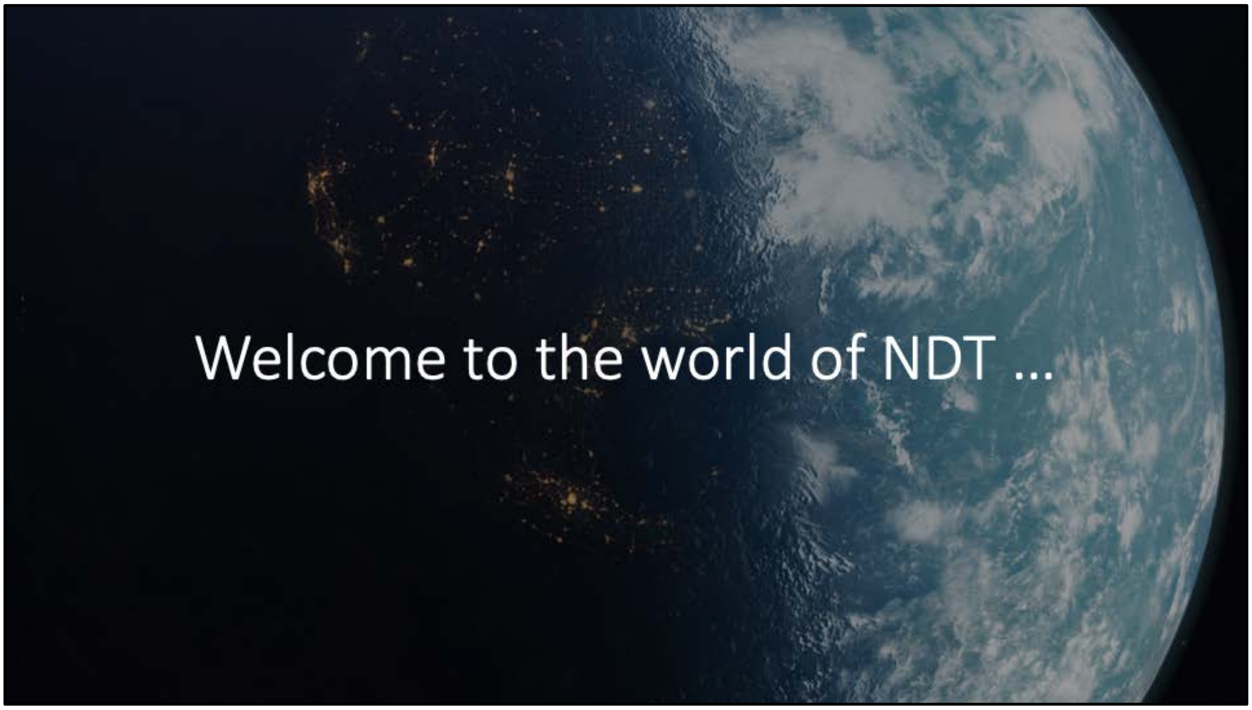
Welcome to the world of NDT …

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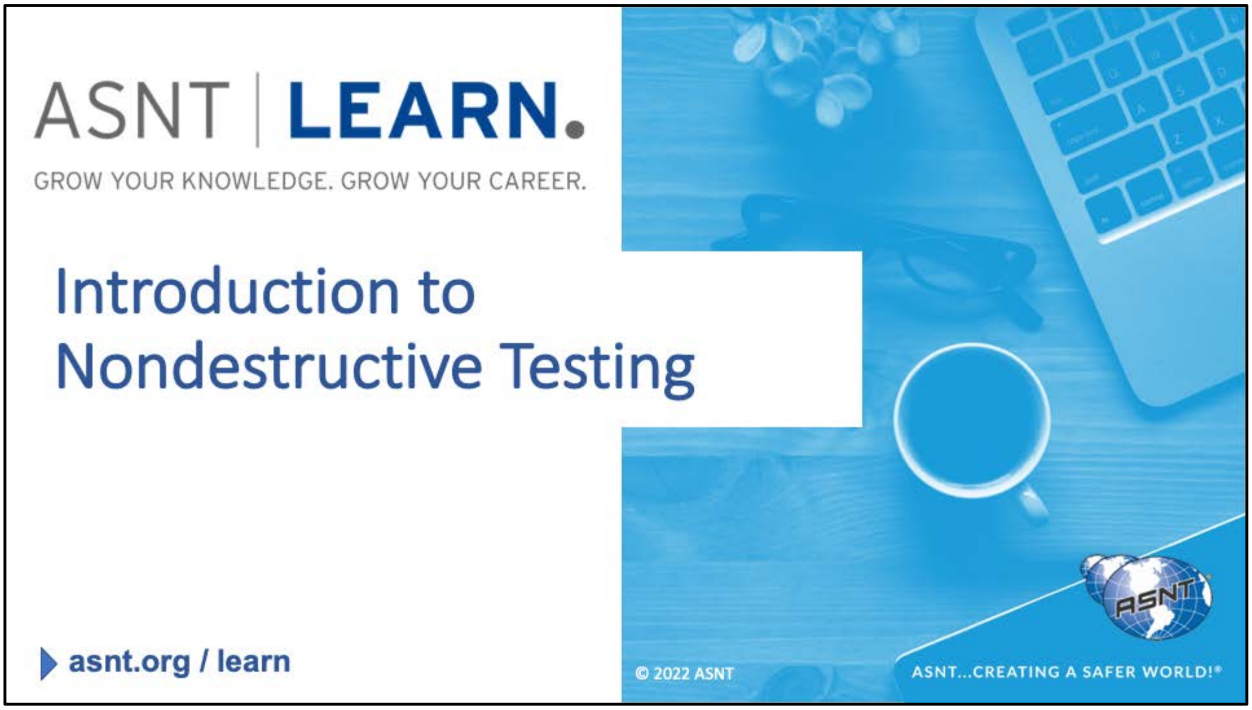
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Introduction to
Nondestructive Testing
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Welcome to the world of nondestructive testing! Whether you're brand new to the field or simply interested in learning what nondestructive testing (abbreviated NDT) is all about, this presentation will show you the ropes—sometimes literally, as technicians perform their inspections in the unlikeliest of places.

Overall, you should come away with an enhanced appreciation of the many ways NDT works diligently to make the world a safer place.

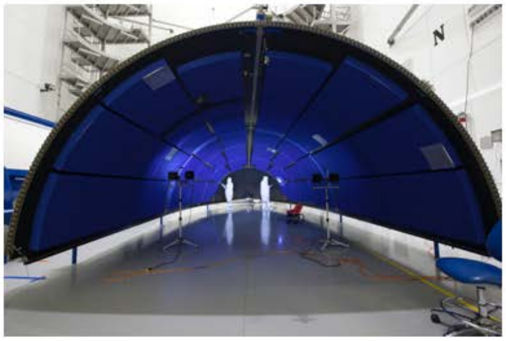
You can probably imagine a world without computer technology. Think of the personal frustration and societal breakdown that would ensue if the Internet stopped functioning, even for a single day.

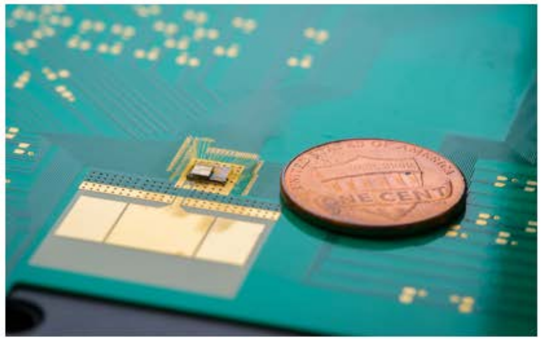
But what would the world be like without nondestructive testing?

Perhaps not as chaotic as a world without computers, but certainly just as dangerous.

NDT is used to:
- ensure product integrity and reliability,
- control manufacturing processes,
- lower production costs, and
- maintain a uniform quality level.

NDT ensures that materials and products of manufacturing and technology are safe for human use.





Overall, NDT is indispensable for ensuring that the materials and products of manufacturing and technology are safe for human use—from the very largest scales to some of the smallest.

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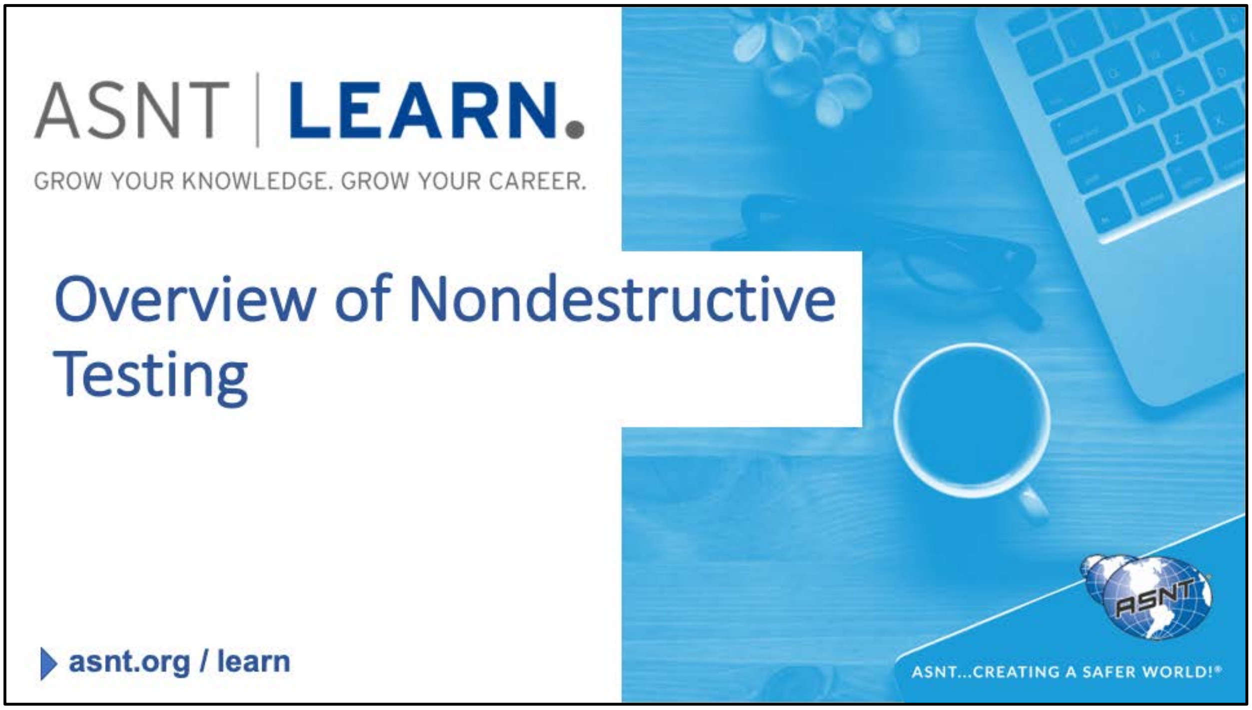
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The next time you:

- take an elevator,
- get on a plane,
- cross a bridge,
- buy a ticket for an amusement park ride,
- pump gas at a service station, or
- turn on your lights ...

Chances are you trust that:

- the elevator will take you to the proper floor,
- the plane will take off and land safely,
- the bridge won’t collapse beneath your feet,
- the amusement park ride will be enjoyable,
- the oil has made it from the refinery to the pump without major spills or leaks, and
- the power facility that generates your electricity is in good working order without danger to life or the environment.

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Think of NDT as a safety net for public use of a wide variety of products. If NDT is doing its job, you'll rarely hear it mentioned in the news ...

... simply because NDT has worked behind the scenes to make a product or part safe for public use or consumption.

Ever inspect a newly purchased product to make sure it doesn’t have any flaws or defects?

Ever check your driveway to make sure your vehicle isn’t leaking oil or to determine the type of fluid being leaked?

What about getting your teeth X-rayed in a dentist’s office to detect cavities or cracks?

NDT performs the same kinds of inspection tasks in industrial, manufacturing, and on-site settings.

In-service NDT is used so that the products in use continue to have the integrity necessary to ensure their usefulness and the safety of the public.

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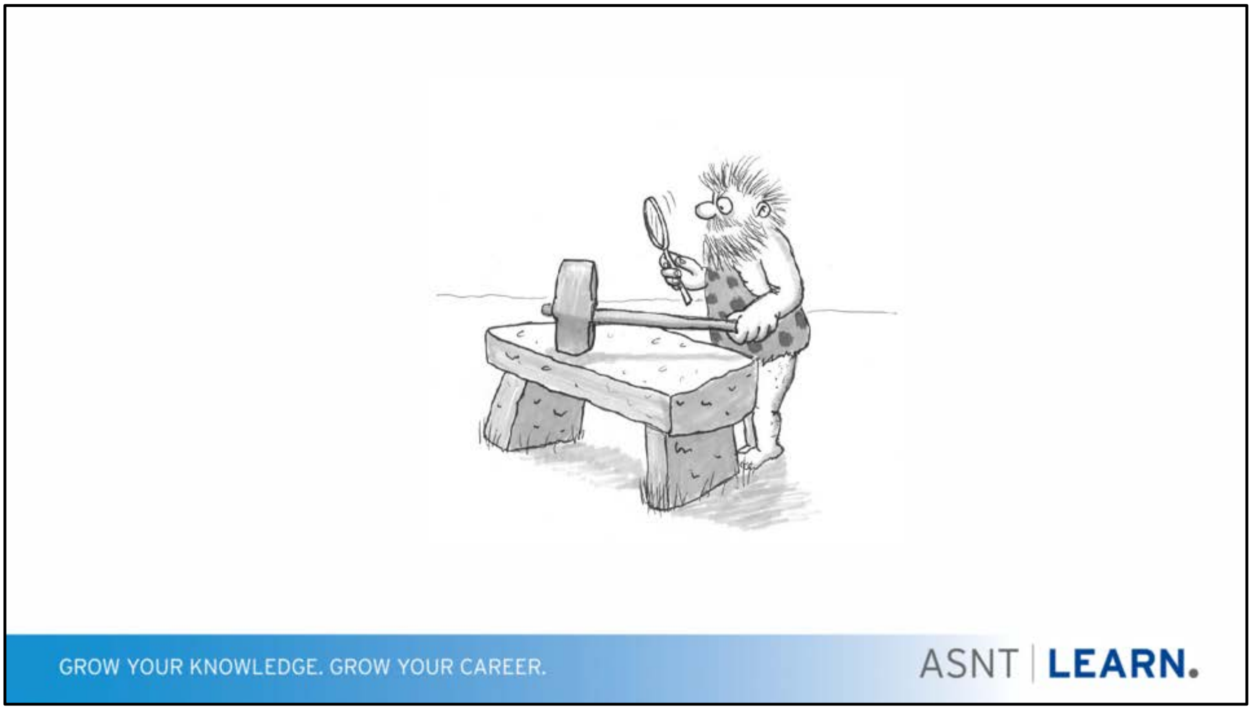
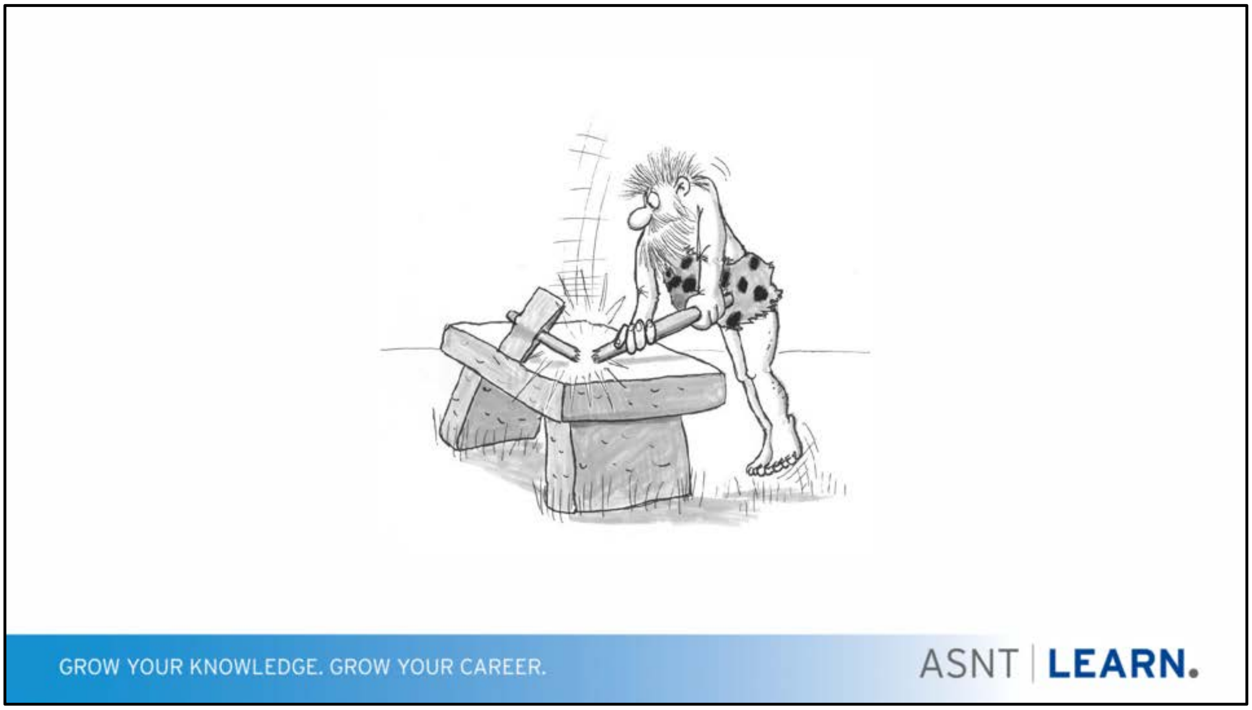


One way to define nondestructive testing is by comparing it to what it is not, namely, destructive testing.

Overall, the NDT approach to materials testing is considered nondestructive in that the inspected item is not harmed and can be placed into service after testing.



Destructive tests are based on the application of extreme loadings that exceed normal operating conditions and typically result in destruction of the test samples.

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discontinuity: Intentional or unintentional interruption in the physical structure or configuration of a part.

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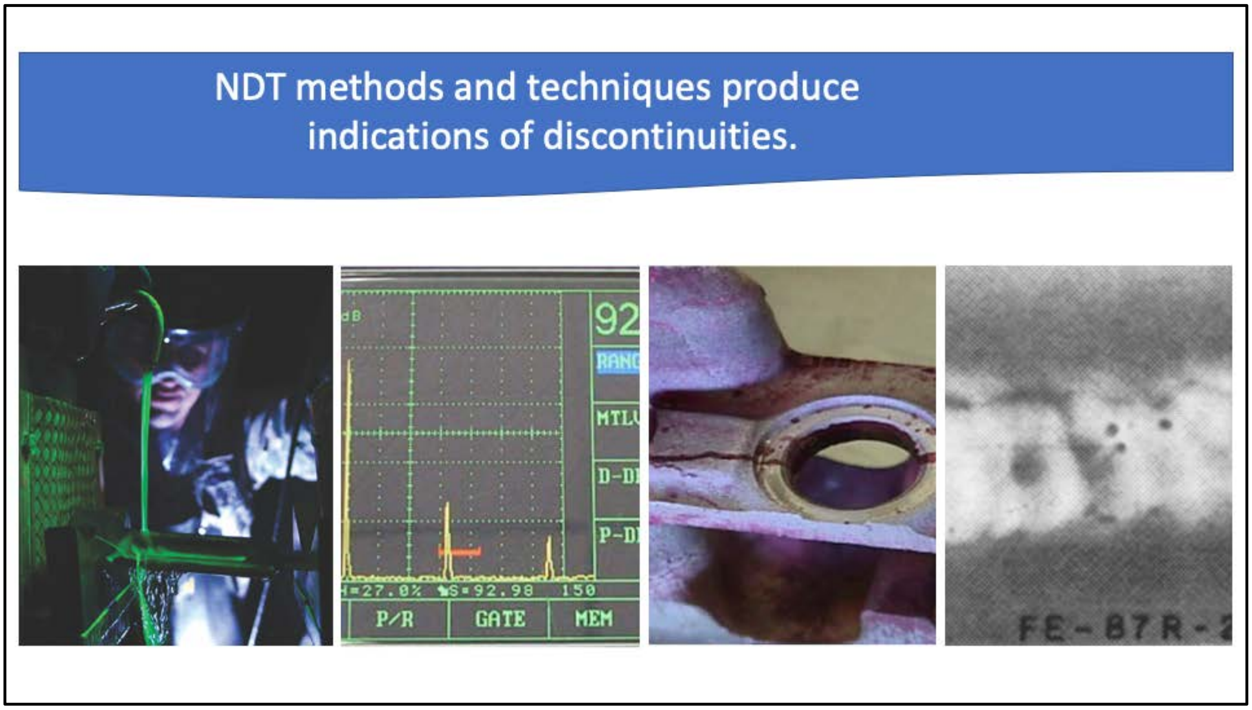
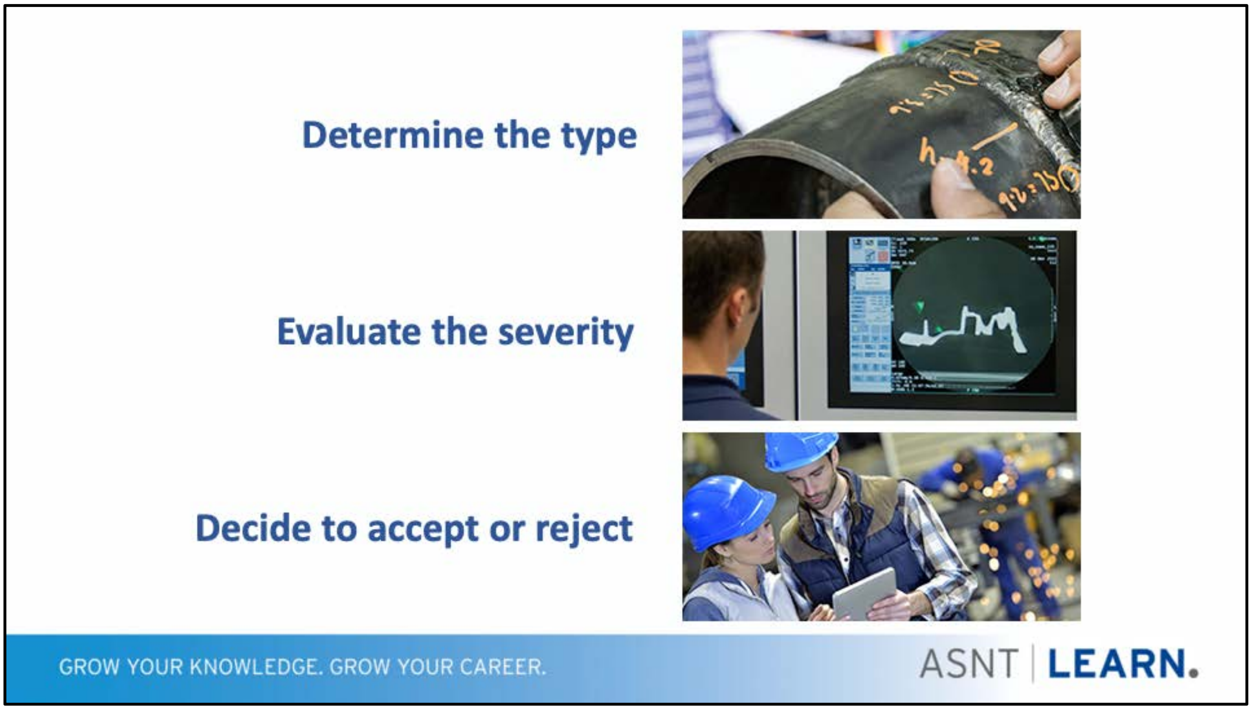
NDT is devoted to the detection and evaluation of discontinuities.

A glossary definition as applied to NDT is an interruption in the physical structure or configuration of a test object, essentially making the part discontinuous.



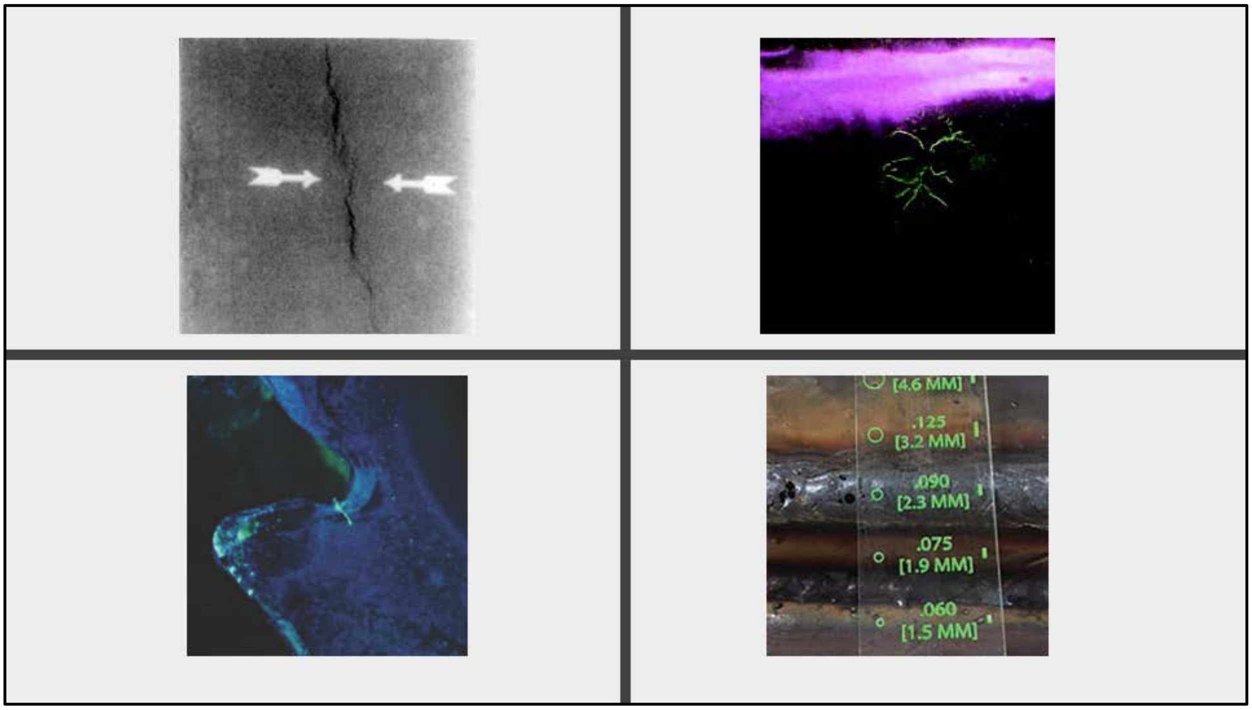
NDT methods and techniques produce indications of discontinuities.

These indications could be in the form of:
- bleedout of dye from a crack,
- magnetic particles fluorescing from a break in a part’s structure,
- dark spots along the radiograph of a weld revealing gas pores in the metal, or
- an ultrasonic-generated blip on a screen indicating a reflector of sound beneath the smooth surface of a part.



Now the job of the inspector or technician is to:

- determine the type of discontinuity, including whether it is relevant or nonrelevant to the functioning of the part or component,
- evaluate its severity if relevant, then
- decide if it is dangerous enough to warrant repairing or scrapping the part being inspected.



A defect is a discontinuity whose size, shape, orientation, or location makes it detrimental to the useful service life of a component, part, or product.

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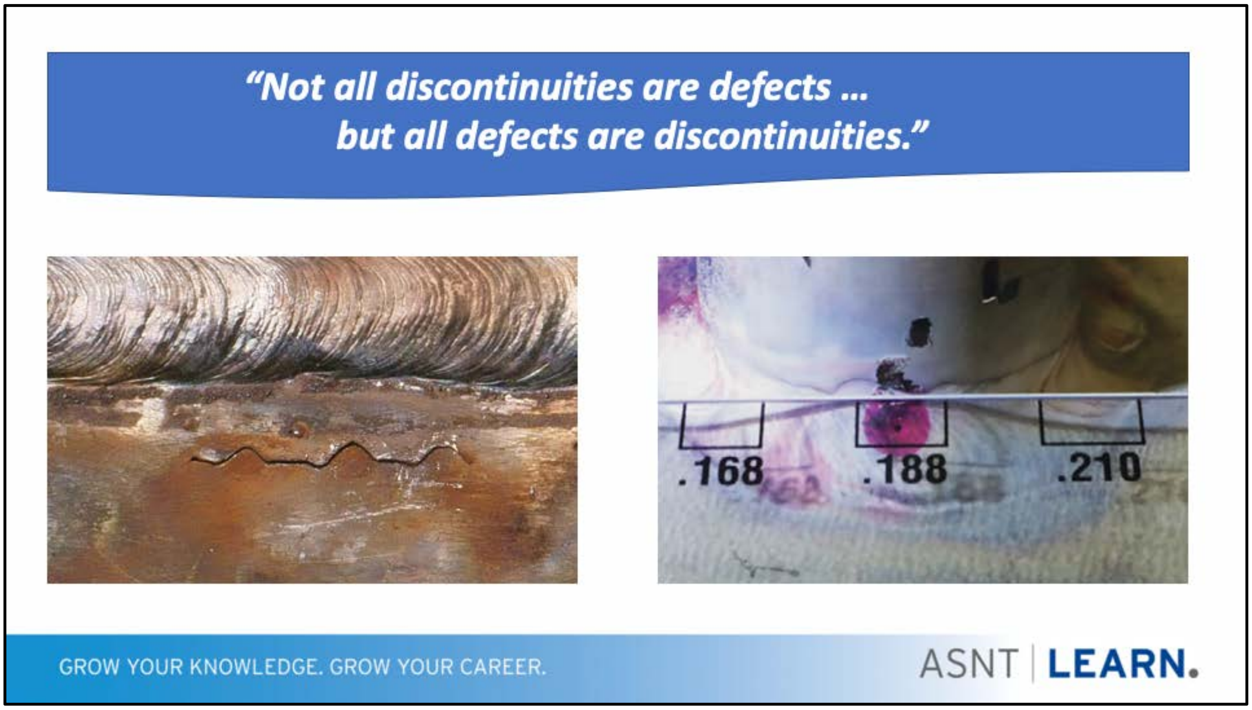
It doesn’t get much worse than the image of a turbine shown here.



From an engineering perspective, not all discontinuities are defects, but all defects are discontinuities.

Since the 1920s, the art of testing without destroying materials has developed from rudimentary means and methods such as the oil and whiting technique of inspecting railroad rails …

... to an indispensable, technologically advanced tool to apply in a variety of industries, including fabrication, construction, manufacturing, and maintenance.

Industry sectors where NDT is commonly practiced include:

Manufacturing – including raw material testing and fabrication as well as newer, more advanced techniques, such as composites and additive manufacturing.

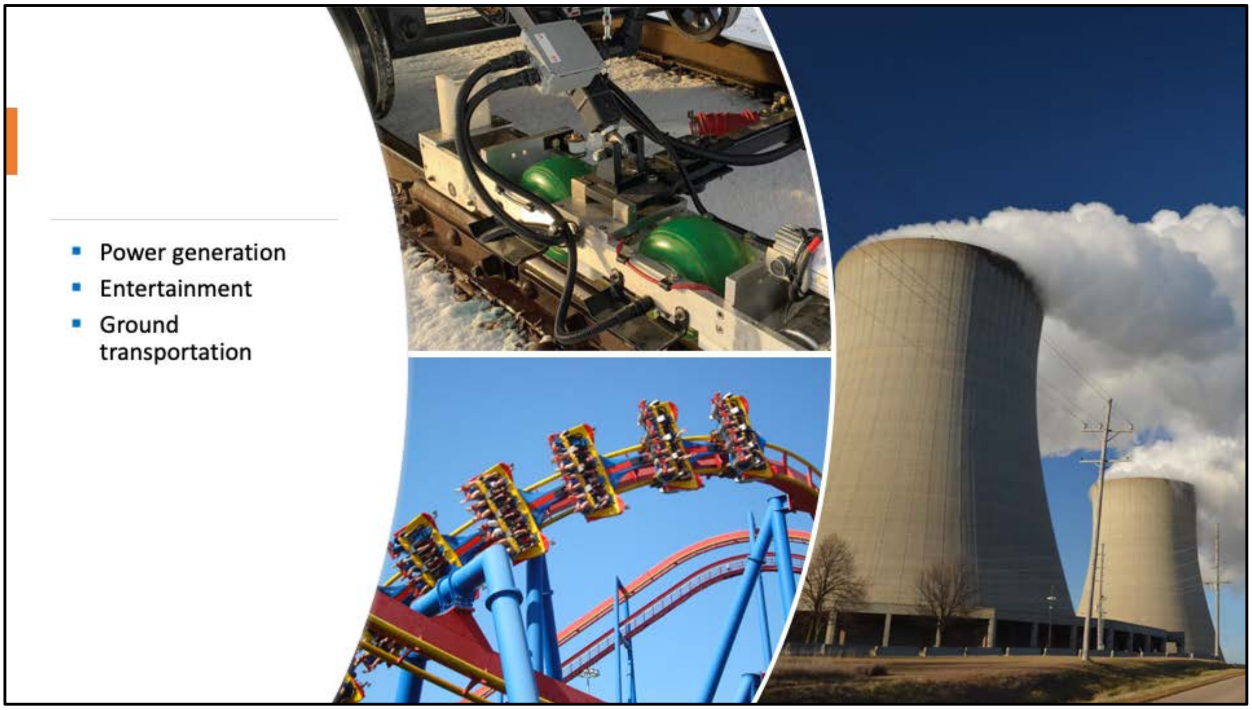
Chemical/petroleum – including the safety of gas transmission lines, storage vessels, and refineries.

Aerospace – NDT is critical for the in-service inspection of aircraft and reusable spacecraft.

Maritime – including the inspection of oil rigs, ships, and offshore drilling platforms.

Construction and infrastructure – NDT is routinely used to validate the quality of welded steel frames of buildings and concrete quality of highway infrastructure, including bridges and overpasses.

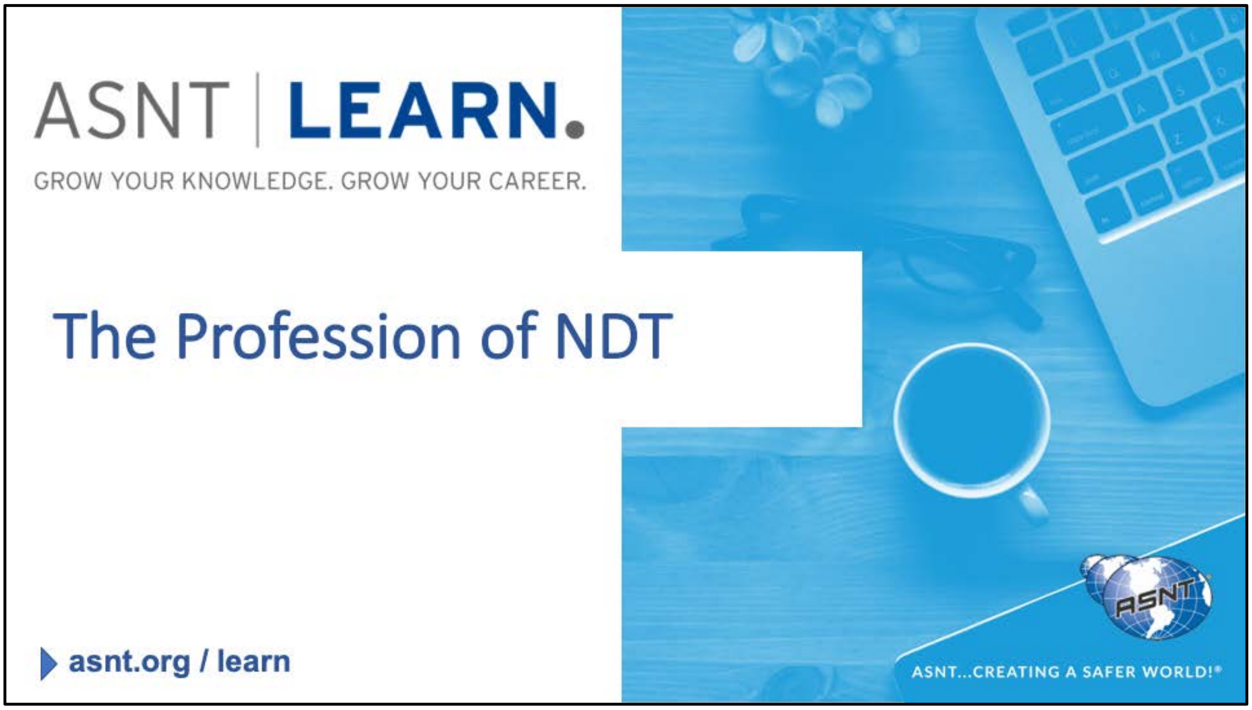
The military – to maintain weapons, validate ammunition quality, and test newly manufactured equipment.



Power generation – to keep power turbines running efficiently, whether powered by gas, nuclear fuel, wind, water, or steam.

Entertainment – in particular, theme park rides to ensure public safety.

Ground transportation – including railway rails and railcar wheels to keep trains running smoothly.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The Profession of NDT
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The profession of NDT encompasses a number of roles and responsibilities. Here are a few of the most common job titles …

Technicians and inspectors – perform the hands-on inspection of parts and components.

NDT Level III personnel – develop inspection procedures, supervise technicians and inspectors, as well as provide access to training and qualifying examinations.

Quality assurance managers – integrate quality control into effective business management models and techniques to improve productivity and ensure workplace and consumer safety.

Instructors and trainers – whether on the job or in the classroom, provide knowledge and expertise in helping NDT personnel advance in their careers and meet training requirements for qualification and certification.

Researchers – develop emerging technologies in NDT to increase sensitivity of an inspection technique and improve the probability of detection of relevant discontinuities.

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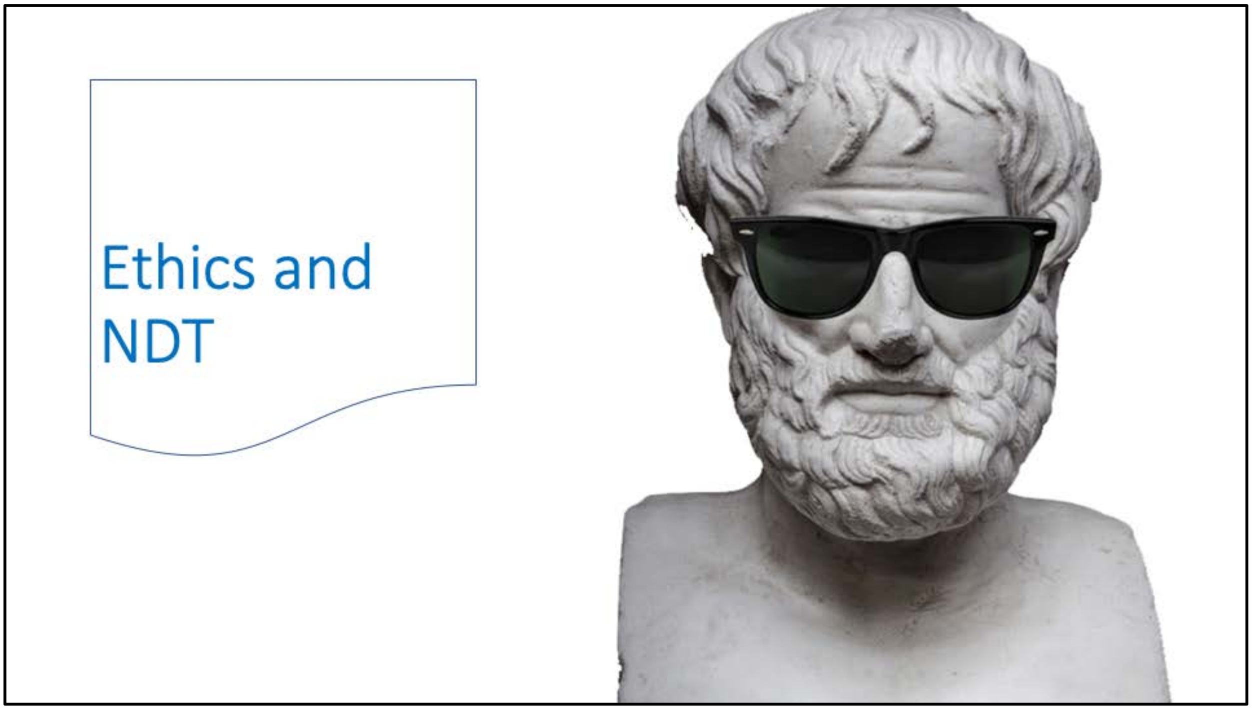
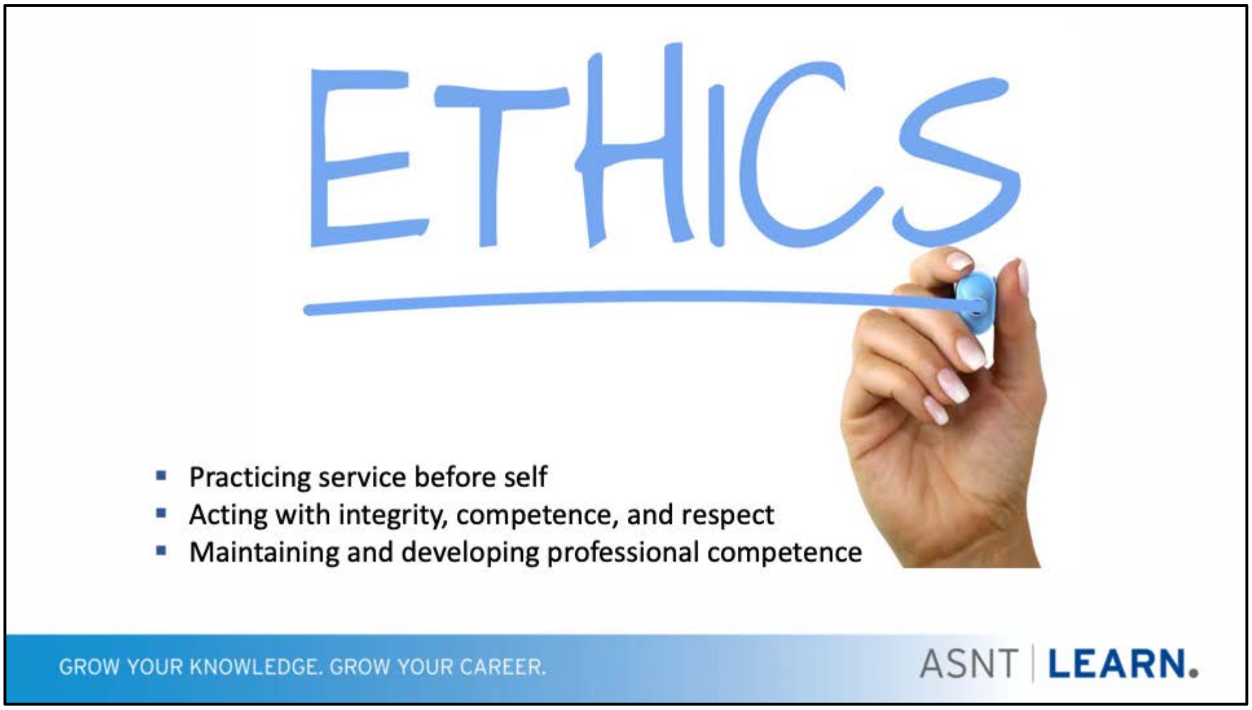
Last but not least ...

Engineers – use NDT data to monitor the risk factors associated with changes in manufacturing processes and designs.

And now as NDT goes digital, IT and software professionals and database administrators are also in demand to assist with digital implementation and data acquisition, dissemination, and archiving.



The study of ethical codes of conduct goes back at least as far as the ancient Greeks, but ethics is still a vital aspect of individual and organizational relationships in modern times.



NDT professionals abide by a code of ethics to achieve and sustain moral benchmarks that typically include:

- Practicing service before self.
- Acting with integrity, competence, and respect.
- Maintaining and developing professional competence.

The success of NDT inspection programs ultimately rests on the NDT inspector conducting each specific test.




Where do NDT professionals perform their functions?

Where does the NDT professional perform their functions?

- In the field – on airplane wings, for instance.
- Inside storage tanks.
- Along pipelines.
- On top of or beneath bridges.
- Under water.

Where else does NDT take place?

Where else can you find NDT practitioners at work?

- In the shop – or on the factory floor.
- In the air – with rope access or hydraulic lifts, or with drones.
- Remotely – with robot crawlers.
- Behind a control panel, running and monitoring automated inspection equipment.

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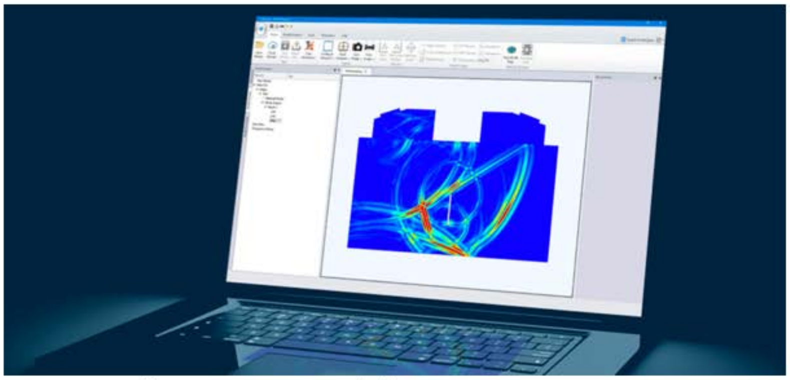
Digitalization of NDT



Olympus, https://www.olympus-ims.com/en/

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Digitalization of NDT inspection includes advancements in digital imaging and sophisticated computer displays of data, and even the use of virtual reality to simulate test environments and 3D printing to produce copies or digital twins of specimens.

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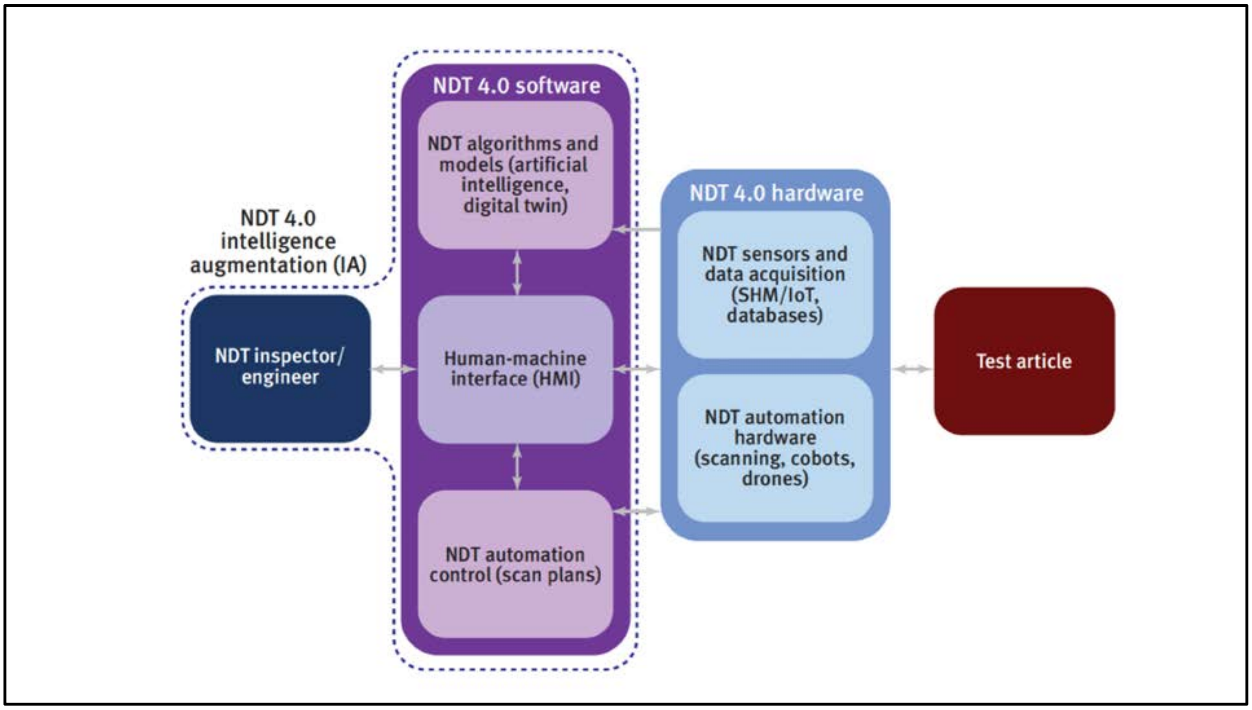
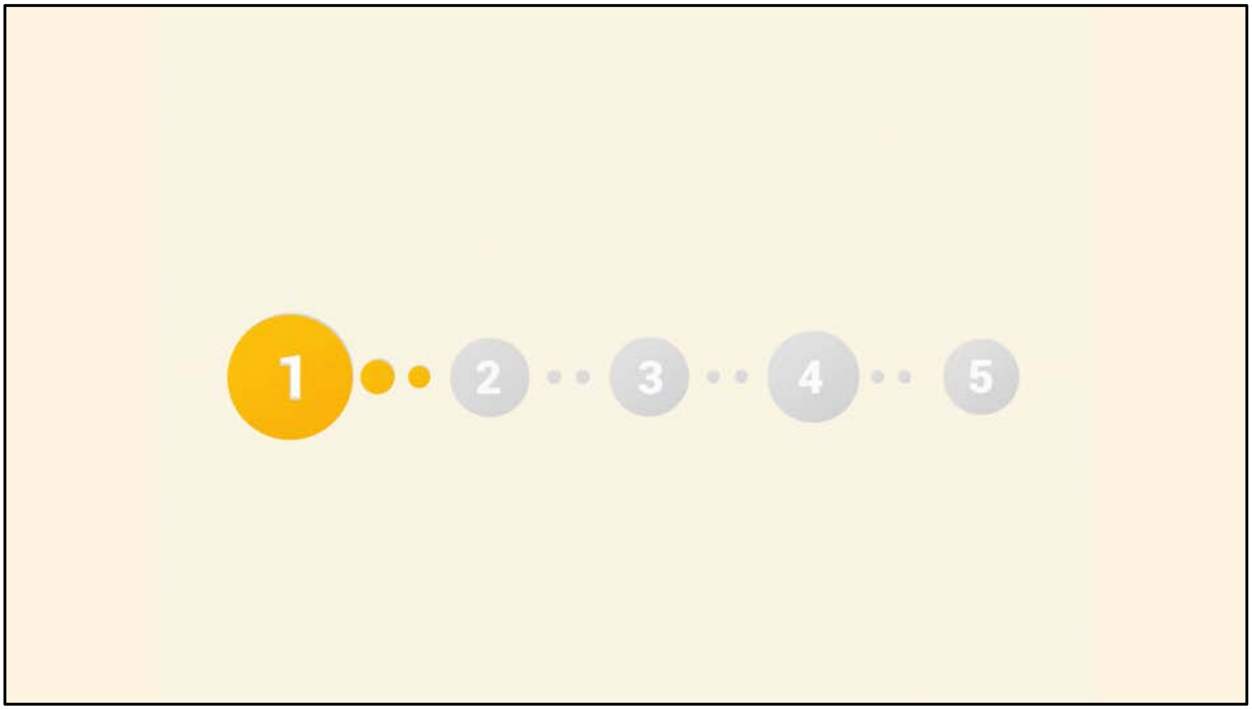


This is due to advancements in Cloud computing and storage, the Internet of things, and the interconnectedness of electronic and computerized devices using machine learning and artificial intelligence that are collectively referred to as NDT or NDE 4.0.

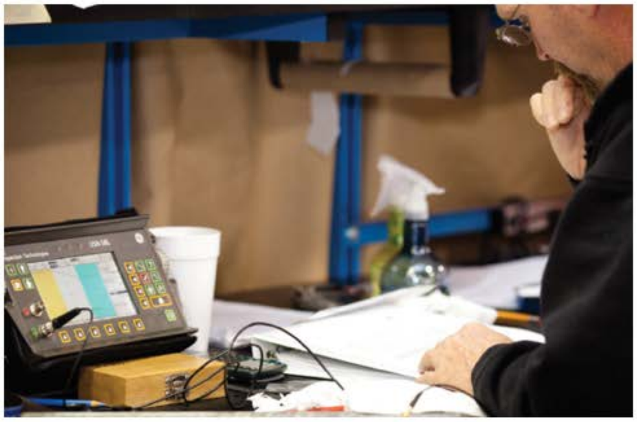
Some NDT professionals have suggested that inspections of the future may be done from the comfort of your office or home.

Well, maybe not this much comfort!



There are five steps in the qualification process for NDT certification.

1. **Review the employer's written practice.**



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First, the candidate should review the employer's written practice to determine qualification and certification requirements.

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1. Review the employer's written practice.
2. **Undergo the required number of training hours.**

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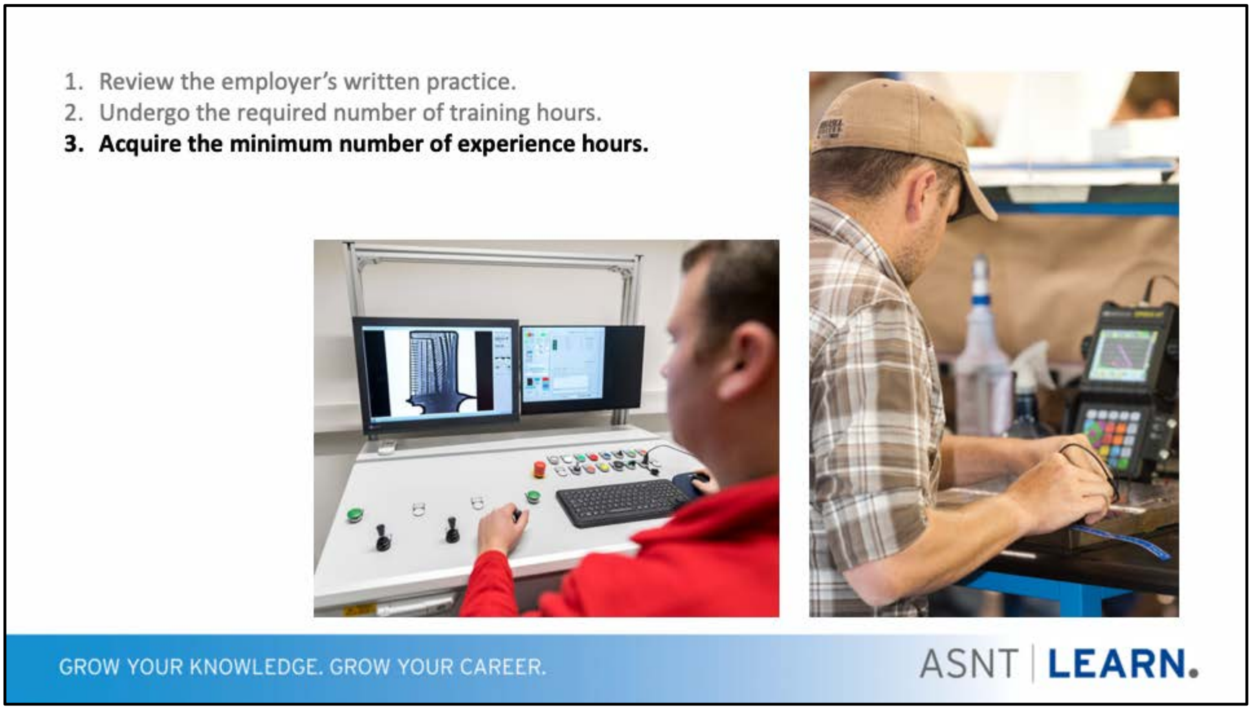
Next, the candidate must undergo the proper number of training hours for the method and level.



Then the candidate must acquire the minimum number of experience hours in NDT and in the method.

1. Review the employer's written practice.
2. Undergo the required number of training hours.
3. Acquire the minimum number of experience hours.
4. **Take a number of examinations.**

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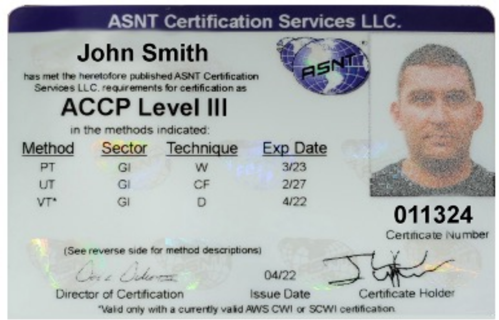
To be fully qualified, the candidate must score well on a number of examinations: computer-based or written tests, as well as practical application-based demonstrations.

1. Review the employer's written practice.
2. Undergo the required number of training hours.
3. Acquire the minimum number of experience hours.
4. Take a number of examinations.
5. **Receive documentation of certification.**



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Certification occurs when the candidate receives a validated wallet card and/or certificate attesting to successful completion of the qualification process.

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Common and Accessory NDT Methods

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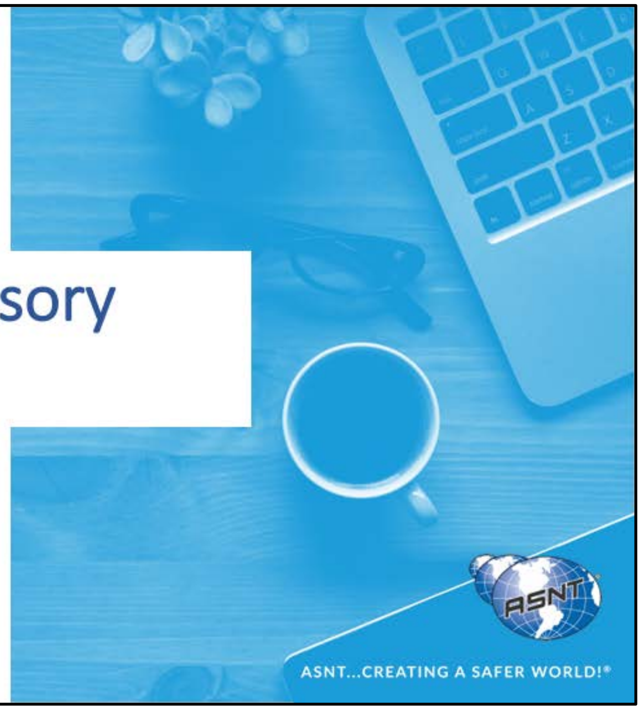
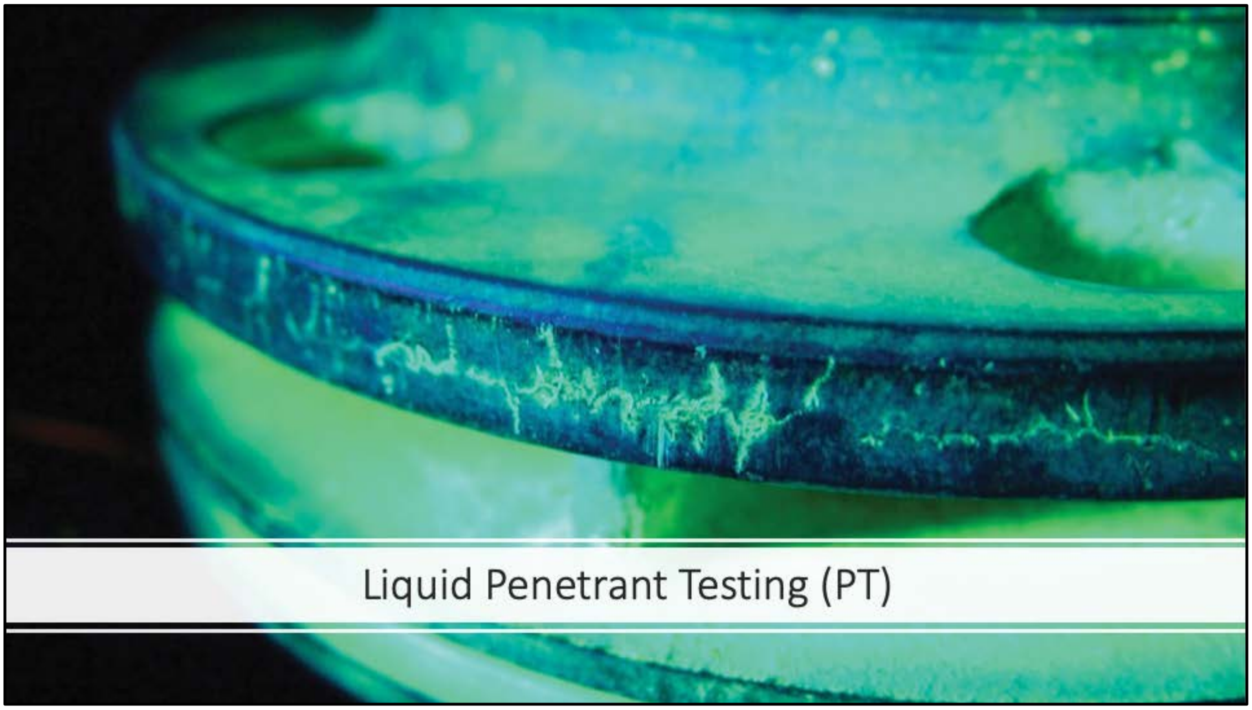
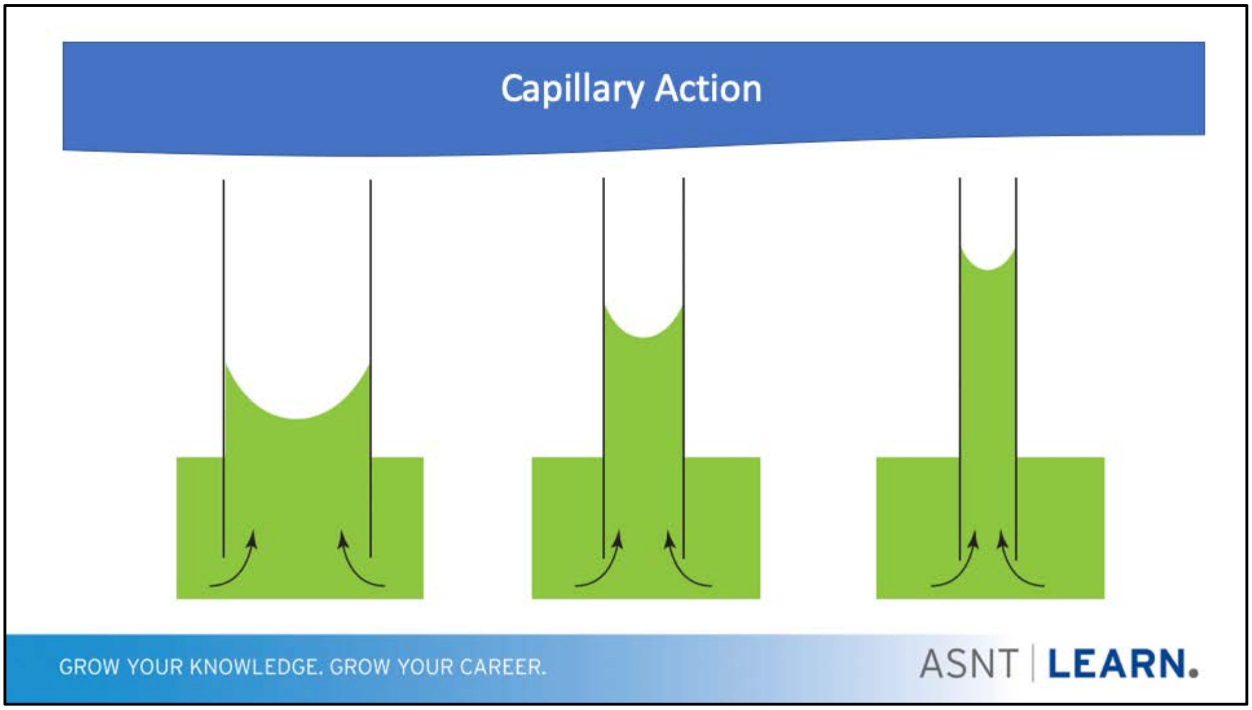



Liquid Penetrant Testing (PT)



You may recall grade-school science experiments demonstrating capillary action, the gravity-defying property that allows liquids to climb up a narrow tube like a straw ...

... or porous material like a paper towel.

Liquid penetrant testing relies on capillary action, surface tension, and wetting ability.

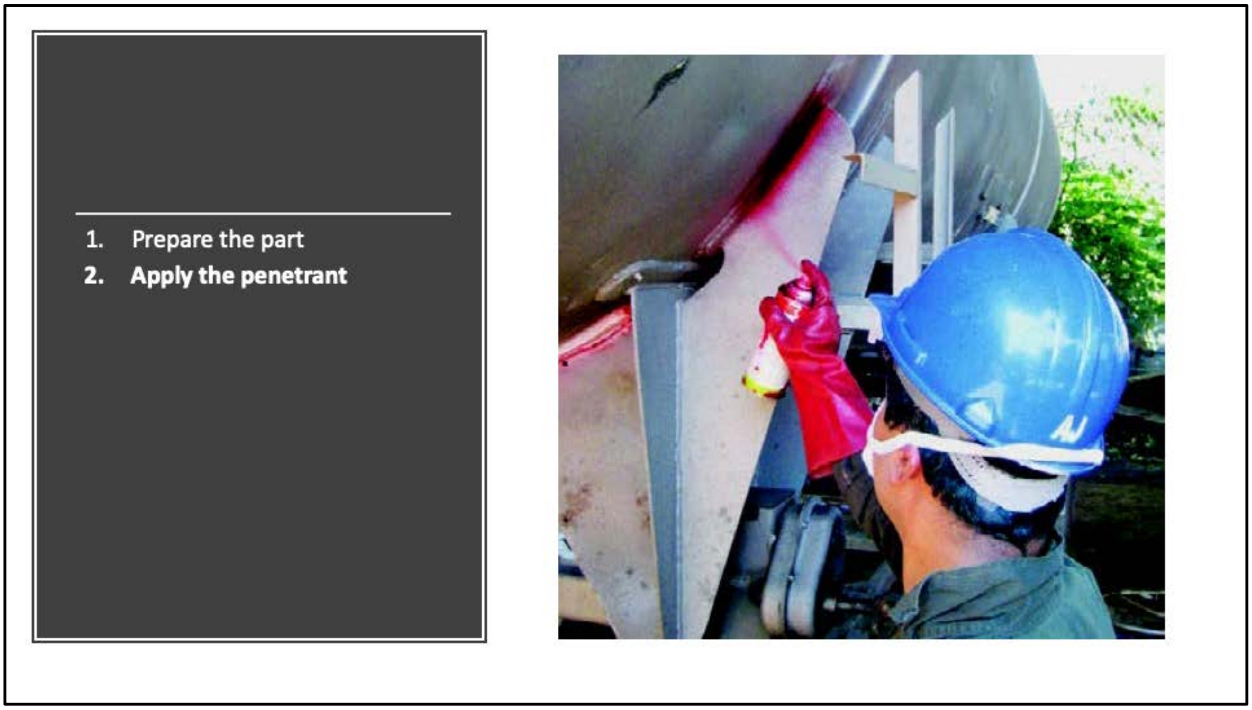
Liquid penetrant testing relies on capillary action, along with surface tension and wetting ability, to create indications from surface-breaking cracks and pores, even from the bottom surface of a test part.

Liquid Penetrant Steps

The steps of a liquid penetrant test follow a fairly straightforward procedure:

1. **Prepare the part**

First, prepare and clean the surface of the part to be tested.



Next, apply the liquid penetrant and allow sufficient dwell time for the penetrant to seep into cracks and pores.

1. Prepare the part
2. Apply the penetrant
3. **Remove excess penetrant**

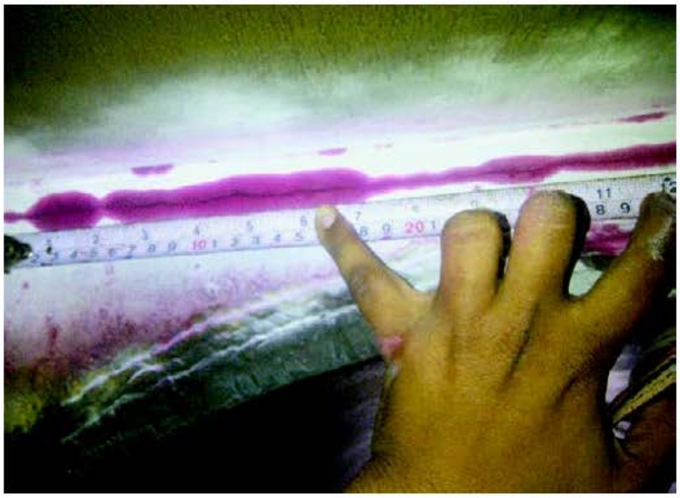
Now remove the excess penetrant.

1. Prepare the part
2. Apply the penetrant
3. Remove excess penetrant
4. **Apply the developer**

The next step is to apply the developer and, once again, allow a sufficient dwell time.

Another step is to dry the part surface (this may be done before or after application of the developer or not at all depending on the technique).

1. Prepare the part
2. Apply the penetrant
3. Remove excess penetrant
4. Apply the developer
5. Dry the part surface
6. **Inspect the part**



Lastly, inspect and evaluate any indications before post-cleaning the part and returning it to service.

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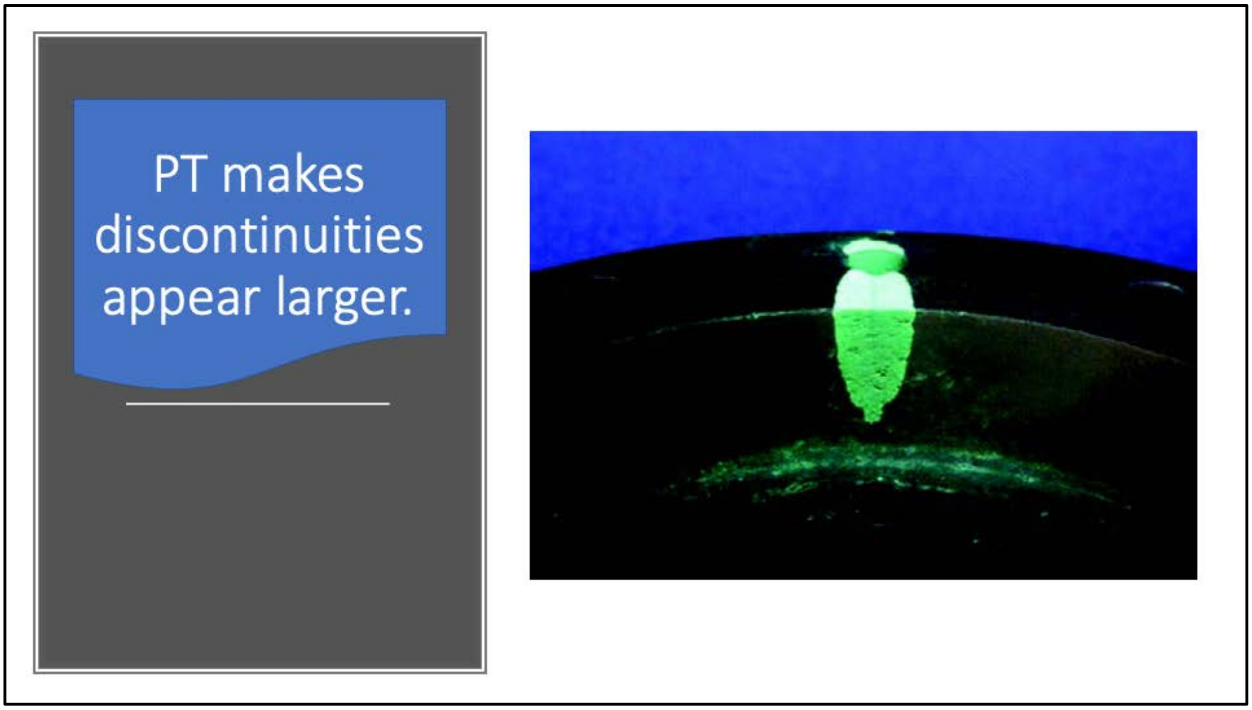
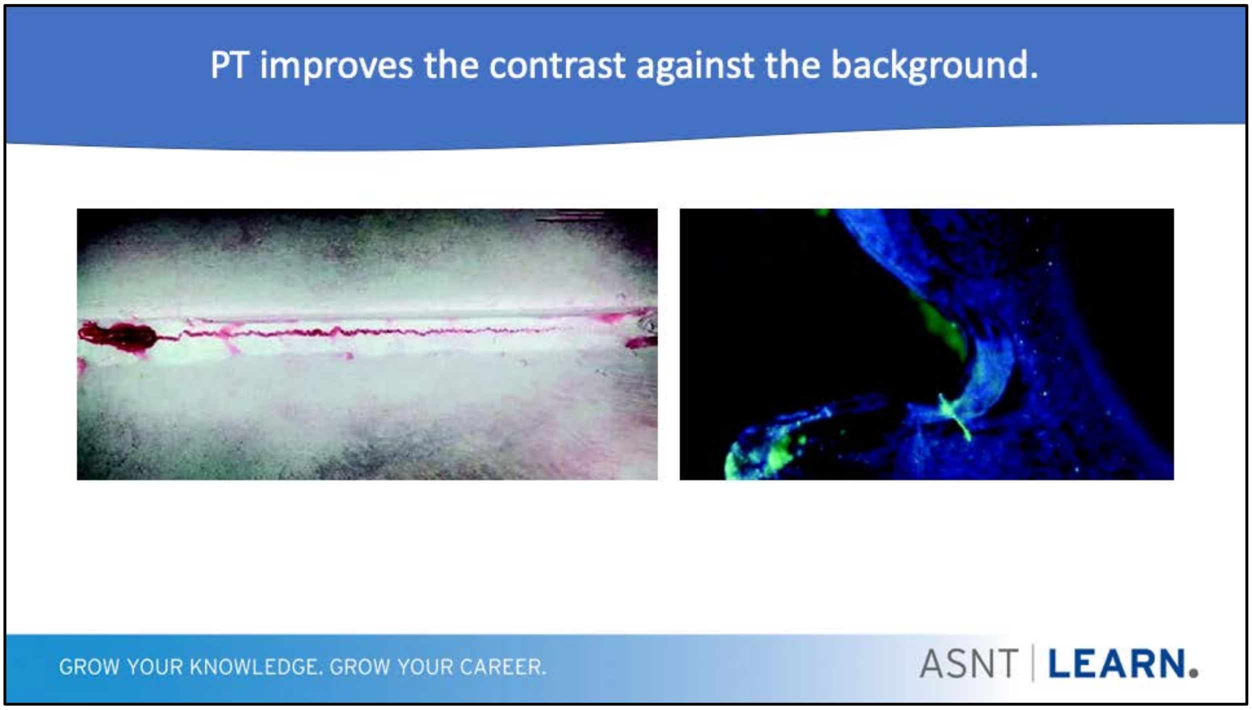
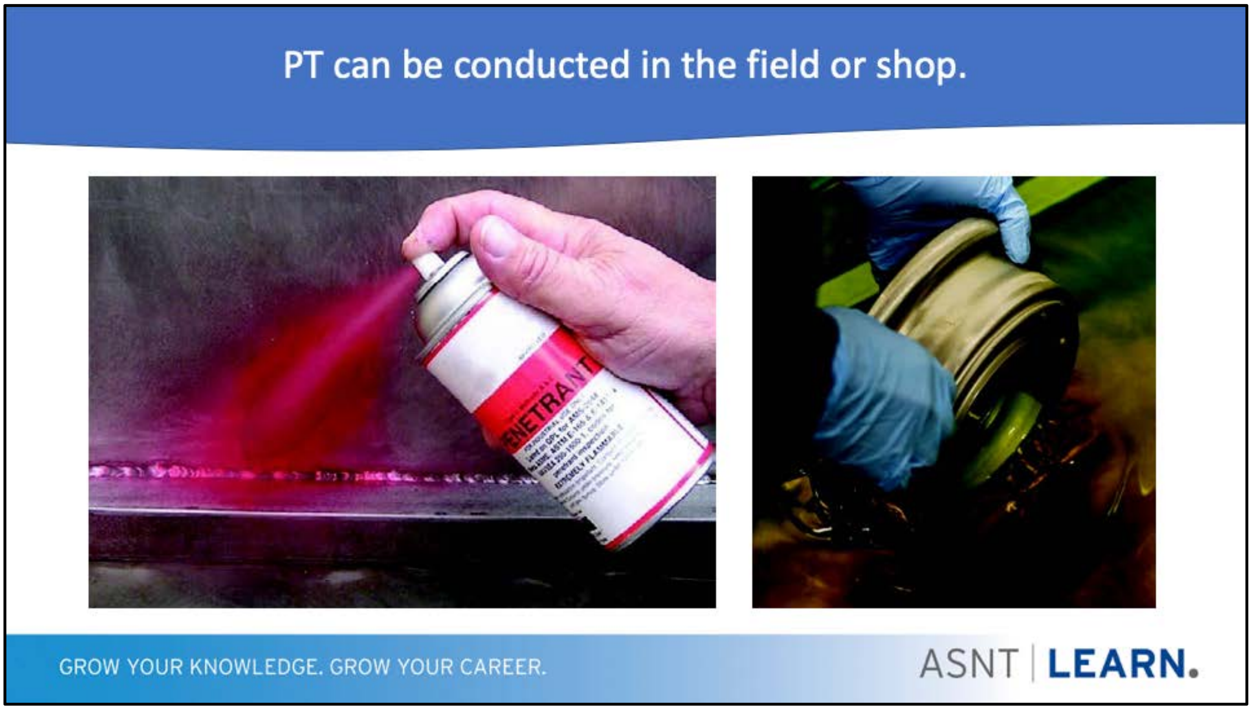


Making discontinuities more visually apparent is the basis of the PT method.



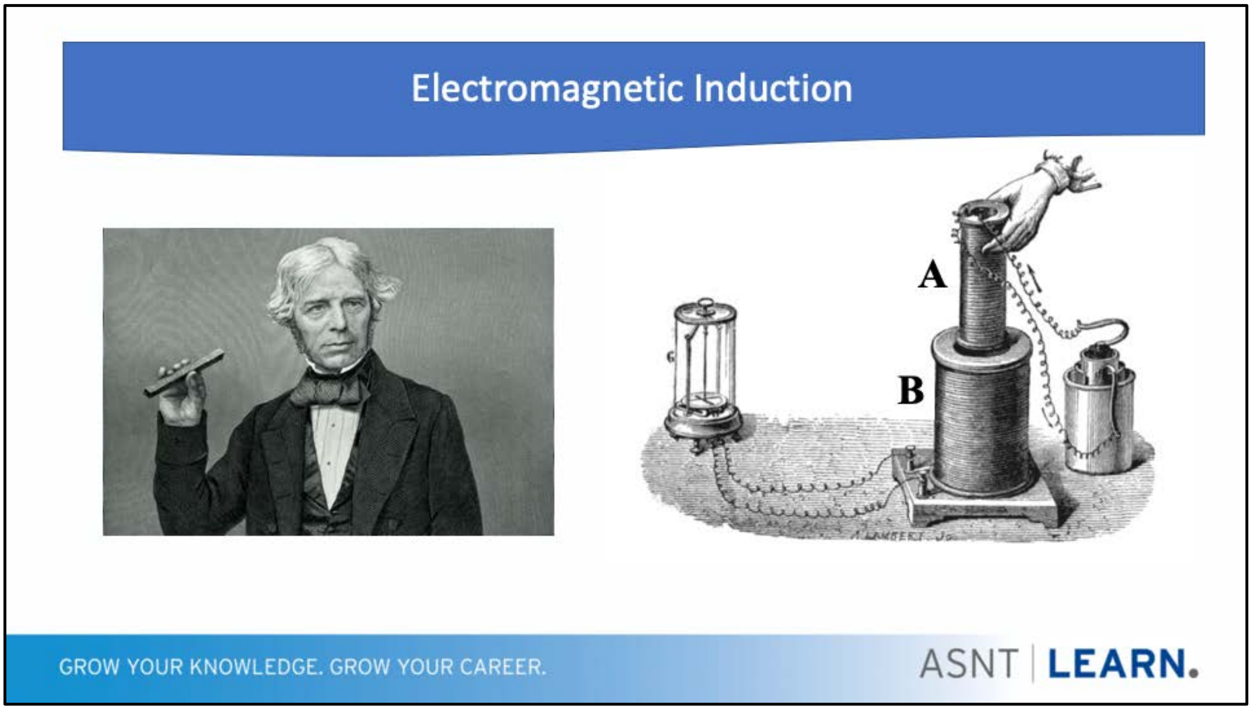
But it also provides a means to improve the contrast with the use of visible or fluorescent dyes.



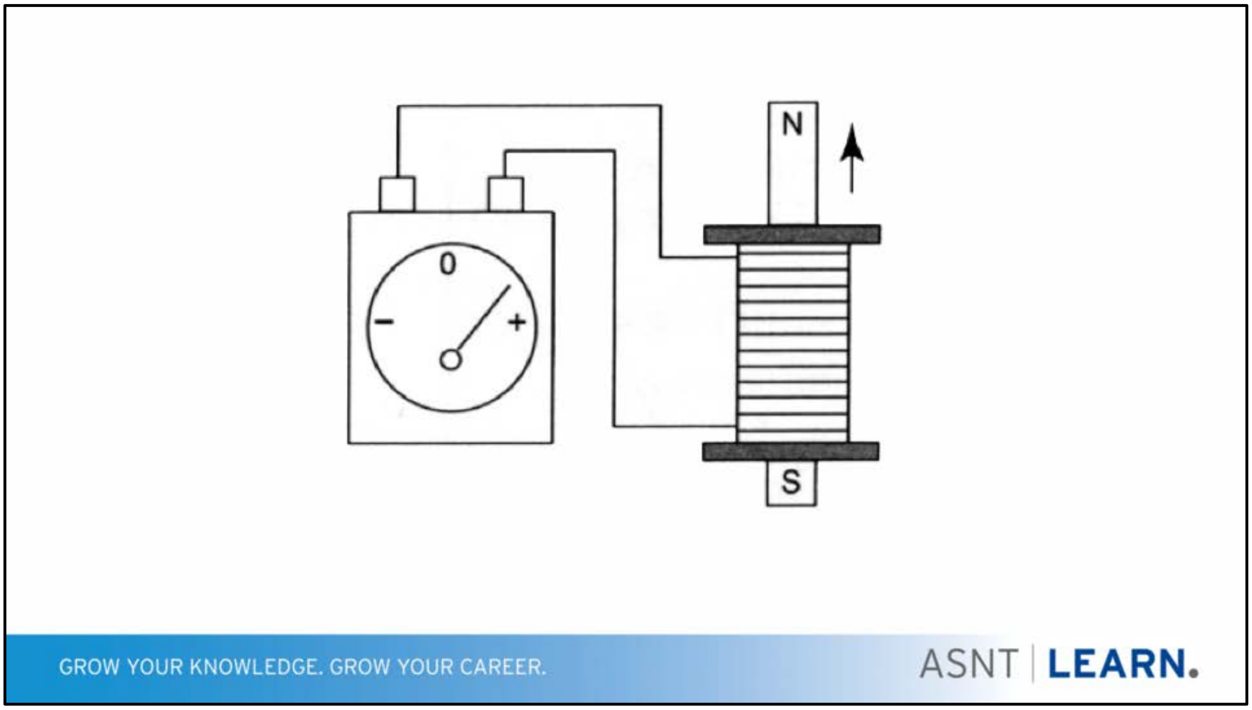
A versatile method, PT may be conducted in the field or the factory floor.

Or PT may be performed in a penetrant processing center with multiple semi- or fully automated stages.

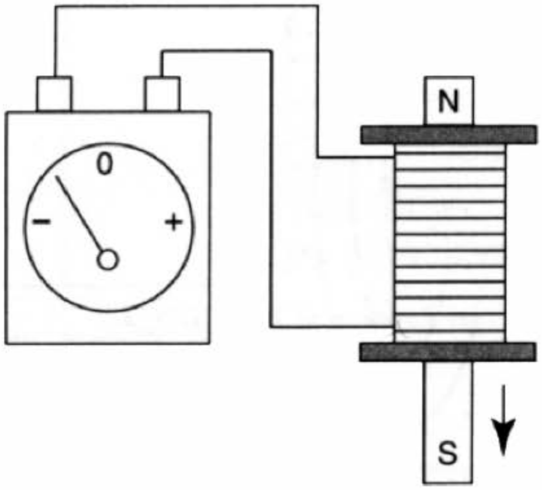
Electromagnetic Testing (ET)



Electromagnetic testing relies on the principle of electromagnetic induction, discovered by Michael Farraday in 1831. Farraday demonstrated the relationship between electricity and magnetism by moving a small coil of wire (A) hooked up to a battery within a larger coil (B).



As the small coil—or magnet, as shown in this diagram—is moved in and out of the larger coil, the magnetic flux in the larger coil changes, inducing an electric current of its own, as measured on a galvanometer.



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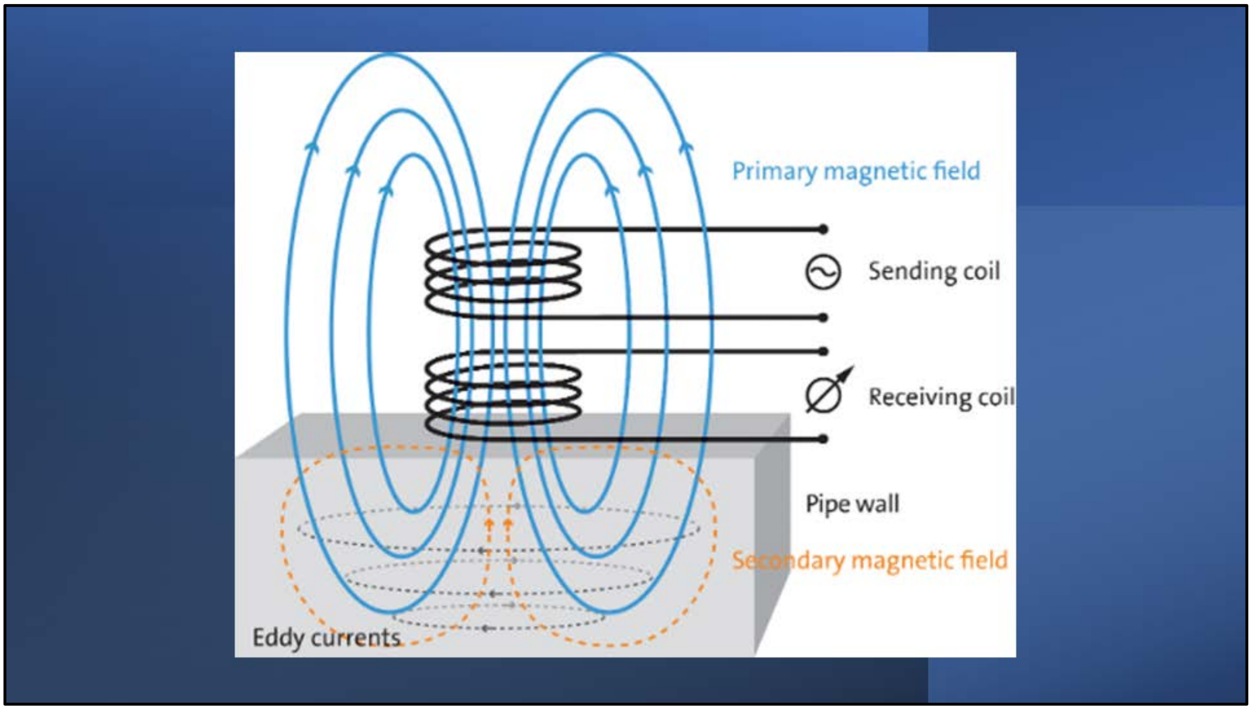
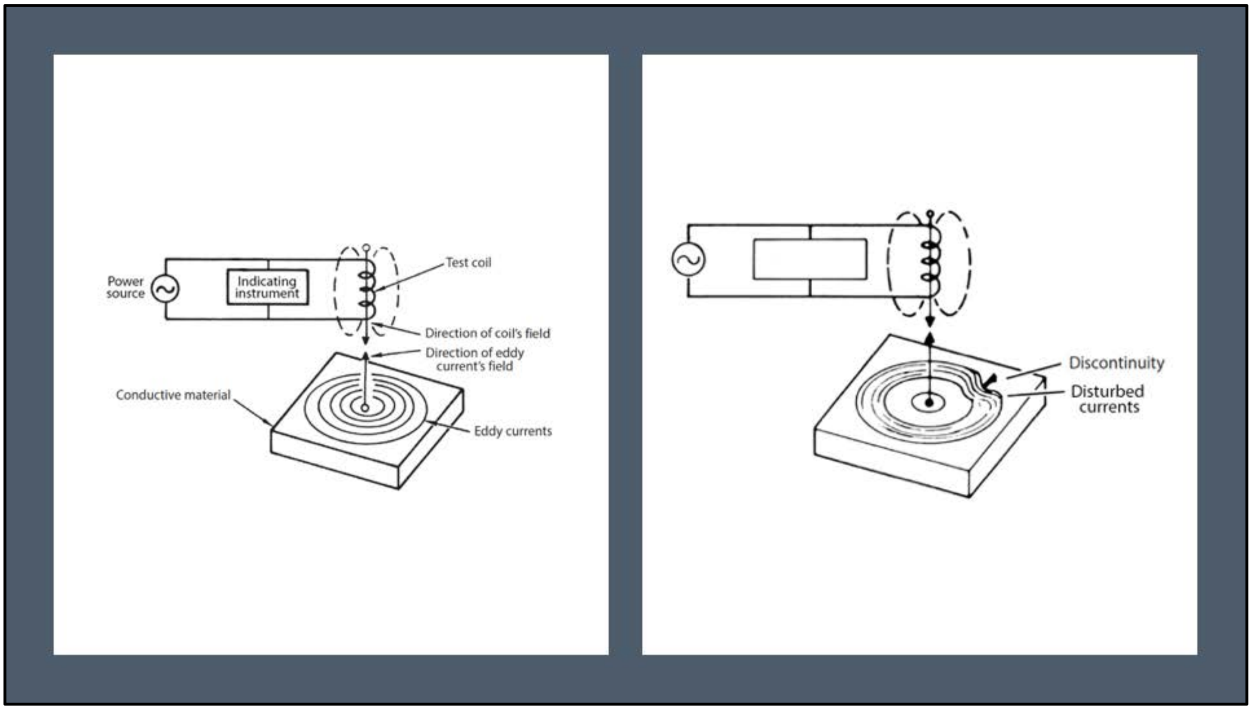
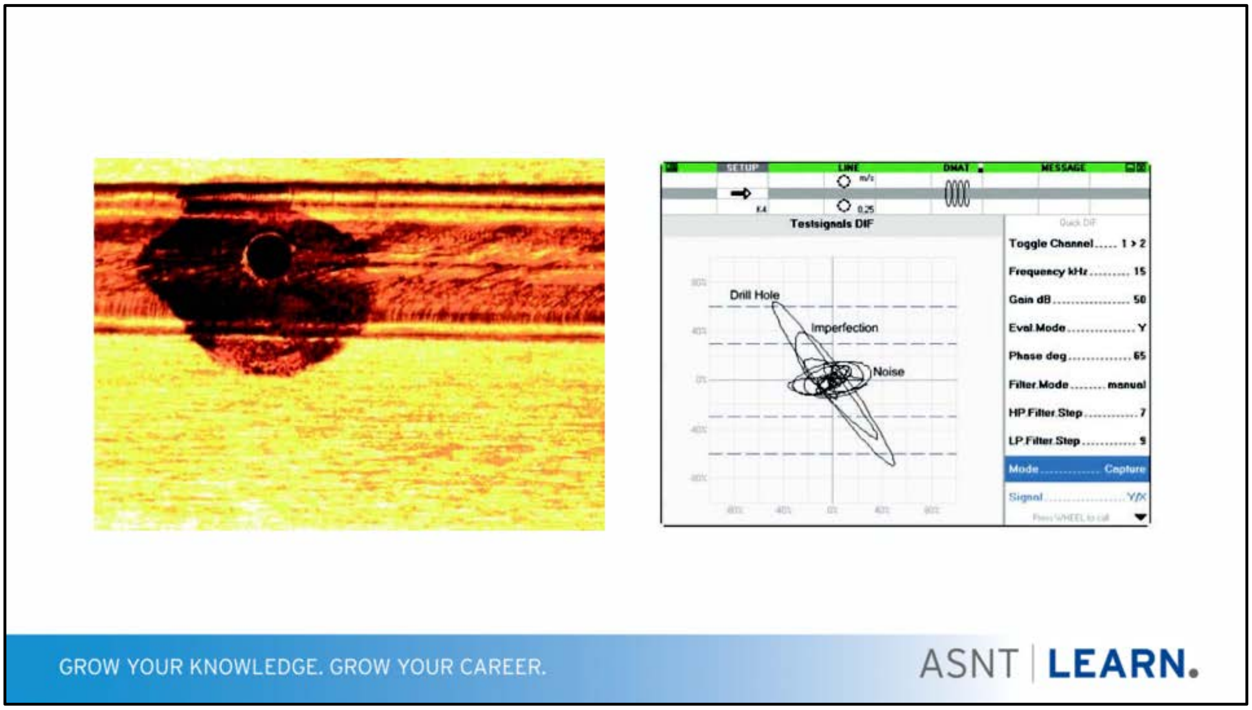
If you are into nature walks, you may have noticed swirling eddy currents in a river or stream.



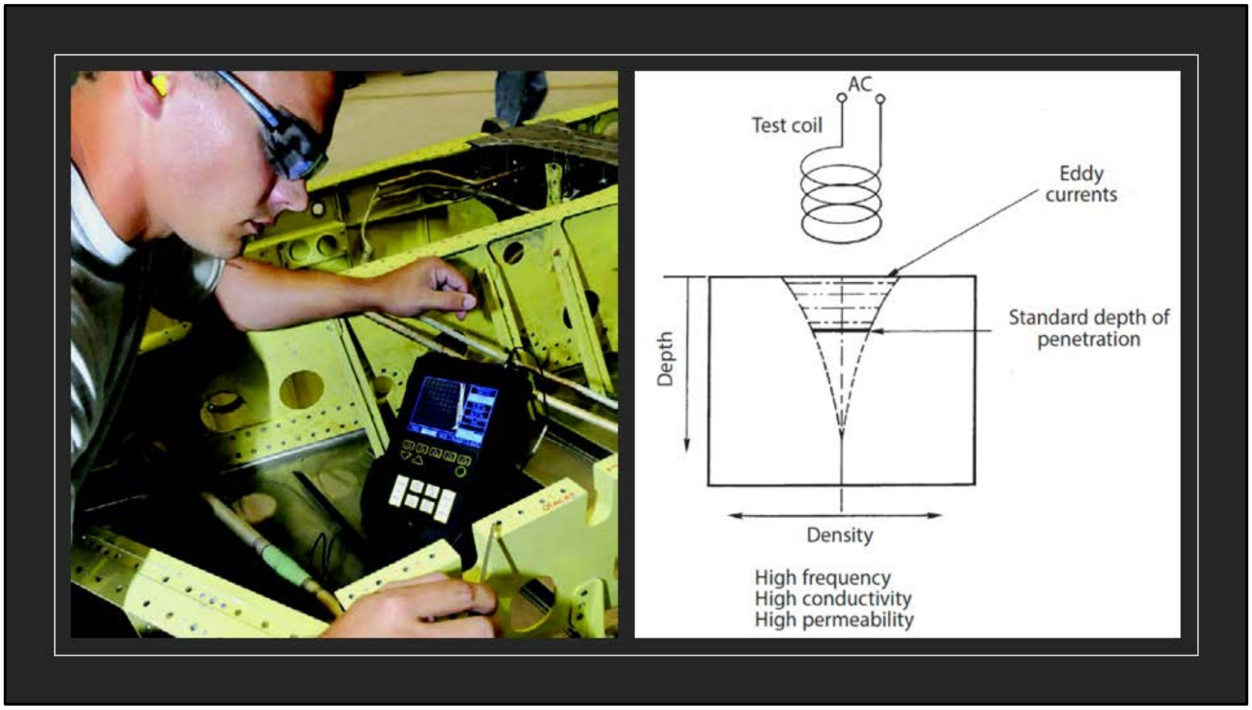
Electromagnetic testing produces something similar using electricity and magnetism. The method uses electrical coils to induce alternating magnetic fields into conductive metal which in turn generate circular funnel-shaped electrical currents, referred to as eddy currents, that produce a secondary magnetic field in opposition to the first.



The flow of eddy currents within the material is disturbed by such factors as cracks, metal loss, and corrosion. In short, electromagnetic testing instruments measure the degree of this disturbance.



Any impedance to the induced current due to an imperfection or discontinuity, such as a drilled hole, registers on a computer or an instrument display screen for interpretation as to the cause.



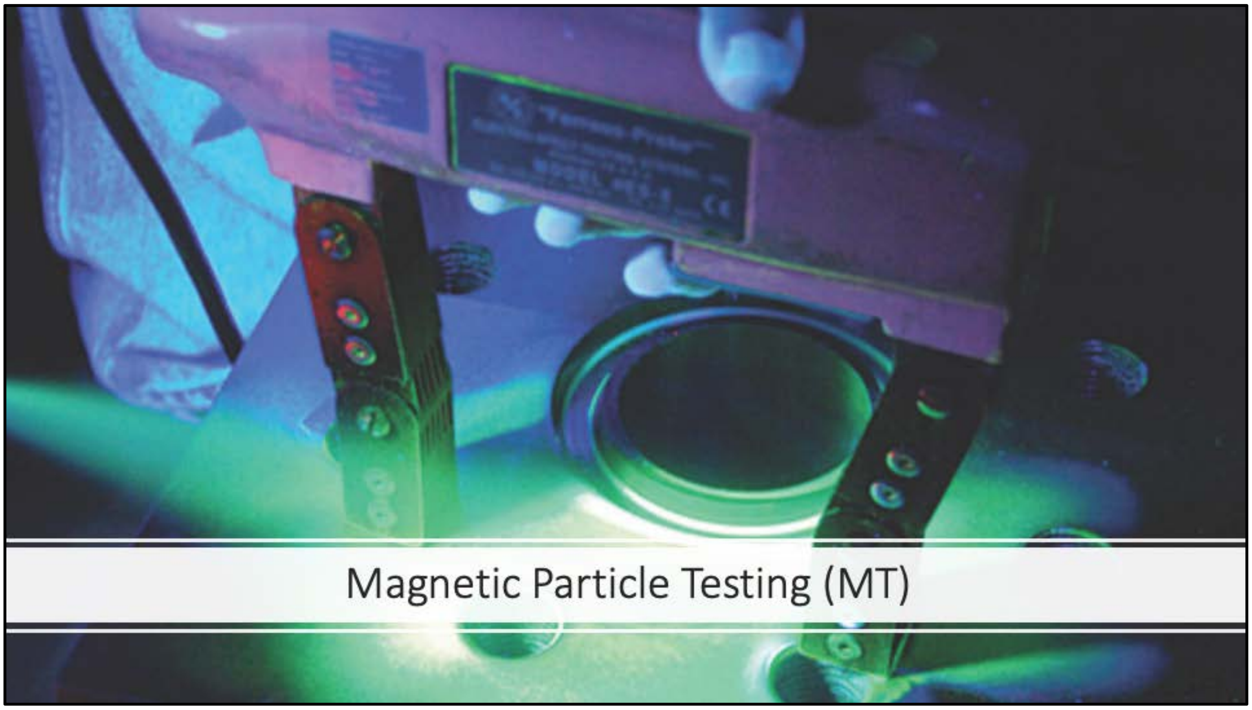
Because the strength of the field decreases with depth, electromagnetic testing is used for detecting surface and near-surface discontinuities, such as cracks.

Electromagnetic testing actually comprises three separate techniques:

Eddy current testing – is the most common ET technique for detecting localized discontinuities in a variety of conductive metals.

Alternating current field measurement – is useful for the detection and sizing of fatigue cracks in objects ranging from railheads to pressure vessels.

Remote field testing – can perform long-range inspections of thick-walled ferrous tubing.



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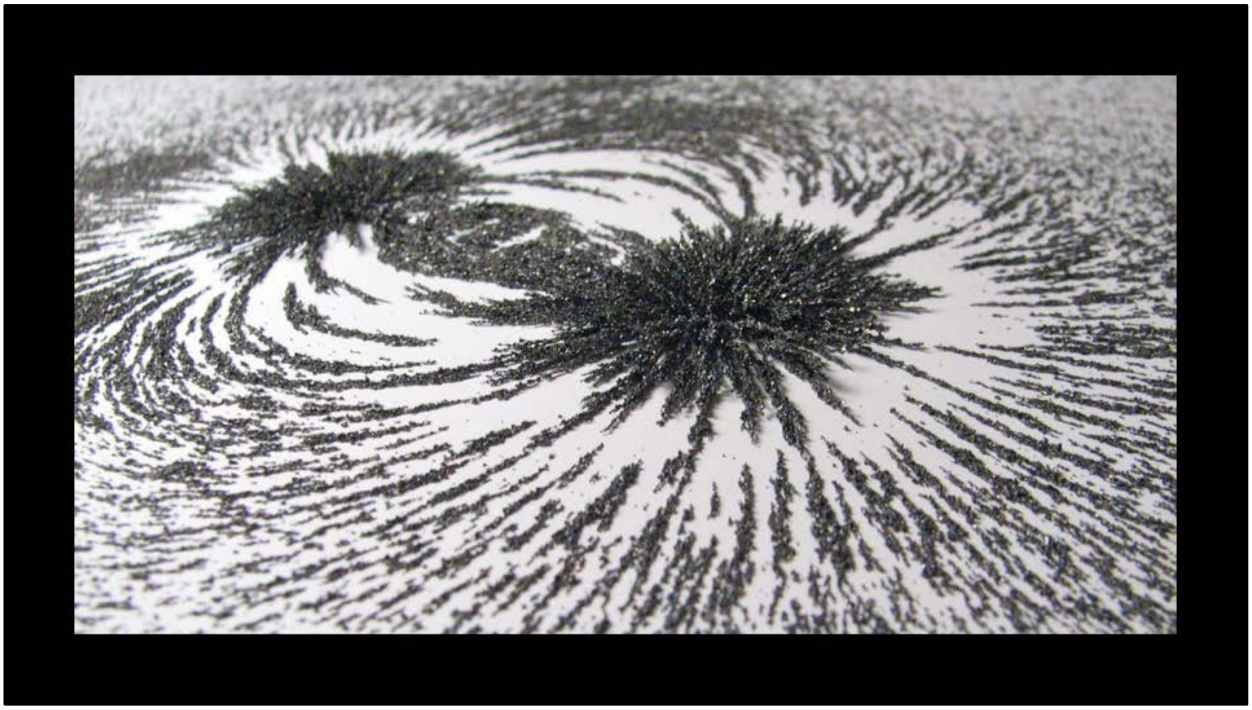
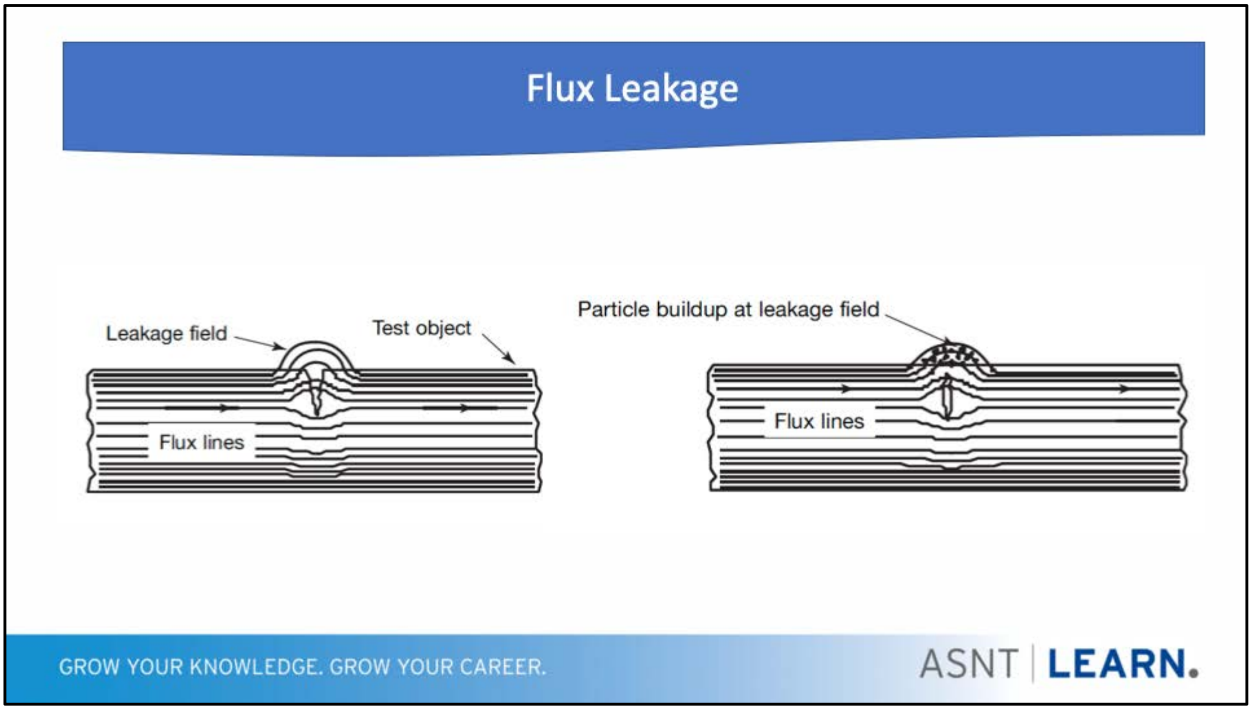
You might have had fun with magnets when you were a kid.

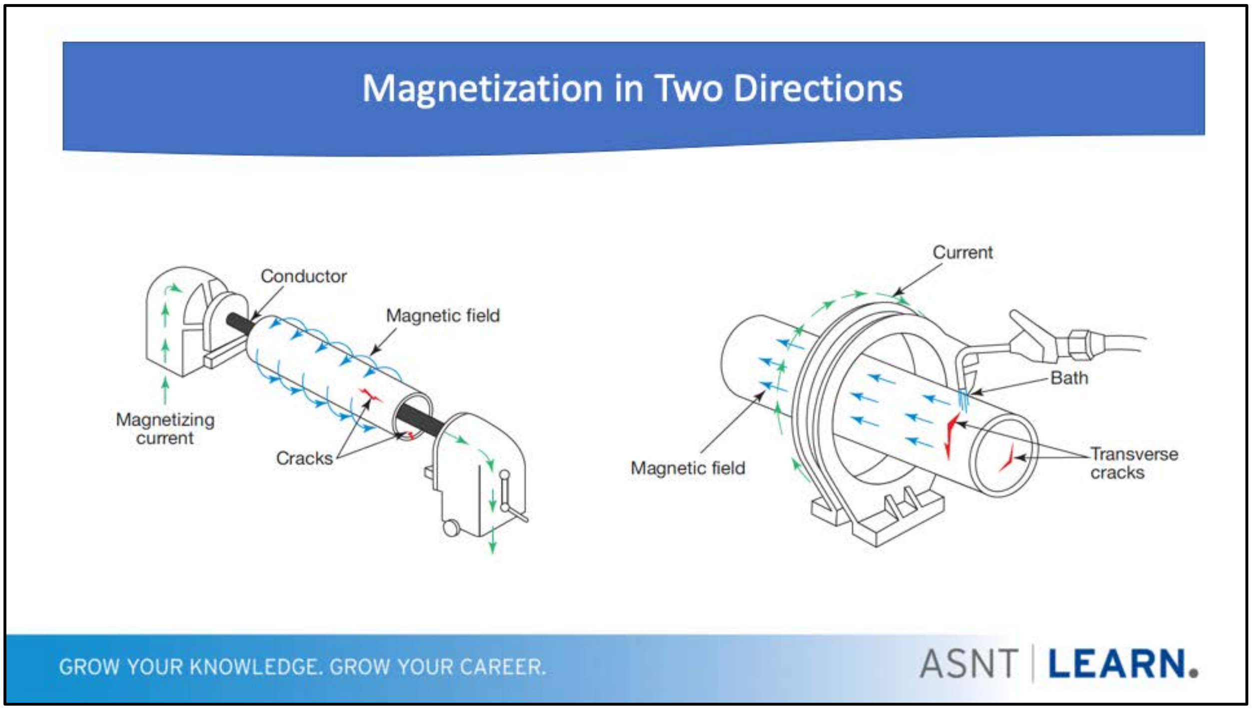


Remember the trick of sprinkling metallic filings around a bar magnet to see how the magnetic fields fan out from the poles?

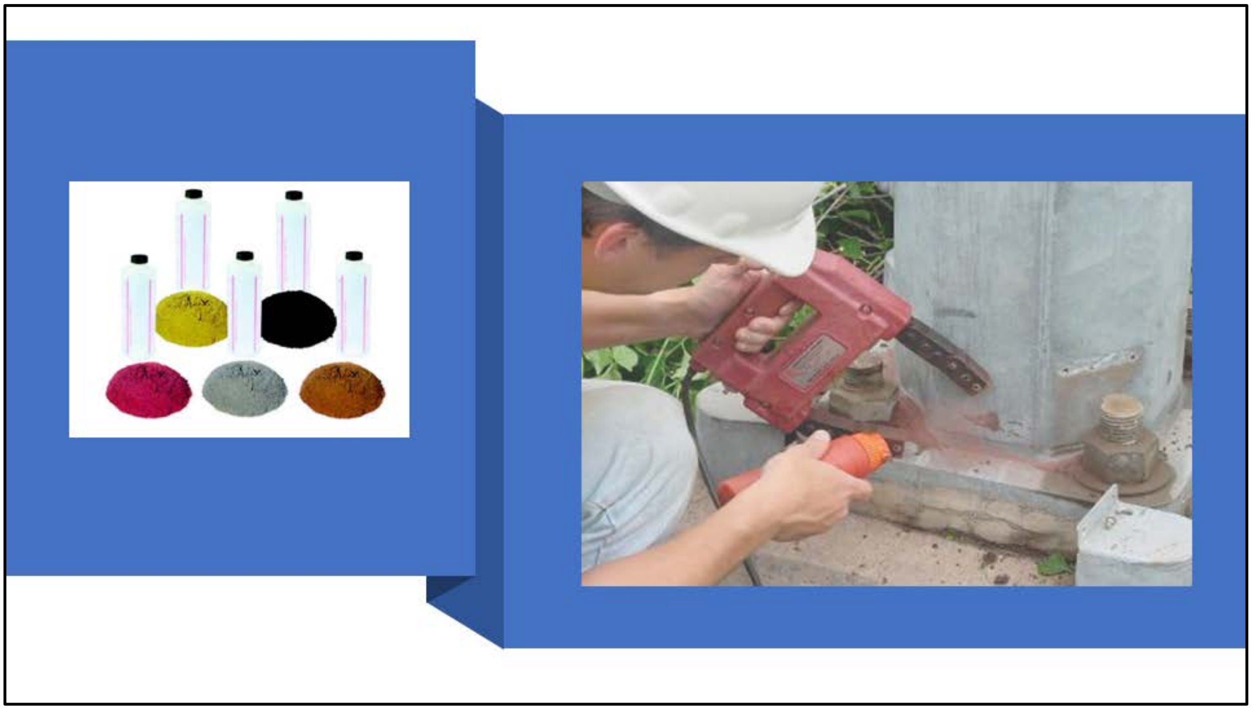


The same principles of magnetism are used with magnetic particle testing to detect surface and near-surface discontinuities that produce a break—or flux leakage—in the flow of magnetism through a part.

The one catch is that the part must be ferromagnetic—that is, capable of being magnetized or essentially turned into a magnet with a flow of electricity.



Typically, circular and longitudinal fields must be used in succession to maximize the opportunity to locate discontinuities, especially cracks, which are more readily detected when lying transverse to the flow of the magnetic field.



Dyed iron particles are applied that adhere to discontinuity locations on the part …

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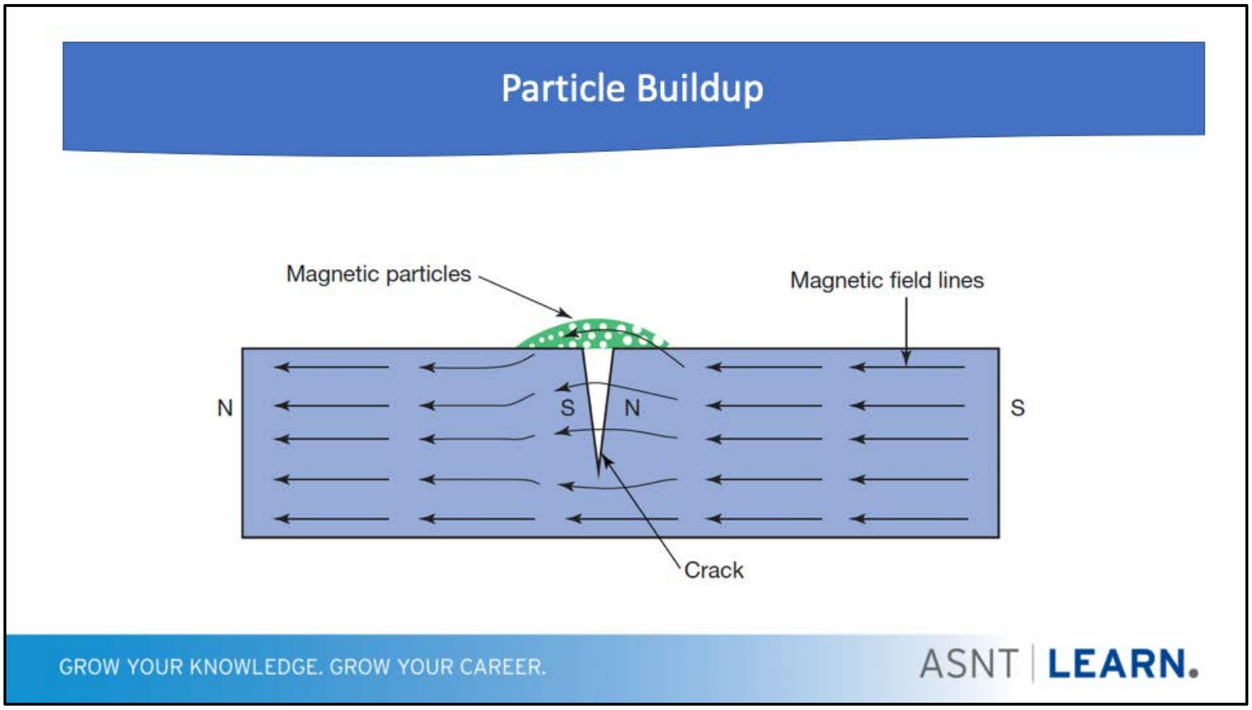

… to produce indications that are visible in white or ambient light or that fluoresce under ultraviolet light.

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Demagnetization

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Following inspection, the part typically must be demagnetized before being returned to service.


Magnetic Flux Leakage (MFL)

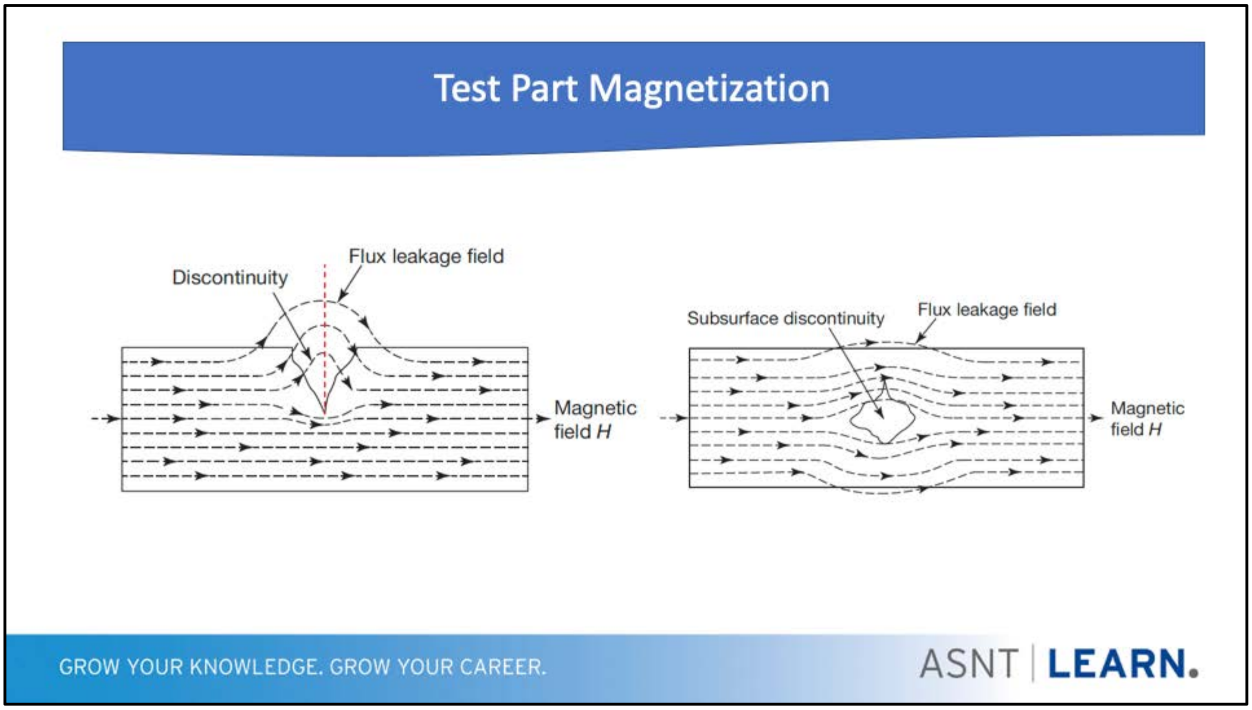
Can you imagine yourself confined inside a drained above-ground storage tank …

… essentially “vacuuming” the floor with a probe for hours at a time to detect corrosion?

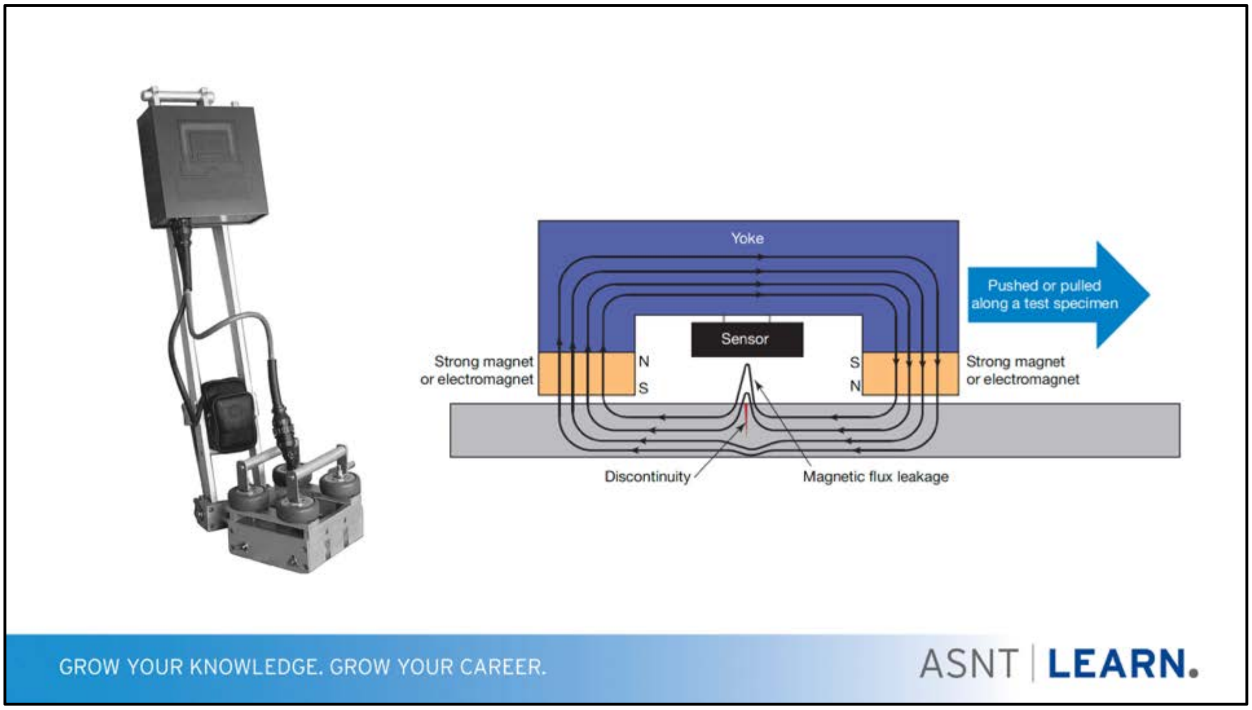
If so, magnetic flux leakage testing may be for you.

Eddyfi Technologies, https://www.eddyfi.com/en

If so, magnetic flux leakage testing may be for you. But it’s certainly not a job for the claustrophobic!

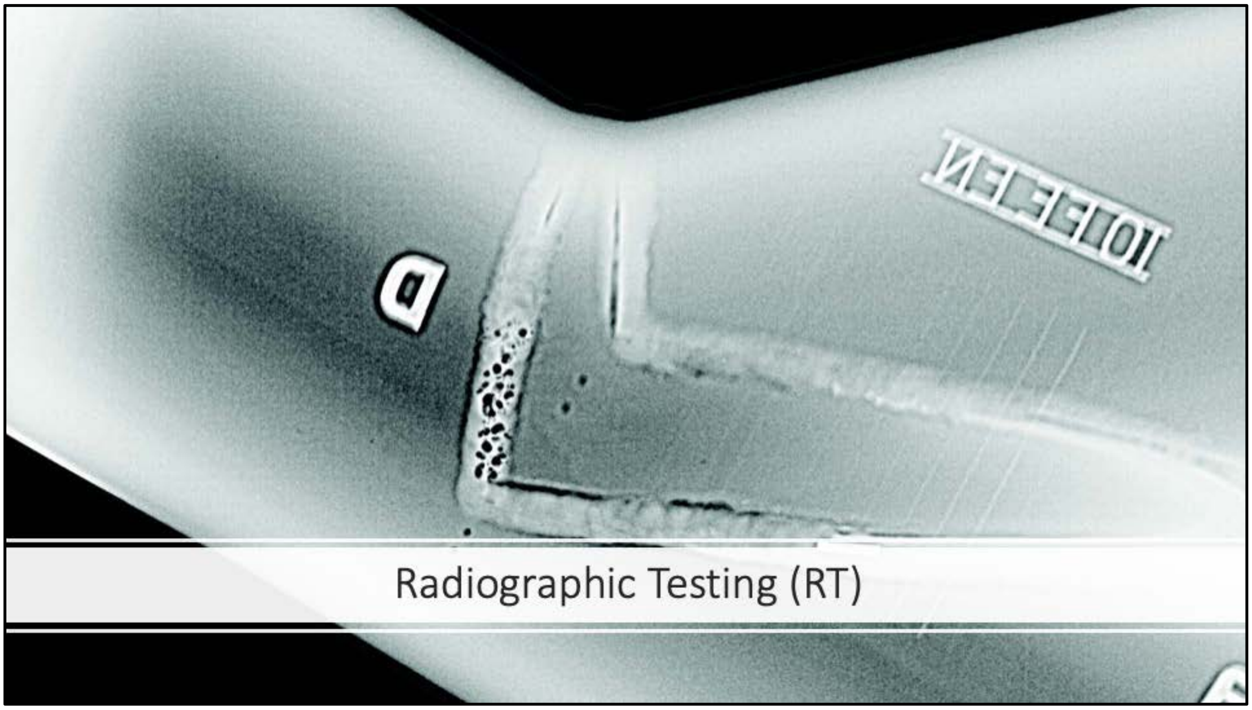


Similar to MT, the magnetic flux leakage testing method involves magnetization of the test object to seek out crack and corrosion-type discontinuities.



However, instead of using metallic particles to outline discontinuities, MFL uses a noncontact sensor to pick up magnetic flux leakage from discontinuities as an electronic signal.

Aside from corrosion beneath storage tank floors, magnetic flux leakage is used to detect cracks and corrosion in the walls of underground pipelines as well as discontinuities in oil well pipe casings, wire ropes used in suspension bridges, and other ferrous steel objects.



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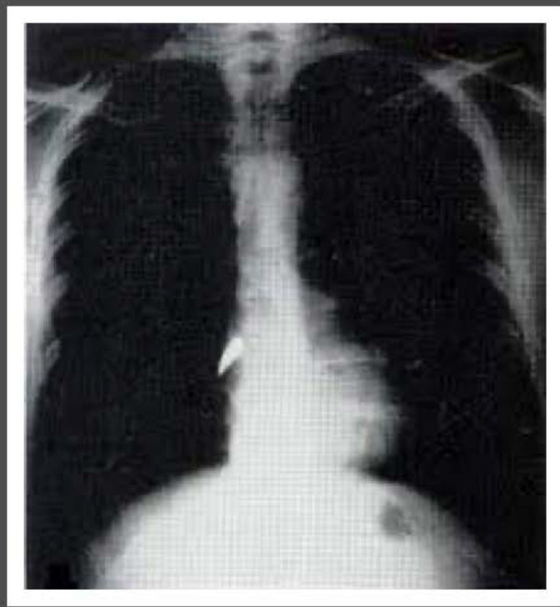
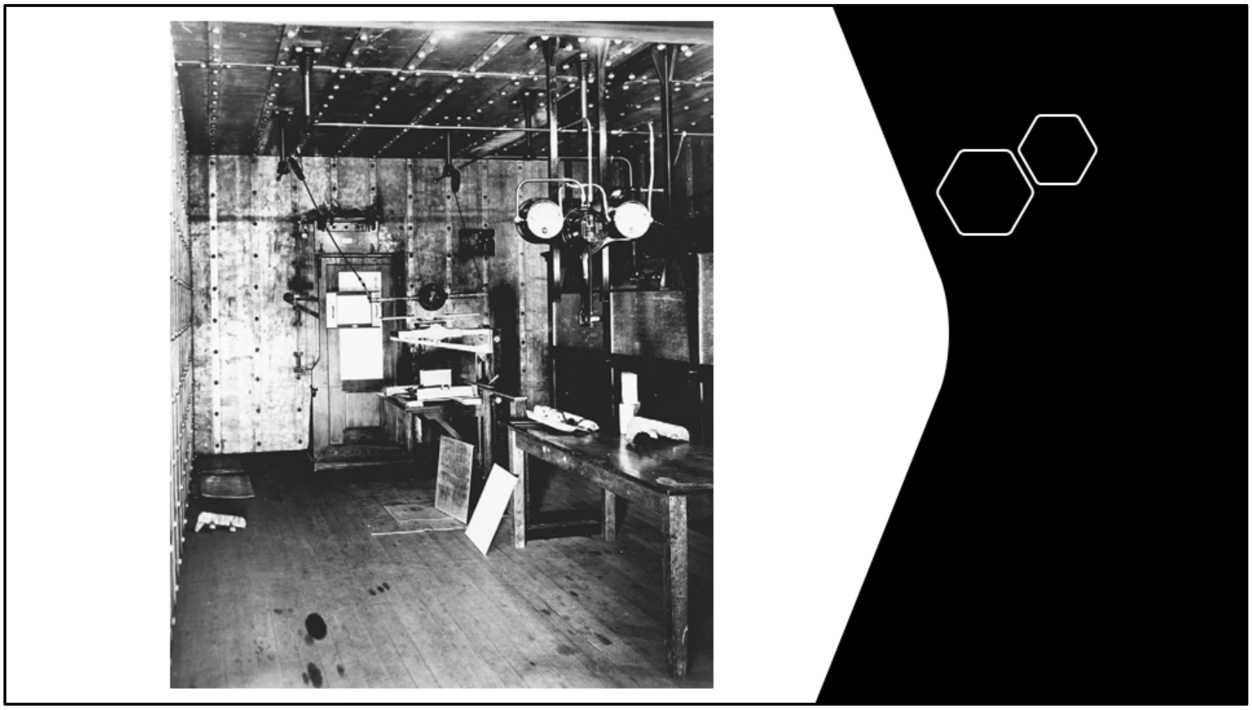
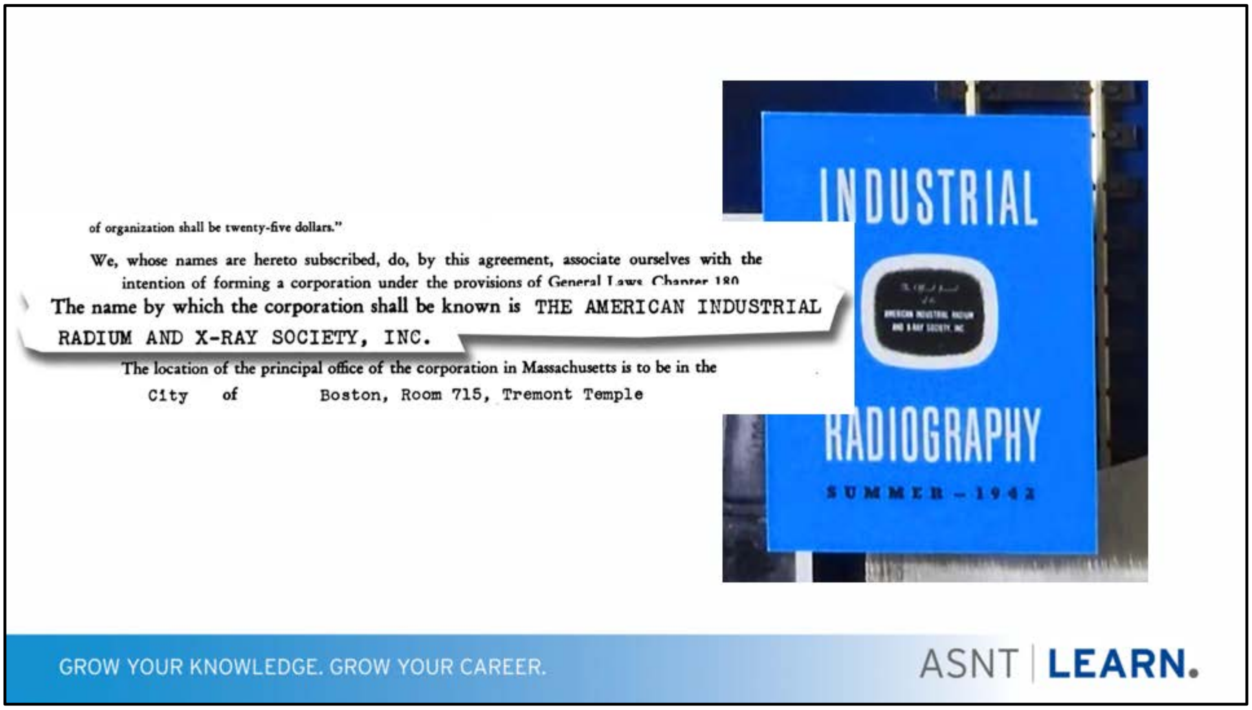


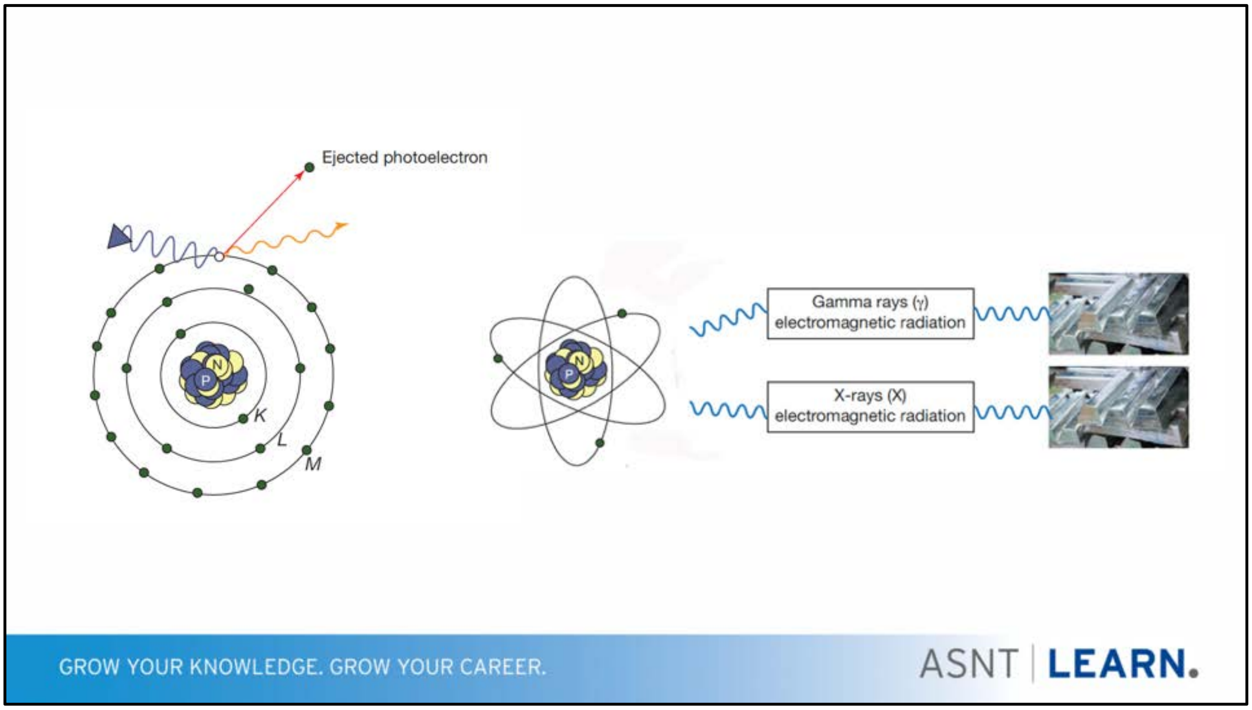
Shortly after the discovery of X-rays in 1895, they were used in the medical field. For example, battlefield surgeons used X-rays to locate bullets in wounded soldiers.



By 1913, X-rays were powerful enough to penetrate materials much thicker and denser than the tissue of the human body.



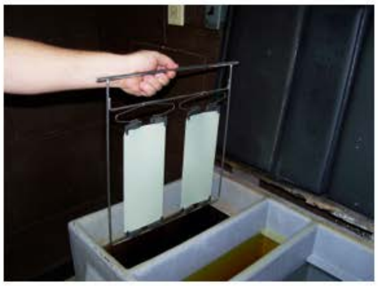
In fact, ASNT got its start in 1941 as the American Industrial Radium and X-Ray Society based on the application of X-rays and gamma rays in manufacturing. The precursor to the society's monthly journal, *Materials Evaluation*, was focused on this single NDT method, as reflected in its title.



Radiographic testing uses ionizing electromagnetic radiation capable of ejecting electrons from their orbits around the nuclei of atoms, thus turning the atom into a positively charged ion.

The radiation is emitted from gamma-ray sources, called radioisotopes, or X-rays produced by X-ray machines to form an image on a detector.

Film Radiography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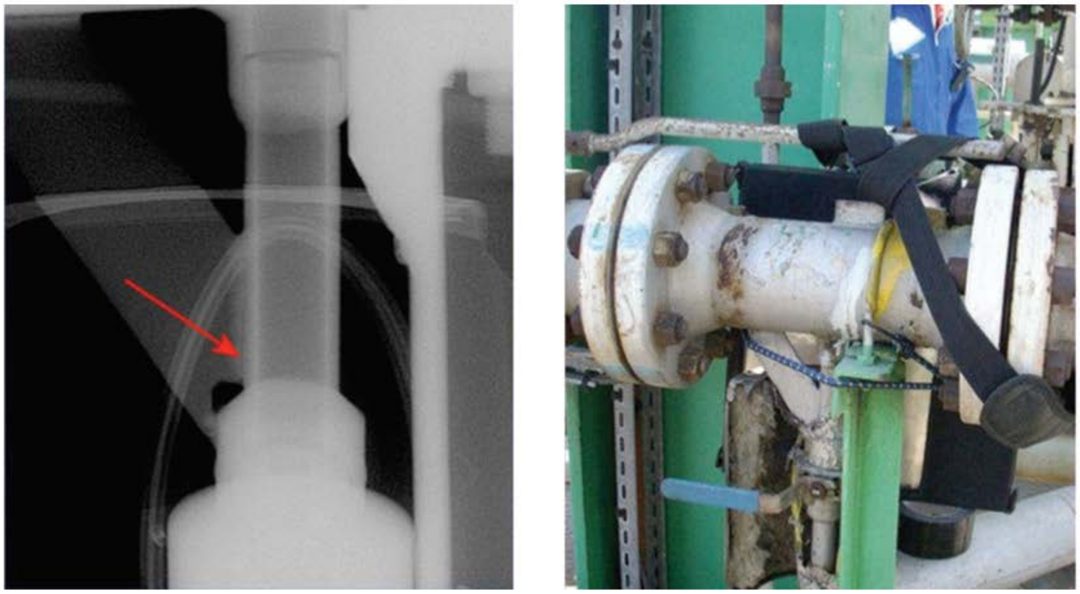
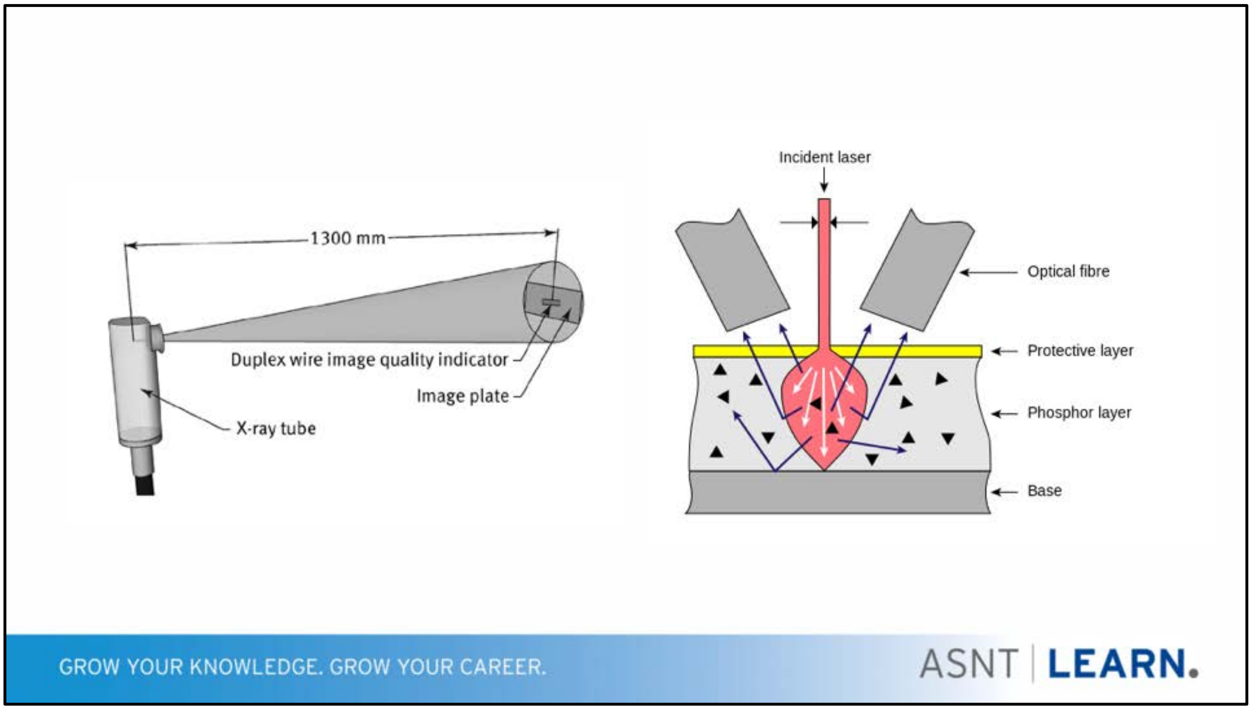
Until recently, radiographic testing has been largely film-based, from the loading of film cassettes to the development of the latent image, to the viewing of the final radiograph.

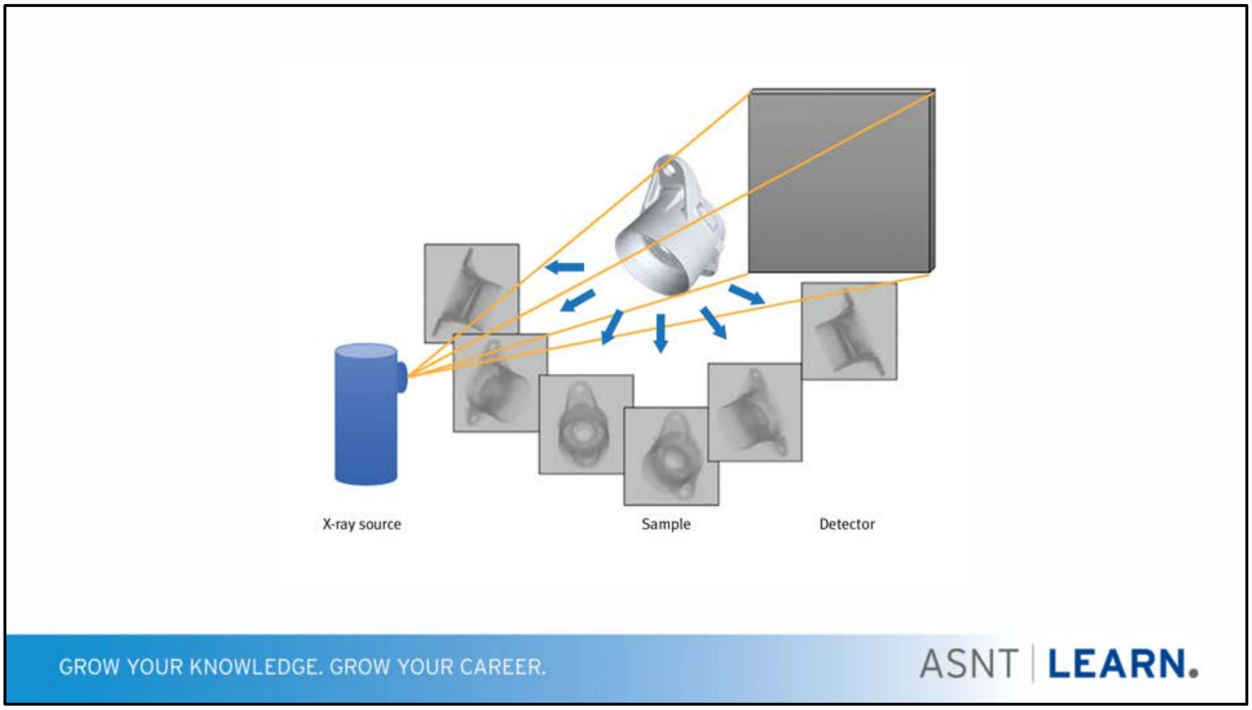
Now the NDT industry is moving toward digital methods including digital radiography and computed radiography.



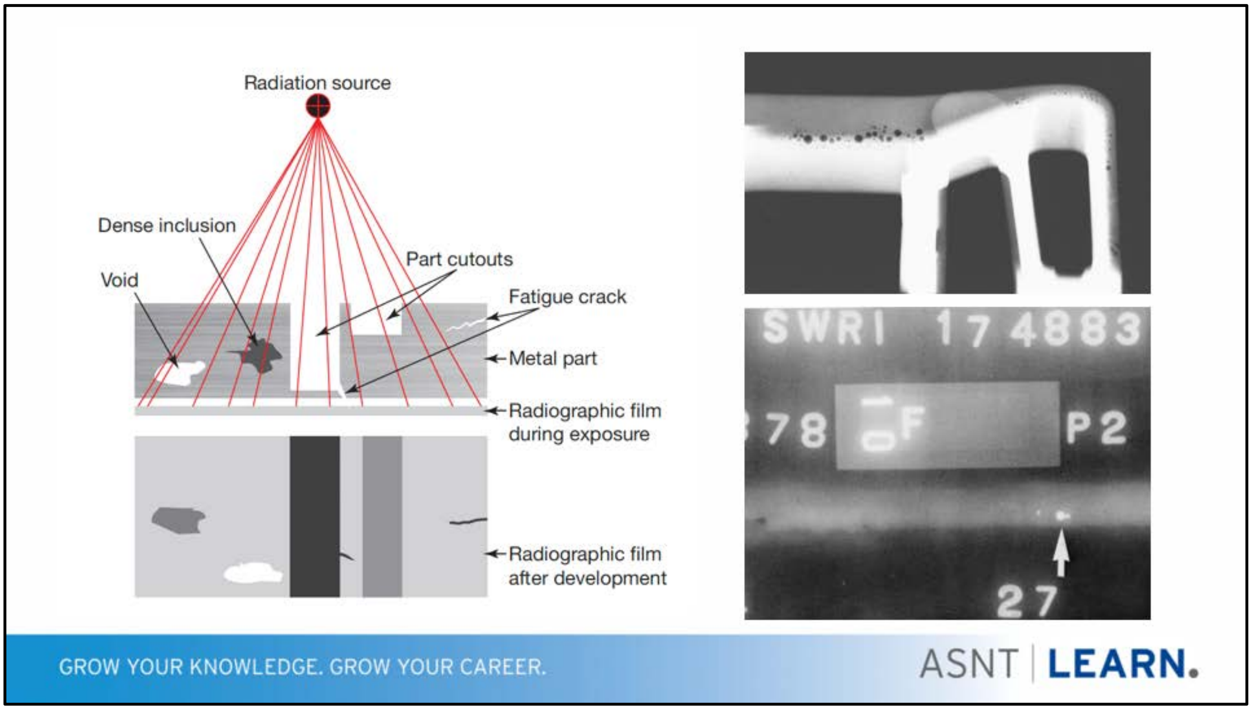
Digital radiography uses flat panel radiation detectors or digital detector arrays (DDAs) to feed images directly into a computer to reveal discontinuities, such as the crack in a pipe flange pointed out here.



In comparison to digital radiography, computed radiography uses reusable phosphor imaging plates or cassettes that are read by a laser scanner, much like a CD or DVD.

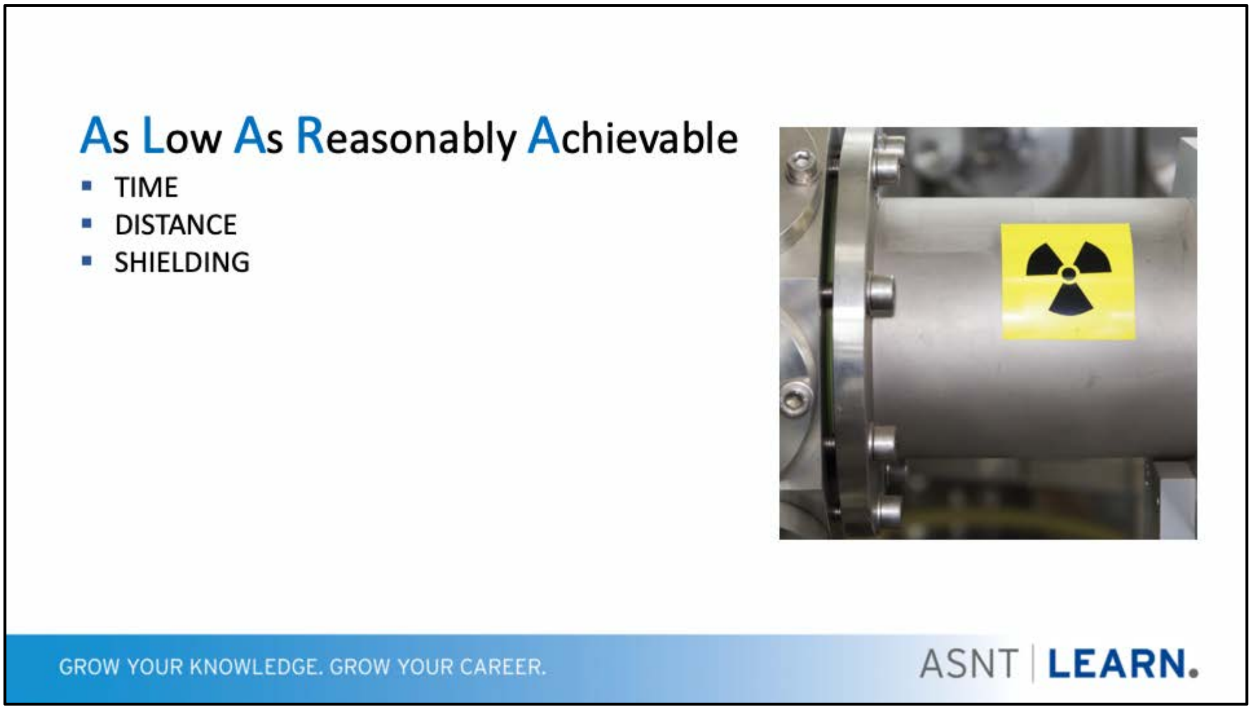


A well-known digital radiographic method is computed tomography, which pieces together radiographic “slices” of a test object to create a three-dimensional model of its interior.



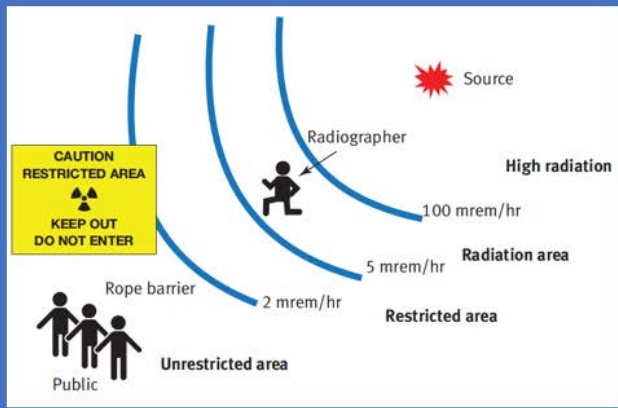
The formation of a radiographic image relies on density differentials in a test object that attenuate radiation differently. Hollow voids and pores, such as those found in a casting, permit more radiation to reach the film or detector, creating dark spots on the radiograph. Discontinuities that are denser than the surrounding metal, such as a tungsten inclusion in a weld, show up as lighter images compared to the surrounding area of the radiograph.

Due to the dangers of ionizing radiation to NDT personnel and the general public, the practice of safety is paramount.

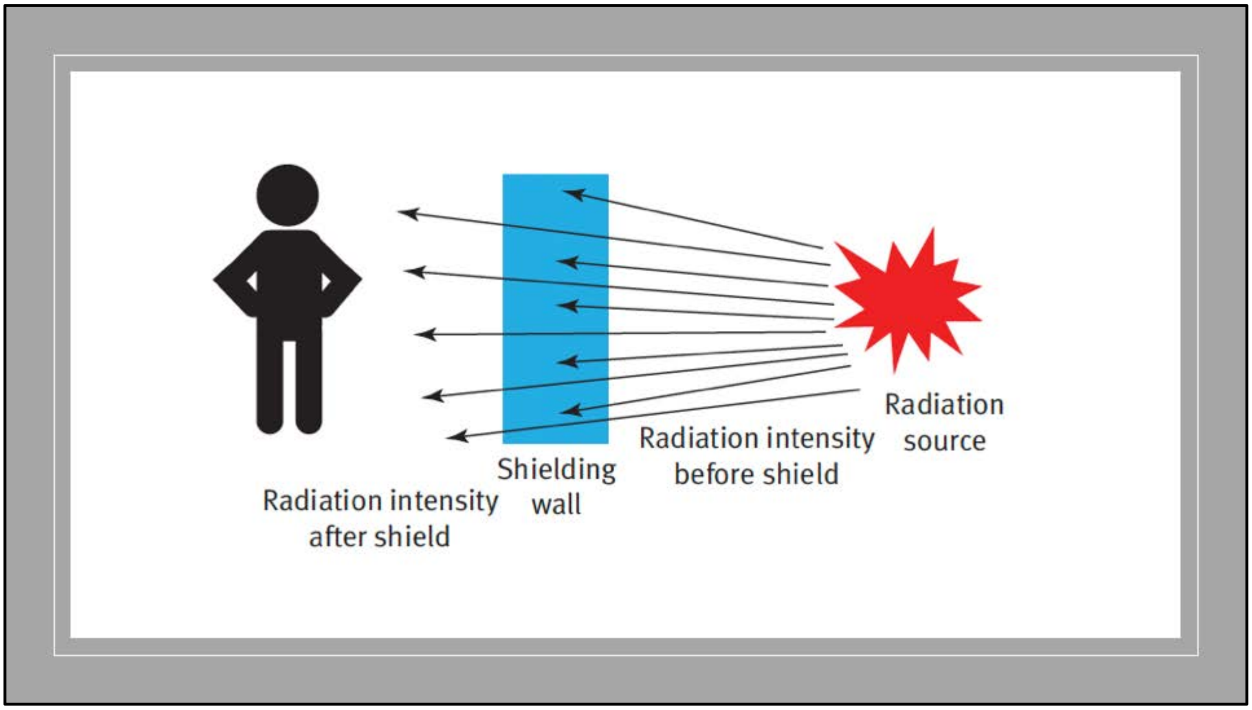


The goal of radiation safety is to keep radiation exposure at a test site as low as reasonably achievable. This can accomplished through safety practices involving three concepts: time, distance, and shielding.

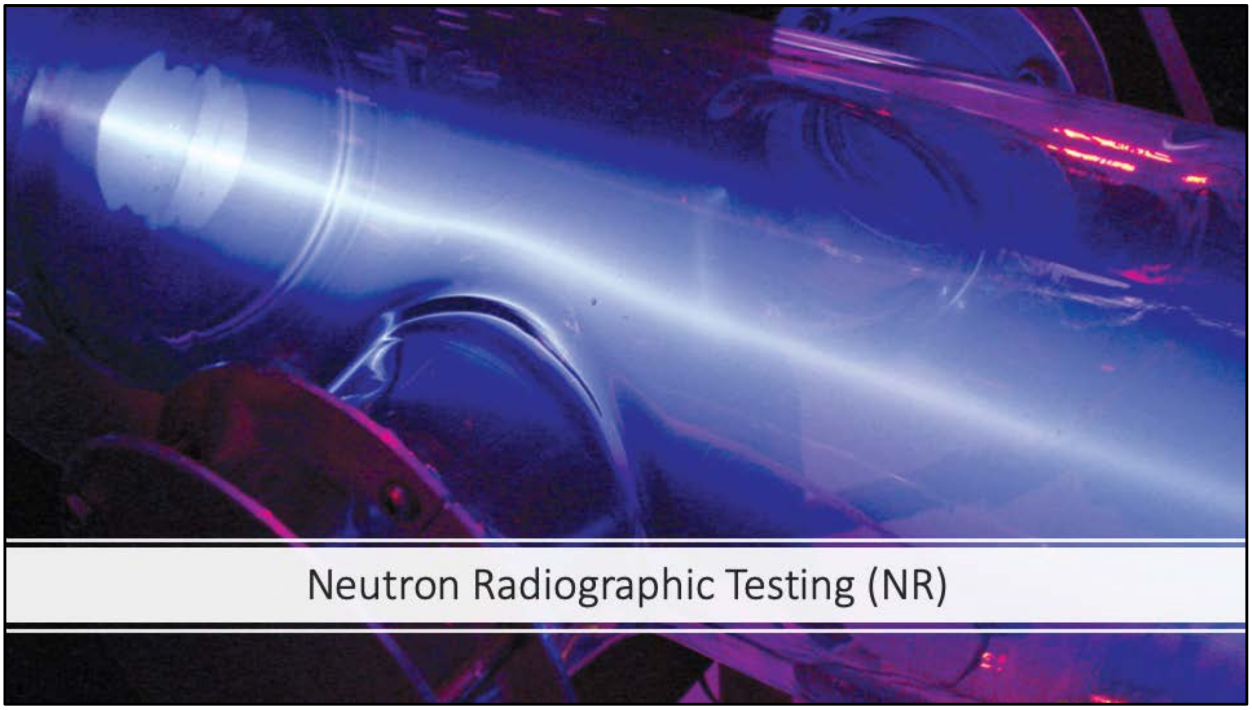
First, it’s important to minimize the time personnel spend working with a radioactive source.



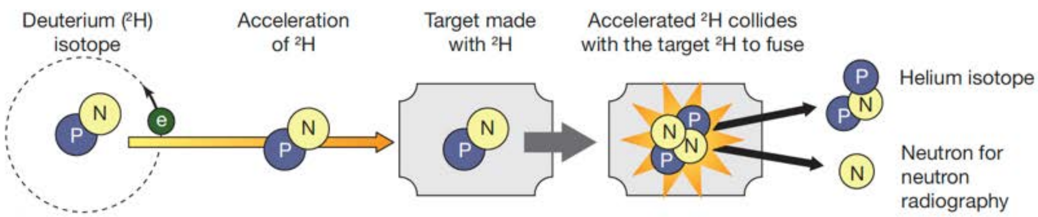
Secondly, it is vitally important to increase the distance between the source of radiation and people, especially non-radiation employees in a facility or the general public at a worksite.



Last but certainly not least, proper shielding of suitable density must be provided to attenuate X- and gamma rays to safe doses.


Neutron Radiographic Testing (NR)

Neutron radiography uses low-energy thermal neutrons.



Neutron radiography, as its name implies, uses low-energy thermal neutrons, instead of X-rays or gamma rays ...

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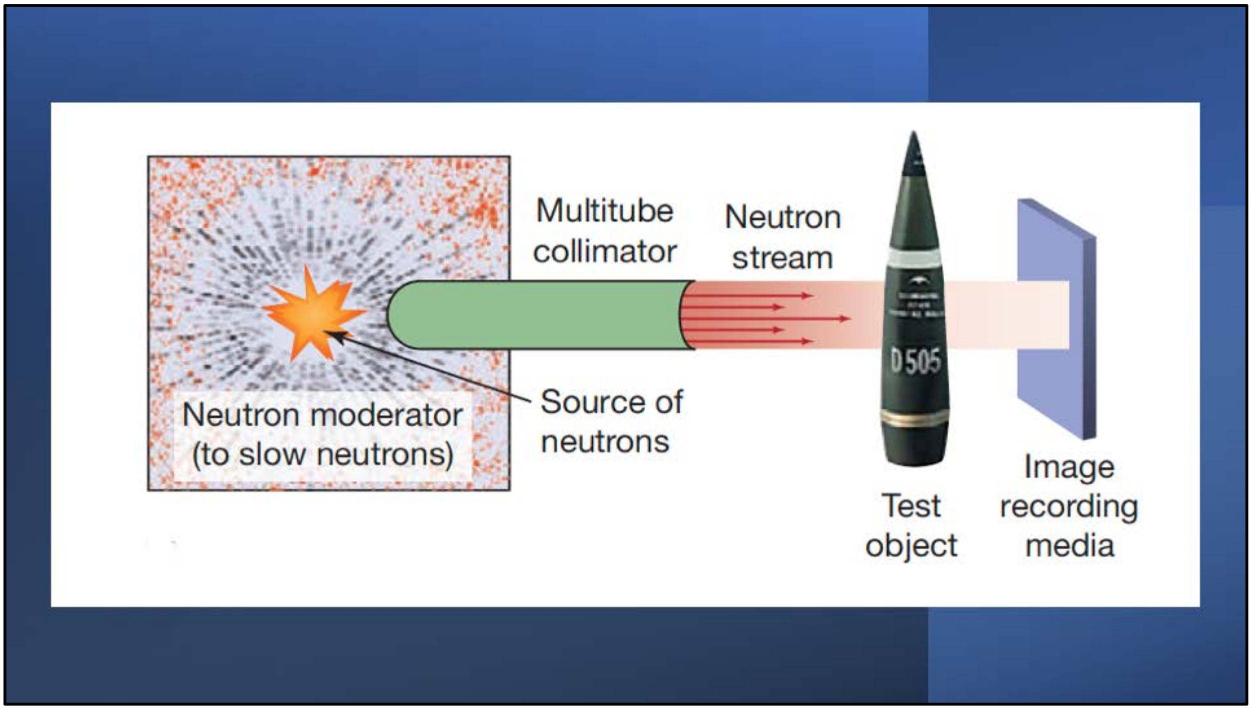
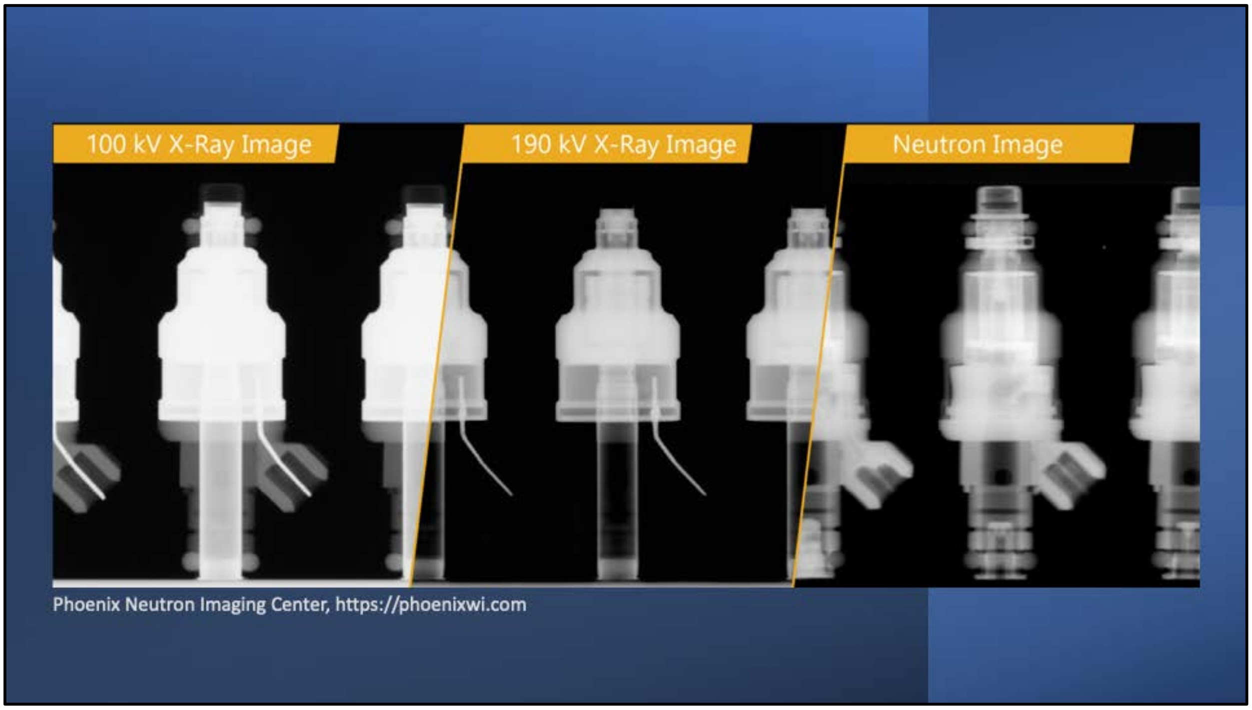
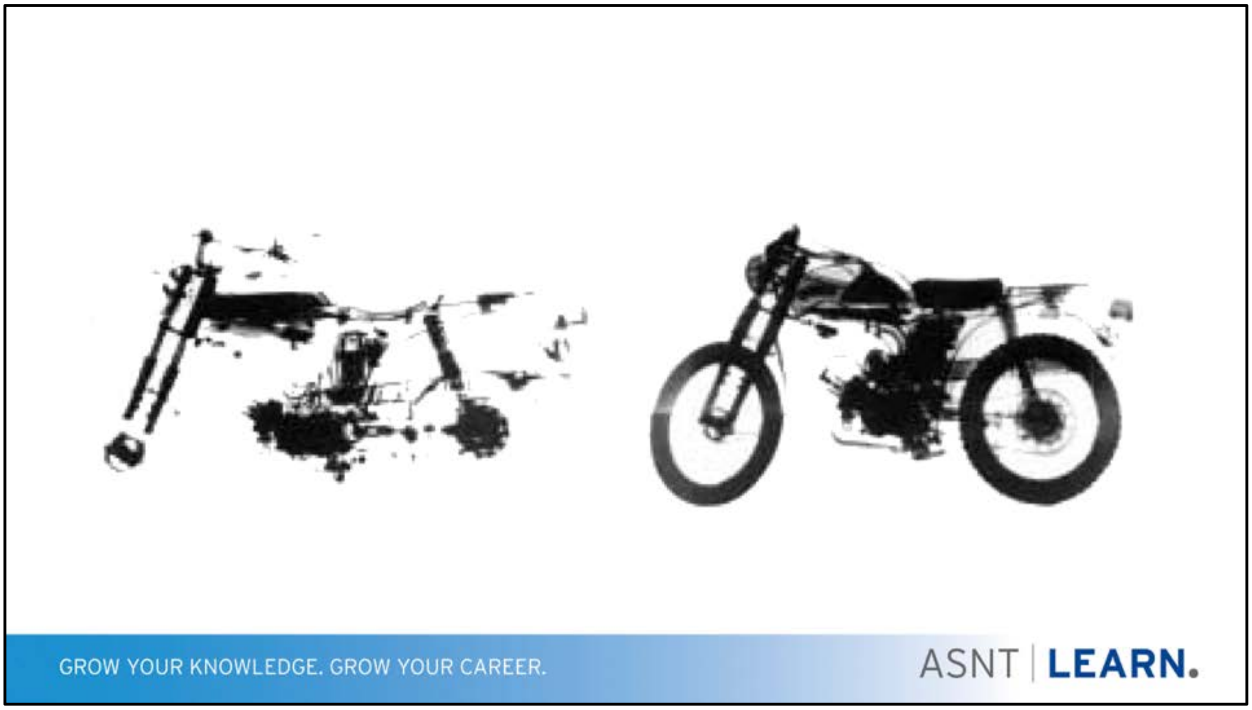


… as a means of capturing a radiographic image.



Compared to RT, NR allows technicians to see clearly lighter elements (such as liquids, rubber, and plastics) in contrast to denser elements.

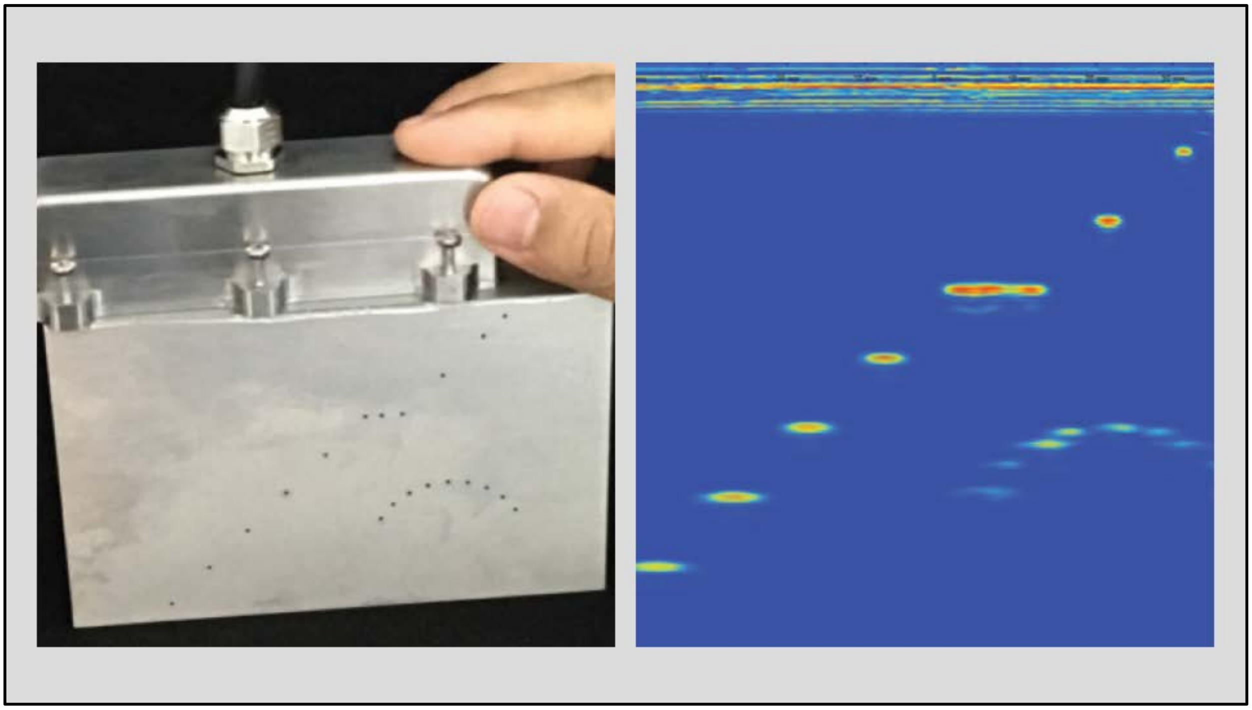


Here we see side-by-side images of a motorcycle taken with radiographic testing (left) and neutron radiographic imaging. As you can see, the neutron radiographic image clearly shows the lighter elements such as the fuel level in the gas tank, the plastic seat, and rubber tires.

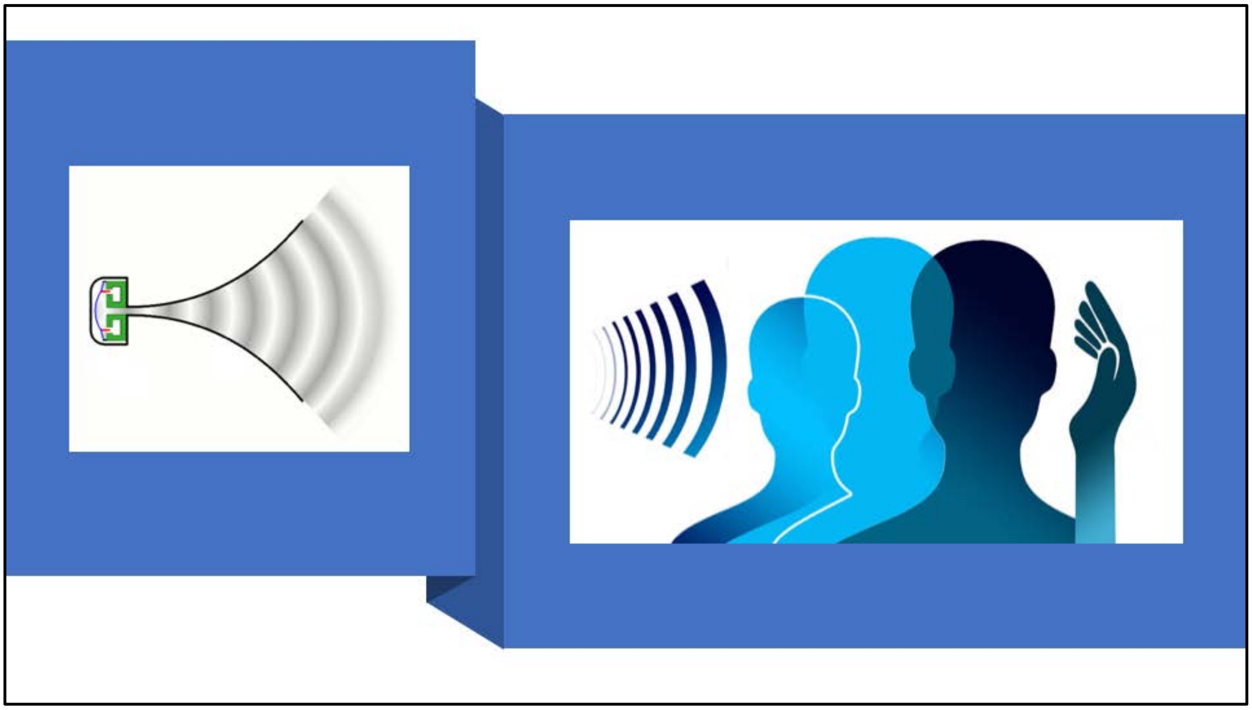

Ultrasonic Testing (UT)

Ultrasound isn’t just for medical purposes of monitoring the development of a fetus or detecting medical conditions …

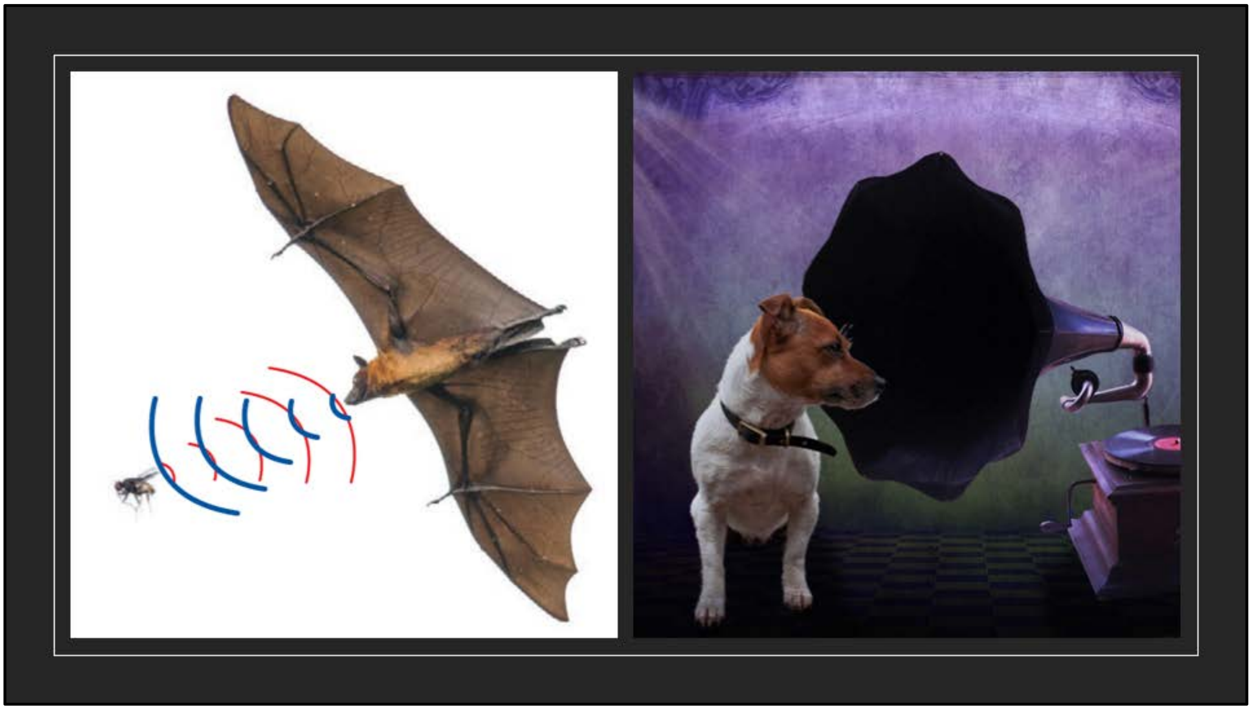
Ultrasonic testing is an NDT method used primarily to perform volumetric inspections of components using conventional methods …



… or advanced techniques, such as the total focusing method, shown here.

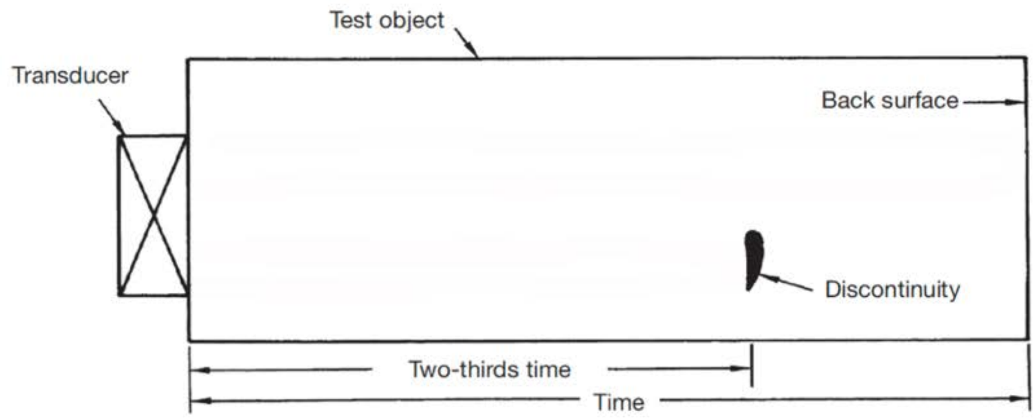


The term “ultrasonic” refers to any sound where the frequency range is above the audible level of human beings at about 20 000 Hz or 20 000 vibrations per second.



Think of echolocation used by bats or the frequencies heard only by canines with dog whistles.

"Time of Flight" of the Sound Wave



By pulsing an ultrasonic sound wave into a test object, the inspector evaluates the time the sound takes to get back to the transducer as an echo.

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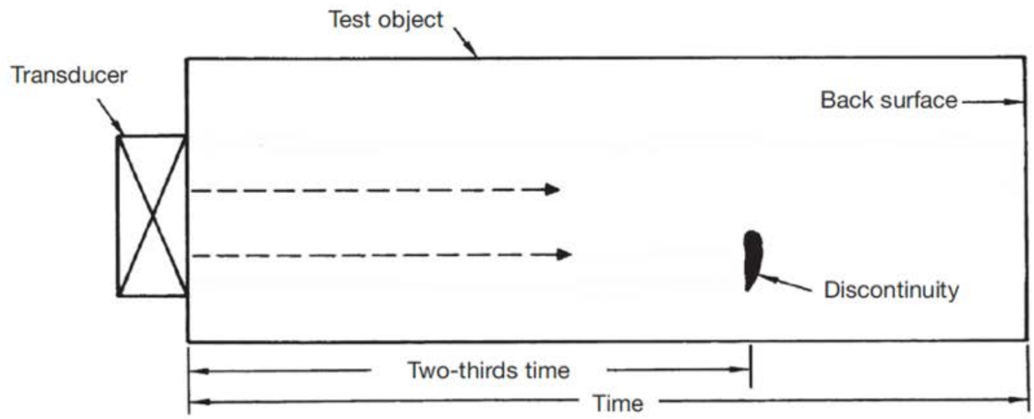
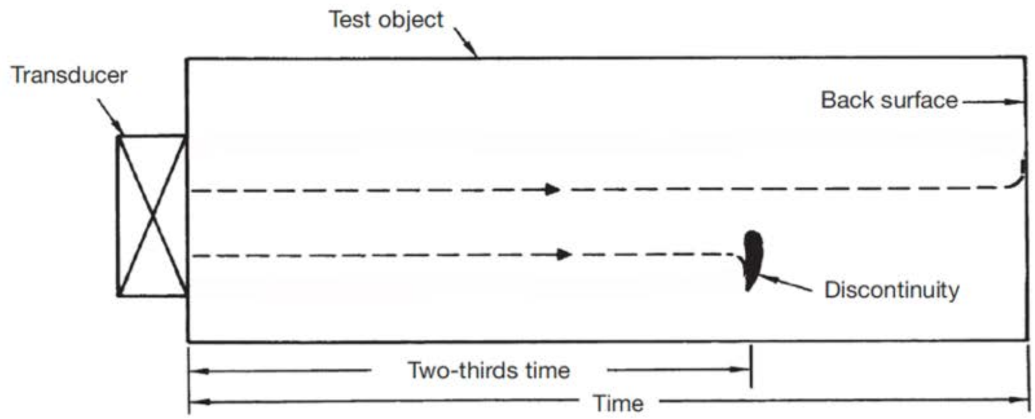
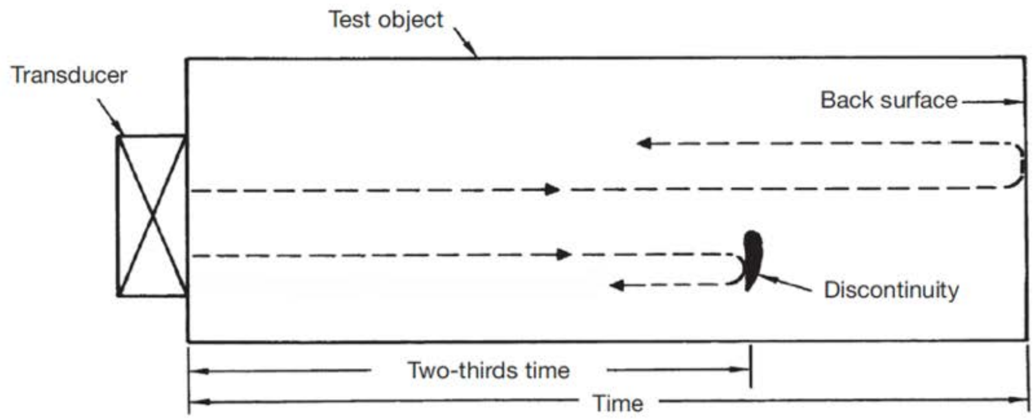
“Time of Flight” of the Sound Wave



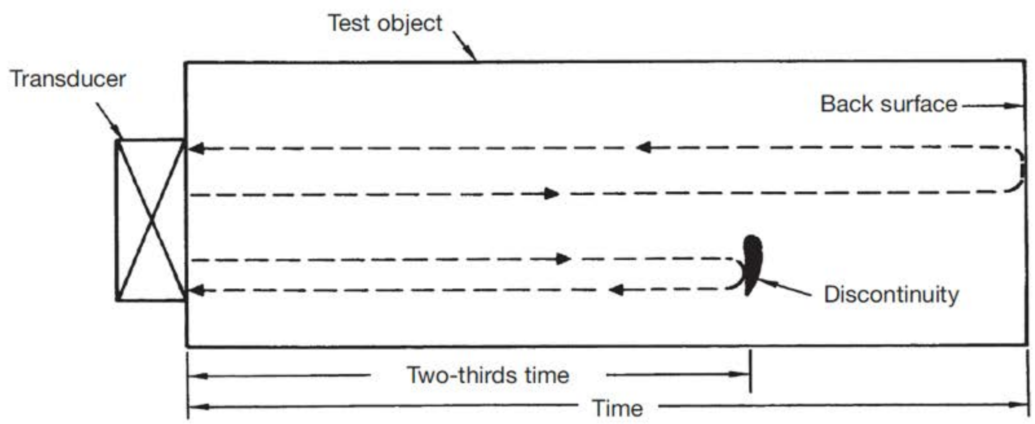
“Time of Flight” of the Sound Wave

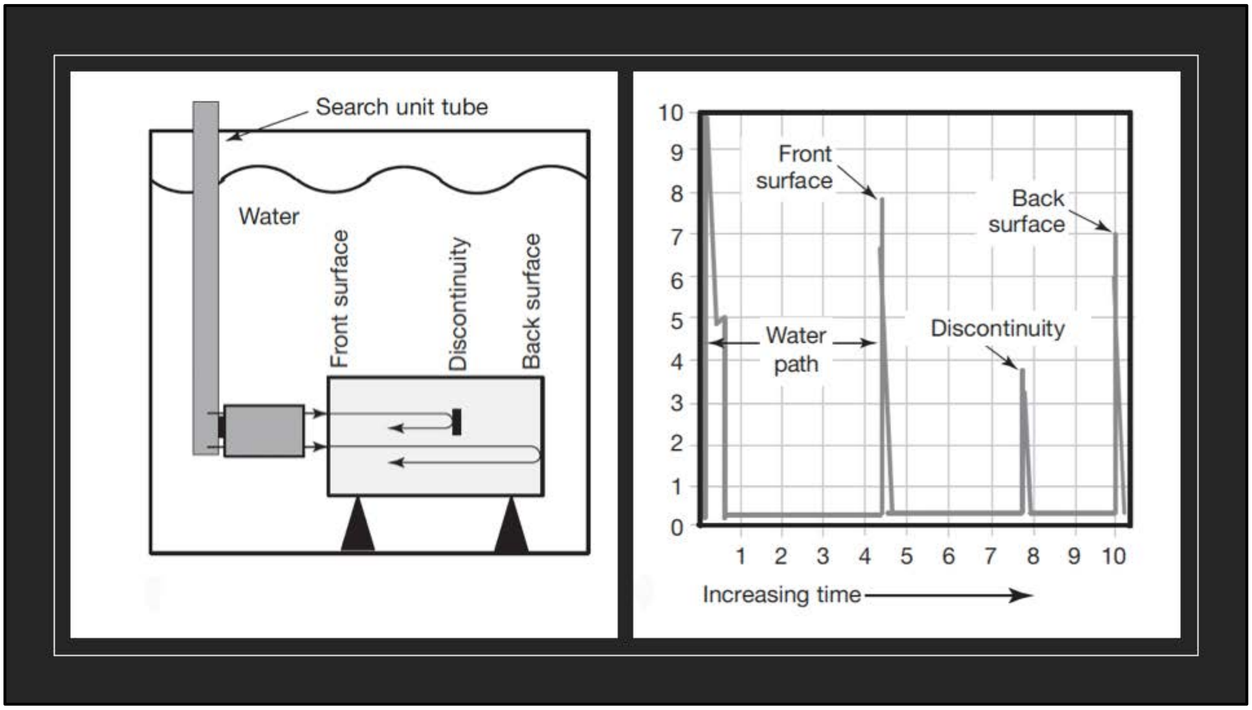


“Time of Flight” of the Sound Wave



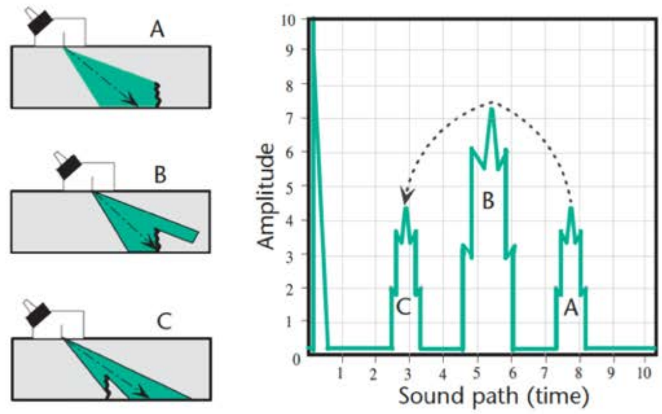
"Time of Flight" of the Sound Wave





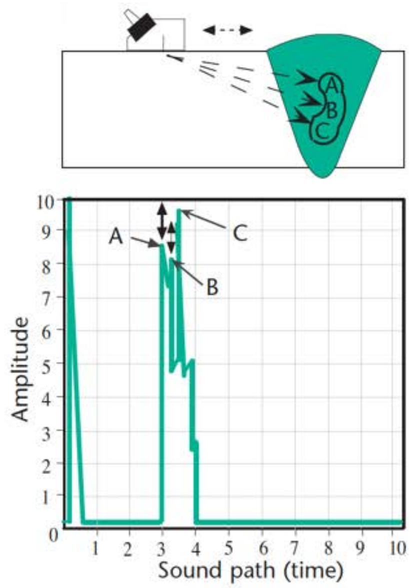
Inspection data is displayed in a format that allows analysis of the signals. In the case of an immersion test, shown here, the ultrasonic technician can identify signals returning from the front and back surfaces of the test object, as well as a discontinuity reflected from within the object.

- **Cracks**



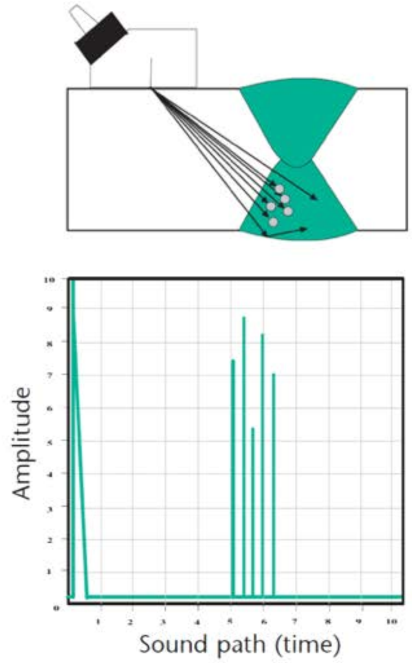
By analyzing the time of flight and amplitude or strength of the return signal, the inspector can locate and identify various types of internal discontinuities such as cracks …

- Cracks
- **Inclusions**



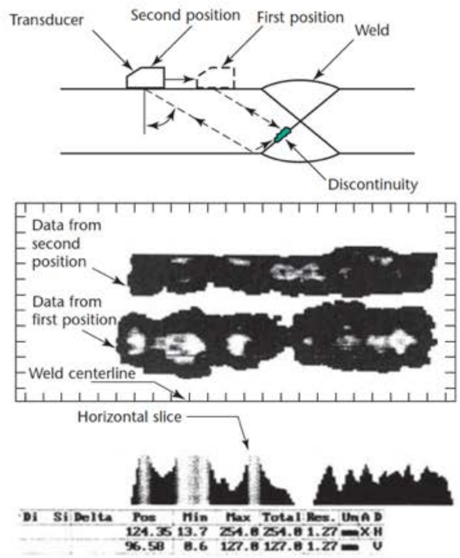
… metallic, slag, or tungsten inclusions …

- Cracks
- Inclusions
- **Porosity**



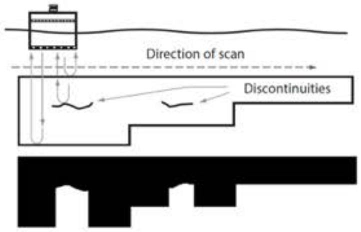
… porosity …

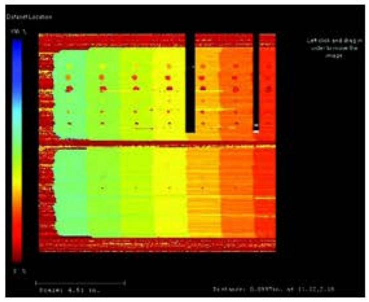
- Cracks
- Inclusions
- Porosity
- **Welding discontinuities**



… and welding discontinuities.

One basic application of ultrasonic testing is its use for quick thickness measurements of pipe walls, plates, and sheets.



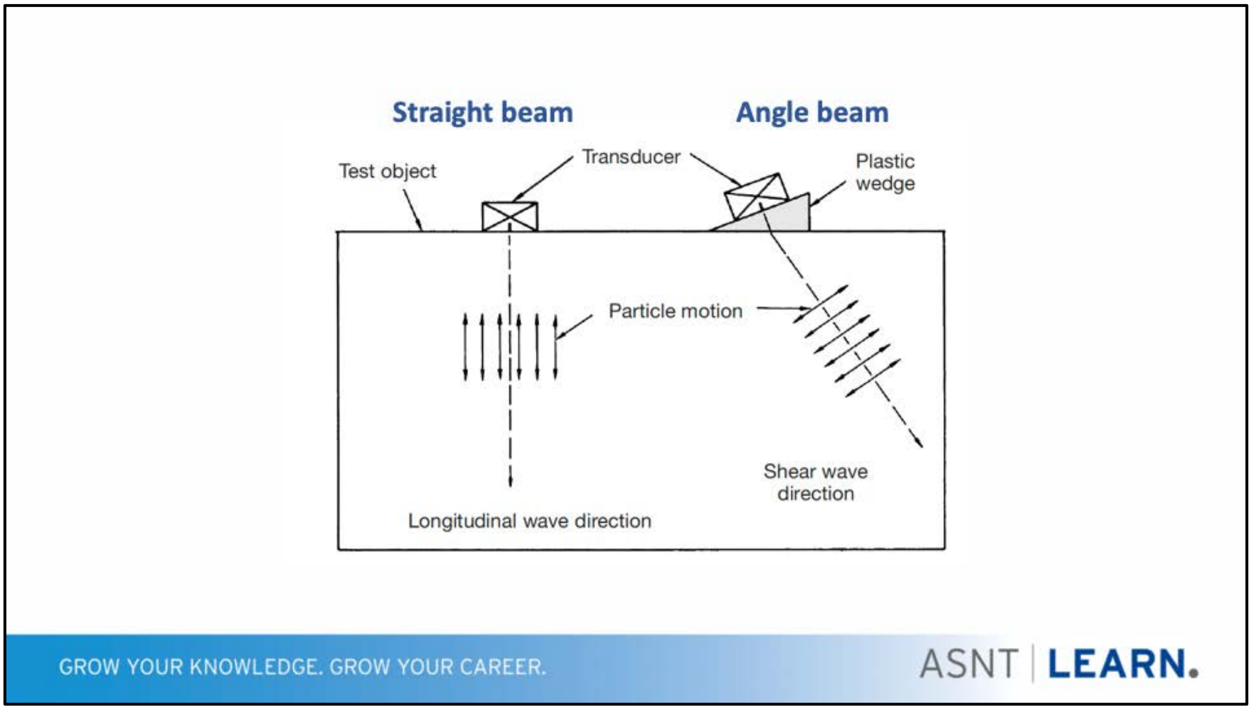


Types of sound displays:

- A-scan
- B-scan
- C-scan

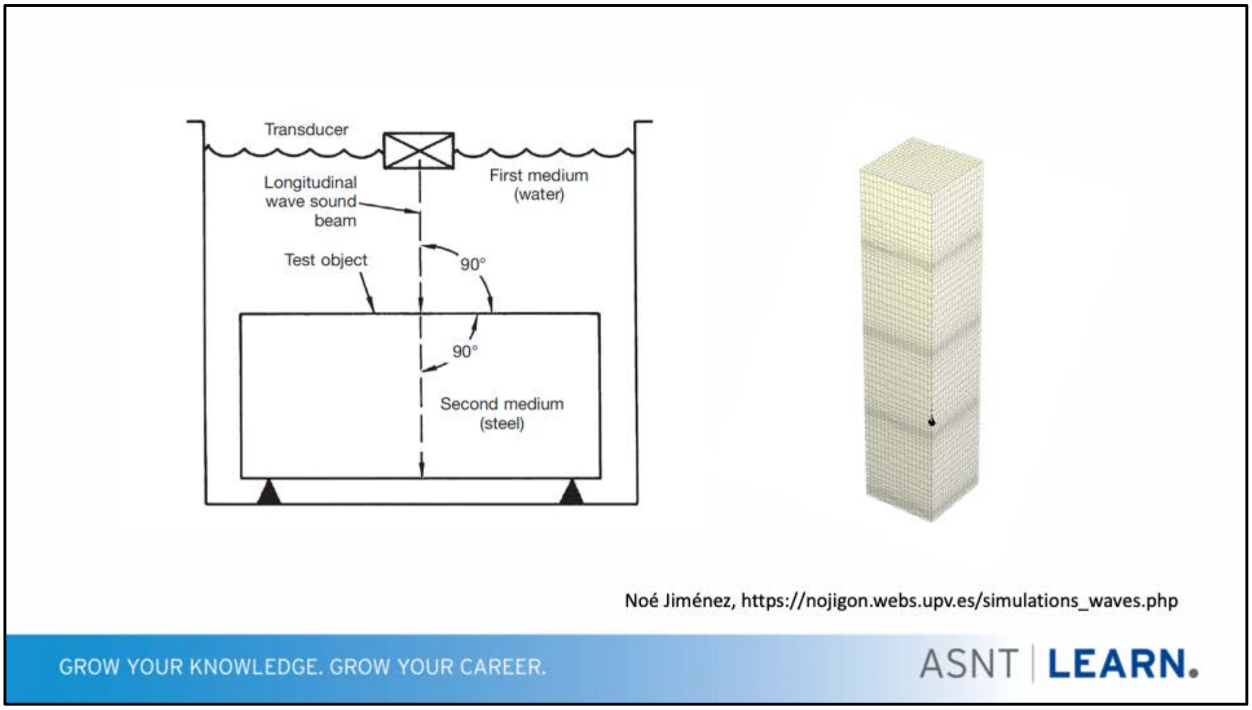
The sound waves may appear as a(n):

A-scan – blips on a computer display screen;
B-scan – providing a side view or cross section; or
C-scan – top or plan view for a full sonic picture.

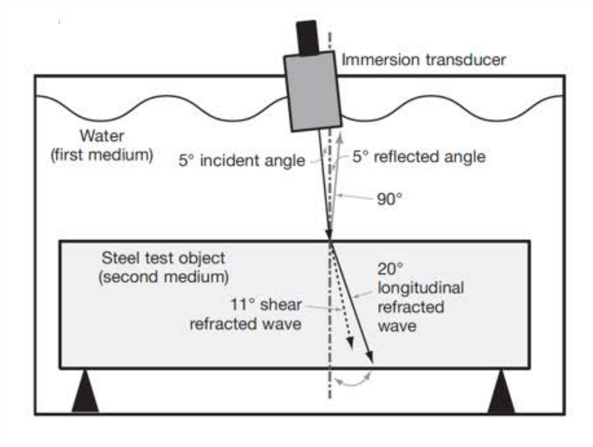


Two main UT techniques include:

- straight-beam and
- angle-beam.



With straight-beam testing, the probe pulses ultrasound into the part at 90° to the entry surface to produce high-velocity longitudinal waves.



Noé Jiménez, https://nojigon.webs.upv.es/simulations_waves.php

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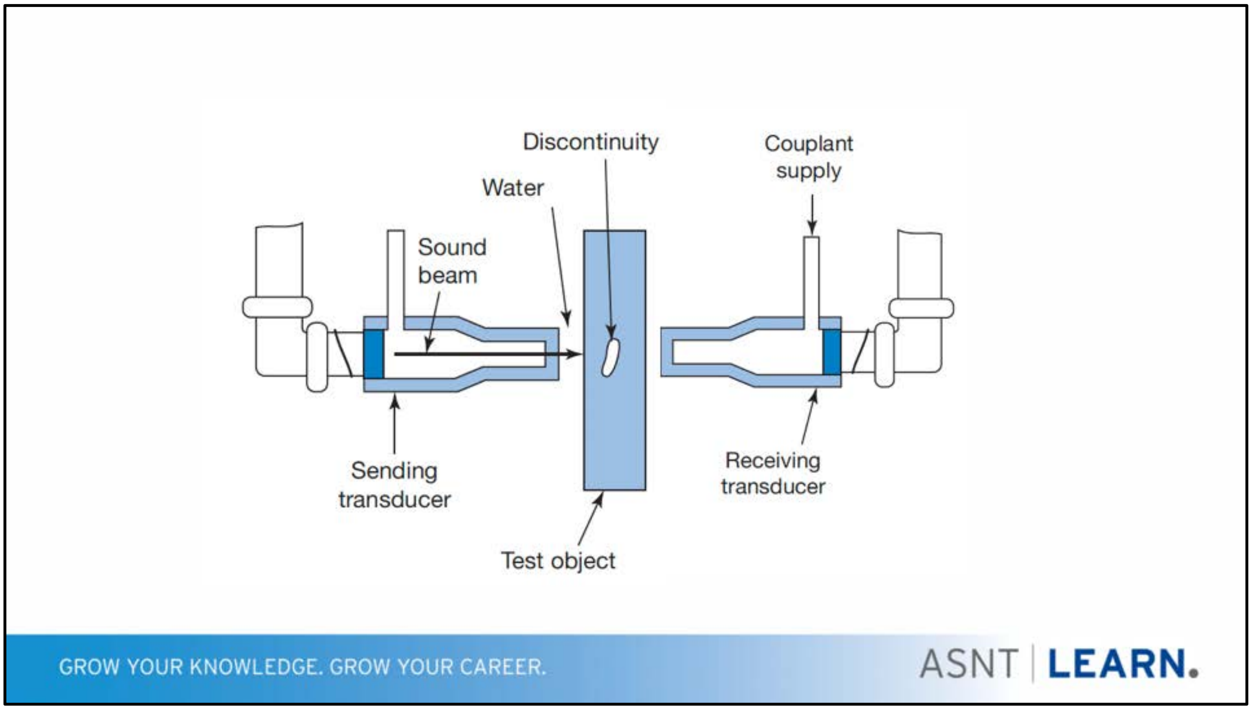
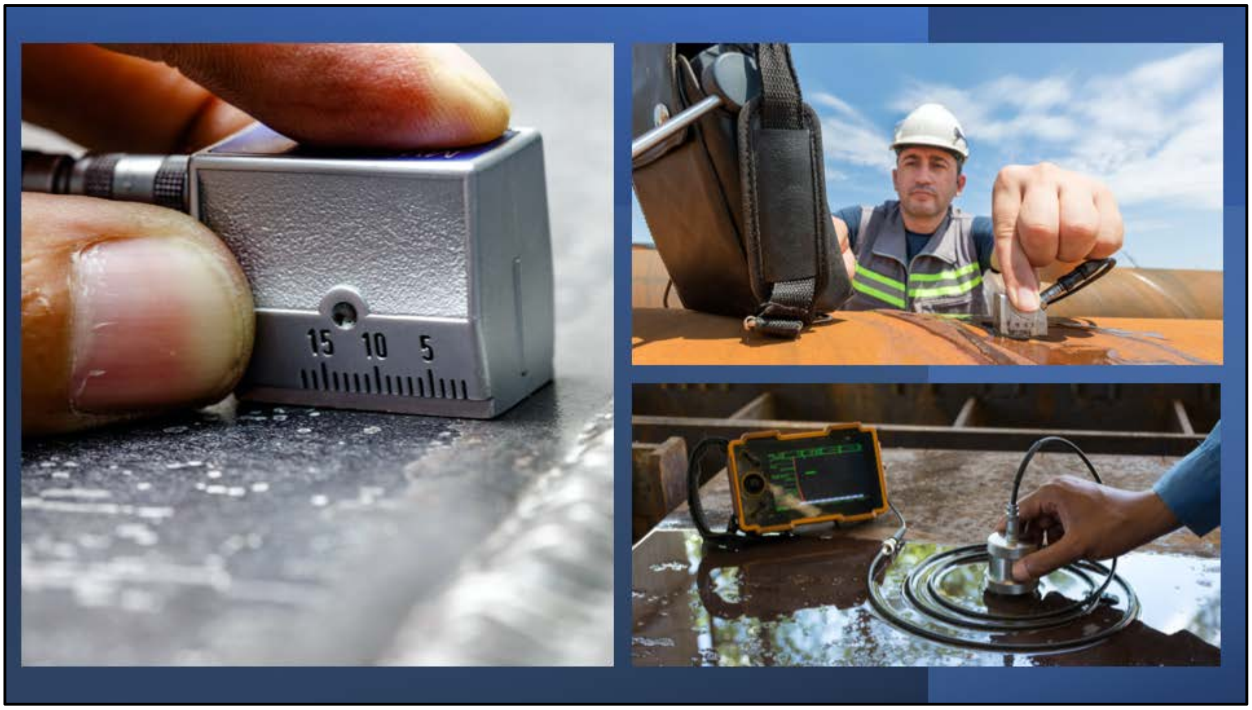
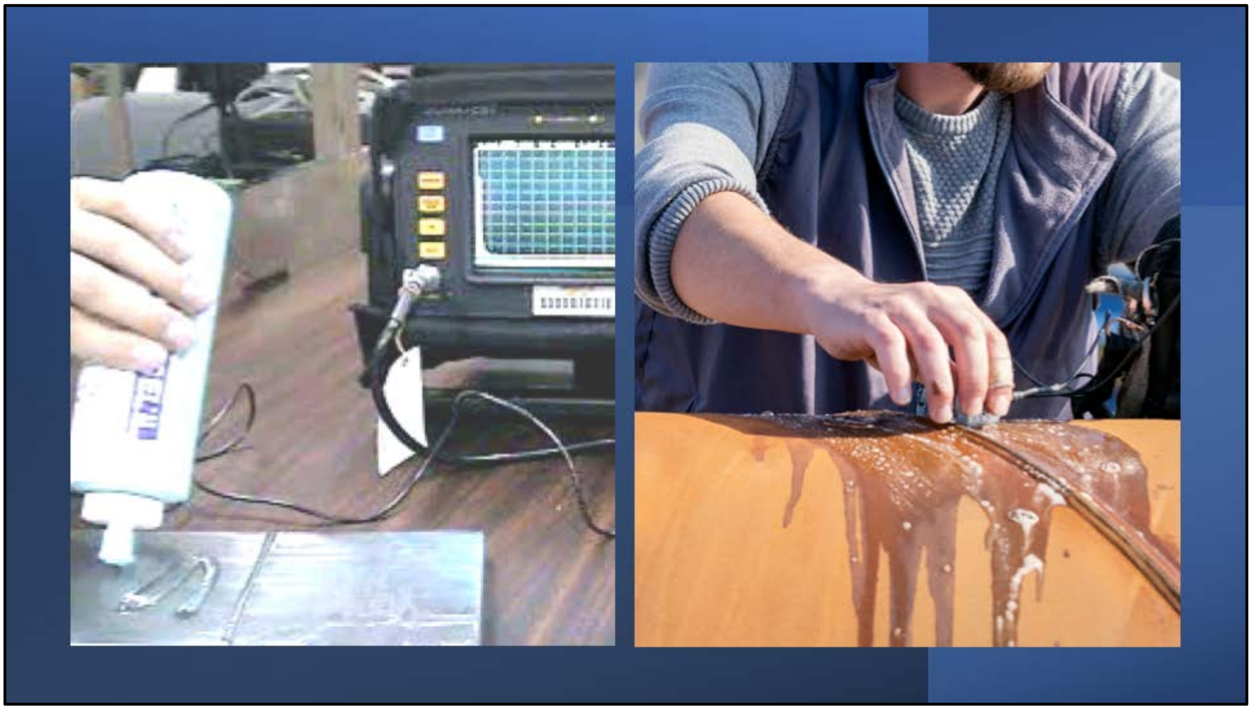
Angle-beam testing pulses the ultrasonic beam at an angle to refract the sound wave in the part or component to produce shear waves for more sensitive weld inspections.



One additional technique is through-transmission with the ultrasound pulsed all the way through the part from a sending transducer to a receiving transducer.

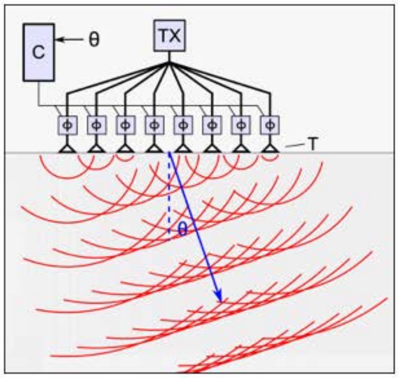


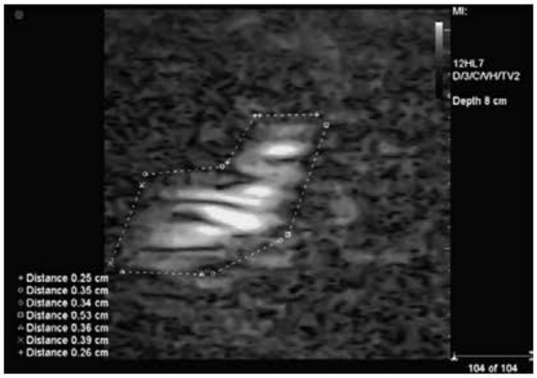
UT techniques can be further categorized based on how the probe or transducer interfaces with the test surface.



Contact testing – uses a couplant, such as a gel or oil, to eliminate “dead air” that would weaken the signal.

Immersion testing – uses water as the couplant.





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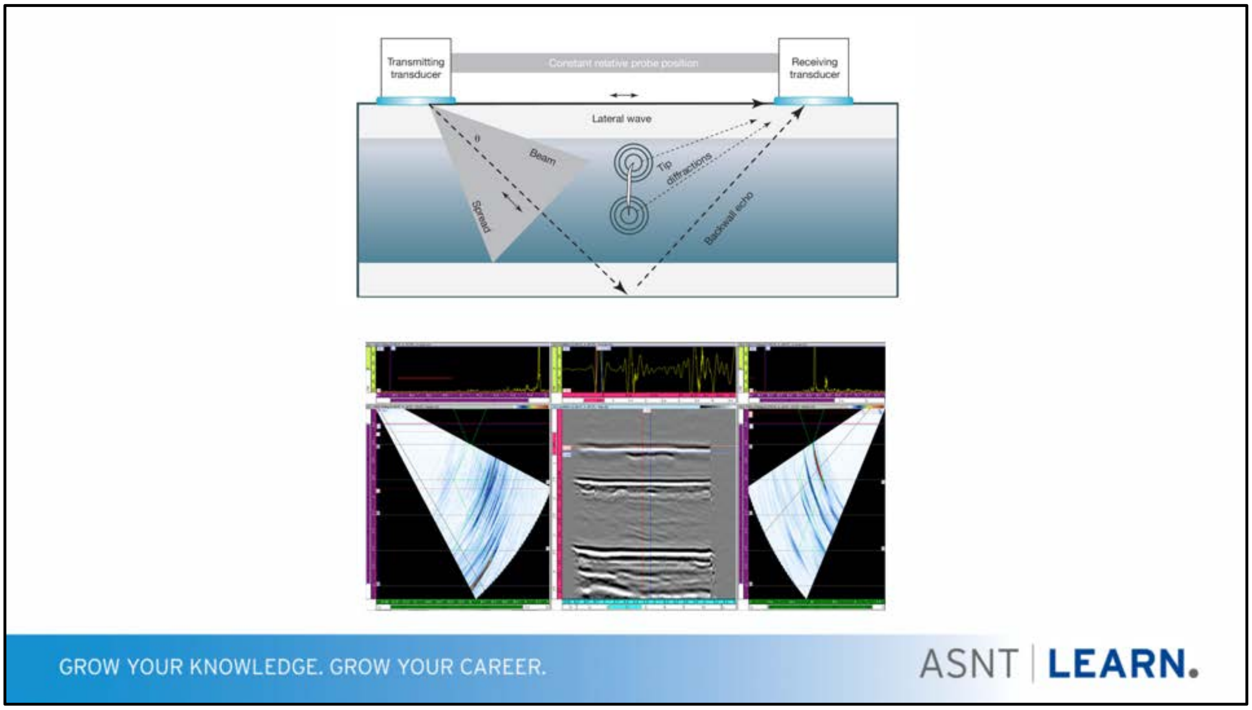
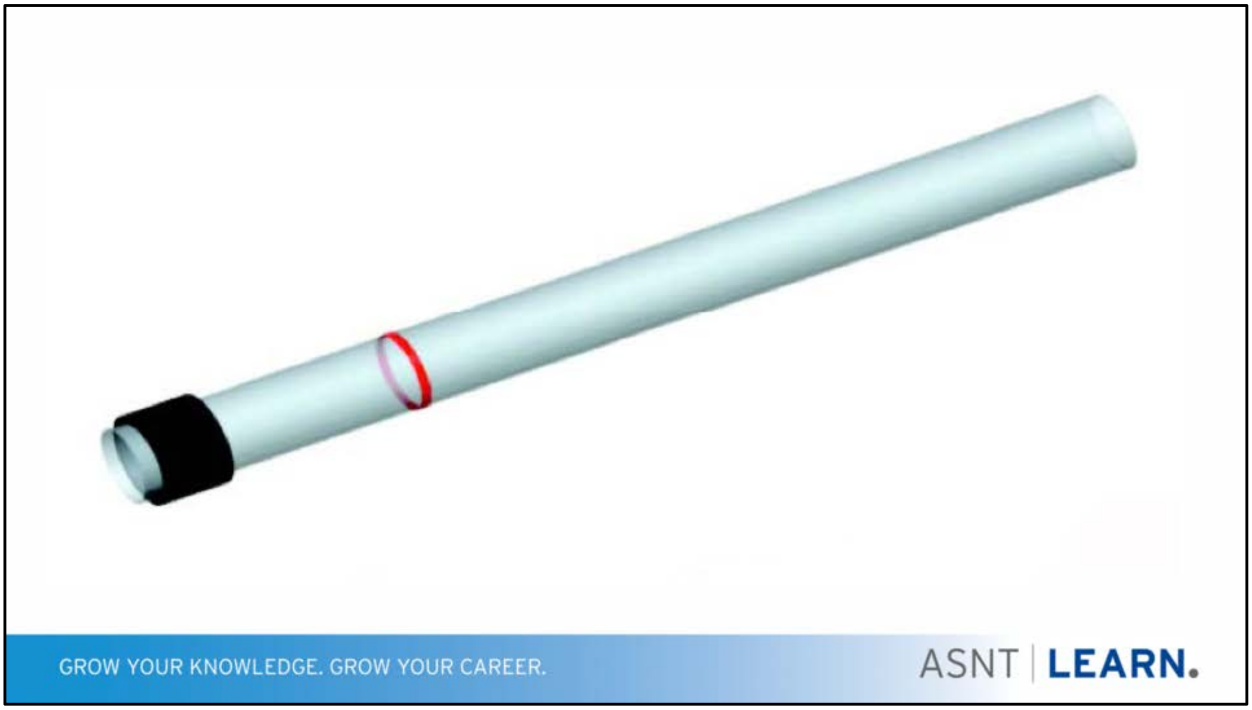
Advanced UT techniques include phased array (PA) which induces an ultrasonic beam with multiple elements to create a wave front that produces a more in-depth image for interpretation.



Another advanced UT technique is time of flight diffraction (TOFD), which uses two transducers to detect the tips of cracks for more effective sizing capability.

Ultrasonic testing may be carried out on a large industrial scale or may be performed with handheld probes and arrays to inspect surface, near-surface, and subsurface discontinuities in a variety of industries.


Guided Wave Testing (GW)



A much newer method than UT, GW is a rapid screening technology that can send low-frequency pulses over long ranges of a pipe wall, plate, or other test object from a single or limited number of test points ...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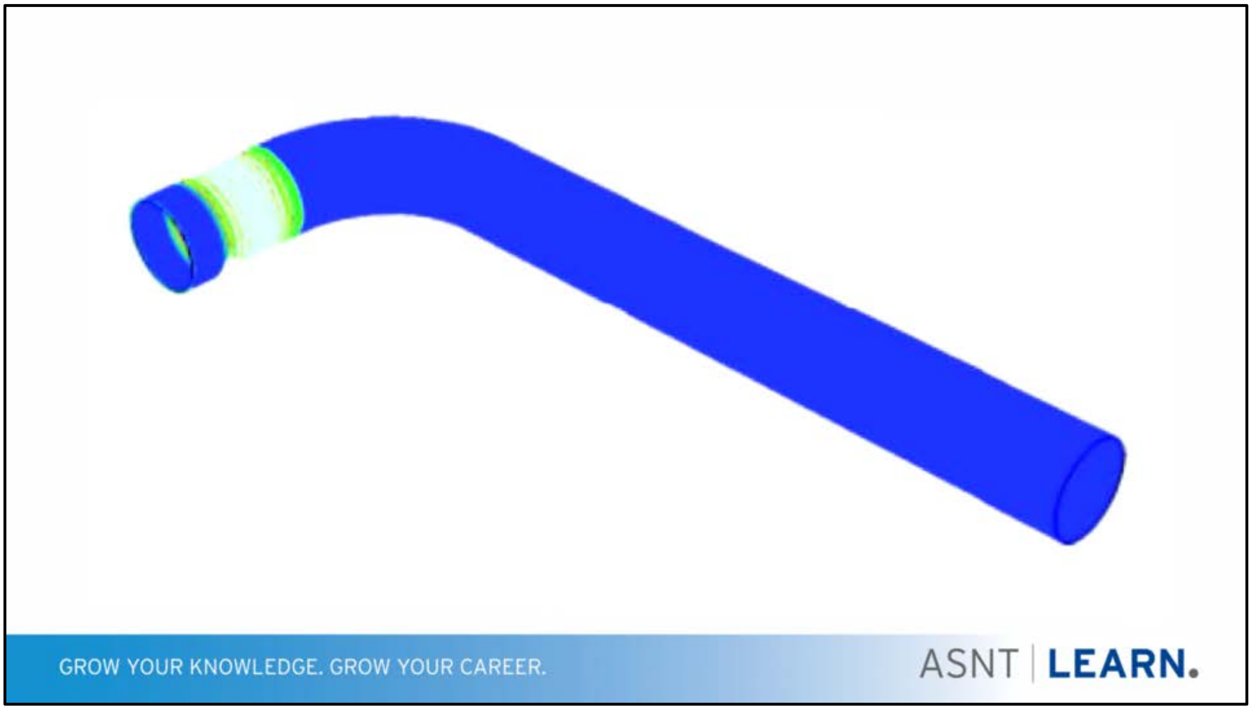
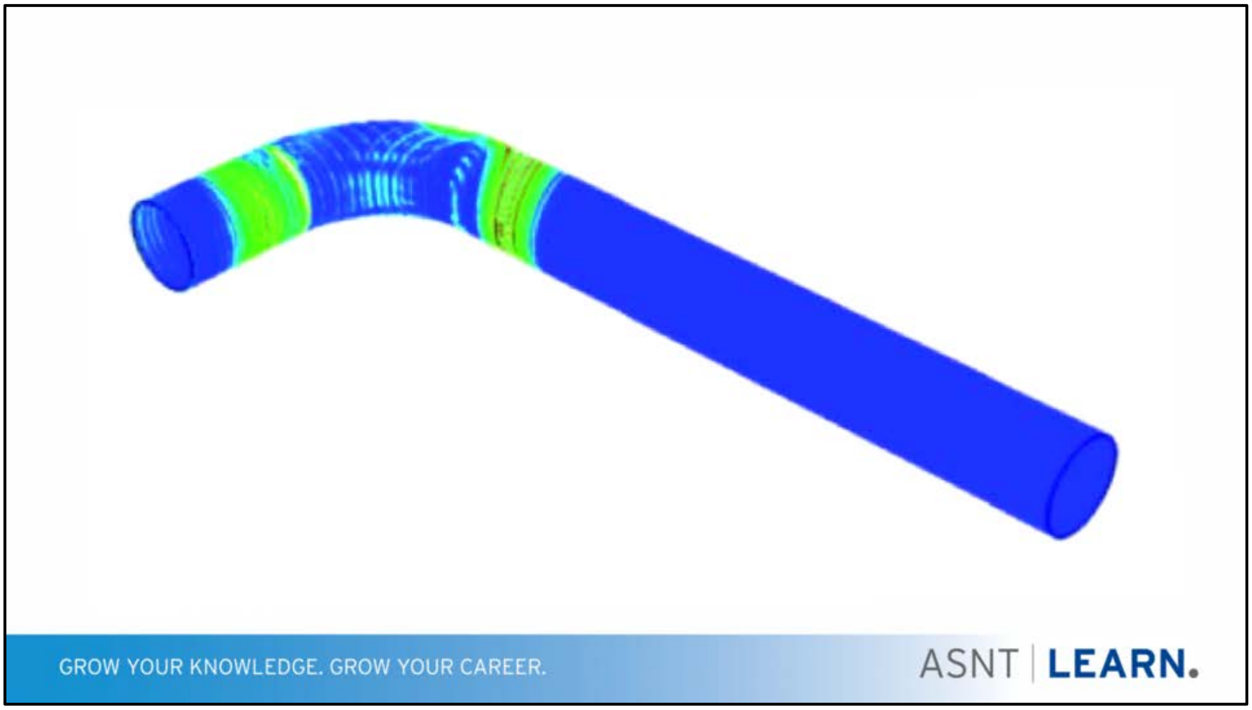


... and even send pulses around curves or bends in pipe.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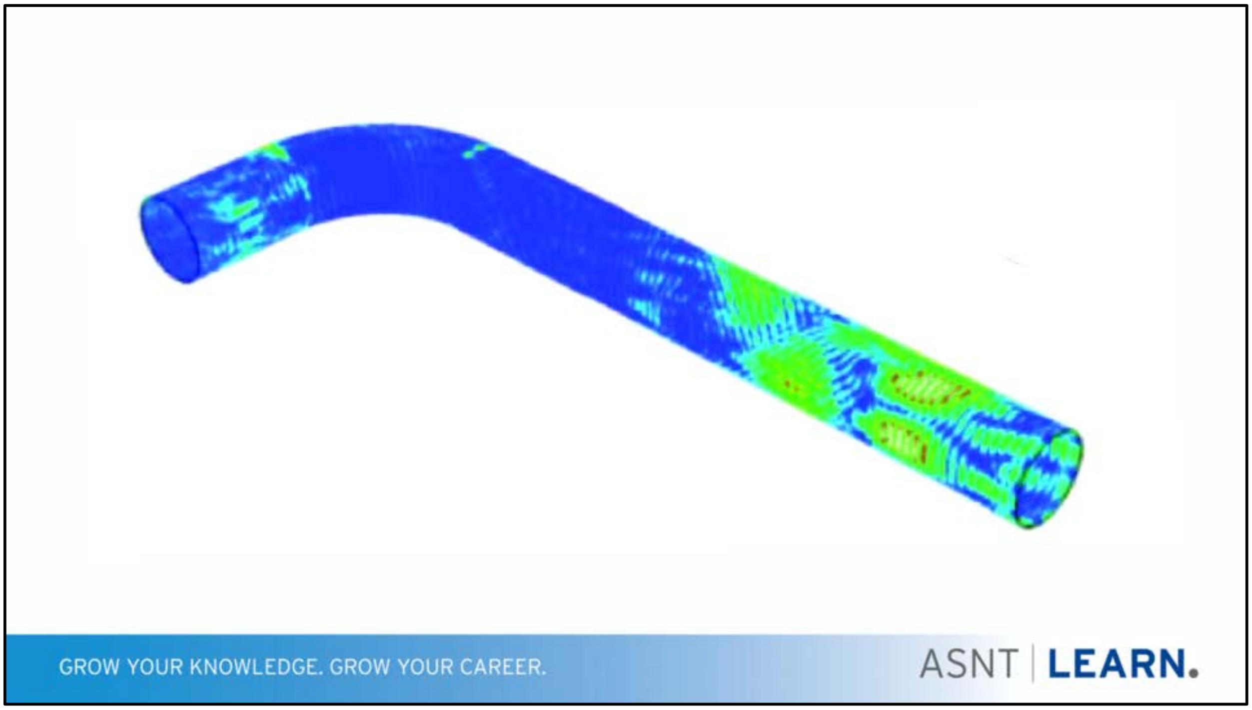
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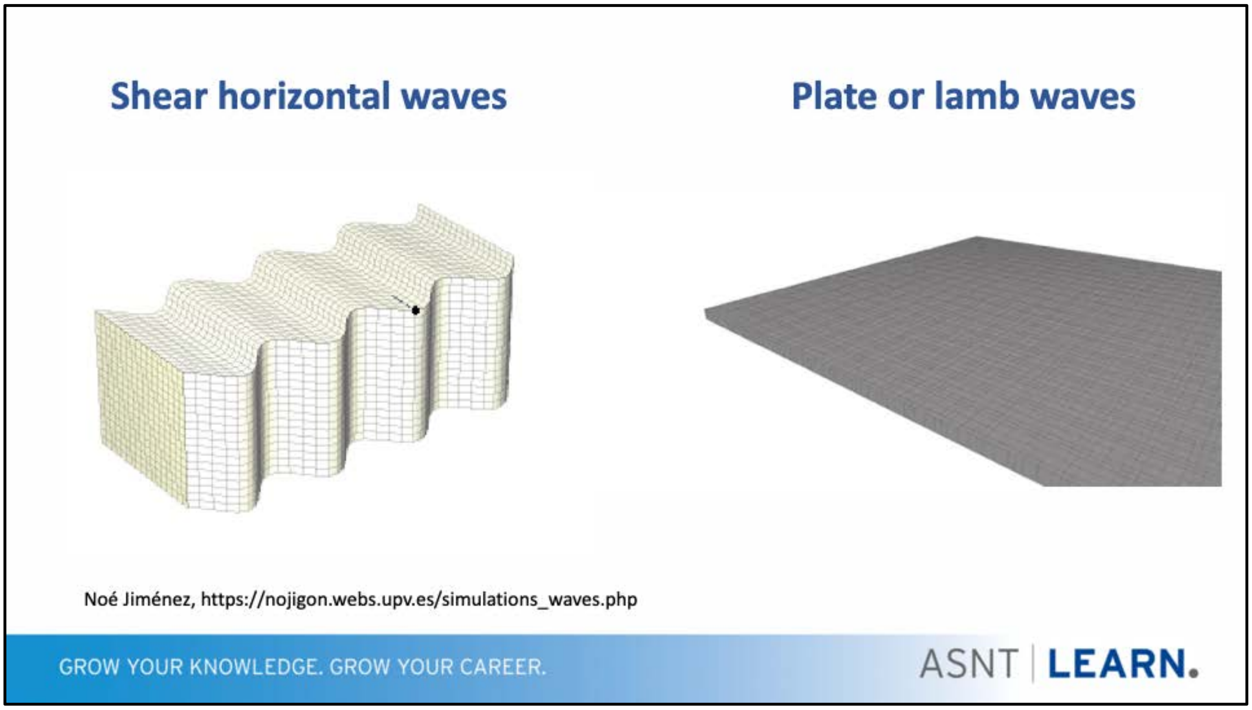

Guided waves take the form of either shear horizontal waves or plate waves, also called lamb waves, moving through a test object with distinct boundaries referred to as a waveguide.

Its initial design and application was for detecting corrosion under insulation in petrochemical plant pipework, but it has found widespread use in other inspection situations.


Visual Testing (VT)

No matter which NDT method is used, one of the greatest, cheapest, and yet most valuable instruments for the detection of discontinuities lying on the surface of a part is …

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Drum roll, please!

The human eye!

As the name implies, visual testing is the observation of a test object, either directly using one's eyes ...

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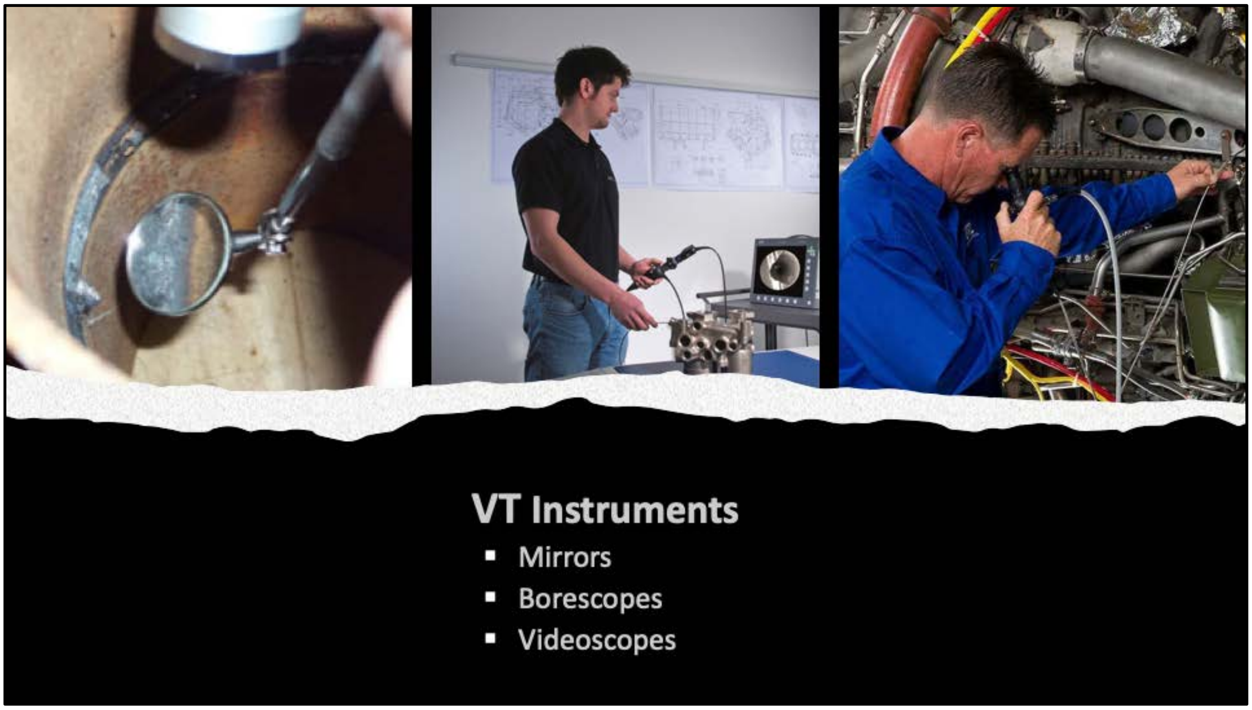

... or indirectly using optical instruments like:

- mirrors,
- borescopes,
- and videoscopes for remote viewing.

VT is used to evaluate the presence of macroscopic surface discontinuities …

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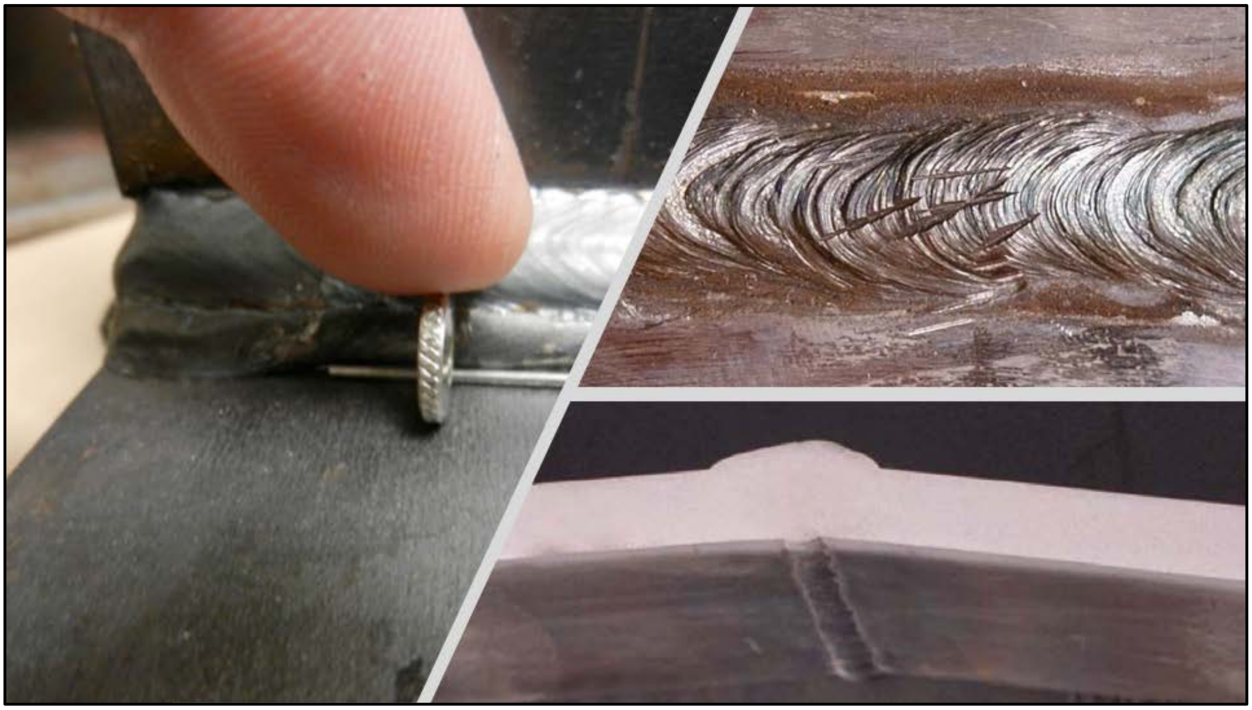
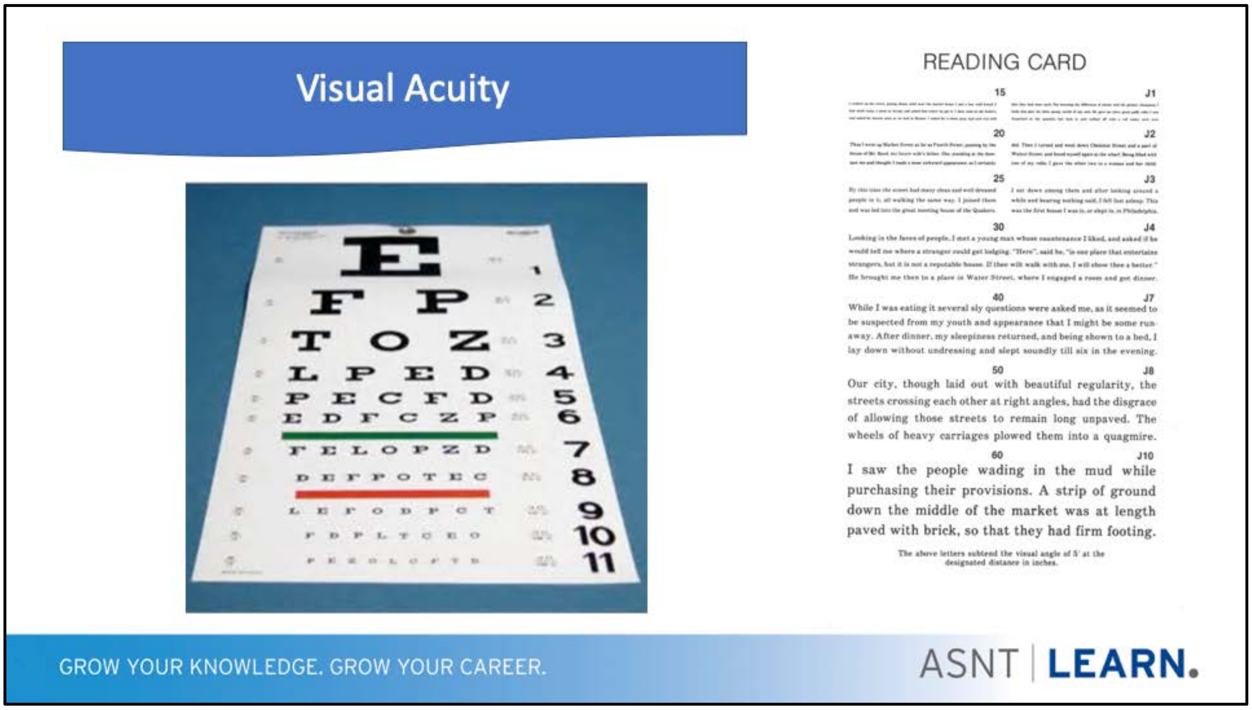
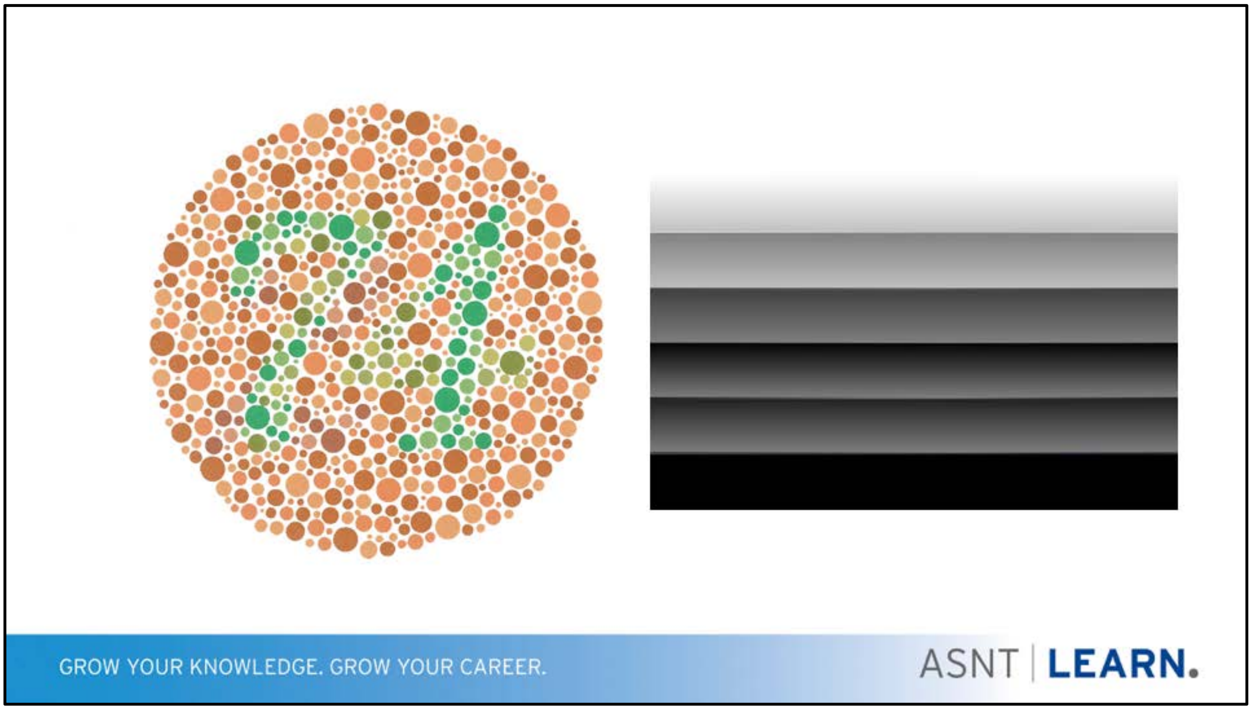
... such as corrosion, cracks, weld discontinuities, and scratches ...



… as well as quality nonconformities, such as misalignment of parts, physical damage, and specification variances.



As you might suspect, visual acuity of the inspector is an essential factor of visual testing.



Color discrimination, as well as being able to differentiate shades of gray, is another important factor that affects visual inspection.

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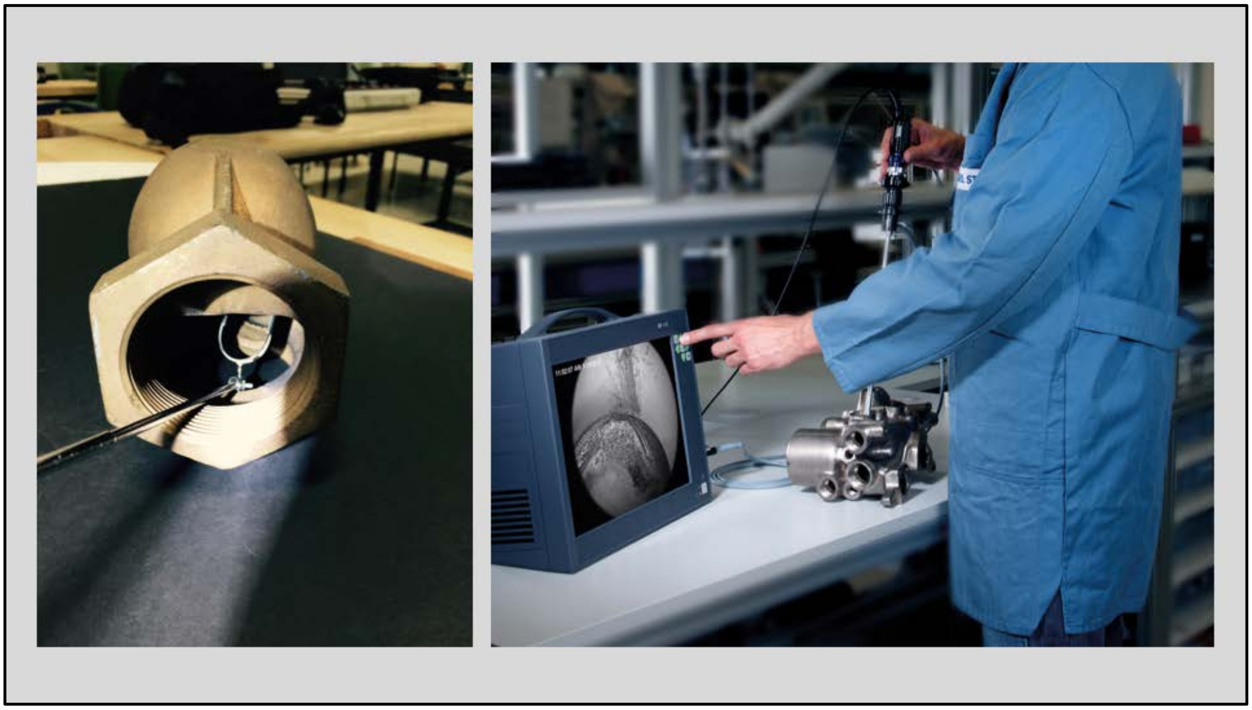
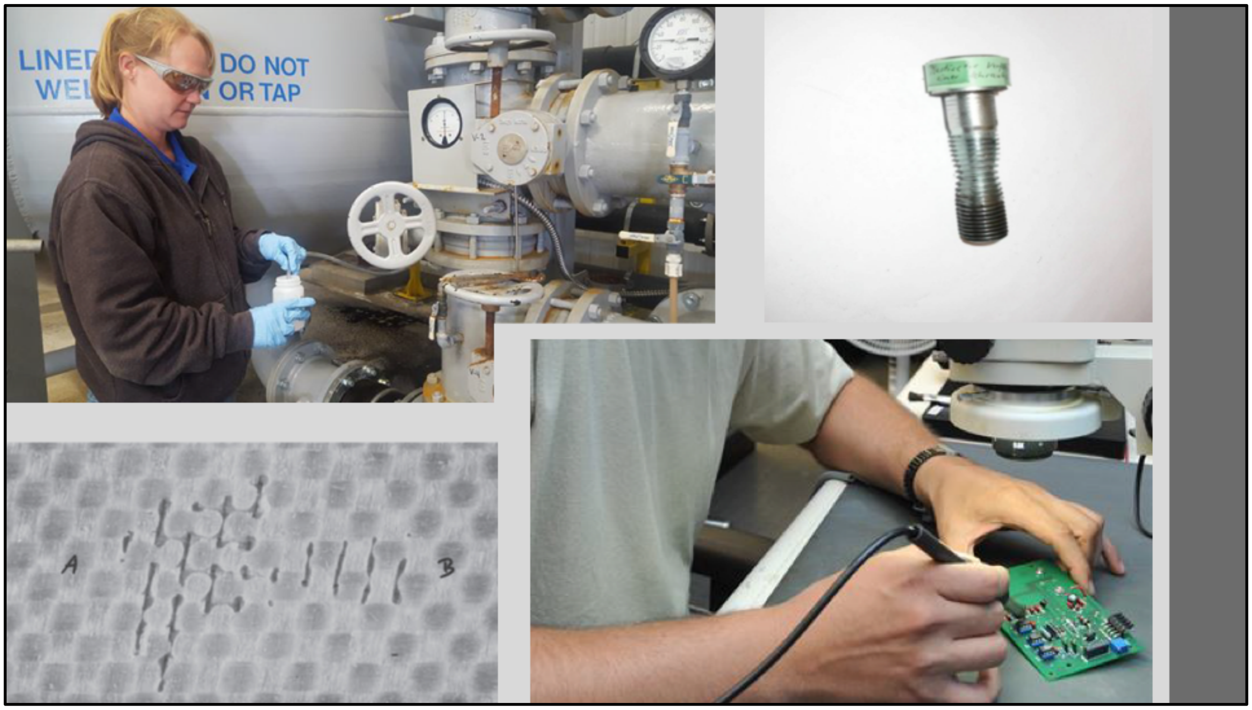
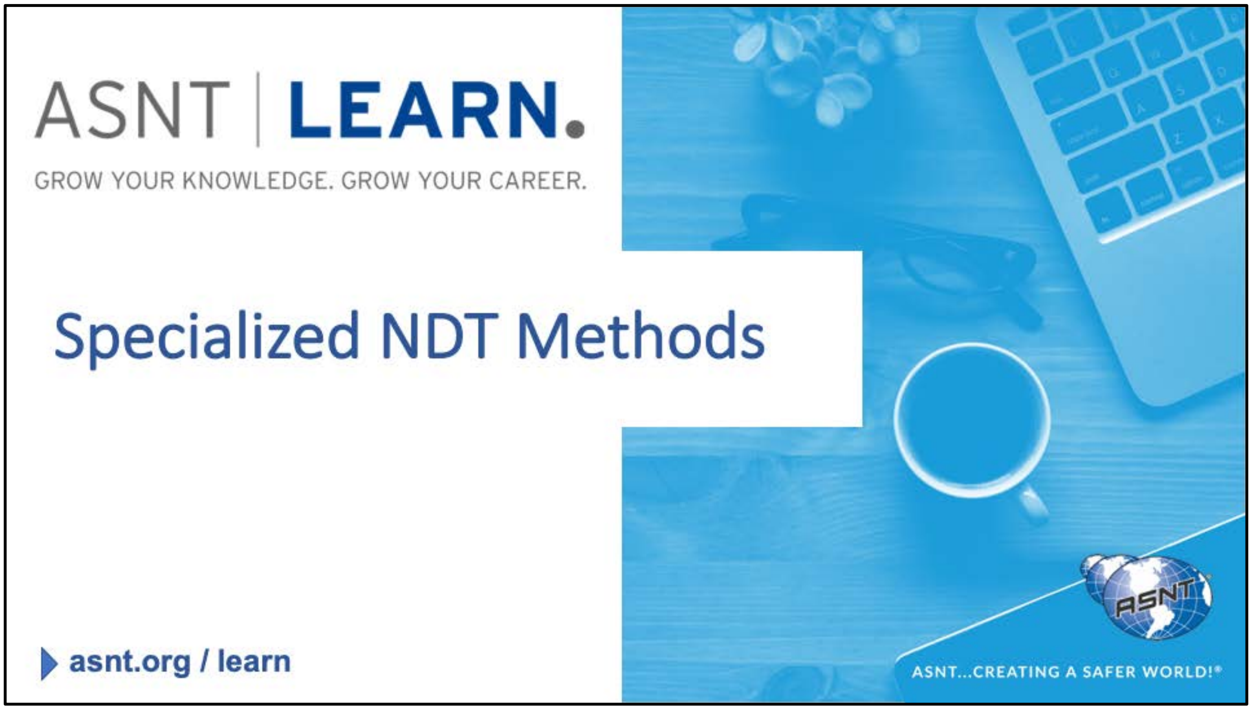


Other uses for visual testing include inspection of ...



Other uses for visual testing include inspection of bolting systems, electronic components, valves, and composites.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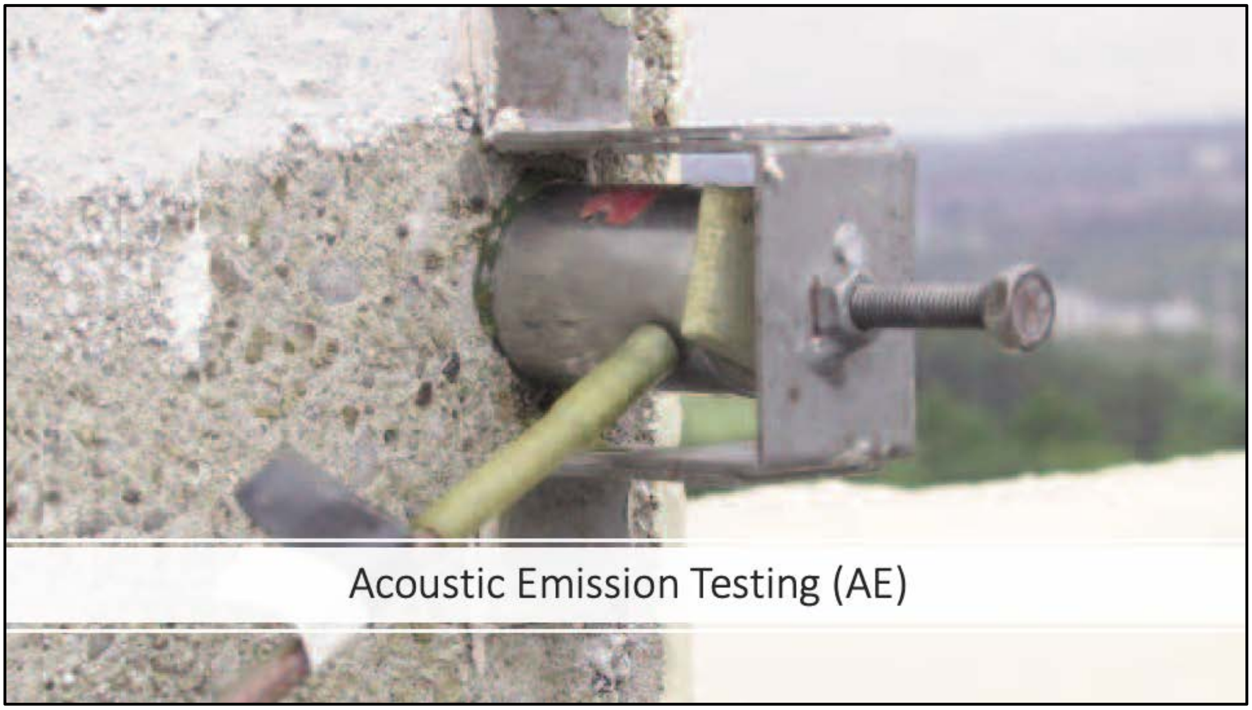
Acoustic Emission Testing (AE)

If a tree falls in a forest, does it make a sound?

Yes, if there's an acoustic emission probe to sense it cracking in two.

Snapping of twigs, breaking of bones, rumble of earthquakes … each of these events conveys a characteristic sound.

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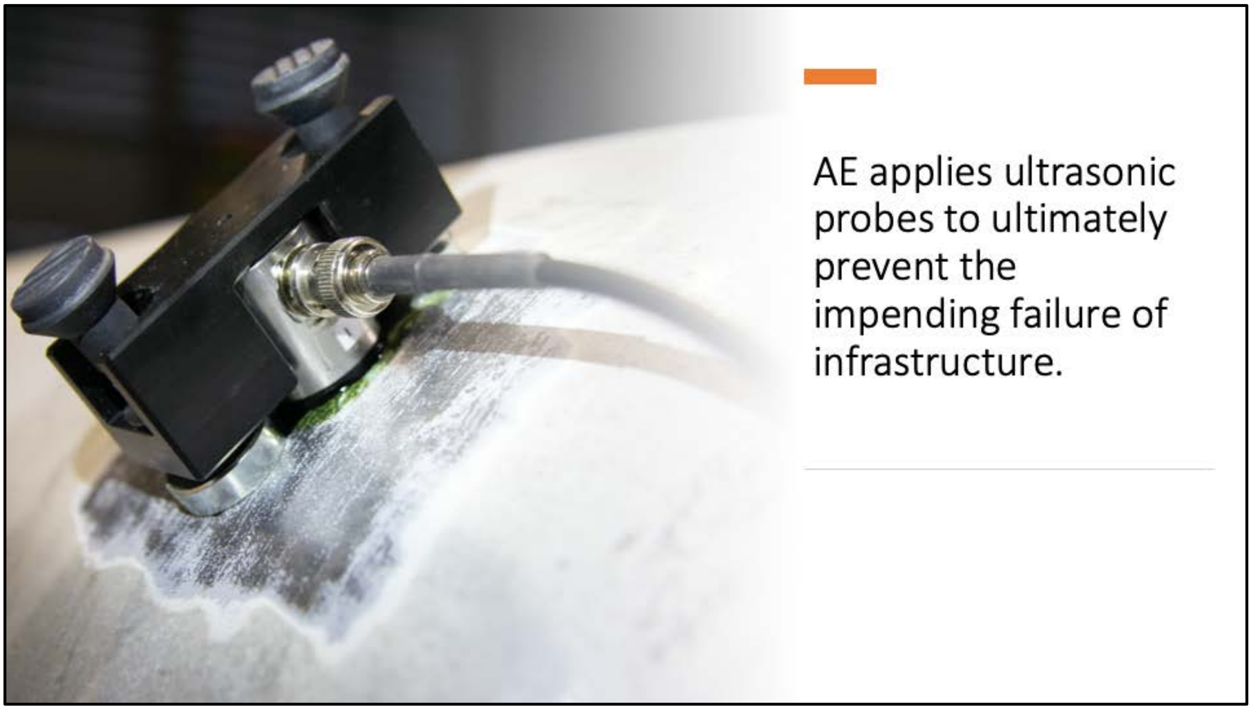
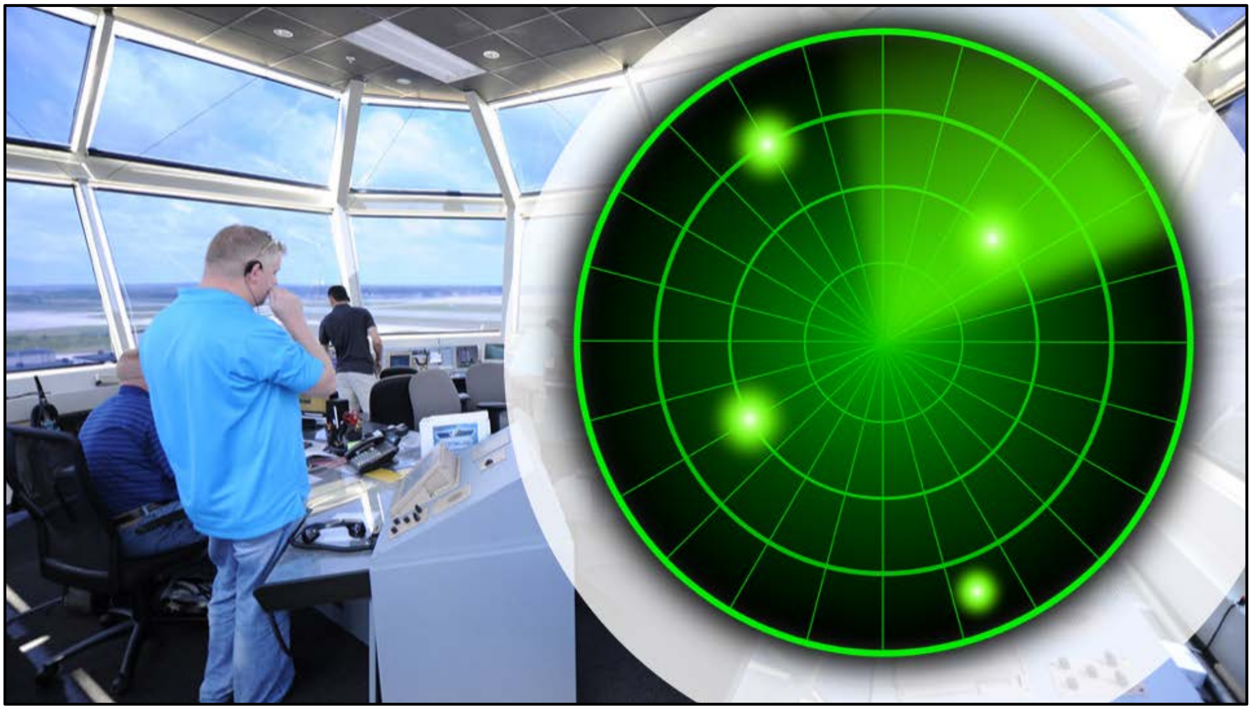
So does the minute fracturing of girders and support structures due to stress in a bridge.



Acoustic emission testing applies probes sensitive to sound inaudible to the human ear to detect and ultimately prevent the impending failure of infrastructure.

Ground Penetrating Radar (GPR)

What do air traffic controllers and ground penetrating radar inspectors have in common?



Radar ...

... which stands for Radio Detection And Ranging technology.

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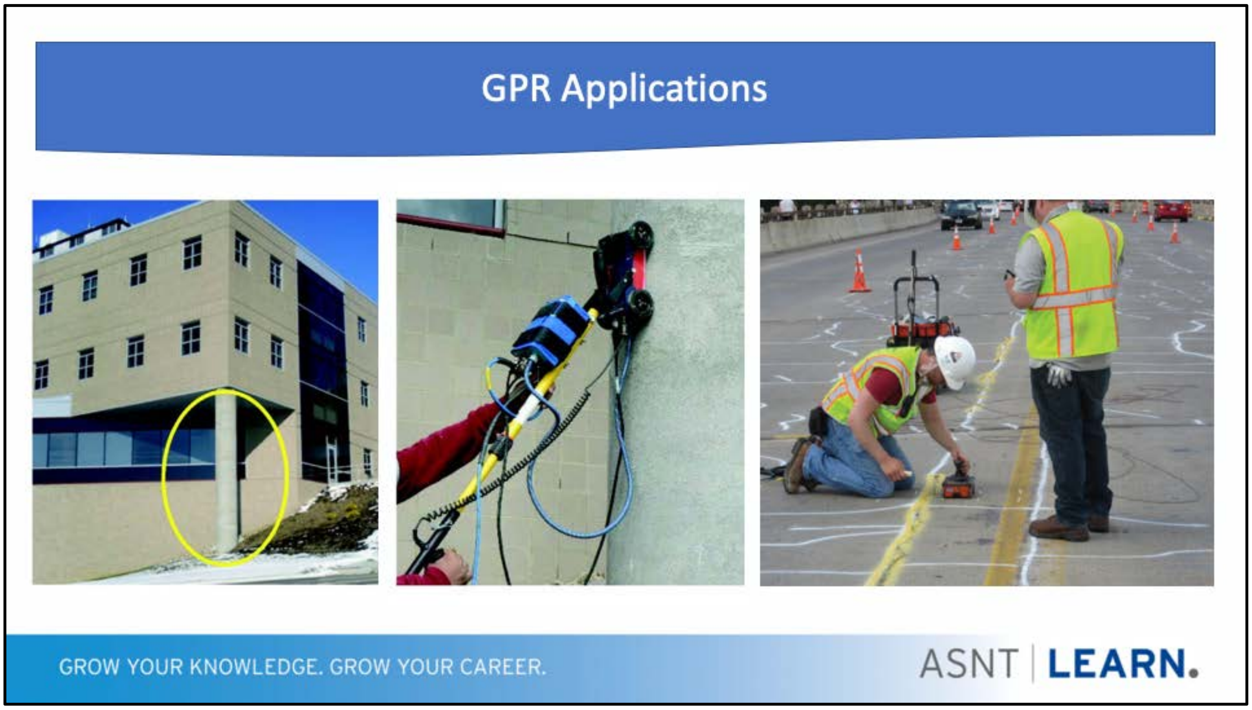
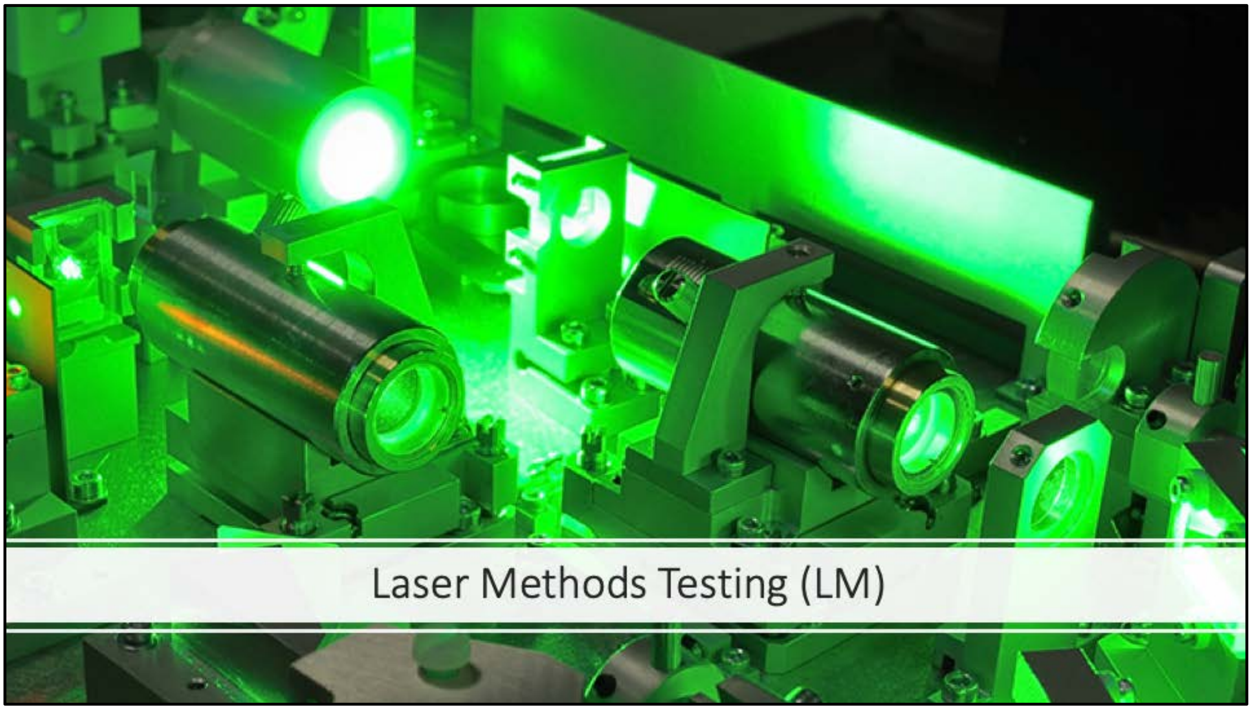
Ground penetrating radar works on a simple principle: electromagnetic waves are emitted from a radar-transmitting antenna, dispersed into the ground, and reflected in part to a radar-receiving antenna when an obstruction or anomaly is encountered.

You've probably encountered this technology if you ever needed to locate underground pipes and wires in your yard before digging.



GPR is also used to monitor the structural integrity of buildings and bridge decks.


Laser Methods Testing (LM)

Lasers are used in everyday life from laser tag to reading barcodes at the checkout line or stockroom for inventory, and from LASIK eye surgery to pointers in PowerPoint presentations.

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- Surface irregularities
- Structural distortion
- Corrosion
- Blistering
- Delaminations

Lasers are used in nondestructive testing to detect:

- delamination or separation of layers in bonded surfaces,
- blistering beneath coatings,
- corrosion between layers of aluminum structures,
- structural distortion, and
- irregularities in surface smoothness.


Leak Testing (LT)

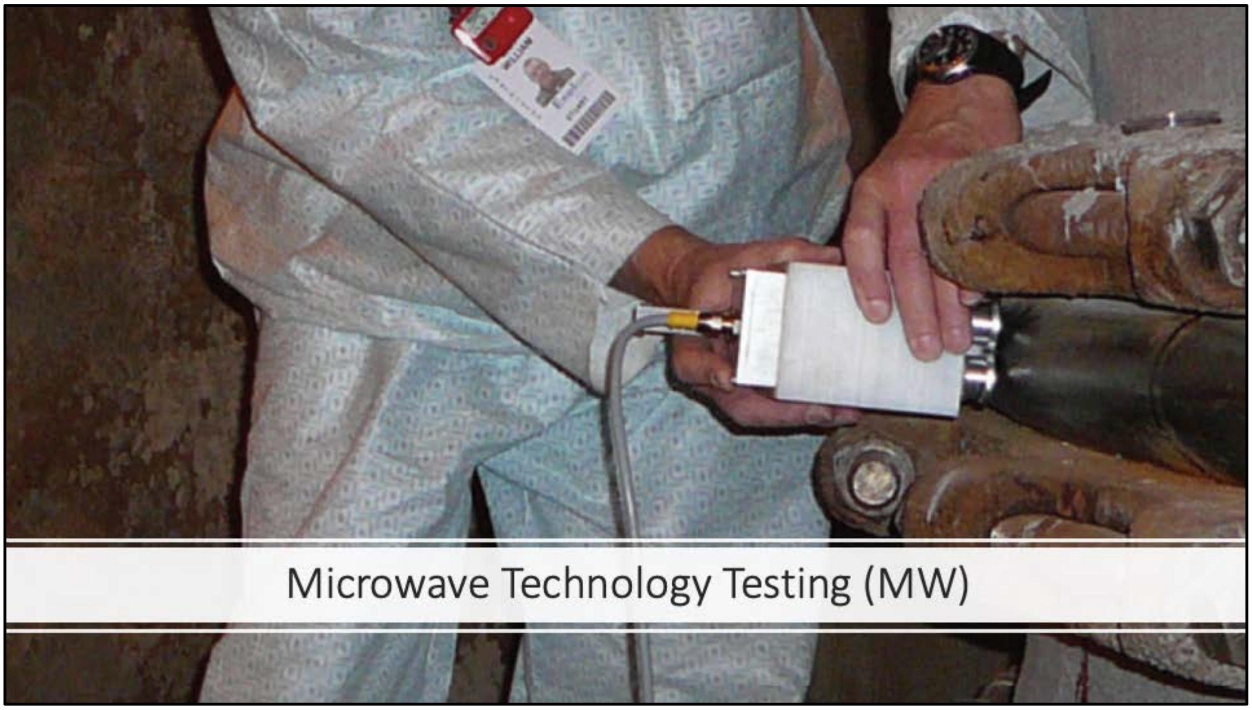
Have you ever held a bicycle innertube under water to detect bubbles emanating from a puncture? If so, you were performing leak testing.

With the NDT method of leak testing, the word "leak" actually refers to the hole that exists and not the passing of fluid or gas through the hole. Technically, a system could have a leak but no leakage!

Operating LT equipment on high-pressure containment objects can be hazardous, as radiation, gases, and pressure vacuums can be harmful or even deadly.


TCQ Automation & Test Solutions, https://www.tqc.co.uk

Work must be precisely controlled within the limits of procedures, codes, and standards to protect workers, the community, and the environment.



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When was the last time you used your microwave oven?

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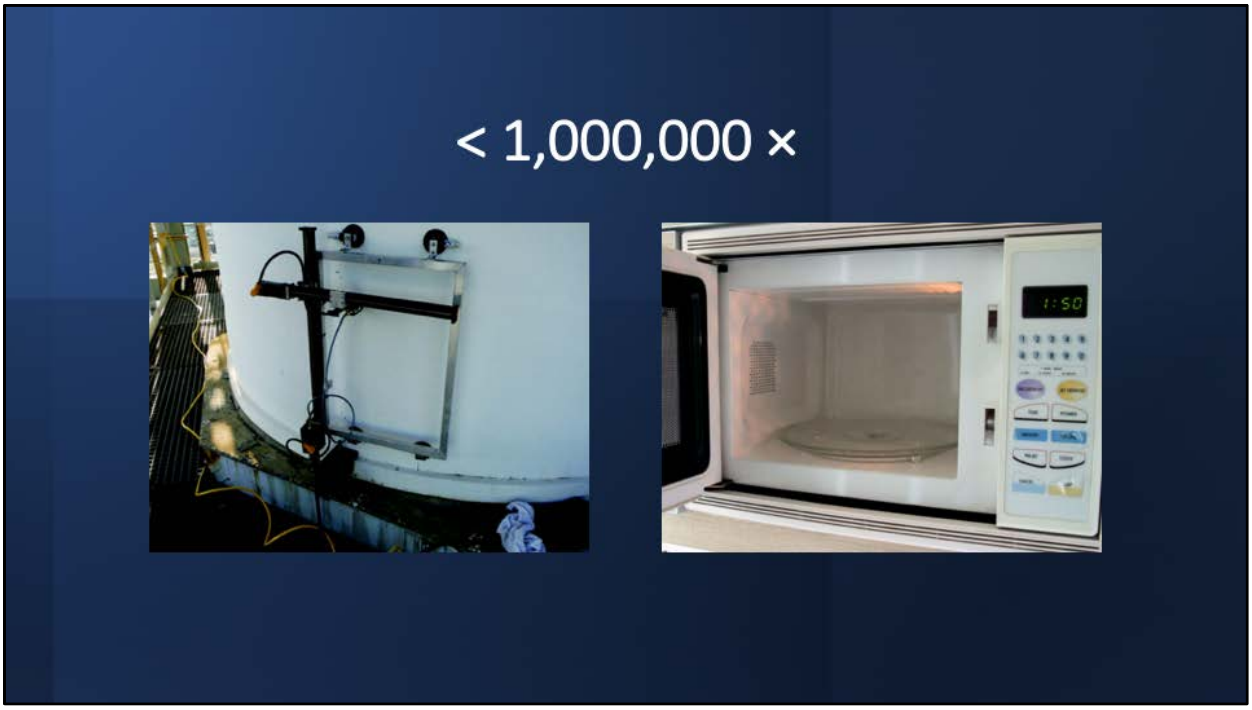
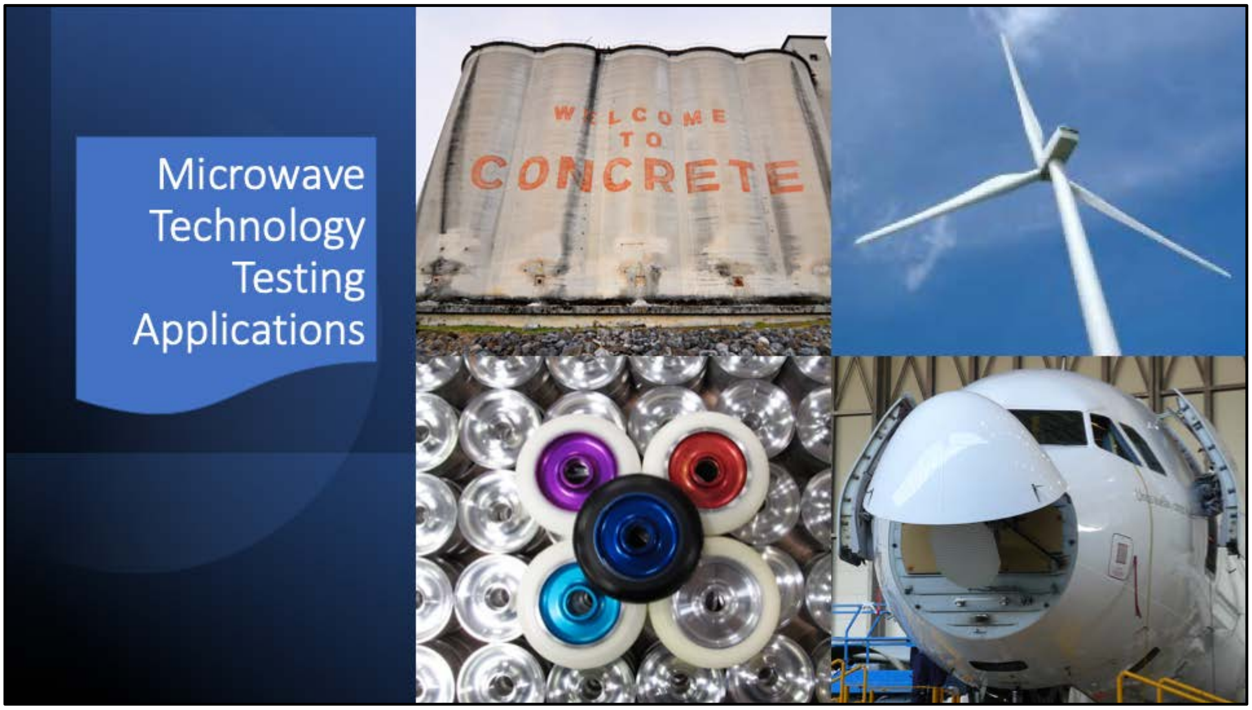
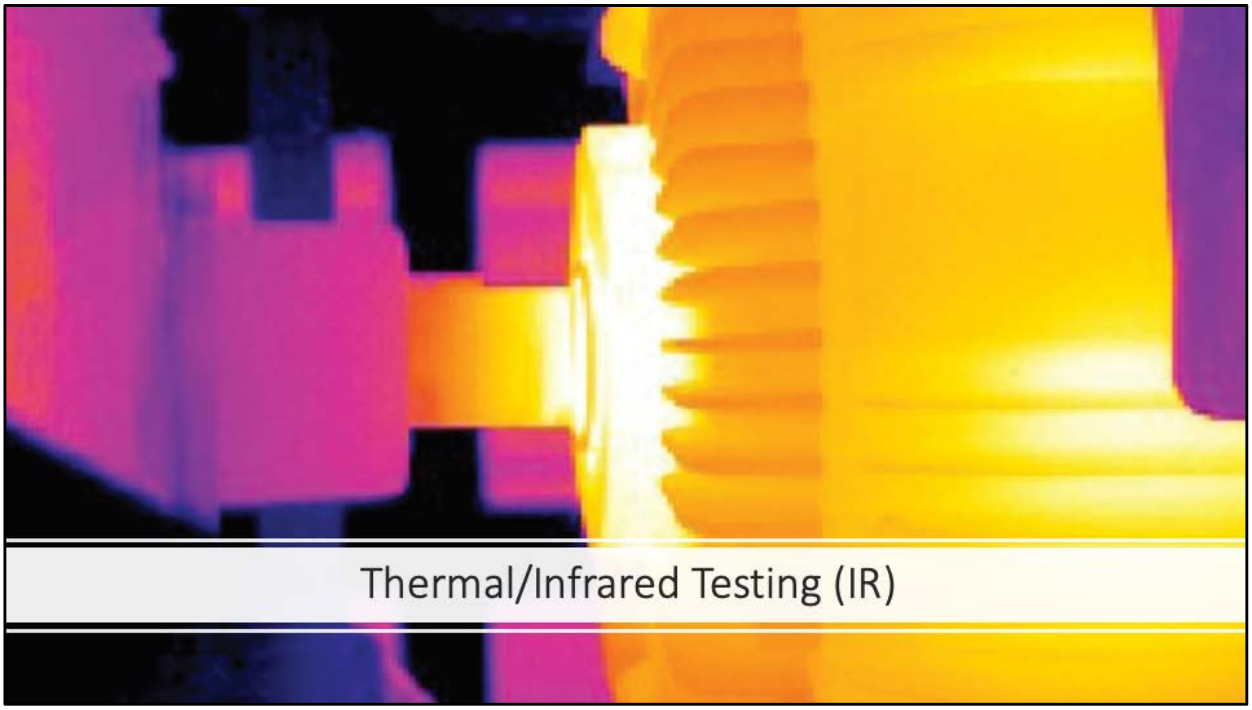
Probably last night to pop a bag of popcorn.



To remain nondestructive in nature, microwave energy used for NDT is approximately 1 million times less powerful than the typical kitchen microwave oven, making the method very safe for personnel and test objects.



Applications of microwave inspection technology include the testing of wind turbine blades, aircraft nose radar domes, concrete, and high-density polyethylene products.


Thermal/Infrared Testing (IR)

You may be familiar with home energy inspectors who use infrared readings to monitor heat leakage from houses.

In the world of NDT, thermal/infrared testing (IR) is widely used to monitor the operating condition of components and reduce costly equipment outages.

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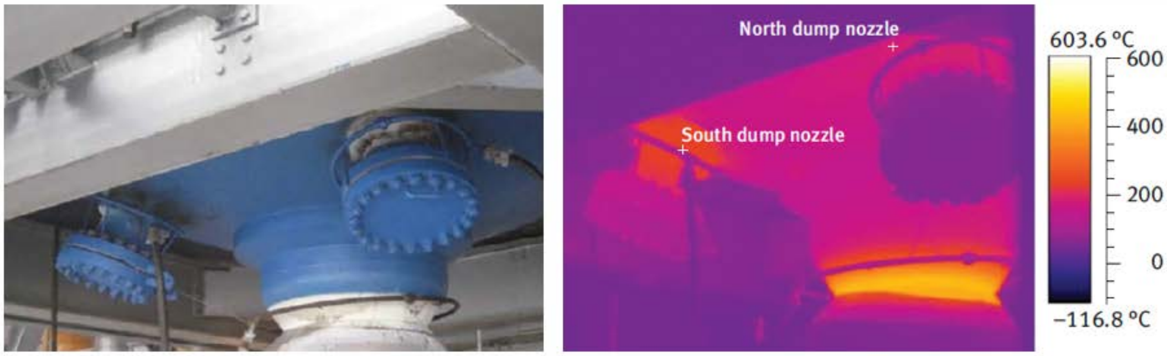

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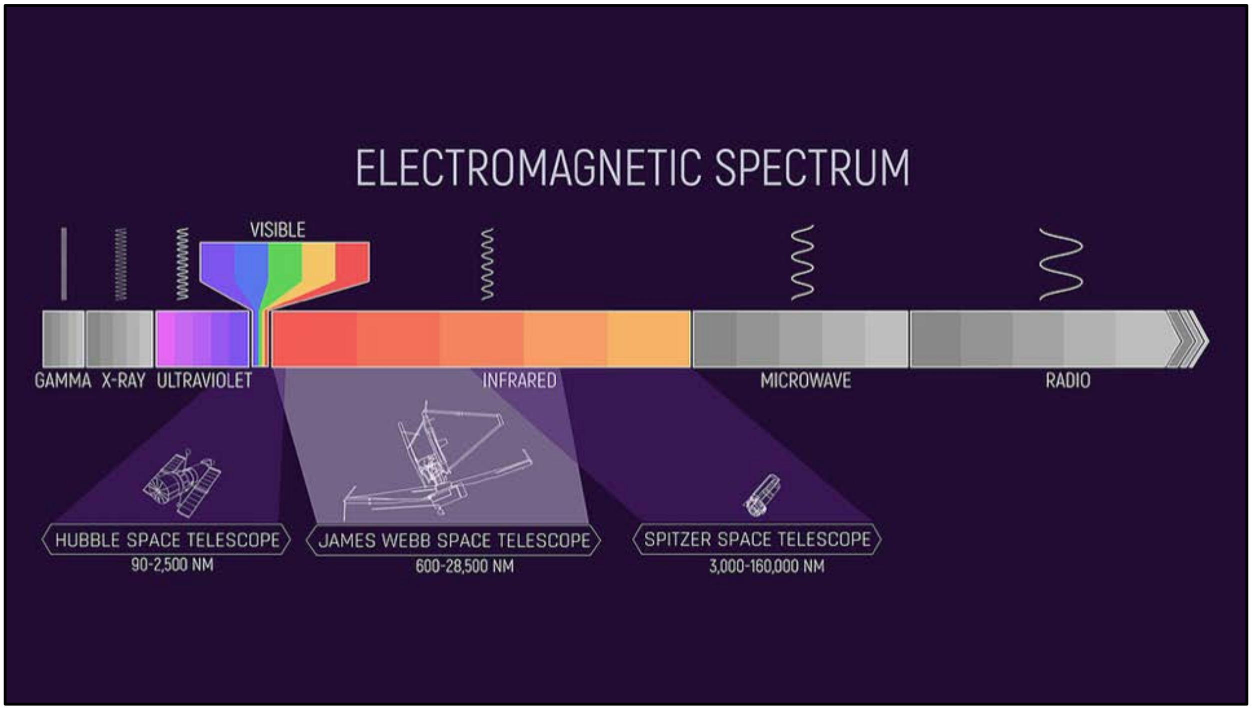
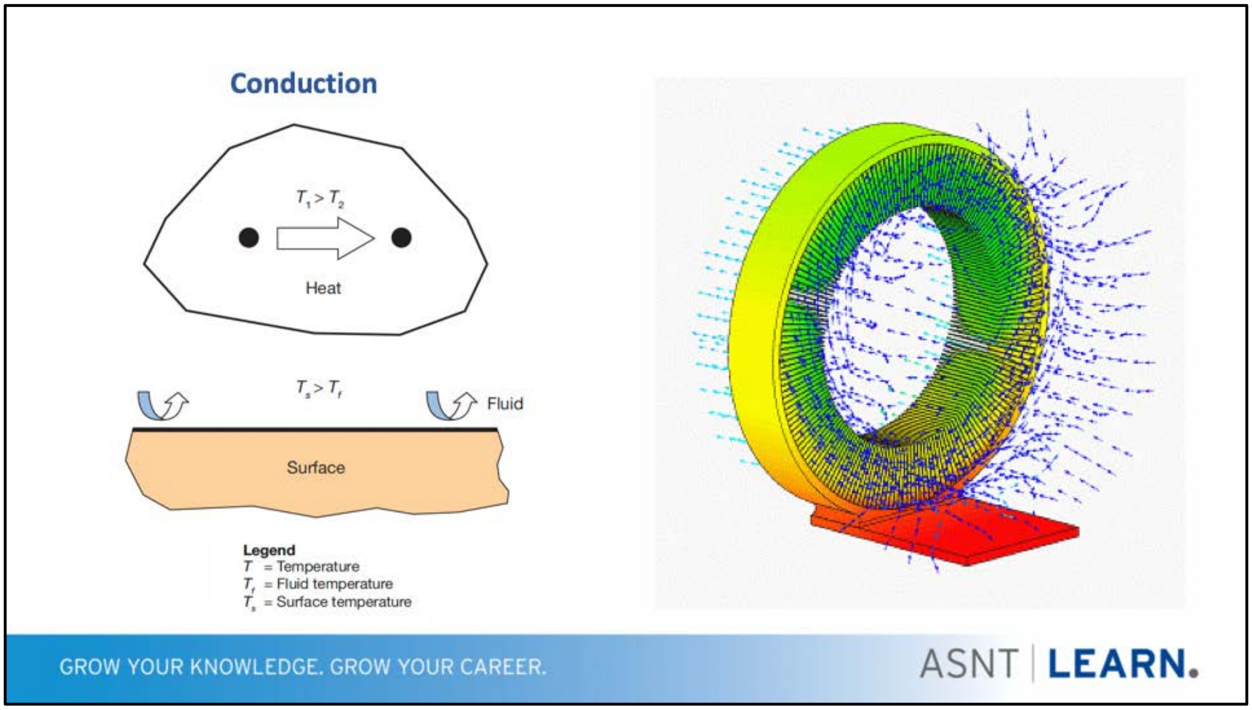
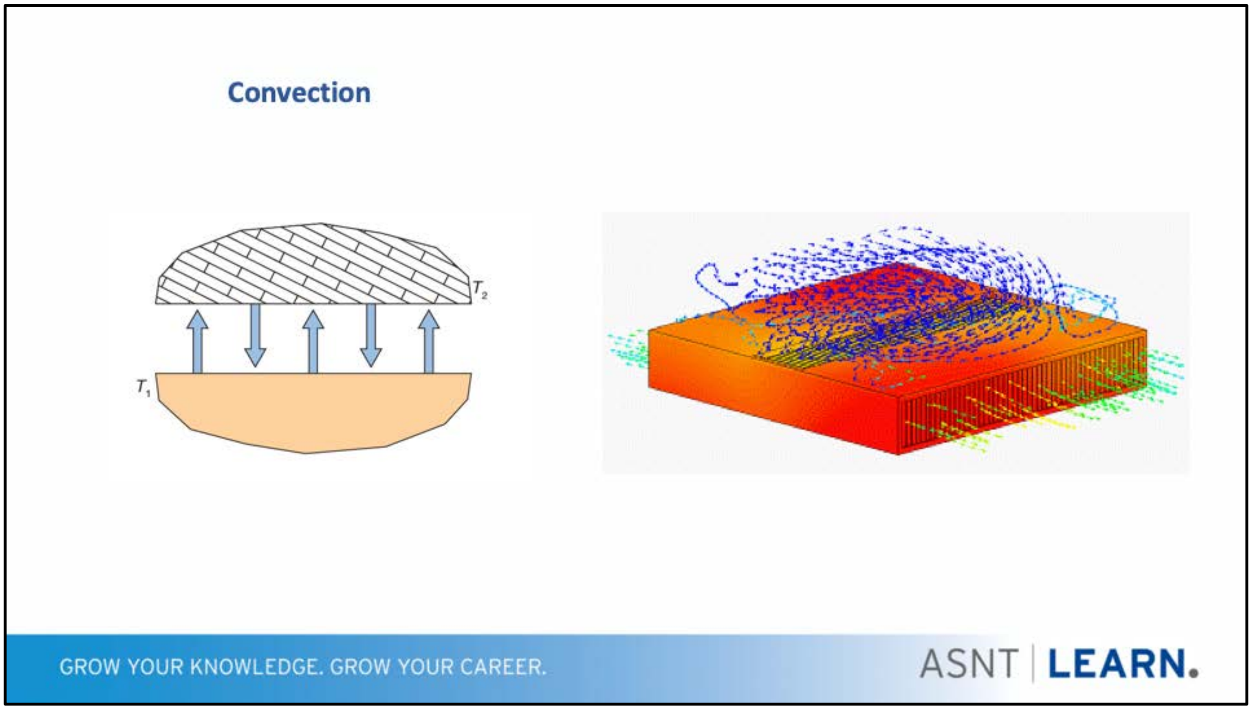
It does this by measuring the temperature of a point or surface.



IR focuses on the energy in the electromagnetic spectrum between visible and microwave wavelengths; infrared is invisible to humans, yet is encountered everyday as heat. Heat can be transferred from one source to another by infrared radiation, convection, and conduction.

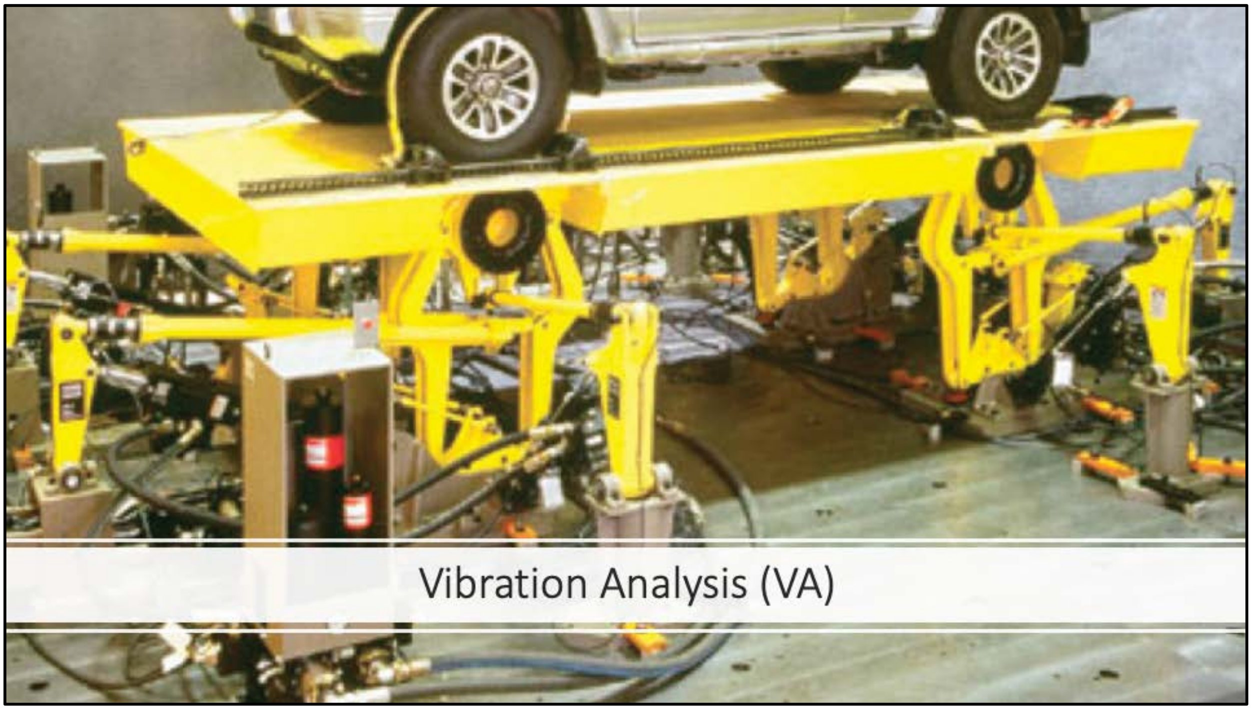


Conduction occurs when a substance is heated and its particles gain energy and vibrate more vigorously. The particles bump into nearby particles and make them vibrate more. This passes the thermal energy through the substance from the hot end to the cold end.

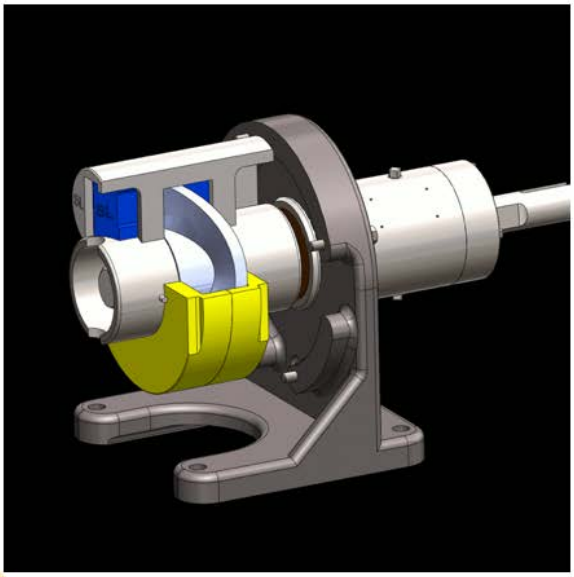


Convection happens when particles with a lot of thermal energy in a liquid or gas move and take the place of particles with less thermal energy. Thermal energy is thus transferred from hot places to cold.

Temperature is frequently considered the key to successful maintenance and is one of the most measured units in industrial process control.


Vibration Analysis (VA)

If you do your own laundry, you know when your washing machine is out of balance when you hear it emitting loud oscillating vibrations.



In a similar way, vibration analysis is an NDT method used to monitor the condition of rotating machinery and electric motors.

Benchmark Reliability Services Inc., https://bmreliability.ca/services/vibration-analysis/

The vibrations from operating mechanical equipment have a unique pattern of oscillations.

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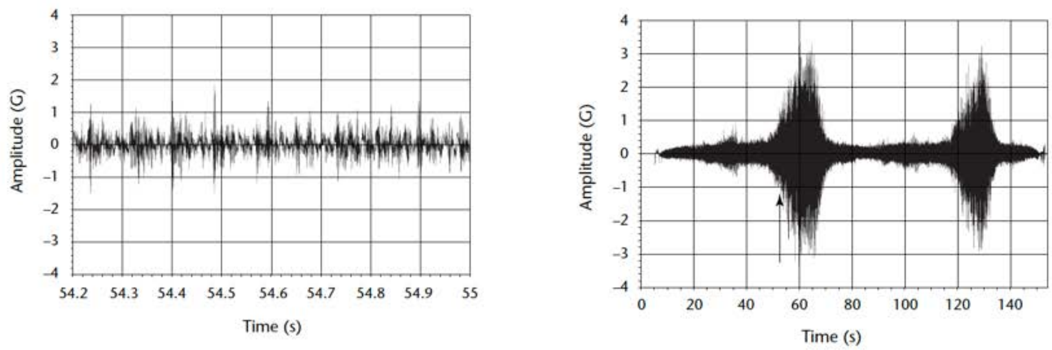
Vibration Patterns



If a change occurs due to cracking or excessive wear and tear, the pattern of vibrations usually changes.

Vibration measurement and analysis is the cornerstone of predictive maintenance to alert personnel at the earliest possible sign of an impending failure.

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Detecting and Reporting Discontinuities

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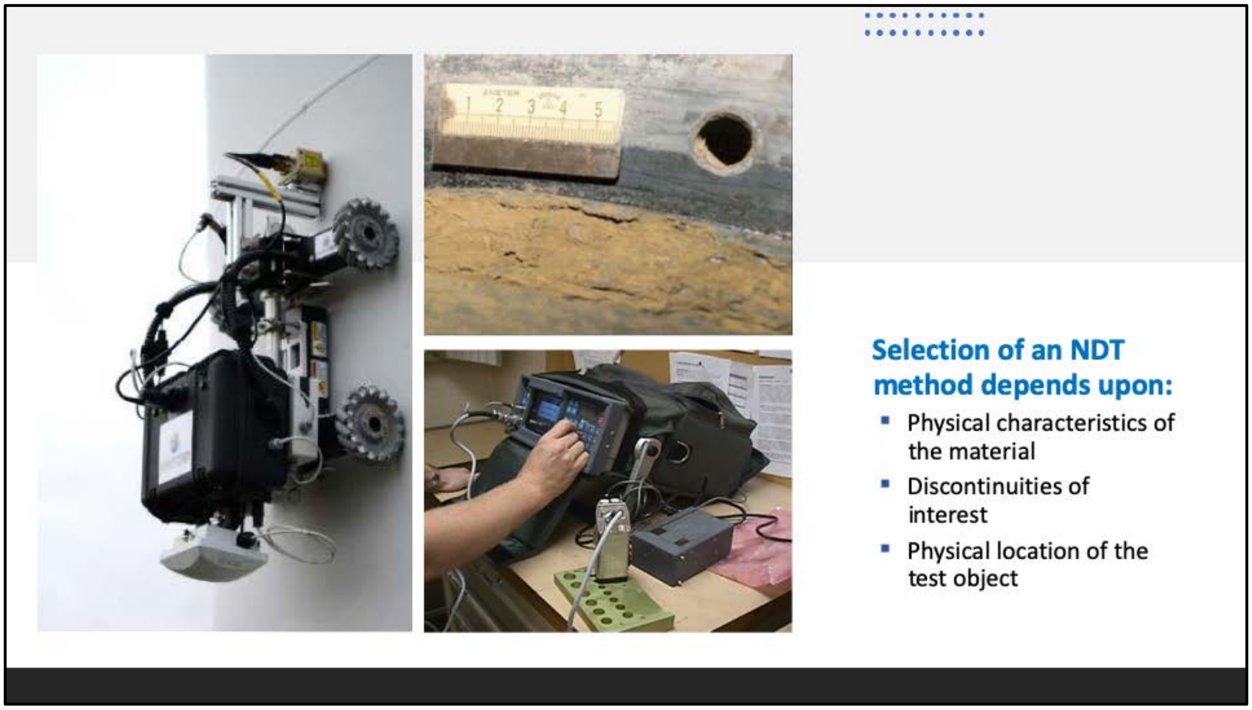


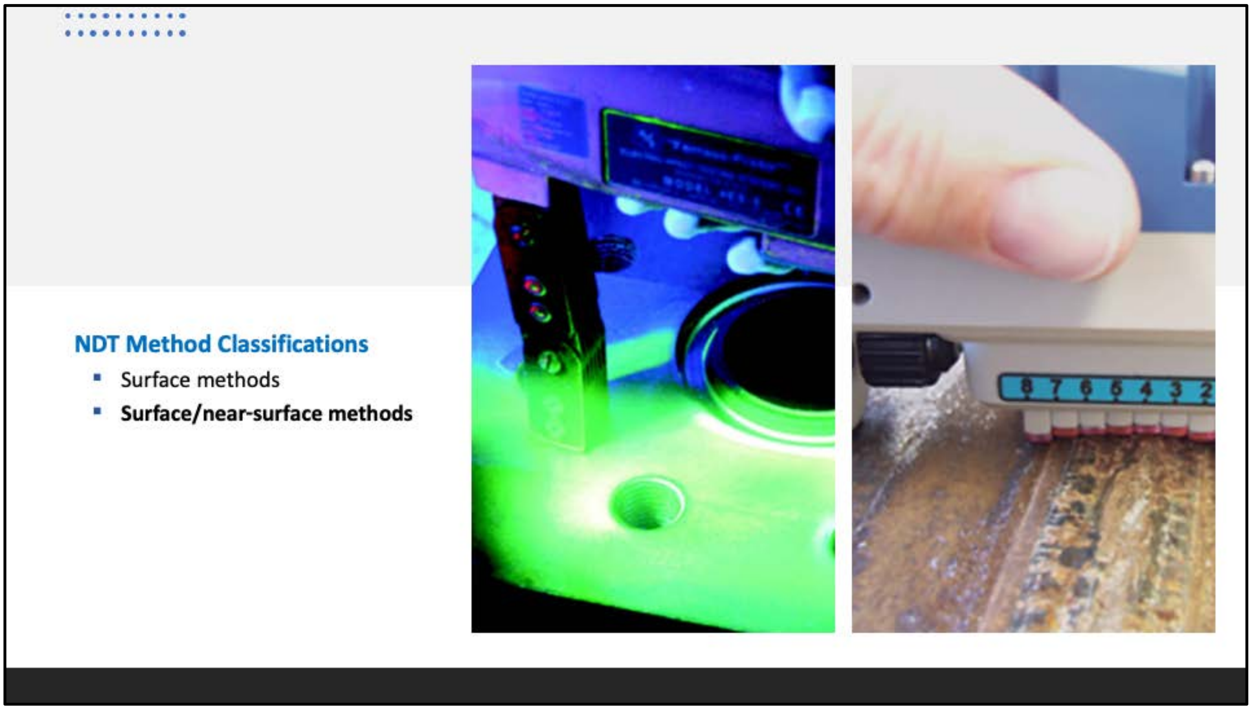
The selection of an appropriate NDT method for a specific application is based upon:

- the physical characteristics of the material (for example, whether it is metallic, magnetic, massive, or irregularly shaped);
- the discontinuities of most interest, including their probable location, orientation, size, and physical makeup; and
- the physical location of the test object and whether more than one surface is available for inspection, and even the type and amount of lighting that is available at the worksite.

NDT Method Classifications

- **Surface methods**

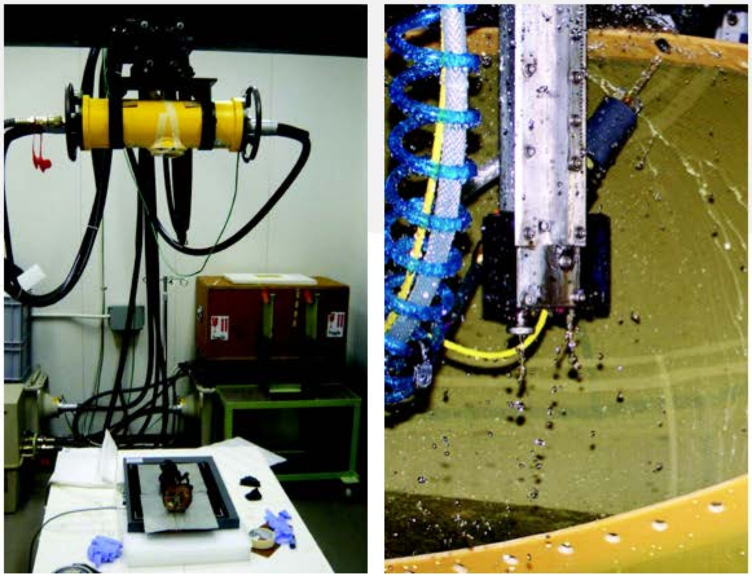
Methods limited to inspection of the surface of a test object include liquid penetrant and visual testing.



Methods can detect discontinuities slightly beneath the surface of a test object include magnetic particle and electromagnetic testing.

NDT Method Classifications

- Surface methods
- Surface/near-surface methods
- **Volumetric methods**



Volumetric methods such as RT and UT can penetrate the interior of a test object.

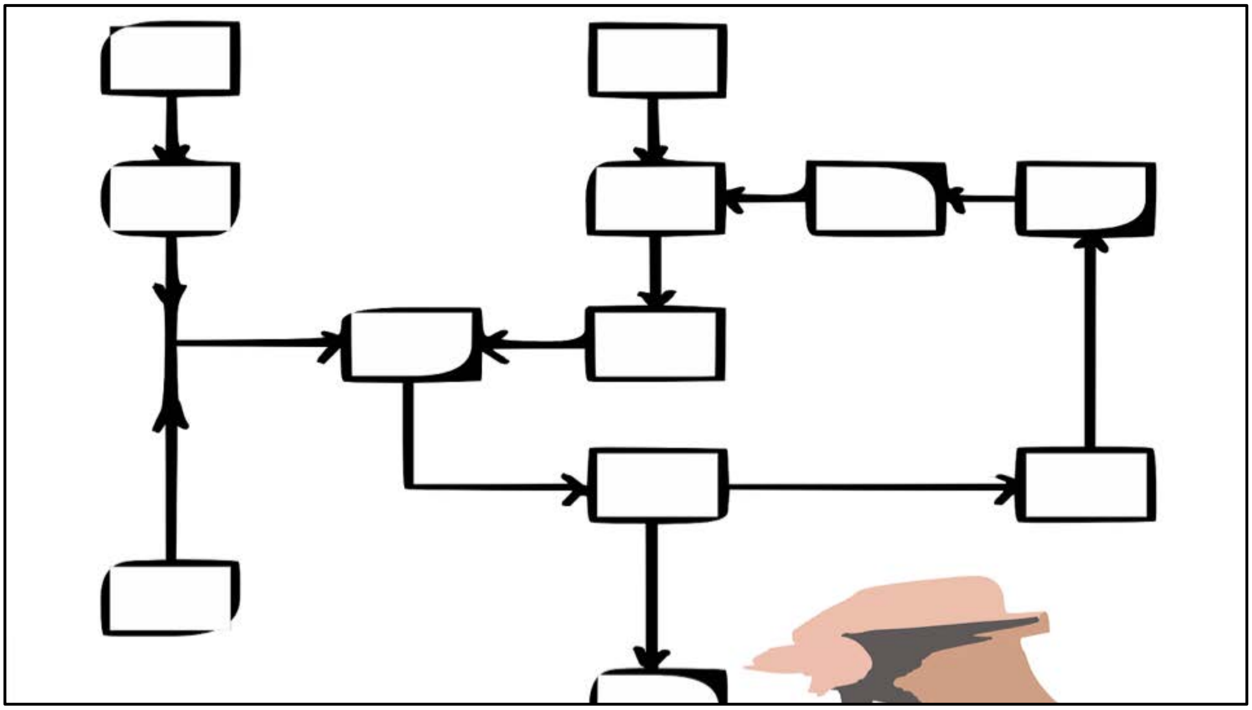
No single NDT method is all-revealing.

Each NDT method has its advantages and limitations.

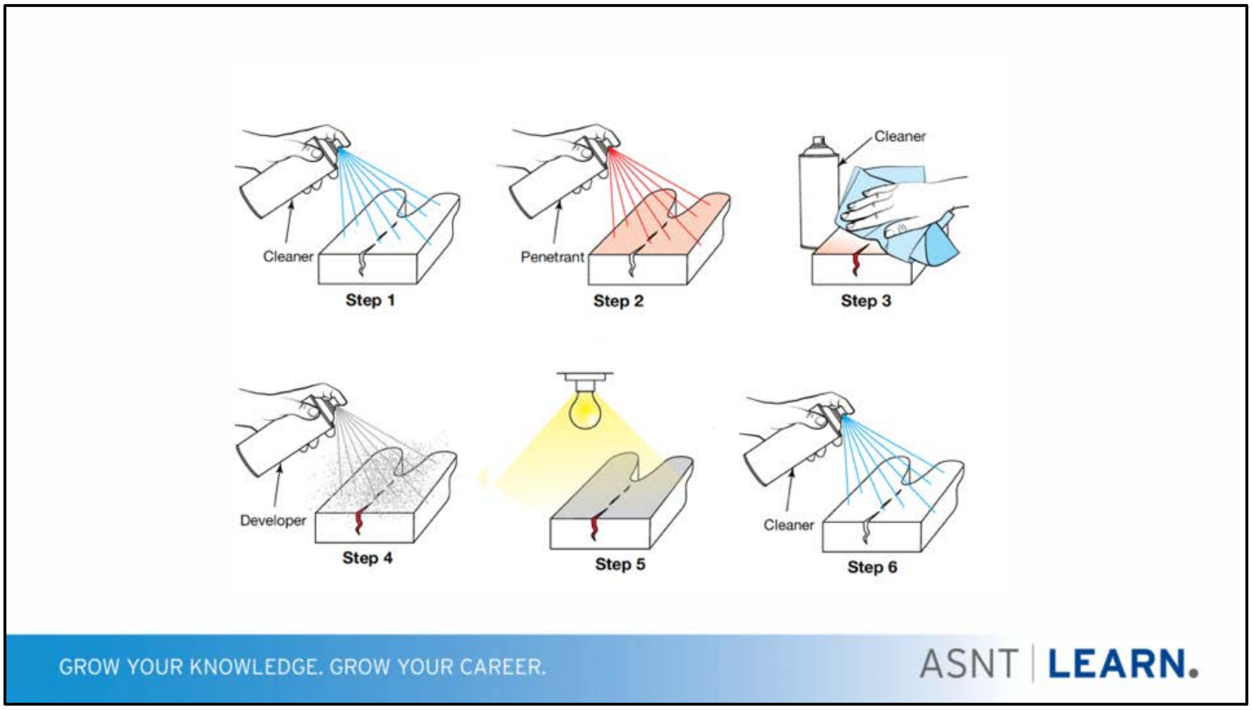
No one nondestructive test method is all-revealing.

In most cases, it takes a series of test methods to do a complete nondestructive test of an object or component

The conduct of facility operations should be performed in accordance with specific instructions from an expert.



This is typically accomplished using written instructions in the form of a technical procedure.



A procedure may be written as a step-by-step process requiring a supervisor's initial or signature after each step.

Procedure No.: P-3650

Procedure Title
Steel Cleanliness by the Magnetic Particle Method

1.0 Scope
This document provides a procedure for magnetic particle inspection of the steel cleanliness specimens prepared in accordance with **Procedure P-2468.**

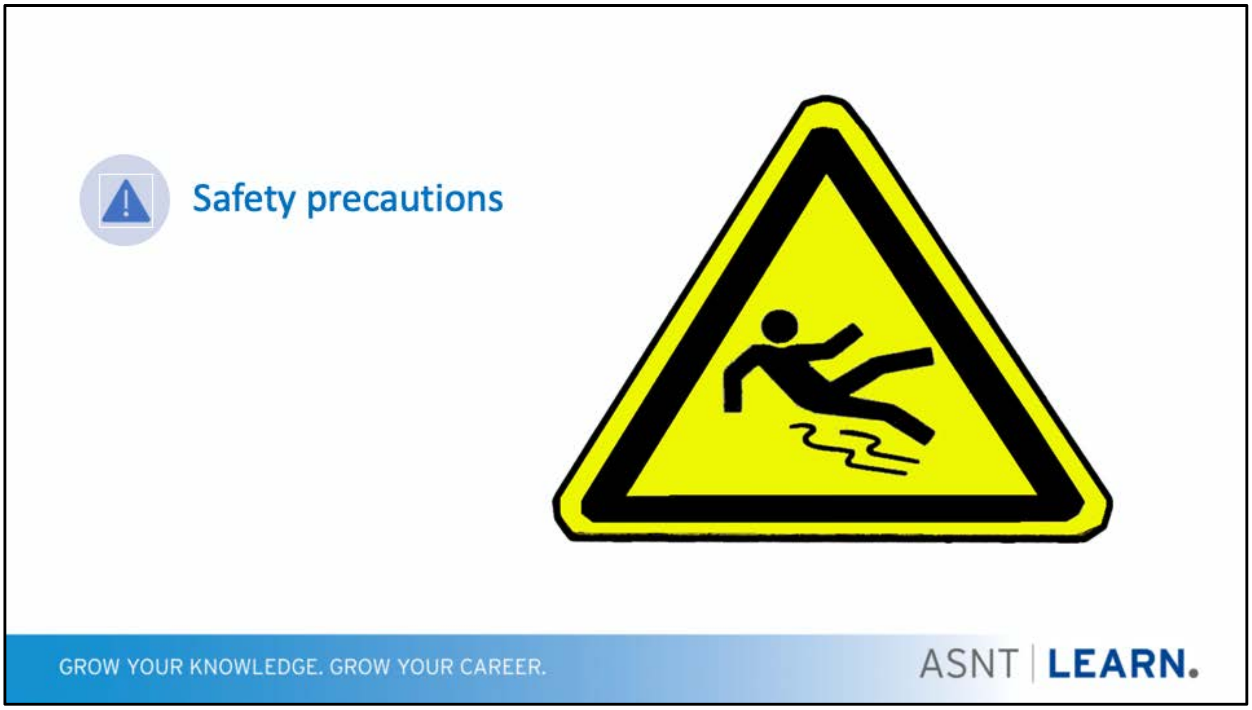
2.0 References
PBA-1004, *Aircraft Quality Steel Cleanliness—Magnetic Particle Method*
PBA-906, *Magnetic Particle Inspection*
ASTM E 1444, *Standard Practice for Magnetic Particle Examination*
ASNT-CP-189, *Personnel Qualification and Certification in Nondestructive Testing (2011)*
P-2468, *Steel Cleanliness Specimen Preparation*

3.0 Personnel
Personnel shall be certified in accordance with ASNT-CP-189 (2011). These tests shall be conducted by certified Level I personnel working to this procedure under the supervision of certified Level II personnel.

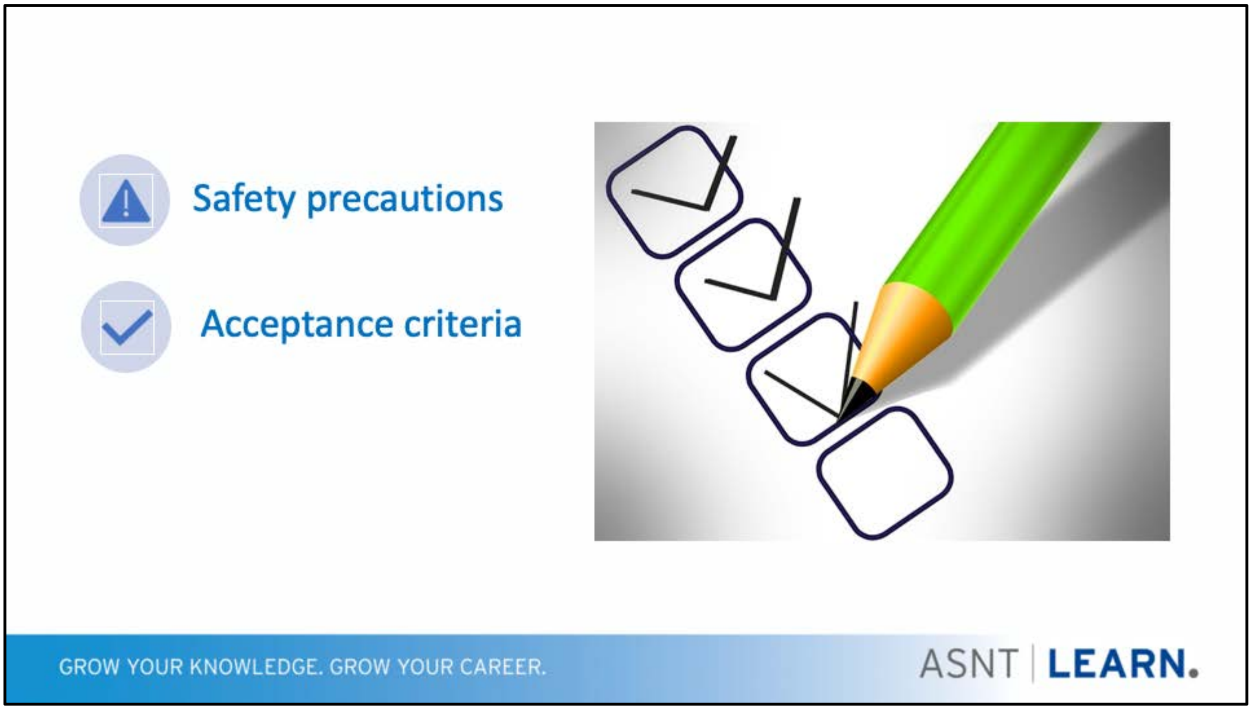
4.0 Equipment
1. Wet horizontal magnetic particle machine with fluorescent suspension
2. Ketos ring
3. 2.5 cm diameter copper bar, 45.7 cm long
4. 100 W minimum pressure mercury-vapor ultraviolet light
5. 100 mL pear-shaped centrifuge tube

5.0 Definition of Terms
Stringers — nonmetallic inclusions in the steel
Steel cleanliness specimen — a steel specimen that has been machined in accordance with Procedure P-2468
Perimeter — perimeter of a square or rectangle is the sum of the four sides
Magnetizing current for a square or rectangular specimen cross section — amperage = perimeter/3.1416 × 400 A/cm
For example, for a bar 1.3 cm thick and 10.0 cm wide:
perimeter = 10.0 cm + 10.0 cm + 1.3 cm + 1.3 cm = 22.6 cm
amperage = 22.6 cm/3.1416 × 400 = 2877 A.
Note: The next highest current available shall be used if current selection is not continuous.

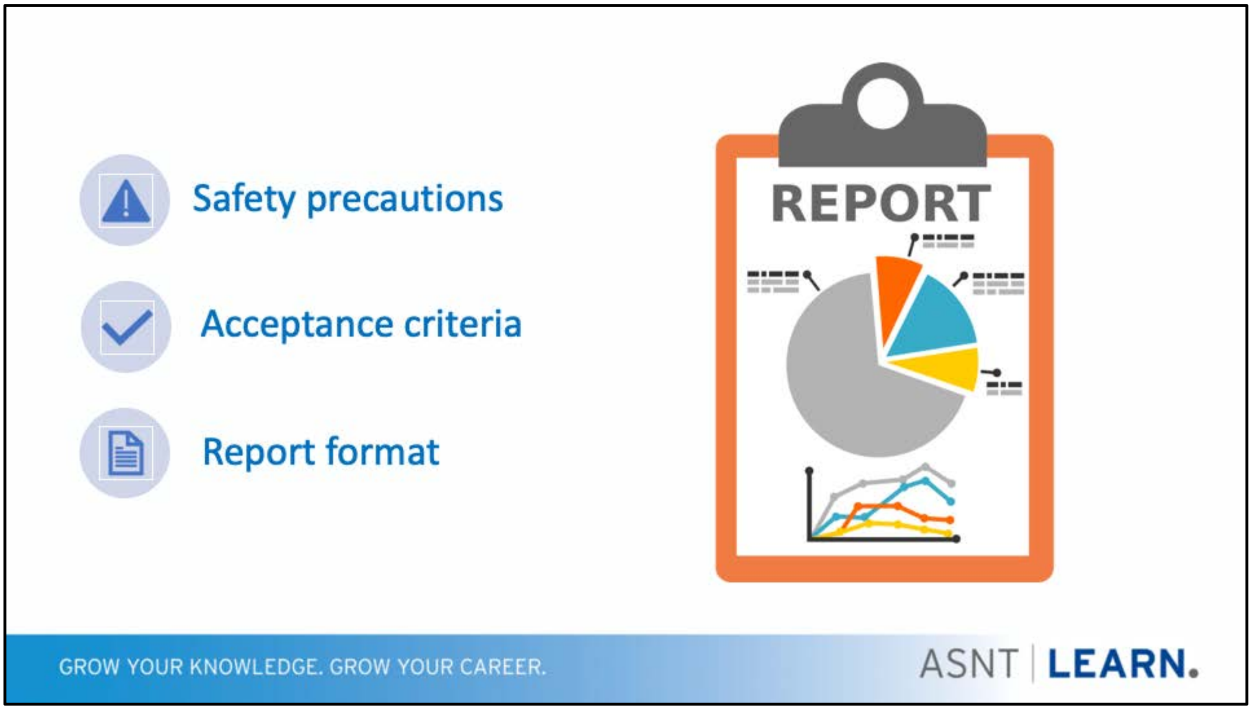
Additional portions of the procedure may address …



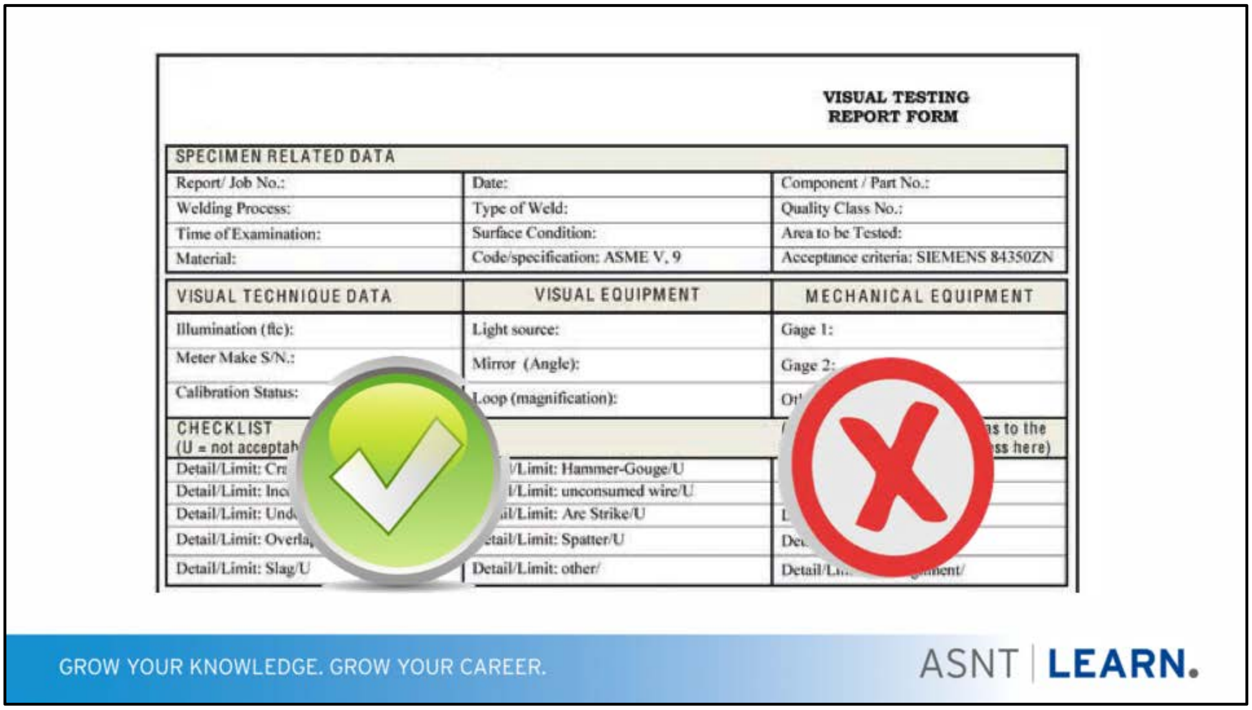
... safety precautions ...



... specific acceptance criteria of indications of discontinuities ...



... and stipulations as to how the final report should be recorded, formatted, and submitted.



Reporting is the ultimate end game of the nondestructive testing process. This is the report submitted to the customer or client or employer identifying all relevant indications of interest and making an accept/reject decision for each.

COMPANY OR LABORATORY NAME
ADDRESS PHONE NUMBER

PART DATA

TECHNIQUE DATA

SCREENS

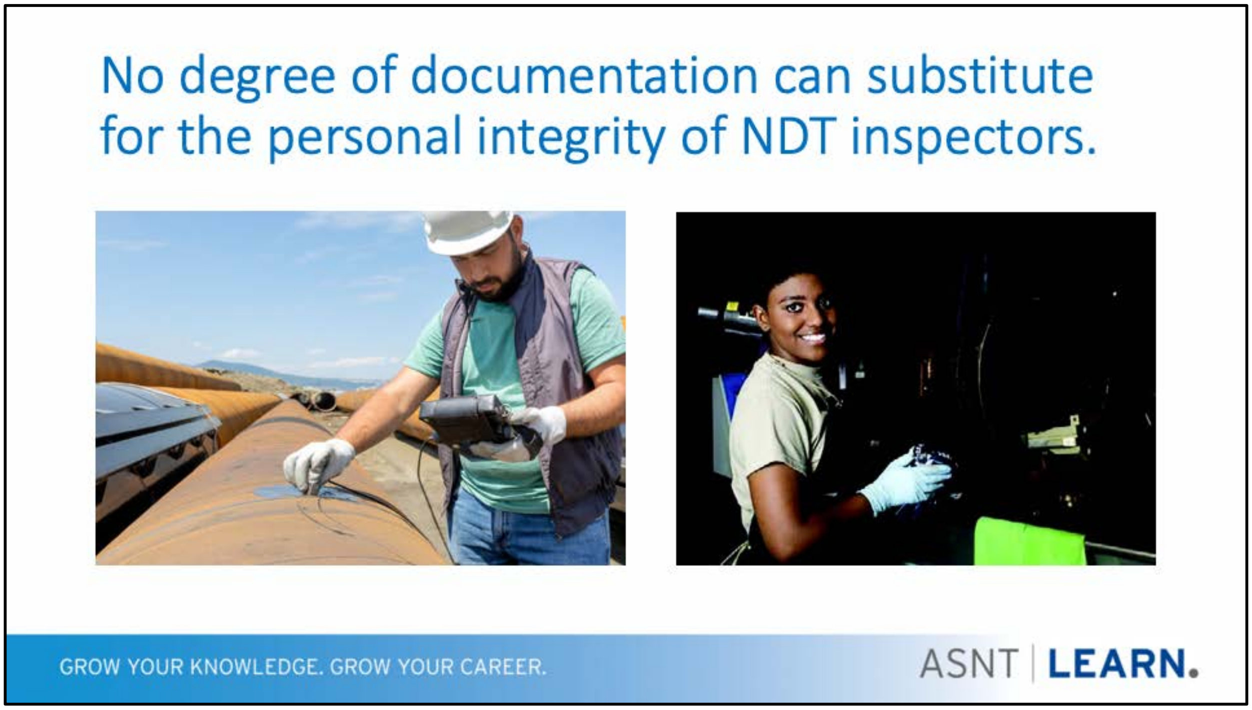
SHOOTING SKETCH

INTERPRETATION DATA

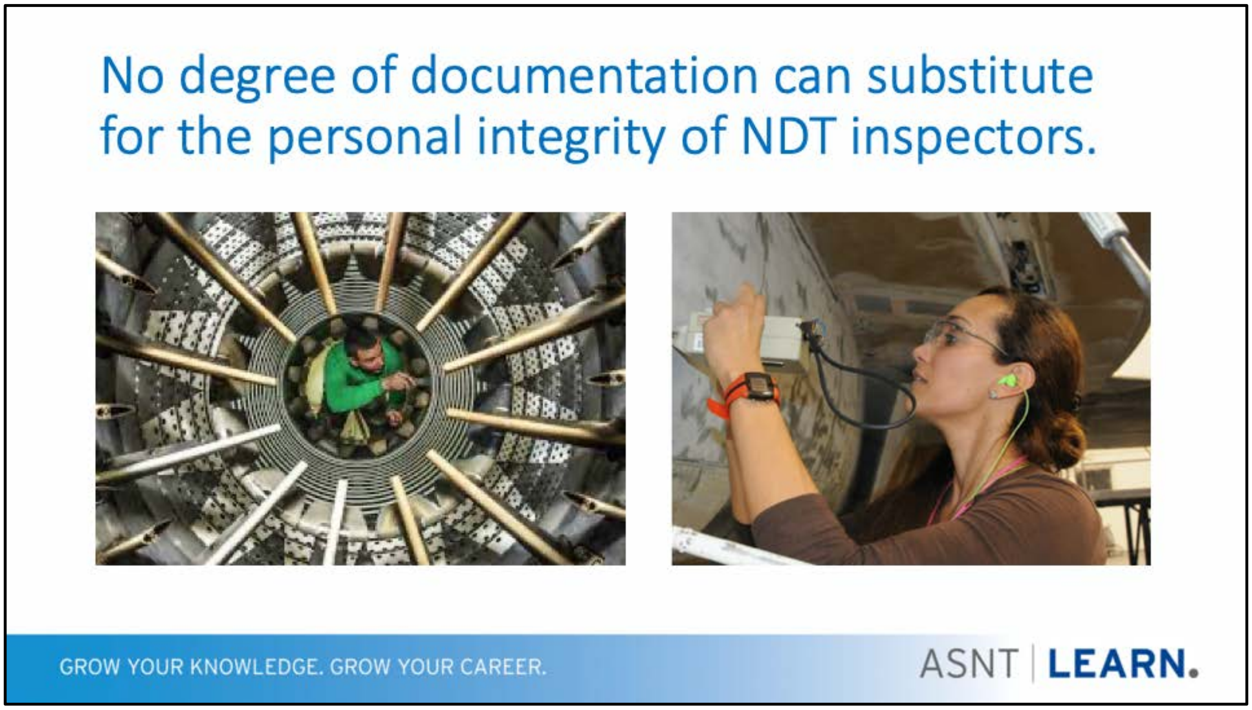
DISCONTINUITY CODE

Traditionally NDT reports are simple paper forms that are filled in and submitted.

With the digitalization of NDT processes, however, more and more reports are digitally derived from computerized data.



No degree of documentation, however, can substitute for the personal integrity required of NDT inspectors ...



... when it comes to ensuring that items under test have been fully and comprehensively examined for the presence of performance-threatening conditions.

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Your Career in NDT

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Interested in finding a job or choosing a career path in NDT?

The ASNT website has several career resources.

A Job Search site provides opportunities for employees to connect with employers.

A Mentoring Program connects experienced ASNT members with individuals who are eager to learn more about NDT or would like guidance on how to get to the next steps in their NDT career.

The July 2020 edition of *TNT* showcases a mother-son duo who managed to make NDT a family affair.

Aumani and Muriel Magloire graduated from Central Piedmont Community College in Charlotte, NC, with matching AAS degrees in nondestructive examination technology with qualifications in six method. They have served as Section Chair and Treasurer, respectively, for the North Carolina Student Section of ASNT.

SNT-TC-1A 2020 | RECOMMENDED PRACTICE

Table 6.3.1 A. Recommended Initial Training and Experience Levels

Examination Method	NDT Level	Technique	Training Hours	Experience: Minimum Hours in Method or Technique	Experience: Total Hours in NDT
Acoustic Emission Testing	I		40	210	400
	II		40	630	1200
Electromagnetic Testing	I	AC Field Measurement	40	210	400
	II		40	630	1200
	I	Eddy Current Testing	40	210	400
	II		40	630	1200
	I	Remote Field Testing	40	210	400
	II		40	630	1200
Ground Penetrating Radar	I		8	60	120
	II		20	420	800
Guided Wave Testing	I		40	240	460
	II		40	240	460
Laser Methods Testing	I	Profilometry	8	70	130
	II		24	140	260
	I	Holography/ Shearography	40	210	400
	II		40	630	1200

A college education is not the only entryway to an NDT career. Training hours are one key to obtaining a Level I or II in NDT.

Per *SNT-TC-1A* 7.1 ...

... “organized training may include instructor-led training, personalized instruction, virtual instructor-led training, computer-based or web-based training.”

Whatever your pathway, you'll find that opportunities in the field of NDT are virtually endless.

What's Next in Your NDT Journey?

ASNT … Creating a Safer World®

Hopefully, you've gained a good overview of the world of nondestructive testing and have a solid foundation from which to begin exploring NDT in more depth. Good luck with your next steps toward helping make the world a safer place.

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