



**February 6, 2012 Rev 0**

## **TECHNICAL NOTE 103: CRYOGENIC TREATING OF BARRELS**

We've been asked by a number of our customers why we don't cryogenically treat our barrels. So, we've written this Tech Note to address our beliefs regarding cryogenic treating.

Cryogenic treating of barrels (cooling the barrel to a VERY low temperature [from -100 to -320 degrees F]) is offered by several companies. Many claims of increased life, accuracy, etc have been made for such treatment.

We have found no scientifically rigorous data to support such claims; but rather compilations of anecdotal statements that do not stand up to review.

Nonetheless, many shooters are tempted to spend money on these and other treatments to improve accuracy, and feel it appropriate to add their opinions to the public record.

### **METALLURGICAL BACKGROUND**

All machine tool steels, plain carbon steels, and low alloy steels (4140 and 4340 for example) retain austenite (the high temperature, face centered cubic (FCC) structure) when allowed to form martensite. This happens whether you use air-hardening steels, oil quenched, or water quenched steels.

**FOR TOOL STEELS:** This is precisely why for certain tool steels, a double or triple temper (double or triple draw) is done. During tempering, the retained austenite transforms to the very brittle fresh-martensite upon cooling from the tempering temperature. So you end up with tempered martensite (good stuff) mixed with fresh-martensite (brittle stuff) and some left over retained austenite (soft but unstable stuff). So you repeat the tempering cycle a few more times to eliminate the majority of the retained austenite. However, for many alloys, you never really get rid of it all just by cooling to room temperature. So, employing cryogenic cooling helps provide the driving force to cause the retained austenite to transform to martensite and then you follow it with one

last tempering heat treat cycle, and voila, you have a better steel. For some tool steels, this has remarkable effects.

**FOR BARREL STEELS:** For steels such as 4140 and 4340 (steels typically used for barrels), the amount of retained austenite is already very low (around 5%) after normal processing. Studies have shown that cryogenic treatment of these steels sometimes has an effect and sometimes does not. The effect, however, (partly due to the low temperature induced transformation of the retained austenite and partly to the formation of fine carbides) is to render the steel in a condition that has slightly better wear resistance, and in some cases actually machines a little bit better. We have found no statistically valid, independent tests that demonstrate better accuracy as a result of cryogenic treatment.

**FOR STRESS RELIEVED BARRELS:** There have been some limited studies that show no difference in barrel accuracy before and after cryogenic treatment. Some people claim that the cryogenic process can eliminate residual stress in the barrel (one of the biggest sources of barrel inaccuracies). While this might be true in some alloys, it is very doubtful that it would happen in typical barrel steels such as 4140 and 4340. In fact, the opposite is true. Deep cryogenic treatment of 4140 has been shown to increase the residual compressive stresses in the material. These stresses, of course, disappear during post cryogenic tempering. Barrel stress relieving by heating it up after manufacture is by far the best way to relieve the stresses. Claims that the cryogenic cooling somehow causes the "molecules" of the steel to align and improve the harmonics have not been demonstrated to us. If you cryogenically treat your barrels, it probably won't hurt them; but we don't expect that it would provide a significant improvement in accuracy.

**FOR BARRELS THAT HAVEN'T BEEN STRESS RELIEVED:** Putting an "as-machined barrel" that has NOT been stress relieved after fabrication through a typical cryogenic process, may improve its accuracy. However, it is probable that the improvement results from the elevated tempering cycle that is part of the typical cryogenic treatment. But it's probably the elevated temperature, not the cryogenic cooling, that does most of the stress relieving.

## **NRA FIREARMS SOURCEBOOK**

We consulted the NRA Firearms Sourcebook to obtain their technical opinion of cryogenic treatment. The Sourcebook discusses cryogenic treatment of barrels in two places: under "Bore Coatings And Treatments" (page 147) and under "Barrel Enhancement" (page 162). Their conclusions are:

--"Such treatments do not generally offer any advantage to hunting-rifle or service-pistol barrels."

--"Tests performed by NRA Publications staffers indicate that cryogenic treatment produces a modest improvement in accuracy (10 percent or less) in some barrels and virtually none in others. Research by Sierra Bullets showed no accuracy

improvement in match-grade barrels, though a slight increase in barrel life was observed.”

## **CONCLUSIONS**

Stress relief is one of the keys to stable barrel material (and, therefore, good accuracy). Cryogenic treatment does not seem to us to be the optimum process to obtain stress relief for typical barrel steels. Cryogenic treatment may provide some minimal wear resistance improvement. However, we do not believe it will provide significant additional barrel life. Typically, hot gas erosion wears out a centerfire barrel before friction between the barrel and projectile can do it; and cryogenic treating does very little, probably nothing, to help reduce hot gas erosion.

Our own testing has not confirmed improved accuracy improvements after cryogenic treatment. Testing by bench rest shooters during early experiments with cryogenic treatment also failed to confirm claims for increased accuracy and barrel life. Specifically, published test results from Sierra Bullets indicated no significant improvement in accuracy, durability, or ease of cleaning.

Until provided with scientifically reproducible data, ArmaLite must recommend that shooters spend their money on high quality ammunition, range time, and quality firearms rather than treatments and accessories that have not demonstrated repeatable improvements.

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*C. WOODS & THE WIZ*