ATTACHMENT 1

Summary of Studies on Water Quality
and Nutrients and Pesticides

SURFACE WATER

Nutrients – A Review of Scientific Studies

The major concern over contamination of surface waters from runoff at golf courses, including The Preserve, focuses on nutrients and pesticides. From turf areas, the major concern over contamination of surface waters from runoff containing nutrients is for phosphorus and nitrate nitrogen.

Phosphorus

Phosphorus is unlikely to create problems at the golf course except under very specialized conditions in ponds and streams. Excessive phosphorus in surface waters may cause unwanted algal blooms and deteriorate water quality. Even though the granular phosphorus fertilizer carriers are greater than 88% water soluble and totally water soluble forms exist for liquid application, the phosphorus becomes rapidly fixed within the soil profile and vertical movement in most soils is only 0.3 to 1.2 inches/year (Young et al., 1985). Possible phosphate movement due to soil erosion could be a point source of pollution in turf systems (Walker, 1990). However, these instances would be very site specific and nonexistent where BMPs are employed and runoff is retained to be filtered within the golf course. Also, by matching the nutrient requirements of the turf with applications of fertilizer, the probabilities for runoff are reduced. Besides the work previously discussed, recent research at Pennsylvania State University by Watschke and Mumma (1989) found no sediment loss associated with runoff from turfed plots and observed phosphate losses which averaged only 0.5 lb/acre when runoff did occur. Their study was conducted on slopes ranging from 9 to 14% under intense precipitation simulations. Total phosphorus loss in surface runoff for the entire growing season from a tall fescue/Kentucky bluegrass turf was only 0.0178 lbs/acre (Gross et al., 1990). More recent work at Pennsylvania State University found that in runoff from creeping bentgrass and perennial ryegrass turf conditions phosphate loss was reduced compared to the initial concentrations in the irrigation water by up to 94%. Similarly, phosphate concentration in leachate from the same turf areas found up to a 77% reduction (Linde et al., 1994). This indicates the turf is acting as a filter to remove nutrients from the water source prior to runoff or leaching occurring. The most vulnerable time for phosphate to be lost is immediately following fertilization when excess irrigation or heavy rainfall would cause movement. This occurrence can be avoided by 1) not fertilizing when

rain is predicted; and 2) making certain that fertilizer is irrigated to remove the material from the leaves into the soil immediately following application.

Nitrogen

Nitrate-nitrogen (NO_3-N) movement in surface runoff can also be minimized by management decisions. Research has shown that the total nitrogen loss from a fertilizer application can be reduced from 9.5% of the total amount applied using urea as the nitrogen carrier to 0.26% by changing to a slowly available carrier such as sulfur coated urea (Dunigan et al., 1976).

In evaluations of the loss of nitrogen in surface runoff under nominal environmental conditions, Morton et al. (1988) found that surface runoff occurred on only two storm events on a Kentucky bluegrass turf in Rhode Island during 2 years of monitoring. Previous environmental factors (rainfall on frozen ground with snow cover and saturated soils from prior rainfall) helped generate the runoff. Nitrogen losses from these events were 0.089 and 0.356 lbs./acre or only 0.16% of that applied. Gross et al. (1990) observed that the loss of nitrogen in the surface runoff from a tall fescue/Kentucky bluegrass turf was only 0.12 lbs/acre for an entire growing season (0.05% of that applied) compared to 10.4 lbs/acre for tobacco, almost 90 times greater. Meisinger and Randall (1991) noted that nitrogen losses in surface runoff are usually small and depend on degree of soil cover, source of nitrogen applied, rainfall intensity immediately after application and soil properties. They also noted that the largest losses will occur when a soluble nitrogen source is applied to a bare soil and a significant runoff event occurs within one day of application. Linde et al. (1994) found that nitrate-N in concentrated runoff from experimental turfgrass plots never exceeded the drinking water standard of 10 ppm and there was actually a decrease of up to 96% in the nitrate-N found in runoff compared to nitrate-N found in the irrigation water. Similar results were found in the leachate with up to 80% of the nitrogen removed compared to amounts found in the irrigation water. Best Management Practices if implemented effectively can effectively eliminate problems associated with nutrient loss during runoff or leaching. Although less than drinking water standards, nitrate concentrations greater than approximately 0.5 mg/l are of concern to the ecological health of an ecosystem (Wetzel 1982).

Movement of pesticides into surface water during runoff events at The Preserve depends on the following: 1) pesticide characteristics such as solubility, adsorption, and persistence; 2) soil characteristics such as soil texture, permeability, water holding capacity, pH, organic matter; 3) site conditions including depth to groundwater, slopes, distance to environmental features, and climate; and 4) management practices such as selection of pesticide, application methods, pesticide rates, timing, and irrigation management. Watschke and Mumma (1989) reported on the potential for surface movement of selected pesticides in undiluted runoff on research plots under an extremely high irrigation rate of 6 inches/hour. They monitored for pendimethalin (a commonly used preemergent herbicide); 2,4-D, 2,4-DP, and dicamba (commonly used postemergent herbicides); and chlorpyrifos (an insecticide). For pendimethalin and chlorpyrifos, no chemical was detected in any of the runoff on all 24 sample dates. These materials based on their chemistry become fixed in the soil after application and do not move. For 2,4-D and dicamba, the amounts in the concentrated runoff exceeded federal water standards on 4 sample dates (2,4-D), and 1 sample date (dicamba) out of 24 sample events, despite these materials being more water soluble and made as foliar applications. However, these levels were only found when runoff occurred within 2 days after application. They noted that under natural storm water runoff conditions and subsequent dilution outfall concentrations would be considerably less. Similar findings with 2,4-D applications were noted by Thompson et at. (1984). Under field conditions the greatest dislodgeable leaf residues of 2,4-D on Kentucky bluegrass were less than 4.5% of the total applied at time 0, immediately after application, indicating very rapid adsorption to the leaf surface and a strong affinity for adsorption. No dislodgeable residues were detected at 3 days after application. Hurto (1991) noted that the dissipation rate of foliarly applied pesticides depends on volatilization, plant absorption and photodecomposition. He summarized that research has found that less than 10% of the applied rate amount can be found as foliar residue the day after application and that within 1 to 3 days after application levels drop to between 1 and 3%. Careful attention to application timing with respect to rainfall and irrigation management can minimize removal of materials which could become nonpoint pollutants. Smith (1995) found that approximately 8% of the applied amount of a 2,4-D+mecoprop+dicamba herbicide application left treated plots due to runoff over a 25-day collection period. Eighty percent of this amount moved during the first irrigation event following application. Since only 6 hours are required after treatment for maximum efficacy, it was suggested that an irrigation 6 to 12 hours after application to wash the excess pesticide from the foliage into the thatch and/or soil would negate the possibility of runoff. Watschke and Mumma (1989) concluded that

nutrient and/or pesticide concentrations in storm water and the impact on surface water would be considerably less than other urban pollutants not associated with well managed turfgrass areas.

GROUNDWATER

The major concern over contamination of groundwater from infiltration also focuses on nutrients and pesticides. From turf areas, the major concern over contamination of ground waters from leaching is for nitrates and pesticides.

Nitrates

Most of the significance associated with nutrient leaching is focused on nitrate nitrogen (NO_3-N). Because nitrates are anions, they do not respond to the exchange capacity of the soil. Consequently, if not taken up by the plant, or fixed in the soil organic fraction through microbial activity, they can become a potential pollution problem in the percolating water. Reviews of the currently published research on nitrogen fertilizers applied to turfgrasses (Balogh and Walker, 1992; Petrovic, 1990) has determined that nitrate-nitrogen concentrations in soil water leaching through the surface soil exceeds drinking water standards of 10 ppm on sandy soils when one of the following conditions exist: 1) high levels of soluble nitrogen are applied, greater than 3 lbs. N/1000 sq.ft. at one time; or 2) very frequent (daily) irrigation is practiced coupled with application of large concentrations of water soluble nitrogen sources. Petrovic further noted that the degree of nitrate leaching is influenced by soil type, irrigation practices, nitrogen source and rate, and season of application. Gilliam (1988) noted that if all of the nitrogen applied to crops in North Carolina in one year went into groundwater, then based on percolating water volumes, the nitrate-N concentration would only be 4 ppm, far below the World Health Organization drinking water standard of 10 ppm. Although less than drinking water standards, nitrate concentrations greater than approximately 0.5mg/l are of concern to the ecological health of an ecosystem.

Anderson et al. (1981) demonstrated that a soil-turf filter can remove applied nitrogen from municipal wastewater at a very efficient level (> 52 % on a 95% sand: 1% silt: 4% clay mix and > 64% on a 89 % sand: 5 % silt: 4 % clay: 2 % organic matter mix). Minimizing nitrate movement is

directly related to best management practices by efficiency in rate and timing of nitrogen inputs through choice of materials and efficiency in rate and timing of irrigation.

All of these factors when addressed should reduce or eliminate nonpoint source losses of nutrients from golf course areas at The Preserve as a direct result of management by the golf course superintendent.

Pesticides

Pesticide contamination concerns are based on findings of several surveys which were conducted in the mid-1980s on drinking water wells and ground water sources which identified agricultural pesticides in the water (Nesheim, 1986; Rao et al., 1988). A number of factors determine the potential for pesticide movement and ground water contamination. Pesticide factors include reactivity with the soil, half-life, and time and rate of application. Soil factors also influence vulnerability with sandy soils low in organic matter having a greater tendency for problems. Soil pH and the presence of channels which may provide macropore flow also are factors influencing movement. The application site itself is also more vulnerable if it has a shallow depth to the ground water table, is in a particularly wet climate or extensive irrigation is practiced or if the pesticides are injected into the soil through the turf canopy (Anonymous, 1989). As part of the overall interaction of management practices, Weber and Keller (1989) have shown that plant water use will slow the leaching of pesticides and allow for more interaction within the root zone where material degradation is faster.

A review of specific studies which have investigated turf application of materials and monitoring for surface and ground water problems have found that the majority of research from currently labeled materials have not exceeded acceptable limits. A recent US Geological Survey study in Florida documented several pesticides that exceeded the MCL (Maximum Contaminant Level) or guidance concentration (USGS, 1996). Findings from other studies have indicated concentrations below regulatory levels. A study by Mitchell et al. (1976) in Delaware found that dicamba (a commonly used postemergent herbicide) leached in putting green soils, but only at a 100 parts per billion (ppb) maximum concentration which did not exceed drinking water standards of 210 ppb. A similar study by Gold et al. (1988) in Rhode Island showed that under home lawn application conditions, dicamba concentrations in the soil water exceeded 1 ppb in less than 10% of the samples and were in

the 5 to 10 ppb range in only 4% of the samples. In this same study, concentrations of 2,4-D (also a postemergent herbicide) exceeded 1 ppb in only 4% of the samples and in 83% of the samples it was below detection limits. The conclusions from these studies were that the turf, due to its dense thatch layer and high soil organic matter content attenuated herbicide movement. The Rhode Island study concluded that the herbicide concentrations did not exceed drinking water standards at any time during the growing season.

In a Florida study, ground water test wells on two golf courses in Palm Beach county were tested for 37 different pesticides. One of these wells was located between two putting greens where the highest incidence of pesticide use on golf courses occurs. Test results indicated that none of the chemicals targeted for detection were found in the water samples from the two golf courses (Kahler, 1990). Additional sampling has also found that no chemicals were detected in any of the water samples from the test wells (Jarrell, 1991, personal communication). Additionally, the EPA has released results of a well water survey conducted over a period of two years. They tested 1,347 randomly selected wells for 126 pesticides and their metabolites. Among the materials used on turf, only atrazine, bentazon, simazine, and dacthal were found and only atrazine was occasionally found at levels above those considered minimal to protect human health (Kahler, 1990).

A study conducted in Florida on 8 golf courses found nutrients and traces of pesticides in ground water, surface water and irrigation ponds (USGS, 1996). This is in a sensitive ecosystem where sandy soils, high rainfall and heavy uses of pesticides and fertilizers occurs. From an ecological view, the majority of the detection were below 1 ppb, and those which were higher were mostly for pesticides that are not toxic to aquatic organisms. However, human health standards were violated when Acephate and Simazine in surface waters, and Bentazon, Arsenic, Atrazine and Acephate exceeded the MCL (maximum contaminant levels) or a guidance concentration. Another recent study in North Carolina also found pesticides in groundwater from a golf course operation. Simazine was found at concentrations of 1.6, 3.1 and 7.4 ppb on three different sample dates (NC Interagency Task Force, 1996). These studies point out the need for judicious use of pesticides, correct selection of pesticides, and for an IPM program.

Balogh and Anderson (1992), in a literature review, summarized results of pesticide studies and indicated that the rate and timing of pesticide application in relation to precipitation/irrigation that produces runoff or leaching episodes is a critical management consideration. No pesticide

application should be made when the possibility of rain is imminent. Materials which require water for activation are best watered into the soil with controlled irrigation. Based on this assessment, a well developed management plan, properly implemented, should provide the environmental protection and enhancement desired with golf course development.

ATTACHMENT 2

Pesticide Use Risk Assessment Data

Table A2. Table of the output for Tier I models GEENEC and SCI-GROW for evaluation of pesticides considered for use at The Preserve Country Club.

Pesticide	Health Advisory Level	LC50	GEENEC Output				Sci-Grow Output	Tier 1:	Tier 1:
			Peak Runnoff	Avg 4 day Runnoff	Avg 21 day Runnoff	Avg 56 day Runnoff	Drinking H2O	Acute Aquatic	Chronic Aquatic
	ppb	ppb	ppb	ppb	ppb	ppb	ppb		
Fungicides									
azoxystrobin	nd	259	3.66	2.27	0.74	0.47	0.265	0.01	0.03
chloroneb	90	4200000	63.251	54.982	48.642	40.236	18.63	0.00	0.00
chlorothalonil	2	49	127.37	40.61	10.01	5.49	4.92	2.60	2.04
cyproconazole	nd	19000	135.628	121.23	112.6	108.684	12.548	0.01	0.06
etridiazole	nd	4000	17.77	6.31	1.59	0.89	1.42	0.00	0.00
fenarimol	500	900	28.39	12.67	3.5	2.1	12.27	0.03	0.04
fosetyl-Al	21000	75800	53.03	51.83	41.69	30.6	0.03	0.00	0.01
flutalonil	nd	5400	16.328	12.554	8.967	6.669	2.258	0.00	0.02
flutalonil	nd	5400	16.328	12.554	8.967	6.669	2.258	0.00	0.02
iprodione	280	2250	13.32	5.74	1.64	1.02	11.93	0.01	0.01
mancozeb	21	400	120.34	34.89	8.19	4.26	5.9	0.30	0.20
maneb	40	1900	109.36	66.4	54.26	33.25	6.33	0.06	0.29
mefenoxan (metalax									
metalaxyl	420	12500	10.71	9.74	6.35	4.24	0.638	0.00	0.01
myclobutanil	200	4200	45.685	22.361	12.321	10.587	2.374	0.01	0.03
PCNB	21	770	29.26	7.71	1.74	0.86	2.08	0.04	0.02
propamocarb	700	235000	7.39	1.88	0.39	0.17	0.006	0.00	0.00
propiconazole	91	3600	9.03	3.89	1.06	0.63	1.65	0.00	0.00
thiophanate-methyl	560	30	24.27	7.26	1.82	1.01	1.3	0.81	0.61
thiram	40	1.3	1.045	1.021	0.896	0.663	0.950	0.80	0.51
triadimefon	210	1600	17.44	10.61	3.46	2.16	1.05	0.01	0.02
triadimefon	210	1600	31.9	19.92	6.53	4.08	5.27	0.02	0.04
vinclozalin	200	52500	1.87	0.47	0.1	0.04	0.006	0.00	0.00
vinclozalin	200	52500	2.89	0.73	0.15	0.06	0.006	0.00	0.00
Herbicides									
2,4-D amine	70	1100	2.69	2.58	2.11	1.61	0.065	0.00	0.02
benefin	2100	800	3.08	0.79	0.16	0.07	2.28	0.00	0.00
bensulide	50	379	20.93	7.46	1.9	1.08	3.09	0.06	0.05
bentazon	20	635000	17.050	15.950	11.650	8.220	2.600	0.00	0.00
clopyralid	4000	1035	12.36	11.953	9.652	8.115	2.361	0.00	0.09
dicamba	200	28000	5.72	5.69	5.54	5.31	0.157	0.00	0.00
dithiopyr	nd	480	36.486	22.325	11.532	17.94	0.009	0.08	0.24
glyphosate	700	86000	3.89	0.99	0.2	0.09	0.006	0.00	0.00
halsulfuron	nd	nd							
mecoprop (MCPP)	35	124000	36.34	34.88	28.46	21.81	3.27	0.00	0.00
oxadiazon	40	320000	2.37	0.64	0.14	0.07	0.057	0.00	0.00
pendimethalin	280	138	4.9	1.28	0.28	0.13	0.098	0.04	0.02
prodiamine	50	72000	1.94	1.37	0.51	0.32	0.356	0.00	0.00
triclopyr	200	138	0.624	0.583	0.552	0.513	0.012	0.00	0.04
trifluralin	5	41	4.8	1.23	0.26	0.11	0.087	0.12	0.06
Insecticides									
acephate	30	730000	85.34	84.91	82.68	79.13	0.06	0.00	0.00
bendiocarb	40	470	5.16	2.37	0.66	0.4	0.025	0.01	0.01
bifenthrin	100	0.15	0.012	0.006	0.001	0.665	0.268	0.08	0.07
carbaryl	700	2328	20.17	12.31	4.02	2.51	0.406	0.01	0.02
chlorpyrifos	105	7.1	3.34	0.86	0.18	0.08	0.071	0.47	0.25
cyfluthrin	175	0.14	0.045	0.031	0.009	0.012	0.034	0.32	0.64
fluvalinate	70	2.9	0.21	0.19	0.148	0.124	0.8	0.07	0.51
halofenozide									
imidacloprid	400	105000	0.025	0.014	0.006	0.006	0.124	0.00	0.00
isofenphos	35	27	0.54	0.35	0.21	0.18	0.038	0.02	0.08
lambda-cyhalothrin	105	0.24	0.034	0.028	0.016	0.012	0.059	0.14	0.67
trichlorfon	1250	18	6.57	6.42	5.73	4.83	0.084	0.37	3.18
Nematicides									
fenamiphos	2	110	63.29	52.61	26.31	16.69	17.04	0.58	2.39

Table A3. Estimated concentrations of pesticides in surface runoff and leaching and associated risk ratios for The Preserve Country Club. This is Tier 2 modeling in the risk assessment.

Pesticide	Estimated Environmental Concentration (a) ppb	LC50 ppb	LC50*0.1 (c) ppb	HAL ppb	Aquatic Risk Ratio (b) Acute	Aquatic Risk Ratio Chronic	HAL Risk Ratio	Comment
Surface Runoff								
Fungicides								
Chlorothalonil	325.6	49	4.9	2	6.64	66.45	162.80	Restrict use
Herbicides								
None								
Insecticides								
Trichlorfon	92.4	18	1.8	1250	5.13	51.33	0.07	Restrict use
Nematicides								
Fenamiphos	45.3	110	11	2	0.41	4.12	22.65	Restrict use
Leaching								
Fungicides								
Chlorothalonil	8.6	49	4.9	2	0.18	1.76	4.30	Restrict use
Herbicides								
None								
Insecticides								
Trichlorfon	9.2	18	1.8	1250	0.51	5.11	0.01	Restrict use
Nematicides								
Fenamiphos	4.2	110	11	2	0.04	0.38	2.10	Restrict use

(a) Surface runoff was assessed with SWRRB-WQ and leaching was assessed with PRIZM2.
Tier 2 analyses were conducted based on the results of the Tier 1 models. See text.
(b) Risk ratios were determined by dividing the estimated concentrations by either the LC50 or HAL. A number greater than one assumes a risk and use is adjusted accordingly.

Turf IPM Field Infestation Report

Hole _____ Scout _____ Date _____

Site (turf species)	Mowing Height	Soil Moisture	Weeds Species No. or %	Diseases Kind %	Insects Species No. or %	Nematodes Species No. or %
Green						
Tee						
Fairway						
Rough						
			1. Crabgrass 2. Other grasses 3. Broadleaves 4. Sedges 5. Others	1. Dollar spot 2. Brown patch 3. Pythium 4. Leaf spot 5. Other	1. Sod webworms 2. Grubs 3. Hyperodes Weevils	1. Sting 2. Lance 3. Ring. 4. Stubby-root 5. Others

Turf IPM Field History Report Form

Hole Number _____ Scout _____ Date: _____

Site	Turf Species	Area	Mowing Schedule	Soil Analysis pH	P	K	Soil Drainage	Fertilization (N/1000 sq.ft.) Spring	Summer	Fall	Winter	Irrigation Schedule
Green												
Tee												
Fairway												
Rough												
Driving range												
Nursery green												
Practice green												

Comments on specific topics such as shade, weather, irrigation, etc.

_____

_____

_____

Sample of Pesticide Use Record

Application Date: _____

Time of Day: _____

Operator: _____

Supervisor: _____

PEST: _____

Weather Conditions

Temperature _____ degrees F

Humidity _____ %

Wind Speed _____ MPH

Wind Direction _____

Rainfall _____ inches

Soil Moisture _____

Pesticide	Active Ingredient	Amount of Formulation	Amount of Water

Adjuvant/Surfactant _____

Amount of Formulation _____

Area Treated: _____ Acres _____ Square Feet

Amount of Pesticide Used: _____

Application Equipment: Sprayer _____ Spreader _____

Remarks:

a. Surface Water Field Sampling Sheet

Station Number: _____ Samplers: _____

Description: _____

_____

Date of Sampling: _____ Time of Sampling: _____

Weather: _____

Field Measurements

Water Temp (°C) _____ Air Temp (°C) _____

pH _____ Specific Cond (μS) _____

Depth of Water (m) _____ Depth Sample Taken (m) _____

Wetted Area (m) _____ Water Flow (m/sec) _____

Calibration of Instruments

Specific Conductance: Meter _____

Reading in IKC1 soln: _____

pH meter Model: _____ Calibration Buffers used: _____

Sample Apparatus: _____

Mode of Trasport: _____

Shipping Date: _____

Remarks: _____

c. Ground Water Field Sampling Sheet

Well Number: _____ Samplers: _____

Description: _____

Weather: _____

Date of Sampling: Day _____ Month _____ Year _____

Time of Sampling: Hour _____ Minute _____

Field Measurements

Water Temp (°C) _____ Air Temp (°C) _____

pH _____ Specific Cond (μS) _____

Depth of Water at which sample was taken (m): _____

Calibration of Instruments

Specific Conductance: Meter _____ Meter Reading in KC1 soln: _____

pH Meter Model: _____ Calibration buffers used: _____

Sample Apparatus: _____

Mode of Transport: _____

Shipping Date: _____

Remarks: _____

d. Soils Field Sampling Sheet

Station Number: _____ Samplers: _____

Description:

_____

Weather:

_____

Date of Sampling: Day _____ Month _____ Year _____

Time of Sampling: Hour _____ Minute _____

Mode of Transport:

_____

Shipping Date:

_____

Remarks:

_____

_____

_____

_____

ATTACHMENT 4
Hazard Communication Program

HAZARD COMMUNICATION PROGRAM

_____

(NAME OR COMPANY)

_____

(LOCATION-DIVISION)

It is the intent of _____, _____
(Name of Company) (Address-Location-Division)

to comply with the requirements of the Hazard Communication Standard in our continuing effort to provide a healthy and safe workplace for our employees.

This program is designed to provide employee information and training (1) the hazardous chemicals known to be in the workplace, (2) the methods that will be employed to protect workers, (3) the precautionary methods employees must follow to protect themselves from hazardous chemicals, (4) the detection of a release of hazardous chemicals and (5) emergency procedures to follow should there be a release of hazardous chemicals and/or employee exposure to them.

WRITTEN HAZARD COMMUNICATION PROGRAM: Copies of the written Hazard Communication Program are available from the office of _____.
(Name of Office or Person)

The program is reviewed annually and is updated as needed. All present or new employees will be given a copy of the program. Employees and/or their authorized representative may obtain an additional copy of the program during normal working ours at a cost of $0.10 per page.

MATERIAL SAFETY DATA SHEETS: Following is a listing of all hazardous chemicals known to be in the workplace; the location(s) of the chemical are also provided:

HAZARDOUS CHEMICAL	LOCATION	USE
1.		
2.	(List all known or suspected hazardous chemicals.)	
3.	(If you do not have copies or all MSDS's, you will need to contact your suppliers for the necessary copies).	

A Material Safety Data Sheet (MSDS) and/or label of each hazardous chemical is filed in the office of _____.

(Name of Office or Person)

Employees and/or their representative may obtain a single copy of an MSDS and/or label during normal working hours at a cost of $0.10 per page. The relevant information on the MSDS will be shared with employees during the hazard communication training program. The MSDS will be available in the workplace to all employees who are urged to review them whenever they have a question regarding the chemical.

NOTIFICATION OF OTHER EMPLOYERS: When other employers bring a work crew onto our property they will be supplied with a copy of the Hazard Communication Program and with copies of the MSDS for hazardous chemicals which could be encountered in their work area. It shall be their responsibility to train their employees, provide personal protective equipment and handle employee emergencies. Any releases or spills of hazardous chemicals shall within minutes, be brought to the immediate attention of _____.

(Name of Office, Person or Position Title)

USE OF LABELS: Whenever possible hazardous chemicals will be kept in their original containers. Should an original container ever become defective (leak) the chemical will be transferred to a similar type container. The label will be transferred to the replacement container and be securely attached. If the label is non-transferrable, a replacement label with all significant information will be prepared and be securely and prominently placed on the new container. This container of a chemical will be used for its intended use as soon as possible.

Placards will be placed on all containers in which hazardous chemicals are used, such as storage tanks for chemicals, solvent tanks for cleaning parts, etc.

EMPLOYEE INFORMATION AND TRAINING: All employees will be provided with information and training on hazardous chemicals in their workplace:

- ✓ At the time of their initial employment.
- ✓ Whenever a new hazardous chemical is brought into their workplace.
- ✓ At least annually.

All affected employees are required to participate in this training. The training will be provided or arranged by _____.

(Name of Office or Person or Position Title)

The employees will be provided with the following information:

- ✓ The requirements of the Hazard Communication Standard.
- ✓ Operations in their work area where hazardous chemicals are present, used or stored.
- ✓ Location and availability of the written Hazard Communication Program and MSDS files.

Employee training will include:

- ✓ Methods and observations that may be used to detect the presence or release of a hazardous chemical in the work area (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.)
- ✓ The physical and health hazards of the chemicals in the work area.
- ✓ The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used and
- ✓ The details of the hazard communication program developed by the employer, including an explanation of the labeling system and the Material Safety Data Sheet, and how employees can obtain and use the appropriate hazard information.

HAZARD CHEMICAL RELEASE, SPILL OR EXPOSURE

Employees will immediately, within minutes, notify their immediate supervisor of any release, spill or human exposure to a hazardous chemical.. If it is a significant release into the atmosphere, a spill on non-owned property or into a surface or ground water supply, notify the local emergency service agency and/or fire department (telephone 911) and/or the State Emergency Response Commission.

If a person or persons are exposed to a hazardous chemical, emergency treatment as specified by the MSDS or label will be immediately applied and whenever a question of further medical treatment may be required, the individual(s) will be transported to

_____.

(Name of Doctor or Emergency Treatment Center)

A copy of the MSDS and/or label will be transmitted with the exposed individual(s).

The supervisor of an area in which a hazardous chemical release, spill or exposure occurs will, immediately after emergency action, notify _____ of the event.
(Name of Office or Person)

EMPLOYEE REQUIREMENTS: Employees are required to follow all standard operating procedures in the handling of hazardous chemicals, including the use of protective equipment. Failure to do so shall provide sufficient reason for reprimands, suspension or termination of employment.

INFORMING OUTSIDE CONTRACTORS

There may be instances where tasks will be performed by contractors that are not company employees. Should there be a hazardous substance in the work area, it is the obligation or our company to make the contractor aware of the situation. This may be accomplished by:

1. A list hazardous substances in the work area.
2. A diagram of the work area with the locations designated where hazardous substances are used and/or stored.

The contractor will be advised that MSDS are on file and available upon request. The contractor will sign an acknowledgment of receipt of information.

ACKNOWLEDGMENT OF RECEIPT

DATE:_____

ON THE ABOVE DATE, I _____
(CONTRACTOR'S NAME)
RECEIVED A LIST OF HAZARDOUS SUBSTANCES USED AND/OR STORED IN THE WORK AREA FROM _____.

I UNDERSTAND THAT MSDS ARE AVAILABLE FOR ALL SUBSTANCES LISTED, UPON REQUEST. I ALSO MAY OBTAIN A DIAGRAM OF THE WORK AREA DESIGNATION USE AND/OR STORAGE OF HAZARDOUS SUBSTANCES.

_____
(CONTRACTOR'S SIGNATURE)

HAZARDS OF NON-ROUTINE TASKS

A non-routine task is defined as one or more of the following:

1. A task not done frequently
2. A task not listed on your job description
3. A task for which you are not trained

Should your Supervisor/Foreman call upon you to perform a non-routine task involving hazardous chemical handling or working in an area where hazardous chemicals are used or stored, the following steps will be taken by the him\her:

1. Give the employee a complete description of the task
2. Brief on hazardous chemicals in the work place
3. Brief on the effects the chemicals may have on the person
4. Determine if the employee is allergic to the chemicals present
5. Brief on proper handling of the chemicals
6. Brief an first aid procedures to take concerning the chemicals
7. State that there will be mandatory use of safety equipment
8. The Supervisor/Foremen will closely monitor the employee while working in the area of hazardous chemicals

RECOMMENDED POSTERS AND RECORDS IN MAINTENANCE AREA

1. OSHA JOB SAFETY AND PROTECTION POSTER
   U.S. Department of Labor
   Occupational Safety and Health Administration

2. EQUAL EMPLOYMENT OPPORTUNITY POSTER
   Equal Employment Opportunity Commission

3. WORKERS' COMPENSATION POSTER
   Obtain from Insurance carrier

4. BE SAGE WITH PESTICIDES POSTER
   Environmental Protection Agency

5. RIGHT-TO-KNOW LAW POSTER
   Toxic Substances Information Center

6. MATERIAL SAFETY DATA SHEETS (MSDS)
   Obtain from distributor for each hazardous chemical used and/or stored.

7. PESTICIDE LABELS
   Obtain from distributor of each pesticide used and/or stored.

8. HAZARD COMMUNICATION PROGRAM
   A written program prepared by the course.

9. RESTRICTED USE PESTICIDE APPLICATION RECORD
   Date and location of application.
   Product name and quantity (pounds or gallons) of pesticide applied
   Area treated and application rate method of application

10. RESTRICTED PESTICIDE CERTIFICATION LICENSE
    Test is given at the Westchester County Cooperative Extension service.
    Required only for individuals purchasing and using restricted pesticides.

ATTACHMENT 5

1997 Pest Management Recommendations
for Commercial Turfgrass

A Cornell Cooperative Extension Publication

1997 Pest Management Recommendations for Commercial Turfgrass

Every effort has been made to provide correct, complete, and up-to-date pest management information for New York State in this publication, which was released for printing November 1996. Changes in pesticide registrations, regulations, and recommendations that occur after publication are regularly available in county Cornell Cooperative Extension offices and on CENET, an on-line information system operated by Cornell Cooperative Extension. (Information about the network, including subscription rates, is available from CENET, Cornell Cooperative Extension Electronic Technologies Group, Cornell University, 40 Warren Hall, Ithaca, NY 14853. A revision of the printed document is issued annually.)

These recommendations are not a substitute for pesticide labeling. Read the label before applying any pesticide.

CONTENTS

Tables

1997 Pest Management Recommendations for Commercial Turfgrass was prepared by Joseph Neal, Department of Floriculture and Ornamental Horticulture; Michael Villani, Department of Entomology, New York State Agricultural Experiment Station, Geneva; Eric Nelson, Department of Plant Pathology; and Andrew Senesac, Cornell Cooperative Extension, Suffolk County.

PESTICIDE INFORMATION

Use Pesticides Safely

All pesticides are regulated by state and federal laws to protect the user and consumer. Read labels carefully. Follow instructions.

Most pesticides are poisonous to humans and animals, but when properly used they are not harmful. Handle pesticides with care. Store them in closed, plainly labeled original containers, out of the reach of children and animals. Keep pesticides in locked storage facilities.

When handling, do not allow pesticides to come in contact with the skin.

Do not apply on a windy day. Do not smoke while handling pesticides. Do not inhale dusts, sprays, or vapors. After handling pesticides, wash hands and face before eating or smoking.

To avoid accidental injury to susceptible plants, avoid drift of sprays and dusts. Use separate equipment for applying hormone-type herbicides such as 2,4-D.

Dispose of empty containers so children cannot play with them.

Please refer to New York State Department of Environmental Conservation Circular 865, part 325, *Rules and Regulations Relating to the Application of Pesticides*, for further information relating to the use of pesticides in New York State.

Pesticide Control Legislation

In accordance with New York State legislation, pesticides that are highly toxic or that are persistent and accumulative are placed on a restricted-use list and may be sold to and used only by certified applicators. Restricted-use pesticides recommended in this publication are identified by an asterisk (*). The list is subject to annual review; consult your Cornell Cooperative Extension agent if you have questions about the status of a pesticide.

CERTIFICATION: Commercial applicators of pesticides as well as private applicators who use restricted-use pesticides must be certified. Certification exams and recertification credits are given throughout the state; consult your Cornell Cooperative Extension agent or regional pesticide specialist if you have questions concerning certification.

Recordkeeping and Reporting

NOTE: New law established for pesticide recordkeeping, effective January 1, 1997:

Manufacturers and importers. Requires annual reports from manufacturers and importers of all sales within the state of each restricted-use pesticide product, including EPA registration number, container size, and number of containers sold to New York purchasers. Records would have to be maintained for at least three years.

Commercial applicators. Requires annual reports from commercial applicators of pesticide use, including EPA registration number; product name; quantity of pesticide used; date applied; and location of application by address, including 5-digit zip code. Records would be maintained for at least three years and would also include the dosage rates, methods of application, and target organisms.

Reporting point of sale. Requires every person who sells or offers for sale restricted-use pesticides to private applicators to report annually each sale of a restricted-use pesticide or general-use pesticide used in agricultural crop production to such applicator, including EPA registration number; product name of pesticide purchased; quantity purchased; date purchased; and location of intended application by address, including 5-digit zip code, or if address is unavailable, by township and 5-digit zip code.

Recordkeeping by private applicators. Requires private applicators to maintain, for a minimum of three years, restricted-use pesticide records, including pesticide purchased; crop treated; method and date of application.

For more information, contact the NYS Department of Environmental Conservation (518-457-7482).

EPA Worker Protection Standard (WPS) for Agricultural Pesticides

The Environmental Protection Agency has revised its Worker Protection Standard (WPS) dealing with the protection of agricultural workers from pesticide exposure (40 CFR Part 170). The new Worker Protection Standard contains requirements designed to reduce the risks of illness or injury resulting from occupational exposures of pesticide handlers and agricultural workers. Accidental exposure of agricultural workers and other persons to pesticides used in the production of agricultural plants on farms, nurseries, greenhouses, and forests are included under these regulations. They include the following:

- Restricted-entry intervals (REIs) for most pesticides
- Personal protective equipment (PPE) for handlers and early-entry workers
- Decontamination supplies and emergency assistance
- Pesticide safety training and posting
- Revised labeling that includes specific WPS instructions

For more complete information on reentry and farm worker protection standards, please contact your local Cornell Cooperative Extension office or the **Pesticide Management Education Program, Cornell University, 5123 Comstock Hall, Ithaca, NY 14853, (607) 255-1866.**

Section 2(ee) Policy

Federal and state laws make it illegal to use a pesticide "in a manner inconsistent with its labeling." Section 2(ee) of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended, defines this term and states that certain types of use, although not specifically stated on the pesticide label, are *not* considered uses inconsistent with the label. These uses, therefore, are acceptable. Under Environmental Protection Agency policy, anyone (including those with a financial interest in the pesticide) may make a 2(ee) recommendation.

All FIFRA Section 2(ee) pesticide recommendations approved by the New York State Department of Environmental Conservation are identified by a number sign (#). **All 2(ee) pesticide recommendations approved based on quantitative efficacy data are identified by a double number sign (##).** These include recommendations for the following: less than the label dosage; unnamed (not on label) target pests; application methods not prohibited by the label; and pesticide-fertilizer combinations. A copy of these recommendations must be in the applicator's possession when using pesticides under a 2(ee) recommendation.

Individual states are allowed to be more restrictive, and New York State has determined that it is necessary to place more stringent requirements on 2(ee) recommendations. Under state regulations Part 325.2(b), "registered pesticides may be used only in accordance with label directions or as modified or expanded and approved by the Department."

Modifications or expansions of registered labels under 2(ee) may be made under the following conditions when used in New York State:

1. All proposed recommendations must be made in writing by a recognized research institution such as the New York State College of Agriculture and Life Sciences at Cornell University or the New York State School of Forestry at Syracuse. Manufacturers, distributors, and crop advisers may make such recommendations as well.
2. The proposed recommendations must be submitted to the Department of Environmental Conservation, accompanied by appropriate data that demonstrate the efficacy or otherwise support the recommendation.
3. Recommendations must be approved in writing by the Department of Environmental Conservation. Once approved, the 2(ee) recommendation can be included in the publications of the research institution.
4. Anyone using a pesticide under an approved 2(ee) recommendation must have the appropriate publication with the approved 2(ee) recommendation in his or her possession at the time of application.
5. Manufacturers proposing changes in registered labels must file for Special Local Need (SLN) registrations under Section 24(c) of FIFRA.

GENERAL REMARKS

Good cultural practices encourage the growth of turfgrass so it can better withstand the ingress of weeds, diseases, and insects. Once pests are brought under control, a more vigorous turf will more quickly fill the open spots caused by the pest. Turfgrass varieties and species that are resistant to certain pests, especially diseases, will provide the longest and most reliable control of those pests. When it becomes necessary to use pesticides to control pests, avoid the continual use of one particular pesticide. A dominance of any one pesticide may allow pests to develop resistance to the chemical, and pests that were once unimportant may become increasingly difficult to control.

Not all pests are easily controlled by chemicals. The recommended treatments may have to be repeated to achieve satisfactory control. Lower rates of systemics, especially herbicides, repeated several times are more effective than an overdose, which could burn the leaves of young growth and thus prevent the movement of the herbicide into the plant. Where a time of application is specified, deviation may cause poor results. Continual use of the same pesticide may encourage the growth of previously unimportant pests.

Systemics can be applied in granular form, but the amount of active ingredient may need to be increased over that normally used in a liquid application. For best results, apply systemic granular herbicides and nonsystemic fungicides early in the morning, when there is plenty of dew on the leaves. Systemic fungicides can be applied at any time and should be followed by watering or rain.

Pesticide Compatibility

Tank mixing of pesticides is allowed if specified on the label or in this bulletin, but precautions are necessary. Each applicator must use the manufacturer's recommended rates and should conduct tests of any specific mixture before using it extensively. Brief guidelines follow: (1) Wettable powder formulations usually can be mixed together safely. (2) Never mix emulsifiable concentrates. (3) Insolubles can be tank mixed, provided that products are sprayed at recommended rates. (4) Only one soluble chemical can be tank mixed with any number of insolubles. (5) Soluble fertilizers and trace elements can be added, provided that the amount does not exceed 1 ounce of solid per gallon of tank spray mix. Table 1, Chemical Compatibility, lists the solubility of common turfgrass products for reference in planning tank mixes.

Recommended Amounts

The specific amounts of herbicides, fungicides, insecticides, and nematicides recommended in this publication are for average conditions. Read the label on the container or the specialized turf label for variations in treatment because of season, temperature, moisture, soil type, variety, age of turf, and severity of the problem. The amounts given are for pounds of active ingredient per acre; see the manufacturer's label for amounts of formulated material per acre or per 1,000 square feet and for the amount of water to be used with liquids.

Table 1. Chemical Compatibility

Fungicides		
Solubles	*Insolubles*	
Banol	Terremec SP	Subdue
	Spotrete	Fore
	Bromosan	Mancozeb
	Spectro	Rubigan
	Clearys 3336	Daconil 2787
	Tersan 1991	Fungo
	Chipco 26019	Bayleton
Insecticides		
Solubles	*Insolubles*	
Dursban	Dursban	
Sevin	Sevin	
Malathion	Oftanol	
Proxol		
Dylox		
Herbicides		
Solubles (Amines & Salts of)	*Insolubles (Dispersibles & ECs)*	
2,4-D	Dacthal	Acclaim
MCPP	Tupersan	Dimension
Dicamba	Balan	
MSMA	Ronstar	
2,4-DP	Pre-M	
Fertilizers		
Solubles	*Insolubles*	
urea	ureaform	
ammonium nitrate	IBDU	
ammonium sulfate		
ammonium phosphate		
methyol urea		
muriate of potash		
potassium sulfate		

Note: Modified from P. A. Sartoretto, Chemical compatibility for tank mixing, *The Golf Superintendent*, February 1977.

How to Determine the Amount of Formulated Materials Needed

Pesticides are usually available in several formulations. In the disease, insect, and weed control tables, you will find the recommended pesticide to use. To determine the amount of pesticide to apply, first note the recommended rate of material based on the active ingredient per area, then note the specific formulation of the material you have on hand.

Tables 2 and 3 list various formulations in the left-hand column and several rates of active ingredient across the top of the table. Table 2 lists the amount of formulated material to use per acre; Table 3 lists the amount to use per 1,000 square feet. For example: You select oxadiazon 2G to control crabgrass on mature Kentucky bluegrass. The area to be treated is 1,000 square feet. The recommended herbicide rate of active ingredient per acre is 4 lb. Using Table 3, find 2G in the left-hand column. Find 4 lb. of AI/A along the top of the table. Look downward to find that 4 lb. 10 oz. of formulated material will be needed to treat 1,000 square feet at the recommended rate of 4 lb. AI/A.

Table 2. Amounts of Formulated Materials Needed to Apply Correct Active Ingredient per Acre (AI/A)

	Recommended Rate, AI/A (lb.)				
Formulation	*1*	*2*	*4*	*5*	*10*
	Amount of Formulation per Acre				
1G	100 lb.	200 lb.	400 lb.	500 lb.	1,000 lb.
2G	50 lb.	100 lb.	200 lb.	250 lb.	500 lb.
5G	20 lb.	40 lb.	80 lb.	100 lb.	200 lb.
10G	10 lb.	20 lb.	40 lb.	50 lb.	100 lb.
1EC or FL	1 gal.	2 gal.	4 gal.	5 gal.	10 gal.
2 EC or FL	2 qt.	1 gal.	2 gal.	2.5 gal.	5 gal.
4EC or FL	1 qt.	2 qt.	1 gal.	1.25 gal.	2.5 gal.
50WP or SP	2 lb.	4 lb.	8 lb.	10 lb.	20 lb.
75WP or SP	1 lb. 5 oz.	2 lb. 11 oz.	5 lb. 5 oz.	6 lb. 11 oz.	13 lb. 5 oz.
80WP or SP	1 lb. 4 oz.	2 lb. 8 oz.	5 lb.	6 lb. 4 oz.	12 lb. 8 oz.

Notes: 25EC is approximately 2 lb./gal. Lannate 24L is 1.8 lb./gal.

Table 3. Amounts of Formulated Materials Needed to Apply Correct Active Ingredient per 1,000 Sq. Ft.

	Recommended Rate, AI/A (lb.)				
Formulation	*1*	*2*	*4*	*5*	*10*
	Amount of Formulation per 1,000 Square Feet				
1G	2 lb. 5 oz.	4 lb. 10 oz.	9 lb. 3 oz.	11 lb. 8 oz.	23 lb.
2G	1 lb. 2 oz.	2 lb. 5 oz.	4 lb. 10 oz.	5 lb. 13 oz.	11 lb. 8 oz.
5G	7 oz.	15 oz.	1 lb. 14 oz.	2 lb. 5 oz.	4 lb. 10 oz.
10G	4 oz.	8 oz.	15 oz.	1 lb. 3 oz.	2 lb. 5 oz.
1EC or FL	3 oz.	6 oz.	12 oz.	15 oz.	1 lb. 13 oz.
2EC or FL	1.5 oz.	3 oz.	6 oz.	7.3 oz.	15 oz.
4EC or FL	.75 oz.	1.5 oz.	3 oz.	3.7 oz.	7.5 oz.
50WP or SP	.7 oz.	1.5 oz.	3 oz.	3.7 oz.	7.3 oz.
75WP or SP	.5 oz.	1 oz.	2 oz.	2.5 oz.	4.9 oz.
80WP or SP	.5 oz.	.9 oz.	1.8 oz.	2.3 oz.	4.6 oz.

Abbreviations

AI/A - active ingredient per acre
EC - emulsifiable concentrate
FL - flowable
G - granular
gal. - gallon
lb. - pound
oz. - ounce
SP - soluble powder
WP - wettable powder

DISEASE CONTROL

Table 4. Cultural Management and Chemical Control of Turfgrass Diseases

Disease (Pathogens)	*Comments*[1]	*Cultural Management*[2]	*Fungicide or Nematicide*[3]
Anthracnose *(Colletotrichum)*	Occurs April–October. Attacks ANNUAL BLUEGRASS, Kentucky bluegrass, fine fescues, and BENTGRASSES.	Avoid N deficiency and drought, especially on annual bluegrass.	*mancozeb* propiconazole thiophanates triadimefon
Brown patch, yellow patch *(Rhizoctonia)*	All seasons. Attacks Kentucky bluegrass, BENTGRASSES, RYEGRASSES, ANNUAL BLUEGRASS, fine-leaf fescues, and TALL FESCUE.	Avoid excess N and water, especially on perennial ryegrass, fescue, and bentgrass. Use resistant varieties of perennial ryegrass. Water early in the day and remove dew from greens. The use of organic fertilizers and composts has been shown to reduce disease severity.	*chlorothalonil* *cyproconazole* fenarimol autolanil iprodione *mancozeb* propiconazole *quintozene* thiophanates *thiram* triadimefon vinclozolin
Copper spot *(Gleocercospora)*	Occurs June–October. Attacks low-cut bentgrass.	No information known on cultural practices to manage copper spot.	*chlorothalonil* fenarimol iprodione thiophanates *thiram* triadimefon vinclozolin
Damping-off, seed rot (various fungi)	Occurs April–October. Attacks all grasses.	Provide good seedbed and conditions for seedling vigor. Species of *Pythium*, *Fusarium*, and *Rhizoctonia* often cause damping-off; select fungicides accordingly.	Seed treatment: *thiram* metalaxyl Seedling spray: varies with the causal fungus.
Dollar spot *(Sclerotinia homoeocarpa)*	Occurs June–October. Attacks Kentucky bluegrass, ryegrasses, ANNUAL BLUEGRASS, BENTGRASS, and fine fescues.	Avoid N deficiency, drought, and night watering. Use resistant varieties of Kentucky bluegrass, fine fescue, and bentgrass. Remove dew from greens. The use of organic fertilizers and composts has been shown to reduce disease severity.	*chlorothalonil* fenarimol iprodione propiconazole thiophanates *thiram* triadimefon vinclozolin

[1]The most susceptible species are printed in CAPITAL LETTERS.

[2]These practices have been shown to affect disease severity. The inclusion of these practices in no way implies that they may eliminate the need for pesticides. Solid programs will integrate good culture with judicious pesticide use.

[3]Contact fungicides are listed in *italics*. See page 21–25 for registered trade names.

*Restricted-use pesticide.

(continued on next page)

Table 4. Cultural Management and Chemical Control of Turfgrass Diseases (continued)

Disease (Pathogens)	*Comments*[1]	*Cultural Management*[2]	*Fungicide or Nematicide*[3]
Fairy rings (various fungi)	Occurs April–October. All grasses.	Mask symptoms by removal of cores, thorough watering, and moderate fertility. In critical areas, fumigate or replace the soil and reseed.	None are effective.
Leaf spots and blights (*Ascochyta, Bipolaris, Curvularia, Dreschlera, Nigrospora, Septoria,* etc.)	Occurs April–October. Attacks KENTUCKY BLUEGRASS, ryegrasses, annual bluegrass, BENTGRASS, and FINE-LEAF FESCUES.	Avoid excess N (especially in spring). Avoid excess benomyl, thiophanate, and triadimefon, and night watering. Use resistant varieties of Kentucky bluegrass, perennial ryegrass, and fine fescue. Raise mowing height.	*chlorothalonil* iprodione *mancozeb* vinclozolin
Necrotic ringspot (*Leptosphaeria*)	Occurs June–September. Attacks KENTUCKY BLUEGRASS, fine fescues, ANNUAL BLUEGRASS, and bentgrass.	Avoid excess N, drought, excess water, and very low mowing. Reduce thatch when practical. Mix perennial ryegrass into Kentucky bluegrass seed or overseed with resistant varieties of Kentucky bluegrass.	fenarimol iprodione
Nematode-caused diseases (various genera)	Occurs April–October. Attacks all grasses.	Apply to prepared seedbed during warm weather. Aerate soil thoroughly before planting. Apply as a drenching application during growing season. Do not handle sod within 30 days. See label directions.	Preplant: 1,3-dichloropropene metam Mature turf: *ethoprop **fenamiphos*
Pink snow mold (*Microdochium*)	Occurs March–June and September–November during cool, wet weather. Snow is not necessary. Attacks ANNUAL BLUEGRASS, Kentucky bluegrass, BENTGRASS, fine fescues, TALL FESCUE, and perennial ryegrass.	Avoid late fall application of N. Rake matted grass in spring. Use resistant varieties of Kentucky bluegrasses.	fenarimol iprodione propiconazole *quintozene* thiophanates triadimefon vinclozolin
Powdery mildew (*Erysiphe*)	Occurs July–September. Attacks KENTUCKY BLUEGRASS and fine fescues.	Avoid excess N and shade. Use resistant (shade-tolerant) varieties of Kentucky bluegrass.	propiconazole thiophanates triadimefon

[1]The most susceptible species are printed in CAPITAL LETTERS.

[2]These practices have been shown to affect disease severity. The inclusion of these practices in no way implies that they may eliminate the need for pesticides. Solid programs will integrate good culture with judicious pesticide use.

[3]Contact fungicides are listed in *italics*. See pages 21–25 for registered trade names.

*Restricted-use pesticide.

(continued on next pa

Table 4. Cultural Management and Chemical Control of Turfgrass Diseases (continued)

Disease (Pathogens)	*Comments*[1]	*Cultural Management*[2]	*Fungicide or Nematicide*[3]
Pythium blight *(Pythium)*	Occurs July–August. Attacks Kentucky bluegrass, RYEGRASSES, tall fescue, annual bluegrass, bentgrasses, and fine-leaf fescues.	Avoid excess N and watering especially on perennial ryegrass, fescue, and bentgrass. Do not mow when grass is wet. Renovate area to increase air flow and drainage.	*etridiazole* fosetyl Al metalaxyl propamocarb
Pythium root rot *(Pythium)*	Occurs March–November. Attacks Kentucky bluegrass, ANNUAL BLUEGRASS, CREEPING BENTGRASS, and PERENNIAL RYEGRASS.	Avoid prolonged wet conditions and excess watering. Raise mowing height if practical. Avoid frequent applications of broad-spectrum systemic fungicides. The use of some composts and organic fertilizers has been shown to reduce disease severity.	fosetyl Al etridiazole metalaxyl propamocarb (NOTE: etridiazole, propamocarb and metalaxyl must be thoroughly watered in. Fosetyl Al can be applied as a spray. Apply fungicides October–November for early spring control.)
Red thread, pink patch *(Laetisaria, Limonomyces)*	Occurs May–October. Attacks Kentucky bluegrass, annual bluegrass, PERENNIAL RYEGRASS, FINE FESCUES, and bentgrasses.	Avoid N deficiency, especially on perennial ryegrass and fescue. Use resistant varieties of Kentucky bluegrass, perennial ryegrass, and fine fescue. The use of some organic fertilizers will reduce disease severity.	iprodione propiconazole *thiram* triadimefon
Rusts *(Puccinia)*	Occurs July–October. Attacks Kentucky bluegrass and perennial ryegrass.	Avoid N deficiency and drought. Use resistant varieties of Kentucky bluegrass and perennial ryegrass.	*chlorothalonil* *mancozeb* propiconazole triadimefon
Smuts *(Ustilago, Urocystis)*	Occurs April–November. Attacks KENTUCKY BLUEGRASS, creeping bentgrass, and colonial bentgrass.	Avoid excess N and drought. Use resistant varieties of Kentucky bluegrass.	fenarimol propiconazole thiophanates triadimefon (NOTE: Apply fungicides in November or March.)
Summer patch *(Magneporthe)*	Occurs June–September. Attacks KENTUCKY BLUEGRASS, fine fescues, ANNUAL BLUEGRASS, and bentgrass.	Avoid excess N, drought, excess water, and very low mowing. Mix perennial ryegrass into Kentucky bluegrass seed or overseed with resistant varieties of Kentucky bluegrass.	fenarimol iprodione propiconazole thiophanates triadimefon (NOTE: Apply fungicides preventively at high rates in April–June.)

[1]The most susceptible species are printed in CAPITAL LETTERS.

[2]These practices have been shown to affect disease severity. The inclusion of these practices in no way implies that they may eliminate the need for pesticides. Solid programs integrate good culture with judicious pesticide use.

[3]Contact fungicides are listed in *italics*. See pages 21–25 for registered trade names.

*Restricted-use pesticide.

(continued on next page)

Table 4. Cultural Management and Chemical Control of Turfgrass Diseases (continued)

Disease (Pathogens)	*Comments*[1]	*Cultural Management*[2]	*Fungicide or Nematicide*[3]
Take-all patch *(Gaeumannomyces)*	Occurs March–June and September–November. Attacks BENTGRASS and annual bluegrass.	Use acidifying fertilizers to reduce thatch pH. Avoid heavy applications of lime. The use of composts and organic fertilizers may reduce the severity of take-all in newly seeded areas.	fenarimol (NOTE: Controlling other diseases with triadimefon or propiconazole may also be helpful.)
Typhula blight *(Typhula)*	Occurs December–April. "Gray snow mold." Attacks Kentucky bluegrass, BENTGRASS, ANNUAL BLUEGRASS, TALL FESCUE, fine fescues, and perennial ryegrass.	Proper fertilizer management to prevent lush turf going into winter. Apply heavy rates of compost to cover dormant turf. Remove excess compost in early spring before turf resumes growth.	*chloroneb* chlorothalonil fenarimol iprodione propiconazole *quintozene* thiram triadimefon (NOTE: Apply fungicides before long-lasting snow cover. Systemic fungicides should not be applied to dormant turf.)

[1]The most susceptible species are printed in CAPITAL LETTERS.

[2]These practices have been shown to affect disease severity. The inclusion of these practices in no way implies that they may eliminate the need for pesticides. Solid programs will integrate good culture with judicious pesticide use.

[3]Contact fungicides are listed in *italics*. See pages 21–25 for registered trade names.

*Restricted-use pesticide.

Selection and Application of Turfgrass Fungicides

Fungicides used for turfgrass disease control can be categorized as contacts and systemics. Many of the older fungicides are contact fungicides. Some common contact fungicides are listed in Table 5.

Contact fungicides are typically applied to foliage to prevent pathogenic fungi from infecting leaves. These fungicides are also effective in killing pathogens on thatch and leaf clippings in the turfgrass canopy. Contact fungicides act by killing both dormant spores and dormant and active mycelia of pathogenic fungi. They must be reapplied frequently so newly formed grass tissue remains protected. For contact fungicides to be effective foliar protectants, they must be allowed to dry on the plant surface after application. Therefore, to achieve most effective control of foliar diseases, they should never be watered in or applied in the rain. If they are used to control pathogen activity in thatch, they can be watered in. Because contact fungicides are largely water-insoluble, their movement through thatch is limited and they may not protect roots effectively.

Many of the modern fungicides used for turfgrass disease control are systemic fungicides. This means that they move in the plant's vascular system from the original site of application to distant parts. For example, a systemic fungicide applied to turf foliage may move through the plant to protect roots as well as leaves against infection by a pathogen. Most of the systemic fungicides currently used are translocated upward in the plant. A few have limited downward movement as well. The plant translocation of each of various systemic fungicides is given in Table 6.

The way systemic fungicides move in the plant influences the manner in which they should be applied so as to achieve effective control of specific types of diseases. These properties should be considered when developing any disease control strategy that includes systemic fungicides. In general, foliar disease control with systemic fungicides is more prolonged when they are drenched into the root zone. For example, foliar applications of upward-moving systemic fungicides provide excellent short-term control of foliar diseases. Drenching the fungicide into the root zone provides a much longer period of protection as well as control against some root and crown diseases. Root disease control with upward-moving systemic fungicides is possible only if they are drenched into the root zone, whereas downward-moving systemic fungicides can control root diseases when applied as a foliar spray.

Systemic fungicides have the following advantages over contact fungicides: (1) longer residual action, (2) protection of root and crown tissues, (3) suppression of pathogens that have already infected plant tissues, and (4) protection of newly formed plant tissues. In addition to the above advantages, many systemics have some contact activity. But systemic fungicides have some disadvantages. Nearly all the systemic fungicides do not actually kill pathogenic fungi but simply suppress pathogen activity. This is usually accomplished through a very specific mode of action. Repeated application of one or more fungicides with the same mode of action provides selection pressure that greatly enhances the opportunity for pathogen populations to become resistant to these fungicides. Once resistance to a particular fungicide develops, that fungicide is no longer effective. Therefore, no one particular fungicide should be used repeatedly over prolonged periods of time.

The development of fungicide resistance can be minimized by (1) alternating fungicides with different modes of action; (2) using fungicides with different modes of action in mixtures; or (3) alternating or mixing systemic fungicides with contact fungicides to give the desired disease control. Systemic fungicides listed in the table within each fungicide class have the same mode of action. Those in different fungicide classes have different modes of action. Therefore, broad-spectrum systemic fungicides that control many different turfgrass diseases should always be mixed or alternated between fungicide classes and never within a fungicide class. Likewise, fungicides specific for Pythium diseases should always be mixed or alternated between classes.

Table 5. Common Contact Fungicides Used for Control of Turfgrass Diseases

Chlorothalonil
Etridiazole
Mancozeb
Quintozene
Thiram

Table 6. Common Systemic Fungicides Used for Control of Turfgrass Diseases

Fungicide Class	Examples	Movement in Plant
	Broad-Spectrum Fungicides	
Benzimidazoles	Benomyl	Upward
	Thiophanate Methyl	Upward
	Thiophanate Ethyl	Upward
Dicarboximides	Iprodione	Upward
	Vinclozolin	Upward
Sterol Inhibitors	Fenarimol	Upward (limited downward)
	Propiconazole	Upward (limited downward)
	Triadimefon	Upward
	Pythium-Specific Fungicides	
Carbamates	Propamocarb	Upward
Acylalanines	Metalaxyl	Upward
Ethyl Phosphonates	Fosetyl Al	Upward and downward

INSECT CONTROL

Table 7. Chemical Control of Turfgrass Insects

Subject	*Insecticide*	*Active Ingredient per Acre*
Japanese beetle grubs (not effective against other grubs)	Milky disease powder—3 oz. (apply 1 level tsp. in spots at 5-ft. intervals in rows 5 ft. apart)	
Noncompatible with insecticides. Presence of grubs and warm (at least 70°F), moist soil required for effective disease development and spread. May take several years to become effective; therefore, use on low-value turf areas.		
Milky (spore) disease, a bacteria that infects Japanese beetle grubs, has been applied extensively on turfgrass in the Northeast for many years but is of questionable value in New York State because (1) the bacteria is most infective to Japanese beetle grubs and is of limited value against other common grub species infesting turfgrass in NYS; (2) soil temperatures in NYS are often too cool for rapid disease buildup; therefore, it often takes several years (minimum) for disease populations to rise to sufficient levels to make an impact on grub populations; (3) milky disease bacteria can only multiply within the living bodies of grubs; thus one must be willing to tolerate a period of relatively high grub populations to obtain disease levels sufficient to control grubs.		
Grubs (e.g., Japanese beetle, European chafer, Asiatic garden beetle, oriental beetle)	bendiocarb (Turcam)	3 lb.
	chlorpyrifos (Dursban)	4 lb.
	*ethoprop (Mocap)	5 lb.
	trichlorfon (Dylox, Proxol)	8 lb.
	*isofenphos (Oftanol)	2 lb.
	carbaryl (Sevin)	8 lb.
	imidacloprid (Merit)[1]	0.4 lb.
Treat when grubs average 8–10 grubs per sq. ft. Sample in early August. Treat during mid-August to moist soil. Water in immediately, avoiding puddling. For spring control, treat as soon as grubs are near surface, normally in April. Only fall treatment will reduce next spring's population. No spring-applied product will control next fall's grubs. Trichlorfon penetrates thatch better than the others do. Do not use chlorpyrifos if any thatch is present.		
The use of entomogenous (insect parasitic) nematodes as a control cannot be given unqualified endorsement at this time. Nematodes have provided grub control equal to or superior to that of currently labeled turf insecticides, but the number of failures is sufficient to caution their use. Failures have been traced to the use of nematodes in poor physical conditions; the use of nematode strains not well suited for control grubs; and soil conditions that prevent nematodes from surviving, reproducing, or persisting in the field.		
Black turfgrass ataenius	isofenphos (Oftanol)	2 lb.
Apply in spring or early summer as damage is first noticed. Water grass with 0.25–0.5 inches of water after application.		
Bluegrass billbug	carbaryl (Sevin)	8 lb.
	chlorpyrifos (Dursban)	2–4 lb.
	*isofenphos (Oftanol)	2 lb.
	imidacloprid (Merit)[1]	0.4 lb.
One application to newly mowed turfgrass between May 15 and July 1 when one billbug per minute is seen on adjacent pavement. Water lightly.		
Hyperodes weevil (Long Island and Westchester Co., primarily)	chlorpyrifos (Dursban)	2 lb.
	*isofenphos (Oftanol)	2 lb.
	imidacloprid (Merit)[1]	0.4 lb.
Treat between forsythia and flowering dogwood "full-bloom" (usually about April 15 to May 7). Repeat treatments for second generation.		

[1]This newly registered insecticide has shown sufficient residual activity in turfgrass to control the fall brood of annual scarab grubs when applied the previous spring or summer. High levels of grub control can be achieved when applications are made between April 1 and August 15, which precedes annual scarab grub egg hatch. There has been considerable debate among turfgrass entomologists about the use of insecticides such as MERIT that are designed to be used before the size and damage potential of the insect population are known. That is, these products are applied before insect eggs are hatched and many times, several months before they are laid. There is great potential for abuse of this product if turf managers use it indiscriminately, that is, without regard to the likelihood of having damaging population of insects on treated areas some time in the future.

*Restricted-use pesticide; may be purchased and used only by certified applicators.

(continued on next page)

Table 7. Chemical Control of Turfgrass Insects (continued)

Subject	*Insecticide*	*Active Ingredient per Acre*
Sod webworm and cutworms	*isofenphos (Oftanol)	2 lb.
	acephate (Orthene)	Read label.
	carbaryl (Sevin)	8 lb.
	chlorpyrifos (Dursban)	1 lb.
	*ethoprop (Mocap)	5 lb.
	trichlorfon (Dylox, Proxol)	8 lb.
Wet lawn before treating. Do not cut grass for one to three days after application. Irrigate for 15 minutes after application. Use endophyte-containing cultivars.		
Evening treatments are preferred. Water after application to move insecticides off grass blades into thatch. Spray with lower rates of water. Do not cut grass for one to three days after treatment.		
Hairy chinch bug	carbaryl (Sevin)	8 lb.
	chlorpyrifos (Dursban)	1 lb.
	*ethoprop (Mocap)	5 lb.
	*isofenphos (Oftanol)	2 lb.
Fine fescues are most susceptible. Water before treatment. Spray with 15–20 gal. of water per 1,000 sq. ft. Water in granular materials after application. Apply in early June. Except with isofenphos and Aspon, a second application two to three weeks later may be necessary. Avoid drought; use endophyte-containing cultivars.		
Ants	chlorpyrifos (Dursban)	
Treat mounds according to label directions. When used for other lawn insects, it should also control ants.		
Moles	Older-type poison baits not effective.	
	Traps continue to be effective when carefully set.	
Moles feed on beetle grubs and earthworms. Mouse damage to turfgrass in very early spring is often attributed to moles.		

*Restricted-use pesticide; may be purchased and used only by certified applicators.

WEED CONTROL

Cultural Management

Weeds will invade a turfgrass area when the turf is weak and loses its competitive advantage over the weeds. The most common causes of turf deterioration that leads to weed encroachment include poor fertility, use of grass species not appropriate for the site, environmental stress, wear, and damage from insects and diseases.

A good cultural program planned around current fertilizer, irrigation, mowing recommendations, and effective insect and disease control is the best defense against weed invasion.

Mechanical Removal

Mowing newly established turf areas early will eliminate many of the weeds that germinate in the seedbed. On small areas that are not heavily infested with weeds, hand-digging is an effective method of control. Be sure to remove as much of the underground plant parts as possible. Where weeds infest large areas, weed populations are heavy, or creeping or rhizomatous weeds dominate, manual removal is generally not practical.

Chemical Weed Control

Two basic strategies for chemical weed control are available—preemergent and postemergent. Preemergent herbicides control only weeds from seed and generally have little effect on emerged plants; consequently, preemergent herbicides are effective only when applied before seed germination. Postemergent herbicides control weeds after they have emerged. Many herbicides are registered to control weeds in turf. Use the following guidelines to select the most appropriate herbicide for your particular weed problem:

Efficacy on the target weed species—Will it control the target weed?

Longevity of residual control (if preemergent)—How long will the control last? Will multiple treatments be necessary? Will the residual interfere with my overseeding program?

Turfgrass species and management —Will the herbicide injure the turfgrass species on my site? Is it registered for close-cut turf such as tees and greens?

Weed status or growth stage —Do I need a preemergent or postemergent product? For a postemergent treatment, does weed age or size (tiller number) affect product or rate selection?

Weed control spectrum —Will other (incidental but important) weeds also be controlled? For example, crabgrass will be controlled, but what about the spurge or goosegrass that occurs sporadically?

Available equipment —Do I want to spray or spread granules? Do I need to alter my equipment (such as changing spray pressure and nozzles) to achieve adequate control?

Proximity of susceptible species —Are there susceptible landscape plants located nearby? Would another product reduce the chances of nontarget effects?

Environmental impact and mammalian toxicity —Is this product the safest or most environmentally friendly option?

Economics —How much does an "acre treatment" cost, and how many acre treatments will be necessary for season-long control with each option? What are the labor and equipment costs associated with repeat or sequential applications?

Tables 8 and 9 provide basic information on herbicides registered for major weed pests, suggested rates of application, and special instructions or precautions. Always consult the herbicide label for full instructions and precautions.

Table 8. Chemical Control of Turfgrass Weeds

Weed	*Herbicide*	*Active Ingredient per Acre*
	ANNUAL GRASSY WEEDS	
	Preemergent Control	
Crabgrass, barnyardgrass, foxtails, panicum	benefin (Balan)	2 lb.
	Apply in early spring for preemergence control on mature turfgrass only. May injure bentgrass.	
	benefin + trifluralin (Team)	2 lb.
	Apply in early spring for preemergence control on mature turfgrass only. Do not use on bentgrass greens or tees.	
	bensulide (Betasan)	7.5–10 lb.
	Apply in early spring for preemergence control on mature turfgrass only.	
	DCPA (Dacthal)	10.5 lb.
	Apply in early spring for preemergence control on mature turfgrass only. May injure fine fescue. Not for use in Suffolk Co., N.Y.	
	pendimethalin (Pre-M, Halts, Weedgrass control)	1.5–2 lb.
	Apply in early spring for preemergence control on mature turfgrass. May also be used on seedling turf with 1 to 2 inches of growth. Do not use on closely cut bentgrass.	
	oxadiazon 2G (Ronstar)	2–4 lb.
	Apply in early spring for preemergence control on mature Kentucky bluegrass, tall fescue, and perennial ryegrass only.	
	NOTE: Ronstar 50 WP formulation is labeled for Zoyzia turf but has injured other cool-season turfgrasses.	
	siduron (Tupersan)	6–12 lb.
	Apply in early spring to newly seeded, seedling, or mature turfgrass for preemergence control. Also effective on young crabgrass seedlings. Use reduced rate, 6 lb./A, on newly seeded turfgrass.	
	*dithiopyr (Dimension)	0.25–0.5 lb.
	Apply in early spring for preemergent control on established turfgrasses. Tolerant turfgrasses include bluegrasses, fescues, ryegrasses, zoysiagrass, and creeping bentgrass. Labeled for bentgrass greens, tees, and fairways. Length of control is rate dependent; use lower rates upstate and higher rates in the lower Hudson Valley. Not for use on Long Island. See label for rate suggestions and precautions.	
	*prodiamine (Barricade)	0.65–0.75 lb.
	Apply in early spring for preemergent control on established turfgrasses. Tolerant turfgrasses include bluegrasses, fescues, ryegrasses, zoysiagrass, and creeping bentgrass. Maximum dose for any application and maximum allowed per year vary with turf type. See label for detailed rate suggestions and precautions.	
Goosegrass (silver crabgrass) Goosegrass germinates two to four weeks after crabgrass. Treat later than for crabgrass.	benefin + trifluralin (Team)	3 lb.
	Apply in spring for preemergence control on mature turfgrass only. Do not use on bentgrass greens or tees. Split applications may be necessary to control late-germinating goosegrass. See the label for details.	

2ee recommendation
*Restricted-use pesticide.

(continued on next page)

Table 8. Chemical Control of Turfgrass Weeds (continued)

Weed	*Herbicide*	*Active Ingredient per Acre*
Goosegrass (continued)	oxadiazon 2G (Ronstar)	4 lb.
	Apply in spring for preemergence control on mature Kentucky bluegrass, tall fescue, and perennial ryegrass only.	
	NOTE: Ronstar 50WP formulation is labeled for Zoyzia turf but has injured other cool-season turfgrasses.	
	pendimethalin (Pre-M, Halts, Weedgrass Control)	2 lb.
	Apply in spring for preemergence control on mature turfgrass only. Do not use on closely cut bentgrass. Second application may be necessary to control late-germinating goosegrass. See the label for details.	
	bensulide + oxadiazon (Scott's Goosegrass/Crabgrass Control)	6.5+1.5 lb.
	For use on bentgrass, greens, and tees. Some injury can be expected.	
	*dithiopyr (Dimension)	0.5 lb.
	Apply in spring for preemergent control on established turfgrasses. Tolerant turfgrasses include bluegrasses, fescues, ryegrasses, zoysiagrass, and creeping bentgrass. Labeled for bentgrass tees, fairways, and greens. Not for use on Long Island. Some turf injury has been observed on native soil (unamended) greens. See label for rate suggestions and precautions.	
	*prodiamine (Barricade)	0.75 lb.
	Apply in early spring for preemergent control on established turfgrasses. Tolerant turfgrasses include bluegrasses, fescues, ryegrasses, and zoysiagrass. More consistent control is obtained by sequential applications of 0.75 lb followed six weeks later by 0.25 lb. This higher rate required to control goosegrass is not safe on bentgrass. Maximum dose for any application and maximum allowed per year vary with turf type. See label for detailed rate suggestions and precautions.	
	Postemergent Control	
Crabgrass, goosegrass, foxtail, barnyardgrass, other summer annual grasses	fenoxaprop (Acclaim)	1/8–3/8 lb.
	Apply to actively growing grassy weeds. Use higher rates for larger weeds. Do not tank mix with broadleaf herbicides. See label for other restrictions. For use on bentgrass tees and fairways use 0.032 lb./A. Follow the special directions on the label.	
	methanearsonates (MSMA)	2 lb.
	Apply after crabgrass is noticeable. It is best applied before crabgrass is large enough to compete seriously with desirable turfgrass. Repeat application may be necessary. Does not control goosegrass effectively. May discolor turfgrass. DSMA is also labeled but is used at higher rates.	
	*dithiopyr (Dimension)	0.38–0.5 lb.
	Postemergent control of young seedling (pretillering) crabgrass but not goosegrass. Addition of 0.25% (by volume) of a nonionic surfactant may improve control. To control tillered crabgrass dithiopyr may be mixed with Acclaim or MSMA. Not for use on Long Island.	
Annual bluegrass in perennial ryegrass	ethofumesate (Prograss)	1–2 lb./A ($^2/_3$–1 $^1/_3$ gal./A)
	Apply in late August or early September to control seedling annual bluegrass. Apply follow-up treatment 30 to 60 days later. Do not exceed 4 lb. AI/A per year. On seedling ryegrass, apply only after ryegrass seedlings are 1 inch tall.	

2ee recommendation
*Restricted-use pesticide.

(continued on next page)

Table 8. Chemical Control of Turfgrass Weeds (continued)

Weed	*Herbicide*	*Active Ingredient per Acre*
	ANNUAL GRASSY WEEDS (continued)	
Annual bluegrass in creeping bentgrass	paclobutrizol (Scotts TGR)	1/3–3/4 lb./A
	For suppression of annual bluegrass and gradual conversion to bentgrass. Use lower rate on sandy soils. Apply in late summer or early fall (no later than October 1 in New York) and again in the spring after 100% green-up. Applications when turfgrass vigor is low may result in undesirable levels of discoloration and growth reduction. May be used on bentgrass greens, but greater caution is advised because the margin for safety is narrower than on higher-cut turf.	
	PERENNIAL WEEDS	
Yellow nutsedge	bentazon (Basagran)	1–2 lb.
	Apply in late June to early July; repeat in 10 to 14 days if necessary.	
	The high rate has injured ryegrass turf; avoid such applications during hot weather to minimize the chances of injury.	
	methanearsonates (MSMA)	2 lb.
	Apply when first active spring growth occurs. Repeat application in 10 to 14 days. May discolor turfgrass.	
Tall fescue or perennial ryegrass in Kentucky bluegrass, fine fescue, or bentgrass turf	chlorsulfuron (Lesco TFC)	2–4 oz./A
	Apply as a spot or limited-area treatment to tall fescue or ryegrass infestations. May take one month to show effect. Some varietal differences in Kentucky bluegrass tolerance have been observed; use with caution. Do not allow spray drift to contact nearby trees or shrubs; injury will result. Injury to trees and shrubs may also occur via root uptake.	
Tall fescue, orchardgrass, quackgrass (and other undesirable perennial grasses) in other turfgrasses	Wipe with Roundup (glyphosate) when tall fescue is taller than desirable grass. Avoid contact with desirable species. If large infestations exist, see section on turf renovation.	
Wild onion, garlic	2,4-D	1 lb.
	Spray during each of two successive springs; second spring cleanup essential because plants regrow from bulbs.	
## Star-of-Bethlehem (*Ornithogalum* sp.)	oxadiazon (Ronstar G)	4 lb.
	Apply in October for two consecutive years. Apply to established Kentucky bluegrass, tall fescue, and perennial ryegrass only.	
	BROADLEAF WEEDS	
	Preemergent Control	
	Winter annuals (germinate in late summer, fall, or early spring)	
Chickweed, common or mouseear	pendimethalin (Pre-M, Weedgrass Control)	2 lb.
	Apply in August before weed germination. Observe all label restrictions pertaining to turf species, mowing height, and maximum dosage.	
	*dithiopyr (Dimension)	0.5 lb.
	*prodiamine (Barricade)	0.75 lb.

2ee recommendation
*Restricted-use pesticide.

(continued on next page)

Table 8. Chemical Control of Turfgrass Weeds (continued)

Weed	*Herbicide*	*Active Ingredient per Acre*
	BROADLEAF WEEDS (continued)	
Henbit and deadnettle	pendimethalin	2 lb.
	bensulide (Betasan, others)	12.5 lb.
	Apply in August before weed germination. Observe all label restrictions pertaining to turf species, mowing height, and maximum dosage.	
	*dithiopyr (Dimension)	0.5 lb.
	*prodiamine (Barricade)	0.75 lb.
Speedwell, annual species such as *Veronica arvensis, V. hederifolia, V. persica, V. peregrina.* Not *V. filiformis.*	oxadiazon (Ronstar G)	2 lb.
	Apply in August before weed germination. Observe all label restrictions pertaining to turf species, mowing height, and maximum dosage.	
	*dithiopyr (Dimension)	0.5 lb.
Summer annual broadleaf weeds (germinate in the spring or summer and die at frost)		
Knotweed, prostrate	pendimethalin (Weedgrass Control)	2 lb.
	Germinates in very early spring; therefore, late fall applications are more effective. A second application in early to mid-June may be necessary to prevent late-germinating weeds.	
Oxalis (woodsorrel)	pendimethalin (Pre-M, Weedgrass Control)	2 lb.
	benefin + trifluralin (Team)	3 lb.
	oxadiazon (Ronstar G)	2 lb.
	Apply in the spring before germination. A second application is usually necessary to prevent late-germinating weeds.	
	*prodiamine (Barricade)	0.75 lb.
Spurge	pendimethalin (Pre-M, Weedgrass Control)	2 lb.
	Apply in late spring before germination. A second application is usually necessary to prevent late-germinating weeds.	
	DCPA (Dacthal)	10–12 lb.
	Apply in late spring before germination. A second application is usually necessary to prevent late-germinating weeds. Not labeled for use in Suffolk County.	
	benefin + trifluralin (Team)	3 lb.
	Apply in late spring before germination. A second application is usually necessary to prevent late-germinating weeds. Follow all label restrictions pertaining to turf species, mowing height, and maximum dosage.	
	oxadiazon (Ronstar G)	4 lb.
	Apply in late spring before germination. A second application is usually necessary to prevent late-germinating weeds. Note the higher rate is required for spurge control. Variable results have been obtained at lower rates. Follow all label restrictions.	

See recommendation
*Restricted-use pesticide.

(continued on next page)

Best Management Practices for Golf Course Maintenance Departments

Florida Department
of
Environmental Protection
Agricultural Source and Water Well Management Section

May, 1995

Best Management Practices for Golf Course Maintenance Departments

Introduction

The maintenance department is responsible for irrigation, mowing, fertilization, pesticide application and general upkeep of the golf course grounds. The maintenance area is where pesticides are loaded into application equipment, mowers and other pieces of equipment are serviced, and pesticides, fuel, fertilizer, and cleaning solvents are stored. This is where pollution of soil, surface water, or ground water is most likely to occur. Contamination can occur when pesticides are spilled, containers or equipment cleaned and the rinsewater dumped on the ground or discharged into surface water, or improperly cleaned containers are stockpiled or buried. Proper management of the maintenance area is an important part of responsible chemical and pesticide use. Poor handling and disposal practices at these sites can lead to serious environmental problems, expose the ownership to extensive legal liability for contamination and cleanup, including penalties and fines, and can create a poor public image for the golf course.

Management practices should be implemented at these maintenance areas that will prevent the contamination of soil, surface water, and ground water by the materials stored and handled at these sites. This document describes a number of "Best Management Practices", or BMPs, which can be put into practice through proper design and operation of the golf course maintenance facilities and equipment.

Best Management Practice Principles

The general approach to best management practices for golf course maintenance departments involves three principles :

- Isolate all potential contaminants from soil and water, and,
- Do not discharge any material other than clean stormwater onto the ground or into surface water bodies.
- Minimize irrigation, fertilizer, and pesticide use requirements through use of Integrated Pest Management and native or naturalized vegetation wherever practicable.

The first principle involves identifying all the materials stored or handled in a golf course maintenance area along with current practices that could cause environmental contamination. The next step is to develop management practices which isolate those materials from soil and water during storage, handling, and disposal. Materials that

may contaminate soil and water include pesticides, fuels, solvents, fertilizers, paints, etc. Storing these materials in covered, lockable storage areas, handling them over impermeable surfaces, cleaning up spills promptly and properly, recycling these materials where possible, and otherwise properly managing wastes will keep these materials from contaminating soil or water.

The second principle is an extension of the first. It includes preventing contamination of stormwater and eliminating the discharge of materials such as equipment wash water to ground or surface waters. Discharge to surface waters can occur directly through dumping to a lake or canal, or indirectly through discharge to a ditch, storm drain or swale. Discharge to ground water may occur by percolation through highly permeable soils, such as the fine sandy soils found in much of Florida, or by flowing into sinkholes, improperly constructed wells or other direct conduits to ground water. Discharges to surface or ground water should be eliminated through the containment and collection of equipment washwaters and proper management of the collected material. Where allowed by the local Department of Environmental Protection (DEP) District office or local authorities, stormwater, and washwater other than that from pesticide application equipment, may be discharged to a swale or retention area that does not connect to a surface water body or provide a direct conduit to the ground water.

Several specific BMPs for golf course maintenance areas are described below which comply with these two general principles. If a material handled or a maintenance practice employed at a golf course maintenance area is not addressed below, golf course managers can use these principles to devise their own BMP for that activity or material.

The third principle, that of minimizing fertilizer, pesticide and irrigation use through use of native vegetation and Integrated Pest Management directly impacts the amount of materials handled annually, reduces the annual maintenance budget, and encourages good environmental stewardship. An example of how a golf course owner or operator can obtain assistance in this area is through the Audubon Cooperative Sanctuary Program (ACSP), a progam of the Audubon Society of New York State, Inc., sponsored by the the United States Golf Association. This voluntary program offers extensive planning, guidance, and technical assistance while requiring no restrictions on the property. All decisions to act on ACSP suggestions are made by the golf course superintendent and course officials.

Specific Best Management Practices

Specific BMPs for golf course maintenance areas are listed below by the type of material handled or the maintenance activity conducted. These are summarized at the

end of this section. Sources for the references provided in each section are detailed at the end of the document.

1.0 Pesticides

1.1. Storage

Storage of pesticides should be in a lockable concrete or metal building, located at least 50 feet from other types of structures to allow fire department access. The pesticide storage area should be separate from other buildings or at least separate from areas used to store other materials, especially fertilizers. Shelving should be plastic or reinforced metal. Metal shelving should be kept painted to avoid corrosion. Wood shelving should never be used because it may absorb spilled pesticide materials.

Figure 1 Storage and Mix/load facility. Courtesy of Collier's Reserve Country Club, Naples, FL.

Floors should be seamless metal or concrete and sealed with a chemical-resistant paint. The floor should have a continuous sill to retain spilled materials and it should have no drains, although a sump may be included. Sloped ramps should be provided at the entrance to allow wheeled handcarts to move material in and out of the storage area safely. Automatic exhaust fans and an emergency wash area should be provided. Explosion proof lighting may be required. It is recommended that the light/fan switch be located outside the building so that both are on when entering or leaving the building. Personal protective equipment should be easily accessible and stored immediately outside of the pesticide storage area. An inventory of the pesticides kept in the storage building and the Material Safety Data Sheets (MSDS) for the chemicals used in the operation should be accessible on the premises, but not kept in the pesticide storage room itself (since that would make them unavailable in time of emergency).

Flammable pesticides should be separated from non-flammable. Dry bags should be raised on pallets to ensure that they do not get wet. Liquid materials should always be stored below dry materials, never above them. Labels should be clearly legible. Herbicides, insecticides and fungicides should be separated to prevent cross

contamination and minimize the potential for misapplication. (Since cross contaminated pesticides often cannot be applied in accordance with the labels, this makes it necessary to dispose of the contaminated materials as wastes. This may require the services of a consultant and hazardous waste contractor, depending on the materials involved.)

Storage building plans are available from several sources, including the Midwest Plan Service, the University of Florida Institute of Food and Agricultural Sciences (IFAS), and the United States Department of Agriculture-Soil Conservation Service (SCS).

1.2 Mixing and Loading

Loading of pesticides and mixing with water or oil dilutents should be done over an impermeable surface (such as lined or sealed concrete) so that spills can be collected and managed. Refer to the DEP publication *D.E.P. Minimum Construction and Operation Standards for Chemical Mixing Centers used for Pesticide Mixing and Loading.* Although use of a chemical mixing center (CMC) is not mandatory, adherence to the standards in the above publication is strongly encouraged.

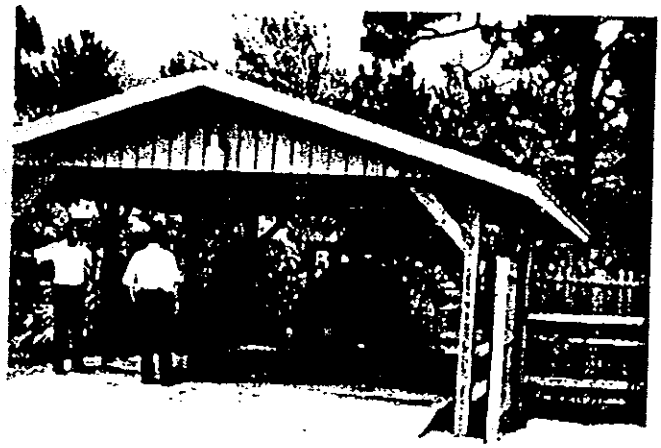


Figure 2 Typical golf course mix/load facility. Courtesy of John's Island West, Sebastian, FL.

The purpose of a CMC is to provide a place where the operator can perform all operations where pesticides are likely to be spilled in concentrated form, or where even dilute formulations may be repeatedly spilled in the same area, over an impermeable surface. Such a surface should provide for easy cleaning and recovery of spilled materials. In its most basic form, a CMC is merely a concrete pad treated with a sealant and sloped to a liquid-tight sump where all of the spilled liquids can be recovered. For small spills, absorbents such as cat litter or sand may be used for clean up of the spill and then applied as a top dressing in accordance with the label rates, or disposed of as a waste. Solid materials, of course, can be swept up and reused.

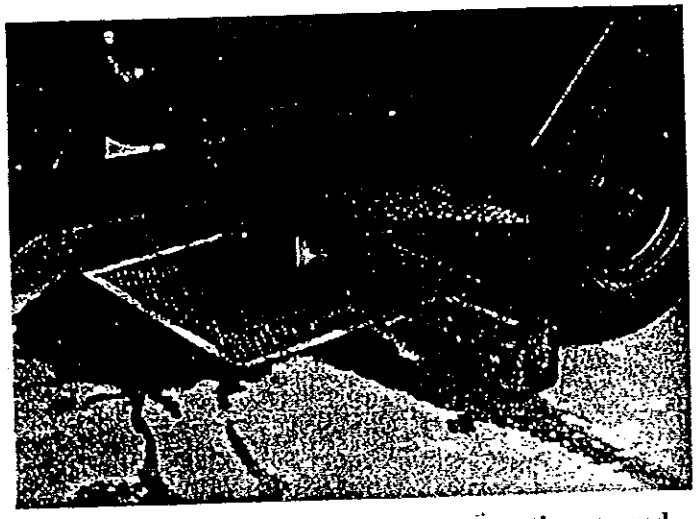


Figure 3 Spills flow into sump, not onto the ground. Courtesy of John's Island West.

Materials other than concrete, such as tough synthetics, may also be used in some cases. These materials are often used for portable CMCs where a permanent facility is not practicable.

Figures 1 through 4 depict some actual CMCs used at golf courses in Florida. Designs for CMCs are available from several sources including the Midwest Plan Service, USDA-SCS, and IFAS.

The first principle of CMC management is that any material that collects on the pad must be applied as a pesticide or disposed of as a waste. Since any water, including rain, that collects on the pad must be used as a pesticide or disposed of as a waste, a roof with a substantial overhang (minimum 30 degrees)

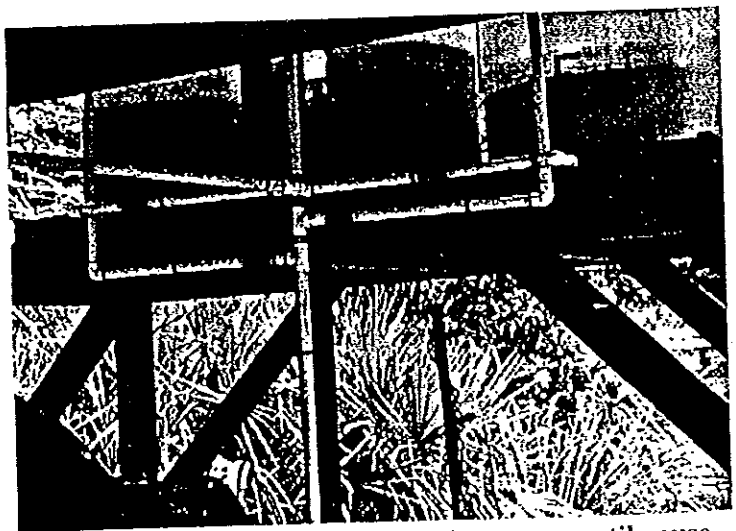


Figure 4 Tanks are used to hold rinsewater until reuse. Note separate H, I, and F tanks. Courtesy of John's Island West.

on all sides is strongly recommended to protect against windblown rainfall. In addition, most CMCs will have a provision for pumping out the sump to storage tanks, one for each general type of pesticide (ie. herbicide, insecticide, or fungicide). In this way, spills and rinsate can be saved and used as make-up water for the next time that type of material is applied. *All spills should be cleaned up immediately, and the sump should be pumped dry at the end of each day, or more frequently when materials are changed to something which is incompatible with that previously used.* Provisions should be made to clean the tires and particularly dirty areas of the equipment exterior prior to bringing it into the pad area to minimize a build up of sediment in the sump. Sediments should be removed from the sump any time materials are changed to incompatible types so that the sediments can be applied as a pesticide to the turf at less than the label rate, instead of requiring disposal as a (possibly hazardous) waste.

It is extremely important to pump out the sump and remove all sediments when changing pesticides in order to avoid disposal problems due to cross-contamination.

Small spills may also be cleaned up by using an absorbent such as cat litter and then applying the absorbent to the turf as a pesticide in accordance with the label instructions, for example, by mixing with dry fertilizer where permitted by the label. Very small operations may find this method preferable at small mixing areas where hand sprayers are loaded.

Pesticide containers should be cleaned immediately upon emptying. Containers should be properly cleaned by pressure-rinsing or triple-rinsing and the rinse water dumped into the sprayer as part of the make-up water. Non-rigid bags should be shaken clean so that all dust and material falls into the application equipment. The clean containers should be stored in a clean area, out of the rain and weather, until they can be disposed of or recycled. Storing the containers in large plastic bags is one popular option to protect the containers from collecting rainwater. *The cleaned containers should be recycled in counties where such a program is available,* or they may be taken to a landfill for disposal. If you are unable to locate information about pesticide container recycling programs in your area, you may contact the University of Florida Pesticide Information Office at (904)-392-4721.

1.3 Pesticide Application Equipment Washwater

Washwater from pesticide application equipment must be managed properly since this washwater will contain pesticide residues. The best management practice for this material is to collect it and use it as a pesticide in accordance with label instructions for that pesticide. This applies to washwater from both the inside and outside of the application equipment. Often, the easiest way to do this is to wash the equipment in the CMC. The pad should be flushed with clean water after washing equipment, and

the captured washwater should be pumped into the rinsate storage tank for use in the next application, or it may be applied to the labeled site as a dilute pesticide. The applicator is allowed by the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) section 2(ee) to apply a pesticide at *less* than the labeled rate. *The sump should then be cleaned of any sediment before another type of pesticide is handled.*

1.4 Pesticide Management Summary

The appropriate practice for the management of pesticide materials depends on the type of material. The proper practice for each type of pesticide material is listed below.

Empty containers	Transport to an approved pesticide container recycling facility after proper cleaning (pressure rinsing or triple rinsing). If no recycling facility is available, after proper cleaning dispose of as solid waste.
Excess formulation	Return to manufacturer, use as a pesticide in accordance with the label, use a hazardous waste contractor to remove and dispose.
Excess mixture	Use as a pesticide in accordance with label.
Material used to contain or collect spills or leaks	Use as a pesticide by applying to a labeled site at *or below* application rate in accordance with label directions for use. If is it necessary to dispose of the material as a waste, contact the DEP District office for information.

Application equipment washwater	Reuse as a dilutant in subsequent applications. Use as a pesticide by applying to a labeled site at *or below* application rate in accordance with label directions for use. Alternatively, treat in a permitted treatment facility, such as an evaporation/degradation system. This requires a DEP industrial wastewater permit. Contact the DEP District office for more information.

2.0 Solvents and Degreasers

2.1. Storage

Solvents and degreasers are generally flammable and toxic and should be stored in lockable metal cabinets in an area away from ignition sources and with adequate ventilation. Do not store near an area where welding or other similar activities are performed. Never store with pesticides or fertilizers. An inventory of the solvents stored and the MSDS sheets for these materials should be kept on the premises, but not in the solvent storage area. Any emergency response equipment recommended by the manufacturer of the solvent should be kept accessible to the storage area, but not inside the area itself.

2.2. Use

Solvents and degreasers should be used over a collection basin or pad that can collect all used material. The collected material should be stored in marked containers until it can be recycled or legally disposed of. There are a number of private firms that provide a service that includes solvent wash basins that drain into recovery drums. These drums are then picked up and the contents recycled or properly disposed of. Solvents should never be allowed to drain onto pavement or soil, or discharged into storm drains, sewers or septic systems, even in small amounts. Routine discharge of even small amounts of solvents can result in the accumulation of contaminants in soil or ground water over time, with serious environmental and liability consequences.

2.3. Disposal

Used solvents and degreasers should be collected, placed into containers marked with the contents and the date and then picked up by a service that will properly recycle or dispose of these materials. An IFAS publication, DSP-2, has more information on this.

3.0 Fertilizers

3.1. Storage

Fertilizers should be stored separately from solvents, fuels, and pesticides since many fertilizers are oxidants and can accelerate a fire. Ideally, fertilizer should be stored in a concrete building with a metal or other-flame resistant roof.

Care must be taken when storing fertilizer to prevent contamination of nearby ground and surface water. Fertilizers should always be stored in an area that is protected from rainfall. Storage of dry bulk materials on a concrete or asphalt pad may be acceptable if the pad is adequately protected from rainfall and from water flowing across the pad. Secondary containment of liquid fertilizer tanks larger than 550 gallons is addressed in 62-762 Florida Administrative Code (F.A.C.). Even where not required, the use of secondary containment is a best management practice.

3.2. Loading

Areas where fertilizers are loaded into application equipment should be protected from rainfall and spilled material cleaned up immediately. Collected material can be applied to the golf course as a fertilizer. If rainfall protection is not available or practical for the loading area, thorough cleaning is essential. Cleaning of the area can be through dry collection methods such as sweeping or vacuuming, or washing down the loading area. Any washwater generated would have to be collected and applied to the course. Discharge of this washwater to storm drains or septic systems is illegal.

4.0 Grass Clippings

Grass clippings removed from mowers should be handled separately from other waste materials and equipment washwater. Many manufacturers now recommend the use of compressed air to blow off equipment. This is more protective of hydraulic seals on the equipment, eliminates the washwater, and produces dry clippings that are easy to

handle. Another method is to clean mowers over a separate concrete or asphalt pad that allows water to run off onto turf or soil, but not into a surface water body or canal. *The CMC should not be used for this purpose, in order to keep clippings and other debris from becoming contaminated with pesticide residue.* The grass clippings will collect on the pad. After drying on the pad, the clippings can be collected and composted or spread in a wooded area or rough.

5.0. Used oil, antifreeze, and lead-acid batteries

Used oil and antifreeze should be collected in marked containers and offered for recycling. *In Florida, recycling is the only legal option for handling used oil. Antifreeze must be recycled or disposed of as a hazardous waste.* There are commercial services that will collect this material. The IFAS publication DSP-2 has information on this subject.

Lead-acid storage batteries, such as used in golf carts and for starting other equipment, are classified as special wastes and must be recycled. All lead-acid battery retailers are required by law to accept returned batteries for recycling. Used acid from these batteries contains high levels of lead and must be disposed of as hazardous waste, unless contained within a battery being recycled.

6.0. Gasoline, Diesel fuel

Fuel storage tanks should be in compliance with DEP storage tank regulations (Chapter 62-761 F.A.C. for underground tanks and 62-762 F.A.C. for aboveground tanks). Call the nearest DEP District office for information on these requirements. In general, underground tanks with volumes over 110 gallons and above-ground tanks with volumes over 550 gallons must be registered and located within secondary containment systems.

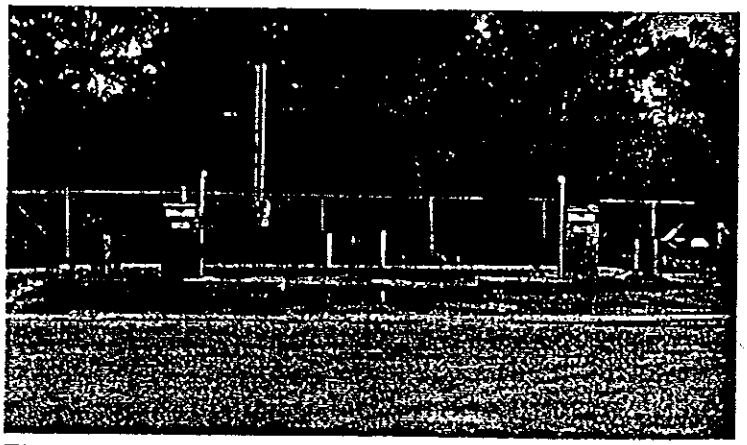


Figure 5 Fueling area. Note the continuous curb. Courtesy of John's Island West.

Fuel dispensing areas should be designed and managed to prevent soil and water contamination. Concrete or

asphalt surfaces should be provided near the fuel pumps. The pumps should not be located where a spill or leak would cause fuel to flow onto the ground or into a storm drain or surface water body.

Secondary containment structures are required for above-ground fuel tanks over 550 gallons. The best practice is for these structures to be roofed to keep out rainfall. Building the containment structure so that it is tall rather than wide will also help with minimizing rainfall accumulation by reducing the amount of surface area of the structure. If the structure is not roofed, then water that accumulates must be managed properly. *If the structure has a discharge port, make certain that it is closed and locked except when uncontaminated rain water is to be drained. The best option is to have no discharge port and to use a portable sump pump to remove water when it is necessary. A discharge port invites the possibility that it may be left open when a leak occurs.*

The first line of management is to minimize the need to discharge. If the containment volume is adequate, evaporation of accumulated rainfall will often be sufficient. Critical levels at which discharge is considered should be established for each facility and the levels marked on the containment wall. This will prevent frequent and unnecesary discharge of small volumes.

The water to be discharged must always be checked for contamination. This can be done by looking for an oil sheen, observing any smell of fuel or oil, or through the use of commercially available test kits. *Never discharge any water that is contaminated.* Contaminated water must be treated on site using commercially available treatment systems, or discharged to an off-site treatment system directly or by being transported by tanker truck to a treatment facility. Never discharge to a sewer system without written permission from the utility. For more information on treatment options, contact the appropriate DEP District office.

Figure 6 Fueling and general equipment wash station.
Courtesy of Collier's Reserve.

If the water is not contaminated, it can be discharged to a stormwater system, retention area, or grassed swale. Do not discharge it during a rain event, since the added flow may cause it to run-off to a sensitive area.

7.0. General Equipment Washing

Washwater generated from the cleaning of equipment other than pesticide application equipment does not have to be collected and applied to the course. This washwater must not, however, be discharged to surface water either directly or through ditches, storm drains or canals. Equipment washwater can contain soaps, fertilizer residues, solids, and lubricating oil residues. This washwater should not contain solvents and degreasers. These materials should be used in a separate operation. See section 2.0 above for information on solvents and degreasers.

BMPs for washwater from other than pesticide application equipment depend on the quantity generated. If quantities less than 500 gallons per day are generated, the DEP District office may allow the washwater to drain to a grassed retention area or swale, as long as no direct contact with a surface water body occurs. Discharge to a septic system is not legal.

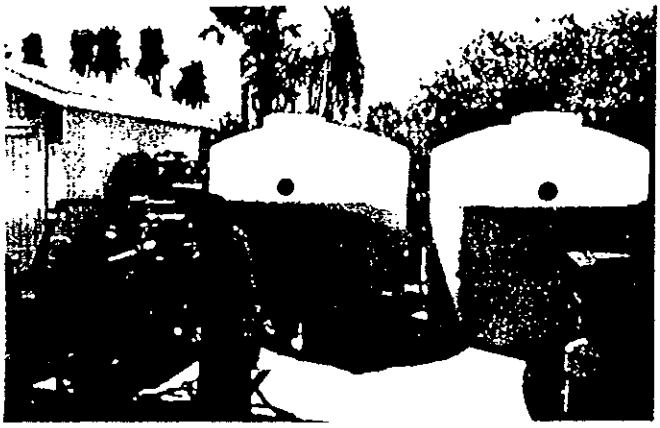


Figure 7 Wash water recycling system. Courtesy of Collier's Reserve.

For larger quantities, the options are:

- use of a washwater recycling system, or
- discharge to a treatment system that has been permitted under DEP industrial wastewater rules, or
- discharge to a domestic sewer system (with written permission from the utility).

If you decide to use a wash water recycling system, care must be taken to operate it properly. *Do not clean pesticide application equipment using these systems.* The introduction of pesticide residues into these systems can result in contamination of the systems and high costs for disposal of contaminated filters and sludges.

If you generate more than 100 gallons per day, you should contact the DEP District Office that is responsible for your area. In many cases, the District office will allow discharges up to 500 gallons per day without a permit provided that the washwater is not going to a surface water body or other sensitive area.

For all quantities generated, the amount of detergents used should be minimized. The amount of water used to clean equipment can be minimized by using spray nozzles that generate high pressure streams of water using low volumes.

Oil/water separators can be used, but must be managed properly to avoid problems. First, *do not wash equipment used to apply pesticides on pads using oil/water separators,* since the pesticide residues will contaminate the oil that is salvaged. Second, be aware that the oil collected in these systems may be classified as a hazardous waste, depending on its composition, making disposal expensive. Oil water separators are not necessary unless the water from the system is to be reclaimed for some particular end use, or large volumes of water are generated and the industrial wastewater permit or receiving utility requires such a system.

8.0 Equipment Storage

Equipment used to apply pesticides and fertilizers should be stored in an area protected from rainfall. Rain can wash pesticide and fertilizer residues from the exterior of this equipment and these residues can contaminate soil or water. Pesticide application equipment can be stored in the Chemical Mixing Center, but fertilizer application equipment should be stored separately.

9.0 Summary

Material or Activity to be Managed	Best Management Practice
Pesticide Mixing and Loading	Chemical Mixing Center and proper operation and maintenance. See summary in section 1.4.
Solvents from equipment washing	Separate solvent collection systems such as solvent wash baths.
Soaps, other non-solvent materials used to wash equipment, oils washed off of vehicles	For less than 500 gallons per day - Washwater areas that allow water to seep into grassed retention areas or swales not connected to surface water. For more than 500 gallons per day - Industrial wastewater treatment system, water recycling systems (provided no pesticide residues enter system), or, with written permission, hook-ups to waste water treatment plants.
Fertilizer storage	Covered fertilizer storage areas with curbs or berms to prevent water from entering. Secondary containment should be used even where not required.
Pesticide storage	Covered, locking concrete or steel buildings with adequate ventilation and metal shelving, no floor drains, and a berm or sill to contain spills.
Used oil, antifreeze	Collection and recycling.
Gasoline, diesel fuel	Compliance with DEP regulations for above-ground and below-ground tanks, closing of stormwater drains in immediate vicinity of fueling point.

Additional Sources of Information

Agricultural Engineering Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida, 32611. Phone: (904)-392-2468.

Audubon Society of New York State, Inc. 46 Rarick Road, Selkirk, NY 12158. Phone: (518)-767-9051

Florida Department of Environmental Protection, Agricultural Source and Water Well Management Section, MS-3515, 2600 Blair Stone Rd., Tallahassee, Florida, 32399-2400. Phone: (904)-488-3601.

Golf Course Superintendents Association of America. 1421 Research Park Drive, Lawrence, KS 66049 Phone: (913)-841-2240.

Midwest Plan Service, 122 Davidson Hall, Iowa State University, Ames Iowa 50011-3080. Phone: (515)-294-4337.

Pesticide Information Office, University of Florida Institute of Food and Agricultural Sciences, Gainesville, Florida, 32611. Phone (904)-392-4721

University of Florida Institute of Food and Agricultural Sciences, Palm Beach County Cooperative Extension Service. 2976 State Road 15, Belle Glade, Fl. 33430. Phone: (407)-996-1655.

United States Department of Agriculture-Soil Conservation Service. P.O. Box 141510, Gainesville, FL 32605. Phone: (904)-338-9555.

United States Golf Association, P.O. Box 708, Far Hills, NJ 07931. Phone: (908)-234-2300

Publications

Audubon Cooperative Sanctuary Program for Golf Courses. Audubon Society of New York State, Inc. 46 Rarick Road, Selkirk, NY 12158. Phone: (518)-767-9051

Designing Facilities for Pesticide and Fertilizer Containment. MWPS-37. MidWest Plan Service.

Disposal Options for Agricultural Wastes. DSP-2. IFAS Palm Beach County Cooperative Extension Service.

Conference Proceedings from the National Symposium on Pesticide and Fertilizer Containment: Design and Management. MWPS-C1. MidWest Plan Service.

Conference Proceedings from the National Symposium on Pesticide and Fertilizer Containment: Design and Management 2. MWPS-C2. MidWest Plan Service.

Minimum Construction and Operation Standards for Chemical Mixing Centers used for Pesticide Mixing and Loading. Florida Department of Environmental Protection, Agricultural Source and Water Well Management Section

FDEP District Offices

Northwest (Pensacola)	(904)-444-8300
Northeast (Jacksonville)	(904)-448-4300
Central (Orlando)	(407)-325-2290
Southeast (W. Palm Beach)	(407)-433-2650
Southwest (Tampa)	(813)-744-6100
South (Ft. Myers)	(813)-332-6975
FDEP Agricultural Source and Water Well Management Section (Tallahassee)	(904)-488-3601

Acknowledgements

The Florida Department of Environmental Protection extends its gratitude to the following for their assistance and advice in producing this document. The staff and management of Collier's Reserve and St. John's Island West golf courses, the Audubon Society of New York State, Inc., the United States Golf Association, the Golf Course Superintendents Association of America, and the Florida Department of Agriculture and Consumer Services.

MWPS-37

Designing Facilities for Pesticide and Fertilizer Containment

Revised First Edition

David W. Kammel
Ronald T. Noyes
Gerald L. Riskowski
Vernon L. Hofman

MidWest Plan Service
Agricultural and Biosystems Engineering Department
122 Davidson Hall
Iowa State University
Ames IA 50011-3080

6. PESTICIDE AND FERTILIZER STORAGES[6]

Pesticide and fertilizer storage facilities serve several functions. A well designed and managed storage facility protects human health, wildlife, the surface environment and groundwater from accidental and working exposure to pesticides. Segregate dry and liquid pesticides and fertilizers in the storage area. The primary design objective is to prevent spills or contaminated water from entering groundwater and surface water and guard human safety. The type and size of a storage facility depends on the size of the present (and future planned) operation and the type and amounts of pesticides and fertilizers used.

Pesticide Storage and Safety

Federal law, implemented by EPA Regulation 40CFR, requires full strength pesticides be stored in a secured facility to provide human safety, reduce vandalism and theft, and to protect groundwater and the surface environment (surface water, ground cover and airspace), and neighboring communities from leak and spill pollution and poison crises. Pesticide security can range from heavy-gauge, minimum-height chain-linked steel security fences with locked gates, to heated, locked, steel cargo containers, modular transportable pesticide and fertilizer storage buildings or custom designed pesticide storage buildings. In all cases, lockable storage and containment for liquid leaks/spills are required.

Packaged Product Pesticide Storage

Keep pesticides dry, cool and out of direct sunlight. Some pesticides require protection from freezing and temperature extremes. Check the labels for shelf life. The temperature range recommended for most liquid pesticides is 40 F-100 F.

Pesticide containers used once and then disposed, or one-way containers, are the most common types of pesticide containers. Inspect packages for broken or leaking containers prior to purchase and immediately after delivery. Store only clean, unopened packages or containers with no exterior residues to lessen the danger of contamination through the skin. Wear the recommended PPE even while handling clean, unbroken pesticide packages to reduce the chance of accidental contact.

Store boxes, jugs and other small packages of pesticides on shelves sized for the appropriate container, usually 12"-15" wide and approximately 18" apart. Lips on shelf perimeters prevent containers from accidentally sliding off the shelf. Steel shelves are easier to clean in the event of a spill. Paint wooden shelves with a chemically resistant epoxy paint or similar finish that is easier to clean. Store containers within easy reach and protect them from damage by sharp objects. A shelf height of 60" allows for lifting containers while standing on the floor. Do not use step stools, ladders or boxes to stand on to reach shelves.

Store herbicides, fungicides and insecticides in separate locations of the storage area to prevent cross contamination. Store dry bagged pesticides on shelves or pallets off the floor to keep them dry. To prevent leaking liquid pesticides from contaminating dry bagged product, store dry pesticides in a separate area and/or above liquid pesticide containers.

Several manufacturers package pesticides in refillable or returnable containers (small volume returnables, SVR) ranging in size from 15-30 gal. Minibulk containers range from 60-300 gal. Using SVR and minibulk containers reduces the problem of unused pesticide and container disposal if the dealer is willing to take back unused product.

Store 55 gal drums and minibulk containers on floor pallets, allowing for easy transport to and from storage buildings. Provide adequate space for forklifts to move minibulks in the storage area. One alternative for minibulk storage is to provide a concrete curbed containment pad large enough to hold the entire contents of the largest minibulk container. Chapter 7, Secondary Containment, gives areas required for containment of minibulk containers.

Tanks storing pesticides and rinsates must be compatible with the product. Some pesticides may attack the material in the tank causing it to soften, weaken and eventually fail. Check with the manufacturers of tanks and pesticides to determine the type of tank material best suited for a specific product.

The space required to store pesticides depends on the type of materials stored and the number and type of containers used. Table 2 shows the dimensions of several types of containers. Use this information to determine the amount of storage space required for the facility.

Planning and Layout

Build the pesticide storage facility as a separate, isolated structure used only for pesticide storage to prevent accidental contamination of feed, seed and fertilizers. Do not store pesticides near food, feed, fertilizers, seed, veterinary supplies and other products. Store pesticides only in original containers. Include an area for storing properly rinsed, empty containers until disposal.

---

6 David W. Kammel, Agricultural Engineering Department, University of Wisconsin Cooperative Extension, Madison.

Table 2. Pesticide container sizes.

Container	Size[a]
One way containers	
1 gal jug	4"x7"x12"
2.5 gal jug	6"x10"x18"
25 lb bags	2"x10"x15"
50 lb bags	4"x15"x25"
5 gal cans	12" dia. x 14" high
55 gal drums	20" dia. x 30" high
Refillable containers	
15 gal SVF[b]	16" dia. x 27" high
60 gal minibulk	40"x24"x33"
110 gal minibulk	36" dia. x 30" high
140 gal minibulk	50"x37"x36"
200 gal minibulk	43" dia. x 53" high
300 gal minibulk	44" dia. x 73" high
500 gal bulk	48" dia. x 75" high
1,000 gal bulk	64" dia. x 87" high
2,500 gal bulk	95" dia. x 117" high

[a]Container dimensions are LxWxH: L=length; W=width; H=height.
[b]Small volume returnable.

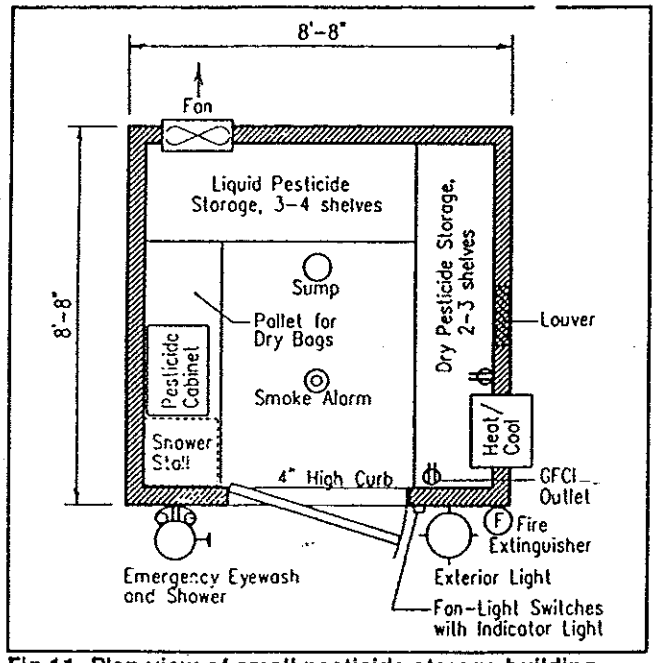


Fig 11. Plan view of small pesticide storage building.

Locate a storage building on a well drained site elevated approximately 12" above surrounding soil elevation. An example of a small storage building layout is shown in Fig 11.

Security

Security is required to prevent accidental poisoning of children, livestock and wildlife. Security also minimizes unauthorized access to pesticides and fertilizers, reducing the potential for accidental spills, vandalism and/or theft. Install a 12-gauge, chain-link fence, a minimum of 6' high, around an open storage area such as pesticide secondary containment. If the fence is on top of a concrete wall, erect the fence so there are no ledges on the outside to allow someone to climb over the fence. If a concrete ledge is available at the base of the fence, install 6' fence above the ledge. Provide locks on storage buildings or locked storage cabinets for small quantities of pesticide. Do not install door locks that must be unlocked from the inside. Also, store rinsate storage tanks and empty containers in a secure area.

Post signs on buildings or fences stating "**Danger-Pesticides**", "**Keep Out!**", "**No Smoking Area**". Signs should be legible at least 50' from the building and located at each entrance to the pesticide storage area. These signs should be visible from all access points to the storage area. Post yellow, orange or red signs at approximately eye level containing words "**Pesticide Storage Area**" in black letters at least 3" high. The state pesticide coordinator can also provide information on signing requirements. Use exterior lights to illuminate warning signs and identify the building at night. A motion sensor or light sensor turns lighting on automatically and saves electricity.

Management

A management plan combined with facility design ensures a safe total system that provides proper storage, plus disposal of empty containers, unused product and rinsates. A well designed and managed storage and handling facility can be considered "good insurance" and could be a factor in reduced insurance policy costs. The cost of building a well designed facility is far less than the potential costs associated with cleanup of a large spill or fire, or with litigation of a lawsuit. Inventory, record keeping, worker safety and emergency action plans are all part of the management plan.

Siting and Setbacks

Setbacks of pesticide storage buildings to property lines or to other buildings on the site should provide as much separation from other use areas as can be reasonably allowed. Locate the storage building (with 1-hr fire wall) at least 50' from other buildings or property lines. For a 2-hr fire wall with no doors, the setback can be 25' from the adjoining building or property line. For a 4-hr fire wall with no doors, there is no minimum setback distance.

When siting a building, consider:

- Prevailing wind directions.
- Residential area proximity and exposure.
- Commercial area proximity and exposure.
- Environmental exposure.
- Fire hazard to surroundings.
- Emergency response services.

Provide access to the storage building site from all directions, if possible, for emergency and fire fighting equipment. A 12' wide road accommodates emergency and fire fighting equipment.

Building Design and Construction

The storage facility design should consider both the potential for fire from flammable vapors and the toxicity to humans from contact with pesticides or

vapors. Select construction materials that are chemically resistant to the products stored. Ventilate areas to prevent vapor buildup.

General Construction

Building construction depends on the types of pesticides and fertilizer stored. Steel frame, post frame, stud frame, concrete and masonry can all be used. Design roof and walls for local snow and wind loads and any other loads applied to the building such as shelving loads and support of equipment. Check with insurance carriers for insurance requirements and fire officials on the building code requirements for construction of the storage facility.

Floor and Wall Surfaces

Choose interior floor and wall surfaces that are impervious to pesticides and easily cleaned and decontaminated. Painted steel, aluminum, fiberglass or high density plastic reinforced plywood panels are all good choices for wall liners. Storage building floors should also be watertight, chemically impervious and skid resistant. Concrete floors with an impervious sealant or an equivalent material that provides strength and impermeability must be used.

Secondary Containment

For inside storage rooms, secondary containment consists of a raised sill or ramp at least 4" high. An alternative is an open grate trench across the entire width of the door opening. Drain the trench to a sump where liquids can be temporarily collected and transferred to storage for reuse or disposal. Buildings can have a curb around their perimeter to prevent spills and fire fighting water from entering or leaving the area. Do not connect drains or sumps to a sewer or septic system or other open discharge. See Chapter 7, Secondary Containment, for more detail.

Fire Safety Design

Fire prevention is the first and most cost effective way of limiting fire hazard. A properly designed building with proper storage of flammables, a management plan and good housekeeping minimizes fire potential.

Design the storage building to protect against potential fire caused by the storage of flammable and combustible liquids inside the building and from fire in adjacent buildings. Many factors determine the advisability and use of fire walls; check your local fire codes for design requirements. Facility design can reduce the need for fire walls. Separate areas of high risk (warehouse) from other areas (office, retail space).

Codes and Regulations

Design requirements for the safe storage and handling of flammable and combustible liquids are covered by several different codes. National Fire Protection Association (NFPA) 30 "Flammable and Combustible Liquids Code", NFPA 395 "Storage of Flammable and Combustible Liquids on Farms and Isolated Construction Projects", and NFPA 43D "Storage of Pesticides in Portable Containers" all cover building construction requirements applicable to flammable and combustible pesticide storage and handling buildings. The National Electric Code (NEC) also covers electrical design for these facilities. See Appendix A for a list of other codes that may be consulted on flammable/combustible liquid storage.

Code Compliance

Many local codes reference or adopt certain national codes, Appendix A, as their own, but may also impose stricter requirements.

Commercial facilities usually fall under local zoning and building codes. On-farm storage of agricultural pesticides may be technically exempt from satisfying code requirements, but following these guidelines ensures a safer facility. **NOTE:** Always check with local zoning and building code officials to determine requirements for siting and constructing a pesticide or fertilizer storage facility.

In general, codes require certain standards for building construction and electrical design to reduce the risk of accidental fire resulting from the storage of flammable and combustible liquids. Proper building construction prevents rapid spread of fire. Proper electrical system design reduces the source of high temperatures or sparks that could ignite a flammable vapor or building materials.

Codes deal with the hazards of storage for flammable pesticides in several ways. One way is to limit the amounts of pesticides stored in a room or building; the larger the amount stored, the higher the risk and the more requirements on fire rated construction. Another way to reduce the fire hazard is to provide automatic fire suppression systems. Automatic dry chemical or similar systems are recommended for pesticide storage. Water sprinkler systems could pose more of a cleanup problem than the fire itself because pesticide contaminated water would have to be cleaned up after the fire.

Area Classification

Another way codes deal with the hazards of pesticide storage is to classify the use of the building. Generally, storage buildings that contain closed containers have less risk from fire than mixing/loading areas where pesticide containers are open and vapors are present.

The fire rating of the building construction and electrical design is based on the classification of the area by NFPA and NEC. Area classification depends on the amount and type of stored material and the use of the area (i.e. storage or dispensing). Container size and classification of liquids influence the quantity of material that can be safely stored in a specific size of building.

Building Use Classification

Storage building construction and electrical design depends on the use of the building. Buildings from which flammable or combustible liquids are *dispensed* are classified differently than buildings that *store* flammable or combustible liquids. Dispensing areas are more likely to have ignitable vapors than storage areas, thus more stringent fire safety design is required.

Classification of Liquids

The risk of fire from a stored liquid pesticide is based on the liquid's flash point. Flash point is the minimum temperature at which a pesticide gives off sufficient vapor to form an ignitable mixture within the air near the surface of the liquid or within the container. Liquids are classified as flammable or combustible according to the following NFPA definitions.

Flammable liquid

A liquid having a flash point below 100 F and having a vapor pressure not exceeding 40 lbs/in^2 absolute at 100 F is a Class I liquid.

Class I liquids are subdivided as follows:

- Class IA liquids include those having flash points below 73 F and having a boiling point below 100 F.
- Class IB liquids include those having flash points below 73 F and having a boiling point at or above 100 F.
- Class IC liquids include those having flash points at or above 73 F and below 100 F.

Combustible liquid

A liquid having a flash point at or above 100 F.

Combustible Liquids are subdivided as follows:

- Class II liquids include those having flash points at or above 100 F and below 140 F.
- Class IIIA liquids include those having flash points at or above 140 F and below 200 F.
- Class IIIB liquids include those having flash points at or above 200 F.

Some agricultural pesticides may have low flash and boiling points classifying them as flammable or combustible liquids. **NOTE:** Always check the label or MSDS of the pesticide to determine its flashpoint.

Separate liquids by class so that only certain areas require the class-specific design suggested by codes. For example, flammable materials require certain fire rated construction while nonflammable products do not. If flammable pesticides are stored with nonflammable pesticides, the building construction and electrical design must still consider the fire hazard of the flammable pesticide. The storage building construction recommendations relative to a fire hazard do not have to be followed if the pesticides stored are not flammable or are stored at temperatures below their flashpoint.

Some pesticides may be incompatible with one another producing toxic fumes or a flammable mixture if they become mixed accidentally. This poses a human safety hazard in the event of a fire or spill.

Explosion Venting

Where class IA or IB liquids are dispensed or where Class IA liquids are stored in containers larger than 1 gal, an exterior wall or roof construction should provide explosion venting design such as light weight roof assemblies, roof hatches or windows. NFPA has more information on requirements for explosion venting. Most pesticides are not flammable according to NFPA definitions, but always verify the flashpoint and class of each pesticide at a facility.

Storage Areas

Storage Container Size

Sizes of containers stored are considered in the safe design of the storage area. NFPA defines several sizes of containers and the corresponding safe storage practices for those containers. Containers are defined as any vessel containing 60 gal or less. A portable tank is a vessel with a capacity of 60-660 gal and designed to be movable. A tank is a vessel with a capacity greater than 60 gal designed for permanent placement.

Pesticide Storage

Provide separate areas for the different classes of pesticides. For example, a small separate storage area for flammable pesticides may be incorporated into a large warehouse for pesticides that are not flammable.

Do not store pesticides below grade or in basements. Many flammable vapors are heavier than air. The vapors can accumulate to a concentration that could be ignited by a spark or other source of ignition.

The storage arrangement of flammable/combustible liquids affects facility design. Consider:

- Aisle width (36" minimum).
- Height of shelves (60" maximum).
- Width of shelves (18" maximum).
- Separation of different classes of materials.
- Individual containment tub for each pesticide.

Storage Cabinets

According to NFPA guidelines, when storing flammable and combustible liquids, size storage cabinets to store no more than 120 gal of Class I, II, and IIIA liquids combined. Of this 120 gal, not more than 60 gal may be of Class I and II liquids. Locate no more than three cabinets in a single storage area. Maintain a 100' separation between three-cabinet groupings.

Use storage cabinets with metal or wood shelves designed with 2" high door sill to contain spilled liquid. Construct wooden cabinets from 1" thick exterior grade plywood and finish with a chemically resistant product that permits easy cleanup. See Fig 12 for a small wood cabinet design. Choose metal cabinets constructed from No. 18 gauge sheet metal with

double walls spaced 1.5" apart. Several safety supply companies manufacture metal cabinets. Shelving can be metal or 1" nominal thickness wood.

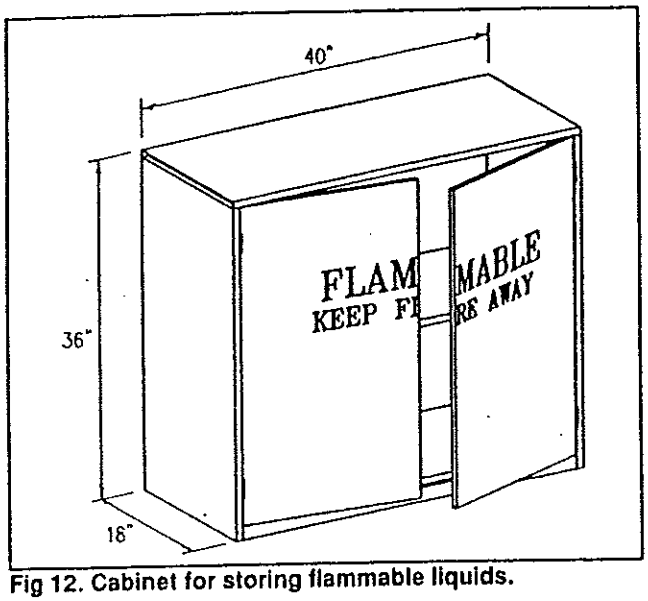


Fig 12. Cabinet for storing flammable liquids.

Fire Rated Construction

Fire walls or partitions separate areas of different uses and fire hazards. A fire wall slows the spread of fire from one area to another area. For example, mixing/loading areas may be separated from retail areas or office with a fire wall. All construction materials for walls, doors, roof, floors and partitions of a pesticide storage area should be constructed of fire resistant materials that meet or exceed local building and fire codes for a minimum of 1-hr fire resistant construction. Provide a parapet which extends at least 3' above the roof line on exterior walls within 10' of a property line or other building.

Concrete, masonry, and steel or wooden stud walls with Type X gypsum wallboard are commonly used types of building construction that have specific fire ratings. Fig 13 shows several cross sections of different fire rated wall construction.

Door Construction

A 36" wide exterior door opening to the outside with a self-closing exit lock allows safe exit and security. Select doors that do not have to be unlocked from

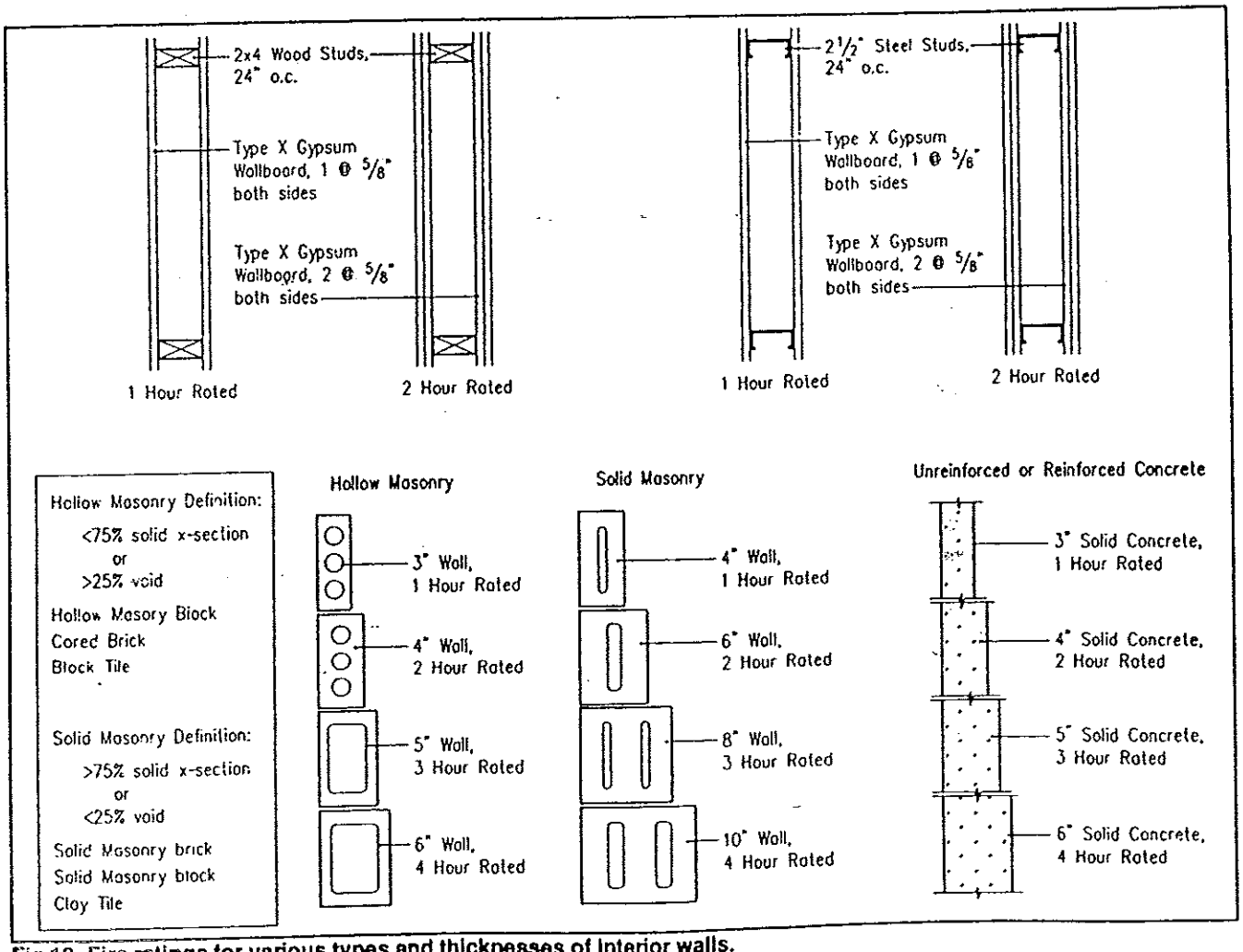


Fig 13. Fire ratings for various types and thicknesses of interior walls.

inside. A metal solid core door with metal jamb and weather seal is recommended. Select a U.L. listed fire rated door according to Table 3.

Table 3. Selecting fire rated doors.

If fire wall rated construction is:	Choose fire rated door of:
4-hr	3-hr
3-hr	3-hr
2-hr	1.5-hr
1-hr	0.75-hr

Use exit doors with panic hardware such as a push bar or plate. Hold-open hardware for the door provides easy access while carrying pesticide containers. In the event of a fire, doors should close automatically. Install an automatic self-closing device such as a fusible link on the hold-open door hardware. In large buildings space exit doors no more than 75' apart.

Separate Inside Storage

NFPA 30 defines several different categories of separate inside storage. Fig 14 shows a schematic of how these areas are defined and Table 4 lists specific requirements that must be met according to NFPA 30. Inside storage rooms have no exterior walls. A cutoff storage room has at least one exterior wall. An attached storage building shares a common wall with an adjacent building with a different use (e.g. office).

For inside storage rooms with no automatic fire protection system and an area of up to 150 ft^2, a 1-hr fire rated construction is recommended. For an inside storage room with no automatic fire protection system and an area greater than 150 ft^2 but less than 500 ft^2, a 2-hr fire rated construction is recommended. A maximum total quantity of liquids stored in these areas is also suggested; consult NFPA 30 for specifi recommendations.

For cutoff storage rooms and attached storage buildings of 300 ft^2 or less, a 1-hr fire rated construction is recommended. Cutoff storage rooms and attached storage buildings of areas greater than 300 ft^2 should have a 2-hr fire rated construction. The wall separating a cutoff storage room or attached storage building and another use area (e.g. office) should have a 2-hr fire rated construction. A maximun total quantity of liquids stored in these areas is also suggested; consult NFPA 30 for specific recommendations.

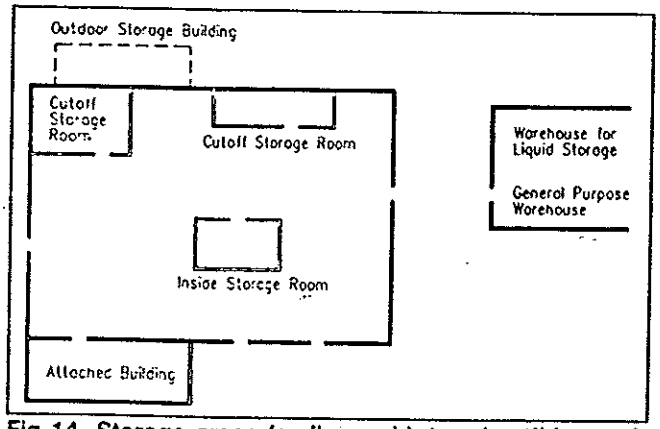


Fig 14. Storage areas for flammable/combustible pesticides—NFPA 30.

General Purpose Warehouse Storage

According to NFPA, a general purpose warehouse can be a separate, single story, detached building, or a portion of a building used for storage only, Fig 14 and Table 4. Separate the pesticide storage area from other storage areas such as fertilizer and feed storage and office or retail space.

NFPA 30 recommends limiting the total quantity of flammable liquids stored in a general purpose warehouse and also recommends the fire construction classification. Refer to NFPA 30 for more specific quantity recommendations.

Warehouse for Liquid Product Storage

According to NFPA, a liquid warehouse can be a separate, single story, detached building or an attached building used for storage of liquids only, Fig 14 and Table 4. NFPA does not restrict the total quantity of liquids stored in a liquid warehouse, but does recommend limiting height and quantity per stack.

Table 4. Storage area check list.
See NFPA 30 for specific requirements on the items listed below.

	Cutoff room and attached buildings	Inside room	Warehouse	
			Liquid	General purpose
Access openings	x	x		
Fire ratings	x		x	x
Explosion venting	x			
Containment	x	x		
Quantity of storage	x	x		
Drainage	x			
Square footage		x		
Venting		x		
Aisle width		x		
Distance separation			x	
Attached liquid warehouse			x	
Separation of liquids				x
Restrictions				x

If a liquid warehouse is located less than 10' from a building or a property line, the exposed wall should be a 4-hr fire wall with a U.L. listed 3-hr fire door.

If a liquid warehouse is located more than 10' but less than 50' from a building or property line, the exposed wall should be a 2-hr fire wall with a U.L. listed 1.5-hr fire door.

Portable Storage Lockers

NFPA defines a hazardous material storage locker as a relocatable prefabricated structure that is transported assembled or ready to assemble at the final location. The design and construction of the storage lockers should meet all applicable local, state and federal regulations. The floor area of the locker should not be greater than 1,500 ft^2. The secondary containment system built into the structure should hold 10% of the total volume of containers or the volume of the largest container in storage, whichever is greater. Consult NFPA for recommended separation distances for these buildings.

Mixing/Loading Area

Mixing/loading areas are a higher risk for potential fire than pesticide storage areas. Building, construction, electrical design and setbacks from property lines and other buildings are more restrictive.

According to NFPA, mixing/loading areas where flammable liquids are dispensed from open containers should be separated from other use areas greater than 150 ft^2 by a 2-hr fire rated wall. Use automatically closing, U.L. listed 1.5-hr doors. Do not mix or handle flammable liquids in a basement or below grade.

Electrical Design

Electrical design for a storage/handling building is covered under the NEC also referred to as NFPA 70 and is typically incorporated into many state and local codes. Size the electrical system to accommodate the load from all lighting, heating and ventilating systems, and other installed equipment for the facility. Include starting demand or motor in-rush current from pumps, mixing equipment and other processing equipment when sizing the electrical systems. Provide an exterior electrical service disconnect in a locked, NEMA rated, weather proof cabinet. Provide duplex outlets with ground-fault circuit-interrupters (GFCI) and locate them outside flammable storage areas. Use vapor proof fluorescent or incandescent lighting fixtures. On small buildings, provide an exterior switch to control both the ventilation fan and the lights. An exterior operation light that indicates when the lights and fan are on is a convenient feature.

Choose electric equipment and wiring designed to prevent a spark from igniting a flammable vapor. Avoid sources of high temperature and sparks in storage and dispensing areas. Duplex outlets, switches, fan blades and motors are all potential sources of sparks. Use U.L. and NEMA listed anti-spark equipment.

Area Classification

Chapter 5 article 500 of NEC defines the area classification for hazardous locations such as pesticide storage/handling facilities. The hazard classification used by NEC depends on the type of material handled (material classification) and the use of the area (storage vs. dispensing).

A stored liquid, considered flammable, requires a Class I designation. If a stored liquid is considered combustible, a Class I determination is required only if the liquid is stored or handled at temperatures above its flash point. If combustible liquids are stored at temperatures below their flash points, no area classification is necessary and the electrical design and installation require no special provisions.

Degrees of Hazard—Division Classification

The NEC recognizes two degrees of hazard. Class I, Division 1 has more restrictive electrical design requirements than Class I, Division 2 because there is a higher risk of an ignitable air/fuel mixture present in the area. Class I, Division 1 wiring is usually referred to as explosion proof. Class I, Division 2 does not require explosion proof wiring and equipment. Article 500-5 of NEC lists the following definitions of Division 1 and Division 2.

In **Division 1**, an ignitable mixture is likely to be present continuously or intermittently under normal conditions of operation, repair, maintenance or leakage. A Class I, Division 1 location is a location in which:

- Ignitable concentrations of flammable gases or vapors can exist under normal operating conditions; or
- Ignitable concentrations of such gases or vapors may exist frequently because of leakage; or
- Breakdown or faulty operation of equipment or processes might release ignitable concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment.

In **Division 2**, an ignitable mixture is likely to be present only under abnormal conditions, such as failure of process equipment. A Class I, Division 2 location is a location in which:

- Volatile flammable liquids or flammable gases are handled, processed or used, but in which the liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment; or
- Ignitable concentrations of gases or vapors are normally prevented by positive mechanical ven-

tilation, and which might become hazardous through failure or abnormal operation of the ventilating equipment; or

- A Class I, Division 1 location is adjacent, and to which ignitable concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

Classification of Storage Areas

NFPA 30, Chapter 4, Flammable and Combustible Liquids Code also addresses container and portable tank storage area classification for electrical design. Where the room or facility is used only for storage of Class I pesticides in sealed containers—that is, no opening of containers—the only special requirement is that inside rooms (with no exterior walls) contain electrical wiring and equipment classified Class I, Division 2.

Electrical wiring and equipment for indoor storage areas in separate or attached buildings, rooms with exterior walls, rooms for storage of Class II and Class III liquids and outdoor drum storage is normally classified as general use.

A mixing/handling area where flammable liquid pesticides are used could be considered Class I, Division 2, if in the judgement of the authority involved, the location would become hazardous only in the event of an accident or emergency other than normal operating procedures. The quantity of flammable material that could escape in an accident, the adequacy of ventilation, the size of the building, and the record of the industry with respect to explosions or fires are all factors considered in determining the classification of the area.

A mixing/loading area where flammable pesticides are transferred from one container to another might be classified as Class I, Division 1 if the local authority considers it to be a special hazard.

Areas adjoining a classified area, but separated by a wall with openings is classified under the more restrictive requirements, as if the wall did not exist. Where the areas are separated by a solid wall, the classified area does not extend beyond the wall. Consult an engineer or code official to help determine the classification of the designed facility, and the extent of classified areas.

If the area is not adequately ventilated, the classification of the electrical design will be more restrictive. For example an adequately ventilated storage area may be classified as Class I, Division 2. An inadequately ventilated storage area would be classified as Class I, Division 1.

Install a lightning protection system to prevent a potential ignition source. Consult NFPA 78 Lightning Protection Code for specific design information.

Explosion-Proof Electrical Systems

Article 501, NEC, describes the requirements for explosion-proof electrical installations in Class I, Division 1 areas. Explosion-proof equipment is designed to withstand an internal explosion while not allowing ignition of surrounding gas or vapor through the release of hot gases or sparks or by an external temperature that would ignite the surrounding atmosphere. In general, a Division 1 area requires:

- Threaded steel conduit (or mineral-insulated metallic sheathed cable).
- Explosion-proof enclosures.
- Conduit seals at any enclosure containing a sparking device or surface temperatures.
- Conduit seals at the boundary between a Division 1 and Division 2 area.
- Approved or U.L. listed lighting and other electrical fixtures.

Requirements for Division 2 areas are relaxed to the extent that explosion-proof enclosures are only required for devices that have hot surfaces or generate sparks during normal operation. Additional types of electrical cable are also allowed for wiring in a Division 2 area.

Equipment approved for use in a Class I area must be marked to show the Class, Division and operating temperature of the piece of equipment. U.L. listed equipment has such markings. All electrical equipment installed in other classified areas must be approved or listed for the appropriate Class and Division.

Sources of Ignition

In areas where flammable vapors may be present, take precautions to prevent sources of ignition such as open flame, smoking, hot surfaces, sparks, friction heat, radiant heat, cutting and welding, spontaneous ignition, lightning, static electricity, ovens, furnaces or heaters. In addition, the surface temperature of equipment installed in Class I areas must not have an exposed surface temperature in excess of the ignition temperature of the surrounding gas or vapor. Use aluminum, bronze or plastic fan blades to reduce the possibility of sparks.

Fire Safety

Place clearly visible exit signs above all points of exit. A red, illuminated, translucent sign with "EXIT" in plain letters not less than 5" high is common in commercial facilities.

Make fire and spill control equipment readily available, including:

- Fire extinguisher.
- First-aid kit.
- Spill clean-up kit.

Locate a portable multi-purpose dry chemical fire extinguisher, having a rating not less than 20-B, on

the outside and not less than 10' from the storage entrance door.

Include a non-spark type fire and/or smoke detector with audible alarm in the design. If possible, equip the alarm to sound at a remote site as well as the facility site.

Fire Suppression

In large facilities, automatic fire suppression systems may be a viable fire safety option. Types of fire protection systems include:

. Water sprinkler.
. Foams.
. Dry chemical.
. Inert gas.
. Carbon dioxide.
. Halon.
. Nitrogen.

Design fire suppression systems to be area specific so water is not spread across the entire facility due to a small fire in an isolated area. More damage may result from deluge type sprinkler systems than the fire itself. Cleanup of a contaminated site from a fire and the contaminated fire fighting water may be more costly than allowing the building to burn itself out. **NOTE:** Discuss the proper way to deal with a fire with the local fire official, emergency responders and the insurance carrier for each facility based on the types and volumes of products handled.

Ventilation

Ventilation minimizes a fire or explosion hazard by reducing the accumulation of significant quantities of ignitable or explosive vapors. Also, ventilation reduces worker-exposure to a hazardous level of fumes or dust from the pesticides during handling.

Provide ventilation at all times by natural or mechanical means. Warm-weather ventilation reduces temperature extremes and vapor buildup. Do not store pesticides in basements or below grade level where vapors might accumulate.

Natural Ventilation

Natural ventilation results from a combination of wind pressure and the natural buoyancy of warm air. Two or more inlet/outlet vents positioned on opposite walls allows cross ventilation. In unheated storage areas, natural ventilation may be the best alternative. In heated storage areas, natural ventilation is more difficult to control and heating costs may be high because of over ventilation.

Provide a minimum of two vents, each 8"x8" (64 in^2) on opposite sides of the building and within 12" of the floor because most flammable vapors are heavier than air. For larger buildings, design the size of the inlet/outlet vents to allow 6 air changes/hr. For mixing areas, size natural ventilation openings to provide 1 ft^2/20 ft^2 of floor area.

Mechanical Ventilation

Mechanical ventilation allows more control of the air quality and temperature in storage and handling facilities, especially in heated storage areas. Locate the fan on the east or south side of the room if possible. If the fan is placed high on the wall duct it to within 12" of the floor. Position air inlets opposite the fan and within 12" of the floor to remove heavier-than-air vapors.

Use explosion proof rated mechanical ventilation in areas where Class I liquids are dispensed from open containers. Use either natural or mechanical ventilation in other storage and mixing areas.

Mechanical Ventilation Rates

When mechanically ventilating pesticide storage areas during occupancy, provide at least 1 cfm/ft^2 of floor area or provide 6 air changes/hr. NFPA 30 recommends a minimum of 150 cfm for any size facility. When facilities are unoccupied, provide 1 air change/hr. (NFPA gives no recommendations for unoccupied storage areas.) Table 5 shows the required ventilation for various sizes of storage and handling areas. If a mechanical exhaust system is used, control it with a switch located outside of the storage area. The ventilation rate for larger buildings can be calculated using the following equation:

6 air changes/hr × Building volume, ft^3/60 min = Ventilation rate, cfm

Table 5. Mechanical ventilation rates and inlet size for pesticide storage and handling areas during occupancy.

Building[a] volume, ft^3	Six air changes/hr		NFPA recommendation Rate of 1 cfm/ft^2	
	Rate, cfm	Inlet size, in^2	cfm	Inlet size, in^2
1,000	150[b]	30	150[b]	30
2,000	200	40	250	50
3,000	300	60	375	75
4,000	400	80	500	100
5,000	500	100	625	125
6,000	600	120	750	150
7,000	700	140	875	175
8,000	800	160	1,000	200
9,000	900	180	1,125	225
10,000	1,000	200	1,250	250

[a] Assumes a ceiling height of 8'.
[b] 150 cfm minimum recommended for any size facility, NFPA 30.

Multiple fans and inlets spaced at intervals along walls provide uniform air movement throughout storage and handling areas.

The NFPA 30 recommendation for ventilation of mixing and handling areas using Class I liquids (or Class II or III liquids above their flash points) is not less than 1 cfm/ft^2 of floor area. A higher ventilation rate may be required to limit flammable vapor-air mixtures during normal operating conditions.

Provide at least 25 cfm/occupant from an outside air source in pesticide storage areas where there are workers. Install a dedicated exhaust over work areas to minimize worker exposure to fumes. Consider a fume hood over work areas or sinks for worker safety; use a dedicated exhaust providing fresh air at a velocity of 80-100 fpm blowing at the face level.

In mixing and handling areas, equip ventilation systems with an alarm that sounds automatically in the event of a failure of the ventilation system. Provide a manual shutoff control for the ventilation system outside the room or building entrance.

Use a time delay switch to turn the fan and lights on but does not allow the door to be opened until the room has been ventilated adequately (at least one air change).

Duct exhaust away from work areas, offices or public areas to prevent human exposure to the exhaust air. Do not recirculate exhaust in the room or building, otherwise vapors and fumes can build up.

Air Inlets

Locate air makeup inlets on the opposite side of the room from the fan and also within 12" of the floor. If makeup air is taken from within the building, equip the inlet with a listed fire door or damper to prevent the spread of fire.

The air makeup inlet should provide 20 in^2/100 cfm capacity. Table 5 shows the area required for different ventilation system capacities. The inlet area can also be calculated using the following equation:

Ventilation rate, cfm ÷ 720 fpm = Inlet area, ft^2

Heated Storage

An insulated, heated building may be needed if pesticides are subject to freezing. Some pesticides can freeze and remain viable while others may be rendered useless if frozen. **NOTE:** Read the label to determine the storage temperatures required for the products stored. In some areas, the storage building may require ventilation or even air conditioning in the summer to prevent pesticides from volatilizing and creating a safety hazard. A storage temperature range of 40 F-90 F for environmentally controlled storage is recommended.

Insulate the walls and ceiling and provide a continuous 6 mil vapor barrier on the warm side of the building, usually the inside wall. Minimum recommended insulation levels are R-11 for walls and R-19 for ceilings.

Do not place packages close to or in direct contact with heaters. Provide heat by low pressure steam, hot water or electric heaters that are U.L. listed for Class I hazardous locations. Never use or allow open flames or smoking in storage or handling areas.

Liquid Fertilizer Storage and Handling

Liquid fertilizer storage tanks must be inside a properly sized walled or bermed leak-proof secondary containment structure. Although it is not mandatory, liquid fertilizer storage should have locked security fencing to avoid vandalism damage. Keep tank drain valves locked except during transfers. See Chapter 7, Secondary Containment.

Impregnation of Pesticides on Dry Fertilizer

Large, dry bulk fertilizer storages are popular in the midwest. Design for ease of customer access and to keep precipitation away from the structure and area. Locate the building on elevated ground with all rain, snow melt or flood water diverted away. Consider railroad access when planning a facility, as it provides an economical means of transporting incoming dry fertilizer. Also, special handling equipment must be used due to the corrosiveness of the material. Fertilizer must be kept dry until used to avoid caking.

Impregnation of dry fertilizer with liquid herbicides has been done in fertilizer plants for a number of years. In the past, pesticides have usually been added to the fertilizer mix while in the blender. This creates problems with contamination of the blender and the immediate area, creating human safety problems.

Some problems that exist with impregnating pesticide on fertilizer granules are:

- Operator may be exposed to pesticide dust and fumes.
- Fertilizer with pesticide requires special handling after it leaves the blender.
- The blender, elevating equipment and applicating equipment require special cleaning.
- Adding pesticide to dry fertilizer may require the use of drying agents to reduce the problem of fertilizer caking.

One new method developed to impregnate pesticide on fertilizer is an impregnater that mounts on the blender unloading elevator. It adds the pesticide as it is being loaded into the applicator or service truck, eliminating contamination of the blender and elevator. The applicator or service tank must still be cleaned.

A newer impregnation method involves injecting pesticide into the fertilizer delivery tubes on pneumatic fertilizer applicators or the feed augers on other models. These systems use a peristaltic or variable displacement piston pump to continuously meter pesticide into each air delivery tube or feed auger on an applicator. This method helps reduce the equipment that comes in contact with the pesticide and must be

cleaned. Some pesticides work well with this method of impregnation while others do not. Impregnation of pesticides on the applicator is relatively new and has several advantages. Less equipment comes in contact with pesticides, the amount of fertilizer with pesticide impregnated on it at one time is reduced, and the impregnation takes place away from the storage and blending plant.

If impregnation of fertilizer is done at the blending plant, a catch/containment area must be provided to clean up spilled fertilizer. Alternatively tarping areas under impregnating equipment and conveyors allows easy cleanup of dry impregnated fertilizer. Excess pesticide impregnated fertilizer must be stored separately fror fertilizer for later use because it is considered a pesticide.

8. MIXING/LOADING FACILITIES AND EQUIPMENT[8]

Surface water, groundwater and soil can be contaminated in areas where pesticides and fertilizers are stored, mixed and loaded into applicator tanks, or unloaded from sprayers and transferred into rinsate holding tanks. If not contained, accidental spills or overflows, unused mixtures and flush water for applicator tanks, plumbing and booms, create a pesticide and fertilizer build-up in surrounding soil that can cause serious contamination. The pesticides and fertilizers used and the mixture characteristics determine if water used to rinse sprayer tanks and plumbing is a hazardous waste. Operators are liable for expensive cleanup, even long after selling the property, if mishandling of pesticides and fertilizers results in environmental contamination.

Facility Planning and Layout

To protect surface environments and groundwater, install permanent concrete pads (or equivalent) at mixing/loading facilities. Plan for present and future storage, security and mixing/loading functions when planning, renovating or retrofitting liquid fertilizer and/or pesticide handling and storage facilities. Personnel and environmental safety, as well as state and federal regulations must be taken into account as facilities are designed.

Precipitation is a major concern when using open concrete mixing/loading pads. Transfer of precipitation may create a future legal problem. Roofed mixing/loading facilities are recommended in all areas of the U.S. to minimize disposal of potentially large volumes of contaminated precipitation which might be considered hazardous waste. Complete buildings with hangar- or garage-type drive-through doors provide the maximum protection against having to handle large volumes of precipitation that might contain dilute solutions of pesticides.

Local weather factors in each geographic location affect structural as well as functional designs. Non-roofed facilities in dry southwestern climates like Arizona may need a containment holding volume of 125% of the largest pesticide or liquid fertilizer tank.

Concrete facilities in warm, high-precipitation areas, like the southeastern and south central U.S., may only require open-sided roofed structures with large roof overhangs over concrete pads to keep precipitation out of containment and loading pads. Operators in central and northern U.S. should install open-front or fully enclosed containment facilities to minimize precipitation handling and provide indoor storage of spray equipment in the off-season. Open-sided roof overhangs should be at least a 30° angle from vertical from the edge of the mixing/loading pad(s) in all directions, Fig 36, to minimize precipitation blow-in. Saving one or two large pesticide hazardous waste disposal bills can pay for a major part of roof construction or even the cost of a complete building.

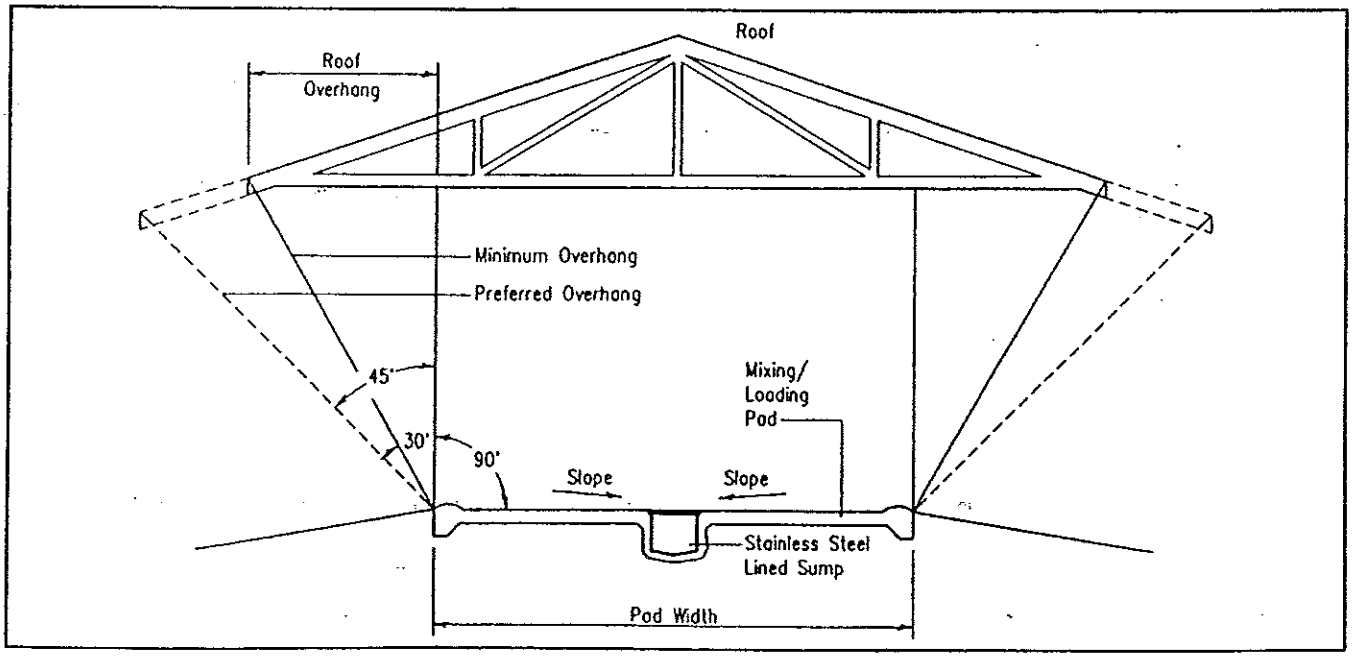


Fig 36. Open-sided roof structure over mixing/loading pad.

8 Ronald T. Noyes, Agricultural Engineering Department, Oklahoma State University, Stillwater.

Mixing/Loading Pad Layout

The layout of mixing/loading pads can improve operational and worker efficiency while reducing personnel and environmental safety risks. Incorporate the following features into a mixing/loading pad:

- Sealed, liquid-tight, reinforced concrete pad to form an impervious barrier between the pesticide or liquid fertilizer handling area and the surrounding earth. Slope mixing/loading pads to drain liquids to shallow pump recovery sumps.
- Sloped pad surfaces plus watertight walls and curbs around the perimeter form shallow depressions to temporarily contain pesticides and fertilizers, rinsate, washwater and precipitation that leak or fall on the pad.
- Independent shallow sumps in each functional containment area for collecting liquids for pumping. Thus, different types of pesticide or liquid fertilizer leaks can be handled without cross-contamination. If properly filtered and managed, liquids recovered from each sump may be reused in subsequent, appropriate field applications. Liquid level alarms may be installed to alert operator when liquid enters a sump.
- Concrete pads designed and constructed to facilitate the addition of open sided roofs or complete buildings over part or all of the concrete pad. Design the outer three sides of the pad to have 4"-6" of level concrete surface before floor slopes start for ease in installing wall sills or for good door seals.
- Roof structures and pad sites, surface dikes and drainage to keep storm water from entering the pad and groundwater from collecting under concrete pads.
- Approach ramps to minimize dust and trash accumulation on pad (especially important for aircraft taxiing).

Functional Organization

Mixing, loading and secondary containment pad sizes and shapes depend on the functions performed, and the orientation and boom width of the equipment. Design pads to extend at least 5′ beyond the edges of sprayer equipment's extended boom on each side to catch any splashed water or boom sprays. Consider space needed for workers to get around and between pieces of equipment easily. Fig 37 illustrates a 45′x70′ aerial applicator concrete mixing/loading pad with security fence. This facility has aircraft tie downs and asphalt approach and departure ramps to minimize dust blowing during taxi operations. Mixing/loading equipment plus pesticide and rinsate storage tanks are secured by a chain-link fence and automatically activated security lights at night.

Fig 37 also shows a mixing/loading pad system with a secondary pesticide containment area. Pesticide storage is located on one side of the mixing/loading equipment station, positioned near the secondary containment sump. Rinsate holding and minibulk tanks are located on the other side of the containment sump.

The loading pad area is designed so aircraft or ground sprayers can enter from either side or enter the pad from the front. The loading pad floor has a variable slope that increases uniformly from a level surface along the outer edges to a maximum slope at the sump against the containment divider wall. The centerline valley has a constant slope toward the sump.

Level outer edges along the sides and front of the loading pad are designed for attaching building wall sills or to seal against large overhead or sliding doors. Slope approach ramps or drives away from the pad to ensure that surrounding watershed storm drainage stays outside the mixing/loading pad. Roofed loading pads are highly recommended.

Single Sump Concrete Mixing/Loading Pad Facility

For smaller or less complex pesticide or liquid fertilizer facilities, a simple concrete pad that drains to a single sump in the center of the pad, Figs 38 and 39, may meet the containment needs. Such pads can incorporate a small pesticide storage building on, or adjacent to them. These buildings, when connected as an extension to the pad with its own containment, provide needed storage without increasing the pad size, Fig 39.

A small (10′x12′) pesticide storage building can be located on one corner of a 30′x40′ or larger pad, Fig 38, or placed in optional positions adjacent to the loading pad, Fig 39. A fenced area for mixing/loading equipment and rinsate tanks can be located close to the storage building. Rectangular pads can be arranged with the storage building and mixing/loading area plus pesticide and rinsate storage tanks in a fenced off section across one end of the elongated pad. This provides similar function with less forming expense as the two-sump pad shown in Fig 37.

Sumps and Drainage

Some state regulations do not allow underground storage of pesticides or rinsates. Shallow sumps are not considered underground storages as they are designed with small holding volumes (usually about 15-50 gal) to be used for immediate liquid recovery and transfer, not storage. Some states require sumps to be stainless steel lined. California requires double walled stainless steel sumps with inspection ports, that are to be checked daily for leaks when the facility is handling pesticides.

Some states require that all sumps be drained with an operator controlled pump to guard against contaminated water inadvertently entering groundwater or surface water channels. Other states do not allow discharge of liquids at any time from containment pads. All liquids have to be recovered and con-

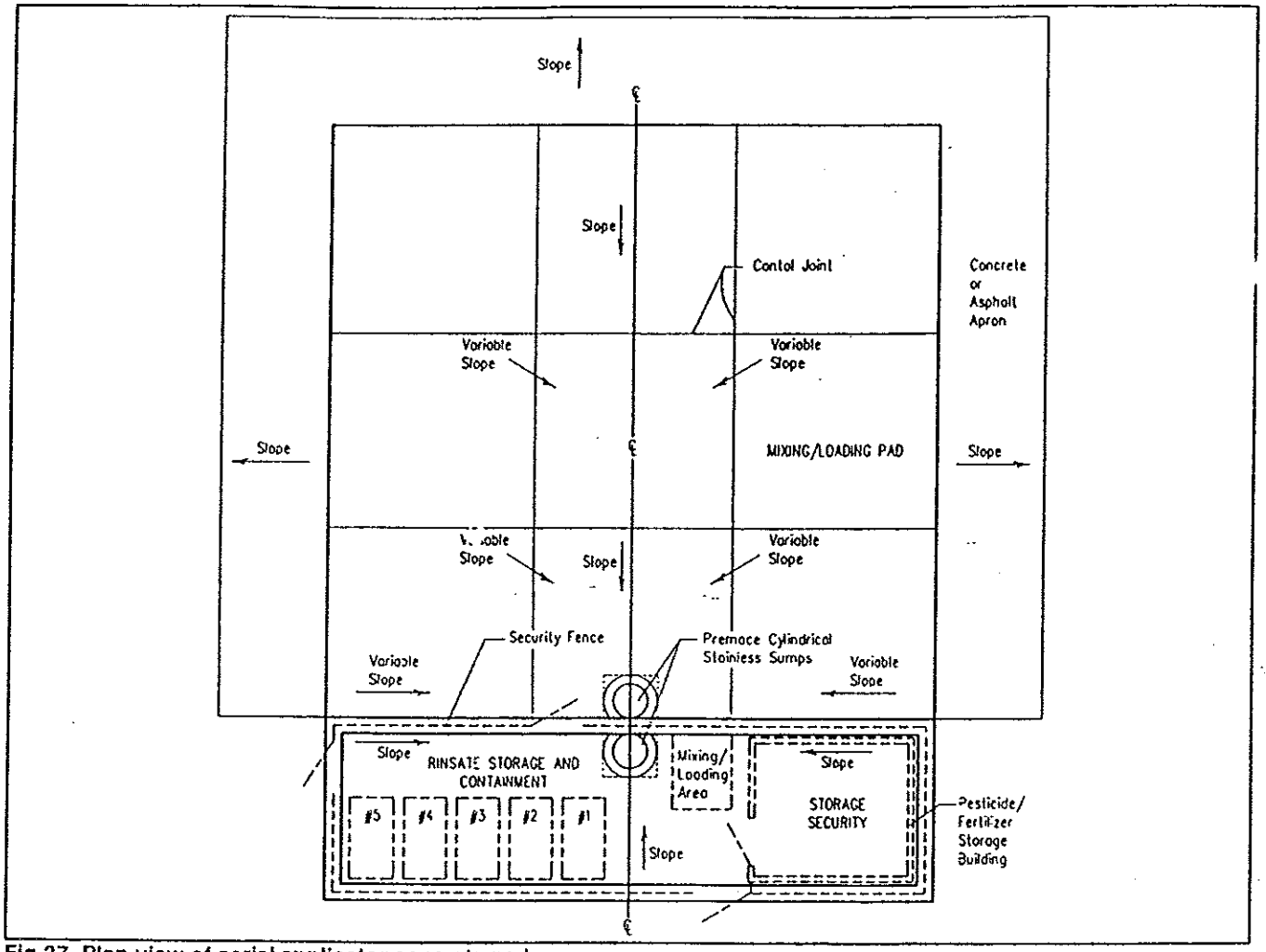


Fig 37. Plan view of aerial applicator concrete pad.

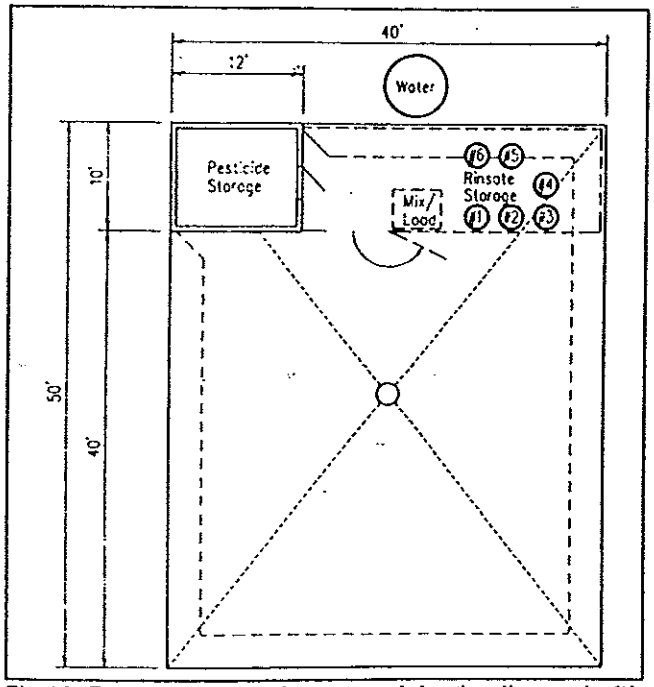


Fig 38. Rectangular single sump mixing/loading pad with storage building and fenced pesticide security area.

tained in holding tanks or be allowed to evaporate. Roofed or completely enclosed concrete pads greatly minimize non-process liquid handling at facilities.

The secondary containment sump recovers leaks and spills and is used to pump out accumulated liquids such as rainwater. Cover the sump with a structural grate for safety; a dust cover over the grate minimizes dust and debris blowing in. Choose load pad sump grates that can support vehicle wheel loading.

Keep sumps covered and cleaned out, especially during spraying seasons. Soil and debris in sumps create a serious disposal problem of potentially hazardous waste. This problem reinforces the value of enclosing the mixing/loading pad area to avoid solid hazardous waste problems resulting from blowing soil and debris. According to EPA regulation, transporting pesticide contaminated soil for disposal requires a licensed hauler of hazardous materials, regardless of whether the pesticide applicator is private or commercial.

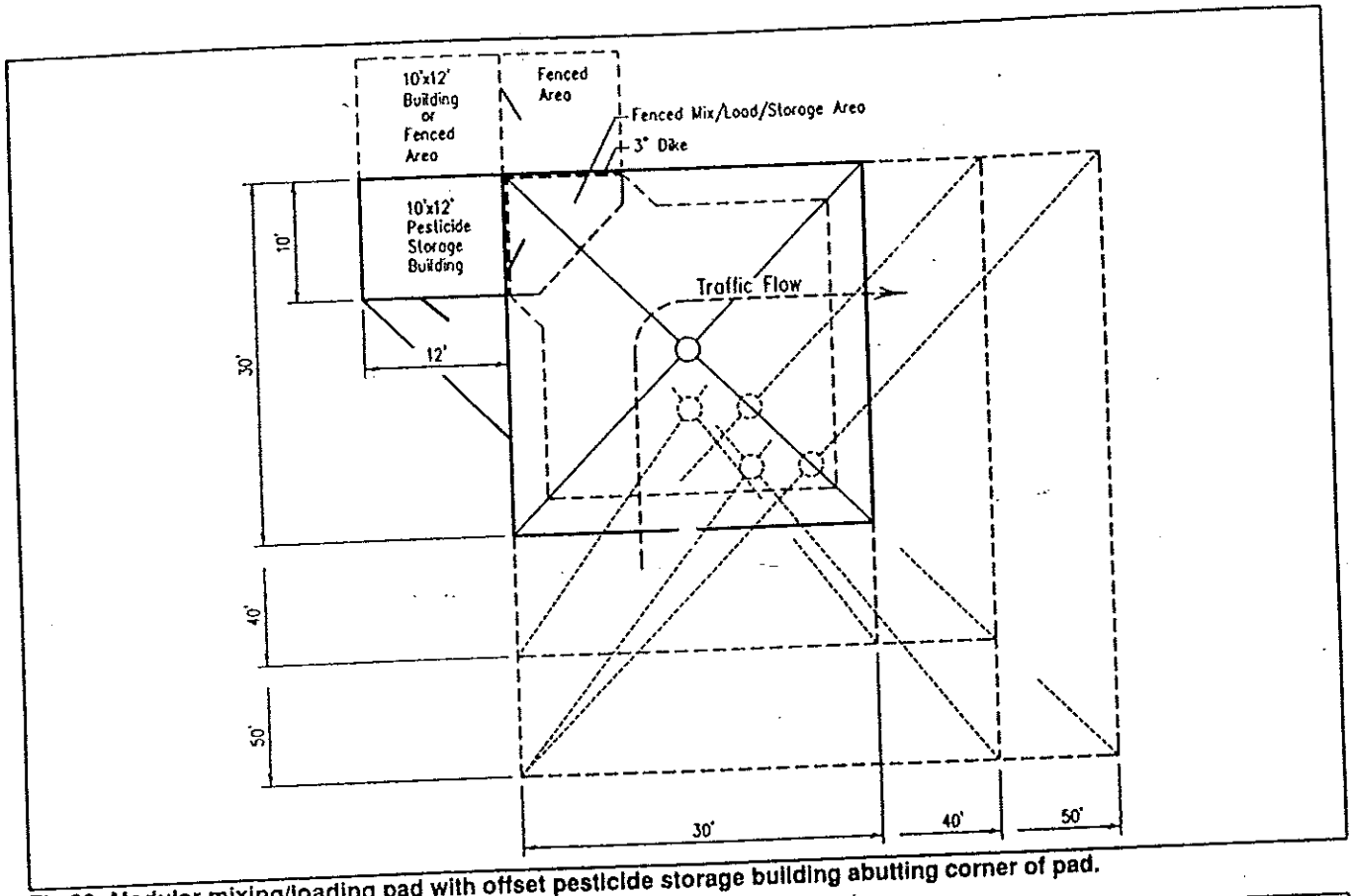


Fig 39. Modular mixing/loading pad with offset pesticide storage building abutting corner of pad.

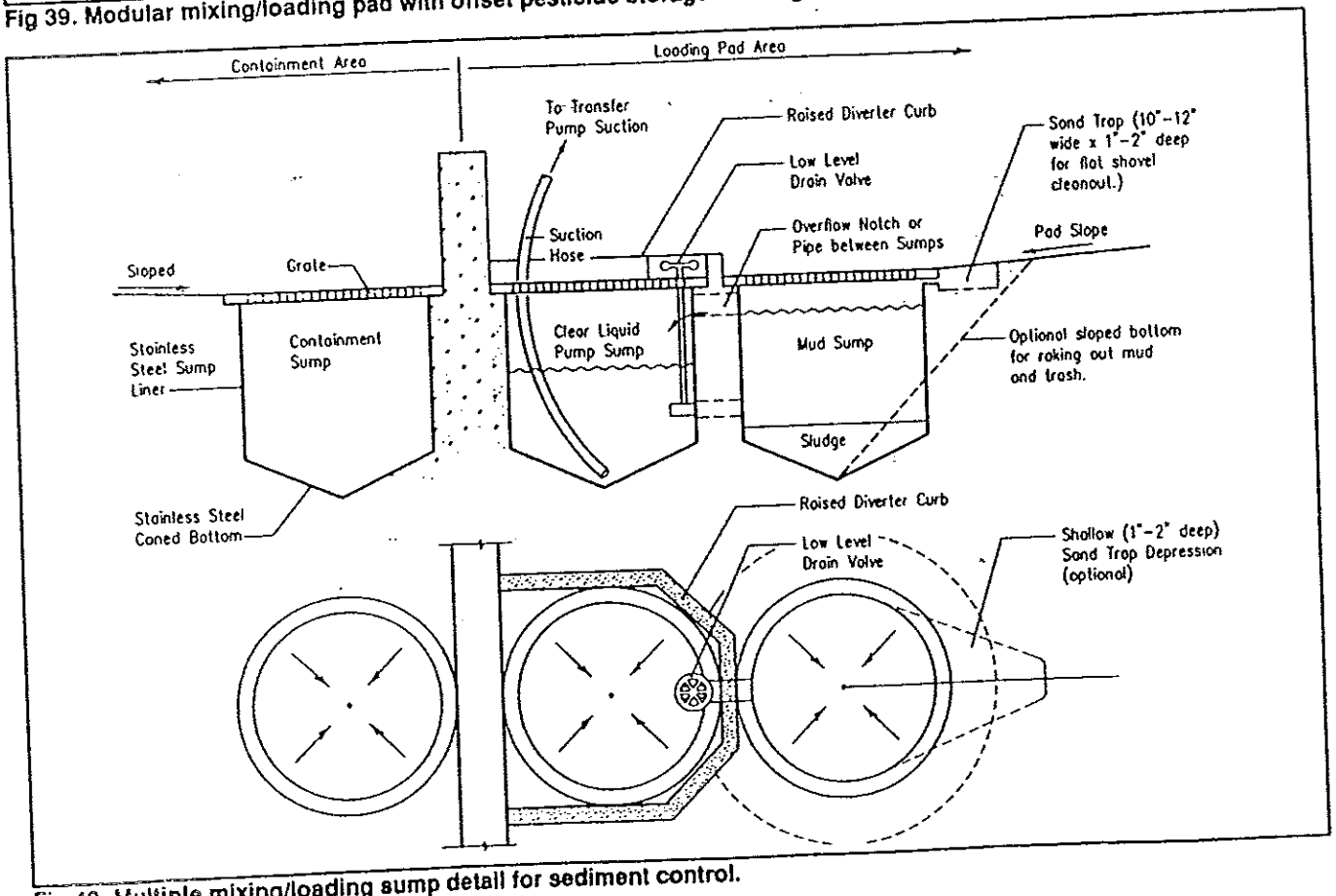


Fig 40. Multiple mixing/loading sump detail for sediment control.

Sump Designs

There are several sump designs that can be used in the mixing/loading pad. A single sump is the simplest and can either be placed monolithically with the mixing/loading pad or a precast concrete or prefabricated stainless steel sump could be installed before the concrete pad is placed. To reduce sludge problems in mixing/loading pad sumps where applicator vehicles are washed, some facilities may need two sumps in series, Fig 40. **NOTE:** Washing sprayers in the field is recommended, but avoid repeated washing in the same location and stay clear of wells, surface water bodies and field tiles and inlets.

Use of a double sump allows segregation of pesticide water and contaminated solids. The first sump acts as a sediment trap or settling basin where larger solids settle out before the liquids overflow into the second sump. Design the first sump for easy sludge cleanout. Water drains around the raised concrete diverter curb into the first sump, then is decanted off the first sump and flows into the second sump. The sump pump or suction hose is placed in the second sump. This water is filtered and transferred into a rinsate storage or waste water holding tank.

A double lined stainless steel sump design is shown in Fig 41. This design allows monitoring of potential leaks from the sump by inspecting the outer sump through the port between inner and outer sump liners. This sump can be fabricated in a range of sizes or dimensions. Install a "stand pipe riser" in the inspection port of a double walled sump so that it can be inspected when liquid covers the sump grate. Lock to prevent vandalism or accidental liquid entry through the unsecured port.

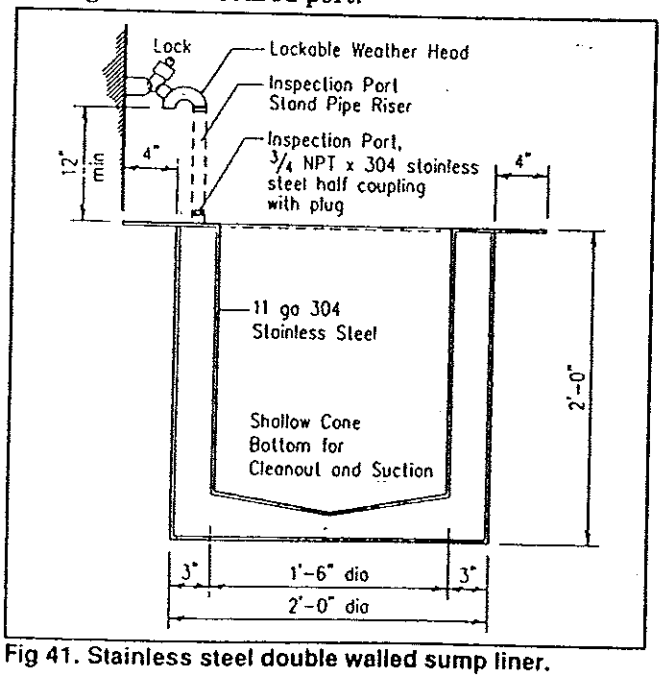


Fig 41. Stainless steel double walled sump liner.

An alternative sump design is shown in Fig 42. A pair of prefabricated stainless steel containers act as primary settling sump and a secondary pump-off sump. Locate these containers in a sump pit or secondary containment area. This design allows easy removal of the sump liner containers when they need to be cleaned out or decontaminated. In this design, by extending the pit design to hold additional removable sump liners, different types of pesticide rinsate can be segregated by diverting to selected sumps. **NOTE:** The secondary sump pit concrete must be carefully sealed.

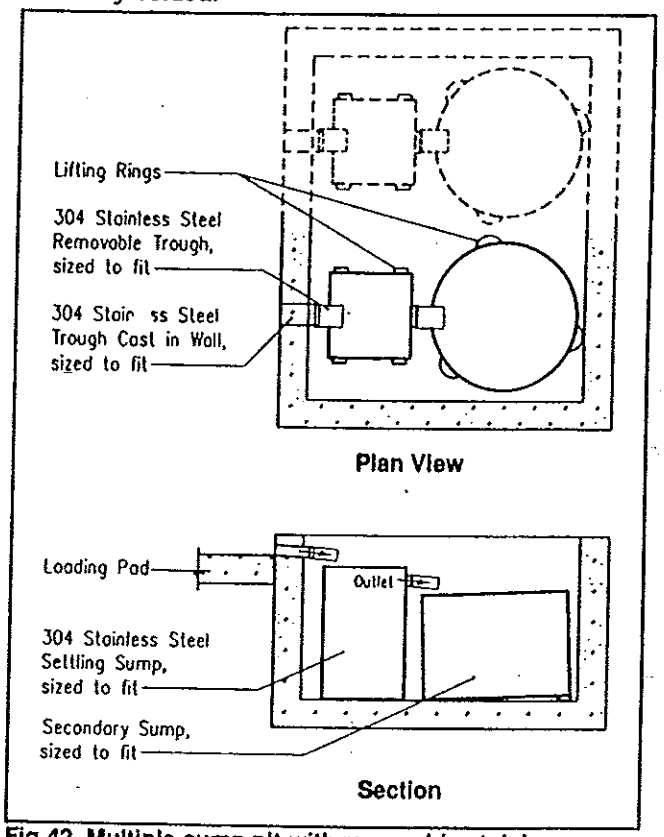


Fig 42. Multiple sump pit with removable stainless sump containers.

Mixing/Loading Equipment Area

Locate batch mixing tanks, water and pesticide transfer pumps and plumbing in the mixing/loading area, Fig 37. Closed mixing system components like pesticide metering tanks, punch/drain/rinse/crush units, rinsing vacuum probes and pesticide container holding, rinsing and drainage equipment, adjuvant venturi eductor and venturi injector plumbing are components that should be considered in planning an efficient, safe mixing/loading system. Position mixing equipment near the containment sump as shown in Fig 43.

Pumps and Pump Containment

In bulk handling systems, install transfer pumps inside their own individual containment dike areas, Fig 44. If a seal in the pump leaks, only the small pump containment area becomes contaminated and requires cleanup. Mount the pump motor base at containment wall height or higher to prevent flooding

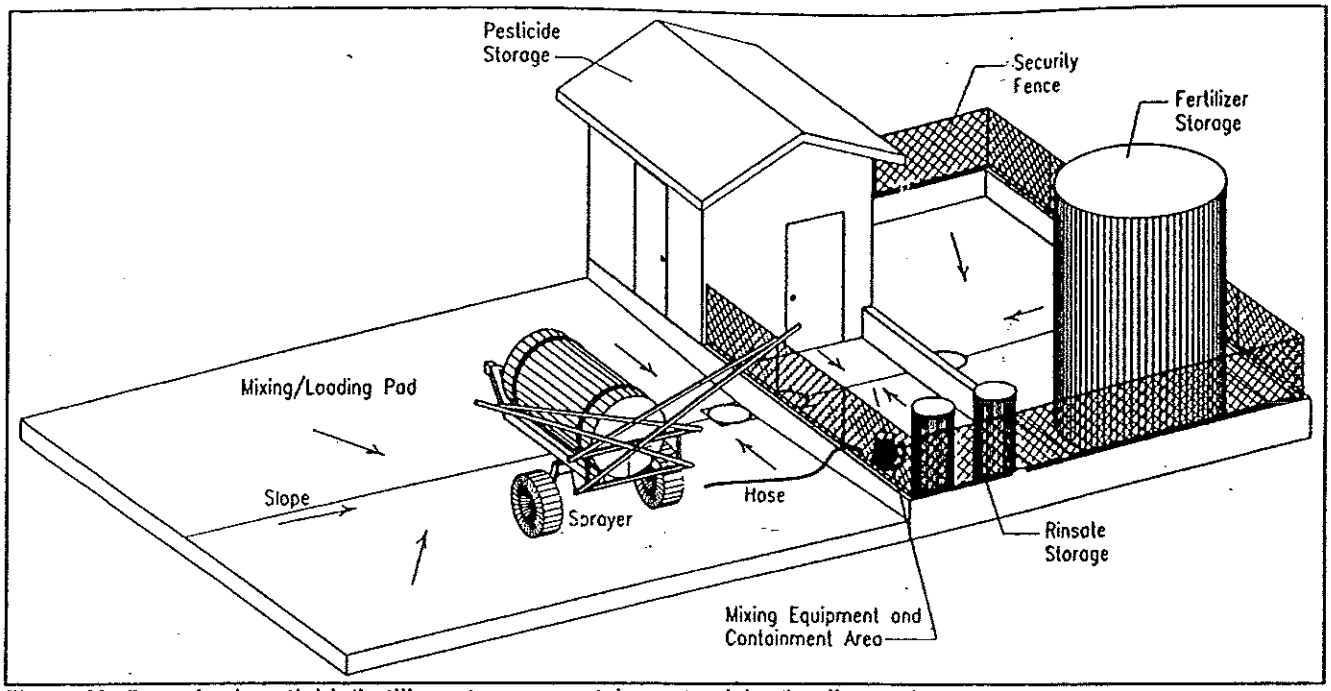


Fig 43. Medium sized pesticide/fertilizer storage, containment, mixing/loading pad.

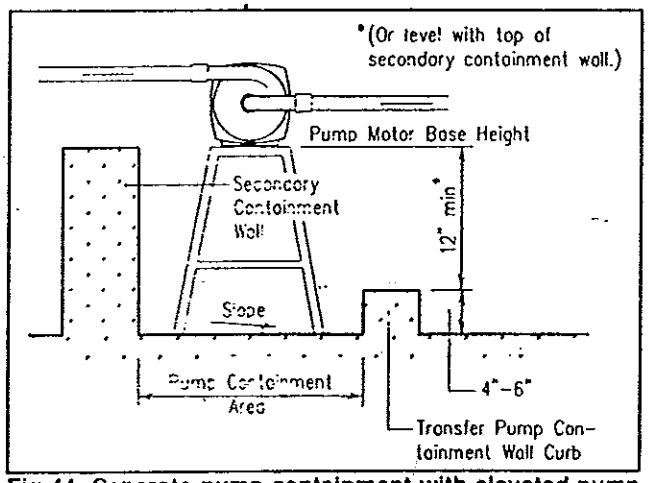


Fig 44. Separate pump containment with elevated pump mount.

the pump, damaging motor windings, and creating an electrocution hazard for workers. A disadvantage of elevating pumps is that higher levels of liquid are needed in water supply tanks to prime pumps.

An alternative to separate pump containment is to place chemical resistant rubber, plastic or stainless steel "drip" pans or tubs under elevated pumps to catch intermittent drips that often occur from pump seals or plumbing connections, especially when switching transfer hoses from suction to discharge connections periodically. Use dry-break hose connectors to minimize drips during frequent hose changes. Install shutoff valves and unions on each side of pumps so they can be easily drained for minimum leakage and removed for repairs. These equipment components help reduce pesticide contamination on floors.

Plumbing Components and Seals

An important part of designing a bulk handling system is selecting metal parts, gaskets and hoses that resist corrosion. Expect high initial cost if low maintenance costs, long life and excellent performance are required. Using the highest quality, most corrosive resistant material is usually the best long-term investment.

Pesticide formulations often contain solvents and surfactants that cause some seal and gasket materials to swell, shrink, soften or dissolve with continuous contact over time. Deterioration is often accelerated by elevated temperatures; this is especially critical when the component is subject to mechanical stress. Select the most chemically resistant materials, such as Teflon, for seals or gaskets that come in direct contact with concentrated pesticides. **NOTE:** Teflon may be incompatible with some pesticides, such as "Prowl" and "Treflan".

Hoses must also be compatible with the pesticides being handled. Hoses manufactured with an inside layer of a cross-linked high-density polyethylene material usually are chemically compatible. Flush hoses and piping after use to extend service life and minimize cross-contamination. Suction hoses must be reinforced for negative pressure or vacuum operation. Collapsed suction hoses can cause cavitation damage to pumps.

Select stainless steel or polypropylene quick-release, dry-break couplers or air-break connectors for plumbing that must be connected on a regular basis, such as hose couplings connecting to pumps, applicator vehicles, bulk tanks or mix tanks. Fit couplings with pesticide or fertilizer resistant "O" rings, seals or gaskets manufactured from Teflon, stainless steel

springs or other chemically resistant material. Check pesticide and fertilizer resistance charts to select appropriate materials, Appendices H, I and J.

Valves

Use corrosion resistant valves made from stainless steel, polypropylene or Kevlar. Minimize the number of valves to operate the system to reduce cost and potential leaks. Mount them in easy-to-reach locations for operator convenience. Use quick shutoff ball valves or plug valves. Provide lockable shutoff valves on outlets of all bulk liquid fertilizer and pesticide storage tanks for security. Use detachable hoses instead of hard plumbing to isolate storage tanks from other plumbing.

Rinsate Storage and Handling

Mark or color-code individually dedicated hoses by the pesticide handled for transfer of rinsates into and out of each individual rinsate holding tank. If dedicated hoses are not used, flush hoses with clean water immediately after handling each pesticide rinsate to avoid cross-contamination of non-compatible pesticides. **NOTE:** Plain water may not clean plumbing satisfactorily. Check product label for proper cleaning and neutralizing procedures.

Do not "hard plumb" or rigidly manifold pesticide rinsate transfer pumps directly to the inlets or outlets of rinsate storage tanks. When using permanent pipe manifolds, rinsate from one tank can accidentally mix with rinsate from other tanks in the collecting manifold. Cross-contamination with rinsate from several tanks could cause serious damage to non-targeted crops or sites. Use hoses with quick release dry-break connectors, cam-lock couplers or other suitable quick couplers so that operators have to make specific decisions and choices when connecting hoses to pump rinsate into and out of each tank. This deliberate process provides more opportunity to evaluate each separate management decision than if complex plumbing manifolds with several valves are used.

Fit rinsate tanks with quick release dry-break and/or cam-lock type fittings for filling into the top and withdrawing from the bottom. Select and position (slope) tanks so that bottom outlets drain the entire tank. Each time a tank is emptied, immediately and thoroughly flush it out to prevent pesticides from drying on tank walls and to wash bottom sediment out. Permanently mount 360° rotating rinsing nozzles in the top of each tank for thorough rinsing and worker safety. Dedicate each tank to only one pesticide or one crop. Cone or hopper bottom tanks make management simpler by improving drainage of all products, including particles that settle out. Hopper bottom tank rinsing and cleanout are easier, compared to flat bottom or horizontal cylindrical tanks. Select tanks with large top access openings for ease of cleanout and inspection.

Use individual hoses to pumps or flexible manifold systems for liquid fertilizer tanks. In case of a major leak or spill, or unusually heavy thunderstorms (25-yr, 24-hr storm) where accumulated rainwater causes liquid fertilizer or rinsate tank flotation, rigid PVC, polypropylene or steel piping manifolds could fracture, causing massive releases and co-mingling of liquid fertilizers or rinsates. Even with a valve directly connected to each tank base outlet, leverage on connected plumbing manifolds could cause pipe nipples to break between the tank wall and the valve. Anchoring tanks and using flexible plumbing are major design requirements.

Keep mixing/loading equipment inside a security fence. Security fences, walls, buildings or other safety measures are needed to keep unauthorized personnel, children or animals from pesticide and fertilizer storage areas. Operators are responsible for contamination and injury caused by vandals, even if a reasonable level of security is provided, but locked tank base shutoff valves and fences can help minimize legal risk and possibly reduce insurance rates.

Closed Mixing Systems—CMS

Closed mixing systems (CMS) greatly minimize human exposure to concentrated pesticides. Ideally, closed system transfer is accomplished by vacuum. With vacuum transfer, hose or plumbing leaks allow air into the system, which slows handling rates, but does not result in spray or rupture-type failures of pressurized handling systems. True closed systems:

- Allow removal of pesticides from sealed containers.
- Allow measuring and transferring pesticides to mixing or sprayer tanks and rinsing empty containers.
- Allow handling of system plumbing and hoses without exposing personnel to pesticide vapors, mists, splashes or spills.
- Provide improved accuracy in pesticide measuring.
- Reduce mixing/loading site contamination.
- Reduce the risk of back siphonage of pesticides into water supplies.
- Reduce the need for full protective suits. Protective gloves, full face shield or goggles and clean clothes are still recommended.

Fig 45 is a diagram of a modular vacuum powered pesticide CMS. It uses a venturi injector mounted on the pressure side of the pump to develop vacuum. This venturi design has a high-flow bypass. When pesticide measuring and transfer is complete, the by-pass valve provides a much higher handling rate (2-3 times increase) for rapid completion of sprayer tank filling.

Where small mixtures are needed, use a supplemental vacuum pump to evacuate the metering tank and draw pesticides into the tank pump to keep from having to pump excessive water through the venturi. Then use the venturi injector with by-pass valve for transfer and mixing/loading operations, Fig 45.

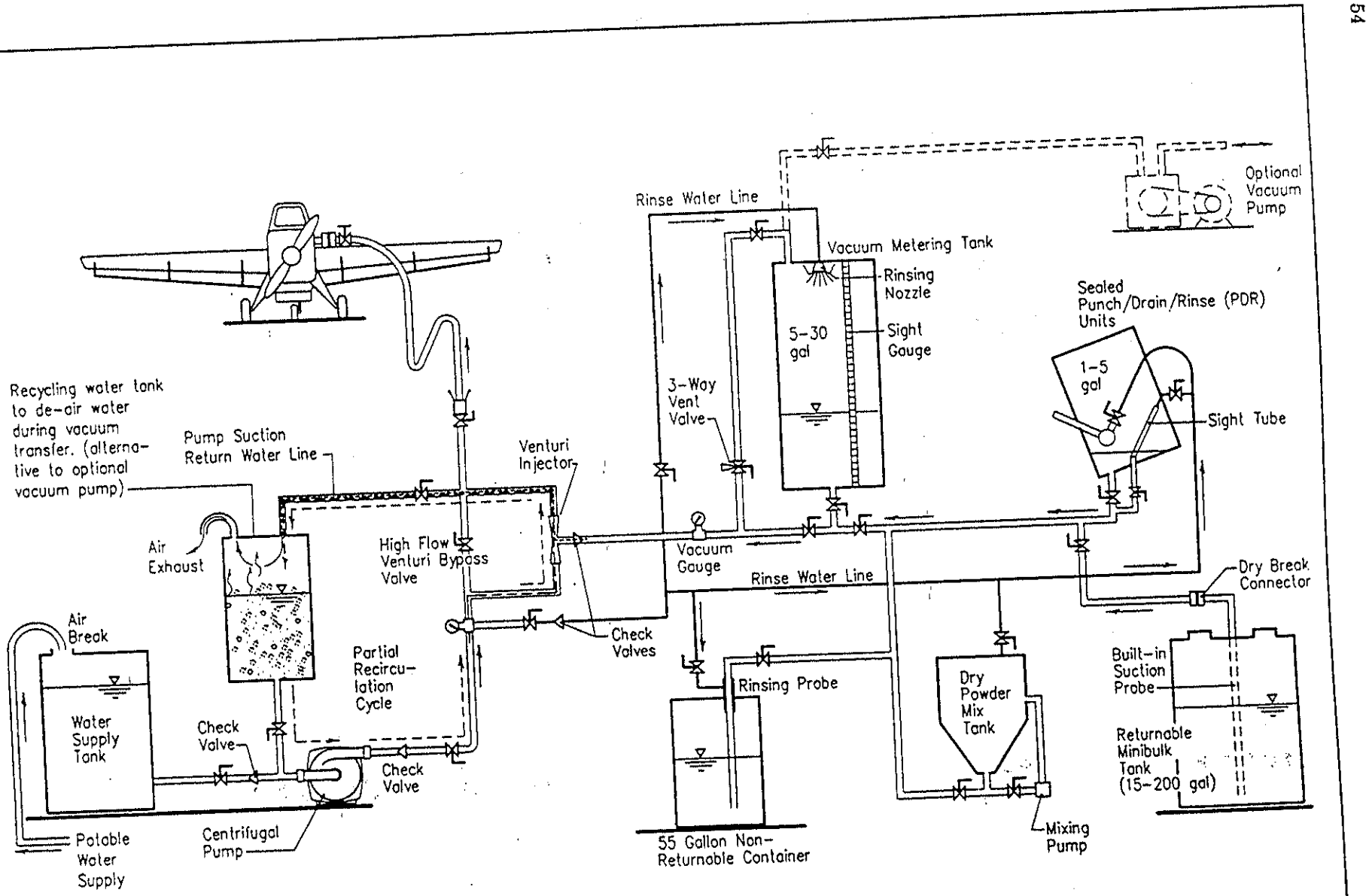


Fig 45. Modular vacuum powered (venturi injector) closed liquid pesticide mixing system flow diagram.

An alternative is to pump makeup water in a closed loop from and back to a small enclosed water holding "de-airing" tank that is vented to the atmosphere, and dedicated for vacuum transfer use. Thus, the amount of water initially pumped into the applicator tank is significantly reduced. This is very important where total transfer volume and available transfer time is limited when making up small batch mixes and pesticide must be transferred initially from shipping or minibulk containers to the metering tank. Plumb this "de-airing" tank to use this water first when filling the applicator tank as pesticide vapors may be absorbed by the closed loop water, so this water must be used immediately to finish making up that load.

NOTE: If a de-airing tank bypass plumbing loop is used as part of the CMS, the discharge hose valve to the spray tank or aircraft hopper may still need to be partially open so that 1/3-1/2 of the liquid flow continues to the applicator tank. Complete recycling of water through the return loop air separator tank (discharge hose valve completely closed) may cause the return line water to be partially aerated (partially filled with air bubbles) from the vacuum tank if the air separator tank volume is marginal. If this occurs, pump pressure will drop, pump cavitation may occur and venturi vacuum level may remain low, slowing or stalling evacuation of the metering tank.

Venturi injectors

Venturi injectors, Fig 46, are static devices that create a vacuum to pull liquid pesticides from containers. The venturi is placed on the outlet (pressure) side of a pump and as the motive liquid (usually makeup water) flows through the venturi restriction, line pressure drops, creating a vacuum that evacuates air from piping and the metering tanks. With appropriate valve settings, pesticides and rinse water are also transferred by the venturi suction.

Venturi injector systems are simple, economical and can rapidly transfer relatively low viscosity pesticides effectively. They are easily incorporated into existing pesticide handling systems. Choose venturi injectors constructed of polypropylene, stainless steel or other corrosion resistant material. Flush injectors (with clean water after each use) to minimize cross-contamination of pesticides. **CAUTION: Plumbing connected to plastic venturi injector side inlets must be flexible or carefully braced because side inlets are structurally weak and break easily.**

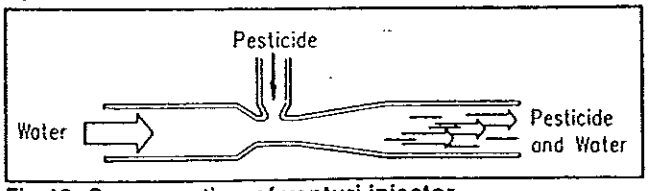


Fig 46. Cross-section of venturi injector.

Venturi injector systems are naturally safer than pressure transfer systems because full strength pesticides are drawn from containers by vacuum or suction. Then, pesticides are mixed with water in the injector, so a dilute strength pesticide/water mixture is transferred under low pressure into applicator tanks.

Metering tanks

Vacuum metering tanks measure or meter the amount of pesticide needed for sprayer tank mixtures. Metering tank sizing depends on the amount of pesticide to be transferred from shipping containers as well as the amount needed for a full sprayer load. Pesticide is evacuated from "one-way" containers with external self-rinsing probes, or from SVR or minibulk returnable tanks with non-rinsing internal suction probes connected by dry break connectors to suction hoses.

Punch/drain/rinse (PDR) containers as shown in the upper right hand corner of Fig 45 are non-pressurized metering tank systems. These units allow 1, 2.5 or 5 gal plastic or metal containers to be set inside, and the cover latched and sealed. The side lever operates a sharp probe that punches a hole in the container bottom. The pesticide drains into the base of the stainless steel tank. A sight tube is used for measuring the pesticide.

After the pesticide has been drained from the PDR, either to the metering tank or the applicator tank, the container is power-rinsed with clean water forced through the side lever pivoting hole punch mechanism, which is rotated during container rinsing, and the rinsate is transferred directly to the sprayer. The empty, power-rinsed container is removed and the next pesticide container is set into the unit for draining. Because holes are punched in the bottom of each container, PDR unit use is limited to completely draining and transferring the liquid from each container.

An area that needs additional operator attention and maintenance on metering tanks are metering sight tubes or sight glasses. These devices are usually clear or opaque plastic or glass tubes about 3/8"-5/8" I.D. that are externally mounted to the top and bottom of metering tanks to allow a visual indication of internal fluid levels. With some pesticides or fertilizers, sight tubes often quickly "cloud up" due to repeated dried residue layers. Connect a power-rinsed water line to the top of each metering tank sight tube to flush it out each time the tank is rinsed so pesticide layers do not obscure the visual tank liquid levels and to minimize cross-contamination of pesticides.

Rinsing probes/internal probes

Self-rinsing probes are used to withdraw pesticides from shipping containers. When containers are empty, rinse water is sprayed inside, washing down pesticide residues that remain as a film inside on the top and walls of containers, plus a few ounces of pesticide in the bottom. Rinsewater is evacuated out of the container and transferred directly into the sprayer, Fig 47.

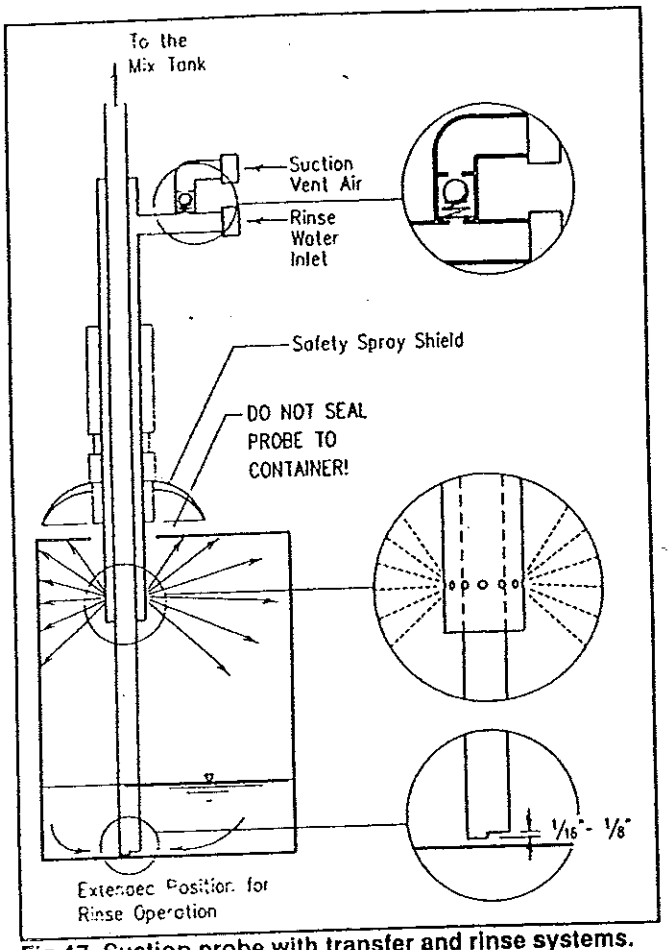


Fig 47. Suction probe with transfer and rinse systems.

External rinsing suction probes are not "true" closed mixing system components because containers must be opened and the probe inserted. Some probes are screwed to the container threaded pour spout creating a seal while others have an air gap between the container opening and probe tube through which vapors can escape and air can enter to ventilate the container volume above the liquid level during withdrawal of pesticide. Thus, even though rinsing probes are used with "closed mixing systems", workers are at some risk while using most external probes.

Care must be used with all probes when removing pesticides, during rinsing and during probe insertion and removal. In cases where the probe body is screwed to the container threaded pour spout, high vacuum build-up can collapse the container sides inward if probe suction air venting is inadequate. This may cause the container sides to crack and leak. Another hazard may occur while rinsing the container at water line or pump pressure (30-60 psi). Without adequate container venting, the internal pressure can cause the container to rupture, with the potential of spraying pesticide or rinsate on workers.

CAUTION: Before using probes that seal to containers, be sure the probe has adequate vent air flow for positive and suction pressure relief during both withdrawing and rinsing operations. Periodic stopping of suction or rinsing operations may be required if the vent air relief volume is marginal. If vent air flow is inadequate or not provided, it is safer to leave the probe disconnected from the container opening to allow vent air movement through the connector opening during suction and rinsing operations.

Another safety hazard that must be considered when using rinsing probes to rinse empty (or partially empty) containers is overfilling containers and flushing rinsate out through the open container inlet gap. Common practice is to operate suction valves and rinse-water line valves simultaneously so initial highly concentrated rinsate is sucked out immediately. Usually 30-45 sec is adequate for power rinsing at rinse water flow rates of 5-8 gpm.

Refillable bulk containers

EPA is encouraging the agricultural pesticide industry to use two-way or refillable containers and to adopt two or three common fittings for shipping containers. Pesticide and fertilizer companies and associations are moving toward standardizing bulk and/or minibulk shipping container fitting designs.

Minibulk or refillable containers have built-in internal suction probes with dry-break connectors to prevent external drips on and around the container. Some companies supply these containers with a pump and meter. At least one repackaging company is using compressed air tanks connected to minibulk or SVR containers to transfer pesticides by pressure. Refillable containers are permanently marked for use with only one type of pesticide and are not rinsed by the applicator or dealer. They are returned to the manufacturer or repackaging agent and repeatedly refilled with the same pesticide on a continuous recycling basis. Refillable containers comprise true closed system components when used with a vacuum/suction type pressure tank transfer system or CMS.

Mechanical Transfer/Open Mixing Systems

Dry pesticides are mixed with water in batch mix tanks by adding part of the required water, pouring in the dry pesticide, stirring into a slurry, adding the balance of the mix water, then recirculating the mixture in the tank for thorough mixing. Batch mixtures are then transferred into applicator tanks, mix tanks are rinsed and the rinsate transferred to the applicator tanks. Although batch mixers vary from fully open topped tanks to units with full hinged covers, they are not sealed and therefore are considered open mixing systems and should be in well ventilated areas. Protective clothing and full face respirator with appropriate canisters for the pesticides being mixed are recommended when using open mixing systems.

Liquid pesticides are often mixed with the carrier before they are added to an applicator tank. A simple method is shown in Fig 48. In this system, the liquid pesticide is removed from a container with a suction

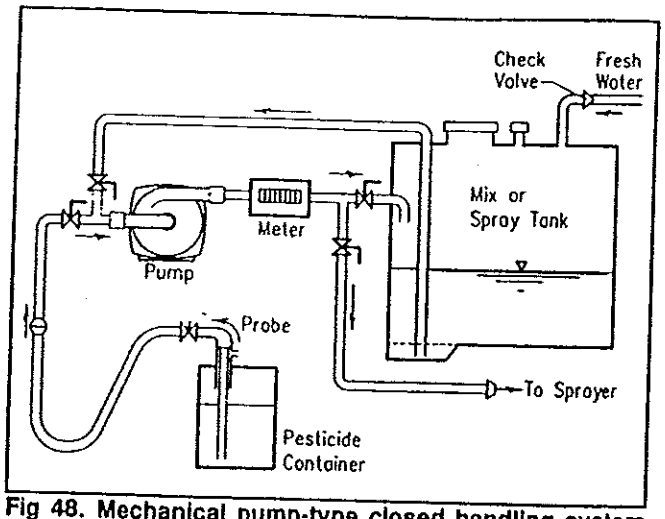


Fig 48. Mechanical pump-type closed handling system with mixing tank.

probe using the pump suction and is pumped through a meter into a mix tank. Then the mixture is recirculated from the tank through the pump and an agitator nozzle in the bottom of the tank for mixing. When completely mixed, the pesticide is transferred to the sprayer. Variations of this system, such as the use of different probes for removing the material from the container, measuring columns, metering tanks or measuring probes in place of in-line flow meters, and venturi injectors can be incorporated. Batch mixing tanks are usually designed with jet agitators on 300-600 gal tanks or mechanical mixing paddles on larger mixing tanks (500-1,000 gal).

Pesticide measurement

Accurate methods of pesticide measurement are essential to good pesticide application management. Pesticide liquid meters similar to those used on fuel pumps are fast, easy to use and operate on the principle of positive displacement. However, accuracy and repeatability may be a problem on less expensive rotary vane or "turbo" meters. All rotary vane meters are inaccurate when used on the vacuum side of pumps or venturi injectors because of air entrained during suction.

For pressure systems, more expensive meters are usually the most accurate and provide the best corrosion resistance. Mechanical or electronic digital readout meters are available that indicate volumes in tenths or hundredths of a gal. Meters must be certified when they are used to measure products that are to be sold and require retesting or calibration at least yearly by state government testing and measures departments. Because the specific gravity of products varies with temperature, it is sometimes necessary to recalibrate meters to control accuracy, but meters that require calibration are usually the best type. Some meters require recalibration by referring to the operator's manual for each significant change of viscosity used.

Sight tubes on measuring columns are simple and easy to use but are only accurate if the container is level. Small-diameter sight tubes (1/4"-3/8" I.D.) may indicate a different level than what is in the container due to viscosity and surface tension of the liquid against the tube wall. Larger tubes (1/2"-5/8" I.D.) provide faster, more accurate metering response. A small-diameter, tall container improves metering accuracy for a given volume metering tank. Use side guards to protect external glass tubes or plastic tubing from breakage or damage to reduce the hazard of contacting a concentrated pesticide. All sight tubes must have a valve at the base of the column that can be closed for emergencies in case the tube is leaking or broken. Plastic or Tygon sight tubes cloud over and require periodic replacement, but are safer than glass tubes from a breakage standpoint. Where plastic sight tubes are desired, choose nylon or polypropylene materials. Power-rinsed water lines connected at the top of sight tubes may eliminate or reduce the frequency of replacement. Select tubes for rinsing and easy replacement.

Metering tanks made of stainless steel with one or more glass windows mounted in the side are available commercially. These must also be kept level to be accurate. Measuring tanks with windows have an advantage over tanks with only sight tubes, as the liquid level is directly visible, and the viscosity of the pesticide and liquid surface tension does not affect measurement as much as sight tubes. But tanks with glass windows are usually more expensive and windows are subject to leakage. All measuring or metering tanks must be equipped with internal rinsing nozzle provisions. Rinse tanks and sight glasses immediately after use before pesticides dry on inside surfaces to avoid cross-contamination problems.

Pesticides are also measured or metered by weight. The unit weight of the active ingredient (AI) is listed on the pesticide container as a ratio or percent of the pesticide product weight. A measuring container can be mounted on a scale platform or suspended on a load-cell and filled by vacuum or pressure transfer to the desired weight. Tank fill and discharge hoses must be flexible on these units to minimize measurement inaccuracies. Fig 49 shows a platform load-cell type scale. Fig 50 shows a single load-cell suspension or tension mounting system. For larger facilities, load-cells or strain gauges can be placed on the mixing tank to eliminate the need for intermediate weighing equipment. On portable load-cell measuring systems, lock load-cells rigidly and remove load while transporting. Moving this type of system may require frequent calibration of load-cell readout units. If used outdoors, wind shields and horizontal stability brackets must be used to minimize wind pressure/swaying effects. Load-cells, control/readout units and connecting electrical or control circuitry wiring cables must be designed for use in pesticide and outdoor environments.

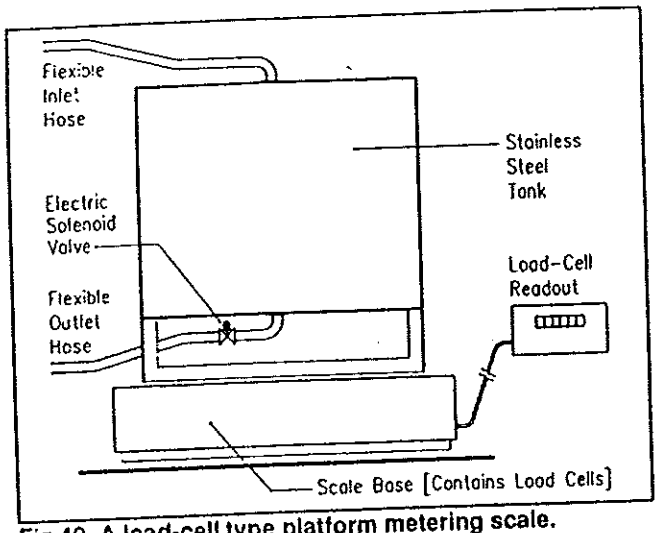


Fig 49. A load-cell type platform metering scale.

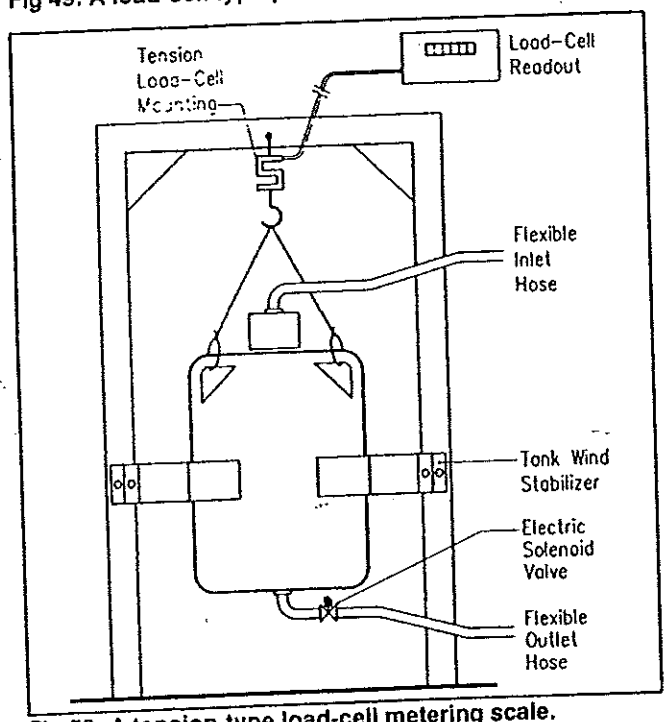


Fig 50. A tension-type load-cell metering scale.

Container Rinsing for Disposal

One-way containers must be pressure-rinsed or "triple hand-rinsed" prior to disposal. Pressure-rinsing for 30-45 sec immediately after initial draining is usually far more effective than triple hand-rinsing. Fig 51 illustrates a method that can be used for pressure-rinsing pesticide containers. Fig 47 illustrates a rinsing probe transfer system. A disadvantage of both rinsing methods is that container caps are not rinsed during container rinsing. A bucket with detergent can be used with a screen basket to rinse one-way pesticide container caps.

The pressure-rinse system shown in Fig 51 is designed to rinse containers inverted over a pesticide mixing tank fill opening. This rinser contains a sharp probe that can punch through the bottom of small

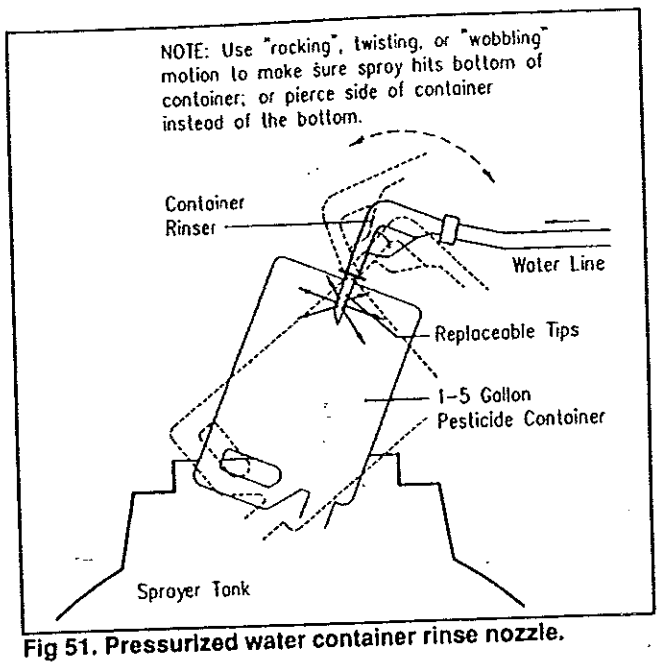
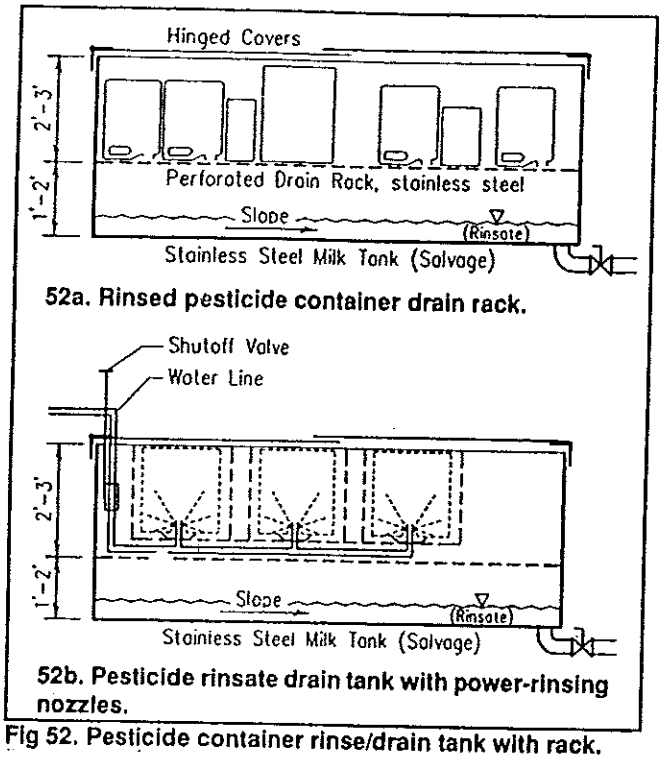


Fig 51. Pressurized water container rinse nozzle.

plastic or metal containers (5 gal or less). The probe contains a series of holes around the nozzle shaft that must be inside the container. With the container inverted over the spray tank fill hole, water is turned on to rinse the container. Flush the container for 30-45 sec as soon as it is emptied to soak and remove residues from container. Avoid letting products dry out before rinsing. When rinsing with hand held pressure rinse nozzles, piercing the side of the inverted container allows better flushing of container bottom. Use a rocking, twisting and wobbling motion during rinsing to direct water jet impact to all interior surfaces.

The rinsing probe transfer system shown in Fig 47 is not a pressure rinse system. It is designed to drain the container of pesticide, then discharge clear water from the rinsing probe water chamber through a series of holes directly below the fill cap. At the same time the probe evacuates the rinsate out and transfers it into the spray tank. One-way pesticide containers are not designed to withstand vacuum or pressure. Caution must be used to prevent collapse or rupture of the container if adequate venting air relief is not provided when the probe body is sealed to the container opening.

Invert freshly rinsed containers on a draining rack in a rinsate drain tank, Fig 52a, to allow all rinsate to drain from containers for easier rinsate recovery and reuse. Power rinse nozzles can be added to rinsate drain tanks, Fig 52b. Several companies have developed portable hose mounted rinse nozzles (utility and commercial models) that pierce the side of plastic or metal containers for pressure rinsing and draining. For heavy use, commercial versions are more rugged and last longer than utility models, and are better suited for metal containers. Most nozzles have replaceable steel piercing probe tips. Make sure nozzle probe tip holes direct spray back toward the



52a. Rinsed pesticide container drain rack.

52b. Pesticide rinsate drain tank with power-rinsing nozzles.

Fig 52. Pesticide container rinse/drain tank with rack.

part of the container that is pierced for complete rinsing. Some early models use only four holes drilled perpendicularly to the probe tube, which provides an inadequate spray pattern. All pressure rinsers must be equipped with a backflow prevention device.

Rinsate Storage Tanks

Rinsate tanks are used for temporary separation and holding of diluted pesticide field mixture rinsate (typically 10:1 dilution ratio from field mixtures). After using each rinsate, wash the inside of the tank and transfer that liquid to the sprayer tank as makeup water along with the field mix rinsate as a continuing management process throughout the spraying season. Strategies to minimize rinsate storage, handling and disposal are discussed in Chapter 11, Rinsate Management and Waste Disposal.

When selecting storage tanks, check with both the pesticide manufacturer and tank manufacturer to be sure the tank is resistant to corrosion from the pesticide being stored. Cross-linked, high density polyethylene or fiberglass tanks of 200-600 gal volumes are usually a good economical selection for rinsate storage. The ability to view liquid levels through plastic or fiberglass tank walls improves management. Inspect polyethylene tanks annually for signs of aging and deterioration to avoid a structural failure. Tanks that are under-roof and protected from direct sunlight and weather usually have a longer service life than those stored in the open.

Galvanized or standard mild steel tanks are not recommended because they corrode quickly causing rust and metal scalings to plug strainers and plumbing. Type 304 or 306 stainless steel tanks are suitable, but are more expensive. Mount pesticide, rinsate and fertilizer storage tanks 3"-6" above the concrete floor for easy location and identification of leaks. Mount the tanks high enough to allow full operation of valves and other equipment. Some operators elevate rinsate holding tanks so they can gravity-flow into mix tanks or sprayer tanks. Setting up to use gravity flow may be expensive so conduct a cost/benefit analysis, comparing gravity flow to pumping.

Water Supply Tanks

Place water storage tanks close to mixing/loading equipment, outside and adjacent to primary and secondary containment pads. Water tanks do not require containment space, but may be stored inside fenced containment to minimize vandalism if space is available and containment volume is properly sized. However, containment volume must be sized for the water tank if it is the largest tank.

Air Gaps, Check Valves and Reduced Pressure Backflow Prevention Devices

Water lines connected to pesticide mixing and rinsate storage tank systems are vulnerable to backflow of pesticides and fertilizers into the water system. Install positive back-flow or anti-siphon protection on water systems that provide water to agricultural pesticide and fertilizer storage and handling operations.

Two accepted methods of backflow protection are the air-break separation and an approved backflow prevention assembly. Individual conventional check valves will not provide reliable backflow protection of water supply lines.

An air-break separation is a vertical air gap between the free flowing discharge end of a water supply line and the fill opening of a water storage tank. This method requires removal and replacement of the tank opening cover each time the tank is filled. An approved separation should be at least 1" or two times the diameter of the supply line measured vertically above the overflow rim of the tank. The supply line is usually fitted with a float controlled shutoff.

A reduced pressure principle backflow prevention assembly is usually approved for use between the water supply line and the pesticide handling facility. Check local regulations to be sure they are permitted.

Install check valves, Figs 53 and 54, in all rinse water or mixture handling lines. Valves for horizontal piping must be spring loaded, Fig 54. Valves in vertical piping can be gravity activated valves such as pump type foot valves, Fig 53. The spring-loaded valve can be used in any position. Check valves usually work well but are known to fail occasionally due to dirt particles or rust scale wedged between the valve and the seat. Check for good operating and proper back flow sealing prior to operating the complete system. Provide shutoff valves to isolate system components for maintenance or emergencies.

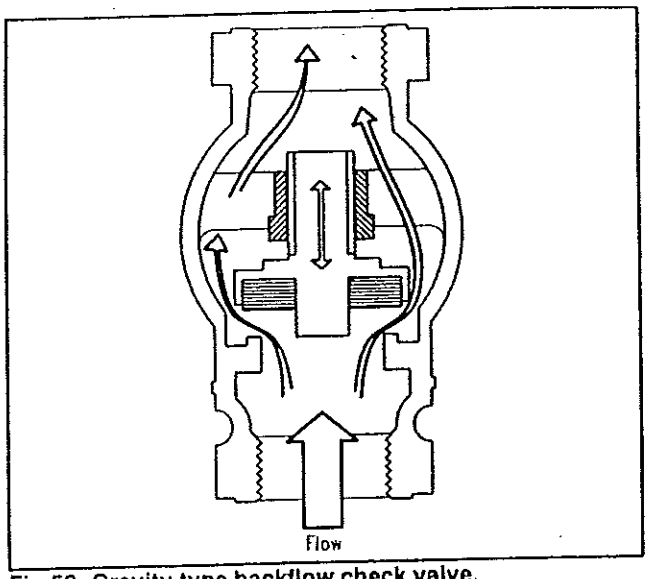


Fig 53. Gravity type backflow check valve.

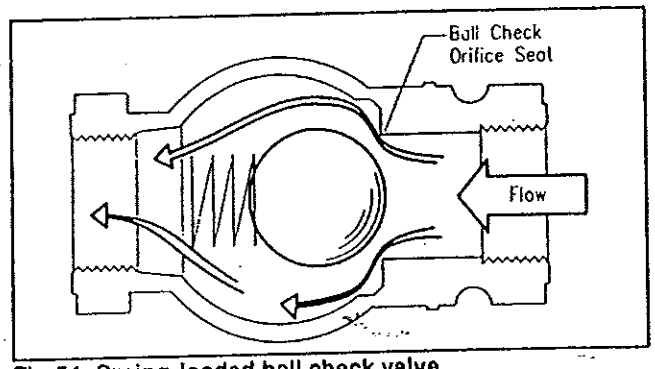


Fig 54. Spring-loaded ball check valve.

Alternative Mixing/Loading Facilities

Watertight, high-strength, reinforced concrete is the preferred material for constructing pesticide and fertilizer mixing/loading pads. Reinforced concrete with flexible chemical resistant surface sealers for pesticide and fertilizer containment, with surface sealed asphalt drives and approach ramps are suitable for use with liquid pesticides and fertilizers. Engineering designs in special circumstances may incorporate alternative materials such as prestressed or post-stressed transportable or in-place concrete modules, asphalt, steel, plastics (polyurethane, polyurea, advanced technology synthetic materials) depending on the type of pesticide and fertilizer, the use of the construction material and the facility use.

Temporary/transportable synthetic facilities

Several manufacturers market portable, flexible or inflatable walled, synthetic, drive-over mixing/loading pads that fold up for transport. Use these units only at remote or satellite operations for temporary field mixing/loading to catch drips and spills, not for permanent mixing/loading facilities. Use small AC or DC powered sump pumps to recover diluted pesticide spills and rinsate.

There are also several types of shallow, rigid-walled plastic or fiberglass trays on the market, approximately 8'x16' and 6" high, with elevated vehicle tracks or ramps that allow truck or field sprayers to be driven into the containment for loading. These are also suitable for temporary use only. There may be more development and use of portable mixing/loading systems as applicators try to reduce the risk of field spills.

Deeper (18"-24") fiberglass containment units are available that can be transported to permanent facility sites in sections for on-site assembly. They are field "seamed" or joined together to use for pesticide rinsate recycling and containment of mixing/loading equipment. Multiple units can also be incorporated for liquid fertilizer tank, pesticide storage and rinsate tank secondary containment.

Bulk Unloading Facility

Large liquid fertilizer outlets may need a separate area for receiving bulk truck shipments while the primary load-out pad is in use, Fig 7. For bulk unload facilities, use a drive pad with level side curbs or walls and floors that slope to a shallow trough at the center (6"-9" deep) which drains to a small, shallow sump to provide the required containment volume. Locate it along one side of the liquid fertilizer bulk storage containment pad. The bulk truck unloading pad should contain more holding volume than the largest transport load plus the storm water level from at least a 25-yr, 24-hr storm.

One company is now prefabricating three-section modular concrete containments for field assembly that are connected and seams are sealed on site. This may be a suitable solution for loading/unloading bulk transport trucks or liquid fertilizer applicator trucks.