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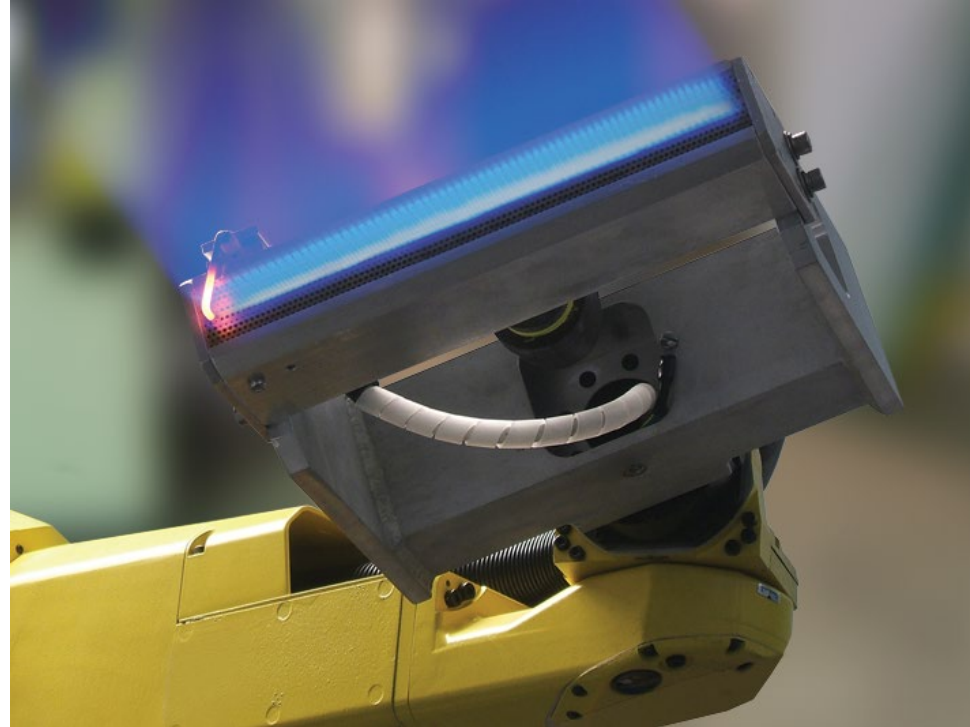
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Getting Started with Flame Plasma Surface Treatment

digital book series



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One of the most important requirements for adhesion is the condition of the surface prior to **bonding with inks, coatings & adhesives**.

In-line flame plasma treating systems are proven to **improve adhesion** properties on a wide variety of surfaces.

Benefits of in-line surface treatment include **stronger bonds**, faster line speeds, and improved product quality.

This ebook covers the basics of **flame plasma surface treatment** and the technologies available for specific applications.



Chapter 1

Why Inks, Coatings & Adhesives Need Help Bonding to Surfaces

**Controlling surface variables
re key to successful adhesion**



Factors affecting Adhesion Dynamics

Material type

Performance-aiding additive load

Adhesive chemistry

Bond stress

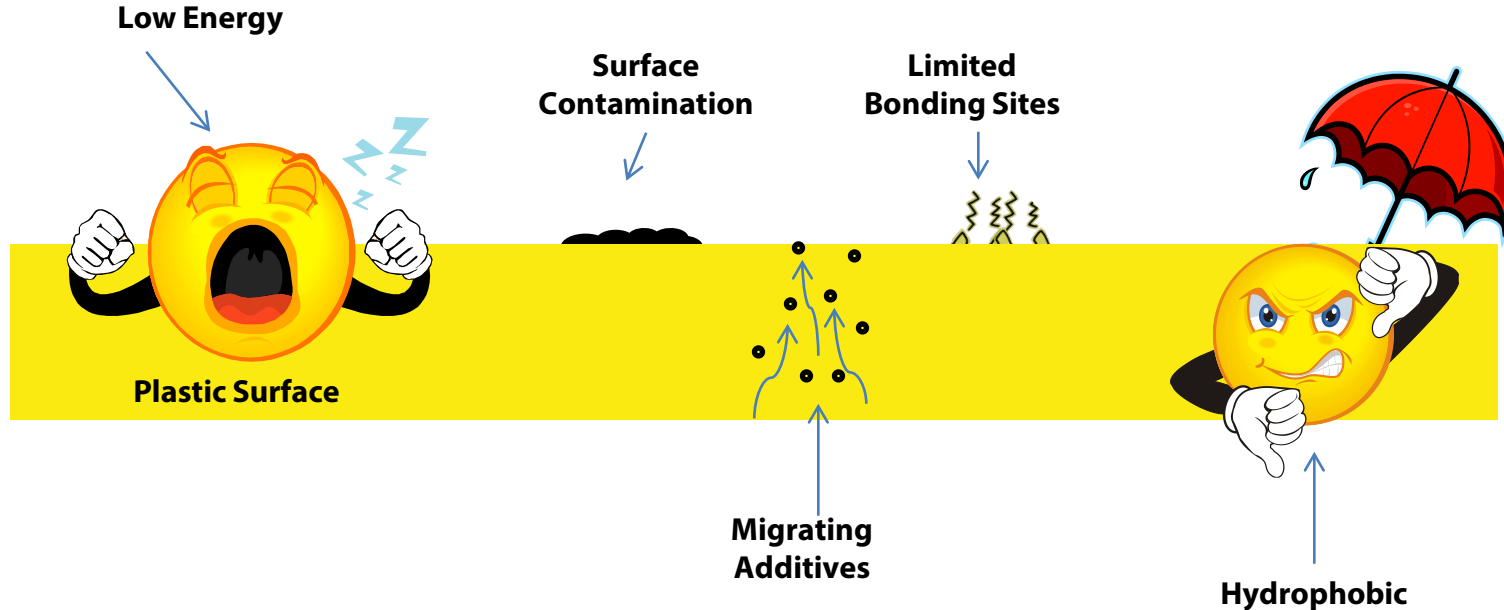
Surface contaminants

Surface roughness

Surface chemistry

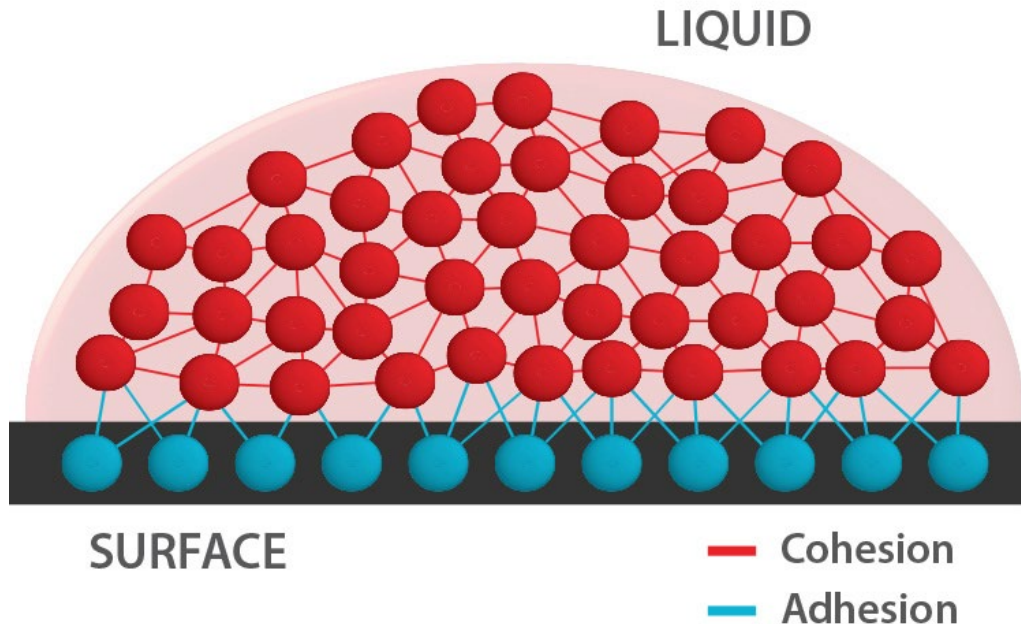


Common Adhesion Impediments Found on Plastic Surfaces



Plastics are generally composed of non polar long-chain molecules with non porous and hydrophobic surfaces. They have low surface energy with few available bonding sites due to low levels of charged ions on the surface. Additionally any type of surface contamination negatively effects adhesion. This includes material additives & release agents which can migrate to the surface

How the Forces of Cohesion & Adhesion affect Wetting Out



Low energy, lack of bonding sites, and surface contamination have a negative impact on molecular attraction, causing liquids to fail to wet the surface.

In simple terms:

When you observe a liquid beading up on a surface you are witnessing **the forces of cohesion** (the property of the liquid's like molecules to remain attracted) being stronger than the **forces of adhesion** (the property of unlike molecules to attract.)

Examples of Poor Adhesion



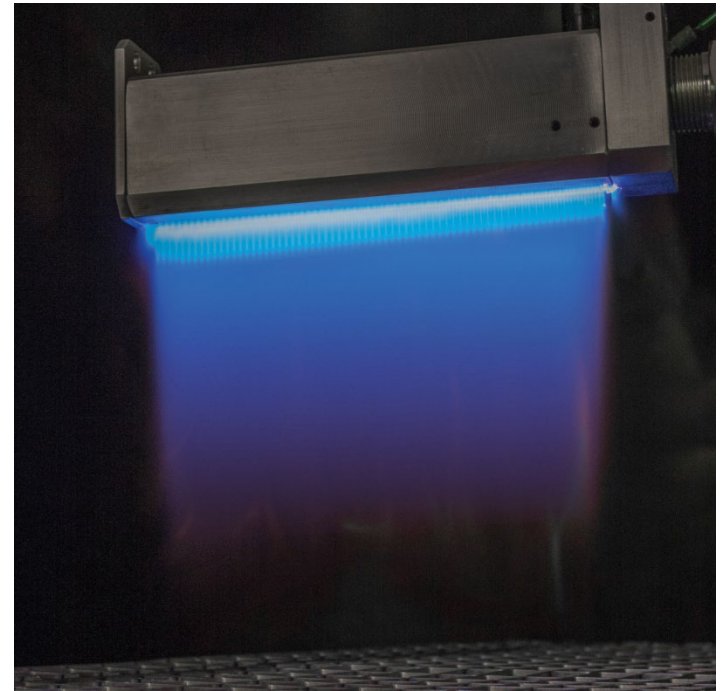
Poor adhesion resulting from surface issues appear in a variety of ways:

- **Inconsistent ink adhesion**
- **Label adhesive failures**
- **Failure of coatings to wet out**
- **Bond strength failures**

Chapter 2

How Flame Plasma Treatment Improves Adhesion

**Flame plasma
cleans, etches and functionalizes
surfaces to improve adhesion**



What is flame plasma?

plasma : n ; “Fourth state of matter”, (Solid, Liquid, Gas, Plasma.)

Flame plasma forms when a hydrocarbon gas and atmospheric air are combined.

Flame plasma surface treaters generate plasma to impart adhesion promotion onto a wide range of surfaces.

Adhesion Promoting Surface Effects

Cleans Surfaces

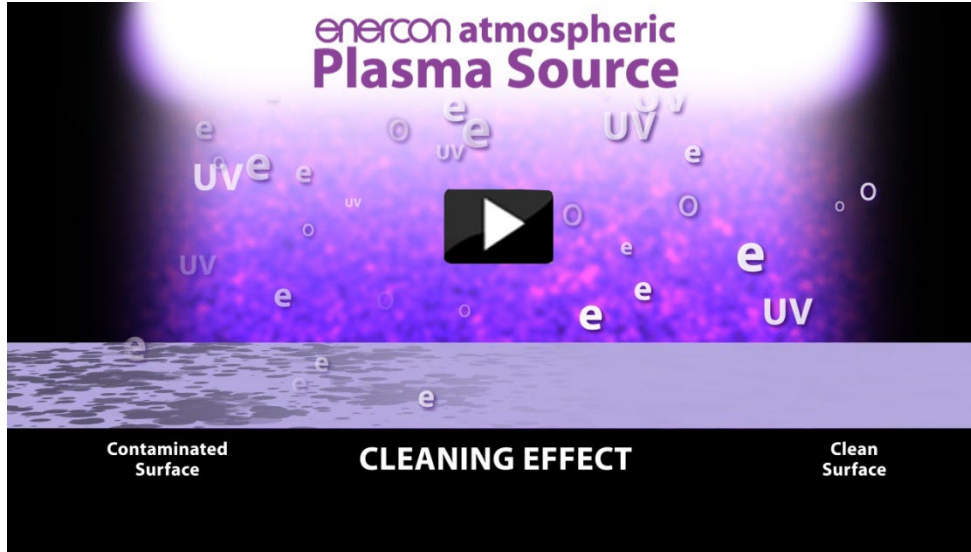
Etches Surfaces

Functionalizes
Surfaces

Flame Plasma is highly effective at **cleaning, etching & functionalizing** a variety of surfaces.

The following pages will provide insights into how flame plasma achieves these effects and how they help promote adhesion.

Plasma Cleaning



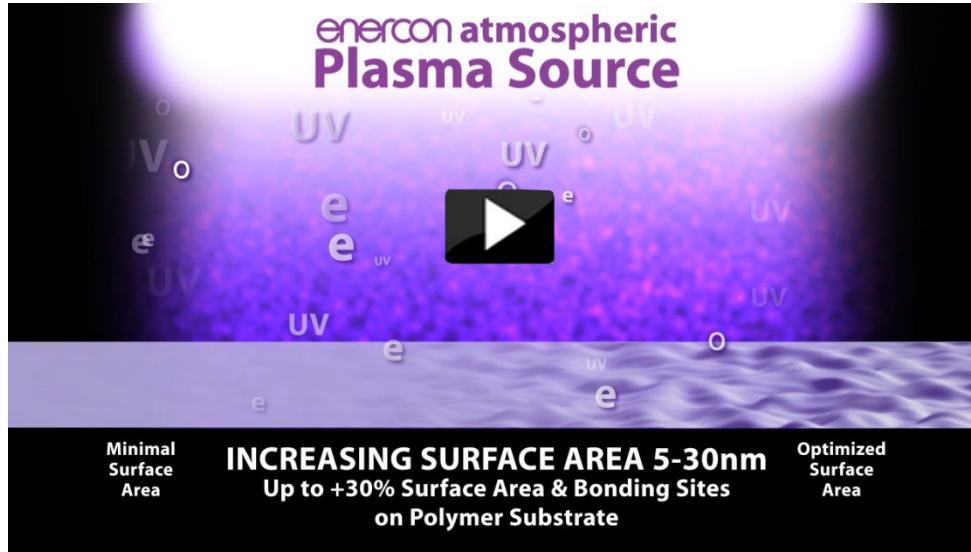
Plasma treatment **removes organic and inorganic impurities & contaminants** from the surface.

Plasma species react with the surface and decompose, volatilize & vaporize low molecular weight contaminants to expose a clean, fresh surface to promote adhesion.

Click the image above to see an animation of plasma cleaning.

Cleans Surfaces

Plasma Etching



Micro etching of a polymer surface is accomplished as charged ions, neutral atoms and radicals, in both the plasma forming gas and the reactive process gas, bombard the surface.

Increasing surface area creates more bonding sites which promotes adhesion success.

Click the image above to see an animation of plasma etching.

Etches Surfaces

Plasma Functionalizing and Activation



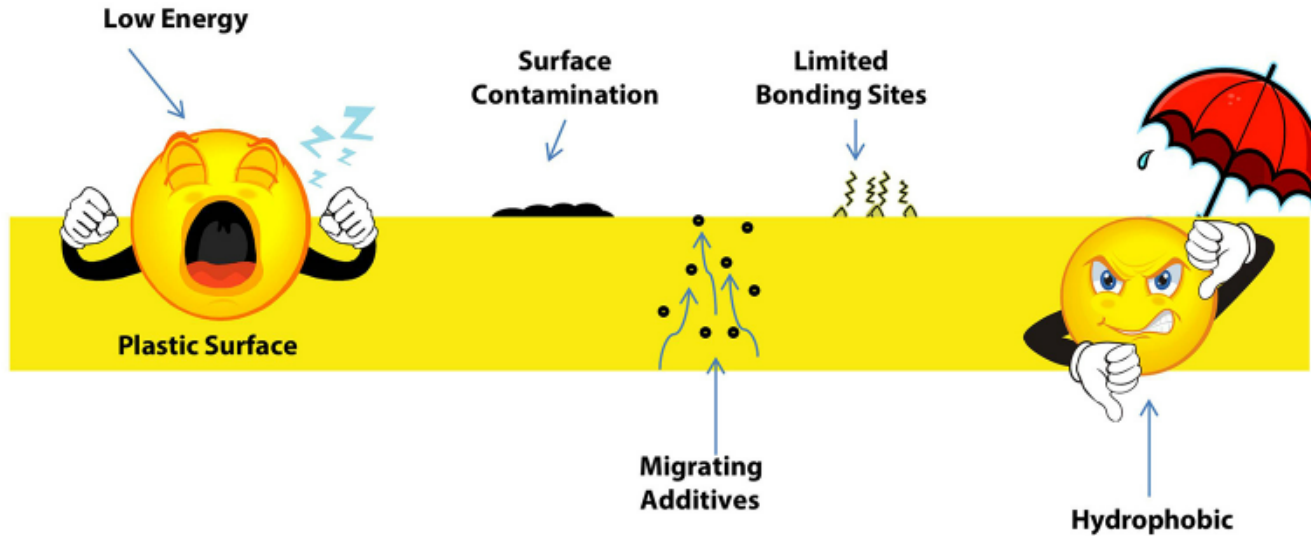
Plasma activation or functionalization is the concurrent process of using radicals & small amounts of UV radiation to break up surface polymer bands to create cross linking of surface molecules.

This process **increases polar groups** which directly contributes to the surface's adhesion properties.

Click the image above to see an animation of plasma functionalizing.

Functionalizes Surfaces

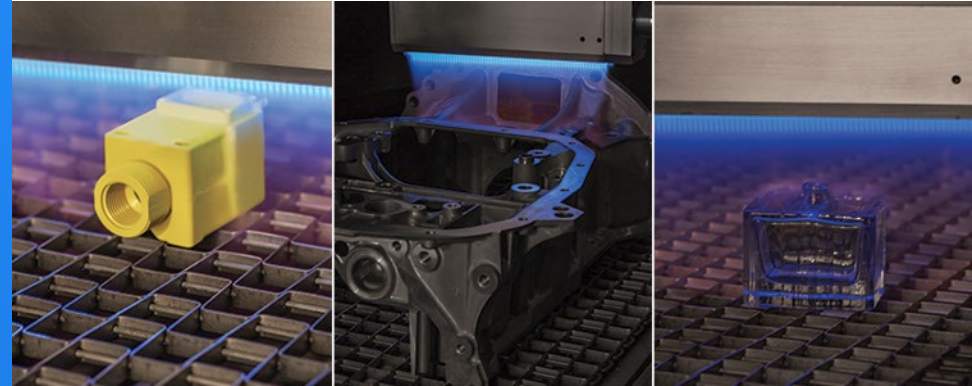
The Transformation of a Surface Prepared for Adhesion



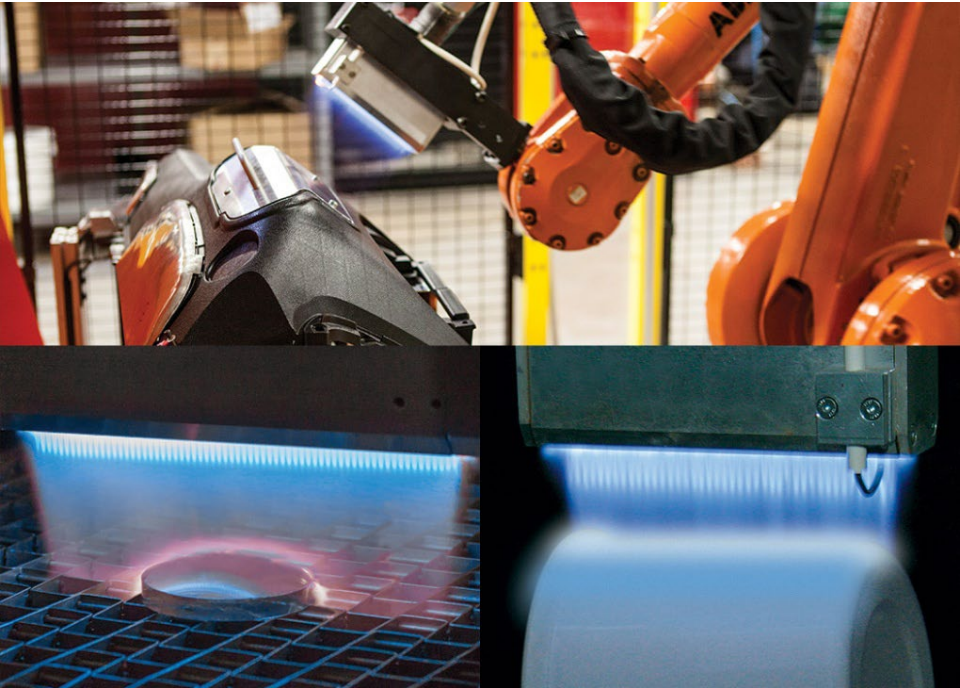
Chapter 3

What type of surfaces
can be treated?

**Flame Plasma Treatment effectively
treats plastics, metals and glass**



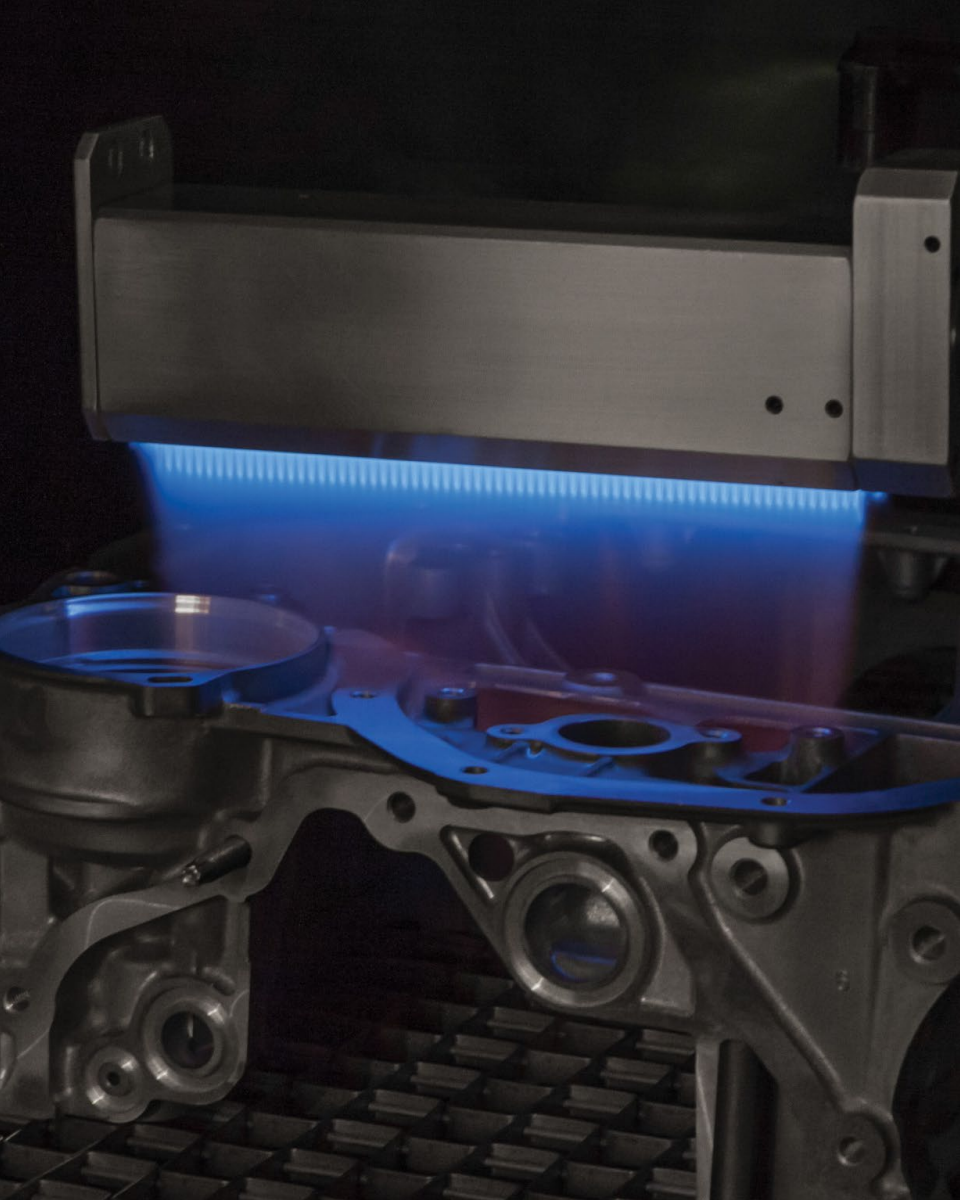
Surface Treatment Plastics



Flame Plasma Surface Treatment is effective at treating a wide variety of plastics and polymers.

Some of the more common plastics requiring treatment include:

ABS, BOPP, PE, PET, PP, TPU & more



Surface Treatment Metals

Flame plasma surface treatment effectively treats metals by removing oils and other contaminants from the surface.

Flame plasma can also functionalize the surface (i.e. increase carboxyl groups) to further promote adhesion.



Surface Treatment Glass

Flame plasma surface treatment is effective at **treating glass for the purposes of cleaning and sterilization.**

Atmospheric plasma treatment may be used to treat glass as well.

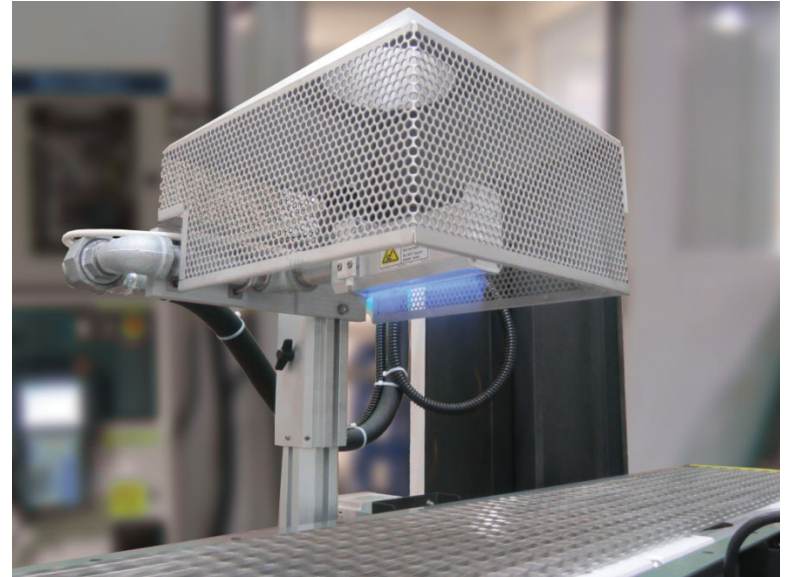


**Is Flame right for you?
Ask an application expert
[Click](#) or call 1-262 255-6070**

Chapter 4

How can I tell if surface treatment changed the surface?

There are number of methods to determine the effectiveness of surface treatment.



Determining the Effects of Surface Treatment

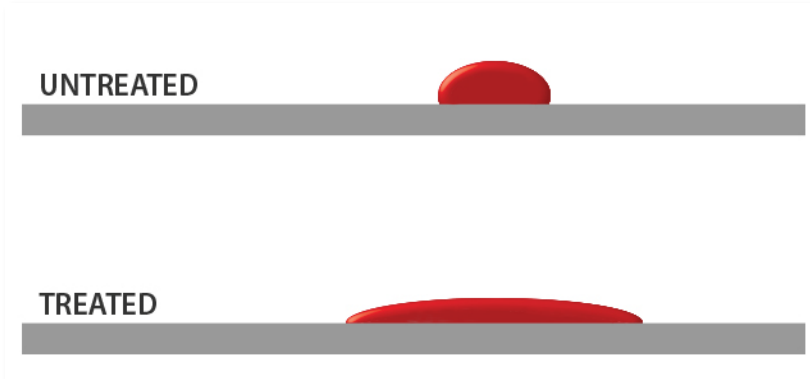


In most cases a surface that has been flame plasma treated will show no change to the human eye.

We'll review a number of different test methods designed to determine the effectiveness of surface treatment.

Its important to remember **the most important test is the success or failure of your ultimate bonding process**, whether that be printing, painting, coating or bonding.

Visually Seeing Results of Flame Plasma Surface Treatment



Instant examples of improved adhesion from surface treating can be observed by watching an ink or adhesive droplet wet out on a surface as shown in the examples to the left.

The liquid on the untreated surfaces fails to wet out whereas the treated surface enables wetting out.



Measuring Surface Energy in Dynes



A popular way of determining the effect of surface treatment is to **measure its change in surface energy with dyne solutions.**

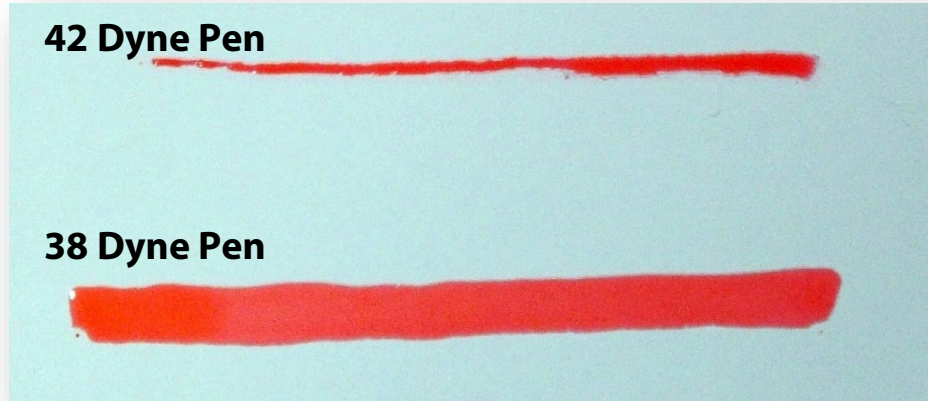
Dyne solutions are calibrated liquids that measure surface energy. They are available in bottles and pens.

Often your ink or adhesive supplier will recommend a specific minimum surface dyne level for adhesion success.



[Click here for more information on dyne testing](#)

Considerations Regarding Dyne Levels



The solid line created by the 38 dyne pen indicates a surface energy of at least 38 dynes. The 42 dyne pen's ink did not wet out indicating a dyne level less than 42 dynes.

Dyne level readings are subjective
 ± 2 dynes is a safe margin of error.

Higher dyne levels and adhesion
In general higher dyne levels are better for adhesion, but once the dyne level threshold for successful adhesion is reached, there are not significant benefits to striving for even higher levels.

Dyne levels do not guarantee adhesion
Dyne level is one of many factors that contribute to adhesion, therefore it is only an indicator of your chances of success.

Surface Treatment Plastics Typical Starting Dynes

Material	Initial Dyne Level	Post Treatment Dyne Level
ABS	31-35	44-72
ETFE	30>	50
ETFE	30>	50
Flexible PVC	33-36	40-56
PEEK	30	>72
PET	35	44-60

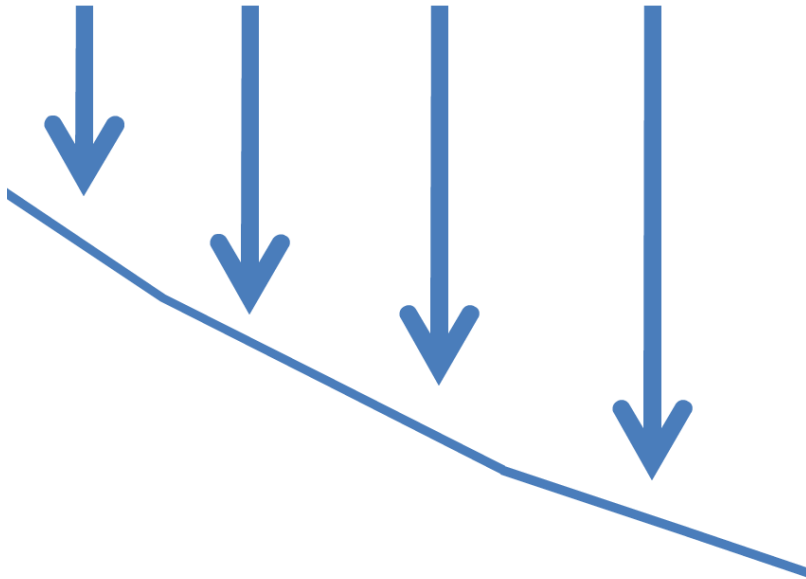
Material	Initial Dyne Level	Post Treatment Dyne Level
Polycarbonate	37	56-72
Polyethylene	32-34	42-60+
Polypropylene	30-34	45-60
Polystyrene	36	52-70
PTFE	30>	50
Rigid PVC	33-36	42-60+
TPU	34	48

Several factors can impact initial and post treatment dyne level readings.
The chart above is provided as a general guideline of typical results.

Considerations Regarding Dyne Levels

- Dyne Level Reducing Factors -

Time Humidity Additives Contamination



Dyne level decay rate vary based on environmental and material factors.

Treatment life may vary from hours to several months.

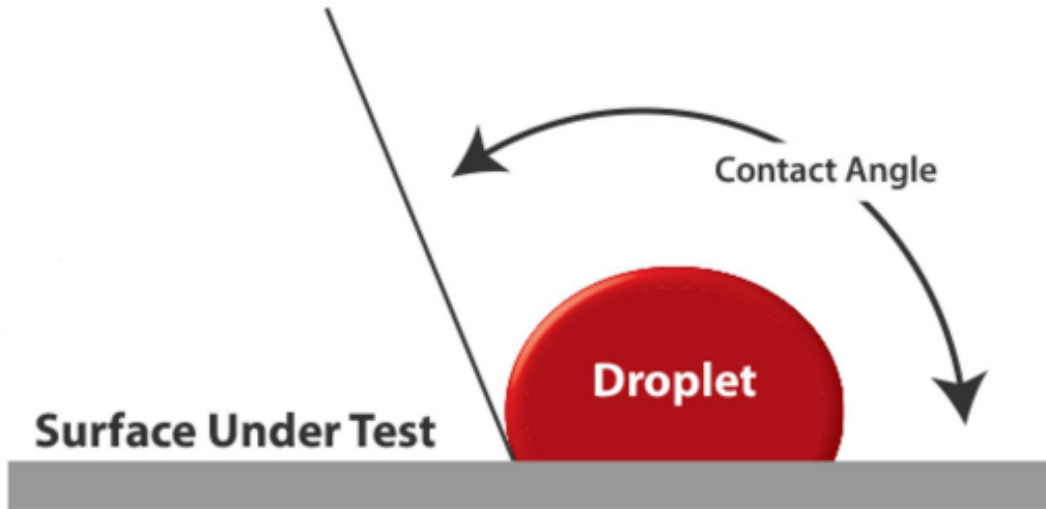
Special care should be taken when handling any surface after it has been treated to not contaminate the surface.

Since dyne levels decay over time it is a best practice to print, coat, paint, laminate or bond to a surface as soon as possible after treatment.

Contact Angle Measurement

Contact angle measures the interaction of a liquid with a solid.

Water droplets which do not run at low angles indicate the material has a high surface energy.



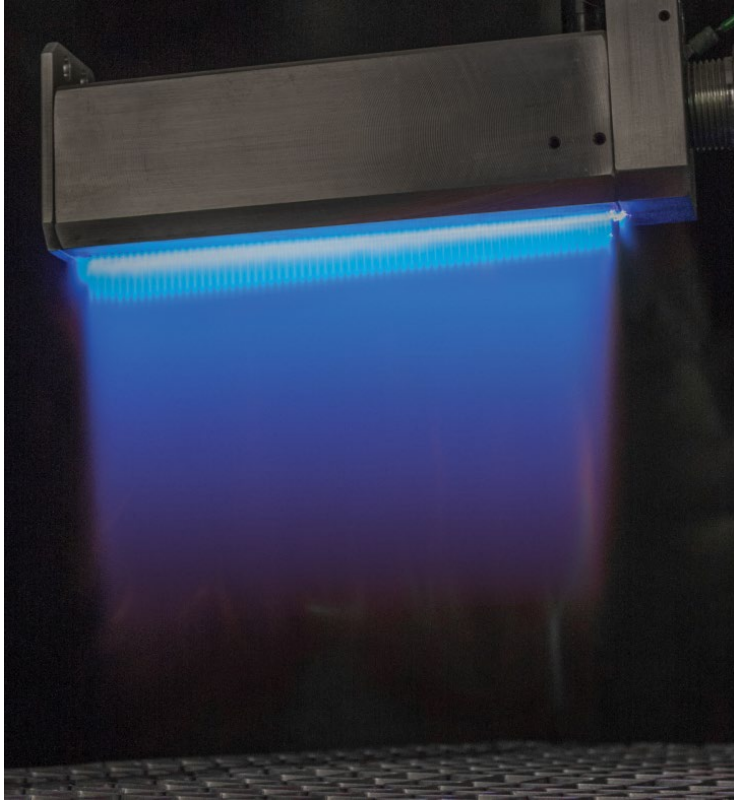
Chapter 5

Flame Series Plasma Treaters & Interconnections

Understanding the capabilities of your Flame Plasma Treater is key to success.



Flame Plasma Characteristics



- Ideal for a wide range of applications
- Uniform treatment for any flat or three-dimensional surface
- Wide treatment patterns
- Operates on natural gas or propane
- Treats conductive and non-conductive materials

How Flame Plasma Treatment Works

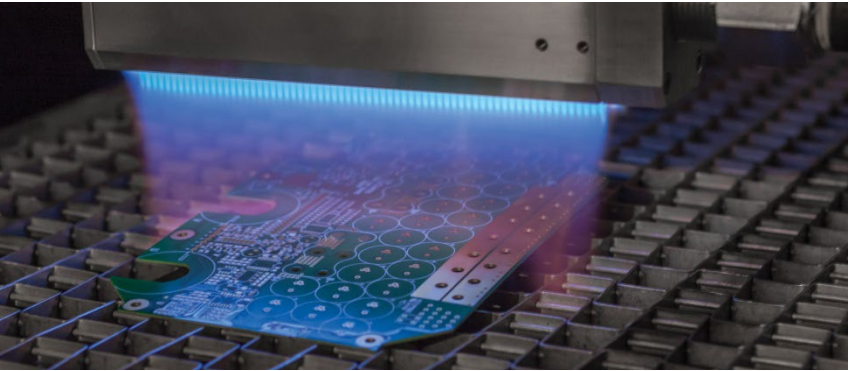


A plasma field is formed when flammable gas and air are combined and combusted to form an intense blue flame.

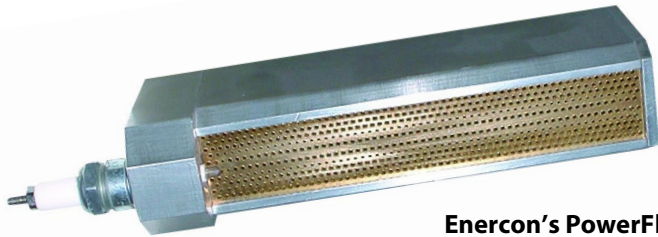
Flame Plasma Treatment offers a safe and reliable means of treatment for virtually any three-dimensional surface.

Treatment is fast, delicate and provides long lasting results.

Enercon's PowerFlame™ High Velocity Burner Technology



- High-velocity ports for powerful treatment
- Multiple burner designs for optimal dwell time
- Uniform treatment across entire width of burner
- Eliminates laning or striations
- Brass inserts are easily removed for cleaning
- Variable treat widths utilizing burner decking



**Enercon's PowerFlame™
High Velocity Burner**

Advanced Combustion Control



- Air/gas ratio control provides a consistent flame over the entire power adjustment range
- Flow meters for air & gas provide precise reproduction of process parameters
- Adjust flame power with a single control
- Operate on natural gas or propane

Enercon's Flame Plasma Safety Features

FAIL SAFE DESIGN

Stops gas flow if any critical device in the cabinet fails

SAFETY SOLENOID VALVES

Redundant valves in the gas train immediately prevent gas flow if any of the monitored variables are not satisfied.

PRESSURE SWITCHES

Mounted to air and gas lines to detect adequate pressure

REVERSE FLOW VALVE

Prevents backflow into the gas line

FLAME DETECTION ELECTRODE

Works in conjunction with the flame safety relay to monitor the presence of the flame at the burner.

FLAME SAFETY RELAY

Monitors flame & controls the redundant safety solenoid gas line valves

Integrating Flame Plasma Treaters into your process



Fixed Location Treatment Head

Parts are conveyed, indexed or otherwise presented to the treatment head.

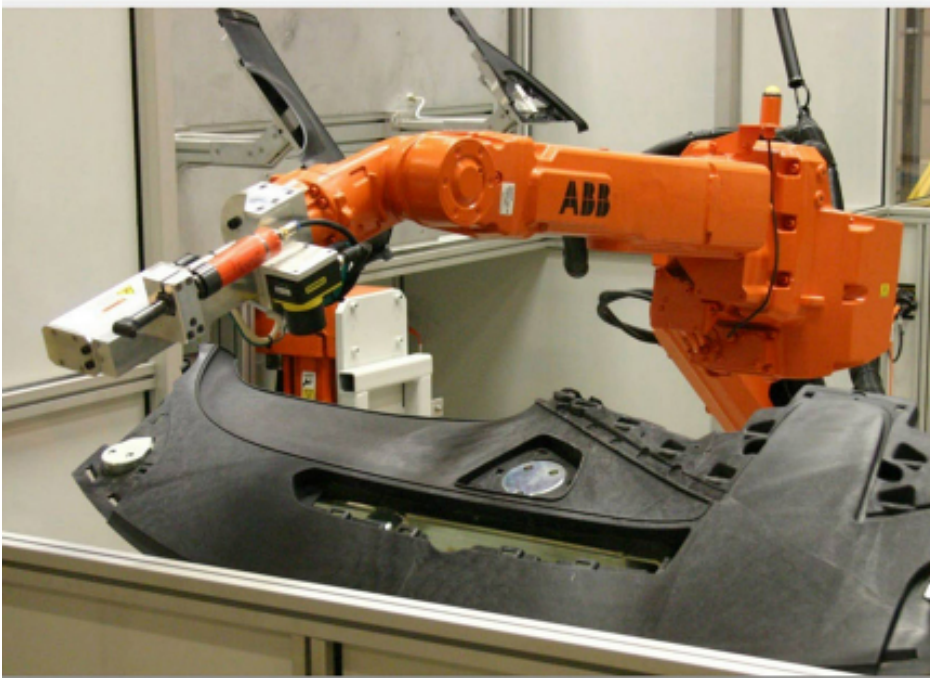
Moving Treatment Head

Head can be indexed or robotically controlled to follow precise treatment patterns.

Films & Webs

Ideal for high speed lines.

Flame Plasma Treatment in Action



Flame Series™ Plasma Treaters may be integrated with robotics to follow precise treatment paths.

In this application, surface energy on an automotive dashboard is increased to improve leather adhesion.

[See story on this application.](#)

Flame Plasma Treatment in Action



The video to the left shows a **Flame Plasma Treater** treating automotive parts.

The resulting increase in surface energy improved leather adhesion.

Flame Plasma Treatment in Action

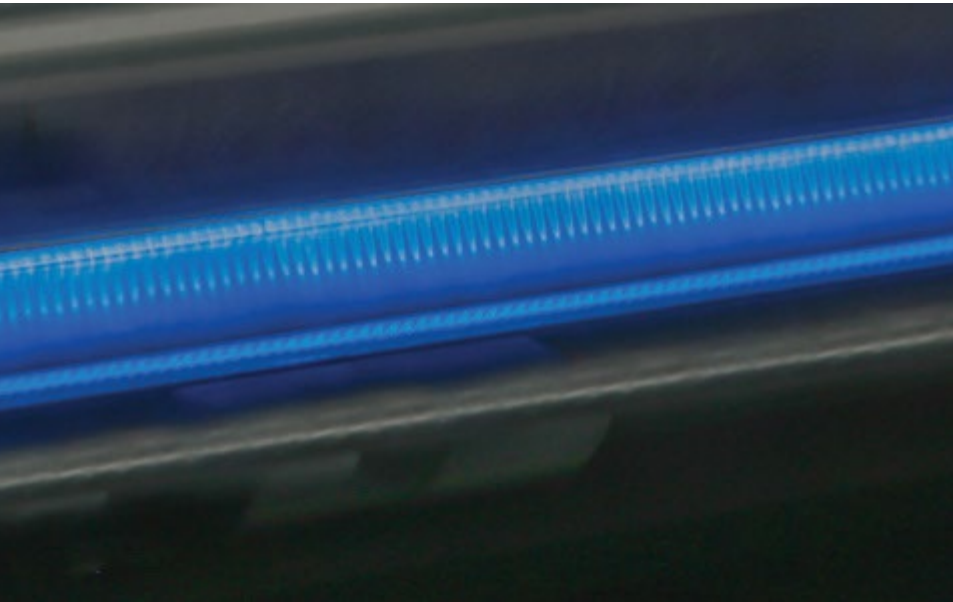


These photos show a **Flame Plasma Treater integrated over a conveyor.**

Plastic caps are treated prior to printing to improve ink adhesion.

[Click here to read a story on this application on our website.](#)

Flame Plasma Treatment for Webs



Flame Plasma Treaters are available in virtually any web width and are ideal for high speed converting and extrusion coating lines.

Flame Plasma Treatment Benefits

- High treatment levels
- Low treatment decay rates
- No backside treatment
- No pin-holing
- No ozone, solvent or UV emissions
- Cost effective process
- No off taste
- No film/product odor
- Surface decontamination

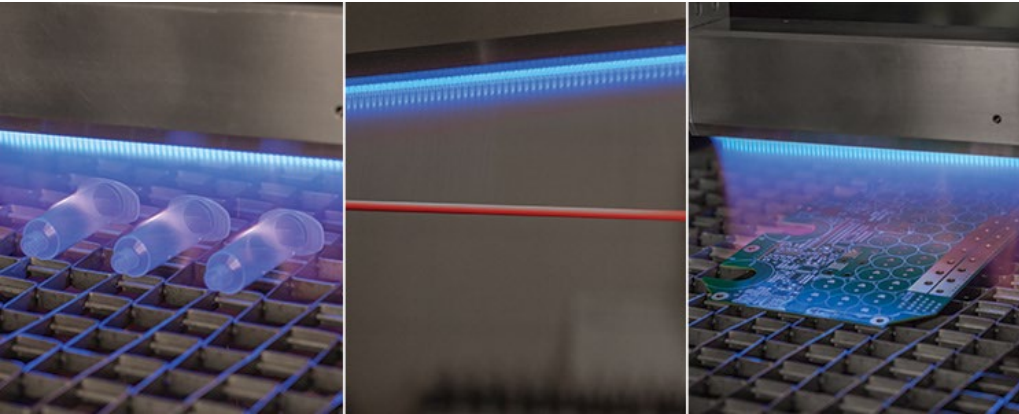
Chapter 6

Getting Started... Review, Free Lab Trials & Enercon Industries

**Putting your application to the test
is the best way to find the optimal
surface treating solution**



Flame Plasma Surface Treating Review



Flame plasma treatment cleans, etches and functionalizes surfaces to improve wettability & adhesion.

Flame plasma treaters are effective at treating plastics, metals and glass surfaces.

Treatment levels decay over time so it is best practice to use treated surfaces as soon as possible.

There are many factors that contribute to adhesion, dyne level is one of them.

Putting Your Application to the Test



What material is the part?
Conductive or non-conductive?
Areas to be treated (one or more sides).
How is the part handled?
Speed, cycle time vs. output?
Volume?

Enercon offers **free laboratory trials** with flame plasma systems.

We can also help you decide if **blow-ion, blown-arc or variable chemistry plasma treatment** might be better suited to meet your application requirements.

Global Perspective and Local Support from a World Leader



For over 40 years Enercon has brought innovative and cost-effective solutions to manufacturers.

Our team is committed to your success & will provide you the finest application expertise & product support.

We invite you to consult with us on your next project.



Enercon's global operations are supported by an international network of equipment and application experts who provide you with global perspective and local support.

Innovative People. Ensuring Your Treating Success.



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Surface Treating. It's our passion.
And, we'd love to help you get started
with your next project.

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decades of application expertise and
steadfast commitment to your success.

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