WELDING INSPECTION TECHNOLOGY

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Introduction

In today's world there is increasing emphasis placed on the need for quality, and weld quality is an important part of the overall quality effort. This concern for product quality is due to several factors, including economics, safety, government regulations, global competition, and the use of less conservative designs. While not singularly responsible for the attainment of weld quality, the welding inspector plays a large role in any successful welding quality control program. In reality, many people participate in the creation of a quality welded product. However, the welding inspector is one of the "front line" individuals who must check to see if all of the required manufacturing steps have been completed properly.

To do this job effectively, the welding inspector must have a wide range of knowledge and skills, because it involves more than simply looking at welds. Consequently, this course is specifically designed to provide both experienced and novice welding inspectors a basic background in the more critical job aspects. This does not imply, however, that each welding inspector will use all of this information while working for a particular company. Nor does it mean that the material presented will include all of the information for every welding inspector's situation. Selection of these various topics is based on the general knowledge desirable for an individual to do general welding inspection.

The important thing to realize is that effective welding inspection involves much more than just looking at finished welds. Section 4 of AWS QC1, *Standard for AWS Certification of Welding Inspectors*, outlines the various functions of the welding inspectors. You should become familiar with these various responsibilities because the welding inspector's job is an ongoing process. A successful quality control program begins well before the first arc is struck. Therefore, the welding inspector must be familiar with many facets of the fabrication process. Before welding, the inspector will check drawings and specifications to determine such information as the configuration of the component, its specific weld quality requirements, and what degree of inspection is required. This review will also show the need for any special processing during manufacturing. Once welding begins, the welding inspector may observe various processing steps to assure that they are done properly. If all these subsequent steps have been completed satisfactorily, then final inspection should simply confirm the success of those operations.

Another benefit of this course is that it has been designed to provide the welding inspector with the necessary information for the successful completion of the American Welding Society's Certified Welding Inspector (CWI) examination. The ten chapters listed below are sources for examination information. The welding inspector must have at least some knowledge in each of these areas. Typically, the information presented will simply be a review, while sometimes it may represent an introduction to a new topic.

Chapter 1: Welding Inspection and Certification

Chapter 2: Safe Practices for Welding Inspectors

Chapter 3: Metal Joining and Cutting Processes

Chapter 4: Weld Joint Geometry and Welding Symbols

Chapter 5: Documents Governing Welding Inspection and Qualification

Chapter 6: Metal Properties and Destructive Testing

Chapter 7: Metric Practice for Welding Inspection

Chapter 8: Welding Metallurgy for the Welding Inspector

Chapter 9: Weld and Base Metal Discontinuities

Chapter 10: Visual Inspection and Other NDE Methods and Symbols

Additionally, selected technical references are included in the "Body of Knowledge" required. These include:

- A Selected Code (AWS D1.1, API 1104, etc.)
- AWS CM, Certification Manual for Welding Inspectors
- AWS A1.1, *Metric Practice Guide for the Welding Industry*
- AWS A2.4, *Standard Symbols for Welding, Brazing, and Nondestructive Examination*
- AWS A3.0, *Standard Welding Terms and Definitions*
- AWS B1.10, *Guide for the Nondestructive Examination of Welds*
- AWS B1.11, *Guide for the Visual Inspection of Welds*
- ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*
- AWS QC1, *Standard for AWS Certification of Welding Inspectors*
- AWS B5.1, *Specification for the Qualification of Welding Inspectors*

Who is the Welding Inspector?

Before turning our discussion to the technical subjects, let us talk about the welding inspector as an individual and the typical responsibilities that accompany the position. The welding inspector is a responsible person, involved in the determination of weld quality **according to applicable codes and/or specifications**. In the performance of inspection tasks, welding inspectors operate in many different circumstances, depending primarily for whom they are working. Thus, there is a special need for job specifications due to the complexity of some components and structures.

The inspection workforce may include destructive testing specialists, nondestructive examination (NDE) specialists, code inspectors, military or government inspectors, owner representatives, in-house inspectors, and others. These individuals may, at times, consider themselves "welding inspectors," since they inspect welds as part of their job responsibility. The three general categories into which the welding inspectors' work-functions can be grouped are:

- Overseer
- Specialist
- Combination Overseer—Specialist

The Overseer is usually one who oversees the duties of several inspectors.The specialist, on the other hand, is an individual who does some specific task(s) in the inspection process. A specialist may or may not act independently of an overseer. The nondestructive examination (NDE) specialist is an example of this category of inspector.

It is common to see inspectors serving as both overseer and specialist. Such an individual may be responsible for general weld quality judgments in each of the various fabrication steps, and be required to perform any nondestructive testing that is necessary. Fabricators may employ several overseer type inspectors, each having their own area of general weld inspection responsibility. Because inspection responsibility is divided in these cases, inspectors may have to rely on others for specific aspects of the total inspection program.

For the purposes of this course, we will refer to the welding inspector in general, without regard to how each individual will be used by an employer. It is impractical to address each individual's situation in the scope of this discussion.

To emphasize the differences in job requirements, let's look at some industries using welding inspectors. We see welding inspection being done in the construction of buildings, bridges and other structural units. Energy related applications include power generation facilities, pressure vessels and pipelines, and other distribution equipment requiring pressure containment. The chemical industry also uses welding extensively in the fabrication of pressure-containing processing facilities and equipment. The transportation industry requires assurance of accurate weld quality in such areas as aerospace, automotive, shipbuilding, railroad apparatus and off-road equipment. Finally, the manufacturing of consumer goods often requires specific weld quality requirements. With the diversity shown by this listing, various situations will clearly require different types and degrees of inspection.

Important Qualities of the Welding Inspector

The first, and perhaps the most important quality, is a professional attitude. Professional attitude is often the key factor for welding inspector success. Inspector attitude often determines the degree of respect and cooperation received from others during the performance of inspection duties. Included in this category is the ability of the welding inspector to make decisions based on facts so that inspections are fair, impartial and consistent. A

welding inspector must be completely familiar with the job requirements. Inspection decisions must be based on facts; the condition of the weld and the acceptance criteria specified in the applicable specification must be the determining factors. Inspectors will often find themselves being "tested" by other personnel on the job, especially when newly assigned to some task. Maintaining a professional attitude helps overcome obstacles to successful job performance.

The individual who does welding inspection should possess certain qualities to assure that the job will be done most effectively. Figure 1.1 illustrates these qualities.

Next, the welding inspector should be in good physical condition. Since the primary job involves visual inspection, obviously the welding inspector should have good vision, whether natural or corrected. The AWS CWI program requires the inspector to pass an eye examination, with or without corrective lenses, to prove near vision acuity on Jaeger J2 at not less than 12 in, and complete a color perception test. Another aspect of physical condition involves the size of some welded structures. Welds can be located anywhere on very large structures, and inspectors must often go to those areas and make evaluations. Inspectors should be in good enough physical condition to go to any location where the welder has

Figure 1.1—The Inspector Possesses a Great Amount of Knowledge, Attitudes, Skills, and Habits (KASH)

been. This does not imply that inspectors must violate safety regulations just to do their duties. Inspection can often be hampered if not done immediately after welding, because access aids for the welder such as ladders and scaffolding may be removed, making inspection impossible or dangerous. Within safety guidelines, welding inspectors should not let their physical condition prevent them from doing the inspection properly.

Another quality the welding inspector should develop is an ability to understand and apply the various documents describing weld requirements. These can include drawings, codes, standards and specifications. Documents provide most of the information regarding what, when, where and how the welding and subsequent inspections are to be done. Therefore, the rules or guidelines under which the welding inspector does the job can be found in these documents. They also state the acceptable quality requirements against which the welding inspector will judge the weld quality. It is important that these documents are reviewed before the start of any work or production because the welding inspector must be aware of the job requirements. Often this pre-job review will reveal required "hold points" for inspections, procedure and welder qualification requirements, special processing steps or design deficiencies such as weld inaccessibility during fabrication. Although welding inspectors should be thorough in their review, this does not mean that the requirements should be memorized. These are reference documents and should be readily available for detailed information any time in the fabrication process. Generally, inspectors are the individuals most familiar with all these documents so they may be called upon by others for information and interpretation regarding the welding.

Most people associated with welding inspection will agree that having inspection experience is very important. Textbooks and classroom learning cannot teach an inspector all of the things needed to inspect effectively. Experience will aid the welding inspector in becoming more efficient. Better ways of thinking and working will develop with time. Experience will also help the inspector develop the proper attitude and point of view regarding the job. Experience gained working with various codes and specifications improves an inspector's understanding of welding requirements and generally improves job effectiveness. To emphasize the need for inspection experience, we often see a novice inspector paired with an experienced one so the proper techniques can be passed along. Finally, we see that inspector certification programs require some minimum level of experience for qualification.

Another desirable quality of the welding inspector is a basic knowledge of welding and the various welding processes. Because of this, former welders are sometimes selected to be converted into welding inspectors. With a basic knowledge of welding, the inspector is better prepared to understand certain problems that a welder encounters. This aids in gaining respect and cooperation from the welders. Further, this understanding helps the welding inspector to predict what weld discontinuities may be encountered in a specific situation. The welding inspector can then monitor critical welding variables to aid in the prevention of these welding problems. Inspectors experienced in several welding processes, who understand the advantages and limitations of each process, can probably identify potential problems before they occur.

Knowledge of various destructive and nondestructive test methods are also very helpful to the welding inspector. Although inspectors may not necessarily perform these tests, they may from time to time witness the testing or review the test results as they apply to the inspection. Just as with welding processes, the welding inspector is aided by a basic understanding of testing processes. It is important for the inspector to be aware of alternate methods that could be applied to enhance visual inspection. Welding inspectors may not actually perform a given test but they may still be called upon to decide if the results comply with the job requirements.

The ability to be trained is a necessity for the job of welding inspector. Often, an individual is selected for this position based primarily on this attribute. Inspectors do their job most effectively when they receive training in a variety of subjects. By gaining additional knowledge, inspectors become more valuable to their employers.

Another very important responsibility of the welding inspector is safe work habits; good safety habits play a significant role in avoiding injury. Working safely requires a thorough knowledge of the safety hazards, an attitude that all accidents can be avoided, and learning the necessary steps to avoid unsafe exposure. Safety training should be a part of each inspector's training program.

A final attribute, which is not to be taken lightly, is the welding inspector's ability to complete and maintain inspection records. The welding inspector must accurately communicate all aspects of the various inspections, including the results. All records developed should be understandable to anyone familiar with the work. Neatness is important as well. The welding inspector should look at these reports as his or her permanent records should a question arise later. When reports are generated, they should contain information regarding how the inspection was done so, if necessary, it can be duplicated later by someone else with similar results. Once records have

been developed, the welding inspector should facilitate easy reference later.

There are a few "rules of etiquette" relating to inspection reports. First, they should be completed in ink, or typewritten. (In today's "age of computers," typing of inspection reports into a computer system is a very effective way of making legible reports, easily retrieved when needed.) If an error is made in a handwritten report, it can be single-lined out in ink and corrected (the error should **not** be totally obliterated). This corrective action should then be initialed and dated. A similar approach is used when the reports are computer generated. The report should also accurately and completely state the job name and inspection location as well as specific test information. The use of sketches and pictures may also help to convey information regarding the inspection results. Then the completed report should be signed and dated by the inspector who did the work.

Ethical Requirements for the Welding Inspector

We have described some of the qualities which are desired of a welding inspector. In addition to those listed above, there are ethical requirements which are dictated by the position. Ethics simply detail what is considered to be common sense and honesty. The position of welding inspector can be very visible to the public if some critical dispute arises and is publicized. Therefore, welding inspectors should live by the rules and report to their supervisors whenever some questionable situation occurs. Simply stated, the welding inspector should act with complete honesty and integrity while doing the job since the inspection function is one of responsibility and importance. A welding inspector's decisions should be based totally on available facts without regard to who did the work in question.

The welding inspector's position also carries with it a certain responsibility to the public. The component and/or structure being inspected may be used by others who could be injured should some failure occur. While inspectors may be incapable of discovering every problem, it is their responsibility to report any condition that could result in a safety hazard. When performing an inspection, inspectors should only do those jobs for which they are properly qualified. This reduces the possibility of errors in judgment.

There are situations that occur that may be reported to the public. If the inspector is involved in a dispute regarding the inspection, he or she may be asked to publicly express an opinion. If stated, the opinion should be based totally on facts that the inspector believes to be valid. Probably the best way to deal with public statements, however, is simply to avoid them whenever possible. The inspector should not volunteer information just to gain publicity. However, in situations where a public statement is required, the welding inspector may wish to solicit the advice of a legal representative before speaking.

The ethical requirements of the job carry with them a great deal of responsibility. However, the welding inspector who understands the difference between ethical and unethical behavior should have little difficulty in performing the job with everyone's best interests in mind.

The Welding Inspector as a Communicator

An important aspect of the welding inspector's job is that of communication. The day-to-day inspection effort requires effective communication with many people involved in the fabrication or construction of some item. What must be realized, however, is that communication is not a one way street. The inspector should be able to express thoughts to others, and be ready to listen to a reply. To be effective, this communication sequence must be a continuous loop so that both parties have an opportunity to express their thoughts or interpretations (see Figure 1.2). It is wrong for any individual to think that their ideas will always prevail. Inspectors must be receptive to opinions to which a further response can be made. Often, the best inspector is one who listens well.

As mentioned, the welding inspector has to communicate with several different people involved in the fabrication sequence (see Figure 1.3). In fact, many situations occur where welding inspectors are the central figure of the communication network, since they will constantly be dealing with most of the people involved. Some people that the inspector may communicate with are welders, welding engineers, inspection supervisors, welding supervisors, welding foremen, design engineers, and production supervisors. Each company will dictate exactly how its welding inspectors function.

The communication between the welder and inspector is important to the attainment of quality work. If there is good communication, each individual can do a better job. Welders can discuss problems they encounter, or ask about specific quality requirements. For example, suppose the welders are asked to weld a joint having a root opening which is so tight that a satisfactory weld cannot be accomplished. They may contact the inspector to pass judgment and get the situation corrected right then rather than after the weld is rejected for being made improp-

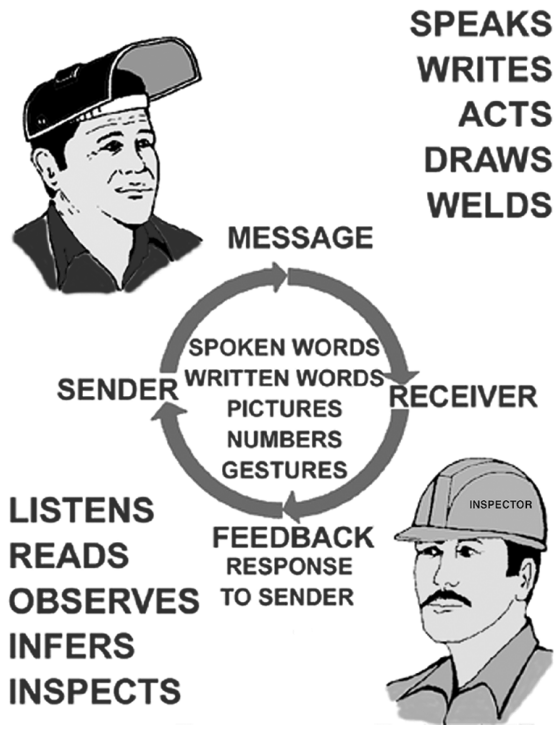

Figure 1.2—The Welding Inspector—A Communicator

erly. When effective communication occurs, the welding inspector has the opportunity to supply answers and/or begin corrective action to prevent the occurrence of some problem. The communication between the welder and an inspector is usually improved if the welding inspector has some welding experience. Then the welder has more confidence in the inspector's decisions. If there is poor communication between these two parties, quality can suffer.

Welding engineers rely heavily on welding inspectors to be their "eyes" on the shop floor or construction site. Engineers count on the inspector to spot problems relating to the techniques and processes specified. The welding inspector can also confirm whether specified procedures are being followed. The welding inspector, in turn, can ask the welding engineer about certain aspects of those procedures as well. Often, if a welding procedure is not producing consistent, reliable results, the welding inspector may be the first person to spot the problem. At that point, the welding engineer is notified so that adjustments can be made to alleviate the problem.

The welding inspector will probably work under the direction of some supervisor. This individual is responsible for verifying a welding inspector's qualifications to perform the work. The supervisor should also answer the

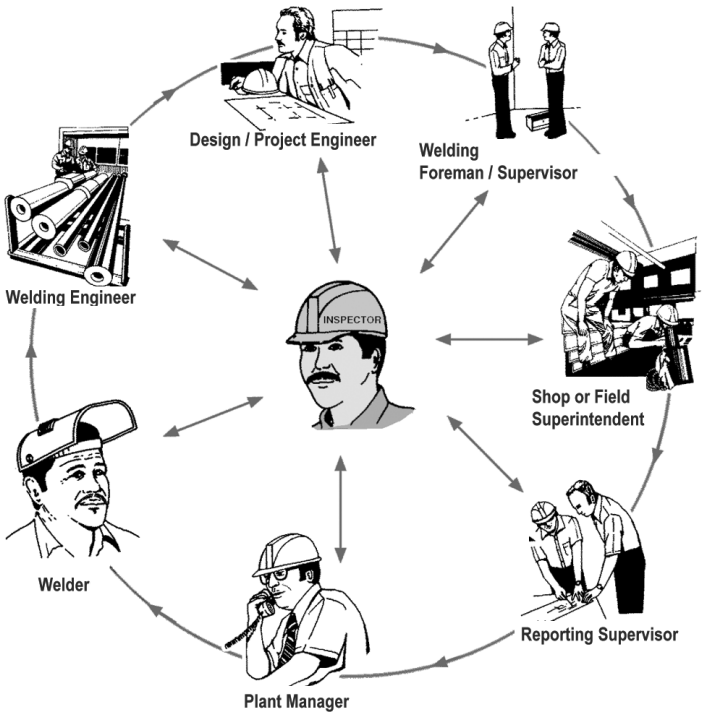

Figure 1.3—Establishing Lines of Communication

inspector's questions and aid in the interpretation of quality requirements. In some industry situations, the welding inspector must bring all questions to the supervisor. In turn the supervisor takes that question to someone in engineering, purchasing, etc. The welding inspector must convey a question clearly so it can be described properly by the inspection supervisor to the other party.

During the actual fabrication process, the welding inspector will have opportunities to speak with many other personnel. In some situations, instead of communicating directly with the welders, the welding inspector will deal with the welding supervisor or foreman. This usually involves specific quality requirements or explanations why some aspect of the welding is rejected.

The welding inspector may also have to gain information from design engineers about the actual weld requirements. During fabrication, other problems may arise which can only be answered by the person who actually designed the structure or component. Another way in which this aspect of communication takes place is through drawings and welding symbols. Although a powerful communication tool, welding and NDE symbols may require clarification by the symbol creator.

Finally, the welding inspector will have some occasion to discuss job scheduling with production personnel. This occurs especially when rejections have been noted which could alter the production schedule. It is important for the welding inspector to keep the production personnel aware of the status of the welding inspection.

When we talk of communication, we are not limiting our attention to speaking. There are several ways in which people effectively communicate. They include speaking, writing, drawing, gesturing, and the use of pictures or photographs. Each situation may be dealt with using one or more of these methods. The method is not as important as the fact that communication occurs; messages are sent, received and understood by all concerned.

Personnel Certification Programs

There are several programs presently available to determine whether an individual possesses the necessary experience and knowledge to perform welding inspection effectively. The American Society for Nondestructive Testing has issued guidelines for certification of NDE personnel in ASNT SNT-TC-1A. This document describes the recommended procedures for certifying inspectors performing nondestructive testing. ASNT recognizes three levels of certification: Levels I, II, and III.

AWS has also initiated an NDE Certification Program. Presently, AWS can certify one Level of Radiographic Interpreter (RI). The RI program certifies inspectors for interpreting weld radiographs. Additional NDE methods' certification is available through the joint efforts of AWS and outside training agencies.

For visual inspection of welds, AWS has developed the Certified Welding Inspector program. The front page of the Application form for the Certified Welding Inspector is shown in Figure 1.4.

AWS QC1, *Standard for AWS Certification of Welding Inspectors*, and AWS B5.1, *Specification for the Qualification of Welding Inspectors*, establish the requirements for AWS qualification and certification of welding inspection personnel. There are three levels of certification in AWS QC1. The Senior Certified Welding Inspector (SCWI) is a person with at least 15 years experience, including 6 years experience while certified as a Certified Welding Inspector (CWI). The SCWI must pass a separate examination from the CWI examination explained below. Information on the SCWI program and examination are found in a separate course, *Welding Quality Assurance and Inspection Manual—A Guide for the Senior Certified Welding Inspector*. The next certification level is the CWI and the third level is the Certified Associate Welding Inspector (CAWI). Both of these certifications are covered in this course. AWS QC1 and AWS B5.1 describe how personnel are qualified and certified, lists the principles of conduct, and notes the practice by which certification may be maintained. Those major elements will be discussed here.

The first step toward certification is the documentation of relevant educational and work experience. To qualify for the Certified Welding Inspector (CWI) examination, the individual must document his or her educational background. In addition, the candidate's years of welding-related experience according to some code or specification must be documented.

With supporting documentation (e.g., copies of transcripts, reference letters, credited hours of training, quarter hours or semester hours), up to two years of work experience may be substituted by post high school educational experience. Substituted educational experience includes an Associate or higher degree in engineering, physical sciences or engineering technology. Trade and vocational courses can be applied to work experience substitution for completed courses related to welding (up to one year maximum).

Candidates with a high school education, either by diploma or state or military equivalence, must have at least 5 years experience. Individuals with eighth grade schooling are required to have not less than 9 years job

American Welding Society
550 N.W. LeJeune Road, Miami, Florida 33126

APPLICATION FOR AWS WELDING INSPECTOR EXAMINATION

Please PRINT or TYPE

AWS USE ONLY
SITE CODE_____
1. Check #_____
2. Date Rec'd_____
3. Amount_____
4. Account #_____

1a. CHECK THE EXAMINATION LEVEL YOU DESIRE
- ☐ A. Certified Welding Inspector **(CWI)**
- ☐ B. Certified Associate Welding Inspector **(CAWI)**

1b. Choose ONE of the following for the CODE BOOK test
- ☐ C-1 AWS D1.1
- ☐ C-2 API 1104
- ☐ C-3 ASME B31.1 & ASME Sec IX
- ☐ C-4 ASME Sec VIII & Sec IX

CHARGE MY: VISA MC AMEX DIN
CARD #_____
EXP. DATE_____

SAMPLE

2. PERSONAL

LAST NAME FIRST MIDDLE INITIAL

STREET APT #

CITY STATE ZIP

LIST COMPANY NAME ONLY IF ADDRESS ABOVE IS COMPANY ADDRESS

TELEPHONE: AREA CODE AND NUMBER SOCIAL SECURITY NO. BIRTH DATE

3. AWS CERTIFICATION STATUS

a. Have you taken a previous AWS QC1 certification examination? ☐ YES ☐ NO

a.1. If Yes, give date and location_____

b. Have you ever been certified as an AWS QC1 ? ☐ YES ☐ NO

b.1. If Yes, print your certification no._____

4. SIC CODES

SOURCE CODE: QC1

Type of Business (Check ONE only)
- A ☐ Contract construction
- B ☐ Chemicals & allied products
- C ☐ Petroleum & coal industries
- D ☐ Primary metal industries
- E ☐ Fabricated metal products
- F ☐ Machinery except elect. (incl. gas welding)
- G ☐ Electrical equip. supplies, electrodes
- H ☐ Transportation equip. - air, aerospace
- I ☐ Transportation equip. - automotive
- J ☐ Transportation equip. - boats, ships
- K ☐ Transportation equip. - railroad
- L ☐ Utilities
- M ☐ Welding distributors & retail trade
- N ☐ Misc. repair services (incl. welding shops)
- O ☐ Educational services (univ. libraries, schools)
- P ☐ Engr. & architectural services (incl. assns.)
- Q ☐ Misc. business services (incl. commercial labs)
- R ☐ Governments (federal, state, local)
- S ☐ other_____

Job Classification (Check ONE only)
- 01 ☐ President, owner, partner, officer
- 02 ☐ Manager, director, superintendent (or assistant)
- 03 ☐ Sales
- 04 ☐ Purchasing
- 05 ☐ Engineer — welding
- 06 ☐ Engineer — other
- 07 ☐ Inspector, tester
- 08 ☐ Supervisor, foreman
- 09 ☐ Welder, welding or cutting operator
- 10 ☐ Architect, designer
- 11 ☐ Consultant
- 12 ☐ Metallurgist
- 13 ☐ Research & development
- 14 ☐ Technician
- 15 ☐ Educator
- 16 ☐ Student
- 17 ☐ Librarian
- 18 ☐ Customer service
- 19 ☐ Other_____

Your Technical Interests (Place a number on line in choice order — 1-2-3, etc.)
- A ____Ferrous metals
- B ____Aluminum
- C ____Non-fer. except aluminum
- D ____Advanced mat'l/intermetalics
- ____Ceramics
- F ____High energy Processes
- G ____Arc Welding
- H ____Brazing & Soldering
- I ____Resistance Welding
- J ____Thermal Spray
- K ____Cutting
- L ____NDT
- M ____Safety & Health
- N ____Pipe & Tubing
- O ____Pressure Vessels & Tanks
- P ____Structures
- Q ____Roll Forming
- R ____Sheet metal
- S ____Stamping & punching
- T ____Bending & shearing
- U ____ Aerospace
- V ____Automotive
- W ____Machinery
- X ____Marine
- Y ____Other

Major product or service of your company_____

Figure 1.4—AWS Certified Welding Inspector Application Form

experience to qualify for the examination. For individuals with less than eighth grade schooling, not less than 12 years is required.

A subordinate level of qualification is the Certified Associate Welding Inspector (CAWI), which requires fewer years of experience for each educational level. All of the experience noted for both the CWI and CAWI must be work associated with some code or specification to be considered valid.

Individuals who qualify for the Certified Welding Inspector Examination take a three-part examination:

Part A—Fundamentals. The Fundamental examination is a closed book test consisting of 150 multiple choice questions. The topics covered in this portion of the exam include reports and records, destructive tests, welding performance, duties and responsibilities, weld examination, definitions and terminology, safety, welding and nondestructive examination symbols, nondestructive examination methods, welding processes, heat control, metallurgy, mathematical conversions and calculations.

Part B—Practical. The Practical examination consists of 46 questions. It requires measurement of weld replicas with provided measuring tools, and evaluation in accordance with a supplied "Book of Specifications." Not all questions require the use of the Book of Specifications; some require the individual to answer from practical knowledge. The Practical Test covers welding procedures, welder qualification, mechanical tests and properties, welding inspection and flaws, and nondestructive tests. Test candidates should be familiar with fillet and groove weld gauges, micrometers, dial calipers, and machinist's scales.

Part C—Open Book Code. This portion consists of questions on the code the individual has selected for this part of the examination. The following codes are applicable to this portion of the examination:

- **AWS D1.1.** The AWS D1.1, *Structural Welding Code—Steel*, examination covers the following subject areas: general requirements, design of welded connections, prequalification of WPSs, qualification, fabrication, inspection, stud welding and the annexes.
- **API 1104.** The API 1104, *Welding of Pipelines and Related Facilities*, examination covers the following subject areas: general, qualification of welding procedures, welder qualification, design and preparation of a joint for production welding, inspection and testing of production welds, standards of acceptability—NDT, repair or removal of defects, radiographic procedure, and automatic welding.
- **AWS D1.5.** The AWS D1.5, *Bridge Welding Code*, examination covers the following subject areas: general provisions, design of welded connections, workmanship, technique, qualification, inspection, stud welding, welded steel bridges, fracture control plan for nonredundant members and the annexes.
- **AWS D15.1.** The AWS D15.1, *Railroad Welding Specification for Cars and Locomotives*, examination covers welding of metal at least 1/8 in thick, specific requirements for welding railroad cars, and the requirements for the manufacturing and reconditioning of locomotives and passenger train vehicles.
- **ASME Section VIII and ASME Section IX, ASME B31.1, ASME B31.3.** ASME Section IX covers the qualification of Welding and Brazing Procedures, and Welders/Brazers. ASME B31.1 is the Power Piping code and ASME B31.3 the process piping code. The examination for ASME Section VIII and ASME Section IX covers the material, design, fabrication, inspection and qualification requirements for pressure vessel construction and welding and brazing qualifications. ASME Section IX, and ASME B31.1, ASME B31.3 covers the material, design, fabrication, inspection and qualification requirements and welding and brazing qualifications for power and process piping.

To successfully complete the examination, individuals must pass all three parts of the test. The passing score in each part for the CWI is 72%; the passing for CAWI is 60%. Beyond completion of the examination, the test candidate must undergo an eye examination to assure that the individual possesses adequate vision, whether natural or corrected. After all test results are successfully completed, the individual is considered qualified to perform visual inspection of welds. When AWS says that this individual is a Certified Welding Inspector, this simply implies that the person's qualifications are documented with an appropriate certificate. The CWI certificate does not state what code the inspector used on the examination, rather the CWI is qualified to use any code.

Welding inspectors are a very important part of any effective quality control program. While there are various categories of welding inspectors, in general they are considered to be those individuals responsible for evaluation of the resulting welding. These individuals must possess physical, mental and ethical qualities in order to be effective. The remaining chapters will detail those aspects of welding considered important for the welding inspector. In addition, these topics are also considered relevant to the AWS Certified Welding Inspector Examination. Therefore, this text is an appropriate guide for individuals to use in preparation for that series of examinations.

In preparation for that portion of the CWI examination covering welding inspector certification requirements, you are encouraged to read and become familiar with AWS QC1, *Standard for AWS Certification of Welding Inspectors*, and AWS B5.1, *Specification for AWS Qualification of Welding Inspectors*. Part of the welding inspector's job is the review and interpretation of various documents relating to the welded fabrication. This requires that the individual have a full understanding of the proper terms and definitions that are used. For this reason, included at the end of each chapter the reader will find, "Key Terms and Definitions" applicable to a chapter's topic. AWS realizes the need for standardized terms and definitions for use by those involved in the fabrication of welded products. In answer to this need, AWS A3.0, *Standard Welding Terms and Definitions*, was published.

AWS A3.0 was developed by the Committee on Definitions and Symbols to aid in welding information communication. Standard terms and definitions published in A3.0 are those that should be used in the oral and written language of welding. While these are the standard, or preferred, terms, they are not the only terms used to describe various situations. The purpose here is to educate, and it is often important to mention some of these common terms, even though they are not preferred terminology. When nonstandard terms are mentioned, they appear in parentheses after the preferred words.

While most of the terms used apply to the actual welding operation, it is important for the welding inspector to understand other definitions which apply to other related operations. Welding inspectors should understand how to describe weld joint configurations and fit up process elements requiring comment. After welding, the inspector may need to describe the location of a weld discontinuity that has been discovered. If a discontinuity requires further attention, it is important that the inspector accurately describe the location of the problem so that the welder will know where the repair is to be made. AWS recommends that standard terminology be used wherever possible, but the inspector must be familiar with nonstandard terms as well.

Key Terms and Definitions

API—American Petroleum Institute. The technical society which provides technical guidance for the petroleum industry.

API 1104—The API Standard, *Welding of Pipelines and Related Facilities*. This standard is often used in construction of cross-country pipelines.

ASME—American Society of Mechanical Engineers. The technical society which provides technical guidance for pressure containing vessels and equipment.

ASNT—American Society for Nondestructive Testing. The technical society which provides technical guidance for NDE.

AWS—American Welding Society. The technical society which provides technical guidance and leadership in all phases of welding.

AWS A3.0—The AWS *Standard Welding Terms and Definitions*. This standard defines welding-related terms with standard definitions.

AWS B5.1—The AWS *Specification for the Qualification of Welding Inspectors*.

AWS B5.11—The AWS *Specification for the Qualification of Radiographic Interpreters*.

AWS D1.1—The AWS *Structural Welding Code—Steel*. Used worldwide for construction of buildings and structures.

AWS D1.5—The AWS *Bridge Welding Code* used in the U.S. for construction of bridges.

AWS D15.1—The AWS *Railroad Welding Specification for Cars and Locomotives*. This specification covers welding of railroad cars and locomotives.

AWS QC1—The AWS *Standard for AWS Certification of Welding Inspectors*. Defines the requirements and program for AWS to certify welding inspectors.

CAWI—Certified Associate Welding Inspector.

CWI—Certified Welding Inspector.

KASH—An acronym for Knowledge, Attitude, Skills, and Habits, the basic tools of a welding inspector.

NDE—Nondestructive Examination. The act of determining the suitability of some material or component for its intended purpose using techniques that do not affect its serviceability. NDE is the preferred term per ANSI/AWS.

NDI—Nondestructive Inspection. A nonstandard term for **nondestructive examination** (see NDE).

NDT—Nondestructive Testing. A nonstandard term for **nondestructive examination** (see NDE).

SCWI—Senior Certified Welding Inspector.

SNT-TC-1A—This ASNT Recommended Practice, *Personnel Qualification and Certification in Nondestructive Testing*, outlines the certification program for NDT technicians.