IS 8002 (1976): Recommended procedure for welding of flexible PVC [MTD 12: Welding Applications]

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(Reaffirmed 2003)

Indian Standard

RECOMMENDED PROCEDURE FOR WELDING OF FLEXIBLE PVC (FLEXIBLE POLYVINYL CHLORIDE)

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INDIAN STANDARDS INSTITUTION
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Indian Standard

RECOMMENDED PROCEDURE FOR WELDING OF FLEXIBLE PVC (FLEXIBLE POLYVINYL CHLORIDE)

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Indian Standard

RECOMMENDED PROCEDURE FOR WELDING OF FLEXIBLE PVC (FLEXIBLE POLYVINYL CHLORIDE)

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 19 February 1976, after the draft finalized by the Welding General Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 In recent years considerable progress has been made in the application of welding in the plastic industry. This standard has been prepared as a guide to the industry in welding flexible PVC.

0.3 In the preparation of this standard assistance has been derived from DIN 16931 'Welding of flexible PVC (flexible polyvinyl chloride) — Directions' issued by Deutscher Normenausschuss, Berlin.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers recommendations for welding flexible polyvinyl chloride (flexible PVC).

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 5687-1970† shall apply.

3. GENERAL

3.1 Flexible PVC is obtained by incorporating plasticizer in PVC powder before melting. The setting temperatures of this material lie below room

*Rules for rounding off numerical values (*revised*).
†Glossary of terms relating to welding of plastics.

temperature and decrease with a rise in plasticizer content. The flexible PVC is welded in a dough like condition. Welding temperature, welding speed, applications of pressure at the point of welding are, therefore, important considerations. It is recommended that flexible PVC is welded at a temperature between 250 and 300°C. At temperatures below 250°C the bond produced in the weld seam will be inadequate, and at temperatures above 300°C the flexible PVC starts decomposing.

4. WELDING PROCESSES

4.1 Flexible PVC may be welded using any of the following processes:

a) Hot gas welding with filler material,
b) Hot gas welding without filler material,
c) Heated tool welding,
d) Friction welding,
e) Impulse welding, and
f) High frequency welding.

5. HOT GAS WELDING WITH FILLER MATERIAL

5.1 Welding Process — The contact surfaces of the parts to be welded and the filler material are heated to the desired temperature by means of hot air and the joint is formed using a pressure roller. This process is not suitable for thickness below 1 mm.

5.2 Equipment

5.2.1 The equipment consists of a blowpipe in which air free from moisture and oil is blown at a rate of 1 000 to 1 500 l/h and at a pressure of about 0·05 MPa (0·5 kgf/cm^2). Examples of electrically-heated and gas-heated equipment are shown in Fig. 1 and 2. The air is heated to the desired temperature on flowing past the electric heating element (*see* Fig. 1) or gas-heated tube coil (*see* Fig. 2). The temperature of the welding air is measured at a point 5 mm from the tip of the blowpipe.

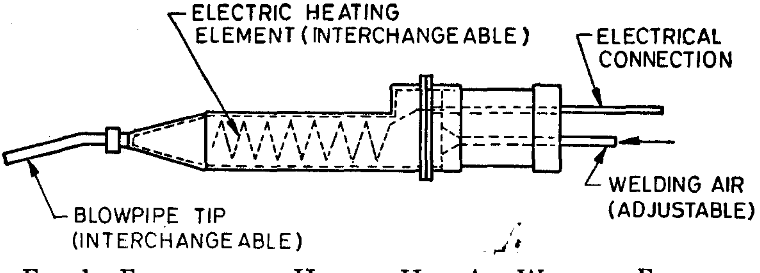


FIG. 1 ELECTRICALLY-HEATED HOT AIR WELDING EQUIPMENT

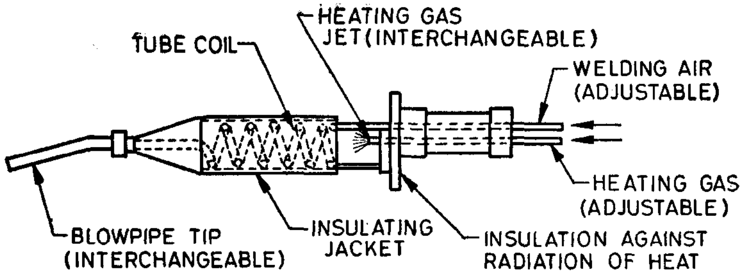
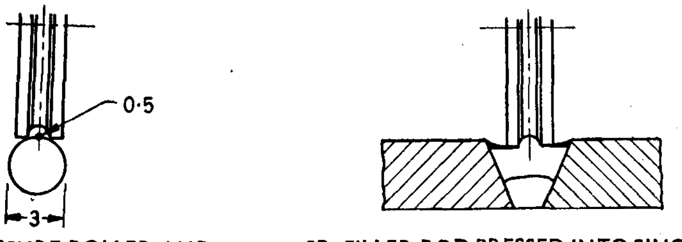


FIG. 2 GAS-HEATED HOT AIR WELDING EQUIPMENT

5.2.2 To produce the pressure on the filler material required for welding, a pressure roller is used which also guides the filler rod (*see* Fig. 3). The surface of the roller may have a groove of 0·5 mm radius when using with filler wires of small diameter (*see* Fig. 3).



3A PRESSURE ROLLER AND FILLER ROD

3B FILLER ROD PRESSED INTO SINGLE-V BUTT WELD WITH PRESSURE ROLLER

All dimensions in millimetres.

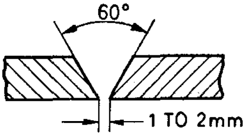
FIG. 3 PRESSURE ROLLER

5.3 Filler Material — The filler material used shall be rods of flexible PVC usually with a circular cross section of diameter 3 mm and over. For welding films and foils, strips of required width can also be cut from the parent material and used as filler material.

5.4 Edge Preparation for Welding

5.4.1 The normally used welded joints are single-V butt, double-V butt and fillet welds. The edge preparations for the single-V joint and the welded joint with and without reinforcement strip are shown in Fig. 4 and 5.

5.4.2 The fusion faces to be welded shall be prepared by cutting, planing, melting, scraping or grinding, or by heating. Particles of dirt shall be removed mechanically, or with a scraper, spoke or emery paper.



4A WELD PREPARATION FOR V BUTT WELD

4B AFTER WELDING

FIG. 4 SINGLE-V BUTT WELD WITHOUT REINFORCEMENT

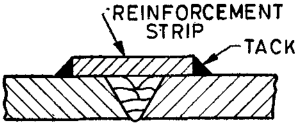


FIG. 5 SINGLE-V BUTT WELD WITH REINFORCEMENT STRIP

5.5 Welding Technique — Welding is normally done from left to right. The filler material is pressed into the weld groove with the pressure roller at the same time guiding it to the right with the left hand. With the welding equipment in the right hand moving to the right the parent material and filler material at the weld joint are heated to the required temperature. For achieving good result work can be carried out at a temperature range of 250-300°C at welding speeds of 60 to 110 mm/min. Temperatures lower than 250°C result in low and uneconomic speeds. The force to be exercised with the pressure roller depends upon the cross section of the filler rod and varies between 1 to 3 kg. Over-heating and the resulting decomposition of the base material, filler material and the welded joint are apparent in the change in colour to black with the procedure mentioned above using pressure roller, the decomposed material will be squeezed to the edge of the weld bead and can, therefore, be easily removed.

5.5.1 The weld may be finished smooth by removing the extra bead using a suitable sharp tool.

5.6 Quality of the Welded Joint — The quality of the welded joint depends upon the following important factors:

a) Shape of the weld,
b) Number of filler rod layers in the weld seam. A few thick layers are better than several thin ones, and
c) The skill of welders and the welding procedure.

5.6.1 The quality of the weld is normally evaluated by the strength of the welded joint in comparison with the strength of the basic material. The density of weld deposit is also of great importance where the joint has to be leakproof.

6. HOT GAS WELDING WITHOUT FILLER MATERIAL

6.1 Welding Process — In this process the contact surfaces of the parts to be welded are heated to the welding temperature (*see* **5.1**) by hot air and united under pressure.

6.2 Welding Equipment — The welding equipment described in **5.2** shall be suitable. In addition a suitable pressure tool is required to apply welding pressure after the contact forces are suitably heated.

6.3 Shape of Welded Joints — The most common form of weld made from this process is lap joint. One or both of the parts to be joined may be chamfered prior to welding. Chamfered edges prevent any air pockets and improve the appearance of the weld. The lower part may be chamfered to 25° for best results (*see* Fig. 6). The overlapping portion shall be three times the material thickness.

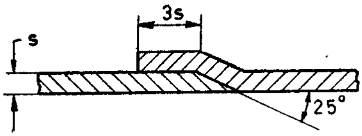


Fig. 6 Lap Weld, Lowermost Part Chamfered

6.4 Preparation of Contact Faces — The contact faces shall be prepared in a manner described in **5.4.2.**

6.5 Welding Technique — The contact surfaces are heated to the required temperature in a manner described in **5.5** guiding the heating equipment in a pendulum movement in the welding direction. The surfaces are then pressed together with a pressure tool. Material decomposed due to over-heating should be removed as indicated in **5.5.**

6.6 The lap weld does not normally require any finishing.

6.7 Regarding the quality of weld the provisions given in **5.6** shall apply.

7. HEATED TOOL WELDING

7.1 Welding Process — The contact surfaces of the parts to be welded are heated to the desired temperature (*see* **5.1**) with suitable heating elements by radiation or contact and united under pressure. Heated tool welding is generally carried out without filler material. When the filler material is used it shall also be heated to the desired temperature using similar heating elements.

7.2 Welding Equipment — The electrically heated heating element should preferably have the wedge shaped design adopted for welded joints. The heating element shall be of a metal of good thermal conductivity having a smooth corrosion resisting surface, for example, copper with aluminized or permanently nickel plated surface. The working temperature of the heating elements should be 250-300°C. It is preferable to use a heating equipment in which it will be possible to measure the current, voltage, temperature and the humidity of the atmosphere.

NOTE — The range of temperature 250-300°C can be established by pressing a piece of flexible PVC against the heating element. Material left on the heating element should not darken in colour for about 3 seconds.

7.3 The parts to be welded shall be free from any impurities (*see* **5.4.2**).

7.4 Types of Weld and Welding Technique

7.4.1 The required temperature of the heating element can be best determined and set by having a few trial welds. If products of decomposition are deposited on the heating element they should be removed. Otherwise there will be hinderance to transfer of heat and the products of decomposition gaining access will impair the strength of the weld.

7.4.2 *Butt Weld Without Filler Material* — The parts to be welded are held such that their contact faces are under moderate pressure against the sides of the wedge-shaped heating element. After reaching the welding temperature the parts are drawn slowly still maintaining the pressure over the blade of the heating element so that they meet and are welded together by forming a bead all round (*see* Fig. 7).

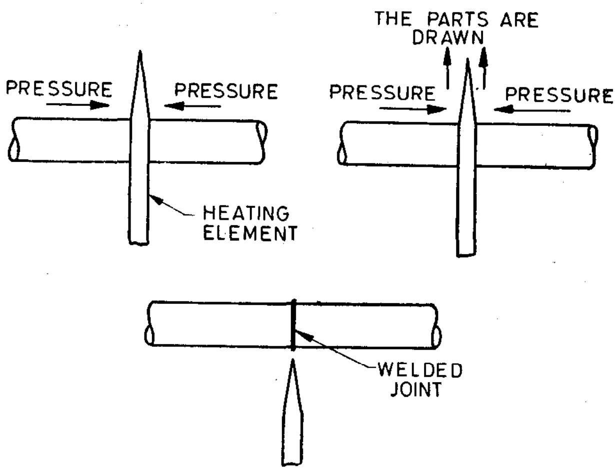


FIG. 7 HEATED TOOL WELDING OF A BUTT JOINT WITHOUT FILLER MATERIAL

7.5 Butt Welds with Filler Material

7.5.1 Regarding filler material and weld preparation the provisions contained in **5.3** and **5.4** respectively shall apply.

7.5.2 *Welding Procedure* — The edges to be welded are heated to the desired temperature with a heating element of the cross section same as of the weld profile. At the same time the welding rod is pressed with a grooved roller on to the top of the heating element, heated in this manner to the welding temperature and welded to the basic material by the combined movement of the heating element and pressure with the roller.

7.6 Lap Weld — The heating element (heated wedge) is moved continuously or by stages in the direction of the weld seam between the two surfaces to be welded, the surfaces heated to welding temperature being united under pressure. The pressure required can be applied by pressure rollers or with a finger (*see* Fig. 8).

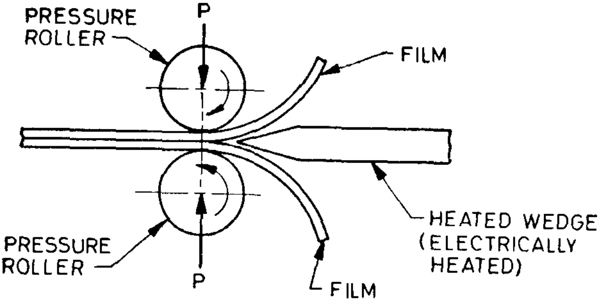


FIG. 8 HEATED TOOL WELDING OF A LAP JOINT WITH A HEATED WEDGE

7.7 Finishing the Weld — The extra weld metal shall be removed with a suitable sharp instrument.

7.8 In heated tool welding the quality of weld depends upon the welding temperature, pressure exercised and the welding speed.

8. FRICTION WELDING

8.1 Welding Process — The contact surfaces of the parts to be welded (mostly solids of rotation) are brought to the necessary welding temperature by frictional heat and welded by pressure without filler material.

8.2 Welding Equipment — The welding equipment consists of devices or machines (for example, a lathe) which enable rotation of contact surfaces of the parts to be welded against each other under pressure and at sufficient speed for the surfaces to be warmed to the welding temperature by frictional heat (*see* Fig. 9).

8.3 Filler Material — Filler material is not required.

8.4 Weld Shapes — Butt joints with welding of contact surfaces are used.

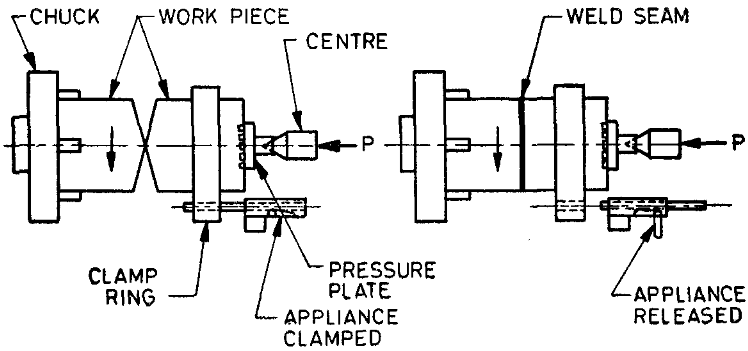


FIG. 9 FRICTION WELDING

8.5 Preparation for Welding — For diameters of parts not exceeding 40 mm both the contact surfaces are faced. For diameters exceeding 40 mm one or both of the contact surfaces are coned with a slope of $\alpha/2$ satisfying the condition $\tan \alpha/2 = \frac{D}{2}$ where D is the diameter of the part to be coned. It would be advantageous to have a hole made in one of the two parts to enable the hot gas escape when the material becomes heated.

8.6 Welding Techniques — The parts to be welded are clamped in the turning device. Between the centres and the fixed tool a pressure plate is inserted to distribute the pressure over a large area. The parts are then turned against each other under pressure. After the contact surfaces reach the welding temperature which is recognized by the formation of a welding bead the pressure is gradually increased. The clamp is then released and the movement of both parts against each other is concluded. The welding pressure is maintained until the weld joint is cooled off.

8.6.1 The weld may be finished smooth by removing the extra bead using a suitable sharp tool.

8.7 Quality of the Welded Joint — In friction welding the strength of the welded joint approaches that of the basic material.

9. IMPULSE WELDING

9.1 In impulse welding process the heat necessary for welding is applied to the junction of the overlapping parts (usually films or foils) by means of impulses from superimposed heating elements under pressure and is subsequently withdrawn under continuous pressure.

9.2 Welding Equipment — The impulse welding equipment consists of a power source, a pressure application unit and heat impulse dies. The heat impulse die has electrical resistance heating elements of extremely low thermal capacity which on being pressed on to the weld seam are electrically heated for a brief period (for example, 0·25 second), and in the same operation withdraw the welding heat from the welding zone under pressure until the weld zone has regained its dimensional stability.

9.3 Weld Form — Lap joints with lap welds are made by impulse welding.

9.4 Preparation of Contact Faces — In impulse welding the contact surfaces do not require any special preparation.

9.5 Welding Technique — The parts to be welded (films, foils) are placed on the pressing table covered with an elastic heat insulator. The heat impulse die is pressed on to the PVC films to be welded by means of suitable appliances and heated electrically for a brief period (single sided heat impulse, *see* Fig. 10). The pressure is maintained until the weld zone has cooled off.

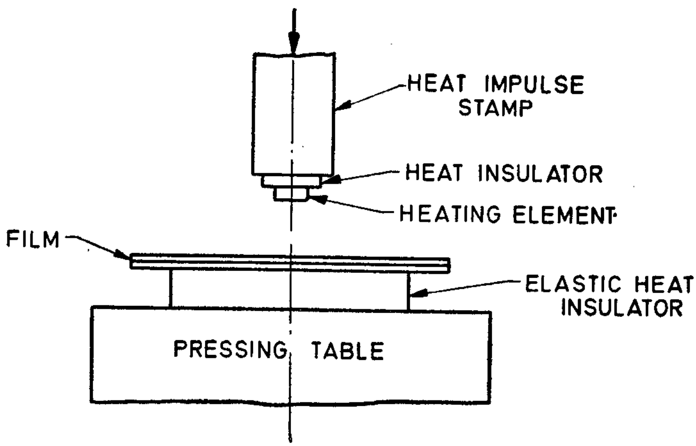


FIG. 10 IMPULSE WELDING WITH SINGLE SIDED HEAT IMPULSE STAMP

9.5.1 In case of PVC films and foils with thickness between 0·1 mm and 0·2 mm, the pressing table is also designed as a heat impulse die (double sided heat impulse, *see* Fig. 11).

9.5.2 With films of thickness over 0·2 mm the quality of weld declines rapidly as the thickness increases. Depending on the size of heating element a weld of length 100-1 500 mm is produced in one operation the requirement of electrical power being 20 W/cm^2 of weld. In Fig. 12 are given for information the operation data on the application limits of impulse welding process.

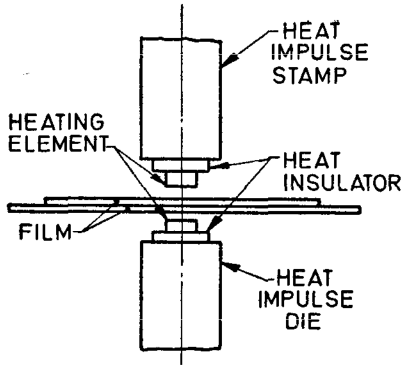
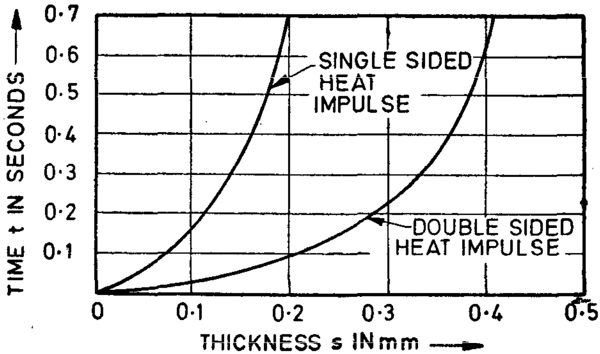


FIG. 11 IMPULSE WELDING WITH DOUBLE SIDED HEAT IMPULSE STAMP



t = duration of impulse

s = total thickness of superimposed films (combined thickness)

FIG. 12 APPLICATION LIMITS OF IMPULSE WELDING FOR FLEXIBLE PVC

9.6 The welds made by impulse welding need no finishing.

9.7 Quality of the Welded Joint — The quality of weld is dependent upon the build up of the thermal field over the heated area of the heating element (*see* Fig. 13). In other words the performance of the heating element has an influence over the quality of weld. It is possible to achieve joint strength up to 80 percent of the strength of the basic material.

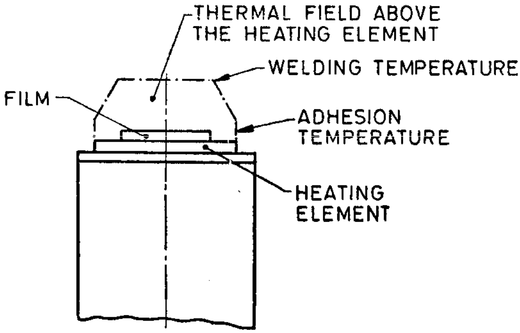


FIG. 13 TRAPEZOIDAL STRUCTURE OF THE THERMAL FIELD ABOVE THE HEATED AREA OF THE IMPULSE STAMP

9.7.1 The lines of stress run along the edge of the weld. The direction and value of stress should, therefore, be anticipated before selecting the position of the welds (*see* Fig. 14).

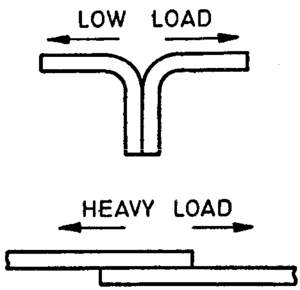


FIG. 14 RECIPROCAL POSITION OF LOADING DIRECTION AND WELDING EDGE

10. HIGH FREQUENCY WELDING

10.1 Welding Process — The joining surfaces of the parts to be welded are heated to the required welding temperature in a condenser field of a high-frequency current source and welded under pressure usually without filler material.

10.2 Welding Equipment — High frequency welding equipment consists of a high frequency generator, welding press and electrodes (welding tool) shaped to the required weld form. The welding tool may be fitted to a cutting blade (*see* Fig. 15).

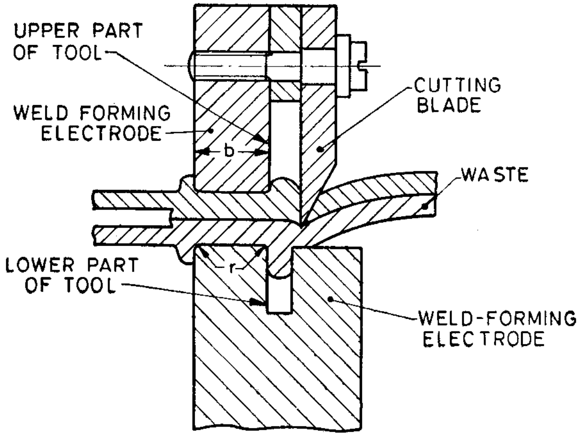


FIG. 15 SYMMETRICAL HF WELDING TOOL WITH CUTTING BLADE

10.3 Weld-Forms — Lap welds and in some cases butt welds are possible in high frequency welding.

10.4 Preparation of Parts for Welding — In high frequency welding the contact surfaces do not require any special preparation.

10.5 Welding Technique — The parts to be welded (films or foils) are placed on the pressing table of the equipment so that they overlap. When the upper part of the equipment exerts pressure the parts get heated by the high frequency energy and welded due to pressure. The HF energy supply is regulated according to the thickness of the material to be welded. After switching off the HF energy supply the pressure is maintained until the weld zone is cooled off and has regained its dimensional stability.

10.6 Finishing the Weld — The weld needs no finishing. When a blade is used in the equipment the waste material is removed (*see* Fig. 15).

10.7 Quality of Welded Joint — The following factors are of importance in achieving good quality in the weld:

a) Accurate measure of the volume of molten material during welding process and its position with respect to the non-molten material.

b) Application of correct pressure during welding. The foils should not be compressed to more than half their original thickness.

c) Freedom from porosity in the weld zone.

In Fig. 16 are illustrated poor and good welded joints made by HF welding.

FIG. 16 QUALITY OF WELD SEAMS GIVEN DIFFERENT TREATMENT

10.7.1 It is recommended that trial welds are made to determine the pressure, HF energy, time and width of electrode in order to achieve good quality welds. The following formulae can be used to arrive at a favourable ratio between the various welding parameters and strength of joint:

$$b = 2\ S \text{ subject to a minimum of } 0{\cdot}8 \text{ mm.}$$

$$r = 0{\cdot}125\ b.$$

where

b = width of weld,

S = total thickness of combined films or foils, and

r = curvature of the electrode.

If b is chosen to be equal to S, the required density of energy N_o will be:

$N_o \approx 10$ W per cm of weld length and the force P_o required will be:

$$P_o \approx 10\,000 \text{ N per cm of weld length.}$$

The pressure required will, therefore, be:

$$P = 1\,000 \text{ N/W}$$

With HF welding machines with mechanically operated electrodes it is possible to produce long welds continuously. The rate of welding depends on the thickness of the film or foil and on the anticipated efficiency of the joint.

(*Continued from page* 2)

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