MDRX 308 Characterization Report

August 13th 2022

Revision -

Contents

Table of Figures

Table of Tables

Table of Equations

1 Introduction

The Micro Dynamics Rifle extreme (MDRx) platform[2] is a semi-automatic auto loading rifle produced by Desert Tech[1], a United States Bullpup manufacturer. Desert Tech is most known for the Desert Tech HTI and SRS series of long-range bullpup bolt rifles that have been adopted by military and police around the world[3].

The MDRx platform is the second generation of semi-automatic rifle produced by Desert Tech, superseding the original Micro Dynamic's Rifle (MDR) that made its debut at shot show in 2014 and the NGSAR[4]. The NGSAR was Desert Tech's entry into the Army's Next Generation Squad Weapon Program based on the MDR platform that concluded in 2022.

The MDRx platform is unique in that it is one of the few rifles on the market that is able to accept full power and intermediate power rifle magazines such as those used for 7.62 NATO and 5.56 NATO ammunition. The other known Rifle is the Colt Modular Carbine CM901[5] which is a .308 semi auto rifle that is able to accept any standard AR15 upper with an adaptor.

The MDRx rifle utilizes a quick-change barrel mechanism that makes the rifle particularly well suited for aftermarket barrels as well as multi caliber swaps. The manufacturer originally claimed the performance of the rifle in all Calibers was between 1 and 2 moa [6]. However, the community over the last 5 years has had a difficult time replicating that data on the full power cartridges such as with the .308 cartridge as reported on May 31st 2022[7].

After the original report was published 3 members of the community offered to corroborate the above test results and began to pursue a wider accuracy characterization campaign of several different rifles, ammunition, and configurations. In addition, the group reached out to Desert Tech Aftermarket Dealer ES Tactical[8] and a consulting Aerospace Systems Engineer Andrew Murrell, CSEP[9] [10]. The results of these characterizations are presented and analyzed herein.

As of July 29, Desert tech began a characterization campaign of the rifle in its different configurations and has indicated that the prior accuracy number used 3 round accuracy test. Desert Tech's new characterization utilize 5 shot groups with factory and precision ammo and reported the best .308 16" barrel performance was 1.6 MOA[11].

2 Scope

The Scope of this report is to expand on the May 31st 2022 testing that used the ES Tactical precision barrel with an expanded shooter pool, factory ammunition, and comparisons against baseline Desert Tech MDRx 308 rifles. The ES Tactical 20" barrel was shipped to multiple shooters. The shooters then tested a multiple of ammunition whose data was then compiled and analyzed against each other to determine baseline accuracy of all configurations, relative performance improvements between configurations, and trend analysis of accuracy data. All data captured used similar test conditions as well as provide verification evidence of the groupings in the Appendices.

The resulting data will be used to inform the community on the limitations of the platform, develop future testing campaigns, conceptualize and develop a case for aftermarket performance improvements, and substantiates, support, or disprove existing theories for platform performance based on characterization data.

3 References

ID	Name	URL If Applicable
[1]	Desert Tech Website	https://deserttech.com/index.php
[2]	Desert Tech MDR Wiki Page	https://en.wikipedia.org/wiki/Desert_Tech_MDR
[3]	Desert Tech Timeline	https://deserttech.com/timeline.php
[4]	NGSAR on Soldier System	https://soldiersystems.net/2020/03/10/the-desert-tech-next-generation-squad-weapons-submissions/
[5]	Colt Modular Carbine Select Fire	https://www.colt.com/detail-page/colt-modular-carbine-select-fire
[6]	Desert Tech Accuracy Report	https://deserttech.com/blog/is-the-mdrx-a-long-range-rifle/?fbclid=IwAR1TL5db74xhGYyzuD_ZxSAIxRRp14GqhjHLzPqH5HX0ANjKzgYt8mkhbnU
[7]	MDRX Reloading Performance Test	https://www.docdroid.net/qAA2rSh/mdrx-reloading-performance-20220531-pdf
[8]	ES Tactical Website	https://www.es-tactical.com/
[9]	Andrew Murrell, CSEP Reloading Citation 1	https://www.doublealpha.biz/us/daa-fast-flow-powder-funnel
[10]	Andrew Murrell, CSEP Reloading Citation 2	https://www.uniquetek.com/store/696296/uploaded/26_Tips_for_Powder_Measure_Accuracy.pdf
[11]	MDRx Rivalry 308 Winchester Report	https://www.youtube.com/watch?v=fVZj8yQoJCQ
[12]	Barrel Locking Block Screws	https://www.reddit.com/r/MDRInfoGallery/comments/vd6i83/barrel_locking_block_screw_information_important/
[13]	Loctite Thread locker Guide	https://www.ellsworth.com/globalassets/literature-library/manufacturer/henkel-loctite/henkel-loctite-user-guide-threadlocking.pdf
[14]	Fastenal Fastener Look Up Table	https://www.fastenal.com/content/merch_rules/images/fcom/content-library/Torque-Tension%20Reference%20Guide.pdf
[15]	Wheeler Fat Wrench	https://www.wheelertools.com/gunsmithing-tools/wrenches-and-screwdrivers/f.a.t.-wrench-with-10-bit-set/553556.html
[16]	Bolt Depot Alloy Steel Bolt Strength Reference	https://www.boltdepot.com/fastener-information/materials-and-grades/bolt-grade-chart.aspx
[17]	AMFG screw torque Calculation	https://www.omniamfg.com/mechanical/2019/5/21/how-to-calculate-maximum-fastener-and-screw-torque
[18]	ASME Unified Inch Screw Threads	https://www.asme.org/codes-standards/find-codes-standards/b1-1-unified-inch-screw-threads-un-unr-thread-form
[19]	Recommended Loctite Procedures	http://www.useloctite.com/downloads/MRO_DoItRight.pdf

4 May 31st 2022 ES Tactical Test Results

On May 31st, an original characterization test[7] of the ES Tactical 20" .308 barrel was published by one of the authors of this report that reported performance of M80 Ball, Custom Loaded Hornady 150 Grain FMJBT, and Custom loaded Hornady 178 Grain HPBT that presented accuracy results between 2.5 MOA and 4.87. Those results will be included in this report and identified as Shooter 1 and lessons learned reported in this Section

4.1 Reported MDRX Platform Deficiencies

1. ES Tactical Reports the Barrel Locking Block flexes the Chassis with higher energy rounds
2. ES Tactical reports Locking Block bolts loosen over time and can contribute to barrel movement
3. Improperly torqued barrel can contribute to inaccuracies
4. Piston System provides torque on the barrel contributing to barrel $flex_1$

Note 1: The fixed gas port location is believed to be the root cause of the performance impact as the barrel torquing occurs before the bullet has left the muzzle. For additional details see Section 9.2.1.

4.2 Future Recommendations

1. Testing two above cartridges with Oppressor Blast Deflector
2. Conduct a load workup on 125 Grain HP
3. Consider chassis improvements to reinforce Barrel Locking Block
4. Conduct testing with gas system disabled to turn rifle into bolt action
5. Consider a dwell between shots to mitigate barrel heating
6. Abandon .308 and switch to lower energy cartridges

5 Characterization Testing

The original testing conducted by shooter 1 was limited in ammunition availability which resulted in a narrow application of lessons learned. The test group began a campaign to characterization the 20" bull precision barrel produced by ES Tactical Barrel, as well as provide relative comparison data on all platforms used by the test group. For additional details of each configuration utilized by the shooters, please see the Shooter Hardware and Notes section of Appendix B through Appendix H. In total roughly 60 tests were conducted with various ammunition and test configurations.

5.1 Barrel Comparison

For relative comparison the Desert Tech OEM .308 barrel is sold in two different configurations while the ES Tactical barrel is sold in various configurations. One of the barrels tested was a modified 20" desert tech barrel, for additional details see Appendix C, Figure 21, and Figure 22.

For a high-level comparison of the barrels used in this test see Table 1 below.

Table 1: Barrel Comparison

	Desert Tech Barrel 16"	Desert Tech Barrel 20" Mod	ES Tactical Barrel
Caliber	.308	.308	.308
Barrel Length	16"	20"	20"
Material	4150 Steel	4150 Steel	416R
Twist	1:10	1:10	1:10

5.2 Shooting Methodology

Test data collected in the characterization was conducted at 100 yards and a single 5 shot group was taken. No data was to be discounted, and a repeat test group would report both tests' results. This was primarily done to ensure characterization of barrel standard deviation.

The reason singular 5 shot (early tests were minimum 5) groupings were conducted was to ensure average performance of the configuration as a normal shooter would expect. For example, if the group shot 10 5-shot groups and picked the best group it would show a potentially cherry-picked group. By limiting it to a single test and scored retests it paints the ideal picture of what a precision shooter could expect in each configuration.

Note, some early data reported, even though they used 5 shot groups, may have retested the ammunition on different days. These sets of data can be identified by being before the May 31st test commission date. However, in all cases verifiable images of the groupings were required and verified via range buddy and appended herein.

All shots were to be taken at 100 yards, and the gas setting was reported on each test. For supporting evidence and shooter notes on the tests taken see Appendix B through Appendix H.

5.3 Barrel Locking Block Screws

ES Tactical recommended a bolt loosening test in early 2021 to shooter 1 who did conduct the verification test without slippage being detected.

In late June 2022, it was detected that Shooter 1's Locking Block/Barrel Block screws had loosened below the manufacturer specifications[12]. Shooter 1 estimates that the loosening of the locking block bolts occurred within 400 rounds of 7.62 rounds expended.

The exact time in which the barrel screws began to loosen was unknown and in turn is believed to have contributed to significant accuracy impacts. After inspection, as seen in Figure 1 and Figure 2 below, the root cause of the failure was due to improperly utilized thread locker on 4 of the 8 fasteners, while lacking thread locker in the remaining fasteners. Loctite Blue (Loctite 242 or equivalent) was used to retain the fasteners, however the thread locker manufacturer reported[13] that Loctite blue is ineffective for fasteners of this size and Desert Tech recommended Loctite Red (Loctite 263) to fasten these bolts as a user fix.

Figure 1: Chassis Screw Holes for Locking Block

Figure 2: Removed Locking Block Screws

Users checked their locking block bolts both in this shooting group as well as in the community, have reported loose screw during initial inspection in greater than 85% of the cases in the 9 documented inspected tests so far.

The loosening of the locking block bolts will impact performance due the fastener design, as seen in Figure 2 above, the two rear fasteners are taper screws, while the front two fasteners are button screws (with no Loctite). The result of which is that the rear screws are in mechanical contact with the chassis and transfer recoil force normal to the taper screw face with the chassis, however the front screws position is retained completely by the friction derived from the clamping force between the chassis and the locking block.

If the front screws loosen, the ultimate result will be that the locking block will pivot up to the backlash of the rear taper screws and ultimately lead to a locking/block trunnion derived barrel whip.

All shooting data in this report, taken before June 2022, did not verify the locking block screws after shooting. Any shooting tests where the screws were loose after test will be identified as such in the Appendix verification Images.

5.4 Locking Block Fastener Torque

As seen in Section 5.3, the custom fasteners that are used in the MDRx provide complications associated with the performance of the rifle. As the fasteners are custom manufactured black oxide alloy steel fasteners, the repeatability of the material strength is not known. The Desert Tech customer service line reports that 40 in-lbf is the proper lubricated (with Loctite red) torque and contact them directly for assembly instructions

When using thread locker, ensure you follow proper preparation procedures [19]. The high-level steps are as follows

1. Clean all threads physically with a brush
2. Use some form of degreaser such as Loctite 7840 to remove grease on all threads
3. Apply Loctite Primer 7649 to the all screw and hole threads. NOTE THIS STEP IS MANDITORY for all bolts with inactive surfaces, such as the Desert Tech black oxide alloy bolts. T
4. Apply Loctite to threads of screw and hole
5. Screw in bolt, repeat steps for remaining bolts
6. Once all bolts are inserted and screwed in Torque Bolts to Spec (In a star pattern)

The team conducted two different calculations, in Appendix A, to verify the Desert Tech torque number and determined that, if you are using a calibrated Wheeler Fat Wrench, **38** in-lbf is the highest torque that should be applied to these fasteners.

6 Test Results by Shooter and Platform

The following images Figure 3 through Figure 8 present the grouped test results by shooter and configuration.

6.1 16” Desert Tech barrel Performance

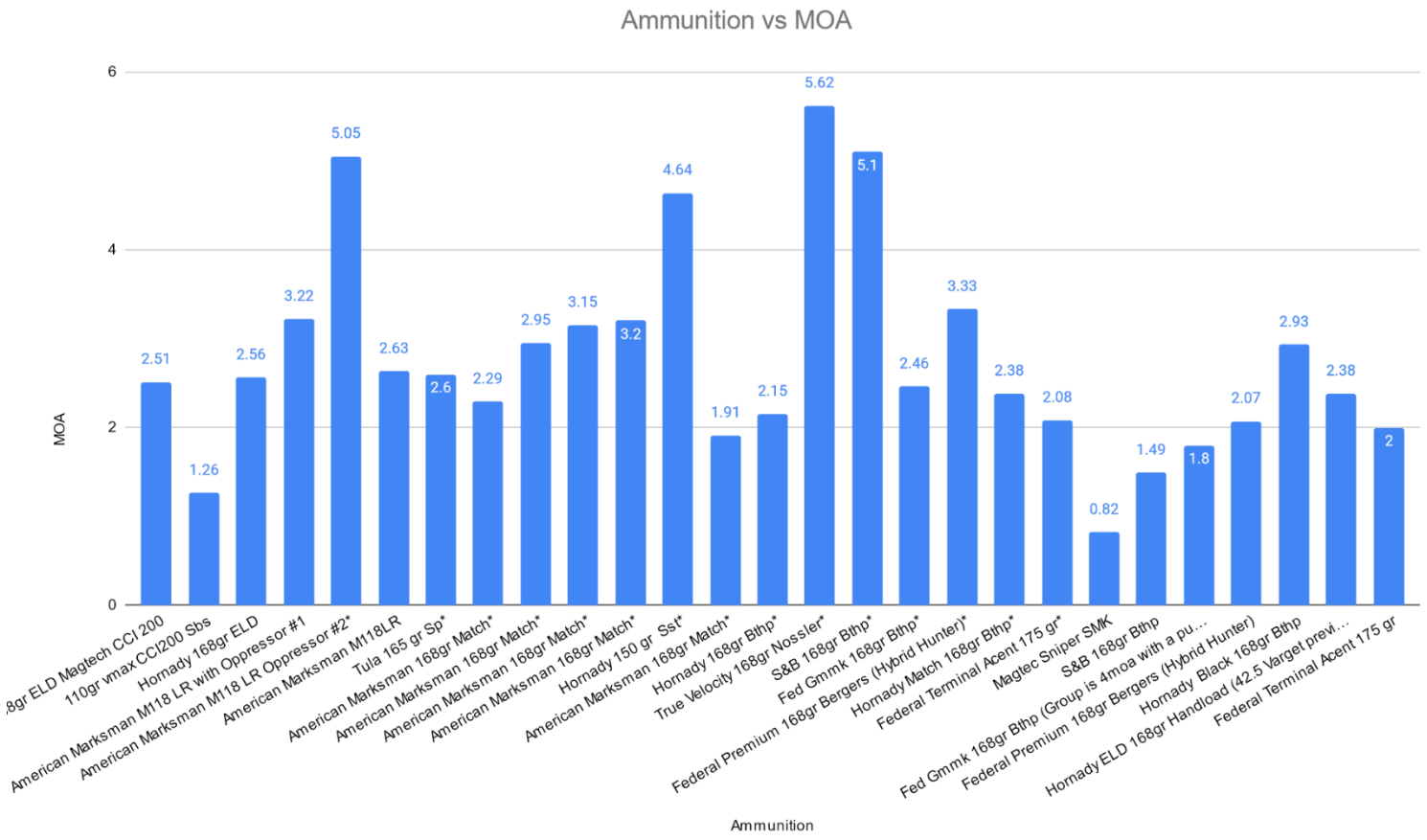


Figure 3: Shooter 3 16” Desert Tech .308 Barrel Performance

6.2 20” Modified Desert Tech barrel Performance

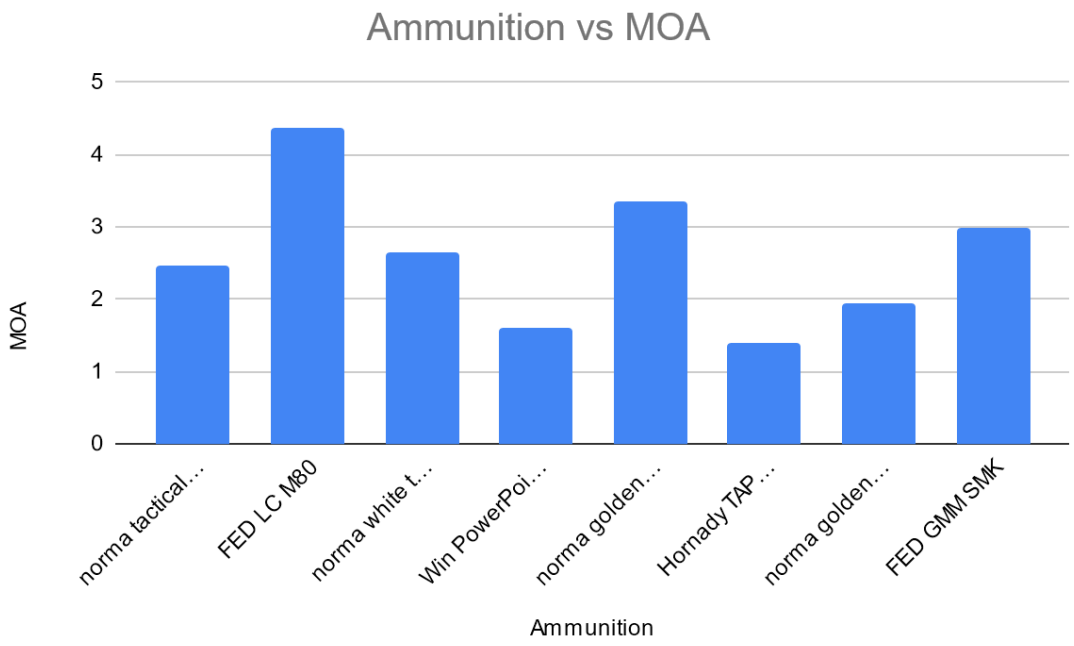


Figure 4: Shooter 2 20” Modified Desert Tech .308 Barrel Performance

6.3 20” ES Tactical barrel Performance

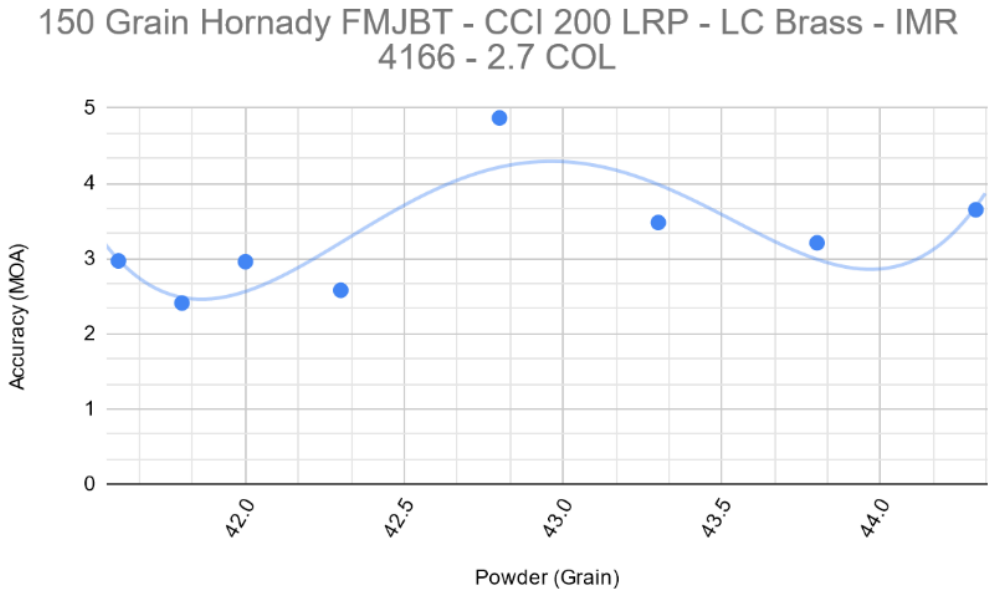


Figure 5: Shooter 1 150 Grain Accuracy Test

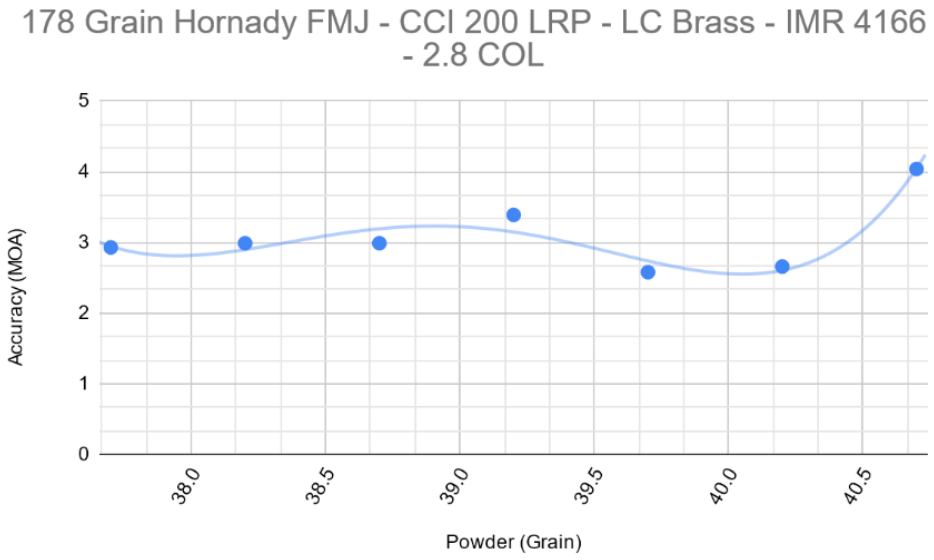


Figure 6: Shooter 2 178 Grain Accuracy Test

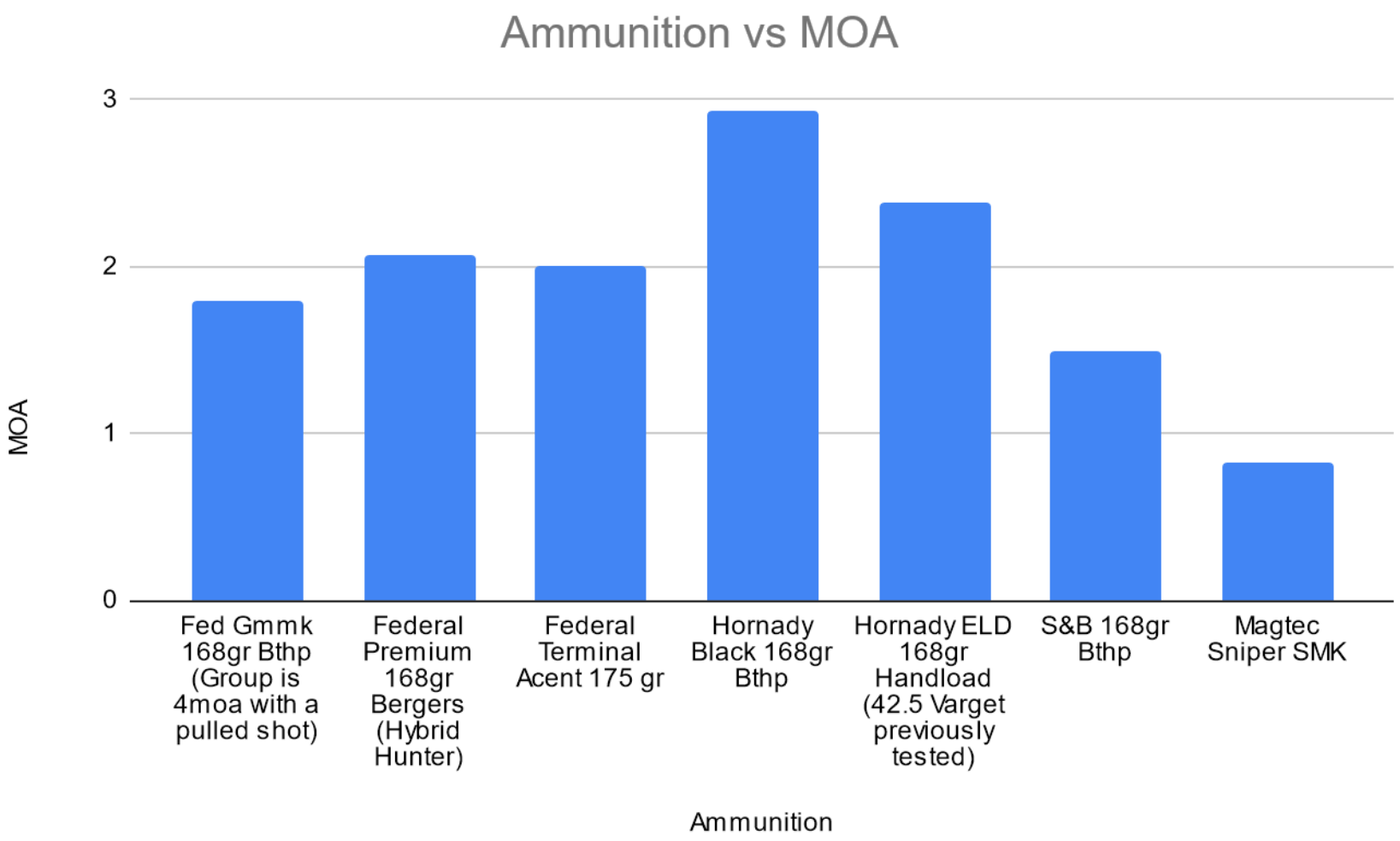


Figure 7: Shooter 3 20” ES Tactical Test Results

6.4 20” ES Tactical barrel Performance Suppressed

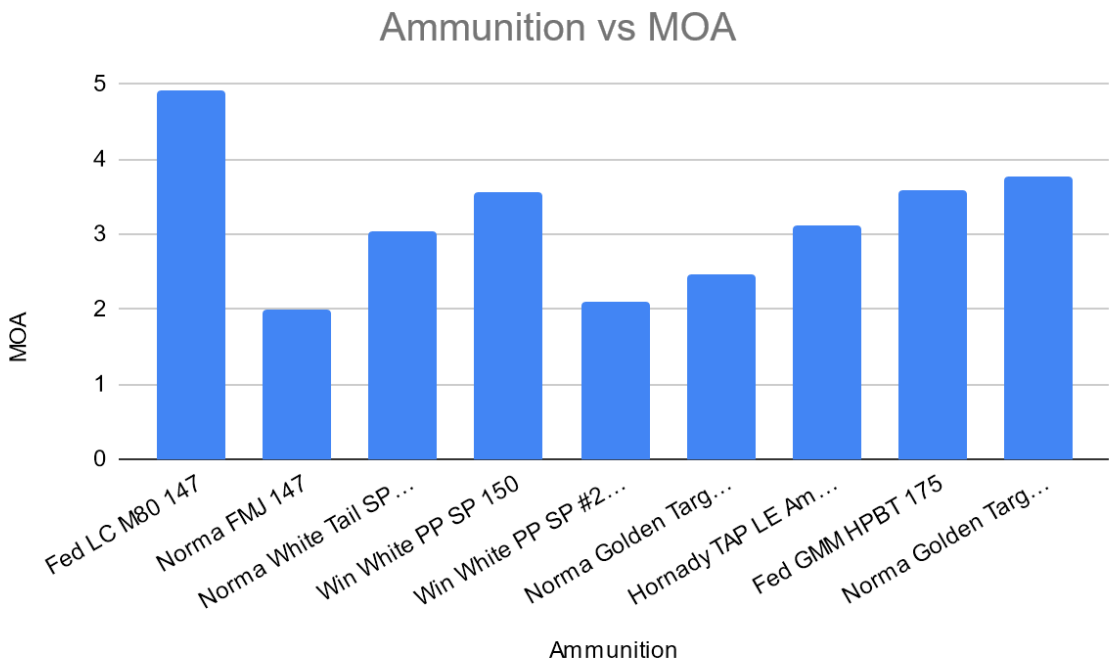


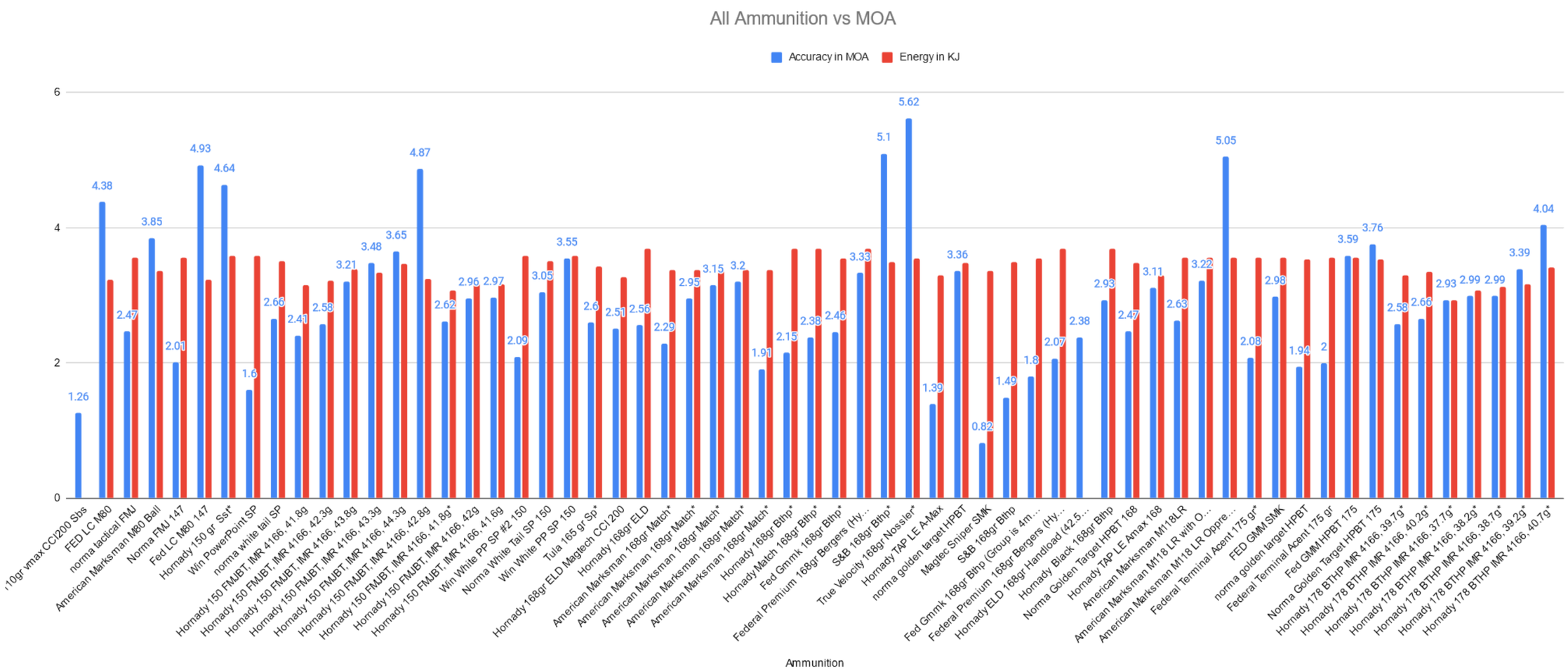
Figure 8: Shooter 2 20” ES Tactical Suppressed Test Results

7 Test Results by Bullet Weight

Due to the nature of the MDRx design, there were considerable concerns that the gas dwell time in the piston cylinder of the gas block as a primary contributor to inaccuracies in the platform, see Appendix C for details and possible solutions. As such, ES Tactical, an accomplished competition shooter and an expert in barrel design indicated that a common symptom of improper dwell is a reduction in performance of higher grain bullets.

7.1 Ammunition energy comparison

There was also a concern that higher energy cartridges may impose additional torque on the barrel causing barrel whipping to occur at a greater magnitude than other calibers. See Figure 9 below for energy plot comparison of available ammunition data. Note, assumptions were made based on what data was available for each test.



Note 1: Energy is Calculated using $Ke=1/2mv^2$ using available ammunition velocity data.

Figure 9: Ammunition Accuracy VS Energy[1]

7.2 Ammunition Accuracy by Bullet Weight

As seen below, Figure 10 through Figure 13 present all data collected regardless of shooter/configuration/grain to trend analysis. Note, only one test was conducted with 110 grain.

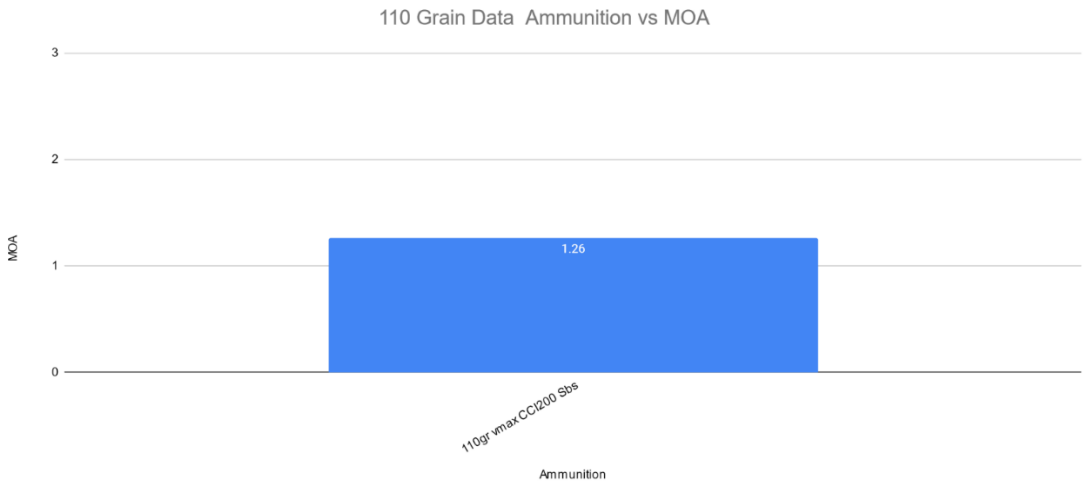


Figure 10: 110 Grain Accuracy Tests

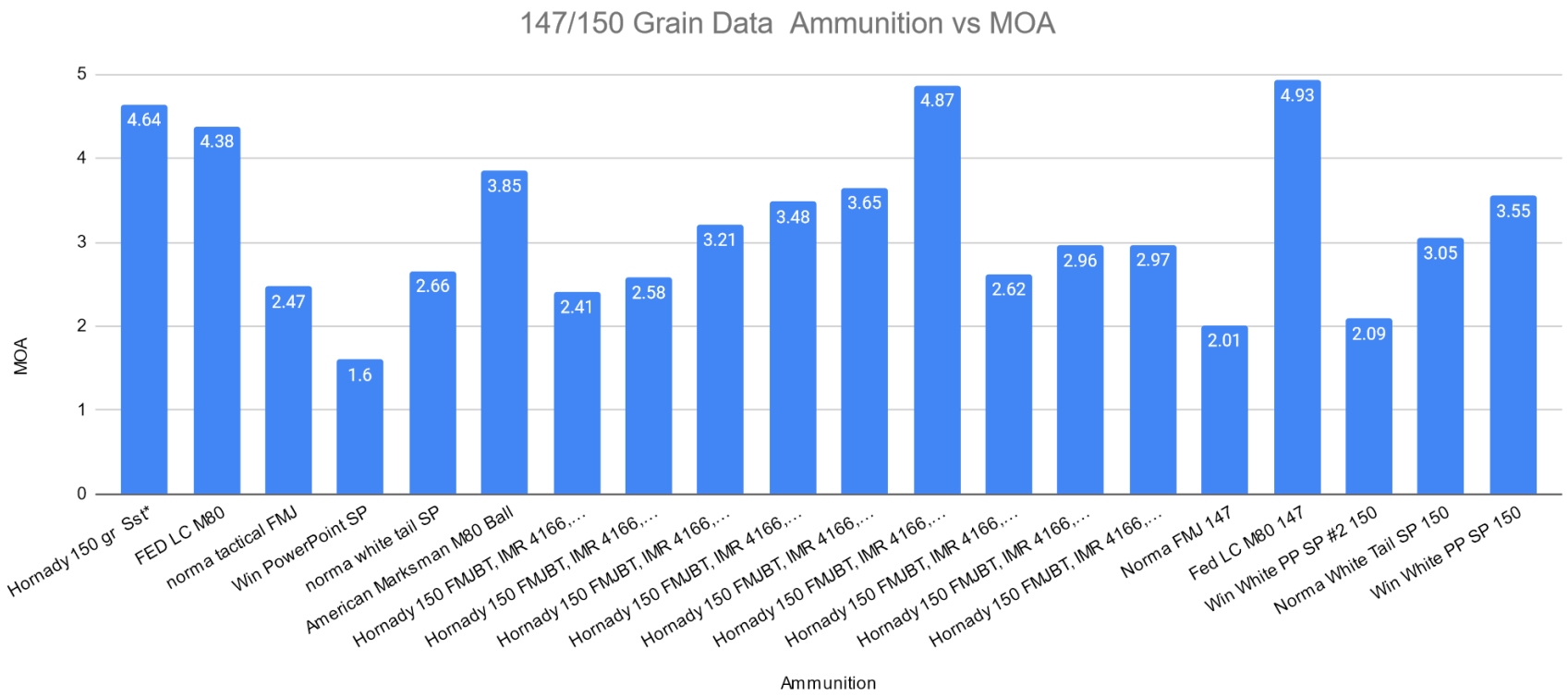


Figure 11: 147/150 Grain Accuracy Tests

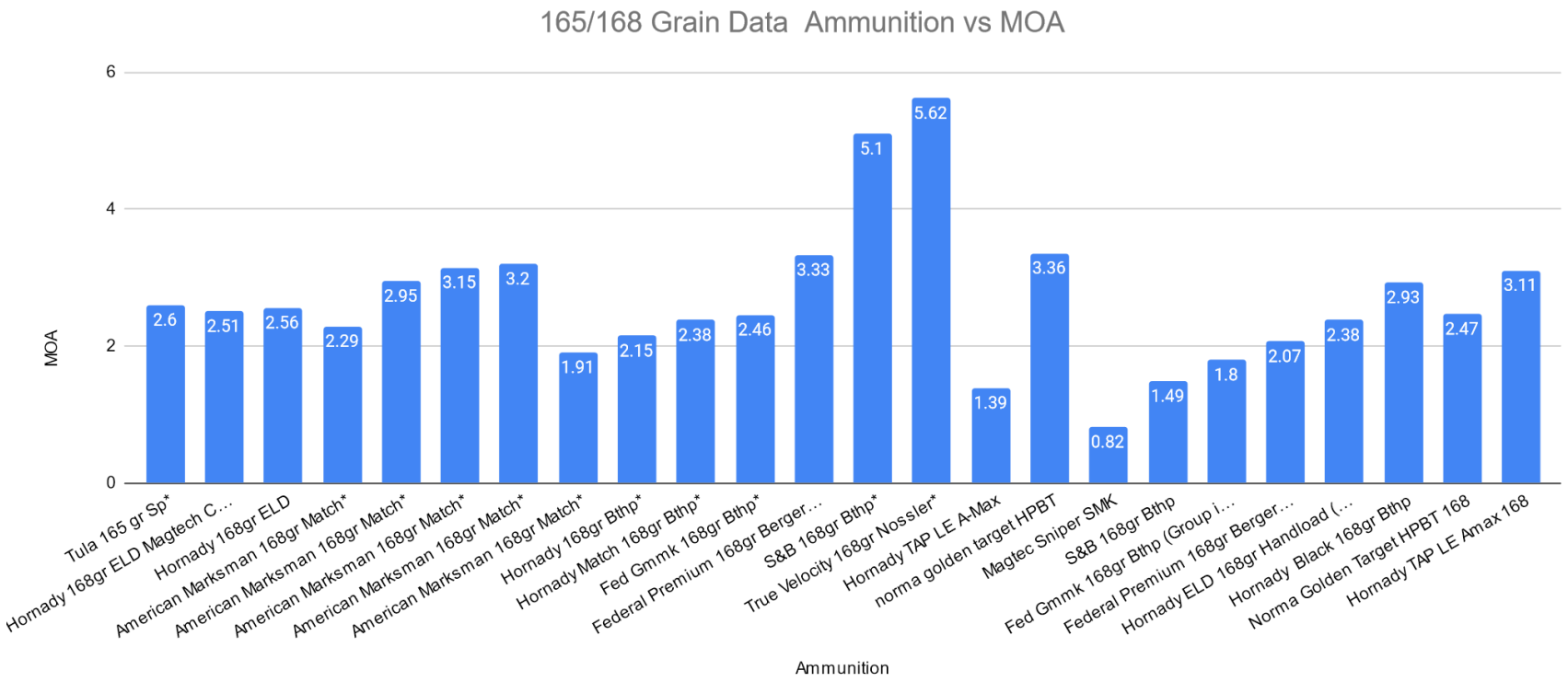


Figure 12: 165/168 Grain Accuracy Tests

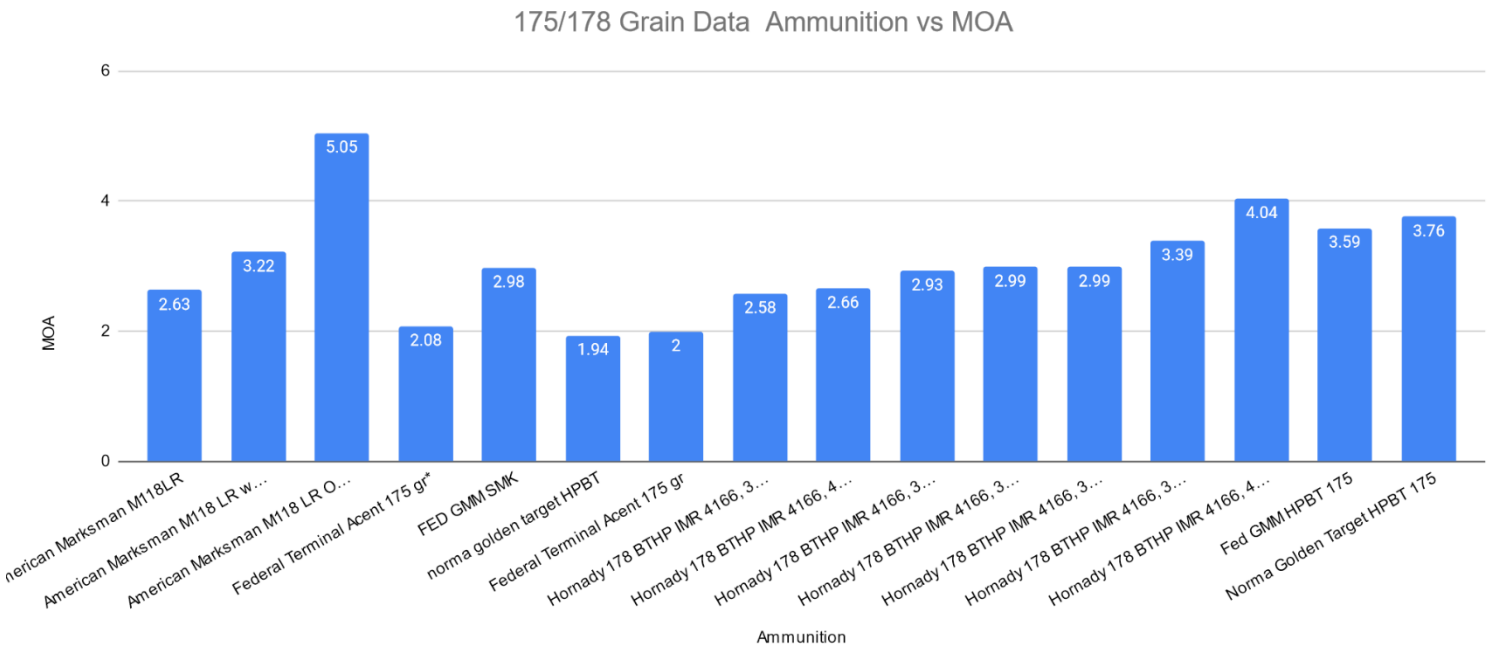


Figure 13: 175/178/ Grain Accuracy Tests

8 Data Analysis

Trends in the data were difficult to detect in the aggregate data form, multiple methods were conducted for data reduction and separated with specific goals in mind to show performance in different areas. Section 8.1 through Section 8.4 present different data separation methods for trend analysis.

8.1 Overall Data Presentation and Analysis

Based on the data presented in Sections 6 and Section 7. Figure 14 below separates and plots the respective data by category. Note, during the data separation the data being compared may reduce the comparison data to several, or in the case of the 147/150 Grain 16" DT barrel test shown below, one test.

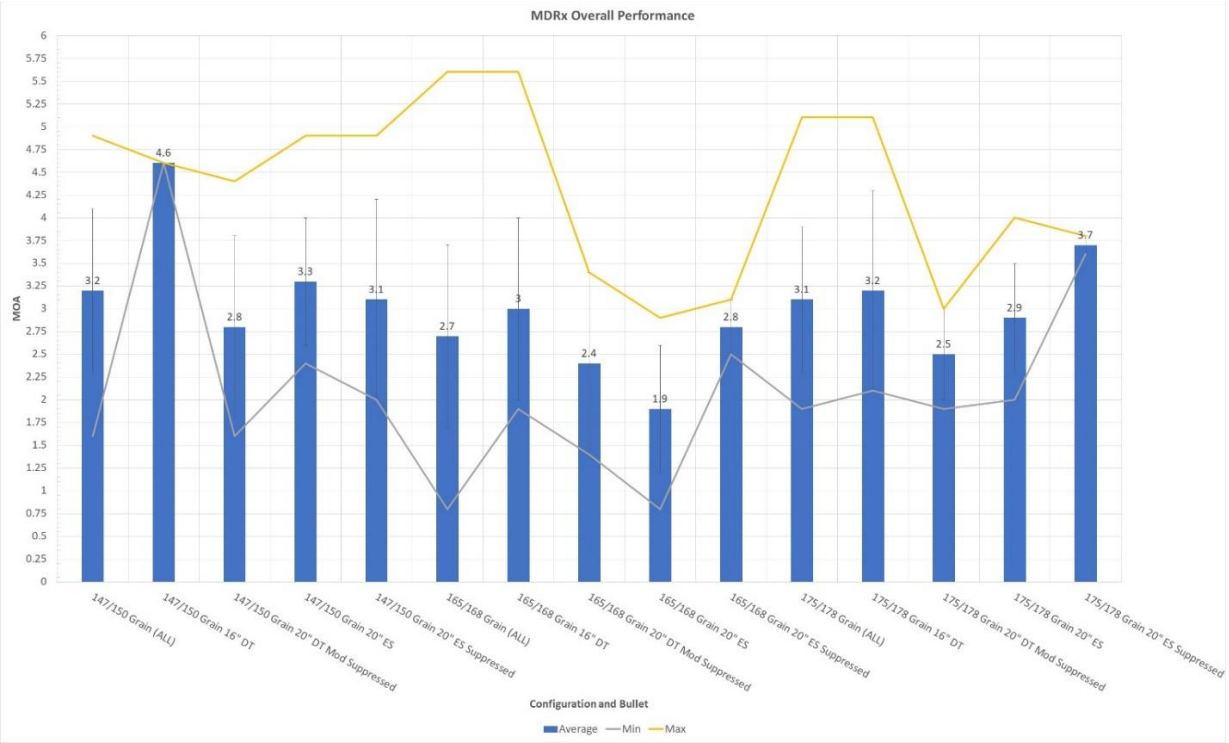


Figure 14: Ammunition performance by configuration and weight

Figure 14's data can been in in tabular form in Table 2 below.

Table 2: Ammunition performance by configuration and weight

Data Analysis Name	Average (MOA)	StD (MOA)	Min (MOA)	Max (MOA)
147/150 Grain (ALL)	3.2	0.9	1.6	4.9
147/150 Grain 16" DT	4.6		4.6	4.6
147/150 Grain 20" DT Mod Suppressed	2.8	1.0	1.6	4.4
147/150 Grain 20" ES	3.3	0.7	2.4	4.9
147/150 Grain 20" ES Suppressed	3.1	1.1	2.0	4.9
165/168 Grain (ALL)	2.7	1.0	0.8	5.6
165/168 Grain 16" DT	3.0	1.0	1.9	5.6
165/168 Grain 20" DT Mod Suppressed	2.4	1.0	1.4	3.4
165/168 Grain 20" ES	1.9	0.7	0.8	2.9
165/168 Grain 20" ES Suppressed	2.8	0.3	2.5	3.1
175/178 Grain (ALL)	3.1	0.8	1.9	5.1
175/178 Grain 16" DT	3.2	1.1	2.1	5.1
175/178 Grain 20" DT Mod Suppressed	2.5	0.5	1.9	3.0
175/178 Grain 20" ES	2.9	0.6	2.0	4.0
175/178 Grain 20" ES Suppressed	3.7	0.1	3.6	3.8

8.2 Bullet Weight Analysis by Grain

As can be see above in Figure 14, the data was separated further and grouped by platform and grain as seen in Figure 15 through Figure 19 and a trend line was generated in all plots to determine relative performance of each bullet weight and class used.

As can be seen in all tests conducted, there does not appear to be reduced performance with increased ammunition grain. The 168 grain bullets outperformed all other classes by a significant margin.

Additional analysis was conducted that removed data with verified loose locking block screws and M80 Ball ammo. The results were that no significant impact to the 168-grain bullet performance superiority was detected.

Note, ammunition below 147 grain was not tested, and there may be opportunity for further testing in the sub 150 grain high velocity .308 ammunition to see if the very nature of precision 168 grain ammunition doesn't overshadow inherent improvements in high velocity ammunition from contributions by gas dwell.

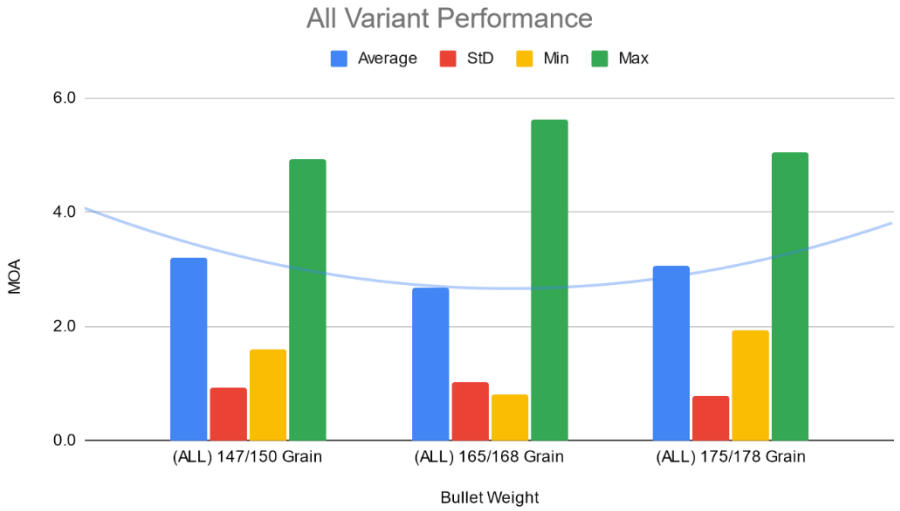


Figure 15: All Variant Performance by Grain

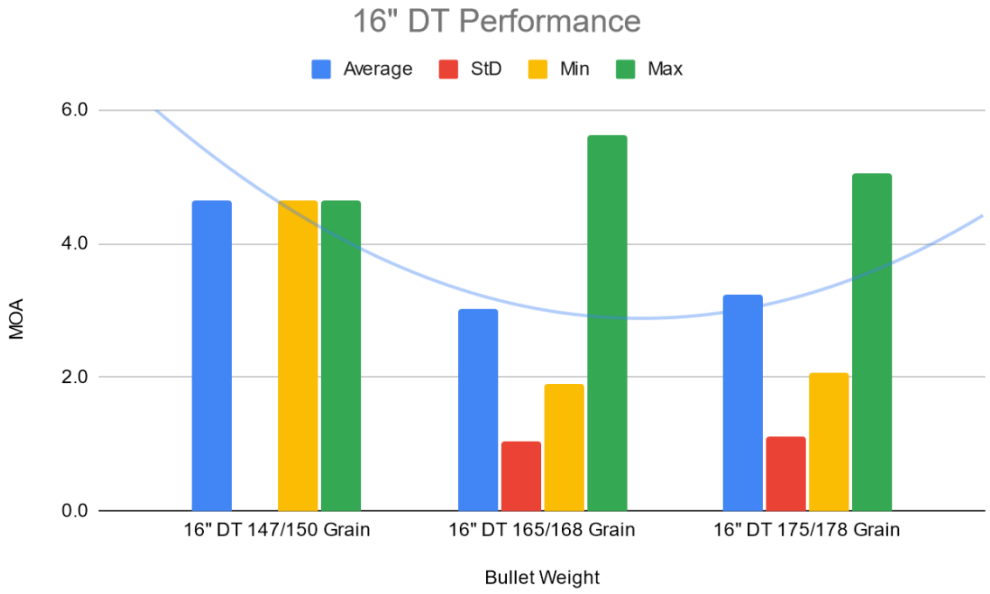


Figure 16: 16" DT Performance by Grain

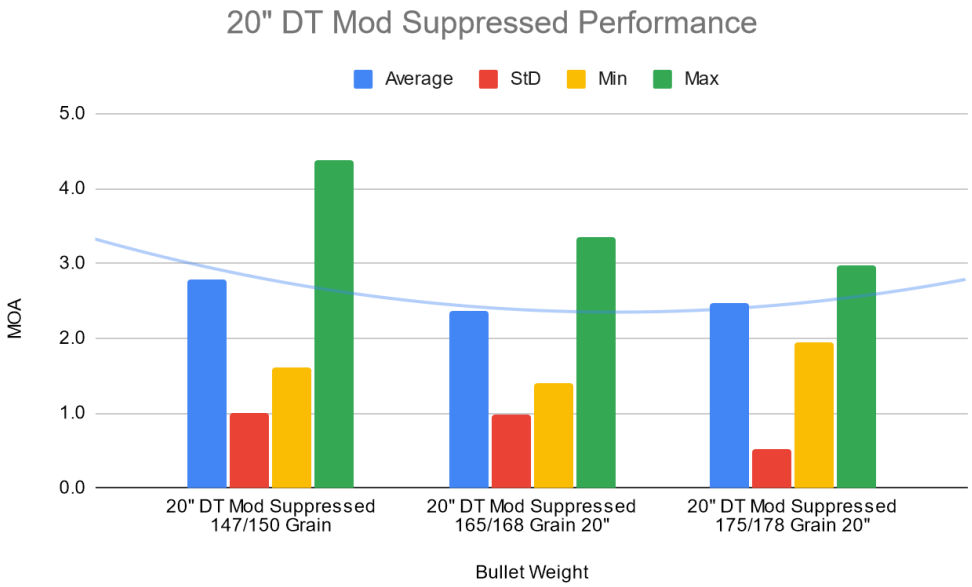


Figure 17: 20" DT Mod Suppressed Performance by Grain

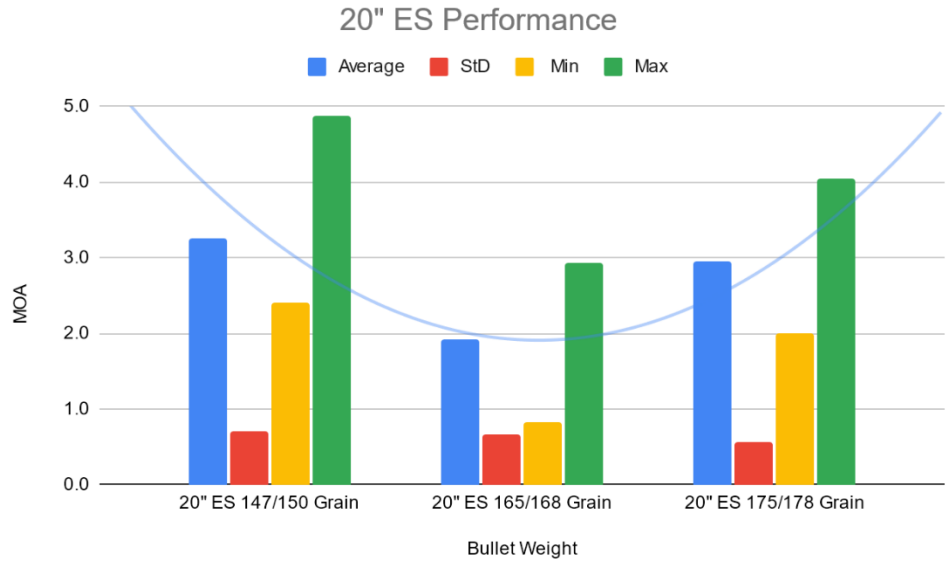


Figure 18: 20” ES Performance by Grain

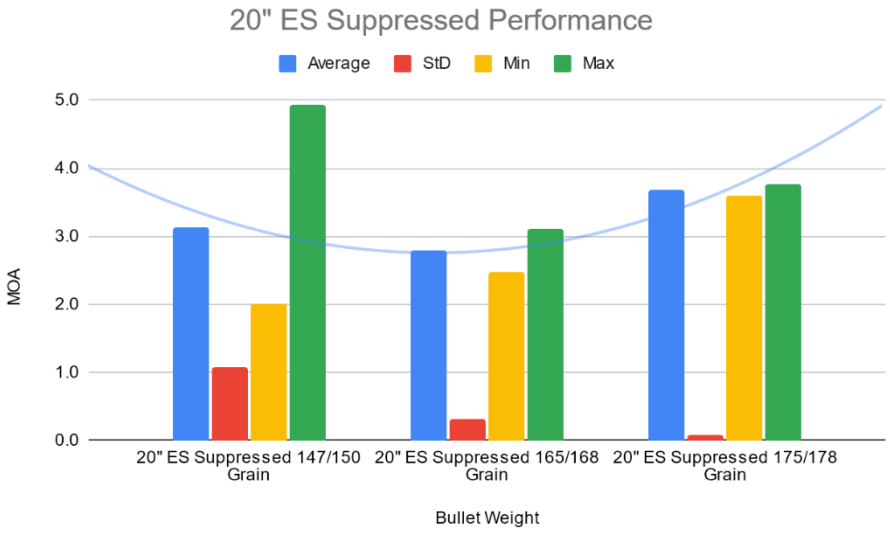


Figure 19: 20" ES Suppressed Performance by Grain

8.3 Numerical and relative Analysis of Bullet Weight

The data presented in Section 8.1 and Section 8.2 above was further reduced with relative comparisons as seen in Table 3. As can been seen in Table 3, the 165/168 grain testing was roughly 19% more accurate than the 150 grain tests.

Table 3: Ammunition Relative Performance by Grain

Data Analysis Name	Average	StD	Min	Max
165/168 Performance over 147/150	119.91%	0.9	2.0	0.9
175/178 Performance over 147/150	104.82%	0.8	2.4	0.9

8.4 Relative Comparison of Rifle Configurations

The final analysis method used was to barrel performance in all categories tested using the 16" Desert Tech Barrel as a control as seen in Table 4.

Table 4: Configuration performance Summary

Data Analysis Name	Average (MOA)	Average StD (MOA)	Average Min (MOA)	Average Max (MOA)
All Bullet Performance 16" DT	3.6	1.1	2.9	5.1
All Bullet Performance 20" DT Mod Sup	2.5	0.8	1.6	3.6
All Bullet Performance 20" DT ES	2.7	0.6	1.7	3.9
All Bullet Performance 20" DT ES Sup	3.2	0.5	2.7	3.9

Table 5 below presents the relative performance difference of the barrels used against the 16" Desert Tech control. The results clearly showed significant improvement in both the modified Desert Tech Barrel as well as the ES Precision barrel with significant improvements in average MOA as well as the Standard Deviation of all ammunition tested.

Table 5: Relative Performance Improvement Summary

Data Analysis Name	Average	Average StD	Average Min	Average Max
DT Mod Improvement Sup over Stock	143.19%	128.76%	175.05%	142.82%
ES Improvement over Stock	134.20%	167.89%	165.01%	129.31%
ES Improvement Sup over Stock	113.65%	218.88%	106.94%	129.75%

9 Conclusion

9.1 Characterization Conclusion

As can be seen in Section 8 above, the stock Desert Tech Barrel has considerable accuracy concerns with an average accuracy of 3.6 MOA and a standard deviation of 1.1 MOA.

The modified DT barrel (Suppressed) was the most accurate of all tested with an accuracy of 2.5 moa and a standard deviation of 0.8 MOA.

The ES Tactical was slightly less accurate than the modified DT barrel, however it was significantly more consistent, roughly 50% more consistent by ammo compared to the stock Desert Tech Barrel.

The most accurate ammunition tested in all calibers was the 168 grain Magtec Sniper SMK fired from Shooter 3 in the 20" ES Tactical barrel.

At this point the Stock DT .308 Caliber appears to have considerable performance and repeatability issues with the ammunition tested and the locking block screws losing torque is a considerable concern as well, however per the data above, and after screw torque was checked, the variability issues persisted.

9.2 Future Recommendations

Due to the limited scope of the characterization, several areas that could use additional focus presented themselves for future testing and trade studies that could improve community knowledge of the platform.

9.2.1 Gas Dwell Testing and Characterization

The original team concept was that the gas dwell time of the MDRx Rifle was adversely affecting the accuracy of the rifle due to the lack of adjustability of the MDRx gas block port location from interference with the handguard. As the gas port is fixed for every barrel length of the rifle the dwell time could not be optimized for barrel length resulting in undesirable gas dwell time.

The overall gas dwell theory is that the as the bullet travels down the barrel, once it passes the gas port the reaction force of the rifle shifts from being completely through the bolt face and to the BCG via the gas block and piston. Once the Piston cylinder pressure is built up sufficiently it will begin to shift the piston towards the BCG resulting in force transfer when the piston makes contact with the oprod.

The result of this shift is an off-axis force resulting in a torque that pushes barrel tip down. If the bullet has yet to leave the barrel the barrel will shift the bullet off its original trajectory resulting in inaccuracies relative to the momentary powder pressure in the barrel.

Based on ES Tactical's experience these dwell issues result in better performance with higher velocity low grain bullets over heavier ones. However, the analysis presented in Section 8.3 was unable to clearly identify such a trend. This could be due to a combination of factors, namely the increased performance of 168 grain projectiles over 150 offsetting accuracy gains from higher velocity projectiles.

This team recommends several follow-on tests to clearly identify the dwell problem

1. Lower grain higher velocity ammunition tests, such as 110 Hornady VMAX, 125 grain Speer TNT, or a copper bullet in similar grain. However, this particular test is difficult to replicate with

factory ammo due to the relative scarcity of low grain 308 ammunition. Which may drive reloading tests as the primary method for characterization.

2. Gas off tests with one of the factory ammunitions above. With the MDRx gas off the contributions from the dwell time will be eliminated. This will result in the greatest evidence of performance by eliminating the gas port force contribution. This can be done in several ways, plugging of the gas port in the barrel, plugging the gas block, plugging the gas plug, or by turning the gas plug past détente number 6 but before the gas plug is able to be released. If the latter option is explored the gas plug should be checked after each shot.
3. Accuracy tests with the same ammunition and barrel, however periodically cut down the barrel to determine if accuracy improves with shorter barrels. If the barrel is shorter the bullet will be in the barrel for a shorter period of time and result in less time for the dwell effects to reposition the bullet in the barrel.

9.2.2 Suppressor Test

The Silencerco omega used in this test by Shooter 2 provided interesting test results in Section 8.4, specifically it performed worse than the same suppressor mounted onto Desert Tech 20" modified barrel. The current theory is that Silencerco is not a high flow suppressor and is providing considerable back pressure in the barrel. This increased pressure increases the torque that the piston exerts on the BCG as discussed in Section 9.2.1 resulting in worse performance. The large prechamber on the modified Desert Tech Barrel may be mitigating some of the pressure buildup in the gas port resulting in improved accuracy.

A flow throw suppressor may not have this limitation and this team recommends a future characterization test with multiple makes and models of suppressors to capture the exact performance impact from different suppressor designs.

9.2.3 Locking Block Fastener Test

The loosened screws of the locking block as seen in Section 5.3, is the primary source for barrel inaccuracies in the .308 platform, both in primary recoil force as well as gas pressure force from the late dwell. As greater energy cartridges are utilized the locking block is required to, and fails to, resist greater force.

As the resistance to motion is reacted by the clamping force friction, methods should be evaluated to improve locking block retention, chassis friction, and anti-loosening mechanisms. If such systems can be developed, the relative performance improvement in characterization test on the same ammo would be telling on avenues for significant performance improvement.

9.2.4 Gas Block Redesign Testing

The fixed position of the gas block on the MDRx is sub optimal for the 20" barrel rifles, and possibly even the 16" barrel. The gas blocks design that contains a picatinny rail keeps the gas block from being designed to slide under the front hand guard. As such no aftermarket barrels can be designed to allow for a varied position gas port to reduce the dwell impact to performance.

This team recommends a gas block redesign that eliminated the picatinny rail and allows the gas block to slide under the hand guard. If such a device can be designed, the gas port can then be moved farther along the barrel to carbine or rifle length for improved accuracy and performance.

If such a device was built relative accuracy tests could be conducted to optimize gas port position for improved accuracy as well as reliability of the rifle.

Appendix A Locking Block Torque Verification

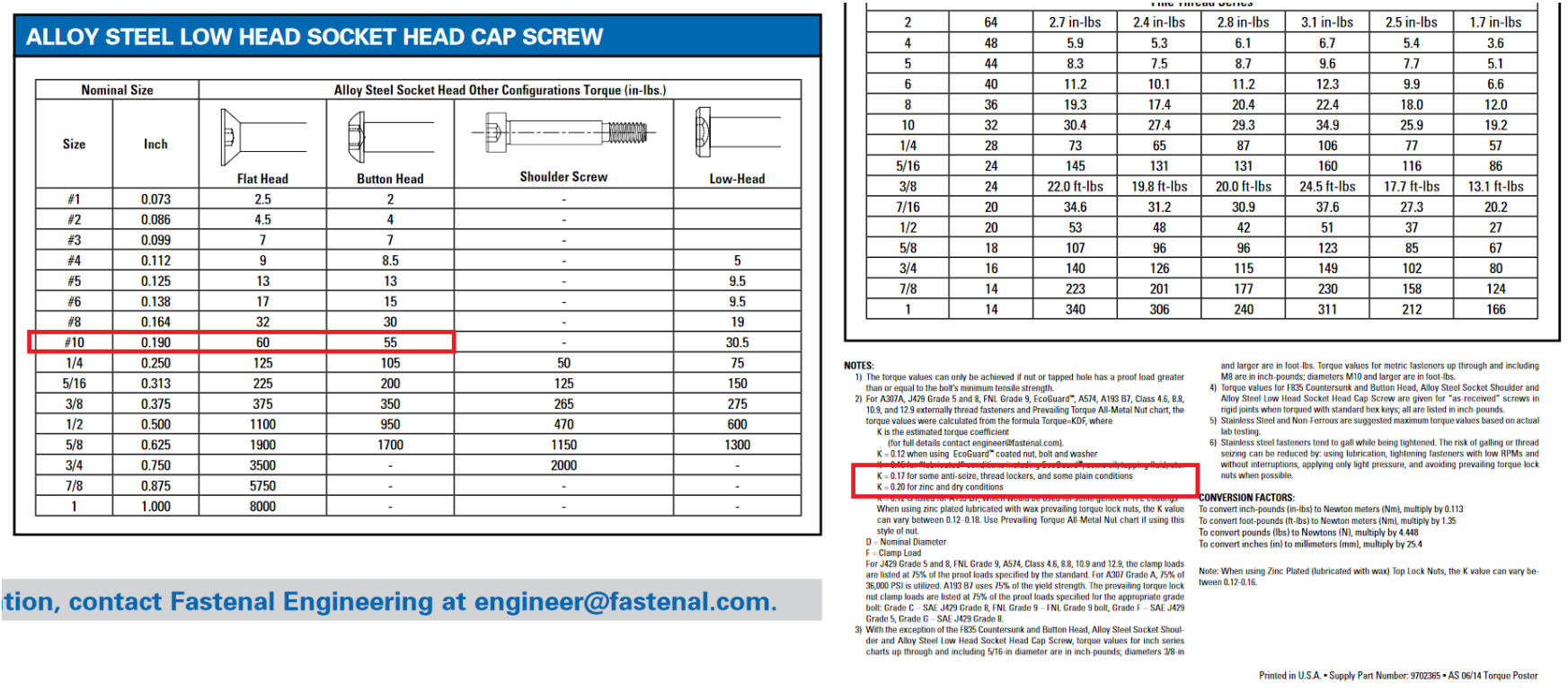
1.1 Fastenal Reported Numbers

Fastenal, a producer of various hardware provides a rule of thumb lookup table[14] as seen below in Figure 20 that presents 55 in-lb for button head screws. This indicates that the front screws fail at lower torque than the rear screws. In addition, the 55 in-lbf reported value is the unlubricated torque. As seen on the table on the right in Figure 20, the lubricated screw value must be adjusted downward. With the equation Torque=KDF where K is the torque coefficient, D is the Diameter, and F is the clamp force. If we resolve this equation to maintain the same clamp force F=T*/(K*D) we see that the clamping force goes up the lower the torque coefficient. This directly translates to increased force on the bolt if the bolt torque is not adjusted.

The lubricated K value of 0.17 is 15% lower than the dry value and as such we need to reduce and as such the resulting maximum safe torque value for the front button head bolt is 46.75 in-lbf. This does not include measurement accuracy. To be safe, we must further reduce the torque to ensure any inaccuracies in the torque wrench that is used does not inadvertently exceed the maximum safe/proof load of the bolt.

The Wheeler Fat Wrench is reported as +- 5%. As most measurement device accuracies are reported at full scale, the maximum torque (65) that the wrench can apply. The resulting maximum uncertainty for the wrench is 3.25 in-lbf. For comparison if a 200 in-lbf torque wrench is used with a +- 5% accuracy the uncertainty of the measurement is +- 10 in-lbf.

Using the wheeler fat wrench, the maximum load the lubricated bolt can be torqued to is 43.5 in-lbf safely. As the screws are custom manufactured with possibly variation in the material used in the bolts, it might be advisable to include a 10% safety Margin. The resulting bolt torque would now be 39.15 in-lbf.



ALLOY STEEL LOW HEAD SOCKET HEAD CAP SCREW

Nominal Size		Alloy Steel Socket Head Other Configurations Torque (in-lbs.)			
Size	Inch	Flat Head	Button Head	Shoulder Screw	Low-Head
#1	0.073	2.5	2	-	
#2	0.086	4.5	4	-	
#3	0.099	7	7	-	
#4	0.112	9	8.5	-	5
#5	0.125	13	13	-	9.5
#6	0.138	17	15	-	9.5
#8	0.164	32	30	-	19
#10	0.190	60	55	-	30.5
1/4	0.250	125	105	50	75
5/16	0.313	225	200	125	150
3/8	0.375	375	350	265	275
1/2	0.500	1100	950	470	600
5/8	0.625	1900	1700	1150	1300
3/4	0.750	3500	-	2000	-
7/8	0.875	5750	-	-	-
1	1.000	8000	-	-	-

tion, contact Fastenal Engineering at engineer@fastenal.com.

2	64	2.7 in-lbs	2.4 in-lbs	2.8 in-lbs	3.1 in-lbs	2.5 in-lbs	1.7 in-lbs
4	48	5.9	5.3	6.1	6.7	5.4	3.6
5	44	8.3	7.5	8.7	9.6	7.7	5.1
6	40	11.2	10.1	11.2	12.3	9.9	6.6
8	36	19.3	17.4	20.4	22.4	18.0	12.0
10	32	30.4	27.4	29.3	34.9	25.9	19.2
1/4	28	73	65	87	106	77	57
5/16	24	145	131	131	160	116	86
3/8	24	22.0 ft-lbs	19.8 ft-lbs	20.0 ft-lbs	24.5 ft-lbs	17.7 ft-lbs	13.1 ft-lbs
7/16	20	34.6	31.2	30.9	37.6	27.3	20.2
1/2	20	53	48	42	51	37	27
5/8	18	107	96	96	123	85	67
3/4	16	140	126	115	149	102	80
7/8	14	223	201	177	230	158	124
1	14	340	306	240	311	212	166

NOTES:

1) The torque values can only be achieved if nut or tapped hole has a proof load greater than or equal to the bolt's minimum tensile strength.
2) For A307A, J429 Grade 5 and 8, FNL Grade 9, EcoGuard™, A574, A193 B7, Class 4.6, 8.8, 10.9, and 12.9 externally thread fasteners and Prevailing Torque All-Metal Nut chart, the torque values were calculated from the formula Torque=KDF, where
   K is the estimated torque coefficient
   (for full details contact engineer@fastenal.com).
   K = 0.12 when using EcoGuard™ coated nut, bolt and washer
   K = 0.17 for some anti-seize, thread lockers, and some plain conditions
   K = 0.20 for zinc and dry conditions
   When using zinc plated lubricated with wax prevailing torque lock nuts, the K value can vary between 0.12 -0.18. Use Prevailing Torque All-Metal Nut chart if using this style of nut.
   D = Nominal Diameter
   F = Clamp Load
   For J429 Grade 5 and 8, FNL Grade 9, A574, Class 4.6, 8.8, 10.9 and 12.9, the clamp loads are listed at 75% of the proof loads specified by the standard. For A307 Grade A, 75% of 36,000 PSI is utilized. A193 B7 uses 75% of the yield strength. The prevailing torque lock nut clamp loads are listed at 75% of the proof loads specified for the appropriate grade bolt: Grade C – SAE J429 Grade 8, FNL Grade 9 – FNL Grade 9 bolt, Grade F – SAE J429 Grade 5, Grade G – SAE J429 Grade 8.
3) With the exception of the F835 Countersunk and Button Head, Alloy Steel Socket Shoulder and Alloy Steel Low Head Socket Head Cap Screw, torque values for inch series charts up through and including 5/16-in diameter are in inch-pounds; diameters 3/8-in and larger are in foot-lbs. Torque values for metric fasteners up through and including M8 are in inch-pounds; diameters M10 and larger are in foot-lbs.
4) Torque values for F835 Countersunk and Button Head, Alloy Steel Socket Shoulder and Alloy Steel Low Head Socket Head Cap Screw are given for "as-received" screws in rigid joints when torqued with standard hex keys; all are listed in inch-pounds.
5) Stainless Steel and Non-Ferrous are suggested maximum torque values based on actual lab testing.
6) Stainless steel fasteners tend to gall while being tightened. The risk of galling or thread seizing can be reduced by: using lubrication, tightening fasteners with low RPMs and without interruptions, applying only light pressure, and avoiding prevailing torque lock nuts when possible.

CONVERSION FACTORS:

To convert inch-pounds (in-lbs) to Newton meters (Nm), multiply by 0.113
To convert foot-pounds (ft-lbs) to Newton meters (Nm), multiply by 1.35
To convert pounds (lbs) to Newtons (N), multiply by 4.448
To convert inches (in) to millimeters (mm), multiply by 25.4

Note: When using Zinc Plated (lubricated with wax) Top Lock Nuts, the K value can vary between 0.12-0.16.

Printed in U.S.A. • Supply Part Number: 9702365 • AS 06/14 Torque Poster

Figure 20: Fastenal Lookup Table

1.2 Calculated Bolt Torque

The team verified the Desert Tech Bolt Torque and clamping force using Engineering assessments of the bolt performance as presented in Omnia MFG's example screw torque guide[17] and Bolt Depot's grade 8 mild steel proof load [16] of 120,000 psi, and ASME B1.1-2003 Appendix B-1 [18]. The following engineering values were used as shown in Table 6. Safe (I.E., lower value) assumptions were used in determining these values.

Table 6: Fastener Metric Table

Metric	Value	Unit
Proof Load	120000	PSI
Major Diameter	0.19	Inches
Minor Diameter	0.156	Inches
Coefficient of Torque	0.15	Constant

$$As = .7854(D - \frac{.9743}{\frac{1}{P}})^2$$

Equation 1

Where:

As = Tensile Stress Area

D=Nominal (Major) Diameter

1/P = Threads per inch

Equation 1 above can be solved to generate a Tensile Stress Area of the Fasteners of .019994 in^2

$$Fap = 0.75 * Lp * AS$$

Equation 2

Where:

Fap = Axial Preload

As = Tensile Area

Lp = Proof Load

NOTE: 0.75 in this equation signifies the fasteners are reusable. For single use fasteners, this value can to be increased to 0.90 but must be discarded as the bolt will have stretched.

Equation 2 can then be solved using the proof load and tensile area to result in a value of 1799 psi.

$$MaxTorque = Dn * Fap * Kt$$

Equation 3

Where:

Dn = Nominal Diameter

Fap = Axial Preload (FClamp)

Kt = Coefficient of Torque

Equation 3 can then be solved resulting in a Max Torque of 42.1 in-lbf

As can be seen in Section 1.1, assuming a Wheeler Torque Wrench is used, a safe torque value for commercial off the shelf 10-32 black oxide alloy fasteners is **38** in-lbf of torque.

Appendix B Shooter 1 Data

2.1 Shooter Hardware and Notes

Table 7: Shooter 1 Rifle Configuration

Shooter	Shooter 1
Rifle	2020 MDRx
Barrel	20" 308 ES Tactical barrel 416R 1-10 Twist
Muzzle Device	J Comp Gen 2
Suppressor	3-15 Vortex PST Gen 2
Optic	Atlas Bipod and Rear Bag
Support Details	Labradar
Chrono	Range Buddy
MOA Calc Method	.75" Dot
MOA Reference	Bill Springfield
Trigger	Locking Block/Trunnion Bolts Loose post test
Notes	Shooter 1

Notes:

- Zero with M80 Ball
- Bore Snake 2X every 2 tests
- Range 100 Yards

Figure 21: Desert Tech MDRx Barrel vs ES Tactical Barrel

- American Marksman M80 Ball – Re-bulleted to Nereloader 147 Grain FMJBT to 2.8” (Not Bimetal)
    - Bullet SKU: 308bulk147fmjbt250
- Hornady 150 Grain FMJBT #3037, IMR 4166, CCI 200 LRP, Federal Lake Once Fired Brass to 2.7”
- Hornady 150 Grain FMJBT #3037, IMR 4166, CCI 200 LRP, Federal Lake Once Fired Brass to 2.8”
    - Neck Tension Controlled at .02” per ES Tactical Recommendation
- Hornady 178 Grain HPBT #30715, IMR 4166, CCI 200 LRP, Federal Lake Once Fired Brass to 2.8”
    - Neck Tension Controlled at .02” per ES Tactical Recommendation
- Reloaded with a heavily modified Dillion 550C Progressive Reloading Press

2.2 Test Results

Table 8: M80 Test

147 Grain FMJBT American Marksman M80 Ball									
Powder (Grain)	**COL (inches)**	**Grain**	**Brand**	**Accuracy (MOA)**	**Speed (FPS)**	**STD (FPS)**	**Pressure Sign**	**Gas Setting**	**Test Date**
N/A	2.8	147	American Marksman M80 Ball	3.85	2756.4	27.514	N	S	20211024

Table 9: 150 Grain Test

150 Grain Hornady FMJBT - CCI 200 LRP - LC Brass - IMR 4166									
Powder (Grain)	**COL (inches)**	**Grain**	**Brand**	**Accuracy (MOA)**	**Speed (FPS)**	**STD (FPS)**	**Pressure Sign**	**Gas Setting**	**Test Date**
41.6	2.7	150	Hornady 150 FMJBT, IMR 4166, 41.6g	2.97	2647.556	11.758	N	N-	20220527
41.8	2.7	150	Hornady 150 FMJBT, IMR 4166, 41.8g	2.41	2639.875	12.343394	N	N-	20211024
42	2.7	150	Hornady 150 FMJBT, IMR 4166, 42g	2.96	2654.33333	6.10100174	N	S	20220527
42.3	2.7	150	Hornady 150 FMJBT, IMR 4166, 42.3g	2.58	2670	20.174241	N	N-	20211024
42.8	2.7	150	Hornady 150 FMJBT, IMR 4166, 42.8g	4.87	2681.7	27.3717007	N	S	20211024
43.3	2.7	150	Hornady 150 FMJBT, IMR 4166, 43.3g	3.48	2718.625	16.2552876	N	S	20211024
43.8	2.7	150	Hornady 150 FMJBT, IMR 4166, 43.8g	3.21	2739.25	24.1751422	N	S	20211024
44.3	2.7	150	Hornady 150 FMJBT, IMR 4166, 44.3g	3.65	2769.1	19.1491514	Y	S	20211024

Table 10: 178 Grain Data

178 Grain Hornady BTHP- CCI 200 LRP - LC Brass - IMR 4166									
Powder (Grain)	**COL (inches)**	**Grain**	**Brand**	**Accuracy (MOA)**	**Speed (FPS)**	**STD (FPS)**	**Pressure Sign**	**Gas Setting**	**Test Date**
37.7	2.8	178	Hornady 178 BTHP IMR 4166, 37.7g*	2.93	2339.71429	24.892	N	N-	20220527
38.2	2.8	178	Hornady 178 BTHP IMR 4166, 38.2g*	2.99	2393.75	15.9902314	N	N-	20220527
38.7	2.8	178	Hornady 178 BTHP IMR 4166, 38.7g*	2.99	2417.2	28.6489092	N	S	20220527
39.2	2.8	178	Hornady 178 BTHP IMR 4166, 39.2g*	3.39	2432.66667	9.1772666	N	S	20220527
39.7	2.8	178	Hornady 178 BTHP IMR 4166, 39.7g*	2.58	2478.4	11.5342967	N	S	20220527
40.2	2.8	178	Hornady 178 BTHP IMR 4166, 40.2g*	2.66	2502.4	22.6459709	N	S	20220527
40.7	2.8	178	Hornady 178 BTHP IMR 4166, 40.7g*	4.04	2524.2	13.0751673	N	S	20220527

2.3 Verification Images

Table 11: October 24 2021 Range Day

	IMR 4166 41.8 Grain 150 Grain FMJBT
	IMR 4166 42.3 Grain 150 Grain FMJBT

	IMR 4166 42.8 Grain 150 Grain FMJBT
	IMR 4166 43.3 Grain 150 Grain FMJBT

	IMR 4166 43.8 Grain 150 Grain FMJBT
	IMR 4166 44.3 Grain 150 Grain FMJBT

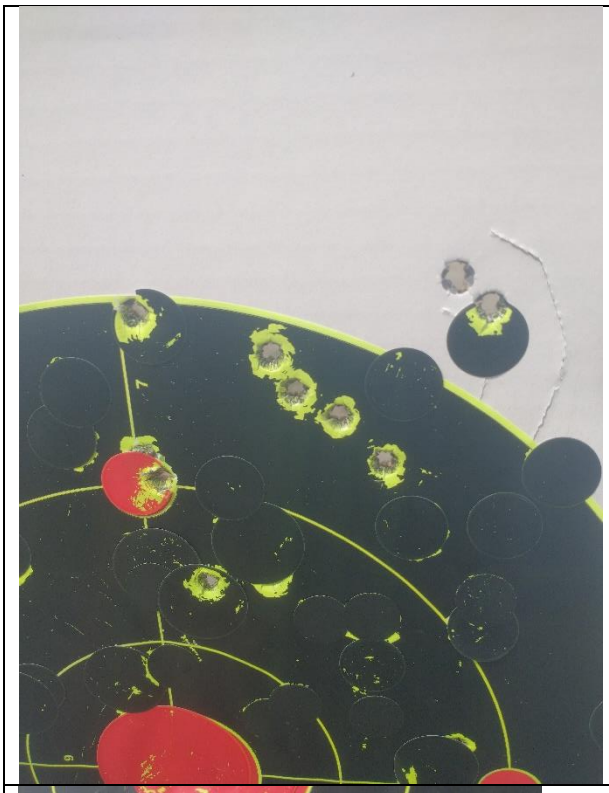
Table 12: May 27th 2022 Range Day Locking Block Bolts Loose Post Test

	M80 Ball Re-bulleted to FMJBT @ 2.8”
	IMR 4166 41.6 Grain 150 Grain FMJBT @ 2.7”

	IMR 4166 42 Grain 150 Grain FMJBT @ 2.7”
	IMR 4166 41.8 Grain 150 Grain FMJBT @ 2.8”

	IMR 4166 40.2 Grain 178 Grain HPBT
	IMR 4166 40.7 Grain 178 Grain HPBT

	IMR 4166 37.7 Grain 178 Grain HPBT
	IMR 4166 38.2 Grain 178 Grain HPBT

	IMR 4166 38.7 Grain 178 Grain HPBT
	IMR 4166 39.2 Grain 178 Grain HPBT

	IMR 4166 39.7 Grain 178 Grain HPBT

Appendix C Shooter 2 Configuration A Data

3.1 Shooter Hardware and Notes

Table 13 Shooter 2 Config A

Shooter	Shooter 2
Rifle	MDRX
Barrel	20in 308 Modded factory
Muzzle Device	Silencerco asr flash hider
Suppressor	Silencerco omega
Optic	Vortex razor g3 1-10
Support Details	Custom DIY
Chrono	n/a
MOA Calc Method	Rangebuddy app
MOA Reference	1" Square
Trigger	Stock
Notes	Speed is Factory Reported Number

Notes:

- Range 100 Yards
- Elevation 2300 ft asl

Shooter 2's barrel was a modified Desert Tech 20" Barrel as seen in Figure 22. The intent of this design was to create an expansion chamber in the barrel underneath the MDRx gas block.

The MDRx gas block is designed in such a way that it is placed flushed with the chassis of the MDRx. The result of which is that in all configurations the gas port on the barrel must be about 9" from the chamber. The result of this design decision is that the gas buildup in the barrel begins to act on the MDRx piston before the bullet as left the muzzle. As such lower velocity rounds and longer barrels are susceptible to having a torque imposed on the bolt carrier group on the piston torquing the barrel downward while the bullet is still in the barrel.

Due to the nature of the MDRx design, it is impossible to move the gas port forward as the MDRx design includes an exposed picatinny real section mounted to the gas block that keeps the gas block. One of the proposed designs was to create an expansion chamber in the barrel below the gas block. This would create a cavity for pressure to build up resulting in a delay of pressure buildup in the Piston Cylinder.

Figure 22: Modified Barrel Image

Figure 23: Shooter Bench

3.2 Test Results

Table 14: Shooter 2 Config A Test Results

(Grain)	Brand	Accuracy (MOA)	Speed (FPS)	STD (FPS)	Pressure Sign	Gas Setting	Test Date
147	Norma tactical FMJ	2.47	2838		n	s	20220604
147	FED LC M80	4.38	2700		n	s	20220601
150	Norma white tail SP	2.66	2789		n	s	20220604
150	Win PowerPoint SP	1.6	2820		n	s	20220531
168	Norma golden target HPBT	3.36	2625		n	s	20220604
168	Hornady TAP LE A-Max	1.39	2552		n	s	20220601
175	Norma golden target HPBT	1.94	2592		n	s	20220604
175	FED GMM SMK	2.98	2600		n	s	20220601

3.3 Verification Images

Table 15: Shooter 2 Config A Verification Images - 20220601

	147 Fed LC M80 FMJ
	168 Hornady A-Max TAP

	168 Hornady A-Max Tap C
	175 Fed GMM

	Win 150 PP SP

Table 16: Shooter 2 Config A Verification Images - 20220604

	147 Norma Tactical FMJ

	150 Norma White Tail SP
	168 Norma Golden Target HPBT

		175 Norma Golden Target HPBT

Appendix D Shooter 2 Configuration B Data

4.1 Shooter Hardware and Notes

Table 17: Shooter 2 Shooter 2 Configuration B

Shooter	Shooter 2:
Rifle	MDRX
Barrel	20" 308 ES Tactical barrel 416R 1-10 Twist
Muzzle Device	Silencerco asr flash hider
Suppressor	Silencerco omega
Optic	Vortex razor g3 1-10
Support Details	Custom DIY bench
Chrono	n/a
MOA Calc Method	Rangebuddy app
MOA Reference	1" Square
Trigger	Stock
Notes	Speed is Factory Reported Number

Notes:

- Range 100 Yards
- Weather PC 81 with Sprinkle
- Elevation 2300 ft asl
- 10 Fouling Shots taken before tests

4.2 : Test Results

Table 18: Shooter 2 Configuration B Test Results

Grain	Brand	Accuracy (MOA)	Speed (FPS)	STD (FPS)	Pressure Sign	Gas Setting	Test Date
147	Fed LC M80 147	4.93	2700			s	20220624
147	Norma FMJ 147	2.01	2838			s	20220624
150	Norma White Tail SP 150	3.05	2789			s	20220624
150	Win White PP SP 150	3.55	2820			s	20220624
150	Win White PP SP #2 150	2.09	2820			s	20220624
168	Norma Golden Target HPBT 168	2.47	2625			s	20220624
168	Hornady TAP LE Amax 168	3.11	2552			s	20220624
175	Fed GMM HPBT 175	3.59	2600			s	20220624
175	Norma Golden Target HPBT 175	3.76	2592			s	20220624

4.3 Verification Images

Table 19: Shooter 2 Config B Verification Images - 20220624

	Fed 175 GMM HPBT
	Fed LC M80

	Norma 147 FMJ
	Norma 150 White Tail SP

	Norma 168 Golden Target HPBT
	Hornady 168 TAP LE AMAX

	Norma 175 Golden Target HPBT
	Win 150 PP SP 2

	Win 150 PP SP

Appendix EShooter 3 Configuration A Data

5.1 Shooter Hardware and Notes

Table 20: Shooter 3 Config A Hardware

Shooter	Shooter 3
Rifle	DT MDRX
Barrel	Factory 16" Barrel
Muzzle Device	See Below
Optic	1-6x24 Optic
Support Details	Range Shooting Blocks
Chrono	
MOA Calc Method	Range Buddy
MOA Reference	
Trigger	Stock
Notes	Speed is Factory Reported Number

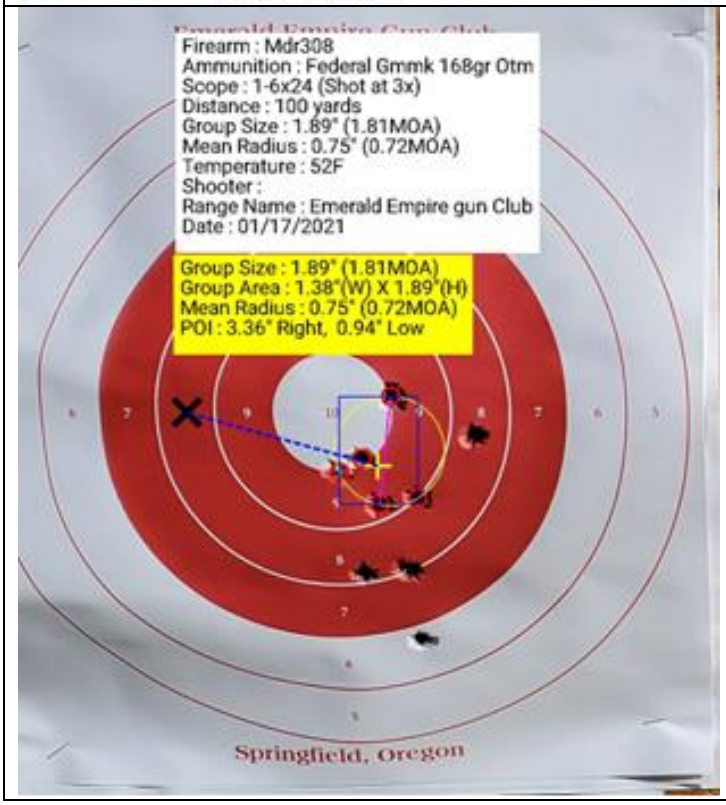
5.2 Test Results

Table 21: Shooter 3 Config A Test Results

Grain	Brand	Accuracy (MOA)	Speed (FPS)	STD (FPS)	Muzzle Device	Gas Setting	Test Date
175	American Marksman M118LR	3.16	2600		Strike Industries King Compensator	N-	20210117
168	Federal Gmmk	1.89	2650		Strike Industries King Compensator	N-	20210117
150	Fiocchi 150	4.12	2890		Strike Industries King Compensator	N-	20210117
168	Hsm	3.45	2625*		Strike Industries King Compensator	N-	20210117
168	Magtech Sniper	1.9	2635		Strike Industries King Compensator	N-	20210117
168	Winchester Match	1.69	2680		Strike Industries King Compensator	N-	20210117
168	Winchester Match	2.18	2680		Strike Industries King Compensator	N-	20210117

5.3 Verification Images

Table 22: Shooter 3 Config A Verification Images - 20210117

	AM M118LR
	Federal Gold Medal Match 168gr 1.81moa

	Fiocchi 150 4.12moa
	Hsm 168gr 3.45moa

	Magtec Sniper 1.9moa
	Winchester Match 168gr (2) 2.19moa

	Winchester Match 168gr 1.69moa (2)

Appendix FShooter 3 Configuration B Data

6.1 Shooter Hardware and Notes

Table 23 Shooter 3 Config B Hardware

Shooter	Shooter 3
Rifle	DT MDRX
Barrel	Factory 16" Barrel
Muzzle Device	See Below
Optic	Vortex Crossfire II 3-9x40
Support Details	Range Shooting Blocks
Chrono	
MOA Calc Method	Range Buddy
MOA Reference	
Trigger	Bill Springfield
Notes	Speed is Factory Reported Number

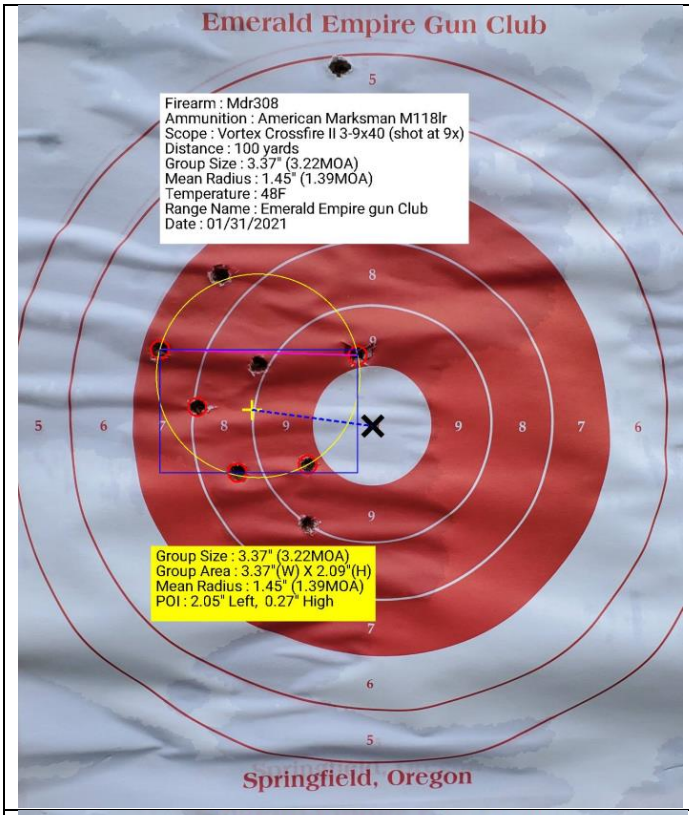
6.2 Test Results

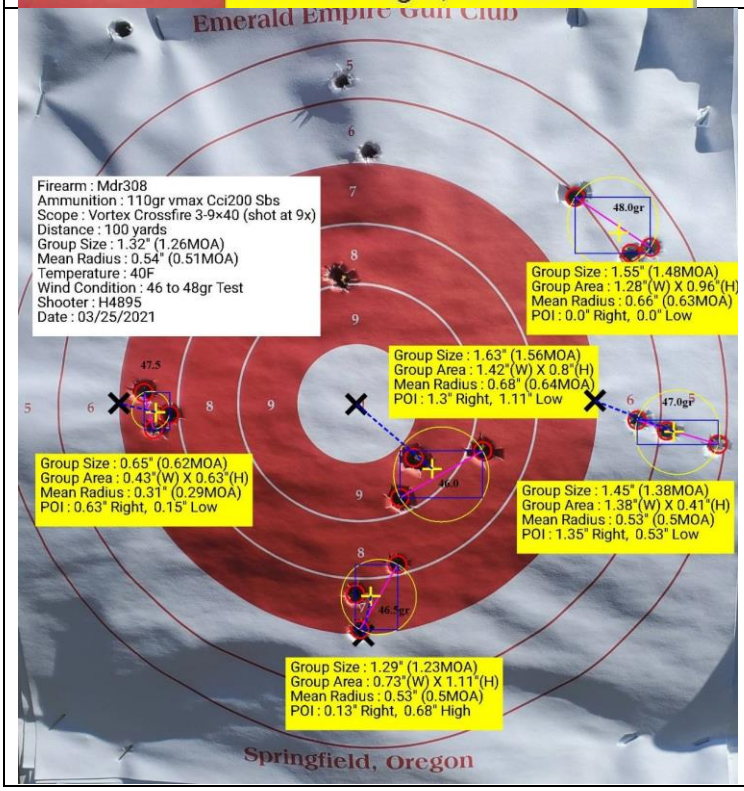
Table 24: Shooter 3 Config B Test Results

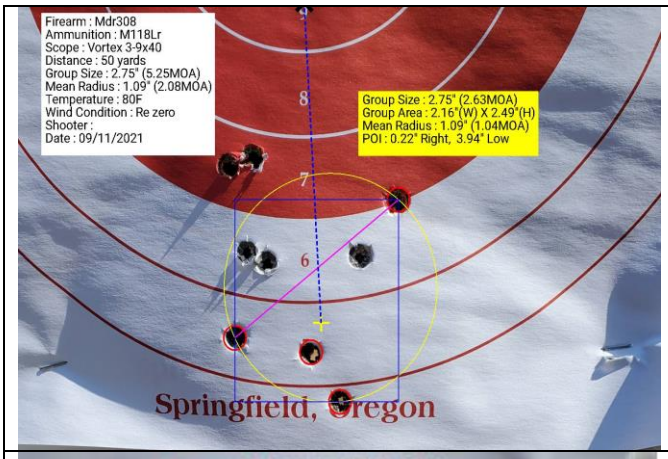
Grain	Brand	Accuracy (MOA)	Speed (FPS)	STD (FPS)	Muzzle Device	Gas Setting	Test Date
168	Hornady 168gr ELD Magtech CCI 200	2.51	2542 Avg* Labradar from 20inch Howa)	5	Ratchet	N-	20210131
110	110gr vmax CCI200 Sbs	1.26			Ultradyne Apollo S	N-	20210325
175	American Marksman M118 LR with Oppressor #1	3.22	2600		Ratchet	N-	20210911
168	Hornady 168gr ELD	2.56	2700		Ratchet	N-	20210911
175	American Marksman M118 LR Oppressor #2*	5.05	2600		Ratchet	N-	20210911
175	American Marksman M118LR	2.63	2600		Ratchet	N-	20210911

6.3 Verification Images

Table 25: Shooter 3 Config B Verification Images

	AM m118 LR
	American Marksman 175gr -2nd group 3.22moa

Firearm : Mdr308 Ammunition : Hornady 168gr Eld Magtec cci200 Scope : Vortex Crossfire II 3-9x40 (shot at 9x) Distance : 100 yards Group Size : 2.62" (2.51MOA) Mean Radius : 0.76" (0.73MOA) Temperature : 48F Shooter : 42.5gr varget Range Name : Emerald Empire gun Club Date : 01/31/2021 	Hornaday ELD 168 Magtec 42.5 Varget cci 200
	MDR 110gr VMAX CCI 200 CBC

	Am 175gr 50 yards
	Hornaday 168gr Eld 2.56moa

	M118 LR with Oppressor Can

Appendix G Shooter 3 Configuration C Data

7.1 Shooter Hardware and Notes

Table 26 Shooter 3 Config C Hardware

Shooter	Shooter 3
Rifle	MDRX 308
Barrel	Factory 16 Inch Barrel
Muzzle Device	See Below
Optic	ACME 1-8 FFP
Support Details	Range Shooting Blocks
Chrono	
MOA Calc Method	Range Buddy
MOA Reference	
Trigger	Bill Springfield
Notes	Locking Block/Trunnion Bolts Loose post test
Notes	Speed is Factory Reported Number

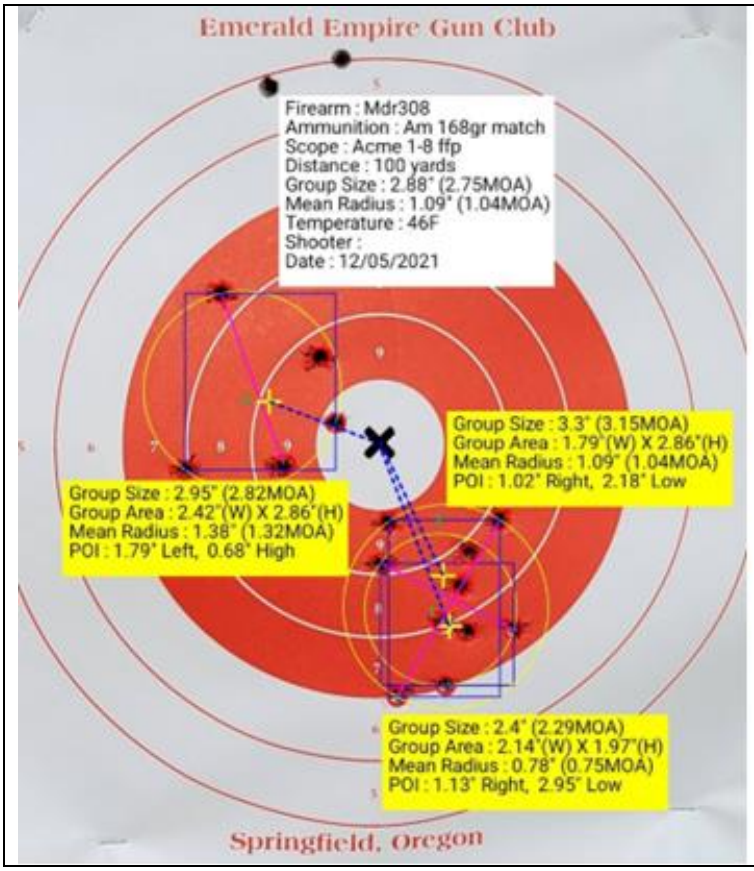
7.2 Test Results

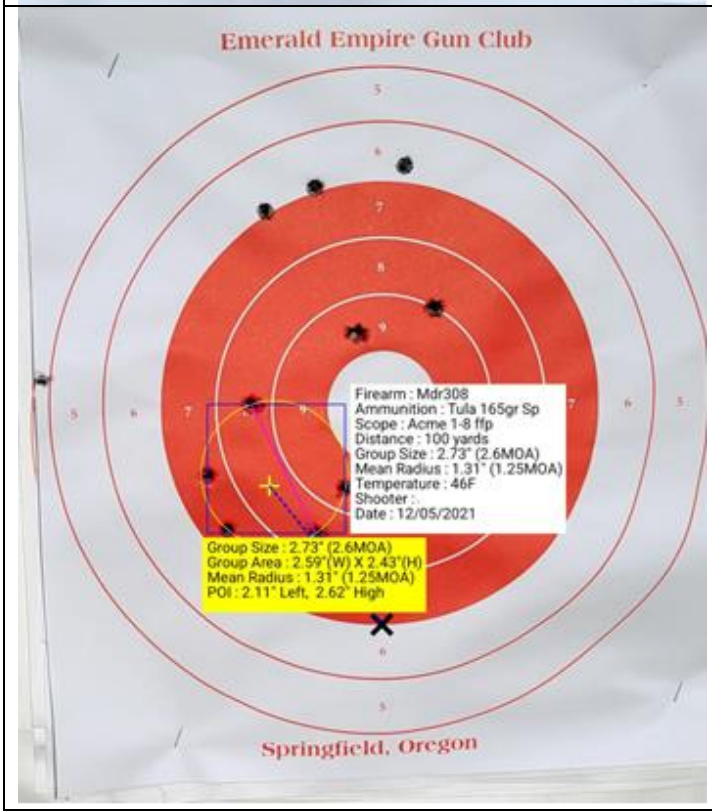
Table 27: Shooter 3 Config C Test Results

Grain	Brand	Accuracy (MOA)	Speed (FPS)	STD (FPS)	Muzzle Device	Gas Setting	Test Date
168	American Marksman 168gr Match*	1.91	2585*		Ultradyne Apollo S	N-	20220320
168	American Marksman 168gr Match*	2.29	2585*		Ultradyne Apollo S	N-	20211205
168	American Marksman 168gr Match*	2.95	2585*		Ultradyne Apollo S	N-	20211205
168	American Marksman 168gr Match*	3.15	2585*		Ultradyne Apollo S	N-	20211205
168	American Marksman 168gr Match*	3.2	2585*		Ultradyne Apollo S	N-	20211205
168	Fed Gmmk 168gr Bthp*	2.46	2650		Surefire Socom	N-	20220403
168	Federal Premium 168gr Bergers (Hybrid Hunter)*	3.33	2700		Surefire Socom	N-	20220403
175	Federal Terminal Accent 175 gr*	2.08	2600		Surefire Socom	N-	20220403
150	Hornady 150 gr Sst*	4.64	2820		Ultradyne Apollo S	N-	20220320
168	Hornady 168gr Bthp*	2.15	2700		Ultradyne Apollo S	N-	20220320
168	Hornady Match 168gr Bthp*	2.38	2700		Surefire Socom	N-	20220403
168	S&B 168gr Bthp*	5.1	2628		Surefire Socom	N-	20220403
168	True Velocity 168gr Nosler*	5.62	2650*		Surefire Socom	N-	20220403
165	Tula 165 gr Sp*	2.6	2625		Ultradyne Apollo S	N-	20211205

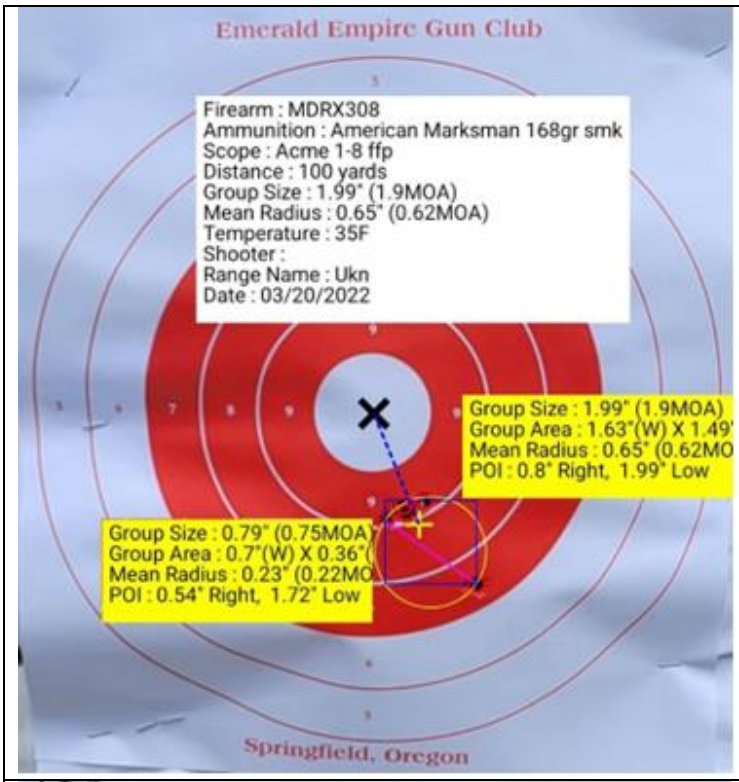
7.3 Verification Images

Table 28: Shooter 3 Config C Verification Images

	Am 168gr 100 yards

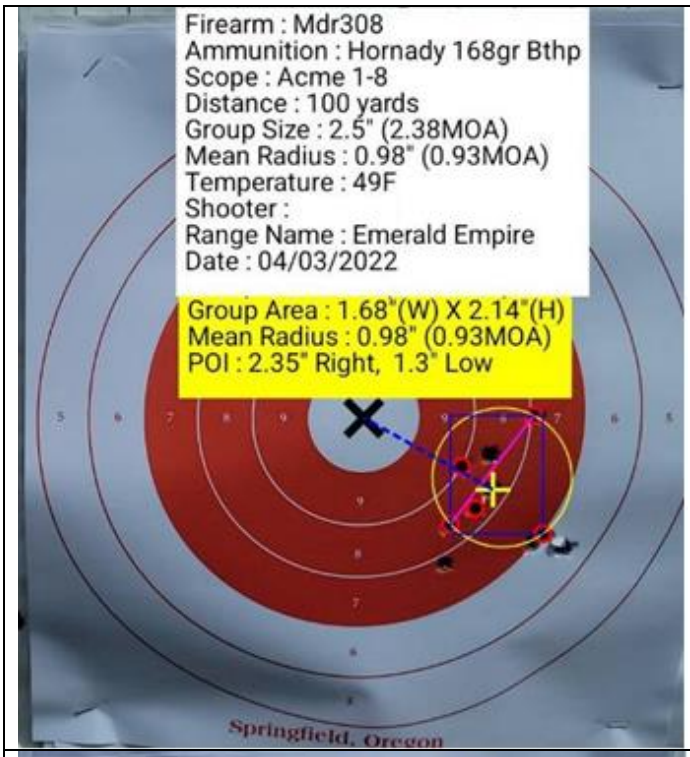
	American Markman 168gr Match 3.2moa
	Tula 168gr SP 2.6moa

	American Marksman 168gr 4 shot group
	American Marksman 168gr 5 shot group 1.9moa

	America Marksman MDRX
	Hornaday 150gr sst 4.64moa

	Hornaday Match 168gr BTHP 2.15moa
	Federal Gold Metal Match168gr 2.46

	Federal Premium Bergers Hybrid Hunter 168gr 3.33moa
	Federal Premium Terminal Accent 175gr 2moa

	Hornady 168gr BTHP 2.38moa
	S_B 168gr Bthp 5.1moa

	True Velocity 168gr Nosler 5.62moa

Appendix H Shooter 3 Configuration D Data

8.1 Shooter Hardware and Notes

Table 29 Shooter 3 Config D Hardware

Shooter	Shooter 3
Rifle	MDRX 308
Barrel	20" 308 ES Tactical barrel 416R 1-10 Twist
Muzzle Device	See Below
Optic	ACME 1-8 FFP
Support Details	Range Shooting Blocks
Chrono	
MOA Calc Method	Range Buddy
MOA Reference	
Trigger	Bill Springfield
Notes	Speed is Factory Reported Number

8.2 Test Results

Table 30: Shooter 3 Config D Test Results

Grain	Brand	Accuracy (MOA)	Speed (FPS)	STD (FPS)	Muzzle Device	Gas Setting	Test Date
168	Fed Gmmk 168gr Bthp (Group is 4moa with a pulled shot)	1.8	2650		Strike Industries J-Compensator	N-	20220729
168	Federal Premium 168gr Bergers (Hybrid Hunter)	2.07	2700		Strike Industries J-Compensator	N-	20220729
175	Federal Terminal Accent 175 gr	2	2600		Strike Industries J-Compensator	N-	20220729
168	Hornady Black 168gr Bthp	2.93	2700		Strike Industries J-Compensator	N-	20220729
168	Hornady ELD 168gr Handload (42.5 Varget previously tested)	2.38			Strike Industries J-Compensator	N-	20220729
168	S&B 168gr Bthp	1.49	2628		Strike Industries J-Compensator	N-	20220729
168	Magtec Sniper SMK	0.82	2577		Strike Industries J-Compensator	N-	20220729

8.3 Verification Images

Table 31: Shooter 3 Config D Verification Images

	Federal 168gr GMMK complete group with pulled shot
	Federal 168gr GMMK

	Federal GM Hybrid Hunter
	Federal Terminal Accent 175gr

	Handload 42.5 Varget 168gr Eld
	Hornaday blk 168gr amax

	Magtech Sniper 168gr
	SNB 168gr 100yards

	snb 168gr zero adjustment and fouling 50 yards