People Make the Difference

By Jeffrey Noruk, Larry Gross, and Ed Bohnart

Background

Robots were first used for arc welding in production in the late 1970s, but the first real successes were not registered until the early to mid 1980s. The first systems utilized welding equipment borrowed from the manual and mechanized world. The first programmers typically came from the electrical engineering or computer departments. As time progressed and robotic arc welding became a "significant niche," the welding industry began to design and build equipment especially for this market. Likewise, the manufacturing companies themselves began to recognize that to be successful, they needed a specific type of person to manage the robotic arc welding systems they were installing.

Need(s) Identified

AWS recognized the need for standards specifically geared to the robotic and automatic arc welding field and created the D16 Committee in 1989. Since then, the D16 Committee has published standards dealing with component selection, risk assessment, and "Do's and Don'ts." In 1996, it was also recognized that the "human side" needed to be addressed to allow robotic arc welding to reach its potential. This spawned the creation of a robot operator qualification document (D16.4) and recently a certification specification (QC19) and test program called Certified Automated Process-Technician/Operator (CAP).

The story of how the Certified Automated Process-Technician/Operator program grew from an idea to reality mirrors the maturing of the robotic arc welding industry and its growing success.

Why Aren't These Robots Making Money?

The first robotic arc welding robots in the early 1980s were installed by large Tier One automotive companies such as A. O. Smith Automotive Products Co. (now Tower Automotive) and large heavy equipment manufacturers such as Caterpillar. These companies had to develop their own electrical interfaces to the welding equipment, modify mostly manual and automatic peripherals, and "grow" their own support personnel. The three biggest reasons why robots have been technically and/or financially unsuccessful in the past are 1) selection of incorrect equipment, 2) failure to introduce a consistent weld joint within the tolerances of the process, and 3) lack of qualified people to operate the systems.

The AWS D16 Committee recognized this. The members first addressed the equipment issue and then the part repeatability requirements through standards and educational seminars. It wasn't realized until the mid 1990s that the single biggest hurdle to further increasing the success rate of robotic arc welding, especially among the small- to medium-sized companies, was the people. The need for qualified personnel was also buoyed by the realization that structures previously welded manually or with mechanized equipment and certified people were now being converted to robotic welding where no operator qualification requirements existed.

AWS D16 Committee Begins Its Work

In the spring of 1995, the D16 Committee received approval of its request to begin work on the first qualification document for robotic support personnel. The model for this was an existing program being used by A. O. Smith Automotive Products Co. that supported their installed base of more than 1600 arc welding robots. Key items that needed to be established included 1) what skills were needed, 2) what prerequisite education was important, 3) how a person would progress from a beginner to an experienced operator, and 4) how this could be measured.

After more than four years of work, D16.4, *Specification for the Qualification of Robotic Arc Welding Personnel,* was completed. It listed four levels of support personnel.

The Next Step — Certification

While the qualification document was being developed, it became apparent to committee members that a means to certify people to this standard would also be necessary. The D16 Committee commissioned a task force to quantify the perceived need and to formalize this into a marketing study, which was completed in 1999 and presented to AWS management. This study showed an industry need for such a program and that it could be an eventual revenue generator for AWS, similar to the CWI program. Permission to proceed was given, and the Certification Committee appointed a special task force to begin work on this certification. The QC19, S*tandard for AWS Certification of Automated Process Operators and Technicians,* was the result.

Challenges Faced

The biggest hurdles faced in developing an effective certification program were 1) how to test the hands-on ability of the individual, 2) finding an adequate amount of reference books to support the development of a written test, and 3) how to effectively differentiate and test for the four different levels identified in the qualification document.

Fig. 1 — Kevan Kokkonen, a welding engineer at Miller Electric Mfg. Co., inspecting the robot gun and making adjustments during practical portion of the examination.

A Weld Must Be Made

The task force felt it was vital to require the candidate to actually make a weld with the robot. This would demonstrate the person's programming and welding ability. Selecting the right test coupon, to represent the greatest cross section of applications while being adequately difficult, was a challenge. Initially, a curved thin sheet metal T-fillet sample was favored, but eventually it was felt that a T-fillet sample with a round tube attached was better. It is made of thicker material that better represents the market, is simpler to make, and requires the use of programming techniques such as circular interpolation and multiple weld starts/stops.

Multiple Robot Types and Languages

The issue of testing multiple robot types with varying programming languages is a challenge not really experienced in the CWI or Welder Qualification programs. It was decided a variety of testing facilities needed to be established based on robot type and geography. Prime locations include technical colleges and robot companies. To date, three locations have been approved (Table 1).

Table 1 — Facilities Testing Multiple Robot Types with Varying Programming Languages

Facility Name	Location	Robot Type
Milwaukee Area Technical College	Milwaukee, Wis.	ABB
Fox Valley Technical College	Appleton, Wis.	OTC
Panasonic Factory Automation	Chicago, Ill.	Panasonic

Written Test

The written test originally consisted of both a closed- and open-book test. Due to the difficulty in finding enough reference books from which applicable questions could be developed, the written open-book test was eliminated. The makeup of the questions was developed based on two criteria — what does the person need to know to be successful, and what reference material exists to support the development of questions? While an adequate number of questions on every subject was developed, it was felt that an improvement would require more robot programming and more real world questions.

Table 2 — Written Test Categories

Topic	Minimum Number	Approximate Percentage
Weld Equipment Setup	10	8
Welding Processes	20	15
Weld Examination	10	8
Definitions and Terminology	10	8
Symbols — Welding & Robotics	5	4
Safety	14	12
Destructive Testing	10	8
Conversion and Calculations	5	4
Robot Programming and Logic	25	20
Welding Procedures	10	8
Kinematic Concepts	5	4
Robot Arc Weld Cell Components-ID	5	4
Total	136 questions	100%

How Many Levels Are Required?

It was recognized that the four levels of operator qualification would not be possible to differentiate through testing. For this reason, Level 1 was made into a company self-certification process, Levels 2 and 3 were combined into the CAP-O class, and Level 4 became CAP-T, which requires the person be a certified welding inspector.

Pilot Test

A pilot test was required to determine if the difficulty of the written and performance tests were adequate and whether they could be administered fairly and safely. It was decided to hold the pilot test in the Chicago area during the 2002 Welding Show. The test experience was broadened by having three different sites with three different robot types. The proctors were selected based on their familiarity with the test and their location. Dave Erbe administered the Chicago test, Ed Bohnart the Appleton test, and Larry Gross and Jeffrey Noruk oversaw the Milwaukee test.

A total of fourteen candidates took the free test. Requirements were a completed application form, adequate experience and educational background, and a willingness to provide constructive feedback. The written test consisted of 136 multiple-choice questions covering the subjects listed in Table 2. The performance segment of the test required the demonstration of the skills listed in Table 3. Some of the most important results and lessons learned were

- The written test took an average of 1 hour and 45 minutes to complete, while the performance segment required, on average, about 2 hours and 20 minutes. The target for each section was 2 hours.
- The average grade for the written test was 83, with the range being from 65–93. The hands-on test scored much higher with an average grade of about 92 and a range from 79–100.
- Seven questions were either eliminated from scoring altogether or more than one correct answer was allowed.
- The test plate used worked well to properly test the programming and welding skills of the candidate. Difficulty could be increased in the future by requiring the demonstration of weaving and downhill travel.
- The range of the candidates' backgrounds and experience was purposely wide to allow the difficulty of the test to be evaluated.
- The performance methodology proved workable for the three different robots utilized in the three different locations, even though the overall cell configurations were different.
- The test produced a total of five CAP-T- and six CAP-O-qualified individuals. Those CAP-T individuals are now available to become proctors themselves.

Table 3 — Performance Test Criteria

Topic
Identification of Components & Demonstration of Use
Demonstrations of Safe Equipement use
Procedure and Welding Process Setup
Robot Programming and Welding of Test Piece
Weld Quality Assessment

Fig. 2 — Jeff Noruk of Servo Robots using the LASER scanner to measure weld size and other discontinuities.

■ There was a need to run a second pilot test to evaluate the changes made and to increase the number of proctors. This was held in June 2002, and the findings confirmed this test was fair and ready for a widespread rollout.

Figure 1 shows Kevan Kokkonen of Miller Electric Mfg. Co. in Appleton, Wis., inspecting the robot torch prior to making his first test plate. Figure 2 shows Jeffrey Noruk at MATC in Milwaukee, Wis., evaluating the finished test plate weld quality with a Servo Robot hand-held WISC inspection system. In Fig. 3, Fox Valley Technical College Robotics Instructor David Hoffman cuts a practical examination piece.

Future Plans

The first CAP test open to the general industry is slated to be held in the Midwest during spring 2003. The goal is to expand into other regions of the country as the number of proctors and test facilities become available. We hope robot companies and technical colleges will provide the backbone of this infrastructure. The CAP test will, in some cases, be made an optional part of a robot company's arc welding training course.

The need for support materials for the test, similar to that available for the CWI program, will be needed. This includes a training guide for self-study as well as AWS-sponsored training courses. The training course is currently under development. This is an area in which the D16 Committee would welcome help.

Fig. 3 — Fox Valley Technical College Robotics Instructor David Hoffman cutting a practical examination piece.

The CAP test for arc welding is just the first of several proficiency tests that will become available in the robot industry. Work on a qualification document for resistance welding operators has just started. Areas such as thermal cutting and laser welding are also in need of this type of program. These types of certification are of benefit to the companies that, in the end, will employ better qualified people. For the individual, the benefits include increased earning potential, improved career opportunities, and a way to differentiate oneself in an ever more competitive field.

Acknowledgments

The authors would like to thank the hardworking members of the D16 and Certification Committee task force, as well as Ed Bohnart for his guidance and AWS Deputy Executive Director Jeff Hufsey, who pulled everything together to make the pilot tests a worthwhile experience.♦

The American Welding Society is sponsoring the Seventh Robotic Arc Welding Conference and Exhibition February 10 and 11, 2003 in Orlando, Florida. The conference will include a tutorial on robotic basics, robotic arc welding of steel and aluminum with case studies, and computer simulations. For further information, contact the AWS Conference Business Unit at (800) 443-9353 ext. 223 or, outside the United States, (305) 443-9353 ext. 223 or via e-mail to gladys@aws.org.

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