



Cryogenic Brake Rotors

by John Bellah

The extreme operating conditions in which an emergency vehicle operates generates considerable heat from the brakes—often far over and above the heat generated under normal service. This excessive heat will first show up as fade, and eventually brake failure. This excessive heat which can well exceed 1000-degrees F, can boil fluid, cause premature failure of the friction material, and cause the rotors to crack and/or warp. Extreme temperatures can warp or even melt plastic wheel-covers and valve stems.

While excessive heat has been a problem with police vehicles, one of the current obstacles began when the manufacturers removed the asbestos from the friction material several years back. While asbestos presents many health issues, asbestos helped to absorb and dissipate the heat. Without asbestos, the heat that used to be dissipated through the friction material now became transferred through the friction material to the rotor and through the caliper, overheating the fluid causing lessened pad and rotor life.

Today's brake rotors, for the most part, are made of what is known as "gray iron." In many respects "gray iron" is an ideal material as it is inexpensive and the graphite flakes inherent in the metal provides some lubrication, preventing noise, vibration, and harshness.

"Gray iron" will also tolerate the extreme heat and cold cycles that brake drums and rotors must undergo. "Gray iron," obviously has some downsides such as cracking and warpage which can occur under extreme temperatures and conditions. This material is not highly refined and can contain various types of recycled metal. This is one of the reasons for hard spots and cracking and can be especially true with some of the cheaper rotors.

Cheaper rotors often have excessive run-out and must be trued prior to installation. Another reason why cheaper rotors shouldn't be used on an emergency vehicle is that the vehicle may be out-of-compliance with Federal Motor Vehicle Safety Standards.

One of the characteristics with "gray iron" is that it expands with heat and contracts when cold—some of the basic facts of physics. Repeated cycles over time produces gasses and internal oxidation, which causes internal cracking. In some instances, the rotor may look serviceable; however, internally cracks are developing.

These cracks, once they reach the surface, will no longer allow the friction material to contact the rotor smoothly and will cause premature wear. A rotor in this condition can become a ticking time bomb if heated to extreme temperatures, say during a pursuit, and is then rapidly cooled by being partially or fully submerged in a puddle of water.

Many agencies use Original Equipment (OE) replacement parts. The manufacturers strongly suggest OE replacement parts, the reasoning in both cases involving liability and warranty issues. OE equipment is procured by bid and one year XYZ may get the low bid, while the following year YZX may be the supplier for the same component. Obviously the OE product has to be good as the manufacturers have to back up any warranty claims.

Necessity being the mother of invention, many fleet operators started looking at other options such as different friction material and drilled and slotted rotors, especially after real or imagined brake issues with the later Ford Crown Victoria and the police version of the Dodge Intrepid.

Metallurgy

Most of us are familiar with heat-treatment of metal. Most of our tools and mechanical components are subjected to some type of heat-treatment, such as tempering, case-hardening, or other treatments. Cryogenic treatment has been around since the 1930's, which was first documented when cryogenics was used on Jumo aircraft engine applications for Junkers airplanes, which were

manufactured in Germany. Cryogenic can treat both metal and plastic.

Cryogenic processing is not a plating or coating. It involves subjecting the material into extreme cold up to minus 300 deg F. Properly done, this process takes several hours and involves numerous steps to drop down to the desired temperature and bring it back to room temperature.

Cryogenic processing changes the crystal structure of the material which can enhance fatigue and abrasion resistance of the material. Many racers use cryogenic processing on the block, cylinder head, and moving components of their racing engines. Users of these treated engines report up to 4% increase in torque, as well as fewer component breakages. They also report better piston ring sealing, higher peak combustion pressures, reduced piston galling, and component failures. Pistons and cylinder heads on treated engines tolerate higher levels of detonation without failure.

Many racers use cryogenic processing on their brake rotors. Porsche, as an example, fits cryogenic rotors for racing applications—specifically 12 and 24-hour endurance races. They discovered that cryogenically treated rotors can last the entire race, saving valuable time during pit stops.

Police use of cryogenically processed brake rotors has been met with varied successes. Some engineers will tell you, in theory, this process should not work on cast iron or plastic, but it does. In brake rotor applications, cryogenic treatment reduces cracking, warping, and hot-spots. This increases both pad and rotor life, and reduces brake fade.

While shorter stopping distances may be claimed, mostly this will be under conditions when the brakes are fading. Reduce fade and you will see shorter stopping distances under extreme conditions. Longer brake life translates to keeping the vehicle in service for longer periods of time, and the lowering of maintenance costs.

Cryogenics, however, is not a "magic bullet." The use of cryogenically treated rotors has many variables: the type of service the vehicle undergoes, the preventive maintenance program involved, pad and rotor types, and the cryogenic processing itself. And, all of the advanced metallurgy and heat-treating in the world won't overcome solid preventative maintenance practices...if the pads and rotors go metal-to-metal, it won't matter if the rotors are treated with Kryptonite.

As cryogenic processing is relatively new in the automotive industry, there are numerous outfits that offer this process, with new companies starting up all over. Process methods vary, from the outfit that merely tosses the components into a vat of liquid nitrogen, to companies that utilize a carefully engineered multi-step process to treat components. Here is an overview of some of the major companies that cryogenically treat brake rotors for emergency vehicles:

Command Automotive

Command Automotive has been around since 2001 with their main focus with police and other severe-duty applications. They offer their SD-1 brake rotor for police and other severe-duty applications. The SD-1 rotor is a proprietary item of their own design, and is manufactured to their specifications.

One feature of this rotor, which the technician will appreciate, is that care is taken to machine all of the burrs and metal flash off so the technician's hands won't be cut during installation. A multidirectional finish is also applied to these rotors, and while the pads may require break-in, the rotors do not. Care is even applied to the finish on the parking brake surfaces on the rear rotors. This eliminates damage to the parking brakes if the officer uses the parking brake to stop the car.

Command offers a lifetime guarantee on these rotors not to warp before minimum thickness is reached. And yes, they can be turned if necessary. They claim that their rotors will outlast standard rotors by 300 to 400% and the pad life is increased by 200 to 300%. You can also use any type of heavy-duty, semi-metallic pad with these rotors. They recommend against using ceramic or Carbon-Metallic© pads.

Retail price on a front rotor for a 2005 Ford Crown Victoria is \$129.48, plus shipping. This compares to the \$129.49 for an OE rotor, which my local dealer in the Los Angeles area quotes as of this writing. They also offer quantity and contract pricing. All of their products are normally carried in stock and Command can ship them out the same day by FedEx, or other common carrier.

Controlled Thermal Processing

Headquartered in Antioch, IL, Controlled Thermal Processing has been around for 25 years, and claims to be one of the foremost cryogenic processing companies. Their methods and equipment have the capability to do cryogenic processing by using 1/3 to 1/2 the amount of liquid nitrogen that their competitor's use.

Rick Diekman, the current owner and operator of the Chicagoland facility, has 10 years of experience in cryogenics and is also the chairman of the ASM International (American Society of Materials) Cryogenic Processing Sub Committee. ASM International is an organization that is dedicated to the advancement of industry technology and the application of metals and materials. Controlled Thermal Processing is also active with the Cryogenic Society of America.

While about half of their business comes from racing, the other half is dedicated to law enforcement brake components. Controlled Thermal Processing utilizes high-quality aftermarket rotors from Affinia (formerly Dana) and cryogenically treats them. Cost for a front rotor on a 2005 Ford Crown Victoria is listed at \$64.43 each, plus shipping.

Controlled Thermal Processing claims that their rotors last two to three times longer than untreated components, which reduces maintenance costs and keeps the vehicle in-service for longer periods. Their rotors do not affect the amount of effort used in braking, and cracking is delayed. Their products have been tested on racetracks and by independent laboratory tests. One of their customers is the US Postal Service.

Diversified Cryogenics

Sold under the name Frozen Rotors™, Diversified Cryogenics™ claims that their rotors will cut brake costs in half. Diversified uses Affinia (Dana) rotors and cryogenically treats them. Retail price for a Crown Victoria lists at \$119.00 each plus shipping. They also offer volume discounts. If the customer wants to supply their own rotors, Diversified can treat them and ship them back, if so requested.

Diversified processing involves a proprietary 60-hour freezing process, which is different than what other processors utilize. They claim a 200% increase in rotor life. They also did extensive testing with the Los Angeles Police Department, simulating a high-speed pursuit on a #17 brake dynamometer with semi-metallic pads. They found that treated rotors were more predictable, ran cooler, and showed less brake fade than the standard rotors.

4-Life Brakes

Based in Ogden UT, 4-Life Brake Rotors are manufactured to meet or exceed OE fit and performance specifications. 4-Life Brakes utilize NAPA Premium rotors and treats them using their proprietary cryogenic process, which has a patent pending. This is a material transformation process, which treats the entire rotor to prevent cracking and warping. As they utilize quality, already-finished castings, no further resurfacing is necessary. 4-Life will also treat the customer's rotors, if requested.

Serving law enforcement agencies since 2000, 4-Life Brakes claims their rotors will increase the useful service life of brake components, and that pads and rotors will last an average of 2 to 3 times longer than OE-type rotors. They also claim shorter stopping distances.

4-Life Brakes can currently supply rotors for Ford and General Motors as well as other vehicles. Retail price for a 2005 Ford Crown Victoria runs at \$79.95, plus shipping. They offer quantity discounts.

Cryogenic Controversy

While the claims of double to quadruple pad and rotor life are impressive, there is certainly a considerable amount of controversy over cryogenically-treated rotors. In the past, many agencies have tested them and some have reported fantastic results, while others have reported little improvement. Closely questioning the agencies that show little or any improvement revealed that the tests were conducted three years or so ago. Brake technology has changed considerably over the last couple of years and that included cryogenics.

Treated rotors probably won't help the detective who starts the unmarked sedan and drives two miles to court where the car will sit for several hours until the return trip to the station. Cryogenic treatment seems to work well under hard usage as it helps to make the pads and rotors operate in a cooler environment, preventing or delaying fade, and preventing warping and eventual cracking which will prematurely shorten the service life of the brake system components. These claims should be substantiated if quality rotors are used and the thermal processing is done by a quality processor.

We recently polled 12 agencies that tested or are using cryogenically treated rotors. These include state police, sheriff's departments, municipal departments, and two EVOC training facilities. Here is what we found.

Los Angeles Police Department

The LAPD has had concerns with police vehicle braking going back almost 50-years. LAPD did conduct some testing of cryogenic rotors about three years ago; however, they felt that cryogenic rotors weren't cost-effective. The LAPD did go to drilled and slotted rotors. Motor transport personnel seem to be happy; however, they reported some cracking of the rotors under high mileage conditions.

Hamilton County, OH Sheriff's Department

Hamilton County surrounds the city of Cincinnati and the sheriff's department runs 140-vehicles, most of them Ford Crown Victorias. They tried several other cryogenic companies; however, they settled on Command Automotive SD-1 rotors as they felt they have given the best service. Their test vehicle was a cruiser where it was obvious that the deputy was hard on brakes as it needed a pad replacement at every oil change. Equipped with Command Automotive rotors, shop personnel report that the cruiser now has racked up 30,000-miles on the same rotors.

Illinois State Police

The Illinois State Police tested cryogenic rotors and did find that they gave a longer service life. However, being a state agency that has to contract their repair work to over 100 different repair facilities throughout the state, procurement and distribution made this a logistical nightmare.

North Carolina Highway Patrol

The highway patrol tested different types of cryogenic rotors over the past four years. Their experience was similar to the Illinois experience, and overall they felt that they weren't cost-effective. One of the reasons for the lack of success is that NCHP uses ceramic brake pads on their vehicles. Most of the cryogenic rotor suppliers do not recommend ceramic pads as they are deemed too aggressive. **St. Louis Park, MN Police Department**

The St. Louis Park Police has 10-marked and 12-unmarked Crown Victorias. After testing OE as well as other brands of rotors they are very well satisfied with Frozen Rotors™ which are supplied by Diversified Cryogenics™, and they have run them for the past four to five years. They report that while they consider the rotors to be initially expensive, once the math is done, they are getting approximately two pad changes per rotor.

Tucson, AZ Police Department

The Tucson Police Department realized that on the late model Crown Victorias, rotor warpage was a problem. Rotors would be good for one session on the rotor lathe before being discarded. Tucson is currently testing 4-Life Brake rotors with OE pads. They report that one of their test vehicles now has gone through four sets of pads and has accumulated 36,000-miles on these rotors, which have no cracks, grooves, or blue discoloration.

Meeker County, MN Sheriff's Department

Chief Deputy Jeff Norlin of the Meeker County Sheriff's Department has been involved in fleet management since 1991. He is another satisfied user of Frozen Rotors™ and reports longer rotor life. He commented that his department's Crown Victorias encounter a wide variety of road

conditions: paved, dirt, and gravel, as well as Minnesota's widely varying temperatures. He did comment that one car in his fleet, which contracts out to a city, has shorter brake component life due to the extensive stop and start conditions it encounters.

Schaumburg, IL Police Department

The Schaumburg Police Department reports good results using rotors from Controlled Thermal Processing for their fleet of Crown Victorias. Where they were getting 7000-miles on OE rotors, they report getting up to 34,000-miles using cryogenically-treated rotors.

Boardman Township, OH Police Department

Michael Carkido is the police mechanic for the Boardman Township Police. In addition to servicing the fleet of 55-cars, he also does all of the upfitting. Brakes became a big issue as Carkido observed that some of the vehicles in his fleet, in addition to the constant replacement of pads and rotors, were used so hard that the plastic wheel covers were beginning to melt due to the heat generated from the brakes. This was especially true with the 2003 and later Ford Crown Victorias.

Carkido felt there must be a better way and he experimented with different pads and rotors. In this day of shrinking budgets, fortunately, the township had funds for him to experiment with, and experiment, he did! This included cross-drilled and slotted rotors, and exotic pads. He even experimented with duct-work to direct cooling air to the brakes.

The complaint of excessive brake noise was one problem and Carkido found the Wagner Thermo Quiet pad which seems to give satisfactory performance for his department. Cryogenically treated rotors from Command Automotive currently work out the best for his department. Pads usually last about 20,000 miles with these rotors. At pad replacement time, he will do a surface cut on the rotors and replace the pads so the car is ready for the road.

Roanoke, VA Police Department

The City Garage for Roanoke handles all of the maintenance for municipal vehicles, which includes the police and sheriff's fleet of approximately 130 Crown Victorias. Roanoke reports they tested rotors from Controlled Thermal Processing and felt that they get about 25% better pad and rotor life from their rotors. They plan to retrofit all of the law enforcement vehicles with cryogenic rotors when they come in for brake service.

FLETC (Glynco, GA)

Training officers in pursuit driving is hard on vehicles and the Federal Law Enforcement Training Center (FLETC) in Glynco is no exception. Michael Coger, Fleet Manager at FLETC reported the brakes got so hot on the training vehicles that not only did the plastic wheel covers melt, but valve stems also melted.

Coger is sold on cryogenic rotors; however, he cautions that not all cryogenically-treated rotors are the same. Cryogenic treatment must be done in careful steps, and if it is not, the results can be disappointing. They had a bad experience with one brand of treated rotors and the whole pallet ended up being returned. The FLETC used to change rotors with every pad change; however, with Command Automotive rotors, rotor life had doubled.

Minnesota Highway Safety Center

Another regional training center in emergency vehicle operations is the Minnesota Highway Safety Center in St. Cloud. Bill Ruhr, of the center, reports in several years of running rotors from Diversified Cryogenics™ that they haven't warped a rotor yet. Ruhr admitted that he was skeptical when they first started running Frozen Rotors™. However, with the success he has seen, he runs them on his personal vehicles, too.

Cryogenic from the OEM?

If cryogenic rotors are so good, why aren't they OE? Cryogenic rotors probably are not necessary on the family car, thus we probably won't see them in the near future as OE except on some high-end cars. Cryogenic rotors will not cure every brake problem, nor will they work if the processor or

the technician doesn't do the job properly. And cryogenics certainly will not cure hit-and-miss maintenance procedures where the car is allowed to deteriorate to a metal-to-metal condition.

One state police agency in the Midwest tested cryogenically treated rotors three years back and found that while service life was longer, stopping distances and fade resistance remained about the same as with OE rotors. Brake technology is constantly changing. Agencies that tested cryogenics some years back may want to retest with what is available today.

John L. Bellah is a law enforcement veteran with over 28-years of service. He has solid background in automotives prior to entering law enforcement and is a member of SAE International. Bellah's experience with high-performance brakes goes back to the late-1960s with Velvatouch Metallik linings. Bellah is a Corporal with the California State University, Long Beach Police Department and may be reached at jbella@csulb.edu.

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