GRAFMETAL

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User manual of GRAFMETAL universal paste and aerosol for marking of metals with CO2 laser (1.8 version)

Scope

Universal paste and aerosol are suitable to be used mostly with CO_2 lasers. The products can be used for marking, engraving and cutting metals. A range of processable materials is provided below.

Marking:

Steel, galvanized steel, stainless steel, acid-resistant steel, other kinds of steel, chromium plated surfaces, aluminium, brass, copper, zinc.

Engraving:

Steel, galvanized steel, stainless steel, acid-resistant steel, other kinds of steel.

Cutting:

Thin steel elements with a thickness of approximately 0.1 mm – 0.5 mm (0.004" – 0.02") (0.1 mm (0.004") – single run, 0.5 mm (0.02") – several runs)

General process description

1. Paste or aerosol are applied to a metal object in a form of a layer. Drying is not needed in case of paste. When using aerosol it is recommended to wait the layer to dry before laser processing.
2. The layer is irradiated with a laser in a desired areas. The layer absorbs the laser light and hardens under its influence. If one uses higher power or lower laser head speed, then it is possible to obtain the effects of engraving or even cutting.
3. After the process one wipes the paste which was not irradiated, which can be done with e.g. a paper towel.
4. The irradiated spots are covered with a durable, grey-black layer; in the case of engraving, in the irradiated areas one will see an incision or indentation or a changed texture of the object; in the case of cutting, the metal is removed from the laser run paths

General remarks

1. Before using <u>PASTE</u> it is recommended to mix it in a container before applying it to metal.
2. Before using <u>AEROSOL</u> it is necessary to shake it for at 1-2 minutes. Shake it once in a while when working with it.
3. It is recommended to perform tests before working with the final metal object. Tests should be performed on the same material type.
4. If the layer adhesion is too weak after laser processing and cleaning (e.g. sometimes noted in case of aluminium, copper, chromium plated surfaces or similar materials), then it is recommended to degrease the surface before applying the product by strongly rubbing the metal with a cloth soaked with alcohol, acetone or similar solvent, but force applied should not be strong enough to produce scratches. If this does not work, then it is recommended to decrease laser speed. If this will not help either, then it is recommended to clean the metal surface with a sandpaper before paste deposition.

5. Laser cover should be closed during the whole time when the device is working. Metals reflect laser light, so if the cover is open, it can deteriorate one's health, lead to burns or lead to blindness. If the laser is not equipped with a cover, then it is necessary to prepare appropriate protection.
6. Using the product for a very long time with insufficient CNC laser table ventilation may lead to deposition of fine soot particles on mechanical and optical laser elements. It is recommended to clean mechanical elements with a paper towel, tissues or ear sticks – dry or after soaking them with isopropyl alcohol, while the optical elements should be cleaned with a cotton cloth after soaking it with isopropyl alcohol. After application of isopropyl alcohol, before using the laser for the subsequent time, one should wait until the solvent evaporates. Any works shall be carried out while the laser power supply is turned off. It is necessary to be cautious while cleaning the optical elements, so they will not get damaged or no longer aligned.
7. It is recommended to periodically monitor if the focusing lens is clean.

Manual

1. Surface preparation

Prepare the metal object. If it is coated with a protective foil then remove it. In some cases it may be beneficial to clean the surface with a cloth soaked with a solvent by rubbing the metal with a proper force. Sometimes, to obtain good adhesion of the marking layer after laser processing, it may be necessary to clean the surface of the metal object with a sandpaper (sometimes encountered while processing e.g. copper or aluminium).

2. Application of the product

Paste:

As a result of long storage, especially in conditions of elevated temperature or when exposed to sunlight, the product may stratify.

Therefore it is recommended to mix the product in a container before every use.

A layer of paste shall be applied to the metal surface. It can be carried out with:

a) a paint brush – the layer is thin, which makes this an economical solution; unfortunately there will be streaks in the layer characterised in the locally low thickness of the paste, which can lead to less precise marking of fine details

b) spatula – the layer is thicker, which uses more paste; since the layer thickness is homogeneous and it has an appropriate thickness, one obtains very precise marking of fine details.

It is not necessary to wait for the layer to get dry – the paste does not get dry, neither it evaporates.

Aerosol:

Shake the container for 1-2 minutes for a proper mixing of the mixture inside. Shake it once in a while when working with it. Inside the container there is a ball, which helps in a process of mixing. If the nozzle is clogged after previous use, clean it by immersing it in petroleum ether or similar solvent and shaking it.

Spray the product on an element to be processed by holding the aerosol container in a position close to vertical in a 30 cm (1 ft) distance between nozzle and object.

Deposit several thin layers, until the object is covered with uniform coating. Apply the aerosol in such a way, that dripping will not take place.

Wait approximately 3 min for drying. When processing steel, this time may be shorter.

3. Laser irradiation

The layer is irradiated with a CO_2 laser light (favourably CO_2 laser with a power of at least 20 W). A solid, grey-black layer forms in the irradiated areas which provides the marking effect, while engraving and cutting is also available. The cutting parameters can be determined based on the data provided in the further part of the User manual.

Marking

Marking effect can be obtained if one performs one laser run with a defined parameters. File is prepared the same way like for engraving of laminates or other laser materials.

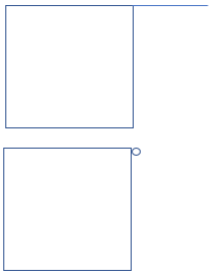
Engraving

Engraving effect is possible if one applies more power or smaller run speeds then in the case of marking. Often it is recommended to have several similar runs, so the initially hardened layer will burn out. File for engraving is prepared the same way like for the engraving of laminates or other laser materials.

Alternatively, if the engraving effect is aimed to be obtained not as a defined area, but just as an engraved path, then one can prepare the same file as for the laser cutting of various materials.

Cutting

To obtain the cutting effect it is necessary to use even more power and smaller run speeds then it is in the case of engraving. There are 2 methods of file preparation:

Using line, circle or point for initial heating of the metal sheet and performing one run of laser processing. If one does not obey this instruction, then several first millimetres will not get cut through. 	Using two runs at desired cutting lines. The first run should be fast and is aimed to harden the layer of paste (like during the marking process), while the second run should be slow and is aimed to cut the metal sheet through.  Thick sheets can also be cut by repeating the operations of applying the paste and irradiation with a laser

Laser cutting file should be prepared the same way it is done, e.g. for cutting acrylic.

It is possible to achieve smoother edges after cutting thin metal sheets by gluing a 1 mm (0.04") cardboard to the bottom side of the metal sheet with a double-sided adhesive tape. This will prevent vibrations and deformations of metal sheet during the processing.

4. Removal of the residual paste or aerosol

After the laser processing on the surface of metal object there will be irradiated areas and not irradiated areas. It is possible to see the effect of the processing if one removes the paste which was not irradiated and cleans the surface of metal. This can be done by wiping the metal object e.g. with a dry paper towel or a cloth. If there are big areas with the paste which was not irradiated, then that paste can be collected and used again. One should be cautious during cleaning, because sharp metal edges cause cuts and bleeding.

Remarks regarding creation of images for direct marking of photos without dedicated software

Creating images on metals during the marking process based on photos may require conducting a series of trials. If the laser software does not allow you to prepare a suitable file, it is suggested to process the photo with tools such as https://www.imag-r.com/ or to transform the photo to black and white (but not to shades of gray) with graphics processing programs.

Example parameters

Reference value: cutting 2 mm (0.08") thick acrylic - CO_2 laser, 80 W x 100% x 30 mm/s (1.2 in/s)

Marking – 1 x 1 mm (0.04 x 0.04") square or bigger, below 10 mm (0.4") Steel, stainless steel, acid-resistant steel, galvanized steel: 80 W x 50% x 80-120 mm/s (3-5 in/s) Aluminium, copper, brass, zinc: 80 W x 50% x 20-80 mm/s (0.8-3 in/s)
Marking – fine details with dimensions below 1 mm (0.04") shall be hardened at speed by the lower range and in the case of very fine elements (e.g. 0.2 mm (0.008") dot) even at speeds of 1/2 of the lower limit, that is e.g. 40 mm/s (1.6 in/s) in the case of steel.
Marking – 10 x 10 mm (0.4 x 0.4") square or bigger Steel, stainless steel, acid-resistant steel, galvanized steel: 80 W x 25% x 100-200 mm/s (4-8 in/s) or 80 W x 50% x 200-300 mm/s (8-12 in/s) Aluminium, copper, brass, zinc: 80 W x 95% x 20-80 mm/s (0.8-3 in/s)

Engraving Steel, stainless steel, acid-resistant steel, galvanized steel: 80 W x 50% x 20-40 mm/s (0.8-1.6 in/s) or at least 2 runs 80 W x 50% x 40-80 mm/s (1.5-3 in/s) or 1) 80 W x 100% x 100 mm/s (4 in/s), 2) 80 W x 100% x 10 mm/s (0.4 in/s)

Cutting Steels with a thickness of 0.1 mm (0.004"): 80 W x 100% x 4 mm/s (0.16 in/s) or 1) 80 W x 100% x 100 mm/s (4 in/s), 2) 80 W x 100% x 10 mm/s (0.4 in/s), 3) 80 W x 100% x 4 mm/s (0.16 in/s) Stainless steel with a thickness of 0.5 mm (0.02"): method 1) 80 W x 100% x 1 mm/s (0.04 in/s) – 3 runs, then 1 run 80 W x 100% x 0.1 mm/s (0.004 in/s) and push the element afterwards; method 2) perform 5 – 10 times a procedure of applying the paste and irradiating it with a laser with parameters 80 W x 100% x 1 mm/s (0.04 in/s) (alternately apply paste and irradiate, apply and irradiate...)

Yield

Paste:
Thin layer: up to 11 m^2/l (118 sq ft/l) (10.7 m^2/kg (115 sq ft/kg)) of paste
Thick layer: up to 6.5 m^2/l (72 sq ft/l) (6.3 m^2/kg (70 sq ft/kg)) of paste
Aerosol:
Thin layer: up to 1 m^2/400 ml container (10.8 sq ft/13.5 fl oz container)

Other remarks

Due to a low thermal conductivity of steel, the size of dot or detail is important for steel, but the size of the steel sheet is less important. For many other processable metals (e.g. aluminium) the irradiation parameters do not change so much with the change of the size of a dot or detail, as they do with the change of the size of a sheet, but it is true just for low sheet dimensions, like 10 x 10 x 0.5 mm (0.4 x 0.4 x 0.02").

Paste thinning

If the paste is too viscous or too dense for a particular application, then it is possible to thin it with a petroleum ether or other volatile simple hydrocarbons like hexane. This can be done by adding the solvent in portions of 5% by volume of paste until the right viscosity is achieved. Then, before laser processing, one needs to wait until the thinner evaporates. Steels are less prone to the negative effect thereof and may be processed after an hour from the application of the thinned paste. In case of aluminium, copper, brass, bronze, zinc it is necessary to wait many hours before the thinner evaporates entirely.

Problem solving

Problem	Solutions
Marking speed is lower than expected.	• Degrease the surface with an organic solvent before deposition of the product. • Apply a thinner layer of the product. In case of paste, this can be done by thinning it according to instructions given above. In case of aerosol, one may deposit a thinner layer by spraying from a higher distance.
Removal of the product after laser processing is too time consuming.	• Apply a thinner layer of the product. In case of paste, this can be done by thinning it according to instructions given above. In case of aerosol, one may deposit a thinner layer by spraying from a higher distance. • Remove the product with a cloth soaked with petroleum ether or similar solvent. • After laser processing put the item in a container with petroleum ether, and after an appropriate time take it out and wipe with a cloth. This solution is suitable for cleaning of many items.
Layer adhesion after marking is too weak, but the laser power is high.	• Before applying the product, metal should be cleaned with a cloth soaked with alcohol or acetone or another solvent with a proper force applied when rubbing. • If this does not help, then the laser speed should be decreased. If this will not help either, then the surface of metal should be treated with sandpaper before deposition of paste.
The layer may be scraped off, when it is hardened on aluminium.	• Before paste application, aluminium may be painted or immersed in a 5% water solution of trisodium phosphate hydrate (time: 5-60 min) to increase the adhesion. After immersion or painting, the aluminium should be rinsed with water and dried prior to paste application.
The layer does not harden during the marking process.	• It is necessary to increase the laser power or decrease the speed.
The layer formed during the marking process has a quite good adhesion to the substrate, but it gets removed after treating it with kerosene.	• It is necessary to increase the laser power or decrease the speed.
The layer formed during the marking process is not uniform.	• It is necessary to increase the laser power or decrease the speed. • If this does not help, then it is recommended to modify the computer file for the marking process.
Removal of the product after laser processing produces scratches on metal surface.	• Try another material for paste removal, e.g. a soft cloth. Use lower pressure when wiping. If needed use a cloth soaked with petroleum ether.
Aerosol instead of giving a uniform coating splashes and yields a non-uniform layer.	• Intensively shake the container before every use. • Try different positions of nozzle head. • It may be necessary to unclog the nozzle. Take off the nozzle and place it in petroleum ether. If needed, unmount the spray head of the nozzle and clean it separately. When dry, assemble everything and make sure that the nozzle head is in position yielding high flow.

	• If this does not help, it may be necessary to unclog the valve. Take off the nozzle and press the valve on the top of aerosol while making sure that it will spray in a safe direction.
One obtains different results for marking small and thin elements and for big elements made of the same material.	• Small elements easily get hot, which changes the marking conditions. • It is recommended to decrease the laser power or to increase the speed.
The layer formed during the marking process crumbles when one cuts the element, which can be observed in a close vicinity of circa 1 mm from the cutting line.	• The marking process should be carried out after the final cutting of the element.
A grey layer like in the marking process is obtained instead of engraving.	• It is necessary to increase the laser power or decrease the speed. Alternatively one can repeat the laser processing program.
Sheet metal bends during processing.	• It is necessary to decrease the laser power or to increase the speed. If the quality of marking or engraving is too poor, then it is recommended to perform several such mild runs. • Alternatively, one can modify the file for laser processing, so such situation will not occur any more.
Sheet metal does not get cut through.	• Make sure, that the laser works fine and its power is well adjusted within the working area. • Increase the laser power or decrease the speed thereof. • If the aforementioned procedure does not help, then instead of one slow run perform one fast run and one slow later.
Within the first several millimetres of the cutting line, the sheet metal does not get cut through.	• It is recommended to use an additional line or a point right before starting cutting the desired line. It will make the sheet get an appropriate temperature.
The edge after cutting is rough.	• One should carry out two runs - the first one should be fast, while the second one slow. During the first, fast run the layer will initially harden, while during the second one metal will get cut.
Marking of an image produces a uniformly black picture.	• One should change the marking file - decrease the brightness before the Newsprint transformation. • It can be beneficial to decrease the resolution.
Marking of an image produces empty spots and big black spots during the same marking job.	• It is recommended to change the marking file - decrease the contrast before the Newsprint transformation.
Marking of a thin sheet metal with a graphics with a big area to irradiate (e.g. a big black square) makes the sheet bend.	• The sheet eventually heats up and bends. It is necessary to either introduce time breaks after each line or to decrease the laser power or to increase the speed or to decrease line density.
Marking with high power laser parameters makes the sheet bend, while the low power parameters produce low adhesion layer.	• It is necessary to either introduce time breaks after each line or to adjust laser power and speed or to decrease line density.
After marking one can notice bands and overexposed spots. It is particularly present when marking relatively big surfaces.	The problems may be a result of uneven distribution of paste on the object, which in fact may be a result of either uneven application of paste or the flow of paste under the influence of compressed air.

	Possible routes of overcoming the issue: • application of thicker and more even layers of paste • decreasing line density • disabling air blow or decreasing the flow of compressed air.
The obtained marking pattern is grey or non uniform.	The layer of preparation is too thin during laser processing or it is being burnt. It is recommended to: • work with one run only with lower laser run speed instead of doing several runs with higher speed • deposit thicker layer of paste • decrease line density • disabling air blow or decreasing the flow of compressed air
A grey-black pattern is obtained during marking, while a black colour is needed.	• Normally when used for marking, Grafmetal yields grey-black patterns. If one wishes to obtain deeply black colour, then it is necessary to deposit Grafmetal and perform laser marking on a marking pattern that was already obtained with the preparation before.
Marking of a thin sheet metal with a graphics with a big area to irradiate (e.g. a big black square) initially gives good results, but they get worse with time and finally one does not get any marking effect.	• The sheet heats up and the paste heats up as well, so it get temperatures so high that it does not have the useful properties any more. • It is necessary to either introduce breaks during the process or to decrease the laser power or to increase the speed or to reduce line density.
Using the product for a long time, e.g. many marked objects or marking a very big element with a big area to be irradiated, makes the laser power decrease by itself. It works worse during metal marking as well as during any other laser job, like cutting acrylic.	• Probably due to an insufficient ventilation, the soot which formed during the process deposited on optical elements of the laser. It is necessary to clean them with a cotton cloth after soaking it with isopropyl alcohol. After application of isopropyl alcohol, before using the laser for the subsequent time, one should wait until the solvent evaporates. Any works shall be carried out while the laser power supply is turned off. It is necessary to be cautious while cleaning the optical elements, so they will not get damaged. One can consider marking with the laser cover opened to solve the ventilation problem, provided that appropriate safety measures will be taken.
The paste is too thin.	• Probably due to a storage in a too high temperature or exposition to sunlight the paste stratified. It is necessary to mix the upper thinner part of the paste with the thicker part at the bottom of the container.
The paste is too thick.	• Probably due to a storage in a too high temperature or exposition to sunlight the paste stratified. The upper, thinner, part of the product was used and the lower part remains in the container. An alternative reason may be a paste leak or other inappropriate storing way. At this stage it is only possible to add a volatile solvent in a form of petroleum ether or hexane, however, after deposition and before laser irradiation it is then necessary to wait until solvent entirely evaporates, which is particularly important in case of aluminium, copper, brass, bronze, zinc. This may require to adjust laser processing parameters again.

During laser processing a flame can be observed. There are flakes flying in a laser processing chamber. The quality of the marked layer is inadequate.	• Probably the laser air blow is is not working, so it is necessary to correct it. Alternatively, one can use slower and weaker laser runs or breaks between runs.
The paste does not work properly when working with thin or small elements	• The element may be overheating. One may apply additional waiting time of laser after each line. • An alternative solution is to increase heat dissipation, e.g. by placing a thick substrate underneath the element and by application of thermoconductive paste between the element and the substrate.
Aerosol nozzle is blocked.	• Remove the nozzle and press the valve for a short amount of time – pay attention to escaping gas! Clean the nozzle with a solvent like petroleum ether and place it back on an aerosol.
Clothes got stained with the preparation.	• It is necessary to hand wash the clothes multiple times by using plenty of dishwashing fluid. Afterwards one can wash them multiple times until desired effect is achieved.

THE PRODUCT IS INTENDED FOR PROFESSIONAL USE ONLY. THE PRODUCER IS NOT RESPONSIBLE FOR ANY INCORRECT USE THEREOF.

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