It is important to think about human factors and how they are defined to be able to better understand their effect on inspection results. This definition will affect how an inspector decides which technique should be used to get the best results from nondestructive testing (NDT).

In engineering, human factors normally refer to the study of human capabilities and limitations in the workplace (CAA, 1998). In the past, human factors were referred to mainly in visual testing techniques and the study of human eyes. Even so, magnetic particle and liquid penetrant testing depend on visual interpretation of the indications developed on the surface of the inspected item, and the only instance human factors have been referred to is when the inspection result is affected by inspector motivation, capabilities, and light conditions at the inspection surface.

In the aviation industry, a study of aircraft accidents was conducted in 1940. It was found that 70% of accidents were attributable to human performance.
When this study was done again after 35 years, it was found that, surprisingly, there had been no reduction in this percentage, and 12% of that was related to maintenance errors, which included NDT inspection (Sears, 1993).

The accident involving Aloha Airlines Flight 243 on 28 April 1988 involved a 5.5 m (18 ft) section of the upper cabin structure suddenly being ripped away in flight due to structural failure (Figure 1). The jet involved in this accident had been examined, as required by U.S. regulation, by two engineering inspectors. One inspector had 22 years of experience and the other, the chief inspector, had 33 years’ experience. Neither found any cracks during the inspection. Accident analysis determined there were over 240 cracks in the skin of the aircraft at the time of the inspection. The ensuing investigation identified many human factor related problems leading to the failed inspection (NTSB, 1989).

After that time, a serious consideration of all human factors was taken into account in the aviation field regarding inspector personnel.

When talking about human factors, the following attributes should be included.
- Human physiology (including health, age, and human body function under different conditions).
- Psychology (including perception, cognition, memory, social interaction, error, and so on).
- Workplace design.
- Environmental condition.
- Human-machine interface.
- Anthropometrics (the study of measurement of the size and proportions of the human body) (CAA, 2003).
- To help understand human factors, a SHEL model (Figure 2) is used (ICAO, 1989). The name is derived from the initial letters of its components.
- S is for software (inspection procedures, manuals, standards, checklist layout, and so on).
- H is for hardware (tools and equipment, physical structure of inspected parts, positioning, and operating sense of controls and instruments).
- E is for environment, that is, the physical environment surrounding the inspector (like temperature, noise, and height), and the work environment, including the management structure, work pattern, and so on.
- L is for liveware (the inspector and the people around him or her).

Human factors concentrate on the interface between the human (L) in the center box and the other elements of the SHEL model.

From the accident investigation and using the SHEL model, the following was found.
- There was a shortage of staff.
- Time pressure existed.
- All errors occurred at night.
- Shift or task handover was involved.
- They all involved a supervisor doing longhand on a task (using his power to demand faster inspection or more production due to a tight schedule or to demand the changing of some indication finding due to a lack of spare parts and so on).
- There was an element of “can do” attitude.
- Interruption of inspection occurred.
- There was failure to use the approved procedure.
- Manuals and/or instructions were confusing.
- There was inadequate pre-planning, equipment, or spares (Sears, 1993).

From these findings, NDT personnel should have proper knowledge of human factors that affect their limitations and capabilities. These factors should be included in their training and understood when performing inspections (CAA, 2002).

**Human Performance and Limitations**

The following is a description for how the senses and brain function under different conditions.

**Vision**

Figure 3 shows parts of the eye. The cornea acts as a fixed focusing device, with between 70 to 80% of total focus ability. The iris controls the amount of light entering the eye by varying the size of the pupil. The shape of the lens is changed by the ciliary muscle, resulting in the final focusing adjustment. This process is called accommodation. The retina consists of light sensitive cells of two types, cones and rods. Cones function in good light, are capable of detecting fine details, and are color sensitive. Rods cannot detect colors and they are poor at distinguishing fine details, but they are good at detecting movement and sensitive at lower light levels. The tiny area known as the fovea is
responsible for the central, sharpest vision. A healthy fovea is key for reading, driving, and other activities that require the ability to see detail. It has a very high concentration of cones (photoreceptors responsible for color vision), allowing one to appreciate colors. The blind spot area has no photosensitive cells at all. An image that falls in this area cannot be seen.

The following factors affect sight clarity.

- Physical imperfection in one or both eyes, temporary eye disease, aging, exhaustion, fatigue, and fever.
- Influence of ingested foreign substances such as: drugs, medication, alcohol, and cigarettes.
- Environmental factors: the amount of light, clarity of air (dust and mist), fumes, gases, and extreme temperature and oxygen levels.
- Factors associated with the object: size and contours, contrast with surrounding areas, relevant motion of the object, distance of the object from the viewer, and the angle of the object from the viewer.

All these factors affect how long the inspector can do the inspection and the number of items the inspector can inspect before the ciliary muscles become fatigued. With this ability to focus on near items weakened, even if the inspector has received satisfactory eye exams (the visual acuity test) as scheduled, he or she will fail to concentrate on near items and see them clearly.

In some conditions where viewing accessibility is limited, a discontinuity indication image may fall out of the fovea area. The inspector may not notice the discontinuity image because it is out of the area of focused vision. It may fall in the blind spot, especially if he/she cannot look at the item with both eyes. If this is the case the inspector may not see it at all (Campbell, 1999).

In addition to the light intensity or direction of illumination to avoid glaring of the inspector’s eyes (with either direct or a reflected light source), many human factors can make the test with visual-based techniques unreliable.
Information Processing

The NDT inspector depends on his/her senses to gather information and this information is then processed by the brain. The limitations of the human information processing system should also be considered.

- Attention can be thought of as the concentration of mental effort on sensory or mental events.
- Perception can be defined as the organization, identification, and interpretation of sensory information in order to represent and understand the environment (Coon, 1983).
- Memory can be considered to be the storage and retention of information, which depends on three processes: registration, storage, and retrieval (Solso, 1995).
- Situational awareness is when the process of attention, perception, and judgment should result in awareness (Endsley 1988). The types of memory are as follows.
- Ultra short-term memory: its sensory stores can be up to 2 s (0.5 s for visual, 2 s for audio).
- Short-term memory: receives a proportion of the information received into sensory stores and allows one to store it long enough to use (from 5 to 20 s).
- Long-term memory: is used to store information that is not currently being used, like knowledge, personal experience, beliefs, social norms, values, motor programs, problem solving skills, and abilities.

The basic elements of human information processing have now been explored. It is important to appreciate that these elements have limitations, for example, doing complex jobs or multiple tasks (like climbing towers and doing an inspection at the same time). This results in divided attention, which will reduce information being used in the decision making process of the brain regarding discontinuity evaluation. This can also reduce awareness, which will affect judgment of indications.

Also, environmental conditions affect brain function. Temperature, oxygen levels, fumes and gasses, and unsafe environments that require extra care all contribute. Physical conditions like health, fitness, sickness, lack of sleep, influence of drugs/alcohol, and uncomfortable conditions all affect the psychological state of the inspectors (especially if he/she has claustrophobia or a fear of heights).

Motivation and Stress

Motivation is what drives humans to do their job in the best way possible (and increase their mental performance). Motivation is affected by the following.

- Level of arousal (which refers to a person’s readiness for performing work. All factors that been discussed here contribute to the level of arousal for a person).
- Stress (can be social stress like financial problems, work load, or anything that can be considered as a psychological load on the inspector).

Both of these can be called stimulants, and the right amount of stimulant will result in optimum performance of a person. If there is a low level or very high level of stimulation, this may result in bad performance and can increase error (Hawkins, 1993).

Environmental, psychological, and physical conditions directly affect the level of stimulation by altering the level of arousal and stress. For each individual there is an optimum stimulation level. The team leader or supervisor (who is usually a Level III) should know each inspector’s capabilities and limitations and provide him/her with the right amount of stimulation (arousal and stress) according to each job variable and condition. This requires a good knowledge and study of human factors in more detail.

Author

Anas Hasan El Rais: Kuwait Airways, NDT workshop.

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Acknowledgments

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Laser Scanning Weld Inspection System

Laser scanning weld inspection systems are the first major development in how weld inspection is conducted in nearly 50 years. Designed for use in the field to improve the reliability and speed of the welding inspection process, these systems can check part fit-up prior to welding to ensure that joint preparation is within procedure requirements, as well as inspect the final weld to a much higher precision than standard weld gages. When using laser scanners, a 3D scan of joints and weld beads is often evaluated for a variety of features including size, porosity, and undercut. These results can be augmented with a picture of the weld and recorded comments saved directly to the system—exponentially enhancing the efficiency of the overall process. Laser weld scanning systems allow inspectors to quantify the undercut, toe angle, and overall bead shape for improved fatigue properties.

Upon selecting a joint weld type and setting the tolerances in a laser scanning system, the quality of a weld can immediately be determined. The three images in Figure 1 are of a portable weld system, demonstrating the joint library, tolerance requirements, and final results.

Laser Scanners use 3D Laser Scanning Technology to be able to Measure and Inspect Welds

The resolution of the laser scanner in Figure 1 measuring capability is 0.1 mm (0.004 in.), based on the laser field of view and the number of pixels present. The accuracy of any single measurement will depend not only on the inherent resolution of the system but also the welded or unwelded joint geometry and surface condition itself. Neither of these encompasses the repeatability and reproducibility (R&R) of the system, which must be determined on real weld samples by having several people measure the same samples and then determining the R&R value. The R&R is typically the result that most companies’ gage control departments are required to record. Of course, it all starts with a fully calibrated system, which involves ensuring the optics have the resolution to
measure a verification block accurately. This same verification block is then used by the operator to verify that the laser scanner continues to measure correctly.

Applications
Laser scanners can be used for a wide variety of industrial applications to improve weld quality and productivity. Using a laser scanner will reduce the subjectivity inherent today with human inspection; it is up to ten times faster and can in fact automatically take one inspection per second for the full length of the weld. A few of these applications will be reviewed in detail so one can better understand how to identify uses where the payback and benefits will be quickly achieved.

Wind Tower Joint and Weld Measurement
Wind turbines depend on a very strong tower structure to withstand the high loads and fatigue conditions they experience in operation. The towers are made up of several sections that are first longitudinally welded and then welded to each other using submerged arc welding. To get optimum performance, the joint must be fit within a tight tolerance prior to welding, and then the weld shape needs to conform to specific requirements to be acceptable. Oftentimes, a report is required to summarize all of the results and is subsequently sent to the customer purchasing the towers. Prior to using a laser scanner, this process was all done with a series of manual gages, which was slow and prone to error during both the measurement phase as well as the transposing of the results onto paper. Laser scanners can take numerous measurements in a fraction of the time, allowing for a consistent result that can generate reports automatically. Refer to Figure 2.

Auditing of Robotic Manufactured Welds
The trend of moving welds from manual welders to robots has been going on for over 30 years, but now it is accelerating and being taken on by small to mid-size companies rather than just large corporations. In the early years, there was a misunderstanding that merely putting a robot into the welding environment would automatically improve everything. This proved to be totally wrong because people quickly found out that major changes to upstream

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**Figure 2.** Laser scanner inspection report.

- **1.** Name based on the search criteria
- **2.** Unit selection drop list (mm/in.)
- **3.** Language selection drop list (English, French, German, Japanese, Chinese)
- **4.** Discontinuity recorded in continuous inspection (for example, id-22-5 represents the fifth discontinuity found in Inspection ID 22)
- **5.** Click on the hyperlinks to get more information (images, comments, and so on)
operations are needed to feed the robot parts designed for automation. Another misconception was that the robot somehow magically would put in the right size weld with the quality required. A laser scanner has proved to be very helpful for auditing robot made welds to ensure the benefits planned for more consistent welds have actually been realized. This can be done by using it manually to audit robot welds once the parts are outside the cell, or the robot can in fact pick up the laser scanner and check its own welds. Figure 3 shows a laser scanner being held by a robot.

Resolving Disagreements between the Customer and Supplier

They say “beauty is in the eye of the beholder” and that is definitely true when doing weld inspection manually and using mechanical /manual gages. The variability between inspectors combined with the inherent error in using manual gages results in many cases where there is a disagreement between two parties. This can be the end customer and the supplier, or it could be the production and quality departments in the same company. The laser scanner has been able to act as a “third party referee” to resolve these differences of opinions. Once it is agreed that the laser scanner’s results will be accepted, the decision becomes easy. See Figure 4, showing how one sets the tolerances for each feature. Figure 5 shows the complete results for one weld.

Why ship parts to a customer or move welded parts to the next operation in a factory without ensuring that the requirements are met? See Figure 6, showing a large weldment being inspected before moving it to the next operation.

Improving Fatigue Life

The weld attributes affecting structural fatigue life are the very ones that are most difficult to accurately measure with manual gages. A laser scanner can provide consistent measurements for the following features.

![Figure 3. Laser scanner being held by a robot.](image)

![Figure 4. Setting the tolerances.](image)

![Figure 5. Results, Including: (a) 2D picture; (b) 3D profile; and (c) measurements.](image)
Undercut: can be roughly measured by special gages, but they are inconsistent and do not calculate the depth per the American Welding Society definition. Traditional undercut measurements normally are too deep because they partially measure the weld bead instead of just the amount below the plate surface. Correct measurement is key to determining conformance to workmanship standards and also for the effect it has on fatigue life.

Toe entry angles: toe angles represent how well the weld metal has “washed/flowed” out onto the adjoining base metal. If the angle is below or near 90°, it reflects cold lap. Toe angles approaching 150° will provide optimum fatigue life and a nice aesthetic appearance.

Height/width ratio: many codes specify a requirement for the ratio of weld height to width to not exceed a certain value to help ensure the weld is not a stress riser. Instead of having to measure both height and width individually and then doing the math, the laser scanner automatically makes this calculation and compares the result to the allowable percentage.

With these accurate measurements automatically recorded, this information can be easily fed back to the product designers so an accurate determination of expected fatigue life can be made. This will help avoid the normal course of action, which is excessive safety margins, which just add cost without any real benefit.

Over Welding

It is a fact that there is a tremendous amount of over welding taking place in all industries and on all products. Over welding significantly contributes to excessive welding cost (AWS, 2001). While it is typically less a problem when the welding is automated, the amount of waste is substantial. One company found that if only 5% of the company’s welders were over welding just 1.6 mm (0.0625 in.) on a typical 6.35 mm (0.25 in.) fillet for 5% of the total weld length, that this would still add up to hundreds of thousands of dollars wasted per year. The historical problem with trying to get one’s arms around this problem is that most weld inspection is really no more than pass/fail with the use of gages and without any actual measurement data. With a laser scanning system, each weld can be precisely measured and the percentage of over welding can be calculated. The result is immediately visible to the welder, inspector, or supervisor, which allows for proactive action to be taken to improve.

Training

Currently, welder training instructor feedback is primarily subjective, which can lead to the welder not getting substantive assistance with which to improve. This applies to both initial training for people who have no previous experience and to existing company employed welders who simply need to improve due to problems meeting the company’s requirements for productivity or quality. A laser scanner can give specific feedback in the form of an actual grade with which both the instructor and student can work to improve.

Summary

A laser scanner can provide many benefits to companies required to do weld measurement and inspection, which will save substantial time and money. One does, however, need to look at the payback of buying this type of system by including the following elements: the purchase price plus the cost to train inspectors to use the system, plus the cost to develop quality assurance/quality control operating procedures. Experience shows that typical paybacks range from one to three years.

Conclusion

Laser scanning systems for weld inspection are definitely the instrument of choice for those who want to make dramatic improvements to both weld quality, and also to reduce wasteful practices such as excessive repair or product rejections.

Most weld inspection is done with gages that do not provide measurements, but only determine whether the weld is good or bad. While this prevents bad product from getting out the door it does not provide the opportunity to implement continuous improvement efforts.

Laser scanners use similar technology that numerous users are already comfortable using such as cameras, smart tablets, and other smart devices. This fact will allow for easier acceptance of the laser scanner system with a short learning curve.

Acknowledgment

For the purposes of this article, the laser scanner referred to in this text and pictures is the Servo-Robot, Inc. WiKi-SCAN welding inspection system.

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**NDT GLOSSARY**

**Visual Testing**

**blind spot:** Portion of the retina where the optic nerve enters, without rods and cones and hence insensitive to light.

**blister:** Discontinuity in metal, on or near the surface, resulting from the expansion of gas in a subsurface zone. Very small blisters are called pinheads or pepper blisters.

**cocoa:** Debris (usually oxides of the contacting metals) of fretting wear, retained at or near the site of its formation—a condition easily identified during visual tests. With ferrous metals, the debris is brown, red, or black, depending on the type of iron oxide formed. For this reason, ferrous debris is called cocoa or, when mixed with oil or grease, red mud.

**defect:** Discontinuity whose size, shape, orientation or location (1) makes it detrimental to the useful service of its host object or (2) exceeds an accept/reject criterion of an applicable specification. Some discontinuities do not exceed an accept/reject criterion and are therefore not defects.

**etch crack:** Shallow crack in hardened steel containing high residual surface stresses, produced in an embrittling acid environment.

**fluorescence:** Phenomenon of absorption of electromagnetic radiation and its reemission at a lower energy (longer wavelength). In visual testing, fluorescence is typically a response to ultraviolet radiation.

**gray level:** Integer number representing the brightness or darkness of a pixel or, as a composite value, of an image comprised of pixels.

**jaeger eye chart:** Eye chart used for near vision acuity examination.

**kinetic vision acuity:** Vision acuity with a moving target. Studies indicate that 10 to 20 percent of visual efficiency can be lost by target movement.

**mottle:** Apparently random positioning of metallic flakes that creates an accidental pattern.

**replica:** Piece of malleable material, such as polyvinyl or polystyrene plastic film, molded to a test surface for the recording or analysis of the surface microstructure.

Practitioner Profile

Jim Houf

This edition of the Practitioner Profile features ASNT Senior Manager of Technical Services Jim Houf. You may recognize Houf from the TNT “Inbox” or from his longstanding involvement with ASNT. Houf’s career in NDT has taken him on a number of different paths as a technician to working at ASNT headquarters.

Q: What is your educational and training background?
A: I graduated from Chillicothe High School in 1966 and attended Ohio University in Athens, Ohio for a year and a quarter. In January 1968 I joined the Navy and served in the Navy Construction Battalions (the Seabees). Following boot camp, Builder “A” school, and combat training on the west coast I was assigned to Construction Battalion Maintenance Unit (CBMU) 301 in Vietnam where I spent 20 months, transferring to CMU 302 when 301 was sent home for decommissioning. With 302, I spent three months in Da Nang and three months at Coastal Group 16, a Vietnamese Navy junk base, building housing units for the Vietnamese sailors and their dependents. As a Builder I did heavy timber construction, rough frame, cement block, and concrete construction. On 1 January 1971 I flew home, and on the 6th I was honorably discharged as a Builder 2nd Class (E5). At that time there was no construction work, but I got temporary work as a night desk clerk on a blast furnace rebuild at a steel mill in Detroit. That’s where I first met Bill Svekric, who was doing NDT work on that job. He was from Columbus, so I told him I planned to attend Ohio State University and major in engineering; he suggested I look into welding engineering. Following that I got on at the (then) 1500-bed VA psychiatric hospital in Chillicothe, was trained as a psychiatric nursing assistant, and worked as such until I went to OSU in the fall. (I jokingly tell people that the psychiatric training was helpful in my later inspection work because there was little that could be thrown at me that I hadn’t seen before.) At OSU I took Bill’s advice and entered the welding engineering curriculum, and it turned out that my department advisor was Dr. Robert C. (“Dr. Bob”) McMaster.

Q: How important is a college degree?
A: For the average technician, it can be helpful but is not mandatory. I majored in welding engineering but didn’t get a degree, but the welding and metallurgical knowledge I did pick up was definitely helpful in my career. However, any NDT technician that is willing to stay current and learn as he or she goes can do well in the NDT field. A lot of the personnel that are doing NDT at the field level are non-degreed people, because the ones with degrees tend to move into management positions. Formal education and classroom training is necessary, but nothing beats being able to work with an experienced NDT people that are willing to take the time to mentor young NDT people.

Q: How did you become involved with NDT?
A: In 1972 I started at working in the summer for Materials Joining Consultants (MJC, where Bill Svekric worked), inspecting cross-country gas pipeline for leaks in southeastern Ohio using a hydrogen flame ion “sniffer.” In the summers of 1973 and 1974 I drove an 18-wheeler furniture truck through 31 states, and in the summer of 1974 I applied for and was accepted for the police department in Richmond, Virginia, but due to a hiring freeze I was never hired. I returned to Ohio and started working full-time with MJC as an NDT technician and worked there until I was laid off in July of 1976. In September I went to work for Conam Inspection and stayed there until 1979, when I went back to MJC. I stayed there until 1980 when I went to work for Welding Consultants, Inc. (WCI), which was started by Bill and his partner, Dick Holdren, also from OSU welding engineering. I stayed with
WCI until 1998 when I was hired by ASNT as a certification specialist to work on the ACCP [ASNT Central Certification Program]. I was laid off in February 1999 due to budget cuts but was recalled to replace the ACCP supervisor in August 1999. The technical services manager position came open in September, and I was appointed as the interim manager, applied for the job on a permanent basis and became the technical services manager in November, the position I have held to date.

Q: What are your certifications?
A: I passed the AWS Certified Welding Inspector exam in 1977 and am an AWS lifetime member. During the time I worked for MJC I had Level I in RT and UT and Level II in MT and PT, got my Level II in RT at Conam Inspection in 1977 and my Level II in UT at WCI in 1980. In 1984 I was certified as an ASNT NDT Level III in MT and PT, let my Level III certs lapse in 1989 and had to retake the MT and PT (and yes, I had to retake the Basic exam) in 1990, when I added RT and UT. In 1999 I earned my AWS Senior Welding Inspector certificate and my ACCP Professional Level III in MT, PT, RT, and UT. In 2005 I earned my ASNT NDT Level III in VT and in 2011 I received my ACCP Professional Level III in VT. I also held the American Society for Quality's Certified Quality Auditor certification from December 1998 to December 2004, when I let it lapse.

Q: Why is it beneficial to certify in multiple methods and organizations?
A: Probably the biggest advantage is that it lends credibility. When a person only has certifications issued by his own organization there can be some doubt about the validity of those qualifications. Having certifications from other organizations tends to remove those doubts. An additional advantage is that it helps you to stay current in related fields.

Q: What committees are you on?
A: I'm an affiliate member of the Conference of Radiation Control Program Directors and a resource person for its G-34 Committee, Committee on Industrial Radiography. I sit on three ASME Boiler and Pressure Vessel Code bodies: I'm a Section V Committee member, I'm the vice chair of the Section V Subgroup General Requirements/Personnel Qualification and Inquiries, and I'm a member of the Section XI Working Group that addresses personnel qualification. Since I'm already at the ASME Code Week meetings I also attend other NDT-related meetings.

Q: Are you active in the Central Ohio Section?
A: I went through the Section chairs back in the '80s and now attend the meetings whenever I can. I know a fair number of the people that are in the Section, but as an ASNT staff member I kind of stay independent because I don’t want to impose on them. However, I do join in on the discussions, though I will not hold office in the Section.
**Q: How has NDT changed during your career?**

A: The technology has advanced exponentially. When I started out, anyone with an MT yoke, a set of PT spray cans (with the never-to-be-found “lint-free” rags), an analog UT scope, a DSC or IIW block, and a handful of transducers and cables was generally considered to be a fully equipped NDT hand. Now there are multiple variations of MT particles and penetrants and steerable, multiphase, multichannel, multi-crystal transducer arrays with more sophisticated variations on the horizon. Radiography has gone from bulky tube heads and space-age radioactive materials (still with a stone-age cranking system) to digital imaging that includes computed radiography, digital radiography, and computed tomography. Had someone said these would be a part of the NDT world 40 years ago they would have been laughed at.

**Q: Did you mentor?**

A: To some extent. For several years I worked with newly trained RT inspectors at an aluminum refinery in Suriname, South America, and my job was to teach them how to use what they had learned. We did gamma radiography with an iridium-92 source and shot pipe welds in the power plant and longitudinal welds in heaters and such in the refinery. One trick that really brought home the need to use a survey meter was to have the assistants take a reading at the 2 mR barrier while facing the job, then having them turn their back to the job and telling me what the reading was, which of course was also 2 mR. Then I pointed out that the difference was that the second reading was taken after the radiation had gone through their body and they hadn’t felt or seen anything. That really brought home the need to always use a survey meter when working around a source.

**Q: You also worked on the Longaberger Basket Building in Newark, Ohio (photo in header).**

A: Yes. From the ground to the top of the handles was 63 m (206 ft).

**Q: Who were your mentors?**

A: I was very fortunate in this regard. When I started with MJC I worked with Bill Svekric and Dick Holdren, the two welding engineers, and one very experienced Level II UT operator, Howard Sagar. The great thing about them was that they took the time to explain what I was seeing, and more importantly, why I was seeing it. After a while they got me to where I could visualize the sound path and that is a giant step towards becoming a good UT inspector. As a novice it’s easy to get lost looking at the UT scope and without someone around with experience it can result in a wrong call, and having someone to backstop you makes all the difference in the world. One non-UT case in point was the time I was using an MT yoke to inspect nickel welds on a cast iron structure across town. No matter what the welders did I was always getting a really strong indication along the edges of the weld that looked exactly like under-bead cracking. I called the office and explained the problem to Bill, who then asked if I’d ever heard the words “magnetic anomaly.” He explained that the difference in magnetic permeability between cast iron and nickel is really great (cast iron: ~5,000; nickel: ~500), which results in a strong magnetic indication at the boundary line. By switching to liquid penetrant, all of those indications went away.

**Q: Why is cooperation between welders and inspectors important?**

A: Being welding engineers, Dick and Bill could talk to welders on their terms and get their trust. The worst feeling in the world is the first time you find something in a weld and the welder says, “I don’t believe it’s there.” Once they find what you called out and understand that what you’re calling out is there, they have confidence that you’re not trying to make them look bad. Welders also generally have a great sense of humor. I had one welder put a sparkler in his stinger [the grip handle that holds a welding rod]. Just as I was walking by he struck an arc, which lit the sparkler. Then he turned to me and said, “How do I turn this thing off?” As a new inspector, you say, “What in the world?” because it looks exactly like a small electrode.

**Q: So you guys had fun?**

A: Oh yeah. They were forever pulling stunts like that. The other trick I felt was really great was when they drove a nail down through a scaffold plank and put the welding ground clip on the point of the nail underneath the scaffold. Then the welder struck an arc on the head of the nail and started a weld puddle down the length of the wood, burying the nail head under the weld puddle. Another welder who was in on the gag then asked me to go over and see if the welder was using “low oak” electrode. I looked over there, and here’s this guy welding down the middle of an oak scaffold board, and you just can’t do that because wood is non-conductive. The current was going back through the weld puddle and down the nail to create the circuit.

**Q: What’s your guiding philosophy about work?**

A: The only reason I had for taking a job was because I hadn’t done it before. One of the things I always kept in mind is that there’s always work. My grandmother lived with us when I was a kid and I was looking for some way to earn money to go to the swimming pool. And she said, “Well, the wallpaper in the back room needs cleaned.” Wallpaper cleaner, the forerunner of play dough, was about the same consistency, and you’d knead it into a ball and starting at the ceiling, wipe off the dust and dirt, and then knead it back in and keep going. It was a hot summer day and I was up against the ceiling, no air conditioning. I told her, “This is about the worst job I’ve ever had.” And she said, “Jim, any honest job is an honorable job.” I never forgot that.

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