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Finding Out For Myself

Part XVII

Express Rifle Case Fillers

by Sherman Bell

It is not what we do not know that hurts us. It is what we are certain of—that turns out to be wrong—that gets us in trouble. ~ Mark Twain. So it is, with some strongly held beliefs concerning the world of guns and shooting. Nowhere in our study of express rifle ballistics does this apply more certainly than the question of the correct way to load a reduced charge of smokeless powder in a black powder cartridge case. With the exception of Trail Boss powder, which we have discussed previously in the Autumn 2008 issue of the *Double Gun Journal*, when we load nitro-for-black in a voluminous black powder case, we must use some method to hold the powder charge in position against the primer. Mention any given method and you will hear opinions both pro and con. While opinions are in overwhelming abundance and predictions of disaster are fairly numerous, actual reports of rifle damage are, thankfully, much rarer. However, persistent reports do exist and must be considered.

To study the behavior of the various types of filler material in nitro-for-black (NFB) loadings, we again turn to a test rifle that is chambered for the .450, 3-1/4" black powder express cartridge (BPE). This rifle has a strain-gage mounted on the barrel at one inch from the breech face. This will give us a read-out of peak pressure at this location and may help identify any methods of using fillers that put higher than wanted stress on our treasured original express rifles. There is also a second strain gage mounted on the Mauser test barrel. This gage is located 2.9 inches from the face of the barrel breech. Mounting a gage in this position, centers it directly over the base of a 300-grain cast lead bullet, when a loaded round is chambered. For consistency, this same linotype-alloy 300-grain bullet is used as in all the previous testing performed on this cartridge and in this Mauser test rifle. All cartridges also have the same 3.740" overall cartridge length as previously used and thus the base of the bullet is in a consistent position at 2.9 inches ahead of the breech face. Measuring the stress at the 2.9" point in the chamber will let us see how the various case fillers affect the pressure developed at the base of the bullet. The bullet base is where damage in the form of ringing of chambers is reported. If a chamber has any significant pressure ring formed it would also cause hard extraction of the fired cartridge case.

I do not know how much pressure it takes to ring a chamber. However, I do know that the strain-gage system is good for measuring relative differences in pressure and has a good record of recording transient events, so we will give it a shot, as they say. At the very least, we hope to find out the relative peak chamber pressures produced by the various types of fillers, even if we do not ring a chamber. If we actually do produce a catastrophic event and record it—so much the better. So, as I begin this small voyage-of-discovery, I hope to answer my curiosity about how several different types of filler material and retaining wads perform. The best result hoped for is that this work may allow us to separate the various methods into good, bad, and ugly categories and therefore identify and avoid the methods that may be a formula for disaster. As with all previous testing, the velocity and pressure values reported are the average values of a multi-shot string.

Kynoch Nitro-For-Black: As in earlier research, it is instructive to see how the original factory NFB ammunition performs. Collectors of rare cartridges have, undoubtedly, already branded me as a hopeless fool, so I decided to shoot one more round of my precious original Kynoch nitro-for-black ammo (NFB), with the forward strain-gage hooked up. This would tell me if the cordite factory load would produce the same pressure at the base of the bullet

Kynoch Nitro-For-Black ammo

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as at the breech, like black powder loads do, or if it would show a change due to the partial case-filling powder charge which was retained by a wad. See the "Finding Out" Part X article published in the Autumn 2005 edition of *DGJ* for a full description of the Kynoch NFB load.

Reviewing the previous data, we find that firing the factory Kynoch NFB ammo, which contained a 370-grain lead bullet and a load of 52 grains of Cordite, produced a velocity of 2002 ft/sec and a pressure of 25,200 psi measured by the strain-gage mounted at one inch from the breech face. This compares to the velocity of 1812 ft/sec and pressure of 21,600 psi produced by a straight black powder load of 120 grains of KIK FFg black powder, driving a 300-grain lead bullet. Now the firing of another round of the original Kynoch NFB ammo, produced a pressure of 26,100 psi at the bullet-base strain-gage position. It should be noted that this ammo used a fiber wad .170" thick between the cordite charge and the bullet base.

With that background information in hand, we get down to the question at issue. Which powder retaining method that can be used in our hand loads are acceptable and which, if any, are risky to the chambers of a rifle? For these tests, I use a "*standard load*" of 48 grains of 4198 powder, a Winchester large rifle primer, and 300-grain LBT lead bullet, cast of Linotype alloy. This is a well-documented load from our previous tests that has produced good regulation of barrels in a vintage double rifle. When using a thin wad of rubberized cork-gasket material to retain the powder, this load

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Cork wad

1 grain tuft of Dacron

12 grains of Dacron

produced 1952 ft/sec velocity and a pressure of 21,700 psi at the one-inch gage position. Note how close this pressure matches that produced by black powder.

Now we begin the tests with various powder retaining methods. As with all my test projects, the outcome is not certain. I have no pre-conceived plan to skew the outcome and no agenda to satisfy. I am here to find out answers. The master plan is to use several different types of powder retainers while keeping other load parameters constant and then compare the pressures produced at the breech and the forward strain gage location (at the base of the seated bullet). All the while, I would be checking the chamber for any sign of ringing at the bullet base. If ringing occurs, I expect the strain-gage pressure reading at the bullet base to show an anomalous value. Hopefully, this comparative data will give us a basis for rating the case filler spectrum. Since I only get one chance to produce a pressure ring in an undamaged chamber, the plan was to start with what I hoped were the least risky types of filler material and proceed down the list to the dark side of the filler world.

No wads at all: The first test, is a rather impractical one. However, I decided to see what is happening inside the chamber when there is no filler at all. It is true that this test has little practical application since we know we must have a filler to promote clean and consistent burning of our powder charge. For this trial the 48-grain charge of powder was allowed to seek its own position with the rifle held horizontally in the normal firing position. As expected, the firing of these loose-powder rounds produced hang-fires and low velocities. The average velocity was 1851 ft/sec and the pressure at one inch was 15,900 psi. At the bullet base the pressure was 16,060 psi and the average velocity of the string was 1849 ft/sec. Note that both the factory NFB load and the no-wad load produced slightly elevated pressures at the bullet base as compared to the one-inch gage position.

Single cork gasket wad: The first test of significance is one using the single cork gasket wad to retain the lightly compressed powder charge of 4198 powder. This test produced a velocity of 1969 ft/sec and a one-inch pressure of 21,400 psi. This agrees very closely with previous tests of this load. With the bullet-base strain-gage hooked up, a 5-round string produced a velocity of 1970 ft/sec and a pressure of 23,200 psi. This gives us a pressure increase of 1800 psi at the bullet base. While not a dangerous pressure rise, it indicates a reaction between the wad and bullet.

Dacron fiber: The next test used Dacron fiber for a case filler material. This is a well-accepted method, that I have used often and with complete success. The first mention of using this material that I know of was in the writings of Ross Seyfried. For the .450 BPE load I used 12 grains of Dacron. This fills the case fully up to the base of the seated bullet, which is the proper method for using this filler material. Firing this load produced a velocity of 1940 ft/sec and a one-inch pressure of 21,400 psi. Note this pressure is identical with that produced by the previous load. For the second string of shots the velocity was 1921 ft/sec and the pressure at bullet base was 20,100 psi. This first load using a case full of filler material produced a slightly lower pressure at the bullet base than the previous tests, where an over-powder wad or even a loose-powder charge was involved.

Tuft of Dacron: To demonstrate the wrong way to use Dacron fiber, I loaded a series of rounds with a small 1-grain

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tuft of fiber over the powder. This ammo produced an average velocity of 1983 ft/sec and a very similar 21,700 psi at the one-inch gage. At the forward gage an elevated pressure of 22,300 psi was recorded. Also of note is that the pressure vs time traces read out by the Oehler ballistic laboratory show a stutter-step of pressure on the rising pressure trace. This step is developed by the bullet-base strain-gage with loose powder and all loads using a single wad and also in this case only partially filled with Dacron. This stutter step is noticeably less pronounced in the trace recorded by the fully filled case using Dacron fiber.

Kapok fiber: The next use of filler material was Kapok fiber. This natural fiber is less dense than Dacron. Seven grains were required over the powder charge to fill the case full to the base of the bullet. Firing this load produced a velocity of 1947 ft/sec and a pressure of 21,200 psi at the one-inch gage. The second string produced a pressure of 19,700 psi at the bullet base. This assures us that Kapok fiber is truly kind to our vintage rifles. As with Dacron there is only a very slight stutter-step in the rising pressure curve recorded by the forward strain gage.

Cotton: Test number five used 8 grains of Cotton as a case filler. The velocity produced was 1933 ft/sec with a one-inch pressure reading of 20,500 psi. The second string of rounds fired with the bullet base gage hooked up produced 1914 ft/sec and a pressure of 20,100 psi. The pressure curves looked identical to those produced by Dacron and Kapok.

Puff-Lon: The next filler material selected is Puff-Lon. This material is promoted as a high-pressure Gas Check, a Lubricant, a Wad, and a Filler. According to the maker, "Puff-Lon filler is made with dry, lightweight powdered synthetic lubricants and molybdenum disulfide impregnated into a lightweight natural cellulose." A charge of 8-1/2 grains of Puff-Lon was poured over the standard 48-grain charge of IMR 4198 powder. Firing this combination produced 1911 ft/sec velocity and a pressure of 19,600 psi at the rear strain-gage. A second string produces 1917 ft/ sec and 21,700 psi at the forward strain gage. This 11% pressure increase at the bullet base is the most significant of the materials tested so far. The pressure trace of the forward strain-gage shows a definite stutter-step similar to those produced by over powder wads.

Vegetable fiber wad: The next test used a single vegetable fiber wad to retain the powder charge in position. With the one-inch gage hooked up, the velocity was 1978 ft/second and the pressure was 21,400 psi or identical to that developed by the cork gasket wad. Using the bullet-base gage the average velocity of the string was 1967 ft/sec and the pressure was 23,000 psi. Again, this is nearly identical performance as with the cork wad retainer and the pressure trace has the same stutter-step as before.

At this point, I must note that there was a time-break in the performance of these tests and when work resumed I found it necessary to use a different lot of Winchester large rifle primers to complete the tests. Not wanting to waste the considerable efforts already made, I present that data as tested but then, in the interest of consistency and correct testing procedure, I performed tests of the "*standard load*" over again with the new component, to check for any differences produced by the necessity of using a different lot of primers. Carefully loading 48 grains of the same lot of IMR 4198 powder and a single cork gasket wad over the new lot of primers

7 grains of Kapok

8 grains of Cotton

8.5 grains of Puff-Lon

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and using the now-standard 300-grain lead bullet, I fired a six-shot string over the ballistic laboratory sky screens. The result was an average velocity of 1965 ft/sec compared to a velocity of 1969 ft/sec recorded for the original tests. The strain gage pressure reading came out at 21,800 psi for the new tests as compared to 21,400 psi for the previous data. In the world of ballistic testing this is as close as one could hope for. I now felt free to continue testing with the new lot of primers without concern of comparing apples to oranges.

Cream Of Wheat: Testing resumed with Cream Of Wheat used as a filler. Forty-five grains of the granular cereal on top of the powder charge, filled the case to the base of a seated bullet. Firing this load produced a velocity of 1907 ft/sec and a pressure at one inch of 25,300 psi. Firing with the forward strain-gage hooked up gave a velocity of 1925 ft/sec and a pressure of 26,000 psi at the bullet base. These are the highest pressures produced so far but there is not a dangerous increase at the bullet base. The pressure curves produced by both gages show a smooth rise with no stutter step as produced by the wads or fiber that did not fill the case completely.

Hard felt: The next test used a single 45-caliber, 1/4" thick Alcan Feltan-Bluestreak wad pressed down firmly over the powder. This type of Alcan wad was once quite popular with shotshell loaders as a firm felt spacer wad in various shotgun gauge sizes. Firing the test load with one of these hard felt wads in place produced a velocity of 1925 ft/sec and a pressure of 20,200 psi from the gage located at one inch from the breech face. The next string of shots produced a velocity of 1911 ft/sec and a pressure of 20,800 psi at the bullet base. As now expected with a single wad retaining the powder, a definite stutter step is observed in the pressure trace recorded at the bullet base. However the pressures are not excessive and the increase at the bullet base is small.

Stacked hard felt: Continuing with the same 1/4" Feltan-Bluestreak wads, now a stack of 6 wads was placed inside the case to fill all of the available space between powder and bullet. I was most curious as to how this test would come out as there are claims about a stack of wads, which eliminates the empty space between powder charge and the bullet, as being a more suitable filler than a single wad over the powder charge. I was somewhat concerned about the large volume of hard wads increasing pressure due to a decrease in the effective internal volume of the cartridge case. Firing the first string produced a velocity of 1939 ft/sec and a pressure of 26,100 psi. The

Vege fiber wad

45 grains Cream Of Wheat

Hard felt wads

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Nitro card

Soft felt

Open-cell foam
Closed-cell foam

second string produced 1930 ft/sec and a pressure of 24,800 psi at the bullet base. The pressure curve recorded at the bullet base did not show the stutter-step in pressure rise that is the signature of a single wad over the powder. This case full of wads did indeed produce the highest overall pressures of the test so far, but there is no spike in pressure produced at the bullet base and no chamber ringing. To keep this in perspective, the factory Nitro-For-Black Kynoch round using a single fiber wad, produced a velocity of 2002 ft/sec and pressures of 25,200 and 26,100 psi.

Nitro card: Returning to a single wad, a hard .135" thick 45-caliber Alcan nitro card was pressed firmly over the powder charge. According to some, this is the worst type of wad to use as a powder retainer. The first string of shots produced variable pressures and one hang-fire. The average figures are a velocity of 1862 ft/sec and a pressure of 17,300 psi at the one-inch gage. This is disregarding the data from the one hang-fire round. The second string produced more robust numbers of 1909 ft/sec and 19,100 psi at the bullet base, but were again rather erratic. The expected stutter step in pressure rise is present in the trace of pressure over the bullet base. That said, the pressure rise over that experienced at one inch may be more due to erratic ignition in the first string than actual effect of the wad. Either way it is not a dangerous pressure spike. I must conclude, however, that the nitro card was not holding firmly in place during powder ignition and so is not a reliable wad to use.

Soft felt: The next test was with a single 1/4" thick wad of white felt holding the powder in place. Firing this load produced a velocity of 1929 ft/sec and a pressure of 20,700 psi at the one-inch gage. All pressure traces were smooth and uniform. Five more rounds fired with the bullet-base gage hooked up produced 1938 ft/sec and a nearly identical pressure of 20,800 psi. Again, as is the case with all single-wad retaining methods, the rising pressure trace has a definite stutter-step.

Stacked soft felt: Using this same wad material, a stack of 6 felt wads filled the .450 Express case from powder charge to the bullet base. The first string produced 1941 ft/sec and an average pressure of 22,300 psi at the one-inch gage. The second string produced 1948 ft/sec and a pressure of 22,400 psi at the bullet base. As with other tests using less compressible stacked wads, the pressures are somewhat increased over that measured when only one wad is used. However, the pressures are not excessive and all traces are smooth and uniform.

Open-cell foam: Nearing the end of our testing, we come to a most interesting filler material and one that has caused much debate and that is foam. There are two basic types of foam material that can be used for a case-filler; open-cell foam and closed-cell foam. Open-cell material allows air to pass freely through it and closed-cell foam does not. Obviously, the compressibility of these two materials is different. Two reports of chamber ringing that I am familiar with, arose from the use of a cylindrical wad of closed-cell foam placed in a cartridge for a case-filler. For the first test of a foam-filler, I chose open-cell foam wads marketed by Kynoch. These are sold as "Nitro-Express Wads" and the size I used is labeled as *"Size 1 for calibers from .375 to .500."* These cylindrical foam wads are just over one-half inch in diameter and about one inch long in their uncompressed state. I loaded two of these foam wads over the

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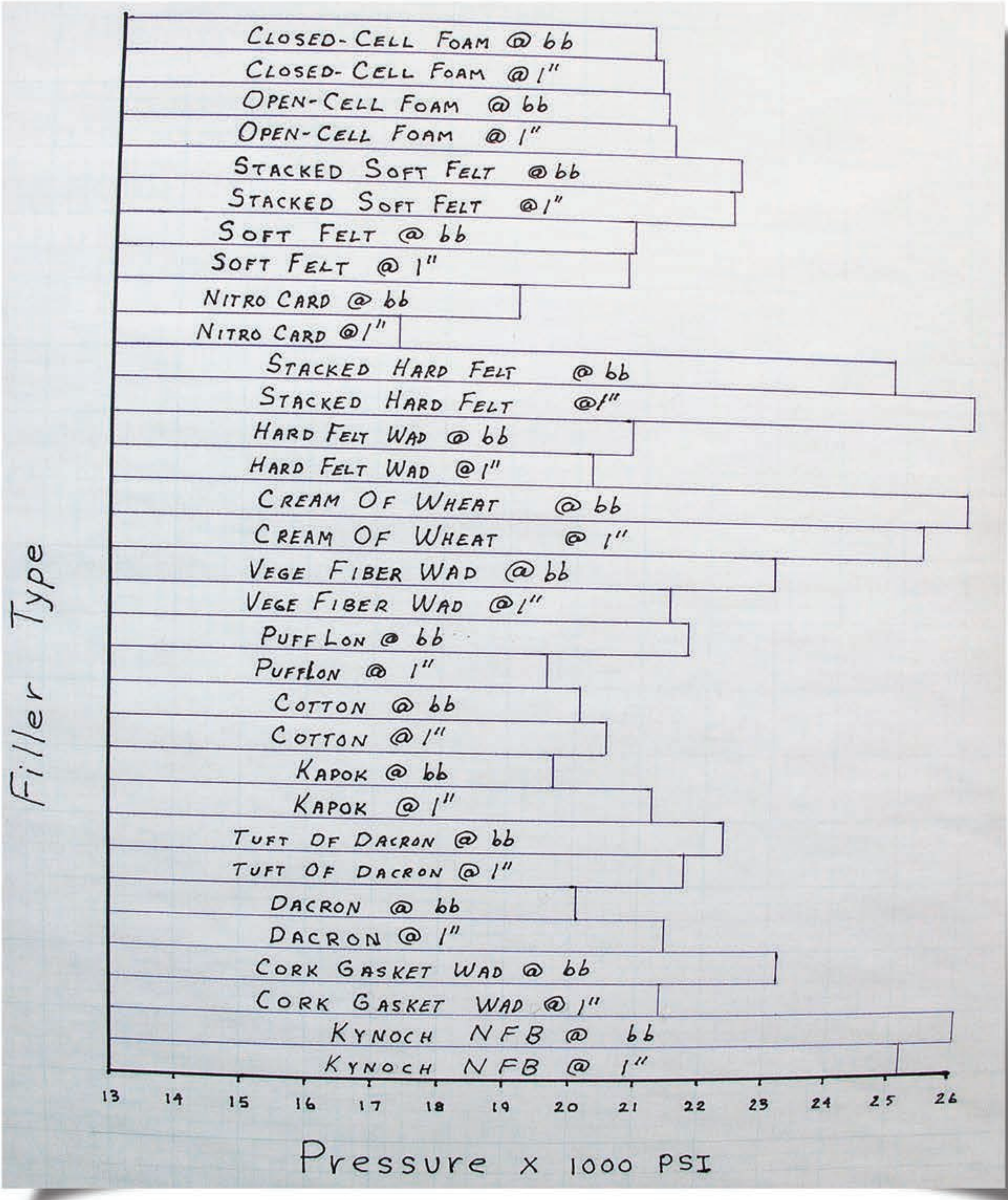

Bar-graph of relative pressures

powder charge in each case. Firing these produced a velocity of 1969 ft/sec and a pressure of 21,400 psi from the one-inch gage position. A second string produced a velocity of 1951 ft/sec and a pressure of 21,300 psi at the bullet base. It is interesting to note that although the easily compressible foam wads filled the case completely from powder charge to bullet-base, the pressure trace from the bullet-base gage shows a definite stutter-step in pressure rise very similar to that produced by a single felt, cork or fiber wad. One can imagine the springy foam being rapidly compressed into a thin cross-section and impacting the bullet base in nearly the same manner as a single wad.

Closed-cell foam: And at last, we come to what I had feared to be the most likely bad actor in the world of case fillers and that is the more rigid closed-cell foam. To make these wads, a cutter fashioned from appropriately sized tubing and sharpened on the outside edge, was used in a drill press. The foam is cut from a two-inch-thick block and is one-half inch in diameter as it comes from the cutter.

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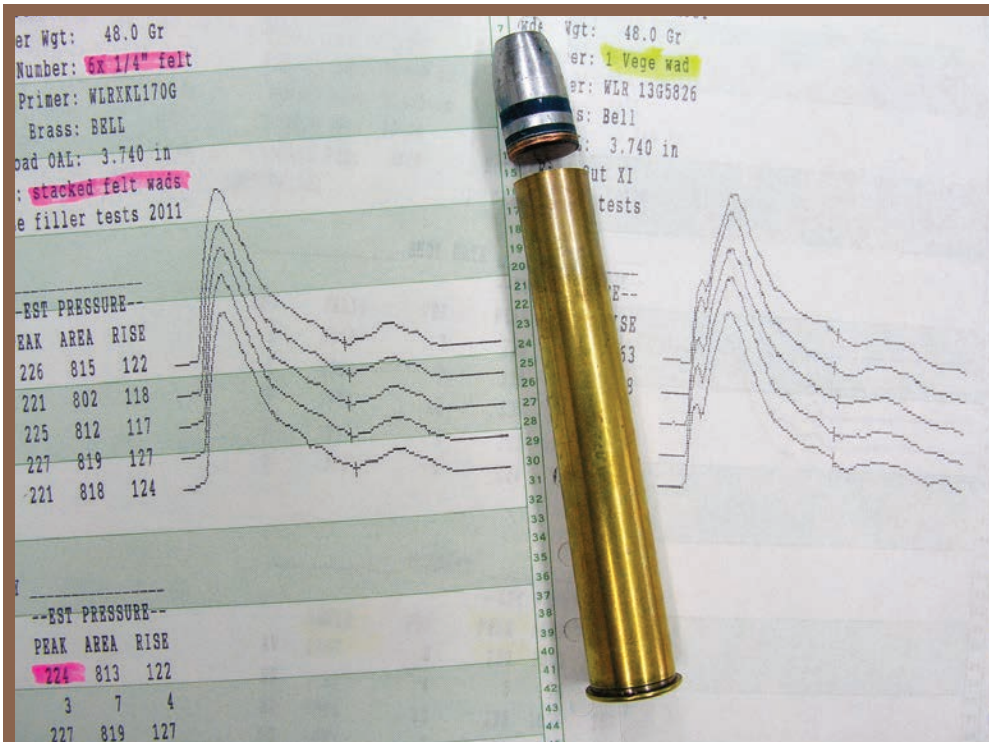
One of these two-inch foam "worms" is sufficient to take up all the empty space between powder and bullet base in the .450, 3-1/4" case. Up to this point, the chamber of my test rifle had come through with no damage from all the various types of powder-retaining methods used. I performed the closed-cell foam test last because I felt it was the most likely to cause a pressure spike and chamber damage. Imagine my disappointment then, when firing the first string produced middle-of-the-road results with a velocity of 1956 ft/sec and a pressure at one inch of 21,200 psi! Holding out hope from some drama to develop at the bullet base, I fired the next string that developed a velocity of 1947 ft/sec and a pitifully normal pressure of 21,100 psi. It seems you just can't produce a disaster when you want one. The pressure traces produced at the bullet-base appear identical to the open-cell foam, complete with stutter step. This leads me to believe that the closed-cell is also being greatly compressed against the bullet base. However, the chamber of the test rifle is completely unharmed after firing ten rounds using this closed-cell foam. Whatever happened inside the chamber did not appear to be causing any excess pressure.

To make all these numbers more digestible, I have provided a bargraph of relative pressures at breech and bullet base from the various methods tried in these tests. This should make a comparison between filler types easier to visualize. We notice immediately that stacked hard felt wads and Cream Of Wheat produced the highest pressures of the fillers tested, but this is tempered by noting that these pressures are approximately equal to that produced by the factory-loaded Kynoch Nitro-For-Black ammunition. The noticeable low pressure demonstrated by the single nitro card test is due to poor performance of the load using this wad and not by any inherent low-pressure quality in the wad itself. The nitro card did not hold the powder charge in place during ignition which resulted in a hang-fire and general low load performance. Careful study of the chart will show that the fiber fillers such as Dacron, Kapok, and Cotton produced admirably low pressure and the pressure at the bullet-base is lower than that recorded at the breech position. The exception is when using a small tuft of Dacron over the powder, which, in my opinion, is the incorrect way to use any fiber filler. It is observed that with single wads, where there is an air space between powder and bullet, the pressure at bullet-base is elevated over the breech pressure. This is also found with the granular fillers such as Puff-Lon and Cream Of Wheat.

So what can we conclude from all these time-consuming tests? The obvious elephant in the room is that no excess pressure developed from the use of these widely different filler materials. Those hoping for clear-cut heroes and villains to surface are disappointed. I thought there would be much more variation in ballistics between the various methods and I was really rooting for closed cell foam to be the bad guy. However, facts have a way of disproving opinions. Now it is entirely possible that the steel in the barrels of our eighteenth-century rifles is inferior in strength and elasticity to the more modern steel in my test rifle. The chambers of an original express rifle are likely more susceptible to ringing. However, the strain-gage system used to measure the transient pressures did not record spikes or high-pressure events likely to produce such ringing. These results do not make me ready to defend all of the 15 different methods of using filler that we have explored here. Personally, I am inclined to avoid the methods that cause a significant stutter step in pressure at the bullet base. The materials such as Dacron, Kapok, Cotton and even felt wads when used in case-filling amounts, give the smoothest pressure curves and generally less pressure increase at the bullet base when compared to that at the breech. The fibers such as Dacron and Kapok remain my favorites because of their convenience and the information gathered by these tests verifies their good performance. Having said all this, there is no "smoking gun" (ouch!) pointing to any one of these methods as inherently evil.



Pressure vs time readouts from bullet base stacked felt wads produced smooth curves on left. Single vege fiber wad produced stutter-step in pressure on right—showing impact of wad on bullet base.

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