



TECHNICAL GUIDANCE

BEST PRACTICE FOR **SECURING SEAMS** IN SINGLE PLY MEMBRANES

ENSURING THAT CLIENTS OBTAIN HIGH QUALITY
POLYMER-BASED SINGLE PLY ROOFING,
THROUGH A PARTNERSHIP OF QUALITY ASSURED
MANUFACTURERS AND CONTRACTORS

GUIDANCE DOCUMENT

BEST PRACTICE FOR SECURING SEAMS IN SINGLE PLY MEMBRANES

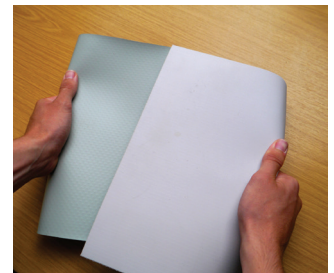
1.0 INTRODUCTION

1.1 PURPOSE: this guide is principally intended to assist main contractors in effective site management and quality control. It may also help designers to appreciate the buildability issues relevant to the techniques used and hence to detailing.

1.2 SCOPE: this guide describes the equipment, techniques and quality control checks necessary for effective and durable seams, methods of testing for integrity and appropriate action in the event of defects. Wherever possible, generic guidance is offered which is applicable to all products, but membrane manufacturers should be consulted for specific advice where highlighted. The SPRA Quality Criteria for membrane manufacturers are also described.

1.3 TECHNOLOGY: in forty years, single ply has become the first choice for waterproofing roof systems in new commercial construction and refurbishment. It is easy to see why. The multiple advantages of light weight, safe and rapid install, adaptability to varied roof geometry and a range of maintenance-free finishes has meshed with trends in client requirement over this period. This has been enhanced by a supply chain arrangement that ensures a system-based approach by membrane manufacturers and a controlled supply through registered contractors who employ installers trained in the particular product. But single ply is just that, a single layer of waterproofing. So the quality, effectiveness and durability of seams formed on site between adjacent sheets are critical. Poor seams undermine confidence in the project as a whole.

1.4 MEMBRANES: the waterproofing performance of single ply membranes is achieved by using long-chain polymers derived from oil. The polymer type and the extent of cross-linking determine their behaviour such that the principal types range from thermoplastics (softened by heat) to thermoset or elastomeric (not significantly affected by heat). These characteristics determine the appropriate method to seal the laps between sheets. The polymer classes in common use in single ply roofing are as follows:



Membrane samples

THERMOPLASTICS

- **Polyvinyl Chloride (PVC):**

PVC-p is a flexible form of PVC due to the addition of high molecular weight plasticizers, which can be heat or solvent welded (depending upon the product). PVC-p-based membranes are generally not suitable for direct contact with bitumen unless a suitable weight of fleece backing is incorporated to separate the two. Generally, such membranes can be recycled back into new roofing product or for re-use in a range of other applications.

- **Flexible Polyolefin (FPO):**

FPO is a large family of heat-weldable polyolefin based upon polyethylene or polypropylene. Preparation of the lap prior to welding may be required. FPO-based membranes are generally suitable for direct contact with aged bitumen. Generally FPO based membranes can be recycled back into themselves or another product.

- **Vinyl Ethylene Terpolymer (VET):**

VET consists of PVC made flexible by blending with Ethylene Vinyl Acetate (EVA). VET can be heat or solvent welded and is compatible with bitumen.

THERMOPLASTIC ELASTOMER (TPE)

A particular group of polymers with the basic properties of polymer but which can be processed as thermoplastics. They exhibit a high resistance to UV/Ozone exposure and do not absorb moisture. Laps are heat welded.

- **Elastomers:**

Ethylene propylene diene monomer EPDM is a naturally flexible material to which carbon black is added for stability. Jointing is normally carried out with tape bonding using a special primer but adhesives can also be used. EPDM is compatible with bitumen.

- **Polyisobutylene:**

PIB incorporates carbon black to provide good physical properties. PIB products available on the UK market are generally solvent welded using tape systems. PIB is compatible with bitumen.

1.5 METHODS: there are several methods for forming seams; each is described together with the equipment required:

- Hot-air welding: for all thermoplastic polymer products. Note that some elastomeric products are manufactured with a thermoplastic coating at the seam edge, enabling hot-air welding.
- Solvent welding: for some PVC thermoplastic polymer products.
- Tape systems: for some elastomeric polymer products.
- Self-adhesion: for some elastomeric polymer products.
- Adhered: for some elastomeric polymer products.

2.0 SPRA QUALITY CRITERIA

2.1 MEMBRANE MANUFACTURERS MUST:

- Only supply single ply membrane products which have current performance certification from British Board of Agrément or another member of the UEAtc¹.
- Provide a comprehensive set of design details appropriate for mechanically fastened, adhered and ballasted (where applicable) methods of attachment.
- Be indemnified for design advice provided.
- Ensure that wind load calculation, if not offered in-house, is carried out by a competent person.
- Provide a comprehensive off-site practical training programme for each product offered. This programme must at least meet BCP² minimum standards.
- Carry out recorded field inspection of completed work on all projects in excess of 100m² where a warranty will be offered.

2.2 CONTRACTOR MEMBERS MUST:

- Employ only those installers who have a current product training card for the single ply membrane in use on a project.
- Operate a registered or UKAS³ quality management system to ISO9001: 2008 or be a member of at least oneSSIP⁴-registered health and safety pre-qualification system.

¹ European Union of Agrément – Technical Committee

² CSCS/Federation approved Basic Competency Programme contributing evidence for Vocational Qualification Level 2: Applied Waterproof Membranes.

³ United Kingdom Accreditation Service

⁴ Safety Systems in Procurement

⁵ BS EN 50525-2-21:2011 Low voltage energy cables of rated voltages up to and including 450/750 V (U0/U). Cables for general applications. Flexible cables with crosslinked elastomeric insulation.

- Manage effectively the supply and safety testing of electrical tools supplied to installers.
- Operate a regular system of toolbox talks designed to reduce risk and improve quality on site.
- Provide comprehensive method statements and risk assessments for all works.

3.0 WELDING EQUIPMENT

3.1 HOT AIR WELDER HAND-HELD: heat from an electrical element set in a ceramic housing is transferred to an exit nozzle by a rear-mounted fan. Temperature is controlled thermostatically. Generally designed for 110v/3.5kVA operation but 220v versions are available for use off-site, in training. A 40mm-wide exit nozzle is used to weld seams in the roof field. A 20mm nozzle is used for details.



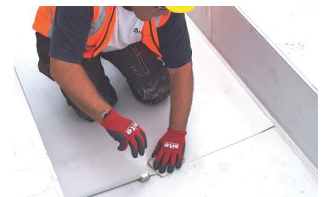
Hand welder

3.2 HOT AIR WELDER MACHINE-OPERATED: a large hot air welding unit is mounted in a wheeled drive unit with variable loading weights and weighted rollers designed to apply pressure. The air exit nozzle is typically 40mm wide, placed in the sheet overlap and the unit tracks along the lap edge to complete the weld in a single pass. Standard output machines are typically rated at 2.9kVA (110v) and 4.6kVA (240v), with armoured cable. Armoured cables must be H07RN-F Flexible Rubber Cable, an industrial strength cable manufactured to BS EN 50525-2-21:2011⁵.



Hot-air welding by machine

3.3 SOLVENT WELDING: bottles containing solvent are connected to brushes, which enable a consistent application of solvent to be applied within the seam overlap.



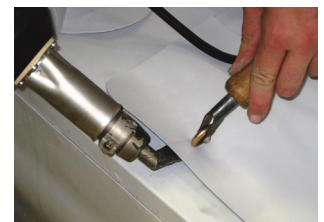
Cold welding with solvent

3.4 HAND ROLLER - SILICONE RUBBER: a silicone rubber roller (approximately 28mm or 40mm width) with its axis at 90° to a handle, enabling the application of pressure on a seam which has been hot-air welded by hand. There are roller facings designed specifically for PVC and FPO thermoplastic membranes. Hand rollers may also be used to apply pressure to adhered or self-adhered seams.



A hand roller (other types shown on p.6)

3.5 HAND ROLLER BRASS: a brass 'penny' roller (approximately 30mm diameter x 5mm width) also with its axis at 90° to a handle, enabling the application of increased pressure to complete specific welding operations at details and cross-joints.



Using a brass roller to apply pressure at a cross-joint

3.6 FINGER WELD PAD: a small polymeric pad used to facilitate welds in confined space such as internal corners.

3.7 START-STOP PLATE: a metal plate used during machine welding to define the termination of the machine nozzle (and the start of hand welding to complete the seam). See also 5.4.



Stop plate for machine-to-hand weld transition

3.8 CHAMFERING TOOL: a hand tool with an enclosed blade, which is used to remove the upper edge of thicker sheets when they are to be overlapped by a second sheet running at 90°.



3.9 INTERNAL CORNER TOOL: a Teflon-coated hand tool to help form neat details at internal corners.



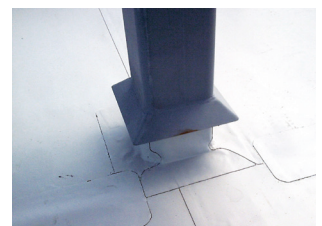
3.10 SEAM TESTING PROBE: a steel probe with a cranked end, which is run along the seam edge to check that the weld of thermoplastic sheets is continuous. See also 8.3.



4.0 SETTING OUT

4.1 PRINCIPLES: The following broad principles should be adopted when planning for setting out:

- The largest possible sheets should be used (to minimise the length of site-formed seams and enhance appearance). In mechanically fastened specifications, this may not be possible at the roof perimeter due to the need for additional attachment.
- If sheets run across the line of fall, laps should ideally run with the direction of fall (i.e. up-slope sheet overlaps the lower sheet). This is principally to aid night-sealing and to reduce water ingress in the event of damage. Seams in single ply membrane are fully resistant to draining water, whatever their orientation.
- Check requirements for lap width and maintain this consistently across the roof. Membranes mechanically fastened by the in-seam method require a greater lap width, to accommodate the width of the fastener plates.
- Minimise the number of cross-joints, which are formed wherever one sheet runs at 90° to another.
- On mechanically fastened systems, check requirements in perimeter zones before deciding a setting out plan. Narrower sheets may be required.
- On metal decks, allow for the effect of changes to deck crown direction. Rows of fasteners should always run at 90° to the crown direction, to distribute loading evenly.



4.2 STORAGE: All single ply membrane must be stored horizontally on a platform above roof or ground level and protected by weatherproof sheeting. Rolls should only be left exposed to the weather during working periods and should be in storage at all other times.

4.3 PREPARING MEMBRANE: Cover strips, flashings and base sheets around penetrations should be finished with corners rounded, to reduce the risk of accidental peel and to distribute stress.

5.0 WELDING TECHNIQUES

5.1 SETTING UP: welding temperature and speed depend upon the product and the ambient conditions. Therefore, at the start of each working period two pieces of membrane should be welded and a test strip checked for strength by a peel test (see next page). Tests should be carried out regularly as changes in the ambient conditions

during the day can require adjustment to the welding tools. Failure to weld test strips can result in under or over heated laps, such that the resulting seam will be weak, requiring unsightly repair. **Note** that some inspection and test plans (see 8.2) may require the retention of peel test samples.

5.2 PREPARATION FOR WELDING:

- **FPO:** preparation with defined liquid and/or machine striation of material to create a suitable surface.
- **Chamfering of membrane edge:** a void may be created at cross-joints in thicker thermoplastic membranes when one sheet passes across another at 90°. This is overcome by chamfering the lower sheet at its edge.



Check with the membrane manufacturer as to which products require chamfering.

5.3 HAND HOT-AIR WELDING: hand welding is generally a three-stage process, as follows:

- **A TACK WELD:** the welder is held stationary very briefly at the back of the overlap and the upper sheet is pressed by thumb to create a small, lightly welded area. These are repeated at 600-900mm centres along the back of the seam. These isolated welds locate the two sheets and stop wind or installer-induced movement during the lap welding process. Tack welds should not be used with mechanically fastened membranes.



Check with the membrane manufacturer as to whether this is required / permitted.

- **A BACK WELD:** a back weld is formed by running the welder nozzle continuously along the back of the lap and applying light pressure with the roller. The objective is to close the back of the lap so that the hot air from the final weld is trapped and thereby most efficient at fusing the polymer surfaces.
- **A FINAL WELD:** working more slowly and with increased roller pressure, the nozzle is moved along the lap front to produce a continuously fused seam. With PVC and VET products, a slight extrusion of polymer should occur at the seam edge; with FPO and other products, this will generally not be visible. The roller should be applied as flat as possible, with pressure in a downward direction, to remove the risk of the upper sheet being dragged so as to create a crease.

5.4 MACHINE HOT-AIR WELDING: initial tests are also essential with machine welding. Welding machines create a weld in a single pass, but it is necessary to monitor effectiveness continuously and to check that the nozzle is clean. Evidence of poor set-up includes poor weld strength or removal of the polymer from the lap edge. Since welding machines cannot work up to abutments and other details, a transition to hand welding will be required. Procedures for this critical operation are part of manufacturer training and must be strictly followed.

5.5 SOLVENT WELDING: in appropriate conditions and with suitable products, solvent welding allows rapid, single pass welding of PVC products. Never solvent weld without checking suitability with the membrane manufacturer. Weather conditions should also be within the range defined by the membrane manufacturer. The lap surfaces must be clean, dry and uncontaminated. The bottle brush is drawn along the lap to discharge a consistent flow of solvent, whilst pressure is applied using a dry cloth in the other hand. Solvent-welded seams generally require application of a liquid seam sealant, which is discharged from a bottle with a small exit nozzle, creating a bead along the seam edge.



Forming a back weld



Forming a final weld



A final weld of weldable EPDM

5.6 ADHERED SEAM - TAPE SYSTEMS: elastomeric polymers such as EPDM and PIB cannot be fused by hot air or solvents and so an adhesive process is used. The membrane selvage is pre-coated in adhesive, which is protected by release paper. When the seam is to be formed - after checking that surfaces are clean and dry – the release paper is pulled clear at 90° to the lap edge and pressure is applied using a roller.

5.7 ADHERED SEAMS – ADHESIVE SYSTEMS: some elastomeric membranes such as EPDM are joined at seams by adhesives. This may include the use of a secondary gun-applied seam sealant.



The products and method must be approved by the membrane manufacturer.

An adhered seam in EPDM using adhesive



Stage 1: adhere the lap



Stage 2: apply pressure



Stage 3: seal the lap



Stage 4: apply pressure



Stage 5: dress lap edge

6.0 SAFETY

6.1 ELECTRICAL TOOLS: all welding tools should display a current Portable Appliance Testing (PAT) sticker (unless they are not yet due the first such test).

6.2 PERMISSIONS: for use of 240v equipment.

- Residual Current Device (RCD) protection at supply.
- Armoured cable to correct grade. See also 3.2.

6.3 WELDING TOOLS: tools should be checked before each work session, as follows:

- Check air inlet and remove any obstruction.
- Check cables and plugs for damage such as abraded insulation, cuts and burns or loose connections.
- Check air exit nozzles and clean as necessary.
- Run a test weld before each work period to establish performance of the welder.

6.4 WELDING METHODS: methods utilise solvents must not be used in confined spaces without natural ventilation. Appropriate weather conditions are also essential. The assessment of risk must be included in the project risk assessment approved before job commencement.

7.0 TEMPORARY SEALS

7.1 At the end of each working period, temporary 'night' seals must be formed at all exposed edges:

- Warm deck roofs: a membrane cover strip is laid along the working edge, welded beneath a lap formed at the waterproof membrane dressed down over the edge of the insulation and adhered to the vapour control layer using suitable adhesive tape.



Check appropriate method with membrane manufacturer.

- Inverted roofs: whatever the method of attachment of the single ply membrane to the deck, a sealed edge must be formed, either by temporary use of a compatible liquid-applied product or by full adhesion of a cover strip which is welded to the field sheet.
- Cold deck roofs: as for inverted roofs.



Effective temporary night seals are essential

8.0 PRE-START, INSPECTION AND TEST

8.1 CONSISTENT HOT-AIR WELD QUALITY: although hot air equipment is thermostatically controlled, this is principally to allow the user to check exit air temperature. It does not allow rapid adjustment to fluctuating supply voltage, as can occur where power supplies are loaded by other large equipment. Consistent power source should be an agenda item for any pre-start meeting and may result in the roofing contractor supplying their own generator. Generally, cable runs in excess of approximately 30m are likely to be problematic.

8.2 AN INSPECTION AND TEST PLAN: should be agreed at or before the pre-start meeting.

8.3 ASSESSING HOT-AIR WELD QUALITY IN-SITU: a metal probe may be used by suitably qualified personnel to check the weld edge but its use will not confirm weld width or overall quality. If unwelded areas are found, the probe may be pulled in the seam direction to assess the quality of the welds adjacent and if these are found to be weak, one or more of the causes in 8.5 (below) may be responsible. The roofing contractor should be in attendance, with welding equipment available, in order to effect repairs and enable a re-test during the same test session.

8.4 WELD WIDTH: the width of the seam weld is defined by the membrane manufacturer and must be strictly followed.



Check appropriate weld width with membrane manufacturers.

8.5 WEAK HOT-AIR WELDS: the correct welding of thermoplastic membranes results in fused polymer of such strength that peel failure occurs outside of the welded surfaces. If welds are found to be weak, there may be several causes:

- Low welding temperature: polymer will not flow and fuse; failure will occur in the welded area.
- Excessive welding speed: as above and may be characterised by very variable weld strength.



Contamination in lap

- Absence of back-weld: this will reduce the temperature and thermal capacity of the heated air and result in weak welds of variable width. The latter effect may be visible in peel samples.
- Excessive heat: FPO membranes generally have a wide welding temperature window and lower minimum than PVC. However, if they are overheated, components used to resist weathering may dissociate, causing weakened welds. This effect may occur during service after installation.
- Contamination of the lap surfaces, with water, fines or chemicals.

8.6 SOLVENT-WELDED SEAMS: solvent welding is highly reliable but its quality will be affected by contamination; excessive time from application to lap closure; solvent thickened by long storage or use at low temperature and by insufficient hand pressure on the seam after closure.

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8.7 ADHERED AND SELF-ADHERED SEAMS: clean, dry and uncontaminated surfaces – in the appropriate weather conditions - are essential for adhesion by whatever means. Conversely, weak or inconsistent welds are most likely to be the result of failure to ensure all these criteria are in place.

8.8 DEMONSTRATING INTEGRITY BY PROXY METHODS: there are various methods for testing single ply membranes for waterproofing integrity. These are described in the [SPRA Guide to non-destructive testing of single ply membranes](#).

9.0 THE MEMBRANE MANUFACTURER'S INSPECTION

9.1 SPRA requires that the membrane manufacturer makes a recorded inspection of all works above 100m² where a product warranty is to be offered. Complex work below this area should also be checked. This inspection may be at practical completion, during the works or both. The number of inspections required will depend upon membrane manufacturer policy, project complexity, changes to design or specification and the experience of the installer.

9.2 The membrane manufacturer's inspection is not a condition assessment. Neither is it part of an inspection and test plan defined by the contract parties. It is a communication between the manufacturer and their registered installer - a snapshot of roof status – and should be interpreted as such.

10.0 REMEDIAL ACTION

10.1 All necessary steps must be taken to avoid remedial action to seams, because appearance and thereby customer confidence will be affected. In particular the contract parties should apply the [SPRA Guide to protection of single ply membrane roofs to protect finished work and stored materials](#).

10.2 Depending upon the product, it may be possible to remedy weak or incomplete welds by supplementary hot air, solvent or adhesive application. However, this is unlikely to be feasible with FPO products.



Always check with the membrane manufacturer to confirm the appropriate remedial action.

10.3 If supplementary welding is not feasible, a cover strip welded along the affected seam, will be required. This is to be defined by the membrane manufacturer but will generally be of minimum 150mm width.

10.4 If weak welds or capillary openings are identified at cross-joints, a cover patch will be required. The patch dimensions should be the greater of the membrane manufacturer's requirement or 50mm beyond the defect in all directions. Corners should be rounded. Remedial welding of the cross-lap should not be attempted. As such patches create three cross-joints to remediate one, careful, efficient setting out and high quality initial installation are essential.

