MDRX Jam Fastener and Barrel De-resonator and Report

Kinetic Systems, ARG

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1.0 Introduction

The Micro Dynamic 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 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.

In mid-2022 Kinetic Systems, Advanced Research Group (ARG) commissioned a large-scale community driven performance characterization[5] of the MDRx 308 Rifle in several different configurations and produced a report titled MDRX 308 Characterization. Based on those findings, several possible improvements were proposed to improve the performance of the Rifle. One of the solutions considered was a method to provide a mechanical interface for the forward fasteners. The ARG partnered with ShootingSight, LLC. [9] and consulting Aerospace Systems Engineer Andrew Murrell, CSEP[11] [12]to evaluate this solution.

Throughout testing, it became more apparent that barrel harmonics was a significant driver in barrel performance and Kinetic Systems ARG evaluated the performance impact of a Limbsaver X-Ring Deresonator[13].

2.0 Scope

The Scope of this report is to test the performance of the ShootingSight, LLC implementation of a Jam Fastener Design and the Limbsaver X-Ring Barrel Deresonator. This report will compare the performance of several different configurations with and without side plates, using historically captured data with several different factory ammunition brands to quantify the impact on performance that the aftermarket part has on the 308 MDRx Rifle with regard to accuracy.

3.0 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]	MDRX 308 Characterization Rev -	https://www.docdroid.net/LS6eOty/mdrx-308-characterization-rev-pdf
[6]	MDRX Side Plate Test Report Rev -	https://www.docdroid.net/16UqPzB/mdrx-side-plate-test-procedure-and-report-pdf
[7]	Loctite User Guide	https://www.ellsworth.com/globalassets/literature-library/manufacturer/henkel-loctite/henkel-loctite-user-guide-threadlocking.pdf
[8]	Wheeler Fat Wrench	https://www.wheelertools.com/gunsmithing-tools/wrenches-and-screwdrivers/f.a.t.-wrench-with-10-bit-set/553556.html
[9]	ShootingSight Website	https://shootingsight.com/
[10]	Self-Loosening Thread Fasteners	https://www.boltscience.com/pages/self-loosening-of-threaded-fasteners.pdf
[11]	Andrew Murrell, CSEP Reloading Citation 1	https://www.doublealpha.biz/us/daa-fast-flow-powder-funnel
[12]	Andrew Murrell, CSEP Reloading Citation 2	https://www.uniquetek.com/store/696296/uploaded/26_Tips_for_Powder_Measure_Accuracy.pdf
[13]	Sharpshooter X-Ring Barrel Deresonator	https://limbsaver.com/products/sharpshooter-x-ring-barrel-dampener
[14]	Varmint Al's Barrel and Tuner Analysis	https://www.varmintal.com/aeste.htm
[15]	Barrel Harmonics and Timing	https://www.shootingsoftware.com/barrel.htm
[16]	Ron Spomer Outdoors Reloading	https://www.ronspomeroutdoors.com/blog/reload-your-own

4.0 Jam Fastener

4.1 Jam Fastener Design

The ShootingSight Jam Fastener design is intended to provide a mechanical interference between the side wall of a conical spacer and the edge of the recess pockets of the front chassis fasteners. With mechanical contact between the spacer and the side wall it would arrest any movement between the fastener and the chassis hole. An early design can be seen in Figure 1 below.

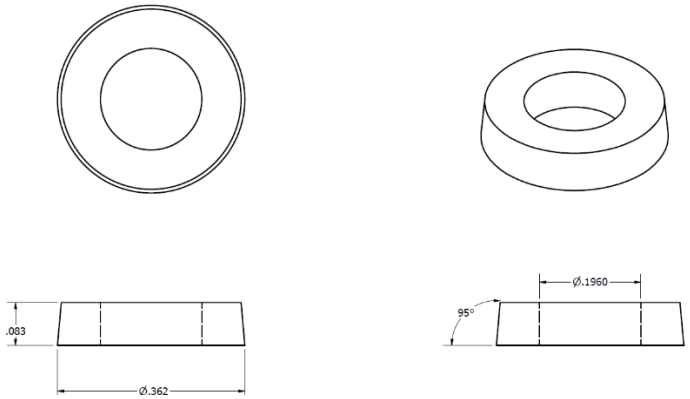


Figure 1: V5.1 Side Plate Left Side Plate

The resulting design was a steel threaded conical spacer threaded onto a prototype torx fastener bolt as seen in

Figure 2. This design operates by permanent deformation of the outside pocket edge of the aluminum chassis by the clamping load.

Figure 2: Jam Fastener

The Fastener was installed and verified to not bottom out in the trunnion before the bolt was torqued down at 30 and 40 in-lbf respectively. The permanent deformation on the chassis can be seen in Figure 3 and Figure 4.

Figure 3: Permanent Chassis Deformation after 30 in-lbf install

Figure 4: Permanent Chassis Deformation after 40 in-lbf install

The resulting test article was fully assembled with 2 front Jam fasteners on each side as seen in Figure 5.

Figure 5: Prototype Installation

4.2 Compressible Washer Design

An alternative configuration was proposed in which a 0.016” thick piece 1100 Aluminum Peel Away shim ,McMaster Carr P/N 9574K75, was placed under the Jam Fastener to increase the bearing surface as the

fastener was screwed down. The 1100 Aluminum shim used has an ultimate tensile strength of 13 KSI, approximately 30%th the tensile strength of the Desert Tech MDRx aluminum chassis. The concept of operations is that the taper cone of the washer would center the fastener in the rifle chassis and the peelable shim would compress when the fastener is torqued providing the normal load path that the rifle was originally designed with. The post install compressed shim can be seen in Figure 6 below.

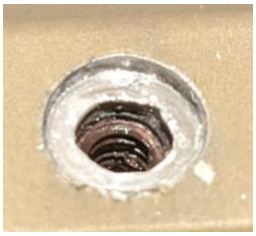


Figure 6: Compressible Washer Installation

5.0 Limbsaver Design

The Limbsaver X-Ring Barrel deresonator is an interesting development in barrel accurizing and operates on a fundamentally different theory than is traditionally accepted for barrel tuning. Traditional barrel tuning has been attributed to a barrel whip affect in which the barrel vibrates like a cantilever beam appoint the fixed points the barrels are attached to. This concept assumes the fundamental position of asymmetric loading on the barrel before the bullet leaves the muzzle. The methods to improve accuracy is to adjust the position of a hanging mass along a barrel length to change the frequency in in which the barrel whips such that the bullet leaves the muzzle at the point of minimum acceleration. For more details on the affect and mathematical modeling of the affect, please see Varmint Al's extensive Finite Element Analysis Engineering page on barrel mechanics.[14]

However, there is a competing traveling wave theory in which the pressure wave along the barrel is symmetric along all faces of the barrel as the bullet travels down it. A barrel is a three-dimensional object with constant force axially to the bore of the barrel. This loading acts as a circular pressure wave that travels down the barrel which significantly complicates the simple barrel whip approximation that has been common in the past. The objective for this tuning method is to change the frequency of the pressure wave such that the circular pressure expansion at the barrel crown does not occur when the bullet leaves the barrel. For more information on this affect, and other alternative theories, see shooting software's analysis of this phenomenon [15].

The Limbsaver X-Ring Barrel deresonator, as seen below in Figure 7, operates on the later principle detailed above. The Limbsaver X-Ring 1.6 ounce rubber grommet that slides down the length of the barrel. Its function is to apply axial pressure on the barrel in an attempt to alter dwell time of the pressure wave before it impacts the muzzle. For comparison the weight of this device is $1/6^{th}$ to $1/12^{th}$ the weight of alternative weight driven barrel tuning solutions.

Figure 7: Limbsaver X-Ring Barrel deresonator

The deresonator can be seen installed under the Reflex handguard of one of the test MDRx 308 rifles in Figure 7 below.

Figure 8: Deresonator installed under Reflex handguard

NOTE, when maximizing performance for long range precision shooting, reloading[16] is often a common occurrence where an optimal recipe for a given rifle is found. As a barrel tuner, like the Limbsaver above, will affect the performance of any cartridge utilized in your Rifle there will be an effect on any prior tuned ammunition. It is currently unclear exactly what performance impacts will occur with combinations of barrel/rifle tuning methods.

6.0 Jam Fastener Test Design

The Jam fastener tests will be compared against the prior characterization and side plate test data. As such the test will be designed to measure relative performance changes between the same shooter with the same ammunition between various configurations of Side plate as seen in Table 1 below.

Table 1: Rifle Test Configuration

Rifle Configuration	Jam Fastener	Compressible Washer
ES Tactical 20" Barrel Assembly with silencerco omega	No	No
ES Tactical 20" Barrel Assembly with silencerco omega and Side plate	No	No
ES Tactical 20" Barrel Assembly with silencerco omega and Jam Fastener	Yes	No
ES Tactical 20" Barrel Assembly with silencerco omega, Jam Fastener and Washer	Yes	Yes

As outlined before in the previous report, the fasteners will be checked for loosening before each test and singular 5 shot groups will be used to generate a baseline. All legacy data used shall be data captured after the trunnion fastener looseness check was detected and implanted in 2022 as reported in the prior characterization report[5]. Any legacy data used will be marked in the appendix as such.

7.0 Procedures Jam Fastener

NOTE: For this section, please read through and be familiar with the Loctite Threadlocker user guide [7].

7.1 Disassembly and Assembly

7.1.1 Procedure

7.1.1.1 Heat original fasteners with a soldering iron and use a Torx bit to loosen all screws on side of the Trunnion at a time

7.1.1.2 Ensure new threaded washer is tightened against each screw head

7.1.1.3 Install new prototype fasteners hand tight

7.1.1.4 Remove fasteners and clean chassis threads with Loctite solvent such as Loctite SF 7601 or acetone and a paper towel

7.1.1.5 Use acetone to clean threads

7.1.1.6 Repeat steps 7.1.1.1 through 7.1.1.3 on other side plate

NOTE: This is to ensure alignment and reduce binding

7.1.1.7 Remove one screw and apply Loctite Primer 7649 to trunnion and screw threads let wait for 15 seconds

7.1.1.8 Apply Loctite 222ms or Loctite 263 [7] or equivalent to screw and threads

NOTE: Do not use Loctite Blue

7.1.1.9 Install fastener hand tight

7.1.1.10 Repeat 7.1.1.7 through 7.1.1.9 for remaining 7 fasteners (OEM and Jam Fasteners)

7.1.1.11 Use a Wheeler Fat Wrench[8] (or Equivalent) to torque all bolts to 38 in-lbf. in a star pattern.

7.1.1.12 Wait 24 hours for adhesive to dry

7.2 Shooting

7.2.1 Procedure

7.2.1.1 Clean Rifle before Range Day

7.2.1.2 Fire minimum 20 test shots to foul barrel and settle trunnion

7.2.1.3 Verify fasteners have not loosened

7.2.1.4 Select 1 factory load

7.2.1.5 Fire 5 rounds of ammunition and measure MOA

7.2.1.6 Repeat 7.2.1.5 for at least 2 more tests

7.2.1.7 Record target images and log MOA

7.2.1.8 Verify fasteners have not loosened

7.2.1.9 Repeat 7.0 for 1100 compressible shim.

8.0 Limb Saver Test Design

For this test, KSA managed to acquire a poor performing MDRx 308 20” barrel. Specifically this barrel’s was performing in the range of 7 moa. By selecting this poor performing barrel for a limb saver, any improvement in the limb saver performance would be more noticeable. Note, this barrel was inspected and no rifling defects were detected. However the gunsmith did indicate there were anomalies detected in the gas block.

The Limb Saver test design is to create a base control test group and then adjust the limb saver in positions near the muzzle device as well as near the gas block, based on the manufacturers recommendation for limb saver placement. After each test, the Limbsaver would be pushed closer to the gas block and retested with a 5 shot group. If a particularly promising group was detected additional verification groups were shot until an ideal mounting position was identified. Note, a MDRx overmolded extended handguard was required to allow the Limbsaver to be positioned under the handguard.

9.0 Procedures Limbsaver

9.1 Assembly

9.1.1 Remove Muzzle Device

9.1.2 Lubricate barrel heavily

9.1.3 Insert Limbsaver with cone tip pointed towards muzzle

9.1.4 Reinstall Muzzle Device

9.1.5 Measure Limb saver position to muzzle device shoulder

9.2 Shooting

9.2.1 Procedure

9.2.1.1 Clean Rifle before Range Day

9.2.1.2 Fire minimum 20 test shots to foul barrel and settle trunnion

9.2.1.3 Verify fasteners have not loosened

9.2.1.4 Select 1 factory load

9.2.1.5 Fire 5 rounds of ammunition and measure MOA

9.2.1.6 Repeat 7.2.1.5 if group size is promising

9.2.1.7 Record target images and log MOA

9.2.1.8 Verify fasteners have not loosened

9.3 Adjustment

9.3.1 Move the limb saver by hand in logical increments, larger increments if poor performance detected, small increments if ideal performance detected.

9.3.2 Record position

9.3.3 Once muzzle device is under the handguard, use long extension blocks/wood/poles to push the limb saver down the barrel. Avoid removing the handguard if possible

9.3.4 Repeat 9.2 after each incremental move of the limb saver.

10.0 Test Data

10.1 Jam Fastener

The Control, Side Plate, Jam Fastener, and Jam Fastener with the compressible washer can be seen below in Figure 9.

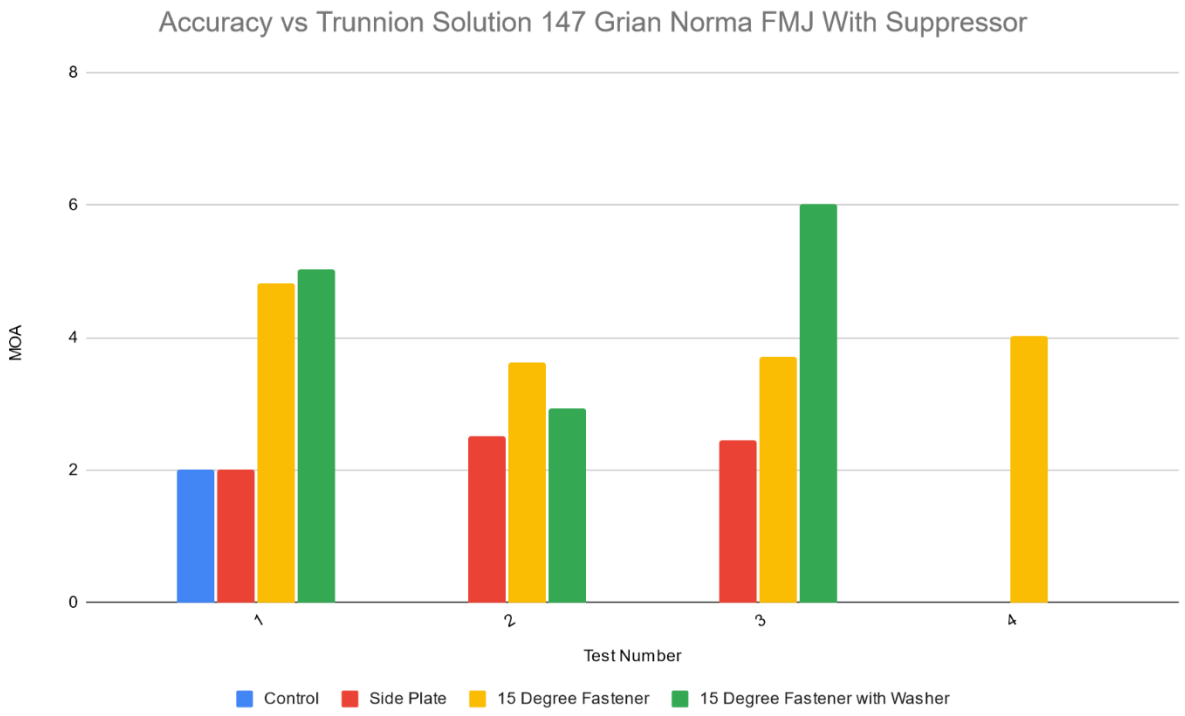


Figure 9: Control, Side Plate, Jam Fastener, and JF and Washer Comparison

10.2 Limbsaver X

The Limbsaver raw test data can be seen below in Figure 10. Figure 11 presents the average Limbsaver performance with a comparison to the 147 grain Norma control, Figure 12 below presents the average Limbsaver test data with a trend line.

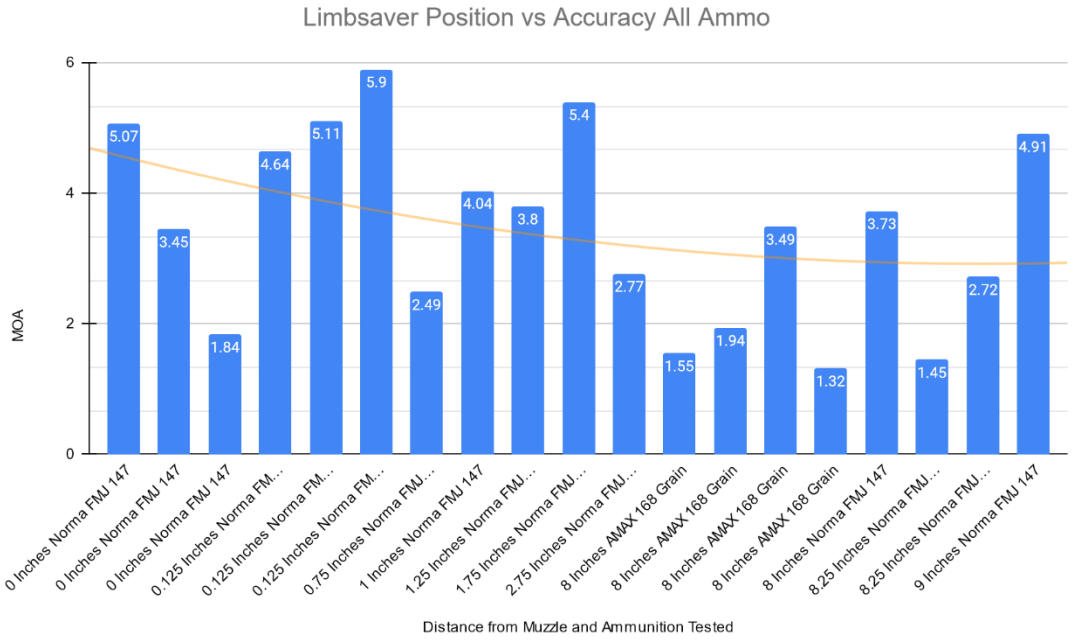


Figure 10: Limbsaver ammunition tests

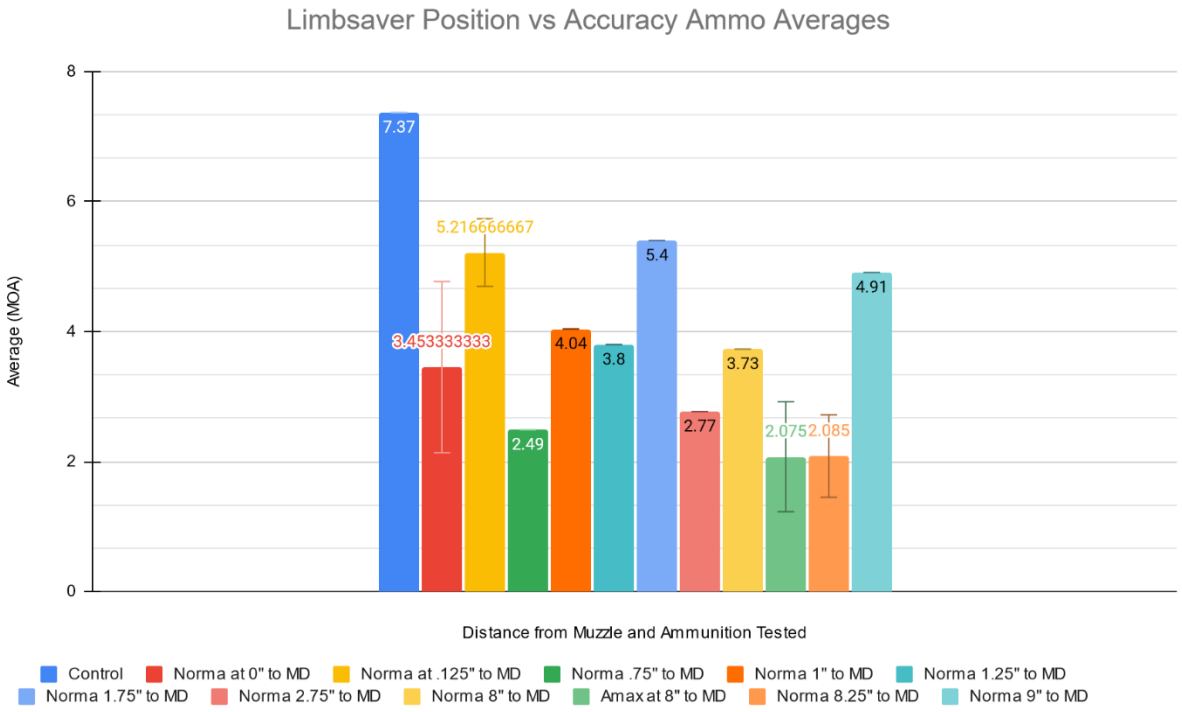


Figure 11: Average Limbsaver Ammunition Tests with Control and Standard Deviation Error

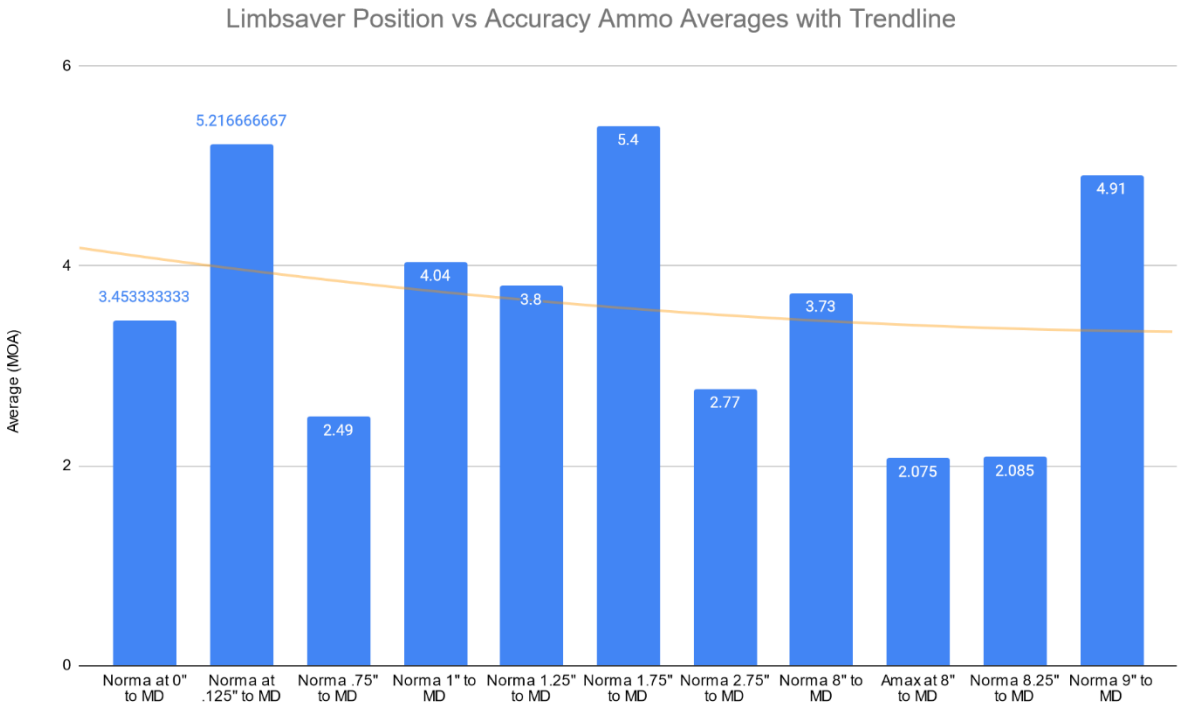


Figure 12: Average Limbsaver tests with trendline

11.0 Data Analysis

11.1 Jam Fastener

As can be seen below in Table 2: Jam Fastener Test Results, the control test with no modifications to the 20" ES Tactical Barrel proved to be the most accurate configuration of the Rifle. The Jam Fastener and Jam Fastener with compressible washer significantly reduced performance.

Table 2: Jam Fastener Test Results

	Average (MOA)	STD (MOA)
Control	2.01	0
Side Plate	2.485	0.035
Jam Fastener	4.05	0.4729164831
Jam Fastener with Washer	4.66	1.285794177

11.2 Limb Saver

As can be seen below in Table 3: Limbsaver Test Results, we see that the Limbsaver performance was ideal when placed roughly 8 inches from the muzzle device. Note, the test data below is limited as the number of intermediate tests between 0" and 8" and did not provide enough test data to determine a Standard deviation of the data sets. The Limbsaver reduced the group size between the control and the 8" position of the underperforming barrel by 71.8%. This provided, by far the greatest improvement of all groups tested by far.

Table 3: Limbsaver Test Results Average

Distance to Muzzle Device	Ammunition	Average (MOA)	STD (MOA)
N/A - Control	Norma FMJ 147	7.37	0.9373366524
0"	Norma FMJ 147	3.453333333	1.318644085
0.125"	Norma FMJ 147	5.216666667	0.5198931514
0.75"	Norma FMJ 147	2.49	0
1"	Norma FMJ 147	4.04	0
1.25"	Norma FMJ 147	3.8	0
1.75	Norma FMJ 147	5.4	0
2.75"	Norma FMJ 147	2.77	0
8"	Norma FMJ 147	3.73	0
8"	AMAX 168	2.075	0.8464779974
8.25"	Norma FMJ 147	2.085	0.635
9"	Norma FMJ 147	4.91	0

12.0 Conclusion

Overall, we see that the jam fastener approach failed to provide any meaningful benefit, in fact it hindered the barrel performance, most likely due the high pressure point load applied at the edge of the chassis hole resulting in sensitivity to plastic deformation.

In addition, the Limbsaver, on the underperforming barrel provided a massive improvement in performance in the two ammo types tested. This device seems to have provided the greatest improvement of all product improvements tested. In addition it is also worth noting that the AMAX and Norma performed similar, which may point to a reduction in ammunition sensitivity with a limb saver installed. Further testing of different ammunition will be required to corroborate before sets of outcomes of the Limbsaver design.

13.0 Future test recommendations

13.1 Barrel to Chassis stiffness improvement

It is clear that chasing reversible methods of improving the barrel's attachment stiffness in the chassis may provide an over constrained condition and reduce performance. However, it does appear that barrel harmonics is the leading cause of barrel inaccuracies in the MDRx platform as this testing showed an impressive improvement of an underperforming barrel tested.

As such KSA recommends further evaluation of performance improvement of the MDRx platform focus on barrel harmonics and gas system, specifically in such a way that would increase the dwell time such that the bullet leaves the barrel before recoil forces react on the barrel.

13.2 Design Improvements

The primary ideal method would be to allow the gas plug to slide under the hand guard and move the gas port as far along the barrel as possible, however this design would require significant redesign of the MDRx Barrel assembly and handguard. A second approach might be to utilize a hybrid gas/piston system such as on the Perun X16 that might allow the gas port to be farther along the barrel while interfacing with the MDRx gas block. Such a gas plug might look something like the one below in Figure 13.

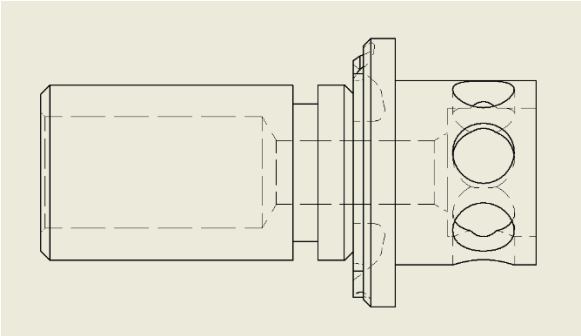


Figure 13: KSA Hybrid Gas Plug Design

13.3 Retrofit Solutions

A third option might be to redesign the gas plug of the MDRx to provide an interference matter stream inside the gas plug using a forward tilted jet flow design.

As can be seen in Figure 14 below the overall theory of the design is to trade Bolt Carrier Group Cycle Rate for dwell time.

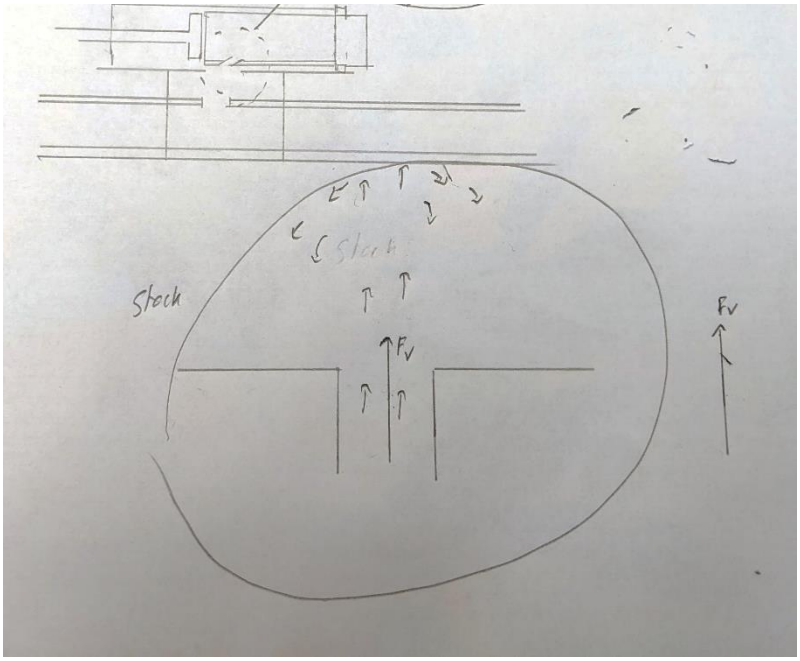


Figure 14: MDRx Gas Plug Matter Stream Design

The diagram in Figure 14 presents a mass flow rate analysis of the current MDRx Gas Plug. Traditional analysis of gas systems assumes a uniform pressure gradient in all directions. This analysis is incomplete as the moment before the uniform pressure gradient there is in fact a particular matter stream that is injected into the cylinder, impacts the opposing wall and spreads in uniform directions until the overall cylinder pressure goes up. For all intents and purposes, the matter analysis is applicable for the fractions of a second before the piston in the gas block moves, and it is these moments that we can manipulate to improve our dwell time.

Figure 15 below presents and alternative gas plug design that tils the gas ports in the gas plug forward towards the muzzle of the Rifle.

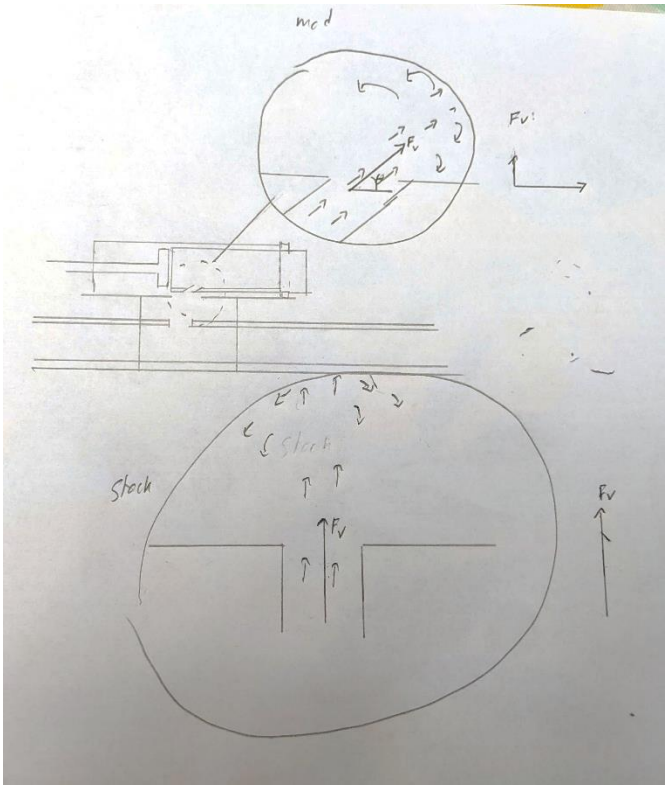


Figure 15: Figure 16: Interference Matter Stream Gas Plug Design.

As can be seen in Figure 15. The overall concept is to force the matter stream to impact an opposing wall and pass through its own matter stream before those super-heated gas particles can make their way back towards the Piston. This mechanism can further be augmented by bring the gas port closer to in line with the muzzle as well as sizing a forward cavity in the gas plug to enhance the effects of interference matter streams. Such a gas plug design might look something like Figure 17.

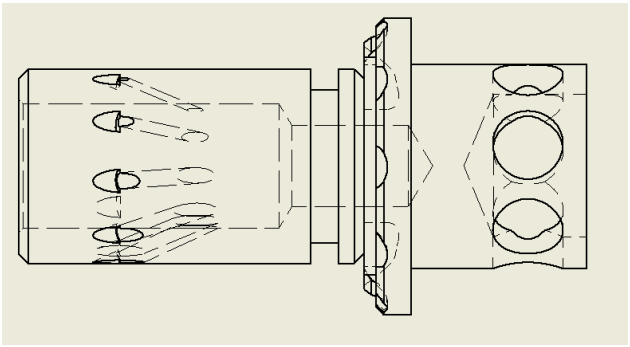


Figure 17: KSA Jet Plug Design

Appendix A Control Data (Legacy)

1.1 Shooter Hardware and Notes

Table 4: Control Rifle Configuration

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
MOA Calc Method	Rangebuddy app
MOA Reference	1"
Trigger	Stock
Notes	
Ammunition Tested	

1.2 Test Results Control

Table 5: Control Rifle Configuration

(Grain)	Brand	Side Plate	Accuracy (MOA)	Gas Setting	Test Date
147[1]	Fed LC M80 147	No	4.93	s	20220624
147[1]	Norma FMJ 147	No	2.01	s	20220624
150[1]	Norma White Tail SP 150	No	3.05	s	20220624
150[1]	Win White PP SP 150	No	3.55	s	20220624
150[1]	Win White PP SP #2 150	No	2.09	s	20220624
168[1]	Norma Golden Target HPBT 168	No	2.47	s	20220624
168[1]	Hornady TAP LE Amax 168	No	3.11	s	20220624
175[1]	Fed GMM HPBT 175	No	3.59	s	20220624
175[1]	Norma Golden Target HPBT 175	No	3.76	s	20220624

Note[1]: Legacy Data from Characterization

1.3 Verification Images Control

Table 6: Control Rifle Configuration

	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

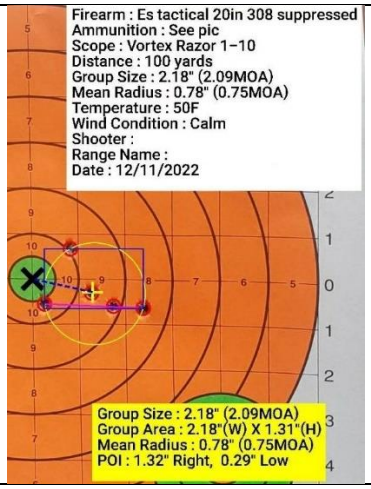
1.4 Test Results Side Plate

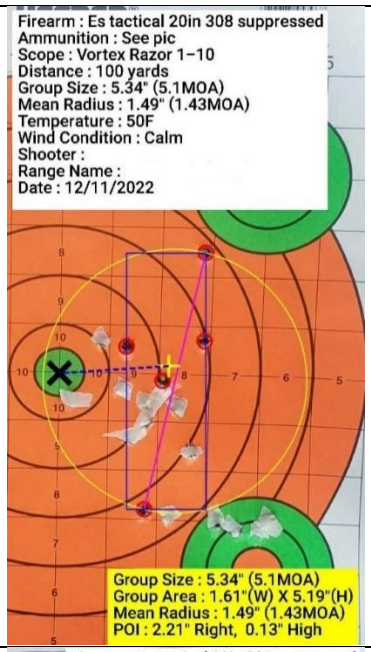
Table 7: Control Rifle Configuration Side Plate Test

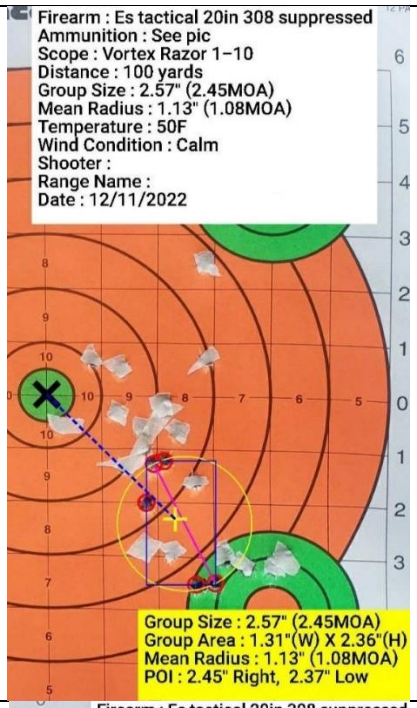
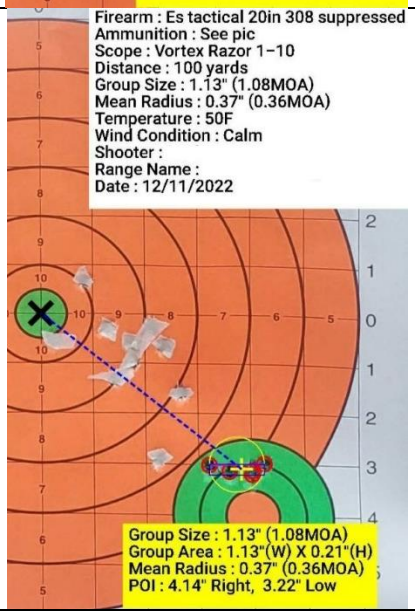
(Grain)	Brand	Side Plate	Accuracy (MOA)	Gas Setting	Test Date
147	Fed LC M80 147	Yes	2.09	S-	20221211
147	Fed LC M80 147	Yes	5.1	S	20221211
147	Norma FMJ 147	Yes	2.52	S-	20221211
147	Norma FMJ 147	Yes	2.45	S	20221211
175	Norma Golden Target HPBT 175	Yes	1.08	S-	20221211

1.5 Verification Images Side Plate

Table 8: Control Rifle Configuration Side Plate Test

	Fed LC M80 147 V1

	Fed LC M80 147 V2
	Norma FMJ 147 V1

		Norma FMJ 147 V2
		Norma Golden Target HPBT 175

Appendix B 15 Degree Jam Fastener Test

2.1 Shooter Hardware and Notes

Table 9: 15 Degree Jam Fastener Test

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
MOA Calc Method	Rangebuddy app
MOA Reference	1"
Trigger	Stock
Notes	15° Jam Fastener

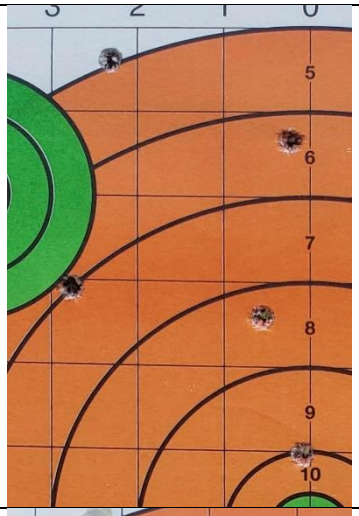
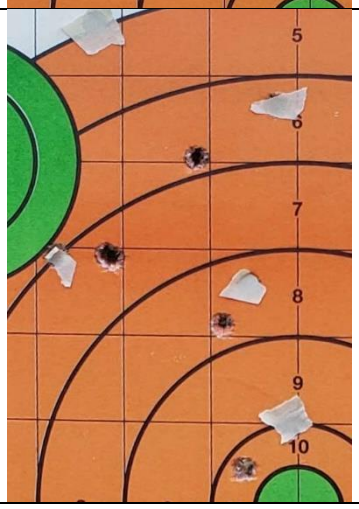
2.2 15 Degree Side Plate Results

Table 10: Shooter 1 15 Degree Jam Fastener Test

(Grain)	Brand	Accuracy (MOA)	Gas Setting	Test Date
147	Norma FMJ 147	4.83	s	20230122
147	Norma FMJ 147	3.63	s	20230122
147	Norma FMJ 147	3.72	s	20230122
147	Norma FMJ 147	4.02	s	20230122

2.3 Verification Images Control

Table 11: Shooter 1 Control Test

	Norma FMJ 147 Test 1 Jam Fastener
	Norma FMJ 147 Test 2 Jam Fastener

	Norma FMJ 147 Test 3 Jam Fastener
	Norma FMJ 147 Test 4 Jam Fastener

Appendix C 15 Degree Jam Fastener Test with Washer

3.1 Shooter Hardware and Notes

Table 12: 15 Degree Jam Fastener Test with Washer Shooter Data

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
MOA Calc Method	Rangebuddy app
MOA Reference	1"
Trigger	Stock
Notes	15° Jam Fastener with Washer

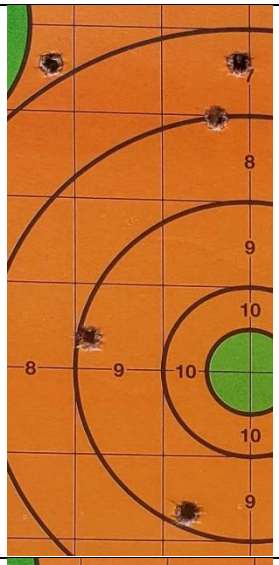
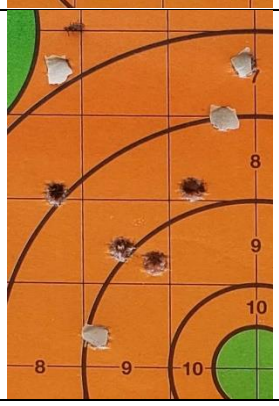
3.2 15 Degree Side Plate Results

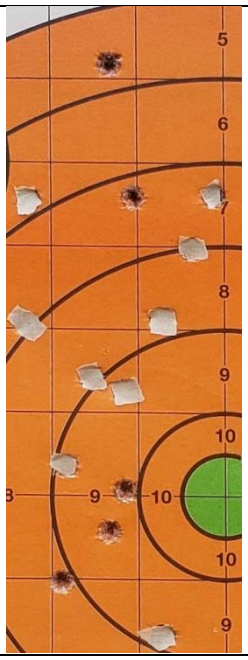
Table 13: Shooter 1: 15° Degree Jam Fastener Test with Washer

(Grain)	Brand	Accuracy (MOA)	Gas Setting	Test Date
147	Norma FMJ 147	5.04	s	20230219
147	Norma FMJ 147	2.93	s	20230219
147	Norma FMJ 147	6.01	s	20230219

3.3 Verification Images Control

Table 14: Degree Jam Fastener Test with Washer Verification Images

	Norma FMJ 147 Test 1 Jam Fastener
	Norma FMJ 147 Test 2 Jam Fastener

		Norma FMJ 147 Test 3 Jam Fastener

Appendix D Limbsaver Testing From Muzzle Device

4.1 Shooter Hardware and Notes

Table 15: 15 Degree Jam Fastener Test with Washer Shooter Data

Rifle	MDRX
Barrel	20" Modified #2 OEM barrel
Muzzle Device	Silencerco asr flash hider
Suppressor	Silencerco omega
Optic	Vortex razor g3 1-10
Support Details	Custom DIY bench
MOA Calc Method	Rangebuddy app
MOA Reference	1"
Trigger	Stock
Notes	Limbsaver Device

4.2 Control Accuracy Results

Table 16: Shooter 1: Control Accuracy Testing

(Grain)	Brand	Accuracy (MOA)	Gas Setting	Test Date
147	Norma FMJ 147	6.95	S	20221228
147	Norma FMJ 147	6.25	S	20221228
147	Norma FMJ 147	7.47	S	20221228
147	Norma FMJ 147	8.81	S	20221228

4.3 Verification Images Control

Table 17: Control Verification Images

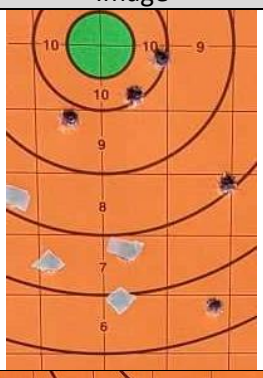
Image	Accuracy (MOA)
	6.95
	6.25

Image	Accuracy (MOA)
	7.47
	8.81

4.4 Limb Saver Accuracy Results

Table 18: Shooter 1: Limbsaver Accuracy Testing

Distance to Muzzle (Inches)	(Grain)	Brand	Accuracy (MOA)	Gas Setting	Test Date
0	147	Norma FMJ 147	5.07	S	20230508
0	147	Norma FMJ 147	3.45	S	20230508
0	147	Norma FMJ 147	1.84	S	20230508
.125	147	Norma FMJ 147	4.64	S	20230508
.125	147	Norma FMJ 147	5.11	S	20230508
.125	147	Norma FMJ 147	5.9	S	20230508
0.75	147	Norma FMJ 147	2.49	S	20230508
1.0	147	Norma FMJ 147	4.04	S	20230508
1.25	147	Norma FMJ 147	3.8	S	20230508
1.75	147	Norma FMJ 147	5.4	S	20230508

Distance to Muzzle (Inches)	(Grain)	Brand	Accuracy (MOA)	Gas Setting	Test Date
2.75	147	Norma FMJ 147	2.77	S	20230508
8	168	AMAX 168 Grain	1.55	S	20230508
8	168	AMAX 168 Grain	1.94	S	20230508
8	168	AMAX 168 Grain	3.49	S	20230508
8	147	Norma FMJ 147	1.32	S	20230508
8	168	AMAX 168 Grain	3.73	S	20230508
8.25	168	AMAX 168 Grain	1.45	S	20230508
8.25	168	AMAX 168 Grain	2.72	S	20230508
9	147	Norma FMJ 147	4.91	S	20230508

4.5 Verification Images Limbsaver

Table 19: Limbsaver Verification Images

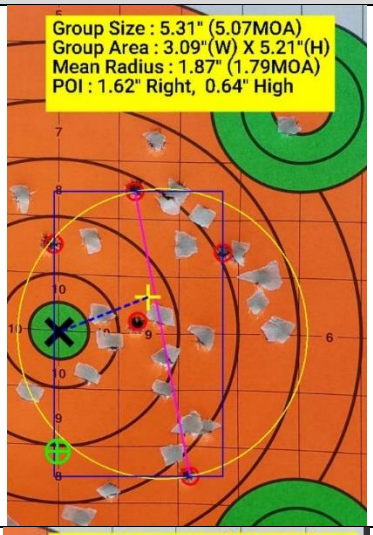
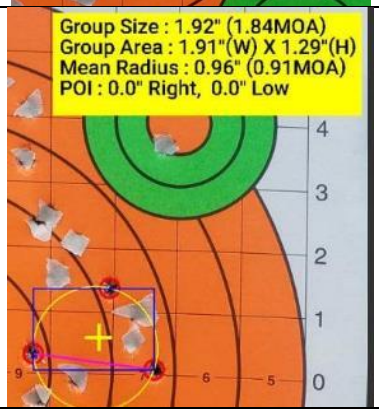
Image	Distance to Muzzle (Inches)
	0
	0

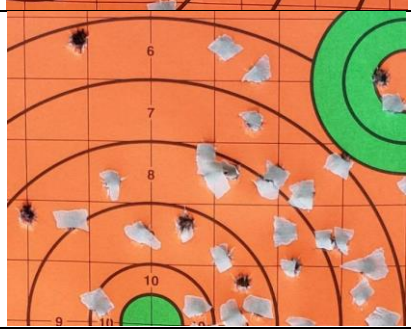
Image	Distance to Muzzle (Inches)
	0
	.125
	.125
	.125

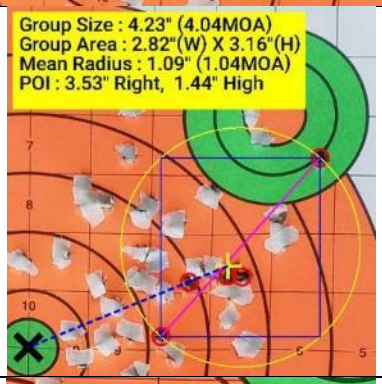
Image	Distance to Muzzle (Inches)
	0.75
	1.0
	1.25

Image	Distance to Muzzle (Inches)
	1.75
	2.75

Image	Distance to Muzzle (Inches)
	8
	8
	8
	8

Image	Distance to Muzzle (Inches)
	8
	8.25
	8.25
	9

Appendix ELimbsaver Testing Under Hand Guard

5.1 Shooter Hardware and Notes

Table 20: 15 Degree Jam Fastener Test with Washer Shooter Data

Rifle	MDRX
Barrel	20" Modified OEM barrel
Muzzle Device	Silencerco asr flash hider
Suppressor	Silencerco omega
Optic	Vortex razor g3 1-10
Support Details	Custom DIY bench
MOA Calc Method	Rangebuddy app
MOA Reference	1"
Trigger	Stock
Notes	Limbsaver Device

5.2 Under Handguard Results

Table 21: Shooter 1: Limbsaver Testing From Muzzle Results

Distance to Muzzle (Inches)	Distance to Gas Block (Inches)	(Grain)	Brand	Accuracy (MOA)	Gas Setting	Test Date
	1	147	Norma FMJ 147	4.91	S	20230508
	1.75	147	Norma FMJ 147	2.72	S	20230508
	1.75	147	Norma FMJ 147	1.45	S	20230508
	2	147	Norma FMJ 147	3.73	S	20230508
	2	168	AMAX 168 Grain	1.32	S	20230508
	2	168	AMAX 168 Grain	3.49	S	20230508
	2	168	AMAX 168 Grain	1.94	S	20230508
	2	168	AMAX 168 Grain	1.55	S	20230508

5.3 Verification Images Control

Table 22: Limbsaver Verification Images

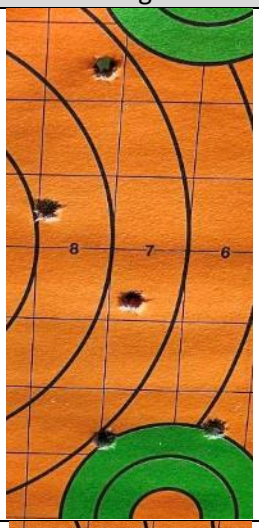
Image	Distance to Gas Block (Inches)
	1
	1.75
	1.75
	2

Image	Distance to Gas Block (Inches)
	2
	2
	2
	2