Calibration & safety of pesticide application equipment

Calibration accuracy and personal safety associated with pesticide application is key to a successful pesticide program.

HOW TO USE THE WORKSHEET (FIGURE 1)

Nozzle Uniformity

1. Enter date, nozzle code and sprayer operating pressure in appropriate box. Verify that all nozzles are the same type and size along the boom.

FIGURE 1

NOZZLE UNIFORMITY AND CALIBRATION WORKSHEET

DATE_____

NOZZLE CODE = _____ PRESSURE = _____

(Volume Conversion) NOZZLE DECIMAL OUTPUT X 128 = _____ OUNCES

NOZZLE CATCH TIME IN SECONDS = _____

#1_____	#5_____	#9_____
#2_____	#6_____	#10_____
#3_____	#7_____	#11_____
#4_____	#8_____	#12_____

AVERAGE OUTPUT _____ OUNCES

AV. OP. X 0.95 = _____ (-5%) AV. OP. X 1.05 = _____ (+5%)

CLEAN OR REPLACE NOZZLE NOT WITHIN 5% OF AVERAGE, REPLACE ALL IF TWO OR MORE ARE WORN.

****

GALLONS PER MINUTE = $\frac{\text{Ozs. X 60}}{\text{Sec. X 128}}$ = _____ = _____ (GPM)

VEHICLE SPEED = $\frac{.682 \text{ X Ft.}}{\text{Seconds}}$ = _____ = _____ (MPH)

NOZZLE SPACING IN INCHES = _____ (W)

CALIBRATION RATE IN GALLONS PER 1,000 Sq. Ft. = $\frac{136.36 \text{ X GPM}}{\text{MPH X W}}$ = _____ = _____ (GPK)

(To Calculate Gallons per Acre: Substitute 136.36 with 5,940)

or

Multiply GPK X 43.56 = _____ (GPA) Gallons per Acre

****

ACCEPTABLE ERROR RANGE = GPK (GPA) X 0.95 = _____ (-5%)
(Target Area vs Sprayed Area)

GPK (GPA) X 1.05 = _____ (+5%)

2. Catch the flow from each nozzle for exactly the same amount of time. The number of seconds used is usually between 20 and 60, but make sure that at least 20 ounces are collected in each calibration jar (to help reduce error size). It is very important to maintain a constant operating pressure throughout the entire operation. Enter catch times in appropriate boxes.

3. Calculate average nozzle output.

4. Determine if any nozzles are significantly worn or clogged by verifying that all flow rates are within + or - % of the average nozzle output. (Typically between 5-10% limit.)

5. Clean, replace or recheck nozzles exceeding the predetermined limit.

Speed Calculator

1. Calculate field spraying speed of the machine by laying out a level test course at least 100 feet long (Use a turf area, not a parking lot or cart path). Fill machine ½ full of water to simulate average load and record the exact amount of seconds to travel entire course at operating speed. Use this data in the equation provided.

Application Rate

** GPM and Speed calculations should appear in appropriate boxes (from previous formulas).

1. Measure nozzle spacing in inches. Enter number (in inches) in box.

2. Calculate the calibration rate using the formula provided. Read the product label to determine if this calibration rate falls within guidelines. Use manufacturer's catalogue charts to help verify your calculations.

NOZZLE SELECTION AND SIZING (FIGURE 2)

1. Determine the recommended calibration rate. (Refer to product label.)

2. Measure nozzle spacing in inches.

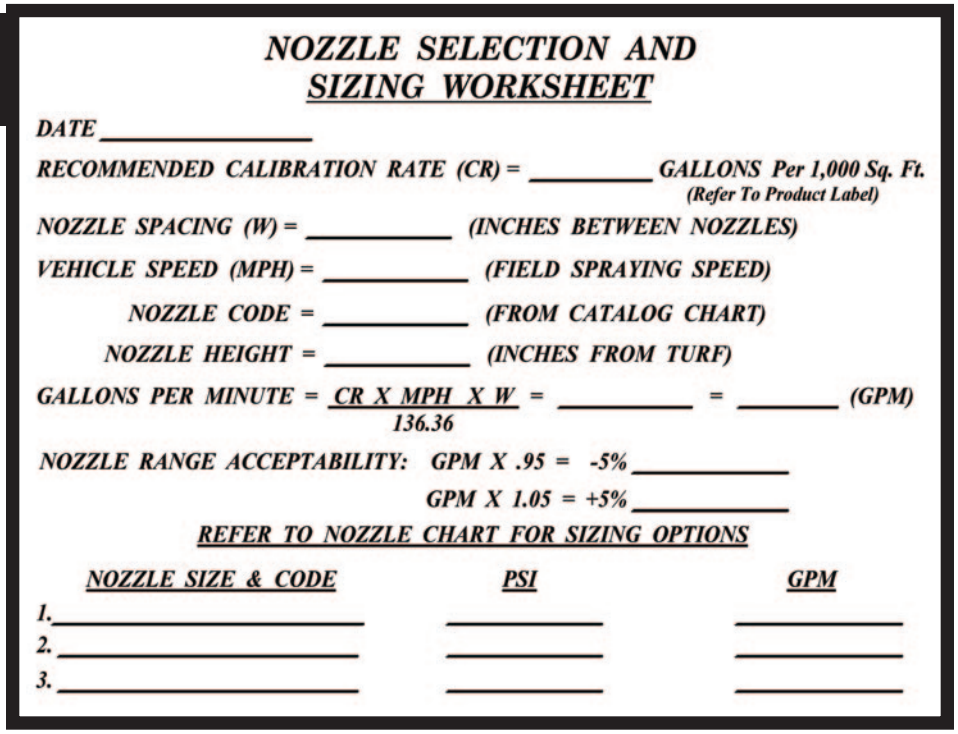
3. Determine the spraying speed you will be using in the field.

4. Determine the appropriate nozzle size from manufacturer's charts.

5. Calculate the nozzle flow rate necessary to achieve the desired calibration rate with the sprayer.

6. Use nozzle manufacturer's catalogue to determine the nozzle identification code that corresponds to the nozzle style and

FIGURE 2



NOZZLE SELECTION AND SIZING WORKSHEET

DATE _____

RECOMMENDED CALIBRATION RATE (CR) = _____ GALLONS Per 1,000 Sq. Ft. (Refer To Product Label)

NOZZLE SPACING (W) = _____ (INCHES BETWEEN NOZZLES)

VEHICLE SPEED (MPH) = _____ (FIELD SPRAYING SPEED)

NOZZLE CODE = _____ (FROM CATALOG CHART)

NOZZLE HEIGHT = _____ (INCHES FROM TURF)

GALLONS PER MINUTE = $\frac{CR \times MPH \times W}{136.36}$ = _____ = _____ (GPM)

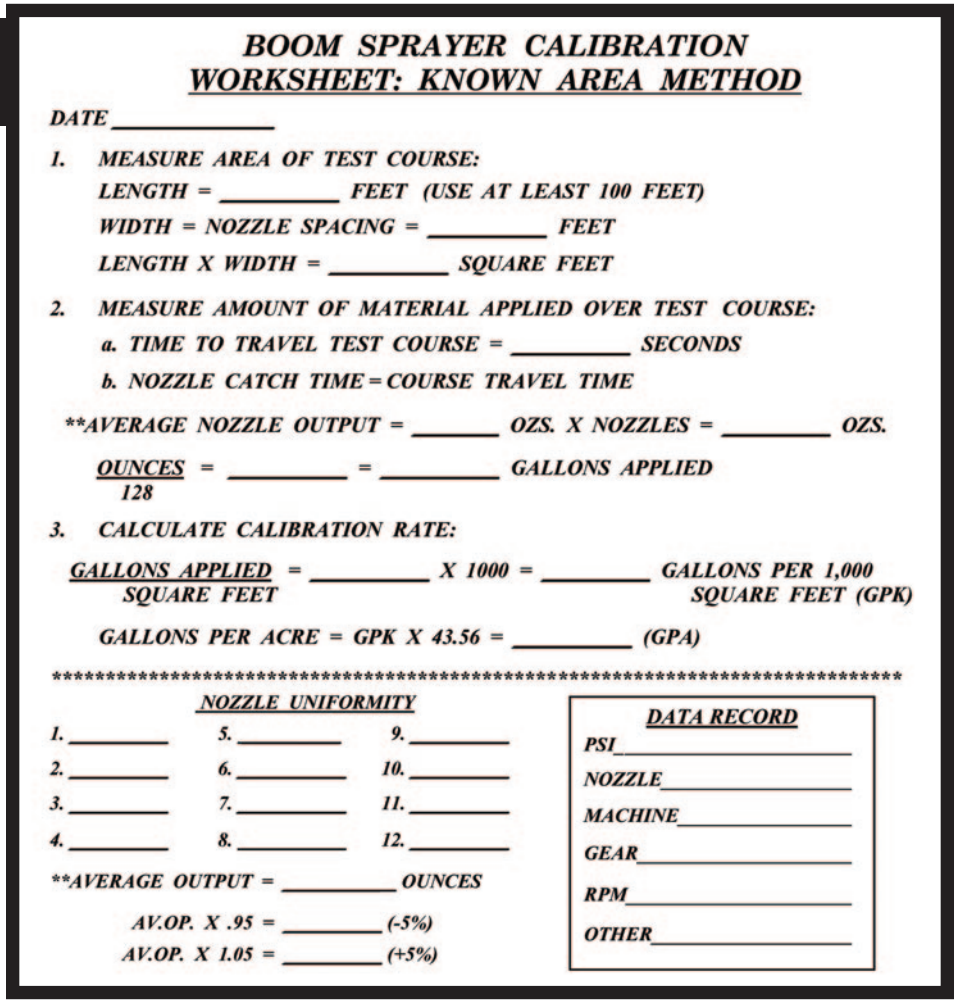
NOZZLE RANGE ACCEPTABILITY: GPM X .95 = -5% _____

GPM X 1.05 = +5% _____

REFER TO NOZZLE CHART FOR SIZING OPTIONS

NOZZLE SIZE & CODE	PSI	GPM
1.		
2.		
3.		

FIGURE 3



BOOM SPRAYER CALIBRATION WORKSHEET: KNOWN AREA METHOD

DATE _____

1. MEASURE AREA OF TEST COURSE:
   LENGTH = _____ FEET (USE AT LEAST 100 FEET)
   WIDTH = NOZZLE SPACING = _____ FEET
   LENGTH X WIDTH = _____ SQUARE FEET

2. MEASURE AMOUNT OF MATERIAL APPLIED OVER TEST COURSE:
   a. TIME TO TRAVEL TEST COURSE = _____ SECONDS
   b. NOZZLE CATCH TIME = COURSE TRAVEL TIME

**AVERAGE NOZZLE OUTPUT = _____ OZS. X NOZZLES = _____ OZS.

$\frac{OUNCES}{128}$ = _____ = _____ GALLONS APPLIED

3. CALCULATE CALIBRATION RATE:

$\frac{GALLONS\ APPLIED}{SQUARE\ FEET}$ = _____ X 1000 = _____ GALLONS PER 1,000 SQUARE FEET (GPK)

GALLONS PER ACRE = GPK X 43.56 = _____ (GPA)

****

NOZZLE UNIFORMITY

1. _____	5. _____	9. _____
2. _____	6. _____	10. _____
3. _____	7. _____	11. _____
4. _____	8. _____	12. _____

**AVERAGE OUTPUT = _____ OUNCES

AV.OP. X .95 = _____ (-5%)

AV.OP. X 1.05 = _____ (+5%)

DATA RECORD

PSI _____

NOZZLE _____

MACHINE _____

GEAR _____

RPM _____

OTHER _____

flow rate chosen for the equipment.

7. Follow nozzle manufacturer's recommendation for proper nozzle height.

BOOM SPRAYER CALIBRATION: KNOWN AREA METHOD (FIGURE 3)

1. Measure a level test course at least 100 feet long on a turf area (not a parking lot or cart path). The width of this test course will be the spacing between each nozzle in feet.

Nozzle Spacing in Inches divided by 12 = Test Course Width in Feet. Total square feet of the area is Length X Width.

2. Fill machine 1/2 full of water to simulate average load and record the exact number of seconds to travel the entire test course at normal operating speed. Use a calibration jar to collect the flow from each nozzle for the same amount of time it took to cover the test course. Calculate the average nozzle output and replace or clean any nozzle with a flow rate not within 5% of the average. Average Nozzle Flow in Ounces divided by 128 oz. per gallon = Average Gallons Applied

3. Record all data for future use. Calculate your + or - 5% acceptable error range (Target Area vs. Sprayed Area). Each time you use your sprayer, the calibration rate must fall within these values. Either repair or replace components causing calibration rate inaccuracy.

TIPS: Check for wear more frequently when spraying wettable powders. Verify the accuracy of your measuring devices.

EASY METHOD SPRAYER CALIBRATION (128TH ACRE TEST)

1. Fill spray tank with clean water.

2. Verify that spacing between nozzles is equal (record in inches).

3. Perform nozzle uniformity test.

4. Measure test course. (Use chart below or formula to determine course length.) (Formula: 4080 / Nozzle Spacing in Inches = Test Course in Feet.)

5. Drive the test course at your normal spraying speed and record travel time in seconds.

6. Park sprayer while maintaining the same engine RPM used to drive the test course.

7. Set pressure to be used while spraying.

8. Collect the output from one nozzle for the same amount of time it took to travel the course.

9. Each ounce collected equals a gallon per application rate. (Example: 52 ounces collected equals 52 gallon per acre application rate)

Nozzle Spacing - Test Course Chart	
Nozzle Spacing (Inches)	Test Course Length (Feet)
20	204
18	227
16	255
14	291
12	340
10	408

TANK MIXING (FIGURE 4)

1. Determine the recommended application rate from the product label. This value can be in fluid or dry ounces.

2. Enter the calibration rate measured from the sprayer.

3. Calculate the product per gallon ratio according to the worksheet.

4. Calculate the amount of product required for each tank or partial tank. Before adding product, you should fill the tank 1/2 full of water and begin agitation. After product's been added, bring tank up to desired level/volume.

For planning purposes, it may be useful to calculate the following:

5. Estimate the area to be treated. This value will be slightly larger than actual green or fairway size due to overspray of irregular areas.

6. Estimate the total water requirements. You can use this figure to determine how many spray tanks the application will require.

7. Estimate the product requirements and check if supplies are adequate before mixing.

TIPS: Verify the markings on your spray tank for accuracy and use a dipstick or flow meter to measure partial tanks. Do

FIGURE 4

TANK MIXING WORKSHEET

*DATE*_____

*PRODUCT NAME*_____

PRODUCT LABEL RATE = _____ *OUNCES PER 1,000 SQUARE FEET*

ACTUAL CALIBRATION RATE = _____ *GALLONS PER 1,000 SQUARE FEET*

PRODUCT PER GALLON = $\frac{\text{PRODUCT LABEL RATE}}{\text{CALIBRATION RATE}}$ = _____ *OUNCES OF PRODUCT PER GALLON OF WATER*

AREA TO BE SPRAYED (estimated) = _____ *1,000 SQUARE FEET*

TOTAL WATER REQUIRED = CALIBRATION RATE X AREA TO SPRAY = _____

TOTAL PRODUCT RQUIRED = PRODUCT RATE X AREA TO SPRAY = _____

****

PRODUCT IN TANK # 1 = GALLONS OF WATER X PRODUCT PER GALLON

(If Required, Calculate Additional Tank Mixes)

PRODUCT IN TANK # 2 = GALLONS OF WATER X PRODUCT PER GALLON

FIGURE 5

CALIBRATION:
ADVANCED SECTION WORKSHEET

DATE _____

1. *CALIBRATE THE MPH YOU NEED TO GET EXACTLY 2.0 GALLONS PER 1,000 SQUARE FEET.*

2. *CALCULATE THE GPM NEEDED FOR 2.0 GALLON PER 1,000 SQUARE FEET. DO YOU NEED TO SELECT A LARGER VOLUME NOZZLE?*

3. *CALCULATE THE ACTUAL NOZZLE PRESSURE.*
   (Refer to Nozzle Manufacture's Flow Chart)

$$\frac{GPM_1}{GPM_2} = \frac{\sqrt{PSI_1}}{\sqrt{PSI_2}}$$

not mix more solution than is required for the operation.

INSTRUCTIONS FOR THE ADVANCED SECTION (FIGURE 5)

You've measured the actual calibration rate of the sprayer. You want to spray a calibration rate of 2.0 gallons per 1000 square feet. Determine how to make the adjustments in question #1 and #2.

1. If you only want to change your sprayer speed to achieve the new calibration rate, how fast would you need to go? MPH = 136.36 X GPM divided by CR x W

2. Instead of changing your speed to achieve a new calibration rate, you decide to change only nozzle flow. What is the new GPM? Do you need to select a larger nozzle or just change the pressure? GPM = CR X MPH X W divided by 136.36

3. This is a useful method to calculate your actual nozzle operating pressure. The formula allows you to compare field measurements to nozzle performance charts. This calculation is used primarily to track the amount of pressure drop in your sprayer.

GPM (1) = Measured nozzle flow from sprayer (Actual Catch).

GPM (2) = Flow rate from nozzle performance chart.

PSI (1) = Actual nozzle operating pressure. PSI (1) is X, the unknown value. Find X to solve the equation.

PSI (2) = Nozzle pressure from chart that corresponds with GPM (2).

LAWN GUNS, BACKPACK AND BOOMLESS SPRAYER CALIBRATION (FIGURE 6)

1. Pick a level turf area and mark a rec-

FIGURE 6

LAWN GUNS, BACKPACKS and BOOMLESS SPRAYERS CALIBRATION WORKSHEET: KNOWN AREA METHOD

DATE _____

1. MEASURE AREA OF TEST COURSE:
   LENGTH = _____ FEET
   WIDTH = _____ FEET
   LENGTH X WIDTH = _____ SQUARE FEET
2. MEASURE AMOUNT OF MATERIAL APPLIED OVER TEST COURSE:
   a. TIME TO TRAVEL TEST COURSE = _____ SECONDS
   b. NOZZLE OUTPUT (catch time-same as travel test course) = _____ OUNCES

   $\frac{\text{OUNCES}}{128} = \frac{\quad}{128} =$ _____ GALLONS APPLIED
3. CALCULATE CALIBRATION RATE:
   $\frac{\text{GALLONS APPLIED}}{\text{SQUARE FEET}}$ = _____ X 1000 = _____ GALLONS PER 1,000 SQUARE FEET (GPK)
   GALLONS PER ACRE = GPK X 43.56 = _____ (GPA)

USEFUL FORMULAS

$\frac{\text{OUNCES}}{128} = \text{GALLONS}$

GALLONS Per 1,000 Sq. Ft. X 43.56 = GALLONS Per ACRE

DATA RECORD

PSI _____
NOZZLE _____
SPRAYER _____
OTHER _____

FIGURE 7

SPREADER CALIBRATION WORKSHEET: KNOWN AREA METHOD

DATE _____

1. MEASURE AREA OF TEST COURSE:

   LENGTH = _____ FEET

   WIDTH = _____ FEET

   LENGTH X WIDTH = _____ SQUARE FEET

2. MEASURE AMOUNT OF MATERIAL APPLIED OVER TEST COURSE:

   MATERIAL WEIGHT PRIOR TO APPLICATION = _____ POUNDS

   MATERIAL WEIGHT AFTER APPLICATION = _____ POUNDS

   TOTAL AMOUNT OF MATERIAL APPLIED = _____ POUNDS

3. CALCULATE CALIBRATION RATE:

   POUNDS APPLIED / SQUARE FEET = _____ X 1000 = _____ POUNDS PER 1,000 SQUARE FEET

   POUNDS PER 1,000 SQUARE FEET X 43.56 = _____ POUNDS PER ACRE

USEFUL FORMULAS

OUNCES / 16 = POUNDS

GRAMS / 454 = POUNDS

DATA RECORD

SPREADER_____

SETTING_____

MATERIAL_____

PASS WIDTH_____

MACHINE_____

GEAR_____

RPM_____

OTHER_____

Pesticide Compatibility

- Read Product Label
  - Review formulation compatibility statements
- Jar Test
  - Use a 1-quart clear glass jar and add 1-pint of clear water
    - add 1-1/2 teaspoons for each pound per acre recommended of the wettable powder
    - followed by 1 teaspoon for each quart per acre recommended of the liquid pesticide
    - shake the jar and let it stand for 2-3 minutes
    - if pesticides are non-compatible;
      - products may separate and form layers *or* a greasy film will form in the mixing container

Note: In some cases a compatibility agent can be added to solve the problem

TIPS:

Maintain a constant operating speed and pressure throughout entire application. Verify the accuracy of your measuring devices. Calibrate your equipment at the same speed, pressure and overlap as you will use in the field.

tangular test course (length X width - square feet) of approximately: 500-2,000 square feet for backpack sprayers and lawn guns, and 20,000-40,000 square feet for boomless sprayers.

2. Measure the exact amount of time to travel the test course under normal spraying conditions. Use a catch can or bag and calibration jar to measure nozzle flow in ounces from the machine for the same exact amount of time it took to cover the test course.

Ounces collected divided by 128 ounces = Gallons applied over test course

3. Calculate the calibration rate according to the worksheet and use it for tank mixing.

4. Record all data for future use.

TIPS: Maintain a constant operating speed and pressure throughout entire application. Verify the accuracy of your measuring devices. Calibrate your equipment at the same speed, pressure and overlap as you will use in the field.

SPREADER CALIBRATION (FIGURE 7)

1. Select a level area, preferably covered with turf and mark a rectangular test course of approximately: 1,000-5,000 square feet for small spreaders, and 10,000-40,000 square feet for larger spreaders.

2. Measure the exact amount of material applied over the area.

This can be done by:

A. Place a (weighed) known amount of material in the spreader. Re-weigh the material left in the spreader after completing the test course; or B. On larger machines, it may be necessary to place calibration marks on the spreader bin or place. A known amount of material in the spreader and measure the total area covered after all material is used.

3. Calculate the calibration rate according to the worksheet.

4. Record all data for future use.

TIPS: Maintain a constant operating speed throughout application. Flow rate and distance of throw vary according to the size and weight of the material. Follow manufacturer's recommendations for overlap. If unavailable, determine the amount of overlap required by placing a series of catch cans perpendicular to spreader travel and measuring the application pattern or use between 75-100% overlap of the width of throw.

Spreader Calibration: Known Area Method

Single Pass Calibration

Measure area of test course…

Test Course Length (ft.) **x** Effective Pattern Width (ft.) = Total sq. ft.

Example: 25 ft. length **x** 5 ft. effective pattern width **=** 125 square feet

Note: Rotary / Broadcast spreader effective pattern width is typically between 75% - 100% less than the overall pattern width.

I.e.: overall pattern width = 10 feet; effective pattern width = 5 feet

1. **Set the rotary spreader's rate gate opening to the recommendation published on the fertilizer bag (*per spreader brand, model, etc.*).**
2. **Partially fill the spreader with a pre-weighed amount of fertilizer to be used in the application.**
3. **Walk at *your* normal application pace. Achieve your application pace several feet before crossing the test course "Starting-line" and maintain your application pace several feet after crossing the test course "Finish-line".**

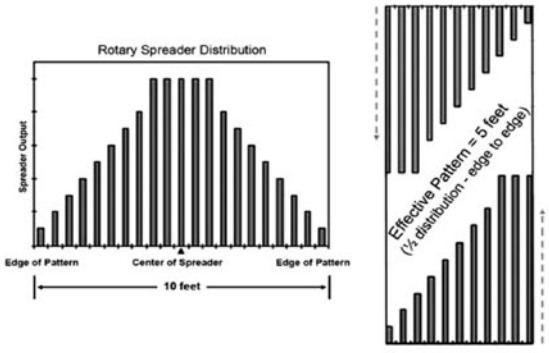
*** Turn the spreader on when the wheels are directly over the "Starting-line"… … (*example: 0 feet*).**

*** Turn the spreader off when the wheels are directly over the "Finish-line"… … (*example: 25 feet*).**

4. **Weigh the amount of fertilizer left in the spreader and subtract that amount from the pre-weighed amount.**

Note: A fraction of an ounce digital or analog scale is required for Single Pass Calibration.

Rotary Spreader Effective Pattern



SAFETY—THE "THREE C'S" PROGRAM

Control the spill. Immediate steps must be taken to control the spill. Make sure you are properly protected, isolate the area, avoid contact with the material, drift, or fumes, and evacuate any nonessential people from the area. Do not leave the spill unless someone can relieve you, preferably someone who has "Three C's" training. Once the spill is under control, get help immediately and notify your supervisor. Depending on the size of the spill, you may need to contact "HAZMAT", police, fire and rescue units, and the Dept. of Natural Resources.

Contain the spill. Contain the spill in as small an area as possible. Use a rake or a shovel to make a dam or dike around the spill to keep it from spreading. Block off any ditches or depressions in the area of the spill to insure the spill's containment. Do not allow the flow of material to reach any bodies of water.

Liquid pesticide spills can be further contained by the use of absorbent materials such as sand, sawdust, kitty litter or absorbent pads. Before using absorbent material, make sure the chemical is compatible with the absorbent material used. A reaction may occur between the spill and the material used to clean up the spill. Pesticides with strong oxidizers may create a fire when mixed with sawdust, thereby compounding an existing problem. (Chlorites in some herbicides and ammonium nitrate in some fertilizers are two examples of oxidizers.)

Dry pesticide spills can be contained by lightly misting the material with water, or by covering the spill with plastic.

Clean up the spill. Liquid: Spread absorbent material over the contaminated area, sweep it up and place it in a heavy-duty plastic bag. Repeat this procedure until the spill is cleaned up.

Dry: Material must be swept up and reused if possible. If material gets wet, becomes contaminated with soil or other debris, it must be swept up and placed in a heavy-duty plastic bag.

To decontaminate or neutralize the area, mix full strength, ordinary household bleach and hydrated lime. Wear protective clothing and work the preparation into the spill area with a course broom. Place the contaminated preparation in a heavy-duty plastic bag. Repeat this procedure several times to insure neutralization of the pesticide. Never hose down the contaminated area to dilute the pesticide. Activated charcoal can be used to minimize significant plant injury in smaller spills. Charcoal can tie up or absorb enough chemical to reduce long-term contamination.

Soil contamination: Remove the top two or three inches of soil, cover with at least two inches of lime and cover the lime with fresh top soil. Dispose of the contaminated soil.

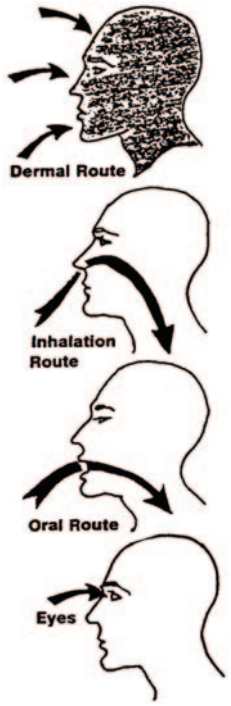
Clean or dispose of all equipment and materials used in the clean up in a manner consistent with label requirements and any EPA, local or state regulations.

All materials used to control, contain, and clean up a pesticide spill must be handled as hazardous waste and must be disposed of in a manner consistent with the label requirements and any EPA, local or state regulations. ■

Jim Nedin has been associated with the turf industry for 40 years. He began his professional career as a golf course superintendent in the early 70's and has taught turf industry related seminars for 30 years. Jim is a private service business consultant, and is currently working with select Toro distributors and The Toro Company, providing technical service support and training, jimwex2@gmail.com.

Routes of pesticide exposure

TO EFFECTIVELY GUARD AGAINST PESTICIDE EXPOSURE, we must first realize the risk involved when handling pesticides and how they enter our bodies.



FOUR ROUTES OF ENTRY

- **Dermal**. Studies show that about 97% of all pesticide exposures occur through contact with the skin. This absorption is accomplished by careless handling, while mixing or loading, applying or disposing of pesticides and their containers. The most common of these would be splashes, spills, or drift, while mixing or loading (handling the pesticide in its most concentrated form).

- **Inhalation**. We all know that the lungs oxygenate our blood. So if we inhale a sufficient amount of a pesticide into our lungs, complete and rapid pesticide poisoning will occur when the blood passes through our lungs then out, to travel in the blood stream throughout the entire body. Poisoning by inhalation is not limited by any means. Damage to tissue in the nose, throat, and lungs can also produce long-term health problems and illnesses.

- **Oral**. More often than not, children are victim of this type of exposure, greatly due to a careless applicator or even a parent who has removed a pesticide from its original container and put it into an unmarked bottle or other storage container. However, for our purposes, one must realize that oral exposure can occur with a simple lick of the lips, smoking, chewing (tobacco or gum), eating or drinking, while handling pesticides.

- **Eyes**. The eye though very small can absorb enough pesticide to be significantly hazardous. Poisoning here is most generally accomplished through the rubbing of one's eyes with contaminated hands. Spills, splashes and drift are also methods of entry to guard against.

TOXICITY (LD50, LC50)

What do we need to know about these two numbers? Simply put, the higher the LD50 or LC50 number, the lower the incidence of poisoning has occurred in laboratory testing of that pesticide. On the other hand, the lower that number, the greater the incidence of poisoning has occurred in lab testing, and those pesticides will generally carry a signal word of "Danger." Signal words are derived from LD (lethal dose) or LC (lethal concentrate) numbers, so if you can't find one of these numbers on the label, or MSDS, follow the signal word precautions.
For personal safety, always wear protective gear and always wash up immediately following contact with any pesticide.

Personal protective equipment

YOU NEED TO DECIDE! Read the label. The formulation, signal word, precautionary statements, personal protective equipment statements, the application method, and the projected length of exposure indicate the personal protective equipment you need.

MINIMUM EXPOSURE

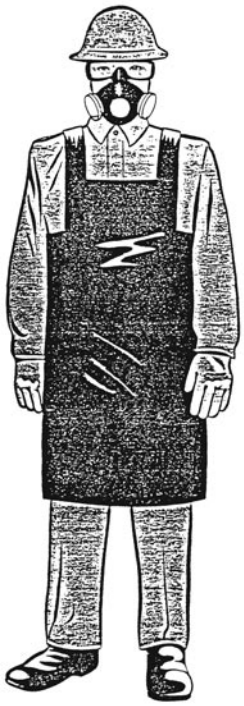
- (Such as granular applications and many other routine pesticide activities.)
- Protective suit (such as fabric coveralls) worn over normal work clothes.
- Chemical-resistant gloves such as rubber, vinyl, or plastic (never use fabric, leather, or paper gloves).
- Socks and shoes or boots

MAXIMUM EXPOSURE

- (Such as direct contact with drenching spray, mist blower or knapsack applications, or handling very highly toxic pesticides.)
- Chemical-resistant hood or hat
- Goggles or face shield
- Respirator (if the label requires it or if dusts, mists, fogs, or vapors will be generated).
- Chemical-resistant protective suit worn over normal work clothes.
- (A chemical-resistant protective suit may cause heat stress under some conditions.)
- Chemical-resistant gloves such as rubber, vinyl, or plastic (never use fabric, leather, or paper gloves).
- Chemical-resistant boots or footwear (never wear leather or canvas footwear).

Handling Concentrates

- This is the minimum protective clothing and equipment you should wear while mixing and loading pesticides which are moderately to highly toxic.
- Protective suit (such as fabric coveralls) worn over normal work clothes.
- Chemical-resistant apron
- Chemical-resistant gloves such as rubber, vinyl, or plastic (Never use fabric, leather or paper gloves)
- Chemical-resistant boots or footwear (Never wear leather or canvas footwear)



- Face Shield or goggles
- Respirator
(If the label requires it)