

**CRAW – O/T**  
**Certified Robotic Arc Welding**  
**Operator and Technician**  
**Examination**

**Performance Test**  
**Candidate Information Booklet**

**Name** \_\_\_\_\_  
(Please print)

**Test Site** \_\_\_\_\_  
(City/State)

**Test Date** \_\_\_\_\_

**CRAW-T Examiner** \_\_\_\_\_  
(Please print)

**CRAW-T #:** \_\_\_\_\_

Revision 4  
June 2004

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## 1.0 Introduction and Purpose of Program

Welding robots have been in use in the manufacturing industry since the late 1970s, using technology developed in the manual and mechanized welding processes. As these robots, and the systems used to control them, gained industry acceptance, it became rapidly evident that the success of robotic arc welding would depend upon specially qualified personnel.

To this end, the AWS D16 Committee on Robotic and Automatic Welding drafted an ANSI standard, AWS D16.4:1999, *Specification for the Qualification of Robotic Arc Welding Personnel*, that defined the requirements for personnel to be considered qualified. AWS has decided that the certification of these individuals is important to the industry, and, consequently, has started a program whereby individuals can apply and, if they meet the requirements as stated in AWS D16.4, can be certified as either Certified Robotic Arc Welding Technicians or Operators.

This booklet is designed to provide information on the written examination and performance test that are required for certification under this program. Please be aware that this booklet is being revised and improved continually to provide the best possible information to the candidates, be sure to download the latest version from the AWS website at:

<http://www.aws.org/certification>

## 2.0 Description of Certification Process

### 2.1 Written Examination

The Written Examination is designed to test your knowledge of welding fundamentals and robotic arc welding systems.

The written examination consists of more than 130 questions on the following subjects:

Subject	Approx % = # of Questions	
Weld Equipment Setup	8	11
Welding Processes	15	20
Weld Examination	8	11
Definitions and Terminology	8	11
Symbols	4	5
Safety	12	16
Destructive Testing	8	11
Conversion and Calculations	4	5
Robot Programming	15	20
Welding Procedures	8	11
Programming Logic	4	5
Kinematic Concepts	4	5
Robot Arc Weld Cell Components	4	5
Totals	100%	136

The questions are mainly multiple choice (there are a few true/false questions) and the candidate has two hours to complete the written examination. The written examinations are administered by AWS authorized personnel at the same locations as the CWI tests are offered. Consult the latest schedule of CWI test dates and locations to find out when an examination will be offered in an area close to you.

## **2.2 Performance Test**

The Performance Test is administered by another certified individual, the Certified Robotic Arc Welding Technician (CRAW-T). It is the responsibility of the Candidate to contact a current CRAW-T to arrange for taking the Performance Test.

The Performance Test is designed to test your ability to manipulate a robotic arc welding cell to achieve desired results. You will be required to demonstrate your familiarity with the components of a robotic arc welding cell, your ability to program the machine to weld a test piece, actually weld up that piece and finally verify the quality of your test piece.

**IMPORTANT NOTE:** Critical to the operation of any welding machine is safety. Before any operations can start, you will be required to show your complete understanding and ability to conduct safe welding operations. If at any time during the Performance Test your Test Proctor has reason to believe that you may be acting in an unsafe manner and that there may be a possibility of injury to persons or damage to equipment, the Test Proctor is authorized to terminate the Performance Test immediately. The Test Proctor has complete discretion on whether to resume the Performance Test or postpone it indefinitely pending further training on the part of the Candidate. Termination of the Performance Test for safety reasons will not be grounds for appeal of any kind by the Candidate.

See Section 5.0 for the detailed description of the conduct of the Performance Test.

## **2.3 Reference Documents**

*AWS A3.0, Standard Welding Terms and Definitions*  
*AWS B1.10, Guide for Nondestructive Inspection of Welds*  
*AWS B1.11, Guide for Visual Welding Inspection*  
*AWS B5.1, Qualification Standard for AWS Welding Inspectors*  
*AWS QC1, Standard for AWS Certification of Welding Inspectors*  
*AWS WI, Welding Inspection*  
*AWS CM-00, Certification Manual for Welding Inspectors*  
*AWS B2.1, Specification for Welding Procedure and Performance Qualification*  
*AWS D8.8, Specification for Automotive and Light Truck Weld Quality: Arc Welding*  
*AWS D16.2, Standard for Components of Robotic and Automatic Welding,*  
*AWS D16.3, Risk Assessment Guide for Robotic Arc Welding*  
*AWS D16.4, Specification for the Qualification of Robotic Arc Welding Personnel*  
*ANSI Z49.1, Safety in Welding, Cutting and Allied Processes (published by the American Welding Society)*  
*NEMA EW-1, Electric Arc Welding Power Sources*  
*AWS Arc Welding with Robots, Do's and Don'ts*  
*Automating the Welding Process, Jim Berge, Industrial Press*

AWS Welding Handbook, Volume 1, 9<sup>th</sup> Edition  
AWS Welding Handbook Volume 2, 8<sup>th</sup> Edition  
Robot Programming Manual (published by robot manufacturer)  
AWS 058, *Arc Welding Automation*, Howard Cary  
AWS A2.4, *Standard Symbols for Welding Brazing, and Nondestructive Examination*  
Jefferson's Welding Encyclopedia 8<sup>th</sup> Edition (published by the American Welding Society)  
RIA 15.06, *American National Standard of Industrial Robots and Robot Systems - Safety Systems*<sup>1</sup>

### **3.0 Test Piece Drawing and Cut List**

See pages 10 and 11.

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<sup>1</sup> Robotics Industrial Association, 900 Victors Way, P.O. Box 3724, Ann Arbor, MI 48106

#### 4.0 Welding Parameters (Typical)

	0.035 Wire Spray Transfer			0.045 Wire Spray Transfer			0.052 Wire Spray Transfer		
	½" Stick Out			5/8" Stick Out			¾" Stick Out		
	WFS	Volts	Travel Speed	WFS	Volts	Travel Speed	WFS	Volts	Travel Speed
<b>ER70S-X</b> <b>90-10</b>	425	26.5	12.03	355	27.5	16.61	285	27.5	17.81
	495	27.5	14.01	425	28.5	19.89	355	28.5	22.18
	565	28.5	16.00	495	29.5	23.17	425	29.5	26.56
	635	29.5	17.98	565	30.5	26.44			
<b>ER70S-X</b> <b>92-8</b>	420	25.5	11.89	350	26.5	16.38	280	26.5	17.50
	490	26.5	13.87	420	27.5	19.66	350	27.5	21.87
	560	27.5	15.85	490	28.5	22.93	420	28.5	26.25
	630	28.5	17.84	560	29.5	26.21			
<b>ER70S-X</b> <b>95-5</b>	425	27	12.03	355	28	16.61	285	28	17.81
	495	28	14.01	425	29	19.89	355	29	22.18
	565	29	16.00	495	30	23.17	425	30	26.56
	635	30	17.98	565	31	26.44			
<b>ER70S-X</b> <b>98-2</b>	420	24	11.89	350	25	16.38	280	25	17.50
	490	25	13.87	420	26	19.66	350	26	21.87
	560	26	15.85	490	27	22.93	420	27	26.25
	630	27	17.84	560	28	26.21			
<b>ER70S-X</b> <b>85-15</b>	420	27.5	11.89	350	28.5	16.38	280	28.5	17.50
	490	28.5	13.87	420	29.5	19.66	350	29.5	21.87
	560	29.5	15.85	490	30.5	22.93	420	30.5	26.25
	630	30.5	17.84	560	31.5	26.21			
<b>ER70S-X</b> <b>80-20</b>	425	27.5	12.03	355	28.5	16.61	285	28.5	17.81
	495	28.5	14.01	425	29.5	19.89	355	29.5	22.18
	565	29.5	16.00	495	30.5	23.17	425	30.5	26.56
	635	30.5	17.98	565	31.5	26.44			
<b>ER70S-X</b> <b>75-25</b>	420	28	11.89	350	29	16.38	280	29	17.50
	490	29	13.87	420	30	19.66	350	30	21.87
	560	30	15.85	490	31	22.93	420	31	26.25
	<b>Plate Size 12G to ¼"</b>			<b>Plate Size 5/16" to ½"</b>			<b>Plate Size ½" &amp; Up</b>		

## **5.0 Conducting the Performance Test**

The following tasks are expected to be completed in a sequential manner. Do not proceed to the next task until the Test Proctor has indicated that it is OK to do so.

### **Part 1 Required Safety Tasks**

#### **Task #1**

Inspect the robot welding system and identify any potential safety hazards prior to commencing the exam.

#### **Task #2**

Identify the pinch points of the robotic welding system.

#### **Task #3**

Demonstrate to the Test Proctor the basic robot cell operation.

#### **Task #4**

Demonstrate the procedure for safe entry into the welding cell for service.

#### **Task #5**

Identify the emergency stops and engage one of them.

#### **Task #6**

Demonstrate the ability to recover the robot system from this e-stop condition.

### **Part 2 Equipment Familiarization Tasks**

#### **Task #7**

Use the robotic arc welding cell to identify each of the welding cell components to the Test Proctor:

- Robot controller
- Robot arm
- Identify each axis of the robot
- Positioner "if applicable"
- Teach pendant
- Robot breakaway
- Welding power supply
- Wire feed unit
- Welding drive rolls
- Welding torch
- Welding gas supply system
- Welding cell safety switches
- Emergency stops
- Operator start button

**Task #8**

Perform inspection of the welding torch, diffuser, drive roll and contact tip. Demonstrate how to replace each of these items.

**Task #9**

Demonstrate how to turn the welding power source and the robot controller on.

**Task #10**

Demonstrate the ability to route welding wire from the wire feeding mechanism through the wire feeding system to the contact tip.

**Task #11**

Check the operation of the wire feeding system with the use of the teach pendant or by other means.

**Task #12**

Ensure that the shielding gas supply system operates correctly by purging the system.

**Task #13**

Ensure that the welding torch water circulator system is on and functioning if a water-cooled torch is used.

At this point the Test Proctor will allow you to practice actual welding on some scrap pieces so that you may fine tune the welding parameters to achieve a satisfactory weld.

**Part 3 Test Piece Preparation and Programming****Task #14**

Demonstrate the ability to move the robot by using the teach pendant as the Test Proctor instructs.

**Task #15**

Check that the correct Tool Center Point has been selected for the torch being used.

**Task #16**

With your robot system, program the following points relative to the Test Piece.

Home position  
Pounce position

**Task #17**

Place the sample part in a position that allows the robot to access all welds required for the Test Piece.

### **Task #18**

Write a basic welding program for the Test Piece specified, this program will consist of these basic types of points.

- a. Joint move over the part to a pounce position
- b. Linear move to the start of the first weld
- c. Weld starting point
- d. Weld end point
- e. Linear move between each weld end and next weld start

Repeat c through e above for all of the welds shown on the Test Piece drawing provided.

Linear move from the stop of the last weld to a retract position

Joint move from the retract position to a safe position

NOTE: Use two welding schedules while programming this sample part and be sure to save your program.

### **Task #19**

Demonstrate the safe operation of the welding program without welding the Test Piece. Perform a dry run.

### **Task #20**

The Test Proctor will now rotate the Test Piece in any direction approximately 2°.

### **Task #21**

Secure the Test Piece to the positioner, table or fixture with clamps. Be sure that the Test Piece is properly secured and that the clamps will not interfere with your welding program.

### **Task #22**

Edit the welding program points so that these points are now in the correct position to weld the Test Piece. While doing this, input a delay or wait command into the welding program.

## **Part 4 Welding the Test Piece and Evaluation**

### **Task #23**

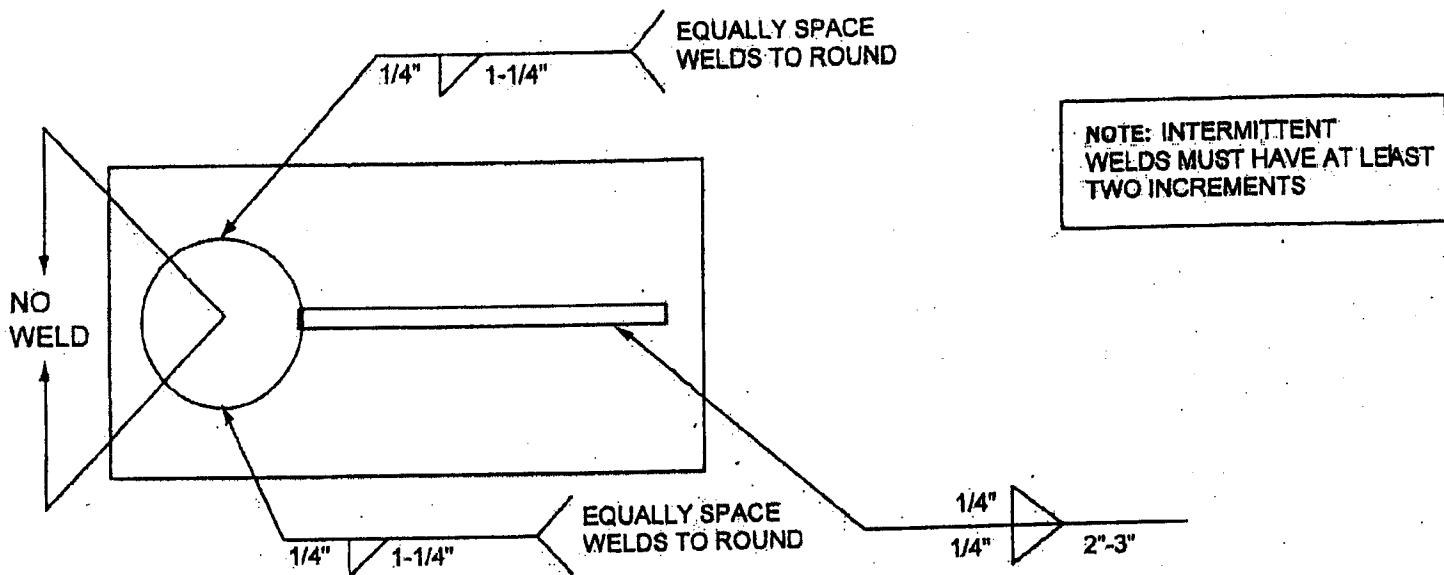
Weld the Test Piece after the Test Proctor has verified your work up to this point.

### **Task #24**

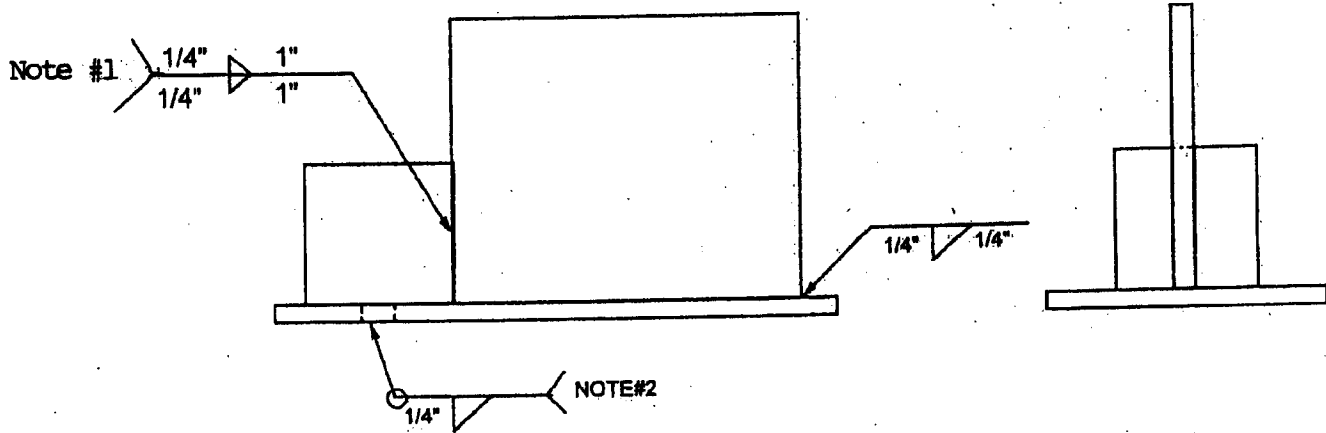
Record the welding parameters that were input into the welding program used to weld the Test Piece. Record this information on the *Performance Test Record* form.

### **Task #25**

Evaluate the welds on the Test Piece by visual inspection using the acceptance criteria contained on the *Weld Quality Assessment Form*. Discuss your findings with the Test Proctor prior to sectioning the welds for etching. If you are not personally performing the sectioning and macroetch of the welds, be sure to clearly mark the location of the welds to be sectioned. Complete the *Weld Quality Assessment Form* based on the visual inspection and macroetch results. The Test Proctor will concur on the acceptability of the weld inspection by initialing on the *Assessment Form*.



NOTE: INTERMITTENT WELDS MUST HAVE AT LEAST TWO INCREMENTS

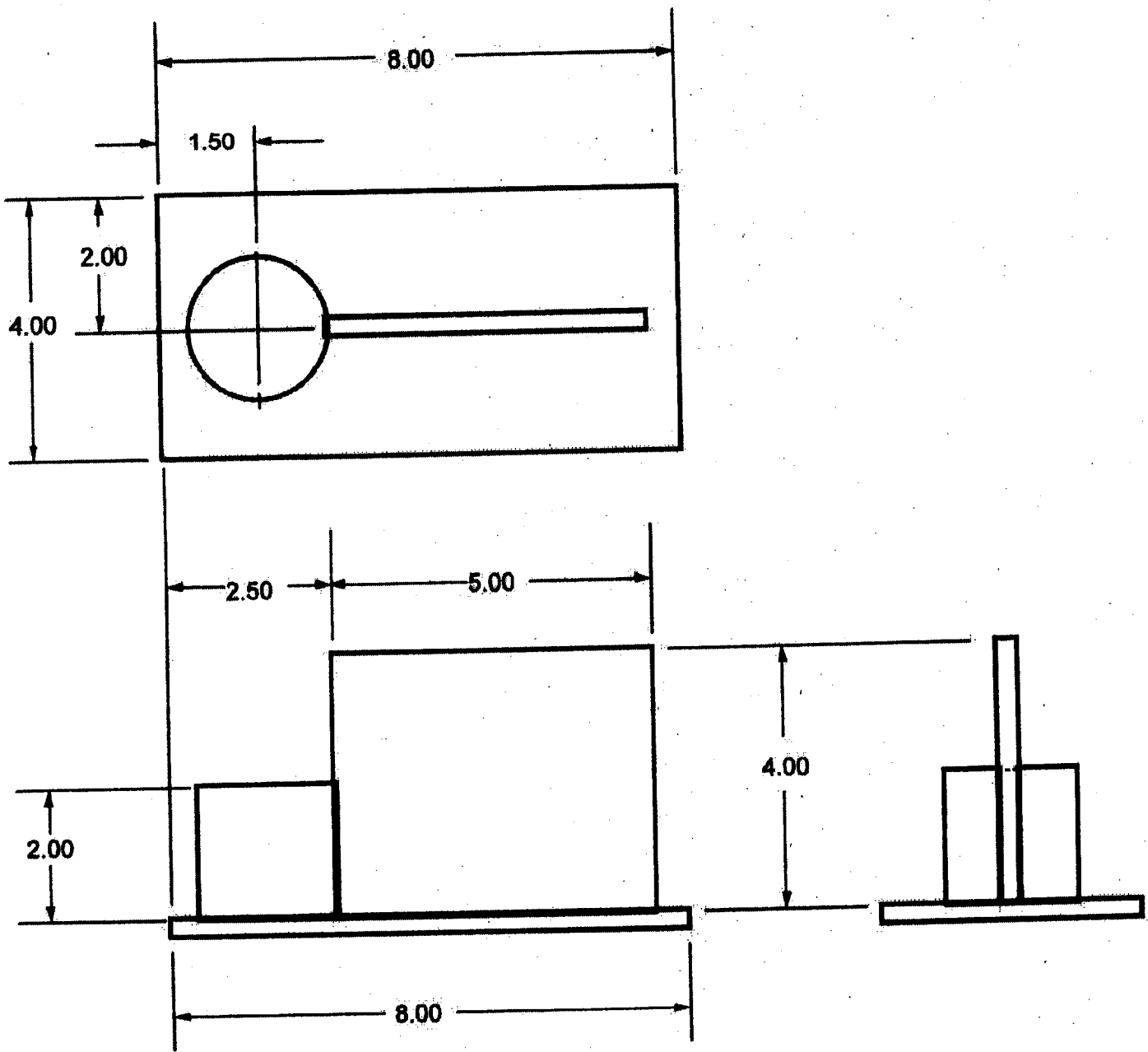


Note #1: Center tack welds on joint.

Note #2: Plug weld may be substituted.

Cut List:

- 1 piece 1/4" cold rolled plate dimensions 4" X 5"
- 1 piece 1/4" cold rolled plate dimensions 4" X 8" (with 3/4" hole 1-1/2" from edge centered under bar)
- 1 piece 2" diameter cold rolled bar



## 6.0 Performance Test Record and Weld Quality Assessment Form

(This form may be photocopied for additional use.)

Candidate Name \_\_\_\_\_ Date of Test \_\_\_\_\_  
 Test Proctor Name \_\_\_\_\_ CRAW-T Cert # \_\_\_\_\_

### Performance Test Record – Actual Parameters Used

Directions: Please fill in the chart below with the parameters used to complete your final test plate. If you used a separate schedule for the boss and plate, fill in these values in the appropriate columns.

Parameter	Boss	Plate
Wire Feed Speed (ipm)		
Current (A)		
Voltage (V)		
Travel Speed (ipm)		
Torch Angle (Off Horz.)		
Torch Angle (Lead/Lag)		
Wire Type Used		

### Weld Quality Assessment Form

Directions: Evaluate the weld designated by the proctor using both visual inspection and destructive cross sectioning. A fillet gauge should be used to determine if the weld meets the size requirements. Cross sectioning should consist of cutting the sample, rough polishing it and then etching it so one can determine the amount of fusion. Fill out the chart below with the results and summarize at the bottom if the weld is acceptable.

<u>Discontinuity</u>	<u>Tolerances</u>	<u>Actual</u>
Weld leg size	Req. Size is +1/8", - 0	
Concavity	Maximum of 1/16"	
Weld Location	+/- 1/4"	
Effective Weld Length	- 0, + 1/4"	
Undercut	Max. depth < 1/16"	
Surface Porosity	Max. Dia. < 1/8"	
Cracks	None Allowed	
Fusion	Root & Legs Are Fused	

Weld Results:                      Acceptable \_\_\_\_\_ Not Acceptable \_\_\_\_\_  
 Signature and Stamp of Test Proctor Indicating Agreement \_\_\_\_\_