

Bodycote Thermal Processing – Livonia  
31888 Glendale  
Livonia  
Michigan  
41850

Tel +1 734 427 6814  
Fax +1 734 266 9247

**Bodycote Thermal Processing Livonia**

**North American Business Unit Headquarters**

**Bodycote Thermal Processing**  
5001 LBJ Freeway, Suite 800  
Dallas  
Texas  
75244  
Tel +1 214 904 2420  
Fax +1 214 904 2424

**Bodycote Hot Isostatic Pressing**  
155 River Street  
Andover  
Massachusetts  
01810  
Tel +1 978 470 1620  
Fax +1 978 475 2951

**Bodycote Materials Testing USA**  
7530 Frontage Road  
Skokie  
Illinois  
60077  
Tel: +1 888 263 9268  
Fax: +1 847 676 3065

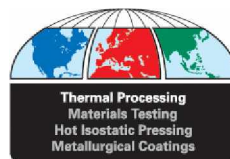
**Bodycote Metallurgical Coatings**  
7856 McCloud Road  
Greensboro  
North Carolina  
27409  
Tel: +1 336 665 0005  
Fax: +1 336 665 0035

**Bodycote Materials Testing Canada**  
2395 Speakman Drive  
Mississauga  
Ontario  
L5K 1B3  
Tel: +1 866 263 9268  
Fax: +1 905 823 1446



[www.bodycote.com](http://www.bodycote.com)

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**Bodycote**



## Livonia Plant Profile

### Bodycote Thermal Processing offers the finest heat treating services available

As a business unit of Bodycote International plc, Bodycote Thermal Processing is the world's largest provider of commercial heat treatment and metal joining services. From more than 240 locations in 21 countries, Bodycote offers a complete network of engineering, heat treatment and metal joining technologies utilizing the most advanced processing equipment. This network of engineers along with the largest array of heat treating processes and processing equipment available provides our customers with the resources to service many needs and solve their heat treat related problems. Bodycote can meet stringent specifications and has a commitment to quality and service that is unparalleled.

Bodycote Livonia is a world class center for low pressure carburizing with high pressure gas quenching. This new technology is the state of the art and represents the future of carburizing processes. Our proven processes are designed to meet specifications with a commitment to quality and service that is unparalleled. The Livonia location is compliant to the Bodycote Management System (BMS) used by all Bodycote Thermal Processing locations in North America. We are proud to offer this new technology to the metalworking industries on a commercial basis and believe many companies will benefit from its advantages.

### Low Pressure Carburizing (LPC) with High Pressure Gas Quenching (HSGQ)

Low Pressure Carburizing (LPC) is an advanced technology that offers the design engineer an alternative to atmosphere carburizing for:

- Improved dimensional control
- Unprecedented part cleanliness
- Improved fatigue properties
- Elimination of intergranular oxides
- Greater depth of high hardness for a given case depth
- Improved case depth uniformity
- Flexibility of cooling rates during quench to better control post heat treatment dimensions and mechanical properties

LPC is a method of carburizing parts under partial vacuum conditions that can place a hard carburized case on parts while eliminating any intergranular oxides, maintaining bright surfaces throughout the heat treatment, and gas quenching to hold critical tight dimensional tolerances.

LPC has been successfully applied to a number of different components including: gears, shafts, bearings, tool holders, and fuel injection components to name a few. Industrial sectors such as automotive, aerospace, gearing, off-road, racing, farm implement, mining, oil field, dies, and tools have found particular benefits from this process.

Recent advances in high pressure gas quenching technology has made this new technology attractive since parts may now be quenched using inert gas rather than oil. This allows for less dimensional movement and clean surfaces after heat treatment. Without these recent innovations, low pressure carburizing would not offer those attractive benefits.



Low pressure carburizing (LPC) cell at Bodycote Livonia



Fully automated handling equipment moves parts through cleaning, preheating, carburizing, quenching and tempering operations in the cell

### Enhanced Mechanical Properties

Since the LPC process is done under partial vacuum conditions, intergranular oxides, common to atmosphere carburizing, are eliminated. These intergranular oxides are brittle oxides that form during atmosphere carburizing between the grains of a metal part. Research has shown that these oxides are the origin of fatigue failures in many carburized parts such as gears. One benefit of LPC over atmosphere carburizing is the elimination of intergranular oxides leading to longer fatigue life of carburized components.

Another benefit of LPC is having higher hardness present at a deeper depth for any given case depth. The carbon gradient profile that results from the LPC process yields this type of case with better strength properties and deeper hardness penetration.

### Improved Dimensional Control

Quenching of carburized parts from the LPC process is done with high pressure nitrogen gas. The cooling rates of the high pressure gas quench is slower than that of oil, salt, polymer, or water quenches commonly used in atmosphere carburizing. This slower cooling rate allows for better retention of critical tight dimensions and can lead to reduced grind stock allowances and savings in post-heat treat machining. The LPC process is also a candidate to replace costly press quenching processes as well. Because the gas quenching can be performed at a variety of pressures (up to 20 bars) and fan speeds, the cooling rates may be customized for each application to meet specified mechanical and microstructural requirements while yielding the lowest possible dimensional movement. This flexibility of cooling rates is not possible with atmosphere carburizing and is another major benefit of the LPC process.



Bodycote – Livonia, Michigan

### Improved Part Cleanliness

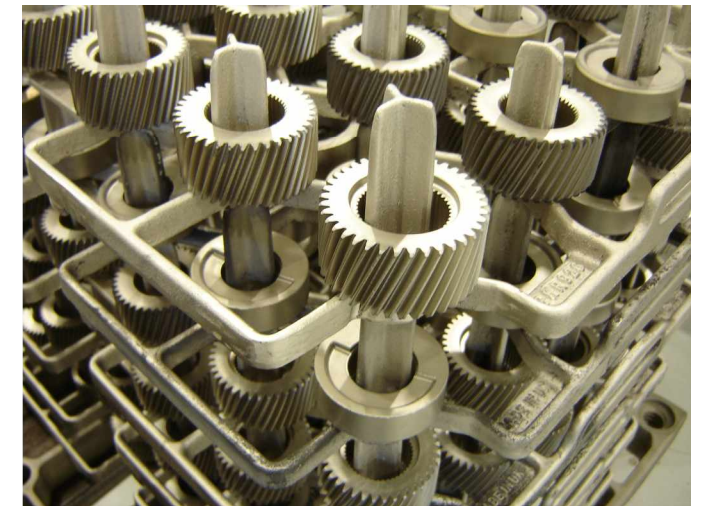
The LPC process is done under vacuum and quenched using inert nitrogen gas. Low pressure carburized parts exit the process completely bright without being discolored or blemished. In many cases, it is difficult to distinguish a heat treated part from a non-heat treated part. Bodycote-Livonia is capable of intentionally discoloring parts in those cases where customers are concerned about mixing heat treated and non-heat treated product.

### Full Automation

Our low pressure carburizing is done in a fully automated cell where our customers parts are handled only when they are loaded and unloaded from the cell. Parts are transferred from operation to operation in a fully automated manner and are not at risk of being damaged by human handling

### Computer Controls & Furnace Monitoring

Every operation that takes place in our LPC cell is completely computer controlled and monitored to provide the most consistent and repeatable results possible. Process capability and maintaining statistical process control is paramount in providing customers with the best quality of heat treatment possible.



Transmission gears fixtured for LPC process

