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TECHNICAL NOTE 49: CARTRIDGE CASE FAILURE IN THE M16 AND SIMILAR RIFLES

Background:
We recently inspected an M15A4(T) rifle that suffered a catastrophic failure. The owner of the rifle in question had hand loaded match-grade cartridges with a common 69 grain bullet. He believes that there was something wrong with the rifle.

Historical evidence would indicate that the owner is incorrect. Almost all catastrophic failures of M16 class rifles are due to excessive pressure far above the original design intent. The excessive pressure can have any of several causes including: defective cartridges (bullets too heavy, too much propellant, inappropriate propellant, incorrect cartridge headspace, lubricant on exterior of cartridge case, cases reused too many times, etc), or bore obstructions (including dirt, sand, water, or a bullet in the bore from a previously fired defective cartridge). Only a small percentage of failures are attributable to breakage of a weapon component-------usually the bolt.

The purpose of this Technical Note is to describe the typical sequence of events for the information of maintenance personnel.

Sequence Of Events:
M16 rifles, and all similar models, suffer damage in a characteristic sequence. Fortunately, the design of these rifles provides considerable shielding that contains the pressure and residue, and prevents injury of the shooter. Army and ArmaLite records reveal no significant injury in any incident, a truly outstanding record.

Excessive Pressures:
When a normal cartridge is fired, pressures inside the cartridge case rise to 55,000 pounds per square inch or more. Defective cartridges or bore obstructions will cause pressures to rise dramatically.

Upon propellant ignition, the interior of the cartridge case is pressurized pretty evenly. As pressures rise the case walls expand and seize the sides of the chamber. The case stretches rearward until the base of the cartridge contacts the bolt face which supports it, putting pressure on the bolt.

A cartridge case failure allows this high pressure gas to escape into the barrel extension, where it flows into contact with the bolt and bolt carrier. As it expands, the gas has a larger working surface to work on than it does inside the cartridge case. This places tremendous stresses on the bolt and carrier.

The high pressure gas bends the front end of the extractor outward, locking it behind the locking lugs of the barrel extension. In rare cases the barrel extension may be split.

The gas strikes the face of the bolt. The energy deposited in the bolt can cause the bolt to split along a line running between the extractor slot and the firing pin hole, shear the lugs from the bolt, break the bolt at the cam pin hole, and/or break the tail off the bolt. Not all of this damage is normally seen on a single bolt.

The gas passes around the bolt body and enters the bolt carrier. It may split the bolt carrier in the middle of the flat surface at the top front of the carrier and blow the flat bottom of the front half of the bolt carrier down into the magazine. The high pressure gas would then pass out the carrier at both the top and the bottom.

The gas passing down the magazine compresses the cartridge stack and blows it, the follower, and the baseplate out the bottom of the magazine and blows open the portion of the magazine outside the magazine well. In some cases the magazine well of the lower receiver is deformed outward in a distinct bulge.

The gas passing through the fracture at the top of the carrier, and other gas still passing around the bolt body, fill the upper receiver and force the sides outward until they split at the top of the receiver. Sometimes, but rarely, a panel of the receiver may blow out. The ejection port is deformed.

In rare cases, the threads at the front of the upper receiver may break off the receiver.

Upon disassembly, we normally note that the cartridge case shows a blowout at the ejection port, swelling to fill the bolt face, and/or complete circumferential separation of the cartridge head from the cartridge body. Powder residue bearing copper vapors coat the parts.

All of these indicators point to cartridge case failure resulting in high pressure gas leakage into the mechanism, and subsequent damage.

Bolt Failure:
Sometimes a fatigued or defective bolt fails. It's sometimes hard to differentiate between a failed bolt and a failed cartridge case without in-depth metallurgical analysis.

Bolt lugs tend to fail in a consistent way, with the lugs nearest the extractor cracking due to fatigue and then breaking off. Then the other lugs will crack and break off toward the opposite side of the bolt, in sequence. Typically several thousands of rounds will be fired between the occurrence of the first visible crack and ultimate bolt failure. In addition, bolts have been safely fired with more than one lug completely missing. These two factors mean that any observant user should have adequate warning of a potential bolt failure.

If the failure is caused by the bolt, high pressure gasses still exit the case as the unsupported case fails, but the cartridge head typically isn't deformed as badly as in the case of an overpressure cartridge.

Bolts are highly, cyclically loaded mechanical components. Thus they should be expected to have a limited life. Firearm designers take great pains to assure that bolt life exceeds anticipated usage and that any failure will occur in a manner which will not injure the shooter or any bystanders.

Before they break, bolts will normally show evidence of cracks or bolt lug loss (near the extractor cutout or the cam pin hole). Bolts showing any form of crack should be replaced before they allow a release of high pressure gas.

The rifle in question clearly failed due to cartridge case rupture.