3M Scotchlite™ Reflective Material High Gloss Film

Application Guide

Welding Guide – HF/RF (High Frequency/Radio Frequency)

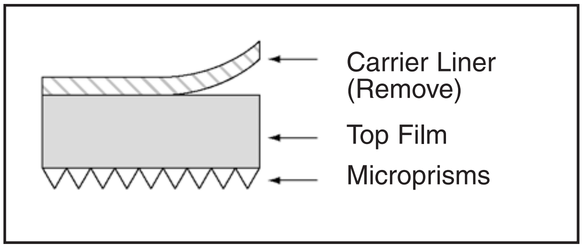
Issue Date: 04/2004
Supersedes: 02/2002

Scope

This guide provides HF/RF welding parameters to achieve durable welded articles incorporating 3M™ Scotchlite™ Reflective Material – High Gloss Film. Read the appropriate product technical data sheet prior to using this guide.

Product Description

Scotchlite reflective material – high gloss film consists of retroreflective microprisms, formed on a flexible, glossy, and UV-stabilized film. The product surface is protected from impressions when in roll form by a polyester carrier liner. *The polyester carrier liner is not part of the finished product. Processor should determine if PET liner must be removed prior to processing. Once the liner is removed, take precautions to not stretch the unprotected film or impress the surface (including impressions from the microprism structures) in order to help minimize appearance imperfections.*



To use the product to achieve retroreflective properties, the microprism structures should face towards the article upon which this film is being applied. Conversely, the smooth surface should face outward.

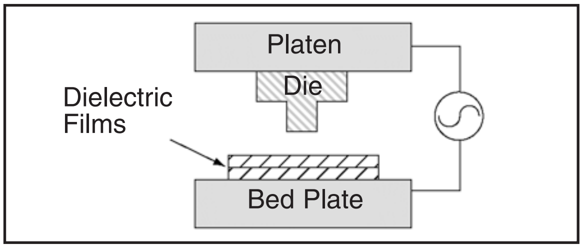
The film does not require a sealing (backside) film to achieve retroreflective properties. However, 3M recommends the application of a sealing film to keep out dirt and water which can result in decreased retroreflective performance.

Principle of High Frequency Welding

Radio Frequency (RF) welding, otherwise known as High Frequency (HF) welding or dielectric welding, is used for fusing together polar plastics, like polyvinyl chloride (PVC or Vinyl) and polyurethane (PU).

When an electric field is applied adjacent to a polar material, the molecules in the material align themselves according to the field's potential. The fluctuation of this field will induce fluctuations in molecular orientation, causing internal friction and heat.

In RF welding machines, polar plastics are positioned between die platens, which act as capacitor plates and are subject to an electric field, which oscillates at a frequency of 27.12 MHz. Pressure causes the platens to close into a fixed gap and presses the materials together producing a successful bond, when combined with the RF electric field.



Substrates

Choose a substrate that has hardness level (plasticizer content) and melt temperatures similar to Scotchlite reflective material – high gloss film. This helps simultaneous heating and melting to occur in both materials, ensuring a good mix and, thus, a satisfactory weld. Use of a plasticized PVC film is recommended for use with Scotchlite reflective material – high gloss film.

The following information with respect to dies and welding is based on 3M's experience with and input from its customers.

Die Materials

Dies are made from three common materials: brass, steel, and aluminum (aluminum dies are sometimes referred to as magnesium dies). Selection will depend on cost, design complexity, and durability.

Brass: Although expensive, brass is very durable and easy to repair. For these reasons, brass is the preferred tooling for large-volume applications.

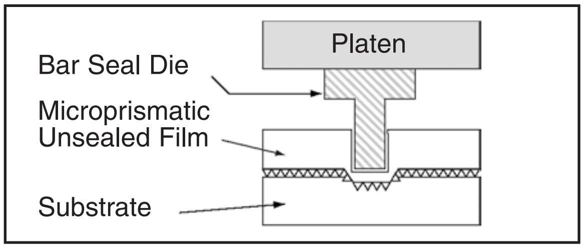
Steel: Lower cost, durable and difficult to repair. Steel is susceptible to rusting and arc pits.

Aluminum/Magnesium: Low cost and easy to make, low durability and difficult to repair. Good for tools of complex patterns, although they require up to 25% more power than brass tools to achieve similar bond strengths.

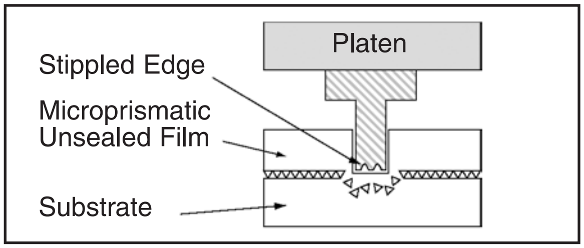
Die Designs

Although the acrylic microprisms in 3M™ Scotchlite™ Reflective Material – High Gloss Film have polar properties, their heat distortion temperature is significantly higher than that of the product's top film. Thus, it is impossible to melt both products simultaneously. This results in the prisms forming a barrier layer between the top film and the substrate upon which the film is being welded. In order to achieve a successful weld, the prism layer must be displaced, enabling the top film to make contact with the substrate. Prism displacement is easily achieved by using dies that can mechanically push the prisms aside during compression. Die design is very important for achieving successful welds.

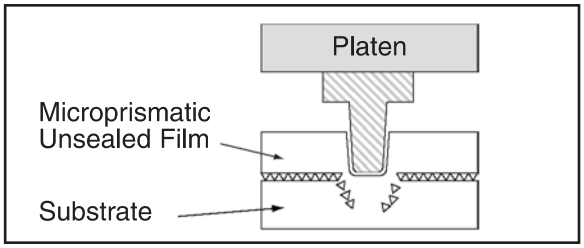
- Appropriate care should be exercised in the design of welding tools as there are a number of unexpired patents covering various welding patterns. 3M makes no representation that any welding pattern selected would be free of claims of patent infringement or violation of any other intellectual property right.
- When welding Scotchlite reflective material – high gloss film, design welding tools to enable the displacement of the acrylic prisms, which would otherwise inhibit the welding process.
- Bar seal tools with large flat surfaces (above 2 mm) and square edges will not encourage prism displacement. They generally push the prism layer downwards into the substrate without dispersal. This design should be avoided.



- For applications where a wide weld area is required, a tool design incorporating stippled edges is effective. These provide spaces adjacent to the weld contact zones that enable prism displacement. Tools with radiused/rounded edges are recommended.

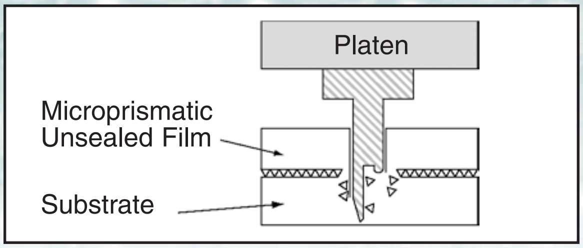


- For a flat, continuous, linear weld, a tool width of approximately 2 mm is recommended. For this application, radiused/rounded tool edges are essential to ensure sideways displacement of the prisms. This allows for better contact between the 3M™ Scotchlite™ Reflective Material top film and the substrate.



Die Designs, continued

- For tear seal welding, the tool profile shown below is recommended. This tooling differs from conventional tear seal tools as it provides a gap between the cutting tip and the sealing flat. This gap provides the space suitable for prism displacement.



Note that the sealing flat should have radiused/rounded edges, again enabling sideways displacement of the prisms.

Buffer Films

Buffer materials have various functions, including electrical and thermal insulation, dielectric enhancement, and compensation for small irregularities in the die surface. Buffers can be made from various materials; common types include polyester and silicone rubber.

A buffer acts as a thermal insulator. Heat generated by the application of the RF field is conducted away by the die platens, producing a temperature gradient within the plastic film. Use of a buffer alters the position of the peak temperature point, thus affecting weld efficiency. This can be resolved by using a preheated die.

A buffer should be used with tear seal tools as a voltage barrier in order to avoid arcs across the platen plates.

Die Positioning and Installation

It is essential that the upper and lower platens are parallel to each other and that the die is parallel to the bedplate platen. Poor alignment results in poor seal uniformity. Also, the tool must remain in close contact with the upper platen to ensure the uniform transmission of the RF field. Poor contact results in an inconsistent weld. The use of shims is discouraged.

The depth of sink (the gap between the final tool position and the lower platen or buffer) will depend upon the materials being converted. When welding 3M™ Scotchlite™ Reflective Material – High Gloss Film this depth can be approximately 1/2 of the total thickness of the films being welded together.

Example: The approximate depth of sink required to achieve a suitable weld between Scotchlite reflective material – high gloss film (thickness 0.3 mm) and a PVC backing (thickness 0.3 mm) would be:

Gap = (0.3 mm + 0.3 mm) / 2 = 0.3 mm

A small gap may result in the over-penetration of the tool within the material (a seal that tears easily). A larger gap may not have acceptable bond strength. Adjustments may be necessary to achieve the optimum gap for the materials being used and the die design. Depth of sink is physically set up using feeler gauges.

For tear seal tools, the gap between the knife tip and the sealing flat will be marginally smaller than the depth of sink.

Equipment Variables

RF welding processes have a number of operating variables including RF field frequency, down stroke pressure, power, and cycle time. Successful welds can be achieved for the same material combinations with a wide range of different setting conditions.

Note: Power dissipation within the plastic materials increases as the frequency of the applied field increases. In theory, high frequency fields would be desirable, but in practice, most RF machines supplied today are standardized at a frequency of 27.12 MHz to minimize electromagnetic interference.

Available machines have power ranges from 1 kW to over 30 kW. The size of machine used will depend upon the tool contact area and the thickness of the plastic materials to be welded. A rough approximation for fusing Scotchlite reflective material – high gloss film to a PVC backing film (total thickness of both films approximately 0.65 mm) is 1 kW per 1000–2000 mm^2 of tool contact area.

Welding Cycles

There are three stages in the welding cycle.

Pre-Sealing stage: The die is lowered and makes contact with the 3M™ Scotchlite™ Reflective Material – High Gloss Film. Preheated tools warm the film at this stage. (Duration is typically 1 to 4 seconds.)

Welding stage: RF energy is applied and the plastic film begins to melt. The die is pushed by pressure through the molten plastic film until the depth of sink is achieved. (Duration is typically 1 to 6 seconds.)

Cooling Stage: The die remains in the final down stroke position while the plastic cools and solidifies.

Equipment Pressure

This usually refers to the pneumatic line pressure and will influence the rate of die compression for a particular application. When welding the Scotchlite reflective material – high gloss film, it may be inappropriate to use maximum pressure settings (which are often used for vinyl-vinyl applications) as this provides too small a cycle time to ensure full prism dispersal.

Equipment Operating Conditions

When the depth of sink has been set, it is then possible to set up machine operating conditions. These will vary greatly as a function of substrate total thickness and tool contact area. Similar weld performance can be achieved with various combinations of the above variables. There are no right or wrong setting conditions for providing a suitable weld. When setting a new die/substrate combination for the first time, it is important to start at time/power settings that are lower than the expected optimum settings. This will allow the converter to adjust upwards until a suitable weld is achieved.

The “output current” control dial signifies when the weld cycle has successfully completed. The control dial will rise steadily until it reaches a peak value, from where it will then fall slightly. This rise in output current is the result of the increase in the dielectric constant of the material as it melts, which increases the capacitance between the electrodes. As the materials fuse together and the depth of sink is achieved, the output current is seen to fall, possibly due to a slight fall in the dielectric constant of the fused material. A successful weld occurs when the output current falls from the peak value. Although the output current is a good indicator of a good weld cycle, it is important to visually inspect the material to verify the acceptability of the weld.

Hints and Tips

⚠ WARNING

DO NOT TOUCH the tool during the weld cycle.
It produces an electrical burn that is extremely painful.

DO NOT TOUCH the tool after the weld cycle. It becomes hot and can cause a burn. Follow all manufacturer recommendations.

- *The polyester carrier liner is not part of the finished product. Processor should determine if PET liner must be removed prior to processing. Once the liner is removed, take precautions to not stretch the unprotected film or impress the surface (including impressions from the microprism structures) in order to help minimize appearance imperfections.*
- Non-heated tool temperatures start out at ambient levels, but after welding for as little as a few minutes can rise to around 50 °C to 60 °C (122 °F to 140 °F). Reduce the power setting as the tool temperature increases to eliminate any possibility of over-welding.
- Welding with the die in contact with the Scotchlite reflective material – high gloss film is recommended for most applications, as prism displacement appears to be more effective in this configuration. Welding through the backing material is possible but may lead to lower bond strength.
- If using a spring loaded slide table apparatus, ensure that the springs do not compromise the depth of sink while the material is in its molten state. This would result in the over-compression of the weld tool, leading to a weakened weld.
- The thickness of the substrate should be similar to that of the Scotchlite reflective material – high gloss film.

Visual Testing

To ensure the integrity of RF welds, the following tests should be performed prior to manufacture and regularly during production. Test frequency is the responsibility of the manufacturer.

1. Inspect the weld line to determine the presence of prisms. The weld line should be free from prisms; otherwise seal strengths may be compromised. Visual microscopic inspection may be necessary.

2. Inspect seal lines. Thin seal lines, caused by over-welding have a propensity to tear. Inspection should occur on samples at selected locations along the seal line. Again, visual microscopic inspection may be helpful.

3. Inspect tear seal welds. The tear seal line should appear straight and clean when viewed from underneath.

Testing Weld Strength

The welded product should be immersed in warm water (65 °C/149 °F) for durations ranging from 30 minutes to 48 hours (depending upon final application). Air within the sealed area will expand, applying stress to the weld. The product should then be placed in another receptacle containing cold water (20 °C/68 °F). This temperature reduction cools the air within the seal, producing a partial vacuum and stimulating water entrance through poor quality seals.

The welded product can also be attached to garments and washed according to the manufacturer's care label. The mechanical action of the wash process may highlight weaknesses in weld integrity.

Troubleshooting

Below is a short guide to assist in identifying potential causes of poor quality welds.

Weld delaminates under stress:

- Die area too large for machine power rating.
- Insufficient power was applied.
- Die temperature is too low.
- Imbalance in temperature across substrates.
- Cycle duration is too short (or duration of preheat, seal, or cool is too short).
- Insufficient tool pressure was applied.
- Depth of sink is too small.
- Die is not parallel with bedplate.

Weld tears open easily:

- Weld cycle is too long, particularly in preheat and weld stages.
- Tool temperature is too high.
- Depth of sink is too large.
- Tool edge is too sharp.

Burn/Arc through:

- RF Power is too high.
- Depth of sink is too large.
- Depth of sink in tear seal tools is too large.
- Tool is not parallel to bedplate.
- No buffer material is present.
- Tool is damaged (warped, arc pits, etc.).
- Weld cycle is too long, particularly in preheat and weld stages.

Suppliers

RF welding equipment manufacturers in the USA:

- Thermex-Thermatron (Louisville, KY) ph: 502-266-5454, fax: 502-266-5453
- Alloyd Company (Elk Grove Village, IL) ph: 815-756-8451, fax: 815-756-1623
- Cosmos/Kabar Mfg. (Farmingdale, NY) ph: 631-694-6857, fax: 631-694-6846

In Europe: • Thimonnier (France) • Kiefel (Germany) • Radyne (UK)

This information is provided for customer convenience only. 3M does not recommend any specific RF welding equipment manufacturer. Customers are solely responsible for choosing equipment suitable for their needs and for ensuring that all equipment meets all applicable workplace safety requirements. For a list of die and buffer suppliers, consult your RF welding equipment manufacturer.

Important Notice to User

LIMITED WARRANTY: In the event any 3M™ Scotchlite™ Reflective Material is found to be defective in material, workmanship, or not in conformation with any express warranty, 3M's only obligation and your exclusive remedy shall be to replace or refund the purchase price, at 3M's option, of such product upon timely notification thereof and substantiation that the product has been stored, maintained and used in accordance with 3M's written instructions.

EXCLUSIONS TO WARRANTY: THIS WARRANTY IS EXCLUSIVE AND IN LIEU OF ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR OTHER WARRANTY OF QUALITY, EXCEPT OF TITLE AND AGAINST PATENT INFRINGEMENT.

LIMITATION OF LIABILITY: Except as provided above, 3M shall not be liable in contract or tort for any loss or damage, whether direct, indirect, incidental, special or consequential, (including, without limitation, lost profits, goodwill and business opportunity) arising out of the sale, use or misuse of the product, or the user's inability to use the product. **THE REMEDIES SET FORTH HEREIN ARE EXCLUSIVE.**

Because of the unlimited variety of potential applications for these products, BEFORE production use, the user (which may be a product designer, product specifier, converter or end product manufacturer or others) must determine that the Products are suitable for the intended use and are compatible with other component materials. User is solely responsible for determining the proper amount and placement of Products. While reflective products enhance visibility, no reflective product can ensure visibility or safety under all possible conditions.

3M may change the product, specifications and availability of the product as improvements are made; therefore, user should contact 3M for latest information before specifying the product.

3M

Personal Safety Products Department
3M Occupational Health and
Environmental Safety Division

3M Center, Building 0225-04-N-14
St. Paul, MN 55144-1000
800-328-7098, Ext. 2
www.3M.com/Scotchlite

3M Canada

P. O. Box 5757
London, Ontario, Canada N6A 4T1
800-364-3577

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