TECHNICAL REPORT

ISO TR 11032

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Manipulating industrial robots — Application oriented test — Spot welding

Robots manipulateurs industriels — Essai orienté d'application — Soudage par points

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented in that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The main task of ISO technical committees is to prepare International Standards. In exceptional circumstances a technical committee or sub-committee may propose the publication of a Technical Report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

- type 3, when a technical committee or sub-committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 11032 , which is a Technical Report of type 2, was prepared by Working Group 2, *Performance criteria and related testing methods*, of ISO/TC 184/SC 2, *Robots for manufacturing environment*.

The unsolved comments to CD 11032.3 and DTR 11032 are compiled in Annex J of this Technical Report.

This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat.

This Technical Report describes a method of tests for manipulating industrial robots for a spot welding application and it should be regarded as a complement to ISO 9283, *Performance criteria and related testing methods*.

It is not a complete application test. The test simulates a welding task. Examples on deviations from a real application test are given in clause 6.

Annexes A - J are informative parts of this Technical Report.

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Introduction

ISO/TR 11032 is part of a series of International Standards and Technical Reports dealing with manipulating industrial robots. Published International Standards cover such topics as safety, general characteristics, performance criteria and related testing methods, coordinate systems, terminology, and mechanical interfaces. It is noted that these International Standards are interrelated and also related to other International Standards.

ISO/TR 11032 is intended to facilitate understanding between users and manufacturers of robots and robot systems. It defines a typical spot welding application, describes a method of tests for robots in this application and gives a format for presentation of test results.

The intent of this Technical Report is to provide evaluation of characteristics particular to spot welding applications. The results can also be used for comparison when the test equipment and the test conditions are the same.

Results from tests where the test tool described in 7.3 has been used shall not be compared with results from tests where the test gun described in F.2.2 has been used since the test conditions are not the same.

Annexes A - E of this Technical Report provides drawings on the equipment used for the described test.

The informative Annexes F - H of this Technical Report provides a method to extend the basic test procedure in this standard to more closely represent a typical spot welding application.

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Manipulating industrial robots - Application oriented test - Spot welding

1 Scope

This Technical Report uses spot welding motion sequences to represent typical spot welding applications. Cycle time values are used as a measure of spot welding performance. A presentation format is provided for consistent presentation of test results.

The term Spot welding used in this standard means Resistance spot welding (RPW) according to the vocabulary accepted by the International Institute of welding (IIS).

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All International Standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 5830:1984, *Resistance spot welding - Male electrode caps*

ISO 8373:1994, *Manipulating industrial robots - Vocabulary*

ISO 9283:1990, *Manipulating industrial robots - Performance criteria and related testing methods*

ISO 9283 Amendment 1:1991, *Manipulating industrial robots - Performance criteria and related testing methods - AMENDMENT 1: Guide for selection of performance criteria for typical applications*

ISO 9409-1:1988, *Manipulating industrial robots - Mechanical interfaces - Part 1: Circular (form A)*

ISO 9787:1990, *Manipulating industrial robots - Coordinate systems and motions*

3 Definitions

For the purpose of this Technical Report, the definitions given in ISO 8373 apply.

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4 Description of application

Spot welding robots are used for joining sheet metal, for example in the car industry. Typical thicknesses of the sheets are from 0,5 mm to 2,0 mm.

Spot welding is performed when the robot is not moving. The movements between spots are typically in the range of 40 - 500 mm. Spots are often placed in groups and motions between these can demand major reorientations of the welding gun.

Robots used for spot welding typically have a rated load between 50 and 150 kg. Robots with a lower rated load can also be applied.

In order to reduce damages on robot and flanges, spot welding guns handled by robots are typically equipped with an equalizing system, which takes care of variability in the robot performance, sheet metal position and variations in electrode tip length.

The spot welding equipment typically consists of one of the following solutions:

a) Spot welding gun, mass: 30 - 120 kg, mounted on a robot.
Transformer 35 - 200 kVA, mass: 50 - 100 kg, ceiling or wall mounted, or standing on the floor with cables (kickless) connected to the spot welding gun.

b) Spot welding gun, mass: 30 - 120 kg, mounted on a robot.
Transformer 35 - 200 kVA, mass 50 - 200 kg, placed on the robot arm and connected to the welding gun with an integrated media supply (current, water, air) or cables (kickless).

c) Spot welding gun with integrated transformer, mass: 50 - 150 kg, mounted on a robot.
Transformer 20 - 80 kVA.
Media supply (current, water, air) along the robot arm or hanging from above.

d) Poke welding gun with a single electrode, mass: 10-30 kg, mounted on a robot. The second electrode provided is stationary .

e) Stationary spot welding gun. The spot welding gun is fixed and the robot is handling the object about the gun.

The welding controller is installed remote or integrated in the robot controller.

Typical communication sequences for spot weldings are shown in Figure 1.

Settings of welding parameters are for instance dependant upon the quality of cables between transformer and the welding gun, sheet numbers and materials, the electrodes and the weld quality demands.

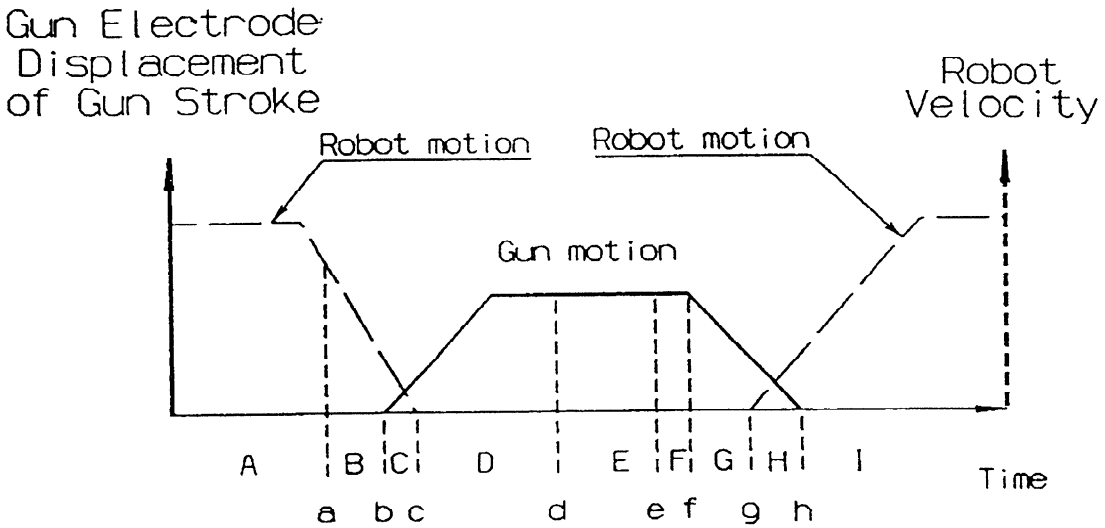
Special demands on the robot for spot welding applications are the ability to make quick movements especially over short distances, to perform rapid reorientations, and have good performance in positioning and controlling the welding gun. It is also important to have smooth motions in order to achieve a short cycle time.

Robotic spot welding involves both static and dynamic forces that will affect the workpiece and these forces will have to be taken into account when optimizing cycle times.

The media supply (current, water, air) to the welding gun (e.g kickless cable) creates dynamic forces that the robot shall withstand.

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A + B + C	=	Robot motion and deceleration
B	=	Communication time
		(Weld order from robot to welding timer, processing output signal to valve for closing gun)
C	=	Robot is decelerating into stop position and gun has started to close
F	=	Cooling time, often used for communication after Weld current clear
C + D +E + F	=	Time for activated valve (Squeeze, Weld Current and Cooling times)
F + G	=	Communication and robot delay time
G + H	=	Time for gun opening stroke
H + I	=	Robot acceleration and motion time
a	=	Event when robot gives weld order to welding timer
b	=	Event when valve for gun closing is activated
c	=	Event when robot stops
d	=	Event when the gun is closed and when the required electrode force is obtained
e	=	Event when the robot start to prepare next action
f	=	Event when command to valve "Open gun" is given
g	=	Event when robot motion is allowed to start (when gun has opened enough).
		The event of "g" may occur after "h".
h	=	Event when gun is open

Figure 1 - Communication sequence for spot welding

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5 Description of test

The purpose of the tests in this report is to evaluate cycle time performance. The cycle time tests selected include typical position sequences, see table 1.

These tests complement the test performance criteria described in ISO 9283. Those tests applicable for spot welding robots are summarized in ISO 9283 Amendment 1 as follows:

- Unidirectional pose accuracy
- Unidirectional pose repeatability
- Distance accuracy
- Distance repeatability
- Pose stabilization time
- Pose overshoot
- Drift of pose characteristics
- Minimum positioning time
- Static compliance

The user has to decide which of these tests, and also which of the tests described in this report, are valid for a specific application.

The testing conditions as described in ISO 9283 (clauses 6.1 through 6.3) shall be applied.

A delay of 0.6 seconds shall be programmed to simulate welding time at each position. No robot motion is allowed during the programmed delay.

Table 1 - Overview of tests

Test	Description
Test 1a (Test plate): Measuring sequence 1:1 Measuring sequence 1:2	 Large reorientations Short motions
Test 1b (Test plate): Measuring sequence 1:1 Measuring sequence 1:2	 As test 1a but for robots unable to reach all test poses
Test 2 (Test beam): Measuring sequence 2:1	 Long distances between the test poses

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5.1 Test 1

This test consists of two different measuring sequences. For details see 8.3. The first sequence 1:1 is an application test showing large reorientations and the second sequence 1:2 is an application test showing short motions.

5.1.1 Test 1.a

This test shall be performed with the test plate and the test tool described in 7.1 and 7.3 and in accordance with the test procedure described in 8.

All the points shall be reached, otherwise test 1.b shall be applied.

5.1.2 Test 1.b

Test 1.b is an alternative to test 1.a for those robots which are unable to reach all test poses. The test plate shall be placed in the most optimized position and angle for the robot.

Measuring sequences as in Test 1.a.

5.3 Test 2

Test 2 is an application test showing the performance of the robot when it is moving the test tool long distances between the test poses.

This test consists of one sequence 2:1. See 8.4.

This test shall be performed with the test beam and the test tool described in 7.2 and 7.3 and in accordance with the test procedure described in 8.

6 Deviation in the test from a real application

The deviations from real applications are:

- The spot welding gun is replaced by a specified test tool and a measurement equipment e.g. light sensor.
- The welding time is simulated by using a fixed programmed delay.
- The welding current is not applied during the test.
- Hoses etc for cooling water and air, cables for welding current and signals are not installed. This means that reaction forces from such sources are not considered in the test.
- The case "d" (see clause 4) poke welding is not included in this test.
- The case "e" (see clause 4) with a stationary welding gun is not included in this test.

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7 Specification of test apparatus

7.1 Test plate

The test plate, used for tests 1.a and 1.b, shall be made according to the drawings in Annex A. Figure 2 shows a view of the assembled test plate.

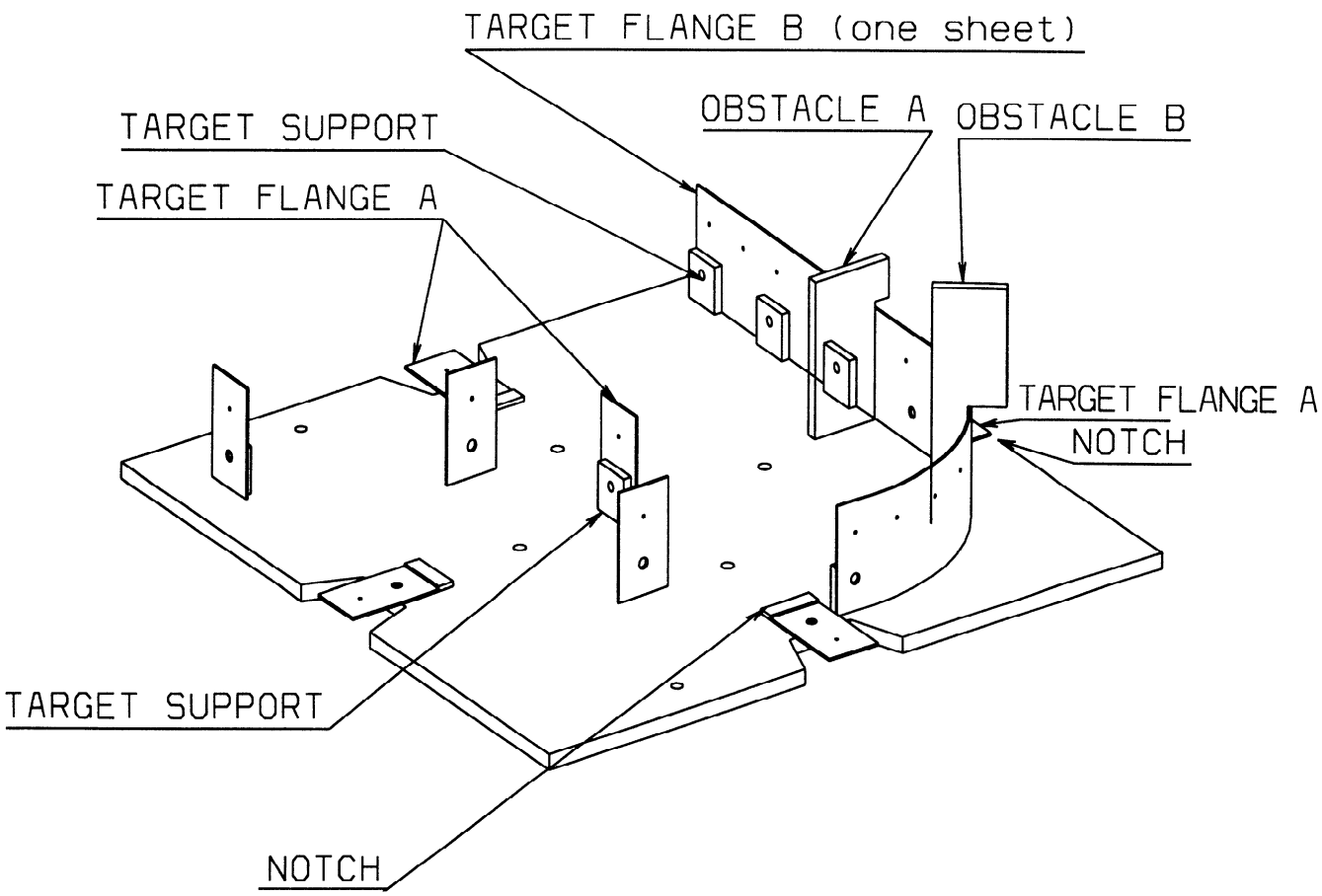


Figure 2 - Test plate

The plate has flanges and obstacles mounted perpendicularly to the plate surface. The robot has to pass the obstacles as described in 8.3.

Each pose on the flanges shall be provided with a hole Ø 2,0 mm.

In test 1.a, the sides of the test plate shall be parallel to the base coordinate system (x and y) of the robot. See figure 3.

The plate centre shall be placed in xz-plane, i.e. the x- and z- coordinates of the plate centre are selectable. The test plate centre shall be placed as close as possible to the centre of the cube defined in ISO 9283 such that all test points can be reached.

The coordinates of the plate centre shall be reported in the test results.

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In test 1.b, the test plate can be placed and orientated for optimum robot operation.

The location coordinates of the test plate (plate centre, position w5 and w6) shall be reported in the test results.

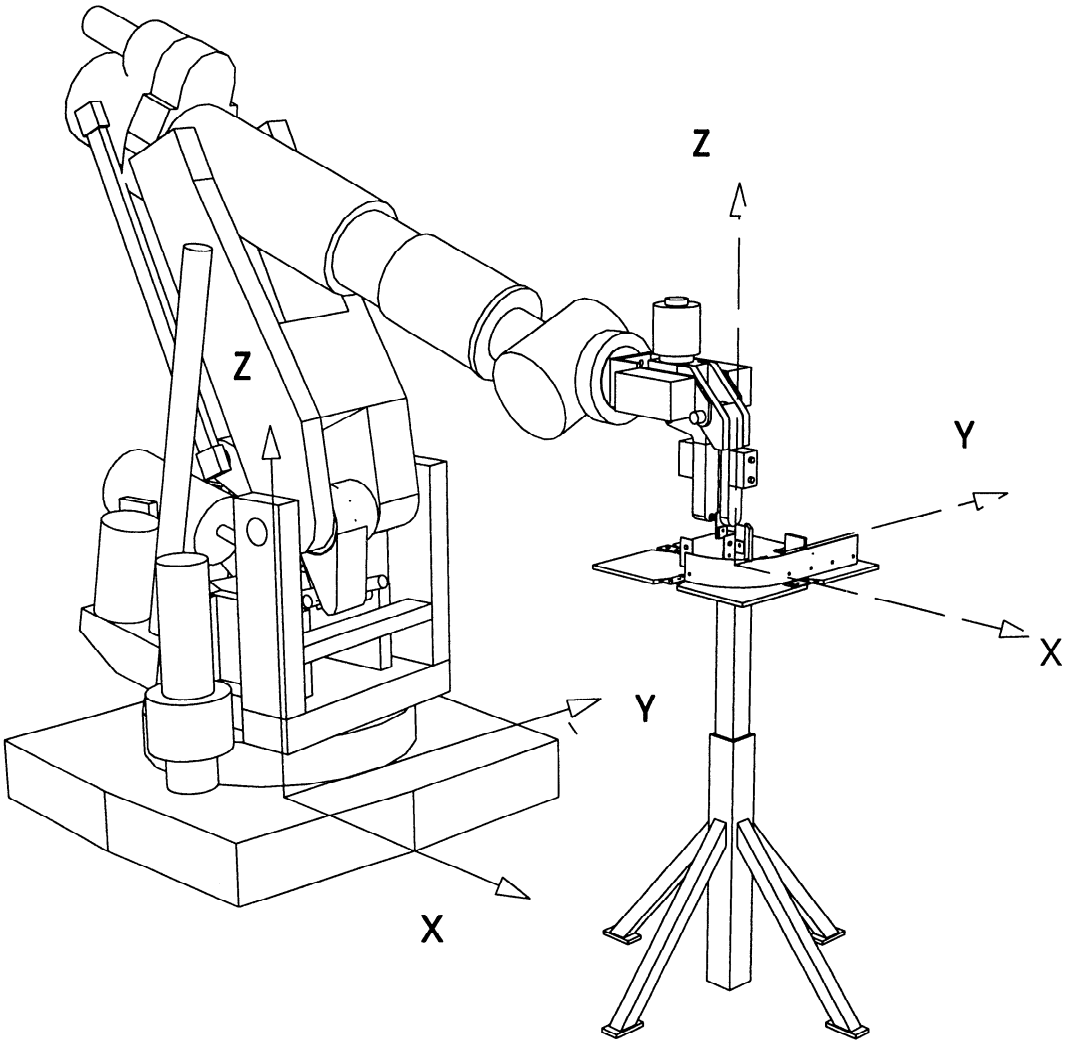


Figure 3 - Test plate and robot with test tool

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