Cryogenic Treatment
for Performance Engines

"What is Cryogenic Treatment?"

Cryogenic treatment of engine parts is a relatively new technology and is a continuation of the science of thermal or "heat treatment" of various materials. While many people are familiar with the term "heat treatment", it is often assumed that raising the temperature of a material and allowing it to cool is the only way to alter its characteristics. During the heat treatment process, the methods of heating and cooling the material are an important part of the procedure, but it has been found that further cooling of the part to temperatures to as low as negative 300°F can continue the transformation of the material and add additional benefits.

Engine builders and machinists have traditionally noted that parts that have been "seasoned" – allowed to go through numerous heating and cooling cycles, are more dimensionally stable for machining and remain more stable during use. This is especially true of parts that have been exposed to very cold temperatures during the seasoning. There are also historical reports of Swiss and German watchmakers that would store metal materials and components in caves over the winter in order to stabilize metals and improve machinability and resistance to distortion – enabling critical tolerances in precision parts to be held more closely.

Today, cryogenic treatment is being conducted in a much more scientific, controlled, and repeatable manner. Computer controlled equipment is used to produce exact temperature profiles and repeatable processes. This allows for documented and repeatable scientific testing to be performed and also produces consistently repeatable results from the treatment.

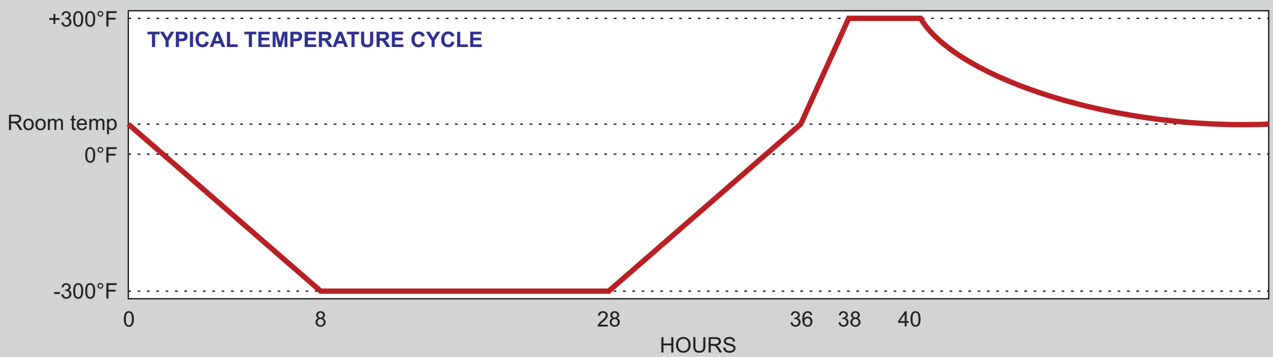
"Why do we need it?"

Most commonly used materials are based on a mixture of ingredients and are imperfect in their structural makeup. As previously mentioned, heat treatment is one way to alter the characteristics of a material being produced. The hardness, tensile strength, fatigue resistance, and wear resistance of the material are just a few of the ways that thermally treating the material can alter its usability for a given application. Cryo-treatment continues this concept and allows for further improvements in the material's performance. Although there are a vast number of ways that cryo-treatment is being used to provide improved performance, cyro-treatment for metal parts being used in motorsports applications is primarily being applied to components in high wear and high fatigue applications, as well as situations where critical tolerances need to be maintained across a range of temperatures. The physical wear characteristics of many parts have shown to be greatly improved. Other parts that are in a high fatigue environment (e.g. valve springs) have also been shown to have substantially increased service life and with consistent performance across their lifespan.

Ly-Con Rebuilding Co.
8231 W. Doe Ave Visalia, CA 93291 (559) 625-1070 www.lycon.com

"How does the treatment process happen?"

The parts to be treated are cooled in a specially-constructed machine that monitors the temperature of the parts inside using computerized controls. Temperatures are controlled in a precise manner according to a user-defined profile. Liquid nitrogen is used to cool the parts, but the parts are not simply dipped in liquid nitrogen. The liquid nitrogen is boiled in a heat exchanger coil inside the chamber and the remaining gas is allowed to circulate inside – with the parts staying "dry" the entire time. Typically, metal parts are cooled to a temperature of -300°F over a period of anywhere from four to ten hours. The parts are then held at -300°F for a dwell-time of anywhere between six to eighty hours – depending on the material being treated and the desired results. Once the cold-dwell is finished, the parts are carefully brought back up to room temperature at a controlled rate. Because of the extreme amount of insulation around the treatment chamber, a heater is actually required to bring the parts back up to temperature in a reasonable amount of time. Both the ramp-down and ramp-up in temperature must be done in a slow and controlled manner to prevent thermal shock and internal stresses from occurring in the part during the process. An additional heat cycle is often added to metal parts to provide further tempering. Typically, steel or aluminum parts are raised up to +300°F for a few hours and allowed to cool naturally when finished. The treatment effects the entire volume of the part, and it usually does not need to be re-treated as normal use or wear occurs.

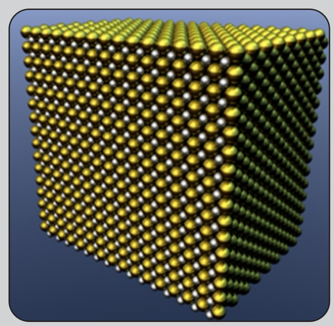


"How does the metal change?"

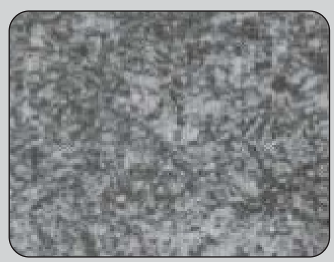
Metals are basically crystal structures, and these structures can be somewhat random and imperfect. The spacing of the atoms in the structure has a theoretical ideal distance in order for the crystals to adhere to each other. Current cryogenic theory suggests that as you cool the part, you are reducing the distance between crystals and removing atomic energy at the same time. As the part is brought back up to temperature, the atoms are allowed to migrate into a more even pattern and spacing to produce a more perfect crystal structure, improving strength as well as thermal and electrical conductivity. Additional theories point to a reduction of vacancies in the crystal lattice and a re-ordering of the alloying elements. Both of these changes improve the "bond" of the crystals to one another, which further improve strength and wear resistance, as the surface metal does not "depart" as easily from its underlying material.

In hardened steels, cryo-treatment is also known to change austenitic crystal structures into martensitic structures. Without getting too technical with metallurgy, this is basically the same thing that is occurring when a metal is heat-treated to improve its hardness and strength. The best heat-treating processes can leave 10% – 20% of the structure as unconverted austenite, but has been seen as high as 40%. Cryo-treatment continues the transformation and further reduces the percentage of austenite as it is converted into a much more pure martensitic structure. This conversion also reduces internal stresses and improves the strength of the material.

Theoretically perfect crystal structure (right)



Untreated steel
1000x Magnified
(right)



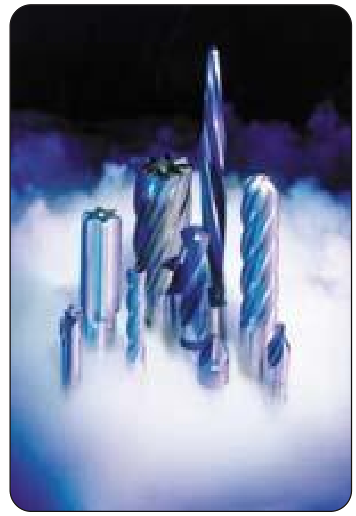
Cryo-treated steel
1000x Magnified
(right)

(Dark areas show formations of carbides)

Cryo-treatment has also been shown to increase the formation of carbides in certain types of steel. These additional carbides act as “hard spots” that help to reduce wear and surface friction. According to some studies, the additional carbides have an even more significant effect on the wear resistance than the removal of the retained austenite. It should be noted that the cryo-treatment process does not make the material significantly “harder” according to conventional hardness tests. Typically, the measured hardness is normally increased by less than 2%. The hardness simply becomes more uniform throughout the entire part. Unlike surface coatings or treatments such as nitriding, the treatment and hardness is consistent through the entire part and cannot be worn or machined off.

“What are the benefits?”

Benefits seen from treatment can vary depending on the application:

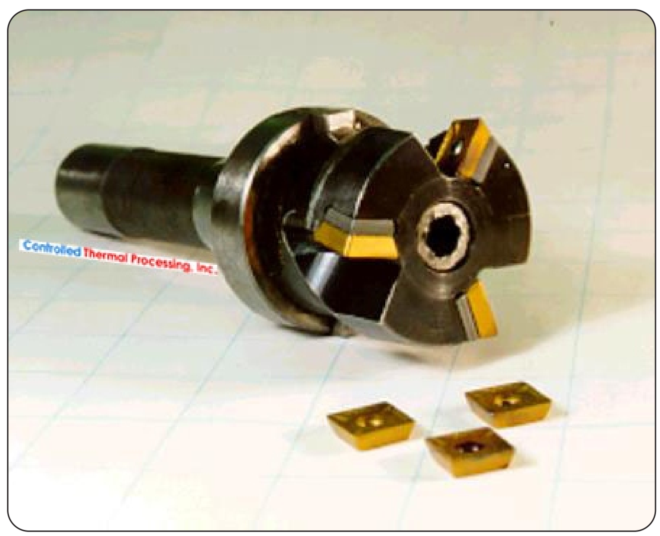


Metal parts show improved strength and fatigue resistance.

Surfaces on machined parts are more resistant to physical wear, showing measurably reduced wear and better visual appearance after time in use. Examples of items that have shown reduced wear are pistons. cylinder bores, piston rings, gear teeth, and bearing surfaces.

Wear surfaces show reduced friction. This translates to better wear rates, less heat being generated, and fewer particles that need to be filtered out of the oil. Reduced friction can also help efficiency for improved power or reduced fuel consumption.

Because of the more consistent crystal structure, thermal conductivity is increased and is more consistent throughout the part. This allows items such as pistons and cylinder bores to stay more optimally round as they expand and contract – improving ring seal and reducing wear. The additional thermal conductivity could lead to better cooling as well.



The improved structure also improves electrical conductivity for reduced resistance and improved electrical properties. Audio companies have been treating interconnect cables and various electrical components to improve their performance characteristics. Power cabling has been shown to have increased efficiency.

Parts that have been treated before final machining show improved machinability, reduced tool chatter, and a smoother and more consistent final surface finish. Cylinder bores also appear to show a noticeable improvement when cryo-treated before the final honing. This promotes faster and more consistent break-in, as well as better sealing for improved power and reduced oil consumption. Cylinder wall appearance has been noted to be much more even after the initial running has taken place.

Cutting and machining tools stay sharp for a longer period of time. One customer reported that their cutting tools on a particular machine would be dull after 3 months. After treatment, they could go 24-months before going dull. This reduced their maintenance time and cost to sharpen these blades by 87% - not counting the longer service life of the blades before they needed total replacement.

Thermal growth and contraction stays much more uniform throughout the entire part. Round objects such as pistons will tend to stay more perfectly round as they expand and contract. Cylinder bores will also stay more evenly round with fluctuations in temperature. This feature is very helpful in maintaining critical tolerances and promoting even wear and loading across the part.

Nearly every item in a performance engine can be improved by cryo-treatment in some way. In some cases, entire assembled engines have been treated as a finished assembly, and then re-lubed and gasketed as a precaution before use.

Application Benefits:

We have seen crankshaft failures on multiple occasions when aerobatic pilots were performing violent tumbling maneuvers at full throttle. After we started cryo-treating these crankshafts (over five years ago), we have seen ZERO failures with the same pilots and engines.

In the tool making industry, increases in service life of 200% to 400% are typical, sometimes as high as 600%.

In a test of treated racing brake discs, a non-treated disc was run for 50 laps with a racing pad and the surface of the disc was scored, cracked, and deemed unsafe. The treated disc was run 56 laps with the same pad, then run an additional 35 laps with a street pad, and was then judged to be good for another 40 laps. Because of the reduced warping and cracking of the disc, pad life was improved by 40%. Other reports in racing applications have seen a typical doubling of disc and pad life. Other tests involving taxi, police, and ambulance use have shown increases of rotor life of three to four times.

In a scientific test of piston ring wear conducted at a university in India, piston ring wear was shown to be reduced by 25% to 34% depending on the ring material.

Fatigue testing in valve springs has shown greatly improved service life. Drag racers that were previously having to change springs after each run have reported being able to run the entire race weekend on a single set of springs. This not only reduces costs, but also reduces the likelihood of potential problems due to repeated disassembly and reassembly.

One circle-track team that was changing valve springs after each race was able to run the entire season on the same set of treated springs.

A local kart racer previously had to be very careful to warm the engine before running it hard. If not thoroughly warmed, he ran the risk of sticking the piston in the bore. After cryo-treatment of the engine parts, piston sticking has been eliminated – even when he tried to do it intentionally. The treated engine also runs stronger than any of his previous engines.

A major NASCAR transmission supplier now cryo-treats all of the gears and shafts inside their racing transmissions for improved reliability. Many other components are also treated by most teams include crankshafts, rear-end gears, axles, brake parts, and many engine parts.

Conclusion:

Cryo-treatment is a cost-effective way to improve the performance, strength, and service life of many components used in aircraft, automotive, and many other applications. The treatment process simply improves and optimizes the internal structure of the metal, making it closer to the theoretical optimum. Increased strength, reliability, and improved performance are common reasons to have parts cryo-treated, but in many cases, the cost to treat the parts is easily offset by reduced replacement and/or maintenance costs later on.

Call or E-mail us to find out how cryo-treatment can benefit you!

Ly-Con Rebuilding Co. **8231 W. Doe Ave, Visalia, CA 93291 (559) 625-1070 www.lycon.com**