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LF-HVOF Spray Coating

A Technical Guide to Masking

Technical Application Series



Liquid Fueled-HVOF Coating

A Technical Guide to Masking

Save Time and Money with the Right Materials and Methods

Tape

GBI manufactures pressure sensitive thermal spray masking tapes. These materials must be smoothed and pressed with force or pressure to create a good bond of the masking tape to the component surface. This is especially true for Liquid Fueled High Velocity Oxy Fuel (LF-HVOF) masking where face-to-back adhesion is critical.



LF-HVOF spray coating is applied to a rotating cylinder.

Silicone adhesives are always used for thermal spray applications because silicone adhesive releases cleanly from most surfaces leaving no residual adhesive. Also silicone adhesives

typically resist the continuous high temperatures approaching 500° F (260° C) associated with thermal spray coating.

Generally speaking, LF-HVOF masking tapes can be constructed from silicone rubber, woven fibreglass, metal foils, and silicone adhesive.

Compounds

GBI masking compounds are two part silicone putties. The compounds are provided in two parts, "A" and "B", so that they can remain stable and usable for long durations. Typical shelf life is 2 years. Once the two parts are mixed, a moulding putty has now been created that can be used to:

- Plug holes.
- Create moulded sleeves and caps

Fabrics

Fabrics, also known as thermal spray masking blankets, are constructed from silicone coated woven fibreglass fabric. Unlike tapes, these fabrics have no adhesive. The lack of adhesive is an important characteristic which allows for the material to be reusable. The fabric can only be used for secondary masking for any type of HVOF application because the fabric will not survive direct contact with HVOF spray.

Pre-Cut or Die-Cut Pieces

Pre-cut or die-cut pieces are pressure sensitive tapes that have been pre-cut on release liners to simplify repetitive masking. Pre-cuts can be produced in sheets using PTFE Group's advanced plotter equipment. The profiles and drawings are stored in a computer (for future use).



Pre-cut and die-cut profiles increase efficiency and safety in the workplace.



PTFE Group provides tapes, fabrics, compounds, and pre-cut or die-cut profiles for masking in various thermal spray coating applications.

Pre-cuts are advantageous for:

- Faster masking leading to time and cost savings
- Creating a safer workplace with less razor blade handling.
- Improving accuracy and consistency of masking profiles.

Die-cut pieces, specifically rotary die cut pieces, are usually reserved for applications involving high volume repetitive masking. Rotary die cutting is accomplished at PTFE Group fabricating centers whereby rolls of tape are generated with the die cut shapes (profiles) on the liner in roll form. As with the pre-cut advantages listed above, rotary die cutting is more economical for applications involving thousands of pieces. A proper cost study should be conducted by the customer before deciding which option is most appropriate for a given situation.

Masking Methods and Techniques to Use for the Best Results

First determine if the area to be masked is considered Primary or Secondary

Primary masking is the critical masking area in direct contact with the spray particles as they impact the component surface. Primary masking is crucial as this is the area where masking and exposed surface meet and most operators want well defined, clean coating lines. These perfect edges can be achieved by using GBI LF-HVOF masking products.

Secondary masking is the non-critical masking area that does not come in direct contact with the spray particles as they impact on the component surface. The secondary masking area is usually furthest away from the targeted zone but operators still need to protect those areas as they can be impacted by stray spray or bounced particles which could become a contaminant. Because these secondary areas are normally larger than the primary masking area a good masking solution would improve masking efficiency (save time and money).

Product Recommendations for LF-HVOF Masking

Tapes

HVMT Orange: A reliable secondary LF-HVOF masking tape used for the purpose of precision masking for challenging applications. Best results will be achieved on large components as a primary mask, or as a secondary masking to be used in conjunction with metal masking or HVMC.

Compounds

HVMC: An aviation engine approved High Velocity Masking Compound suitable for use with all gas fuel and LF-HVOF coating systems.

Fabrics

S/W 35 – White silicone coated glass fabric (only use for secondary masking far away from spray particles)

*HVMC = High Velocity Masking Compound; HVMT = High Velocity Masking Tape

How to select the correct masking products for Primary Masking areas

To select the correct primary masking products, the operator needs to consider what factors will most affect the masking tapes, compounds, and fabrics. There are several factors to consider:

Is the profile of the component intricate or basic?

Basic profiles are easier to mask. Often 2-3 layers of GBI HVMT



A turbine blade is masked with 170-10s (Red) and 160-5s (white) Masking Tapes as primary and secondary masking.

Orange will survive applications with flat or easy profiles when spray particles impact on a 90 degree angle. Some operators may elect to use 1 layer of GBI HVMT Orange with a shield of metal masking (shim stock or tooling). In this case, the metal masking absorbs most of the impact of the spray particles while the tape prevents

bridging of the coating to the masking and allows for better edge definition.

Intricate profiles are more challenging and require a good masking plan. Usually tape is required as a masking base with an engineered metal masking or tooling which will cover the taped areas only exposing on the leading edge. The metal will absorb most of the high energy spray particles while the exposed tape will help with edge definition and prevent bridging of the coating.

Green Belting Industries Masking Compound can be used as a moulding putty to take the shape of difficult profiles while protecting areas from grit blast and HVOF sprayed coating particles. Some operators will adjust the ratio of Part A to Part B by using a ratio of 25:75. By using 25% Part A and 75% Part B, the putty will cure to a softer rubber that will resist the erosion which can occasionally occur with LF-HVOF application of tungsten carbide.

Does the grit blast or prep blast require coarse grit or fine grit?

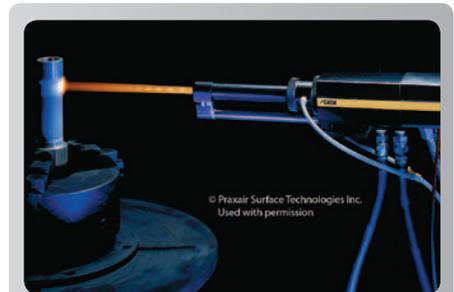
All thermal spray coatings require a prep blast stage to etch the component surface so that a coating will form a strong bond. In most cases, HVOF coatings require a well etched surface which is accomplished with coarse grit. All of the recommended GBI HVOF masking products will survive heavy abrasive grit blasting (high abrasion). If the grit used is very coarse (less than 24 grit aluminum oxide), operators will likely need more than one layer of HVMT Orange.

What type of exposure to the plume of the flame will the masking materials experience? Continuous exposure or intermittent?

LF-HVOF coating is a hot process which results in a very high rate of heat transfer through the masking materials. This process has much higher kinetic energy compared to other thermal spray processes including GF-HVOF. Limiting the exposure to the surface of tape is critical as long dwells will cause the erosion and failure of exposed tape (HVMT Orange). If long dwells are un-avoidable,

HVMC should survive when used correctly. HVMT Orange will require protection from the flame by using metal masking.

Operators should also try to engage air cooling whenever possible to control the substrate temperatures. Cooling the surface temperature helps the silicone based masking products survive by keeping continuous temperatures well below 500°F (260° C). Air cooling can be achieved with forced air or vaporized nitrogen systems.



LF-HVOF spray is very hot and will destroy any tape if direct exposure to the flame persists. High quality tapes such as HVMT Orange when used in conjunction with metal masking and/or indirect exposure to the flame can provide effective masking.

Will air cooling be engaged?

Air cooling is the process of forcing air or vaporized nitrogen through a cooling jet towards the surface of the component being coated. The purpose of the cool air is to control the surface temperatures of the component so that the coatings can form and bond correctly with minimal cracking. Fortunately for silicone masking products, the desired temperature range of



Air cooling reduces substrate temperature and increases masking performance.

the surface of most coated parts is well below 500°F (260°C), therefore air cooling inadvertently helps masking survive.

There are situations where air cooling is not possible. For these situations we recommend the use of masking compounds where possible. For tape applications, tape and metal masking are generally encouraged.

Will the spraying occur on a 90° angle?

Thermal spray coating technicians universally strive to spray coatings on a 90° angle to maximize the bond of the coating to the substrate. For situations where LF-HVOF coatings will be applied on a 90° angle, HVMT Orange (with metal masking) will generally work for most applications as will our compounds.

Unfortunately, the geometries of the components do not always allow for 90° angles of spray. In fact, many profiles may be sprayed from 75-90°. From a masking perspective, the further removed from a 90° angle of spray the greater the chance of the masking tape being lifted. This lifting could potentially occur as the spray particles impact the edge of the tape which may create a lift of the material from the component surface. To combat the lifting scenario, operators are encouraged to use HVMT Orange tape with HVMC reinforcement of the overlaps. To prevent lifting, HVMT Orange tape is pressure-sensitive so it is imperative that force (pressure) be applied in order that the strongest bond of the adhesive to the component surface is achieved. Another strategy is to use HVMT Orange tape with metal masking tight against the masking tape surface.

What is the coating thickness?

This is an important consideration. For LF-HVOF applications, coating deposition can be achieved relatively quickly compared to GF-HVOF. From a masking perspective, the thicker the coating, the more exposure to heat and abrasion due to the fact that more passes are required. In most cases thinner coatings of less than 15 mil can be masked using two layers of HVMT Orange. Most coatings will be thick enough to require metal masking and HVMT Orange. HVMC should work for all coating thicknesses.

Is the powder (coating) being applied coarse or mild?

LF-HVOF systems use a variety of feedstock (powders). Commonly sprayed powders are: Tungsten carbide, chrome carbide, MCrAlY (alloy), and stainless steel. Although all materials will be considered abrasive if sprayed with LF-HVOF, the carbide coatings are by far the most abrasive. For applications involving carbide coatings, we recommend at least two to three layers

of HVMT Orange or metal masking with HVMT Orange underneath. Generally, HVMC will work for most applications involving masking against carbide coatings when NOT used on flat surfaces).

How to select the correct masking products for Secondary Masking areas

To select the correct secondary masking products, the operator needs to consider what factors will most affect the masking tapes, fabrics, and compounds. There are several factors to take into account:

What is the size of the secondary masking zone?

For large areas use of the S/W 35 Silicone Coated Fibreglass (also known as a thermal spray masking blanket) is recommended. This material is a reusable form of masking that can be used to cover large areas quickly and will help to eliminate “excessive tape masking”. Generally this fabric must be mechanically fastened.



S/W 35 Masking Blanket is used as secondary masking to mask larger areas, and is re-usable.

Large areas with difficult profiles should utilize fabric and tape together for the most cost effective solution. Small areas should generally use a combination of HVMT Orange and a metal mask.

Is overspray acceptable?

Depending on the work instructions, some jobs will allow for overspray. In those cases, masking in general is not needed.

Most precision jobs will not allow for over spray. In these situations, HVMT Orange is recommended.

Shadow masking

Shadow masking is a technique for protecting component surfaces by using metal plates that are strategically placed in the path of the spray particles to create a protected shadow of the area that must not receive coating. This technique is an effective method for masking against LF-HVOF but with a negative side effect: the coating line will be blurry with overspray. For situations where a clear line is required, operators should apply HVMT Orange along the coating line. The plate will shield the single layer of tape from direct spray exposure and the tape will allow for perfect edges.

Masking Strategies for Common Profiles and Components

Cylinders, Rollers, Shafts

Most rollers and cylinders have keyways which can be masked with Green Belting HVMC. The GBI compounds are a very quick and reliable solution for masking keyways and repetitive masking can often be created.

Journals can be masked quickly with HVMT Orange (depending on the standoff distance and dwell time). The tape can also be covered by metal shim stock.

Cooling holes

Many aviation and IGT engine vanes and components found in the hot combustion zones of the engine contain very small holes on the surface to assist with controlling the temperature of that part while in service. Generally, operators try to protect cooling holes so that coating and grit does not penetrate and build up although masking cooling holes is difficult and time consuming. The best solution for masking cooling holes is using High Velocity Masking Compound (HVMC). This masking technique involves mixing the compound in a 25:75 (Part A & Part B) ratio which creates a putty that can be used to fill the holes. The putty can be trimmed and the surface cleaned only after curing is complete (15 minutes). After the masking is cured, grit blast is required to etch and clean the surface of the component followed by the bond coat of HVOF spray. After coating is complete, the putty can be burned out of the hole at 1000°F (540°C) for one hour or the putty can be physically removed with precision drills and abrasives.

Fan blades

A fan blade may have multiple areas where coating is required. It is common to apply HVOF coatings to sections of the blade roots where abrasion resistance is needed. These complex shapes will often require masking made from HVMC to produce re-usable masking caps (to target areas such as z-notches). HVMT Orange can also be used to accomplish secondary masking in a single layer further removed from the critical coating zone.



Gas and Oil Related Components (Pumps, Valves, Shafts, Compressors, etc.)

Components used in the gas and oil industry are coated with wear resistant coatings (and corrosion resistant coatings) that can be applied with LF-HVOF systems. Given the difficult geometries or profiles of these components, we often recommend using a combination of HVMT Orange for critical masking areas with HVMC for filling holes and producing sleeves and masking moulds. Metal masking can also be used strategically on its own or in conjunction with HVMT Orange.

Recommendations for Heat, Abrasion and Conformability

Extreme Heat

LF-HVOF is not as hot of a process as APS, however the transfer rate of heat through the masking material is a major consideration.

The size and profile of the part will also contribute to the heat generated and sustained on the part surface. For example, small parts will generally heat faster and remain exposed for longer time periods compared to larger components. Extreme heat can occur when heat from the LF-HVOF coating process has no chance to escape from the masked component (very small parts). For these situations we recommend metal tooling with a layer of HVMT Orange underneath the metal to maintain the coating line and to prevent bridging of the coating.

High Abrasion

LF-HVOF is a very abrasive process, especially when carbide coatings are being sprayed. The masking has to withstand high abrasion. Standard thermal spray tapes will disintegrate and fray. HVMT Orange will survive coarse grit from prep blasting and can often survive the spray process with coarse dense tungsten carbide and chrome carbide. Depending on the size of the component, the HVMT Orange may be used as secondary masking with metal tooling taking the immediate impact of the coating particles.

The strongest material produced by GBI for abrasion resistance is the compound, HVMC. This compound will survive all forms of HVOF and grit blast when used correctly (filling holes and creating masking moulds).

Conformability

One of the main problems with tapes designed for high energy coating processes is the thick construction of the materials. Often, competing tapes will be constructed of multiple layers or laminate materials which results in a tape that is too stiff which will not conform to difficult profiles. HVMT Orange is a unique tape that is a single layer and highly conformable. Using a conformable tape and metal masking combination is important: the tape (HVMT Orange) offers the intricate protection due to conformability that is difficult for metal masking. The metal tooling shields most of the tape from direct particle impacts.

In some cases, a non-tape solution is the best. GBI's HVMC compound can be used to make intricate reusable masking moulds that will take the shape of any profile. A component such as a complicated blade root would benefit from this type of masking solution.

Tape plus Metal: The Combined Solution

In terms of masking materials, there is no one size fits all solution. It is very common to use multiple masking materials for the most effective masking of a component. A common masking strategy involves Metal Masking profiles along with Tape, Compounds, and/or Fabric.

Shadow Masking with Metal and Tape

Shadow Masking is a masking strategy whereby metal plates are used to mask off the area where a coating cannot be tolerated. While effective, shadow masking may often require tape on the component to prevent a blurry section of overspray because the tape allows for precision coating lines.

Metal Masking Tooling with Tape

Often metal masking tools are designed to encapsulate a component while exposing only the areas where a coating is to be placed. Not surprisingly, the coating will build up on both

the component and the masking. This can be a big problem as the coating will chip and crack when the tooling is removed. To solve this problem, thermal spray masking tape (ideally HVMT Orange) is used where the masking and component meet to act as a buffer to prevent bridging and cracking of the coating and to ensure perfect coating lines.

Strategies to Maximize LF-HVOF Masking Time and Cost Savings

Inspect the Component and Masking Prior to Spraying

Make sure proper pressure has been applied to the tape. The operator must remove all air-pockets and ripples to ensure that the adhesive is fully engaged with the component surface.

If you are concerned about bridging of the coating, then we recommend prior to grit blast, using a second layer of tape (narrow strips) where the coating meets the masking. Upon completion of the grit blast, the narrow strips may be removed leaving a smooth surface that will prevent any change of bridging and cracking of the coating.

Eliminate any areas where tape is not in contact with the component, for example tape should not be used to cover holes (HVMC should be used instead)..

Check for surface contaminants (oil, FPI oil using a black light, grease, paint, old coating etc.).

Review coating plan to make sure the component and gun are moving to prevent excessive heat (which of course is bad for both the masking and the coating).

Make sure (where possible) that air cooling jets are engaged.

Ensure your Masking Department has the best tools for the job

Utility knives, razor blades, and/or scissors – Tapes and fabrics are usually cut and precision cuts are required as opposed to hand tearing.

Masking tables with protective covers – will prevent parts from becoming scratched while also providing a surface where tape can be cut.

Lighting – All precision masking jobs require good lighting to be able to accurately mask with tapes, fabrics, and compounds.

Smoothing instrument – Most masking operators will utilize objects or tools for smoothing tape. Remember that thermal spray masking tapes are “pressure sensitive” thus they require sufficient pressure to bond well. Smoothing instruments can be fabricated plastic hand held tools but ideally have multiple surfaces to adapt to different profiles.

Rack/bar for holding tape rolls – In the interest of safety and efficiency, masking departments should have racks or bars to contain and dispense tape easily. This is the best way to store various sizes at each work station.

Don't forget these important Health and Safety considerations

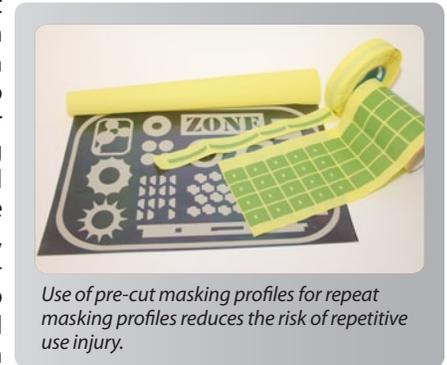
Avoid cuts

Unfortunately, cuts to hands and fingers do occasionally occur. Cutting injuries result in down time (not to mention pain and possibly infection). Cuts can be reduced by employing the following:

- Pre-cut sheets of masking tape containing pre-cut profiles. Not only is this strategy safer, it also speeds up masking, ultimately generating time and cost savings.
- Kevlar gloves. Where possible, employees should consider using Kevlar gloves to avoid cuts from blades and also from sharp component areas.

Avoid repetitive motion disorders

Some companies perform masking of repetitive shapes. Peeling the liner off of thermal spray masking tapes can sometimes lead to repetitive motion injuries (particularly if breaks, rest periods, or job rotations do not occur). This problem is more often seen with operators who consistently use wider width rolls of masking tape such as 4” and greater. To reduce the potential for injury, GBI recommends pre-cut masking profiles to minimize liner removal and avoid excess strain on wrists. Furthermore, most masking operators are moving towards narrower width rolls such as 2” wide to help reduce repetitive motion disorders.



Use of pre-cut masking profiles for repeat masking profiles reduces the risk of repetitive use injury.

Contain release liners to minimize trip and fall hazards

Masking departments should be kept clean, especially the floors. Unfortunately, many shops forget to immediately dispose of release liners (which are discarded after the tape is unwound). A good practice is to have several garbage containers beside the masking work space to prevent release liners ending up on the floor which can lead to slipping hazards. This potential hazard is especially common when customers use products with clear polyester release liners (they are very slippery and harder to see compared to yellow PVC release liners).

Additional tips for successful masking

Never hand tear thermal spray masking tapes

Avoid hand tearing even though some thermal spray tapes may have weaker breaking strength. Tearing by hand will seriously damage the integrity of the product. Thermal spray masking tapes utilize a base of woven fibreglass and when torn by hand, the fibreglass is exposed as a potential contaminant to the coating. The frayed glass can also shadow the coating line, leading to rework.

Always apply firm pressure to ensure strong adhesion of the tape to the component.

Thermal spray masking tapes are pressure sensitive, meaning

they require force to properly wet out and adhere. A smoothing tool or instrument (even fingers) should be used to create a good bond of the tape to the component.

Avoid the use of solvents.

Where possible solvents should not be used on thermal spray masking tapes or the components to be masked. Strong solvents can break-down and liquefy the adhesives and silicone rubbers. For example, if a strong solvent is used and tape is immediately applied to that surface, the tape will not adhere well.

Mild solvents can be used to clean a surface prior to applying the tapes, however the operator should make sure that the solvent has flashed off completely.

Never allow for silicone adhesive tapes to freeze but refrigeration is okay.

Freezing of silicone rubber tapes may interfere with the chemistry of the product, leading to poor adhesion values, and does NOT extend the life of the product. Refrigeration of tapes will not have a negative effect on thermal spray masking tapes.

Best storage conditions are at room temperature, but avoid excessive humidity and excessively dry storage.

When using GBI tapes, take precautions to not leave the tapes in dirty areas because tapes can pick up dirt and dust particles, particularly on the roll edges.

These particles can reduce the tack and adhesion of the tapes as well as potentially becoming a contaminant to the coating so a clean working environment is important.

Where possible, try to avoid narrow strips of masking tape less than 1/2" wide.

Tapes can be manufactured in widths of less than 1/2", however, operators risk tape lifting due to small surface coverage (adhesive coverage) versus the relative force of the HVOF spray.

In other words, extremely narrow strips of tape have a better chance of lifting, tearing, or moving compared to strips of tape that are 1/2" or greater in width.

Engage forced air cooling to control the surface temperatures where possible.

Remember that temperatures beyond 500° F (260°C) will break down silicone tapes, compounds, and fabrics. The higher the temperature beyond 500°F (260°C) the faster the break down will occur.



Air cooling reduces substrate temperature and increases masking performance.

LF-HVOF masking is very challenging and is

often compared to high temperature grit blasting. The LF-HVOF process creates three distinct challenges for masking products:

1. High heat transfer through the masking material (heat beyond 500°F [260°C] attacks the adhesive quickly).
2. High abrasion which can erode and fray typical thermal spray masking tapes.
3. Very high kinetic energy that can often rip and disintegrate the masking materials.

GBI HVMT Orange and HVMC were designed with the above challenges in mind. These products offer economical alternatives for operators who wish to reduce their reliance on metal masking and will help operators and thermal spray job shop owners achieve time and cost savings.

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PTFE GROUP OF COMPANIES



Canada

green belting industries

381 Ambassador Drive
Mississauga, ON L5T 2J3
Canada

T: 905.564.6712
F: 905.564.6709
E: order@greenbelting.com

www.greenbelting.com

Italy

mapelli

Via del Lavoro 43
20060 Vignate (MI)
Italy

T: +39.02.90967258
F: +39.02.90967236
E: info@mapelli-ptfe.com

www.mapelli-ptfe.com

UK

biscor

Unit 1, Broadfield Business Park
Pilsworth Road
Heywood OL10 2TA UK

T: +44 1706 396690
F: +44 1706 396691
E: info@biscor.com

www.biscor.com

USA

greenbelt industries

45 Comet Avenue
Buffalo, NY 14216
USA

T: 1.800.668.1114
F: 905.564.6709
E: order@greenbelting.com

www.greenbelting.com

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