

**THE SEVERE DUTY VEGETATION SHREDDER
TECHNICAL TESTING OF CAPABILITY
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Severe Duty Vegetation Shredder Technical Test

A variety of tools and equipment for locating and clearing mines are available. The predominant method for demining however, is still focused around manual detection, probing, and mine excavation by individual human beings. One of the primary obstacles to the effective clearance of land mines is vegetation in the minefield. Most minefields are in place for several years or even decades before clearance operations are begun. These areas are, by intent, hazardous and therefore lay untended for years. Unabated by man, a variety of vegetation types over grow these areas and make accessibility to the mined terrain and excavation of the individual mines more difficult and dangerous for demining teams.

The Severe Duty Vegetation Shredder (SDVS) is designed to safely remove this obstacle to demining by opening up the general accessibility of a mined area, reducing the impediments to sweeping with hand held mine detectors, improving the deminer's visibility of the threat, reducing the risk to the deminer by eliminating the hazardous process of going into the minefield on foot to clear brush, and by reducing the need for hauling away residual cut vegetation. The SDVS was designed and built by Israel Aircraft Industries Ramta Division. The prototype unit was delivered in December 2001 and a variety of tests were performed over the period of 20-24 May 2002 to evaluate the performance of the Severe Duty Vegetation Shredder. These tests, along with other information collected on the SDVS, are described in this report.

System Description

The Severe Duty Vegetation Shredder is a vehicle-based system for shredding bushes, heavy grass, and small trees that hinder effective detection and removal of land mines from densely vegetated areas. The system is based on a 200 HP class construction tractor and is designed to shred the vegetation to the side of the path that the tractor travels.

The system can be operated from a previously cleared lane in order to reduce/eliminate the vegetation from adjacent uncleared areas (see figure 1). It cuts a swath just under 2 meters wide and can be stowed in front of the vehicle blade for cross country travel purposes. The interface between the shredder and tractor is designed to allow freedom of movement between the tractor and the shredding implement to permit contour tracking over uneven ground.



Figure 1 Reaching in to suspect area

The system consists of the shredding implement, the mainframe vehicle interface, the hydraulic power supply, and the crawler tractor.

The shredding implement is a modified commercially available component (see figure 2). The shredding implement is hydraulically driven and has a horizontally rotating shaft with hardened cutting knives pinned to its surface. The drum rotates at 1800 RPM. The knives are commercially available “wear items” and can be replaced in about half an hour. The direction of rotation provides for an upward stroke of the knives on the leading edge of the system. Skids at the edges of the shredder provide a bearing surface for the shredder to ride on if the operator maneuvers the shredder too close to the ground surface.



Figure 2 Shredding Implement

The mainframe vehicle interface replaces the standard dozing blade on the crawler tractor. The mainframe provides for the three point hitch that allows the shredding implement to “float” along adjacent to the path the tractor is traveling. In addition the mainframe provides a plus or minus 30 degree “roll direction” rotation of the shredding implement to keep the cutter parallel with the ground when traveling over terrain with a transverse slope different from the path of the tractor such as when cutting a drainage ditch or road shoulder.

The mainframe ties in with the lift and lower features of the tractor and allows the cutter to operate from 1-2 feet below the surface of the tracks to 6 feet above the surface of the tracks (see figure 3). The tilt feature of the tractor/mainframe interface can contribute additional height and



rotation of the shredding implement beyond the lift lower function and shredding implement rotation function. The “float” of the 3 point hitch allows the shredder a couple of degrees of rotation freedom and several inches of elevation freedom so the operator is not required to precisely control the terrain tracking of the shredder. In addition, the mainframe provides for the shredder to be folded around to the front of the tractor into a travel position (see figure 4).

Figure 3 Installation of Mainframe on tractor



Figure 4 Travel Position

The hydraulic power pack supplies up to 80 kw of hydraulic power to turn the cutting rotor. The pack weighs approximately 1000 kg and is designed to mount on the rear of the tractor using the



attachment pins for the standard ripper (see figure 5). The pack features a load sensing system designed to efficiently match flow conditions with working demand. Hydraulic hoses are routed along the left side of the tractor to power the shredder. Rotor speed is infinitely variable from 0 to 1800 rpm with the power pack operating at full speed. The hydraulic power pack is driven from an air cooled diesel engine and houses an 80 gallon hydraulic oil reservoir and 20 gallon fuel tank. It is capable of operating 6-8 hours depending upon conditions.

Figure 5 Rear Mounted Hydraulic Power Pack

Test Site Description

The Severe Duty Vegetation Shredder was tested near an Army test site in Virginia. In an effort to minimize the variety of conditions found at the test site and compare results with other vegetation clearance systems the vegetation and terrain have been characterized into four categories as described below:

Category 1 (Easy)	Category 2 (Moderate)	Category 3 (Difficult)	Category 4 (Very Difficult)
Light vegetation with minimal saplings up to 3cm diameter	Moderate vegetation with sparse brush and saplings up to 6cm diameters	Moderate vegetation with brush, saplings and trees up to 10cm diameter	Heavy vegetation with dense brush, saplings and trees greater than 10cm diameter
Fairly level terrain with minimal ruts	Level to light rolling terrain with some ruts	Rolling terrain with lots of ruts	Steep hills with lots of ruts, very rugged terrain
Minimal debris and obstacles	Some debris and obstacles	Moderate debris and obstacles	Heavy debris and obstacles

Shredding Tests

The performance of the SDVS was measured through a series of timed tests cutting increasingly difficult vegetation and terrain features. The first tests were performed in 1 meter high grass. The portion of the field shown in figure 6 was cleared in 1 hour with no difficulty. Operation in

this area did highlight the need for a minimum level of operator training. It is possible for the right lower corner of the mainframe to plow soil while the operator concentrates on the left side and the shredder. Once the test operator was familiar with this possibility, no further problems of this kind were encountered. The uniformity of cut while not as good as a grass mower, was adequate. In total 1404 sq meters were cut giving a rate for an inexperienced operator of .35 acres/hour. The area was sufficiently cleared to give access to all sites for hand held detector sweeping and mine excavation.



Figure 6 Category 1, Grassy Test Area (After Shredding)

The second test area in which the Severe Duty Vegetation Shredder performed consisted mainly of 1 to 2 meter high, dense scrub brush with occasional large bushes and saplings in the range of 10-15 centimeter diameter stalks on a gently sloping hillside. The shredder operated in this area for 3.4 hours and cleared 2615 sq. meters of land giving a clearance rate of .18 acres/hr. Again, no problems were encountered in this field and the clearance was performed in a continuous operation. Some stubs in the 3-5 centimeter range were left, and in places the mulch was thick enough to require clearing by hand to expose the ground surface. Figure 7 and 8 show the area before and after the shredding operation from approximately the same vantage point. Some inadvertent plowing with the mainframe occurred but this tendency was significantly reduced by the end of the test.



Figure 7 Category 3 Vegetation Before Shredding



Figure 8 Category 3 Vegetation After Shredding

The final vegetation category in which the shredder was operated consisted of a mix of dense brush with trees ranging in diameter from 10 – 25 centimeters and up to 10 meters high. Figure 9 shows the test area before the shredding took place. Most of the dense tree growth in the figure is near the far end of the test area.



Figure 9 Category 4 Vegetation Before Shredding

Trees up to 12 centimeters in diameter could be mowed down with the shredder in pretty much continuous fashion. Trees in range of 12-20 centimeters could be efficiently felled by raising the shredder high and pushing the tree over and then bringing the shredder down on top of the bent stalk (see figure 10).



Figure 10 Bringing Down 10 m Tree

Trees in the range of 20-25 centimeters could also be brought down, but the strain on the system was heavy and large residue is likely. After two hours of operation in this category 3 and 4 vegetation, the shredder knives were examined. Two were heavily bent but still in place and contributing to the shredding action. All knives showed evidence of minimal wear. At one point in the testing a barbed wire coil became tangled in the shredder. The after action photo is shown in figure 11. Half way down the cleared land on the left is a protrusion of uncleared bush surrounding the remaining barbed wire fence protruding into the now cleared area.



Figure 11 Category 4 After Shredder

Two final areas were cut in which a significant discontinuity in the elevation and slope of the terrain was present between the path of travel of the tractor and the path of the cutter. The first area was an uphill embankment along a roadway approximately 70 meters in length. The strip contained mainly category 2 vegetation consisting of weeds and saplings up to 10 centimeters in diameter. The highest point reached on the embankment was 1.4 meters above the road surface on which the tractor traveled. The slope of the embankment relative to the road surface varied between 25 and 32 degrees. The before and after photographs of the area are shown in figures



12 and 13. In all 342 sq. meters were cleared along this embankment. The only problem encountered was a bottoming out of the cutter in the soil as the operator tried to reach the highest points from the roadway. This did stall the cutter drum, but resulted in no damage to the machine. The time spent clearing the strip was 40 minutes, giving a clearance rate on the uphill, category 2 vegetation of .13 acres/hour.

Figure 12 Uphill Embankment



Figure 13 Uphill Embankment, After Shredding

The downhill embankment, like the uphill trial contained weeds and category 2 saplings. The slope and elevation differences were not measured, but are roughly comparable to the uphill



case. The cleared areas were along the sides of a stretch of roadway 230 meters in length. Clearing proved much easier in cutting banks sloping downhill from the side of the tractor than uphill from the side of the tractor. Both sides of the roadway were cleared in 65 minutes with no problems. See figures 14 and 15. The total area cleared was 1542 sq. meters for an effective clearance rate of .38 meters/hour.

Figure 14 Downhill Embankment, Before Shredding



Figure 15 Downhill Embankment, After Shredding

Mine Sensitivity Tests

A simple and quick test of the tendency of the shredder to cause unwanted detonations of landmines during operations was performed. Four M15 landmines containing functional smoke generating fuzes were buried under 1 inch of soil cover. The shredder was maneuvered such that the weight bearing skids would pass over each of the mines. The first pass of the tractor was

made with the skids appearing to just make contact with the ground surface. The height of the upper pins on the three point hitch were measure at 68.5 centimeters above the ground, and each subsequent pass was made with the pins 2.5 centimeters lower in order to gradually increase the ground pressure applied to the mines. The first pass caused one of the mines to detonate, and each of the 3 successive passes caused one of the remaining mines to detonate. Clearly the risk to the shredder and vehicle is high if the operator allows the shredder to ride on the skids in areas



containing antitank landmines since the lightest pressure we were able to apply cause mine detonation. Operators could be trained to avoid making ground contact with the shredder but additional evaluation would need to be performed to assess whether this would be effective in reducing the risk from mines sufficiently in an operational situation.

Figure 16 Mine Burial for Sensitivity Test

Transportation and Transportability

The system (less the tractor) was shipped from Israel to the US by sea vessel, then by commercial truck to the test site. The system and all components were placed on shipping pallets for transportation but could have fit within one 20' ISO Container. The system is transportable by truck, rail, vessel, and C-130 aircraft or other larger aircraft. In its unassembled state, the system and all components other than the tractor can be containerized for shipment. Once on site the system was assembled and installed on the D7R crawler tractor. The installed system was transported between sites at the test range on a flat bed trailer (see figure 17).

Specifications and Dimensions

System weight:	2300 kg
Hydraulic pack weight:	1050 kg
Tractor weight:	20500 kg
Width (travel position):	3.67 m
Width (working pos.):	5.66 m
Swath Width:	1.80 m



Figure 17 Shredder System and Tractor on Trailer

Facilities and Equipment

No special facilities are required for storage and maintenance of the shredder. Assembly of the unit required the use of a forklift, porta power jacking system, impact wrench, standard hand tools and pry bars, a large open end wrench set (1 ¾" – 2"), and a hand held tachometer. Additionally spill containers and rags were required for handling the hydraulic connections.

Installation and Maintenance

Installation of the shredder on the D7 required 3 ½ working days to complete, of which 2 days were devoted to removal of the existing ripper. It is estimated that an experienced crew of 3 people performing the installation on a tractor with the ripper already removed could complete the installation in less than 1 day.

The D7 is supportable worldwide. The shredder and hydraulic portions of the system are constructed of standard components and are supportable. Most items unique to the shredder are field repairable. Daily maintenance on the SDVS required less than 30 minutes to accomplish. During the conduct of the test, two repairs were required on the D7 tractor, 1 repair on the hydraulic power supply, and none on the shredding implement and mainframe. The tractor repairs were unrelated to the SDVS system. The hydraulic power supply hydraulic thermostat did fail and was bypassed for the duration of the test. The only operational problem occurred when the shredding implement encountered and tangled a wire fence. Approximately 45 minutes and heavy wire cutters were required to unwrap the cutting drum. Wear from category 1, 2, and 3 vegetation is expected to be slow and knives may be expected to last hundreds of hours. Wear in the areas containing thick hard wooded trees was heavy and knives may need replacement every 1 or 2 days. Minor spreading and bending of some of the knives required them to be

replaced at the test conclusion, see figure 18. The manufacturer provided an Operation and Maintenance Manual which is comprehensive and well written.



Figure 18 Knives Wear at Test Conclusion

Personnel and Training

Operation of the shredder is not difficult for someone familiar with heavy equipment. Some technique is required for manipulation of the unit in the heavier working conditions. The operator's view of the shredding implement is much better than many tractor-operated working tools. The view of conditions and debris in the vegetation and in front of the shredder is not good and a second operator providing external monitoring as well as a site review prior to operations are recommended to avoid driving into trouble. All maintenance and operator functions and training could be given in 1 day with 3 days of follow on practice in operating techniques.

Conclusions

The Severe Duty Vegetation Shredder performed well in all conditions tested. Although somewhat of an overkill for the category 1 and 2 vegetation, the ability of the SDVS to handle category 3 vegetation with relative ease and category 4 with some difficulty puts it in a class beyond the simple arm mounted mowing decks and bushhogs. The construction platform used

for the SDVS is not a vehicle normally associated with vegetation cutting, but did offer some advantages in terms of being able to push down the larger stalks in front of the shredder. In addition, the platform can carry other earth working tools for mine clearance which require the weight and drawbar available. Having a compatible and complementary vegetation cutting capability for these tools is a big plus. In addition the flexibility of the cutter in following ground contour and reaching across terrain features and up and down side slopes was an unexpected and most appreciated capability.

The skill level to use the cutter is considered low to moderate. A novice can operate the system under non-hazardous conditions very quickly. Development of operational skills and techniques can be accomplished within a few weeks.