Section B

Survey Summaries

Part I - Sprayer Manufacturer/Distributor Survey and Product Literature Review Results

Section 1 - Manufacturer/Distributor Survey Results

A - Survey Development and Implementation

In order to develop the mailing list of US sprayer manufacturers and distributors, professional organization membership rosters, farm publications, and the Internet were used. In this search, it was discovered that several Canadian manufacturers manufacture and sell application equipment in the US, especially in states bordering Canada. Since these companies make their equipment available in the US, they are included in the survey group. The search revealed 104 US and Canadian manufacturers and distributors that were included on the survey mailing list. Company contact information is located in Appendix A.

The study included six sprayer types:

- mounted (three-point hitch) boom
- trailed boom
- self-propelled boom (including heavy-duty truck mounted sprayers)
- skid mounted
- mounted airblast
- trailed airblast.

In order to determine engineering control availability differences within each sprayer type, each type was broken down into three sub-categories based on the following mix tank sizes:

- less than 250 gallons
- 251 to 500 gallons
- 501 gallons and larger.

All told, 18 different sprayer categories are used in this study. Manufacturers and distributors were asked to identify the types of sprayers they manufacture or distribute and whether the engineering controls listed are standard, optional or not available. A sample survey is provided in Appendix B.

Each survey mailing contained a cover letter explaining the purpose of the study, a copy of the survey form, and a postage-paid return envelope. Postcard reminders were sent out two weeks after the original mailing to those companies who had not responded. Approximately six weeks after the first mailing, a replacement survey form along with a postage-paid return envelope was mailed to non-respondents.

Of the 104 surveys mailed, 46 responses were received for a response rate of 44.2%. One respondent indicated their company manufactures and markets sprayers in Europe but does not sell them in the US. Another respondent indicated they do not manufacture sprayers at all. Due to the relatively low survey response rate and the desire to better understand engineering control availability, it was decided to review product literature/specifications for companies not responding to the survey to determine their engineering control offerings. The results of the product literature search are discussed in Section 2 of this part.

B - Survey Results

Current Manufacturer/Distributor Status

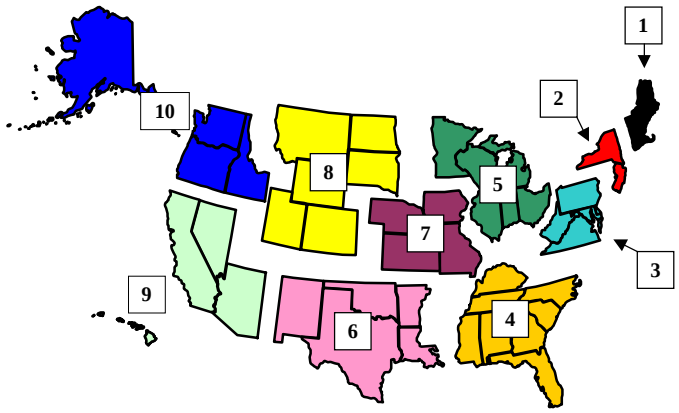
As previously indicated, 46 companies responded to the survey mailing. These companies represent sprayers sold in the US and manufactured in at least five different countries including the US, Canada, the Netherlands, Brazil and Denmark. As shown in Table 1, most manufacturers build and market sprayers for field crop production. (Field crops include corn, soybeans, and grains.) It should be noted that there may be overlap between categories due to some manufacturers offering one sprayer type that is used in more than one commodity group, particularly for the orchard/grove, vineyard, turfgrass and ornamental commodities.

Table 1. Companies Producing Sprayers for Specific Agricultural Commodities

Commodity	*Number of Companies*[A]
Field Crops	35
Orchard-Grove	12
Vineyard	13
Turfgrass	17
Other Ornamentals	13
Small Fruits	10
Other (includes research, vegetable, and pasture)	4

[A] Numbers do not represent all survey respondents due to some not completing this question

Map 1. EPA Regions



Using the EPA regions shown in Map 1, it can be seen that within each commodity group the number of sprayer manufacturers and distributors is fairly even across all regions. Table 2 shows that all regions have a significant number of sprayer suppliers for field crops in comparison to the other commodities. On average, there are about 23 manufacturers supplying field crop sprayers per region whereas the next highest commodity group, turfgrass, has an average of 12 companies per region. Variations in the number of manufacturers and distributors between regions could be attributed to regional variations in agricultural production and demand for the different types of spray equipment.

Table 2. Number of Manufacturers Supplying Sprayers in Each EPA Region (By Commodity Group)

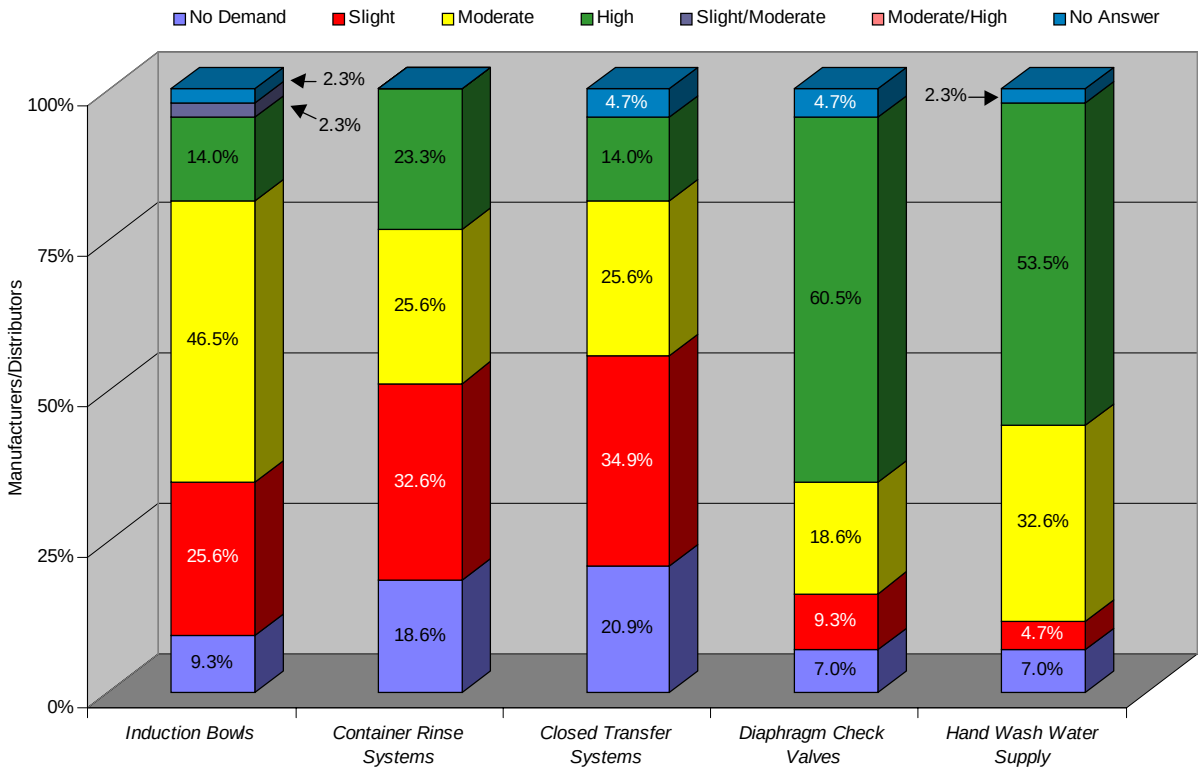
EPA Region	Field Crop	Orchard/ Grove	Vineyard	Turfgrass	Ornamental	Small Fruit	Other
1	19	7	8	11	10	9	3
2	21	8	8	12	11	10	3
3	21	8	8	12	11	10	3
4	23	10	10	13	10	9	3
5	28	9	9	13	11	10	3
6	25	7	8	12	7	6	2
7	28	7	6	13	7	7	2
8	25	6	6	11	6	6	2
9	18	10	11	10	10	9	2
10	20	10	11	9	9	8	2
Average	22.8	8.2	8.5	11.6	9.2	8.4	2.5

Commodity Group

Current Engineering Control Demand

The majority of manufacturers and distributors feel that engineering control demand falls mainly into two categories -- high demand or slight demand. Figure 1 shows that 6 of the 14 engineering controls are considered by the majority to be in high demand. The three controls leading this list are hydraulic boom fold/extend as indicated by 65.1% of the companies, diaphragm check valves by 60.5%, and hand wash water supplies by 53.5%. For 5 of the 14 controls the majority of respondents noted the second most popular response, slight demand. The top three engineering controls in this group include direct injection systems with 58.1% of the companies, air-assisted booms with 48.8%, and twin fluid nozzles with 37.2%. Protective clothing lockers received the highest number of "no demand" replies from 44.2% of the respondents. The other response categories for current engineering control demand are summarized in Figure 1.

Figure 1. Manufacturer View of Current Engineering Control Demand



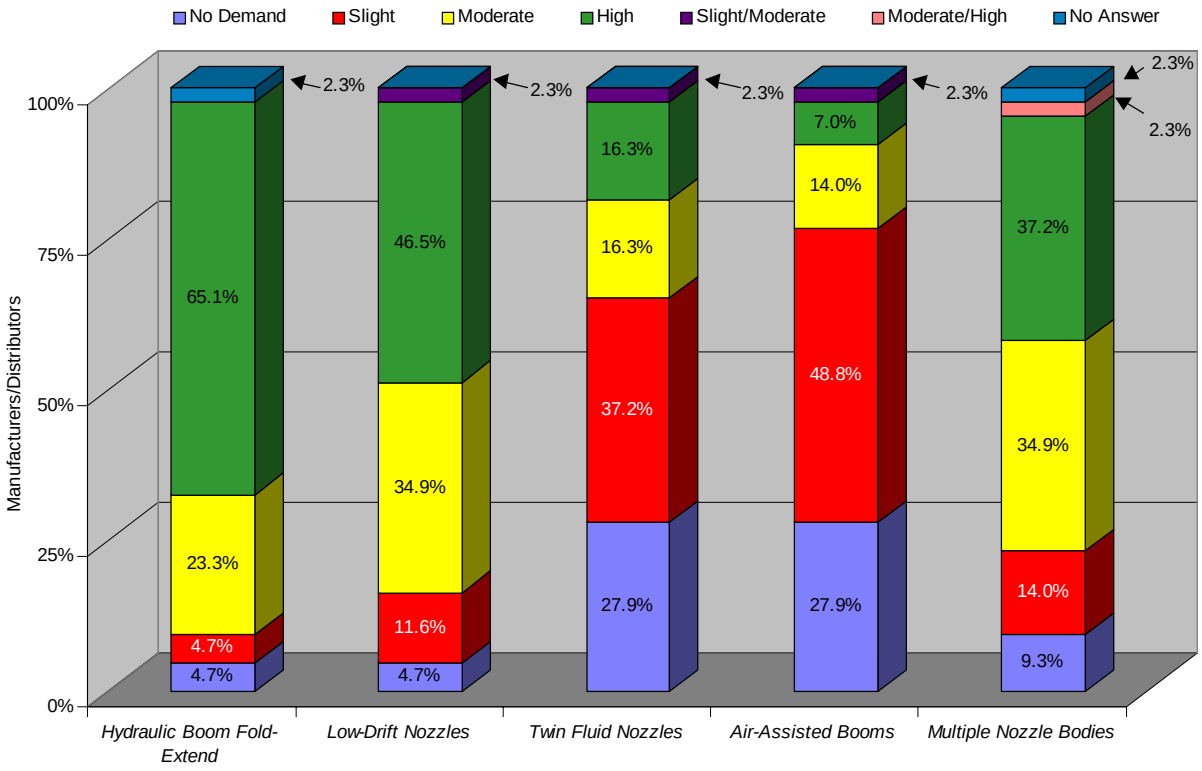
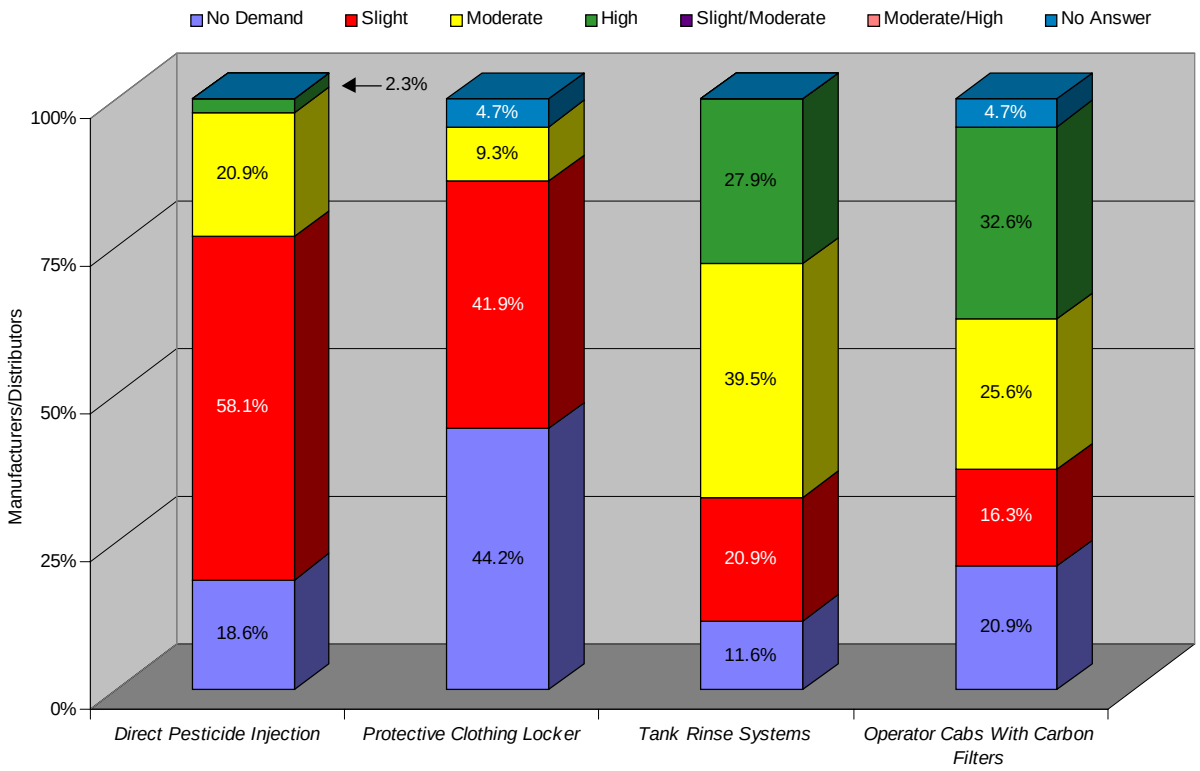


Figure 1. Manufacturer View of Current Engineering Control Demand (continued)



Future Engineering Control Demand

Manufacturers and distributors who replied there is no current demand for an engineering control were asked if they see that particular control having its highest demand 1 year, 2 years, 5 years, or over 5 years from now or never. Five controls are shown by the majority to have definite times to highest demand. Everyone responding to this question agreed that they expect demand for the hand wash water supply to be at its highest in 2 years. All respondents expect low-drift nozzles to have their highest demand 5 years or more from now. Half of the respondents said diaphragm check valves might have their highest demand in 2 years. Container rinse systems are noted by 37.5% and air-assisted booms by 41.7% of the respondents as possibly having a high demand in 5 years.

Most respondents identified three controls as never having a demand. Half of the respondents envision operator cabs with carbon filters never having a high demand. Twin fluid nozzles and protective clothing lockers are seen to have no future demand by 41.7% and 36.8% of the respondents, respectively.

Table 3. Time Until Greatest Demand For Engineering Control[1,2]

	Chemical Induction Systems	Container Rinse Systems	Closed Transfer Systems	Diaphragm Check Valves	Hand Wash Water Supply	Hydraulic Boom Fold-Extend	Low-Drift Nozzles
Never	25.0%	12.5%	25.0%			50.0%	
1 year							
2 years	25.0%	25.0%	12.5%	50.0%	100.0%		
5 years	25.0%	37.5%	25.0%	25.0%			50.0%
Over 5 years		12.5%	25.0%				50.0%
No Answer	25.0%	12.5%	12.5%			50.0%	
Don't Know				25.0%			

	Twin Fluid Nozzles	Air-Assisted Booms	Multiple Nozzle Bodies	Direct Pesticide Injection	Protective Clothing Locker	Tank Rinse Systems	Operator Cabs with Carbon Filters
Never	41.7%	33.3%		25.0%	36.8%		50.0%
1 year							
2 years	16.7%	8.3%			15.8%	20.0%	25.0%
5 years		8.3%	25.0%	25.0%	10.5%	20.0%	
Over 5 years	25.0%	41.7%	25.0%	25.0%	31.6%	20.0%	12.5%
No Answer	16.7%	8.3%	50.0%	25.0%	5.3%	40.0%	12.5%
Don't Know							

[1] As reported by those companies having no current demand for the engineering control.
[2] Percent totals may not equal 100% due to rounding.

Engineering Control Innovations

Each manufacturer was asked to indicate if they are developing any engineering controls beyond those discussed in the survey. Listed below are some of the innovations currently being developed. Company names have been withheld to maintain confidentiality. Emerging engineering controls include:

- easier sprayer controls and cab climate;
- hydrostatic drive spot sprayers to eliminate the need for carrying backpack sprayers that leak and cause back and leg injuries;
- volutes that direct spray and air flow at a low profile directly to the plant, limiting drift;
- electrostatically charging particles in spray;
- direct injection of spray in air stream;
- boom flush system;
- automatic rate system; guidance display; variable rate, GPS (global positioning system) controlled selective spraying systems;
- programmable logic controller (PLC) controlled safety systems;
- sensor systems; precision metering pumps; and variable rate metering;
- tunnel sprayers and sprayer towers;
- "sprayer remote control" that allows operator to turn on and off the sprayer remotely during maintenance and;
- injection systems allowing injection of pesticide directly into the nozzle body.

Current Engineering Control Availability

Looking at engineering controls common to all sprayer types and sizes (excluded are hydraulic boom fold/extend, air-assisted booms, twin fluid nozzles and operator cabs), the most often identified standard engineering control is the diaphragm check valve. Diaphragm check valve availability outnumbers the second most popular standard control, hand wash water supply, by a 2-to-1 margin. Eight of the 18 sprayer categories in the survey have most companies offering standard diaphragm check valves. Four of the 18 categories have hand wash water supplies as a standard feature.

Low-drift nozzles were identified most often as an optional control in 16 of the 18 sprayer categories in the study. Container rinse systems, multiple nozzle bodies, and tank rinse systems are the next most often identified optional controls, each in 15 of the sprayer groups.

Protective clothing lockers are the most unavailable engineering control. This control was identified as unavailable from most companies in14 of the sprayer groups. Chemical induction systems are a distant second with a majority of companies in 6 of the categories.

The following pages highlight the current availability of engineering controls. The summaries are organized from those controls used for the greatest exposure risk to those used for lesser exposure risks. Detailed results of the manufacturer survey are provided in Appendix C. A listing of available engineering controls by sprayer type, size and manufacturer is given in Appendix E.

Closed Transfer System

Of the 18 sprayer categories, 10 show a majority of respondents indicating closed transfer systems are optional equipment. Sprayers in this group include 251-gallon and larger mounted boom and mounted airblast sprayers, all 501-gallon and larger trailed boom and trailed airblast sprayers, and 250-gallon and less skid mounted and trailed airblast sprayers.

All respondents in the 250-gallon and less self-propelled boom sprayer category indicate they do not provide closed transfer systems. Closed transfer systems are also not available on the majority of 251-gallon and larger self-propelled boom sprayer or 250-gallon and less mounted boom sprayers.

Table 4. Popular Responses for Closed Transfer System Availability

Availability	Sprayer Type and Size	Percent of Respondents
Standard	---	---
Optional	Trailed Airblast - 250 gallons and less	75.0%
	Mounted Airblast - 251 to 500 gallons	66.7%
	Mounted Airblast - 501 gallons and above	66.7%
	Mounted Boom - 501 gallons and above	58.3%
	Skid Mounted - 501 gallons and above	57.1%
	Trailed Boom - 250 gallons and less	54.5%
	Trailed Boom - 251 to 500 gallons	53.3%
	Trailed Boom - 501 gallons and above	50.0%
	Trailed Airblast - 501 gallons and above	50.0%
	Mounted Boom 251 - to 500 gallons	42.9%
Not Available	Self Propelled Boom - 250 gallons and less	100.0%
	Self Propelled Boom - 501 gallons and above	58.3%
	Self Propelled Boom - 251 to 500 gallons	57.1%
	Mounted Boom - 250 gallons and less	52.9%

Ten companies reported closed transfer system prices that average $395.30 per system. The lowest average cost of $171.30 is for mounted and trailed boom sprayers and the highest average of $1125.00 is for self-propelled boom sprayers. Reported costs range from a low of $90.00 on a mounted boom sprayer to a high of $1500.00 on a self-propelled boom sprayer.

Table 5. Closed Transfer System Average Cost

Sprayer Type	Average Cost
Mounted Boom	*$171.33*
Trailed Boom	*$266.00*
Self-Propelled Boom	*$1125.00*
Skid Mounted	*$125.00*
Mounted Airblast	*Not Reported*
Trailed Airblast	*Not Reported*
Overall Average Cost	***$395.30***

Direct Injection System

Fourteen of the 18 sprayer categories have most respondents offering optional direct injection. All 501-gallon and larger mounted airblast sprayers offer direct injection as an option. Other sprayer categories with the majority of companies offering optional direct injection include all sizes of trailed boom and skid mounted sprayers; 251-gallon and larger mounted boom, self-propelled boom, and mounted airblast sprayers; 250-gallon and less trailed airblast sprayers; and 501-gallon and larger trailed airblast sprayers. Three sprayer categories have most companies not offering direct injection at all. These include 250-gallon and less mounted airblast and mounted boom sprayers and 251- to 500-gallon trailed airblast sprayers.

Table 6. Popular Responses for Direct Injection Availability

Availability	Sprayer Type and Size	Percent of Respondents
Standard	---	---
Optional	Mounted Airblast - 501 gallons and above	100.0%
	Skid Mounted - 251 to 500 gallons	80.0%
	Trailed Airblast - 250 gallons and less	75.0%
	Self-propelled boom - 501 gallons and above	75.0%
	Self-propelled boom - 251 to 500 gallons	71.4%
	Mounted Airblast - 251 to 500 gallons	66.7%
	Skid Mounted - 250 gallons and less	62.5%
	Trailed Boom - 251 to 500 gallons	60.0%
	Mounted Boom - 501 gallons and above	58.3%
	Skid Mounted - 501 gallons and above	57.1%
	Trailed Boom - 250 gallons and less	54.5%
	Trailed Boom - 501 gallons and above	54.5%
	Trailed Airblast - 501 gallons and above	50.0%
	Mounted Boom - 251 to 500 gallons	47.6%
Not Available	Mounted Airblast - 250 gallons and less	62.5%
	Trailed Airblast - 251 to 500 gallons	57.1%
	Mounted Boom - 250 gallons and less	52.9%

Direct injection systems, based on the survey results, are the second most expensive engineering control in this study. For the 11 companies sharing direct injection system prices, the overall average cost is $6263.64 per system. The lowest average direct injection price is $4950.00 for mounted boom sprayers and the highest average cost of $7500.00 is for both mounted and trailed airblast sprayers. There is a significant range in price with a low of $2000.00 on a trailed boom or self-propelled sprayer and a high of $12,000 on either a trailed boom or a self-propelled boom sprayer.

Table 7. Direct Injection System Average Cost

Sprayer Type	Average Cost
Mounted Boom	*$4950.00*
Trailed Boom	*$6362.50*
Self-Propelled Boom	*$5666.67*
Skid Mounted	*$6500.00*
Mounted Airblast	*$7500.00*
Trailed Airblast	*$7500.00*
Overall Average Cost	***$6263.64***

Container Rinse System

Container rinse systems are most often found as optional equipment in 15 sprayer categories. Trailed airblast sprayers 250 gallons and less and mounted airblast sprayers 501 gallons and larger have all companies offering optional container rinse. Other sprayer groups with most companies offering optional container rinse systems include: all mounted boom and skid mounted sprayers; 500-gallon and less mounted airblast sprayers; 251-gallon and larger trailed boom sprayers; and 501-gallon and above self-propelled boom and trailed airblast sprayers. Most 250-gallon and less trailed boom sprayer manufacturers do not offer container rinse systems at all.

Table 8. Popular Responses for Container Rinse System Availability

Availability	Sprayer Type and Size	Percent of Respondents
Standard	---	---
Optional	Mounted Airblast - 501 gallons and above	100.0%
	Trailed Airblast - 250 gallons and less	100.0%
	Skid Mounted - 501 gallons and above	71.4%
	Trailed Boom - 251 to 500 gallons	66.7%
	Self-propelled boom - 501 gallons and above	66.7%
	Mounted Airblast - 251 to 500 gallons	66.7%
	Skid Mounted - 250 gallons and less	62.5%
	Mounted Airblast - 250 gallons and less	62.5%
	Skid Mounted - 251 to 500 gallons	60.0%
	Trailed Boom - 501 gallons and above	59.1%
	Mounted Boom - 501 gallons and above	58.3%
	Trailed Airblast - 251 to 500 gallons	57.1%
	Mounted Boom - 250 gallons and less	52.9%
	Trailed Airblast - 501 gallons and above	50.0%
	Mounted Boom - 251 to 500 gallons	47.6%
Not Available	Trailed Boom - 250 gallons and less	54.5%

The average cost of container rinse systems for 16 companies providing prices is $334.94. The average cost for each sprayer type shows the lowest cost of $67.50 is for skid mounted sprayers and the highest cost of $737.50 is for trailed airblast sprayers. Prices vary considerably between companies with the lowest price of $50.00 on a skid mounted sprayer and the high price of $975.00 on a trailed airblast sprayer.

Table 9. Container Rinse System Average Cost

Sprayer Type	Average Cost
Mounted Boom	*$145.67*
Trailed Boom	*$371.75*
Self-Propelled Boom	*$331.25*
Skid Mounted	*$67.50*
Mounted Airblast	*$500.00*
Trailed Airblast	*$737.50*
Overall Average Cost	***$334.94***

Chemical Induction Systems

The majority of sprayer categories (11 of 18) show chemical induction systems as optional equipment. Induction systems are optionally available on all 501-gallon and larger mounted airblast sprayers. Three-fourths of 501-gallon and larger self-propelled boom sprayers and trailed airblast sprayers less than 250 gallons and greater than 501 gallons also offer optional induction systems. Other sprayer groups with most companies offering optional induction systems include 251-gallon and greater mounted and trailed boom sprayers, 251- to 500-gallon self-propelled boom and mounted airblast sprayers and 501-gallon and larger skid mounted sprayers.

Six categories have the majority of companies not offering induction systems at all. Mounted boom sprayers less than 250 gallons show 76.5% of the companies not offering induction systems. Other sprayer categories in this group include 250-gallon and less trailed boom, skid mounted, and mounted airblast sprayers and 251- to 500-gallon skid mounted and trailed airblast sprayers.

Table 10. Popular Responses for Chemical Induction System Availability

Availability	Sprayer Type and Size	Percent of Respondents
Standard	---	---
Optional	Mounted Airblast - 501 gallons and above	100.0%
	Self-propelled Boom - 501 gallons and above	75.0%
	Trailed Airblast - 250 gallons and less	75.0%
	Trailed Airblast - 501 gallons and above	75.0%
	Self-propelled Boom - 251 to 500 gallon	71.4%
	Trailed Boom - 501 gallons and above	68.2%
	Mounted Airblast - 251 to 500 gallons	66.7%
	Trailed Boom - 251 to 500 gallons	60.0%
	Skid Mounted - 501 gallons and above	57.1%
	Mounted Boom - 251 to 500 gallon	52.4%
	Mounted Boom - 501 gallons and above	50.0%
Not Available	Mounted Boom - 250 gallon and less	76.5%
	Skid Mounted - 250 gallons and less	75.0%
	Trailed Boom - 250 gallon and less	63.6%
	Mounted Airblast - 250 gallons and less	62.5%
	Skid Mounted - 251 to 500 gallons	60.0%
	Trailed Airblast - 251 to 500 gallons	57.1%

The average cost of an induction system is $698.94. Based on sprayer type, trailed boom sprayers have the lowest average cost at $462.33. Mounted airblast sprayers have the highest average cost at $1237.50. The least expensive system is found on a mounted boom, trailed boom, or skid mounted sprayer and costs $185. The most expensive system, $2000.00, is found on a self-propelled boom sprayer.

Table 11. Chemical Induction System Average Cost

Sprayer Type	Average Cost
Mounted Boom	*$566.22*
Trailed Boom	*$462.33*
Self-Propelled Boom	*$1150.00*
Skid Mounted	*$573.33*
Mounted Airblast	*$1237.50*
Trailed Airblast	*$1012.50*
Overall Average Cost	***$698.94***

Multiple Nozzle Bodies

In 15 of the 18 sprayer categories, the majority of companies offer multiple nozzle bodies as optional equipment; 8 categories having 75% or more of the respondents indicating so. The sprayer categories with most companies offering optional multiple nozzle bodies include 251-gallon and larger self-propelled boom sprayers; all mounted boom, trailed boom, skid mounted, and mounted airblast sprayers; and 250-gallon and less trailed airblast sprayers. Most companies that offer multiple nozzle bodies as standard equipment do so for only 501-gallon and larger trailed airblast sprayers.

Table 12. Popular Responses for Multiple Nozzle Body Availability

Availability	Sprayer Type and Size	Percent of Respondents
Standard	Trailed Airblast - 501 gallons and above	75.0%
Optional	Trailed Boom - 501 gallons and above	90.9%
	Skid Mounted - 251 to 500 gallons	90.0%
	Trailed Boom - 251 to 500 gallons	86.7%
	Skid Mounted - 501 gallons and above	85.7%
	Mounted Boom - 251 to 500 gallons	76.2%
	Mounted Boom - 501 gallons and above	75.0%
	Skid Mounted - 250 gallons and less	75.0%
	Trailed Airblast - 250 gallons and less	75.0%
	Trailed Boom - 250 gallons and less	72.7%
	Self-Propelled - 251 to 500 gallons	71.4%
	Mounted Airblast - 251 to 500 gallons	66.7%
	Mounted Airblast - 501 gallons and above	66.7%
	Self-Propelled - 501 gallons and above	66.7%
	Mounted Boom - 250 gallons and less	64.7%
	Mounted Airblast - 250 gallons and less	50.0%
Not Available	---	---

The average cost of multiple nozzle bodies is $15.64 apiece. By sprayer type, the lowest average cost is $12.16 for mounted boom sprayers and the highest average cost is $36.67 for mounted airblast sprayers. Prices range from a low of $6.00 per nozzle body on a mounted boom, trailed boom or skid mounted sprayer to a high of $50.00 each for a mounted airblast sprayer.

Table 13. Multiple Nozzle Body Average Cost

Sprayer Type	Average Cost (Each)
Mounted Boom	*$12.16*
Trailed Boom	*$12.63*
Self-Propelled Boom	*$15.00*
Skid Mounted	*$11.00*
Mounted Airblast	*$36.67*
Trailed Airblast	*$27.50*
Overall Average Cost	***$15.64***

Hydraulic Boom Fold/Extend

Hydraulic boom fold/extend systems are most often optionally available in 6 of 12 sprayer categories. (Hydraulic boom fold/extend is not available on airblast sprayers.) Most companies offer optional hydraulic boom fold/extend on all mounted boom and skid mounted sprayers with 501-gallon and larger skid mounted sprayers having the highest percentage at 71.4%. Five sprayer categories have most respondents providing standard hydraulic boom fold/extend. Included are all self-propelled boom and 251-gallon and larger trailed boom sprayers. Self-propelled boom sprayers 501 gallons and larger have the highest percentage with 83.3% of the respondents. On 250-gallon and less trailed boom sprayers most companies do not offer hydraulic boom fold/extend.

Table 14. Popular Responses for Hydraulic Boom Fold/Extend Availability

Availability	Sprayer Type and Size	Percent of Respondents
Standard	Self-Propelled Boom - 501 gallons and above	83.3%
	Self-Propelled Boom - 251 to 500 gallons	71.4%
	Trailed Boom - 501 gallons and above	59.1%
	Self-Propelled Boom - 250 gallons and less	50.0%
	Trailed Boom - 251 to 500 gallons	46.7%
Optional	Skid Mounted - 501 gallons and above	71.4%
	Skid Mounted - 250 gallons and less	62.5%
	Skid Mounted - 251 to 500 gallons	60.0%
	Mounted Boom - 250 gallons and less	52.9%
	Mounted Boom - 501 gallons and above	41.7%
	Mounted Boom - 251 to 500 gallons	38.1%
Not Available	Trailed Boom - 250 gallons and less	45.5%

Hydraulic boom fold/extend is one of the more expensive engineering controls in the study. The average hydraulic boom fold/extend system cost is $4700.03. For the 12 sprayer categories that can offer hydraulic boom fold/extend, the lowest average cost of $3659.83 is for mounted boom sprayers and the highest average cost of $10,000.00 for self-propelled boom sprayers. Individual prices range from a low of $1500.00 on a mounted boom, trailed boom or skid mounted sprayer to a high of $15,000.00 on a trailed boom sprayer. There is also a tremendous gap between the low and high prices within each sprayer type. The smallest price difference of $4300.00 is found in the skid mounted sprayer category and the biggest difference of $13,500.00 is in the trailed boom sprayer group.

Table 15. Hydraulic Boom Fold/Extend System Average Cost

Sprayer Type	Average Cost
Mounted Boom	*$3659.83*
Trailed Boom	*$5103.94*
Self-Propelled Boom	*$10,000.00*
Skid Mounted	*$3936.67*
Overall Average Cost	***$4700.03***

Diaphragm Check Valves

Diaphragm check valves have fairly high standard availability in comparison to other controls in the study. They are standard items from most companies in 8 of the 18 sprayer categories. Self-propelled boom sprayers have the highest percentage of companies offering standard diaphragm check valves at 71.4%. Self-propelled boom sprayers 501 gallons and larger have the second largest at 66.7%. Other sprayer groups offering standard diaphragm check valves include all mounted boom, 251-gallon and larger trailed boom, and 250-gallon and less mounted airblast sprayers. Skid mounted sprayers 501 gallons and larger have most companies (71.4%) offering optional diaphragm check valves. Other sprayer categories having high optional check valve availability include: 251-gallon and larger mounted airblast sprayers; 500-gallon and smaller skid mounted sprayers; 250-gallon and less trailed boom sprayers; and 501-gallon and larger trailed airblast sprayers.

Table 16. Popular Responses for Diaphragm Check Valve Availability

Availability	Sprayer Type and Size	Percent of Respondents
Standard	Self-Propelled Boom - 251 to 500 gallons	71.4%
	Self-Propelled Boom - 501 gallons and above	66.7%
	Mounted Boom - 501 gallons and above	58.3%
	Mounted Boom - 251 to 500 gallons	55.0%
	Trailed Boom - 501 gallons and above	54.5%
	Mounted Boom - 250 gallon and less	47.1%
	Trailed Boom - 251 to 500 gallons	46.7%
	Mounted Airblast - 250 gallons and less	37.5%
Optional	Skid Mounted - 501 gallons and above	71.4%
	Mounted Airblast - 251 to 500 gallons	66.7%
	Mounted Airblast - 501 gallons and above	66.7%
	Skid Mounted - 250 gallons and less	62.5%
	Skid Mounted - 251 to 500 gallons	60.0%
	Trailed Boom - 250 gallons and less	54.5%
	Trailed Airblast - 501 gallons and above	50.0%
Not Available	---	---

The average cost for diaphragm check valves is $10.26 each with individual valve prices ranging from a low of $3.50 to a high of $35.00. Trailed boom sprayers have the lowest price per check valve ($6.64); self-propelled boom sprayers have the highest ($23.50).

Table 17. Diaphragm Check Valve Average Cost

Sprayer Type	Average Cost (Each)
Mounted Boom	*$8.50*
Trailed Boom	*$6.64*
Self-Propelled Boom	*$23.50*
Skid Mounted	*$8.75*
Mounted Airblast	*$18.00*
Trailed Airblast	*$18.00*
Overall Average Cost	***$10.26***

Hand Wash Water Supply

Hand wash water supplies are optionally available on most sprayers in 11 of the 18 sprayer categories. Skid mounted sprayers 501 gallons and larger have the highest majority with 85.7% of the companies. Skid mounted sprayers 251 to 500 gallons in size have the next highest percentage of companies at 80.0%. As shown in Table 18, 500-gallon and less mounted boom sprayers, 250-gallon and less trailed boom and skid mounted sprayers, all mounted airblast sprayers, and 251-gallon and larger trailed airblast sprayers also have most companies offering an optional hand wash water supply. Four categories, including 251-gallon and smaller self-propelled boom and trailed boom sprayers show most sprayers are built with a standard hand wash water supply.

Table 18. Popular Responses for Hand Wash Water Supply Availability

Availability	Sprayer Type and Size	Percent of Respondents
Standard	Self-Propelled Boom - 501 gallons and above	75.0%
	Trailed Boom - 501 gallons and above	72.7%
	Self-Propelled Boom - 251 to 500 gallons	57.1%
	Trailed Boom - 251 to 500 gallons	53.3%
Optional	Skid Mounted - 501 gallons and above	85.7%
	Skid Mounted - 251 to 500 gallons	80.0%
	Skid Mounted - 250 gallons and less	75.0%
	Mounted Airblast - 251 to 500 gallons	66.7%
	Mounted Airblast - 501 gallons and above	66.7%
	Mounted Boom - 250 gallons and less	58.8%
	Trailed Airblast - 251 to 500 gallons	57.1%
	Mounted Airblast - 250 gallons and less	50.0%
	Trailed Airblast - 500 gallons and above	50.0%
	Mounted Boom - 251 to 500 gallons	47.6%
	Trailed Boom - 250 gallons and less	45.5%
Not Available	---	---

Hand wash water supplies have an average cost of $171.00. Self-propelled boom sprayers have the highest average cost at $366.67. Mounted and trailed airblast sprayers are tied for the lowest average cost at $75.00. A large price difference exists within a couple of sprayer types. Self-propelled boom sprayers showed a $700.00 difference between a low of $50.00 and a high of $750.00. Trailed and mounted boom sprayers both showed a $458.00 variation in price between a low of $50.00 and a high of $508.00.

Table 19. Hand Wash Water Supply Average Cost

Sprayer Type	Average Cost
Mounted Boom	*$148.33*
Trailed Boom	*$183.25*
Self-Propelled Boom	*$366.67*
Skid Mounted	*$98.75*
Mounted Airblast	*$75.00*
Trailed Airblast	*$75.00*
Overall Average Cost	***$171.00***

Operator Cabs

The survey only asked self-propelled boom sprayer manufacturers and distributors questions on operator cabs. All 251- to 500- gallon self-propelled sprayers have standard operator cabs. Standard cabs are also available on 91.7% of 501-gallon and larger sprayers. The smaller sprayers (250 gallons and less) are split evenly between standard and unavailable cabs.

Respondents were asked to indicate if their cabs are available with carbon filtration that meet the American Society of Agricultural Engineers (ASAE) standards for agricultural cab environmental air quality (standard S525 parts 1 and 2). Of the 10 respondents, 6 indicated that all sprayer models they manufacture or distribute are available with carbon filtration meeting the standard. One company indicated they offer the filters on some of their models. Three respondents noted they do not offer filters that meet the standard.

Cabs are by far the most expensive engineering control in the study. One respondent provided cab prices that range from $40,000.00 to $80,000.00 per cab. All other companies offering cabs noted they couldn't provide specific prices because the cost is included in the total sale price of their sprayers.

Protective Clothing Locker

Protective clothing lockers are one of the most unavailable engineering controls. Skid mounted and mounted airblast sprayers 250 gallons and smaller in size have the highest percentage of companies not providing protective clothing lockers. Other sprayer groups having most companies not offering protective clothing lockers include: all mounted and trailed boom sprayers; 251-gallon and larger self-propelled and trailed airblast sprayers and less than 500-gallon skid mounted and mounted airblast sprayers. Most companies building 250-gallon and less trailed airblast and 501-gallon and larger skid mounted sprayers offer optional protective clothing lockers.

Table 20. Popular Responses for Protective Clothing Locker Availability

Availability	Sprayer Type and Size	Percent of Respondents
Standard	---	---
Optional	Trailed Airblast - 250 gallons and less	75.0%
	Skid Mounted - 501 gallons and above	57.1%
Not Available	Skid Mounted - 250 gallons and less	75.0%
	Mounted Airblast - 250 gallons and less	75.0%
	Self-Propelled Boom - 251 to 500 gallons	71.4%
	Mounted Boom - 251 to 500 gallons	66.7%
	Self-Propelled Boom - 501 gallons and above	66.7%
	Mounted Airblast - 251 to 500 gallons	66.7%
	Mounted Boom - 250 gallons and less	64.7%
	Trailed Boom - 250 gallons and less	63.6%
	Trailed Boom - 501 gallons and above	63.6%
	Trailed Boom - 251 to 500 gallons	60.0%
	Skid Mounted - 251 to 500 gallons	60.0%
	Trailed Airblast - 251 to 500 gallons	57.1%
	Mounted Boom - 501 gallons and above	50.0%
	Trailed Airblast - 501 gallons and above	50.0%

Protective clothing lockers have an average price of $318.75 each. Mounted boom sprayers have the lowest average cost at $200.00 each and self-propelled boom sprayers have the highest average cost at $425.00. The lowest individual cost of $150.00 is found on a trailed boom sprayer and the highest of $600.00 on a self-propelled boom sprayer.

Table 21. Protective Clothing Locker Average Cost

Sprayer Type	Average Cost
Mounted Boom	*$200.00*
Trailed Boom	*$266.67*
Self-Propelled Boom	*$425.00*
Skid Mounted	*$350.00*
Mounted Airblast	*No Responses*
Trailed Airblast	*No Responses*
Overall Average	***$318.75***

Air-Assisted Booms

Of the 12 sprayer categories that could offer air-assisted booms (air-assisted booms are not available on airblast sprayers), 10 have most companies indicating the booms are unavailable; self-propelled boom sprayers 250 gallons and less in size having all respondents not offering them. Most companies who manufacture trailed boom, skid mounted and mounted boom sprayers also do not provide air-assisted booms. The majority of 251- to 500-gallon self-propelled sprayer manufacturers offer optional air-assisted booms. No companies offer these booms as standard equipment.

Table 22. Popular Responses for Air-Assisted Boom Availability

Availability	Sprayer Type and Size	Percent of Respondents
Standard	---	---
Optional	Self-Propelled Boom - 251 to 500 gallons	57.1%
Not Available	Self-Propelled Boom - 250 gallons and less	100.0%
	Trailed Boom - 250 gallons and less	81.8%
	Trailed Boom - 501 gallons and above	81.8%
	Trailed Boom - 251 to 500 gallons	80.0%
	Skid Mounted - 501 gallons and above	71.4%
	Skid Mounted - 251 to 500 gallons	70.0%
	Skid Mounted - 250 gallons and less	62.5%
	Mounted Boom - 251 to 500 gallons	57.1%
	Mounted Boom - 250 gallons and less	52.9%
	Mounted Boom - 501 gallons and above	41.7%

Average prices for air-assisted booms could not be calculated due to very few companies providing prices. Companies that offered prices indicated a per nozzle price rather than a per boom price. It is believed that the respondents confused air inclusion nozzles with air-assisted booms.

Low-Drift Nozzles

Low-drift nozzles are found as optional equipment on the majority of sprayers in 16 of 18 sprayer categories. Self-propelled boom sprayers 251 to 500 gallons in size have the highest percentage of companies providing optional low-drift nozzles (85.7%). Self-propelled boom sprayers 501 gallons and larger have the second highest percentage (83.3%). Other sprayer types with most companies offering optional low-drift nozzles include all sizes of mounted boom, trailed boom, skid mounted and trailed airblast as well as mounted airblast sprayers 250 gallons and less and 501 gallons and larger in size.

Table 23. Popular Responses for Low-Drift Nozzle Availability

Availability	Sprayer Type and Size	Percent of Respondents
Standard	---	---
Optional	Self-Propelled Boom - 251 to 500 gallons	85.7%
	Self Propelled Boom - 501 gallons and above	83.3%
	Trailed Boom - 251 to 500 gallons	80.0%
	Skid Mounted - 251 to 500 gallons	80.0%
	Trailed Boom - 501 gallons and above	77.3%
	Trailed Airblast - 250 gallons and less	75.0%
	Trailed Airblast - 501 gallons and above	75.0%
	Skid Mounted - 501 gallons and above	71.4%
	Mounted Boom - 501 gallons and above	66.7%
	Mounted Airblast - 501 gallons and above	66.7%
	Mounted Boom -250 gallons and less	64.7%
	Trailed Boom - 250 gallons and less	63.6%
	Skid Mounted - 250 gallons and less	62.5%
	Mounted Boom - 251 to 500 gallons	61.9%
	Trailed Airblast - 251 to 500 gallons	42.9%
	Mounted Airblast - 250 gallons and less	37.5%
Not Available	---	---

The average cost for a low-drift nozzle is $4.75. As Table 24 shows, the lowest average cost of $2.00 each is for self-propelled boom sprayers and the highest average cost is $6.00 apiece for both mounted and trailed airblast sprayers. The lowest individual nozzle cost is $2.00 and is found on a self-propelled boom sprayer and the highest cost of $10.00 is found on both a mounted and trailed boom sprayer.

Table 24. Low-Drift Nozzle Average Cost

Sprayer Type	Average Cost (each)
Mounted Boom	*$4.97*
Trailed Boom	*$4.86*
Self-Propelled Boom	*$2.00*
Skid Mounted	*$4.27*
Mounted Airblast	*$6.00*
Trailed Airblast	*$6.00*
Overall Average Cost	***$4.75***

Twin Fluid Nozzles

Twin fluid nozzles are optionally available from most companies in 7 of 12 sprayer categories. (Twin fluid nozzles are not typically found on airblast sprayers.) Self-propelled sprayers in both 251- to 500- gallon and 501-gallon and larger sizes lead the list with 71.4% and 66.7% of the companies, respectively. All sizes of mounted boom sprayers and 251-to 500-gallon trailed boom and skid mounted sprayers also have most companies offering optional twin fluid nozzles. Twin fluid nozzles are not available on any 250-gallon and less self-propelled sprayers or the majority of 250-gallon and smaller trailed boom and skid mounted sprayers and 501-gallon and larger trailed boom sprayers.

Table 25. Popular Responses for Twin Fluid Nozzle Availability

Availability	Sprayer Type and Size	Percent of Respondents
Standard	---	---
Optional	Self-Propelled Boom - 251 to 500 gallons	71.4%
	Self-Propelled Boom - 501 gallons and above	66.7%
	Trailed Boom - 251 to 500 gallons	60.0%
	Mounted Boom - 501 gallons and above	58.3%
	Mounted Boom - 250 gallons and less	52.9%
	Skid Mounted - 251 to 500 gallons	50.0%
	Mounted Boom - 251 to 500 gallons	42.9%
Not Available	Self-Propelled - 250 gallons and less	100.0%
	Trailed Boom - 250 gallons and less	54.5%
	Trailed Boom - 501 gallons and above	54.5%
	Skid Mounted - 250 gallons and less	50.0%

The average price of twin fluid nozzles is $7.74 each. The lowest average cost is $7.04 per nozzle for skid mounted sprayers and the highest average cost is $8.18 each for mounted boom sprayers. The lowest priced nozzle ($6.12) is available on a mounted boom, trailed boom, or skid mounted sprayer. The highest priced nozzle ($10.00) is on a mounted boom sprayer. No self-propelled sprayer manufacturers or distributors reported nozzle prices.

Table 26. Twin Fluid Nozzle Average Cost

Sprayer Type	Average Cost (each)
Mounted Boom	*$8.18*
Trailed Boom	*$7.73*
Self-Propelled Boom	*No Responses*
Skid Mounted	*$7.04*
Overall Average Cost	***$7.74***

Tank Rinse System

Tank rinse systems are optionally available on most sprayers in 15 of the 18 sprayer categories. All sizes of mounted boom, trailed boom, skid mounted, mounted airblast and trailed airblast sprayers have most companies offering optional rinse systems. Only 251- to 500-gallon self-propelled sprayers have most companies providing standard tank rinse systems.

Table 27. Popular Responses for Tank Rinse System Availability

Availability	Sprayer Type and Size	Percent of Respondents
Standard	Self-Propelled Boom - 251 to 500 gallon	42.9%
Optional	Trailed Airblast - 250 gallons and less	100.0%
	Trailed Boom - 251 to 500 gallons	81.8%
	Trailed Boom - 501 gallons and above	81.8%
	Skid Mounted - 251 to 500 gallons	80.0%
	Mounted Boom - 251 to 500 gallons	76.2%
	Mounted Boom - 501 gallons and above	75.0%
	Skid Mounted - 250 gallons and less	75.0%
	Skid Mounted - 501 gallons and above	71.4%
	Mounted Airblast - 251 to 500 gallons	66.7%
	Mounted Airblast - 501 gallons and above	66.7%
	Mounted Airblast - 250 gallons and less	62.5%
	Mounted Boom - 250 gallons and less	58.8%
	Trailed Airblast - 251 to 500 gallons	57.1%
	Trailed Boom - 250 gallons and less	54.5%
	Trailed Airblast - 501 gallons and above	50.0%
Not Available	---	---

The average cost for container rinse systems is $703.44. Prices range from a low average of $513.11 for mounted boom sprayers to a high average of $1100.00 for self-propelled boom sprayers. Individual prices show the lowest cost of $250.00 on a self-propelled sprayer and the highest of $1299.00 is on a trailed boom sprayer. The variation in price could be attributed to different styles of rinse systems and the cost of the different components used to build these systems.

Table 28. Tank Rinse System Average Cost

Sprayer Type	Average Cost
Mounted Boom	*$513.11*
Trailed Boom	*$701.85*
Self-Propelled Boom	*$1100.00*
Skid Mounted	*$939.33*
Mounted Airblast	*$662.50*
Trailed Airblast	*$662.50*
Overall Average Cost	***$703.44***

Section 2 - Product Literature Review

A - Overview

As mentioned at the beginning of Section 1, the response rate for the written survey was lower than anticipated. In order to get a better picture of engineering control availability, product literature/specifications were reviewed for survey non-respondents.

An attempt was made to obtain product literature/specifications from all survey non-respondents. Requests were sent via US mail and the Internet (either directly through company web sites or by electronic mail (e-mail)) to all non-respondent manufacturers and distributors. After the initial contact, follow-up letters, e-mails and phone calls were used to get as many non-respondent companies to forward literature as possible. For the companies that did not forward materials, their web site (if available) was searched to obtain any on-line literature or specifications.

B - Results

Of the 58 companies not returning a survey, product information was obtained from 35 of them. In reviewing the literature, it was apparent that many companies do not provide a thorough listing of available engineering controls. This made it difficult to determine engineering control availability for several manufacturers and distributors and quite possibly contributes to the high number of results labeled "not indicated."

As a check to see how often product literature does not mention available controls, five survey respondents who manufacture 501-gallon and larger trailed boom sprayers were randomly selected. The number of engineering controls noted as standard or optional on their survey was compared to the number of controls listed in their product literature. What was found is a wide variation between engineering controls noted on the survey and those listed in the product literature. The variation ranges from one company not mentioning trailed boom sprayers in their product literature (they indicated in their survey response that they manufacture them) to another company mentioning in their literature 6 of the 7 controls they noted on their survey. Table 29 shows the differences found between the five companies. With this in mind, information gathered from the product literature might not provide information on all engineering controls available to the sprayer buyer. Since price lists were not provided with most product literature, engineering control costs for non-respondents is not summarized. Detailed numbers, organized by engineering control, are provided in Appendix D.

Table 29. Engineering Control Availability - Survey Versus Product Literature

	Number of Engineering Controls Discussed	
	In Survey	*In Product Literature*
Company 1	7	6
Company 2	10	***
Company 3	10	3
Company 4	10	6
Company 5	10	5

*** Respondent indicated on survey that their company manufactures trailed boom sprayers but none are described in their product literature.

In reviewing the literature it was found that half of the engineering controls in the study are not indicated for most companies, regardless of sprayer type and size. These controls include closed transfer systems, direct injection systems, container rinse systems, diaphragm check valves, protective clothing lockers, air-assisted booms and twin fluid nozzles. The balance of the engineering controls have at least one sprayer category with a majority of companies showing the control as standard or optional. Table 30 shows these controls and which sprayer types and sizes fit this criterion.

Table 30. Engineering Control Availability for Survey Non-Repondents

Engineering Control	Sprayer Type and Size	Majority Offer Control As
Chemical Induction Systems	Trailed Boom - 501 Gallons and Above	Optional
Multiple Nozzle Bodies	Mounted Boom - 250 Gallons and Less	Optional
	Mounted Boom - 501 Gallons and Above	Optional
	Trailed Boom - 250 Gallons and Less	Optional
	Trailed Boom - 251 to 500 Gallons	Optional
Hydraulic Boom Fold/Extend	Self-Propelled Boom - 501 Gallons and Above	Standard
	Mounted Boom - 250 Gallons and Less	Optional
	Trailed Boom - 250 Gallons and Less	Optional
	Self-Propelled Boom - 250 Gallons and Less	Optional
	Self-Propelled Boom - 251 to 500 Gallons	Optional
	Skid Mounted - 501 Gallons and Above	Optional
Hand Wash Water Supply	Trailed Boom - 501 Gallons and Above	Standard
Operator Cabs	Self-Propelled Boom - 501 Gallons and Above	Standard
Low Drift Nozzles	Mounted Airblast - 251 to 500 Gallons	Standard
Tank Rinse System	Self-Propelled Boom - 501 Gallons and Above	Standard

Part II - State Pesticide Regulatory Agency Survey

A - Overview

Since states may have more stringent engineering control use regulations than the federal government, it is necessary to identify which states have engineering control regulations and what they entail. In order to determine this, each state's pesticide regulatory agency was surveyed. Using the membership roster for the American Association of Pesticide Control Officials' (AAPCO) available at the AAPCO web site (aapco.ceris.purdue.edu), one official was selected from each state who appeared to be most responsible for administering that state's pesticide regulatory program. These individuals were asked questions about:

- engineering control requirements in their state and which EPA pesticide toxicity category(ies) they may be required for;
- if and when engineering controls not currently required may become required;
- percentage of farms in their state currently using engineering controls;
- availability of engineering control educational information;
- amount of engineering control training provided to pesticide enforcement field staff and;
- proposed or pending engineering control legislation.

A sample survey showing the specific questions is provided in Appendix B.

In administering the survey, the same procedure used with the sprayer manufacturers was followed. A survey form and a postage-paid return envelope were sent to each official along with a cover letter explaining what the survey is about and why they were selected for this study. Two weeks after the initial mailing, follow-up postcards were sent to all non-respondents. About six weeks after the first mailing, a second survey form along with another postage-paid envelope was sent to those individuals still not responding.

B - Results

Current Engineering Control Requirements

Out of 50 surveys mailed, 44 responses were received for an 88.0% response rate. Of the states responding, only 10 have some sort of engineering control requirements above current federal requirements. Three other states indicated having engineering control requirements, but most said they fit under the federal Worker Protection Standard.

Engineering control requirements vary by state. Some states do not have regulations for land-based application systems but have engineering control requirements for aerial application systems. Also, some states have control regulations that apply only to commercial applicators and not to private applicators which includes many farm operators. States requiring engineering controls and the controls required are shown in Table 1.

As mentioned earlier, some states have control requirements for pesticide applicators other than farm operators. Michigan requires aircraft applicators to use container rinse systems, closed transfer systems, diaphragm check valves and tank rinse systems. They also require commercial applicators to use hand wash water supplies. Ohio noted that they have a regulatory agreement regarding low-drift nozzles and air-assisted nozzles but the respondent did not elaborate on what the arrangement entails.

It should be noted that the respondent for the state of Washington might not have understood our question. The respondent indicated that closed transfer systems, diaphragm check valves, and low-drift nozzles are required for two of the least toxic categories of pesticides (category 3 and 4).

Table 31. States Requiring Engineering Controls

State	*Engineering Control*	*EPA Toxicity Category Required For*
Alaska	Hand Wash Water Supply	All
Arizona	Hand Wash Water Supply	All
California	Closed Transfer System	Category 1
	Hand Wash Water Supply	All
Illinois	Diaphragm Check Valves	All
	Hand Wash Water Supply	All
	Protective Clothing Locker	All
Michigan	Container Rinse	All - aerial only
	Closed Transfer System	All - aerial only
	Diaphragm Check Valves	All - aerial only
	Hand Wash Water Supply	All - commercial only
	Tank Rinse System	All - aerial only
Mississippi	Diaphragm Check Valves	All - aerial[1]
	Low-drift Nozzles	All - aerial[1]
Nebraska	Direct Pesticide Injection	All - chemigation only
New Hampshire	Diaphragm Check Valves	All
	Hand Wash Water Supply	All - (as per label)
New Jersey	Hand Wash Water Supply	All
Washington	Closed Transfer Systems	Category 4
	Diaphragm Check Valves	Category 3
	Hand Wash Water Supply	All
	Low-drift Nozzles	Category 3

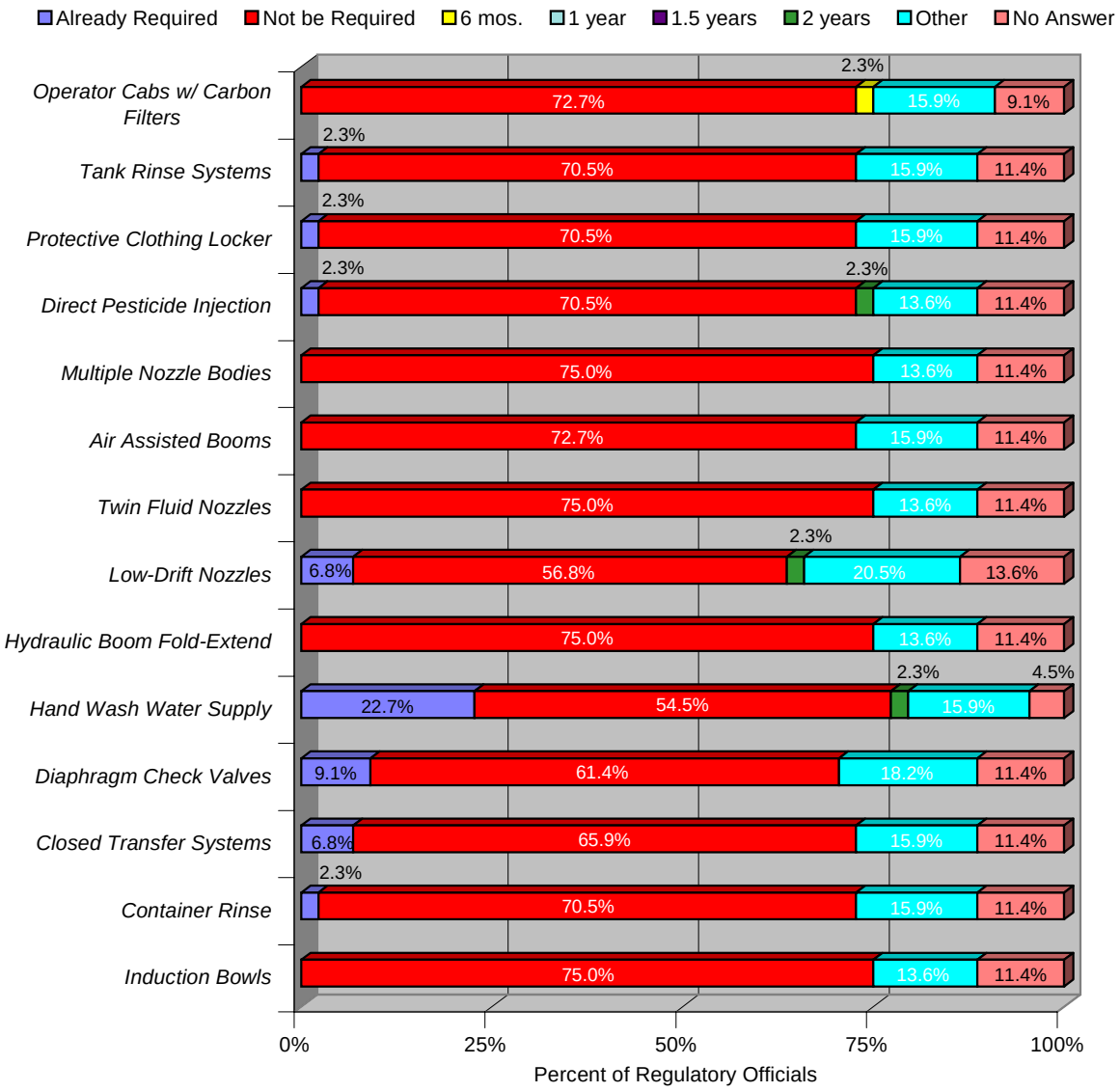
[1] also required for hormone-based herbicides

Future Requirements

Each regulatory official was asked to indicate when, if ever, their state will enact regulations requiring the use of any engineering controls not currently required. Most states noted that controls currently not required would still not be required for the foreseeable future. Figure 1 shows the percentage of states that envision having engineering control requirements. Multiple nozzle bodies, twin fluid nozzles, hydraulic boom fold/extend and induction bowls are each viewed by three-quarters of the respondents as not being required in the future.

A few states do expect to have future engineering control requirements: New Mexico might require diaphragm check valves in about 4 years; Wyoming might require hand wash water supply, low-drift nozzle, and direct pesticide injection use in 2 years and; Illinois might mandate low-drift nozzle use in the next 10 years. Minnesota stated they are currently (at the time of survey completion) developing a policy for operator cabs with carbon filters and might have this completed within 6 months. All other states selecting "other" as their response did not indicate specifically when the controls could become a requirement. Also included in the "other" category are states that replied that engineering controls are mandated as part of the Worker Protection Standard (i.e., hand wash water supplies).

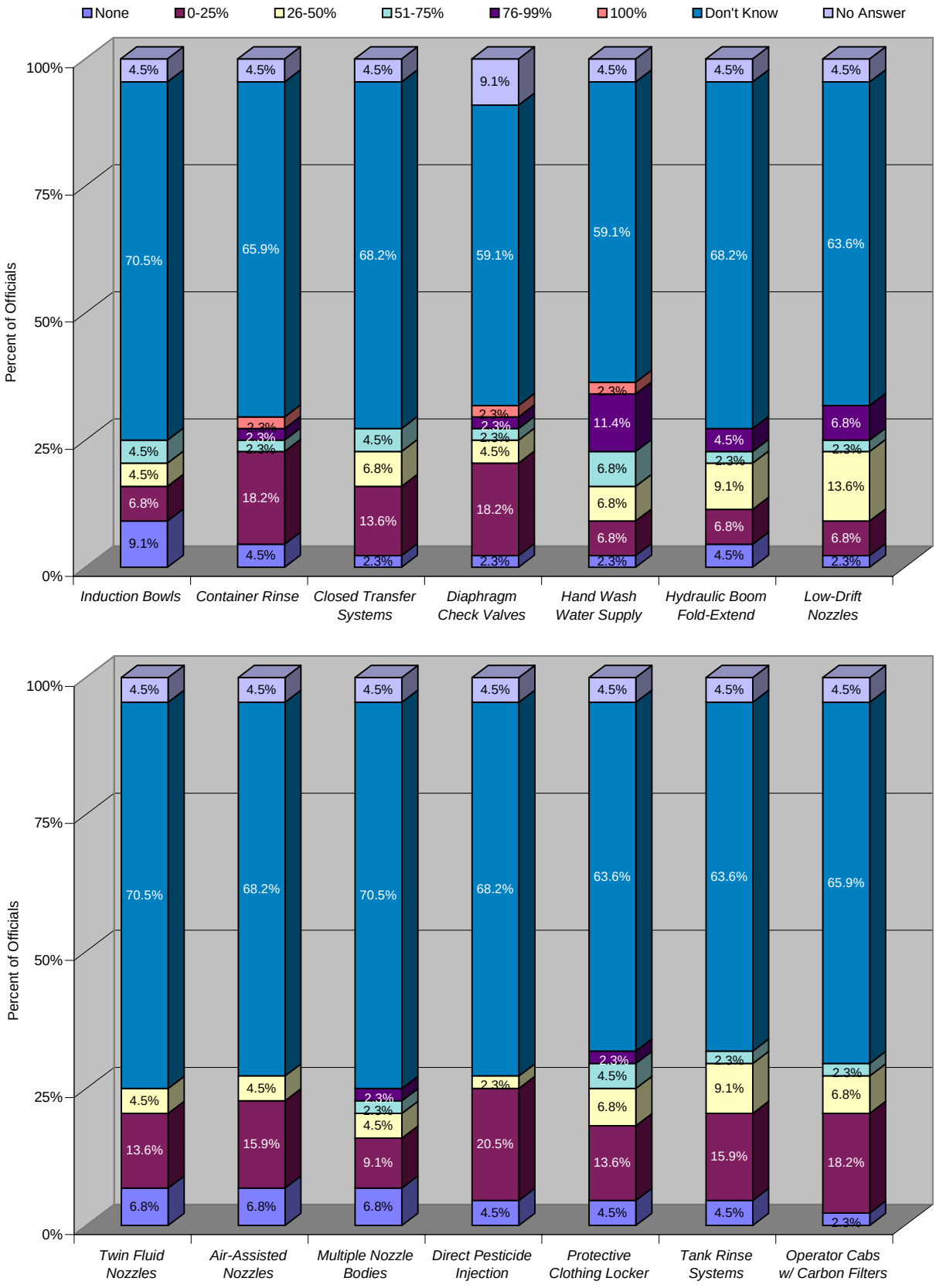
Figure 2. Future State Engineering Control Regulation Adoption Timeline



Observations of Engineering Control Adoption by Farm Operators

Regulatory officials were asked to indicate the percentage of farm operations in their state that use the various engineering controls. As Figure 2 clearly indicates, most officials do not know how many farm operations use engineering controls. For states giving specific numbers, most controls do not appear to be widely adopted. Container rinse systems, diaphragm check valves and hand wash water supplies each have one state showing them being used on all farms. The other controls are much less prevalent. All but hand wash water supplies and low-drift nozzles fit into the "none" or "0 to 25%" categories. Hand wash water supplies are shown by 11.4% of the respondents to be adopted by 76% to 99% of the farms in their state. Low-drift nozzles are identified by 13.6% of the officials as used by 26% to 50% of the farms.

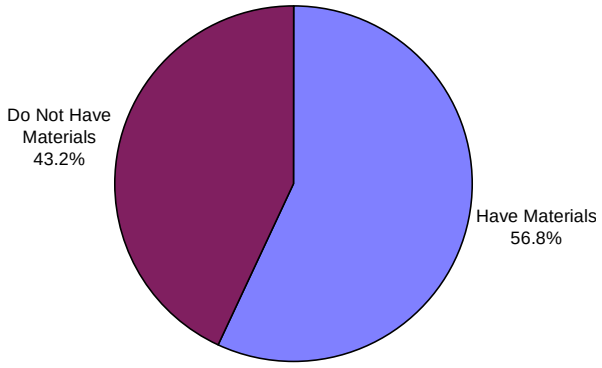
Figure 3. State Regulatory Officials View of Current Engineering Control Use



Training/Educational Materials Provided

Today, many regulatory agencies use what is termed "compliance assistance." Compliance assistance is a way of using education and information to work with the regulated community and help them meet regulation requirements. In order to offer compliance assistance for engineering controls, regulatory staff should receive adequate training and have access to educational materials. Regulatory officials were asked about how much training is provided to their field staff and what educational materials are made available to their field staff.

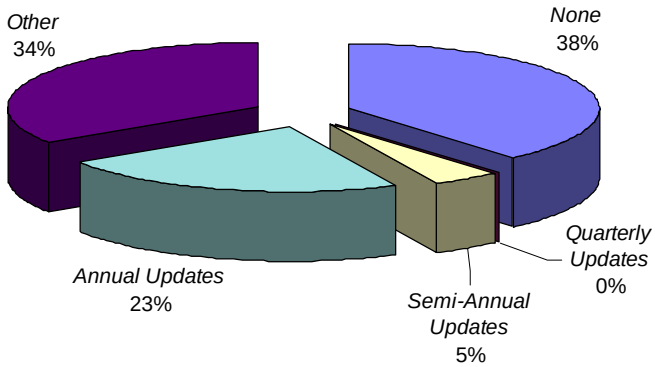
Figure 4. Engineering Control Educational Material Availability



The responses for educational material availability show that 56.8% of the respondents have educational materials on engineering controls. Included in this group are respondents who have materials on backflow prevention devices. (These devices were not included in the study). The respondents were not asked to identify the specific controls they have educational materials on. Two respondents commented that their materials are from the state land-grant university.

Responses to the question about field staff training showed that 38.6% of the states do not offer any training to their field staff. The second most popular response, "other," asked respondents to indicate how much training is provided to their field staff. The responses can be summarized into two distinct categories -- as needed and as part of certification/recertification programs. Looking at the results shown in Figure 4, by combining the top two responses it is apparent that regulatory agency field staff are not provided a tremendous amount of engineering control training. This could make assisting farm operators with regulatory compliance difficult unless adequate and regular training is provided, especially to new inspectors/agents. This is not to say all states do not provide regular training. Roughly 23% of the respondents said they offer annual training sessions to their field staff.

Figure 5. Engineering Control Training Provided to State Regulatory Agency Field Staff



Pending/Proposed Legislation

The final question posed to the regulatory officials was about pending or proposed engineering control use legislation in their state. Several states responded, though few of them actually provided any information related to engineering controls. California noted that at the time of survey completion they had regulation packages on the table regarding engineering controls for methyl bromide use in structural and soil fumigation. Other responses received related to the areas of backflow prevention for chemigation and containment requirements for pesticide handling facilities; items that are not part of this study.

C - Summary

In general, there seems to be little activity at the state level related to engineering control requirements. Very few states currently require engineering control use. States that do not have engineering control regulations, for the most part, do not plan to adopt any in the foreseeable future.

Education and training of regulatory field staff (inspectors/agents) varies. Most states do not provide engineering control training to their field staff. States that do provide training most often offer it on an as-needed basis or as part of certification or recertification programs.

Part III - Pesticide Applicator Training Coordinator Survey

A - Overview

Each state has pesticide applicator trainers (PAT's) who are responsible for developing educational programs and materials for pesticide applicators in their state. In the survey for this group, information on how each state conducts pesticide education and what level of engineering control education takes place were sought. Questions were asked related to:

- the respondents familiarity with various engineering controls;
- types of educational materials and methods used;
- the amount of general engineering control discussion for all materials and methods;
- the level of discussion in materials and programs about specific engineering controls;
- the number of training sessions available to extension personnel and applicators about specific engineering controls;
- the respondent's pesticide education program ability to meet the educational needs of applicators if engineering controls become required;
- the percentage of farms using engineering controls in their state and;
- applicator interest in learning about various engineering controls.

A sample survey is included in Appendix B.

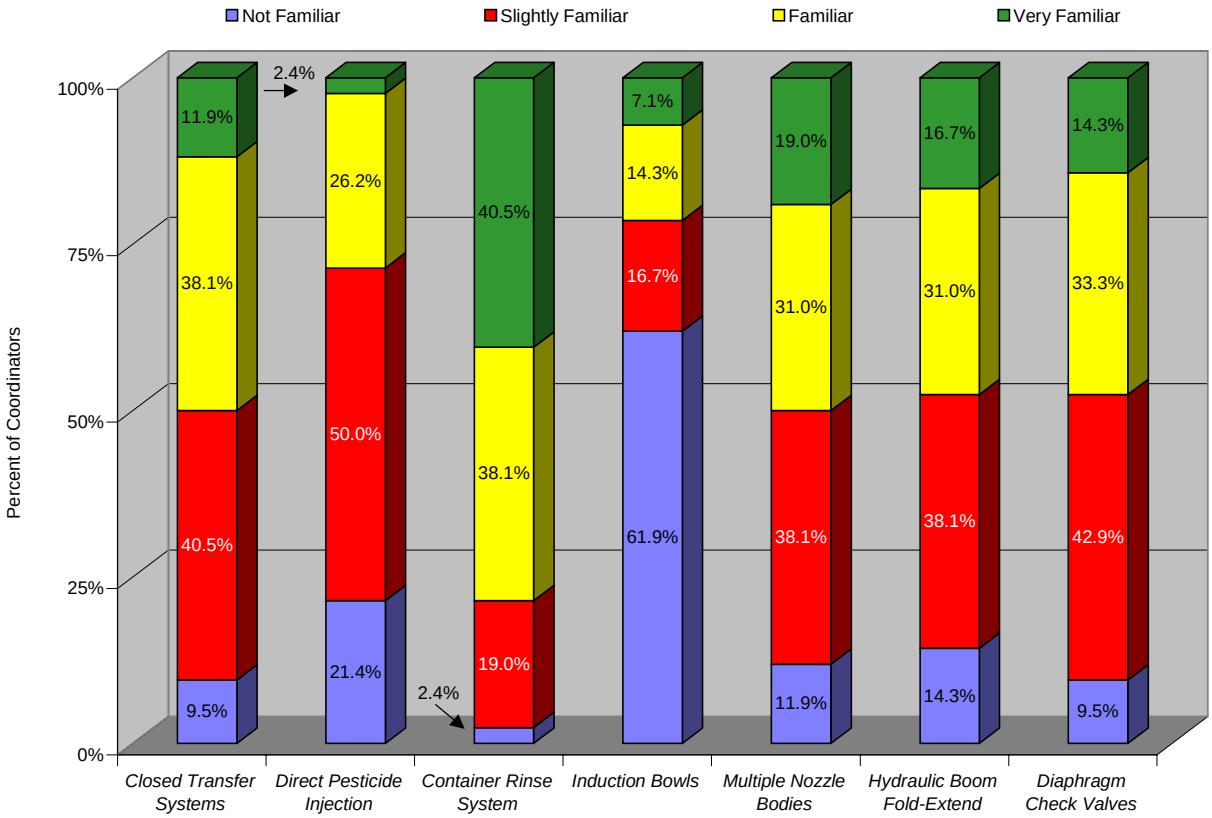
The survey was administered in the same manner as the others in the study. The PAT coordinator for each state was identified using the membership listing of the American Association of Pesticide Safety Educators (AAPSE) available at aapse.ext.vt.edu. The 50 coordinators were mailed a survey form and postage-paid return envelope along with a cover letter explaining the study and why they were selected for the survey. Two weeks after the initial mailing, a follow-up postcard was sent to all non-respondents. Approximately 6 weeks after the original mailing, another survey form and postage-paid return envelope were mailed to individuals who still had not responded.

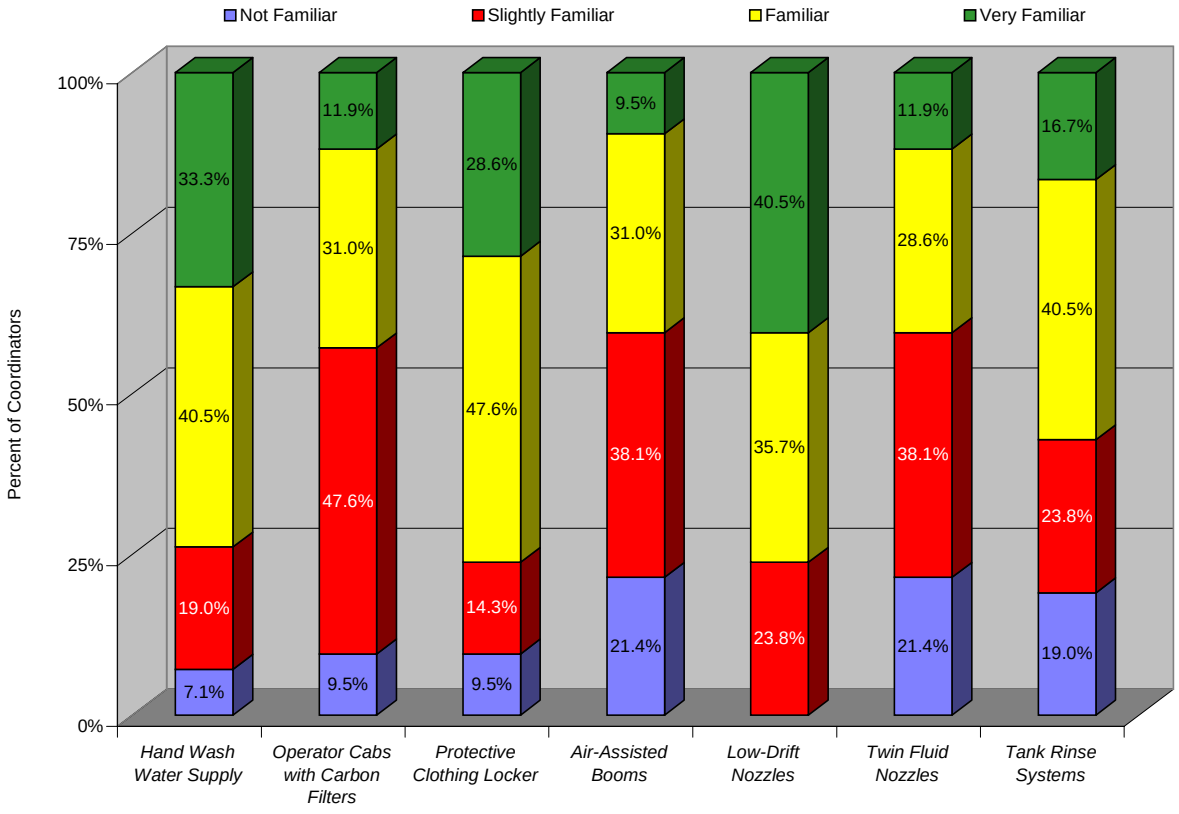
B - Results

Of the 50 surveys mailed, responses were received from 42 coordinators for a response rate of 84.0%. The respondents represent an average of 13.5 years of pesticide education experience. The years of experience range from one person just starting in their position to one respondent with 30 years.

The coordinators' overall familiarity with engineering controls varies. As shown in Figure 1, most coordinators showed they have at least slight familiarity with 8 of the 14 engineering controls listed. The least familiar engineering control, as indicated by 61.9% of the respondents, are chemical induction systems. The most familiar controls include container rinse systems and low-drift nozzles both with 40.5% of the respondents indicating so.

Figure 6. PAT Coordinator Engineering Control Familiarity





Engineering Control Discussion for Various Educational Materials/Methods

All respondents were asked to identify the types of educational materials and programs they use in their pesticide education programs (Table 1). All coordinators indicated they use presentations to applicators. Training manuals are a close second with 40 respondents. Web streaming is the least used educational medium with only 4 states using this technology. Four coordinators indicated they use other materials or methods not listed on the survey. The coordinators listed that they use such methods and materials as hands-on field days, demonstration equipment (i.e., spray tables), field demonstrations, online tutorials, web courses, and resource books as alternative methods and materials.

Table 32. Educational Materials/Methods Used

Rank	*Material/Method*	*Number of States (out of 42)*
1	Presentations to Applicators	42
2	Training Manuals	40
3	Videos	39
4	Fact Sheets/Bulletins	39
5	Web Pages	31
6	Train-the-Trainer Materials	20
7	CD-ROMS	10
8	Satellite	10
9	Other	4
10	Web Streaming	4

The coordinators were asked to provide feedback on the level of engineering control discussion provided in their educational programs and materials. First, they were asked about the detail of engineering control discussion for each educational material and method they use. Next, the coordinators were asked to identify how detailed the discussion is for each specific engineering control. They were asked to classify the discussion level as any of the following: no discussion, a general discussion (i.e., a paragraph or less) or a detailed discussion (i.e., a chapter or entire publication).

Overall, respondents tend to provide a general level of engineering control discussion. For the 10 educational methods listed in the survey, 8 of them have most respondents indicating "general" on their surveys. Only web streaming has most coordinators (75.0%) noting they provide detailed engineering control discussions. Almost 42% of the respondents indicated they provide no engineering control discussion on their web pages.

Figure 7. Engineering Control Discussion (by Material/Method)

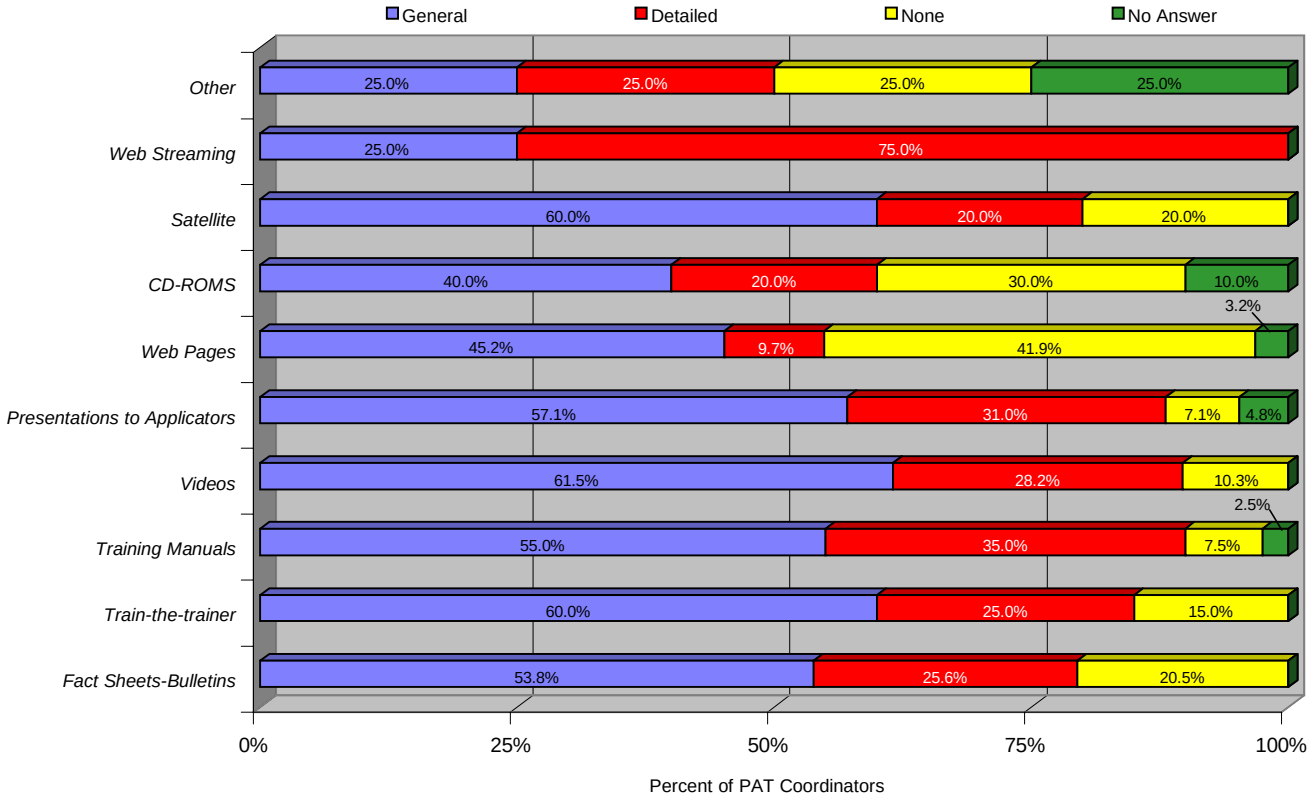


Table 33. Individual Engineering Control Discussion Popular Responses

Engineering Control	*Popular Response*	*Percent of Respondents*
Chemical induction systems	None	66.7%
Container rinse systems	General	64.3%
Closed transfer systems	General	64.3%
Diaphragm check valves	General	66.7%
Hand wash water supply	General	69.0%
Hydraulic boom fold/extend	None	52.4%
Low-drift nozzles	General	59.5%
Twin fluid nozzles	None	52.4%
Air-assisted booms	None	54.8%
Multiple nozzle bodies	None	54.8%
Direct pesticide injection	General	50.0%
Protective clothing locker	General	71.4%
Tank rinse system	General	54.8%
Operator cab with carbon air filter	None	47.6%

When the coordinators were asked for the amount of discussion provided about the individual engineering controls, the responses, for the most part, were similar to the educational material results. Table 2 lists the most popular responses along with the percentage of respondents. For the 14 engineering controls, 8 show most coordinators generally discuss them. Leading this list with 71.4% of the coordinators is the protective clothing locker. Induction bowls, hydraulic boom fold/extend, twin fluid nozzles, air-assisted booms, multiple nozzle bodies, and operator cabs with carbon air filtration are not discussed in most coordinator's educational literature or programs.

Training Sessions

PAT coordinators often conduct training sessions for extension agents/educators and pesticide applicators. Each coordinator was asked to indicate the number of training programs they have conducted on each engineering control for these audiences.

Figures 3 and 4 show that both extension agents/educators and pesticide applicators are not provided a tremendous amount of engineering control training. For extension agents/educators, most coordinators reported for the 14 engineering controls, they haven't provided any training sessions for 11 of them. Similarly, most coordinators also indicated they have not provided training sessions for 10 of the controls to pesticide applicators.

There are a few controls for which most coordinators have offered training. Educational sessions on container rinse systems have been provided more often than any other control. One or more sessions on low-drift nozzles, hand wash water supplies, container rinse systems, and protective clothing lockers also have been included in most applicator training programs.

Figure 8. Engineering Control Training Sessions Provided to Extension Agents/Educators

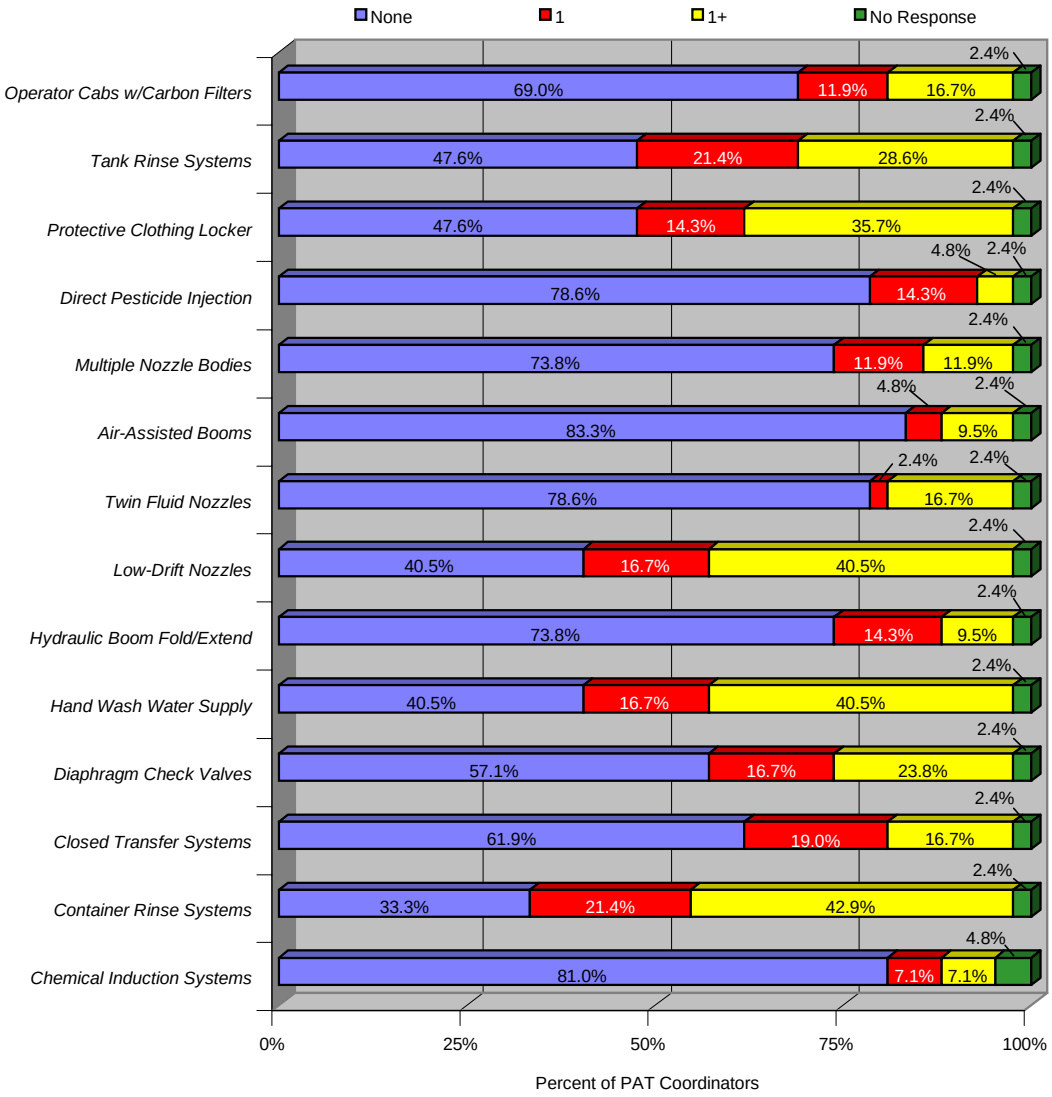
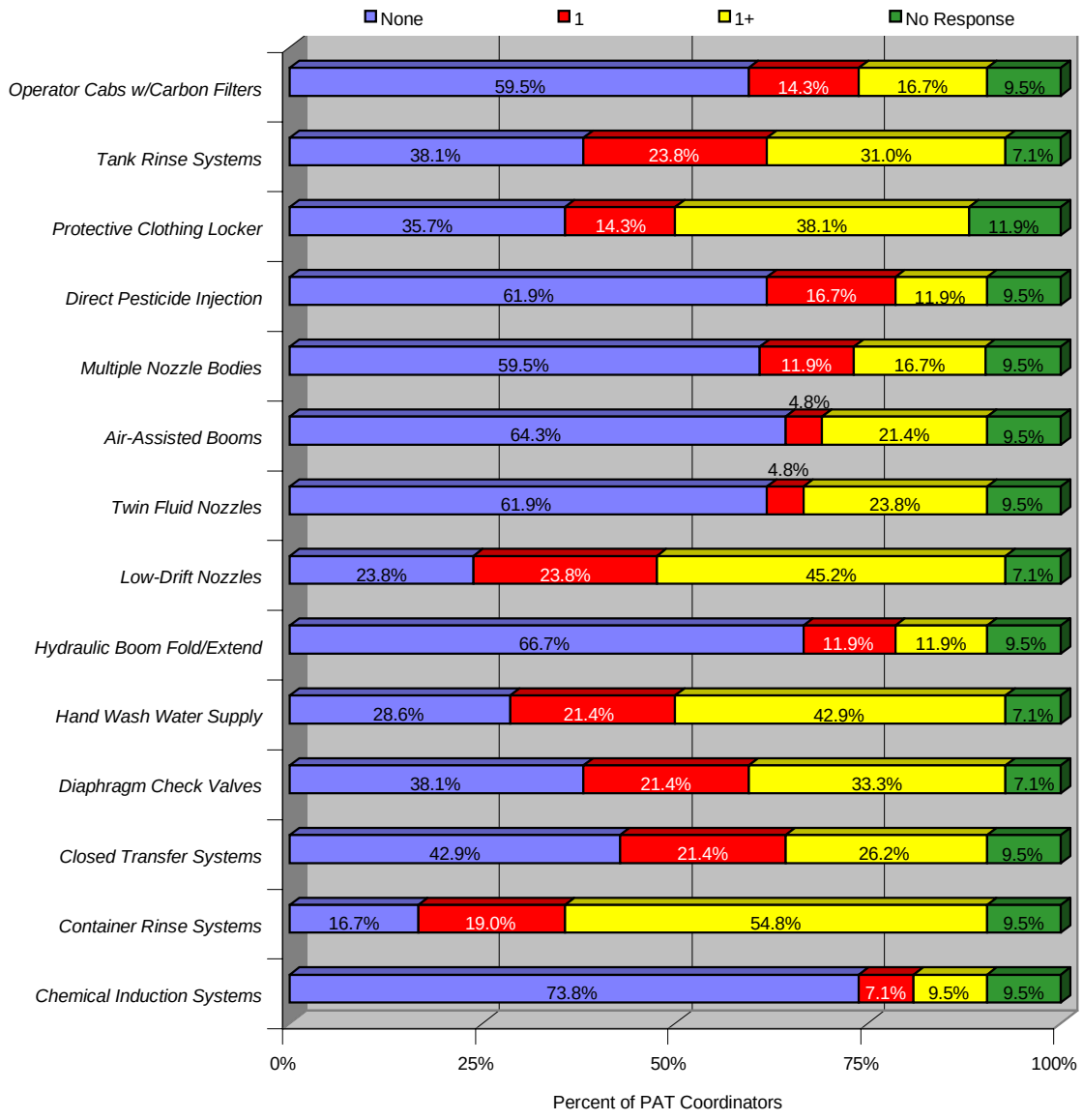


Figure 9. Engineering Control Training Sessions Provided to Pesticide Applicators



Trainer Preparedness

Since the results of this study may be used to develop pesticide application risk mitigation strategies using engineering controls, it is important to determine how well prepared PAT programs are to handle engineering control education and training. The PAT coordinators were asked to rate their program's preparedness on a scale of 1 to 10 with 1 being unprepared and 10 being completely prepared. The responses ranged from 1 to 10 with the average being 4.8. This means that coordinators feel their organizations are somewhat prepared to handle engineering control education.

The coordinators were asked to comment on what support they need to get their programs fully prepared for engineering control education. The responses can be categorized into 5 major areas: educational materials, human resources, training, financial and miscellaneous. A summary of the responses follows. Actual comments received are provided in Appendix F.

- Twenty-three coordinators provided comments relating to educational materials. Most remarks centered on the need for slide sets, videos, training materials, web sites with materials or resources, etc. to educate applicators about engineering controls. Specific suggestions included development of written materials on a national level that could be inserted into training manuals and other printed media, a centralized web site where engineering control information could be downloaded, and development of specific training modules and/or curriculums related to engineering controls.
- Eight coordinators identified human resource needs as important. Several respondents commented on the need to hire (or in one case replace) an agricultural engineer that can handle engineering control education. One suggestion included the possibility of hiring regional engineers. Others commented on the need to hire competent staff/personnel or other individuals with technical expertise on engineering controls.
- Six respondents identified training needs. Most comments indicated that training for PAT coordinators is needed.
- Three coordinators brought up finances as a concern. Two of them said they would need an increase in funding to hire technical staff to handle educational material and program development.
- Seven coordinators mentioned needs that cannot be classified under the previous four categories. Two of the coordinators mentioned they would need more information and justification for engineering control training in their state. Two other coordinators gave comments related to using controls, particularly the need to know the usefulness and problems associated with various engineering controls as well as who supplies the equipment.

Observation of Engineering Control Use

For the most part, PAT coordinators do not know how many farms in their state utilize engineering controls (see Table 3). Most coordinators indicated "Don't Know" as their response for 11 of the 14 engineering controls in the survey. Three controls were labeled by most as being used on 1% to 25% of the farms in their state. These controls include container rinse systems, closed transfer systems, and direct pesticide injection systems.

Table 34. PAT Observation of Engineering Control Use (Majority Responses)

Operations Using	Engineering Control
1% to 25%	• container rinse systems • closed transfer systems • direct pesticide injection
Don't Know	• induction bowls • diaphragm check valves • hand wash water supply • hydraulic boom fold/extend • low-drift nozzles • twin fluid nozzles • air-assisted booms • multiple nozzle body • protective clothing locker • tank rinse system • operator cabs with carbon filtration

Interest in Learning about Engineering Controls

The final question posed to PAT coordinators pertained to farm operator interest in learning about engineering controls. The coordinators were asked to indicate if farm operators are not interested, slightly interested, interested or very interested in learning about each of the 14 engineering controls. The majority of responses fall into either the slightly interested or interested categories. Only two controls -- low-drift nozzles and tank rinse systems -- fit into the "interested" category. All other controls are in the "slightly interested" group. The results of this inquiry are summarized in Figure 5.

Figure 10. PAT View of Farm Operator Interest in Learning about Engineering Controls

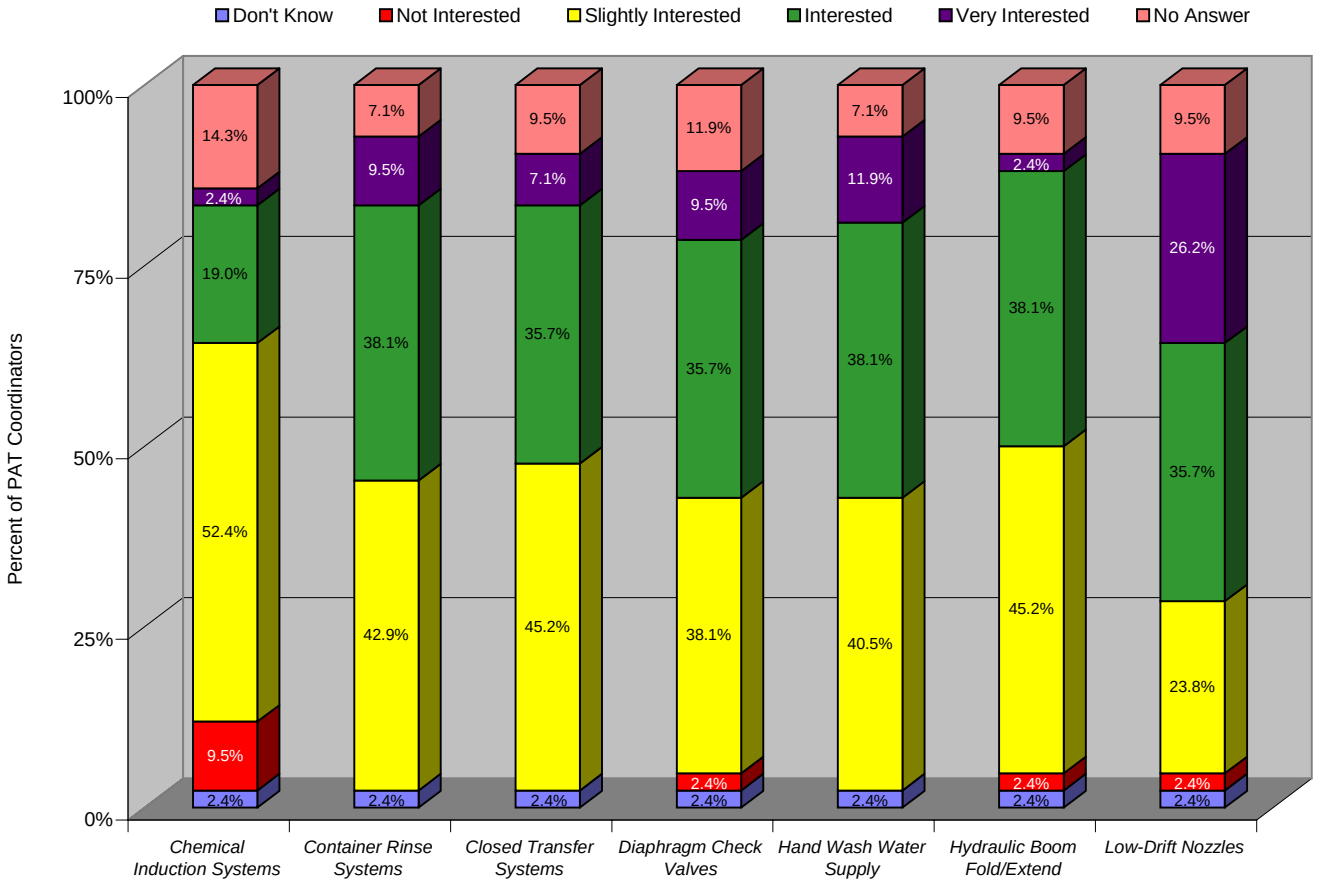
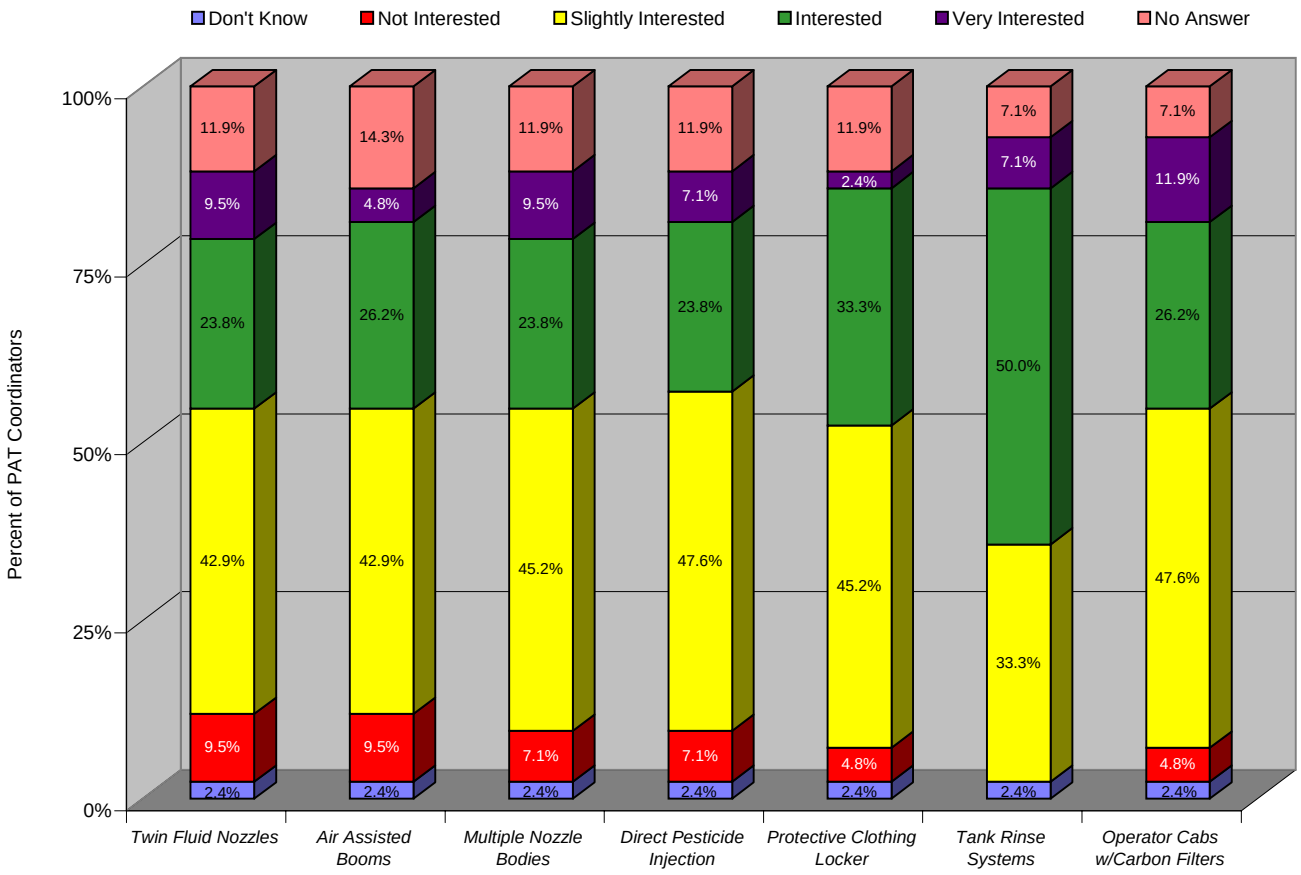


Figure 5. Farm Operator Interest in Learning (continued)



C - Summary

PAT coordinators indicated that they have at least slight familiarity with all engineering controls in the study, except for chemical induction systems. Presentations to applicators and training manuals are shown as the top two educational methods and materials. For the educational materials and methods listed in the survey, most coordinators noted they tend to facilitate general discussions regarding engineering controls. For the specific engineering controls in the study, 8 of them are only generally discussed in educational materials and programs and the rest are not discussed at all. Both extension agents/educators and pesticide applicators are not afforded many training opportunities for most engineering controls.

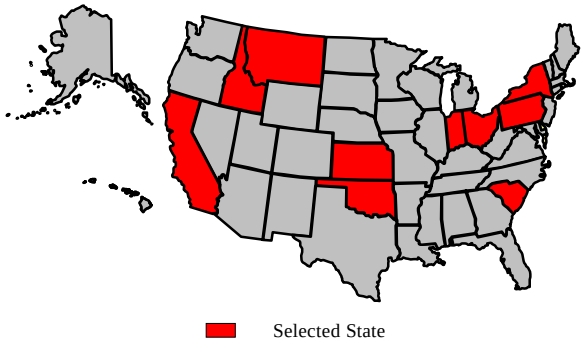
On average, PAT coordinators feel they are not well prepared to meet any increased educational demands resulting from required engineering control use. Four main areas are identified where coordinators feel assistance is needed to improve their preparedness. These areas include development of engineering control educational materials; hiring more staff (i.e., agricultural engineers, pesticide education staff, etc.) to conduct educational programs or to develop new materials and programs; and training sessions for PAT coordinators on engineering controls. More funding to help support applicator training programs in the area of engineering controls would help to expand education and training for PAT coordinators and their respective audiences.

Part IV - State Pesticide Inspector/Field Agent Survey

A - Survey Development and Implementation

A fourth area of interest is the number of farm operations that use engineering controls. To determine this, state pesticide inspectors and field agents (referred to as inspectors throughout this summary) who have regular contact with agricultural operations were surveyed. Rather than survey all inspectors in the US, ten states were selected at random. States selected are shown in Map 1. For the selected states, the inspectors were asked questions about the following:

Map 2. States Selected for Inspector/Field Agent Survey



- their familiarity with various engineering controls;
- observations of engineering control use;
- engineering control recommendations they have made;
- farm operator engineering control familiarity;
- farm operator attitude toward engineering control use;
- number of farm operations adopting engineering controls and;
- factors used in selecting engineering controls.

A sample survey is included in Appendix B.

The survey procedure was altered slightly to accommodate differences in how states administer their pesticide enforcement programs. In California, the county agriculture commissioner has chief responsibility for pesticide inspection and enforcement rather than the statewide California Department of Pesticide Regulation. Because of this, we selected the top 20[1] agricultural counties in the state and mailed the survey to the agricultural commissioner in those counties.

The inspector survey was administered the same way as the previous three groups. Survey forms with a postage-paid return envelope and a cover letter explaining the purpose of the survey were sent to all inspectors on our list. Two weeks after the initial mailing, reminder postcards were sent to all non-respondents. Approximately six weeks after the original mailing, a replacement survey form and postage-paid return envelope were sent to any remaining non-respondents.

[1] based on the cash value of all agricultural commodities

B - Results

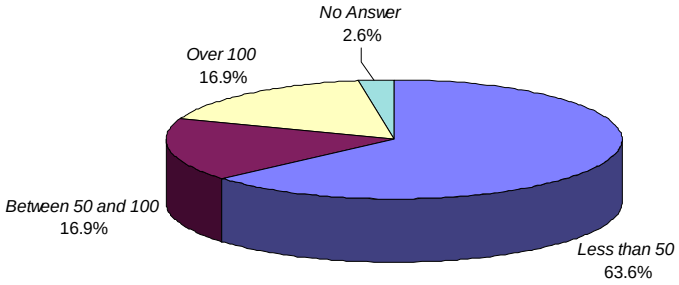
Of the 108 surveys mailed, 83 responses were received for a 76.9% response rate. Despite efforts to contact only those inspectors with agricultural pesticide responsibilities, six inspectors responded they do not work in the agriculture sector. Two other responses indicated the inspectors were not completing the survey for unspecified reasons.

Profile of Inspectors

The inspectors were asked to indicate how many farms they typically visit in a year based on the following scale: less than 50, between 50 and 100, or over 100. The majority of inspectors (63.6%) indicated that they visit less than 50 farms per year. Both the between 50 and 100 and over 100 categories have relatively few inspectors reporting they visit that many farms (16.9% for each category).

The inspectors were also asked to provide an estimate of the average size farming operation they visit. The average farm size for all respondents is 413.2 acres. There is quite a range in farm acreage reported depending on the inspector's location. The smallest acreage reported was 10 acres from a California inspector. A Montana inspector reported the largest of 5000 acres.

Figure 11. Number of Farms Visited Annually

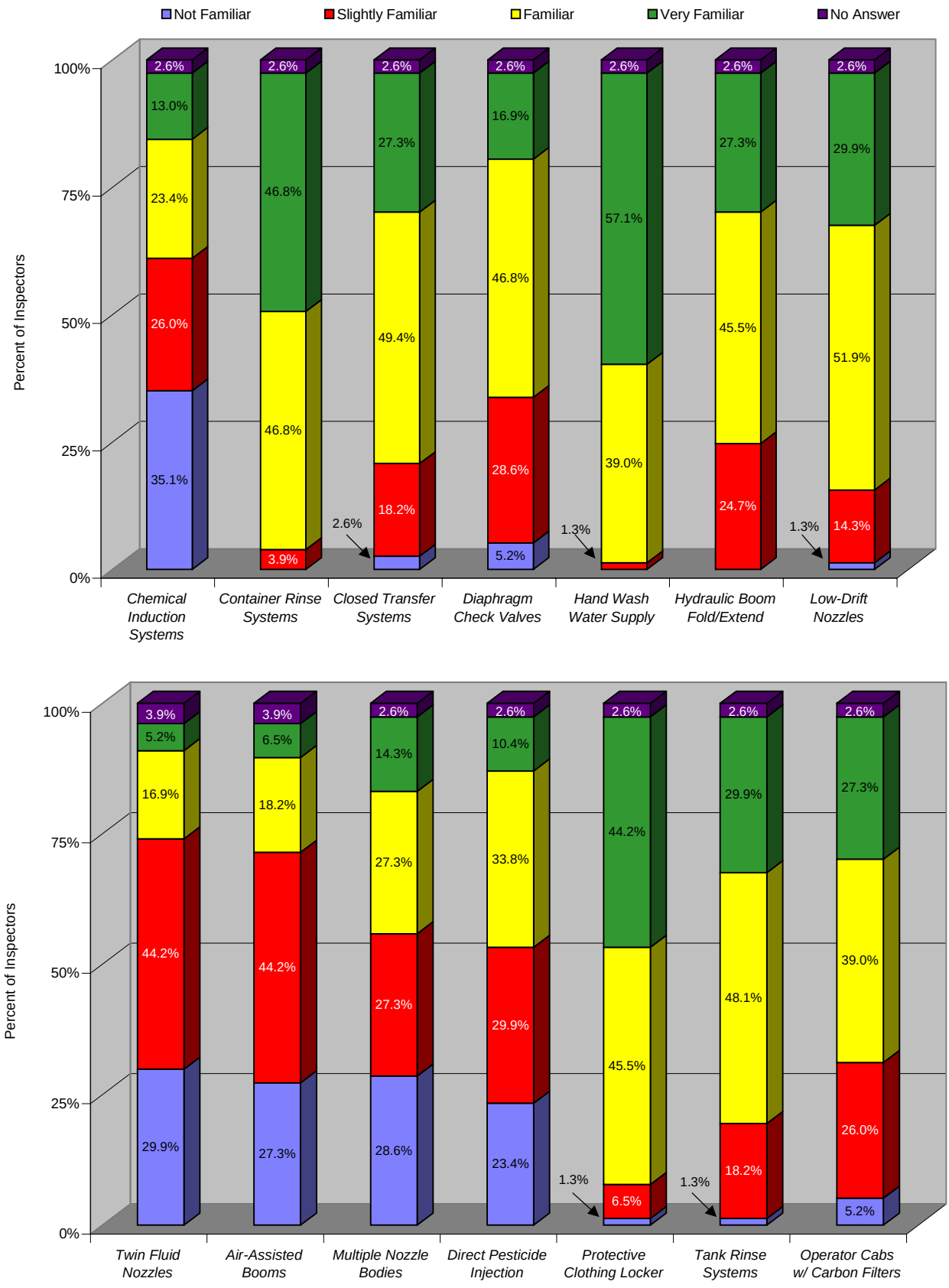


Inspector Engineering Control Familiarity and Recommendations

Since inspectors in many states are in a position to help encourage the use of engineering controls, they were asked questions about their familiarity with the various controls. The inspectors were also asked if they have literature about engineering controls to provide farm operators and which engineering controls they have recommended that a farm operator use.

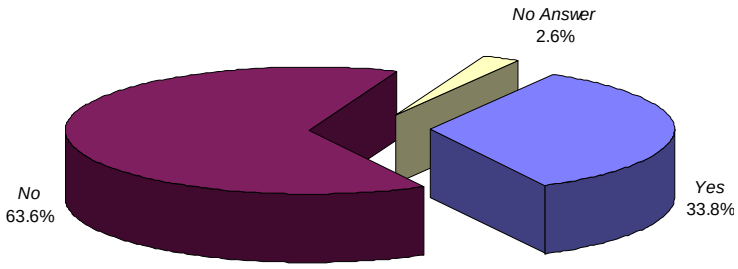
The inspectors were instructed to classify their familiarity with the engineering controls in the study based on four categories: not familiar, slightly familiar, familiar or very familiar. As shown in Figure 2, a majority of inspectors are familiar or very familiar with 9 of the 14 engineering controls. Most inspectors reported that they are slightly or not familiar with the remaining 5 controls. The most familiar controls include hand wash water supplies (96.1% being knowledgeable) and container rinse systems (93.6% being knowledgeable). Twin fluid nozzles and air-assisted booms are the least familiar engineering controls with 74.1% and 71.5% of the inspectors, respectively, report slight knowledge of them.

Figure 12. Inspector Engineering Control Familiarity



Inspectors were asked whether or not they have educational literature to provide farm operators (Figure 2). Nearly 64% of the inspectors reported not having literature to provide. This is in contrast to the 56.8% of state regulators who said their state has educational materials. Two inspectors noted they have literature but it is very limited.

Figure 13. Inspector Educational Material Availability



The inspectors were asked to indicate whether or not they have recommended any engineering controls to farm operators. It should be noted that three inspectors, each from different states, indicated they do not make recommendations, two of them reinforced that they only enforce regulations. This aside, Table 1 shows that for 8 of the controls, most inspectors at some point have recommended their use to a farm operator. Hand wash water supplies are the most often recommended control as indicated by 81.8% of the inspectors. The remaining six controls have not been recommended by most inspectors.

Table 35. Engineering Control Recommendations - Popular Responses

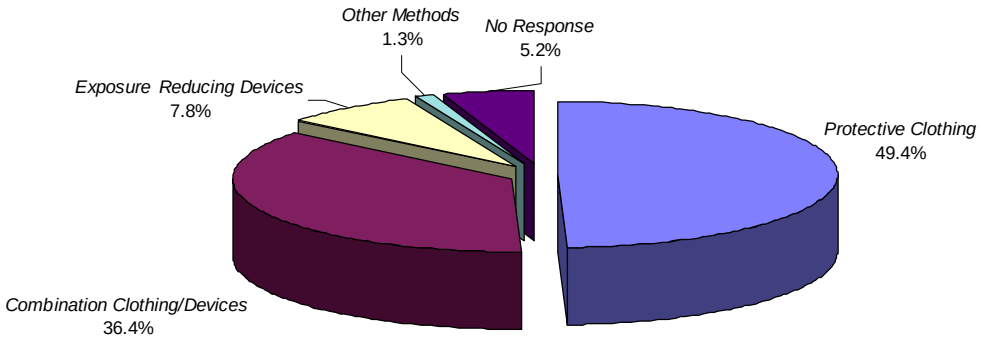
Recommended	Not Recommended
Hand Wash Water Supply (81.8%)	Twin Fluid Nozzles (81.8%)
Protective Clothing Locker (72.7%)	Air-Assisted Booms (77.9%)
Low-Drift Nozzles (68.8%)	Chemical Induction System (72.7%)
Container Rinse (64.9%)	Hydraulic Boom Fold/Extend (72.7%)
Closed Transfer Systems (55.8%)	Direct Pesticide Injection (71.4%)
Tank Rinse System (54.5%)	Multiple Nozzle Bodies (70.1%)
Diaphragm Check Valves (50.6%)	
Operator Cabs with Carbon Filters (50.6%)	

Observations of Engineering Control Use

The main purpose of the pesticide inspector/field agent survey was to determine the level of engineering control use by farm operators. Inspectors were asked to indicate if they felt farm operators most frequently used protective clothing, exposure reducing devices (engineering controls), a combination of clothing and devices or some other method to reduce pesticide exposure risk. The inspectors were also asked to indicate the percentage of farm operations they visit using each engineering control.

When asked their views on what farm operators use to reduce pesticide exposure risk, almost half of the inspectors (49.4%) indicated that protective clothing is most frequently used (Figure 4). Only 7.8% of the inspectors indicated that they felt exposure reducing devices (engineering controls) were used most often. One inspector noted "other" methods are used most often and indicated that the equipment consists of leather gloves and a baseball-type cap.

Figure 14. How Farm Operators Reduce Pesticide Exposure Risk



Inspectors were asked what percentage of farms they visit use each engineering control based on the following: none, 0-25%, 26%-50%, 51%-75%, 76%-99%, or all of the farms. Overall, most engineering controls are used by relatively few farm operations. For 11 of the 14 controls, most inspectors indicated that 0% to 25% of the farm operations they visit use them.

Hand wash water supplies are the most used engineering control with almost one-third (31.2%) of them noting 76% to 99% of the farms they visit use them. The reported high use rate could be attributed to worker protection regulations that require hand wash water supply use and the fact that inspectors included all forms of wash water in addition to sources mounted on spray equipment in their responses. Twenty-six percent of the inspectors reported seeing 26% to 50% of the farms using low-drift nozzles and diaphragm check valves. Figure 5 shows the results for the other controls.

Figure 15. Inspector Engineering Control Use Observations

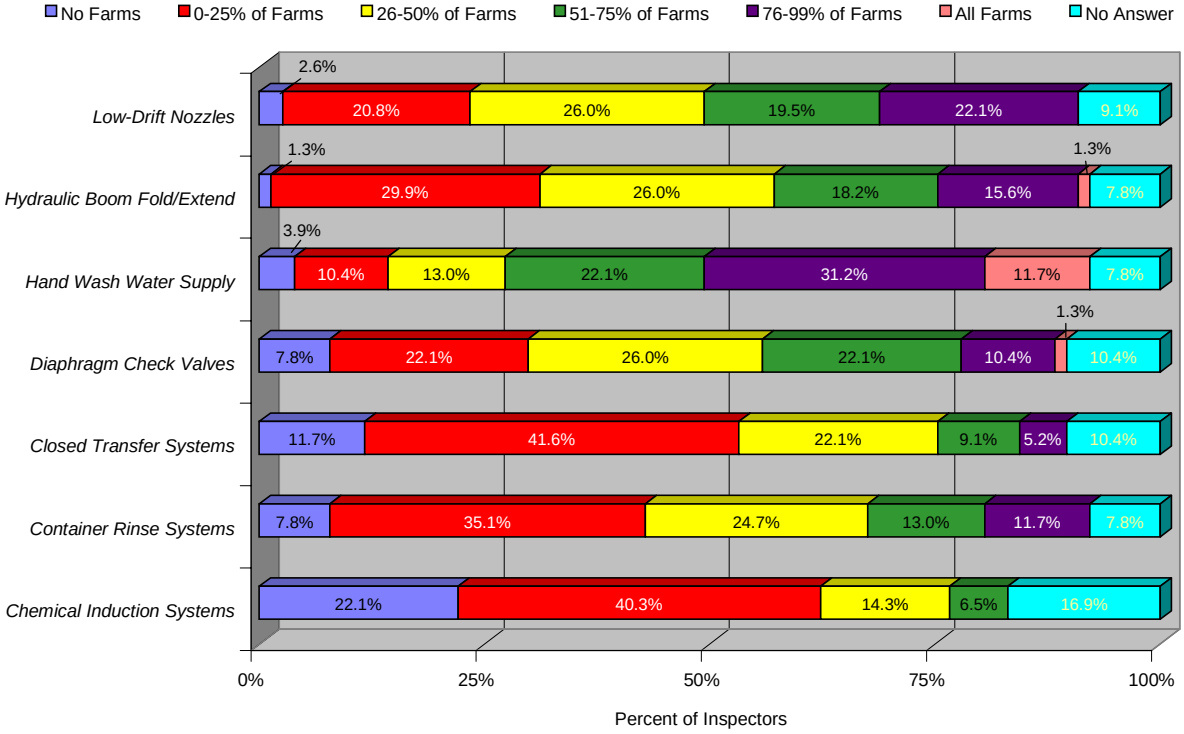
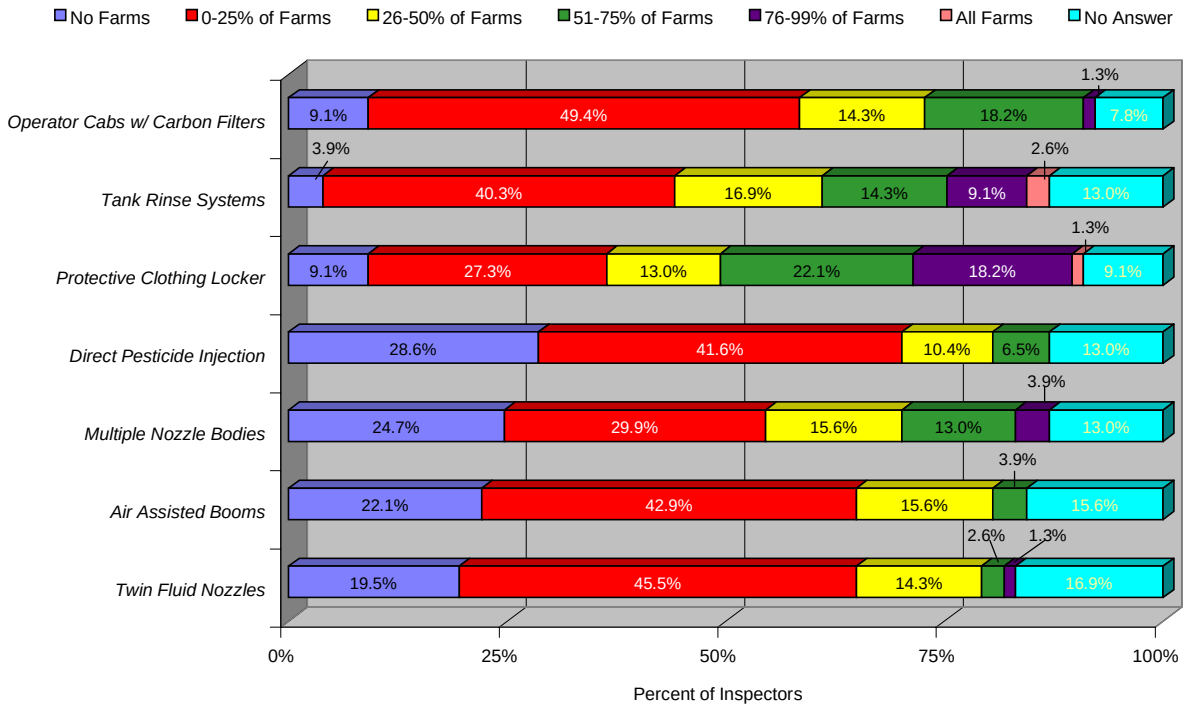


Figure 5. Inspector Engineering Control Use Observations (continued)



Inspectors were asked to provide information on what types of farm operations they see using engineering controls. Sixty-two inspectors noted seeing field crop operations employing engineering controls (Table 2). Vegetable farms received the second highest number of responses (41 inspectors). Small fruit operations were noted as utilizing the fewest engineering controls (9 inspectors). Twelve inspectors reported seeing other commodities using engineering controls (cotton, cut flowers, nursery, greenhouse, forestry, pasture, hay and tobacco).

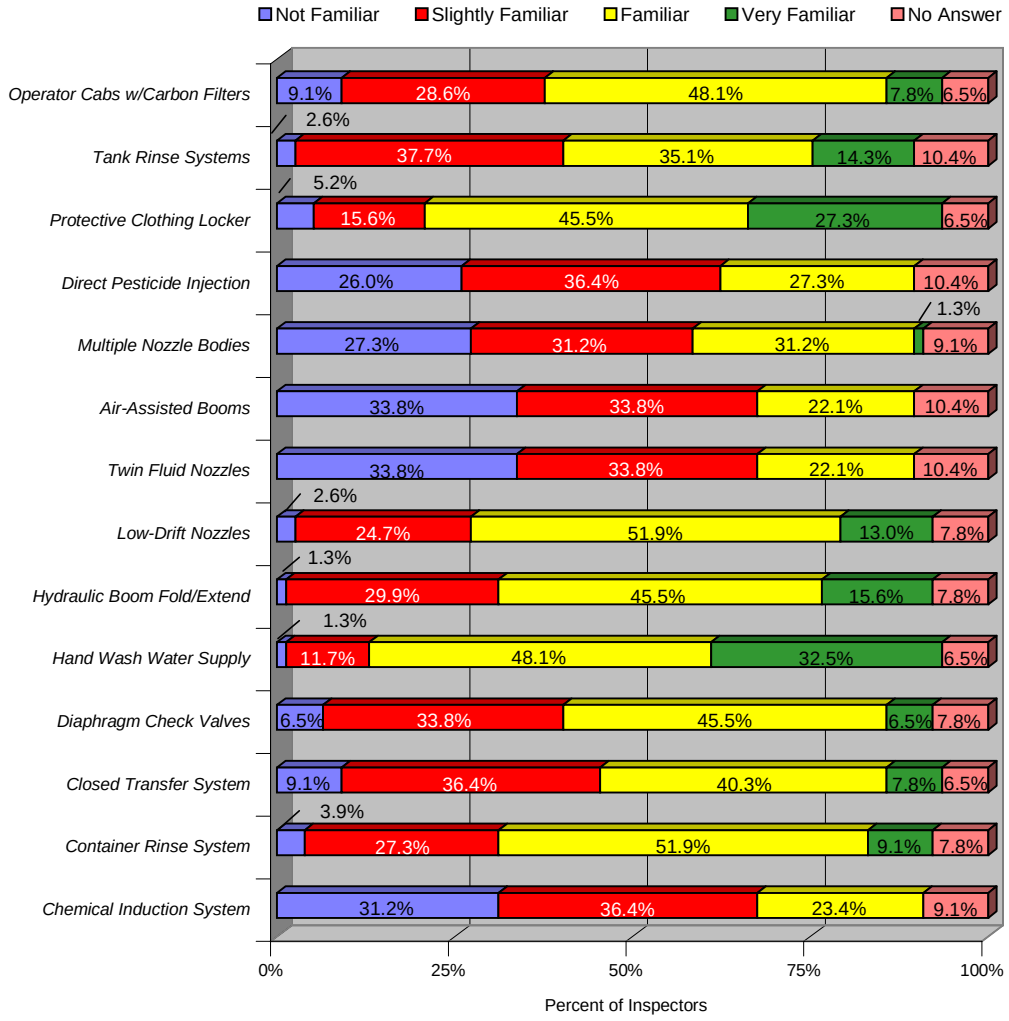
Table 36. Commodities Using Engineering Controls

Commodity	*Number of Inspectors*
Field Crops	62
Vegetables	41
Tree Fruit	40
Vineyard	21
Turfgrass	21
Nuts	13
Small Fruits	9
Other	12

Farm Operator Familiarity with Engineering Controls

Each inspector was asked to rate farm operator familiarity with each engineering control. In general, most farm operators appear to have some level of familiarity (slightly familiar or better) with all controls included in the survey. Twin fluid nozzles and air-assisted booms have the highest percentage of inspectors reporting "not familiar" (33.8%). Container rinse systems and low-drift nozzles each have a majority (51.9%) of the inspectors noting "familiar."

Figure 16. Farm Operator Engineering Control Familiarity - Inspector View

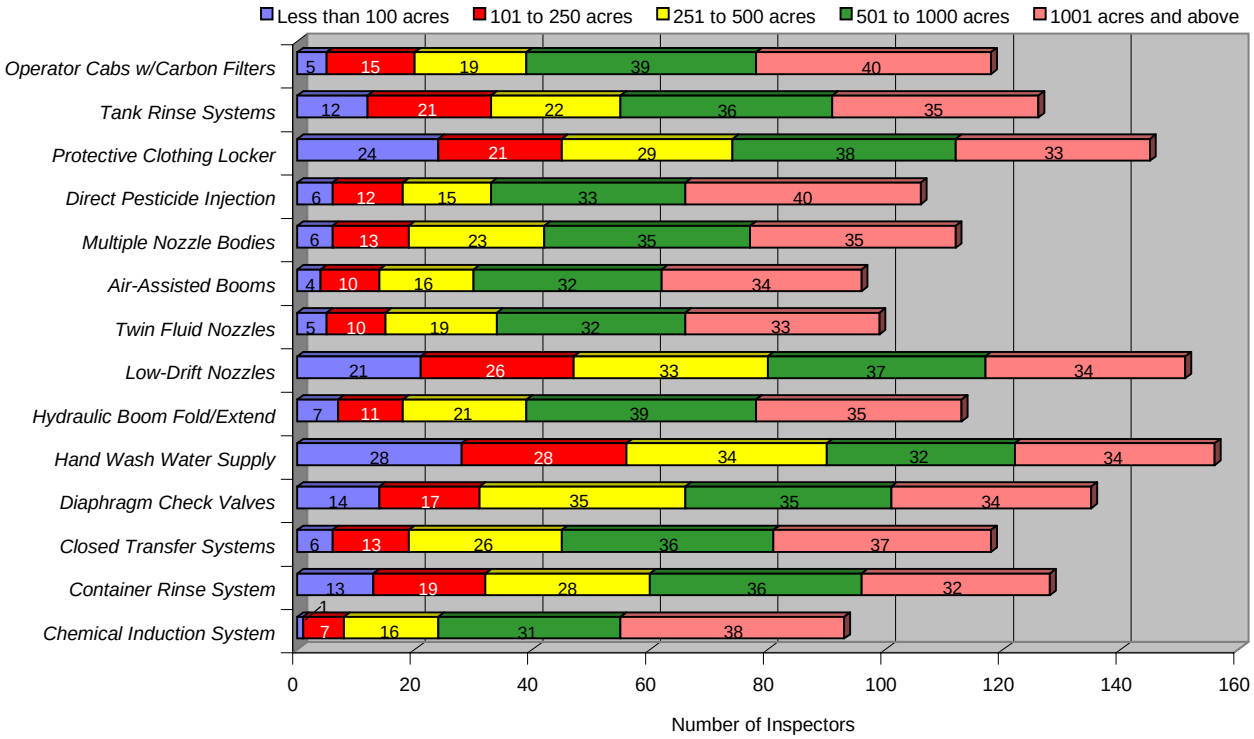


Farm Sizes Adopting Engineering Controls

Inspectors were asked to equate farm size with adoption of engineering controls. They were asked to select farm size as less than 100 acres, 101 to 250 acres, 251 to 500 acres, 501 to 1000 acres or 1001 acres and larger. In general, the inspectors noted that they felt larger farms, typically 501 acres and above, are more likely to adopt engineering controls. This was the case for all controls except hand wash water supplies, low-drift nozzles and protective clothing lockers which are adopted by more farms in the 1 to 500 acre size range.

Relatively few small farms are noted as adopting engineering controls. The hand wash water supply was most frequently reported as being used on 100-acre and less sized farms. This might be attributed to regulations requiring hand wash water being made available to workers. Small farms (less than 100 acres in size) also frequently employ protective clothing lockers. Chemical induction systems are the least likely to be adopted by small farms as only one inspector noted so.

Figure 17. Farm Sizes Most Likely to Adopt Engineering Controls[1]



[1] *Total number of responses for each control are not equal due to inspectors selecting multiple responses.*

Voluntary Versus Mandatory Engineering Control Use

Since the survey results may be used to develop future engineering control use policies, the impact of requiring engineering controls on the receptiveness of farm operators was determined. The inspectors were first asked how receptive farm operators would be to voluntary use of engineering controls and, then, how receptive they would be if engineering control use is required.

The majority of inspectors indicated that for 9 of the 14 controls, farm operators would be receptive to voluntarily using them (Table 3). Hand wash water supplies and low-drift nozzles received the highest number of responses each with 58.4% of the inspectors. Most inspectors indicated that farm operators would be slightly receptive to voluntarily using the other 5 engineering controls. Air-assisted booms lead this group with 44.2% of the inspectors indicating "slightly receptive."

Table 37. Voluntary Engineering Control Use - Majority Responses

Receptive	Slightly Receptive
Hand Wash Water Supply (58.4%)	Air-Assisted Booms (44.2%)
Low-Drift Nozzles (58.4%)	Twin Fluid Nozzles (42.9%)
Diaphragm Check Valves (53.2%)	Multiple Nozzle Bodies (41.6%)
Container Rinse System (51.9%)	Chemical Induction Systems (40.3%)
Tank Rinse System (48.1%)	Direct Pesticide Injection (36.4%)
Protective Clothing Locker (45.5%)	
Hydraulic Boom Fold/Extend (42.9%)	
Operator Cabs with Carbon Filters (42.9%)	
Closed Transfer System (41.6%)	

The inspectors changed their views slightly when asked about mandatory engineering control use (Table 4). Closed transfer systems and hydraulic boom fold/extend shifted to the slightly receptive category if required. Most inspectors (55.8%) believe low-drift nozzles would be well received by farm operators if required. Twin fluid nozzles, on the other hand, show the majority of inspectors (44.2%) indicating they would not be well received. Two inspectors made additional comments to this question that included, "In my experience, farmers do not like to be told they have to do anything," and "They will become hostile if these become required by law."

Table 38. Required Engineering Control Use - Majority Responses

Receptive	Slightly Receptive
Low-Drift Nozzles (55.8%)	Twin Fluid Nozzles (44.2%)
Container Rinse Systems (48.1%)	Air-Assisted Booms (41.6%)
Diaphragm Check Valves (46.8%)	Chemical Induction Systems (40.3%)
Hand Wash Water Supply (46.8%)	Closed Transfer Systems (37.7%)
Protective Clothing Locker (46.8%)	Hydraulic Boom Fold/Extend (37.7%)
Operator Cabs with Carbon Filters (41.6%)	Direct Pesticide Injection (37.7%)
Tank Rinse Systems (40.3%)	Multiple Nozzle Bodies (36.4%)

Figure 8 compares the responses between voluntary and mandatory (required) use. Responses for several categories change, some significantly. One of the largest changes is in regards to low-drift nozzles, which show a 600% increase in the number of "not receptive" responses when moving from voluntary to mandatory use. This increase appears to be due to a shift of responses from the slightly receptive and receptive categories. Other significant swings include protective clothing lockers and hydraulic boom fold/extend. A 233.3% and a 220.0% increase in the number of not receptive responses occurred, respectively, in each category.

Figure 18. Farm Operator Receptiveness - Comparison between Voluntary and Required Engineering Control Use

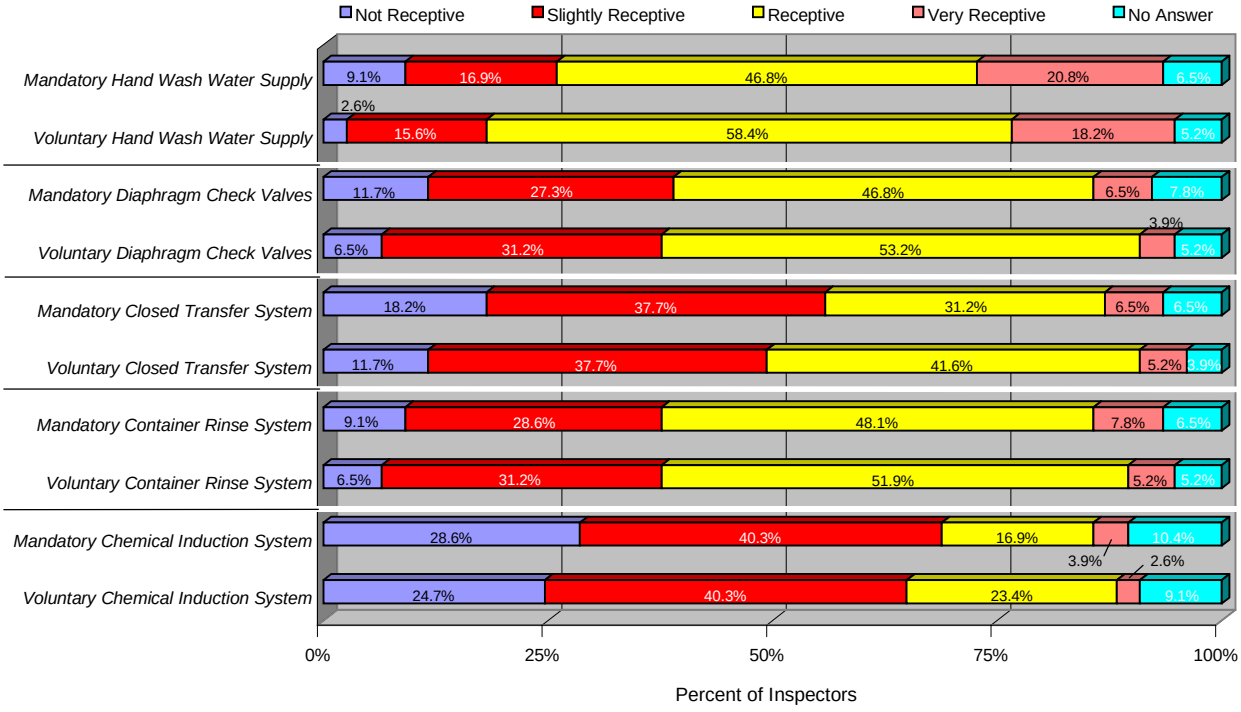
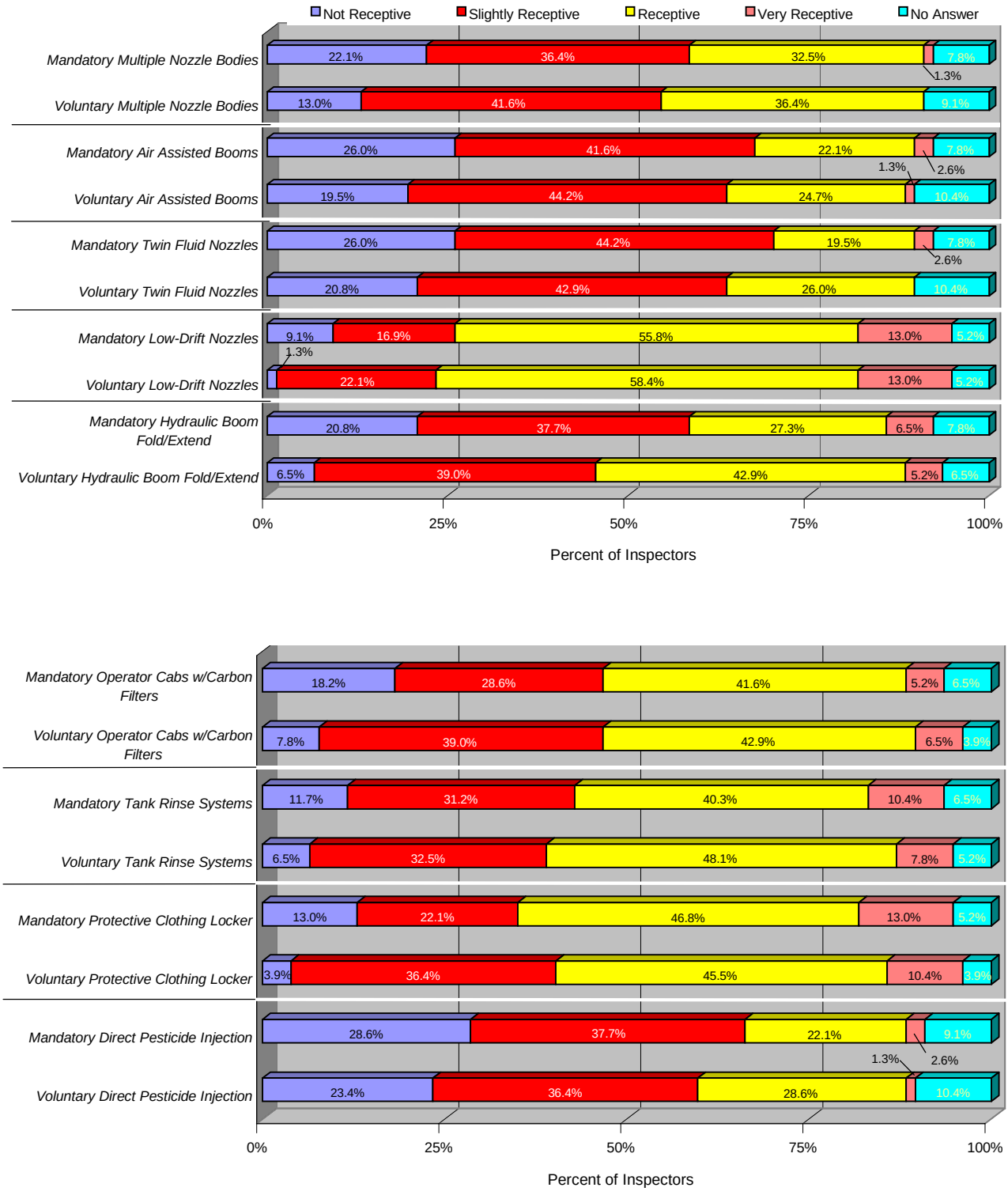


Figure 19. Farm Operator Receptiveness - Comparison between Voluntary and Required Engineering Control Use (continued)

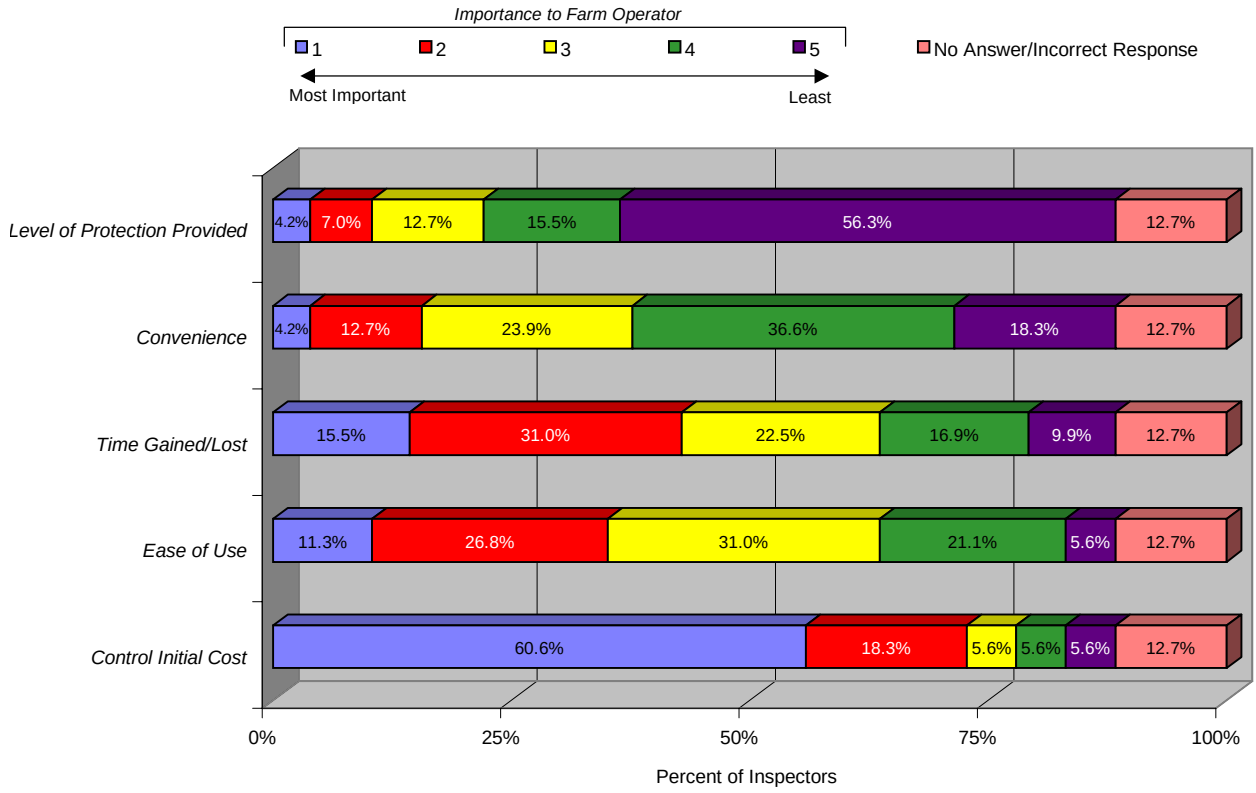


Engineering Control Selection Criteria

In order to understand what is important to farm operators when selecting engineering controls, inspectors were asked to order the following factors on a scale of 1 to 5, where 1 is the most important factor to a farm operator and 5 is the least important factor:

- engineering control initial cost;
- ease of use;
- time gained or lost in the spraying process;
- convenience of the engineering control and;
- level of protection provided by the engineering control.

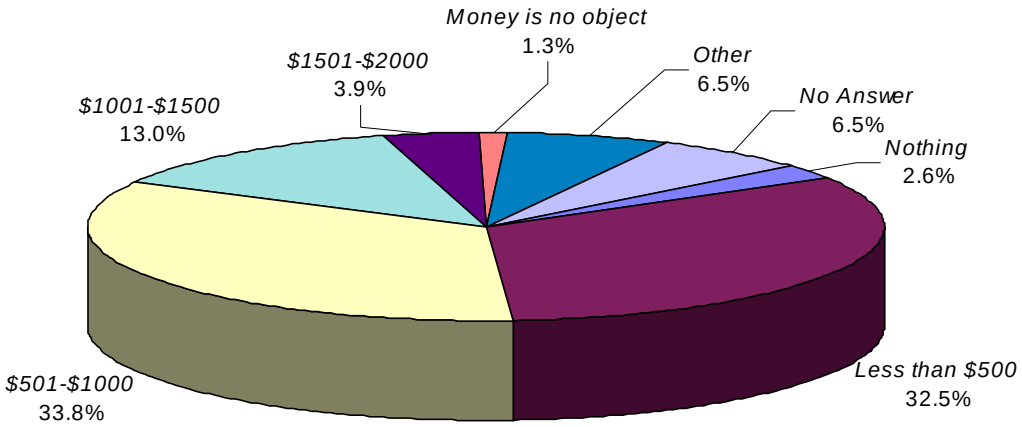
Figure 20. Factors in Engineering Control Selection



As shown in Figure 10, engineering control cost was rated most important by 60.6% of the inspectors. The level of protection provided by the engineering control was ranked by 56.3% of the inspectors as being the least important factor.

By coincidence, inspectors were asked what they felt farm operators would be willing to spend on purchasing engineering controls. Responses from 66.3% of the inspectors indicate that farm operators would be willing to spend $1000.00 or less on engineering controls. Most inspectors (33.8%) said they felt farm operators would be willing to spend between $501 and $1000. Looking at the extremes, 2.6% of the inspectors indicted that farm operators they visit would spend nothing on controls and 1.3% noted that money is no object.

Figure 21. Inspector View of Price Farm Operators Willing to Pay for Engineering Controls



C - Summary

The pesticide inspector/field agent survey results show several things. One is that inspectors have some familiarity with the engineering controls in the study. Most inspectors report that they have, at some point, recommended the use of 8 different engineering controls to farm operators. Inspectors identified larger farms as being more readily acceptable to using most engineering controls. The inspectors also showed there is little change in the perceived attitude of farm operators between voluntary engineering control use and mandatory control use. Finally, the inspectors indicated that cost is the top factor they see farm operators using to select engineering controls and farm operators most likely would be willing to pay no more than $1000 for an engineering control.