green belting

Gas Fueled-HVOF Coating
A Technical Guide to Masking

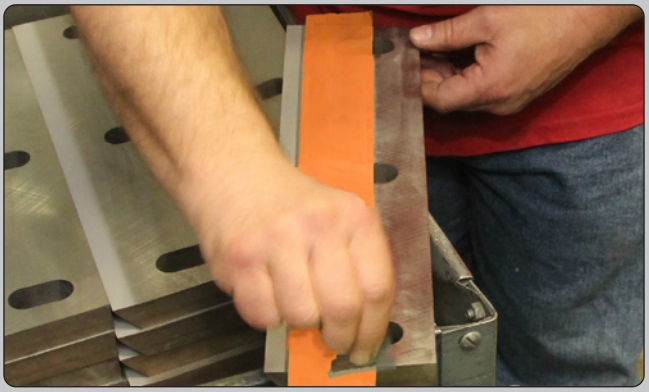
Save Time and Money with the Right Materials and Methods

Tapes

Green Belting manufactures pressure sensitive thermal spray masking tapes. These materials must be smoothed with pressure to create a good bond of the masking tape to the component surface.

Silicone adhesives are always used for thermal spray applications for two reasons: 1. Silicone adhesives typically resist the continuous high temperatures approaching 500°F/ 260°C that are associated with thermal spray coating, and 2. Silicone adhesive releases cleanly from most surfaces leaving no residual adhesive.

Thermal spray masking tapes are typically constructed with silicone rubber, woven fiberglass, metal foils, and silicone adhesive.



Applying HVMT Orange Masking Tape to a plate prior to receiving GF-HVOF Coating.

Compounds

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 Fiberglass 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 Green Belting advanced plotter equipment. The profiles and drawings are stored in a computer (for future usage).

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 Green Belting 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 for 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 GF-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).

SW-35 Masking Fabric is used to cover large surface areas.

Product Recommendations for GF-HVOF Masking

Tapes

- **High Velocity Masking Tape (HVMT) Orange** – Highly conformable premium masking tape best suited for masking against the most demanding high temperature and high abrasion applications.
- **179-20S** – A double layered combination HVOF tape made up of a layer of silicone coated fiberglass tape and a layer of 2 mil aluminum foil.
- **179-25S** – A double layered combination HVOF tape made up of a layer of silicone coated fiberglass tape and a layer of 4 mil aluminum foil.

Compounds

- **High Velocity Masking Compound (HVMC)** – An aviation engine approved High Velocity Masking Compound suitable for use with all gas fuel and liquid fuel HVOF coating systems.

Fabrics

- **SW-35** – White silicone coated glass fabric (only use for secondary masking).

How to Select the Correct Masking Materials 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 1-2 layers of HVMT 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 HVMT Orange with a shield of metal masking (shim stock or tooling).

Intricate profiles are more challenging and require a good masking plan. Small, intricate parts and profiles will require a conformable (flexible) masking material. We recommend one of these options for GF-HVOF:

1. Masking Compounds (HVMC) to be used as a moulding putty to take the shape of difficult profiles while protecting areas from grit blast and HVOF sprayed coating particles.
2. HVMT Orange may be used to mask difficult profiles. The overlaps can be reinforced with HVMC to prevent lifting. The tape can also be used in conjunction with metal tooling to produce a reliable mask.

170-10S (Red) and High Velocity Masking Compound (Blue) provides primary masking and 160-5S (White) Masking Tapes is used for secondary masking on this turbine blade.

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 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 or intermittent?

GF-HVOF coating is a hot process which creates a very high rate of heat transfer through the masking materials resulting in the need to find ways to lower the temperature of the substrate. The most common method of temperature control is to ensure that the spray gun is constantly moving while the component is also moving (such as, a component spinning on a turntable while a robot manoeuvres the gun in a pre-programmed route). From a masking perspective, operators must limit the exposure of the flame to the surface of GF-HVOF tapes and compounds.

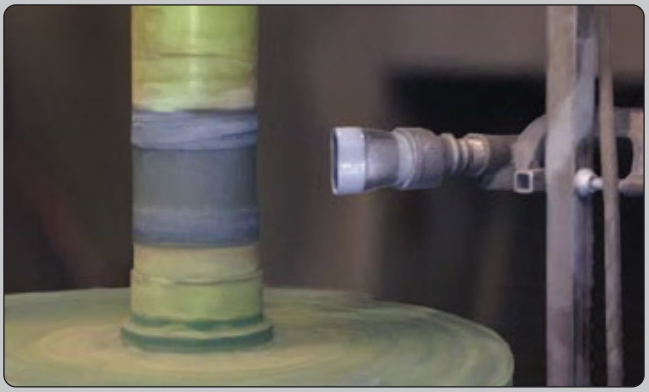
Operators should try to engage air cooling whenever possible to control the substrate temperatures. Cooling the surface temperature helps the silicone based masking products survive by keeping continuous temperatures well below 500°F (260° C). Air cooling can be achieved with forced air or vaporized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

If longer dwells exist (possibly due to the small size of the component), then the operator should consider using multiple layers of HVMT Orange or a single layer of HVMT Orange covered with metal tooling. The masking compounds should survive longer dwell times.

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 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. For tape applications, multiple layers of HVMT Orange will be required.



Air cooling reduces substrate temperature and increases masking performance.

Will the parts be sprayed manually or robotically?

Most facilities today utilize gun mounted robots to carry out the coating tasks, especially for HVOF coating. Spraying robotically is a safer process for operators compared to spraying manually and is good for achieving standardized and repeatable results (consistency).

In terms of GF-HVOF masking products robotic spraying reduces the chance of overheating or burning as the robot has been programmed to follow an effective "route" or "traverse" minimizing dwell times for both the ideal coating properties and the survival of the masking.

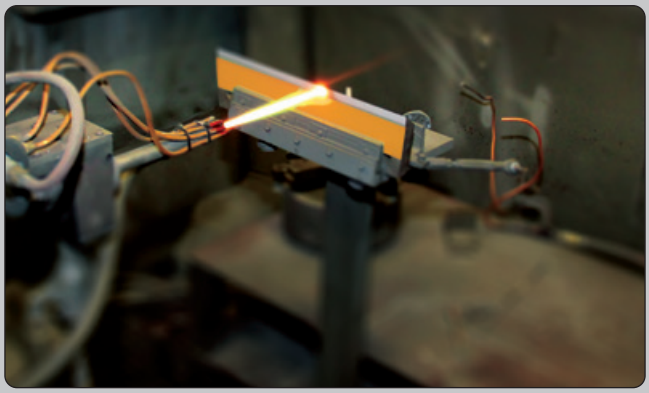
In a manual spraying environment the skill of the operator is the key to avoid any excessive exposure to the flame. Unlike robots that can be programmed to continue their routes without pause, humans can inadvertently expose the component and masking to excessive flame, potentially resulting in burning of thwe masking. If the operator or the supervisor has concerns about excessive flame exposure the customer may want to consider a strategy that includes at least two layers of HVMT Orange. Where applicable, the masking compounds should be considered as they can tolerate higher abrasion and longer exposure to the flame.

Robots are often used to apply thermal spray coatings.

Will the spraying occur on a 90° angle?

Thermal spray coating technicians universally strive to etch and coat substrates on a 90° angle to maximize the bond of the coating to the substrate. For situations where GF-HVOF coatings will be applied on a 90° angle, HVMT Orange will generally work for most applications as will our compound.

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° and in some severe instances, angles of 45° may occur. 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. For the overlap areas HVMC may be applied 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.



GF-HVOF spray coating is applied at a 90° angle to a plate masked with HVMT Orange Masking Tape.

What is the coating thickness?

This is an important consideration. For GF-HVOF applications, coating deposition usually takes considerable time; often dozens of passes are required before the required coating thickness is achieved. 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 one to two layers of HVMT Orange.

If coating thickness will be in excess of 15- 20 mil, the operator may choose to use an additional layer of tape, or he/she may deploy metal masking over the top of the tape to guarantee success. HVMC should work for all coating thicknesses.

Is the powder (coating) coarse or mild?

GF-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 GF-HVOF, the carbide coatings are by far the most abrasive. For applications involving carbide coatings, we recommend at least 2 layers of HVMT Orange. Generally, HVMC will work for most applications involving masking against carbide coatings (when NOT used on flat surfaces).

How to Select the Correct Masking Materials 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 SW-35 Silicone Coated Fiberglass (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 into position.

Large areas with difficult profiles should utilize fabric and tape together for the most cost effective solution.

SW-35 Masking Blanket is used as secondary masking to mask larger areas, and is reusable.

Masking Strategies for Common Profiles and Components

Cylinders, Rollers, Shafts

For large areas use of the SW-35 Silicone Coated Fiberglass (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 into position Most rollers and cylinders have keyways which can be masked with HVMC.

Compounds provide a very quick and reliable solution for masking keyways and repetitive masking can often be created. Compounds easily withstand the high abrasion associated with all grit styles.

Journals can be masked quickly with a variety of thermal spray masking tapes or glass cloth tapes and often wider rolls are recommended for convenience. These silicone coated Fiberglass tapes will withstand most styles of grit. Note, you may need multiple layers of tape if using grit that is coarser than 46 grit.

Large surfaces of rollers or shafts can be protected by using SW-35 silicone coated glass fabric as secondary masking with a strong GF-HVOF masking tape close to the targeted zone or critical area.

Reliable masking always involves HVMT Orange masking tape. When a critical edge is needed, with no fraying from abrasion, then the correct product choice should be two layers of HVMT Orange or a single layer of HVMT Orange with metal masking.

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 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 50:50 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 (7 minutes). After the compound 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 reusable masking caps (to target areas such as z-notches). HVMT Orange is a good tape solution for fan blade masking.

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 GF-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

The size and profile of the part will contribute to the heat generated and sustained on the part surface. For example, small parts will generally heat faster and be exposed to the flame more continuously than larger components. Profiles such as inside diameters can also generate tremendous heat. Multiple layers of HVMT Orange should be used for high heat applications as this tape is both flame retardant and self- extinguishing.

Extreme heat can occur when heat from the GF-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

GF-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. Two layers of HVMT Orange will survive coarse grit from prep blasting and then the spray process with coarse dense tungsten carbide and chrome carbide.

The strongest materials produced by Green Belting for abrasion resistance are the compounds: 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 and will not conform to difficult profiles. HVMT Orange is a unique tape that is a single layer and highly conformable. This conformability combined with strong face-to-back adhesion is the reason why HVMT Orange will not lift during GF-HVOF spraying.

In some cases, a non-tape solution is the best. HVMC 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 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 Thermal Spray 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 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

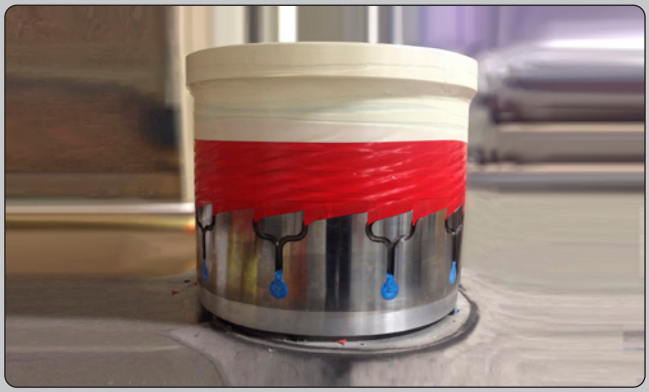
Utility knives, razor blades, and/or scissors – Tapes and fabrics must be cut. Precision cuts are required as opposed to hand tearing. Hand tearing exposes glass filaments which are potential contaminants.

Masking tables with protective covers – 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 and 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.



A part masked with 170-10s Red Masking Tape, and High Velocity Masking Compound (Blue) is ready for inspection prior to receiving the spray coating.

Don't Forget These Important Health and Safety Considerations

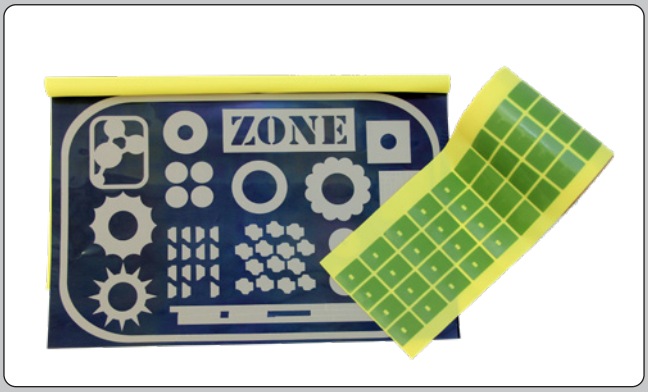
Avoid cuts

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, Green Belting 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 Fiberglass and when torn by hand, the Fiberglass 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 breakdown 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 before applying the tape.

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, lead 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.

Protect tapes from dirt and dust contamination

When using 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 ¼" wide

Tapes can be manufactured in widths of less than ¼", however, operators risk tape lifting due to small surface coverage (adhesive coverage) versus the relative force of the 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 ¼" 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.

GF-HVOF masking is very challenging and is often compared to high temperature grit blasting. The GF-HVOF process creates two distinct challenges for masking products:

1. 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.
2. Kevlar gloves. Where possible, employees should consider using Kevlar gloves to avoid cuts from blades and also from sharp component areas.

HVMT Orange and HVMC withstand challenging masking situations. 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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As an ISO 9001 Quality Registered Company, our ongoing procedure for quality assurance starts with thorough inspection of all raw materials to ensure compliance with our required specifications. All manufacturing processes are closely monitored, and finished product is tested against our high internal standards and customer specifications. This assures that we always deliver consistently high quality products.