Specific Application NDE Method Leads to Development of Novel Microwave NDE Technique

By Bob Stakenborghs, PE, Evisive, Inc.

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Several years ago, a need was identified to develop an improved nondestructive inspection method to volumetrically inspect dielectric materials. Specifically, an inspection method for detecting defects in rubber expansion joints was needed to assist in preventing leaks in large electric power plant steam condensers. In response to this demand, a microwave based inspection technique was developed and patented by Evisive, Inc. Once the technique was developed and tested, it was found to be a powerful NDE technique that had uses for many dielectric materials. The technique can also be successfully used on composite materials containing conductive components but whose construction makes them overall nonconductors or bulk dielectrics, for example, carbon fiber composites.

Expansion Joint Inspection

Most steam-cycle electric power plants employ rubber expansion joints between the condenser and the turbine. The expansion joints have multiple composite layers. Typical dimensions for such an expansion joint are in the neighborhood of 40 meters (131') circumference, by 25 cm (9.8") wide, by 1 cm (0.4") thick. Under normal operating conditions, there is a vacuum on the inside of the joint, and 1 atm pressure on the outside. Thus when such a joint fails, it is prone to fail catastrophically.

A defect can begin, for example, when a small crack allows moisture inside the rubber. Moisture can then wick along the cords that form part of the composite. The moisture can cause the cord to deteriorate, which can lead to adjacent layers delaminating from one another. Defects such as these inside a joint are difficult to detect through conventional nondestructive means.

If the joint were made of metal, then well-established ultrasonic inspection techniques could be used. However, ultrasonic inspection cannot be used for rubber or soft plastic because the polymers absorb nearly all sound energy, and reflect essentially none. The mesh or fabric of a composite material so highly scatters and disperses the ultrasonic waves that an extremely noisy refection results. Eddy current measurements or magnetic measurements do not work well in rubber either, because rubber does not conduct electricity.

Radiography is also not particularly helpful since X-ray radiation is used to detect changes in bulk density. Under most operating conditions the most common flaw leading to failure is delamination. In a delamination failure, an essentially two-dimensional separation occurs between adjacent component layers. This separation between layers does not typically result in a detectable change in local density, and is therefore not detectable in a radiograph.

The current state of the art for nondestructive testing of rubber

Bio –

Bob Stakenborghs is the Engineering Manager for Evisive, Inc., in Baton Rouge, Louisiana. He has over 25 years of mechanical engineering experience in various engineering and management positions within the electric power production industry. Bob's primary involvement has been in the design and specification of mechanical equipment for use in the nuclear power industry. His current focus is microwave inspection techniques for piping and pressure retaining components for the power and petro-chemical industry. Bob has a BSME from LSU and an MSME from Catholic University.

parts is to use a Durometer, a needle that penetrates a portion of the rubber, and connects to a strain gauge. Durometers have poor practical utility, but they represent the best technology currently available for non-destructive testing of rubber joints.

In order to adequately inspect these rubber joints, an apparatus and method for the nondestructive inspection of dielectric materials was required. Since there were known problems associated with current inspection technologies, a new method was needed. The problem was solved by developing an inspection technique that used microwaves. Microwaves were found to easily penetrate the dielectric material and return signals containing relevant information. Several years of development and testing led to the patenting of a novel inspection method that employs microwaves as the interrogating beam.

Microwave Method

The inspection technique that was developed is based on monochromatic, phase coherent electromagnetic radiation, preferably in the 5-50 gigahertz frequency range (i.e. - microwaves) impinging on the sample. A detectable signal is returned at each interface where the dielectric constant changes (e.g. - where there are delaminations, cracks, holes, impurities. or other defects.) The transducer may be moved relative to the specimen at any desired speed and the scanning speed need not be uniform.

Microwaves are radiated from the transducer to the specimen being tested. Each time the beam comes to an interface between materials of different dielectric constants (e.g. - the interface between the air and the specimen, or the interface between the bulk specimen and a flaw within), a detectable signal is generated based on the angle of incidence, the differential in the dielectric constants between the materials (which is related to the index of refraction), the surface geometry, and other factors.

Testing has shown that this technique can successfully detect cracks, voids, foreign material inclusions (e.g., water or oil), thickness changes, density changes, delaminations, changes in dielectric constant (which in rubber may, for example, indicate hardening), and other defects in essentially any dielectric or bulk dielectric materials. It was also found that different types of defects have distinguishable characteristics.

Early Applications

Figure 1 depicts the results of an early experimental scan of a defect in an expansion joint of the type commonly used in steam-cycle electric power plants. The sample was a Maryland FIexcon® "dog bone" expansion joint that was 28 inches (71 cm) long, 9 inches (22.8 cm) wide, and 5/8 inches (~1.6 cm) thick. An artificial defect was created in the specimen that was 1/4 inch (~6.4 mm) wide, 2 inches (5 cm) long and 3/16 inch (~4.8 mm) deep.

This defect simulated the size of defects commonly suffered by such joints while in service. The scan depicted in figure 1 was made normal to the surface in the displacement domain, with a scan 17.69 inches (44.9 cm) long. The artificial defect was on the opposite side of the joint from the scanner, and was located 14.78 inches (37.5 cm) into the scan. No special signal analysis was required to extract the defect signal from the noise.

The broad, symmetric waveform was found to be characteristic of a thickness change resulting from removal of rubber in the joint. This type of damage (removal of rubber from an expansion joint) commonly occurs after a period of service, and may be caused, for example, by mechanical wear or gouging of the joint by loose or damaged internal hardware. While hardening and other age-related degradation may be detected by inspection with a Durometer, the type of internal damage that was detected here, that is damage that can lead to catastrophic failure, cannot be detected with previously available technologies. This type of damage could only previously be detected by first obtaining access to the inside of the joint, thus requiring an expensive unit outage. The new NDE technique provides a previously unavailable solution to this problem that allows internal defects to be detected without shutting down the unit, thus avoiding costly down time.

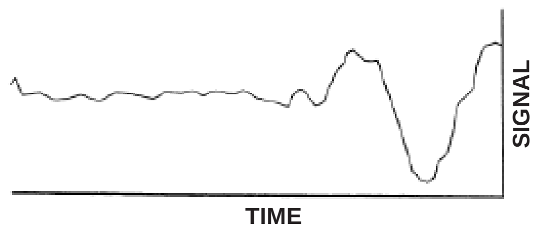

Figure 1.

Defect Detection Capability in Other Materials

Following the successful testing of the inspection method on the expansion joint material, the microwave technique was steadily improved and its effectiveness as an inspection method was investigated for other dielectric materials. One of the first materials to be tested was fiberglass piping. This piping is commonly used in harsh applications.

The scanning technique is based on the principle that a change in the return signal of a specimen generally indicates the presence of a flaw.

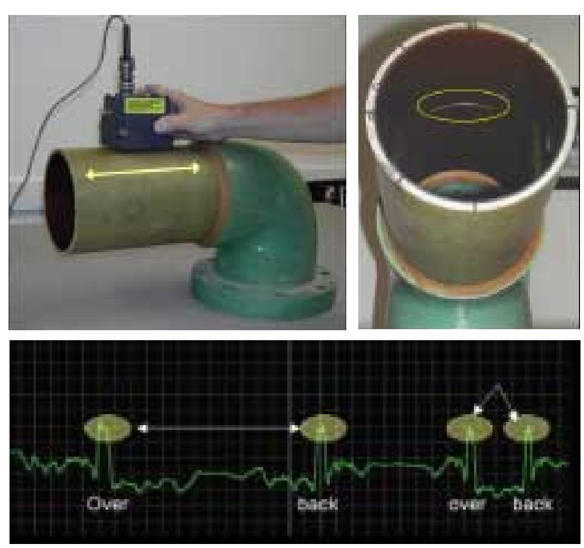

Figure 2.

This “different is bad” approach can be used to identify changes in thickness, foreign material inclusions, cracks, and other defects. As the location of the transducer changes relative to the specimen, a defect can be seen as first moving into and then moving out of the microwave beam. It was concluded that inhomogeneities (defects) essentially act as microwave reflectors that move relative to the transducer.

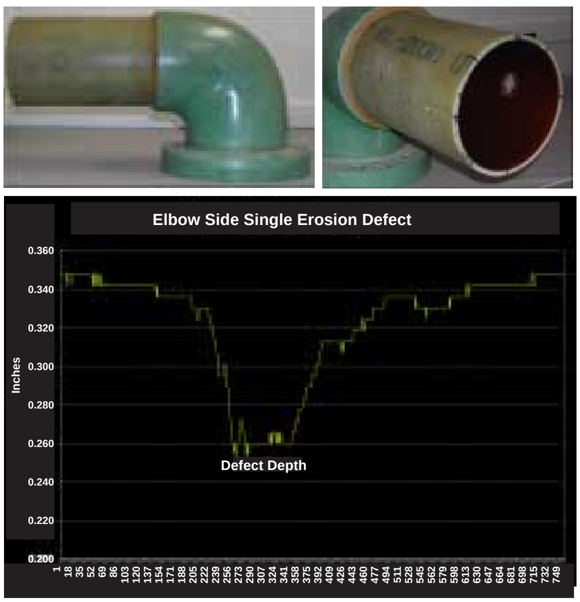

Figure 3.

As reflectors “move” toward or away from the transducer, a characteristic return signal is produced for each reflector as discrete signal samples are taken at discrete locations. Axial “motion” of the reflector produces a change in the return signal as the reflector moves through the interrogating microwave beam. This phenomenon is clearly shown in Figure 2.

Figure 2 is an example of defect detection using the early microwave scanning equipment. Shown is a piece of fiberglass pipe with a mechanically induced radial defect, and its corresponding scan. The defect is 3 inches (7.6 cm) long by 0.08 inches (2 mm) deep. The presence and location of the defect can clearly be established by the corresponding scan.

Depth or Thickness Measurements

It was also found that the return signal is consistent in nature with respect to defect location or specimen thickness. This provides a means for accurate and repeatable representation of specimen thickness or defect depth. Using this information, a calibration curve of the relationship between depth and signal may be determined. This is typically done by the use of a calibration block of the same material as the test specimen containing either varying thicknesses of material or actual test defects at varying depths.

The following figures (Figures 3, 4, and 5) demonstrate several simple and yet practical applications of the microwave technique for depth or thickness measurement. Figure 3 shows a fiberglass pipe with a mechanically produced side defect. The defect depth was measured with calipers to be 0.08 inches (2 mm) into the pipe wall, leaving a thickness of 0.26 inches (6.6 mm). The pipe wall was likewise measured to be 0.34 inches (8.6 mm) thick. As can be seen in the scan, the calibrated microwave scan accurately indicates both the wall thickness and the defect depth.

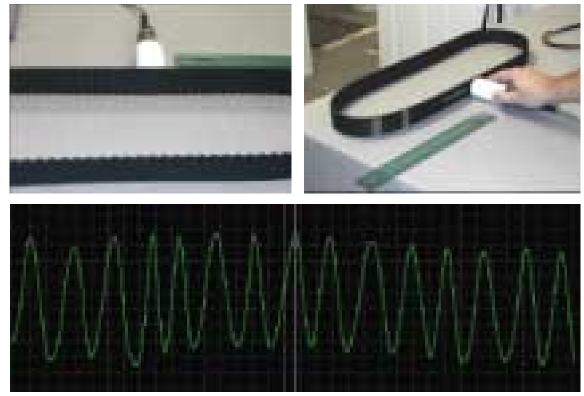

Figure 5.

Figure 4.

Figure 4 shows a similar fiberglass pipe with three mechanically produced side wall defects of varying depth. Again, the microwave scan accurately indicates the depth, or amount of removed material, at each defect location.

Figure 5 shows another potential application where exact defect depth measurement is not required, but where periodic change in thickness is of interest. A Browning synchronous gearbelt was examined to determine if it is possible to count the number of teeth per inch. As can be seen in the accompanying scan, the gearbelt tooth pattern is clearly discernible.

Advanced Applications

These early scans provide only a fraction of the possible applications for this technique. As the development of the hardware and accompanying software moved forward, other potential applications were quickly identified. These include PE (polyetheylene) piping weld examination, fiberglass wrap pipe repair examination, and foam insulation inspection. The next article will provide examples of more recent, advanced scans using improved data collection and viewing software.

Microwave NDE Technique – Testing of FRP and PE Piping – Examples

By Bob Stakenborghs, PE, Evisive, Inc.

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Once the microwave inspection method was determined to be capable of providing reliable and meaningful inspection results for defects located on the exterior, interior, and interior surfaces of non-metallic components, potential industry applications were identified. Upon investigation, these applications proved to be numerous and varied in nature. This is the result of an apparent lack of reliable inspection techniques for many non-metallic components that are rapidly becoming materials of choice in many industries. Non-metallic materials are displacing steel in many applications due to their unique corrosion resistance and high strength to weight properties. Some of the potential applications for microwave inspection that were identified include:

- Piping and piping components such as fiberglass and polyethylene
- Piping repairs such as fiberglass wrap
- Construction materials such as wood, fiberglass and composite materials
- Insulation materials such as spray on foam and ceramics
- Coatings such as epoxy and polyurea

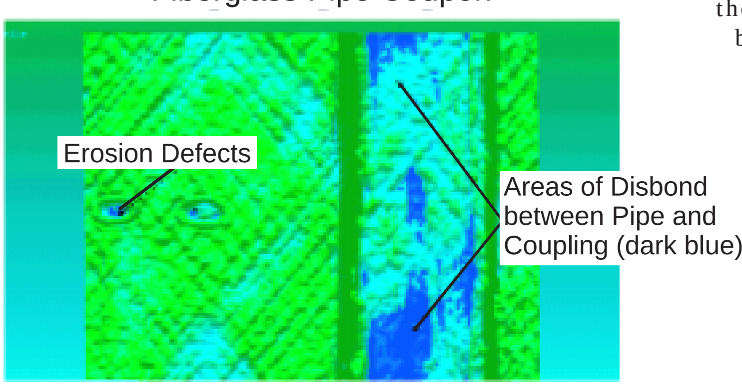
While the early scans clearly demonstrated the viability of the microwave technique for defect detection, it soon became apparent that the level of detail available using the microwave inspection technique was far greater than previously imagined. This became clear as the number and differing types of inspected samples grew.

Inspection Advancement

As with most new technologies, advancements occur as usage increases, sometimes put as "necessity is the mother of invention". This is certainly true with the microwave inspection technique. As different types of samples were provided for inspection, new apparatus and techniques were developed to perform the inspections. The apparatus changes included the development of various geometries of microwave probes. It was shown that subtle variations in probe geometry can provide substantial differences in the level of detail of the scan. One of the biggest improvements for the microwave technique came in the form of the data gathering and presentation.

A commonly used data gathering and display program was modified and became the cornerstone for capturing the millions of bits of data that a typical scan generates. Once the data is collected, the software allows the image to be manipulated to enhance features. Also, since it is in digital form, the scan results can be stored and retrieved later to provide information on how a part or a defect has changed over time. This allows determination of the growth rate of a defect, which is critical to determining ultimate service life. The scans shown below were all generated with the latest generation of the microwave equipment and data gathering software. Since new applications are still being identified, the technique is being modified to suit the need, which is a tribute to its versatility.

Fiberglass Pipe Coupon



Scan Results
(Shown rolled out into flat plane for ease of viewing)

Figure 2.

Figure 1.

Fiberglass Piping

Fiberglass piping is used extensively in the petro-chemical industry for various services, including highly corrosive fluids. Of particular interest is the non-destructive examination of the joints. Since a typical fiberglass joint is glued, a common defect is lack of glue. This leads to poor adhesion and can result in the joint becoming unstable due to thermal growth or other mechanical loading.

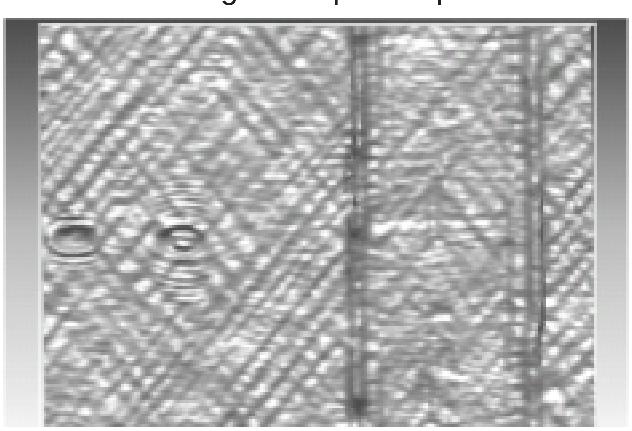
As part of the proof of principle testing for this method, several samples of fiberglass piping and joints were provided by various end users and examined. The following photograph (Figure 1) shows one of the samples that was provided.

Figure 1 shows a sample that consisted of two 4 inch fiberglass (FRP) pipes joined by a glued coupling. The coupling was a fiberglass casting, which did not have any glass reinforcing. The joint had been made with insufficient glue and two internal defects in the piping had been mechanically introduced to simulate typical erosion defects. The scans below show typical microwave inspection results.

Figure 2 illustrates the level of detail in the microwave scan. The radial direction of the pipe/coupling is from top to bottom in the scan, while the axial direction is left to right. The coupling is the area between the two red lines on the scan. The red lines appear as a result of the thickness change from the coupling to the pipe. The areas of disbond and the erosion defects are clearly visible. The fiberglass reinforcing is seen as the criss-cross pattern present throughout the image. Of particular interest is the presence of the reinforcing pattern in the region of the coupling. Since the coupling is known to contain no reinforcing, the presence of the pattern in this area indicates that the microwave scan penetrates the coupling and is "seeing" the pipe enclosed in the coupling. Also, the gap between the two pipes beneath the coupling is clearly visible in the scan.

Figure 3 is a gray scale representation of the same digital data. This image demonstrates the versatility of the data gathering and representation technology. The ability to view the scan in gray scale often provides additional clarity and definition to subtleties of the scan.

Fiberglass Pipe Coupon



Grayscale Image of Scan Results

(Note Clear Ability to Detect Pattern of Fiberglass Roving)

Figure 3.

Polyethylene (PE) Piping

Polyethylene piping is used extensively in the petro-chemical and utility industries for various services, including harsh environment service. Its use is becoming more prevalent due to its low cost versus steel piping and its ability to withstand corrosive environments.

One of the problems with this piping is the current inability to non-destructively examine the weldments. Standard methods, such as radiography and ultrasonics, have proven to not be capable of reliably detecting flaws in the weldments. There are two types of weldments common in PE piping. They are the thermal fusion butt weld and the electro fusion coupling weld.

Microwave inspection is a method that is capable of penetrating the entire wall of the piping. This provides a unique interrogation of the entire weld thickness for flaw detection.

As part of the proof of principle testing for this method, many samples of welded PE piping were provided by various end users and examined. The samples included 2 inch and 4 inch nominal diameter piping welded using either thermal welding or electro-fusion welding technique. Many of these samples were provided as "blind" samples. That is, neither the flaw type or its location were known.

Figure 4.

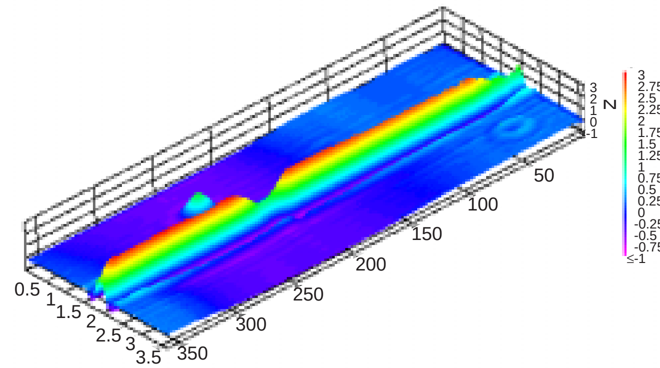


Figure 5.

In order to process the increasingly large number of samples in a timely fashion, a "scan lathe" was developed for laboratory use. The scan lathe rotates the sample while scrolling the microwave probe down its length. The scan lathe is shown in figure 4. The sample is placed between the two end plates. A typical scan time for a 4 inch nominal diameter pipe is less than 5 minutes.

The piping samples were PE piping manufactured with welded joints and electro-fusion joints. Many of the samples included defects in the welded joints, such as various inclusions (i.e. - dirt, grass, grease and other materials field experience indicates might be included). The electro-fusion joints were manufactured with defects that involved the amount of insertion in the coupling. Figure 5 is a typical scan of a PE piping weld showing a joint defect.

The scan depicts the piping radially in the X direction (0 to 360 degrees) and axially in the Y direction (0 to 3.5 inches). The full weld is shown from 0 to 360 degrees between Y = 1.5 to 2.25. The defect is clearly shown at x = 225 degrees. The defect was a grease inclusion at this location.

Field Application

In order to make to method useful, a means was required to allow piping inspection in field applications. A field inspection device was developed, which allows scanning of pipe in a fashion similar to portable ultrasonic inspection equipment. Figure 6 shows a typical field inspection installation.

Figure 7 is an example of a scan of a large bore (8 inch nominal diameter) PE pipe with manufactured defects. This scan was produced using the portable scan equipment shown above. The coupon was manufactured by thermal welding and had eight defects embedded in each side of the pipe prior to joining. The defects are clearly visible in the scan.

The scan shown in Figure 7 took less than 30 minutes, including set-up time. The field scanning apparatus has been successfully demonstrated in an operating plant environment and is use has been proceduralized.

The scans shown in this article represent only a small fraction of the total scanning experience to date and illustrate the practicality of the technique as it applies to the piping industry. The next article will explore some of the more exotic materials that find microwave inspection useful.

Basic Field Scanner Setup

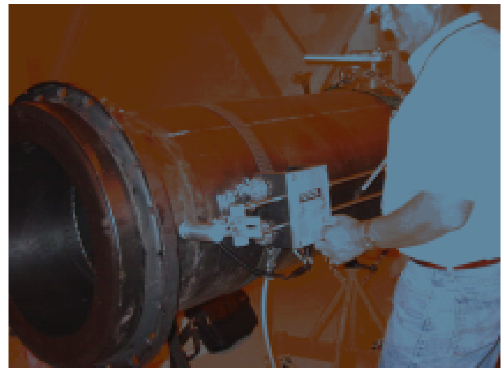
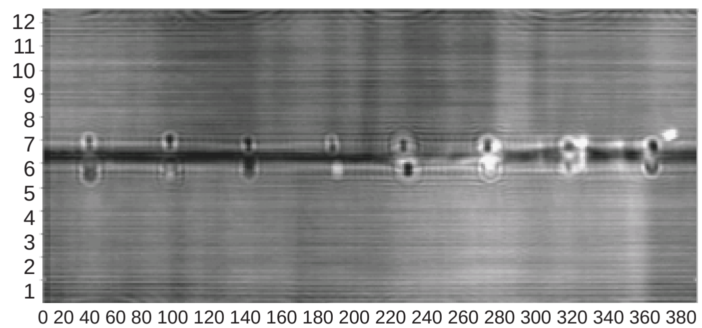


Figure 6.

Polyethylene Pipe Gray - scale Scan Image

Coupon has 16 Embedded Defects



The coupon shown above is a piece of nominal 8 inch (8.5 inch OD) polyetheylene pipe, approximately 12 inches long with 8 defects embedded in each side of the thermal fusion butt weld. Note the 1/16 inch by 1/16 inch foil marker at X=0, Y=1.

Figure 7.

PVRC Workshop...continued from 10

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fracture and plastic collapse. The 12mm (~1/2in) deep surface flaws assumed to exist in the header were also acceptable. The critical height of a surface flaw in the stub, with a length equal to the weld toe circumference, was found to be only 5.3mm (0.2in). If the minimum surface flaw height that can be reliably detected using visual or magnetic particle NDE is less than the tolerable height, say 3mm (~_in), then larger unacceptable flaws (height >5.3mm) can be detected by NDE and dealt with. Therefore, it may be concluded that non-detectable surface flaws do not threaten the integrity of the stub repair in the as-welded condition. Based on the above and assuming that no other mechanisms (eg. creep-fatigue) may lead to extension of the original flaws, it was concluded that the weld repair was fit-for-service under operating loading in the as-welded condition.

Financial Justification

It was shown that avoiding PWHT was technically justified. The cost of this fracture mechanics analysis was negligible in comparison with the total cost associated with carrying out PWHT on site which was cumbersome and expensive. The main advantage of the codes' thickness criterion is its simplicity. Unfortunately, it is not possible to use fracture mechanics to justify a general relaxation or rationalisation of the thickness criteria in the codes. The chances of making a successful case for avoidance of PWHT are best with a good knowledge of the fracture mechanics input parameters. Assumptions regarding fracture toughness, flaw sizes and applied stresses can be crucial to the outcome of the analysis.

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Chief Editor's note:

Microwave NDE is showing promise for areas that have so far been very difficult, if not impossible to inspect with NDE. The following examples show applicability for FRP, concrete, polyethlyene, plywood, spray on foam insulation, ceramics, and a composite rotor. The "IJ" makes no promises or endorsements for these applications and presents them for informational reasons only. The reader should establish and perform their own qualification demonstration testing prior to use of any of these techniques.

Microwave NDE Method - Application Examples

By Bob Stakenborghs,
PE, Evisive, Inc.

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Once the effectiveness of the microwave NDE technique was firmly established for polyethylene and fiberglass piping and piping components, other types of materials were collected and inspected to determine the range for which the technique could prove useful. It was soon discovered that this technique has broad ranging capabilities that cover essentially any bulk dielectric material. Coupons were either prepared locally or sent in from different manufacturers, both national and international, to determine the effectiveness of the technique for specific applications. As noted in previous articles, examination techniques have been developed that further enhance the results obtained using the microwave NDE method. In many cases, the technique provides startlingly clear images of defects in materials for which no previous inspection technique existed.

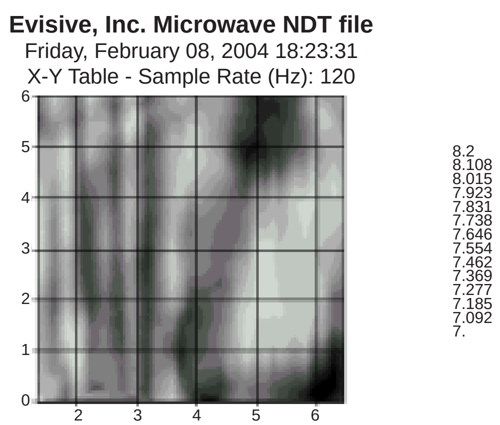

Figure 2. Microwave scan of plywood coupon showing internal and external wood structure.

Figure 1. Photo of Plywood Coupon with no known defects.

The figures included in this article provide visual evidence of the effectiveness of the microwave NDE technique. Note the clarity of the internal defects and structures of interest apparent in all of the scans.

Figures 1 and 2 show a plywood panel with no known defects. Figure 1 is a photo of the plywood panel and figure 2 shows the microwave scan of the panel. The scan clearly shows wood grain features both on and beneath the surface of the wood.

Figure 3 shows a honeycomb fiberglass panel coupon with intentionally embedded defects. The defects are disbonds at the substrate, potted

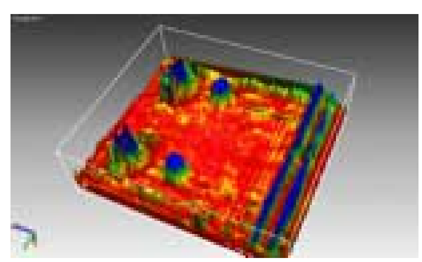

Figure 3. Fibreglass coupon with embedded defects including disbonds, splice joint, and potted cores.

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disbonds are at the far left, the potted cores in the center, and the splice joint at the right of the image. None of the defects were visible at the surface of the coupon.

Figure 4 shows a scan of a 3" by 6" ceramic matrix composite (CMC) coupon with 3 embedded defects. Again, the defects were not visible from the surface of the material.

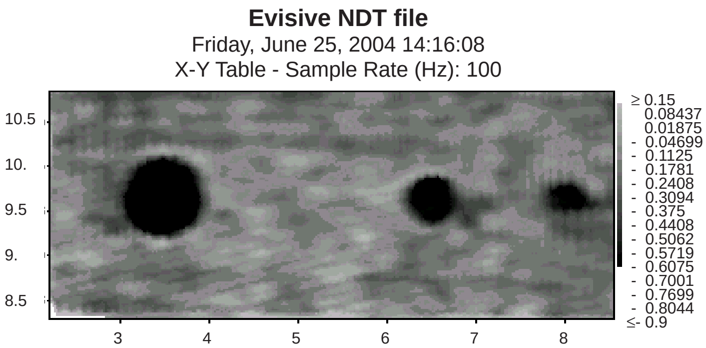

Figure 4. Ceramic coupon (silicon carbide CMC) with three embedded defects.

Figures 5, 6, and 7 are of a composite aircraft rotor. Figure 5 is a photo of a piece of the rotor with known embedded defects. Figure 6 is a microwave scan taken from the top side of the rotor. It clearly shows the defects as well as other internal structures not seen from the surface. These include the rotor spar (straight line up and down on the image) and an open cell, seen on the upper right corner of the image in figure 6. Figure 7 is a scan taken from the underside of the coupon. Again, the defects are visible in this scan as well as the internal structures, on the reverse side of the scan from figure 6.

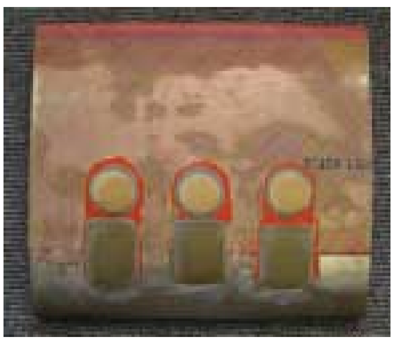

Figure 5. Photograph of aircraft composite rotor with embedded defects.

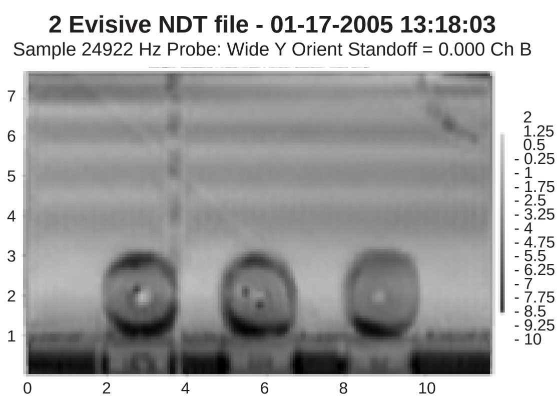

Figure 6. Microwave NDE scan of rotor, front side. Note interior details such as spar (vertical line) and open cell (right upper corner).

Figure 8 is a picture of a concrete coupon that has been sprayed with varying thicknesses of a polyurea coating. Figure 9 is the microwave scan image of the coupon shown in “three dimensional” representation. The return signal varies proportionally with the thickness of the polyurea and goes from left to right in the scan from thinner to thicker. The conical shape at the right of the scan and the spherical opening on the left of the scan are return signals from embedded steel reinforcing bar in the concrete substrate.

Figure 10 is a microwave scan of a passenger tire that, except for variations in the tread spacing due, presumably, to mold irregularities, was without apparent defects. Figure 11 is a microwave scan of the same tire after three intentional defects were embedded. First the tread was shaved at approximately X=10 to X=20(to simulate a shift in the steel belt. A change in tread thickness would present the same appearance. Next, the steel belts were disturbed from the ID, with no damage visible from the OD, at X=34(on the tread centerline, at Y=3.3. Finally, a disbond was created between the steel belt and the overlying tread at X=85 to X=95(and from Y=0 to Y=1 inch. All three of these embedded defects are clearly visible in the scan image shown in figure 11.

Figure 12 are multiple scans of a fiberglass pipe overwrap repair with embedded defects. The multiple scans differ in that, through a specialized technique, the scan focuses on differing depths in the material. This brings defects and internal structures of interest into and out of focus in successive scans. This is important when inspecting material that may have defects located at various depths below the surface.

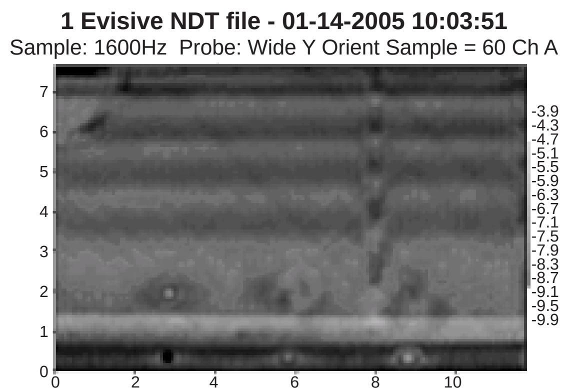

Figure 7. Microwave NDE scan of rotor, back side. Defects visible from reverse side as well as spar and open cell (reversed positions from figure 6).

Figure 8. Concrete block with application of varying thicknesses of polyurea coating.

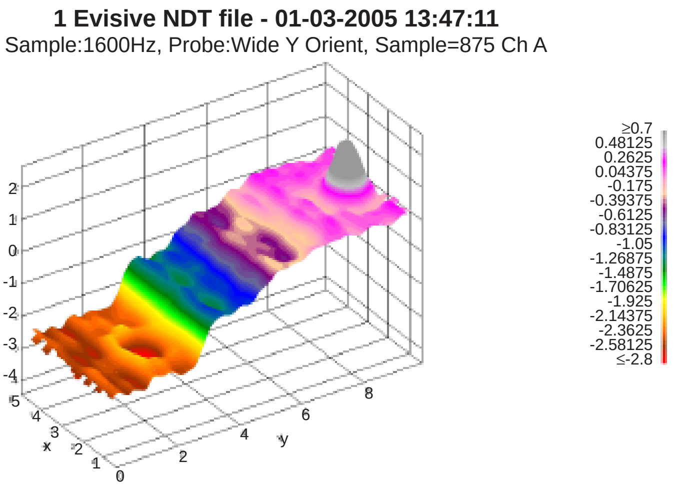

Figure 9. Microwave NDE scan of polyurea coated concrete showing response to varying thickness of coating. Note rebar indications (conical and circular features) at top and bottom of scan.

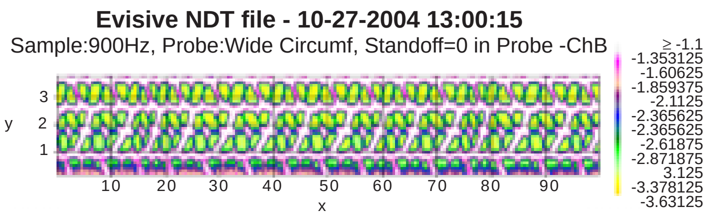

Figure 10. Microwave NDE scan of passenger tire with no known defects.

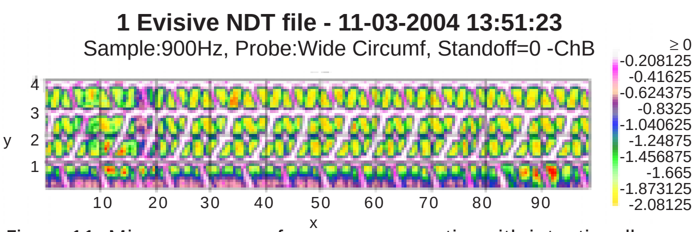

Figure 11. Microwave scan of same passenger tire with intentionally induced defects at X = 10 and 90 degrees.

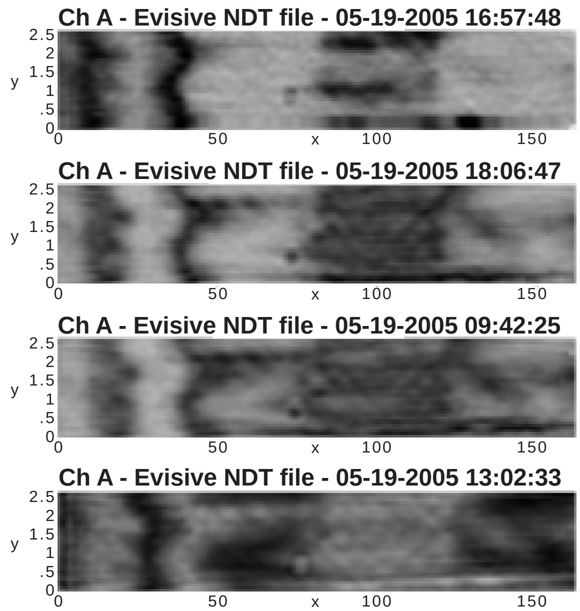

Figure 12. Multiple microwave NDE scans of fiberglass overwrap repair showing internal structures and embedded defects. The scans were taken with a specialized technique that allows information from various depths within the sample to be highlighted or focused. This results in various defects and internal structures of interest to move in and out of focus in successive scans.

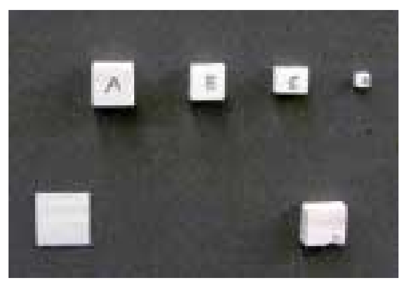

Figure 13. Location of intentional defects in Spray On Foam Insulation Coupon, prior to application of 4 inches of insulation.

Figures 13 and 14 are of a prepared coupon of a spray-on foam insulation (SOFI). Figure 13 shows the coupon prior to the application of the spray-on foam, indicating the location and types of defects. The scan image in figure 14 clearly shows all of the defects. Note that the scan image retains the geometric configuration of the defects. The defect in the right lower corner of the image represents a roll-over defect, where various passes of foam have a defect at the seam between passes. The other defects represent voids and delaminations. Detection and location of defects in this SOFI material is currently of some considerable interest to NASA.

Figure 15 and 16 are of a rubber piping expansion joint. Figure 15 is a picture showing intentionally embedded defects. The defects have been emphasized in the close-up photograph by surrounding them in white.

The image in figure 16 clearly shows not only the two intentionally embedded defects, but also the axial mold line, which can also be seen in the photograph. Note that this mold line is not evident from the OD.

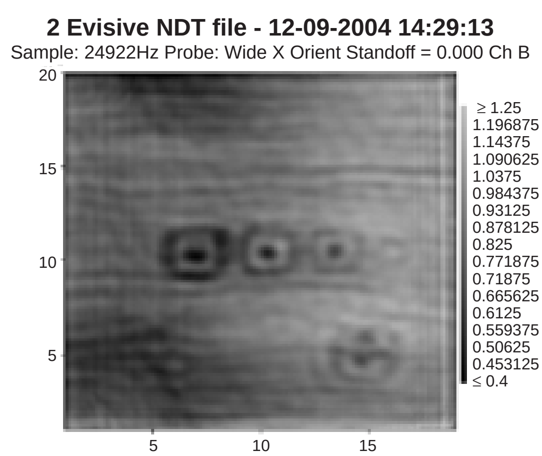

Figure 14. Microwave NDE Scan of Spray On Foam Insulation coupon showing internal defects.

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In conclusion, the microwave NDE method represents a significant enhancement over current NDE methods for detecting various types of defects in bulk dielectric material. The equipment is compact, portable, and requires minimal set-up time. It is non-contact, requires access to only one side of the specimen under test, and the results, as can be seen from the scans, are easily interpreted. Additionally, the images are produced from digital information that can be stored indefinitely. Once stored, they can be compared to information obtained from future scans to show the appearance of, or growth of, defects in the material.

The method is also proving to be valuable in determining thickness and density of bulk dielectric material, such as ceramics and coatings. Other enhancements, such as focusing of signal return, indicate the flexibility of the method and its capability to return information specific to discrete areas of the material being interrogated. Its full capabilities are still under investigation and new applications continue to be identified.

Figure 15. Interior of a rubber piping expansion joint showing intentional defects and “Mold line”.

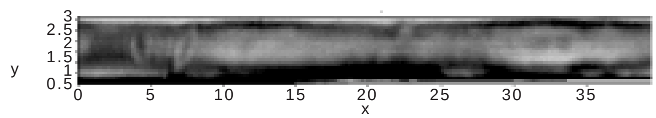

Figure 16. Scan image showing both intentionally embedded defects. The “mold line” is visible.

Bio –

Bob Stakenborghs is the Engineering Manager for Evisive, Inc., in Baton Rouge, Louisiana. He has over 25 years of mechanical engineering experience in various engineering and management positions within the electric power production industry. Bob’s primary involvement has been in the design and specification of mechanical equipment for use in the nuclear power industry. His current focus is microwave inspection techniques for piping and presure retaining components for the power and petro-chemical industry. Bob has a BSME from LSU and an MSME from Catholic University.

New Release of API/ASME 579 The *de facto* International Standard for Fitness-For-Service

By David A. Osage, President and Principal Engineer
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API RP 579 Task Group Chairman

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API is preparing to release the next edition of API 579 Fitness-For-Service (FFS) the first quarter of 2006. The many major enhancements that have been made to the next edition of API 579 are summarized in this article. The major enhancements made to API 579 will permit Owner-Users to evaluate new types of damage including HIC/SOHIC and Dent-gouge combinations, and allow detailed remaining life assessments of components operating in the creep range. In addition, new procedures for stress analysis have been developed that will enhance the usability and accuracy of Level 3 Assessments resulting in longer run-times for damaged components.

To avoid confusion with other ASME B&PV Codes and Standards, existing Sections in the 2000 edition of API 579 are being renamed to Parts.

A summary of enhancements to existing Parts and new Parts covered in the 2006 Edition of API 579 is shown below.

- Part 5 - Assessment of Local Thin Areas, assessment procedures for gouges being relocated to Part 12
- Part 7 - Assessment of Blisters and HIC/SOHIC Damage, assessment procedures for HIC/SOHIC damage have been added
- Part 8 - Assessment of Weld Misalignment and Bulges, assessment procedures for bulges being modified, assessment procedures for dents being relocated to Part 12
- Part 10 - Assessment of Equipment Operating in the Creep Range, assessment procedures for remaining life calculations for components with or without crack-like flaws are provided
- Part 12 - Assessment of Dents, Gouges, and Dent-Gouge Combinations, new Part
- Part 13 - Assessment of Laminations, new Part

A summary of enhancements to existing Appendices and new Appendices covered in the 2005 Edition of API 579 is shown below.

- Appendix B - Stress Analysis Overview for a FFS Assessment, complete rewrite to incorporate new elastic-plastic analysis methods and fatigue evaluation technology developed for the ASME Div 2 Re-write Project
- Appendix C - Compendium of Stress