



### Focus

## Fluorescent Penetrant Inspection of Drum Rotors, Deep Well Spools and Other Components with Internal Cavities

by Lisa J.H. Brasche

With nearly 40,000 installed engines in the civil turbojet engine fleet in 1999<sup>1</sup> and similar numbers in military use, the jet aircraft engine plays a vital role in public transportation and in our nation's defense. Magnetic particle, eddy current, ultrasonic and radiographic testing are among the methods commonly used in production and inservice inspection of engine materials and components. However, the method most widely used for engine components is *fluorescent penetrant inspection* (FPI). Over 90 percent of propulsion components are inspected with this method at least once in their lifetime. During the years from 1996 to 2000, the Federal Aviation Administration (FAA) issued nearly 200 airworthiness directives calling for the use of FPI. Additionally, several industry specifications exist providing guidance for FPI with Society of Automotive Engineers AMS 2647B, the standard put in place to address aerospace specific requirements.<sup>2</sup> For most critical rotating components, Type 1, Level 4 ultrahigh sensitivity penetrants are required, either Methods C (solvent removable) or D (post-emulsifiable, hydrophilic).

Most engine components are inspected with FPI as part of production qualification and will be inspected inservice for detection of service-induced cracking. Attention must be paid to each step in the process to ensure process performance.

#### Need for Best Practice Document

The size, weight, and shape of many engine components warrant special consideration and are the focus of a recent industry initiative to generate a best practices

document. Figure 1 shows a typical drum rotor and spray application of penetrant. Drum rotors are comprised of several disks or stages that are welded or bonded together. With weights in excess of 200 lb (91 kg), these components present many challenges for FPI including the need for special handling equipment. While the sling shown in Fig. 1 prevents metal-to-metal contact, precautions should be taken to ensure that contact points on the inner bore are not affected by the sling. This includes ensuring that penetrant is applied beneath the sling and is not smeared at the contact points. Similar precautions are needed at each step in the FPI process, particularly at the developer stage.



Figure 1. Surface of drum rotor is covered thoroughly and systematically during penetrant application. UV-A source is used to ensure all surfaces have been covered.

**Complexity of Internal Cavities.** Though the exposed external surface offers geometrical complexity similar to single stage disks, the interior is even more challenging with internal cavities with tight clearances and deep wells. In addition to making interior inspection surfaces hard to view, the complex internal cavities tend to trap fluids and are difficult to

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Indications or discontinuities sought in the aerospace industry are typically very small and because the components being inspected are so critical, their detection must be reliable. An industry committee under the aegis of the Federal Aviation Administration's *Center for Aviation Systems Reliability* was formed to generate a best practices document for the fluorescent penetrant inspection of components with hollow or concave interior spaces not readily accessible to that form of inspection. "Fluorescent Penetrant Inspection of Drum Rotors, Deep Well Spools and Other Components with Internal Cavities," details procedures that will be appended in the coming year to SAE International standard AMS 2647B, "Fluorescent Penetrant Inspection Aircraft and Engine Component Maintenance."



Our "Practitioner Profile" of Matt Mead gives us an insider's perspective of RT and PT as applied in high strength sheet metal design for aerospace.

Bill Briody has prepared another informative safety article. This time he provides sobering statistics for work-related eye injuries, as well as descriptions and appropriate applications of the personal protective equipment available to prevent those injuries.

Comments and suggestions are always appreciated. *TNT* wishes you a happy and prosperous new year.

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examine for dryness in preparation for the application of developer or for determining if sufficient developer has been applied. All of these things increase the difficulty of completing inspection processes within allotted times. Given the consequences of failure for these critical components, an industry committee with members from engine manufacturers, airlines, the FAA, and academia has worked to generate a best practice document that will incorporate the following process parameters as an appendix to AMS 2647 within the next year.

### Steps for Success

The first step in a successful FPI process is a clean, dry part with thoroughly clean internal rotor surfaces. A soft clean cloth can be used to wipe inspection surfaces to determine if the rotor has been cleaned appropriately. If the clean cloth wipe reveals the rotor is not sufficiently clean, the risk of contaminating the penetrant is increased significantly and recleaning using approved procedure is warranted.

**Applying Penetrant.** When properly cleaned, penetrant can be applied to the inspection surfaces of the rotor. Dipping the part into a penetrant tank and then manipulating it to allow for proper drainage is the preferred method of application. All inspection surfaces should be observed with a handheld *near ultraviolet* or *ultraviolet-A* (UV-A) lamp to ensure sufficient coverage of the penetrant. A fixture that allows easy rotation and manipulation of the component during all stages of penetrant processing including penetrant application, rinsing, washing, and draining is recommended. Note that air pockets may exist inside the cavities and the part should be rotated to achieve full penetrant coverage of all interior surfaces. There should be no metal-to-metal contact between component and fixtures and the fixture should not smear or otherwise contaminate critical areas.

**Compatibility of Materials.** Fixture materials must be compatible with fluorescent penetrant system materials that would cause contamination of the part being processed. Fixture materials that break down in penetrant materials also cause contamination of penetrant materials and can impede the ability of the penetrant system to detect defects. Figure 2 shows a fixture that meets these recommended criteria. Depending on fixture design, portions of the part may need to be processed more than once to effectively inspect all critical areas. Care must be taken in instances where inner bore surfaces are in contact with the fixture just as indicated in the description with Fig. 1.

## Tech Toon



**Extending Penetrant Dwell Time.** In earlier work performed as part of the FAA funded FPI research program at Iowa State University, it was shown that extending penetrant dwell time led to brighter indications, particularly for small, tight cracks in shot peened surfaces. As a result of this work, a minimum penetrant dwell time of 30 min. to a maximum of 2 h is recommended.

**Prewash.** Upon completion of penetrant dwell time, a prewash is used to remove all excess penetrant from the component. Using a vacuum or siphon system to remove excess penetrant from the component's internal cavities before prewash is extremely helpful and minimizes contamination of the prewash tanks. The least possible time should be used to remove excess penetrant, not exceeding 90s in any one area. Excess water should be suctioned or siphoned from the internal cavities prior to the emulsification step.

**Emulsification is Critical Step.** Emulsification as shown in Fig. 3 is a critical step in the process and attention to contact time is crucial. Complexity of geometry can lead to challenges in the emulsification step. Emulsifier should be applied uniformly across the entire rotor for a consistent amount of time with a preference for dipping the part as opposed to spray applications. Emulsifier contact time is defined as the time beginning with the first contact of emulsifier with the part until the part is completely submerged and rotated over 360 degrees in the stop bath. It is important to ensure 100 percent coverage with special attention to areas between the disks where air pockets are likely to exist. A fixture that allows 360 degree rotation within the dip tank can be extremely helpful to ensure full coverage of all surfaces in the recommended time. Typical maximum contact time for emulsification is 2 min. If time permits, suction or siphoning can be used to remove excess emulsifier but only if their use does not endanger adherence to contact time limits.

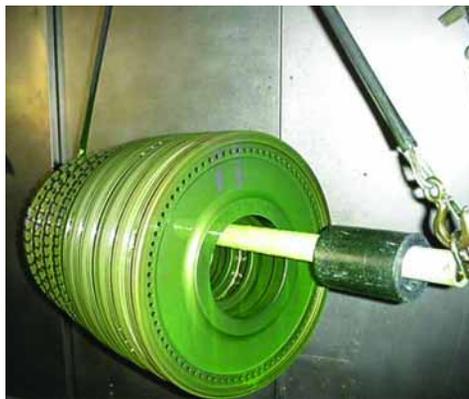


Figure 2. Fixture preventing metal-to-metal contact allows 360 degree rotation throughout inspection process.

### Stop Bath Controls Emulsifier Contact Time.

A stop bath is recommended for the post wash step and is the best method to control emulsifier contact time. The stop bath should be of sufficient dimensions to allow complete immersion of the part. The part should be rotated in the stop bath immediately upon immersion to ensure full contact of the stop bath water with all part surfaces including cavities where air is likely to be entrapped. The stop bath should consist of water that has a maximum emulsifier content that is no greater than 0.25 percent. The use of a test tube containing 0.25 percent emulsifier can be used as a color comparator to the stop bath, thus providing an indication when the bath should be changed. If a water spray is used to stop emulsifier action and remove emulsifier, the pressure and distance parameters specified in the facility's approved fluorescent penetrant inspection documents should be followed. If the distance requirement is not achievable, the pressure should be reduced to achieve equivalent fluid velocity at the surface.

**Drying Parts in Preparation for Developer.** Suctioning or siphoning of excess water is recommended for internal cavities and blotting of excess water is acceptable where puddling occurs with care taken to ensure that smearing of potential indications does not occur.

As with other parts, drying temperature should not exceed 160 °F (71 °C) and drying time should be kept to a minimum. Prior to developer application, it should be verified that all internal cavities are dry.

**Application of Dry Developer.** Dry developer should be applied using a manual wand or a bulb if a wand is not available. Typical dust cloud chambers do not provide adequate coverage of all interior surfaces. The inspector should take care to move the wand so that all interior surfaces receive a coat of developer.



Figure 3. Sling used to transfer component from emulsifier bath to stop bath allows free rotation of part. Rotor can also be turned on drum rotor to allow for free rotation of part.

Using a mirror or borescope can be helpful in assessing application. Parts should not be exposed to UV-A radiation while developing as this may lead to UV-A fading<sup>3</sup>. Minimum developer dwell time is 10 min. and should not exceed 2 h prior to start of the inspection. Total development time including inspection time should not exceed 4 h.

### Guidelines for Inspection

The complexity of these components requires use of a viewing system and controlled scanning that adhere to the following guidelines:

1. The part should be mounted on a fixture for inspection that allows the part and/or the viewing system to be freely rotated in both circumferential directions, while allowing the viewing system to remain stable and focused (Figs. 4a and b). The inspector should have a documented method for ensuring full coverage of areas being inspected with overlap between scan indexes.
2. The viewing system must include sources of both visible and ultraviolet radiation. The viewing system should also include image capture capability to document indications found during the inspection process (Figs. 5a and b).
3. If so equipped, all light guides, control, or other cables as well as end optics or

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Figure 4. Sets of fixtures conform to varied geometry of parts: (a) fixture used to inspect drum rotor; (b) fixtures loaded on single cart facilitate portability.

Focus continued from page 3.

camera assembly must be secured appropriately to avoid any hindrances during inspection. It is also important to note clearance limitations so that the viewing system is capable of accessing the internal cavity with ease while maintaining a controlled viewing distance to the inspection area.

- The viewing system should be fixed at a distance that ensures the required minimum resolution and illumination required throughout the inspection area. Length and the geometry of the system must allow viewing optics to be positioned in close proximity to the *region of inspection*. Control of the viewing system must be provided to maintain the maximum viewing distance as well as to provide measurable scan indexing to satisfy resolution requirements. An acceptable resolution test can be conducted using the USAF-1951 *Resolution Test Chart*. As shown in Fig. 6, the target elements consist of pairs of horizontal and vertical patterned lines contained within groups of varying size. In meeting the performance specification for resolution, not only must the specified element be observed, but it must also be resolved with a vivid distinction between the patterns.

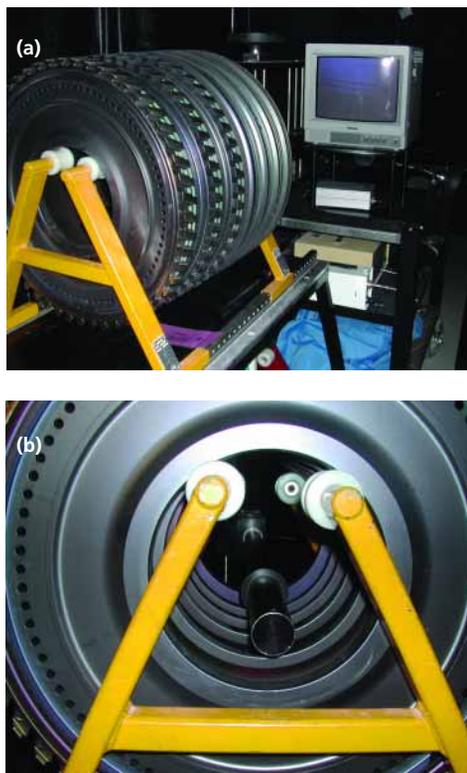


Figure 5. Drum rotor mounted on inspection fixture: (a) viewing system shown in background; (b) view through center of drum rotor showing viewing system inserted.

- The resolution target should be selected to reflect performance requirements for inspection of the component. Typical targets for drum rotors are Group 1, Element 5 as shown in Fig. 6. Once the perpendicular distance to obtain the desired resolution of the target is determined, this viewing distance should be recorded and care taken not to exceed this distance during the inspection. This is known as the *maximum standoff distance*. A 10 percent overlap between successive scan indexes is also recommended to ensure proper coverage (Fig. 7c).
- The angle of view should also be controlled during the inspection process. In order to determine the *angle of field*, or *viewing angle*, a test article with a fluorescing indication representative in width and color of a fatigue crack of the desired size, is required. The USAF 1951 *Resolution Test Chart* may be used for this purpose, though an actual fatigue crack in a flat plate is preferred. The viewing system should be configured as it will be during the drum rotor inspection application, including the angle between the end optics and the inspection surface. The test article is placed in a dark location with the viewing system and the UV-A lamp powered on. The end optics are moved closer and further away from the test article until the indication is readily visible, in focus, and in the geometric center of the field of view. The resultant vertical off-set distance must not exceed the maximum viewing distance determined in the previous step (should be the same, but may be less). This distance

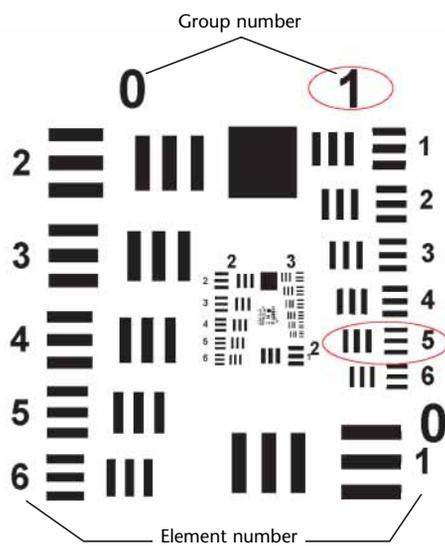


Figure 6. The 1951 USAF Resolution Test Chart, conforming to MIL-STD-150A, is a resolution standard used to assess resolving power of optical imaging systems.

- should not be exceeded during the inspection and is shown as  $H_1$  in Fig. 7a.
- To determine the maximum viewing angle, laterally move the test article from the center of the field of view to the extents of the field of view until the brightness and resolution of the indication is just acceptable. The distance moved from the center provides the radius of view as denoted by  $R_1$  as shown in Fig. 7a. The angle of field can be calculated by exercising the formula, while using the value of the vertical distance  $H_1$  and the radius of view  $R_1$ . Once this angle of field, denoted by  $\alpha$  is determined, the formula can be used to calculate new values of  $R$  to be used in controlling the maximum index for each inspection region (Fig. 7b). This will ensure that at no time during the inspection of the drum rotor will the maximum field of view be exceeded. The maximum viewing angle may not exceed 50 degrees, despite the results of the above test.

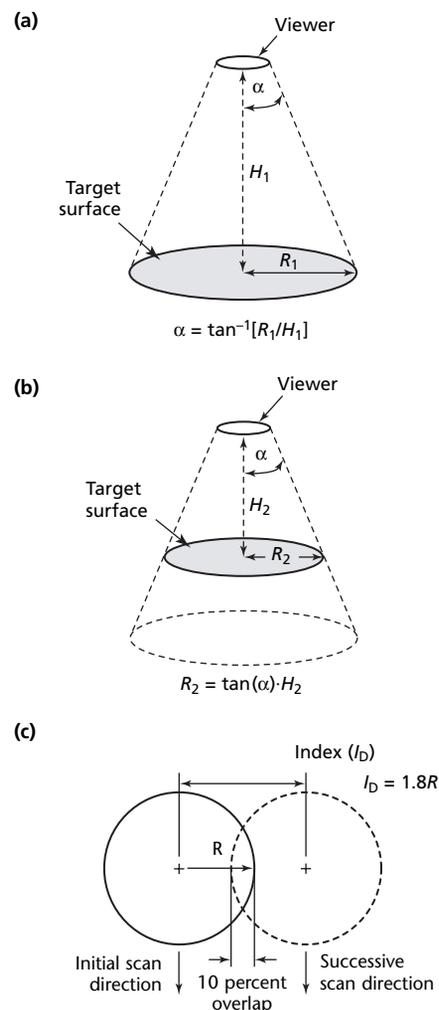


Figure 7. Definition of setup parameters for the viewing system.

8. Characterization of the source lamp output is also a necessary step and should be measured with the viewing system configured as in the actual inspection setup using the parameters defined in the preceding steps. A UV-A intensity of at least 2000  $\mu\text{W}/\text{cm}^2$  and a maximum intensity of 5000  $\mu\text{W}/\text{cm}^2$  is recommended. The maximum is set to reduce the potential of UV-A fading.<sup>4</sup> The visible or "white" light output should not exceed 2 fc (21.5 lx) within the effective field of view and at the distance *H*.
9. Questionable penetrant indications are to be evaluated in accordance with applicable fluorescent penetrant inspection procedures.

### Probability of Detection Study

The results of a 2006 *probability of detection* (POD) study were reported in which a mock-up simulating the complexities of drum rotor inspection was used.<sup>4</sup> The 90/95 POD point was found to double when comparing inspection inside the drum rotor using a controlled visual system to the 90/95 point for the same samples in bench top inspection. The use of a mirror increased the 90/95 point to unacceptable levels and is not recommended.

### Conclusion

The information presented in this article has been provided to aid the inspector in understanding the requirements for drum rotor inspection. However, as with all inspection processes, the inspector should follow the required practices of the cognizant engineering organization. Because of the important contributions FPI makes to engine safety, several research programs are underway with FAA funding. Results of these research efforts are comprehensively documented on the FAA *Center for Aviation Systems Reliability* (CASR) Web site, <<http://www.cnde.iastate.edu/faq-casr/fpi>>. There the "Engineering Assessment of Fluorescent Penetrant Inspection" provides extensive linking to the publications and technical results detailing the FPI research.

### Acknowledgements

This document summarizes recent efforts of an industry committee to generate best practices for drum rotor and deep well spools. The author is indebted to members of the committee for their efforts. Contributors

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# Feature

## Job Safety – Personal Protective Equipment for Eyes

by William W. Briody

Employers are required by the Occupational Safety and Health Administration (OSHA) of the US Department of Labor to provide employees with *personal protective equipment* (PPE) in those situations where engineering or administrative controls are not possible or are ineffective in providing workplace safety or health protection. Basic PPE includes devices or clothing designed to provide suitable levels of protection for the eyes, head, hands, feet and body in hazardous work environments. Each year, thousands of people suffer work-related eye injuries. All aspects of nondestructive testing begin and finish with visual inspection, and all NDT technicians and inspectors must take the necessary precautions to preserve their eyesight by understanding the correct forms of eye protection for their particular work environment and by properly applying that protection.

### Injury Statistics

In 2004, the Bureau of Labor Statistics of the US Department of Labor noted that approximately 1.3 million American workers were injured on the job and required recuperation away from work. Of that number, 36,680 were eye injuries, 80 percent of which were injuries incurred by men. More than 50 percent of eye injuries were reported by individuals between the ages of 25 and 44.<sup>1</sup> Beginning in 1993, the US

Department of Labor estimates that eye injuries have totaled more than \$300 million each year in lost production, medical expenses and worker compensation.<sup>2</sup> The medical profession has made a great deal of progress in treating, repairing and restoring eyes but many accidents result in some degree of permanent impairment and even blindness.

### Assessing Hazards

The five principal types of hazards to eyes as determined by OSHA are impact, heat, chemicals, dust and optical radiation. Table 1 lists examples of each type and related tasks in which they commonly occur. Many of the tasks listed are those performed when conducting quality control or nondestructive testing. Before assigning personal protective equipment to employees, employers must first assess the risk of exposure to eye and face hazards in the work environment and then be prepared to protect against the highest level of those hazards.

### Protection Levels — Good, Better, Best

Under OSHA regulations, all types of safety eyewear must be ANSI Z87 approved and must be marked designating them as such. Basic categories of eye protection include safety glasses or spectacles, goggles, face shields, welding shields and helmets and

respirators. Combinations such as glasses or goggles in conjunction with face shields should be used as necessary.

**Safety Glasses or Spectacles.** Much stronger and more impact-resistant than regular glasses, safety glasses or spectacles are the type of eye protection required as a minimum in any industrial operation. Safety glasses with side shields or in a style configured to wrap around the eyes are preferred. Safety glasses may be treated to prevent fogging. An eyewear strap or retainer should be used to maintain a snug fit. Hybrid versions of safety glasses, more closely related to goggles, with foam or rubber around the lenses are available and can provide protection from dust and flying particles better than that provided by conventional safety glasses with only side shielding. Wrap-around glasses that can be converted to goggles with soft seals may also offer better peripheral vision than conventional goggles.

**Goggles.** Designed to fit tightly to the face, goggles provide greater protection from fumes, powders, vapors and dust (particularly important when wearing contacts). When working in an environment with large particulates, goggles with direct venting can be used to prevent fogging. When working in environments where fine dust or when splashing is a concern, indirect venting must be used.

**Face shields.** In addition to high impact protection, shields offer full-face protection from splashing of liquids or flying particles. The curve of a face shield however, can direct any chemicals or particles entering at the side of the shield into the eyes. For that reason, safety glasses or goggles should always be worn under a face shield. Face shields can be coated or tinted for heat or splatter protection.

**Welding Shields/Helmets.** Of all occupational eye injury cases reported in 2004, the greatest number (2,240 injuries) were incurred by those employed in welding, cutting, soldering and brazing.<sup>1</sup>

## Assessing the Work Environment for Hazards to Eyes

Hazard type	Examples	Common related tasks
<b>Impact</b>	Flying objects such as large chips, fragments, particles, sand and dirt	Chipping, grinding, machining, masonry work, wood working, sawing, drilling, chiseling, powered fastening, riveting and sanding
<b>Heat</b>	Anything emitting extreme heat	Furnace operations, pouring, casting, hot dipping and welding
<b>Chemicals</b>	Splash, fumes, vapors and irritating mists	Acid and chemical handling, degreasing, plating and working with blood
<b>Dust</b>	Harmful dust	Wood working, buffing and general dusty conditions
<b>Optical radiation</b>	Radiant energy, glare and intense light	Welding, torch-cutting, brazing, soldering and laser work

Source: US Department of Labor, Occupational Safety & Health Administration "Eye and Face Protection eTool".  
<http://www.osha.gov/SLTC/etools/eyeandface/index.html>

Lacking sufficient protection during welding or cutting operations, a worker's eyes and the tissue surrounding the eye can be damaged by UV radiation burns or welder's flash. Welding shields and helmets incorporating special absorptive lenses to filter the intense light and radiant energy generated during these operations provide full face and eye protection. Welding shields and helmets must be worn by those individuals actually performing the welding operation and by helpers and any observers as well. The shields must also be worn in conjunction with goggles or safety glasses. Lenses used for welding light protection are rated from 1.5 to 14, with 14 as the darkest lens. All welding light protection lenses must be marked with their shade number.

**Respirators.** Available in full-face and half mask configurations, respirators provide the greatest degree of protection against such hazards as general dust, chemical and smoke, although they may not be compliant with ANSI Z87 requirements for impact protection. When wearing a half-face respirator, it is important that it does not interfere with the proper positioning of any protective eyewear.

## Summary

The Bureau of Labor Statistics reports that nearly 3 out of 5 eye injuries were sustained because workers were not wearing eye protection.<sup>2</sup> Here are the things you can do to prevent injury to your eyes.

- Be aware of potential eye hazards in your work environment by conducting an eye hazard assessment.
- Eliminate hazards before beginning your work. Implement machine guards, work screens or other equipment controls for those hazards that can't be removed.
- Use appropriate eye protection. Wear only certified industrial eye protection that is clearly marked with ANSI Z87.1 on frames and lenses.

Most workers should wear goggles but, at a minimum, wear safety glasses with side protection or hybrid configurations that provide the comfort of glasses, the protection factor of goggles and better breathability. A face shield affords greater protection when used over goggles or glasses. A full-face respirator provides the best general protection. When welding, make sure that you are using a helmet or

goggles with the correct lens shade and that others exposed to the dangerous light levels also have sufficient protection. Additional information to assist in the selection of PPE for the eyes and a list of frequently asked questions can be found by selecting the OSHA *Eye and Face Protection eTool* at <[www.osha.gov/SLTC/etools/eyeface](http://www.osha.gov/SLTC/etools/eyeface)>.

## References

1. Harris, Patrick M. "Nonfatal Occupational Injuries Involving the Eyes, 2004." Washington, DC: Bureau of Labor Statistics, US Department of Labor (August 2006).
2. "Eye Protection in the Workplace." Fact Sheet No. OSHA 93-03. Washington, DC: Occupational Safety and Health Administration, US Department of Labor (January, 1993).

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## INBOX

**Q: For Ultrasonic Testing, much of the work done to ASME, API and other similar codes and specifications is done using a 2.25 MHz transducer. What is the logic behind using this specific frequency as opposed to a 2 or 3 MHz transducer? P.K., Canada**

A: Most of the standards you have referenced do not specifically require a 2.25 MHz transducer but usually give a range of frequencies that can be used. The ASTM Standard E-164, *Standard Practice for Ultrasonic Contact Examination of Weldments*, states that frequencies in the range from 1.0-5.0 MHz are generally used but does not mandate a specific frequency within that range. Article 5 of Section V of the *2004 ASME Boiler & Pressure Vessel Code* requires a frequency in the same range, 1.0-5.0 MHz, but leaves the actual frequency up to the user. In the 2002 AWS D1.1 *Structural Welding Code — Steel*, paragraph 6.22.7.1 requires a frequency of 2.0-2.5 MHz, and also states that this applies

only to ferrous and aluminum materials with thicknesses of 5/16 in. (8 mm) or greater. When discussing this we need to keep in mind the relationship between codes, standards and NDT procedures. Codes and standards are generally written to be applied to a wide range of product forms and materials and as a result often give a range of values for certain requirements (as shown above). A company NDT procedure is written to address specific applications within the range of such standards so the Level III must take into account the specific requirements and limitations of the task in question. These include the differences in sound velocity and grain size in the material to be inspected and transducer penetration ability, resolution, wedge angle and near field length. Since 2.25 MHz transducers are widely available and fall near the midpoint of most required frequency ranges, it does seem to be the frequency of choice for many applications.

**Q: Eddy current testing is sometimes called electromagnetic testing. Is there a difference between the two terms? P.M., Columbus, Ohio**

A: The Electromagnetic Committee of ASNT's Technical and Education Council has officially recognized four electromagnetic test techniques for purposes of personnel qualification: eddy current testing, remote field testing, magnetic flux leakage testing, and alternating current field measurement. All four share the same physical principles but differ according to equipment and applications. Each of the four gets a chapter of its own in the *NDT Handbook*, third edition: Vol. 5, *Electromagnetic Testing*. The next edition of *ASNT Recommended Practice No. SNT-TC-1A* will make these four techniques official, and training aids for each may follow. Magnetic particle testing is also an electromagnetic technique but over time has established testing regimens and a body of knowledge all its own. Here too, the classification of methods is based on industry practices as much as on their science.

**E-mail, fax or phone questions for the Inbox to the Editor: <[hhumphries@asnt.org](mailto:hhumphries@asnt.org)>, phone (800) 222-2768 X206, fax (614) 274-6899 X206, fax (614) 274-6899. TNT**



# PRACTITIONER PROFILE

## Matthew Mead

*Matt Mead began his career building robotic applications. He now works for a company that does high strength sheet metal design and fabrication for aerospace. They use digital X-ray and penetrant testing to examine welds. In addition to work in NDT, he manages a flow lab that precisely measures airflow through the parts.*

### **Q: How did you start in NDT?**

A: I worked for many years building robots used for anything from deburring parts to robotic applications on the Delta 4 booster rockets. Exotic Metals called and asked if I could build some robotic applications for them. One of the first of those was for digital X-ray. In getting the robotic X-ray installed, I worked with the X-ray Level III a lot, putting the system together and getting it to work correctly. We spent about two years developing specifications and qualifications for digital X-ray of welded components.



### **Q: Can you describe the robotic digital X-ray setup for us?**

A: This is for tubing or sheet metal components. Each part has a particular part number and the inspector puts the part in a three-jawed chuck and selects the program specific for that part. The robot has the digital X-ray panel on one side of the arm. The other side of

the arm has an X-ray tube. The robot walks around the part, X-rays it and projects images on a computer screen. The inspector accepts or rejects the images. A Level III writes and approves the program. Level IIs run the program.

### **Q: What kind of training or background does the Level II need?**

A: Here at Exotic, you have to be a Level II in conventional film X-ray before you can become certified in digital X-ray. Once you are a conventional X-ray Level II, then you can become a digital X-ray Level II. We call it a Level II Specialist.

### **Q: Has most of your NDT training come about on the job?**

A: A lot of it has and also our local Pacific Northwest ASNT put on a 40-hour Level II radiography course that I took. Our Level III here also puts on radiography and penetrant courses here as needed to train inspectors that are coming along. I am certified Level II in radiography and penetrant inspection — fluorescent penetrant inspection.

### **Q: How is NDT configured in your manufacturing process?**

A: We have four different penetrant inspection areas, some within manufacturing cells. Particular cells work only on specific sets of parts. For example, for engine buildup on the Boeing 737, eleven parts go through that cell and that's all. The parts are cut, ground, welded, X-ray and penetrant inspected all within that cell. We also have two conventional X-ray booths, a real-time X-ray booth and a digital X-ray booth.

### **Q: How do you typically spend a work day?**

A: The morning starts out with the QA manager and the shop supervisor and a couple of our NDT folks getting together. There may be a set of parts that have problems — an NDT problem or a final inspection or manufacturing problem. Those parts come to an area in the shop. Most of the time, we look at the part itself to determine the problem. Sometimes we go back to the drawing to see exactly what the drawing says. Does this part meet the drawing? If not, we run it through different areas of the shop to polish out a scratch or reweld to resolve an X-ray defect or whatever. The rest of the day is involved with audit prep, technique definition and other responsibilities.

### **Q: What indications are you looking for?**

A: We are looking at welds mainly with X-ray and penetrant. We do TIG welding here — gas tungsten arc welding that produces very high quality welds. Within welds, we look for porosity, lack of fusion — tungsten inclusions — as well as other indications. One of the biggest benefits of our digital X-ray is the feedback to our welders. When a welder is done welding up a part, he brings it over to digital X-ray. He knows immediately whether those welds are good or bad. No waiting for the inspector to X-ray the part with film, running the film through the developer and then inspector and welder looking at a piece of film. They can both look at that weld right on the computer screen. It's a huge time saver. Digital X-ray components are much more expensive than film but you don't have the cost of the film itself, no hazardous wastes, none of the chemistry of film. I don't think you will be able to shoot every part with digital X-ray so I don't think you'll see film going away. Not in the near future at least.

### **Q: What's the worst part of the work you do in NDT?**

A: One of the most troublesome things is the paperwork. We do a lot of new parts here so the first time a part comes through it's kind of good and bad. The good part is that you are developing new techniques whether it's a penetrant inspection technique or an X-ray inspection technique. That's fun but along with that you have to generate an X-ray technique and those have to be submitted to the

customer for approval. Keeping that paperwork, getting all the numbers and keeping it all straight is tough to do. That's part of what my job is — to work on these new parts and develop the techniques. We do have Level IIs here that also develop some of the techniques but actually getting them down on paper and submitting them to the customer is what I do. Also, we have about eleven inspectors here. The majority of them have a penetrant cert and some have X-ray certs and I keep all their certifications up-to-date and documented.

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

A: The best part of the work here is that each day is never the same, there's always something new — new parts or developing a new technique for a new part coming in. It's challenging to come out and make interpretations for really tight acceptance criteria. That's part of the fun of the job.

**Q: What new areas of NDT would you like to investigate?**

A: Aerospace uses a great deal of ultrasonic inspection, whether in airplane inspections or for detail parts. We don't do ultrasonic inspections here but a lot of the discussion in Section meetings centers around ultrasonics and I would like to know more.

**Q: What do you consider the growth areas of NDT?**

A: I think digital radiography is just in its infancy. There are new technologies coming out that are going to really help the NDT

department. Costs have been prohibitive — that's one of the biggest drawbacks to implementing digital radiography. But those costs are going to be coming down in the next few years and it will be more cost effective for smaller companies to invest in digital radiography equipment. Another growth area is computed radiography. CR is going to be one of the next big things coming out.

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

A: Yes, I plan to take the Level III tests for RT and PT.

**Q: Has your membership in ASNT benefitted you?**

A: I think the biggest benefit to our membership in ASNT is networking with other people. You know you can talk with all the inspectors here within your shop but getting outside that and seeing how other people are using NDT helps Exotic metals.

**Q: What advice can you offer to those considering a career in NDT?**

A: That's a tough question. People within the shop here ask me "What do I have to do?" and I think the biggest, toughest part for getting people certified in X-ray or penetrant or whatever in NDT, is the training. The community colleges here in our area do not have NDT as part of their curriculum anymore. Our Section is working with community colleges in the area to get them to put the NDT courses back together. So, I think figuring out where to get your training is very important and getting your training hours completed is a huge accomplishment. **TNT**



## ASNT Student Poster Presentation Winners

Students enrolled in the Nondestructive Testing Technology program at Southeast Community College in Milford, Nebraska won first, second and third places in ASNT's Student Poster Presentation competition held at the Society's Annual Fall Conference in Houston, Texas. Kyle Smith's presentation "ET Fastener Hole Crack Detection" won the \$500 first prize. The second place award of \$300 was made to Blake Hansen for his presentation, "NDT Methods to Inspect Wood." Preston Hardin was awarded the \$200 dollar third prize for "Computed Tomography."

Selection committee members for 2006 included Sharon I. Vukelich (ASNT President 2005-2006), Dr. Claudia V. Kropas-Hughes (Professional Program Committee Chair) and Ricky L. Morgan (2004-2006 Section Operations Council Chair).

### Submission for 2007

In addition to cash awards, participation in the Student Poster Presentation competition provides NDT students an opportunity to present their research efforts to a select judging committee and to conference attendees as well. Winners are also recognized and are presented with plaques at the Society's annual awards banquet.

Students interested in participating in the Student Poster Presentations at the 2007 ASNT Fall Conference to be held in Las Vegas, NV are requested to submit a brief abstract of their research to ASNT by September 4, 2007. Only applications from currently enrolled, full-time students are eligible. Participants must be in attendance to present their posters as they are being judged. Poster entries cannot

exceed 4 ft x 4 ft in size and should include a clear, concise representation of the NDE research effort, sufficient text to explain the NDT concepts at work (in large, legible format) and illustrations or graphics to demonstrate the work.

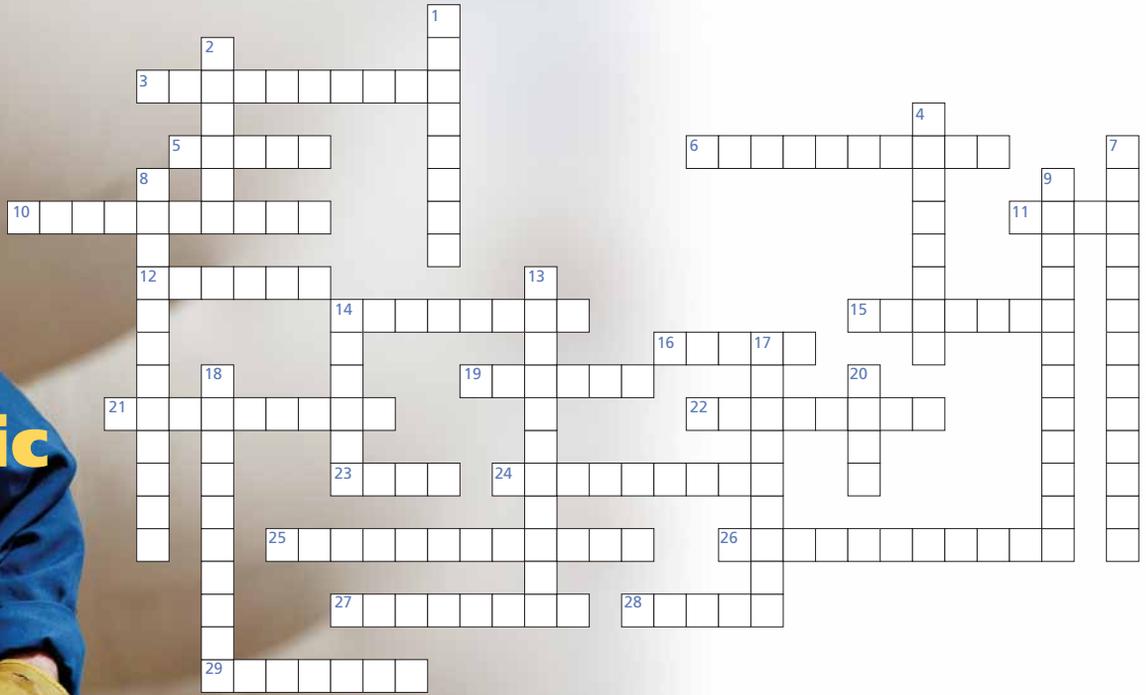
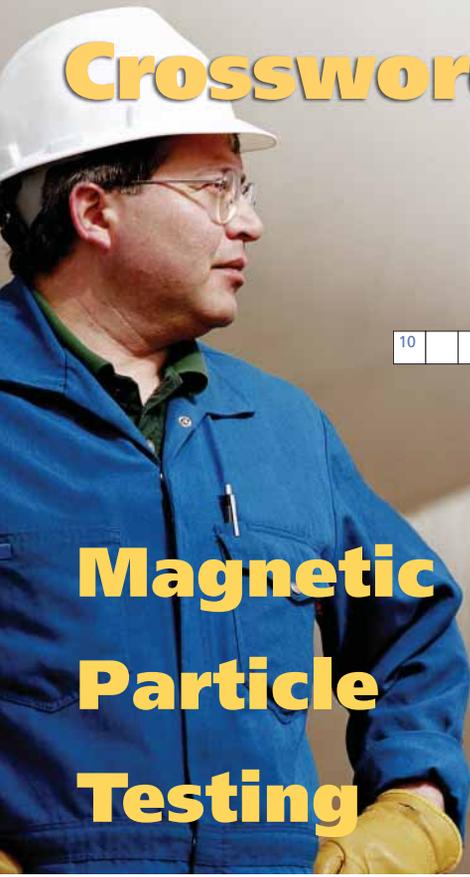
Winners will be selected based on originality of poster design, analysis and interpretation of work, quality and level of technical content, factual and technical accuracy and use of examples.

Direct inquiries for the Student Poster Presentation competition to Jacquie Giunta <jgiunta@asnt.org>, (800) 222-2768 X213. **TNT**



Kyle Smith of Southeast Community College receives congratulations and plaque from 2005-2006 ASNT President, Sharon I. Vukelich for his first place presentation, "ET Fastener Hole Crack Detection."

# Crossword Challenge:



## Across

3. To detect \_\_\_\_\_ defects on the inside diameter of a hollow part, you should pass current through a central conductor.
5. \_\_\_\_\_ strength is a major factor in determining the success of magnetic particle inspection.
6. A part has reached its \_\_\_\_\_ point when magnetism cannot be increased even though the magnetizing force continues to increase.
10. The \_\_\_\_\_ curve is used to indicate the relationship between the magnetizing force and the strength of the magnetic field produced in certain materials.
11. The MT method can be used to detect surface and \_\_\_\_\_ surface discontinuities.
12. An electric current through a copper wire creates a magnetic field \_\_\_\_\_ the wire.
14. Direct induction (head shot) will produce a \_\_\_\_\_ field.
15. If a crack exists in a circular magnet, the attraction of magnetic particles to the crack is caused by a \_\_\_\_\_ field.
16. The unit typically used to denote flux density is the \_\_\_\_\_.
19. The \_\_\_\_\_ of a test specimen is a factor in determining the correct number of ampere-turns required.
21. Magnetic particle build-up from a discontinuity is \_\_\_\_\_ when the discontinuity is oriented 90 degrees to the magnetic field.
22. Magnetic flux lines that are \_\_\_\_\_ to a discontinuity produce no indications.
23. The dry continuous method using half-wave rectified current with prods is best for the detection of \_\_\_\_\_ lying discontinuities.
24. The right hand rule describes the \_\_\_\_\_ of current flow when lines of magnetic force surround a conductor.
25. Electrical yokes as well as coils around the test piece produce \_\_\_\_\_ fields.
26. The ability of a material to retain a magnetic field is called \_\_\_\_\_.
27. When using the prod method, the amount of \_\_\_\_\_ is determined by the distance between the prods.
28. Magnetic lines of force seek the path of \_\_\_\_\_ resistance.
29. Alternating current (AC) is a better means of bringing out an indication.

## Down

1. \_\_\_\_\_ force represents the reverse magnetizing force necessary to remove the residual magnetism in a material.
2. The strongest magnetic field in a coil is at the \_\_\_\_\_ edge.
4. \_\_\_\_\_ residual fields are the most difficult to demagnetize.
7. \_\_\_\_\_ material is strongly attracted by a magnet and is capable of being magnetized.
8. A specimen may be \_\_\_\_\_ by reversing direct current (DC) fields.
9. The ease with which material can be magnetized is referred to as \_\_\_\_\_.
13. The magnitude of the residual magnetic field in a specimen is dependent on the strength of the applied \_\_\_\_\_ force.
14. Magnetic lines of force form a \_\_\_\_\_ loop.
17. The magnetic field is \_\_\_\_\_ when the magnetizing field is flowing.
18. The \_\_\_\_\_ method or technique is the most sensitive.
20. The strength of the magnetic field induced in a part is often referred to as \_\_\_\_\_ density.

Questions adapted from *Supplement to Recommended Practice No. SNT-TC-1A (Q&A Book) - Magnetic Particle Method, Book B.*

## Answers

- |                  |                  |                  |                  |
|------------------|------------------|------------------|------------------|
| 1. coercive      | 4. circular      | 11. near         | 14. circular     |
| 2. inside        | 5. field         | 12. around       | 15. leakage      |
| 3. demagnetizing | 6. saturation    | 13. strongest    | 16. gauss        |
| 4. closed        | 7. ferromagnetic | 14. parallel     | 17. least        |
| 5. permeability  | 8. demagnetized  | 15. longitudinal | 18. surface      |
| 6. magnetizing   | 9. permeability  | 16. gauss        | 19. length       |
| 7. ferromagnetic | 10. hysteresis   | 17. least        | 20. density      |
| 8. demagnetized  | 11. near         | 18. surface      | 21. strongest    |
| 9. permeability  | 12. around       | 19. length       | 22. parallel     |
| 10. hysteresis   | 13. strongest    | 20. density      | 23. deep         |
| 11. near         | 14. circular     | 21. strongest    | 24. direction    |
| 12. around       | 15. leakage      | 22. parallel     | 25. longitudinal |
| 13. strongest    | 16. gauss        | 23. deep         |                  |
| 14. circular     | 17. least        | 24. direction    |                  |
| 15. leakage      | 18. surface      | 25. longitudinal |                  |
| 16. gauss        | 19. length       |                  |                  |
| 17. least        | 20. density      |                  |                  |
| 18. surface      |                  |                  |                  |
| 19. length       |                  |                  |                  |
| 20. density      |                  |                  |                  |
| 21. strongest    |                  |                  |                  |
| 22. parallel     |                  |                  |                  |
| 23. deep         |                  |                  |                  |
| 24. direction    |                  |                  |                  |
| 25. longitudinal |                  |                  |                  |

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DIGITAL PRODUCTS

FILM PRODUCTS

FILM DIGITIZERS



Focus continued from page 5.

include Ayoob Ahmed, Dave Arms, A Broz, Lee Clements, Tom Dreher, Bill Griffiths, Keith Griffiths, Karl Gruca, Charles Haffey, Phil Keown, Terry Kessler, Wayne Kitchen, John Lively, Rick Lopez, Brian MacCracken, Bill Nappi, Thadd Patton, Steve Press, Ward Rummel, Kevin Smith, Rob Stephan, Bob Stevens, Jeff Stevens and Paul Swindell.

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