2007 – 2009 OKLAHOMA DEPARTMENT OF TRANSPORTATION SPRAYER EQUIPMENT ASSESSMENT & CALIBRATION WORKSHOPS

FINAL REPORT - FHWA-OK-09-08

ODOT SPR ITEM NUMBER 2156

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16 . ABSTRACT

Oklahoma State University (OSU) Roadside Vegetation Management (RVM) Program personnel assessed and inventoried 82 ODOT herbicide spray units. At these workshops, 259 ODOT herbicide applicators were trained in sprayer system parts identification, system assessment and proper calibration. A report card highlighting a 16 point check list of sprayer system components was used in the system assessment process on each unit. The 16 point check list included assessment of the spray tank and lid condition; tank shut-off valve; in-line filter screens; drift control injector (if present); water pump; pump power source engine or motor; system hoses and plumbing fixtures; tank agitation system; all pressure gauges; pressure regulators; nozzle type and condition; spray head control arm; nozzle shut-off solenoids or other; in-cab control switches; auxillary handgun applicator and hoses; as well as the computerized sprayer monitoring device and its interface parts. A single OSU RVM staff member was assigned to each spray unit. That staff member spent approximately 1 hour per crew in assessment for most units. Units with more extensive problems required over 1.5 hours of staff time in assessment. This does not include the time needed if parts needed replacement. ODOT Employees observed and closely participated with OSU RVM personnel as the systematic assessment and calibration was conducted. Many simple problems could be corrected during the course of the assessment/calibration workshop whereas more fundamental and major problems required the unit be worked on by ODOT Division mechanics at a later date. Herbicide sprayer report cards were completed for each spray unit and were provided to county unit supervisors and to each ODOT field division headquarters. Final recommendations and inventory data were developed and reported to each division headquarters. Additional specific recommendations are provided in this report.

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We would like to thank the divisions for their participation in this training and assessment endeavor. Without their cooperation, the scope of this report would have been dramatically limited. We encourage suggestions as to how this type of report can be made more informative and useful in the future. As always we welcome and encourage input from all levels & branches within ODOT. Appreciation is also expressed to Ms. Stephanie Larimer who prepared and formatted large portions of this manuscript.

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METRIC CONVERSION PAGE

SI (METRIC) CONVERSION FACTORS

Approximate Conversions to SI Units

Symbol	When you know	Multiply by	To Find	Symbol
		LENGTH		
in	Inches	25.40	millimeters	Mm
ft	Feet	0.3048	meters	M
yd	Yards	0.9144	meters	m
mi	Miles	1.609	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.0929	square meters	m^2
yd^2	square yards	0.8361	square meters	m^2
ac	Acres	0.4047	hectacres	ha
mi^2	square miles	2.590	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	Gallon	3.785	liters	L
ft^3	cubic feet	0.0283	cubic meters	m^3
yd^3	cubic yards	0.7645	cubic meters	m^3
		MASS		
oz	Ounces	28.35	grams	g
lb	Pounds	0.4536	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Degrees Fahrenheit	(°F-32)/1.8	degrees Celsius	°C
		FORCE and PRESSURE or STRESS		
lbf	Poundforce	4.448	Newtons	N
lbf/in^2	Poundforce per square inch	6.895	kilopascals	kPa

Approximate Conversions from SI Units

Symbol	When you know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.0394	inches	in
m	meters	3.281	feet	ft
m	meters	1.094	yards	yds
km	kilometers	0.6214	miles	mi
		AREA		
mm^2	square millimeters	0.00155	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.196	square yards	yd^2
ha	hectacres	2.471	acres	ac
km^2	square kilometers	0.3861	square miles	mi^2
		VOLUME		
mL	milliliters	0.0338	fluid ounces	fl oz
L	liters	0.2642	gallon	gal
m^3	cubic meters	35.315	cubic feet	ft^3
m^3	cubic meters	1.308	cubic yards	yd^3
		MASS		
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.1023	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	degrees Fahrenheit	9/5(°C)+32	degrees Celsius	°F
		FORCE and PRESSURE or STRESS		
N	Newtons	0.2248	poundforce	lbf
kPa	kilopascals	0.1450	poundforce per square inch	lbf/in^2

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1.0 INTRODUCTION

This report documents the findings of herbicide sprayer calibration workshops conducted as a part of the Federal FY 2007 - 2009 Joint Project 2156: *Roadside Vegetation Management Training and Consultation*, Task 4, “Conduct Equipment Sprayer Inspection and Calibration Workshops.”

Boomless roadside sprayers are the primary means by which broadcast herbicide applications are made in the ODOT roadside vegetation management program. The most common broadcast sprayer unit consists of a skid mounted tank on a truck and the appropriate sprayer system components to correctly apply herbicides. This configuration of components is identified in the *Boomless Roadside Herbicide Sprayer Assessment Guide* (1). Additionally, this type of sprayer is detailed in Chapter 10 of the *Oklahoma Roadside Vegetation Management Guidelines* (2).

1.1 PROBLEM

The majority of ODOT employees have limited to no experience with pesticide application equipment when they first start work in the area of vegetation management for ODOT. Under-application of herbicides will provide little or no weed control while over application may cause detrimental effects on vegetation. Additionally, both under and over application of pesticides are illegal in Oklahoma. Consequently, the need for new employees to receive training in the correct setup and use of equipment is crucial. Periodically an independent expert assessment of ODOT herbicide application equipment is needed so that an independent expert opinion can be rendered on the status of herbicide spray equipment. Because each of the eight ODOT Divisions’ vegetation management equipment may differ, a periodic inventory and assessment can generate valuable information detailing each spray unit configuration. This in turn allows maintenance managers to make equipment upgrade decisions for each county unit and identify those units that are not receiving the proper equipment maintenance.

1.2 PURPOSES

The purposes of the herbicide sprayer equipment assessment and calibration workshops were to inventory ODOT herbicide spray equipment and to train ODOT personnel in equipment calibration and spray system troubleshooting. Ultimately, these actions should lead to ODOT applicators making cost effective, accurate and efficacious weed control applications that maintain appropriate site distances in the clear or safety zones along highway rights of way. More experienced herbicide applicators successfully completing the workshops will be able to train junior ODOT employees in the future. Trained ODOT employees will have the skill sets necessary to assess and calibrate their own equipment on a regularly scheduled basis.

1.3 OBJECTIVES

The specific objectives of the sprayer equipment assessment and calibration workshops were:

1.) To train new or inexperienced spray crew employees on herbicide sprayer

a. system set up
b. proper operation
c. proper calibration

2.) To create a report card on each herbicide sprayer's design and performance.

3.) To encourage experienced members of each ODOT yard/spray crews to serve in training other less experienced crew members in the future;

2.0 MATERIALS AND METHODS

2.1 GENERAL COMMENTS

During the years 2007 – 2009, two OSU RVM personnel visited each of eight ODOT field divisions. Two OSU staff assessed and inventoried 82 ODOT herbicide spray units. At these workshops, 259 ODOT herbicide applicators were trained in sprayer system parts identification, system assessment, proper calibration and the use of sprayer speed adjustment charts. Resources used in the training effort included a draft version of and later a final version of the *Boomless Roadside Herbicide Sprayer Assessment Guide* (1) and Appendix A as well as sprayer speed charts which were identical to those from the *Final Report on* the *2004 – 2006 Oklahoma Department of Transportation Sprayer Equipment Assessment & Calibration Workshops* (3).

A report card (Appendix B) was completed for each sprayer (unit). The report card contained a 16 point check list of sprayer system components. The check list included assessment of the spray tank and lid condition; tank shut-off valve; in-line filter screens; drift control injector (if present); water pump; pump power source engine or motor; system hoses and plumbing fixtures; tank agitation system; all pressure gauges; pressure regulators; nozzle type and condition; spray head control arm; nozzle shut-off solenoids or other; in-cab control switches; auxiliary handgun applicator and hoses; as well as the computerized sprayer monitoring device and its interface parts. A single OSU RVM staff member was assigned to each spray crew and sprayer unit. That staff member spent approximately 1 hour per spray unit crew in assessment for most units. Some units with more extensive problems required over 1.5 hours of staff assessment time. Any corrections to the spray systems undertaken by OSU or ODOT employees at the workshops required time in addition to that quoted for the assessment. Employees observed and closely participated with OSU RVM personnel as the systematic assessment and calibration was conducted on each unit.

OSU staff explained that there was an expectation that the more experienced crew members should use their training and skill set to further train new or less experienced ODOT spray crew members in the future. Additionally OSU RVM staff explained that the Oklahoma Department of Agriculture, Food and Forestry (ODAFF) has expressed a desire that applicator personnel should undertake sprayer system calibration before each individual tank load of herbicide is applied. We encourage compliancy with that request. Additionally we recommended that ODOT calibrate a.) before each spray season, b.) one-half way through each spray season, c.) after there has been any mechanical repair or equipment replacement, d.) after every tip angle adjusted or pattern width changed and e.) if the applicator's intuition, instinct, deductive logic or inductive logic tells that there is a spray system problem.

Comments from ODOT applicators attending this training were very positive. OSU RVM recommendations were made in a sincere effort to allow applicators to operate their spray rigs in a confident, knowledgeable and accurate fashion. Most spray rigs had small individual problems that could be fixed by the field crews. Small sprayer problems were addressed verbally to each spray crew and were not listed in the reports nor are they discussed in this Final Report. However, more fundamental and major problems required that the unit be worked on by Division mechanics at a later date. Herbicide sprayer report cards were completed for each spray unit and copies were provided to county unit supervisors and to each ODOT field division headquarters within two weeks of the calibration workshop. The cover letter with the report card explained to the unit supervisor and field division headquarters that the sprayer problems listed on the report card were significant enough that they should address them as soon as possible unless otherwise stated on the report card. We explained that spray crew, supervisors or Division headquarters personnel should feel free to call the OSU RVM team if they had any questions on fixing the reported problems. For inventory as well as informational purposes, truck numbers and sprayer numbers were provided in the reports as well in the Tables of this Final Report. A detailed discussion of the individual findings of the sprayer assessment/calibration workshops are covered for each ODOT division respectively in Sections 3.0 – 10.0 of this report. A state-wide summary of the major findings and recommendations are covered in Section 11 of this Final Report.

3.0 ASSESSMENT, RECOMMENDATIONS AND INVENTORY FROM THE DIVISION ONE SPRAY EQUIPMENT AND CALIBRATION WORKSHOPS

3.1 GENERAL COMMENTS

A total of seven field unit crews consisting of 16 applicators were trained in calibration from Division 1 during April 15, 16 and 17, 2008 (Table 1). It is unfortunate that McIntosh and Muskogee County crews were unable to attend and take advantage of this long standing, previously scheduled training effort. Even if trucks and sprayers were inoperable, crews could still have benefited from attending and working with other county units. There was an approximate 50% reduction in attendance from Division 1

personnel from 2008 as compared to the 2006 calibration workshop. Consequently, only seven of the nine units that operate in Division 1 were assessed and some crews were absent. It was brought to our attention that McIntosh County borrowed the Haskell County spray unit and due to unfamiliarity with Boom Buster tips, made a 3X in the area where all three tips overlapped during an application involving 1500 gallons of herbicide mixture. We would encourage Division 1 county units or Division 1 headquarters to contact the OSU RVM Program staff for consultation/training when crews convert from Estes brand solid stream heads to Boom Buster type tips. Special attention should be given to the Adair County sprayer unit as mentioned in section 3.5 below.

3.2 BOOM BUSTER NOZZLE CONFIGURATION & SUPPORT BRACKET DESIGN

ODOT fabricators can consult the OSU publication *L-322: Boomless Roadside Herbicide Sprayer Assessment Guide* (1) [Appendix A] which was sent to division headquarters on October 15, 2007 in order to view a photograph representing the proper alignment of Boom Buster tips. The Wagoner County unit is represented in the color picture identified as item number 10 in that *Guide*. Tips should be aligned in a horizontal plane were one tip does not interfere or "shadow" the other tips. The Adair County unit, *Truck #86-4898 – Sprayer # unassigned*, a unit so new that a sprayer number was not yet assigned, had a vertical tip orientation that was incorrect. Tom Barnes, Division 1 HQ Automotive Shop Superintendant, was contacted by phone on April 18, 2008 and informed of the proper orientation of tips and directed to item 10 of the *Guide* (2). Additionally, bracket material and support bolts should be of a size to withstand shock and vibrations produced from stiff truck suspension.

3.3 SPRAYER SYSTEM NOZZLE TIPS

Five of the nine units available for inspection in 2006 were solid stream nozzle heads (Table 1). As funds become available, we recommend transitioning these units to Boom Buster type tips.

3.3.1 ESTES SOLID STREAM SPRAYER HEADS

Those units using Estes solid stream heads should use the original tip configuration of the lowest bank of tips utilizing three 2520 VeeJet tips which will treat a 0 to 9 foot wide swath. The middle bank of tips should be three 1520 VeeJet tips, treating a 9 – 18 foot wide swath. The top bank of tips should be three 0020 solid stream tips treating an 18 – 27 foot wide swath. These tips are available from Wylie Sprayers in Oklahoma City (phone: 405-946-4896).

3.3.2 BOOM BUSTER TYPE SPRAY TIP

The remaining four Division 1 units utilize Boom Buster tips. Boom Buster tips are designed to operate one at a time to treat specific widths of roadside easements. They should never be run simultaneously. A single 437-R tip is capable of producing an effective spray pattern width of 27 -30 feet (dependent upon wind resistance). A 375-R tip is capable of producing an effective spray pattern of 21 feet. A 260-11R tip is capable of treating an effective width of 11 feet. These are the three tips that have applications warranting their use on ODOT spray trucks. These tips are available from several sources including Wylie Sprayers in Oklahoma City (phone: 405-946-4896). Costs of the Boom Buster type spray heads from Wylie Sprayers on May 1, 2009 were: 260-11R ($109.80); 375R ($115.03) and 437R ($122.20).

Spray trucks using Boom Buster style tips use electric solenoid valves or electric ball valves (Spray Systems Mod. 344B EC-2 ball valve, max. pressure rating 300 psi, Wylie Sprayers, Oklahoma City, phone: 405-946-4896, approx. cost $185) to control which tip is used during herbicide applications. Tip spray pressure is maintained at 25 psi by inline pressure regulators such as the Watts brand Series 223 LP10 1 inch, inline water pressure reducing valve (10-35 psi range, maximum pressure rating 300 psi) by Watts Regulators (source Grainger Inc., phone: 918-836-8631, 10707 E. Pine St., Tulsa, OK 74116).

3.4 SPRAYER IN-LINE FILTER SIZE

ODOT spray systems use large tips and should only use 20 or 30 mesh screens. The larger holes in the 20 to 30 mesh screens will allow liquid drift control products to pass through more easily. Adair County truck #86-4898 and Checotah Interstate, sprayer number 27-1146 are currently using 50 mesh screens and should replace these screens with 20-30 mesh screens to avoid any screen clogging issues. Wagoner County sprayer # 27-244 has an additional 100 mesh screen plumed in just before pressure regulators that should be replaced with a 50 mesh screen however, this screen is redundant and could be eliminated all together.

3.5 ADAIR COUNTY SPRAYER UNIT

The Adair County yard has received a new truck and a sprayer that used to be a magnesium chloride sprayer. There are several issues with this unit that need to be addressed. Adair County unit truck #86-4898 - Sprayer number unknown (unit so new crew did not know sprayer number), was mentioned in previous comments about Boom Buster tip alignment (see Boom Buster Nozzle Support Bracket Design in Appendix A).

Additional system changes that were needed on the Adair county unit included:

A.) The auxiliary gasoline motor was mounted higher than the bottom of the spray tank. This created air gaps between the pump and tank contents. The engine needed to be lowered so that the motor does not have to pull water/herbicide mixture upward to “prime” the pump. The pump could run empty when tank water levels are below the pump height causing the pump to overheat and fail.

B.) The spray tip control arm needed to be redesigned or replaced with a more durable unit or materials while the mount ram needed a minimum of 5/16 or 3/8 diameter bolts.

C.) The smallest Boom Buster tip present, a 280-6R, produced a pattern width only 6 feet wide. This pattern was too narrow for use on ODOT easements. A Boom Buster model 437-R should replace it so the order of nozzles includes one 437-R, one 375-R, and one 260-11R tip.

Most Division 1 spray rigs had individual and specific problems. Some of these problems could be fixed by the local ODOT crews; however, some may require ordering parts (tips, electric solenoid valves, etc.). We recommended these changes be completed through the field division headquarters.

Table 1. Division 1 Herbicide Sprayer Assessment/Calibration Workshop Data.

Div. Field Unit	Truck ID #	Sprayer ID #	Motor Model	Water Pump Model #	Herbicide Delivery Sys.	Workshop Attendance	Workshop Date
Adair County	86-4898	Unassigned	Auxiliary Gas Motor 8hp Honda	Ace pump GE-800	Incorrect design (see report card) Boom Buster 375-R, 260-11R, 180-6R	2	4-17-08
Checotah Interstate	86-4775	27-146	Hydraulic Hypro HM3	Hypro 9303	Solid Stream Head – 9 nozzle-(4)2520,(2)1520,(3)0020	1	4-15-08
Cherokee County	86-4690	27-217	Hydraulic Hypro HM3	Hypro 9303	Solid Stream Head – 9 nozzle-(2)6520,(3)2520,(1)1520,(3)0020	4	4-17-08
Haskell County	86-4560	27-243	Hydraulic Hypro HM3	Hypro 9303	Boom Buster Head-437R, 375R, 260-11R	2	4-16-08
McIntosh County	Unit unavailable		Hydraulic		Solid Stream Head – 9 nozzle	0	4-15-08
Muskogee County	Unit unavailable		Auxiliary Gas Motor		Solid Stream Head – 9 nozzle	0	4-15-08
Okmulgee County	86-3909	27-285	Auxiliary Gas Motor 8hp Honda	Ace pump GE-860	Injector System w/ Boom Buster Head-437R, 375R, 260-11R, 180-6R	1	4-15-08
Sallisaw Interstate/ Sequoyah County (shared unit)	86-4753	27-218	Auxiliary Gas Motor 8hp Honda	Ace pump GE-800 GE-860	Solid Stream Head – 9 nozzle-(1)6520,(1)2520,(4)1520,(3)0020	2	4-16-08
Wagoner County	86-4810	27-244	Auxiliary Gas Motor 8hp Honda	Ace pump GE-800 GE-860	Boom Buster Head-437R, 375R, 260-11R	4	4-17-08

4.0 ASSESSMENT, RECOMMENDATIONS AND INVENTORY FROM THE DIVISION TWO SPRAY EQUIPMENT AND CALIBRATION WORKSHOPS

4.1 GENERAL COMMENTS

A total of 10 field unit crews consisting of 24 applicators were trained in calibration from Division 2 during April 21, 22 and 23, 2009 (Table 2). Overall Division 2 spray rigs were functional, but on most trucks we found issues identified in 2006 that were not addressed or corrected by 2009. This is a situation that needs to be addressed by Division 2 administration to insure deficiencies are corrected.

Continuing problems include the absence of a recommended, working Calc-An-Acre, missing pump in-line filters and missing tank sparge tubes. A discussion of the proper tank agitation system can be found in (2), the *Roadside Vegetation Management Guidelines*, 3rd Ed., Ch.10.2.

Of the 10 spray units assessed four were using older Estes spray heads equipped with solid stream nozzles and VeeJet angled nozzles. Boom Buster nozzles were utilized in the other six spray units. The statements in Sections 4.2 through 4.6 of this Final Report are a summary of sprayer problems in the Division in addition to comments on individual reports.

4.2 INSTALLATION OF CALC-AN-ACRE SPEED MONITORING DEVICE

Seven of 10 Division 2 spray trucks were either missing a working Calc-An-Acre to digitally monitor their sprayer speed or the installed Calc-An-Acre was nonfunctional (Table 2). Without this key component of a spray rig, accurate herbicide application is almost impossible. The need for a precision speed monitoring device is discussed in the *Roadside Vegetation Management Guidelines*, 3rd Ed., Ch.11.6 (2).This inadequacy should be corrected immediately, before the next spray season. Failure to rectify this situation can have undesirable consequences as discussed in *Roadside Vegetation Management Guidelines*, 3rd Ed., Ch.11, p. 11-14 (2). We recommend that new Calc-An-Acre II units and Astro II GPS Speed Sensors be purchased for each spray truck and that the old, non-functional units be replaced. Calc-An-Acre II costs are approximately $302 each while the Astro II GPS Speed Sensor costs approximately $330 each from Wylie Sprayers of Oklahoma City (phone 405-946-4896). However, pricing structure was dependent upon the number of units ordered and some price reduction would come about with multiple unit purchases.

4.3 CONVERSION TO BOOM BUSTER TIPS

All sprayer units in Division 2 utilizing Boom Buster 437R and 375R nozzles require 1 inch piping from the delivery side (pressure side) of the pump to the nozzles. Units that

converted from Estes solid stream nozzles to Boom Buster tips need to re-plumb and use pipes, regulators and hoses that are one inch diameter. Failure to use the proper sized fitting and hoses will result in the inability to deliver the correct operating volume to the Boom Buster nozzles. Installation procedures are, "For single nozzle installation, the supply line from the pump must be one pipe size larger than the nozzle thread size. Example, if the nozzle has a 0.5 inch thread (spray head 260-11R), the supply line must be 0.75 inch. Example, if a 0.75 inch thread size nozzle (spray head 375R or 437R) must have a 1 inch supply line, etc."

Manifolds on older style Estes Spray Heads used by Marshall County and Pushmataha County should be replaced with 1 foot length of nipples and "T's" to make new manifolds capable of supplying adequate spray volume to Boom Buster tips. Examples of these manifolds can be viewed in the image of item #10 in the *Boomless Roadside Herbicide Sprayer Assessment Guide* (Appendix A). The Pittsburg County spray unit is properly equipped with the correct plumbing configuration to utilize Boom Buster tips and would serve as a good "blueprint" to follow.

New pressure regulators (inline water pressure reducing valve) will be required for Boom Buster nozzles. It is the opinion of the OSU RVM personnel that the Watts brand 1 inch, Series 223 LP10, (pressure range 10 – 35 psi) pressure regulators (source: Grainger Inc., 10707 E. Pine St., Tulsa, OK 74116, phone: 918-836-8631, approx. cost $283.80) are preferred because they operate within the desired pressures ranges ODOT uses (about 25-30 psi) for herbicide application. Regulator pressure setting screws should not need to be either screwed all the way in or all the way out. This may indicate debris in the regulator and they should be cleaned and reset.

4.4 SPRAYER IN-LINE FILTER SIZE

Boom Buster nozzles are large tips and should preferably use 20 or 30 mesh screens. The larger holes in the 20 to 30 mesh screens will allow liquid drift control products to pass through more easily. Spray units continuing to use 9 or 12 nozzle solid stream systems require a 50 mesh screen present before the tip and a 30 mesh screen between the pump (low pressure side) and tank. Small diameter particles that would pass through Boom Buster tips will clog small solid stream tips unless removed by additional 50 mesh screens. ODOT fabricators can consult the *Boomless Roadside Herbicide Sprayer Assessment Guide* (1) or Appendix A which was sent to division headquarters October 15, 2007 for an image representing the proper placement of the in-line screen. Specifically, please see item #3 of the diagram in Appendix A.

4.5 SPRAYER TIPS

Six of 10 division two spray trucks are using Boom Buster style tips. Boom Buster tips treat varying widths of roadside easement depending upon tip used. Spray patterns start from the edge of the road surface and extend outward to various widths. Boom Buster spray tip model numbers, effective spray width and estimated cost are discussed in Section 3.3.2 of this report.

These tips are to be operated one tip at a time to treat specific widths of roadside easements. They should never be run simultaneously. Spray trucks using Boom Buster style tips use electric solenoid valves or electric ball valves to control which tip is used during herbicide applications. Tip spray pressure is maintained at 25 psi by inline pressure regulators.

Worn or damaged tips with need of diffuser replacement should be sent back to the manufacturer (Evergreen Products, P.O. Box 598, Griffin, GA 30442, phone: 478-982-5593) for refurbishing at approximately half the cost of a new tip. New tips can be ordered from Wylie Sprayers in Oklahoma City (phone: 405-946-4896). If ODOT needs to order a large stock of Boom Buster Tips, ODOT should expect a fairly lengthy period of time before large orders are shipped due to stocking/manufacturing limitations. Due to this delay period, it is recommended that replacement tips be kept on hand by county yards.

4.6 BOOM BUSTER TIP MOUNTING

Mounting of Boom Buster tips to spray heads should be done so that angle of tip adjustments can be made. In other words, tips should not be rigidly mounted. Some units that are converting to Boom Buster tips are welding tip couplers to old Estes Spray Heads. These tip attachments should be designed to allow proper angle setting while the spray head is in the level or horizontal position. ODOT fabricators can view image #12 of the *Boomless Roadside Herbicide Sprayer Assessment Guide* (Appendix A) to view a photograph representing a working tip attachment design. Spray head angle actuators should only be used to address “Cut” or Fill” slopes as they are encountered to maintain proper spray pattern widths. Otherwise spray heads should be operated in the level position.

Table 2. Division 2 Herbicide Sprayer Assessment/Calibration Workshop Data.

Div. Field Unit	Truck ID #	Sprayer ID #	Motor Model	Water Pump Model #	Herbicide Delivery Sys.	Workshop Attendance	Workshop Date
Atoka County	86-4229	27-150	8hp Honda	Ace pump GE-800-LE	Solid Stream Head – 12 nozzle 0020(4),15/20(6),25/20(2) VeeJet	1	4-23-09
Bryan County	86-4954	27-149	8hp Honda	Ace pump GE-800-LE	Boom Buster Head – 437R, 375R, 260-11R	6	4-23-09
Choctaw County	86-4299	27-290	8hp Honda	Hypro pump model#(unknown)	Solid Stream Head – 12 nozzle 0015(4), 15/15(5)25/15(2) VeeJet	3	4-22-09
Latimer County	86-4231	27-232	9hp Honda	Ace pump GE-800-LE	Solid Stream Head – 9 nozzle 0002(3), 15/20(1), 25/20(3), 65/20(2) VeeJet,	3	4-21-09
Leflore County	86-4807	27-154	9hp Briggs & Stratton Vanguard	Davey pump Firefighter+5 series	Solid Stream Head – 12 nozzle 0020(4), 15/20(6), 25/20(2)	1	4-21-09
Marshall County	86-4106	27-231	8hp Honda	Ace pump GE-800-LE	Boom Buster nozzles 437R, 375R, 260-11R	1	4-23-09
McCurtain County	86-4965	27-153	8hp Honda	Ace pump GE-800-LE	Boom Buster nozzles – 437R, & 260-11R	2	4-22-09

Table 2. Division 2 Herbicide Sprayer Assessment/Calibration Workshop Data (Continued).

Div. Field Unit	Truck ID #	Sprayer ID #	Motor Model	Water Pump Model #	Herbicide Delivery Sys.	Workshop Attendance	Workshop Date
Pittsburg County	86-4181	27-152	8hp Honda	Ace pump GE-800-LE	Boom Buster Head – 437R, 375R, 260-11R	1	4-21-09
Pushmataha County	86-4181	27-152	8hp Honda	Ace pump GE-800-LE	Boom Buster nozzles - 437R, 375R, 260-11R	4	4-22-09
Talihina Yard	86-4568	27-181	8hp Honda	Ace pump GE-800-LE	Boom Buster nozzle - 437R	2	4-21-09

5.0 ASSESSMENT, RECOMMENDATIONS AND INVENTORY FROM THE DIVISION THREE SPRAY EQUIPMENT AND CALIBRATION WORKSHOPS

5.1 GENERAL COMMENTS

A total of 17 field unit crews consisting of 48 applicators were trained in calibration from Division 3 during April 8, 9 and 10, 2008 (Table 3).

5.2 SPRAYER IN-LINE FILTER LOCATION

All division three spray rigs need installation of in-line screens between the tank shut-off valve and the system water pump. In constructing Division three spray rigs, fabricators can consult the *Boomless Roadside Herbicide Sprayer Assessment Guide* (1) or Appendix A to view a diagram representing the proper location of the In-line screen. The In-line screen and its placement are designated as item number three in that *Guide*. The in-line filters are currently plumbed between the pump and the electric solenoid which protects most sprayer components but not all. While this is not causing major problems, we would recommend installing the filter in the proper location to better protect pump components.

5.3 SPRAYER IN-LINE FILTER SIZE

ODOT spray systems use large tips and should only use of 20 or 30 mesh screens. The larger holes in the 20 to 30 mesh screens will allow liquid drift control products to pass through more easily. Garvin County, Sprayer number 27-174 and Purcell Interstate, sprayer number 27-177 are currently using 50 mesh screens and should replace these screens with 20-30 mesh screens to avoid any screen clogging issues.

5.4 SPRAYER TIPS

All Division 3 spray trucks are using Boom Buster style tips. All division three spray rigs (exception is Shawnee Intestate) are using a single 437-R tip capable of producing an effective spray pattern width of 27 -30 feet (dependant upon wind resistance). Some county units indicated the addition of a smaller tip, 260-11R, capable of treating an effective width of 10-12 feet, would be very helpful and safer for treating narrower easements. These tips are available from several sources including Wylie Sprayers in Oklahoma City (405-946-4896).

Boom Buster style tips are to be operated one tip at a time to treat specific widths of roadside easements. They should never be run simultaneously. Spray trucks using Boom Buster style tips use electric solenoid valves or electric ball valves to control which tip is used during herbicide applications. Tip spray pressure is maintained at 25 psi by inline pressure regulators such as the Watts brand Series 223 LP10 1 inch, inline water pressure reducing valve (10-35 psi range, maximum pressure rating 300 psi) by Watts Regulators (source: Grainger Inc., 10707 E. Pine St., Tulsa, OK 74116, phone: 918-836-8631, approximate cost $283.80). The Spray Systems brand Model 344B EC-2 electric ball valve (max. pressure rating 300psi) costs approximately $185 and may be ordered from Wylie Sprayers in Oklahoma City (phone 405-946-4896).

5.5 CAB/TIP MOUNTED PRESSURE GAUGES

Correctly functioning 0-60 psi gauges close to the spray tip and at all locations where they are mounted are also required. Consequently, as part of the 2008 equipment assessment, each spray rig was critiqued regarding properly functioning gauges and some gauges were replaced by the OSU RVM personnel. The OSU RVM team is hopeful that crews will monitor and replace damaged gauges as is necessary, they are relatively inexpensive.

5.6 UNITS NEEDING UPGRADED ENGINES/PUMPS

Pontotoc County sprayer number 27-175 and Pottawatomie County sprayer number 27-176 are utilizing extremely old engines and/or pumps. These two units have experienced issues related to the age, degree of wear and maintenance requirements of these aged engines/pumps. As funds become available, we recommend that these units be upgraded to the same engines/pumps that are used on the Division three's other sprayer units.

Most spray rigs had individual and specific problems most of which should be fixed by the local ODOT crews but some may require ordering parts (tips, electric solenoid valves, etc.) through their respective field division headquarters.

Table 3. Division 3 Herbicide Sprayer Assessment/Calibration Workshop Data.

Div. Field Unit	Truck ID #	Sprayer ID #	Motor Model	Water Pump Model #	Herbicide Delivery Sys.	Workshop Attendance	Workshop Date
Coal County	86-4508	27-178	Hydraulic Hypro HM3	Hypro 9303	Boom Buster (1) – 437R	1	4-9-08
Garvin County	86-4505	27-174	Auxiliary Gas Motor 8hp Honda	Ace Pump GE-800	Boom Buster (1)– 437R	5	4-8-08
Hughes County	86-4914	27-184	Hydraulic Hypro HM3	Hypro 9303	Boom Buster (1) – 437R	2	4-9-08
Johnston County	86-4719	27-184	Auxiliary Gas Motor 9hp Honda	Ace pump GE-800	Boom Buster (1)– 437R	8	4-9-08
Lincoln County	86-4532	27-110	Auxiliary Gas Motor 8hp Honda	Ace pump GE-860	Boom Buster (1)– 437R	4	4-10-08
McClain County	86-4506	27-180	Auxiliary Gas Motor 8hp Honda	Ace Pump GE-800	Boom Buster (1)– 437R	5	4-8-08
Okfuskee County	86-4509	27-185	Auxiliary Gas Motor 8hp Honda	Ace Pump GE-800	Boom Buster (1)– 437R	1	4-10-08
Pontotoc County	86-4511	27-175	Auxiliary Gas Motor 9hp Briggs	Gorman pump (8/30/78)1492	Boom Buster (1)-437R	2	4-9-08
Pottawatomie County (Two spray units)	86-4766	27-179	Auxiliary Gas Motor 8hp Honda	Ace pump GE-860	Boom Buster (1)– 437R	8	4-10-08
Pottawatomie County (Two spray units)	86-4767	27-176	Auxiliary Gas Motor 10hp Briggs	Gorman pump 1492	Boom Buster (1)– 437R	2	4-10-08

Table 3. Division 3 Herbicide Sprayer Assessment/Calibration Workshop Data (continued).

Div. Field Unit	Truck ID #	Sprayer ID #	Motor Model	Water Pump Model #	Herbicide Delivery Sys.	Workshop Attendance	Workshop Date
Purcell Interstate I-35	86-4535	27-177	Auxiliary Gas Motor 8hp Honda	Ace Pump GE-800	Boom Buster (1)– 437R	6	4-8-08
Seminole County (Two spray units)	86-4510	27-183	Auxiliary Gas Motor 8hp Honda	Ace pump GE-860	Boom Buster (1) – 437R	2	4-9-08
Seminole County (Two spray units)	86-4737	27-178	Auxiliary Gas Motor 8hp Honda	Ace pump GE-860	Boom Buster (1) – 437R	2	4-9-08
Shawnee Interstate I-40	**Unit unavailable**		Auxiliary Gas Motor		Boom Buster Head – 437R, 375R, 260-11R, 180-6R		

6.0 ASSESSMENT, RECOMMENDATIONS AND INVENTORY FROM THE DIVISION FOUR SPRAY EQUIPMENT AND CALIBRATION WORKSHOPS

6.1 GENERAL COMMENTS

A total of 10 field unit crews consisting of 47 applicators were trained in calibration from Division 4 during April 17, 18, 19 and May 9, 2007 (Table 4).

6.2 HYDRAULIC SYSTEMS

With the exception of Kingfisher County unit, most Division 4 spray trucks were equipped with “fixed output” hydraulic pumps (Commercial Intertech model P20). Fixed-displacement pumps can cause hydraulic fluid overheating by forcing unused (hydraulic fluid pumped exceeds hydraulic motor use capacities) excess hydraulic fluid through by-pass valves. Forced by-pass causes a build up of heat in the hydraulic system causing pressure lose and constant need for system pressure adjustment by the spray truck operators. Division 4 has developed a unique cooling system to compensate for the excessive heat generated by routing hydraulic fluid back through the spray tank before being returned to the hydraulic fluid tank. While this does cool the hydraulic fluid so that pressure loss is minimal, there have been instances of continuing heat build up and even rupture of the rerouted hydraulic line within the spray tank causing contamination of the spray tank contents. Division 5 has experienced this problem and has attributed the heat build up to mismatched hydraulic pump outputs and specific hydraulic motor requirements.

Variable-displacement (also known as “On-demand” hydraulic pumps) hydraulic pumps are being used in Division 6 to avoid this issue entirely. These pumps deliver only the required amount of hydraulic fluid needed to operate the hydraulic motor turning the water pump. The water pump pressurizes and delivers the herbicide and carrier to the targeted area of the roadside. Use of variable displacement pumps avoid the problems caused by fixed-displacement pumps which cause hydraulic fluid overheating by forcing unused excess hydraulic fluid through by-pass valves. Forced by-pass causes a build up of heat in the hydraulic system causing pressure lose and constant need for system pressure adjustment by the spray truck operators.

The OSU RVM team understands Division 4 mechanical support staff’s goals in rerouting the hydraulic fluid through the spray tank however; this is essentially a “make do” design that has built-in risks and requires special considerations. This type of hydraulic fluid routing is also affected by placement of the line within the spray tank. Hydraulic lines attached to internal tank baffles can result in the hydraulic line being suspended at the half empty level in the tank. As tank contents drop below the suspended hydraulic line, there is no longer a cooling effect upon the hydraulic line resulting in increasing hydraulic fluid temperatures and corresponding continuous fluctuations in water pump output pressures. This is not a desirable scenario.

If operators find spray system pressures will not remain consistent through the calibration process or the actual spray application, they should contact the Division's mechanical support staff for system fine tuning to resolve the issue. It is the opinion of the OSU RVM Program personnel that as hydraulic pumps fail or upgrade funding becomes available, it would be best to transition to the variable-displacement hydraulic pumps. It is also advantageous if there is consistency of spray system components from county to county and should be a very desirable goal for division four.

6.2.1 HYPRO® 9303C WATER PUMPS

Hypro® 9303C water pumps come co-joined to several different hydraulic motors from distributors depending on hydraulic fluid delivery rates from the hydraulic pump mounted on the truck. Examples of these configurations from Hypro® include a 9303C water pump and the following hydraulic motors: HM1 - 10 gpm, HM2 - 5 gpm, HM3 - 20 gpm, HM4 - 7 gpm and the HM5 - 10 gpm. Hydraulic pump and hydraulic motor operation is not a specialty of the OSU RVM team however; we are aware of the difficulties if hydraulic pump / hydraulic motor capacities are not matched properly.

6.3 CALC-AN-ACRE DIGITAL SPEED MONITORING DEVICES

Of the 9 spray units assessed in 2007, 5 were either missing a Calc-An-Acre or they were non-functional. In 2004, the OSU RVM team recommended that each Division 4 truck found without a working digital speed monitoring device be equipped as soon as possible with a Calc-An-Acre. We understand that at the time of this report writing, Division 4 was working toward that goal. We want to reiterate the critical nature of accurate herbicide applications that are possible with the inclusion of this component on spray rigs. Some were equipped with a sensor system that works off of signals emitted through the transmission. A few trucks were using the sensor-magnet system. Both systems are acceptable as long as there are no frequent difficulties. If one of the systems should fail, it is the recommendation of the OSU RVM team that trucks be switched over to the Astro II GPS sensor readily adaptable to current Calc-An-Acre units (this item was reported in the *2006 ODOT Equipment Technology Report* (4). Calc-An Acre units can be easily checked for accuracy by traversing an accurately marked 200ft course at 10 mph in 13.6 seconds. If the course is traveled at the afore mentioned speed in the set time allotment, it can be assumed that the device is functioning properly. If not, the unit should be recalibrated according to instructions provided by the manufacturer.

6.4 CAB/TIP MOUNTED PRESSURE GAUGES

During the 2004 Equipment Assessment/Calibration training efforts in Division 4, recommendations were that each spray truck be fitted with 0-60 psi pressure gauge at the truck cab so that operators could easily monitor the overall working status of the

spray system. This cab mounted gauge will allow the operator to see the system pressure easily without trying to view tip mounted gauges through the review mirror. Trying to see the tip mounted gauge is almost impossible when the truck is moving due to vibration and the small size of the dial face on a tip mounted gauge. Correctly functioning 0-60 psi gauges close to the spray tip are also required to accurately calibrate spray systems. Consequently, as part of the 2007 equipment assessment, each spray crew was provided 0-60 psi liquid filled pressure gauges to mount at the cab or at the tip as needed. The OSU RVM team is hopeful that crews will monitor and replace damaged gauges as is necessary, they are relatively inexpensive.

6.5 FRONT MOUNT VERSUS REAR MOUNT TIP PLACEMENT

Some Division 4 spray rigs had rear mounted spray tips. It would be very helpful to spray rig operators to mount the spray tip on the front of the truck were the operator(s) could view the spray tip without taking their eyes off of the road. Additionally, several spray crews (and the OSU RVM team) were very supportive of efforts to move their trucks spray tips to the front of the truck. The OSU RVM team members feel this will add an additional degree of safety to the spray operations due to increased tip visibility and less distraction from oncoming traffic.

6.6 SLOW SPEED CRUISE CONTROL

During the 2007 equipment assessment, we were made aware that the spray crews would welcome a slow speed cruise control if it were feasible. Some divisions have trucks that may be able to be electronically reprogrammed to utilize this feature. If this can be accomplished with relative ease and reasonable capital investment, the use of this low speed control device may decrease driver fatigue and increase spray application efficiency.

6.7 IN-LINE SCREENS STRAINERS

Some spray trucks were still not equipped with in-line screens and some had “home made” screens. Those without should install a 30 mesh screen to protect the water pump and tip from debris. Those with inappropriately sized screens (“home made”) should be provided with the appropriate size mesh screen.

Table 4. Division 4 Herbicide Sprayer Assessment/Calibration Workshop Data.

Div. Field Unit	Truck ID #	Sprayer ID #	Hydraulic Motor Model #	Water Pump Model #	Herbicide Delivery System.	Workshop Attendance	Workshop Date
Garfield County #1	86-4725 (Fixed output hydraulic pump)	27-106	Hypro HM4C (7 gpm)	Hypro 9303C	(2) Boom Buster – 437R	4	4-18-07
Garfield County #2	86-4674 (Fixed output Hydraulic pump)	27-101	Hypro HM1C (10 gpm)	Hypro 9303C	(2) Boom Buster – 437R	3	4-18-07
Grant County	86-4675 (unknown Fixed output hydraulic pump)	27-0104	No ID Tag	No ID Tag	Boom Buster – 437R	4	4-17-07
Guthrie I-35 Interstate	86-4312 (Fixed output hydraulic pump)	27-275	Hypro HM1C (10 gpm)	Hypro 9303C	(2) Boom Buster – 437R	8	4-19-07
Kay County	86-4762 (unknown Fixed output hydraulic pump)	27-240	No ID Tag	No ID Tag	(2) Boom Buster – 437R	5	4-17-07
Kingfisher County	86-4764 (? Variable displacement hydraulic pump)	27-105	Hypro HM1C (10 gpm)	Hypro 9303C	(2) Boom Buster – 437R	7	4-19-07
Logan County	86-4724 (Fixed output hydraulic pump)	27-111	Hypro HM1C (10 gpm)	Hypro 9303C (rebuilt)	(2) Boom Buster – 437R	4	4-19-07
Noble County (Unit was down 4-18-07)	86-4678 (fixed output hydraulic pump)	27-239	Hypro? (no tag)	Hypro? (no tag)	(2) Boom Buster 437-R (right & left) (1) 260-11R (right)	5	5-9-07
Payne County	86-4629 (Fixed output hydraulic pump)	27-107	Hypro HM1C (10 gpm)	Hypro 9303C	(2) Boom Buster – 437R	5	4-18-07
Tonkawa I-35 Interstate unit 104	86-4676 (Fixed output hydraulic pump)	27-0103	No ID Tag	No ID Tag	(2) Boom Buster – 437R	2	4-17-07

7.0 ASSESSMENT, RECOMMENDATIONS AND INVENTORY FROM THE DIVISION FIVE SPRAY EQUIPMENT AND CALIBRATION WORKSHOPS

7.1 GENERAL COMMENTS

A total of 14 field unit crews consisting of 45 applicators were trained in calibration from Division 5 during April 3, 4 and 5, 2007 (Table 5).

7.2 HYDRAULIC SYSTEM PROBLEM

Mechanical support personnel (recounted by Jeannette Allen, Division 5 Shop Superintendent) pin-pointed a major hydraulic system problem in 2005 when OSU RVM personnel assessed Division 5 equipment. Applicators had indicated that there was a need to continually adjust hydraulic spreader and spinner knobs to compensate for a loss of pressure at the spray rig tip. This appears to have been caused by hydraulic fluid by-pass of 4 gpm that was generated by an operating system that used a hydraulic pump providing 25 gpm into a hydraulic motor requiring only 21 gpm. Hydraulic line plumbing consisting of two hydraulic hoses (one from the spinner, 10 gpm, and one from the spreader, 15 gpm) was necessary to operate the hydraulic motor (Hypro HM3C, required 21 gpm). The 4 gpm difference was forced as by-pass through a relief valve in the hydraulic pump back to the hydraulic fluid reservoir. This created excessive heat buildup, expanding metal in the pump creating additional loss in pump pressure further requiring spinner and spreader adjustment.

The correction to this problem was a new hydraulic motor (Hypro HM5C, 10 gpm) married to a Hypro 9303C water pump (pump/motor suggested source Wylie Sprayers). Only one line from the spinner is required to deliver the necessary volume of hydraulic fluid (10 gpm) with this motor, eliminating any forced by-pass of unnecessary excess hydraulic fluid.

Five yard trucks appeared to be more prone to this problem than ten yard trucks. Ten yard trucks may have had a greater hydraulic oil volume capacity; capable of increased heat dissipation. New trucks equipped with “on demand” hydraulic pumps will ultimately do away with the problem by delivering only the amount of hydraulic fluid required by the hydraulic motor eliminating by-pass issues. Addressing this issue will allow ODOT personnel to make consistent and accurate herbicide applications.

7.3 AGITATION SYSTEM ON NEW POLY-TANKS

Old fiberglass tanks should be and are being replaced with polyethylene tanks. The polyethylene tanks are equipped with three jet-agitation type nozzles inside instead of a preferred single tank-length sparge tube that was used in the past. A sparge tube retro-fit action should be practiced on polyethylene tanks if ODOT continues to use herbicides

formulated as water dispersible granules, such as Oust XP (sulfometuron) and Diuron 80 WDG (diuron). Continued use of the dispersible granule formulations can be expected, therefore the retrofit is highly encouraged. A sparge tube running the length of the spray tank tends to move the entire tank contents without leaving “dead spots” in the tank where dispersible granules can settle out and thus require additional clean out procedures as discussed in Chapter 10-2 of the 3rd edition of the *RVM Guidelines* (2). The plumbing utilized on the three jet-agitation type nozzle system is comprised of smaller diameter hoses and may not be adequate to allow large volume carrier return. This setup results in unacceptable agitation in the tank. If herbicide settling issues are encountered, the OSU RVM program recommendations are to retro-fit a sparge tube with a single return agitation hose that is as large in diameter as the outlet on the water pump on these units

7.4 CALC-AN-ACRE DIGITAL SPEED MONITORING DEVICES

Division 5 spray trucks use three types of components on their Calc-An-Acres to derive digital speed readings. Some units use a direct transmission wiring harness, some use a “sensor/magnet” system and some units are utilizing the Astro II GPS sensor adaptor. If properly functioning, each of these methods will provide accurate digital speed readings. In the event one of the older sensor methods such as the sensor/ magnet or direct transmission harness fails, the OSU RVM Program recommends adoption of the Astro II GPS receivers to the Calc-An-Acre units (Generation I & II Calc-An-Acres).

Overall, there were marked improvements in sprayer maintenance and crew awareness of sprayer functionality as compared to that seen in our previous calibration workshops conducted in this Division. Division 5 has taken positive steps in addressing hydraulic issues and providing each spray unit with a working Calc-An-Acre. Division 5 has encouraged spray crews to make requests of maintenance shop for assistance with mechanical issues and for components that need replacing.

Table 5. Division 5 Herbicide Sprayer Assessment/Calibration Workshop Data.

Div. Field Unit	Truck ID #	Sprayer ID #	Hydraulic Motor Model #	Water Pump Model #	Herbicide Delivery Sys.	Workshop Attendance	Workshop Date
Beckham County	86-4475	27-0166	Hypro-HM3C	Hypro-9303C	Boom Buster – 437R	1	4-5-07
Blaine County	86-4828	27-0163	Hypro-HM3C	Hypro-9303C	Boom Buster – 437R	2	4-3-07
Custer County	86-4826	27-0161	Hypro-HM3C	Hypro-9303C	Boom Buster – 437R	3	4-4-07
Dewey County	86-4794	27-0162	Hypro-HM3C	Hypro-9303C	Boom Buster – 437R	3	4-3-07
Elk City Interstate I-40	86-4780	27-0169	Hypro-HM3C	Hypro-9303C	Boom Buster – 437R	6 (3-Div. HQ Shop)	4-4-07
Greer County	86-4543	27-0168	Hypro-HM5C	Hypro-9303C	Boom Buster – 437R	3	4-5-07
Harmon County	86-4544	27-0158	Hypro-HM5C	Hypro-9304C	Boom Buster – 437R	3	4-5-07
Hydro Interstate I-40	86-4796	27-0160	Hypro-HM3C	Hypro-9303C	Boom Buster – 437R	3	4-3-07
Jackson County	86-4658	27-0167	Hypro-HM3C	Hypro-9303C	Boom Buster – 437R	2	4-5-07
Kiowa County	86-4428	27-0268	No tag (Hypro-HM3C?)	No tag	Boom Buster – 437R	2	4-4-07
Kiowa County	86-4827	27-0156	No tag (Hypro-HM3C?)	No tag	Boom Buster – 437R	2	4-4-07
Roger Mills County	86-4829	27-0164	Hypro-HM3C	Hypro-9303C	Boom Buster – 437R	8	4-4-07
Tillman County	86-4850	27-0155	Hypro-HM3C	Hypro-9303C	Boom Buster – 437R	4	4-5-07
Washita County	86-4867	27-0163	Hypro-HM1	Hypro-9303C	Boom Buster – 437R	3	4-4-07

8.0 ASSESSMENT, RECOMMENDATIONS AND INVENTORY FROM THE DIVISION SIX SPRAY EQUIPMENT AND CALIBRATION WORKSHOPS

8.1 GENERAL COMMENTS

A total of nine field unit crews consisting of 22 applicators were trained in calibration from Division 6 during April 24, 25, and 27, 2007 (Table 6).

8.2 HYDRAULIC SYSTEMS

All Division 6 spray trucks, with the exception of the Ellis County unit, are using variable-displacement “on-demand” hydraulic pumps. These pumps deliver only the required amount of hydraulic fluid needed to operate the hydraulic motor turning the water pump. The water pump then pressurizes and delivers the herbicide and carrier to the targeted area of the roadside. Use of variable displacement pumps avoid the problems caused by fixed-displacement pumps which cause hydraulic fluid overheating by forcing unused excess hydraulic fluid through by-pass valves. Forced by-pass causes a buildup of heat in the hydraulic system causing pressure lose and constant need for system pressure adjustment by the spray truck operators. If operators find spray system pressures will not remain consistent through the calibration process or the actual spray application, they should contact the divisions mechanical support staff for system fine tuning to resolve the issue. We feel that consistency of spray system components from county to county is a very desirable situation and should continue to be a goal of Division 6.

8.3 CAB MOUNTED PRESSURE GAUGES

During the 2005 Equipment Assessment/Calibration (3) training efforts in Division 6, recommendations were made that each spray truck be fitted with a 0-60 psi pressure gauge at the truck cab. This allows operators easy monitoring of the overall working status of the spray system. This cab mounted gauge will allow the operator to see the system pressure easily without trying to view tip mounted gauges through the rear view mirror. Trying to see the tip mounted gauge is almost impossible when the truck is moving due to vibration and the small size of the dial face on a tip mounted gauge. During our assessment in 2007, we found the 2005 recommendation had not been accomplished. Consequently, as part of our 2007 equipment assessment, each spray crew was given a 0-60 psi liquid filled pressure gauge to mount at the cab. The OSU RVM team is hopeful that crews will follow through with our gauge placement recommendation.

8.4 CALC-AN-ACRE DIGITAL SPEED MONITORING DEVICES

Our 2007 assessment revealed that all Division 6 spray trucks were fitted with new Calc-An-Acre speed monitoring devices as was recommended following our 2005 assessment of the Division. Most trucks were equipped with a sensor system that works using signals emitted through the transmission. A few trucks were using the sensor-magnet system. Both systems are acceptable as long as there are no frequent difficulties. If one of the systems should fail, it is the recommendation of the OSU RVM team that trucks be switched over to the Astro II GPS sensor readily adaptable to current Calc-An-Acre units. We reported upon this recommendation in the *2006 ODOT Equipment Technology Report* (4). Calc-An Acre units can be easily checked for accuracy by traversing an accurately marked 200ft course at 10 mph in 13.6 seconds. If the course is traveled at the speed mentioned earlier in the set time allotment, it can be assumed that the device is functioning properly. If not, the unit should be recalibrated according to instructions provided by the manufacturer.

8.5 SPRAY SYSTEM PUMPING

Most water pumps were reduced from 1.5 inch suction side opening diameter to 1.25 inch diameter fittings and hose. While this does not adversely affect ODOT's spray application, it is best to maintain 1.5 inch diameter plumping to take full advantage of the water pumps delivery capabilities. It would be our recommendation that further suction line restrictions be avoided.

8.6 FRONT MOUNT VERSUS REAR MOUNT TIP PLACEMENT

Some Division 6 spray crews consist of only one operator. It would be very helpful to these individuals to mount the spray tip on the front of the truck were the lone operator could view the spray tip without taking their eyes off of the road. Additionally, several spray crews (and the OSU RVM team) were very supportive of efforts to move their trucks spray tips to the front of the truck. The OSU RVM team members feel this will add a degree of safety to the spray operations due to increased tip visibility and less distraction from oncoming traffic.

8.7 SLOW SPEED CRUISE CONTROL

Division 6 spray trucks are relatively new and may have the capability to utilize a slow speed cruise control. During the equipment assessment, we were made aware that the spray crews would welcome a slow speed cruise control if it were feasible. In discussions with Division 6 mechanical support staff (Steve German), the possibility to "reprogram" trucks to use the cruise control at low speed was considered. If this can be accomplished with relative ease and reasonable capital investment, the use of this low

speed control device may decrease driver fatigue and increase spray application efficiency.

Table 6. Division 6 Herbicide Sprayer Assessment/Calibration Workshop Data.

Div. Field Unit	Truck ID #	Sprayer ID #	Hydraulic Motor Model #	Water Pump Model #	Herbicide Delivery Sys.	Workshop Attendance	Workshop Date
Alfalfa County	86-4823	27-171	Hypro HM4C	Hypro 9303C	Boom Buster – 437R	2	4-24-07
Beaver County	86-4800	27-145	Hypro HM4C	Hypro 9303C	Boom Buster – 437R	2	4-26-07
Cimarron County	86-4779	27-142	Hypro HM4C	Hypro 9303C	Boom Buster – 437R	3	4-26-07
Ellis County	86-4564 (fixed displacement hydraulic pump)	27-140	Hypro HM4C	Hypro 9303C	Boom Buster – 437R	1	4-25-07
Harper County	86-4825	27-186	Hypro HM4C	Hypro 9303C	Boom Buster – 437	3	4-25-07
Major County	86-4799	27-139	No ID tag	No ID tag	Boom Buster – 437R	3	4-24-07
Texas County	86-4778	27-144	Hypro HM4C	Hypro 9303C	Boom Buster – 437R	4	4-26-07
Woods County	86-4824	27-138	No ID tag	No ID tag	Boom Buster – 437R	2	4-24-07
Woodward County	86-4729	27-141	Hypro HM4C	Hypro 9303C	Boom Buster – 375R	2	4-25-07

9.0 ASSESSMENT, RECOMMENDATIONS AND INVENTORY FROM THE DIVISION SEVEN SPRAY EQUIPMENT AND CALIBRATION WORKSHOPS

9.1 GENERAL COMMENTS

A total of 10 field unit crews consisting of 35 applicators were trained in calibration from Division 7 during July 14, 15, and 16, 2009 (Table 7). Overall Division 7 spray rigs were in good to very good condition. The following statements are a summary of sprayer problems in addition to comments on individual reports.

9.2 HYDRAULIC SYSTEM OVERHEATING ISSUES

An overriding common problem was hydraulic oil heat buildup and subsequent spray pressure loses. The problem is a mechanical issue and while OSU RVM personnel are professionally trained in vegetation management, we are not hydraulic system experts. Truck hydraulic systems are outside of our area of expertise. Division 7 continues to experience hydraulic fluid over heating during spray operations. This is the same issue Division 5 had with their spray trucks (see Section 7.2 of this Final Report). Division 7 trucks are equipped with Force America, Inc. (Eric Echeverria, Operations Leader, Force America Inc., 2939 Irving Blvd., Suite 310, Dallas, TX 75247, Main Phone: (214) 678-0740, Toll Free Phone: (800) 893-7225, Direct Phone: (469) 341-2111, www.forceamerica.com) “Fixed-Output” hydraulic pumps on the front of spray trucks.

Herbicide applicators indicated that there was a need to continually adjust hydraulic spreader and spinner knobs to compensate for a loss of pressure at the spray tip. This appears to have been caused by excess hydraulic fluid by-pass that was provided by a system using two hydraulic hoses (one from spinner, and one from spreader) providing 25 gpm from the hydraulic pump, plumbed into the hydraulic motor (Hypro HM1C) which required about 9 to 14 gpm to operate. The difference was forced as by-pass through a relief valve back to the hydraulic fluid reservoir, creating excessive heat buildup, expanding metal in the pump creating additional loss in pump pressure requiring spinner and spreader adjustment.

The correction to this problem currently in use by ODOT is the HM1C (9-14 gpm) hydraulic motor. It will run correctly without by-pass heat buildup if only one line from the spreader/spinner control is used and if it delivers the 10 gpm required by the motor. Flow meters should be utilized to check pump output and to determine compatibility with hydraulic motor requirements. Compatibility specifications can be found at the HyPro Global Spray Solutions website (5). Division 7 personnel responsible for addressing truck hydraulic issues related to this problem are encouraged to contact Jeannette Allen, Division 5 Shop Superintendent regarding corrections of Division 5 truck issues. Additionally, OSU RVM personnel have been told that “on-demand” hydraulic pumps will also alleviate this problem but, at higher purchase price per pump.

Division 5 (see Section 7.2 of this Final Report).used a new hydraulic motor, the Hypro HM5C, to replace older model HM3C motors and correct the hydraulic fluid heat buildup problem. The new hydraulic motor only requires 13-18 gpm hydraulic fluid and only one line from the spinner/spreader to deliver the necessary volume of hydraulic fluid (15 gpm). As a cost example, Division 5 purchased the hydraulic motor (Hypro) and water pump (Hypro9303C) together from Wylie Sprayers for about $500.

9.3 CALC-AN-ACRE DIGITAL SPEED MONITORING DEVICE

Four of the nine spray units assessed had Calc-An-Acre functionality issues. Division 7 is to be commended upon taking steps to provide this necessary equipment to their county units. OSU RVM recommends each truck use a Calc-An-Acre II and an Astro II GPS unit available from Wylie Sprayers in Oklahoma City (405-946-4896). Without this key component of a spray rig, accurate herbicide application is almost impossible. This inadequacy should be corrected before the next spray season. The Stephens County unit did not have a Calc-An-Acre or GPS unit and needed to install one as soon as possible. The Murray County unit had an obsolete model and needed a Calc-An-Acre II and Astro II GPS device. The Grady County and I-35 Ardmore units had Calc-An-Acre II and Astro II GPS units that did not work correctly. These crews needed to check the wiring of these devices and work toward getting their speed monitoring devices functioning.

9.4 BOOM BUSTER SPRAY NOZZLES

All Division 7 spray trucks are using Boom Buster style tips. The Boom Buster style tips are made of stainless steel with nylon diffusers that actually create the pattern. The steel tips should last for decades; however, the nylon diffusers have a life expectancy of 4 to 5 years of use before needing replacement. Some ODOT spray trucks have nylon diffusers that showed various signs of aging and cracking. Many cracks require the use of magnifying glass to see them. We recommend that all ODOT spray rigs that have tips with cracked diffusers carry a new spare replacement tip on board their spray rig. Boom Buster tip diffusers provide no warning when they will ultimately break other than showing signs of cracking. If a replacement tip is on board this repair would only be a minor inconvenience and should not otherwise impede additional spray operations. Tips with cracked diffusers should be returned back to the manufacturer (Evergreen Products, P.O. Box 598, Griffin, GA 30442, phone: 478-982-5593) for refurbishing at approximately half the cost of a new tip. New tips can be ordered from Wylie Sprayers in Oklahoma City (phone: 405-946-4896).

9.5 DROP TIP REMOVAL

Almost all Division 7 spray rigs have utilized a “drop tip” in addition to the 437-R Boom Buster tip. They require extra maintenance and are not an essential part of a spray rig when Boom Buster tips are utilized correctly. Use of drop tips is adding an additional 4 gpm spray output that requires increased flow from the water pump and correspondingly higher pressure to produce flow. Removing the tip will also remove the need for drop tip screens, housings/fittings and the individual tip.

The OSU RVM recommendation is to remove the drop tip and reposition the Boom Buster 437-R tip (on laterally adjustable mounting systems) so that the drop tip is not needed. This is done in most other ODOT divisions that use Boom Buster tips. The tip should be close enough to the truck so that the tip pattern begins at the rear tire track and sprays outward toward the end of the 26-28 foot pattern. If drivers position the front tire on the hard surface white-line, the edge of the roadside will be treated without missing any vegetative strip along the shoulder.

Most spray rigs in Division 7 had a few small individual and specific problems. Most of these problems could likely be fixed by the local ODOT crews. However, parts (tips, hoses, gauges, etc.) for repairs might be ordered through field division headquarters.

Table 7. ODOT Division 7 2009 Herbicide Sprayer Assessment/Calibration Workshop Data.

Div. Field Unit	Truck ID #	Sprayer ID #	Hydraulic Motor Model #	Water Pump Model #	Herbicide Delivery Sys.	Workshop Attendance	Workshop Date
Caddo County	86-4931	27-126	Hypro-HM1C	Hypro-9303C	Boom Buster – 437R	2	7-14-09
Carter County	86-4963	27-127	Hypro-HM1C	Hypro-9303C	Boom Buster – 437R	2	7-16-09
Comanche County	86-4875	27-128	Hypro-HM1C	Hypro-9303C	Boom Buster – 437R	7	7-14-09
Cotton County	86-4930	27-129	Hypro-HM1C	Hypro-9303C	Boom Buster – 437R	6	7-15-09
Grady County	86-4742	27-130	Hypro-HM1C	Hypro-9303C	Boom Buster – 437R	2	7-14-09
Ardmore I-35	86-4929	27-188	Hypro-HM1C	Hypro-9303C	Boom Buster – 437R	1	7-16-09
Jefferson County	86-4708	27-131	Hypro-HM1C	Hypro-9303C	Boom Buster – 437R	3	7-15-09
Love County –Unit unavailable due to hydraulic issues	unknown	unknown	unknown	unknown	Boom Buster – 437R	3 (trained on Ardmore I-35 unit)	7-16-09
Murray County	86-4497	27-172	Hypro-HM1C	Hypro-9303C	Boom Buster – 437R	5	7-16-09
Stephens County	86-4813	27-133	Hypro-HM1C	Hypro-9303C	Boom Buster – 437R	4	7-15-09

10.0 ASSESSMENT, RECOMMENDATIONS AND INVENTORY FROM THE DIVISION EIGHT SPRAY EQUIPMENT AND CALIBRATION WORKSHOPS

10.1 GENERAL COMMENTS

A total of 10 field unit crews consisting of 20 applicators were trained in calibration from Division 8 during April 29, 30 and May 1, 2008 (Table 8). The Delaware County Unit was assessed at the Tulsa Headquarters workshop on April 30, 2008 and was not in working order. The crew indicated they would attend the May 1, 2008 workshop at Craig County however they were unavailable for sprayer calibration training.

10.2 HYDRAULIC PUMP PRESSURE ISSUES

Two county units, Nowata County and Ottawa County, were experiencing water pressure losses as hydraulic systems heated up. There are a number of possible causes and the OSU RVM personnel referred this specific case to ODOT truck mechanics. The OSU RVM Program personnel are well versed in the operational aspects of the herbicide sprayers and vegetation management. Our personnel are not experts in the workings of the trucks' hydraulic systems.

10.3 SPRAYER IN-LINE FILTER SIZE

ODOT spray systems use large tips and should preferably use 20 or 30 mesh screens. The larger holes in the 20 to 30 mesh screens will allow liquid drift control products to pass through more easily. If 50 mesh screens are present between the pump and tank, they should be replaced with 20 to 30 mesh screens. Some units had additional screens between the pump and Boom Buster tips. Those screens are not necessary and could be removed reducing drift control screen clogging issues. ODOT fabricators can consult the image of item #3 in the *Boomless Roadside Herbicide Sprayer Assessment Guide* (Appendix A) which was sent to division headquarters on October 15, 2007 to view a photograph representing the proper placement of the in-line screen.

10.4 SPRAYER MANIFOLD SYSTEM MONITORING GAUGE

Several Division 8 spray units that used a manifold system supporting three Boom Buster tips were lacking a manifold pressure system gauge. This pressure gauge should be 0 – 100 psi oil-filled type. This gauge is necessary to allow operators to monitor proper pumping system pressure and allowing them to quickly respond to issues that lower the pump-to-tip required pressure differential. This pressure differential should be by psi readings of approximately 52 – 60 psi in the manifold versus tip regulated pressure of 25 psi. If water pump systems cannot sustain this differential, it

may indicate a worn pump, a malfunctioning hydraulic motor or a malfunctioning truck hydraulic system. ODOT fabricators can consult the image of item #10 in the *Boomless Roadside Herbicide Sprayer Assessment Guide* (Appendix A).

10.5 PRESSURE REGULATORS

Some Division 8 sprayer units were equipped with Watts brand 25 to 75 psi pressure regulators while some were equipped with Watts brand 10 to 35 psi regulators (source: Grainger Inc., 10707 E. Pine St., Tulsa, OK 74116, phone: 918-836-8631). It is the opinion of the OSU RVM personnel that the Watts brand 10 to 35 psi pressure regulators are preferred because they operate within the desired pressures ranges that ODOT uses (desired spray tip pressure of 25 psi) for herbicide application. There is the possibility that 25 to 75 psi pressure range regulators may not function reliably at the lowest end of their operational range. Operators should be vigilant in observing if the 25 to 75 psi operations range regulators are functioning properly or not. Regulator pressure setting screws should not need to be either screwed all the way in or all the way out. This may indicate debris in the regulator and they should be cleaned and reset.

10.6 SPRAYER TIPS

All Division 8 spray trucks are using Boom Buster style tips. All Division 8 spray rigs were using a 437-R tip capable of producing an effective spray pattern width of 27 -30 feet (dependent upon wind resistance), a 375-R tip capable of treating an effective spray pattern of 22-23 feet (dependent upon wind resistance), and a 260-11 tip capable of treating an 11 foot spray pattern tip These tips are available from several sources including Wylie Sprayers in Oklahoma City (phone: 405-946-4896).

These tips are to be operated one tip at a time to treat specific widths of roadside easements. They should never be run simultaneously. Spray trucks using Boom Buster style tips use electric solenoid valves or electric ball valves to control which tip is used during herbicide applications. Tip spray pressure is maintained at 25 psi by inline pressure regulators. Pressure regulators as well as spray tips can be ordered from Wylie Sprayers in Oklahoma City (phone: 405-946-4896). Most spray rigs had individual and specific problems. Some of these problems could be fixed by the local ODOT crews; however, some may require ordering parts (tips, electric solenoid valves) through field division headquarters.

Table 8. Division 8 Herbicide Sprayer Assessment/Calibration Workshop Data.

Div. Field Unit	Truck ID #	Sprayer ID #	Hydraulic Motor Model	Water Pump Model #	Herbicide Delivery Sys.	Workshop Attendance	Workshop Date
Craig County	86-4665	27-221	Hypro HM3	Hypro 9303C	Boom Buster Head – 437R, 375R, 260-11R	1	5-1-08
Creek County	86-4672	27-287	Hypro HM3	Hypro 9303C	Boom Buster Head – 437R, 375R, 260-11R	2	4-30-08
Delaware County	86-4667	27-228	Hypro HM3	Hypro 9303C	Boom Buster Head – 437R, 375R, 260-11R	2	4-30-08
Mayes County	86-4591	27-223	Hypro HM3	Hypro 9303C	Boom Buster Head – 437R, 375R, 260-11R	2	5-1-08
Nowata County	86-4666	27-222	Hypro HM3	Hypro 9303C	Boom Buster Head – 437R, 375R, 260-11R	4	4-29-08
Osage County	86-4842	27-224	Hypro HM3	Hypro 9303C	Boom Buster Head – 437R, 375R, 260-11R	2	4-29-08
Ottawa County	86-4843	27-225	Hypro HM3	Hypro 9303C	Boom Buster Head – 437R, 375R, 260-11R	1	5-1-08
Pawnee County	86-4670	27-246	Hypro HM	Hypro 9303C	Boom Buster Head – 437R, 375R, 260-11R	1	4-30-08
Rogers County	86-4669	27-227	Hypro HM1	Hypro 9303C	Boom Buster Head – 437R, 375R, 260-11R	3	4-30-08
Washington County	86-4668	27-226	Hypro HM3	Hypro 9303C	Boom Buster Head – 437R, 375R, 260-11R	2	4-29-08

11.0 STATEWIDE SUMMARY OF SPRAY EQUIPMENT ASSESSMENT AND CALIBRATION WORKSHOPS AND RECOMMENDATIONS

11.1 GENERAL SUMMARY OF SPRAY EQUIPMENT ASSESSMENT AND CALILBRATION WORKSHOPS

A total of 259 ODOT employees were trained in calibration with 82 spray units calibrated in the three years (2007-2009) of this project. Equipment assessment followed a protocol established using a formal "report card" (Appendix A). Report cards were filled out on-site while ODOT spray crews were present during assessment. These crews were instructed to present their copy to the unit supervisor if the supervisor was not present. A written report was sent to each Division Maintenance Engineer within two weeks following the completion of assessment/calibration in their division. Many of the sprayer issues could have been identified prior to our assessment sessions if spray crews and their supervisors would have reviewed the *Roadside Vegetation Management Guidelines*, 3rd Ed., Ch.10.7, *Checklist for Sprayer Problems* (2) and performed an in-house assessment of their equipment. An additional assessment tool is the *Boomless Roadside Herbicide Sprayer Assessment Guide* (1) and Appendix A. It is important to note that many divisions responded quickly to OSU RVM equipment recommendations and they may have already been addressed at press time of this Final Report. If in the future we detect that deficiencies previously identified in calibration/assessment workshops have not been corrected it may be necessary for ODOT leadership to take a more active and formal role in helping to address spray system issues. We discussed this position in "Section 7.0 Assessment, Recommendations and Inventory from the Division Five Spray Equipment and Calibration Workshops" in this Final Report.

11.2 RECOMMENDATIONS CONCERNING HYDRAULIC SYSTEM MOTORS AND SYSTEM PUMPS

Currently, ODOT herbicide sprayers utilize either hydraulic motors or auxiliary gasoline engines (Tables 1 – 8) powering a centrifugal pump. Each of these motor types has unique advantages and disadvantages. Of the 82 sprayer units assessed (Tables 1-8), 59 units (72%) were hydraulic powered and 23 units (28%) were driven by gasoline engines. Both engine types are acceptable as long as each is working properly.

It is critical for trucks utilizing hydraulic motor systems to have adequate hydraulic fluid cooling capacity. Overheating hydraulic fluid causes hydraulic system fluctuations resulting in unstable hydraulic motor RPM's. OSU RVM personnel encourage ODOT personnel to replace "fixed output" hydraulic pumps with "variable output" hydraulic pumps. "Variable output" pumps provide only the required amount of hydraulic fluid needed to operate hydraulic equipment, including hydraulic motors to power the herbicide sprayer water pump. "Fixed output" hydraulic pumps must deliver the exact

amount of hydraulic fluid required by a specific hydraulic motor or else the excess hydraulic fluid is forced back through by-pass valves causing the buildup of heat from fluid friction. This heat buildup in hydraulic fluid causes fluid to thin and causes loss in pump pressure. This inability to maintain steady delivery line pressure requires the applicator to continually change hydraulic motor speeds in an attempt to keep line pressures constant. The end result is improper application rates due to irregular line pressures. Truck hydraulic systems are outside of our area of expertise. However, other ODOT Divisions that have replaced “fixed output” pumps with “variable output” pumps have not experienced hydraulic fluid heat buildup problems after refurbishing their systems.

Gasoline motors are used in Division 1 (56% of units), Division 2 (100% of units) and Division 3 (86% of units). Gasoline motors may have an advantage in hilly terrain due to the motor being independent of the truck’s hydraulic system and engine RPM. Consequently, gasoline engine driven spray pumps produce more consistent output. Gasoline engine use in Divisions 1, 2 and 3 may be partially due to the hilly to mountainous terrain.

11.3 RECOMMENDATIONS CONCERNING HERBICIDE APPLICATION SYSTEM SPRAY TIPS

Spray tips are one of the most important parts of the delivery system in that they impart the final mechanical influence when the herbicide plus water carrier leaves the spray system. Most ODOT sprayers are using these types of tips either alone or in a series of up to three tips attached to a solenoid-controlled spray head (see Tables 1 – 8). We recommend that units that use the older technology solid stream nozzles now convert to Boom Buster tips. The use of spray application heads having three tips is a configuration that allows maximum sprayer capability and flexibility on easements of different widths.

The three tip spray head units usually consist of Boom Buster type tips capable of treating varying widths of roadside easement. Spray patterns start at the edge of the road surface and extend outward to various widths. The Boom Buster type tips useful for ODOT are the 437R tip, producing a spray pattern width of 0 to about 27 -30 feet; the 375R tip, producing a spray pattern of 0 to about 22-23 feet; and the 260-11R, producing a spray pattern of 0 to 11 foot wide. All pattern widths are dependent upon wind resistance. A local source of Boom Buster spray tips includes Wylie Sprayers in Oklahoma City (phone: 405-946-4896). On May 1, 2009; Wiley Sprayer quoted prices of these tips as follows:Boom Buster 260-11R - $109.80 each; Boom Buster 375R – $115.03 each and Boom Buster 437R – $122.20 each. These tips are to be operated one tip at a time to treat specific widths of roadside easements. They should never be run simultaneously. Spray trucks using Boom Buster style tips use electric solenoid valves or electric ball valves to control which tip is used during herbicide applications. Tip spray pressure is maintained at 25 psi by inline pressure regulators. We recommend that spare tips of each tip size used by individual spray units be purchased and held in reserve. In the event one is broken, quick repairs can be made in the field.

11.4 RECOMMENDATION CONCERNING PLUMBING FROM PUMP TO SPRAY NOZZLE

All sprayer units utilizing Boom Buster 437R and 375R nozzles require 1 inch piping from the delivery side (pressure side) of the pump to the nozzles. Units that converted from Estes solid stream nozzles to Boom Buster tips need to re-plumb and use pipes, regulators and hoses that are one inch diameter. Failure to use the proper sized fitting and hoses will result in the inability to deliver the correct operating volume to the Boom Buster nozzles. Installation procedures quoted from tip installers (Diversified Fabricators Inc., 1325 US 41 Bypass S. Griffin, GA 30224, Phone 770 412-0429) follow. For single nozzle installation, the supply line from the pump must be one pipe size larger than the nozzle thread size. An example: if the nozzle has a 0.5 inch thread (such as tip 260-11R), the supply line must be 0.75 inch. A 0.75 inch thread size nozzle (such as tip 375R or tip 437R) must have a 1 inch supply line. We fully support this supply line recommendation. If all three tips, 437-R, 375-R, 260-11R, are used to construct a spray head, all supply lines should be 1 inch diameter lines.

11.5 RECOMMENDED STANDARDIZATION OF HERBICIDE SPRAYER SYSTEMS

The use of spray heads with multiple tips, control arms and manifolds should be designed as closely as possible to photographs 10, 12 and 13 contained in the *Boomless Roadside Herbicide Sprayer Assessment Guide* (1) and Appendix A which was sent to all field Division headquarters on October 15, 2007.

11.6 RECOMMENDED POST-SPRAY SEASON EQUIPMENT TROUBLE SHOOTING AND TUNE-UP

One approach that may assist ODOT Divisions in keeping roadside sprayers in proper working order is to initiate the following steps before the sprayer is removed from the truck at the end of the spray season.

1. The ODOT yard superintendant should accompany the spray crew leader and use the “sprayer report card” (Appendix B) to compile information of known issues that need repair prior to the next spray season.
2. If the problematic issues cannot be fixed at the yard level, move to step 3.
3. The completed “sprayer report card” should be sent to the Division headquarters Shop Superintendant for follow up repair or further action.
4. The Division Shop Superintendant should keep a file for review of recurring issues that appear to be unit-specific. At that point, it would be advised that corrective measures be taken by the Division headquarters. This was an approach discussed at ODOT Division 4 on September 10, 2009 and favored by T.J. Bolay, Shop Superintendent.

Boomless roadside herbicide sprayers will continue to be a necessary piece of application equipment for ODOT vegetation managers in the future. It is incumbent upon ODOT to provide the necessary equipment and funding to keep these units in proper functioning order. We encourage ODOT Administrators to continue to make investment in equipment upgrades, equipment maintenance and operator training a priority.

12.0 REFERENCES

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5. HyPro Global Spray Solutions. 2009. Series 9303 Hydraulic Motor Drive Features and Specifications. Available on-line at: http://www.hypropumps.com/en-us/Products/Pumps_Summary/Centrifugal/Hydraulic/9303_Main/9303_Features.htm (Verified 21 December 2009).

APPENDIX A

BOOMLESS ROADSIDE HERBICIDE SPRAYER ASSESSMENT GUIDE

Boomless Roadside Herbicide Sprayer Assessment Guide

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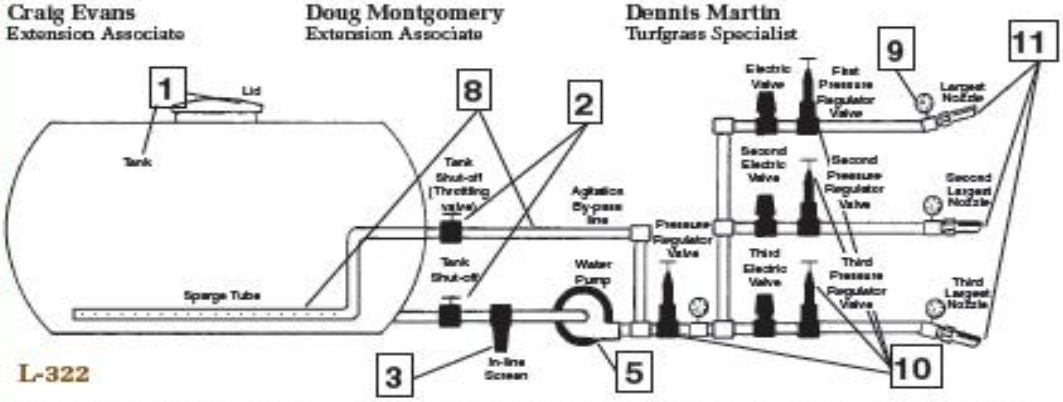

L-322

(for additional information, consult the *Oklahoma Roadside Vegetation Management Guidelines*, Current Edition, Ch. 10 & 11)

IMPORTANCE OF THE COMPONENTS

Sprayer tank holds the herbicide/water mixture and must be constructed with a material that is resistant to potential corrosion from certain herbicide formulations. There should be no leaks of tank contents anywhere.

The lid should form a watertight seal when closed to avoid spills. A vent hole or vented lid should be present to prevent the formation of a vacuum in the tank.

A tank shut-off valve is required to isolate the tank contents (herbicide and carrier) from the rest of the spray system. This valve allows removal or repair of spray rig components without loss of tank contents or undo exposure of applicators to herbicides during repairs of the sprayer. Valves may be gate valves or ball valves.

Herbicide spray mixture needs to be filtered properly with the use of screens. Screens protect the working parts of the spraying system and help prevent nozzle tip(s) from clogging. For centrifugal pumps, an in-line screen no smaller than 30-mesh is recommended. Finer meshed screens can become clogged with drift control additives and should be avoided at this location. The screen should be placed on the suction side of the pump between the pump and the tank shut-off valve. It should be cleaned frequently (daily).

4. Drift Control Injector

This is an "add on" piece of equipment. It functions to introduce liquid drift control into the suction side of the pump through a drop tube into or just behind the pump. A washer with a 3/16-inch hole centered in the washer, ground to fit inside a ball valve (with the ball valve fully open), allows the proper amount of drift control flow into the suction side of the pump. Water flow back up into the system can cause drift control products to thicken and should be avoided. If drift control injectors are used, they should be plumbed between the in-line screen and the water pump.

5. Water Pump

The heart of the sprayer system is the pump. It must deliver the necessary flow to the nozzle(s) at the desired pressure to ensure proper application. It is recommended that pump flow capacity should be 20 percent greater than the largest flow rate required by the nozzle(s) and hydraulic agitation to compensate for pump wear. The inability to maintain constant or consistent spray pressure may indicate a deteriorated pump. The single stage centrifugal pump is the most popular type pump for low-pressure roadside sprayers.

6. Pump Motor

Pump motors can be hydraulic or gasoline "pony" motors. Hydraulic motors are more applicable to flat terrain and are tied to the truck motor's RPM (as truck RPM increases or decreases, hydraulic motor RPM may fall or increase. "On demand" hydraulic motors do not do this.). "Pony" gasoline motors are independent of the truck motor and truck motor RPM. "Pony" motors are favored when spraying hilly terrain. Either motor should run smoothly without wide swings in motor RPM to ensure proper application rates.

7. Hoses/Plumbing

The use of synthetic rubber or plastic hoses (high pressure types) having a burst strength greater than the peak operating pressure of the sprayer system are recommended. The use of any other type hose, such as garden hose, is discouraged. Hoses or sprayer lines must be properly sized for the system, flexible, durable, and be resistant to oils and solvents in herbicide formulations. They must also be resistant to weather (i.e. sunlight, ozone, etc.) and general abuse such as twisting, pulling, shock load, or "hydraulic hammer" effects and vibration. If cracks or aging are evident, components should be replaced.

8. Agitation System

An agitator or agitation system is required to mix the components of the spray mixture uniformly and keep them mixed. Some herbicide formulations such as emulsions, wettable powders, liquid, or dry flowables require constant agitation. Constant agitation is needed to keep these herbicide formulations in suspension or they may separate or settle out within the sprayer tanks. Non-functioning/broken agitators should be fixed. Tank length sparge tubes are preferred.

9. Pressure Gauges

Pressure gauges are an integral part of every spray system to correctly indicate an accurate pressure at the nozzle tip(s). A liquid filled pressure gauge, with a maximum reading of 100 psi, is recommended for use on spray rigs and should be mounted as close to the nozzle tip(s) as possible. This provides a more accurate pressure reading during the spraying operation and during the calibration process. Gauges should be visible to operators in the cab to monitor application pressure consistency (a second gauge is necessary if nozzle(s) is rear mounted). Replace all non-functioning gauges.

10. Pressure Regulators

Pressure regulators control the output pressure of spray nozzles. Pressure regulators are used most often when multiple nozzles are used. Single nozzle spray rigs may not have a true "pressure regulator." Instead, they may have an agitation-line throttling valve that controls the amount of bypass returning to the tank. Individual pressure regulators should operate within a selected pressure range without being screwed all the way in or out. If pressure regulators are not adjustable they should be disassembled, cleaned, and tested. Replace if nonfunctional or broken.

11. Spray Nozzles

Nozzle type determines the uniformity and volume of the spray mixture applied, the completeness of coverage, and the amount of drift. Stainless steel or hardened stainless steel tips are recommended because they are non-corrosive and resistant to abrasion. Boom buster tips produce a more uniform droplet size (fewer fine droplets). When ordering right-of-way nozzles, the letter "R" needs to be added to the specific nozzle model number. Tips with cracked diffusers (nylon tip insert) should be replaced and returned for refurbishing.

12. Control Arms

Control arms are usually electronically controlled rams that adjust the angle of spray nozzles so they can follow the contour of "fill slopes" or "cut slopes." Initial tip angles should be set with the control arm in the level, or horizontal, position. Proper functioning allows spray pattern width adjustment as slopes are encountered. Improper width adjustment can result in over- or under-application of spray mixtures. All control arms should respond to controls operated by applicators or they should be checked/replaced.

13. Nozzle Shut-off valve(s)

Nozzle shut-off valves are usually activated by an electric solenoid or ball valve that is operated remotely by the applicator. This valve is mounted on the output or discharge line near the nozzle tip(s) to turn the nozzles on or off. It is imperative that this valve be operating properly (not leaking) to avoid misapplication on rights-of-way near sensitive areas. If non-functioning, they should be fixed or replaced.

14. In-cab Switches

Switches turn spray solenoids on and off, activate control arms, and can control hydraulic motor speeds. All should function properly every time they are turned on or off. If the switch does not function properly every time, replace or repair it.

15. Handgun & Hoses

Handguns are used to make spot applications with high carrier rates (50 to 250 GPA, carrier rate is found on the herbicide label). Handguns should turn on and off consistently with no leakage. Hoses should be made of pressure rated materials resistant to bursting. Hoses should be checked regularly for cracks or aging and replaced before hose failure.

16. Calc-An-Acre

This instrument is a digital speed monitoring device that, when properly calibrated, allows a very precise (to the nearest 0.1 MPH) measurement of the ground speed of the sprayer. These devices help provide for consistent and accurate applications. Calibration instructions are included with the device when purchased. Each spray rig should be equipped with a properly working unit to simplify speed adjustment necessary to maintain consistent herbicide application rates (*Roadside Vegetation Management Guidelines*, Current Edition, Ch. 11).

TROUBLESHOOTING GUIDE

1. No delivery of spray liquid through the nozzles.
   Check for:
   a. Empty tank.
   b. Clogged lines, screens, or nozzle tips.
   c. Sharp kinks in hoses.
   d. Tank vent closed.
   e. Improper or poor mixing of herbicide(s).
   f. Pump failure.
   g. Pressure regulator failure (if one is used).

2. Fluctuating pressure.
   Check for:
   a. Material in supply tank is low.
   b. Dirty screens.
   c. Trash in the seat of the pressure regulator (if one is used).
   d. Pump drive slipping (if using auxiliary engine).
   e. Trash in pump.
   f. Hydraulic fluid too hot and not adequately cooled (if using hydraulic fluid driven centrifugal pumps).

3. Excessive abrasive action in the pump.
   Check for:
   a. Sand, grit, dirt, or crystals.
   b. Failure to use suction screen.
   c. Poor agitation of chemicals or mixtures containing solids.

4. Starved pump.
   Check for:
   a. Shut-off valve to pump is closed.
   b. Too small of a suction hose or pipe.
   c. Leaks in suction line.
   d. Collapse in suction hose.
   e. Kinks in suction hose.
   f. Too long of suction line.
   g. Too high suction line lift.
   h. Stopped up in-line screen.
   i. Worn pump.

5. Dry pump (no flow or liquid in pump).
   Check for:
   a. Running pump too long without liquid.
   b. Running pump too long while trying to prime the pump.
   c. Points mentioned in number 4 above.

Oklahoma Cooperative Extension Service
Division of Agricultural Sciences and Natural Resources
Oklahoma State University

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APPENDIX B

HERBICIDE SPRAYER REPORT CARD

ODOT Herbicide Sprayer Report Card (*by* _____)

signature

Date: _____ **ODOT Div/Unit:** _____

Applicator Names: _____

_____

Sprayer Type:

_____ Boomless truck sprayer
_____ Boom-type tractor sprayer
_____ Small capacity sprayer
_____ Shoulder/guard-rail sprayer attachment
_____ Boomless tractor sprayer
_____ Powered hand-gun sprayer
_____ Rope-wick/Wiper applicator

Sprayer Part(s)	Good	Bad	Comments or Repair(s) needed:
Tank/lid			
Tank shut-off valve			
In-line Screen -Mesh ( )			
Drift control Injector			
Water pump			
Pump/powered by ___hydraulic ___aux. gasoline			
Hoses/Plumbing			
Agitation system			
Pressure gauge(s) In cab ___ Outside cab ___			
Pressure Regulator(s)			
Nozzle(s) Type:			
Control Arm			
Nozzle shut-off - Solenoid - other			
In-cab switches			
Handgun & hose			
Calc-An-Acre - Cable/magnet -DSA			

Recommended Sprayer Design Changes: (plumbing restrictions, nozzle height, hydraulics, etc..)

White Copy - OSU Yellow Copy - County/Int. Unit Pink Copy - Field Div. Hq.