surfaces should be prepared by buffing or flapper wheel to improve measurement accuracy.

Succeeding thickness surveys must be placed in the exactly the same location each time measurements are taken. This is critical for accurate corrosion rate studies. If piping is insulated, drilling out the inspection plug will ensure exact positioning and increase accuracy with the added potential of being more cost effective than removing the insulating material. Various types of inspection plugs are available (see Figure 3). Accurate mapping with measured locations and the orientation of the

Figure 2. Thickness measurement locations at points of increased flow and turbulence in piping connections: (a) before and after branching and (b) *T* connection.

(a)





survey at each TML should be provided with the report data. This information is essential for projecting accurate trends.

Digester Piping. Digester blow piping is exposed to an extremely abrasive and corrosive environment. It is important to pay close attention to inner and outer bends of sweeps and elbows when testing these piping systems. They are more susceptible to thinning than, for example, the top side of a straight run of pipe. Careful attention should also be given to flanged connections and junctions of separate lines into common headers. This piping is normally quite thick, usually greater than 3/4 in. (1.9 cm). Before the development of ultrasonic thickness testing technology, it was common practice to drill holes half-wall deep in sweeps or elbows. When leaks were observed, the piping was scheduled for replacement. Properly scheduled UT thickness testing determines the corrosion rate trends used to predict the retirement of piping sections. Acid and Caustic Piping. Most acid piping is composed of stainless steel, alloy 20, duplex or other corrosion resistant steels. These should be inspected using the same methods previously discussed. However, couplant used with these materials should not contain more than 250 ppm of chloride or fluorides. These can initiate corrosion in some stainless materials.

Liquor Tanks. The spent chemical from the digesting process used to break down wood fiber in pulp production is called *black liquor* and is used as fuel in black liquor recovery boilers. Heat generated in recovery boilers is used in paper machine dryer cans and associated equipment and also in the production of steam for power. Many older bulk tanks used to store black liquor are built from carbon steel. Corrosion and pitting can be a problem specifically in the vapor space or tidal areas of

continued on p 6

Figure 3. Drilled inspection plug ensures exact positioning and increases accuracy and efficiency.



the tank. Thickness testing is a valuable tool in their maintenance. Readings are normally taken at the eight major and minor compass points of the shell courses but areas commonly subject to corrosion should have a small grid layout and be specifically inspected. Thickness locations must be located accurately and pit gaging of suspect areas should also be performed if corrosion is present. Subtracting the pit depth from the digital thickness reading will be required to determine minimum thickness for remaining life calculations on the shell course.

It is best to use specialized magnetic flux leakage floor scanning equipment for inspecting the tank floor. This equipment can detect corrosion caused by water egress under the floor. In the absence of such equipment, digital thickness should be performed on all shell plates in a grid pattern to give an adequate representation of their condition. Black Liquor Recovery Boilers. Black liquor recovery boilers use black liquor as fuel in the generation of steam. During this process, black liquor that is initially 72 percent solids becomes smelt, a molten liquified material that runs down side walls and across a slanted floor (or smelt run) and then through smelt spouts that discharge into a dissolving tank. Water introduced to molten smelt can cause violent explosions, resulting in severe damage and potential fatalities. For this reason, thickness surveys and trending in these structures are particularly important. A thorough inspection of the water wall and floor tubes in the lower furnace should be done on an annual basis to determine the replacement schedule for components as they reach code minimum thickness. In this critical boiler, it is not uncommon for a mill to specify a minimum thickness for tube replacement that is 20 percent greater

Do you have a topic of interest to NDT practitioners and can you use recertification points?

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than the code requirement. Digital thickness testing is used throughout the remainder of the furnace, superheater, generating bank and areas susceptible to sootblower erosion.

Smelt is dissolved by a chemical known as *green liquor* in the smelt dissolving tank. The flow of fluids in this tank is extremely turbulent. It is important that a check for erosion be made in areas around the agitators normally found in the four corners of the tank. Smelt scours the metal near these nozzles and failures caused by internal erosion are not uncommon. All the processes described thus far are also used on fossil fuel and bark burning recovery boilers.

Paper Machine Dryers. Dryer cans are normally inspected one section per year on a five-year cycle. As an example, a machine with five sections would require a five-year cycle. A minimum of two scans 180 degrees from each other across the face of the dryer should be performed on those cans that can be internally inspected. Four compass points should be done if internal inspection is not possible. This can be done digitally on a grid pattern but is normally performed using a bubbler system and crawler to do a linear scan across the face of the dryer.

Bark and Chip Handling Equipment. Debarking drums and slasher decks in woodyards are subject to an abrasive atmosphere. Ultrasonic thickness testing is used on this equipment to determine replacement schedules or weld metal restoration of cladding.

Conclusion. Accurate and legible reporting is of utmost importance if data is to be practically applied. Computer generated trending software can be extremely useful but simple concise reporting is all that is really needed. As an inspector, it is important to note that it is attention to detail and inspections performed with an overall view in addition to data collection that ensures a successful operation.

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FYI: Ultrasonic Phased Array

Advances in electronics miniaturization, computer processing capabilities and fabrication methods for ultrasonic transducers have reduced the cost of implementing ultrasonic phased array inspection systems. Though still expensive relative to conventional UT equipment, both manual and automated inspections using phased array are finding greater application in industry.

Advantages of Dividing Large into Small

Large conventional ultrasonic probes give good flat coverage but have a small beam angle. Small elements have a much larger beam divergence angle. It is this large angle that makes possible the most useful features of the phased array technique—beam steering and dynamic focusing. In its simplest form, an array is a single large transducer (piezoelectric material) cut into very small segments or elements. It takes less energy to excite the smaller mass of these tiny elements. As a result, they transfer and receive energy with much greater efficiency. Typically, element sizes range from 0.02 – 0.1 in. (0.5 - 2.54 mm) although arrays can have custom element sizes and can be arranged in custom configurations with the particular geometry developed to meet an ultrasonic application need. Linear, annular (circular elements divided into doughnut-shaped elements) and matrix arrays are basic configurations.

Virtual Transducer

The basic premise for all phased array transducers is that the small, individual elements are independently driven. Computer software defines which elements are activated. They may be pulsed in groups to simulate conventional transducer excitation or individually. The elements selected at any point in a sequence are a small fraction of the total number within an array. Selection of the elements to be activated, the delay sequence for firing, element amplitudes and delays in reception are all programmed into operating software. In effect, the computer creates a virtual transducer. Electronically controlling the time at which each individual element in the virtual transducer is activated varies the sound field characteristics resulting in a range of different focal points and beam refraction angles.

Beam Steering and Dynamic Focusing. Beam steering is the ability to dynamically synthesize an ultrasonic beam of any angle within the overall beam spread of an individual element by sequentially firing each element in an array to create a wave front following the desired angle. Selecting the array firing order and pulse delays can also be used to dynamically focus an ultrasonic beam. Both beam steering and dynamic focusing can be changed on a pulse by pulse basis to effectively sweep through test material. They may also be combined to give a resultant beam both focused and angled. Additionally, excitation and receiver gain settings for each of the sets of elements can be controlled allowing amplitude density profiles in the integrated sound beam to be adjusted. This electromechanical process is call beam forming.

Electronic Positioning. Since practically all aspects of the sound beam are being controlled electronically, many iterations, or sequences of iterations, can be run in nearly real-time. This allows a single array to inspect a component with variable inspection angles and focusing depths almost simultaneously. For instance, depending on the array design and the component thickness, a one-dimensional linear array, with the major axis oriented normal to a pipe weld, may interrogate close to an entire planar cross-section of the weld by sweeping through a series of inspection angles without having to mechanically index the

transducer. Theoretically, an entire pipe weld can then be examined with a single circumferential scan motion. By electronically moving the virtual transducer across the entire physical array, the sequential electronic positioning of the virtual transducer creates the same physical scanning motion that would be achieved by mechanically positioning a traditional transducer over the same physical distance equal to the total length of the array. The electronic scanning motion of automated inspection with phased array replaces mechanical motion, reducing wear and operating costs and increasing system reliability. **Conclusion.** Initial costs for the electronics and software development required to operate phased array systems are more expensive than conventional ultrasonic counterparts. Also, array probes are much more expensive than standard ultrasonic transducers and each is generally designed for only a few applications at best. As more applications become commonplace, it is expected that demand for phased array systems and certain array probes will rise and manufacturers will produce these as off-the-shelf items. Use of phased array systems is expected to increase, simply to minimize inspection times or to address complex geometries and material conditions not being adequately inspected with conventional methods.n

Adapted from texts contributed by Michael T. Anderson of Pacific Northwest National Labs and Terry Banach of Agfa NDT, Krautkramer Testing Machines.

Editor's note: Interested technicians are encouraged to browse the Internet for more information. Many phased array equipment manufacturers have Web sites with informative text, animated drawings and tutorials regarding phased array.



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TNT Practitioner Profile: Brian Murray



Brian Murray grew up in Thunder Bay, Ontario on the edge of Lake Superior and spent much of his free time as a youth exploring wrecked ships on the lake bottom in that area. His love of diving has developed into an NDT career

that gives him the opportunity to work on interesting and challenging projects around the globe.

How did you first become involved in NDT?

I attended the College of Oceaneering and became aware of NDT taught there, although I didn't take that class. I had been diving commercially for about four years at that point. Later I took ultrasonics, mag particle, liquid penetrant and radiography classes at Hellier Associates to expand my job horizons.

Was this sponsored by your employer?

Actually I paid for it on my own. I got a job with an NDT company for a while to get the qualifying hours. I was doing ultrasonic, liquid penetrant and mag particle in refineries in addition to commercial diving.

How did you become interested in diving?

I grew up in Thunder Bay Ontario, and as a teenager, did a lot of diving in Lake Superior in the shipwrecks there. The lake also has a lot of places where there were old ports — docks. We figured out where those were and we'd dive in those areas to find old bottles and plates and such to sell for extra beer money.

What kind of diving gear do you use?

For commercial work, it's almost exclusively surface supply diving equipment—various full helmet models with two—way communication. You have to be able to speak and be in communication with crew topside.

Are age and physical ability factors in diving?

You're required to pass a physical yearly and I would say you have to be in better than average physical condition. As for age, a guy that works in our company in Alaska is in his seventies. He's really experienced and keeps in pretty good condition.

Is there a strict safety regimen in diving?

We follow federal guidelines and there's another group — ADC (Association of Diving Contractors) that puts out a recommended practice. Also, we're in the pile drivers union and

they have a set of guidelines that we have to follow to be compliant.

Where have you traveled in your work?

Africa, Asia, the Arctic — Hudson Bay area, Hawaii. Alaska in the oilfields, Prudhoe Bay doing underwater welding and mag particle on an ice resistant bridge.

Temperature must be a factor in those dives.

It is. Up there we normally bring a hot water setup and wear hot water suits over the top of a wet suit or surf suit. Basically, a hot water heater on the boat pumps hot water down through veins in the suit.

What NDT methods are used underwater?

Underwater mag particle would be the more common thing to be used and ultrasonics with thickness and shear wave. We've used eddy current underwater and you can actually use radiography too.

How are they adapted for underwater use?

Underwater mag particle uses a direct current yoke and a special iron filing solution mixed with fresh water to make a pink iron particle bath. A fluorescent light is used as well. Results are limited by water visibility. UT thickness readings can be done two ways; the digital D meter you can take with you to do spot readings but that's limited. Or, we use a flaw detector topside with a long coaxial cable with two technicians — one below to manipulate the probe and one topside to watch a scope.

What kind of structures do you examine?

Well, bridges and for offshore petroleum, flooded member detection of jacket legs on the rigs. We clear marine growth and then visually inspect for physical damage. In suspect areas, depending on what you're looking for, we follow through with another method. Fractures are confirmed with underwater mag particle. Flooded member detection of jacket legs uses a UT method that can tell if there's water at a given point. You scan down until you get a sound path through to the other side of the jacket leg. If there's water in there, you're able to read both surfaces. If there isn't, you're only able to read one wall thickness.

Do you perform NDT only underwater? No, if you can do NDT underwater, you can pretty much do it anywhere.

Describe the underwater environment for us.

It depends on the region you are working in. On the nicer end of things, if you are working in

the Caribbean, West Africa, here in California or in Hawaii, the water is a lot warmer — and clear. In Alaska, visibility can be zero and the water extremely cold. We do a lot of harbor work and visibility is limited to maybe ten feet.

What depths do you generally work in?

It varies project to project. For ships husbandry work, which encompasses NDT, depths wouldn't exceed 60 or 70 feet for an oil tanker — up to three or four feet on a barge or shallow drafting vessel.

What types of certification do you have?

Divers have their own qualifying papers for diving. The NDT aspect, if you go by TC-1A guidelines, is still company certification. You have the training and qualifying hours in the NDT methods but your exams are with your company and that's pretty much the way it's set up right now. I am interested in the central certification process and very pleased to see you can transition into ACCP.

What plans do you have for additional training or certification?

That would be transitioning to the ACCP cert and then I'd like to prepare for Level IIIs. What's the worst part of your work in NDT?

You do a lot of data collection. It can be pretty tedious. You have to be detailed minded. The reporting and accurate data collection are the least attractive aspects of it but you have to do it. It's just part of the job.

What's the best part of your work in NDT? The travel, definitely.

What do you consider NDT growth areas?

Growth areas would depend on the industry but I think the technology for ultrasonic phased array equipment is really going to expand, especially coupled with the computer.

How has ASNT membership benefitted you?

Access to publications and Section meetings. I'm able to talk to people in other industries that apply NDT. Some technology can roll over into other industries. In underwater, it's limited, but methods can be modified to fit new purposes.

What advice would you offer to someone.

What advice would you offer to someone considering a career in NDT?

Spend the time it takes to develop various skills. I was a diver for four years before I took any NDT training and I did NDT in addition to diving for a few more years to get a strong foundation. Underwater welding and rigging have worked out well for me.n

TNT Inbox:

Q: The density of film processed through our auto processor is changing slowly and I'm not sure why. The processor seems to be working properly. A: Check the replenishment rate. If the change in density has been gradual, you may be over or under replenishing. Some common causes could be a detector switch malfunction or adjustment; pump setting, malfunction or accuracy. Filters or lines could be clogged.

Q: My company is discussing changing to thermoluminescent dosimeters. What are these and how do they work?

A: Thermoluminescence is the emission of light from an irradiated material after gentle heating. After heating, the amount of light emitted is correlated

to the amount of ionizing radiation that was absorbed in the material. Lithium fluoride is the most common material used in gamma and neutron personnel dosimeters. Advantages of thermoluminescent dosimeters (TLDs) include linear dose response, reusability, stability, short readout time and near tissue-equivalence. Disadvantages include loss of information after readout and lack of information about incident radiation that film badges can provide.

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