TECHNICAL REPORT

ISO/TR 13950

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Plastics pipes and fittings — Automatic recognition systems for electrofusion

Tubes et raccords en matières plastiques — Procédés de reconnaissance automatique d'un électrosoudage

Reference number
ISO/TR 13950:1997(E)

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 on 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 technical committees is to prepare International Standards, but in exceptional circumstances a technical 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 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 Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.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 13950, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids,* Subcommittee SC 5, *General properties of pipes, fittings and valves of plastic materials and their accessories — Test methods and basic specifications.*

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Annexes A to G form an integral part of this Technical Report.

This study was undertaken by working group ISO/TC 138/WG9 at the request of the manufacturers of electrofusion fittings.

The purpose of the study was to collect together all the automatic recognition systems for electrofusion and to draw up a description of these different systems, attempting to harmonize the terminology used.

This document has been drawn up on the basis of pre-standardization work carried out by an expert group (PC3) within GERG (European Gas Research Group).

If necessary, a performance standard may be added to this document at a later stage.

Introduction

The electrofusion process for the assembly of thermoplastic pipes consists of heating the interface between the pre-assembled pipe and fitting using electrical energy. This is generated by a heating element which forms part of the fitting. The temperature will eventually reach a level high enough to ensure the fusion of the solid material.

The two melted surfaces are then pressed together for a given time. The fusion occurs during cooling by the recrystallization of the material through the interface.

Because of the difficulties encountered by ISO/TC 138/SC 4 with the standardization of the fusion parameters and dimensions of the electric connections of thermoplastic electrofusion fittings on one hand, and because of the growing number of products on the market on the other, users considered it preferable to establish rules for the manufacture of fusion machines usable with the different products.

To ensure the correct operation of these machines, and to limit user errors, it was decided to focus on the automatic identification of the fusion parameters.

This document presents the automatic recognition systems available today.

Any manufactured electrofusion fittings using one of these identification methods must be compatible with one of the systems described in this document.

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this Technical Report may involve the use of patents (see clause 5).

ISO takes no position concerning the evidence, validity and scope of these patent rights.

The holders of these patent rights have assured ISO that they are willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world.

Attention is drawn to the possibility that some of the elements of this Technical Report may be the subject of patent rights other than those identified in clause 5. ISO shall not be held responsible for identifying any or all such patent rights.

Plastics pipes and fittings — Automatic recognition systems for electrofusion

1 Scope

2 Normative references

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

ISO/IEC 7810:1995, *Identification cards — Physical characteristics.*

ISO/IEC 7811-1:1995, *Identification cards — Recording technique — Part 1: Embossing.*

ISO/IEC 7811-2:1995, *Identification cards — Recording technique — Part 2: Magnetic stripe.*

ISO/IEC 7811-3:1995, *Identification cards — Recording technique — Part 3: Location of embossed characters on ID-1 cards.*

ISO/IEC 7811-4:1995, *Identification cards — Recording technique — Part 4: Location of read-only magnetic tracks — Tracks 1 and 2.*

ISO/IEC 7811-5:1995, *Identification cards — Recording technique — Part 5: Location of read-write magnetic track — Track 3.*

3 Definitions

For the purposes of this Technical Report, the following definitions apply.

3.1 fitting: Accessory for the connection by fusion of thermoplastic pipes and/or other accessories.

3.2 socket: Female part of a fitting in which the fusion is performed.

3.3 coupler: Fitting constituted by two sockets.

3.4 monofilar coupler: Fitting constituted of two sockets for which fusion is performed in a single operation.

3.5 bifilar coupler: Fitting constituted of two sockets for which fusion is performed separately.

3.6 saddle: Electrofusion fitting for by-passing, branching, ballooning or other operations.

3.7 reduction: Electrofusion fitting for the assembly of two pipes and/or male terminating fittings of different dimensions.

3.8 elbow: Electrofusion fitting with two sockets with an angle.

3.9 tee: Electrofusion fitting with three electrofusion sockets or two sockets and one male end.

3.10 plug: Electrofusion fitting with one socket for plugging tubes and other accessories.

3.11 connector: End of the cable connecting the electrofusion accessory to the fusion machine.

3.12 terminal: Fixed part of the heating element located on the outside of the fitting to enable electrical connection to be made with the fitting.

3.13 terminal shroud: Part of the fitting enabling the connector to be mounted externally.

3.14 nominal fusion time: Fusion time, in seconds, specified by the fitting manufacturer at the reference temperature and for the electrical parameters, such as nominal resistance, voltage and current, specified by the manufacturer.

3.15 real fusion time: Fusion time, in seconds, used in reality, taking account, if necessary, of the ambient temperature and/or the real electrical parameters.

3.16 fusion voltage: The voltage, in volts, applied to the fitting during the fusion cycle.

3.17 fusion current: The current, in amps, flowing in the fitting and its supply circuit during the fusion cycle.

3.18 nominal fusion energy: The energy, in kilojoules, specified by the fitting manufacturer at the reference temperature and for the electrical parameters whose values fall within the tolerance ranges specified by the manufacturer.

3.19 real fusion energy: The energy, in kilojoules, consumed by the fitting at a given ambient temperature and for electrical parameters whose values fall within the tolerance ranges specified by the manufacturer.

3.20 resistance of the heating element

3.20.1 nominal resistance: ohmic resistance of the heating element at 23 °C used in the basic design calculations for the electrofusion fitting, as specified by the manufacturer.

3.20.2 identification resistance: ohmic resistance of the heating element at 20 °C measured on any electrofusion fitting.

3.20.3 measured resistance: ohmic resistance at the ambient temperature measured on any electrofusion fitting.

3.21 resistivity: Reciprocal of the conductivity of the heating element, in ohm metres.

3.22 temperature coefficient of the heating element: Gradient of the change in resistance versus temperature, in reciprocal kelvins.

3.23 MEMO electrofusion elements: Electrofusion elements with a special terminal shroud containing an integrated microchip, enabling these electrofusion elements to be fused with units equipped with a MEMO facility.

4 Description of procedures

4.1 Numerical recognition

4.1.1 Principle

Methods for numerical recognition are based on systems such as bar codes, magnetic cards and microchips. Fusion parameters are recorded in code form on the data medium. At the manufacturer's initiative or in response to user request, other information may also be encoded for fitting identification, identification of test data, fusion cycle optimization, additional safety measures, etc.

For a heating cycle, the system reads, processes and memorizes the information recorded on the data medium.

Successive messages are displayed or signal tones emitted to request the operator to follow a procedure, defined by the fitting manufacturer, specific to the fitting in question and including its recognition.

4.1.2 Field of application and limits

Numerically controlled fusion machines capable of reading fusion parameters can be used for all electrofusion and electroheating assembly techniques.

The limits of this type of fusion control unit shall be detailed by the manufacturer in terms of

— the maximum energy to be delivered;

— the fusion programmes incorporated;

— the fusion adaptations incorporated;

— the limits of the programmable parameters.

4.1.3 Bar codes

The system for entering data using bar codes offers a number of different possibilities for use, both for fitting suppliers and manufacturers of the fusion machine:

— The fitting manufacturer records on the bar code the data he considers will be needed to ensure correct assembly. The amount of data can depend on particular requirements or if there is a new technical development.

— The control unit manufacturer is free to develop his own software and the technical design of the unit. He can choose which data to display, which commands will be available, the criteria for fusion cycle emergency stop, and the display and recording of the various faults, the memorization method for fusion data, etc.

4.1.3.1 Description of the technique

The bar codes used are:

— the 24-character "2-in-5" interleaved type as summarized in table 1;

— the 32-character "2-in-5" interleaved type including traceability coding as summarized in table 2.

4.1.3.2 Description of coding

The coding used has 24 or 32 characters. One of these characters is a control character. A complementary character set can be added if further data is required.

Table 1 — Coding diagram for the 24-digit structure

<table>
<tr><td>24</td><td>CONTROL</td></tr>
<tr><td>23</td><td rowspan="2">Δ t LEVEL CORRECTION
regulation at a pre set temperature</td></tr>
<tr><td>22</td></tr>
<tr><td>21</td><td rowspan="3">t
s ⩽ 899
min ⩾900 or ε or θ
inf = 000</td></tr>
<tr><td>20</td></tr>
<tr><td>19</td></tr>
<tr><td>18</td><td>K or K' (± %) + (± ρ) f θ °C</td></tr>
<tr><td>17</td><td rowspan="3">Ω OHMIC VALUE FOR THE ACCESSORY</td></tr>
<tr><td>16</td></tr>
<tr><td>15</td></tr>
<tr><td>14</td><td rowspan="2">level U or I</td></tr>
<tr><td>13</td></tr>
<tr><td>12</td><td>U, I or P and Position "," for Ω</td></tr>
<tr><td>11</td><td rowspan="3">∅ of the ACCESSORY EXPRESSED IN mm and " or N°</td></tr>
<tr><td>10</td></tr>
<tr><td>9</td></tr>
<tr><td>8</td><td>. trademark</td></tr>
<tr><td>7</td><td>. types: tapping tee — coupler — sockets</td></tr>
<tr><td>6</td><td>others ⁎ < J Y C T</td></tr>
<tr><td>5</td><td>. Δ : correction ε.f of θ °C</td></tr>
<tr><td>4</td><td>. heating cycle</td></tr>
<tr><td>3</td><td>. calculation of ε</td></tr>
<tr><td>2</td><td>. reference θ °C</td></tr>
<tr><td>1</td><td>. cooling time</td></tr>
</table>

The meaning of the characters is given in clauses A.1 to A.9.

Table 2 — Coding diagram for the 32-digit structure

The 32-digit bar code is divided in two parts:

Common part (digits 1 to 19) which describes all data related to the characteristics of the element to be fused.

Specific part (digits 20 to 32) which describes all data related to the technique used to fuse the element.

< ---------- Common Part ---------------->	< -------- Specific to the technique -------->
1...19	20...32

Common part format:

Manufacturer				**Type**		**Diameter**			**Batch code**						**SDR**	**Material**		
A		B																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Electrofusion format: U or I Regulation

U-I		Ω			ΔΩ	φθ	t			θ		CK
20	21	22	23	24	25	26	27	28	29	30	31	32

Electrofusion format: Energy regulation

U-I		Ω			ΔΩ	φθ	Σ			θ		CK
20	21	22	23	24	25	26	27	28	29	30	31	32

Electrofusion format: Power regulation

U-I		Watt			ΔΩ	φθ	Σ			θ		CK
20	21	22	23	24	25	26	27	28	29	30	31	32

The meanings of the symbols used is given in annex G.

4.1.4 Magnetic cards

The system of data insertion by means of magnetic cards offers different possibilities for the fitting supplier as well as for the user and for the control unit manufacturer.

— The fitting manufacturer records on the card the number of items of data necessary for the completion of an optimal fusion joint. In order to establish the fusion programme he can choose between the functions described in clause B.4. He can adapt the data according to his wishes using nominal or real values. A fusion programme can contain up to 90 characters.

— The control unit manufacturer is completely free to develop his own software as well as the technological concept of his unit. He can choose, among others, the data appearing on the display, the different commands, the emergency stop of the fusion cycle as well as the display and recording of the different faults, the fusion data storage mode, etc., unless prescribed in other standards.

— With respect to the quality assurance of every fusion a record containing all or part of the fusion process data can be stored either on the magnetic card or in the control box memory. When the fusion has been completed successfully and recorded on the magnetic card, the magnetic card cannot be used again to carry out another fusion.

4.1.4.1 Description of the technique

The use of the magnetic card for the transmission of data to a fusion control unit requires the following information:

— the card format;

— the magnetic tracks to be used;

— the recording technique;

— the data storage mode;

— the variables and the units in which they are expressed.

4.1.4.2 Physical characteristics of the magnetic card

The magnetic card (ID-1) used is described in ISO/IEC 7810 and the various parts of ISO/IEC 7811. The card shall not contain embossed characters. The 3 tracks as described in ISO/IEC 7811-4 and ISO/IEC 7811-5 can be used to store data (fusion programme: tracks 1 and 2 only, and a fusion record: tracks 1, 2 and 3) on the card.

4.1.4.3 Description of the encoding

ISO/IEC 7811-2 specifies the characteristics of the magnetic stripe. The structure of the information on tracks 1, 2 and 3 is given in clause B.1.

4.1.4.4 Data storage

For the data storage the basic rules indicated in clause B.4 shall be followed.

4.1.5 Recognition using a MEMO microchip

4.1.5.1 Principle

The electrofusion element is equipped with an integrated microchip. The electrofusion element makes possible the fully automatic recognition of fusion parameters and bi-directional data exchange.

Individual production and fusion parameters are stored directly in the electrofusion element. After the operation the fusion protocol is thus directly registered in the electrofusion element. It is also possible to record additional data such as time and date of installation, the name of the technician as well as the exact geographical location of the fusion element. At any time and throughout its entire life cycle this data can be retrieved from the electrofusion element and reprocessed by analysis software. Integration of all recorded data in a central database provides clear advantages such as systematic localisation of incorrect pipeline elements, statistical evaluation of distributed pipe network data and optimisation of the planning and the extent of pipeline renewal programs.

4.1.5.2 Field of application

Fusion units equipped with a MEMO facility are able to fuse MEMO electrofusion elements having an integrated microchip.

4.1.5.3 Electrofusion element with an integrated microchip

Electrofusion elements need to have a special terminal shroud designed to reach and locate the microchip (see figure F.1).

4.1.5.4 Description of the system

Each MEMO electrofusion element terminal shroud has a moulded flexible ring and notch to reach and locate the integrated microchip (see figure F.1).

The microchip contains the electrofusion element fusion parameters. The fusion parameters are recognised by a special connector. The special connector makes data exchange possible and delivers the required power to the electrofusion element.

The recognition system is shown in table F.1.

4.2 Electromechanical recognition

4.2.1 Principle

The primary function of the electromechanical recognition method consists of converting the measured value of an identifying resistance into a fusion time.

Other functions can be carried out, such as fitting identification by the implanted resistance method.

4.2.2 Field of application and limits

Electromechanical recognition can be used when fittings are provided with the correct terminal housing and terminal pin configurations.

The value of the implanted resistance or the displacement of keying features on the terminal shrouds determine the fusion jointing times.

The limits of the system are:

— the key switch is limited to 36 fixed values;

— the implanted resistor is limited to the range of resistors available from resistor manufacturers.

4.2.3 "Key switch" connectors

On each electrofusion fitting the cylindrical part of the terminal shroud has a moulded key and a notch.

For each cylindrical part, the key is moulded to fit the notch according to one of eight configurations which depend on the fitting fusion time.

The positions between the key and notch are determined by the connectors, and this positioning is marked by the fusion control unit to ensure the correct fusion time. When the moulded cavity has been designed with the terminal configuration specified, recognition of fitting fusion can then be copied.

4.2.3.1 Description of the system

Each electrofusion fitting terminal shroud has a moulded key and a notch as shown in figures C.1 and C.2. The fusion time for each key-notch configuration is given in table C.1.

A special connector is used to determine the direction of the key and the notch and then deliver the required power to the fittings.

There is a specific recognition method for each terminal shroud which is configured in one of the 8 circular positions connected to the 8 resistors.

When connected to the fitting, the position of the key is determined by the moulded notch inside the connector, and the control unit measures the value of the selected resistor. These two values are digitized and used to determine the fusion time read off from a table stored in the control unit.

By sequential switching between the connectors, the value of the resistance can be considerably increased to produce a significant difference in voltage levels and thereby reducing the effects of short-circuits and electrical drift caused by foreign matter.

This recognition system is shown in diagram form in figure C.2.

4.2.4 "Implanted resistor" connector

A high value resistor is implanted in one of the terminal pins of an electrofusion fitting. The value of this resistor is read by the control unit and the fusion time is determined automatically by the control box from stored data.

4.2.4.1 Description of the system

A high value resistor is placed in the fitting terminal as shown in figure D.1. This terminal is moulded into the fitting together with a second plain terminal in the other fitting connector, see figure D.2.

The values of the implanted resistor together with the equivalent fusion times are given in table D.2.

The connector (see figure D.3) from the control box to the fitting is used to recognise the resistor value and to supply power to fittings. The fusion control unit determines the fusion time from the recognised resistance value using stored data.

4.3 Self-regulation

4.3.1 Principle

This fusion control process functions using the physico-chemical state of the material at the fitting/pipe interface. It automatically incorporates variations in fit, assembly temperature, supply voltages and the electrical resistance of the fitting.

During the fusion of a fitting to a pipe, the energy supplied causes an increase in temperature in the area around the heating element: the thermoplastic material therefore passes from the solid to the liquid state. This change in state is accompanied by a volume expansion which increases the pressure in the fusion zone. The quality of the fusion is essentially governed by the triple set (P = pressure, T = temperature, t* = time during which the temperature of the material is less than the fusion temperature). The principle of self-regulation is to use the data terms (P, T) to govern the fusion time and thus to calculate the optimum t*.

This requires no adjustment or fusion time correction. The pressure built up in the melted material interrupts the supply circuit.

4.3.2 Field of application and limits

The automatic regulation system enables fittings equipped with the appropriate terminal shroud to be processed.

The limits of this recognition system are:

— either specific to the system:

fixed value for the fusion parameter "fusion voltage".

— or specific to the machine:

maximum available energy.

4.3.3 System description

Each fitting has two calibrated wells positioned above the fusion zone. When the voltage is applied, the heating wire melts the material in the well, firstly at the level of the wire itself, then over a greater area. Figure E.1 shows the melted zone at a given moment: this zone continues to spread in time [in figure E.1 from zone limit (a) to zone limit (b) at the end of fusion]. The wells are designed with the optimum dimensions and geometry for each fitting, ensuring that the melted material in the well bottom rises only when the correct physico-chemical state has been attained at the interface. A sensor located in the connector and being an integral part of the supply cable is fitted over each well. It detects the rising level of molten material and transmits a signal to the fusion control unit which cuts the electricity supply. A diagrammatic representation of the whole detection process is given in figure E.2 for a flat-bottomed well.

4.3.4 Dimensional characteristics

The terminal shroud shown in figure E.3 is universal and can be used with all self-regulating fittings.

5 Patents

In conformity with the ISO Directives, Part 2, annex A, the rules for references to patents on items described in International Standards have been observed. The companies British Gas, Fusion Plastics, Gaz de France, NKK, PE Industries, Sauron and Wavin have notified the working group that their patents cover totally or partially some items described in this Technical Report. Those companies have expressed the wish that their product should be integrated in the Technical Report.

5.1 British Gas, letter 26 March 1991

Patent	UK	2151858 B	16 December 1983
	Europe	0151340	19 November 1984

Application date: see patent

Title: Coupling devices for use with electrofusion fittings of thermoplastic material.

5.2 Fusion Plastics, letter 17 September 1993 and 31 March 1994

Patent	UK	2137026	March 1983
	Europe	0076043	September 1982
	Canada	1193819	September 1985
	USA	4486650	December 1984
	South Africa	82/7746	October 1982
	Japan	1603737	September 1982
	Australia	567083	September 1982
	Denmark	5626/82	December 1982
	Indonesia	9161	February 1983
	Japan	267002/1988	October 1988

Application date: see patent

Title: Electro-Fusion fitting

5.3 Gaz de France (J. Sauron), letter 9 July 1991

Patent	France	8416691

Application date: 31 October 1984

Title: Procédé et machine pour la réalisation de soudures automatiques de pièces en matière plastique comportant un bobinage intégré.

5.4 Gaz de France (J. Sauron), letter 9 July 1991

Patent	France	8618117
	Europe	87402868.1
	US	133478
	Canada	554160
	Japan	324171
	China	87108163
	South Korea	8714828

Application date: 23 December 1986

Title: Procédé pour conduire et contrôler l'élévation de température de pièces chauffées électriquement.

5.5 NKK Corporation, letter 27 September 1991

Patent	Japan	6324820
	Europe	0149410 and extensions

Application date: 23 May 1988

Title: Process and device for the control of the welding time of an electrically welded union

5.6 PE Industries, letter 28 May 1991

Patent	France	8320420	19 December 1983
		8416782	30 October 1984
		8608822	16 June 1986
	Monaco	1677	2 December 1983
		202	15 January 1985

These patents have been extended, in whole or in part, to several countries: USA, China, Austria, Belgium, Italy, Luxembourg, Netherlands, Germany, United Kingdom, Switzerland, Liechtenstein, Sweden, South Africa, Algeria, Argentina, Australia, Canada, South Korea, Denmark, Egypt, Arabian Emirates, Spain, India, Iran, Japan, Morocco, Mexico, Pakistan, Taiwan, Tunisia

Application date: see patent

Title: Microswitch

5.7 PE Industries, letter 28 May 1991

Patent	France	8817420
	Extended to Europe	8940330.7

Application date: 29 December 1989

Title: Dispositif pour détecter au cours du soudage des variations dans l'état de la matière plastique d'une pièce de raccordement

5.8 Wavin, letter 27 April 1995

Patent PCT/EP 94/03158 — AT, AU, BB, BG, BR, BY, CA, CH, LI, CN, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, KZ, LK, LU, LV, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UA, US, UZ, VN, EE, LR, SI, KE, LT, TT

Application date: 24 September 1993

Title: Quality assurance for electrofusable jointing elements

5.9 Wavin, letter 27 April 1995

Patent PCT/EP 94/01338 — AT, AU, BB, BG, BR, BY, CA, CH, LI, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, KZ, LK, LU, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UA, US, VN, CN, LV, NE, TT, KE, LT, SI

Application date: 10 May 1993

Title: Electrical connector for thermoplastic electrofusion elements

Should it be revealed after publication of this Technical Report that licences under patent rights, which appear to cover items included in the Technical Report, cannot be obtained under reasonable and non-discriminatory terms and conditions, the Technical Report shall be referred back to the technical committee for further consideration.